ashurst

Low Carbon Pulse Compendium

October 6, 2020 to October 5, 2021

The author of this compendium and each edition of Low Carbon Pulse is Michael Harrison.

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Introduction

Welcome to the Low Carbon Pulse Compendium (***LCPC***): ***LCPC*** has combined each edition of Low Carbon Pulse (***LCP***) published from October 6, 2020, to October 5, 2021, twenty eight editions in all, into one document.

Background:

- **Time and place:**

  Edition 1 of Low Carbon Pulse was written on a Saturday morning on the mezzanine level at the Hilton Hotel, Hohola, Port Moresby, National Capital District, PNG. As well as PNG, other editions have been written in Cairns, Sydney and Singapore.

  Before COVID-19, the author spent time "on the road" working with clients on projects and transactions across Asia Pacific, and into the MENA. Likely future editions of Low Carbon Pulse will be written on Saturdays in equally evocative and wonderful locations.

- **Evolution of Low Carbon Pulse:**

  Edition 1 of Low Carbon Pulse covered a seven day period, and had a relatively meagre word count. Subsequent editions have covered 14 day periods, with the scope of the subject matter covered increasing over time.

  Also the rate of progress towards achievement of net-zero greenhouse gas emissions has increased, and continues to do so; in short, there has been more news to cover.

  The most recent editions of Low Carbon Pulse have been longer than earlier editions as news and trends, and the roles of Governments, Central Banks, International Agencies, Policy Banks and the private sector have been covered ahead of COP-26.

- **Reasons to be thankful:**

  The last 12 months have been both challenging and unusual for many people in many places.

  The author has been fortunate to spend time with clients and colleagues in Port Moresby, Singapore and Sydney, avoiding lockdown for the last 18 months – something of an Odyssey.

  In many ways, the period from March 2020 has been as satisfying as any in the author's career. Clients and colleagues have maintained a sense of humour, including occasionally laughing, but more often than not grimacing or sighing, or both, at the "sense of humour" of the author. For clients and colleagues in PNG who have hosted me for 12 out the last 18 months, thank you, including for the recently conferred soubriquet, "the low pulse carbon".

  Thank you to all.

Purpose of *LCPC*:

- **Anniversary Edition:**

  As the anniversary of Edition 1 of Low Carbon Pulse approached, it became clear that some readers would like a consolidated document, containing each edition of Low Carbon Pulse.

- ***LCPC* and Anniversary Edition of Low Carbon Pulse:**

  This ***LCPC*** (which is published alongside the Anniversary Edition of Low Carbon Pulse) contains all 28 editions of Low Carbon Pulse published to date.

  Within Section 3 of this ***LCPC*** (under ***NZE Reports***) is a table containing a link to each paper, report and study referenced in Low Carbon Pulse. This provides a virtual library.

  Also within Section 3 of this ***LCPC*** are the July and August Reports on Reports, a feature introduced to allow consideration of papers, reports and studies to manage the length of Low Carbon Pulse.

- **Hope of use**

  It is hoped that this ***LCPC*** is of use. This ***LCPC*** is searchable.

Michael Harrison, Senior Partner, Energy, Resources, and Infrastructure

(And, on weekends, researcher and author of Low Carbon Pulse.)

PROGRESS TOWARDS NET-ZERO EMISSIONS
OCTOBER 6, 2020

Low Carbon Pulse - Edition 1

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to the first edition of Ashurst's Low Carbon Pulse.

These regular updates will outline key developments covering each aspect of progress to net-zero globally, such as renewable energy generation, storage and distribution, technological developments, new and developing policy settings, and major project developments and transactions. We will also bring you more detailed insights into particular developments or issues.

This Edition covers the seven day period from September 27, 2020 to Sunday 4, October 2020.

European Parliament increases reductions

The European Parliament has voted in favour of increasing to 60% the reduction in ***GHG*** emissions by 2030 compared to ***GHG*** emissions in 1990 (***-60%***). The ***-60%*** contrasts with the ***55%*** reduction (- 55%) proposed by the European Commission. It will be interesting to see if ***-55%*** is replaced by ***-60%***. Some European Union member states are likely to legislate to increase their national reduction targets in any event. By the second week in December 2020, it will be clear what the reduction target is to be under EU law.

Note: The ***GHG*** emission reduction target was set at 55% – see Edition 4 of Low Carbon Pulse

See: *The Guardian - EU parliament votes for 60% greenhouse gas emissions cut by 2030*

EGCO Fuel Cell Power Plant operational

In early October 2021, ECGO Group's 19.8 MW Fuel Cell Power Plant at Gangdong-gu, Seoul, commenced the supply of electrical energy to Korea Electric Power Fuel Cell Power Corporation (***KEPCO***). In addition to the supply of electrical energy, the Gangdong-gu Plant supplies heat. The Plant uses a fuel cell that combines hydrogen from natural gas and oxygen to produce electrical energy and heat as a result of an electrochemical reaction, not exothermic combustion.

See: *EGCO Group powers up "Gangdong" Fuel Cell Power Plant in South Korea*

GAUSSIN – ATM-H2 and APM-H2

The French corporation, Gaussin, has unveiled two new vehicles for use in logistics ports – the ATM-H2 and the APM-H2. Vehicles used in logistics and port hubs are viewed as being more than likely to transition from the use of fossil fuels to hydrogen. The ATM-H2 has a towing capacity of 38 tonnes (for use in logistics hubs) and the APM-H2 has a pulling capacity of 75 tonnes (for use in the movement of containers at container terminals). These vehicles use a fuel cell that combines hydrogen with oxygen to produce electrical energy.

See: *In a world premiere, GAUSSIN unveils two new hydrogen vehicles, the ATM H2 and the APM H2*

Hyundai Motor Company – a roadmap on the road

Hyundai announced the formal launch of its plan to develop 1,600 XCIENT Fuel Cell heavy-duty trucks by 2025, said to be the world's first mass-produced fuel cell powered heavy truck. The fuel cell produces electrical energy using hydrogen stored in a 32 kg hydrogen tank (storing compressed hydrogen at 350 bar). XCIENT Fuel Cell heavy-duty trucks were delivered to customers in Switzerland in July 2020. Hyundai's plan is aligned with the "Hydrogen Economy Roadmap of Korea 2040" (and the Hydrogen Economy Promotion and Hydrogen Safety Management Law, a clear legal framework for government support for the hydrogen industry and for safety standards).

See: *World's first fuel cell heavy duty truck, XCIENT Fuel Cell, heads to Europe for commercial use*

Peoples Republic of China transitioning to net-zero emissions by 2060

President Xi Jinping has announced a plan for ***PRC*** to transition to net-zero emissions by 2060. The implications of the implementation of this policy setting are far reaching, both for ***PRC*** and other countries. This would be more transformational than transitional. For ***PRC***, this will necessitate grandparenting of coal-fired power stations, and other fossil fuel generation, and re-imagining steel manufacture. For countries that export thermal and metallurgical coal to the ***PRC*** and iron ore there will be huge implications. During COVID-19, the export of metallurgical coal and iron ore to ***PRC*** have helped cushion the impact of COVID-19 for State Governments in Australia.

For those that understand that potential for Australia to take a leading role in the production of hydrogen as an energy carrier this should be seen as an opportunity: by some estimates, the renewable resources across Northern Australia (above the Tropic of Capricorn) would allow the development of 25,000 GW of renewable energy capacity (about ½ of the estimated production to achieve global decarbonisation), which in turn would allow the production of Green Hydrogen.

See: *Climate change: China aims for 'carbon neutrality by 2060'*

Spanish Government approves *Hydrogen Roadmap: a Commitment to Renewable Hydrogen (CRH)*

The Spanish Government has joined governments of other major European economies and the European Union (***EUHS***) in the approval of a roadmap for hydrogen. The ***CRH*** is aligned with the ***EUHS***: among other things, the ***EUHS*** contemplates 6 GW of installed electrolysers by 2024 and 40 GW by 2030. For these electrolysers to produce Green Hydrogen between 80 and 120 GW of new renewable electrical energy capacity will be required.

As with other road maps, the ultimate destination is clear -- zero-emissions or carbon / climate neutrality by 2050. The detailed route to get there is less clear. This said, the ***CRH*** has a focus on achievable objectives, including 300 to 600 MW of installed electrolysers for Green Hydrogen production, by 2025, increasing to 4 GW of installed electrolysers by 2030. Increasing the production of Green Hydrogen is key to 25% of industrial hydrogen consumption being provided by Green Hydrogen by 2030 (one of the objectives set out in the roadmap). Achievable outcomes are also outlined for transportation, including buses, light and heavy vehicles, and trains.

See: *The Spanish Government approves the "Hydrogen Roadmap: a commitment to renewable hydrogen"*

UK Government wants to quadruple off-shore wind

UK Prime Minister, Mr Boris Johnson, wants to increase off-shore wind electrical energy generation of the UK to 40 GW by 2030 (***40 by 30 Plan***), at an estimated cost of GBP 50 / USD 58 billion. This additional 30 GW of capacity would cover an area of approximately 9,500 square kilometres (or six times the size of Greater London). Since 2010, the electrical energy generation capacity of the UK off-shore wind industry has increased ten-fold from 1GW to 10GW. While the ***40 by 30 Plan*** is ambitious, it is reflective of a broader recognition that off-shore wind is a key renewable resource that needs to be developed as part, if not as the core, of energy transition. It is understood that in spring 2021 the UK Government will hold a contract auction for the first tranche of the ***40 by 30 Plan***.

Note: The contract for differences auction took place, and is summarised in Edition 9 of Low Carbon Pulse.

See: *Boris Johnson's Wind Energy Plan needs $58 billion from industry*

USA Industry releases *The Road Map to a US Hydrogen Economy* (*URM*)

The ***URM*** recognises key sectors of the US economy to which hydrogen can contribute to assist in energy transition. The sectors include power generation and grid balancing / stability, energy carrier for industry (including difficult to decarbonise industrial users), energy carrier for commercial and residential buildings and transportation. This recognition demonstrates the versatility of hydrogen as part of the shift to hydrogen as part of energy transition. While the ***URM*** recognises that there is a long way to go, it is stated that a competitive hydrogen industry can meet 14% of total US energy demand by 2050, resulting in 16% decrease in ***GHG*** emissions and 36% decrease in NOx emissions.

See: *'Road Map to a US Hydrogen Economy' promotes scale-up activities in the growing hydrogen economy*

Low Carbon Pulse - Edition 2

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to Edition 2 of Ashurst's Low Carbon Pulse. This edition continues to monitor the pulse of progress to net-zero, outlining key developments covering aspects of energy transition globally from the past two weeks, from October 12, 2020 to October 25, 2020.

During November or early December we will also bring you the first of a series of articles on hydrogen, titled ***The Shift to Hydrogen (S2H2): Elemental Change***, with the first providing an overview of the increasing momentum towards use of hydrogen. ***Why Hydrogen? Why Now?***

Japan to reduce *GHG* emissions to net zero by 2050

On October 23, 2020, Nikkei Asia broke the news that Japanese Prime Minister Yoshihide Suga is to commit Japan to reducing ***GHG*** emissions to net zero by 2050 (***2050 goal***). In committing to the ***2050 goal***, Japan will align its commitment with those of the European Union (***EU***). To achieve the ***2050 goal*** it is anticipated that automotive, electrical energy, steel industries (and other difficult to decarbonise industries), and public transport, will be required to develop and to use new technologies. It is expected that policy settings will be announced shortly to provide concrete measures as to how to achieve the ***2050 goal***. The ***2050 goal*** is consistent with a carbon free society by 2050, and follows concrete measures consistent with the ***2050 goal***, including the development of offshore wind capacity and hydrogen import capacity.

As with the announcement of the People's Republic of China of net zero ***GHG*** emissions by 2060 (outlined in Edition 1 of Low Carbon Pulse), achieving the ***2050 goal*** will impact countries that export coal and LNG (and other energy carriers) to Japan. For example, best estimates are that Japan imports 45% of both Australia's coal and LNG exports. For Australia (as noted below) there are opportunities to become a major exporter of hydrogen (including to Japan), and possibly a major exporter of renewable electrical energy: Australia is blessed with some of the world's best renewable energy resources for solar and wind, and is starting to develop them.

See: *Japan to reduce greenhouse-gas emissions to net zero by 2050*

Japan continues as a hydrogen first mover

In December 2017 (under the Basic Hydrogen Strategy (***BHS***)) the Japanese Ministerial Council on Renewable Energy, Hydrogen and Related Issues, among other things, announced a plan to import up to 300,000 metric tonnes per year of hydrogen by 2030. The ***BHS*** is agnostic as to the form or colour of hydrogen imported - liquid hydrogen gas (***LHG***), methylcyclohexane (***MCH***) and ammonia (***NH_3***) were all contemplated expressly.

Since December 2017, Kawasaki Heavy Industries has developed the world's first ***LHG*** carrier, the Suiso Frontier (launched in December 2019, Suiso meaning hydrogen in Japanese), Chiyoda Corporation has shipped its first cargo of ***MCH*** from Brunei to Japan (in June 2020), and Sabic and Mitsubishi Corp have shipped the world's first cargo of Blue Ammonia (in this instance being hydrogen sourced from the production of petroleum products with ***CO_2*** captured) from the Kingdom of Saudi Arabia to Japan (in late September 2020). In March 2020, the world's first renewable energy powered hydrogen plant was completed at Fukushima.

On October 14, 2020, the Japanese Industry Minister, Hiroshi Kajiyama announced that Japan will create a commercial hydrogen fuel supply chain by 2030. The core of this policy setting is the continued development of sea-borne carriers, with US$800 million in funding to be made available in Japan's next fiscal year for these purposes. In making the announcement, Minister Kajiyama said: "*Given the growing momentum in actions taken by many countries toward wider use of hydrogen, we have come to share a common understanding that hydrogen is an essential energy for decarbonisation*".

Note: In addition to liquefying hydrogen, it is possible to compress it (compressed hydrogen gas or ***CHG***). A number of corporations are working on the development of ***CHG*** technologies, including ***CHG*** carriers.

See: *Japan aims to set up commercial hydrogen fuel supply chain by 2030*

Japanese industry integral to momentum on hydrogen development

The establishment of the Japan Hydrogen Association (***JH2A***) was announced recently by nine Japanese companies, namely ENEOS Corporation, Iwatani Corporation, Kawasaki Heavy Industries Limited, Kobe Steel Ltd, Sumitomo Mitsui Financial, Group Inc., Kansai Electric Power Company, Inc., Toshiba Corporation, Toyota Motor Corporation and Mitsui & Co Ltd.

The establishment of the ***JH2A*** is to be formalised in December 2020 (see Edition 5 of Low Carbon Pulse). The objective of the ***JH2A*** is to help drive the development of a new hydrogen society in Japan. The ***JH2A*** is a further acknowledgement by the private sector of the importance of alliances among private sector participants and governments so as to develop and to implement appropriate policy settings. While not all Japanese corporations actively involved in developing and using technologies are members of the ***JH2A*** (notably Mitsubishi Corporation), it is to be expected that the ***JH2A*** will promote policy settings that are responsive to the development of the new hydrogen society.

See: *Launch of a preparatory committee for "Japan Hydrogen Association (JH2A)"*

Achieving net zero *GHG* emissions virtually impossible without CCUS

In a recent report, the International Energy Agency (***IEA****)* concluded that achieving net zero ***GHG*** emissions will be virtually impossible without carbon capture, utilisation and storage (**CCUS**). On a fairly consistent basis, Governments and Big Oil appear to agree with this conclusion. The issue with CCUS is the development of technology that will result in the capture and storage of CO_2 on a permanent basis, or the capture and use CO_2 into solid form (carbonisation) or into another form that does not produce ***GHG***.

The development of CCUS technology is key to the development of the Blue Hydrogen industry (hydrogen produced using fossil fuels with CO_2 captured permanently so that it is not released into the atmosphere), and to the continued use of technologies in the difficult to decarbonise industries (including cement, chemical and iron and steel production). In theory, Green Hydrogen (hydrogen produced from electrolysis of H_2O using renewable electrical energy) could negate the need for CCUS over time, but the issue is time, how long? By when?

The development of CCUS and carbon capture and storage (CCS) is an area in which Governments can take a leading role. For example, the Norwegian Government is providing funding for the Longship Project, which provides funds to the Equinor, Shell and TOTAL for the Northern Lights Project to capture CO_2 from industrial sources (cement production and waste to energy).

The total cost of the Longship Project is USD 2.7 billion, with the Norwegian Government providing US$1.8 billion. While it is recognised that over time the ***GHGs*** emitted from cement production and waste to energy may be displaced by Green Hydrogen, the Longship Project is about acting in the near term to abate ***GHG*** emissions that would otherwise arise (in reality, not in theory): "*For Longship to be a successful climate project, other countries also have to start using this technology*" Norway's Prime Minister, Erna Solberg.

The development of the Longship Project demonstrates that acting in the near term is key, because in the medium and long term there is no guarantee that technologies required to allow the production of Green Hydrogen will be scalable to supply Green Hydrogen as an energy carrier to the demand side of the hydrogen market, i.e., this is not a policy setting of "wait and see", it is a "see and fix" policy setting.

See: *CCUS in Clean Energy Transitions*

Capturing and storing a fossilised carbon footprint

On October 14, 2020, it was announced that Microsoft has signed an Memorandum of Understanding (***MOU***) with Equinor to determine the basis upon which the Northern Lights Project can be used to capture and to store a quantity of ***GHGs*** equal to the quantity of ***GHGs*** emitted for the purposes of its business since it was founded in 1975 (***Zero Carbon Reset***).

Microsoft is a technology partner in the Northern Lights Project: the stated goal of Microsoft is "*to contribute [its] technology and know-how, but explore how new solutions like the North Lights Project can help [it] meet [its] own carbon negative goals by 2030*". If Equinor and Microsoft devise a basis on which a ***Zero Carbon Reset*** can be achieved, this may provide another pathway to effective funding of CCS / CCUS projects, as those that have contributed to ***GHG*** emissions in the past, recognise the continued impact of them.

See: *Equinor collaborates with Microsoft on Northern Lights carbon capture and storage value chain*

Reductions in *GHG* emissions – measuring actual reductions:

The Equinor / Microsoft ***MOU*** has prompted consideration of how to measure ***GHG*** emissions, at both a corporate and a country level. Given the dynamics of world trade, industrial and manufacturing activities are often undertaken in lower cost jurisdictions, and in those lower cost jurisdictions there is increased demand for energy. As the trading activity of corporations increases, so does their energy use, whether in the country of their establishment or any country in which they undertake activities. By analogy, the same is true of countries: a country achieves a reduction in ***GHG*** emissions by virtue of transition from industrial and manufacturing activities, with those activities undertaken overseas. As such, from a policy setting perspective there is an argument for "***GHG tracking***", and for regulating towards a true cost of carbon, including in respect of goods imported into a country.

Solar renewable energy – cheapest electrical energy in history

The ***IEA*** has stated in its World Energy Outlook 2020 that: "*For projects with low-cost financing that tap high quality resources, solar PV is now the cheapest source of electricity in history.*" The ***IEA*** report goes on to say that solar projects with these characteristics are able to generate electrical energy "at or below" USD20 per MWh or

US$0.02 per KWh, i.e., 2 cents. This is cheaper than the cost of generating electrical energy from coal and natural gas.

Given these factors, it is anticipated that as photovoltaic solar projects achieve greater scale, the unit cost will reduce further. Over time this is likely to result in the grandparenting of coal and natural gas fired power generation as that generation approaches end of design life, in particular in India and the People's Republic of China. Further, the lower the cost of photovoltaic solar power, the more competitive Green Hydrogen will become both as an energy carrier and to displace fossil fuels in higher temperature processes in difficult to decarbonise industries.

See: *World Energy Outlook 2020*

Northern Australia – Asia's renewable energy and Hydrogen hub

A study undertaken by Monash University concluded that Australia (Western Australia, North Territory and Queensland in particular) has some of the best renewable energy resources in the world, resources that could allow the installation of up to **25,000 GW of renewable energy capacity**. With two recent announcements it is possible that this potential is set to be realised.

Given the proximity of Australia to Asia, the available water sources (in some parts of Australia), it is possible that Australia's role as one of the largest exporters of LNG (second to Qatar) may transition to being one of the largest, if not the largest, exporter of liquid hydrogen gas (***LHG***).

On October 16, 2020, the Western Australian State Government approved the first stage (15 GW) of the proposed 26 GW wind and solar project in Western Australia's Pilbara (***Asian Renewable Energy Hub*** or ***AREH***). On October 23, 2020, the ***AREH*** achieved major project status, which will streamline the approvals process. Consistent with policy settings in the energy sector in Western Australia, the ***AREH*** is committed to providing electrical energy domestically to the Pilbara (including the extractive industries located there), currently using predominantly fossil fuels to generate electrical energy. In addition, it has been reported that the ***AREH*** will produce Green Hydrogen, with exports projected to commence by 2028. The ***AREH*** will contribute greatly to the achievement of the Western Australia Government's ***Renewable Hydrogen Strategy***. The ***AREH*** will cover an area of 6,500 km2 of the East Pilbara and Broome region. It is anticipated that the ***AREH*** will have the capacity generate up to 100 TWh of electrical energy each year.

Separately, the approval process in the Northern Territory has commenced in respect of what would be the world's largest solar farm or, adopting the phrase evocative of the pastoralist history of Australia, "solar station". The solar station would be located on the Newcastle Waters Station in the Northern Territory. The current thinking for the electrical energy generated at the 10 GW capacity solar station will supply up to 20% of the electrical energy load of Singapore via a 3,800km submarine interconnector. It is reported that Mike Cannon-Brookes is involved, as is Australian business tycoon, Dr. Andrew Forrest AO.

See: *Asian Renewable Energy Hub*

Global Power System Transformation Consortium and grid transition

In the context of energy transition, the current focus on decarbonisation generally has been renewable energy, energy storage, CCS / CCUS, new technology, hydrogen production from fossil fuel sources and from $\boldsymbol{H_2O}$, difficult to decarbonise industries, and technological development. There has been less focus on grandparenting and repurposing existing infrastructure and facilities and fleets. It is fair to say that there had been even less focus on the transmission and distribution systems, and how they operate.

The Global Power System Transformation Consortium (***G-PST***) comprises:

- **six leading Grid operators**: Australia Energy Market Operator, the California Independent System Operator (***CAISO***), Electric Reliability Council of Texas, EirGrid (Ireland), Energinet (Denmark) and National Grid Electricity System Operator (UK's National Grid);
- **policy banks**: the World Bank and Asian Development Bank; and
- **leading research institutes**: CSIRO (Australia), Fraunhofer Institute, Imperial College London, Latin American Energy Organisation, Institute of Electrical and Electronics Engineers, Electric Power Research Institute, Danish Technical University and the National Renewable Energy Laboratory (United States).

The purpose of the ***G-PST*** is to foment: "a rapid clean energy transition at unprecedented scope and scale", and to share findings and information with Grid operators in developing countries in Africa, Asia and Latin America. In fomenting change, ***G-PST*** will provide clear pathways as to how solar and wind electrical energy (and associated technologies) arising from an anticipated USD10 trillion of investment by the end of 2030 may be integrated into existing grids. In so doing, if these aims are realised, this will contribute greatly to a 50% reduction in ***GHG*** emissions arising from electrical energy generation.

The members of ***G-PST*** are located in countries or states that have adopted renewable energy at faster rates (in particular intermittent / variable solar and wind electrical energy capacity), albeit some of which having material fossil fuel fired generation capacity. It is to be expected that the ***G-PST*** will take a grid wide / whole of system approach, to balance / complement the more technology specific approach policy settings. In the Australian context, while the transition from base load and peaking power stations has not been without its challenges, on October 11, 2020 for the first time 100% of the load in the state of South Australia was matched by the dispatch of electrical energy from renewable sources.

See: *Global Power System Transformation Consortium*

California issues its first tender for energy storage

A key means of grid security and stability is energy storage, including battery and pumped. Grid integrity and stability are ongoing issues. In the light of the impact of the fires in California it has been reported that ***CAISO*** and California Public Utilities Commission (***CPUC***) have reached the view that neither the energy market nor the energy system may be regarded as "fit for purpose". In this context, the ***CPUC*** has indicated that it will revise Electric Rule 21 to facilitate the connection of energy storage projects to the grid. Further, the ***CPUC*** has announced the intention to procure energy storage by 2026: the plan is for California to add close to 14 GW of additional renewable capacity (11GW of solar and nearly 3GW of wind) as well as 8.9 GW of short term energy storage and 1 GW of pumped storage.

See: *California issues first tend for long-duration storage to support wind and solar*

140 refuelling stations by 2050 will be sufficient for Germany

One of the issues for the heavy goods vehicle / trucking industry has been the number of refuelling stations that it will require. The Fraunhofer Institute has concluded that by 2050 140 refuelling stations (for heavy good vehicles / trucks) will be sufficient for Germany, with 70 refuelling stations required by 2030. It is considered that this number of stations will enable hydrogen use to form part of Germany's strategy to achieve its ***GHG*** targets both in 2030 and 2050, in each case with hydrogen as an integral part of its energy policy.

Clearly each country will be different, but, as with CCS / CCUS, this is an area in which Government and other sectors are able to work together to achieve a planned outcome that responds to the developing market rather than getting ahead of it, and ensuring that as the market develops it does so on an efficient basis.

See: *Fuel cell trucks: 140 refuelling stations are enough*

Summary of progress so far from World Energy Council

A World Energy Council study has been released this week. Among other things, the study states that while the international hydrogen market is on the move (as evidenced by the number of countries that have released and intend to release road maps and strategies outlining hydrogen goals), what is needed are concrete measures and plans and policy settings to achieve the goals that many countries have been setting for themselves: "*The measures currently described [in road maps and strategies] will, in many cases, not be sufficient to trigger the envisaged growth*" (Carsten Rolle).

The study recognises that Germany, Japan and Korea are likely to be key importers of Green Hydrogen (demand for Green Hydrogen from large hydrogen supply sources). For the demand side to develop, it is recognised that importing and exporting countries need to work closely. There a number of examples of this, including Japan and Germany working with Australia, and Germany working with Morocco. These "market making" international partnerships are critical to allow the development of the supply side allowing demand side to shift to hydrogen.

See: *World Energy Council-Germany: The Global Hydrogen Age has Arrived*

Supply and demand side development fundamental

Continuing the theme of market development, in the hydrogen plans, road maps and strategies developed by various countries, it is recognised that it is critical to develop both supply side and demand side of the hydrogen market in a controlled and sustainable way. This is fundamental.

In a lead piece, Michael Liebreich, Senior Contributor, BloombergNEF, underscores this fundamental point: at the moment, the theory is that Green Hydrogen (being hydrogen produced using electrolysis technology to split H_2O into H_2 and O, using renewable energy) will be competitive with, and displace, each other incumbent technology, but Mr Liebreich points out that Green Hydrogen needs to compete with every other **zero-carbon option**. This is where the theory Green Hydrogen meets reality of the market for energy carriers.

The approach taken by the Norwegian Government in funding the Longship Project may be regarded as significant because this investment is a near term investment to achieve a zero carbon outcome, using current technology, fully aware that technological development may supersede CCS / CCUS.

See: *Liebreich: Separating Hype from Hydrogen – Part Two: The Demand Side*

Korean Government funding for hydrogen

Along with Japan, the Republic of Korea (***ROK***) is a first mover. Indeed both countries have whole of economy outlooks based on hydrogen "hydrogen based society" or "hydrogen society" (in the case of Japan) and "Transition to Hydrogen Economy" (in the case of Korea). In mid-October the Prime Minister of ***ROK***, Jeong Sye-gyun, committed ***ROK*** to becoming a Hydrogen Economy and to the development of technology to allow ***ROK*** to become one of the leading players globally. As a statement of intent, Prime Minister Jeong was clear: "*The hydrogen economy is already spreading throughout everyday life, [it is] not in the distant future … Countries around the world are competitively preoccupied with the hydrogen economy*".

At the heart of policy setting in ***ROK*** is the Hydrogen Economic Committee. The purpose of the Committee is to provide policy settings that "*will open the road to a hydrogen economy, [and to go where] no one has been*".

The policy settings from the Hydrogen Economic Committee include: USD800 million of hydrogen related funding, requiring the power industry to purchase electrical energy derived from fuel cell technology thereby achieving a market of an appropriate scale, and as we noted in Edition 1 of Low Carbon Pulse the first step in the implementation of this policy setting has occurred with KEPCO's procurement from Bloom Energy and gas pricing reform, oil and gas companies to develop refuelling stations for commercial vehicles, Kohygen developing refuelling stations for municipalities, and development of hydrogen cities.

These policy settings, are consistent with the announcement in early September 2020 of the development of 28 MW Fuel Cell capacity to provide electrical energy to the cities of Hwasyng (19.8 MW) and Paju (8.1 MW) in Korea's Gyeonggi Province. The Fuel Cell facilities are to be developed by US based Bloom Energy and ***ROK*** world leading SK Engineering and Construction.

See: *Prime Minister Jeong Sye-gyun to Leap Forward as a Pioneer in Hydrogen Economy through the Green New Deal*

US perspectives – roadmap to 2050 and offshore wind

In an interesting article, Brad Rouse provides a roadmap as to how the USA can get to 100% carbon free and 100% renewable electrical energy by 2050. By Mr Rouse's estimates, this is achievable. To achieve this, rather than increasing photovoltaic solar and wind renewable capacity at a rate of 20 GW per annum, it will be necessary to add

130 GW per annum. Mr Rouse's thesis is that it is necessary to green the grid: effectively cease to dispatch electrical energy derived from fossil fuel across any grid. Consistent with this, all sources of energy need to be electrified. Absent technological advances, the electrification of everything will not result in the decarbonisation of all parts of the US economy, but it will make considerable progress. For this reason, Mr Rouse considers that there needs to be an "**aggressive price for carbon**".

In relative terms, the US is being portrayed as a later adopter of off-shore wind. As at mid-October 2020, the US has seven offshore wind-turbines - five off Rhode Island, and two off the coast of Virginia. While this may seem low, things are changing with two rounds of solicitation, the most recent in July 2020 for up to a 2.5 GW of offshore-wind capacity (the two rounds being part of the Sunrise Project), attracting bids from global players such as Equinor and Iberdrola. A key feature of the Sunrise Project is that it anticipates partnering arrangements between bidders and 11 pre-qualified New York ports.

While Rhode Island, Virginia, and New York may be the early movers among the US States, it is clear that others are moving offshore: New Jersey and Massachusetts each plan developments. As yet the capacity of the offshore developments is better expressed in terms of MW, rather than GW as may be expected given the wind resources off the Atlantic Coast.

See: *100% Carbon Free, 100% Electric, Up Our Game 6×*

ICCT study update

In March 2020, the **ICCT** released a study (***March Study***) floating and examining the feasibility of replacing current fossil fuel powered and propelled container ships with fuel cell technology. The ***March Study*** stated that 99% of the container traffic voyages made in 2015 could be powered by hydrogen with minor repurposing, by using around 5% of cargo capacity for hydrogen fuel or adding an additional port of call. An update to the ***March Study***, considers the infrastructure required at any additional port of call. While it may be regarded as early days for the repurposing of container vessels, the recent announcement from the ***PRC*** to achieve carbon neutrality by 2060 demonstrates that where there is a will the shipping and port sectors will find a way.

See: *Liquid hydrogen refuelling infrastructure to support a zero-emission U.S.–China container shipping corridor*

Alberta's Natural Gas Vision and Strategy

The Canadian province of Alberta has a **Natural Gas Vision and Strategy (*ANGS*)**. The ***ANGS*** outlines the long term support for long term growth of the natural gas industry in Alberta (producing 2/3 of Canada's natural gas). As with most road maps and strategies the ***ANGS*** outlines what is needed in general terms in terms of legal frameworks, but is bold in defining the size and shape of the petrochemical and hydrogen industries. For the purposes of the development of the hydrogen industry, ***ANGS*** contemplates the use of CCUS to allow the production of Blue Hydrogen (Grey Hydrogen is hydrogen derived from natural gas without CCUS, with CCUS the hydrogen is Blue). The ***ANGS*** is interesting. Understandably, given that Alberta is natural gas rich, its focus is on the Blue Hydrogen industry.

See: *Natural gas vision and strategy*

PROGRESS TOWARDS NET-ZERO EMISSIONS
NOVEMBER 8, 2020

Low Carbon Pulse - Edition 3

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to Edition 3 of Low Carbon Pulse sharing significant energy transition news that has come to our attention during the period October 26, 2020 to November 6, 2020.

Time frames for transition to Carbon Neutrality from three of Asia's largest economies

In Edition 1 of Low Carbon Pulse, it was noted that the People's Republic of China (***PRC***) is to transition to carbon neutrality by 2060 (***2060 Goal***) and to achieve its ***GHG*** emission peak before 2030. Edition 2 of Low Carbon Pulse noted the impending announcement of Japan's transition to a carbon neutral society. It was anticipated that President Xi Jinping's ***2060 Goal*** might be reflected in the ***PRC***'s 14th Five-Year Plan (2021-2025) for National Economic Development, and the Long Range Objectives Through the Year 2035. The Communist Party of China (***CPC***) Central Committee's proposals for formulating the 14th Five-Year Plan (2021-2025) for National Economic and Social Development and the Long-Range Objectives Through the Year 2035, was adopted at the fifth plenary session of the 19th CPC Central Committee on October 29, 2020 (***Five-Year Plan***).

The ***Five Year Plan*** includes targets for reductions in ***GHG*** emissions by 2025, not, as yet, the ***2060 Goal***. One of the elements of the Plan is to reduce carbon emissions, support some places to take the lead in reaching the peak of carbon emissions, and to formulate an action plan for peak carbon emissions by 2030.

Some commentators suggest that the targets will require a relatively steep reduction in the use of fossil fuels (in particular coal) in the near to medium term, by use of new technologies to capture and store carbon so as to facilitate the transition from the use of fossil fuels. A policy setting being discussed is the introduction of an absolute ***GHG*** emissions cap. As with all economies recovering from the impact of COVID-19, these policy settings will need to be balanced with drivers of recovery, including the difficult to decarbonise cement and steel industries. It has been estimated for ***PRC*** to achieve the ***2060 Goal*** investment of more than USD 5 trillion will be needed, including towards continued development of renewable power generation capacity.

See: *China's 2060 carbon neutral goal bill could hit over $5 trillion*

The progress being made in ***PRC*** in the development of renewable energy capacity on a project by project basis is globally significant (for example, China Huaidan Corporation's recently announced 2.2GW solar farm and 220 MW energy storage system near Shuzhou), and in combination is globally critical.

See: *China's 2060 net-zero goal needs large-scale negative emissions tech*

On Tuesday October 27, 2020, Japan's Prime Minister, Mr Yoshihide Suga announced formally the goal that Japan aims to transition to net zero ***GHG*** emissions by 2050 (as foreshadowed in Edition 2 of Low Carbon Pulse). To achieve this goal, Prime Minister Suga noted that research and development was required in key areas, and that the transition went hand in hand with digitising the Japanese economy. Prime Minister Suga said that: "*Responding to climate change is no longer a constraint on economic growth*" it was an imperative to growth. The goal has been welcomed broadly, both for the contribution to the reduction in ***GHGs***, and for recognition that this transition will be good for economic growth in Japan, and regionally with like-minded countries, including the ***PRC***.

On Wednesday October 28, 2020, the Republic of Korea's (***ROK***'s) South Korea's President, Mr Moon Jae-in, announced in the National Assembly of ***ROK***, that ***ROK*** will be carbon neutral by 2050. The announcement of this goal, was accompanied by a vow to replace coal with renewables by 2050. The 2050 goal and the coal objective are part of the Green New Deal, which provides for funding of up to USD 7 billion and anticipates some tried and test policy settings, including ceasing to finance overseas coal generation plants and implementing a carbon tax, as well as the creation of urban forests, recycling and creating low-carbon industrial complexes. As is the case with Japan,

ROK sees the possibilities of hydrogen as one of the means of achieving its 2050 goals. It might be expected that ***ROK*** 's transition from coal is likely to be undertaken at a quicker rate than any transition away from natural gas: there are no reported plans to develop new coal fired power stations in ***ROK***.

See: *Korea's Green New Deal*

Within the last two months, three of Asia's largest economies, and the world's first, fifth and sixth largest ***GHGs*** emitters have set clear goals. Over the coming months and years, we will follow the development of policy settings to achieve these goals, and the impact of, the setting and achievement of these goals on countries that export fossil fuels to each of them. As things stand, many commentators are suggesting, consistent with the time frames that are required to transition from coal (both thermal and metallurgical), that ***GHG*** emissions are expected peak by 2030.

See: *Japan to set emission ambition of net zero by 2050*

North Sea carbon capture and storage (CCS) projects

As may be apparent from the first three editions of Low Carbon Pulse, there are a number of perspectives that recur, and some are themes. One of these is the view of the International Energy Agency (***IEA***) that it will be "virtually impossible" to achieve ***GHG*** emissions reduction targets without CCS projects. The question posed in response to this perspective is how quickly can this occur.

Following hot-on-the-heels of the Longship Project (outlined Edition 2 of Low Carbon Pulse), an alliance has been announced by oil and gas major, BP, to develop a CCS project in the North Sea: the ***GHG*** is to be stored in saline acquifers below the sea bed. As reported, the CCS will allow the storage of nearly 50% of the industrial ***GHG*** emissions arising in the UK in a CCS facility in the North Sea.

The CCS project will store ***GHGs*** captured at two separate carbon capture projects on the east coast of England. Other participants in this alliance are other Big Oil companies, Eni, Equinor, Shell and Total, and the National Grid. As currently scheduled, the CCS project will be operational by 2026. In other countries considerable geotechnical work is planned to determine appropriate under storage sites.

See: *China’s 2060 net-zero goal needs large-scale negative emissions tech*

[**Note:** see Edition 23 of Low Carbon Pulse for developments.]

France releases tenders for hydrogen projects:

On September 9, 2020, France released its ***National Strategy for the Development of Carbon Free Hydrogen*** (the ***Strategy***). The ***Strategy*** has defined three goals:

- to install enough electrolysers to make a significant contribution to the decarbonisation of the economy;
- to develop clean mobility, in particular for heavy vehicles; and
- to build an industrial sector in France that creates jobs and guarantees a certain technological expertise.

Consistent with the ***Strategy***, two requests for proposals have been released.

One entitled "Briques technologiques et démonstrateurs hydrogène" (technology bricks and hydrogen demonstrators) for the production and transport of hydrogen for which proposals are due by December 31, 2022.

The other one, called "Ecosytèmes territoriaux hydrogène" (territorial hydrogen ecosystems), focuses on industrial and mobility applications, particularly for utilities and heavy goods vehicles / trucks through renewables or carbon-free hydrogen. Proposals are due on December 17, 2020, March 16, 2021 and September 14, 2021.

Both requests for proposals reflect the view that the heavy goods vehicles / trucks and the public transport sectors will be early movers in the transition from use of fossil fuels to use of hydrogen as an energy carrier.

See: *France launches tenders for hydrogen projects*

Port of Rotterdam (the story so far) and hydrogen exchange:

The Port of Rotterdam is the first port globally to use a hydrogen powered terminal tractor - the YT203-H2, which is currently deployed in the United Waalhaven Terminals. The terminal tractor has been developed by zepp.solutions (the fuel cell system developer) and Terberg Benschop (tractor manufacturer).

This deployment is consistent with ***Government Strategy on Hydrogen*** (***GSH***) published by the Dutch Government, and continues initiatives already underway in the Dutch ports sector, including the ***Porthos project*** in Rotterdam (capturing CO_2) and the associated ***H-Vision project*** (to allow large scale production of Blue Hydrogen). The ***Porthos*** / ***H-Vision projects*** illustrate the need for pragmatic policy settings: Blue Hydrogen is seen as paving the way for Green Hydrogen production by developing a supply of hydrogen. This approach to policy settings recognises that while Blue Hydrogen production is a worthwhile end in itself, it does not set in stone the policy settings. This approach to policy setting is consistent with the Norwegian Government in respect of Longship Project (as outlined in Edition 2 of Low Carbon Pulse).

As is the case with many plans, road maps and strategies of Governments, the ***GSH*** recognises the importance of the port and industry sectors in achieving climate neutral industry by 2050. Also the ***GSH*** recognises the role for cooperation across the globe, and in so doing recognises the roles that different countries may take. One of the roles that the Netherlands is naturally suited to take is that of a location for a trading and close to potential load (for delivery by pipeline) for, and loading (for delivery as export) of, hydrogen.

Four Dutch port authorities and Gasunie are arranging a study to be undertaken into the practical design of a hydrogen exchange. This initiative follows the conclusion that a hydrogen exchange (and electricity exchange) could act as a catalyst for the development for trade in a hydrogen market (and clean energy) contemplated in a study titled, ***A Hydrogen Exchange for Climate***. It can be expected that other ports and clusters of ports around the world will follow suit, with some ports already having established energy exchanges, and able to respond to provide a market for this new trade, for example the Hainan Energy Exchange (at the free port of Hainan, China).

Finally, the ***GSH*** recognised the role that the Northern Netherlands was likely to play was significant in the near term. On October 30, 2020, the Northern Netherlands Hydrogen Investment Plan was published. The Plan contemplated Euros 9 billion of investment. The Plan is the work of businesses and government bodies and describes the region as the **Hydrogen Valley** (of Europe). The adoption of Silicon Valley terminology reflects both the potential of the hydrogen industry, but also the importance of the development of technology to it.

See: *Hydrogen exchange offers opportunities for a hydrogen market*

See: *The Northern Netherlands Hydrogen Investment Plan 2020*

Russia – In the Framework

By a decree published on November 4, 2020 (the day before the USA formally left the Paris Agreement), President Vladimir Putin has directed his government to work towards ***GHG*** emission reductions while at the same time ensuring strong economic development (***Russian Decree***). As is becoming apparent around the world, the two are not mutually exclusive, in fact increasingly one is seen as necessary for the other. The ***Russian Decree*** directs government to work towards a reduction in ***GHG*** emissions of up to 70% of 1990 levels by 2030. Given the size, and other characteristics, of Russia, it is contemplated that carbon sequestration is likely to play an important part in achieving these goals.

While response to the ***Russian Decree*** has been mixed and muted (possibly because of the wall to wall coverage of the US Presidential Election), the ***Russian Decree*** provides clear goals. The strength of the goals may be regarded as more closely aligned with those of corporations that are members of the **World Business Council on Sustainable Development** (see below) than the Paris Agreement, but the ***Russian Decree*** is tied to the achievement of ***GHG*** emissions of up to 70% of 1990 levels (and as such not forward looking to 2050 only) and should be seen as an opportunity for economic development and increased trade.

As with other top 10 emitters of ***GHGs*** globally that have leant forward since the start of September 2020, with the ***Russian Decree***, Russia has recognised the need for ***GHG*** emission reductions.

The **Paris Agreement** is an agreement between Parties to the United Nations Framework Convention on Climate Change (***UNFCCC***). The central objective of the Paris Agreement is to keep global temperature increases to ***2°C*** below pre-industrial levels, and to pursue initiatives to keep increases to ***1.5°C*** below pre-industrial levels. Also under the Paris Agreement, Parties to the ***UNFCCC*** agree to reduce 1990 (or later) ***GHG*** emissions.

See: *Putin orders Russian government to work towards Paris climate goals*

South Australia – Green, On the Grid and making the most of it

- **A Green Grid:**

Edition 2 of Low Carbon Pulse noted that South Australia had matched 100% of the electrical energy load of the State dispatched from renewable energy sources – a world first. As a practical matter, this demonstrates that South Australia has one of the best developed renewable energy capacity bases in the world, with a little over 57% of annual load being matched by dispatch from renewable electrical energy sources. Given the geographical location and the resources of South Australia, it has been ahead of the pace of change to respond to energy initiatives, including its container deposit scheme (to recycle beverage containers) and its transition to renewable energy. The same can be said on the shift to hydrogen. South Australia's ***Hydrogen Action Plan*** has near and medium term goals, and outlines how to achieve them. As it says on the tin: "*South Australia has the wind, sun, land and infrastructure to be a world class renewable hydrogen supplier*".

- **Green Hydrogen Hubs:**

On Tuesday October 27, 2020, the Government of South Australia announced plans to develop three hydrogen production hubs in South Australia. The Government recognising that hydrogen "*is shaping up as a game changer*", *but it is necessary to get [the cost down] so that [it is] an … attractive option for heavy transport, power generation and use by industry.*" South Australian Energy Minister, Mr Dan van Holst Pellekaan.

Consistent with thinking in a number of countries, the three hydrogen production hubs are to be located at ports, in the case of South Australia, at Port Bonython, Port Adelaide and Cape Hardy / Port Spencer. It was reported on November 6, 2020, that ***H2U*** is to develop a AUD 240 million hydrogen production facility, and related infrastructure at Port Bonython.

South Australia Premier, Mr Steven Marshall, is reported as saying: "*The $240 million demonstrator phase of the project is of global significance, but is just the pre-cursor to a much larger production and export facility, that could see us strengthen our energy ties with traditional partners*".

See: *Hydrogen policy paying off as South Australia lands new $240m plant*

- **A place in the sun:**

Given South Australia's transition to renewable energy since the mid-2000s, and the clear support of the Government of South Australia, it is possible to see the State becoming a leading exporter of clean energy, both nationally through the East Coast Grid and internationally through the export of hydrogen as an energy carrier. This will require an increase in installed renewable energy capacity (and associated energy storage), possibly to between three and six times current renewable energy capacity. It has been estimated that if the three hydrogen production hubs are developed, and the potential of them maximised, that South Australia will have up to 12 GW of installed renewable energy capacity.

See: *Hydrogen Prospectus shows epic future for SA Renewables*

- **A place underground:**

In addition to the progress to the development of the three hydrogen production hubs, and the production of renewable hydrogen (i.e., Green Hydrogen), South Australia has reserves of brown coal which is possible to gasify to produce synthetic gas (syngas) which will then be used as feedstock to produce hydrogen, fertiliser in the form of ammonia (NH_3), which may be processed further to produce urea ($CO(NH_2)_2$).

The USD 2.8 billion ***Leigh Creek project*** appears to be proposing the use of different technology: we understand that up to 41 gasifiers will be used to source raw coal gas from the brown coal of the Leigh Creek Mine (coal gas comprising predominantly methane (***CH_4***)) which will then be processed to produce syngas. As with the other activities in South Australia, this is an exciting development. While the ***Leigh Creek project*** will be subject to the usual approval processes, it demonstrates again the ability of South Australia to respond to opportunity.

See: *South Australia names hydrogen hubs to foster "epic" growth in wind and solar*

Singapore's first utility scale energy storage system (*ESS*)

It was reported on October 27, 2020, that the first utility scale ***ESS*** was installed: the ***ESS*** has been supplied and installed by ***Wartsila*** for ***Sunseap Energy Ventures***. The ***ESS*** is supported by Singapore's ***Energy Market Authority*** and Singapore Power Group.

In the context of the supply of electrical energy in Singapore, this may be regarded as a key element of the development of a system able to respond to load requirements so as to achieve optimal operation and grid flexibility, and as more intermittent and variable renewable energy sources may be added to the grid, assure system integrity and stability.

See: *Sunseap leads NTU, Wärtsilä consortium for Singapore's first utility-scale energy storage system*

A break though to carbon neutrality

Breakthrough Energy is a collection of entities founded by Bill Gates, former CEO and Chair of Microsoft Corporation, and other technology business leaders. ***Breakthrough Energy*** was founded to speed the transition to clean energy sources, and a clean energy future.

On November 4, 2020, it was announced that ***Breakthrough Energy*** is supporting the European Green Hydrogen Acceleration Center (***EGHAC***). Consistent with its name, the goal ***EGHAC*** is to accelerate the development of the Green Hydrogen economy in Europe to Euro 100 billion by 2025.

The ***EGHAC*** is to be managed by ***EIT InnoEnergy***. Jacob Ruiter, ***EIT InnoEnergy*** board member stated: "*The commercialisation of Green Hydrogen is absolutely vital if Europe is to achieve its ambitious goals of becoming the first net zero continent by 2050. Quite simply, there is no better way of decarbonising heavy industry and heavy transport, and it can play a significant role in supporting grid flexibility through storage.*"

This establishment of ***EGHAC*** is entirely consistent with the broad recognition that government, industry and technology developers and providers need to come together to develop technology and markets in tandem, and, in parallel, if possible.

See: *Bill Gates Fund and EIT InnoEnergy Announces New Initiative to Speed Climate Neutrality*

World Business Council on Sustainable Development (*WBCSD*)

The ***WBCSD*** was established in 1995 to provide guidance to many of the world's largest corporations as to the ways and means of achieving and maintaining sustainable practices in their businesses. The vision of the ***WBCSD*** is of: "*a world where more than 9 billion people are all living well and within the boundaries of our planet*". The mission of the ***WBCSD*** is: "*to accelerate the transition to a sustainable world by making more sustainable businesses more successful*."

In an initiative consistent with the 30 year time-lines announced by Japan and Korea, membership criteria for the ***WBCSD*** require corporations to have plans to achieve net zero ***GHG*** emissions within 30 years, i.e., by 2050.

Amongst, 200 others, Equinor is a member of the ***WBCSD***, as are other Big Oil club members.

See: *GHG Management*

Equinor announces its own road map to 2050 net zero target – "every step of the way"

On November 2, 2020, Equinor, (international energy company), announced that: "*Equinor is committed to being a leader in the energy transition*". Recognising ***GHG*** emission reductions as part of energy transition is as much about ultimate consumption (i.e., combustion) of energy carriers as it is about extraction, production, refining and transportation and distribution of them, Equinor is committed to reducing ***GHG*** emission "*every step of the way*". Equinor estimates that 85% of ***GHG*** emissions from fossil fuels arise on consumption of the products derived from oil and natural gas.

To ensure that Equinor walks every step of the way, it has recognised Scope 1, 2 and 3 ***GHG*** emissions from the ultimate use of fossil fuels by reference to the equity participation that Equinor has in the mass of fossil fuels produced. As is the case with good policy settings for Government, the Equinor reduction settings work to the near term (2025), the medium term (2030 to 2035) and long term (2050). Equinor's stepped path is in line with Norway's policy settings generally, including to reduce net carbon intensity to zero by 2050.

As is the case with an increasing number of the members of the Big Oil club, Equinor is embracing energy transition as part of its own business transition. In tandem or in parallel, or possibly even as part of the "every step of the way" business strategy, is the near term intention to develop 4 to 6 GW of renewable energy capacity by 2026, and the medium term intention to develop 12 to 16 GW by 2035, representing Equinor's equity participation in both joint and sole developments of renewable energy.

See: *Norwegian oil giant Equinor announces 2050 net-zero target*

First, 40 by 30, Second 11 by 30, and third Grid integrity and stability

At the governing Conservative Party conference in September 2020, Prime Minister, Mr Boris Johnson, announced plans to increase the off-shore wind capacity of the United Kingdom from 10 GW to 40 GW by 2030 (***40 by 30***).

The Scottish Government has published its goal to harvest up to 11 GW of power from off-shore wind (***11 by 30***).

As these goals have been reflected upon, the work required to achieve them has focused the minds of industry participants, commentators and journalists. A number of newsfeeds have reported on the need for grid development and augmentation to be coordinated, and to get well-ahead of the development of new off-shore wind field capacity so as to allow timely and effective connection of that new capacity to the grid.

To many industry participants, this should be regarded as shared responsibility and risk, and needs to be seen and contracted as such: there have been many instances around the world in which connection and dispatch has been delayed as a result of the time taken to undertake and to complete stability and system integrity assessments, and the coordination of them across projects. It is not economically efficient or sustainable to have to use queuing to manage timing of connection, and may even act as a "drag" on investment.

Background: In simple terms, the development of the supply side of the electricity market is one half of the task, the other half of the task is the delivery of the electrical energy generated to the load for it while maintaining the integrity and the stability of the grid transmitting the electrical energy to the load. As a general statement, the greater the proportion of intermittent or variable electrical energy generation (including solar and wind) the more challenging it is to maintain system integrity and stability.

See: *Offshore wind policy statement*

Interconnection

As the renewable energy industry considers the location of the world's best renewable energy resources, threshold questions arise, critically, whether is it possible to transmit energy as electrical energy to load or is it necessary to produce an energy carrier, for example, hydrogen, and to deliver that energy carrier to the market in which it will be consumed / used.

The announcement of the proposed 3,800 – 4,500 km (700 km on-shore, 3,800 km sub-sea) high voltage direct current (***NT / SIN HVDC***) interconnector to transmit electrical energy from the 10 GW ***Newcastle Waters Solar Station project*** in Australia's Northern Territory to deliver 2.2 GW of electrical energy to Singapore has prompted a number of participants to turn their minds to what is possible technically, and what this means within a financial model. Edition 2 of Low Carbon Pulse provides detail of the ***Newcastle Waters Solar Station project***.

The Norway to Britain ***North Sea Link*** (the Statnett and National Grid project) is scheduled to commence transmission in 2021. The ***North Sea Link*** comprises a 720 km submarine link. The ***NT / SIN HVDC*** (now ***Sun Cable Project***) will be longer by a multiple of between just over 5.

While the financial modelling parameters of these projects are well understood, it does not harm to remind ourselves of the key dynamics, assuming that the supplier of electrical energy is transmitting that electrical energy to the load:

1. development and operation and maintenance costs of the solar facility, the interconnector and energy storage, on the cost side of the model, expressed in USD per kWh; and
2. revenue from electrical energy, which in the case of a solar facility is a function of:
   - the term of the supply; and
   - quantity of electrical energy capable of dispatch, in turn being a function of:
     - the capacity factor of the solar facility, being the nameplate of the renewable energy facility, its capacity, actually generated for dispatch, said to be in a range of 10% to 25% (with large-scale photovoltaic facilities having capacity factors at above 20% in certain countries); and
     - the line losses, being the loss of energy that results from the transmission of the electrical energy from the point of dispatch to the load.

See: *Photovoltaics News, in PV Magazine*

Low Carbon Pulse - Edition 4

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to Edition 4 of Low Carbon Pulse - sharing significant news in the progress towards net-zero emissions. This edition covers the period November 7, 2020 to November 22, 2020.

Green back backed

On November 3, 2020, the US Presidential Election took place. At the time of going to print, the transition to the Mr. Joe Biden administration has begun. Mr. Biden will be the 46th President of the United States. It is expected the US will re-enter the Paris Agreement; re-entry can occur on 30 days' notice from the President. If this happens, the US will likely re-establish its original commitment to reduce ***GHG*** emissions of between 26% to 28% of the 2005 levels by 2025. [**Note:** The US's NDC is increased to 50 to 52% of 2005 levels by 2030.]

It is hoped we will see the return of the wider global climate leadership of the US. Could the US join the European Union (***EU***), the People's Republic of China (***PRC***), Japan and the Republic of Korea (***ROK***) – in making accelerated reduction commitments? The answer is yes. It is expected that Mr. Biden will commit to the reduction in ***GHG*** emissions from the generation of electrical energy to zero emissions by 2035, and to net zero-emissions by 2050. Following the inauguration of President-elect Biden, we will continue to track the US policy settings in Low Carbon Pulse.

While the US is unlikely to achieve its original ***GHG*** emission reduction commitments, there is a good deal of progress to build upon. On November 12, 2020, the USA ***Energy Information Administration*** reported that it expected that 23 GW of wind power capacity would be added during 2020 (with a total of 29 GW of wind and solar). While there are tax credit reasons for this level of build-out during 2020 (which are to cease), it would be reasonable to assume, on re-entry of the US to the Paris Agreement, and recalibration of ***GHG*** emissions commitments, that this pace of development will continue or increase.

If the US re-enters the Paris Agreement, and, as anticipated, commits to net zero ***GHG*** emissions by 2050, the US, with the ***EU***, the ***PRC***, Japan and ***ROK*** (about two thirds of the global economy, and approximately 75% of markets for exported fossil fuels) will be broadly aligned, and committed to investing heavily in low or zero carbon technologies.

The Paris Agreement recognises that to respond to the effects of increased ***GHG*** in the atmosphere, it is necessary to commit to hold: "the increase in global average temperature to well below 2°C above pre-industrial levels **[*Stabilisation Goal*]** and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels **[*Stretch Goal*]**…".

See: *Green energy is about green backs*

A record year for renewable electrical energy

On November 9, 2020, the International Energy Agency (***IEA***) reported that 2020 will be a record year for the development of renewable energy. The calendar year will see 200 GW installed; an increase of 4 GW on 2019. With 144 GW between them - the ***PRC*** (89 GW), the US (29 GW) and the ***EU*** (26 GW) are responsible for two-thirds of that capacity. Stating the obvious: this has been achieved through COVID-19 period.

On the ***IEA***'s base case, it anticipates that installed capacity will increase at a steady, but flat, rate during 2021 through the end of 2025. On an accelerated case, the ***IEA*** predicts a marked increase to over 260 GW of installed capacity in 2021, and a steady rate of growth to the end of 2024, with a further marked increase to approximately 310 GW to be installed in the year to the end of 2025. Perhaps the reality will be somewhere in between.

By 2025, the ***IEA*** is anticipating that solar and wind renewable power will have the greatest level of installed capacity of any electrical energy generating source. As noted before (Edition 3 of Low Carbon Pulse) - installed renewable energy capacity does not equal used renewable energy. If the wind isn't blowing or the sun isn't shining (and overnight) - there might be nothing to dispatch.

See: *Renewables 2020*

Green Hydrogen is a top emerging technology

The World Economic Forum (***WEF***) identifies Green Hydrogen as one of the top technologies to emerge during 2020, being a technology with the greatest potential to transform industry and society. While Green Hydrogen is not new, its use is increasing, and it is expected to be developed at an increasing rate, hence it is regarded as a top emerging technology.

While the ***WEF*** does not develop or implement policy settings it does influence them. The report describes, in short hand, Green Hydrogen as "*zero-carbon energy to supplement wind and solar*". In long hand, Green Hydrogen is an energy carrier that will allow decarbonisation of energy production and use generally, including industries that are difficult to decarbonise.

The ***WEF's*** report identifies other technologies: Sun**-Powered Chemistry** (conversion of ***CO_2*** (a ***GHG***) into common materials), **Electric Aviation** (Enabling air travel to decarbonise), and **Lower Carbon Cement** (Construction material that combats climate change). Four of the Top 10 emerging technologies relate to abatement / reduction of ***GHG*** emissions.

The ***WEF*** is an independent international organisation for public and private cooperation. The ***WEF*** promotes engagement among the foremost leaders across society to shape industry and global and regional agendas. Green Hydrogen is the term used to describe hydrogen that is production from the splitting of ***H_2O*** using electrolysers powered by electrical energy from renewable energy sources. Neither the production, nor the use, of Green Hydrogen results in ***GHG*** emissions, other than water vapour.

See: *Top 10 emerging technologies of 2020*

Hydrogen re-fuelling infrastructure

The ***Hydrogen Council*** estimates that USD 30 billion will need to be invested globally to develop hydrogen re-fuelling infrastructure (***HRI***) as the hydrogen industry develops to supply vehicles. This may be regarded as a conservative estimate.

HRI is an area in which government and business can work together. It is clear that a good deal of thought is being applied to efficient and optimal development of ***HRI***. The approach to ***HRI*** for heavy good vehicles / trucking industry in Germany was also outlined in Edition 2 of Low Carbon Pulse.

In Paris, over 500 fuel cell electric vehicles (***FCEV***) provide taxi services, using hydrogen supplied by Air Liquide via 4 hydrogen re-fuelling stations. On November 11, 2020, the ***European Network of Transmission System Operators for Electricity*** (***ENTSO-E***), announced a proposal to develop 10 hydrogen storage facilities at locations around Paris. The proposed €1 billion project would provide total storage for up to 11 GHh of hydrogen. As a result of the project, Parisian transport company, Societe du Taxi Electrique Parisian, estimates that 50,000 taxis could provide taxi services using ***FCEV*** technology.

The Paris HRI project is one of 25 energy storage projects and schemes identified by ***ENTSO-E*** across the ***EU***. We will consider these energy storage projects and schemes in future editions of Low Carbon Pulse.

See: *Plans for 50,000 hydrogen-powered taxis in Paris*

Japan continued run of firsts

As reported in the first three editions of Low Carbon Pulse, Japan is a first mover in the shift to hydrogen. Japan's first mover status has again been emphasised by the news that in March 2021 an import terminal at Kobe will receive its first hydrogen cargo [**Note:** In the event, this occurred in February]. The import terminal is being developed by Kawasaki Heavy Industries (***KHI***) and Iwatani. (Amongst other things, Iwatani is positioning itself as a storage and delivery business, including in respect of HRI in Japan and the US.)

The import terminal comprises receipt and storage facilities for liquified hydrogen gas (***LHG***). As reported in Edition 2 of Low Carbon Pulse, ***KHI*** developed the first ***LHG*** vessel, commissioned in December 2019.

The involvement of ***KHI*** in the development of the means of transporting, and importing hydrogen into Japan, reflects its understanding of the need to develop a hydrogen economy in absolute terms: "*Hydrogen is indispensable for Japan to reach the zero emission goal. Renewable energy isn't enough to meet the nation's hefty energy needs*" (Motohiko Nishimura, Head of the Kawasaki hydrogen development centre).

Jochen Eickholt, executive board member of Siemens Energy AG has provided a helpful perspective on the development ***LHG*** in temporal terms: "*It won't take decades for the hydrogen industry to develop, like it took LNG, but it won't happen overnight*".

And of course the ***LHG*** industry does not need to develop overnight, but for Japan to achieve carbon neutrality by 2050 it is projected that it will be importing 36 million metroc tonnes per annum of ***LHG*** by 2050.

In short, there is an imperative for the development of the ***LHG*** industry, there was a different imperative for the LNG industry.

See: *Japan bets big on hydrogen for zero-emission future*

An EU Roadmap, "off-road capacity" development

Currently the countries of the ***EU***, have 12 GW of installed off-shore renewable energy capacity. On November 19, 2020, the ***EU*** announced a plan to increase installed off-shore capacity five-fold to 60 GW by 2030 (***60 by 30***), and twenty-five fold to 300 GW by 2050 (***300 by 50***). (This plan is in addition to the continued build out of shore-based renewable energy projects.) This plan is intended to enable the ***EU*** to achieve net-zero emissions by 2050, and it is clear recognition that the previous rate of progress in the mobilisation of renewable energy was not going to achieve the ***Stabilisation Goal***. The price tag attached to installing this capacity is put at €790 to 800 billion (USD 940 to 945 billion) by 2050.

EU Commissioner, Mr Frans Timmermans (leading the European Commission's work on the European Green Deal and European Climate Law to give effect to the 2050 carbon neutrality target) said: *"[The EU] aims are ambitious, but with [the EU's] vast sea basins and our global industrial leadership, the EU has all that it needs to meet the challenge".*

As noted in Edition 3 of Low Carbon Pulse, connection and system integrity and stability arise as issues to be addressed on the development of any intermittent / variable supply of electrical energy. Also the augmentation and development of any grid needs to take place well-ahead of the development of off-shore capacity, as does electrical energy storage (***ESS***). As the ***EU*** off-shore plan develops, Low Carbon Pulse will provide updates, including in respect of the attendant need for grid augmentation and ***ESS*** development before electrification.

See: *Europe seeks $940 billion boost for giant offshore wind farm* and *European Union plans mammoth expansion of offshore wind farms*

Zero heroes

In a recent news article, a number of ***Zero Heroes*** were identified, each of which seemed a sound assessment. This caused us to reflect on countries not in the article that were worthy of mention. Chile came to mind. Earlier in 2020 Chile updated its National Determined Contribution (***NDC***) under the Paris Agreement, committing to becoming a net-zero emission country by 2030. As such Chile became the first developing country (under the Paris Agreement) to commit to net-zero emissions.

A key strategy for Chile is to use surplus renewable energy to produce Green Hydrogen. Chile generated 44% of its electrical energy from renewable sources in 2019, which is projected to reach 70% by 2030. Chile is projecting production of up to 25 million metric tonnes per annum of Green Hydrogen by 2050. Chile views the key export markets for its Green Hydrogen as the North Asian markets of ***PRC***, Japan and ***ROK***, each of which has committed to net-zero emissions in recent times (see Editions 2 and 3 of Low Carbon Pulse).

By 2030, Chile is projecting production of up to 5% of the supply side of the global Green Hydrogen production market. Chile's National Green Hydrogen Strategy contemplates that by 2040 it will become a world class exporter of Green Hydrogen. The ***IEA*** has projected that Chile could produce up to 160 mtpa of Green Hydrogen, in equivalent energy terms, the same as the current LNG export industry.

As is the case with South Australia (see Edition 3 of Low Carbon Pulse), the government of Chile is front and centre in the development of its hydrogen production industry.

Edition 5 of Low Carbon Pulse will consider Spain.

See: *National Green Hydrogen Strategy. Chile, a clean energy provider for a carbon neutral planet* and *Climate heroes: the countries pioneering a green future*

Difficult to decarbonise industries

It is well understood that hydrogen is a low or no carbon energy carrier, providing the means to displace fuels (and feedstocks) that give rise to ***GHG*** emissions on use, including fossil fuels used for combustion in difficult to decarbonise industries, such as the cement, chemical, petrochemical and refining, and iron and steel industries. To many commentators, integrated energy companies and oil and gas companies are well-placed to participate effectively in the move to decarbonise. Chemical, petrochemical and refining companies may be regarded as being well-placed, including to produce hydrogen for use in the chemical industries, especially those chemical companies that are already producing hydrogen, and are producing chemicals, petrochemical and refining using large scale electrolyser technology, and are trusted by the market to produce. Just as integrated energy and oil and gas companies have a way to market, so do chemical, petrochemical and refining industry participants.

See: *Sectors that are challenging to decarbonise*

The potential for a Green Sahara and Greener plains, and the Greening of the Land Down Under

As noted in Edition 3 of Low Carbon Pulse, and as is becoming increasingly apparent, certain countries and regions have world class renewable resources, and have the potential to be major suppliers of electrical energy from renewable resources or major suppliers of hydrogen as an energy carrier, delivered through pipelines or ships. Interconnectors may be less expensive than pipelines, but the use of pipeline to haul energy carriers is regarded as delivering a greater proportion of the energy carrier produced to the point of use.

As noted at the end of Edition 3 of Low Carbon Pulse, there will be a point at which fixed infrastructure (whether an electrical power interconnector or a gas pipeline) does not deliver an economic outcome that is workable. In these circumstances, the assessment will turn to whether delivery by other means will result in a workable economic outcome. (In the case of the use of gas pipelines to haul hydrogen, the pipelines will have to have higher compression than natural gas pipelines, which will make them more energy intensive to operate.)

In the same way that Australia has emerged as a possible source of renewable electrical energy (using interconnectors) and hydrogen (using ***LHG***, and possibly other forms of hydrogen) to Asia, so North Africa has emerged as a regional with world class renewable resources that may be able to provide electrical energy or hydrogen to Europe.

The German economic stimulus package announced on June 3, 2020, provided €9 billion to allow the "ramp up of hydrogen technologies". Of the €9 billion, €2 billion is earmarked for use on the development of hydrogen projects outside Germany. This includes North Africa and Ukraine, and, yes Australia (a feasibility study is being undertaken jointly by Australia and German governments to determine whether it is possible for Australia and Germany to develop supply, in Australia, and demand, in Germany, for hydrogen). It is easy to read this funding provided by the economic stimulus package as consistent with the German **National Hydrogen Strategy** (***NHS***), which was published a week later on June 10, 2020.

In July 2020, the European Commission (***EC***) released "A hydrogen strategy for a climate-neutral Europe" (***EU H_2S***). The ***EU H_2S*** states: *"Hydrogen is enjoying a renewed and rapidly growing attention in Europe and around the world. Hydrogen can be used as a feedstock, a fuel or an energy carrier and storage, and has many possible applications across industry, transport, power and building sectors. Most importantly [H_2] does not emit CO_2, and almost no air pollution when used."*

The ***EU H_2S*** contemplates supply of hydrogen from outside the ***EU***. While too early to make a call, it is possible to see the development of electrolysers in North Africa to produce Green Hydrogen.

See: *The hype and hope of Sahara Desert Green Hydrogen*

Supply and Demand Development

In many ways, the ***NHS*** is an exemplar as a framework for policy setting and investment decision making, not just for hydrogen. Critically, the ***NHS*** recognises the need for an integrated system to make progress and to realise value, the roles of government (and as such the public sector) and private sector in developing that integrated system, and the need for a near, medium and long term perspective responsive to change.

Critically, the ***NHS*** appears to be both achievable, and affordable. It recognises the time necessary for the shift to hydrogen production and use as part of an integrated energy production and delivery system. While there is recognition that the need for a partnership between the private and public sectors is critical, this is not to the exclusion of the dynamics of any market.

Most importantly, the German ***NHS*** recognises the importance of achieving supply side and demand side certainty. The Netherlands' national hydrogen strategy makes the same point, if anything, with greater clarity and in greater depth.

Australia

In previous editions of Low Carbon Pulse, developments in Western Australia, the Northern Territory and South Australia have been featured. In this edition we feature two more States, and mention a further two projects in Western Australia.

The most populous State of Australia, New South Wales (***NSW***), has announced plans to promote the development of 12 GW of renewable energy by 2030, and 2 GW of energy storage. Twelve years ago, the Government of NSW was intent on privatising its electricity industry, which it did through the sale of generation capacity over a four to five year period.

At the time of privatisation, the vast majority of the generating capacity in ***NSW*** was coal fired, with the coal coming from ***NSW***'s Hunter Valley. At the time of the early privatisations of generation assets, a key concern was the high price of coal, with coal from the Hunter Valley being marketed at export parity prices from the Port of Newcastle resulting in a prospective under supply of coal from 2012 / 13. How things have changed, in particular the rate of change across the energy industry. As ***NSW*** continues Australia's transition to net-zero emission, it is likely that, at least in part, the Hunter Valley will benefit being a new renewable energy zone.

As might have been anticipated, some of the companies that acquired generation capacity from ***NSW*** Government, in one instance in 2013, and who are investing in system security in ***NSW***, have raised concerns about the impact of the level and speed of change on their investment.

Tasmania, one of Australia's least populous States, is blessed with water and wind. Just as Tasmania has attracted renewable energy investment, it is now attracting interest in hydrogen projects. A green ammonia project at Bell Bay is attracting the attention of one of the Big 3 integrated energy companies in Australia, Origin Energy, and one of the world's Big 3 iron ore producers, Fortescue Metals Group (***FMG***).

Origin Energy is contemplating the development of a 500 MW electrolyser (possibly bigger), with electrical energy required to power the electrolyser provided by renewable energy. The electrolyser would be the world's biggest and would produce Green Hydrogen which would then be used to produce Green Ammonia.

The interest of ***FMG*** is stated as being in the development of a 250 MW plant to produce green ammonia. Again, this scale of plant would be the world's biggest.

See: *Australia's New South Wales unveils $23bn renewable energy push, Origin looks at massive renewable hydrogen project in Tasmania* and *NSW to transform Hunter coal region into state's next renewable energy zone*

Infinite green from infinite blue

Western Australia continues Australia's run of world scale project proposals. ***Infinite Blue Energy*** has announced plans to develop an integrated renewable energy and Green Hydrogen production facility. The Arrowsmith integrated production facility will install an electrolyser and up to 160 MW of solar and wind capacity to produce 9,000 tonnes (9,000,000 kgs) of hydrogen annually. The Arrowsmith facility would source some electrical energy over the Western Power transmission grid, and for these purposes needs to connect to the grid.

See: *Massive Green Hydrogen project signs network deal with Western Power*

Hydrogen Renewables Australia's Murchison Green Hydrogen Project

Hydrogen Renewables Australia has announced a partnership with leading global infrastructure fund, Copenhagen Infrastructure Partners (***CIP***). The Murchison Green Hydrogen Project will use electrical energy sourced from photovoltaic solar and wind renewable energy sources to electrolyse desalinated water. The Murchison Green Hydrogen Project is interesting in a number of respects, including the expansion of the project to blend with natural gas for haulage in Western Australia's Dampier to Bunbury natural gas pipeline.

See: *Western Australia's 5000 MW renewable hydrogen project moves forward*

PRC – The ever increasing speed on the road to net-zero emissions

It has been reported that the ***PRC***'s National Energy Administration (***NEA***) has confirmed that 18.7 GW of new photovoltaic solar renewable energy capacity has been installed in the calendar year 2020 to the end of September.

This comes as to Asia Europe Clean Energy (Solar) Advisory (***AECEA***) has reported that it projects that up to 38 GW of photovoltaic solar capacity will be installed during the full calendar year (with some estimates earlier in the year having predicted as much as 55 GW), and that up to 48 GW will be installed during calendar year 2021.

AECEA is suggesting that ***PRC*** is likely to accelerate progress, building on the fact that in 2019 15.3% of primary energy consumption was of electrical energy from renewable sources. It is possible that ***PRC*** may look to achieve up to 19% by 2025, this would mean that the ***PRC*** would have up to 600 GW of installed renewable capacity by 2025. This would allow the current target of 20% by 2030 to be revised upwards.

See: *China could add 48 GW of solar next year*

Updated Hydrogen Program Plan published by DOE

USA Department of Energy (***DOE***) published an updated version of its ***Hydrogen Program Plan***. The origins of hydrogen policy settings in the US can be traced back to the 2002 National Hydrogen Energy Technology Roadmap, which provided "*a blueprint for the public and private efforts required to fulfill a long-term national vision for hydrogen energy …*".

The updated ***Hydrogen Program Plan*** reflects the focus of ***DOE*** on the need for coordinated Research, Development and Demonstration (***RD&D***) activities to enable the use of hydrogen across multiple sectors of the US economy to deliver on the stated Vision: " *… a prosperous future for the nation, in which clean hydrogen energy technologies are widely affordable, widely available and reliable, and are an integral part of multiple sectors of the economy across the country*".

Interestingly, but not surprisingly, the ***Hydrogen Program Plan*** is agnostic as to the colour of hydrogen but contemplates the production of clean hydrogen from a diverse hydrogen production technologies, principally the use of steam methane reforming using CCC / CCUS, anerobic digestion to allow reform of anaerobic digester gas, and ***H_2O*** splitting using a range of technologies, not just electrolysis.

See: *The US Department of Energy Hydrogen Program Plan, November 2020*

Business Finland publishes National Hydrogen Roadmap for Finland

Business Finland (a public organisation directed by the Finnish Ministry of Employment and Economy) has published a ***National Hydrogen Roadmap for Finland***.

The ***Roadmap*** is clear as to historical, current and future uses: *"Hydrogen has been used as an industrial chemical for more than 100 years. Today … used to manufacture ammonia, and … fertilizers, as well as methanol and hydrogen peroxide, both vital feedstocks for a wide variety of different chemical products … Producing hydrogen via low or totally carbon-free ways, and using this "good" low-carbon hydrogen to replace hydrogen with a larger carbon footprint, we can reduce carbon emissions … ."*

Hydrogen is seen as playing a key role in Finland's national goal of carbon neutrality by 2035. The ***Roadmap*** does not contain policy settings, rather it is, and each initiative contemplated by it, is intended to provide a "knowledge base for further work" including shaping policy settings for Finland, and "determining the role of hydrogen in the national energy and climate policy".

As with the ***DOE Hydrogen Program Plan***, the Finnish ***National Hydrogen Roadmap*** provides a good analysis of the role that hydrogen can play across sectors, and the scale of the demand side of the prospective market for hydrogen, and in the case of the ***Roadmap*** the role that Finish business can play across the hydrogen value chain.

See: *Hydrogen Roadmap for Finland*

Roadmaps for on-shore: "Sea Routes and Classification Rules" for floating the off-shore industry

In Europe and in North Asia, and increasingly off the East Coast of the US, the development of off-shore wind field capacity is seen as key to the reduction of ***GHG*** emissions. Off-shore wind field capacity can be fixed bottom or floating. While fixed bottom off-shore capacity has been the prevailing wind technology, floating off-shore wind capacity is being contemplated increasingly. On November 10, 2020, it was announced that vessel classification society DNV GL has released the first integrated set of rules for floating off-shore wind structures. The rules are reported as allowing for classification for many structures, including barges, semi-submersibles, tension leg platforms, and vertical floating columns.

Mr Knut Orbeck-Nilson, CEO of DNV GL – Maritime made the telling observation that: *"By bringing many new players into the sector, floating off-shore wind can create a massive space of opportunity for years, vessel operations and off-shore companies. [Realising] this industry will require businesses from many different sectors and new types of standards to enhance cross-sector co-operation."*

Alliancing in One Team Operations

The observation of Mr Orbeck-Nilson, CEO of DNV GL reflects what is already happening in ***ROK***. On November 18, 2020, two of ***ROK***'s major corporations, Doosan Heavy Industries (***DHI***) and SK Engineering and Construction (***SK E&C***), announced that they had come together to form a One Team Operation (***OTO***) cooperation system. Under the ***OTO*** arrangement, ***DHI*** is to take responsibility for the development of off-shore technology and ***SK E&C*** will take responsibility for the development of the off-shore wind project, including obtaining approvals and other project development activities. ***DHI*** has been participating in technology development for a while, including as part of the Korea Institute of Energy Technology. And in September 2020, ***DHI*** and Hyundai Heavy Industries combined with Korea National Oil Corporation (***KNOC***) to develop the Donghae 1 floating off-shore project.

See: *South Koreans form floating wind alliance*

Bloom Energy and SK E&C – on a run of success

Edition 2 of Low Carbon Pulse reported that ***Bloom Energy*** and ***SK E&C*** were to provide fuel cell capacity to the cities of Hwasyng and Paju in Korea. On November 18, 2020, ***Bloom Energy*** and ***SK E&C*** were announced as having won the tender to supply fuel cell capacity to the Korean Industrial Complex Corporation. While not on the same scale as the Hwasyng and Paju projects, the project is an integrated solution that comprises solar generation capacity and EES in the form of battery storage (***BESS***).

See: *Bloom Energy and S&K EC win competitive bid for Korea's Changwon RE100 Project to supply 100% hydrogen powered solid oxide fuel cells and electrolyzers*

First, 40 by 30, Second 11 by 30, Third, Grid Integrity, and Fourth a Superhighway

First three editions of Low Carbon Pulse featured major news about the development of the off-shore wind industry. This fourth edition is no different. Scottish Power, National Power and SSE have announced a decision to develop the Eastern Link to carry electrical energy from Peterhead and Torness along the east coast to Selby and Hawthorn Point in the north of England (***Superhighway***). It is stated that the ***Superhighway*** will have 2 GW of capacity, and may be doubled over time.

See: *Firms agree Scotland to England renewable energy 'superhighway'*

FID close on Dogger Bank C

SSE is reported to be close to a final investment decision to develop the final phase of the 3.6 GW Dogger Bank off-shore wind project (each phase having over 200 wind-turbines): the first two phases, Dogger Bank A and B commenced construction in early 2020. Each of SSE and Equinor holds a 50% interest in the Dogger Bank project. SSE is overseeing the development of the Dogger Bank project to completion. Following completion, Equinor will assume responsibility for the operation. The electrical energy generated will be transmitted using high voltage direct current technology. Once operational the Dogger Bank project will be capable of dispatching sufficient electricity energy for 4.5 million homes in the United Kingdom.

In addition to its interest in the Dogger Bank project, SSE holds a 49% interest in the 1.075 GW Seagreen 1 off-shore wind project, with TOTAL holding a 51% interest, which is expected to achieve completion in 2022/23.

See: *SSE plans to triple renewable energy production by 2030* and *The biggest job in offshore wind? Equinor hunts chief for $11bn Dogger Bank*

A 10 point plan from Number 10 (Green Industrial Revolution)

One of the points in the UK Government's ten point plan (***10 PP***) is the ***40 by 30*** (see Edition 1 of Low Carbon Pulse), and to develop 5 GW of low carbon hydrogen production capacity by 2030. The ***10 PP*** provides funding for use of hydrogen in homes, and for the sale of new petrol and diesel cars to end by 2030 (an acceleration of previous plan to phase out by 2040).

On releasing the ***10 PP***, UK Prime Minister Mr Boris Johnson said that this was the "*beginning of the UK's plans to net zero*". In the context of the development of off-shore wind projects, it is important that as well as addressing connection and system integrity and stability electrical energy storage (***EES***) is part of the development plan.

See: *Boris Johnson sets out 10 point plan to get UK back on track for net zero and UK green plan backs nuclear, hydrogen to support 250,000 jobs*

Low Carbon Pulse - Edition 5

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to Edition 5 of the Low Carbon Pulse – sharing significant news in the progress towards net-zero emissions. This edition covers the period from November 23, 2020 to December 13, 2020.

On December 7, 2020, the Global Ashurst Towards Zero Emissions team published the first article in The Shift To Hydrogen (S2H2) Elemental Change series. This is a sibling publication to Low Carbon Pulse.

With the calendar year ending, and the looming holiday season in many parts of the world, publication of Low Carbon Pulse will recommence in mid-January 2021, with three editions planned for the month, including a special focus on the ramifications of the US election result for net-zero.

From the Global Ashurst Towards Zero Emissions team, best wishes and seasons' greetings to you all.

COVID-19 and *GHG* emissions

Throughout the COVID-19 period, the World Meteorological Organisation (***WMO***) has provided a reasonably consistent message. ***GHG*** levels in the atmosphere reached record levels in 2019, to a little over 417 ppm to May 2020, with the rate of increase in concentration slowing (marginally) during 2020, as ***GHG*** emissions have fallen.

This fall is not sufficient to stop the increase in the concentration of ***GHG*** in the atmosphere (let alone to start to reverse it-this takes time). *"The last time the Earth experienced a comparable concentration of* ***CO_2*** *was 3 to 5 million years ago, when [the] temperature was 2°-3° Celsius [or 3.6° to 5.4° Fahrenheit] [above today] … . But there weren't 7.7 billion inhabitants." (****WMO**** Secretary General, Professor Petteri Taalas)*

Population growth and associated economic activity will continue, so taking a "wait and see approach" is not a viable strategy. As is increasingly the case, we are not waiting to see, but the pace at which ***GHG*** emissions are reduced is key. Commitments to reduce ***GHGs*** exist, but the pace of reduction needs to quicken, with the developed world best placed to take the lead on this, with the next target to strive for being negative ***GHG*** emissions.

Despite COVID-19, or perhaps, at least in part, because of it, 2020 has seen record levels of new renewable electricity energy capacity developed, and record commitments to develop more, and commitments to carbon neutrality by 2050, critically, from the Peoples Republic of China (***PRC***), Japan and Republic of Korea (***ROK***), and to enhanced commitments from the European Union (***EU***), and the United Kingdom (***UK***), and the clear momentum for the development of hydrogen as an energy carrier. As such, there is a clear basis for cautious optimism.

To this cautious optimism, with the anticipated re-entry of the US into the Paris Agreement, and the appointment of Mr John Kerry, as Climate Envoy, it is possible to add more optimism with the anticipated return of the US to global climate leadership shown under the Obama Administration.

At the European Hydrogen week starting on November 23, 2020, it was noted that: *"2020 will be remembered first and foremost for other things, but it has also been a big year for hydrogen at the EU level".*

It is difficult to fault this assessment, and it is appropriate to add that the momentum for hydrogen as an energy carrier is at a global level. The key is not to overstate the rate of progress, or to underestimate the scale of investment and time required, for hydrogen to develop as an energy carrier.

The ***UNEP Emissions Gap Report 2020*** published in December 9, 2020, anticipates a fall in ***GHG*** emissions by 7% compared to 2019 and promotes the idea of a "green pandemic recovery" which will bring the world close to achieving the ***Stabilisation Goal*** in the Paris Agreement (see Edition 4 of the Low Carbon Pulse).

See: *Carbon dioxide levels continue record levels despite COVID-19 lockdown*; *Greenhouse Gases still at Record Levels Despite COVID-19 Lockdowns, UN Warns*; and *UN: Greenhouse gas levels hit record high despite lockdowns*

***EU* accelerates to 55 by 30**

As foreshadowed in the first item of Edition 1 of Low Carbon Pulse, on December 10, 2020, ***EU*** leaders determined on an ***EU***-wide net ***GHG*** emissions reduction of 55% by 2030, compared to 1990 levels. This is seen as a realistic acceleration of the ***EU*** reduction target. The basis for this acceleration was stated clearly in September, 2020, in a European Commission statement: *"Achieving this increased climate ambition will require an investment boost, which will contribute to a green recovery from the current COVID-19 crisis. In this context, the European economic response to COVID-19 offers a unique opportunity to accelerate the transition to a climate-neutral economy".*

This increased commitment, from 40% to 55%, is further cause for cautious optimism. During the final quarter of 2020, the realisation of a need to accelerate reductions has been manifested in increase commitments to reduce ***GHG*** emissions from the ***PRC*** to the ***EU***.

The UK is accelerating to 68% by 2030 and possibly 78% by 2035

In the first week of December, 2020, the UK Government announced that it will accelerate the rate of reduction in ***GHG*** emissions from 55% of 1990 emission levels by 2030, to 68% by 2030 (***68 by 30***). The UK Prime Minister, Mr Boris Johnson, called the accelerated rate of reduction "ambitious". The UK Business and Energy Secretary, Mr Alok Sharma, stated that it reflected "*the urgency and scale of the challenge that our planet faces*".

It is to be hoped that the change to the UK's commitment will encourage other countries to increase their reduction commitments too. Increased rates of reduction are required to allow the ***Stabilisation Goal*** of the Paris Agreement to be achieved. An increase in any country's commitment to reduce ***GHG*** is effected through a change to that country's Nationally Determined Contribution (***NDC***) under the Paris Agreement (see Edition 4 of Low Carbon Pulse).

On December 9, 2020 the UK's Climate Change Committee (***CCC***) delivered its "***Sixth Carbon Budget - UK's path to Net Zero***" which reports on how to achieve net zero ***GHG*** emissions by 2050. A key recommendation is the need to develop 100 GW of offshore wind by 2050 (***100 by 50***), noting that the Budget contemplates up to 125 GW. This recommendation builds on the ***40 by 30*** policy setting announced in October, 2020 by UK Prime Minister Mr Boris Johnson (see Low Carbon Pulse 1). In the most detailed roadmap yet delivered globally, routes to stated goals and destinations are now provided. [**Note:** By mid-october 2021 the UK Government was accelerating this.]

One of the routes is the implementation of the ***100 by 50*** policy, is the use of "low-carbon" hydrogen and carbon-negative solutions. There is a role for CCS / CCUS, but not over the long term, rather it is a route to the production of clean-carbon hydrogen. The role for hydrogen is clearly stated in the Budget, with a route required to achieve a goal of 25 TWh of low carbon hydrogen by 2030 (and up to 90 TWh by 2035). This will allow a shift to low carbon hydrogen use by industry (in particular in difficult to decarbonise industries) and provide sufficient supply of hydrogen consistent with the phasing out of all existing gas boilers by 2033, and all new boilers being hydrogen ready by 2025.

The ***CCC*** provides a clear basis for the UK to progress towards zero net emissions by 2050. It is for the UK Government to determine whether, and, if so, how best, to implement the recommendations of the ***CCC***. It is timely to remind oneself that progress towards zero emissions started as an environmental and social policy, but is now a fully integrated, and the most important, economic, environmental and social policy issue. In the words of the Head of the International Energy Agency's renewables division, Mr Paolo Frankl, "*Energy transition depends on government policy, regardless of wind and solar*".

All the signs are good with the UK Government having already announced ***68 by 30***, as policy, consistent with the recommendation of the ***CCC***. If the UK Government accepts the enhanced target of a 78% reduction in 1990 ***GHG*** emissions by 2035 (***78 by 35***), the UK will be well and truly at the front of the pack among developed countries in having policy settings that will achieve net zero emissions by 2050.

See: *World's first national roadmap to net zero by 2050 calls for 100GW backbone of offshore wind.*

Japan is providing funding for acceleration

On December 4, 2020, Japan's Prime Minister, Mr Yoshihide Suga, announced that the Government of Japan is to establish a ¥ 2 trillion (USD 19.2 billion) fund to provide funding to, and otherwise to provide support for, companies to 2030 for the purposes of achieving Japan's 2050 ***GHG*** target (see Editions 1 and 2 Low Carbon Pulse).

The key message from the Japanese Government (and relevant for other governments globally) is that Japan regards the move towards zero ***GHG*** emissions as both an economic growth, and an environmental, strategy, emphasising again the perspective of the Japanese Government that hydrogen will play a central role in the Japanese economy: *"Positioning the inexhaustible hydrogen as a new power source, we will realize large scale, low cost hydrogen production equipment. We will also develop hydrogen airplanes and hydrogen cargo ships"… "In order to shift our thinking toward such a virtuous cycle of environment and growth, the government will take a big step forward in environmental investment in this economic measure*."

In the statement, Prime Minister Suga, made it clear that "*Environmental preparedness is no longer a constraint on economic growth*". For those that have long worked in the renewable energy sector (and the sustainability sector generally), the practical application of the triple bottom line looks as though it is becoming a reality.

See: *Japan to Create a 2 trillion yen ($19.2 billion) Green Fund to Include Hydrogen*

Japan is continuing as a first mover

While not a surprise (given the Japanese Hydrogen Strategy published at the end of 2017 and the shipment of Blue Ammonia from the Kingdom of Saudi Arabia in September 2020), the Japanese government has recently confirmed its intention to introduce the use of ammonia into power generation (mixing ammonia with coal) and to use ammonia to power and to propel shipping.

Director General of Oil, Gas and Mineral Resources at the Ministry of Economy Trade and Industry, Mr Ryo Minami, stated that: "*Ammonia is expected to be introduced as fuel on a commercial basis for thermal power generators and shipping in the late 2020s, and it is expected to be used [in] significant amounts by around 2030*". In 2021, the combustion of ammonia and coal will be tested as part of a feasibility study being under taken by the government body, the Industrial Technology Development Organisation.

In August 2020, NYK Line, Japan Marine United Corporation and ClassNK entered into a joint research and development agreement to commercialise the use of an ammonia-fuelled ammonia gas carrier (***AFAGC***) and an ammonia floating storage and regasification barge (***A-FSRB***). Ammonia, in gaseous form at room temperature, is refrigerated and compressed for transportation using LPG vessels (which are capable of multi-purpose use). There are likely to be clear benefits in the development of dedicated ***AFAGCs*** and ***A-FSRBs***.

In the short term, Blue Ammonia will be used, but in the longer term Green Ammonia is considered as a highly promising low emission fuel. Strictly, ammonia is not a ***GHG*** free energy carrier because on its oxidation (use) ***NOx*** arise, but ***CO_2*** does not arise, and ***NOx*** may be regarded as easier to capture.

See: *Japan pushes ahead with ammonia as a shipping fuel of the future*

Japan Hydrogen Association (*JH2A*)

Edition 2 of Low Carbon Pulse reported on the establishment of the ***JH2A***, and that the establishment would be formalised in December, 2020. On December 7, 2020, an event was held to mark the establishment of the ***JH2A***. The event was accompanied by the release of a document providing details "About the Japan Hydrogen Association" (***Formalisation Document***), and formalising its establishment.

The ***Formalisation Document*** provides a real sense of the coordinated way in which Japanese business intends to provide resources so as to be able to work effectively with government and together.

The ***Formalisation Document*** states that as of December 2, 2020, 87 corporations are members of the ***JH2A***, including ENEOS Corporation, Iwatani Corporation, Kawasaki Heavy Industries Ltd, Kobe Steel, Ltd, MITSUI & CO, LTD, Sumitomo Mitsui Financial Group, Inc., The Kansai Electric Power Corporation, Inc., Toshiba Corporation, and Toyota Motor Corporation.

Stabilisation Goal within reach

On December 1, 2020, the BBC ran a report "***Climate change: Temperature analysis shows UN goals "within reach***"". While Ashurst has not verified the findings of the report, the headline is that the implementation of the commitments of countries (critically the ***PRC***, Japan and Korea), and the implementation of the carbon neutrality agenda of US President-elect Mr. Joe Biden, will result in a 2.1°C increase in temperature, which is just outside the ***Stabilisation Goa***l of the Paris Agreement (see Edition 4 of Low Carbon Pulse). The obvious point to make is that the conclusion of the report is based on each country actually implementing these commitments.

See: *Climate change: Temperature analysis shows UN goals 'within reach'*

Resumption of US leadership on climate change anticipated

As will be apparent from a number of other pieces in this Edition 5 of Low Carbon Pulse, December 4, 2020, was a busy day. Edition 4 of Low Carbon Pulse noted that it seemed likely with the election of President-elect Mr. Joe Biden that the US would resume its leadership role in the progress towards zero ***GHG*** emissions. As the Biden Administration rolls out its policies, we will cover them, and we will run a US Inauguration Low Carbon Pulse on January 20, 2021. [**Note:** Edition 27 of Low Carbon Pulse]

As important as the role of the US Government is the role of US business and business leaders. On December 4, 2020, Bill Gates, one of the titans of world business and philanthropy, outlined a USD 35 billion plan for US leadership on climate change. Mr Gates wrote: *"[We] need to revolutionize the world's physical economy – and that will take, among other things, a dramatic infusion of ingenuity, funding, and focus from the [US] Federal Government… This is the most important thing the US can do to leader the world in innovations that will solve climate change."*

The plan proposed by Mr Gates resonates. As does the open letter from many leading corporations calling for greater leadership on climate change (under the auspices of the Center For Climate and Energy Solutions (***C2ES***)), including Amazon, Bank of America, BASF, BHP, BP, Citi, Danone, DuPont, Edison, Entergy, Ford, General Motors, Goldman Sachs, Google, JP Morgan Chase, LafargeHolcim, Microsoft, Morgan Stanley, National Grid, Nestle, NRG Energy, Ørsted Offshore, PG&E, Schneider Electric, Shell, TotalEnergies, Unilever, and Walmart.

See: *Bill Gates just released a plan for US leadership on climate change, including $35B in funding*

Consistent with the need for innovation, a new report from Coalition for Urban Transitions (***CUT***) "Climate-Emergency, Urban Opportunity" has highlighted that the introduction of low carbon policy settings and measures in cities needs to be part of the move towards zero emissions.

See: *Climate Energy, Urban Opportunity* and *The Shift to Hydrogen (S2H2): Elemental Change*

Fixed Bottom Wind - A first for Japan's offshore wind industry

On November 27, 2020, Japan's Ministry of Economy, Trade, and Industry (***METI***) and the Ministry of Land, Infrastructure, Transport and Tourism (***MLIT***) opened the tender process for the first auction for fixed-bottom off-shore wind by Japan. The tender is stated to be open until May 27, 2021. The tender relates to four offshore areas, three located off Akita Prefecture, and the fourth located off Chiba Prefecture.

The tender process for fixed-bottom wind follows the off-shore wind tender for floating wind in June 2019. Both the floating wind and the fixed bottom wind are undertaken pursuant to the *Renewable Sea Area Utilisation Law* that came into effect in April 2019.

There is an excellent Ashurst article on the current tender process: ***Making headway in Japanese offshore wind – Auction guidelines face bidder scrutiny***.

See: *Japan Launches First Fixed Bottom Offshore Wind Auction*

PRC + H2 = A year of development

In preparing to launch Low Carbon Pulse, we considered jurisdictions that were best placed to accelerate to hydrogen economies - in our assessment the most important was the ***PRC***. Why? Continued policy making at each level of government (central, provincial and municipal) and the level of activity through the COVID-19 period. Increasingly, our perspective is reinforced. The prospect of achieving scale for the fuel cell technology market may be paving the way for low cost Green Hydrogen production by the middle of this decade. Edition 4 of the Low Carbon Pulse, noted that there is a need for close cooperation between government and business. The ***PRC*** is well-placed to achieve this, including through the ***China Hydrogen Alliance***.

It is estimated that close to 67% of the hydrogen produced each year in the ***PRC*** (around 20 million tonnes) is produced from hydrocarbon feedstocks, with the balance produced as a by-product of chemical production and coking and steelmaking (30%) and renewable resources (3%).

Members of the ***China Hydrogen Alliance*** have been instrumental in leading the development of hydrogen refuelling infrastructure (***HRI***), Sinopec is involved in the development of ***HRI***, and Shandong Weichai is at the forefront of fuel cell technology development. Sinopec, as an existing producer of hydrogen, is perfectly placed to undertake energy transition, as is the case with other oil and gas companies. In some ways, Sinopec is leading the way, with commitments of USD 13 billion to the development of hydrogen businesses.

While a good number of provinces in the ***PRC*** have announced hydrogen policies as part of broader plans and strategies, Guangdong, Hebei, Ningxia, Shandong and Tianjin have published plans and strategies and set policies specific to hydrogen. Shandong province in particular has been active throughout 2020. Consistent with other plans, road-maps and strategies published (at various levels of government, the ***PRC*** has the same emphasis on renewable energy, focusing on wind power (particularly offshore wind for coastal provinces), and photovoltaic solar power.

Adding hydrogen

On November 22, 2020, Sheikh Mohammed bin Zayed directed the Abu Dhabi National Oil Company (***ADNOC***) to explore opportunities to position the UAE as the world leader in exploiting hydrogen, "the ultimate green fuel".

ADNOC is an integrated oil and gas company, that produces all manner of hydrocarbon derived products, including hydrogen. ***ADNOC*** is able to build on existing infrastructure to derive increased mass of hydrogen from hydrocarbon sources, in the first instance, to produce clean hydrogen, and ultimately the cleanest hydrogen of all, Green Hydrogen.

As is the case with other countries in the Gulf Region, the UAE has world class renewable energy resources, as well as existing world class hydrocarbon resources. In this regard, the Mohammed bin Rashid Al Maktoum Solar Park in Dubai is likely to be the first solar-powered hydrogen plant in the Gulf Region.

See: *Why hydrogen is the fuel of the future for UAE*

Ørsted Offshore Overseas

On November 24, 2020, Ørsted announced its intention to develop a 1.6 GW offshore wind project off the west coast of the Republic of Korea (***ROK***), 70 km from Incheon City, home to greater Seoul's major international airport, Incheon (Seoul's other airport being Gimpo Airport, serving domestic and regional air routes). The project will build upon the leading reputation of Ørsted.

On the basis that the project proceeds (noting that a final investment decision is yet to be made), the headlines facts and stats for the project include that it will provide electrical energy for up to 1.4 million homes, and displace the use of coal and gas fired power stations, fired by imported coal and LNG. This will reduce ***GHG*** emissions by 4 million metric tonnes per annum, and as such makes a material contribution to ***ROK***'s renewable energy target to achieve net-zero emissions by 2050. Also the project will provide close to 8% of the planned 12 GW of installed capacity by 2030.

Interestingly, the project will be located in the relatively shallow waters of the West Sea or Yellow Sea (depending the country from which it is viewed). The development of offshore wind projects in shallow waters and in the proposed location has both development cost and operational cost benefits.

See: *Orsted Plans to Develop Offshore Wind Projects in South Korea*

NorthH$_2$ – A Giant built by Giants

On December 8, 2020, Shell announced that it is planning to develop the largest "wind-to-hydrogen" (***W$_2$H$_2$***) project in Europe. The ***W$_2$H$_2$*** project comprises a 10 GW offshore wind field to provide electrical energy for an electrolysis plant that is to produce 1 million metric tonnes per annum of Green Hydrogen by 2030 (assuming full field development).

The project is called the ***NortH$_2$ Project***, and will be located off the North Coast of the Netherlands. On completion of full field development, at 10 GW, the offshore wind field will be a little over 2.5 times the size of the Dogger Bank Project (described in Edition 4 of Low Carbon Pulse). The Green Hydrogen produced will be transported using pipeline infrastructure of natural gas pipeline owner, Gasunie. It is intended that the off-takers of the Green Hydrogen will be industrial users in the Netherlands and Germany (under-pinning the capital investment required for the Project), with quantities of Green Hydrogen also to be made available for domestic and transport use.

Equinor and RWE have joined the ***NortH$_2$ Project***. In addition to these energy giants, the province of Groningen, Groningen Seaports are involved in the Project.

From a policy setting perspective, the ***NortH$_2$ Project*** is consistent with the ***EU*** goal of 300 GW of offshore wind capacity by 2050.

See: *Big energy partners join Shell's giant NortH$_2$ wind-to-hydrogen project*

BEV or FCEV? Or both?

As noted previously, the automotive industry (manufacturers of passenger vehicles) is best placed to provide consumers with the choice between ***BEV*** and ***FCEV***, including possibly favouring one technology over the other: using renewable energy both ***BEV*** and ***FCEV*** have the potential to be ***GHG*** emissions free.

Some automotive vehicle manufacturers are providing consumers with a choice of both ***BEV*** and ***FCEV*** (in addition, at least for the time being, ICE and hybrid), others are flagging clearly that they prefer ***BEV*** over ***FCEV***. While the two technologies are not mutually exclusive, one may be preferred over time (for those who remember Betamax v VHS, yes dear reader, the author is that old, this dynamic will be clear), but it appears more likely that together both of these technologies will be the mainstay technologies for the foreseeable future for all forms of passenger vehicles, including motor bikes and scooters in many parts of the world.

The issue for Governments is ensuring that they do not pick favourites, and more importantly that disproportionate investment is not made in ***HRI***, direct or indirect.

A quick reminder of defined terms:

BEV: Battery Electric Vehicles derive electrical energy from the energy carrier media stored by battery to power and to propel vehicles, with the battery re-charged by electrical energy. Use of a ***BEV*** does not give rise to any ***GHG*** if renewable energy is used to generate the electrical energy used to re-charge.

FCEV: Fuel Cell Electric Vehicles derive electrical energy from hydrogen in compressed form stored in a pressurised tank from which hydrogen is converted into electrical energy, and water vapour, to power and to propel vehicles, with the hydrogen tank refuelled at ***HRI***. Use of a ***FCEV*** does not give rise to any ***GHG*** if renewable energy is used to produce the hydrogen.

ICE: Internal Combustion Engine (a long established technology) that derives energy from the combustion of motor spirit (gasoline or petrol) or diesel, sometimes with a fuel crop derived additive, by an engine (that fires the fuel to produce energy, heat and noise) to power and to propel motor vehicles, with the fuel tank refuelled at gas / petrol stations use of an ICE, which gives rise to ***GHGs*** on the combustion (and as such oxidation), of the motor spirit / diesel.

Hybrid: A phrase describing a motor vehicles that combine **ICE** and **BEV** technology.

See: *German Lobbyists are Pushing Hyrdogen Fuel Cells - But German Automakers have moved on*

Port of Los Angeles "shore to shore" H2 storage

On November 25, 2020, it was announced that high pressure hydrogen storage (***HiHy***) facilities are to be installed by Shell at Long Beach, California. The scale of the ***HiHy*** facilities (or the ***Shore to Store Project***) will allow the reduction of ***GHG*** emissions on the route from the Port of Los Angeles to Ontario.

European companies, Tenaris and NEL Hydrogen, have partnered to develop the ***HiHy*** technology, through research and development to production since 2018.

See: *Tenaris Partners with Nel Hydrogen for California Hydrogen Truck Refueling Network*

The Big Battery

For those resident in, or lucky enough to have visited, "country Australia", in particular the east coast, and south east, of Australia, Queensland, New South Wales, Victoria, and South Australia, there is a phenomenon known as "The Big": towns known for a particular activity or commodity will promote that by a big depiction of that activity or commodity somewhere within the town. **The Big**, in any country town, is a favourite photo opportunity for those passing through. The best known of "**The Bigs**" are The Big Banana, The Big Guitar, The Big Lobster, The Big Merino (breed of sheep that produces high quality wool), The Big Pineapple, **The Big** Potato, and The Big Prawn. Somewhat improbably, Dadswells Bridge in Victoria, claims The Giant Koala.

It appears more than likely that sooner rather than later, one of the towns in "country Australia" is going to claim the title of: The Big Battery, The Big Solar, The Big Wind! There are many contenders for each new Big.

An early contender for the Big Battery is the "Victorian Big Battery" (***VBB***) to be developed near Geelong, Victoria. The ***VBB*** (an Australian beer joke) is being developed by Neoen and Tesla. The ***VBB*** will be 300 MW / 450 MWh, and is expected to come into service towards the end of 2021.

See: *Big batteries are getting bigger and smarter, and doing things fossil fuels can't do*

All change, but no one paradigm

There is "no one size all" model for energy transition, and there is no clear line of sight to what energy delivery systems, and what energy use, may look like as we progress towards zero emissions. Australia has long been called the lucky country (it is blessed with two of the three means of "real economy" wealth creation, growing food and raising livestock, and mineral, oil and gas resources). The moniker of the "lucky country" is likely to continue: Australia is blessed with some of the best renewable resources in the world (solar and wind), close to major energy carrier export markets, and having established relationships with those markets, including the ***PRC***, Japan and ***ROK***. The States and Territories of Australia (will feature in the Zero Hero piece of Edition 6 of Low Carbon Pulse) have made considerable progress towards zero emissions in a relatively short period of time, each in different ways, and with different reasons for making progress. It appears likely (see Editions 2, 3 and 4 of Low Carbon Pulse) that Australia will become a key Green Hydrogen producer and supplier.

While there may be a sense of being a later adopter of renewable energy, Australia is now leading in some States, and, as a general statement, has embraced electrical energy storage (***EES***), in particular battery electrical energy storage (***BESS***). Australia has a National Electricity Market (***NEM***) covering the Eastern States of Queensland, New South Wales, the Australian National Territory, Victoria, Tasmania and South Australia. In this market, the generators that are also retailers ("gen-tailers") of electrical energy are innovating in their product offerings and business models in a period of unprecedented market disruption. (The transmission and distribution systems are owned separately, with prices regulated to provide benchmark infrastructure rates of return.)

In this ever changing electrical energy market, ***EES*** is needed for grid integrity and stability (together with pumped hydro) and to store electrical energy at times of over supply to the ***NEM***. This is giving rise to new markets, including, in the case of ***EES***, a market for ***EES*** capacity.

Green Industrial Revolution … continues

On November 30, 2020, it was announced that the Department of Business, Energy and Industrial Strategy (***BEIS***), in the UK, approved its largest battery storage facility (***BSF***) to date, the Intergen 320 MW / 640 MWh capacity ***BSF***. The ***BSF*** is to be located at the DP World London Gateway, on the River Thames, in Essex. On completion, the ***BSF*** will be the largest in the UK, and in Europe. The ***BSF*** has the potential to be expanded to 1,300 MWh (or 1.3 GWh). The ***BSF*** provides a further illustration of the role of ***EES*** in responding to satisfy load and to ensure system integrity and stability.

See: *Europe's largest battery project gets approval in the UK*

CH_4 Emission Transparency – Reliable Data provides the best basis for outcomes

Projects and transactions across many industries are underpinned by reliable data that measures on a consistent basis: the more reliable that data, the more measurable the outcome, and the more likely that the required outcome will be achieved.

On November 23, 2020, 62 oil companies signed an international agreement pledging to report ***CH_4*** emissions more effectively (***Transparent Reporting***). The level of ***CH_4*** in the atmosphere has increased since the mid-2000s, reflecting increased use of natural gas, but contributing to ***GHG*** emissions.

This initiative is part of the Climate & Clean Air Coalition's Oil and Gas Methane Partnership (***OGMP***), coordinated by the United Nations Environmental Programme (***UNEP***), the ***EU*** and the Environmental Defense Fund. The ***UNEP*** has stated that the ***Transparent Reporting*** mechanism is a "new gold standard", that will assist in the reduction of ***GHG*** emissions, including a 45% decrease in ***CH_4*** emissions by 2025, and between 60% and 70% by 2030. As part of the ***Transparent Reporting*** initiative, oil and gas companies will provide details of their ***CH_4*** reduction targets to the ***UNEP***.

The ***Transparent Reporting*** initiative is aligned with the World Business Council on Sustainable Development (***WBCSD***) initiative detailed in Edition 3 of Low Carbon Pulse that requires corporations to have plans to achieve net zero ***GHG*** emissions.

It has been noted that while European oil and gas producers committed to ***Transparent Reporting***, US companies are yet to do so.

A quick reminder of defined terms:

CH_4 is methane, which is the predominant hydrocarbon compound in natural gas. Methane is the second most prevalent ***GHG*** and has a higher ***Global Warming Potential*** than ***CO_2***.

Global Warming Potential (**GWP**) in respect of any ***GHG***, the potential for 1 tonne of that ***GHG*** to contribute to climate change in comparison to one tonne of ***CO_2***, with the GWP of ***CH_4*** being up to 84 times that of ***CO_2***.

United Nations Environmental Programme (*UNEP*) identifies and analyses global environmental problems. The ***UNEP*** works within the conventions and programs of the United Nations. The ***UNEP*** was established in 1972 following the Stockholm Conference on Human Environment. The ***UNEP*** works within the frameworks provided by a number of conventions and UN bodies, including the Basel Convention and the Stockholm Convention.

Environmental Defense Fund (***EDF***) is a non-government, not for profit, organisation established in 1967, and one of the world's leading, and longest established, environmental organisations, widely recognised for its science only based approach. The ***EDF*** has worked with the Climate & Clear Air Coalition since 2014.

See: *The Danger of Big Oil's New Methane Emissions Pledge*

All roads lead to renewed electrical energy systems

On November 24, 2020, Enel, the largest utility in the ***EU***, announced plans to invest up to €160 billion (USD 190 billion) by 2030. The investment plan is an integrated plan to develop and to integrate renewable energy sources into the Grid.

The plan includes the development of 75 GW of new renewable capacity to 120 GW by 2030. (This represents an increase of 2.7 times current capacity of 45 GW).

These plans are consistent with the stated objective of Enel to achieve an 80% reduction in the level of 2017 ***CO_2*** emissions by 2030.

See: *European Utility Giant to Invest $190 Billion In renewable Infrastructure* and *European utility giant to invest $190 Billion in renewable infrastructure*

Biogas and Biomethane

The established producers of industrial gas, Air Liquide and Air Products, are well-placed, in fact, ideally placed, to develop their businesses to produce the full range of gaseous energy carriers. On November 24, 2020, Air Liquide announced plans to develop two bio-methane units.

A quick reminder of defined terms:

Biogas is a phrase used to describe gas derived or produced from organic matter, including from the use of anaerobic digestion of organic matter.

Biomethane is a phrase used describe ***CH_4*** derived or produced from biogas by the removal of other organic and inorganic compounds present in the biogas.

See: *Air Liquide Launches Biomethane Activity in Italy With Two New Production Units*

All diesel trains to run on H_2

Consistent with Germany as a first mover, Deutsche Bahn and Siemens have announced a plan to test a hydrogen-powered train. The test is planned to commence in 2024, and to continue for 12 months. Deutsche Bahn currently operates around 1,300 diesel powered trains across those parts of its network not electrified. The plan is intended to pave the way for the phasing out of all diesel powered trains by 2050.

Siemens is one of the technology developers and providers leading the way in the passenger transport sector. Michael Peter (CEO of Siemens (SIEGY) Mobility) stated: *"Hydrogen drives are an advanced emission-free form of propulsion that will help decarbonise rail transport and make a significant contribution to achieving … climate targets".*

Austria not far behind Germany, and Italy ahead of both in orders

On December 1, 2020, it was announced that Alstom's ***Coradia iLint Fuel Cell*** train had completed three months of test operations on the regional lines of OBB (Austrian Federal Railways). In addition to completion of three months of tests successfully, the Fuel Cell Technology train has been approved by the Ministry for Climate Protection, Environment, Energy, Mobility, Innovation and Technology. Germany has previously approved the Corodia iLint Fuel Cell train. The Fuel Cell train is now ready to move into production.

See: EGEB: *World's first hydrogen fuel cell train is approved in Austria* and *Alstom's hydrogen train successfully completes three months of testing in Austria*

Alstom is to supply six Fuel Cell Technology trains and has granted options for eight more to Ferrovie Nord Milano (***FNM***) the main transport company in Lombardy, Italy. The first delivery is expected within 36 months. The ***FNM*** trains will use Alstom ***Coroadia iLint Fuel Cell Technology***.

See: *CleanTechnica – Alstom To Supply Italy's First 6 Hydrogen Trains*

100,000 by HGVTs 2030

On the first day of the European Hydrogen Week (***EHW***), a study was released that outlined the scale of the anticipated heavy good vehicles and trucks (***HGVT***) by 2030. It is reported that a coalition of 62 companies have committed to work together to deploy 100,000 H_2 ***HGVTs***, and to develop ***HRI*** comprising between 1,000 and 1,500 re-fuelling stations by 2030.

This scale of deployment and development is seen as core to achieving the commitment to reduce ***GHG*** emissions from the transport sector by 90% of 1990 levels by 2050. It is estimated that ***GHG*** emissions from the transport sector give rise to around 25% of ***GHG*** emissions arising with the ***EU***, and contribute significantly to air pollution, particularly in urban areas.

It was recognised at ***EHW*** that the ***European Clean Hydrogen Alliance*** has a critical role to fulfil by promoting the necessary investment to achieve this scale of development.

See: *Plans for 100,000 hydrogen trucks and 1,000 hydrogen stations by 2030 unveiled during European Hydrogen Week*

Greenlights for New Green Islands

In June 2020, the Danish government announced consideration of the development of green power islands in the Baltic and North Seas. On November 23, 2020, the Danish Ministry of Climate, Energy and Public Utilities confirmed progress of feasibility studies, with a decision to be taken in Q1 of 2021 as to the locations of green islands in the North Sea. *"The [green] island will help to increase the amount of renewable energy significantly, and at the same time make it possible to transform green power into fuels for heavy transport … both on land, at sea and in the air. In other words, the [green] islands will supply the green electricity which is the prerequisite for the climate-neutral Denmark and Europe of the future".* (Minister of Climate, Energy and Public Utilities, Dan Jorgensen.)

The Danish Energy Agency and Energinet (grid operator, for electrical energy and natural gas in Denmark) will start detailed studies for each location, with a view to finalising those studies by 2024. It is anticipated that initially the new green islands will add an additional 3 GW of installed capacity of off-shore wind power, increasing to up to 10 GW. A final investment decision is expected in 2021.

As a result of the green islands, and other projects, the Danish government intends to install 7.2 GW of off-shore wind capacity between 2027 and 2030, including the green islands, the 1 GW Thor Project in the North Sea, and a proposed 1.2 GW project in the Baltic Sea.

The feasibility studies being undertaken have started to firm-up the likely location as 60 kilometres west of Thorsminde, on Denmark's west coast.

See: *Denmark Moves Forward with Energy Islands*

Repurposing and future use

The North Sea has a considerable amount of existing infrastructure developed over 50 years as the oil and gas resources from beneath the sea were extracted. While the development of the North Sea oil and gas industry was effective, in relative terms it was expensive.

The Crown Estate of Scotland, on behalf of the Scottish Offshore Wind Energy Council (***SOWEC***), is in the process of procuring a study to determine whether it may be possible to repurpose any existing infrastructure, to allow the more efficient, and cost effective, development of hydrogen production and transmission. This study will be fed into a broader assessment of the pace with which hydrogen projects may be developed from the late 2020s to 2050.

The study is significant in that it is likely to inform investment decisions, but also provide a basis for extracting value from existing assets, in particular as oil and gas progress towards zero emission outcomes.

See: *Crown Estate Scotland Seeking Study on Repurposing of Oil and Gas Infrastructure for Hydrogen*

[**Note:** see Edition 26 of Low Carbon Pulse]

Dogger Bankable News

- **Dogger Banked**: Edition 4 of Low Carbon Pulse, outlined the 3.6 GW Dogger Bank Project. On November 26, 2020, Equinor and SSE reached financial close for Dogger Bank Phases A and B. The achievement of financial close for the first two phases of the Project is significant on a world scale, being the largest project financing of an offshore wind project.
- **Eni Sails to Dogger Bank, and Dogger Bank sale to Eni**: Following the announcement of financial close on Dogger Bank Phases A and B, on November 26, 2020, it was announced that Eni SpA (the Italian Oil and Gas Giant) is to take a 20% stake in the Dogger Bank Project. It was reported that the 20% stake will cost Eni a combined GBP 405 million (USD 554 million), including the purchase price payable to Equinor and SSE, and equity funding commitments in respect of the Project.

  Eni is committed to reducing its ***GHG*** emissions by 80% by 2050, and its investment in the Dogger Bank Project will contribute to that. Eni has plans to invest in more than 55 GW of renewable energy capacity by 2050, from a little under 1 GW currently.

  Equinor continues as one of the development phase pace setters in the sector, developing and then selling down interests, having done something similar with US assets earlier in 2020.

  And the UK would appear to be well on the way to ***40 by 30*** (see Edition 1 of Low Carbon Pulse).

  See: *Dogger Bank Owners Close Largest Ever Offshore Wind Project Financing* and *Eni Joins North Sea Wind Power Grab with Dogger Bank Deal*

Roof-Top Solar Installations Top 2 million in Germany

At the end of October 2020, it was reported that 2 million photovoltaic (***PV***) solar roof-top systems had been installed in Germany. In many ways the use of the ***PV*** roof-top solar (and increasingly any external surface of buildings) is the quiet over-achiever in the move towards zero ***GHG*** emissions. The German Solar Industry Association (***BSW-Solar***) indicates that this marks an: "energy transition milestone".

As is the case with many energy transition initiatives, the rate of the development of roll-out of roof-top solar should be accelerated. The challenge for governments is to ensure that this occurs, and that there remain clear regulatory pathways. This is no different for the German Government.

In many more developed countries home owners and businesses have installed ***PV*** solar systems, both to use, and to export, the electrical energy produced.

As with other renewable energy projects, issues of connection, grid integrity and stabilisation arise, but these issues are regarded as manageable. Grid operators are continuing to respond to integrity and stabilisation issues.

Most recently in Southern Germany, RWE decided to address these issues with "a plug and play" gas fired power plant solution to ensure that integrity and stability is maintained: the "plug and play" modules are able to be plugged-in relatively quickly, and once plugged-in they have a five-minute start. This is a smart response by RWE, both in terms of current intermittent dispatch sources, but also going forward.

Also some business and government entities are entering into "corporate power purchase agreements" under which renewable energy is sold to them. In many ways this is an industry of itself. In some jurisdictions, the market for corporate power purchase agreements is growing, year on year, with businesses and governments contracting to purchase renewable electrical energy. In some jurisdictions, it has changed the market (for example, in Australia during 2020 corporate power purchase agreements have been signed for more than 1 GW of renewable energy).

See: *Germany hits 2 million system installations* and *RWE's 300-MW 'Grid Stability' Gas Plant Will Debut GE LM2500XPRESS Technology*

Reverse auctions work for decommissioning fossil fuel as well as for renewable energy builds

Germany has just completed the first reverse auction decommissioning of 4.8 GW of coal fired electrical energy generating capacity. Under the reverse auction decommission process, successful bidders (bidding the lowest cost to cease generating electrical energy and to decommission) will cease to dispatch electrical energy into the electricity market.

The reverse auction decommissioning model provides a means to grandparent fossil fuel generation capacity in a controlled way that provides both generators and electricity markets with clarity.

See: *Germany's first coal plant phase-out auction a success, with 4 8gw to close*

Difficult to decarbonise, made easy in Duisburg

Difficult to decarbonise industries include cement, chemical, petrochemicals and refining, glass, and iron and steel-manufacture because of the need for high heat temperature as part of the production process, with the heat derived from the combustion of feedstock sourced from carbon, whether fossil fuels or other carbon fuels (including refuse derived fuels, including paper and wood in the case of cement manufacture).

In Duisburg, Germany, it is proposed to use Green Hydrogen to manufacture Green Steel. The proposal is at feasibility study stage at the moment, with an electrolysis plant, with capacity of up to 500 MW, to produce Green Hydrogen and oxygen for use at the thyssenkrupp steel mill. The feasibility study is being undertaken by STEAG (an energy company based in Essen) and thyssenkrupp (technology and iron and steel).

For a technology provider and steel producer like thyssenkrupp there is an ability to create supply and demand, and as such not to wait on the development of a hydrogen supply market.

See: *Green Hydrogen made for Green Steel is Duisburg*

Lower Cost Decarbonisation

In a recent report, McKinsey has suggest that the ***EU*** can move towards net zero emissions, at net zero cost. The overarching theme is that there are many roadmaps, and decarbonisation pathways, but not "all are cost optimal".

See: *How the European Union could achieve net-zero emissions at net-zero cost*

[**Note:** see Edition 2 of Low Carbon Pulse for like report for Germany.]

Vietnam – Intertidal / Nearshore Project and On-shore Projects to be Fitted In

On December 3, 2020, the Ministry of Industry and Trade in Vietnam outlined an extension of the feed-in-tariff (***FiT***) scheme, and the amount of the proposed ***FiT***. While the level at which the ***FiT*** is proposed has been the subject grumbling, the proposed ***FiT*** provides a clear line of sight to market.

See: Vietnam: *New Wind Power FIT Proposed, GWEC Warns of Negative Effects*

Zero Hero – Spain

Edition 4 of Low Carbon Pulse, launched a new feature profiling countries that have already achieved or are well-placed to achieve zero emission outcomes, and to contribute to the ability of other countries in achieving the same outcome.

Spain has world class renewable energy resources ("plentiful sunshine and windy hillsides"). Spain has limited oil and natural gas reserves, and a declining coal industry. Power generation in Spain consistently sources over 40% (and not infrequently 50%) of its electrical energy from renewable sources. The Spanish grid operator, Red Electrica de Espana (***REE***), indicates that nuclear sources provide electrical energy for about 21% to 22% Spain's load, with wind, hydro and solar providing between 35% to 54%, with the balance, of up to 30%, provided by gas fired capacity and coal (up to 2.5%).

In November 2020, Iberdrola announced plans to invest €75 billion (USD 89 billion). As is the case with Enel (outlined above), the investment is for both the development of renewable energy capacity and grid augmentation and development to allow the connection of intermittent capacity while maintaining system integrity and stability.

For Spain, climate change is a serious challenge, with rainfall annually on average being 25% less than 50 years ago. The plains in central Spain (famously where rains fall) and in the south east risk becoming semi-arid. In 2018, Spain announced plans to transition from fossil fuels, and source 75% of its electrical energy from renewable sources by 2030, and 100% by 2050. For these purposes, Spain is committed to installing 3 GW of renewable energy each year, for 10 years. For these purposes, Spain has overhauled its auction mechanism. An auction is currently underway.

On October 6, 2020, the Spanish Government announced its ***Hydrogen Roadmap: a Commitment to Renewable Hydrogen*** (***CRH***). The headlines of the ***CRH*** were covered in Edition 1 of Low Carbon Pulse.

On November 12, 2020, Spain announced its plan to be carbon neutral by 2050. Through 2024 Spain is committed to spending €27 billion on renewable energy, and related infrastructure. This is a small part of the cost of policy settings now contemplated, with €750 billion contemplated as the cost of the transition to carbon neutrality and a 90% reduction in the level of 1990 ***GHG*** emissions. It is anticipated that, with the policy settings announced in November 2020, renewable energy will supply over 95% of electrical energy demand.

Postscript to Edition 4 Zero-Hero Chile

On November 24, 2020, Chile announced that in May 2021 it would launch an auction for 2.3 TWh of renewable energy and storage, with the bidding rules to be published in December 2020.

See: *PV Magazine: Chile to launch auction for 2.31 TWh of renewables + storage in May*

PROGRESS TOWARDS NET-ZERO EMISSIONS
JANUARY 13, 2021

Low Carbon Pulse - Edition 6

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to Edition 6 of the Low Carbon Pulse – sharing significant news in the progress towards net-zero emissions. This edition covers the period December 14, 2020 to January 12, 2021.

The momentum described in the first five editions of Low Carbon Pulse has continued, and appears likely to continue during 2021.

On January 20, 2021, we will publish Edition 7 of Low Carbon Pulse focussing on the implications for the US and the world of the anticipated re-accession of the US to the Paris Agreement, and other changes arising from the new US administration. On January 26, 2021 we will publish Edition 8 of Low Carbon Pulse.

From the Global Ashurst Towards Zero Emissions team, Happy (Belated) Calendar New Year.

Japan targets 10 by 30 and 45 by 40

Edition 1 of Low Carbon Pulse reported on UK plans to develop 40 GW of off-shore wind by 2030, describing this as ***40 by 30***. We have continued to use this short-hand in editions of Low Carbon Pulse.

On December 17, 2020, it was reported that Japan is targeting the development of 45 GW of off-shore wind capacity (fixed-bottom and floating) by 2040, and ***10 GW by 2030***. If this report proves to be correct, taken with other news, Japan will be achieving close to 27% of its electrical load being sourced from renewable energy by 2030. This is consistent with the announcement in late October (see Edition 2 of Low Carbon Pulse) of net zero emissions by 2050.

See: *Clean Energy News and Analysis – Japan Sees Off-shore wind as energy of the future, targets 45 GW by 2040*

PRC leading the race to decarbonise

On January 01, 2021, Nikkei Asia published an article that makes a persuasive case for the People's Republic of China (***PRC***) leading the race to decarbonise. One of the more startling figures in the article is that the ***PRC***, the US, the ***EU*** and Japan together will need to invest up to USD82 trillion to achieve carbon neutrality by 2050. This is the highest investment figure that we have seen reported.

At the ***Climate Ambition Summit*** that took place virtually on December 12, 2020, the ***PRC*** President, Mr Xi Jinping made pledges, which if implemented, will ensure that peak ***PRC GHG*** emissions occur by 2030. The scale of the projects that are being announced, and the speed of the development of projects in the ***PRC***, reflects a current and real commitment to renewable energy at the centre of decarbonisation.

While not core, it should be noted that the ***PRC***'s carbon trading system is scheduled to commence on February 1, 2021, and once implemented fully will apply to a little over 1/3 of the ***GHG*** emissions arising in the ***PRC***, providing further impetus to decarbonisation. Consistent with a more controlled economy, provincial governments will impose caps on ***GHG*** emissions. As with other emissions trading schemes around the world, businesses on which caps are imposed may buy the right to emit ***GHG*** from other businesses. To many, this is an exciting development. Given the size of the ***PRC*** economy, it is to be expected that the ***PRC ETS*** will overtake the ***EU*** emissions trading scheme as the world's largest emissions trading scheme. It would not be a surprise to seek the scope of the ***PRC ETS*** extended in the near to medium term.

See: *NikkeiAsai – Climate Change – China out in front in global race to eliminate CO2 emissions*

Insurers ceasing fossil fuel insurance

In a number of countries insurers are indicating to long standing customers in the fossil fuel industry that they are going to cease to write insurance for them. As a firm, Ashurst has seen this dynamic in the coal industry, both thermal and metallurgical coal, emerging for some time.

On December 17, 2020, Lloyds of London announced that it would cease to write insurance for new coal, oil sands and arctic energy projects by 2022, and cease to insure businesses undertaking activities in these areas, and seemingly other fossil fuel businesses, completely by 2030. Lloyds Chair, Mr Bruce Carnegie-Brown has been reported as saying: "*We want to align with the UN sustainability development goals and the principles in the Paris [Agreement].*"

This is one instance in which the headlines in newsfeeds and news sources are lagging behind the practical every day challenges facing fossil fuel industry participants: a number of coal miners have been told that 2021 is that last year in which insurers will write insurance for them. Many participants in the industry are looking to captive and to self-insurance options as part of their business models. While international oil companies (***IOC***s) and national oil companies (***NOC***s) are familiar with these concepts, for many in the coal mining industry this is a road less travelled.

See: *The Guardian – Lloyds Market to quit fossil fuel insurance by 2030*

Green Hydrogen Corridors and Hubs

A number of energy agencies and energy industry participants are anticipating the development of Green Hydrogen corridors (***GH2Cs***). The designation of ***GH2Cs*** reflects that a number of areas of the world are being defined as prospective for the development of Green Hydrogen and Green Ammonia production based on the quality of their renewable resources, including the ***PRC***, Australia, the Near and Middle East and North Africa, as well as Brazil, Chile, India, Mexico, and Southern Europe (principally Portugal and Spain for the time being) and the Southern US (the sunbelt States).

It is clear that Algiers, Morocco, Saudi Arabia, Abu Dhabi, Australia, and Chile, given existing connections and renewable resources, are likely to be key export countries. The ***PRC***, India, Mexico and the US are blessed with renewable resources, and large home markets that will allow them the scale-up to develop their own Green Hydrogen corridors within their own boundaries, and the ability to scale-up production for export to take advantage of that scale.

See: *Oil Price.com – The World's First Major Hydrogen Hubs Are in the Making*

Global Road Map for net-zero emissions by 2050

On January 11, 2021, the International Energy Agency (***IEA***) released a press statement indicating that during 2021 it will produce the first global comprehensive roadmap for the energy sector to reach net-zero emissions by ***GHG*** – ***The World's Roadmap to Net Zero by 2050***.

The ***IEA*** continues to provide key data and information for all participants in the energy sector, and more broadly. The ***World's Roadmap to Net Zero by 2050*** is intended to provide all participants (including governments and the private sector) with a description of what is required to achieve the ***Stretch Goal*** under the Paris Agreement (to limit the increase in global temperature to ***1.5°C*** above pre-industrial levels).

It is anticipated that ***The World's Roadmap to Net Zero by 2050*** will be released on May 18, 2021. The Global Ashurst Towards Zero Emissions team will cover its subject matter publication soon after its release. [**Note:** see Edition 18 of Low Carbon Pulse]

See: *IEA - World Energy Outlook 2020*

South Australia – a place with abundant sun and wind

During December 27, 2020, in the state of South Australia, 99.6% of the electrical energy supply across the grid was sourced from renewable energy: the mix of electrical energy was wind, photovoltaic solar (roof-top and utility scale) and batteries, with limited electrical energy sourced from gas-powered facilities. Approximately 1/3 of South Australian homes have roof-top photovoltaic solar, with combined photovoltaic solar name plate capacity of 1.42 GW.

Throughout 2020 in South Australia, as an average, electrical energy sourced from renewable resources contributed 59.6% of electrical energy supply: 42.9% wind and 16.7% photovoltaic solar. If the rate of progress towards the use of renewable energy continues at a rate consistent with current trends in South Australia, it is estimated that the average of electrical energy supply will increase to 63.5% in 2021, and to 100% by 2030.

As noted in Edition 3 of Low Carbon Pulse, South Australia is planning to develop renewable resources to allow it to become a world scale producer and exporter of hydrogen. This is based on the natural dynamic of solar and wind arising applying a capacity factor of 10% to 25%. South Australia intends to develop a renewable energy system sufficient to supply electrical energy to match 100% of electrical load, and to provide sufficient additional electrical energy to enable the production of Green Hydrogen, requiring between three and six times the current nameplate capacity of renewable energy sources in South Australia.

Building on this, on December 16, 2020, the Government of South Australia predicted that by 2050 it could have more than 500% of current local grid demand being produced as renewable energy. The ***South Australian Government Climate Action Plan 2021 – 2025*** states:

If Australia is to become the global superpower for the production of green energy carriers (Green Hydrogen and green ammonia) it is likely that it will have to develop 600 to 700 % renewables. One thing is clear, Australia has world class renewable energy sources, and as such is not only able to achieve these levels, but also much greater levels.

See: *Photovoltaic, AEMO South Australian Electricity Report for 2020* and *Clean Energy News and Analysis – South Australia sets sights on stunning new target of 500 pct renewables*

UK – a place in the wind

On December 26, 2020, in the UK electrical energy generated from wind farms provided over half the electrical load across the grid: being 50.7% of all electricity generated in the UK on that day. About 60% of the wind power was onshore, 40% offshore. In total, nearly 75% of all electrical energy generated on December 26, 2020, was from clean sources. As a result, applying ***GHG*** accounting, each KW/h of electrical energy emitted a little less than 80 grams of ***GHG***, a record low for the UK.

The UK is well on the road to decarbonisation of electrical energy generation, it is the difficult to decarbonise sectors where progress is probably best focused from a policy setting perspective in the near to medium term. In this context, transportation is the UK's largest source of ***GHG*** emissions. The challenge for the UK is the transition to ***BEVs*** and ***FCEVs*** powered and propelled transportation, public and private, while continuing to develop its rail and road networks.

See: *Gizomodo – Climate Change – Great Britain Set a Wind Energy Milestone*

Reports and forecasts summarised – it's good news, but we need to accelerate rates of reduction

The Stabilisation Goal under the Paris Agreement

In Edition 5 of Low Carbon Pulse it was noted that a report had concluded that if countries implemented their commitments to reduce ***GHG*** emissions (including to achieve net zero emissions), the achievement of the ***Stabilisation Goal*** under the Paris Agreement (ie to limit the increase in global temperature to **2.0°C** above pre-industrial levels) is within reach, with a **2.1°C** rise in global temperatures compared to pre-industrial levels.

In a report published in the journal ***Nature Climate Change*** on January 4, 2020, it is stated that the level of ***GHG*** emissions currently at large in the atmosphere will result in a **2.3°C** rise in global temperatures compared to pre-industrial levels: effectively meaning that this projected increase in temperature is "baked-in" (***Baked-in Temperature Increase***). This is only part of the story.

Analysis from the Breakthrough Institute has explained that a reduction in ***GHG*** emissions will result in the Earth's natural systems being able to absorb ***CO_2***. This has been likened to a sink with water with the drain to the sink partially open – the water level will still rise due to the incoming water, but if the flow is reduced the water level will drop due to the drain remaining open (***Anticipated Reaction***).

Zeke Hausfather of the Breakthrough Institute has noted that: "*The main takeaway .. is that this is good news, because it means that how much warming happens this century and beyond is up to us.*"

The two reports and the perspective of the Breakthrough Institute are reconcilable, and such a reconciliation results in good news: if the commitments to reduced emissions are realised then the rate of increase in global temperatures will be slowed due to the ***Anticipated Reaction***, and the occurrence of the ***Baked-in Temperature Increase*** will be slowed.

The ***Nature Climate Change*** report emphasises a point that is known, but often not focussed upon – the criticality of the rate of climate change: "*It is .. the rate of warming that makes climate change so terrible. If we got a few degrees over 100,000 years, that would not be a big deal. We can deal with that. But a few degrees over 100 years is really bad*". (Andrew Dressler, a co-author of the report.)

The quicker the rate of climate change, the greater the concern.

This is why there is increased emphasis by some countries on increasing the rate of reduction of ***GHG*** emissions in the near to medium term, so as to slow the rate of change. The quicker the rate of reduction, the slower the rate of climate change.

See: *The Guardian, January 7, 2021, Global heating could stabilise if net zero emissions achieved, scientists say*

… But 50% increase in CO_2

The United Kingdom Meteorological Office has forecast that during first half of 2021 ***CO_2*** levels in the atmosphere will reach a 50% increase compared to pre-industrial levels. Consistent with what is stated in the preceding piece, the issue that is of concern is the rate of increase: it took 200 years or so for ***CO_2*** levels to increase by 25%, and it has taken 30 years to increase a further 25% to 50%.

This brings into sharp focus that the rate of reduction in ***GHG*** emissions needs to be accelerated. It is to be hoped that during 2021 (the year of ***COP-26***) more countries will follow the lead of the ***EU*** and the UK to increase the rate of reduction by 2030, and to continue to press accelerate to net zero as soon as practicable. It is fair to say, that increasing the rate of reduction in the near to medium term will put the world in a better place to achieve the ***Stabilisation Goal*** than focussing on net zero emissions by 2050.

See: *The Times, January 8, 2021 – Grim Milestone as CO_2 levels hit 50% more than the pre-industrial age*

Abu Dhabi National Energy Company (TAQA) achieves financial close on Al Dhafra

December was a busy month of the financial close on world scale renewable energy projects. First, Dogger Bank - the world's largest off-shore wind project (see Edition 5 of Low Carbon Pulse) – was banked. Second, and in some ways a first, on December 23, 2020, it was reported that ***TAQA*** and its partners (Masdar, EDF Renewables and Jinko Power) achieved financial close on the 2GW Al Dhafra Solar PV Project, located 35 km from Abu Dhabi City.

The Al Dhafra Solar PV project is both world scale and world defining: 2 GW of capacity with a world record-low tariff bid of US$ 0.0135 kW/h, which was lowered further to US$ 0.0132 KW/h or 1.35 cents a KWh through the project financing (and associated hedging). To our knowledge, in real terms, the Al Dhafra Solar PV Project provides for the supply of electrical energy at the lowest cost in history.

As noted in the first in the series of the Shift to Hydrogen (S2H2): Elemental Change articles, in real terms electrical energy is now being supplied at historically low costs.

See: *Renew Economy – World's largest solar plant – 2 GW – secures project financing*

Indian record low tariff

During the final quarter of 2020, a number of renewable energy auctions took place. On December 22, 2020, it was reported that the tendered price for 500 MW of electrical energy in Gujarat (as usual run as a reverse auction, i.e. lowest price winning) had resulted in India Rupee 1.99 kWh (or US$ 0.0269 or 2.69 cents a KWh).

See: *PV Magazine – India – Indian PV auction delivers final record low price of $0.0269/KW/h*

Germany – roof-top solar investments to continue

In Edition 5 of Low Carbon Pulse, it was noted that Germany had achieved 2 million roof-top solar installations. On December 16, 2020, the German Solar Association (***BSW***) stated that the increase in roof-top solar was not limited for photo-voltaic.

As is the case in most jurisdictions, the sustained growth in roof-top solar is dependent on policy settings. ***BSW*** considers that: "By *shifting a few energy policy levers, the installation pace be doubled [or even tripled] in a timely manner and the dependence on subsidies reduced*".

What this could mean in practice, is that year on year roof-top solar may increase to between 10 GW and 15 GW of installed capacity each year, compared to 4.8 GW in 2020.

With solar will come increased use of battery storage, and therefore increased flexibility.

The scope for roof-top solar in Germany is significant in the context of the electrical energy supply for the country, with the increased use of roof-top solar reducing the need for utility scale solar or wind for the purposes of electrical energy, and allowing faster progress towards energy transition.

See: *PV Magazine – Germany's solar boom set to continue in 2021*

Power-to-X: what? where? And how much?

Over the last quarter of 2020, the concept of ***Power-to-X*** became part of the lexicon of energy transition, in particular in the context of renewable energy and energy carriers produced using renewable energy, including synthetic gases and liquid non-biofuels.

Conceptually the model of ***Power-to-X*** tests what is required for the world to be powered entirely by renewable sources and energy carriers produced using sources by 2050. For these purposes, ***Power-to-X*** assumes that future fuels / green fuels or powerfuels will establish themselves to supply different markets, and be capable of use in different markets, including ammonia, hydrogen, methane and methanol, each being an energy carrier in liquid form.

Power-to-X does not involve the use of fossil fuels, but does contemplate the use of renewable carbon sourced feedstocks that on net basis do not give rise to the emission of ***GHG***. The concept contemplates the use of ***CO_2*** as a feedstock to create powerfuels.

Among other things, the concept and model assumes that a global market for, and global trade in, powerfuels will develop, allowing imports from Africa, the Near and Middle East and South America into Europe, and Australia and South America into Asia, in particular into North Asia.

If the market for, and trade in, powerfuels were to develop, in the context of imports from Africa, the Near and Middle East, and South America, its estimated value is €2.1 trillion a year by 2050, with up to €10 trillion of renewable energy sources and powerfuel production facilities required by 2050. The market and investment for Asia may be regarded as up to three times this size.

Power-to-X describes a concept by which future fuels or green fuels will provide up to 30% of global energy needs, and sub-concepts (power-to-mobility (***P-t-M***) and power-to-heat (***P-t-H***)). The concept is best described in the Finnish National Hydrogen Roadmap: ***Power-to-X*** (***P2X***) refers to a number of electricity conversion, energy storage, and reconversion pathways that utilise electric power and allow the decoupling of power from the electricity sector for use in other sectors (such as transport and chemicals)".

The role of ***Power-to-X*** is outlined in a joint study undertaken by Finland's Lappeenranta University of Technology (***LUT***) and the German Energy Agency (***DENA***), commissioned by the ***Global Alliance Powerfuels***.

See: *PV magazine - Power-to-X may cover 28% of global energy demand by 2050*

Pumped storage – a global opportunity

Pumped storage has long been regarded as a viable means of storing energy - to some, pumped storage provides ideal "battery storage": pumped storage generates electrical energy from the latent energy stored in water, typically generated during times of higher or peak load, and pumping the water back into storage at times of lower load. In a number of jurisdictions, pumped storage has been viewed, and in an increasing number of jurisdictions is viewed, as a means of providing system integrity and stability.

The challenge with pumped storage in some instances has been that while the generation of electrical energy from stored energy in water is renewable energy (***green power***) on production, the electrical energy used to pump the water back into storage has not been green, rather black power has been used for this purpose. The implication of this varies by jurisdiction: at best black power does not achieve the required or hoped for ***GHG*** outcome, more black power being used than ***green power*** generated, and at worst the generator using black power is required to acquit carbon certificates of some kind in respect of the black power used with a resulting unit cost impact, unless exempted from doing so, or the cost of doing so is a cost recoverable / spread across grid system charges.

Increasingly, the development of renewable energy sources and the profile of electrical energy use has meant that there are times in the day during which ***green power*** can be used to pump the water back into storage. As increased renewable energy capacity is installed, it may be expected that there will be sufficient ***green power*** to pump water back into storage, and to allow pumped storage to complement (or possibly to compete with) battery storage.

The ***Global Atlas of Closed-Loop Pumped Hydro Energy Storage*** identifies 616,818 sites globally as suitable for pumped storage facility development. If all the sites were developed there would be 23.1 million GWh of pumped storage capacity. "*The total global storage capacity is 23 million GWh, 300 times larger than the world's average electricity production of 0.07 million GWh a day*". Using around 1% of the sites identified would result in 100% of electrical energy load being satisfied by this renewable energy resource.

Consistent with the point made above, electrical energy is required to pump water back into storage, and as such this is not a 100% pumped storage, zero % other renewables discussion.

See: *PV Magazine – Sustainable pumped-hydro across 616,818 sites*

E-mobility plugged-in to play

In 2020, Plug Power Inc raised around US$ 1 billion to allow it to build out its manufacturing footprint to produce electrolysers (developed across five sites) and fuel cells to provide Green Hydrogen to fuel for 40,000 forklifts. In addition, Plug Power, Inc has a clear line of sight to provide hydrogen vehicles at airports and to power industrial robotics and stationary power at data centres.

On January 7, 2021, it was announced that Plug Power Inc. and SK Group intend to form a strategic alliance with the objective of accelerating the development of the hydrogen economy in the Republic of Korea, and in Asian markets more broadly. It is understood that SK Group will invest up to US$ 1.5 billion in Plug Power, Inc.

Plug Power, Inc. is a clear leader in fuel cell technology, Green Hydrogen production and distribution.

As noted in Editions 3 and 4 of Low Carbon Pulse, the SK Group is active in the fuel cell technology, fixed and mobile uses of fuel cell technology, including working with Bloom Energy on a number of fixed fuel cell technology projects.

See: *Plug Power - Plug Power and South Korean SK Group to Form a Strategic Partnership to Accelerate Hydrogen Economy Expansion in Asian Markets*

US has Biggest *BESS*

In December 2020, the world's largest battery energy storage system (***BESS***) commenced operation. Phase 1 of the Moss Landing Energy Storage ***BESS*** was connected to the Californian grid on December 11, 2020. The vital statistics of Phase 1 are 300 MW / 1,200 MWh. Phase 2 (to be completed in August 2021) will add a further 100 MW / 400 MWh. Ultimately, the Moss Landing Site has the potential to host 1,500 MW / 6,000 MWh of ***BESS*** capacity. The level of renewable energy rolled out during 2020 (see Edition 5 of Low Carbon Pulse) and the level of activity in ***BESS*** illustrates that the Biden Administration has a good deal to build on.

See: *Energy Storage News – At 300 MW / 1,200 MWh, the world's largest battery storage system so far is up and running*

Australian States and private sector

In the third piece on Zero Heroes (countries punching above their weight in progress towards zero emissions), we have chosen to reflect on the States and Territories and the private sector in Australia: the previous two pieces extolled the progress made by Chile and Spain (see Editions 4 and 5 of Low Carbon Pulse).

Australia is a Federation of six States and two Territories, each of which has its own Government. In addition, there is a Federal Government, which receives taxes from corporations and individuals and, among other things, has the power in respect of, and responsibility for, commerce within Australia, and overseas trade.

On December 12, 2020, 75 leaders met virtually to participate in the ***Climate Ambition Summit***: the ***Summit*** was held instead of the postponed annual Conference of the Parties. Following the ***Summit*** (organised by the UK, UN, France, Chile and Italy) having 24 countries in attendance, the ***EU*** adopted revised emissions targets. During the ***Summit***, Canada announced an increase in its carbon price to C$ 170 per tonne by 2030, Denmark announced an end to oil and gas exploration activities within its jurisdiction, and India announced "450 by 30", i.e. the development of 450 GW of renewable energy by 2030 (ten-fold the off-shore wind target of Japan, and more than ten-fold that of the UK), driven by the scale of the load in India. It has been widely reported that the Federal Government of Australia was sidelined at the ***Climate Ambition Summit***.

See: *Australia left behind as world leaders brush off Morrison's empty climate gestures*

The Federal Government of Australia has long been regarded as "dragging the chain" (in the Australian vernacular) on the percentage reduction of ***GHG*** emissions: in comparison, whereas the UK is committed to a reduction of 68% in ***GHG*** emissions compared to 1990 levels by 2030, Australia remains committed to a reduction of 26 to 28% of 2005 levels by 2030.

The States and Territories are progressing at a faster rate.

RENEWABLE ENERGY AS A PERCENTAGE OF ELECTRICAL ENERGY, CURRENT AND PROPOSED BY 2030					
State/Territory	**2019 renewable generation**	**2030 renewable energy target**	**State/Territory**	**2019 renewable generation**	**2030 renewable energy target**
Australian Capital Territory	See NSW	100%	New South Wales	17.1%	None.
Nothern Territory	N/A	50%	Queensland	14.1%	50%

RENEWABLE ENERGY AS A PERCENTAGE OF ELECTRICAL ENERGY, CURRENT AND PROPOSED BY 2030					
South Australia	52.1%	100%	Tasmania	95.6%	100%
Victoria	23.9%	50%	Western Australia	20.9%	None

The Federal Government introduced policy settings at the turn of the 21st century to encourage the development of a renewable energy industry, through the imposition of obligations on retailers and large users of electrical energy to source a percentage of their electrical energy from a renewable source. It is however the supply side and the demand side of the Australian electricity industry, and State and Territory governments, that are primarily responsible for the scale of the development of the renewable energy industry, including integrated energy companies such as AGL, EnergyAustralia and Origin Energy, and overseas developers of renewable energy capacity, and an ever increasingly dynamic corporate power purchase agreement market (see Edition 5 of the Low Carbon Pulse). In many ways, Australia has lead the way in the adoption of ***BESS***, in particular South Australia. PV Magazine reported on December 17, 2020, that Australia has a pipeline of electrical energy storage pipelines at 7 GW, with more than 900 MW of this pipeline to be delivered by 2024.

See: *PV magazine - Australia's battery energy storage pipeline at 7 GW*

The adoption of ***BESS*** in response, at least in part, to grid connection and integrity and stability issues, has placed Australia at the forefront of the use of ***BESS***. The Federal Government is seeking to respond to these issues, but ideally initiatives would have been undertaken some time ago so as to avoid the issues in the first place. There was no shortage of representations to the Federal Government from the private sector on how best to address these issues ahead of time, and since.

The paradox is that Australia has a clear pathway to higher percentage rates of reduction in ***GHG*** emissions, indeed it may be regarded as having a relatively easy pathway, some may say much easier than most other countries. Critically, Australia is blessed with world class renewable energy resources (solar and wind) across its land mass: unlike many countries, Australia is not limited by onshore capacity such that it does not need to develop off-shore wind (or solar) capacity: on-shore Australia has the capacity to provide close to half the world's required electrical energy supply and Green Hydrogen and Green Ammonia production close to the largest markets – i.e. half the renewable energy capacity to deliver on the ***Power-to-X*** model.

It is this dynamic that may be regarded as driving the development of:

- world scale renewable energy solar and wind stations in Western Australia and the Northern Territory (see Edition 2 (*Northern Australia – Asia's renewable energy and H2 hub*, including the Asian Renewable Energy Hub (up to 26 GW of solar and wind) and the Newcastle Waters 10 GW Solar Station) and 4 of Low Carbon Pulse; and
- Hydrogen Hubs along Australia's south and eastern coasts (see Edition 3 (*South Australia – Green On the Grid and making the most of it*) and 4 (Australia, among other things, detailing the development of Green Ammonia and Green Hydrogen projects being contemplated by Fortescue Metals and Origin Energy, and *Infinite green from infinite blue*) of Low Carbon Pulse; and
- the continued and projected development of ***BESS*** (see above) and pumped storage.

Fortescue Metals Group (one of the Big Three global iron ore producers) and Origin Energy (one of the Big Three integrated energy companies) are embracing Green Ammonia and Green Hydrogen, both having strong connections with North Asia, Fortescue Metals Group in particular is blazing a trail (across all parts of the hydrogen chain, and in multiple jurisdictions), with almost weekly announcements on "in principle agreements" with key customers and participants in the developing industry.

In addition, Australian companies able to use hydrogen rather than natural gas in their processes are looking to switch (for example, Orica is looking at moving to the use of hydrogen rather than natural gas as the feedstock for the production of ammonium nitrate).

The pathway to ***GHG*** emission reductions is recognised by the States and Territories of Australia, each responding at its own pace, but nevertheless responding, including the fossil fuel blessed states of New South Wales and Queensland, and Western Australia. South Australia and Tasmania are leading the way (Tasmania having achieved net zero emissions in 2018). Principally, the States and Territories are setting targets for the percentage of renewable energy used in the particular State or Territory and promoting the use of large scale ***BESS***.

GHG EMISSIONS REDUCTION TARGETS			
State/Territory	**zero net emissions by**	**State/Territory**	**zero net emissions by**
Australian Capital Territory	2045	New South Wales	2050
Northern Territory	2050	Queensland	2050
South Australia	2050	Tasmania	2050
Victoria	2050	Western Australia	2050

There is an argument for the status quo, with the Federal Government grandparenting fossil fuel industries and industries dependent on lower cost electrical energy, and the States and Territories and the private sector looking to achieve their own emissions reduction targets, and looking to develop export markets. For example, Fortescue Metal is making progress on a number of fronts, including in December by signing a Memorandum of Understanding with Japanese pace-setters Kawasaki Heavy Industries (leaders in the means of transportation) and Iwatani Corporation (leaders in the means of distribution to the point of use), and in early January signing an MOU with South Korean steel maker POSCO.

Of course, the *pathway* could be the *new super-highway* were the Federal Government to provide policy settings to accelerate the development of renewable energy, including embracing the transition of key global coal and LNG exporter to key Green Hydrogen and Green Ammonia exporter by 2040. There is a sustainable argument for the Federal government to take this role.

While successive Federal Governments in Australia may be regarded as having "dragged the chain", there is an opportunity to embrace change to encourage the private sector to respond. At the moment, the private sector is responding ahead of policy settings: most recently Origin Energy has announced an intention to locate a 700 MW ***BESS*** at its Eraring Coal Fire Power Station anticipating the closure of the Power Station in 2030. There are many tools available to the Federal Government to accelerate progress, for example, the use of a reverse auction process to allow coal fired power stations to cease to dispatch, and to promote the renewal of the electricity sector, and in so doing provide the benefit of lower cost electricity and the export of hydrogen (and ammonia).

Low Carbon Pulse - Edition 7

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to Edition 7 of Low Carbon Pulse. This edition is published within the two week cycle between the Editions 6 and 8 of Low Carbon Pulse to mark the likely change of course of the US as a result of the change in administration.

In this Edition 7 we focus on the implications for the US and the world of the anticipated re-accession of the US to the Paris Agreement, and other changes that have been flagged by the new US Administration, and possible policy settings that may be considered.

This Edition 7 of Low Carbon Pulse is shorter than the earlier editions. This is because while we are keen to set the scene, we are acutely aware that the policy settings for progress towards net-zero emissions will be rolled out over time. As policy settings are rolled out, we will report on them in Low Carbon Pulse.

Background

As outlined in the first five editions of Low Carbon Pulse, Q4 of 2020 saw considerable recognition of the need to commit, and to introduce policy settings, to ensure that by the middle of this century net-zero ***GHG*** emissions are achieved, and the rate of reduction by 2030 and 2040. The Peoples Republic of China (***PRC***), Japan and the Republic of Korea committed to net-zero ***GHG*** emission outcomes by 2060, 2050 and 2050 respectively. In December 2020, the ***EU*** and the UK committed to accelerate materially the reduction in ***GHG*** emissions by 2030, with clear policy settings providing a pathway to achieving those accelerated reductions, and consistently renewable projects were completed and net-zero carbon initiatives were announced.

In contrast to the deepening of commitments in the week of the US elections, now former, President Trump delivered on a commitment to remove the US from the Paris Agreement. This commitment had been flagged by the Trump administration as part of its desire to support the fossil fuel industry in the US. At the same time as the policy on the Paris Agreement was moving in one direction, the significant percentage of major US corporations (including utilities) were heading in the other direction, including by committing to net-zero emissions by 2050 with a number committed to negative carbon emissions, some going back to the date of their incorporation (for example, Microsoft). Even with this non-alignment, it is fair to say that the US has made considerable progress towards net-zero emissions.

Fulfilling great potential

In a similar vein, while the Trump administration supported the fossil fuel industry, US businesses continued to develop renewable energy, with considerable success. As a result of the continued success of the renewable energy industry it is anticipated that nearly 85% of new US electrical energy capacity developed in 2021 will be carbon free. Renewable energy from solar will lead the way, with a new record of 15.4 GW of new utility scale photovoltaic solar capacity anticipated to be added to the grid during 2021. In relative terms, the US has great potential in roof-top solar. As such, there is a good deal about which to be positive – the potential exists, the only issue is the speed of realisation. Until this potential is realised, coal and nuclear power will continue to provide the majority of US electrical energy, at 30% and 56% respectively. This said, the falling cost of solar and wind energy is starting to provide its own momentum for change: the only way the cost of renewable energy is going is down, and the only place for coal and nuclear costs to go are up.

In addition to the cautious optimism arising during Q4 (outlined in Edition 5 of Low Carbon Pulse), the re-entry of the US into the Paris Agreement and the appointment of Mr John Kerry as Climate Envoy provides a basis for real optimism globally, in particular as the US returns to global climate leadership shown under the Obama Administration.

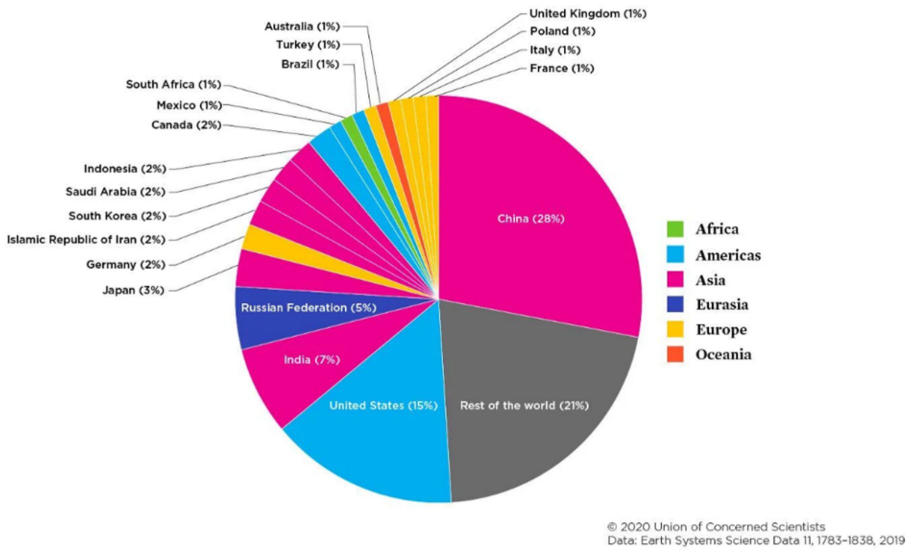
Helen Mountford of the World Resources Institute describes optimistically the outlook of the Biden Administration: *"Science will once again guide America's policymaking and inauguration day will mark a new era for climate ambition in the US. [President Biden] will have a lot on his plate, there's no doubt that [President] Biden intends to make a full court press on climate change".*

The important thing is that the Biden Administration appears to recognise that re-instating the Obama Administration policy settings will not be sufficient, policy settings need to be bolder. Mr. Brian Dees, President Biden's nominee of director of the National Economic Council has noted: *"It's not sufficient [to pick up where we left off] for where the science says we need to be and it's not sufficient because we've lost critical time over the last [few] years".*

During 2020 it was reported that the ***GHG*** emissions arising from the US fell by 10.7%. As explained in Edition 5 of Low Carbon Pulse, this fall will not reverse the increase in ***GHG*** in the atmosphere, but will slow slightly the rate of increase. The industries in which the falls were the greatest were transport (in particular air transport) and electrical energy generation. The fall in ***GHG*** in 2020 is greater than the fall in 2009 in the aftermath of the Global Financial Crisis.

See: *Almost All New US Power Plants Built in 2021 Will Be Carbon-Free*; *Solar to be No. 1 in US for new 2021 electricity generating capacity* and *US emissions plummet to lowest levels in post-World War II era*

Best estimate of current *GHG* emissions by country



As will be apparent from the International Energy Agency (***IEA***) pie chart, it is estimated that the US gives rise to around 15% of ***CO_2 GHG*** emissions annually, with the ***PRC***, contributing together, over 40% of global ***GHG*** emissions. Given the size and nature of the US economy, it is critical to have the US re-enter the Paris Agreement to allow the achievement of the Paris Agreement goals.

The US is the only country that is a top five country both in terms of ***GHG*** emissions (second) and ***GHG*** emissions per capita (fourth): while the ***PRC*** and India are top five (first and third respectively) in terms of ***GHG*** emissions, they are outside the top ten on a per capita basis (thirteenth and twenty first respectively).

Irrespective of one's views on the relevance of facts and statistics, for net-zero ***GHG*** emissions to be achieved globally, the onus must rest on developed countries to do more than reduce their proportionate share of ***GHG*** emissions reductions so as to achieve net-zero emissions by 2050. More developed countries will need to accelerate the rate of reduction of ***GHG*** emissions arising from their economies. The ***EU*** and the UK have recognised this responsibility consistently, and each has doubled-down on this recognition in December 2020. In due course, the next step is to take the lead of major corporations such as Microsoft and move to introduce negative emission policy settings.

Biden Administration's head-line grabbing plans

Headlines

At the core of the Biden Administration's ambitions is the achievement net-zero emissions by 2050. This will require policy settings in place that will achieve net-zero emissions by 2050, and more importantly to achieve milestones every five years between now and then. Within this overall target is a proposed decarbonisation of the electrical energy industry by 2035. The achievability and cost of this needs to be stress-tested. What is clear is the US has the capacity to achieve this outcome, the challenge is doing so in a way that balances economic, environmental and social implications of doing so (***Balanced Equation***).

USD 2 trillion funding is contemplated for these purposes under the Biden Administration. We anticipate that this will be insufficient recognising the need for grid development. [**Note:** see Editions 23 and 24 of Low Carbon Pulse]

It was reported on January 20, 2021, (Washington DC time) that one of the three executive orders signed on the afternoon of President Biden's inauguration, included one to effect the re-accession of the US to the Paris

Agreement. It is expected that over the coming weeks, President Biden will sign executive orders in respect of environmental requirements and standards. The heavy lifting on policy settings, to implement the Paris Agreement, and to accelerate reductions in ***GHG***, will require legislation.

Possible headlines

For some commentators, the US needs an Operation Warp Speed on Climate Change. Among the suggestions made are that the Federal Government should become the off-taker of electrical energy from renewable energy sources thereby providing an immediate boost to the market for the development of renewable energy. This would be radical in a US context, and to our knowledge is not part of the day one plans of the Biden Administration. Nevertheless this suggestion is worth consideration at least to allow the industry to achieve greater scale and in doing so reduce unit costs.

While the preference of all governments is to have the private market pull itself up by its bootstraps, the issue here is more about providing the initial impetus to allow the private sector to bootstrap, rather than the Federal Government continuing to have a role in the electrical energy market.

Similar arguments arise in respect of carbon capture, utilisation and storage (**CCUS**), although in the US (and in other countries) there is an argument for government stepping in to develop CCUS facility, and monetise the investment through use or sale. In many ways, the economic argument is stronger for CCUS than for renewable energy.

The issue is how and what, and as importantly, how quickly

Electrical energy cost control

The "how" and "what" will develop over time, but it is more likely than not that whatever is done, the costs to the customer must be kept at levels comparable to current levels. Critical to this is the cost of electrical energy, and the need to keep the cost of electrical energy at or below 6% of US GDP in relative terms, and at or about the same cost level for businesses and households. These are the economic and social elements of the ***Balanced Equation***.

East Coast and Sunbelt

It is apparent that along the East Coast of the US that there is an increasing acknowledgement that off-shore wind power is likely to provide a viable source of electrical energy without causing the concerns held by many folk around on-shore wind.

In addition, across the sunbelt of the southern States of the US it is clear that the private sector is already exploiting the world class renewable resources that exist, both solar and wind. Given some of the world scale projects that have been concluded in the Greater Gulf Region (see Edition 6 of Low Carbon Pulse for a summary of the up to 5GW by 2030 strategy), and replicate in the US Gulf Coast Region, including the record low cost outcomes for the dispatched electrical energy. [**Note:** The Gulf Coast and West Coast are now a key focus as well.]

The US has the solar (and wind resources) to achieve this level of renewable energy development as quickly as any country in the world, and in our view a clear pathway to achieving the lowest cost dispatched electrical energy outcomes. We refer to lowest cost dispatched electrical energy on the basis that this does not include transmission and distribution cost.

Also it is to be noted, on a Gulf to Gulf comparison, that the Mohammed bin Rashid Al Maktoum Solar Park is providing electrical energy to the Emirates Global Aluminium smelter. (While the electrical energy is off-taken for the gird, the use of electrical energy is matched to renewable energy, and tracked and traced using the International Renewable Energy Certification System.)

Fossil fuel grandparenting

In addition, each industry affected by progress to net-zero emissions may require some level of grandparenting: while overall the projections are that the renewable energy industry will give rise to more jobs overall, these jobs will not be located on a person by person basis in the areas in which industries in need of grandparenting are located. Again the economic and social elements of the ***Balanced Equation*** need to be considered.

Taking the electrical energy industry as the focal point, achieving net zero emissions by 2050 will require considerable additional investment by 2030 by increasing wind and solar capacity to between 600 GW and 1,000 GW (on the basis of anticipated electrical energy usage in 2050), increasing the capacity of the grid by between 60% and 80%, having 50 million ***BEVs*** and up to to 3 million re-charging stations, and doubling (for household heating) and tripling (for business and commercial heating) the use of heat pumps. The increase in the capacity of the grid is a key part of the equation, and it needs to be stress tested early to ensure that the grid developments and enhancements are undertaken ahead of the connection for new renewable energy.

Regulation of otherwise booming industries

From the late noughties to 2014 / 2015, the US led the world in shale development. One of the issues with extraction of hydrocarbons from shale and traditional sources of oil and gas is fugitive methane (***CH_4***) emissions on extraction, transportation and on processing to produce hydrocarbon products. The Biden Administration is flagged the new regulation of ***CH_4*** emissions.

The ***IEA*** has released *A Regulatory Roadmap and Toolkit – Driving Down Methane Leaks form the Oil and Gas Industry*.

Hydrogen

Back in the late 1990s, and early 2000s, and in George W. Bush's first term, hydrogen was labelled the *freedom fuel*. David Yellen has called hydrogen the "*Swiss Army knife*" of the transition to clean energy. We embrace this analogy.

The market for Green Hydrogen is developing, and it is to be expected that it will offer the US domestic and export benefits but to a level that may be regarded as dwarfing the perceived benefits of shale. In context, BloombergNEF estimates that US$ 11 trillion will need to be invested in production and storage globally by 2050 to ensure that

Green Hydrogen can meet 25% of the project global energy needs by 2050 – being the level of demand that is not easily met by electrical energy, including the difficult to decarbonise industries.

To achieve this around 25,000 GW of new renewable energy will be required. This is in addition to the near doubling of electrical energy capacity to supply sufficient electrical energy by 2050. In short, there are three sources of demand for new renewable energy capacity, first, to displace use of fossil fuels as a source of energy, secondly, to anticipate and to match growth in demand for electrical energy attendant on population growth, and thirdly to allow the development of the Green Hydrogen and Green Ammonia industries.

As noted in the first article in *The Shift to Hydrogen (S2H2): Elemental Change* series, the US has world class renewable resources that will allow it to become a superpower in the production of hydrogen, allowing it to decarbonise difficult to decarbonise industries with the US (including the cement, chemical, and steel sectors), and to decarbonise transport.

Low Carbon Pulse - Edition 8

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to Edition 8 of Low Carbon Pulse – sharing significant news on the progress towards net-zero emissions globally. This edition covers the period from January 12 to January 26, 2021, returning to the two week cycle after Edition 7 was published within the cycle to mark the new administration in the US.

In April, the Ashurst Global Towards Zero Emissions team will publish the second article in the *The Shift to Hydrogen (S2H2): Elemental Change* series (considering the prospective relevance to each industry). The team will publish the first article in the *Hydrogen for Industry* series (considering production of hydrogen from waste) in May or June.

Results are in … and the leaders are …

PRC – Most installed renewable energy in 2020

During 2020, the Peoples Republic of China (***PRC***) installed a further 72 GW of wind-power (a doubling of the previous record for installed capacity in a year), and 48 GW of solar power (a little under the previous record of 53 GW). Add to this a further 13 GW of hydropower, and the ***PRC*** installed 113 GW of renewable energy capacity within calendar year 2020. While the rate of installation of new wind-power capacity can be explained by the impending sunset for / winding-down of wind power subsidies (take your pick of the puns), it is to be expected that the ***PRC*** will continue to add renewable capacity at a rate of 100 GW (or more) each calendar year.

The level of renewable capacity installed in the ***PRC*** exceeded the level anticipated by the International Energy Agency (***IEA***) (reported in Edition 4 of Low Carbon Pulse) on November 9, 2020. The anticipated Q4 surge in installation was a strong surge.

US – Greatest fall in *GHG* emissions in 2020

In 2020, it is estimated that ***CO_2*** emissions arising globally fell by 2.3 billion tonnes, or 6.4% of total global emissions, compared to 2019: this is around twice the ***GHG*** emissions arising annually from activities in Japan. The US had the greatest fall in percentage terms.

Globally, the greatest fall was in the aviation sector, with an estimated 48% fall in emissions from 2019 levels. The combined source modelling of the team at Tsinghua University in Beijing considers that the fall is less than might have been expected - Zhu Liu of the Carbon Monitor program at the University is reported as having said: *"The emissions decline is .. less than .. we expected. … when the pandemic ends, we … will see a very strong rebound".*

The 6.4% figure resonates with those familiar with the work of the United Nations Environment Programme (***UNEP***): the ***UNEP*** estimates that to achieve the ***Stretch Goal*** of the Paris Agreement (see Edition 4 of Low Carbon Pulse), ***GHG*** emissions would have to be reduced by 7.6% each year to 2030. In other words, to achieve the ***Stretch Goal***, collectively, policy settings globally need to more than replicate the fall in ***GHG*** emissions results from COVID-19. Also, this illustrates, and the devil is in the detail, the industries, which if decarbonised, will be able to make the greatest reduction in ***GHG*** emissions. It is to be hoped that by the time of ***COP-26*** later in 2021, the impact of COVID-19 will have been analysed for these purposes.

See: *Wind Power & Renewables Surge To New Record In China* and *COVID curbed carbon emissions in 2020 — but not by much*

World's first hydrogen receiving terminal completed ahead of schedule

On January 22, 2021, it was announced that Kawasaki Heavy Industries Ltd (***KHI***) has completed the Kobe LH2 Terminal (***Hy touch Kobe***), ahead of the March 2021 schedule. ***Hy touch Kobe*** is the world's first receiving terminal: the terminal will receive liquid hydrogen gas (***LHG***) delivered by an ***LHG*** carrier, store the ***LHG*** (at minus 253°C) and re-gasify the ***LHG*** for use.

The core technology used to receive and store ***LHG*** is not new, and was developed by ***KHI*** to store ***LHG*** as part of the Japanese space program.

As reported in Editions 2 and 4 of Low Carbon Pulse, ***KHI*** launched and commissioned the world's first ***LHG*** carrier (Suiso Frontier) in December 2019, and as with a number of Japanese corporations is leading in technology development and commercialisation.

See: *Kawasaki completes world's first liquefied hydrogen receiving terminal*

Adapting to the impact of climate change – an area for increased focus

In an insightful article in the *Japan Times*, the environmental impacts of increased ***GHG*** levels in the atmosphere are tracked. On the basis of this tracking, the article's thesis is that: "***Japan is as vulnerable to climate change as any other country in the world***". The consequences outlined in the article, including the damage to the economy and environment in real terms, emphasise the need to plan for the impact of climate change on Japan.

Bill Gates, in a LinkedIn article ahead of publication of his book on climate change (***How To Avoid Climate Disaster: The Solutions We Have and the Breakthroughs We Need***), identifies four key needs, one of which is the need to adapt to climate change in all aspects of human activities, including infrastructure development.

This focus on adapting to climate change provides the opportunity to look forward, especially for countries more, or most, vulnerable to climate change, and to analyse the prospective cost of adaptation if ***GHG*** emissions are not reduced as targeted, and in any event.

The ***United Nations Adaption Gap Report***, 2020, identifies the likely differential in costs for different nations: the thesis is that the actual costs of adaption are greater in real terms in developed countries, but will impose a proportionately greater burden on developing countries as a proportion of GDP. Also, and consistent with the *Japan Times* article, even if targets for ***GHG*** emissions are achieved, the effects of climate change can be seen, and the burden of addressing those changes is proportionately greater for developing countries, particularly in Africa and Asia.

The Global Ashurst Towards Zero Emissions team expects this to be an increased area of focus in the near term. While this is not a subject intended to be covered in Low Carbon Pulse, this area will be covered in other Ashurst publications, and in providing input on any proposed policy settings.

See: *The true cost of the climate crisis on Japan*

Renewable energy use achieves cross-over

During 2020, the countries within the European Union (***EU***) used more electrical energy derived from renewable energy (38%) than derived from fossil fuels (37%, including 13% coal) (***cross-over***). As important as this statistic is, the near, medium and long term trend of the installation of renewable electrical energy sources is consistent with achieving 2030 ***GHG*** emission reduction targets, and net-zero emissions. (see Edition 5 of Low Carbon Pulse for EU's new 2030 ***GHG*** emission reduction target.)

On January 18, 2021, the European Environment Agency (***EEA***) (reporting on 2019 numbers of 34% renewable energy and 38% fossil fuel, rather than the 2020 numbers) released a study reporting that the switch from fossil fuels achieved across the ***EU*** since 2005 has "*significantly reduced emissions*" while providing "*clear improvements*" in respect of the environment. The findings of the study are not earth shattering, rather they confirm that the deployment of renewable energy has the benefits that were predicted - earth preserving.

See: *History made: Renewable energy surpassed fossil fuels for European electricity in 2020* and *Shift to renewables 'significantly decreased' emissions*

US Off-shore wind in sails

As noted in Edition 7 of Low Carbon Pulse, off-shore wind projects on the US's East Coast are gathering momentum. The background to this is that off the East Coast of the US there are world class renewable resources (and off the Gulf Coast and West Coast for that matter), and off-shore wind farms can be located to deliver electrical energy to regions of major load along the East Coast. Also, as is the case with off-shore wind in some other parts of the world, wind speed increases during the late afternoon as the sun sets, which offers an opportunity to achieve greater efficiency in renewable energy system development.

On January 4, 2021, the Bureau of Ocean Energy Management released a draft environmental impact statement for the ***South Fork Wind Project*** (the Project sponsored by global leader Ørsted headquartered in Denmark) off Long Island. This is New York's first off-shore wind project. Final approval of the ***South Fork Wind Project*** is expected by the end of Q2 2021. For the author, South Fork no longer conjures up the skyline of Dallas and the Ewing Family Ranch.

On January 13, 2021, the Governor of New York, Mr Andrew Cuomo [now former Governor] announced the award of two off-shore wind project concessions to Equinor (another global leader, this time based in Norway). (The solicitation process for the concessions commenced in July 2020, being the largest solicitation for renewable energy in the US, at 2.5 GW.) The State of New York is to contract with Equinor Wind US LLC for the development of two off-shore wind farms, both off Long Island.

On January 20, 2021, the President of the US, Mr Joe Biden, announced that the US would re-accede to the Paris Agreement, and target a zero-emissions electrical energy grid by 2035. To achieve this target, renewable resources need to be developed, including use of off-shore wind, and the US Sunbelt. It is anticipated that the Biden Administration will make off-shore wind, and the development of renewable energy capacity across the Sunbelt, a key part of its ***GHG*** emission reduction policy settings. As is the case on all renewable electrical energy projects, the development and augmentation of the grid will be critical (see Edition 7 of Low Carbon Pulse).

See: *US Offshore Wind Is Off To The Races (At Last!) - CleanTechnica* and *Gov. Cuomo focuses on green economy during day 3 of New York State of State address*

Clock-ticking to February 19, 2021

While President Biden signed an executive order to re-accede to the Paris Agreement on January 20, 2021, the US will not actually re-accede until February 19, 2021. Re-accession of itself is not enough (see Edition 7 of Low Carbon Pulse). It is to be anticipated that policy settings will be introduced to target greater ***GHG*** emission reductions, at a faster rate than previously contemplated. The issue is, what is the target? And by when? The good thing is that a number of US States have reduction targets that are more ambitious that those of the original US commitment under the Paris Agreement, and they have continued to progress towards the achievement of those targets.

Ahead of February 19, 2021, on January 22, the American Petroleum Institute (***API***) announced that it will support Federal regulation of associated and fugitive emissions of methane (CH_4). (see Edition 7 of the Low Carbon Pulse – *Regulation of otherwise booming industries.*)

"Runnin' down a dream": Aussie and US "rock" legends combine

In Australia, a further part of the vision of Dr Andrew Forrest, AO, came into focus on January 21, 2020. Fortescue Metals Group (***FMG***), founded by Dr Forrest in 2003, and one of the Big Three Australian iron ore producers (and the world's fourth largest producer) sees the development of a Green Steel industry as the next step in its renewable energy development program. In the words of Dr Forrest, and the late, great Tom Petty, Dr Forrest is "runnin' down a dream".

FMG has the iron ore, and the use of Green Hydrogen (produced by the electrolysis of water using renewable electrical energy) would enable it to become a world leading Green Steel producer. The steel industry is recognised as a difficult to decarbonise industry, with blast furnace steel production requiring the use of metallurgical coal, the use of which results in ***GHG*** emissions: blast furnaces (but not electric arc furnaces) use coke derived from metallurgical coal. Green Hydrogen would displace the use of metallurgical coal, and as such allow steel production to progress towards net-zero emission outcomes. The development of iron ore trains by ***FMG*** to haul iron ore would be further progress towards Green Steel production.

See: *US rock legend inspiring magnate's Green Steel revolution*

Running down pathways and roads

On January 19, 2021, the ***Hydrogen Council*** issued a report entitled ***Hydrogen decarbonisation pathways***. The key take-away from the report is that there is "no one pathway" to be followed for the production of renewable hydrogen; the report considers pathways for both Green Hydrogen and Blue Hydrogen production. Critically, the report emphasises the need for pathways to production to be responsive to the circumstances. This concept appears to be established practice already: an increasing number of countries (15 in 2020) produced or supplemented hydrogen plans, road-maps and strategies, each of which was framed to a greater or lesser extent to the supply capability and demand side load of each country, often by industry and sector.

The report considers the feedstock required for renewable hydrogen production. This includes that 9 kgs of water is required to produced 1 kg of hydrogen. The report contrasts this level of water usage with the levels of water required for the generation of electrical energy and the production of energy carriers using other technologies - in short, more, considerably more, water is required using other technologies.

The report is a useful compendium of "hows", both as to feasibility and to the need for an open mind as to the need for the development of both Green and Blue Hydrogen to provide to the supply side to allow the development of the demand side for hydrogen.

Also the report continues the assessment of many commentators that Blue Hydrogen and CCUS capacity needs to be developed in the near to medium term to provide a supply side for hydrogen: conservative estimates contemplate that by 2050 500 million tonnes of hydrogen will be needed each year, and that this will be a mix of Blue and Green.

See: *Hydrogen Decarbonization Pathways - Hydrogen Council*

Decarbonisation of road freight

In a report published on January 22, 2021 (*Decarbonising Road Freight: Getting Into Gear*), Shell and Deloitte concluded that to achieve net-zero emissions by 2050, and seemingly the ***Stabilisation Goal*** under the Paris Agreement, in absolute terms, ***GHG*** emissions arising from the road transportation industry need to reduce by 60% of 2018 levels. The report states that about 9% of global CO_2 emissions arise from road freight activities (with the US, ***EU***, ***PRC*** and India together responsible for more than half CO_2 emissions arising globally from road freight transportation).

Given that road freight transportation is expected to double by 2050, the conclusion is that pathways need to be found to allow reduction in the levels of ***GHG*** emissions arising from current and future road freight. At the moment, the world's "carbon budget" includes no allowance for the doubling of road-freight, and as such a road freight transport needs to be a focus of all policy makers and corporations alike. ***BEVs*** and ***FCEVs*** are regarded as the answer by many commentators, but as the report points out, the answer is more nuanced.

At the same time as the publication of ***Decarbonising Road Freight: Getting Into Gear***, separately Shell published a report entitled ***Decarbonising Road Freight: Shell's Route ahead***, outlining its plans to decarbonise the tankers used by it to haul its products by road. The Shell report outlines the levels of ***GHG*** emissions that Shell is targeting, including a target to reduce ***GHG*** emissions by 30% compared to 2018 levels by 2030. This rate of reduction will allow Shell to reduce ***GHG*** emissions arising from road freight haulage in line with the Shell / Deloitte conclusion.

For policy makers globally, the objective should be to require road hauliers, to provide pathways, to achieve the required level of ***GHG*** emission reductions. Transportation may be regarded as a difficult to decarbonise industry, and road freight haulage the most difficult sector of the industry, including because of the need for fleet renewal, and the competitive nature of the industry. As such, some level of government policy setting may be required to encourage first movers, by ensuring that they are not disadvantaged competitively.

See: *New Shell Report on Road Freight Decarbonisation*

Any which way, its Hertz

On January 21, 2021, it was reported that the transmission system operators (***TSOs***) for Denmark (***Energinet***) and Germany (***50Hertz***) have agreed a framework to work together on the Bornholm Energy Island in the Baltic Sea. As noted in previous editions of the Low Carbon Pulse, and the first in ***The Shift to Hydrogen (S2H2): Elemental Change: Why H2? Why Now?***, timely development of transmission infrastructure (both interconnectors and system augmentation) is critical to the realisation of the benefits of off-shore wind development, including from any Energy Island. The framework for ***Energinet*** and ***Hertz50*** to work together facilitates both the development of the Energy Island and more efficient connection and system integrity and stability.

"For Europe's energy future, the seas that surround us are of central importance". [***50Hertz*** CEO, Stefan Kapferer]

See: Edition 5 of Low Carbon Pulse for *Greenlights for Green Islands* (i.e., Energy Islands).

On January 15, 2021, it was announced that the VindØ consortium, assisted by Copenhagen Infrastructure Partners (***CIP***), is to develop an Energy Island in the Danish sector of the North Sea. The consortium comprises two Danish pension funds, PensionDenmark and PFA, and Denmark's largest utility company, Andel. The Energy Island is around 100 kilometres from shore. The development of the Energy Island will be completed by 2030, and will provide 3 GW of off-shore wind capacity.

This is regarded as the first stage of development, with 10 GW of wind-capacity, associated battery electrical storage system hosted on the Energy Island, and ***Power-To-X*** (see Edition 6 of Low Carbon Pulse) contemplated on the full development of the project.

See: *German and Danish TSOs Form Bornholm Energy Island Pact*

Baltic and North Seas – hot spots, even in winter

Baltic Sea

For the most part, countries with coastlines to the Baltic and North Seas have well developed legal frameworks for the grant of concessions to allow the development of off-shore wind (and solar). On January 13, 2021, it was reported that the Parliament of Poland (the Sejm and the Senate) passed the *Offshore Act* to regulate the development of off-shore energy in the Polish sector of the Baltic Sea. It is expected that the *Offshore Act* will enter into force in February 2021.

At the moment an initial 5.9 GW of off-shore wind capacity (***first phase***) is contemplated, with the contracts for differences to be granted by the President of the Energy Regulatory Office (***URE***) to allow the projects a line of sight to revenue for the sale of electrical energy. The ***second phase***, building on the ***first phase***, is contemplated as including reverse auctions in 2025 and 2027, each for 2.5 GW of capacity, such that by 2027 Poland will have an operational or contracted 10.7 GW of off-shore wind capacity. Ultimately, up to 28 GW of off-shore capacity may be developed for connection to the grid.

North Sea

On January 15, 2021, the Crown Estate Scotland opened the process for applications for the ScotWind seabed leasing for off-shore wind projects. The application process closes on March 31, 2021. (The closing date was extended.) The process for applications was opened following the publication, by Marine Scotland, of the Sectoral Marine Plan for Offshore Wind Energy outlining areas for development, including the North Sea. [**Note:** see Edition 22 of Low Carbon Pulse]

See: Breaking: *Polish Parliament Passes Offshore Wind Act* and *ScotWind offshore wind leasing round opens for applications*

Another Australian Hydrogen Hub (H2H)

In September 2020, through an expression of interest (***EOI***) process, the Western Australian Government invited ***EOIs*** in respect of the proposed Oakajee Strategic Industrial Area (**Oakajee SIA**) Renewable Hydrogen initiative. The ***EOI*** process closed in December 2020.

On January 21, 2021, Minister for Regional Development, Agriculture and Food and Ports (among other roles), Ms Alannah MacTiernan announced that 65 ***EOIs*** had been received to produce and export renewable hydrogen. The announcement commented on the range of ***EOIs*** received, both country or origin, and participants.

The early stage assessments for the purposes of the ***EOI*** indicated that renewable resources for the ***Oakajee SIA*** could be up to 270 MW of wind, and 1,250 MW (1.25 GW) of solar, electrical energy (1.5 GW in combination). Given the level and range and type of interest, from whole of supply chain to supply chain participant, it will be interesting to follow the development of the project.

See: *Three new hydrogen hubs on South Australia's horizon*

Electrolysers from concept, to feasibility, to FEED, to development

The key technological advance necessary to allow the development of a Green Hydrogen supply industry is the commercialisation of electrolysers to achieve the required scale, efficiency and utilisation.

During the second half of January 2021, there appears to have been an increase in the news around electrolysers at various stages in the development process:

- **thyssenkrupp** has won an order to supply and to install a 88 MW Proton Exchange Membrane (***PEM***) electrolyser for Hydro Québec following completion of a feasibility study. The hydrogen production facility is to be located in Varennes, Quebec, and will use renewable power provided by Hydro Québec to power the electrolyser to produce up to 11,000 tonnes of Green Hydrogen annually. The Green Hydrogen (and oxygen) produced will be supplied to a biofuel production plant to produce biofuels from residual waste, with the biofuels to be supplied to the transport sector;

- **TotalEnergies** and Engie have entered into a co-operation agreement to design, build and operate a renewable hydrogen production facility in southern France to use electrical energy from solar farms to power a 40 MW ***PEM*** electrolyser to produce 5 tonnes of Green Hydrogen a day to meet the needs of TOTAL's La Mède bio-refinery: the development is reported to be dependent on funding support from the ***EU*** and the French Government;
- **ITM** (leading technology provider) and Linde (global industrial gases giant) have concluded a sale agreement for the supply of a 24 MW ***PEM*** electrolyser to be installed at the Leuna Chemical Complex in Germany, with Linde to build, own and operate the electrolyser plant to produce Green Hydrogen for Linde to supply to industrial customers using Linde's existing pipeline system, and for distribution (in liquified form) to hydrogen refuelling infrastructure (***HRI***) and other industrial customers; and
- **Nel Hydrogen** is to supply a 20 MW ***PEM*** electrolyser to Iberdrola to use a renewable electrical energy system (comprising a PV solar farm and a lithium-ion battery electrical storage system of 20 MWh) to produce Green Hydrogen to be supplied to Fertiberia's ammonia (NH_3) plant in Puertollano, to displace CH_4 used to produce NH_3.

As will be noted, each of these projects is shore based, and each project is delivering Green Hydrogen to established off-takers of energy carrier feedstock to support existing demand or an existing customer base, or both.

In short, the Green Hydrogen supplied by these projects is being under-written by credit-worthy off-takers, or defined markets, and as such the projects are "bankable" if they are, or were to be, project financed. These projects do not require those building, owning and operating the ***PEM*** electrolyser to take market risk on the price for the Green Hydrogen produced in a way that gives rise to unquantifiable market risk (effectively price risk as things stand). Also note that the Green Hydrogen produced is to be used in industries that may be regarded as more difficult to decarbonise.

At least in the near to medium term, it is to be expected that ***PEM*** electrolyser projects will require credit-worthy off-takers to contract under longer term contracts for the supply of Green Hydrogen, including the mega Green Hydrogen projects contemplated around the world (see Editions 1 to 6 of Low Carbon Pulse).

These are onshore projects NorthH_2: *'Ideal conditions': Canada to link huge Green Hydrogen plant to hydropower*, *Total And Engie Plan France's Largest Green Hydrogen Plant*, *ITM Power Announces Sale to Linde of World's Largest PEM Electrolyser*, *Nel to supply 20MW PEM solution to Spanish hydrogen plant.*

Solar energy makes sense

As reported in Edition 6 of Low Carbon Pulse, the Al Dhafra Solar Project achieved financial close, with a world record-low tariff bid of US$ 0.0132 KW/h. The Al Dhafra Solar Project follows the earlier 1 GW Mohammed bin Rashid Al Maktoum Solar Park, another trail blazing energy project in the United Arab Emirates (***UAE***).

On January 19, 2021, it was announced that Dubai Electricity and Water Authority (***DEWA***) has contracted with Emirates Global Aluminium (***EGA***) to supply power from the Mohammed bin Rashid Al Maktoum Solar Park for its smelter. This makes the ***UAE*** the first country in the world to produce aluminium using solar power. It was also announced that production from the ***EGA*** smelter may increase in line with the planned expansion of the Mohammed bin Rashid Al Maktoum Solar Park. The contracted power, while sourced through the grid, is being "tracked and traced" using the International Renewable Energy Certification System.

See: *Dubai solar park says it has started powering aluminium production*

PROGRESS TOWARDS NET-ZERO EMISSIONS
FEBRUARY 10, 2021

Low Carbon Pulse - Edition 9

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to Edition 9 of Low Carbon Pulse - sharing significant news on the progress towards net-zero emissions globally. This edition covers the period from January 26, 2021 to February 9, 2021.

Monday morning good news story for the Crown Estate and UK Treaury

On February 8, 2021, the successful tenderers for the six off-shore wind field 60 year leases (in the UK's Round 4 leasing program) were announced. By common consent the auction has been a great success, with leases for a little under 8 GW of new off-shore wind capacity awarded. As such, the development of the awarded lease areas will result in the UK having around 20 GW of off-shore wind capacity, and as such well on the way to 40 GW by 2030 (see Edition 1 of Low Carbon Pulse).

RWE was awarded two leases, each lease for 1.5 GW, and each being in the area of Dogger Bank. A joint venture of Green Investment Group and TotalEnergies, was awarded a lease for 1.5 GW in the nearshore area off the Humber Estuary and Lincolnshire Coast.

Three leases in the Irish Sea are said to have been of particular interest to bidders, with BP and Energie Baden-Wurttemberg AG (***EnBW***) being successful in respect of two of the leases (both in nearshore locations), each for 1.5 GW, permitting the development of 3 GW of installed capacity. Cobra Instalaciones y Servicios and Flotation Energy were successful in respect of the third lease in the Irish Sea for 0.48 GW.

Off-shore wind in the sails of South Korea:

On February 2, 2021, the Republic of Korea (***ROK***) announced a plan to develop up to 8.2 GW of off-shore wind capacity by 2030. The plan is the subject of a Memorandum of Understanding (***MOU***) between the Government of ***ROK*** and a number of major ***ROK*** corporations (***SKCs***), KEPCO, SK E&S, Hanwa Engineering and Construction, Doosan Heavy Industries & Construction, CS Wind and SamKang M&T.

Under the ***MOU***, the Government of ***ROK*** will provide funding for around one fifth the total of development cost of USD 43.2 billion, with the ***SKCs*** funding the balance. This announcement is part of ***ROK***'s Green Deal, and is consistent with the achievement of ***ROK***'s commitment to achieving net-zero emissions by 2050 (see Edition 3 of Low Carbon Pulse).

This mega-project continues the global trend to develop off-shore wind capacity, in the case of ***ROK*** to provide electrical energy to displace existing carbon intensive generating capacity, and in the case of in some parts of the world to allow the production of Green Hydrogen.

See: *South Korea unveils US$43 billion plan for world's largest offshore wind farm*

Green Lighted "Green Islands" in the Deep Blue:

Edition 5 of Low Carbon Pulse noted that the during Q1 of 2021 a final investment decision (***FID***) was expected in respect of a green (power) island in the Danish sector of the North Sea. On February 4, 2021, the Danish Energy Agency effectively made that ***FID*** announcing the choice of location for the first "green (power) island" (***Jutland Project***) approximately 80 kilometres off the coast of Jutland.

The ***Jutland Project*** is to proceed in the form of a public private partnership (***PPP***). Under the ***PPP***, the Danish State is to retain 51% majority ownership, with a framework to be developed for the ownership of the remaining 49%. The ***Jutland Project*** will be the location of sub-station, and other electrical, infrastructure that will consolidate electrical energy from wind-turbines and dispatch that electrical energy to the main-land.

Phase 1 of the ***Jutland Project*** will comprise 200 off-shore wind turbines with a combined installed capacity of 3 GW. Future phases will install up to a further 7 GW. The fully developed ***Jutland Project*** would produce sufficient electrical energy for 10 million homes across northern Europe. The estimated development cost of the fully developed ***Jutland Project*** is USD 34 billion.

As reported in Edition 8 of Low Carbon Pulse, another green (power) island is planned off-shore of Denmark - the 2 GW ***Bornholm Energy Island***, in the Baltic Sea. A framework agreement between ***Energinet*** and ***50Hertz*** providing for the connection to Danish and German grids, and the delivery of electrical energy into them has been concluded. The development of ***Bornholm Energy Island*** will give the Denmark two green (power) islands, one in the North Sea, one in the Baltic.

In combination, and assuming completion by 2030, the two green (power) islands will allow Denmark to achieve its target of reducing its ***GHG*** emissions to 70% of 1990 levels by 2030. [**Note:** see Edition 26 of Low Carbon Pulse]

See: *Denmark wants to build a renewable energy island in the north sea*

French off-shore plans:

France is to run procurement processes for up to 8.75 GW of off-shore wind capacity from 2020 to 2028 (this will increase the installed off-shore wind capacity to between 5.2 GW and 6.2 GW, and likely more): as currently planned, by 2028 France will have around 12.4 GW of off-shore wind capacity installed or in development (this includes the six existing projects approved for development and the most recently awarded 0.6 GW Dunkirk project).

The first procurement for the award of the eighth off-shore development (to install 1 GW of capacity has opened). The first phase of the procurement process involves lodging application submissions by March 12, 2021, with those selected going forward into a competitive dialogue phase, and ultimately the preferred proponent will be selected. This 1 GW off-shore wind farm is to be located around 32 kilometres off the Normandy coast.

See: *French offshore wind tender enters competitive dialogue stage*

More off-shore wind forecast … 43.7 by the end of 21:

It is forecast that during 2021 installed off-shore wind capacity will increase by 11.8 GW, having increased by 2.2 GW in 2020. If this forecast proves to be correct, by the end of 2021 globally there will be 43.7 GW of installed off-shore capacity. While newsfeeds report on the hot spots of the North and Baltic Seas, and off-shore wind development in Japan and South Korea, the People's Republic of China (***PRC***) continues to lead the way with the installation of nearly 7.5 GW of off-shore wind capacity anticipated during 2021.

See: *Rystad energy global installed offshore wind capacity to grow by 37% in 2021*

The European Union is targeting off-shore wind capacity of 60 GW by 2030 (***60 by 30***) and 300 GW by 2050 (***300 by 50***). The UK wants to achieve ***40 by 30*** (see Edition 1 of Low Carbon Pulse).

In 2020 it is reported that the off-shore wind sector in Europe attracted around USD 31.7 billion of investment. Already, within the first month of 2021, this figure has been "blown away" by the ***Jutland Project***.

See: *Europe's offshore wind sector saw a record $31 billion of investment in 2020*

Hyosung Heavily into H2 as Linde Hops into *ROK*:

On February 4, 2021, one of the world's largest industrial gas producers, Linde, announced that it is to develop a world scale hydrogen liquefaction facility in Ulsan, ***ROK***, using Linde's hydrogen liquefaction technology: the facility will take hydrogen arising from the Hyosung Chemical plant, and process and liquefy it.

The hydrogen liquefaction facility will produce around 30 tonnes (30,000 kg) of hydrogen a day (and between 11,000 and 13,000 tonnes annually). This is sufficient to fuel 100,000 passenger vehicles.

The development is part of a broader joint venture between Linde and Hyosung Corporation, with Hyosung Corporation to develop hydrogen refuelling infrastructure (***HRI***) at 120 locations across ***ROK*** (to be located at 50 new and 70 existing locations). This represents the continued roll-out of the Hyosung business model: it has already developed ***HRI*** at 15 locations in ***ROK***.

This in turn is consistent with the Hydrogen Roadmap for South Korea and subsequent "Roadmap for the activation of the hydrogen economy" under which the ***ROK*** government is targeting 6.2 million passenger vehicles and the development of ***HRI*** at 1,200 locations across South Korea. In addition, South Korea's Ministry of Trade, Industry and Energy, has "roll-out targets" for buses (40,000), taxis (80,000), and trucks (30,000) by 2040.

See: *Linde unveils plans for Asia's largest liquid hydrogen facility*

South Korean Hydrogen Law comes into force:

On Friday February 5, 2021, the *Economic Promotion and Safety Control of Hydrogen Act* (***Hydrogen Law***) came into force in ***ROK***: in broad terms the ***Hydrogen Law*** deals with fuel cells, hydrogen vehicles and ***HRI***.

As is the case in most jurisdictions, existing laws do not cover and regulate all activities to be undertaken in the "hydrogen economy". This is a key issue for both development, and for business as usual, activities. The ***Hydrogen Law*** provides this regulation, effectively "plugging gaps" and, in so doing, regulating activities. It should be expected that most other countries will develop hydrogen laws.

In addition to plugging gaps, the ***Hydrogen Law*** provides consumer protection and fuel cell use initiatives, so as to achieve the "roll-out" of targets.

Also, as is the case in most jurisdictions, the policy settings, existing and emerging, in ***ROK***, are playing to the economic strength of ***ROK*** as a world leading producer of road vehicles of all kinds.

See: *World's first 'hydrogen law' takes effect. What's in it?*

Green Hydrogen momentum continues to build:

Edition 4 of Low Carbon Pulse quoted Jochen Eickholt, executive board member of Siemens Energy AG: *"It won't take decades for the hydrogen industry to develop, like it took LNG, but it won't happen overnight".*

In a report entitled ***2050: The Hydrogen Possibility***, Wood Mackenzie quantifies the momentum around Green Hydrogen: since Q4 of 2019 the pipeline of projects has grown to 26 GW of installed electrolysers. This is consistent with the plans, roadmaps and strategies released by various countries that contemplate the development of installed electrolysers.

This momentum seems to be matched by the speed at which some electrolyser technology providers are anticipating that the unit cost of producing 1 kg of hydrogen using electrolyser technology will fall. For example, NEL considers that a unit cost of USD 1.50 is achievable by 2025. If this is achieved, it is stated that Green Hydrogen would be price competitive with fossil fuels derived energy carriers by the middle of this decade.

See: *WoodMac on Green Hydrogen: It's Going To Happen Faster Than Anyone Expects*

BMW buys aluminium produced using solar ("low emission metal"):

Edition 8 of Low Carbon Pulse reported on the supply of electrical energy by the Mohammed bin Rashid Al Maktoum Solar Park in the UAE to Emirates Global Aluminium (EGA) – a world first. On 2 February, 2021, ***BMW*** announced that it had contracted with ***EGA*** for the supply of "lower emission metal" during 2021.

CEO of ***EGA***, Mr Abdulnasser Bin Kalban stated: *"We are delighted to have the BMW Group as our first customer for low carbon CelestiAL aluminium from EGA … Solar aluminium is a step in the right direction – it uses a natural and abundant source of energy in our desert environment to produce a metal that is vital to the future of our planet".*

BMW stated that the use of "lower emission metal" would allow it to reduce its ***GHG*** emissions by 2 million tonnes over 10 years, or approximately 3% of the reductions in ***GHG*** emissions that ***BMW*** is going to require of its supplier network, to allow ***BMW*** to achieve its ***GHG*** emissions targets, being both direct and indirect ***GHG*** emission reductions. This is part of a broader ***GHG*** emission reduction commitment of ***BMW*** to allow it to achieve its target of reducing its ***GHG*** emissions to 80% of 2019 levels by 2030.

See: *Harnessing the power of the desert sun: BMW Group sources aluminium produced using solar energy*

South Australia – that increasingly well-known place in the sun:

On January 29, 2021, it was reported that South Australia achieved a world first in 2020: for the first time the entire load of a grid (being the grid in South Australia) was powered by solar energy. As well as this world first, South Australia has the lowest cost electrical energy in Australia.

As noted in Editions 3, 4 and 6 of Low Carbon Pulse, South Australia is not going to resting on its laurels, it is energising the State to develop Green Hydrogen projects. [**Note:** see Edition 28 of Low Carbon Pulse]

See: *"World first": South Australia achieves 100pct solar, and lowest prices in Australia*

Andhra Pradesh closes renewable energy auction process:

On February 4, 2021, it was announced that the Indian State of Andhra Pradesh had closed its renewable energy auction process for the development of 6.4 GW solar power projects to connect to the grid. It is understood that bids were submitted for 14.9 GW, and as such the auction was over-bid by 8.5 GW.

While the level of over-bidding indicates the interest in the development of this tranche of renewable capacity, the level of interest did not result in the anticipated record low bids (or come particularly close to the record low bids outlined in Edition 6 of Low Carbon Pulse.)

See: *India's 64GW solar auction concludes with final price of 0-034-kwh*

Hammer falls on Spain's reverse auction round:

In late January 2021, it was announced that Spain had brought down the hammer on the first of its new renewable energy auctions (see Edition 5 of Low Carbon Pulse (***Zero-Hero-Spain***) outlining Spain's initiatives and plans).

The Ministry of Ecological Transition awarded rights in respect of over 3 GW of solar and wind (over 2 GW of solar PV and 1 GW of wind, with European low pricing of €2.00 kWh). This award goes to fulfilment of Spain's commitment to develop on-shore solar and wind capacity, with the expectation being the Spain will auction at least 1.5 GW annually in each of the five years, 2021 to 2025.

See: *Spain renewable energy auction achieves record low wind price*

Even Climate Change Litigation is gaining momentum:

In January 26, 2021, the United Nations Environmental Programme (***UNEP***) released its *Global Climate Change Litigation Report*. The report is worth reading, providing a real insight into the many bases on which cases may be brought, and as such the ways in which governments and corporations can be pursued, not always successfully it has to be said.

In a Big Battery Country, a Battery of Batteries Green Lighted:

Edition 5 of Low Carbon Pulse touched on the Australian phenomenon of "The Big", anticipating that sooner, rather than later, one town in Australia would claim the name "The Big Battery". On February 5, 2021, CEP announced a plan to develop a 1.2 GW battery energy storage system (***BESS***) in Kurri, Kurri, in the coal heartland of New South Wales, the Hunter Valley.

This announcement expands on CEP's stated plans to develop a network of industrial scale roof-top solar and ***BESS*** installations around Australia with up to 1.5 GW of capacity. If the Kurri, Kurri ***BESS*** is developed, CEP will have 2.7 GW of ***BESS*** capacity. This would give Australia two mega ***BESS*** owners, with Neoen (headquartered in France) building or planning to build 1.7 GW of ***BESS*** capacity (Hornsdale, The Big Battery at Geelong, Goyder South, and a further facility near Sydney).

As an aside, Kurri, Kurri is the preferred site of Australia's Federal Government for a gas-fired power station.

See: *CEP plans world's biggest battery at Kurri Kurri*, *There's yet another contender in the rise of the mega batteries*

On February 5, 2021, it was announced that pace setter, Meridian Energy, had gained approval for the development of a ***BESS*** near the border town of Albury, in the south of New South Wales, Australia. The ***BESS*** will be co-located at the run-of-river Hume hydroelectric facility. The ***BESS*** will be able to draw electrical energy direct from the Hume hydroelectric facility, i.e., avoiding any line loss arising from drawing power from the grid. Meridian Energy is well-known for innovation in battery storage across networks.

See: *Hydro-powered big battery approved for Southern New South Wales*

Green Hydrogen round up:

On January 29, 2021, it was reported that Masdar City, in the UAE, intends to develop an electrolyser using electrical energy from solar sources to produce Green Hydrogen. The solar-powered electrolyser is to be built in Masdar City, involving the Abu Dhabi Department of Energy, Etihad Airways, Khalifa University of Science and Technology, Marubeni, Siemens and the Lufthansa Group.

See: *Solar powered hydrogen for Masdar City*

On January 29, 2021, Shell, Mitsubishi Heavy Industries and the municipal heat provider Warme Hamburg, were reported to have joined forces with Swedish utility company, Vattenfall, for the purposes of the redevelopment of Vattenfall's ***Moorburg coal-fired*** power station on the River Elbe. The intention is to develop a 100 megawatt Green Hydrogen facility using electrical energy from both solar and wind sources. The ***Moorburg coal-fired*** power station is to cease to dispatch electrical energy derived from fossil fuel under Germany's reverse auction process for decommissioning of fossil fuel plants (see Edition 5 of Low Carbon Pulse). (RWE, Uniper and Vattenfall may be regarded as having achieved good outcomes from the decommissioning reverse auction process.)

See: *Coal to Green Hydrogen*

On February 2, 2021, an article (appearing in *Resource Magazine*) entitled "***The Potential for Hydrogen for Decarbonisation***" considered renewable energy and nuclear energy for the purposes of the production of Green Hydrogen. Amongst other things, the article provides a succinct statement of the advantages of Green Hydrogen: **1.** it is cheap long term storage of energy; **2** it can be used to derive heat (in industrial process) and in heating (including of Buildings); and **3**. it is a zero carbon feedstock and fuel for industrial processes.

The article notes that efficiency issues arise at each stage of production to use of Green Hydrogen - the production, transportation, delivery and use (if used to derive electrical energy that is then transmitted over a grid): it takes more electrical energy to derive 1 kg of Green Hydrogen than energy contained in the 1 kg of produced (each 1 kg contains 33.3 KWh of energy), it takes further electrical energy to cool and to compress or to liquify Green Hydrogen for transportation, further energy to transport it and it takes electrical energy to store Green Hydrogen until its use.

The efficiency (or energy) loss factor is a key consideration for all developers, equity investors, financiers (including development banks) and customers. The efficiency factor will inform the uses to which to put Green Hydrogen, in particular whether it is appropriate to use Green Hydrogen as a fuel for larger scale electrical energy generation.

See: *The potential for decarbonisation*

Green Ammonia round-up:

On February 8, 2021, it was announced that ***JERA*** (Japan's largest electrical energy generation company) and Natsional Bhd (Petronas, Malaysian's NOC) entered into a Memorandum of Understanding (***MoU***) in relation of a range of low carbon, to no carbon, initiatives, including ammonia (and hydrogen and LNG for bunkering of vessels). Petronas stated that the signing of the ***MoU*** was the result of the shared vision of ***JERA*** and Petronas to achieving net-zero carbon emissions.

As a result of the partnership outlined in the ***MoU***, ***JERA*** (and Chubu Electric Power) will procure "ammonia free of ***CO_2***" (the electrical energy used to produce the ammonia will be from renewable sources), with the Green Ammonia procured to be used for electrical energy generation.

See: *Japan's Jera to produce ammonia for power with Malaysia's Petronas*

Nuclear Hydrogen (Pink Hydrogen):

It was reported on January 26, 2021 (in world nuclear news), that speakers at the fifth annual ***Atlantic Council Global Energy Forum*** discussed the use of steam arising from the generation of nuclear energy as feedstock for to produce hydrogen and to produce potable water. The use of light-water-cooled and high-temperature gas cooled reactor designs were considered for these purposes. *"Large-scale, low cost hydrogen is the key ingredient … to enable decarbonisation of tough to abate sectors … we estimate the target price [for the production of hydrogen to be [US] 90 cents per kg. Current projections for renewables-generate hydrogen don't expect to see those costs [of production] until 2050".*

It is clear that the use of nuclear energy, and steam arising from it for the production of pink hydrogen, would assist greatly in achieving the goals of the Paris Agreement. This is a theme that is emerging in a number of countries, critically, in Japan.

See: *Non-grid nuclear applications hold key to decarbonisation*

Negative *GHG* Emissions … not new, but higher profile likely:

A number of jurisdictions around the world are considering, at a more granular level, how to achieve their net-zero emission targets, and some are concluding that negative ***GHG*** emissions initiatives are needed if net-zero emissions targets are to be achieved. Just as the use of Blue and Green Hydrogen has gathered momentum over the last two years or so, it should be expected that negative ***GHG*** emission outcomes will gather momentum over the next three to five years, possibly sooner.

In the carbon budget of each jurisdiction, as a practical matter, there is a limit as to rate, and level, of reduction in ***GHG*** emissions that is achievable by transitioning to renewable energy and, in due course, shifting to hydrogen use. More than this, certain human activities are less susceptible to ***GHG*** emission reductions, including Agriculture, Forestry and other Land Use (**AFOLU**), and Aviation. As such, while most ***GHG*** reduction policy settings go to achieving net-zero ***GHG*** emission targets, they do not remove existing and future ***GHGs*** from the atmosphere, only negative ***GHG*** emission initiative policy settings can achieve this.

California is committed to achieving net-zero ***GHG*** emissions by 2045. As California considers the policy settings required to achieve this, it has looked at is carbon budget and realised that it is necessary to develop and to implement policy settings to achieve 125 million tonnes of negative ***GHG*** emissions by 2045.

The ***Lawrence Livermore National Report*** outlines the most cost effective and plausible means of achieving 125 million tonnes of negative ***GHG*** emissions while at the same time balancing California's carbon budget.

In table form, the conclusion is as follows:

NEGATIVE *GHG* EMISSION INITIATIVE	MEANS OF ACHIEVING NEGATIVE *GHG* EMISSION	NEGATIVE *GHG* EMISSION OUTCOME
Land Management	Restoration of grasslands / wetlands, alter forestry cycle times and use of perennial crops	25 mtpa
Fuel production from organic waste	Derivation of hydrogen from organic waste using pyrolysis (possibly gasification) and biogas derivation / production	84 mtpa
CO_2 DAC	Development of DAC technologies	16 mtpa

The second and third negative ***GHG*** emission initiatives assume that CCS / CCUS will be available permanently to capture and store, or to provide a use (including methanation) for ***CO_2*** and CO arising on the derivation of hydrogen and biogas, and the ***GHG*** sourced from the atmosphere using DAC. The report notes that California has sufficient natural geological formations to allow up to 100 years of CCS / CCUS at the required rate for these negative ***GHG*** emissions outcomes.

And finally … balancing the carbon budget and the Californian State budget: it is estimated that these negative ***GHG*** emission initiatives would cost California USD 8 billion a year. It is increasingly apparent that governments will have to make policy decisions around the true cost of achieving ***GHG*** emission reduction targets, including to frame thinking and the explanation of that thinking to the constituencies: the value of the broader economic, environmental and social benefits arising from negative ***GHG*** emissions initiatives is considerably greater than their monetary cost. The challenge is that constituencies can see the benefit of infrastructure and services paid for by the state budgets, carbon capture, not so much.

See: *Here's what it could cost for California to hit zero-emissions goal*

For those wanting to find out more about the production of hydrogen from waste, *Hydrogen Production from Biomass and Organic Waste* provides a good read. Also towards the end of May 2021 in the first Hydrogen for Industry publication, the Global Ashurst Towards Zero Emission team will publish a summary paper on Hydrogen from Waste. A subsequent *Hydrogen for Industry* publication will provide a summary paper on *Negative **GHG** Emissions: What they are? And why they are needed.*

PRC Carbon Emissions Trading Scheme goes live:

Edition 6 the Low Carbon Pulse noted that the ***PRC***'s national Carbon Emissions Trading Scheme (***PRC ETS***) would go live on February 1, 2021.

It is reported that on February 1, 2021, this happened, and the world's largest (cap and trade) ***PRC ETS*** opened for business. Under the ***PRC ETS***, 2,200 enterprises emitting more than 26,000 tonnes of ***GHG***s a year are permitted to trade their emissions quotas. Enterprises with this level of annual ***GHG*** emissions naturally means that the ***PRC ETS*** will apply to coal and gas-fired power plants, and manufacturing facilities with captive power plants.

As might be expected, refineries and petrochemical facilities also come within the ***PRC ETS***, including those of SOEs Sinopec (including Shanghai and Maoming), PetroChina (Wepec and Jinzhou) and Sino-chem (Hongrun), and privately owned enterprise, Hengli.

Hydrogen Buses and Train News:

On January 27, 2021, the ***PRC*** rolled out its first fuel cell, lithium battery, hybrid powered and propelled locomotive, which has a design speed of 80 km an hour, and at this speed is able to run for 24.5 hours on a full-load of hydrogen.

See: *China rolled out its first self-developed hydrogen fuel cell hybrid locomotive*, *Fuel cell-battery hybrid locomotive unveiled*

On January 29, 2021, it was announced that Spain's first hydrogen-powered and propelled passenger train is to be completed in prototype form by 2023. The train is being developed by Talgo, using Hexagon Purus technology, and is called Vittal-One.

See: *First hydrogen train to feature hexagon purus technology*

On February 3, 2021, it was reported that the first of 15 Solaris Urbino 12 hydrogen-powered fuel cell hybrid buses had been delivered by Solaris Bus & Coach (***Solaris***) to RVK, with the balance of 14 buses to be delivered from July to December 2021. This continues the deployment of hydrogen-powered fuel cell buses across RVK locations (starting in 2020).

See: *First solaris fuel cell bus delivered to RVK*

On February 9, 2021, it was reported that ***Solaris*** is to supply OBB Postbus with the 40 fuel cell powered buses to be used throughout Austria.

See: *Solaris to supply obb postbus with 40 hydrogen fuel cell buses*

While buses hydrogen powered and propelled buses are becoming the norm, in the ***PRC*** it is clear that electric busses have become the norm. For example, in Shenzen has 16,000 electric buses, with the buses recharged at charging depots.

See: *China offers a great electric transport example to Australia*

Corporate PPAs … boom to continue:

On January 26, 2020, Bloomberg New Energy Finance released its ***Corporate Energy Outlook***. The Outlook reports on activity in 2020, and prospects for 2021. During 2020 more than 130 corporations globally signed clean energy contracts (***Corporate PPAs***), with an estimated 23.7 GW of renewable energy contracted under those ***Corporate PPAs***. The US leading the way with 11.9 GW of renewable energy contracted under ***Corporate PPAs***.

Corporate PPAs are being entered into by corporations for economic, environmental and social, reputational and sustainability reasons. Often in the absence of policy settings that encourage or require ***Corporate PPAs***, the supply side of the market is responding to the clear demand.

See: *Corporations purchased record 24GW of renewables in 2020*

TOTAL continues to execute on its renewable strategy:

On February 5, 2021, it was announced that TotalEnergies had agreed to purchase four large-scale solar projects and battery electrical energy storage (***BESS***) assets located near Huston, Texas. TotalEnergies is purchasing 2.2 GW and 600 MW of ***BESS*** from SunChase Power and MAP RE/RS. TotalEnergies is going to commit to a 1 GW Corporate PPA / Clean Energy Contract for renewable power generated by these assets.

See: *Oil Major Total Buys Texas Solar Projects*

Corporations being urged to declare plans for net-zero by 2050 …

As has been noted in a number of editions of the Low Carbon Pulse, corporations are committing to net-zero emissions even in the absence to policy settings requiring these commitments. This trend is gathering momentum.

On January 26, 2021, the CEO of BlackRock, Mr Larry Fink, highlighted climate change as both a business and investment priority for BlackRock. The message from Mr Fink is clear and unmistakable: *"Given how central … energy transition will be to every company's growth prospects, we are asking companies to disclose a plan for how their business model will be compatible with a net-zero economy… We are asking how this plan is incorporated into your long-term strategy and reviewed by your board of directors".*

Mr Fink has been clear and unmistakable on net-zero since early 2020, if not before. *"We know that climate risk is investment risk … But we also believe that climate transition presents [an] historic investment opportunity."*

See: *Blackrock CEO urges companies present plans*

Net-Zero Roundup:

Corporations setting net-zero emissions: during this cycle of LCP (from January 26, 2021 to February 9, 2021), General Motors to be carbon neutral by 2040, MasterCard, Nissan.

PROGRESS TOWARDS NET-ZERO EMISSIONS
FEBRUARY 24, 2021

Low Carbon Pulse - Edition 10

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to Edition 13 of Low Carbon Pulse – sharing significant current news on progress towards net-zero emissions globally. This edition covers the period from February 10, 2021 to February 24, 2021.

During the next month or so, the second article in *The Shift to Hydrogen (S2H2): Elemental Change* series entitled ***What needs to be decarbonized? And what role can hydrogen play?*** will be published, providing an assessment of ***GHG*** emissions by sector and industry and the role that renewable electrical energy (electrons) and hydrogen (molecules) has to play in the decarbonization of each sector and industry.

Lone Star State committed to more renewables:

The challenges for the people of the Lone Star State have been front-and-centre in the news cycle for the last week or so. While cold-comfort at the moment, the good news for the people of Texas is the plan to add 35 GW of renewable energy (solar and wind) capacity over the next three years (as reported by the Electric Reliability Council of Texas, Inc. (***ERCOT***)). This will provide more reliable capacity and provide a clear means for grid integrity and stability: the more renewable energy on a grid, assuming appropriate connection and ancillary services including ***BESS***, the more reliable the grid. More than this, it is reported that with appropriately calibrated policy settings (including around incentivizing investment), and the promotion of clean energy contracts / corporate power purchase agreements, renewable energy capacity may increase by more than the predicted 35 GW over the next three years.

It is to be expected that battery electrical storage systems (***BESS***) and fuel cell energy storage systems (***FCESS***) will accompany the increased development and use of renewable energy across the Lone Star State (and other Sunbelt States). As touched on in previous editions of Low Carbon Pulse, the US has the leading ***BESS*** provider, and, in Ballard Power Systems, Bloom Energy Corporation and Plug Power Inc., corporations well able to respond to the demand for ***FCESS***.

See: *Texas to Add 35 Gigawatts of Wind & Solar in Next 3 Years — Boosting Grid Resilience; and The Texas Cold Blast Was A Warning To Hydrogen Investors*

US moving in from the cold:

On February 19, 2021, the US rejoined the Paris Agreement (see Edition 7 of Low Carbon Pulse).

The question from a number of sources has been: *Now What?* Leaving to one side the establishment of the organizational structures that have been put in place, in April 2021 the Biden Administration will announce revised ***GHG*** emission reduction targets [**Note:** see Edition 15 of Low Carbon Pulse]. After this announcement, it is expected that policy settings will accelerate US action to reduce ***GHG*** emissions. Both before and after the announcement of revised ***GHG*** emission reduction targets, there is a good argument for the answer to the question "*Now What?*", to be a simple: let the US renewable energy industry continue to do what it is doing well. Just provide the industry with guide-rails. With Federal support added to the support of so many cities and States, it is hoped that market-based responses will deliver the required ***GHG*** emission reductions. This belief on market based responses is informed by the fact that the renewable energy sector in the US had a record year in 2020, despite the broader economic contraction, and this is anticipated to continue. For example, it is anticipated that across the US more than 10 GW of utility-scale ***BESS*** will be installed in 2021, up from the 4.5 GW of ***BESS*** installed in 2020. This trajectory for 2021 was apparent (long) before the unprecedented cold conditions in the Lone Star State, but the power outages as a result of those cold conditions demonstrate the need for the deployment of ***BESS*** across grids, as an integrated part of each grid, thereby ensuring the integrity and stability of grids. This will allow the benefit of increased renewable energy to be delivered to US businesses and households in the form of lower electrical energy prices across stable grids (see Edition 7 of Low Carbon Pulse).

Australia (19.2 GW of ***BESS*** and hydrogen electrolysers were added to the pipeline of projects in 2020, and the packing of the pipeline continues), the Peoples' Republic of China (***PRC***) and the US are leading the way in use of ***BESS*** to ensure grid integrity and stability. As with a number of parts of the pathway to net-zero emissions, innovation and scale are developing at the same pace or even ahead of the demand side for the market for ***BESS***.

While Australia, the ***PRC*** and the US have been leading the charge on ***BESS***, it has become apparent that other countries are seeing the benefits of the use of ***BESS***.

Examples include:

- **France**: a 1 GW solar-plus-storage project, Horizeo, is planned by Engie and Neoen in Saucats;
- **Israel**: a 300 MW tender process is underway to provide solar-plus-storage in the Negev Desert;
- **Italy**: 2 ***BESS*** facilities are planned for Sicily, Italy: a 700 MW project is planned by Steag and KGAL and a 78 MW project is planned by Lightsource BP;
- **Ireland**: the first utility-scale ***BESS*** was commissioned in early 2020, and activity has continued, with a pipeline of 2.5 GW of utility-scale ***BESS*** projects now planned;
- **Sweden**: to address the impact of high-spot electrical energy prices in the summer of 2020, but to avoid high capital costs of grid augmentation and enhancement, the use of solar-plus-storage is likely to be considered as a scalable and timely means of addressing the impact of a constrained grid; and
- **Germany**: 42% of total electrical energy is sourced from renewable resources, and there is increasing recognition of the need for a mix of utility, business and residential scale electrical storage solutions.

See: *US set to led utility scale storage market in record year*

Brazilian government and industry caucus around Green Hydrogen HUB:

On February 17, 2021, the ***Hydrogen Council*** and ***McKinsey & Co*** issued a report on the state of the development of the global hydrogen economy. The report noted that projects with a projected spend of around USD 300 billion have been announced for development by 2030, with 85% of those projects announced in Asia, Europe and Australia. The number of announcements does not seem to be slowing.

On 19 February, 2021, a partnership of the Federation of Industries Ceará, the Federal Universtiy of Ceará, and the Government of Ceará announced the launch of the Green Hydrogen HUB. During the launch the Government of Ceará signed a memorandum of understanding with Enegix Energy (an Australian corporation) for the development of a hydrogen hub at the Port of Pecém.

Enegix Energy is to develop the hub, including an electrolysis plant, with the reported development cost of the entire hub being USD 5.4 billion.

The announced development is consistent with two of the three themes identified in the Hydrogen Council / McKinsey & Co report – the development of hubs and the importance of ports. While the timeline for the development of this project may be medium to longer term, this reflects the need for the continued development of the "demand side" for hydrogen (if the demand is not there, the investments will not stack up).

See: *Brazil announces US$ 5.4B Green Hydrogen hub for global supply*

South African government creates hydrogen shift valley:

On the other side of the South Atlantic, the South African Government announced the establishment of Platinum Valley as a location for a hydrogen technology cluster for companies to develop solutions to allow South Africa to develop hydrogen applications across the country.

The initial purpose is stated to be identifying "concrete project opportunities for kick-starting hydrogen cell manufacturing". This is an important step for HySA. While South Africa may not be considered as a key market, it is telling that the South African government is positioning the country to play a meaningful role. In time, it is possible to see South Africa becoming an exporter of hydrogen.

See: *South Africa moves to manufacture, commercialise hydrogen fuel cell technology*

Net-zero *GHG* emissions, more to do, and with greater pace:

The author has read with interest Mr Bill Gates' book, ***How to Avoid a Climate Disaster***. The book provides a clear plan for the way forward to net-zero ***GHG*** emissions, including that we cannot rely on renewable electrical energy sourced from solar and wind resources to do all the work.

Reasonably consistent themes are emerging from many sources; critically the retirement of coal-fired power stations, and for solar and wind capacity to grow by between 3.5 to 5 times current levels by 2030. Augmented, and new, grid and pipeline systems are required, and CCS / CCUS needs to be functioning to capture up to 300 mmtpa of ***CO_2***.

To achieve these outcomes, policy settings are needed. Some policy settings already exist, and those in the ***EU*** may be considered as providing (the current) high-water mark for policy settings. It should be noted however that the ***EU*** policy settings have been developed against a back-drop of a highly developed renewable energy industry (developed over the last 20 years by support policy settings), and a clear acceptance by a healthy majority that decarbonization of energy use is fundamental to achieving net-zero ***GHG*** emissions by 2050, and, if anything, it is necessary to increase the pace of decarbonization.

The policy settings in the ***EU*** are not necessarily the starting point for other countries - but they are informed and (critically) they are capable of achievement. This does not mean that there is accord and consistency across all Member States on the detail of how to achieve net-zero ***GHG*** emissions by 2050.

Hydrogen Utilization Study Group (H2SG) Update:

Just under 12 months ago the ***H2SG*** commenced an assessment of the means to establish large-scale demand for hydrogen in the Chubu region of Japan. On February 19, 2021, the ***H2SG*** released a report entitled "***Summary of Activities for Hydrogen Utilization in Chubu in 2030***". The report takes as its starting point the Basic Hydrogen Strategy (released by the Ministry of Economy, Trade and Infrastructure (***METI***) on December 26, 2017).

Undertaken on a rigorous basis, the report outlines potential demand for hydrogen in the Chubu region in 2025 (***social implementation stage***) and in 2030 (***commercialization phase***), and the means of satisfying that potential demand from import terminal to end-user. The sectors contemplated as end-users (providing demand) are Airports and Ports, Industrial (including refining and petrochemical and steel producers), Gas and Power (or possibly more appropriately given the findings of the report, Gas-to-Power), and Transport (with delivery to hydrogen re-fueling stations).

The underlying premise is that clean hydrogen will be imported into Japan to satisfy demand. As has been noted on a number of occasions in Low Carbon Pulse, Japan is agnostic as to the colour of hydrogen.

Interestingly, and to some extent surprisingly, the report finds that the largest likely demand for 2030 comes from Refining and Petrochemical and Gas-to-Power end-users, with around 80% of demand anticipated as coming from end-users in these sectors. Within the Chubu region, the report concludes that Chita is the most likely location to establish a large-scale liquified hydrogen gas (***LHG***) import and re-gasification terminal (or ***MCH*** receival and processing facility, or both), with new hydrogen pipelines and existing natural gas pipelines to be used to deliver re-gasified hydrogen gas to users.

Unsurprisingly, the report finds that ahead of the ***commercialization phase*** it will be necessary for policy settings to be developed to provide financial support for the capex and opex necessary to achieve commercialization. Consistent with the need to develop supply and demand in tandem (see Edition 2 of Low Carbon Pulse (***Supply and demand side development fundamental***) and the first article in ***The Shift to Hydrogen (S2H2): Elemental Change, Why H2? Why Now?***), the report notes the need for the establishment of "*stable hydrogen supply source*" and "*offtake agreements with major end users*", the two being entirely related and interdependent in the context of a developing market.

The corporations participating in the study, in alphabetical order, are Air Liquide Japan G.K., Chubu Electric Power Co. Inc., ENEOS Holdings, Inc., Idemitsu Kosan Co. Ltd, Iwatani Corporation, Mitsubishi Chemical Corporation, Nippon Steel Corporation, Sumitomo Corporation, Sumitomo Mitsui Banking Corporation, Toho Gas Co Ltd. and Toyota Motor Corporation.

See: *Japan: Consortium releases update activities report of hydrogen utilization study group in Chubu*

Hydrogen Energy Supply Chain (*HESC*) project produces first hydrogen:

On February 15, 2021, it was announced that hydrogen was produced from the ***HESC Project*** in the Latrobe Valley, Victoria, so concluding the first hydrogen supply chain. This is a world first Hydrogen Supply Chain project. Among other things, the Hydrogen Energy Supply Chain uses the Kawasaki Heavy Industries (***KHI***) designed and built ***LHG*** carrier (the Suiso Frontier) to deliver ***LHG*** to the ***KHI*** designed and built ***LHG*** terminal at Kobe, Japan.

The Hydrogen Energy Supply Chain project showcases cooperation and dedication of Japanese and Australian corporations. The corporations involved in the ***HESC Project*** are ***KHI***, Electric Power Development Co., Ltd (J-Power), Iwatani Corporation, Marubeni Corporation, Sumitomo Corporation, and AGL Energy, investing in Australian end of the supply chain, and Shell, ENEOS Corporation and Kawasaki Kisen Kaisha, Ltd (K-Line), investing in the Japanese end of the supply chain.

Floating and Fixed bottom off-shore wind:

The potential for the use of off-shore wind to provide electrical energy is becoming a reality (see previous editions of Low Carbon Pulse). The World Bank has assessed that the use of 10% of the identified off-shore wind resources could satisfy global electrical energy demand.

On February 12, 2021, it was announced that Cornell University has produced a "Wind Atlas".

It is clear that countries and corporations are continuing to realize the potential of off-shore wind: on February 17, 2021, Spanish integrated energy giant Iberdrola announced its plans to develop a USD 1.2 billion 300 MW off-shore floating wind project. This plan is part of a broader plan to develop up to 2 GW of floating off-shore wind projects off the coasts of Galicia, Andalusia and the Canary Islands, which itself is part of a plan to have 60 GW of installed renewable energy capacity by 2025. As ever though, low or lower cost renewable energy is required for the move to make Green Hydrogen viable.

The ***Wind Atlas*** follows the production of the ***Global Atlas of Closed-Loop Pumped Hydro Energy Storage*** atlas (reported in Edition 6 of Low Carbon Pulse).

Nuclear energy hydrogen roadmap:

In early to mid-February 2021 the Nuclear Industry Council (***NIC***) finalized a ***Hydrogen Roadmap***. The ***NIC*** frames priorities and thinking for UK government industry collaboration. The potential for large-scale and small modular reactors to produce emissions free hydrogen (***Pink Hydrogen***) is well known (see Edition 9 of Low Carbon Pulse), and it would appear likely that it will continue to receive consideration.

The ***Hydrogen Roadmap*** may be regarded as aligned with the ***Forty by '50: The Nuclear Roadmap*** (the Forty referring to 40% of the UK's clean power by 2050). While nuclear energy continues to have mixed reviews, it has the capacity to provide clean energy and clean hydrogen, and as such make a meaningful and sustained contribution to progress towards net-zero ***GHG*** emissions.

See: *UK nuclear industry launches hydrogen roadmap*

Green Ammonia round-up:

In mid-February, 2021, Aker Horizons AS announced the launch of Aker Clean Hydrogen, with the intention to develop 5 GW of clean hydrogen and clean ammonia capacity by 2030, including the development of the 450 MW Herøya Green Ammonia production facility (with Statkraft and Yara), a European first, and using NEL ASA electrolysers;

See: *Aker Horizons Launches Aker Clean Hydrogen to Industrialize Clean Hydrogen and Reduce CO2 Emissions Globally*

Yara:

- **Yara's Pilbara, Western Australia, plant proceeding**: Yara intends to install electrolysers to derive hydrogen from H_2O, and produce 3,500 tonnes of Green Ammonia a year;
- **Sluiskil expansion**: Yara has indicated that it is considering installation of electrolyers at its ammonia plant in Sluiskil, the Netherlands, using renewable energy from a 100 MW off-shore wind field. The expanded Sluiskil plant would have the capacity to produce 75,000 tonnes of ammonia a year;
- **Porsgrum progress**: Yara has announced plans to install electrolysers at its ammonia plant in Porsgrum, Norway, using hydro-electric renewable electrical energy from the Norwegian grid (around 98% of electrical energy in Norway is hydro-electric sourced), with the Green Ammonia produced to be used to power and to propel shipping (with the final investment decision dependent on the support of the Norwegian government);
- **Acid Test – Red Sea**: Air Products Red Sea, KAS, Green Ammonia plant may be regarded as the "acid-test" for the development of scalable Green Ammonia production with the plant planned to produce 1.2 mmtpa of Green Ammonia, using renewable energy from solar;
- **Ammonia Valued**: CF Industries has announced plans to install an electrolyser to develop the capacity of its existing ammonia plant (in Donaldsonville, Louisiana). In one of the quotes of the year, CF Industries, CEO, Mr Tony Will articulated the change to the ammonia (NH_3) industry:

  "*Up to this point, we have made a business by selling the nitrogen value of the [ammonia] molecule.*

  What's really exciting about this is now there is an opportunity and a market that values hydrogen….".

While ammonia remains to be "proved-up" as an energy carrier, rather than as a nutrient carrier, ammonia has a higher energy density as an energy carrier than liquid hydrogen, but is less energy intensive in reaching its point of liquid storage. Also the point is well made that infrastructure exists with 120 ports globally equipped with ammonia terminals.

COLOUR CODED AMMONIA (SEE ***THE SHIFT TO HYDROGEN (S2H2): ELEMENTAL CHANGE SERIES***)			
Blue Ammonia: H_2 from CH_4 with CO_2 captured & stored (CCS) or captured & used, combined with N using Haber-Bosch process	**Green Ammonia**: H_2 (from electrolysis of H_2O using renewable energy) combined with N using the Haber-Bosch process	**Grey (or Brown) Ammonia**: H_2 derived from CH_4 (without CCS) combined with N using the Haber-Bosch process	**Turquoise Ammonia**: H_2 from the pyrolysis of CH_4 which produces carbon black, storing CO_2 in solid form.

Green Hydrogen round-up:

- On February 19, 2021, Province Resources announced plans to develop a 1 GW solar and wind complex in the Gascoyne, Western Australia. As is the case with many locations around Australia, the site identified by Province Resources has strong on-shore wind resources, and equally prospective solar resources. Province Resources is keeping its options open: one of the good things about Green Hydrogen is that its production is necessary to produce Green Ammonia, and as such a decision on Green Hydrogen or Green Ammonia is not a pressing issue. The ***HyEnergy*** facility will have capacity to produce 60,000 tpa of Green Hydrogen or 300,000 tpa of Green Ammonia.

  See: *Province resources eyes Green Hydrogen*
- On February 16, 2021, Enel Green Power and Saras signed a memorandum of understanding to develop a Green Hydrogen supply project at the Saras Refinery, at Sarroch, in Sardinia. The plans for the supply project include the development of a 20 MW electrolyser. This joins Enel Green Power's other projects in Chile, Italy, Spain and the US to supply Green Hydrogen to decarbonize difficult to decarbonize industries.

  See: *Enel green power and saras team up to develop Green Hydrogen*
- On February 14, 2021, Shoreham Port (on the UK's south-coast, close to Brighton) announced the development of a 20 MW electrolysis plant adjacent to the locks at the port to produce Green Hydrogen to be used for fuel-cell buses and heavy goods vehicles and port cranes and forklifts, and, in due course, for vessels.

  See: *Shoreham port launches plan for Green Hydrogen plant*
- On February 12, 2021, a coalition of 30 energy organizations launched "***HyDeal Ambition***", outlining the means to producing Green Hydrogen at €1.5 kg before 2030, for delivery across Europe. The Green Hydrogen would be produced on the Iberian Peninsula using renewable electrical energy from 95 GW of solar capacity to provide electrical energy for 67 GW of electrolyser capacity to produce 3.6 mtpa of Green Hydrogen.

  See: *Coalition of 30 energy players forms to deliver Green Hydrogen across europe at the price of fossil fuels*

Green Steel around up:

- **Italian Green Steel**:

  Danieli, Leonardo and Saipem have announced a framework agreement providing the basis for the joint supply of technologies and services for the purpose of reducing CO_2 emissions arising from steel production: in short, the technology is described as hybrid, combining electric furnaces using electrical energy with direct iron ore reduction plants capable of using methane or hydrogen as feedstock for high-temperature reduction of iron ore. Under the framework agreement, Danieli is to provide the electric furnaces and the direct iron reduction technology, Leonardo will provide technology and safety solutions, and Saipem is to provide construction and installation services, and the technologies for use (including combined use) of methane and hydrogen, and ***CO_2*** capture.

See: *Danieli Leonardo and saipem working together for the green conversion of steel*

- **French Green Steel:**

  On February 22, 2021, Liberty Steel Group, Paul Wurth and Stahl-Holding-Saar signed a memorandum of understanding for the purposes of framing the prospective development of a 2 mmtpa Direct Reduction Iron (***DRI***) plant and a 1 GW electrolyser plant for the production of Green Hydrogen. As with the Italian Green Steel plan, initially natural gas and hydrogen would be used to produce direct reduction iron, and hot briquetted iron (***HBI***), with use of natural gas to be phased out over time, and hydrogen to be used to provide the high heat temperatures required to achieve direct reduction in iron ore. The proposal is to use the ***DRI*** and the ***HBI*** produced in the Liberty electric arc furnace in Ascoval, France, with any ***DRI*** not used there to be used at the Liberty Ostrava and Galati steelworks, and at Stahl-Holding Saar's Dillinger and Saarstahl facilities in Germany.

  See: *Liberty develop hydrogen steel making plant*

  As noted in Low Carbon Pulse 5 in respect of the thyssenkrupp steelworks in Duisburg, steel producers are able to develop demand for Green Hydrogen, satisfying that demand by own-supply. This allows them to develop Green Hydrogen supply further as the demand side develops.

- **Building on existing facility and supply chain footprints** … in addition to own-supply, super-majors, BP (at its refinery at Lingen) and Shell (at its Rhineland refinery) are involved in the production of clean (including green) hydrogen in Germany, each shifting production from Grey to Green Hydrogen. As the demand side for Green Hydrogen develops, including for the production of Green Steel, existing infrastructure can be augmented to supply that demand.

> **Direct Reduction Iron (DRI)**: iron ore that is subject to direct reduction by use of a reducing gas (at a high heat temperature).
>
> **Pig Iron**: iron ore that is subject to melting with charcoal (deriving from coking coal) and limestone.

BlackRock's focus on *GHG* emissions continues:

Edition 9 of Low Carbon Pulse quoted BlackRock CEO, Mr Larry Fink, and the importance to BlackRock of corporations in which it might invest having a net-zero emissions plan. BlackRock has between USD 7 trillion to 8.7 trillion of investments under its control and management, including substantial investments in oil and gas companies.

BlackRock is reported to have developed its thinking further in respect of oil and gas companies requiring them to disclose their ***GHG*** emissions and to set targets to reduce them, across each of the three scopes of emissions.

See: *https://www.motherjones.com/environment/2021/02/worlds-biggest-investor-blackrock-asks-oil-giants-to-reveal-their-carbon-emissions*

Decarbonization to Net-Zero *GHG* emissions:

On February 19, 2021, Eni SpA announced that it will decarbonize all products and processes by 2050, thereby increasing its earlier 80% target to what is effectively a 100% target. To provide a clear pathway to achieving this net-zero target, Eni plans to reduce ***GHG*** emissions by 25% by 2030, and by 65% by 2040. Accompanying the net-zero target are renewable energy and carbon capture storage targets: 15 GW by 2030 and 60 GW by 2050, and 7 mtpa by 2030 and 50 mtpa by 2050. As is the case with other majors, Eni will transition to a predominantly gas company (including LNG) over time, which is entirely consistent with projects under development in Angola, Indonesia, Mexico, Mozambique, Norway, and UAE.

See: *Eni aims for full decarbonisation by 2050 despite short-term growth in oil and gas volumes*

On February 17, 2021, it was reported that TotalEnergies has set itself a new renewable electrical energy capacity target of 100 GW by 2030. To achieve this outcome TOTAL CEO, Mr Patrick Pouyanne recognizes "more than USD 60 billion worth of projects will have to be financed over a period of 10 years".

See: *Oil major total targets 100gw of wind and solar capacity by 2030*

Shell is committed to being a net-zero emissions energy business by 2050 or sooner. A net-zero emissions energy business does not add to ***GHG*** in the atmosphere.

Framing, Testing and Understanding any commitment to zero, net or otherwise

In considering any commitment to net-zero or carbon neutrality from any country (or corporation) it is helpful to frame and to test that commitment, so as to understand it, as follows:

- **Net-zero GHG emissions**: achieving a balance between ***GHG*** emissions produced and ***GHG*** removed from the atmosphere: consistent with the Paris Agreement, including Scope 1, 2 and 3 emissions.
- **Gross-zero GHG emissions**: the cessation of the production of ***GHG*** emissions (zero means zero): not consistent with basis of current human activities, on the basis that it is not practicable, some may say possible, to cease release of all ***GHG*** emissions.
- **Net-zero CO2 emissions**: achieving a balance of CO2 emissions produced and CO2 removed from the atmosphere: not consistent with the Paris Agreement, because not all ***GHG***s are included.
- **Net-zero CO2-e emissions**: achieving a balance of CO2 equivalent emissions (hence CO2-e) produced and CO2 equivalent emissions removed from the atmosphere: consistent with the Paris Agreement.
- **Carbon neutral commitment**: achieving a balance between CO and CO2 emissions produced, and removed from the atmosphere: not consistent with the Paris Agreement, because not all ***GHG***s are included, and only Scope 1 and 2 emissions.
  In addition, phrases such as zero carbon emissions, carbon neutral and net zero are commonly used. More often than not it is not clear whether they are intended to refer to all ***GHG***s, rather than being limited to carbon (CO and CO2).
- **Net Negative** and **Negative GHG Emissions** are used to refer to the production of a lesser mass of ***GHG*** emissions than the mass of ***GHG*** emissions removed from the atmosphere (whether by a country or a corporation).
- **Carbon Negative** is used to refer to the removal of a greater mass of ***GHG*** emissions from that atmosphere than the mass of ***GHG*** emissions that are being, in real time, or have been, historically, emitted

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Low Carbon Pulse - Edition 11

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

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During April, we will publish the second article in *The Shift to Hydrogen (S2H2): Elemental Change series*. It will be titled ***What needs to be decarbonized? And what role can hydrogen play?*** It will assess ***GHG*** emissions by sector and industry, and the role that renewable electrical energy (electrons) and hydrogen (molecules) has to play in the decarbonization of each sector and industry.

PRC's 14th Five Year Plan:

On March 5, 2021, the National People's Congress (***NPC***) and Chinese People's Political Consultative Conference (***CPPCC***) were authorised to release the draft outline of the 14th five-year plan (2021-2025) for national economic and social development and the long-range objectives through the year 2035 (***Summary***). It is a high level summary outlining development, guidelines and main targets.

The key take-away from the Summary is that the ***PRC*** is targeting 20% (***20% Target***) of total energy use to be sourced from non-fossil fuel sources. The challenge for the ***PRC*** is that it is continuing to develop and to urbanise, and in this context it is likely to have to continue to revisit its policy settings. In this context, with increased growth in total energy use, and therefore the mass of ***GHG*** emissions arising, and the speed of that growth (as the ***PRC*** progresses to peak ***GHG*** emissions), it may be that the ***20% Target*** will need to be revisited, possibly before 2025.

IEA review energy use in Japan:

See: *China's five-year plan: baby steps towards carbon neutrality*, *News Analysis: How China's five-year plans catalyse its rejuvenation*, *China Focus: Revival-seeking China unveils action plan for modernization*, *China to formulate action plan for peaking carbon emission before 2030*, *China to promote green development during 14th Five-Year Plan period: report*

In the first week of March, the International Energy Agency (***IEA***) issued a report on energy use within Japan. The report commends the Green Growth Strategy in line with Carbon Neutrality in 2050 released in December 2020. The ***IEA*** report summarises the energy mix currently being contemplated in Japan as follows: the demand for electrical energy to be matched by between 50 and 60% from renewable electrical energy, 10% from hydrogen and ammonia as fuel, and between 30 and 40% from nuclear and thermal plants, with those thermal plants using CCS / CCUS (with any new thermal plants to be required to be "carbon capture ready").

The overriding theme of the ***IEA*** report is the layered and multifaceted nature of the transition on which Japan is embarking, not defined by, but needing to be responsive to, the current level of fossil fuel use in Japan, and the limited "cavern" sites suitable for CCS. Japan is responding to these factors, having already developed the world's first hydrogen energy chain (see Edition 10 of Low Carbon Pulse), and looking at the means of use of ***CO_2***, arising / derived from chemical production, including methanation, and the development of low carbon technologies (including concrete production that does not require cement).

Up to 210 GW of solar PV to be installed in 2021:

Global:

Leading publication, BloombergNEF (***BNEF***), forecast, on February 24, 2021, that up to 210 GW of solar photovoltaic (***PV***) capacity may be installed in 2021. The forecast of up to 210 GW exceeds earlier forecasts. On the forward curve for 2022 and 2023, installation of PV solar capacity installation is forecast at 221 GW and 240 GW.

Head of Solar at ***BNEF***, Ms Jenny Chase, has noted that the ***PRC*** has "hit the accelerator" given its commitment to achieve net-zero ***GHG*** emissions by 2060.

In a great quote, something that may apply to any number of countries, Ms Chase says: "I don't think anyone really knows how they're going to get to net-zero, but the obvious place to start is just to build a load of renewables"

See: *Up to 209GW of solar PV to be installed in 2021, BloombergNEF forecasts*

Leading countries:

As might be expected, the ***PRC*** is forecast to lead the way in 2021 (and thereafter) with up to 75 GW to be installed (and given the final installations in 2020, it might be as high as 90 GW). The ***EU*** and the US are increasing the installation of solar capacity. Importantly, India is starting to gain momentum in the installation of utility-scale solar in 2021, with up to 10 GW of photovoltaic solar forecast to the installed, with around 5.7 GW of new solar capacity to be installed by mid-2021.

While India is developing its renewable energy capacity, it needs to be doing so at a faster pace than the ***PRC***. To do this, it is likely that more developed countries will provide assistance to India in this endeavour, possibly first to transition to natural gas in terms of scale base-load, while at the same time working with the Government of India to develop the roll-out of solar and renewable capacity.

See: *India could install 9.7 GW of new utility-scale solar in 2021*

Renewable energy market hot in Chile:

It was reported on March 3, 2021, that Spanish renewable energy company **Iberdrola** has proposed the development of a 1.17 GW solar (675 MW) and wind (496 MW) project in the north of Chile (***ERNC Antofagasta Project***). Spanish oil and gas major is in a joint venture with **Iberdrola**, and, it is reported that Repsol has an option to acquire **Iberdrola**'s interest from 2025. Repsol, through Repsol Renovables, plans to have installed 4.5 GW of clean energy generation capacity by 2025.

See: *Spanish company plans 1.17 GW hybrid solar-wind complex in Chile*

France's ninth round of large scale solar:

On February 21, 2021, ***CRE*** (France's energy regulator) announced the result of the ninth tender for larger and utility-scale photovoltaic solar projects, awarding 451.9 MW of on-shore capacity. Leading French renewable energy company, Neoen was awarded 73.8 MW of capacity, with other leading players, Engie (awarded 61.4 MW) and Total Quadran (49.4 MW). The telling feature of the ninth round compared to the eighth round was that the price per kWh was higher. These tendered prices tend to indicate a less willing market, or fewer participants, or possibly both.

See: *France allocates 451.9 MW in ninth tender for large scale PV*

UK defines role of new investment policy bank:

In the latest UK budget handed down on March 3, 2021, the UK Government published details of the new UK Infrastructure Bank (***UKIB***). The ***UKIB*** is being set up: (**i**) to help tackle climate change, particularly meeting the UK Government's net-zero emissions target by 2050; and (**ii**) to support regional and local economic growth. It is hoped that the ***UKIB*** will repeat the success of the UK's Green Investment Bank (now part of Macquarie Bank).

The ***UKIB*** is intended to accelerate investment in UK Infrastructure, with the emphasis on the following key objectives: (**a**) to provide leadership in the market for the development of new technologies; (**b**) to facilitate the crowding-in of private capital into key infrastructure sectors; (**c**) to provide cornerstone investment into new projects; (**d**) to make available financial tools to facilitate the development of new infrastructure projects; and (**e**) to bring together core stakeholders in order to facilitate further investment in key sectors.

While the ***UKIB*** is to have a broad mandate, it will focus on clean energy, digital, transport, waste and water, and will have financial capacity of £22 billion (£12 billion of equity and debt capital, and the ability to issue £10 billion of guarantees). ***UKIB*** will draw funds from HM Treasury and may borrow from the private markets.

The creation of the ***UKIB*** goes a considerable way to fulfilling the role of the European Investment Bank (***EIB***) before Brexit.

Roof-top solar growth not topping out down-under:

Early indications are that the roof-top solar installations in 2021 will be over 3.5 GW in the Australian market. It is fair to say that the Australian market reached a tipping point on both roof-top and utility solar installation a while ago, but both parts of the sector have shown no sign of topping out. While Australia has a relatively small population by size of country, the population is concentrated, and the concentration is likely to continue to fuel the growth in roof-top solar, the cost of which, like utility photovoltaic solar, continues to fall in real terms.

See: *Rooftop solar installs head for more than 3.5GW in 2021 after record start to year*

Germany undertakes first centralised off-shore wind tender:

On February 26, 2021, three off-shore wind fields were tendered by Germany, two sites in the North Sea (with combined capacity of 658 MW, located about 30 to 40 kilometres north of Borkum Island) and one site in the Baltic Sea (with capacity of 300 MW, located about 40 kilometres northeast of Rugen).

The tender process is open until September 1, 2021, and is being run under a centralised model dealing with funding, grid connection and planning approvals and permitting. The bidder or bidders with the lowest funding requirement from Government will prevail. Those awarded will be required to install the bid capacity by 2026.

See: *Germany Puts Three New Offshore Wind Sites Out to Tender*

Concentration on *COP-26* and 2030:

It will be apparent that 2030 is a key date for the move towards net-zero carbon by 2050; it provides direction and speed of travel, and the speed of travel appears to be increasing.

- **Iberdrola** (the Spanish renewable energy colossus) plans to spend €150 billion to expand its installed renewable energy capacity to around 95 GW by 2030, to develop further its portfolio of solar and wind assets, and to add battery storage and production of Green Hydrogen (with electrolysers increasingly being regarded as energy carrier production and energy storage facilities).

  See: *Iberdrola to spend €150bn trebling its growing wind and solar empire*

- **End of year stock-take**: Stock-takes undertaken by Parties to the Paris Agreement, and submission of ***GHG*** emissions data ahead of ***COP-26***, indicate hoped for reductions in ***GHG*** have not been achieved. On February 26, 2021, the UN released a report which concludes that the ***NDCs*** of Parties would achieve a less than 1% reduction in ***GHG*** emissions from 2010 levels by 2030 (based on projected increases in ***GHG*** by 2030).

  In light of the report, UN Climate Chief, Ms Patricia Espinosa stated: "*What we need to put on the table is much more radical and much more transformative than we have been being until now*". This might be expected to be the case at COP-26. It is difficult not to agree with this assessment, but developed nations need to be doing more themselves, and they need to be assisting other countries, critically, India, to decarbonise.

At the moment, it is necessary to adopt book-end thinking, between the ***Stabilisation Goals*** (which is arguably within reach – see Edition 5 of Low Carbon Pulse) and the ***Stretch Goal*** (at the moment, by common consensus among the climate scientists is not within reach).

This book-ending is critical - achieving the ***Stretch Goal*** is an ideal. It would be good however if the narrative, and thinking, reflected this. Also it would be good if all thinking was framed against the ***NDCs*** of each country, and in the context, progress towards electrification. For example, the US renewable industry was making huge strides in the installation of renewable energy sources absent supportive policies at a Federal level, and the ***PRC*** has been installing renewable energy sources at an ever increasing rate since well-before President Xi's announcement of the ***PRC*** progressing towards net-zero by 2060.

While climate change needs cool heads, it needs deeper reduction commitments from more developed countries to allow countries at a different point on the development curve to be able to reach peak emissions at a point in time at some point between the ***Stretch Goal*** and the ***Stabilisation Goal***.

It is known that there is a global carbon budget, and it is hoped that the ***IEA***'s The ***World's Roadmap to Net Zero by 2050*** will allow a greater focus on the global carbon budget. The ***IEA's Roadmap*** is due to be released on May 18, 2021, well ahead of ***COP-26*** in Glasgow in October 31, 2021. This gives Parties to the Paris Agreement time to get their collective heads around the need to do more.

See: *Carbon-cutting pledges by countries nowhere near enough: UN report*, *We are nowhere near keeping warming below 1.5°C despite climate plans*

CLEAN Future Bill:

On March 3, 2021, the ***CLEAN Future Act*** was reintroduced in the US Congress. The headlines focused on progress to achieve net-zero ***GHG*** emissions by 2050, with an intermediate target of achieving a 50% reduction from 2005 levels by 2030. It has been recognised that while the Biden Administration has a number of levers, there needs to be legislation.

See: *Democrats Relaunch Bill To Make U.S. Carbon Neutral By 2050*

Carbon Tax and CCS / CCUS:

In contrast, it has been reported that the American Petroleum Institute (***API***) is close to supporting a carbon tax as an alternative to federal regulation, including under the ***CLEAN Future Act***. It is reported that ***API*** supports an economy-wide carbon tax (or if you will a carbon pricing mechanism) as the primary policy setting on climate change. The stated logic for this is to keep energy affordable. This contrasts with mandatory obligations under federal regulation. In this context, major oil and gas companies, including Chevron, Exxon-Mobil and Occidental are looking at the development of CCS / CCUS, being a recognised means of sequestrating, rather than reducing ***GHG*** emissions, "a bury instead of [decarbonise] strategy".

As will be apparent from policy settings globally, it is possible to decarbonise energy use, while at the same time maintaining affordable energy. Modelling shows that this is achievable in the US, possibly even more so because of the ability of the private sector in the US to innovate and to respond to policy settings. It is clear that there remains a balance to be struck between decarbonisation of energy use achieving net-zero ***GHG*** emissions by 2050, and to reach peak ***GHG*** emissions as soon as possible. In many parts of the world, natural gas has an increasing role to play (including LNG), and this is recognised, but to be assured of addressing climate change, policy settings need to decarbonise energy production and use over time. Those policy settings should acknowledge the need to grandparent some fossil fuel sources over time.

In a recent World Economic Forum paper it is noted that the energy mix in 2030 will comprise up to 2/3 of fossil fuels, and that in this context it is not possible to have coherent policy settings without including CCS / CCUS. The paper reminds us that ***GHG*** emissions must decline by 7% each year until 2030 if the ***Stretch Goal*** (in the Paris Agreement) is to be achieved. As such, there is a need to reduce ***GHG*** emissions at a utility level scale.

A recent Wood Mackenzie report supports this proposition. The Wood Mackenzie report also notes that carbon pricing must increase by 600% if carbon pricing is to discourage activities that give rise to ***GHG*** emissions. It is clear that it is known what needs to be done, but policy settings are needed to allow the private sector to respond in a timely manner to those policy settings, while at the same time recognising that government has an active role to play in CCS / CCUS.

See: *Top oil and gas lobbying group close to backing a carbon tax*, *Exxon's CEO sees golden opportunities in carbon capture*, *Why private capital is the key to unlocking carbon capture at scale*, *Carbon needs to be much pricier to limit climate change: Report*

Natural Gas as a transition fuel:

In some parts of the world the use of natural gas is being phased out, principally because it is regarded, correctly, as giving rise to ***GHG*** emissions. And yet in other parts of the world, natural gas is seen as a transition energy carrier, allowing electrification of countries. This is particularly the case in East Asia, South Asia and South East Asia. Further, natural gas continues to be a key energy carrier in Japan and Republic of Korea, and this is likely to remain the case.

While an immediate transition to renewable electrical energy and energy carriers may be regarded as the preference, it is likely that natural gas (including LNG) will continue to be used in staged progress towards net-zero ***GHG*** emissions, including with greater monitoring and capture of fugitive emissions and more effective CCS / CCUS, and the use of carbon credit mechanisms to match the ***GHG*** arising from the use of natural gas.

See: *Natural Gas Is Driving Decarbonization In India*

The emerging clean energy superpowers:

In a widely reported speech given in Sydney, Australia, AXA IM, Chief Investment Officer, Mr Chris Iggo, has provided an institutional investor perspective on corporations and countries. At the corporation level, Mr Iggo noted that "the status quo is becoming uneconomic" over the medium term. The Building and Infrastructure and Agriculture, Forestry and Other Land Use sectors will need to respond to being carbon emitters.

Mr Iggo noted that renewable energy could be:

> " ... *a great long story for Australia and some emerging market countries which are renewable energy-rich. A full transition to renewable energy could really transform these economies*..."

See: *Switch to 100 pct renewables will drive economic growth, but watch for green bubbles: AXA*

New Hydrogen Corridor:

On February 24, 2021, it was announced that 78 organisations have established a consortium – the ***Basque Hydrogen Corridor***. The objective of the consortium is to develop 34 identified projects to develop a hydrogen supply chain, and to allow Spain to benefit from the development of the hydrogen industry, and then as a hydrogen economy.

The projects contemplated are to be developed in two phases, the first phase to run to 2026. During the first phase, the plan is to develop a hydrogen supply chain to produce and to deliver 20,000 tonnes of renewable hydrogen a year, including the production of Green Hydrogen, with the use to which the Green Hydrogen is to be put, already understood, with all use within the region. This approach to development of supply and demand is both innovative and is likely to be transformative, and reflects the approach that is being taken in Japan (see Edition 10 of Low Carbon Pulse).

In addition to the production of Green Hydrogen, a hydrogen biogas plant is to be developed to derive hydrogen from municipal solid waste.

See: *basque-hydrogen-corridor-unveiled-a-e1-3billion-hydrogen-project*

***BESS* and BECCS news round-up :**

Edition 5 of Low Carbon Pulse reported on the Victorian Big Battery (***VBB***), a 300 MW / 450 MWh battery electrical storage system (***BESS***) to be developed near Geelong, in Victoria, Australia by French renewable energy company, Neoen. On February 24, 2021, it was announced that Neoen had secured AU $160 million of debt financing from the Clean Energy Finance Corporation (***CEFC***) for the ***VBB***. The ***BESS*** technology will be provided by Tesla.

See: *Neoen lands $160 million in CEFC finance for Australia's biggest battery*

On February 4, 2021, Schlumberger New Energy announced a ***BECCS*** (bio-energy and carbon capture and sequestration) project with Chevron and Microsoft. The ***BECCS*** project (a world first), will convert agricultural waste biomass into syn gas, the syn gas will be mixed with oxygen to generate electrical energy, with the ***GHG*** arising captured and stored permanently in geological formations (cavern capture). The process is described as giving rise to a net-negative carbon emission outcome, with 300,000 tonnes of ***GHG*** captured and stored.

See: *Schlumberger New Energy, Chevron, and Microsoft Collaborate on Carbon Negative Bioenergy*

European Partnership proposal delivered :

On February 23, 2021, the European Commission (***EC***) delivered a proposal to establish 10 new European Partnerships and to invest close to €10 billion in digital and green transition, where "the goal is to speed up the transition towards a green, climate neutral and digital Europe, and to make European industry more resilient and competitive".

One of the 10 new European Partnerships is the ***Clean Hydrogen Partnership*** (***CPH***), the objective of which is to accelerate the development of a clean hydrogen value chain for Europe using clean technologies. Critically, the focus of the ***CPH*** will be the development of supply for clean hydrogen to the difficult-to-decarbonise industries and the transport sector.

The ***CPH***, together with the existing ***Hydrogen Alliance***, will be key to the ***EU***'s objectives manifest in the Green Deal and the ***EU Hydrogen Strategy*** for a climate-neutral Europe.

See: *EU proposal to set up a clean hydrogen partnership*

In addition to the ***CPH***, the other proposed new partnerships are: Global Health, Innovative Health Initiative, Key Digital Technologies, Circular Bio-based Europe, Clean Aviation, Europe's Rail, Single European Sky ATM Research, Smart Networks and Metrology.

Nine of the 10 proposed new European Partnerships will be considered by the European Parliament before they are presented to the Council of Ministers for consideration and adoption. (The tenth proposed new European Partnership, relating to uniform Metrology (measurements and standards), will be considered by the European Parliament's economic and social committee, before being considered by the Parliament and the Council of Ministers.)

Greening of the shipping and trading industries:

In related ***EU*** news, it has been reported that a number of European shipping and trading companies have written to the ***EU*** to promote the use of Green Hydrogen and Green Ammonia on the basis that they are sustainable. It is reported that the letter articulates what may be regarded as an inconvenient truth: sourcing energy carriers from other carbon intensive sources (including fuel crops), does not provide a sustainable solution, emitting more ***GHG*** than the fossil fuels they displace. "*Green Hydrogen and ammonia offer a clean future for the shipping and fuels industry. The **EU** must give them the investment certainty they need to flourish by requiring all ships carrying European trade progressively to make the switch*".

The writers of the letter estimate that making the switch to Green Hydrogen and Green Ammonia will require €1.4 trn on the basis of data from the Global Maritime Forum.

See: *European shipping players call on EU to promote Green Hydrogen and ammonia as marine fuel*

Hungary and Poland to transition to nuclear:

Hungary is phasing out the use of coal-fired power plants, with the last plant to be shuttered in 2025, and continuing to develop its nuclear capacity so as to be clean energy reliant by 2030. Poland is planning to develop its first nuclear power plant in Gdansk and its second on the site of the current Belchatow coal-fired plant.

See: *Hungary and Poland plan nuclear to replace coal*

Technology and innovation:

It is often said that there needs to be innovation and technological development to achieve progress towards net-zero ***GHG*** emissions. Two of the worlds' leading businesses in their respective fields, Accenture and Microsoft (through a joint venture, Avenade) intend to work together to advise energy, power and utility companies how to decarbonise their value chains, and how to lower the cost of that decarbonisation.

See: *Accenture and Microsoft Collaborate to Help Accelerate U.K.'s Transition to Net-Zero Carbon Emissions*

Blue Hydrogen round-up:

- On February 25, 2021, it was announced that Itochu (a leading Japanese trading house) and Air Liquide (recognised as one of the leading industrial gas producers) are going to develop a Blue Hydrogen facility in central Japan. The feedstock for the production of hydrogen will be natural gas derived from liquified natural gas (***LNG***), with the ***CO_2*** emissions arising on production to be captured and stored, and used by industrial customers.

  On full development, the Blue Hydrogen facility will produce up to 3 mmtpa of hydrogen, which is currently contemplated to provide an energy carrier for fuel-cell electric vehicles.

  The development of the facility is consistent with the Basic Hydrogen Strategy for Japan (including being agnostic as to the colour of hydrogen), in the move to becoming a hydrogen based economy. Further, the project indicates that a key underlying assumption of many commentators that Japan will source hydrogen as an import will require some adjustment.

  From Q3 2020, it has become increasingly clear that ***CO_2*** is being viewed as an opportunity for business involving producing ***CO_2*** that can be captured as part of the production of hydrogen, cement or iron and steel. ***CO_2*** is used in the production of building materials, carbon additives (including graphene), chemicals, fuels, polymers and proteins. The largest potential market is considered to be in the building industry. This market may be expected to grow as governments develop legal and regulatory frameworks that recognise and accommodate the development of hydrogen production, delivery and use, and that of the by-products of its production.

  See: *Itochu and France's Air Liquide to build giant hydrogen plant*

- Equinor and Gassco are reported to be considering the development, jointly, of a Blue Hydrogen export pipeline from Norway to Europe. The pipeline being contemplated would deliver Blue Hydrogen having an electrical energy potential of between 50 and 100 TWhs (noting that the total electrical energy use in the Netherlands in 2012 was 114 TWh). The Blue Hydrogen would be sourced from a plant to be developed, possibly near to the Northern Lights project.

Northern Lights project

The Northern Lights Project is part of a full-scale CCS project. The full-scale project involves the capture and liquefaction of ***CO_2*** in the Oslo region (from both cement production and from waste-to-energy), and will be shipped to an on-shore terminal from where it will be transported through a pipeline for storage permanently.

The full-scale project is being funded as to USD 1.8 billion of its US$ 2.7 billion development cost by the Norwegian Government, the Government's policy is to achieve a complete and scaled value chain in Norway by 2024 (the Longship Project). As reported in Edition 2 of Low Carbon Pulse, the balance of the funding for the Northern Lights project will be provided by Equinor, Shell and TotalEnergies.

Green Ammonia and Green Hydrogen round-up:

- World leading infrastructure firm, Copenhagen Infrastructure Partners (***CIP***) is planning to develop what will be the largest Green Ammonia production plant in Europe, to be located at Esbjerg, Denmark. The plant (dubbed the **Power-to-X facility**) will use renewable electrical energy sources from off-shore wind fields to produce Green Hydrogen from a 1 GW electrolyser which will then be combined with nitrogen to produce Green Ammonia.

  The Green Ammonia is intended to be marketed to the agricultural sector as a fertiliser (nitrogen carrier) and the shipping industry as fuel (hydrogen carrier). On the basis that the Esbjerg **Power-to-X facility** displaces ammonia sourced from fossil fuels (or other carbon intensive fuels), it will reduce ***GHG*** emissions by around 1.5 mmtpa.

  (Edition 6 of Low Carbon Pulse explains the concept of **Power-to-X**.)

  See: *Europe's Largest: CIP to Launch Offshore Wind-powered Ammonia Plant in Denmark*

- On February 2021, Plug Power Inc. (covered in previous editions of Low Carbon Pulse) announced the development of a 120 MW PEM electrolyser using renewable energy from hydro-electric sources. The PEM electrolyser is to be located at New York's Science, Technology and Advanced Manufacturing Park (***STAMP***), and will produce 500 tonnes per day of Green Hydrogen by 2025, moving to 1,000 tonnes per day by 2028. This is the largest PEM electrolyser to be announced in the US, and demonstrates the role that Plug Power is playing in PEM promotion.

  US Senate House Leader, Mr Charles (Chuck) Schumer has called for the Department of Energy to support Plug Power's plan to develop a network of Green Hydrogen production facilities across the US.

  See: *Plug Power To Build North America's Largest Green Hydrogen Production Facility In Western New York, Senator Schumber Wants Federal Doe to Help Build a New National Green Hydrogen Fuel Supply Chain*

- On March 5, 2021, it was announced that Haldor Topsoes is to develop a solid-oxide electrolyser (***SOEC***) (in contrast to a PEM). It has been stated that: "With Topsoe's SOEC ... more than 90% of the renewable electricity that enters the electrolyser is preserved in the Green Hydrogen it produces. This is significantly more efficient than the other available technologies in the market".

  If the advanced publicity is matched in practice, this level of efficiency of electrolyser (***EoE***) is likely a game changer: at current levels of ***EoE*** it takes 55 kWh of electrical energy to produce 1 kg of Green Hydrogen having energy content of 33.3 kWh. An ***EoE*** of 90% means that it will take 37 kWh of electrical energy to produce 1 kg of hydrogen. If the other essentials remain the same, critically, utilisation of the electrolyser, this will allow increased roll-out of electrolysers. By a rough and ready estimate, this looks like up to a 20% cut in the operating costs of electrolysers to produce Green Hydrogen.

  See: *World's first large-scale SOE electrolyser factory could cut cost of Green Hydrogen by 20%*

- In Edition 10 of Low Carbon Pulse it was noted that Province Resources was considering the development of a Green Hydrogen project. On March 4, 2021, it was reported that Province Resources is proceeding with the development of the renewable electrical energy parts of this project, including the planned installation of 1 GW of solar and wind capacity

  See: *Australian mining company moves ahead with 1 GW Green Hydrogen project*

Green Steel news round-up :

- H2 Green Steel (***H2GS***): On February 24, 2021, it was announced that a "Green Steel" venture is to be undertaken in Boden-Lulea, Sweden which on development will be the world's largest producer of Green Steel; on full development the H2 Green Steel project will produce 5 mmtpa of Green Steel. The development cost of the H2 Green Steel project is estimated as USD 3.05 billion.

  The proposed thyssenkrupp upgrade to its existing Duisburg steel works by undertaking the HydrOxy Hub Walsum project (reported upon in Edition 5 of Low Carbon Pulse), continues to be reported upon.

  On February 26, 2021, it was reported that the HydrOxy Hub Walsum project is seeking recognition as an Important Project of European Common Interest (***IPCEI***) for the purposes of obtaining funding. The current contemplated scale of electrolysis plant to produce Green Hydrogen is 500 MW.

  It is reported that ***H2GS*** is the flagship project of the *European Green Hydrogen Acceleration Center* (**EGHAC**).

  See: *Gigascale Green Hydrogen plant planned for northern Sweden*

- The key locational feature of the HydrOxy Hub Walsum project (and other actual and proposed Green Steel projects) is that it is located at the point of use of hydrogen (and oxygen). Another key reported feature of the project is that the renewable electrical energy required for electrolysis will be supplied, at least in part, from the consolidation of electrical energy from roof-top solar. This may be regarded as a first, and reflects the increased development and use, and the continued development of roof-top solar in Germany. Given the location of the Duisburg plant, this will realise efficiency because it will reduce line-losses.

See: *German steel giant wants to set up 500 MW Green Hydrogen plant*

Off-shore wind continues to build:

On February 25, 2021, marine surveys were reported to have started off the coast of Binh Thuan province (Vietnam) paving the way for the development of the Enterprize Energy's the Thang Long 3.4 GW off-shore wind project. The Thang Long project received a formal grant of a site survey licence and direction to proceed with formal survey works and to submit a development plan in 2019. (Enterprize Energy selected its EPCI contractor in July 2020, responsible for the design, fabrication, transportation of the wind-turbine and substation foundations, as well as off-shore transformer station and subsea cables.)

See: *APEM Surveying Wildlife at Vietnam's 3.4GW Offshore Wind Project*

On February 24, 2021, it was announced that four memoranda of understanding were signed by the La Gan Wind Power Development Corporation and suppliers. The La Gan project is being developed by ***CIP***, Asia Petroleum Energy, and Novasia Energy. The project is intended to be developed in phases, initially with the installation of between 500 to 600 MW through the end of 2024, with the balance of 3,000 MW to be installed between 2026 and 2030.

Vietnam

It is understood that Vietnam currently has around 54 GW of installed electrical energy, and that the Government intends for that capacity to be increased to 130 GW by 2030. The Thang Long and Le Gan off-shore wind projects are both located off Binh Thuan province, an area of good wind resources.

The development of off-shore wind capacity is likely to be a key part of that increase - preliminary estimates indicate up to 160 GW of off-shore wind field capacity, given the long coast line, water depths that are within the range of current technologies and engineering, and good wind resources (and a lesser typhoon risk when compared to other parts of South East and North Asia).

It is apparent that the Government recognises the benefit of starting the development of off-shore wind capacity in a timely fashion.

Decarbonising the Aviation industry:

Low Carbon Pulse and ***The Shift to Hydrogen (S2H2): Elemental Change*** series, highlight that "difficult to decarbonise" industries must be at the core of progress towards net-zero ***GHG*** emissions. Transport is no exception (estimated to be responsible for between 16.2% and 16.5% of direct ***GHG*** emissions globally).

It is recognised that decarbonising energy use in the Aviation industry is likely to be at the more, or at the most, difficult end of the spectrum. This does not mean that the Aviation industry is ignoring the achievement of net-zero ***GHG*** emissions, rather it is considering how best to achieve net-zero, including the use of lower carbon additives and possibly lower carbon sourced fuels. The Aviation industry is estimated to be responsible for up 2% of ***GHG*** emissions globally (although this fell in 2020 as a result of the significant reduction in air travel).

On February 26, 2021, it was reported that the CEO of major US airlines met with key Biden Administration climate change advisers, with the subject matter of the meeting being the use of green fuels to power and to propel aircraft. This followed meetings with the electrical energy and automobile industries.

See: *Exclusive: US airline CEOs to meet with White House on cutting carbon footprint*

On the same day, a report from Thrust Carbon outlined how the airline industry might use carbon-offsets to achieve net-zero ***GHG*** emissions.

At the core of ***How to Decarbonize the Aviation industry***, closely followed by the ever-present follow up question, and ***Who Should Pay?*** Is it passengers (through increased fairs), shareholders (through increased costs and lower dividends) or tax payers (through government subsidies)? To many observers, the ***How to Decarbonize*** should be unbundled from the follow-up question, with the answer to that question most naturally being that the user-should pay ultimately, both as to amount and over time.

See: *'More than affordable': Aviation could offset its way to 'carbon neutrality' with minimal impact on profitability*

One of the 10 new European Partnerships proposed by the ***EU*** relates to hydrogen and pursuing the "next generation of low carbon aircraft".

On February 26, 2021, Shell announced plans to develop its Rhineland refinery to produce new biofuels from bio-power-to-liquid plant and upgrading the hydrogen electrolysis plant at the site, from 10 MW to 100 MW, using the technologies of ITM Power and Linde. These developments are part of the planned transformation of the site into the Shell Energy and Chemicals Park Rhineland.

Net-zero round up :

Aviva (a leading insurer and asset manager) is targeting achieving net-zero ***GHG*** emissions by 2040 across its investment portfolio. Aviva is reported to have written to the 30 companies in its investment portfolio with higher ***GHG*** emissions, seeking them to commit to ***GHG*** emissions targets aligned to the Paris Agreement within the next 12 to 36 months.

Aviva has set intermediate targets in ***GHG*** emission reductions across its investment portfolio, 25% by 2025, and 60% by 2030. Aviva is committed to achieving net-zero ***GHG*** across its own operations by 2030, and investing GBP 6 billion in green assets and investments by 2025.

See: *Aviva sets target for net zero carbon footprint by 2040*

On March 3, 2021, FedEx announced its intention to become carbon neutral by 2040. FedEx has pledged USD 2 billion to commence the electrification of its fleet of more than 180,000 delivery vehicles. As reported in Edition 9 of Low Carbon Pulse, the global carbon budget does not have room in it for the prospective doubling of road freight traffic in the next 20 years. As such the move from FedEx is most welcome. It is hoped that this becomes a trend in freight businesses globally.

See: *"More Than 50 Companies Have Vowed To Be Carbon-Neutral By 2040"*

Low Carbon Pulse - Edition 12

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to Edition 12 of Low Carbon Pulse – sharing significant current news on the progress towards net-zero emissions globally. This edition covers the period from March 8, 2021 to March 22, 2021.

Development of the People's Republic of China (*PRC*) *ETS*:

Editions 6 and 9 of Low Carbon Pulse reported on the commencement of the ***PRC***'s national Carbon Emissions Trading Scheme (***PRC ETS***), the world's largest in terms of ***GHG*** emissions. Upon commencement on February 1, 2021, the ***PRC ETS*** provided a scheme for 2,200 to 2,225 enterprises (depending on the newsfeed or source you read). The enterprises give rise to an estimated 14% of global ***GHGs*** (and over 50% of ***PRC***'s ***GHGs***). The ***PRC ETS*** is intend to control, and to reduce over time, the mass of emissions from these enterprises. The ***PRC ETS*** is central to the achievement of President Xi Jinping's objective of achieving peak emissions by 2030.

Since the commencement of the ***PRC ETS*** on February 1, 2021, there have been two further developments, each contemplated in the framework of the ***PRC ETS***. First, the proposed commencement of trading nationwide in respect of emissions quotas, with quotas to be registered for trading (and transferred) overtime to allow an orderly commencement to trading. Secondly, the extension of the ***PRC ETS*** to include enterprises undertaking activities not included in the initial iteration of the ***PRC ETS***. It is currently proposed that the ***PRC ETS*** should include the ship-building and shipping industries.

See: *China looks at adding shipping to the world's largest emissions trading scheme*

EU *ETS* ... consistent but different:

In contrast to the ***PRC ETS***, the ***ETS in EU*** (***EU ETS***) relates to 40% of ***GHG*** emissions arising within the countries covered by the ***EU ETS***. This is reflective of the old ***GHG*** emission reduction target of 40% by 2030. It is understood that legislation will be presented in June under which the ***EU ETS*** will be revised, and possibly expanded, in line with or to reflect the increase in the amended ***GHG*** emission reduction target of 55% by 2030.

The organisations whose ***GHG*** emissions are covered by the ***EU ETS*** must hold or purchase sufficient emission allowances to allow them to undertake activities that give rise to a stated mass of ***GHG*** emissions. These organisations are permitted to purchase a limited number of international credits off-set against the mass of ***GHG*** emissions arising from those activities.

The emission allowances and international credits are often referred to as carbon credits. In addition, it appears increasingly likely that the ***EU ETS*** will be expanded to include shipping involved in trade to the ***EU***, not just within the ***EU***. From a policy setting perspective, this is consistent with the proposed ***EU*** cross border tax.

Emissions Trading Schemes and Carbon Taxes (each a Carbon Price)

While there is no hard and fast rule, carbon emissions trading schemes work on the basis that ***GHG*** emissions arising from a particular activity are limited (or capped), with the businesses undertaking those activities permitted to emit a capped mass of ***GHG*** emissions. Looking at this another way: each permit (***PTE***) allows the holder to emit one tonne of ***CO_2-e***, and each business must hold a number of ***PTEs*** equal to the mass of ***GHG*** emissions emitted by it. Ordinarily, the ***PTEs*** may be traded, hence "emissions trading scheme". Under ***ETSs*** supply and demand determines the price of each ***PTE***. This is a so called "cap and trade" ***ETS***. As a policy setting, ***ETSs*** provide for a reduction in the number of ***PTE***'s over time, and as such the mass of ***GHG*** permitted over time. The theory being that the fewer the ***PTEs'***, the higher the price, and the more likely businesses emitting ***GHGs*** will cease to undertake activities giving rise to the ***GHG*** emissions. ***ETS's*** allow the market to set a ***Carbon Price***.

From a policy setting perspective, an ***ETS***, covering a proportion of the ***GHG*** emissions arising, is normally accompanied by a Carbon Use or an Energy Use Impost (***Carbon Tax***), covering ***GHG*** emissions arising that are not covered by the ***ETS***. A ***Carbon Tax*** relates to the purchase of goods derived from carbon that has given, or will give, rise to ***GHG*** emissions, or both. Also ***Carbon Taxes*** can relate to the use of electricity or heat that is generated from a non-renewable source. The imposition of a ***Carbon Tax*** allows government to set policies that encourage low / lower, or no, ***GHG*** emission outcomes. The ***Carbon Tax*** structure may provide that low / lower ***GHG*** emission outcomes are exempt from, or are subject to a lower rate of ***Carbon Tax***. As with an ***ETS***, a ***Carbon Tax*** sets a ***Carbon Price***.

In theory, an effective ***ETS*** results in a reduction in ***GHG*** emissions in the most efficient way, while at the same time encouraging lower, low, or no carbon emissions. In theory, an effective ***Carbon Tax*** sends a cost signal to the purchaser of goods or electricity or heat from a non-renewable source not to purchase those goods or that electricity or heat, and to purchase a lower, low, or no carbon option or options.

If the ***ETS*** is working as intended, the unit cost of the good or electricity or heat from a non-renewable source will increase, and as such the combined effect of the ***ETS*** and the ***Carbon Tax*** is to signal a purchasing decision. This relies on there being a lower, low, or no carbon option or options, and other policy settings need to allow these options to become viable and sustainable. A ***Carbon Tax*** allows investment decisions to be taken on the basis that a renewable option is, or renewable options are, able to compete with the non-renewable / carbon intensive

EU carbon border tax:

On March 10, 2021, the European Parliament voted to approve the imposition of a carbon border tax on goods from countries that do not have a carbon price. While the details of the carbon border tax (amount and commencement date) have yet to be finalised (likely released in June 2021), what is known is the name of the new impost: the Carbon Border Adjustment Mechanism (***CBAM***). [**Note:** see Edition 22 of Low Carbon Pulse]

From a policy setting perspective, the ***CBAM*** may be regarded as sound at every level. Critically, it encourages sourcing goods from countries that have a carbon price.

The ***CBAM*** responds to the argument, by some countries that have chosen not to introduce a carbon price that until all countries have a carbon price, pricing carbon, exports jobs: the imposition of ***CBAM*** has the potential to foreclose on the ***EU*** market for goods exported from a country like Australia, which has yet to price carbon.

See: *Europe votes in favour of carbon border tax, could hit Australian exports*

Floating solar goes under the radar:

As might be imagined for something that floats on water, the success of the ***PRC*** policy (the Top Runner program) to use former coal mining areas in the Anhui and Shandong provinces (where water has collected as a result of subsidence) has gone under the radar. Leading player, Sungrow Floating (having deployed more than 1.1 GW of floating photovoltaics globally) has identified opportunities to repeat the success of the Top Runner program elsewhere in the world, including continuing to do so in Malaysia, Thailand and Vietnam, and to extend into the Indian, Philippine, South Korean, and Taiwanese markets.

See: *Lessons can be learnt from China's support for floating solar, Sungrow says*

In the Republic of Korea (***ROK***), the Ministry of Environment clearly sees the potential for floating photovoltaics. There are plans to deploy up to a further 2.1 GW of floating photovoltaic capacity by 2030, including five projects to install up to 147 MW of capacity on dams (Chungju, Gunwi, Hapcheon, Imha and Soyang River).

The new planned program joins the 2.1 GW floating solar complex on ***ROK***'s west coast, where floating photovoltaic capacity is being installed close to the Saemangeum tidal flats (behind the Saemanguem seawall). The floating solar tidal flats project is being developed in two stages, with 1.2 GW of electrical energy to be available from the end of 2022, and the balance of the capacity to be available by 2025.

See: *South Korea wants to deploy another 2.1 GW of floating PV by 2030*

ROK investment programs:

Consistent with ***ROK***'s plans to move to a hydrogen economy SK, South Korea's third largest chaebol, and its largest refiner of hydrocarbons, has announced plans to invest in new infrastructure. SK is planning to invest USD 16 billion to develop an "ecosystem" at Incheon (an industrial hub) by 2025. The planned ecosystem includes the production of 30,000 tonnes a year of liquified hydrogen (***LHG***) by 2023, using the SK Incheon Chemical plant.

In addition, 250,000 tonnes of clean hydrogen will be produced in the vicinity of the Boryeong LNG Receiving and Regasification Terminal (south of Incheon) using re-gasified LNG (comprising ***CH_4*** predominantly) as the feedstock for the production of Blue Hydrogen (with the capture and storage of ***CO_2*** arising from the oxidation of the ***CH_4*** used to derive ***H_2***). 80,000 tonnes of the annual hydrogen production will be distributed to hydrogen re-fueling infrastructure facilities (***HRI***), and 200,000 tonnes will be transported by a new pipeline to feed a new 400 MW fuel cell power plant, i.e., for the generation of electrical energy, consistent with a key policy setting in ***ROK*** around the use of fuel cell technology for electrical energy generation.

See: [*South Korean Energy Firms Step Up Hydrogen Investments*]

The *PRC* is to Renewables, what the KAS is to hydrocarbons:

In a thought provoking piece on OilPrice.com, Alex Kimani reflects on the meaning of energy independence (as distinct from energy security). Alex Kimani notes that the ***PRC*** is: the world's largest manufacturer of renewable energy equipment (with 7 of the top 10 manufacturers being ***PRC*** corporations); the world's largest installer of renewable energy capacity; and the largest importer of hydrocarbons from the Kingdom of Saudi Arabia (***KAS***) (with the relationship with the ***KAS***, and other countries in the Gulf Region, growing stronger).

The development of the global market for solar renewable energy has benefited from the scale achieved by the ***PRC*** manufacturers, with the unit costs contributing greatly to the reduction in the cost of the development of solar projects. The ***PRC*** has achieved scale, and will continue to benefit from scale.

The Biden Administration has pledged a planned USD 1.7 trillion of investment in energy infrastructure to allow the US to achieve net-zero ***GHG*** emissions by 2050, including the installation of 500 million photovoltaic solar panels across the US. For the US to achieve this proposed (and much needed) reduction in ***GHG***, it would benefit greatly from the supply of renewable energy equipment from the ***PRC***. After a recent meeting, it seems likely that the ***PRC*** and the US are likely to cooperate to achieve net-zero ***GHG*** emissions, including the likely removal of tariffs on solar equipment imposed by the previous administration.

See: *New Way To Invest In The $11 Trillion Hydrogen Boom*

Finally, in an article in the South China Morning Post (published on March 18, 2021), Su-Lin Tan recognises the scale of the USD 6.4 trillion investment required to allow the ***PRC*** to achieve net-zero ***GHG*** emissions by 2060. Further, the article recognises that while ***PRC*** renewable energy equipment manufacturers are preeminent, they face challenges of sourcing raw materials to allow the manufacture of equipment for the roll out of renewable energy capacity, critically, aluminium, cobalt, copper, lithium and nickel.

See: *China's carbon neutral 'transformation' could cost US$6.4 trillion, but plan has 'Achilles' heel'*

India imposes import duties and mulls net-zero by 2050 commitment:

In a mixed bag of news over the last two weeks, on March 9, 2021, India announced that from April 1, 2022, import duty of 40% will apply to solar modules, and 25% on solar cells. This move will allow India technology providers to develop so as to meet the increasing demand for photovoltaics, but may result in higher prices for electrical energy derived from solar farms than would otherwise be the case.

It has been widely reported that India is considering committing to achieving net-zero ***GHG*** emissions by 2050. The fact that India is considering this reflects the number of countries that have now committed to net-zero, including during Q3 and Q4 of 2020. In the lead up to ***COP-26*** (to be held in Glasgow in November 2021) it is likely India will feel obliged to make this commitment.

While Low Carbon Pulse rarely provides opinion, if India is to make a commitment to achieve net-zero ***GHG*** emissions by 2050, as part of making that commitment, India should develop a clear pathway to achieving net-zero and obtain clear commitment from other countries and development banks consistent with achieving net-zero. The whole world will benefit from achievement of net-zero by India, and to the extent needed, development countries should provide assistance.

"Hydrogen Republic of Germany":

Along with North Asian countries, Germany continues to progress towards becoming a hydrogen economy, committed to Green Hydrogen production. The North Sea port city of Hamburg provides a case study in planning and integration.

At the port, Hamburg Warme, with Shell, Vattenfall, and Mitsubishi Heavy Industries (***MHI***), are planning to develop a 100 MW electrolyser. Gasnetx Hamburg, working with the environmental agency responsible for the City of Hamburg, is planning the development of the "***Hamburg Hydrogen Industry Network***" (***HH-WIN***) to supply hydrogen to energy intensive industrial customers, and also to provide hydrogen to power and to propel public transport.

The developments in Hamburg are planned with those for other German states, Bremen, Lower Saxony, Macklenburg-Western Pomerania, and Schleswig-Holstein), to develop 500 MW of electrolyser capacity by 2025.

See: *Hydrogen: Hamburg Sets the Pace for Europe*

More Northern Europe News:

On March 8, 2021, plans were announced for the development of the world's first hydrogen powered and propelled ferry. Norwegian ferry operator, Norled, is reported as having agreed terms with Linde for the supply of liquid hydrogen from its 24 MW PEM electrolyser plant, located within its Leuna Chemical Complex in Germany. Linde will supply associated on-shore and on-board ***LHG*** storage facilities. The supply is due to commence in 2022.

See: *Hydrogen-powered ferry to become a near-term reality*

First Australia and Germany, now Canada and Germany – no shortage of options for Hydrogen Republic:

The Canadian and German Governments are committed to hydrogen, and have committed funding, in the case of Canada, of around USD 1.5 billion, and Germany of USD 10.75 billion. On March 16, 2021, Canada and Germany signed a Hydrogen Cooperation Deal to establish an energy partnership - The German-Canadian energy partnership. It is reported that the focus of the partnership will be renewable energy supply and security, technological innovation, with a particular focus on the development of clean hydrogen supply.

See: *Canada, Germany Sign Hydrogen Cooperation Deal*

Japan – Australia:

As foreshadowed in earlier editions of Low Carbon Pulse, the world's first Hydrogen Energy Supply Chain (***HESC***) is now producing grey hydrogen (some might call it brown hydrogen) derived from brown coal in the Latrobe Valley, liquefying the grey hydrogen and exporting the liquefied hydrogen (***LHG***) to Japan, abroad the world's first ***LHG*** carrier to the world's first receiving terminal and storage facility in Kobe.

In a ceremony to mark the establishment of the ***HESC***, the Australian Federal Government Energy Minister, Mr Angus Taylor said that: "[Australia has] the potential .. to be [one of the] world leaders in the production and export of hydrogen...". It is more than likely that Japan and Australia will now re-forge links based on energy, until now dominated by thermal and metallurgical coal (from New South Wales and Queensland primarily), and liquefied natural gas (from Western Australia, the Northern Territory and Queensland). The opportunity is across all colours of hydrogen, including Grey, Blue and Green.

It is worth noting, that the Australia Federal Government provided funding for the development of the ***HESC***, and at various points along the way the funding was questioned. It is fair to say that now the funding appears entirely justified.

See: *Dirty coal to hydrogen: Trial aims for clean-energy solution*

Electrical energy to produce, liquefy and store hydrogen:

As will have been clear from previous editions of Low Carbon Pulse, the source of electrical energy to produce, cool and compress hydrogen or to liquefy hydrogen as ***LHG***, and to store that hydrogen determines the colour of that hydrogen. Hydrogen produced using renewable energy to power electrolysers to split water is referred to as Green Hydrogen, hydrogen produced using electrical energy from the grid to power electrolysers is referred to as Yellow Hydrogen, and hydrogen produced using steam derived from the production of electrical energy from nuclear power is referred to as ***Pink Hydrogen***.

Green Hydrogen and Pink Hydrogen are Clean Hydrogen (as is Blue Hydrogen, and as is Purple Hydrogen, being hydrogen using electrical energy from a nuclear energy source).

As the ***EU*** progresses towards the development of a regulatory framework for the hydrogen industry, an issue has arisen as to whether it is necessary at this time to place a criterion on the mass of ***CO_2-e*** arising from the production of hydrogen. At the moment it is proposed that the criterion should be 2.256 kg/***CO_2-e*** / kg of ***H_2***. In response to this proposal, a number of energy companies (as prospective producers and users) and industrial companies (as prospective users) have questioned whether it is necessary to impose any criterion at this point in the development of the hydrogen industry, including major companies: ABB, ArcelorMittal, EDF, Engie, Fortum, NMV, Uniper and UPM.

See: *__EU__ taxonomy shutting the door to grid-powered hydrogen, critics say*

Australia sources 40% of load from solar:

On Friday March 5, 2021, a little under 40% of the load for electrical energy across the National Electricity Market or NEM (covering New South Wales (NSW), Queensland, South Australian and Victoria, and the Australian Capital Territory) was from a solar source. Interestingly, the split was 13.5% utility scale solar, and 26.6% roof-top solar. (With wind and hydro, a little under 50% of total load came from renewable electrical energy sources.)

The ever increasing penetration of solar electrical energy, is resulting in low/lower cost electrical energy across the NEM. This is resulting in the actual and announced decommissioning of power stations, Liddell (in NSW) and Yallourn (in Victoria). As yet, Australia has not introduced a scheme (equivalent to that in Germany) to provide coal-fired power stations with a softer landing on decommissioning, rather the decommissioning of coal-fired power stations is managed through what some regard as reasonably long notice periods. There is an argument for the introduction of a decommissioning scheme to provide greater certainty for coal-fired power stations owners, and for the renewable energy sector (including companies that own both coal-fired power stations and renewable energy and ***BESS*** businesses).

What participants in the Australian electrical energy market can feel in their bones, is confirmed by the Institute of Energy Economics and Financial Analysis (***IEEFA***) Report, Australia's Opportunity to Plan Ahead for a Secure Zero-Emissions Electricity Grid. The headline from the report is the expectation that coal-fired power stations will be closed sooner than expected (reflecting the projected revenue decline for coal-fired power stations). In anticipation of the closure of coal-fired power stations, the report is clear in stating that planning is needed, and provides guidance.

Drawing on what is happening globally, it seems to the Global Ashurst Towards Zero Emissions team that part of the policy framework to allow effective planning is to introduce a grandparenting regime to allow the decommissioning of coal-fired power stations using a reverse auction scheme similar to that used in Germany.

See: *Australia achieves record large solar energy output on Friday*, *Energy: IEEFA Australia: Preparing the grid for a future without coal, blackouts or emissions*

Ah but when the sun sets … from record highs to VOLL:

On Friday March 11, 2021, the gross pool price in the NEM in South Australia reached the value of lost load (the ceiling price at which off-takers from the grid shed load, AUS 15,000 MWh).

At a time of low demand for electrical energy, transmission maintenance being undertaken and a fire occurred at a gas-fired power station, as the sun set on Friday, supply fell short of load. As the sun rose the following morning, and for the balance of the weekend, the gross-pool price was negative (as supply exceeded load), with most of the demand being met by roof-top solar. To manage grid integrity and stability (including to avoid risk of "islanding"), the system operator, AEMO, required a portion of roof-top solar capacity to be "switched-off" from the grid.

There are some lessons to be learned from these system events, lessons that go beyond the headline of AUS 15,000 MWh (compared to the annual average in 2020 of around AUS 36 MWh or 3.6 c KWh).

The overarching lesson appears to be that there is a need for more electrical energy storage, ***BESS*** or pumped storage, or both, and in due course, access to hydrogen in storage.

The need to manage dispatch of electrical energy in new ways is not limited to Australia. At the opposite end of the load curve, cold weather and recharging of ***BEV*** is understood to have stretched the Norwegian system in circumstances in which all capacity on its grid system was available. Flexible and immediate responses are needed, both to add electrical energy, and to shed load.

See: *Fire takes out biggest gas generator in South Australia, AEMO curtails rooftop solar*

Cyprus, Greece and Israel to connect power grids:

It was reported on March 8, 2021, that Cyprus, Greece and Israel are considering the development of a subsea electrical energy interconnector (the EuroAsia Interconnector) to enhance efficiency across grids. Also the ***EuroAsia Interconnector*** will allow each country to optimise renewable electrical energy capacity, particularly solar, so as to allow each country to move towards net-zero ***GHG***, and to minimise the need for non-renewable electrical energy.

The plan is reflected in a Memorandum of Understanding among the countries. It is anticipated that the ***EuroAsia Interconnector*** will have capacity of between 1,000 to 2,000 MW, with completion planned for 2024, with full operation by 2025. The ***EuroAsia Interconnector*** has been under consideration for a while, having been on the ***EU***'s Projects of Common Interest (***EPCIs***) since 2015.

See: *Greece, Cyprus and Israel take a further step to link their grids*

Eni and Cassa Depositi e Prestiti Equity in joint venture:

On March 11, 2021, it was announced that Eni SpA and Cassa Depositi e Prestiti Equity (***CDP Equity***) entered into a joint venture (called ***GreenIT***) to fund the development of 1 GW of renewable electrical energy projects across Italy. The equity interests in ***GreenIT*** are divided between Eni (51%) and ***CDP Equity*** (49%). The plan is for ***GreenIT*** to develop utility scale plants. ***GreenIT*** has the option of using government property (buildings and land) for the purpose of the joint venture. ***CDP Equity*** is the Italian sovereign wealth fund, administered by the government run investment bank - Cassa Depositi e Prestiti (***CDP***).

See: *Italian sovereign wealth fund joins forces with Eni to deploy 1 GW of solar and wind*

Agriculture, Forestry and Land Use:

Understandably there is a continued focus on the decarbonisation of energy production and energy use. This is because between 70 and 75% of ***GHGs*** arise from energy production and use. The use of renewable electrical energy sources has decarbonised energy use in part, and continues, to decarbonise electrical energy use, and increasingly it seems likely that Blue Hydrogen and Green Hydrogen will decarbonise use of energy carriers, and over time displace the use of fossil fuel (and other carbon intensive fuels).

The reduction of ***GHG*** arising from Agriculture, Forestry and Other Land Use (***AFOLU***) is going to be as important, but more difficult. From a report published on March 8, 2021, Nature Food, has developed a new global emissions database estimating ***GHG*** arising in the 25 years from 1990 to 2015. Ascribing ***GHG*** across the entire food system (direct and indirect emissions), it is estimated that 18 billion tonnes (18 Gt) of ***GHG*** arise each year from the food system, or 36% of total global ***GHG*** emissions (on the basis of 50Gt of ***GHG*** emissions). Of the 18 Gt of ***GHG*** emissions, 71% of which arise directly from agriculture and other land use (direct ***GHG***).

The balance (indirect ***GHG***) of the ***GHG*** arise from the "land to landfill" value chain, including processing and production, transportation to and from processing and production, packaging (including materials derived from hydrocarbons for that purpose), retail, and waste.

While these numbers and percentages may be on the higher side compared to other estimates and models, it is clear that between 20% and 25% of total global ***GHG*** emissions are arising directly from ***AFOLU*** each year.

There is increasing focus on the concept of negative ***GHG*** emission initiatives. At the same time, as many have seen coming for a while, a number of investors do not regard the use of carbon offsets as a sustainable tool for organisations to achieve net-zero emissions. This position is now reflected in new guidelines developed by a group of investors that includes the AXA Investment Managers, Brunei Pension Partnership, Legal and General and PIMCO.

Renewable energy and *BESS* news round-up:

- On March 9, 2021, French renewable energy giant Neoen announced its plan to develop a 500 MW solar, wind, and battery storage hub in the New England region of NSW (***The Thunderbolt Energy Hub***). ***The Thunderbolt Energy Hub*** will combine 120 MW of solar, 380 MW of wind, and 400 MW ***BESS*** (with the MWh yet to be finalised).

  The Thunderbolt Energy Hub follows the planned development by Neoen of the 500 MW Great Western Big Battery project to be located close to Lithgow, NSW. Both ***The Thunderbolt Energy Hub*** and the Great Western Big Battery are ideally located on the grid network.

  See: *Neoen adds huge Thunderbolt project to massive wind and solar pipeline in New England*

- As noted above, the Yallourn coal-fired power station in Victoria is to be closed by EnergyAustralia (one of Australia's big three integrated energy companies, with AGL Energy and Origin Energy), and EnergyAustralia is to develop the Jeeralang Big Battery (350 MW and 1,400 MWh) to be delivered in 2026, two years before the proposed decommissioning date for Yallourn. AGL Energy is understood to be planning a 500 MW ! 1,000 MWh ***BESS*** for Liddell (to close in 2023), 250 MW ! 1,000 MWh at Torrens (to close partially in 2023), and 200 MW ! 800 MWh for Loy Yang A. Origin Energy is progressing plans to install a 700 MW ! 2,800 MWh ***BESS*** at its Eraring coal-fired power station.

  It is clear that within the last five years the landscape of the Australian electricity grid system has changed in a manner no one could have predicted. The rate of change is expected to increase.

Battery Life is Good for LG:

On March 12, 2021, ***ROK*** chaebol, LG announced that over the next four years or so it will expand electrical production capacity in the US by 70 GWh, at a cost of USD 4.5 billion. Following this expansion, LG will have production capacity of 110 GWh. This expansion is responding to the growth in demand for pouch cell batteries, electrical energy storage systems and cylindrical cell EV batteries.

See: *Sunrise brief: LG plans massive U.S. investment in battery production for EVs and energy storage*

While this is big news of itself, the implications of the capacity growth are wide ranging in the medium and longer term. In an ideal world, policy makers will give consideration to the medium and long term benefits (and possible challenges) of EVs as a source of electrical energy for grid use (as is the case in certain areas of France at the moment).

The electrical energy stored in batteries, including Big Batteries and batteries located in buildings and in vehicles, has now become a possible, and in some parts of the world, a viable source of electrical energy to grid.

Solar and wind round-up:

- On March 15, 2021, the shortlisted bidders in the fourth round of large-scale photovoltaic solar (***Large Scale Solar or LSS***) in Malaysia were announced. The Malaysian Energy Commission has indicated that the lowest bid is at USD 0.0429 KWh. The tender was for 1 GW, with bids received for 823.6 MW, and as such, slightly under-subscribed. The lowest bid is in the 30 to 50 MW project capacity category. In the smaller, 10 to 30 MW category, the lowest bid is understood to have been at USD 0.049.

  See: *Malaysia's 1 GW PV tender attracts lowest bid of $0.0429/kWh*

- On March 15, 2021, it was reported that the tender for 1 GW of large-scale photovoltaic solar was more than eight-times oversubscribed, with 131 project proposals having aggregate capacity of 9.44 GW of installed solar capacity. The Turkish Ministry of Energy is running the tender process, with the applications currently under review as part of the pre-qualification process underway, leading to the final phase shortly.

  The tender process is intended to provide renewable electrical energy to 36 cities, with a spread of installed capacity from 50 MW (in each of Van, Antalaya, Gazinatep, and Mardi) to 30 MW (Uşak, Erzurum, Budur, Mersin, Osmaniye, Yozgat, Batman, Ağri, Askaray, and Adiyanam), with Ankara and Diyarbakir to 40 MW of new installed capacity. With the size of the projects in the remaining 21 cities varying;

  See: *Turkey's 1 GW PV tender more than eight times oversubscribed*

- On March 18, 2021, it was reported that Ørsted has commenced construction works at the 900 MW Greater Changhua 1 and 2a off-shore wind fields, with installation works likely within 2021. The off-shore wind fields are located 35 to 60 kilometres from the coast line of Changhua County on Taiwan's west coast. This is the first of Taiwan's off-shore wind field developments, with completion planned for 2022;

  See: *Offshore Installation Starts at Ørsted's 900 MW Wind Farm in Taiwan*

- In a research paper reported on March 17, 2021, it is anticipated that Poland will increase large-scale solar photovoltaic installed capacity by around 2 GW a year in each of the next five years, adding to the current 4.1 GW of installed large-scale solar photovoltaic capacity;

  See: *Poland to add another 11 GW of PV over the next five years*

- On March 17, 2021, it was reported that Spanish renewable energy giant, Iberdrola has contracted with Cosmo Eco Power to join, and to develop jointly with Cosmo Eco Power, the 600 MW Seihhoku-oki off-shore wind field project, off northwest Japan. It is noteworthy that this is the sixth off-shore wind project to which Iberdrola has committed over the last 12 months or so;

  See: *Iberdrola Joins 600 MW Offshore Wind Project in Japan*

- On March 14, 2021, the US Federal Government is reported to have released the final environment impact assessment (***FESI***) for the first large-scale off-shore wind field project in the US, the Vineyard Wind Project of the US East Coast, south of Cape Cod, east of Long Island. The ***FESI*** provides a positive assessment overall.
- On March 19, 2021, the Environment America Research & Policy Center and Frontier Group issued a report, Offshore Wind for America. The report concluded that the US off-shore wind resources have the potential to deliver 7,203 TWh of electrical energy a year. The projected electrical energy use of the US in 2050 is 7,930 TWh. The areas of off-shore wind resources identified by the report as most prospective are the Atlantic and Gulf regions. The report is timely in that it continues, and is likely to add momentum to, the development of what appears to be an as yet untapped world class resource base for the US.

  See: *Offshore Wind Could Meet Nearly All of US 2050 Electricity Demand – Report*

Blue Hydrogen round-up:

On March 18, 2021, BP announced a 1 GW Blue Hydrogen project to the be located on Teeside (***H2 Teeside***) and to be completed by 2030. The ***H2 Teeside*** project will be the largest Blue Hydrogen project in the UK, with the mass of hydrogen produced equating to 20% of the 5 GW of clean hydrogen production target for the UK. The ***H2 Teeside*** project will provide a means for the decarbonisation of energy production and use in the Teeside area, with the capture and storage of up to 2 mtpa of ***CO_2-e*** emissions, stated to be 5% of the UK's industrial ***GHG*** emissions. [**Note:** see Edition 22 of Low Carbon Pulse]

See: *bp plans UK's largest hydrogen project*

UK half way, and way ahead:

On March 18, 2021, it was reported that the ***GHG*** emissions arising in the UK are at 51% of 1990 levels, and at their lowest since 1879. In other words, the UK is half way to meeting its net-zero ***GHG*** emissions target by 2050. This is good news for the UK, and is good news for other countries because it shows that with appropriately calibrated policy settings, based on the science of climate change, it is possible to make progress towards net-zero.

While COVID-19 has accelerated the rate of ***GHG*** reduction, the underlying trend towards net-zero is well-established and strong. But, and there is always "a but", the UK experience shows that policy settings are required, and those policy settings must drive the reduction in ***GHG*** emissions, but, and this is the "really big but", the UK needs to do the same again, and to do so in the context of the more difficult to decarbonise activities and industries.

The UK is not resting on its laurels in respect of policy settings: Edition 11 of Low Carbon Pulse outlined the establishment of the ***UK Infrastructure Bank***. On March 17, 2021, the UK Government provided further specificity in respect of the intended focus of funding to decarbonise energy use in the Building (including schools and hospitals) and the Industrial sectors. Secretary of State for Business, Energy and Industrial Strategy, Mr Kwasa Kwarteng said: "*We were the first major economy to put into law our target to end our contribution to climate change, and today we're taking steps to be the first major economy to have its own law-carbon industrial sector*."

See: *Analysis: UK is now halfway to meeting its 'net-zero emissions' target*, *Government to announce £1bn fund to help reduce emissions*

Green Ammonia and Green Hydrogen round-up:

- On March 12, 2021, it was reported that Eco Energy World (already developing a 300 MW solar project in Queensland) is going to develop a 200 MW Green Hydrogen plant and a 100 MW energy storage facility at the Port of Gladstone, Queensland. This development will continue the transition at the Port of Gladstone from one of the world's largest export ports for fossil fuels (coal and natural gas, as LNG).

  So far the Port is working with sponsors in respect of the development of ***The H2-HubTM Gladstone*** facility, contemplated as a staged development of electrolyser capacity up to 3 GW, having production capacity of up to 5,000 per day of ammonia (***Hydrogen Utility project***).

  There are further plans from Sumitomo (250,000 to 300,000 metric tonnes) and Origin Energy to develop Green Hydrogen and ammonia facilities at the Port of Gladstone.

  While well before the start of the Low Carbon Pulse series, and as such not covered (until now), it is worth recollecting that a trial cargo of Green Hydrogen was shipped from Queensland to Japan in 2019. Like most Australian states, Queensland has world class solar resources (rich solar radiation and consistently long day-light hours, and the Port of Gladstone is an ideal location to develop hydrogen and ammonia production capacity).

- On March 18, 2021, it was announced that Origin Energy and POSCO (the leading ***ROK*** steel maker) are to cooperate to create a Green Hydrogen supply chain from Australia to ***ROK***. There is a theme that is starting to emerge - that the export market for Green Hydrogen does not have to be the finished product, in that customers are happy to view green ammonia as a feedstock for the production of Green Hydrogen, with Green Ammonia (***NH_3***) to be shipped, and Green Hydrogen derived at the country or to be imported as required.

  See: *Origin Energy and POSCO to Cooperate on Green Hydrogen*

Green Steel news round-up:

- Edition 11 of Low Carbon Pulse, H2 Green Steel (***H2GS***) reported that a "Green Steel" venture is to be undertaken in Boden-Luleå, Sweden, which, on development, will be the world's largest producer of Green Steel: on full development, the ***H2 Green Steel*** project will produce 5 mtpa of Green Steel, with 2.5 mtpa to be produced by 2026. The development cost of the ***H2 Green Steel*** project is estimated as €3.05 billion.

  In further news, it is apparent that the project is backed by, among others, Mr. Daniel EK (founder of Spotify), Scania and Vargas, and headed by Mr. Henrik Henriksson (Scania CEO), with investment banks Morgan Stanley, Societe Generale and KfW IPEX Bank as financial advisers.

  See: *Sweden's H2 Green Steel plant is $4bn green giant fuelled by hydrogen*

- On March 17, 2021, ArcelorMittal launched Xcarb, three initiatives forming part of its fulfilment of its commitment to net-zero ***GHG*** emissions by 2050: the initiatives consist of: Green Steel certificates (aimed squarely at Scope 3 emissions compliance in the context of steel produced using blast furnace technology), recycled and renewably produced steel (aimed squarely at steel produced from recycled steel using electric arc technology), and its innovation fund (aimed at developing technologies). These initiatives are of particular interest in the ***EU*** policy setting environment, and reflect the ever increasing focus of enterprises on Scope 3 emissions).

  See: *ArcelorMittal launches XCarbTM, signalling its commitment to producing carbon neutral steel*

- Edition 8 of Low Carbon Pulse (""*Runnin' down a dream*": *Aussie and US "rock" legends combine*") noted the plans of Fortescue Metals Group, established by Dr Andrew Forrest, AO, to develop Green Steelmaking capacity in Australia. These plans continue to develop, as does the rock them – "Another BRIC in The Wall".

  On March 17, 2021, it was announced that Fortescue Metals (through Fortescue Future Industries (***FFI***)) intends to develop the means to allow further Green Steel production, this time in Brazil, another iron ore producing country. ***FFI*** has signed an agreement with Port of Açu, Brazil, for the purposes of the development of a 300 MW Green Hydrogen plant to produce up to 250,000 tonnes of green ammonia a year. "*This will be the first Green Hydrogen plant in the country and will place FFI and Açu at the fore-front of clean energy production and green industrialization of Brazil*."

  See: *Fortescue to build second hydrogen plant*

Low Carbon Pulse - Edition 13

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to Edition 13 of Low Carbon Pulse – sharing significant current news on progress towards net-zero emissions globally. This edition covers the period from March 22, 2021 to April 4, 2021.

Here is a link to the second article in the Shift to Hydrogen (S2H2): Elemental Change series, titled *What needs to be decarbonised? And what role can hydrogen play?*

PRC to use mixed energy sources to generate electrical energy:

Over the last seven to eight months the strategy of the People's Republic of China (***PRC***) to achieve net-zero ***GHG*** emissions by 2060 has being taking shape. As is the case with other North Asian countries, the ***PRC*** is more "energy output driven" than it is "energy source driven". It is increasingly clear that the ***PRC*** is aiming to use a mix of lower-carbon and carbon-free electrical energy sources, including natural gas, hydrogen gas, renewable electrical energy (***REE***) and nuclear, while at the same time managing more carbon intensive sources of energy, critically, coal, in the medium to long term.

As part of this "energy output driven" strategy, the ***PRC*** is looking to retrofit coal-fired power station capacity to use hydrogen (and ammonia) as a fuel source. Most recent estimates indicate that the ***PRC*** is contemplating that up to 100 GW of hydrogen powered electrical energy (***HPEE***) will be installed by 2050, increasing to 200 GW ***HPEE*** by 2060. As is the case with Japan and South Korea, it is apparent that the ***PRC*** is agnostic as to the colour of hydrogen (and ammonia) used.

As noted in previous editions of Low Carbon Pulse, it is expected that gas-fired power station capacity will increase. Best current estimates are that by 2050, the ***PRC*** will peak at 330 GW of installed gas-fired capacity, which will decline to 2060 as the net-zero ***GHG*** emissions target is approached, and more ***HPEE*** and ***REE*** is installed, and ***GHG*** are removed from the atmosphere after 2060.

Finally, in respect of ***REE***, it is estimated that by 2050 and 2060 the ***PRC*** will have 3.2 TW and 3.55 TW of installed solar capacity, 2.2 TW and 2.5 TW of installed wind capacity, and 570 GW and 580 GW of hydroelectric power. With 200 GW and 250 GW of nuclear power by 2050 and 2060. Coal-fired power generation is to be phased out by 2060, and reach peak of 1.1 TW of installed capacity in 2025.

See: *China to adapt power generation to run on hydrogen*

Sinopec provides the gas, Great Wall provides the vehicles:

Sinopec is one of the world's largest producers of hydrogen (grey at the moment). Sinopec has developed hydrogen refuelling infrastructure (***HRI***) in Guangdong, Guangxi, Shanghai, and Zhejiang. By 2025, Sinopec plans to have increase its network of ***HRI*** to 1,000. Sinopec is committed to the increased production of hydrogen, to produce clean hydrogen (Blue Hydrogen and Green Hydrogen). By 2050, it is projected that the demand for clean hydrogen in the ***PRC*** will be around 60 mtpa. Sinopec is positioning itself to produce hydrogen (and ammonia) of all colours, and to distribute to ***HRI*** (see Edition 5 of Low Carbon Pulse – ***PRC + H2 = A year of development***).

On March 29, 2021, it was announced that Great Wall Motors is to launch Fuel Cell Electrical Vehicles (***FCEVs***) into the World's largest vehicle market, the ***PRC***. One of the vehicles is a 840 km range SUV. It is to be expected that municipal and provincial governments within the ***PRC*** will continue to support the development of the ***FCEV*** market, including for longer range, and heavier payload vehicles.

See: *Sinopec sets sights on hydrogen*

The Kingdom of Saudi Arabia (*KAS*) chilled about Blue *LHG*:

In 2020 the KAS, national oil company, Saudi Aramco, announced the development of the Jafurah shale gas project at an estimated cost of USD 110 billion. The Jafurah shale gas project resource is estimated at 200 trillion cubic feet of gas, with ***CH_4*** (methane) and ***C_2H_6*** (ethane) to be extracted from this world scale resource.

On March 22, 2021, Saudi Aramco announced that it was going to use methane (***CH_4***) from the Jafurah shale project to produce Blue Hydrogen, and either to liquefy that Blue Hydrogen (as ***LHG***) or to produce Blue Ammonia, or both, rather to liquefy the methane as LNG as had been contemplated previously.

The production of Blue Hydrogen (and Blue Ammonia from it) requires the capture and storage permanently of ***CO_2*** arising from either autothermal reforming (***ATR***) or steam methane reforming (***SMR***) of methane.

In Edition 2 of Low Carbon Pulse it was noted that Sabic and Mitsubishi Corporation shipped Blue Ammonia from the ***KAS*** to Japan. In Edition 12 of Low Carbon Pulse it was noted that it might be expected that the ***KAS*** and the ***PRC*** will continue to strengthen ties, including in respect of Blue Hydrogen and Blue Ammonia.

See: *Saudi Arabia Skips LNG, Bets Big on Hydrogen*

Hyundai Heavy and Saudi Aramco partner on heavy lifting:

On March 23, 2021, it was reported that Hyundai Heavy Industries is developing on-board carbon, capture and storage systems, and containment systems for new ***CO_2*** carriers, capable of carrying ***CO_2*** and LPG at the same time. The duel gas ***CO_2*** and LPG carriers are being developed in partnership with Saudi Aramco.

See: *Hyundai Heavy unveils slew of CO2 shipping projects*

Indonesia – it is a big numbers game:

It has been reported that Indonesia is considering committing to net-zero ***GHG*** emissions by 2070. As reported, it is considered that this commitment is achievable given the current level of development within Indonesia, but that it will be a challenge. At around about the same time as the reports on net-zero ***GHG***, it was reported (some may say that reporting re-emerged) that Indonesia is seeking to achieve net-zero plastic by 2040. The combination of the two net-zero targets indicates that Indonesia is committed to addressing emissions and pollution over the medium to longer term.

It is reported that on March 17, 2021, the Climate Change Management Director General, Ruandha Agung said: *"By 2050, we will start working toward the goal of net-zero emissions. Hopefully, Indonesia can reach the goal by 2070*."

As is the case with India (reported in Edition 12 of Low Carbon Pulse), ahead of ***COP-26***, to be held in Glasgow, Scotland, from October 31, 2021, Indonesia is likely to come under pressure to commit to net-zero ***GHG*** emissions formally, and probably sooner than 2070.

As with India, it would be a great outcome if Indonesia were to commit to achieving net-zero ***GHG*** sooner than 2070, but in doing so, it would be even better if developed countries were to commit to provide support to Indonesia to achieve net-zero ***GHG*** emissions.

(By the end of Q4 2021, the Global Ashurst Towards Zero Emissions team will publish a longer form article on the policy settings around plastics across ASEAN, including Indonesia.)

See: *Indonesia mulls net-zero emissions target by 2070*

President Joko Widodo of Indonesia is one of the 40 world leaders invited to the Leaders' Summit convened by US President Joe Biden for April 2021.

Biden invites world leaders to climate summit on April 22 and 23:

On March 26, 2021, it was announced that President Joe Biden is to host a Leaders' Summit on Climate Change. The Leaders' Summit will be virtual, and will be streamed live.

The announcement of the Leaders' Summit noted that: "**By the time of the Summit, the *United States* will announce an ambitious 2030 emissions target as its new Nationally Determined Contribution under the Paris Agreement**".

The key themes for the Leaders' Summit are to include, galvanising efforts during the next decade to limit global warming to the ***Stretch Goal***, mobilising public and private sector finance to allow achievement of net-zero ***GHG*** emissions, the economic benefits of progress toward net-zero, and encouraging technology innovation and development.

This is a positive development, and is consistent with narratives, and clarity of thought emerging, in respect of the need for all developed countries to do more by increase ***GHG*** reductions ahead of 2030. Achieving the ***Stretch Goal*** is possible, but capital needs to be deployed now to achieve a 7.5% to 10% compound rate of increase in renewable electrical energy capacity to be certain of achieving this.

Also it is hoped that during 2021 developed countries commit to the provision of support to enable developing countries to increase their ***GHG*** emission reductions, in particular Pakistan, India, Bangladesh, Sri Lanka and Indonesia.

PARIS AGREEMENT GOALS	
Stabilisation Goal	to hold the increase in global average temperature to well below 2˚C above pre-industrial levels
Stretch Goal	to pursue efforts to limit the temperature increase to 1.5˚C above pre-industrial levels

See: *President Biden Invites 40 World Leaders to Leaders Summit on Climate*

Taqa on Track:

On March 31, 2021, ***Taqa*** (the Abu Dhabi National Energy Company) announced plans to develop 27 GW (12 GW domestically, 15 GW globally) of renewable electrical energy by 2030.

Taqa Group Chief Executive and Managing Director, Jasim Thabet, noted that the objective of Taqa is "to become a champion for low carbon power and water".

Nuclear as part of energy transition to net-zero:

There continues to be a strong narrative around the use of nuclear energy in progress towards net-zero, both for and against. At the moment, it is clear that the European Commission (***EC***) continues to grapple with the use of nuclear energy, in particular whether nuclear energy will be considered as sustainable for the purposes of being entitled to various benefits under European Union (***EU***) law.

If nuclear energy is included in the taxonomy of the European Union (***EU***) as sustainable, it will qualify for financing, and other, benefits, subject always to compliance with environmental requirements.

See: *EU experts to decide nuclear power qualifies for green investment label-document*

Corporations in transition:

It is clear that at a macro level, and at a micro level, climate change is existential. A clear manifestation of this is the transition of *International Oil Companies* to *International Energy Companies*. In this context, there is recognition of a new concept of "reservoir to bowser", and the need to develop renewable electrical energy, and in due course, hydrogen, businesses.

Over the last couple of weeks, two venerable names in different industries and sectors have announced a change in the nature of activities to be undertaken by them:

- First, Coal India Limited (***CIL***), the world's largest coal miner, announced on March 25, 2021, that it is invest in a joint venture to develop 3 GW of solar energy, and other clean power projects. ***CIL*** is to joint venture with state-owned enterprise ***NLC India*** in this enterprise. The enterprise is to compete in tenders for solar and other clean power projects. The scale of coal use in India and production by ***CIL*** indicates the road to be travelled: India uses about 1 billion tonnes of coal a year, with ***CIL***'s production being in the region of 710 mtpa. India plans to have 175 GW of installed renewable energy capacity by the end of 2022, and 450 GW by 2030.

  See: *World's biggest coal company bets on solar power*

- Secondly, Wilhelmsen Group (***WG***) has established a new division to its business, New Energy. The establishment of New Energy mirrors the transition that *WG* CEO, Mr Thomas Wilhelmsen sees coming: "*In the next few decades, we will see a shift from oil and gas to renewable energy. The speed of change and investments needed, requires a dedicated focus to capitalise on the opportunities which will arise*".

  The perspective of Mr Wilhelmsen echoes the perspective of policy makers around the globe, and, increasingly, the perspective of institutional and private equity investors: the change that is upon the global energy sector, and as such upon all energy users, represents opportunity of a scale that has not been seen since the industrial revolution.

  See: *Shipping major Wilhelmsen switches focus to renewables*

Climate Action 100 + wants +++ climate action:

In previous editions of Low Carbon Pulse, the increasing focus of investors on net-zero ***GHG*** emissions, and how corporations are going to achieve net-zero ***GHG*** commissions consistent with the Paris Agreement has been noted (see Editions 3, 9 and 12 of Low Carbon Pulse).

On March 23, 2021, the investor group ***Climate Action 100+*** (comprising 575 leading investors globally, including the world's two largest, BlackRock and State Street) reported on leading corporations' progress.

As might be expected, the report concluded that as yet no corporation surveyed for the purpose of the report has "earmarked" sufficient capital to meet ***GHG*** reduction commitments consistent with net-zero ***GHG*** emissions by 2050. As noted above, capital needs to be deployed to achieve the ***Stretch Goal***.

The survey results are not surprising, and to many the purpose of the report has been achieved – clear identification by ***Climate 100 +*** that capital needs to be deployed by corporations now.

Increasingly the capital flows of investors will drive the need for increased capital deployment by corporations, and with this there will be convergence of the expectations of the members of ***Climate 100 +*** and capital deployment of corporations surveyed for the report.

See: *Climate Action 100+ investor group calls on the world's biggest polluters to lift their game*

Sustainable financing from the World Bank / IFC:

It is understood that the World Bank and its associated organisations are considering new policies for funding and support, including for energy projects. The International Finance Organisation (***IFC***) and the Multilateral Investment Guarantee Agency (***MGA***) are reported as planning to align to the net-zero ***GHG*** outcomes of the Paris Agreement in respect of new direct financing, as to 85% by July 2023, and as to 100% by July 2025.

Among other things, the Paris Agreement contemplates "making finance flows consistent with a pathway towards low greenhouse gas emissions (the Stabilisation and Stretch Goals and net-zero) and climate-resilient development" (see Article 1(c)).

See: *World Bank plans climate shift but no fossil fuel halt: Report*

The darkest hour is before the dawn:

Whenever a new publication or report places an estimated cost on energy transition, it tends to grab a headline or two. The Global Ashurst Towards Zero Emissions team does not report on each cost estimate, first, because the cost estimates are best understood by those that have developed them, and secondly, the bases of estimates tend to be many and varied.

The reported fact is that the world is, on average, 1.1˚C warmer now than it was in 1850. If ***GHG*** emissions continue at the current rate of progress, by the end of the 21st century, the world will be considerably warmer than the ***Stretch Goal*** under the Paris Agreement.

On March 16, 2021, ***IRENA*** issued a publication that is preview to a longer form publication. The preview to the ***World Energy Transitions Outlook*** (titled ***"Preview to World Energy – Transitions Outlook – 1.5˚C Pathway"***), is helpful. What is most telling from the Preview is the scale of the development of renewable energy capacity required to achieve the ***Stretch Goal*** under the Paris Agreement, i.e., limiting the rise in global temperature to a 1.5˚C increase compared to pre-industrial levels.

What appears to have caught the imagination of a number of commentators is the estimated cost of achieving the scale of development of renewable energy capacity. For other commentators, it is both the cost of doing so, and who is going to pay for this development that is of interest. Ultimately the discussion best had is the one that ***IRENA*** is promoting: "What needs to be done? How best to do it?".

As is the case on the publication of the ***IEA***'s ***The World's Roadmap to Net Zero by 2050***, the Global Ashurst Towards Zero Emissions team will report on the ***IRENA*** full-form publication following its release.

Another Hydrogen Valley:

It would seem that each country with a Hydrogen Plan, Roadmap or Strategy, has or is going to have a hydrogen valley or a hydrogen corridor. On March 24, 2021, it was announced that Italy is to develop its first hydrogen valley.

As is the case in other countries, the involvement of Government is key, with ***ENEA*** (the National Agency for New Technologies, Energy and Sustainable Economic Development) integral. The purpose of establishing the valley is to cluster organisations to develop a national supply chain for the production, transportation, storage and use of hydrogen: the Government will fund the development of a campus to house those involved in the project. The role of ***ENEA*** includes engaging organisations (including corporations, research institutions and universities) contractually on tasks.

See: *Plans unveiled for Italy's first hydrogen valley*

Solar round up:

- On March 23, 2021, it was announced that work has commenced on the AUS 768 million, 720 MW / 400 MWh solar storage New England Solar Farm (comprising 2.4 million solar panels, and 150 power conversion units and lithium Battery Electrical Energy Storage (***BESS***)).

  The New England Project has been described as Australia's largest hybrid solar ***BESS*** project to date. The Project developer UPC / AC Renewables Australia has commended the support of the local community and landowners for the Project to allow it progress over the last three years.

  See: *Work begins on 720 MW / 400 MWh solar+storage project in Australia*

- On March 23, 2021, it was reported that the use of floating solar photovoltaic panels on canals in California is viable. Floating PV on waterways is being used successfully in India. It is to be expected that PV panels on canals (and waterways) will be used increasingly, especially in countries, and regions of countries, with higher ambient temperatures.

  See: *Solar canals already competitive with ground-mounted PV*

- On March 23, 2021, it was reported that Sunseap Group has commenced operations of its floating photovoltaic solar farm in the Strait of Johor. For the island state of Singapore, the use of the waters around its coast offers accretive renewable electrical energy supply. Sunseap Group continues to maximize opportunities for renewable electrical energy generation across (and around) Singapore, including through world scale roof-top solar installations.

  See: *Singapore now home to one of the world's largest floating solar farms*

- On March 30, 2021, it was reported that Plug Power plans to develop a Green Hydrogen production plant in Pennsylvania using renewable electrical energy supplied by renewable energy giant Brookfield Renewable from its Holtwood hydroelectric facility. Plug Power anticipates that the plant will commence production by the end of 2022, with the plant to produce up to 15 tonnes of Green Hydrogen a day.

  Low Carbon Pulse has reported on Plug Power's business development previously, most recently in Edition 11 of Low Carbon Pulse in respect of the planned 120 MW electrolyser to be located at ***STAMP*** in New York.

  The development of the Green Hydrogen production plant in Pennsylvania continues Plug Power's plans to be producing 500 tonnes of Green Hydrogen a day by 2025.

  See: *Hyundai Heavy unveils slew of CO_2 shipping projects*

- Low Carbon Pulse has covered the USD 26 billion Newcastle Waters Station in Australia's Northern Territory since the announcement of its development by the Sun Cable consortium. On March 31, 2021, it was reported that the approvals process for the development of what will be the world's largest photovoltaic solar farm is continuing, with an associated development application having been lodged for the first phase of the solar manufacturing and assembly facility.

  From various reports, whether or not the project will produce Green Hydrogen and Green Hydrogen using renewable electrical energy from the project or export that electrical energy to Singapore through a submarine interconnector is a matter that appears to be being kept open.

  See: *Sun Cable submits plans for gigawatt-scale solar manufacturing plant in Darwin*

- On April 1, 2021, it was reported by Tenergie that its first photovoltaic 33,000 m_2 greenhouse in the Bouch-du-Rhone region of France, with installed capacity of 2.1 MW, has achieved high yields on higher value food, and generated 3.1 GWh of renewable electrical energy since established in 2017. The use of photovoltaic solar in higher-value crop farming appears likely set to continue, and to expand, both in France, and in other countries.

  See: *French photovoltaic greenhouse delivers 3.1 GWh and 4 tons/hectare of asparagus in one year*

Wind round up:

- On March 22, 2021, Australia's first off-shore wind field project – the 2 GW Star of the South (***SOTS***) Project (owned in part by Danish infrastructure and renewable energy giant Copenhagen Infrastructure Partners) - outlined the route of the interconnector from the location of the ***SOTS*** (off-the south coast of Gippsland, Victoria) to connect with the NEM, involves "making landfall" at Reeves Beech. Australia is not known for off-shore wind field project development, but the Bass Strait (between Victoria and Tasmania), has world class off-shore wind resources.

  See: *Australia's first offshore wind project reveals underground transmission route*

- On March 23, 2021, it was reported that off-shore wind field resources in the Gulf of Mexico are sufficient to provide Texas (the ***Lone Star State***) with over 150% of its electrical energy demand. As noted in Edition 10 of Low Carbon Pulse, the answer to the recent challenges faced by the ***Lone Star State*** is to increase the renewable electrical energy generation from wind. The off-shore wind fields of the Gulf, provide the State with an ideal opportunity to do this.

  See: *Offshore wind 'could deliver 166% of Texas power'*

- On March 24, 2021, it was announced that RWE (the German renewables electrical energy giant) has made a positive final investment decision to develop its 1.4 GW USD 4.1 billion Sofia off-shore wind field in the UK (the ***Sofia Project***). The Sofia Project is to start on-shore work in Q2 of 2021, with off-shore work to construct expected to proceed during 2023, with completion scheduled for Q4 of 2026. RWE was awarded a "contract for difference" for the Sofia Project in 2019, at a strike price of GBP 39.65.

  Chief Commercial Officer of RWE Renewables noted that the Sofia Project would help deliver on the ***40 by 30*** ambitions of the UK (see Edition 1 of Low Carbon Pulse).

  See: *RWE Sanctions Development of 1.4 GW Sofia Offshore Wind Farm*

  On March 29, 2021, further progress was reported with Sembcorp Marine and GE Renewable having won electrical transmission works valued at USD 826 million for the Sofia Project.

  See: *Sembmarine and GE land $826m deal for one of world's largest wind farms*

- In Edition 8 of Low Carbon Pulse noted that the Crown Estate Scotland had opened the process for applications for ScotWind seabed leasing. In Edition 9 of Low Carbon Pulse, the successful bids received by the Crown Estate and UK Treasury were reported.

  As a result of the level of the successful bids for leases in the waters around England and Wales, the Crown Estate Scotland increased the cap per square kilometre for bids. The cap was increased from GBP 10,000 and GBP 100,000 per square kilometre for seabed leases. With 8,600 square kilometres under tender, if the caps are reached, the Crown Estate Scotland is set receive tender responses in an amount equal to GBP 860 million. The proceeds of the tender are payable directly into consolidated fund for Scotland, and as such available for public expenditure in Scotland. [**Note:** see Edition 22 of Low Carbon Pulse]

  See: *Scottish* seabed windfarm auction set to bring in £860m

- On March 30, 2021, it was reported that Equinor's ***Hywind project***, 15 miles off Aberdeen, has broken records for maximum output from an off-shore wind field. ***Hywind*** uses floating off-shore wind technology, in some of the most storm prone waters off Scotland. The floating wind technology is awe-inspiring in its dimensions - 75 metres of the superstructure submerged beneath the water, and 175 metres above the water, with the blades being 154 metres in diameter. Given the success of ***Hywind*** it is reported that Equinor is looking for opportunities to continue to deploy the technology.

  See: *Roaring success of Scottish windfarm shows global potential*

- On March 31, 2021, it was reported that the first off-shore wind field is being planned for The Philippines. Triconti ECC, comprising Philippine, Swiss and German interests, is reported as having undertaken feasibility studies for up to 1.2 GW of off-shore wind field capacity in Aparri Bay (northern Philippines) and the Guimaras Strait (central Philippines).

  See: *Philippines to build first offshore wind farm*

- On April 1, 2021, Ørsted (global renewable energy giant) announced plans to develop a 2 GW off-shore wind field to provide electrical energy to 1 GW of electrolyser capacity (to be developed in two equal phases of 500 MW), which would then deliver Green Hydrogen to industrial users though hydrogen pipelines in Belgium and the Netherlands (***SeaH2Land project***).

  The production of Green Hydrogen would provide Green Hydrogen to ArcelorMittal, Dow and Yara. While a final investment decision remains to be taken, as currently contemplated it is planned that the ***SeaH2Land Project*** will be producing Green Hydrogen by 2030.

  See: *Ørsted to link a huge offshore wind farm to 'renewable' hydrogen production*

- In Edition 12 of Low Carbon Pulse the potential of off-shore wind in the US was described. As foreshadowed in Edition 7 of Low Carbon Pulse, the Biden Administration has announced a plan to expand the development of offshore wind capacity, with 30 GW contemplated by 2030 (***30 by 30***). This is good news, but this alone is not going to achieve the clean electrical energy target by 2030.

To accompany this news, and to facilitate the development of ***30 by 30,*** the Energy Department is committed to the provision of USD 3 billion in loan guarantees, and the Interior Department has identified a "Wind Area" from Long Island to the New Jersey coast. (The US has approximately 120 GW of on-shore installed wind capacity.)

Vineyard Wind 1 project (the first of the large-scale off-shore wind field) has appointed DEME to transport and to install wind turbines for the project. The Vineyard Wind 1 project is being developed by Vineyard Wind, a joint venture between Avangrid Renewables, and, world infrastructure and renewable electrical energy investment giant, Copenhagen Infrastructure Partners.

See: *Biden administration announces plan to expand wind power*

Green Hydrogen (and ammonia and methanol) roundup:

- Edition 10 of Low Carbon Pulse (***Brazilian government and industry caucus around Green Hydrogen Hub***) outlined developments in respect of the USD 5.4 billion Enegix Energy project (***Base One Project***). Enegix Energy has provided further details as to the scale of the ***Base One Project***, critically that the project is to produce 600 million kg (or 6 million tonnes) of Green Hydrogen a year from full operation in 2025. To provide electrical energy for the ***Base One Project***, Enegix Energy is contemplating 3.4 GW of renewable electrical energy (solar and wind).

  See: *$5.4 Billion Project Aims to be World's Largest Green Hydrogen Producer in 2025*

- On April 2, 2021, it was reported that the proposal for funding from the European Union (***EU***) for the Wacker Chemie AG (***Wacker***) Green Hydrogen and renewable methanol is progressing (the ***RHYME Project*** **r**enewable **hy**drogen and **me**thanol). ***Wacker*** intends to develop a 20 MW electrolyser plant with Linde GmbH, and to use H_2 and CO_2 to derive renewable methanol. Both the Green Hydrogen and the renewable methanol will be used as feedstock in chemical production by ***Wacker***. The funding sought for the ***RHYME project*** is from the ***EU*** Innovation Fund (to provide funding until 2030): the ***EU*** set aside a €10 billion fund to support innovative technologies.

  See: *WACKER and Linde Project for Generating Green Hydrogen Reaches Next Selection Stage for **EU** Funding*

Northern Europe Clean Hydrogen Coastline:

In Edition 12 of Low Carbon Pulse (under "***Hydrogen Republic of Germany***") lauded "as a case study in planning and integration" plans of the City of Hamburg (including the port, connected to the North Sea by the Elbe River) for the ***Hamburg Hydrogen Industry Network*** (***HH-WIN***), and the integration of those plans with those of Bremen, Lower Saxony, Macklenburg-Western Pomerania and Schleswig-Holstein, and the development of 500 MW of electrolyser capacity by 2025.

On March 24, 2021, a number of major industrial companies (including EWE, ArcelorMittal and FAUN Group) in Northern Germany announced plans to develop a network, spanning the Dutch, German, and Danish coastline, to develop an integrated hydrogen network (***Clean Hydrogen Coastline***) comprising 400 MW of electrolysers and storage by 2026.

In two line simple sentence CEO of steel manufacturer ArcelorMittal, Mr Reiner Blackscheck sums up what is required for industrials (including in Difficult to Decarbonise Industries) to transition of Green Hydrogen: *" … the transformation process [requiring] the technology change in order to use Green Hydrogen in production. To do this, we need a functioning supply of hydrogen at economic costs so that we can keep the Bremen steel location competitive over the long term".*

To provide demand for "a functioning supply of hydrogen", ArcelorMittal plans to invest up to USD 1.4 billion to develop both a direct reduction iron ore (***DRI***) facility (using natural gas (predominantly CH_4) as the reducing gas in the first instance until the provision of Green Hydrogen from across the ***Clean Hydrogen Coastline*** network), and an electric arc furnace (***EAF***).

The sponge iron******* produced at the ***DRI Facility*** will be used the ArcelorMittal's Bremen and Eisenhuttenstadt steel mills. EWE and FAUN plan to develop ***HRI*** to provide further demand for the functioning supply of hydrogen.

The need for supply and demand to develop in tandem is critical. Germany and Japan (at government and corporate level) have a particular focus on this, and how to achieve it.

See: *$1.5bn plans unveiled to integrate hydrogen into the northwest German coastline* and *ArcelorMittal to transition two German steelmaking plants to Green Hydrogen*

The integrated hydrogen network may be regarded as consistent with the plans outlined in a publication titled "European Hydrogen Backbone" outlined "*How Dedicated Hydrogen Infrastructure Can Be Created*". The Publication was sponsored by Enagas, Energinet, Flyxys Belgium, Gasunie, GRTgas, NET4GAS, OGE, ONTRAS, Snam, Swedegas, and Terega.

Direct Reduction Iron** (DRI***) aka **Sponge Iron**: iron ore that is subject to a direct reduction by using a reducing gas (at a high-heat temperature).

Pig Iron: iron ore that is subject to melting with charcoal (derived from coking coal) and limestone.

Lacq Hydrogen Project – no lack of ambition:

On April 2, 2021, plans were announced to develop and to deploy 6,800 km of pipeline across Europe by 2030, and a 22,900 km hydrogen network across Europe by 2040. The development and deployment would accelerate the development of the Green Hydrogen industry in Spain: the Aragon region of Spain would provide renewable electrical energy from world class solar resources to produce Green Hydrogen.

See: *Huge Franco-Spanish hydrogen project set create Green Hydrogen infrastructure*

Green steel round-up:

- On March 18, 2021, the ***WindH2*** project started operations in Germany. ***WindH2*** is an association of leading corporations: steel giant Salzgitter, Avacon (a subsidiary of E.ON) and Linde (world leading industrial gases corporation). The project involves the use of wind-power to produce renewable electrical energy using seven turbines provided by Avacon installed on the Salzgitter site, providing 30 MW of installed renewable energy capacity. This renewable electrical energy will be used to power two PEM electrolysers to derive Green Hydrogen, with the Green Hydrogen used in the Salzgitter Low ***CO_2*** Steelmaking technology. Linde will continue to supply hydrogen.

See: *Salzgitter, Avacon and Linde commission WindH2 project*

- On March 24, 2021, it was announced that ***HYBRIT*** is to develop a new Green Steel mill in Gallivare, Sweden, to produce fossil-free sponge iron (also known as direct reduction iron). The Gallivare Green Steel mill will have a total steel-making capacity of 2.7 million metric tonnes per annum by 2030. The Gallivare Green Steel mill will join the pilot Green Steel mill at Lulea that has proved up the technology. In addition, there are plans to develop an underground storage facility to store Green Hydrogen.

  The project is part of an integrated supply chain, from "mine-to-mill-to-manufacturer", among the ***HYBRIT*** partners (LKAB, SSAB and Vattenfall), to transform their respective businesses: for LKAB as the supplier of iron ore, SSAB as the steel mill owner and operator, for Vattenfall as a producer, and retailer, of electrical energy and heat, and the producer and supplier of Green Hydrogen. (Vattenfall is ultimately a Swedish state-owned company.)

  Hybrit Development AB, owned by LKAB, SSAB, and Vattenfall, was established to develop technology to enable the production of steel using hydrogen, rather than coal. Significant support has been provided by the Swedish Energy Agency, through Industriklivet.

  See: *HYBRIT: SSAB, LKAB and Vattenfall to begin industrialization of future fossil-free steelmaking by establishing the world's first production plant for fossil-free sponge iron in Gällivare*

Progress to Green Steel and scale in Green Hydrogen:

In previous editions of Low Carbon Pulse, it has been noted that the supply of Green Hydrogen to the steel industry, both self-sourced and third party sourced, is likely to result in the accelerated development of the Green Hydrogen industry: the scale of use of Green Hydrogen in the Green Steel industry will allow scale to be achieved in production, with an established demand side (for Green Steel production), allowing decisions to be made to produce more, or to have capacity to produce more, Green Hydrogen (see Edition 5 of Low Carbon Pulse).

This narrative is being developed by the European Green Hydrogen Acceleration Center (***EGHAC***) which was established with the assistance of EIT InnoEnergy and Breakthrough Energy. EIT InnoEnergy has now played a role in the ***H_2*** Green Steel Initiative. (see Edition 11 of Low Carbon Pulse).

In an interesting article in the **environment journal**, the benefit for the development of the Green Hydrogen industry of the focus on the Difficult to Decarbonise Industries is explained cogently. "*To build organically the existing chain to produce Green Hydrogen would take years. Recognising that the world simply does not have that time…*" Green Steel can underpin supply.

See: *How the pull of Green Steel can make Green Hydrogen competitive*

The nomenclature of *BESS*:

While most readers will know the nomenclature of Battery Electrical Storage Systems (***BESS***) some may not.

In Low Carbon Pulse when referring to ***BESS***, MW and MWh figures are used to describe the size of the ***BESS***: the MW figure describes the maximum output of the stored electrical energy of the ***BESS***, and the MWh figure describes the period MWh in storage, for example, 100 MW, and 100 MWh indicates that at the maximum output the ***BESS*** can deliver 100 MWh for an hour, in contrast to 100 MW and 400 MWh indicates that at maximum output the ***BESS*** can deliver 100 MWh for 4 hours.

As is becoming increasingly apparent, as ***BESS*** use is increasing, the higher each number, and the quicker the response time, the better from a grid integrity and stability perspective. Hence "Big Batteries".

In the recent ***Energy Storage Summit USA 2021***, these issues were discussed, as were the factors that will inform the size of ***BESS*** by location, including the energy density per square kilometre. In this context, "long-range" ***BESS***, having capacity to supply for over 6 hours, is likely to be used less in areas of higher energy density than areas of lower energy density because in areas of higher energy density land use and value is likely to be at a premium. Given these dynamics, it is apparent that a broad range of multi-faceted ***BESS*** solutions are likely to be developed, on grid, and off-grid, at meter, and behind the meter, including micro-grids.

In this brave new world of ***BESS***, ***BESS*** storage of 10/12/24 hours is being contemplated for business users, and up to ***72*** hours for telecommunications companies, including to guard against the consequences of land-borne weather events.

See: *Long-duration storage: multitude of solutions set to step up to the plate*

The possible use of Fuel Cell Storage Systems:

Like issues arise for data centres. Currently the last resort of background power for data centres tends to be diesel generation sets. It has been reported that Microsoft is considering (including undertaking research on) the use of hydrogen fuel-cell technology as an alternative to diesel generation.

The work that Microsoft is continuing to do is consistent with its commitment to be carbon negative by 2030, i.e., Microsoft is committed to the removal of more ***GHG*** emissions from the atmosphere than the mass of ***GHG*** emissions arising in real time from its activities, and if Microsoft's plans eventuate, overtime to remove a greater mass of ***GHG*** emissions than ***GHG*** emission arising from its activities since its establishment (see Edition 2 of Low Carbon Pulse).

See: *Microsoft: Hydrogen fuel cells will enable data centers to completely rethink electrical systems*

Hydrogen from waste and waste water:

On March 31, 2021, it was announced that ***Pure Hydrogen*** and ***Wildfire Energy*** have agreed to develop a new facility to derive hydrogen from waste (***H2fW plant***) in Queensland, Australia. It is contemplated that the ***H2fW plant*** will produce up to 1,500 kgs of hydrogen a day. The ***H2fW plant*** is to use ***Wildfire Energy***'s Moving Injection Horizontal Gasification (***MIHG***) process. At the moment it is understand that the hydrogen will be cooled and compressed for delivery to customers.

See: *New Australian waste-to-hydrogen plant unveiled that will produce 1,500kg per day*

On March 30, 2021, it was announced that ***Ways2H*** and ***Japan Blue Energy*** have completed the development of a waste water facility (located at the Sunamachi Water Reclamation Centre, Tokyo) that derives hydrogen from waste water sludge. Between 45 to 50 kg of hydrogen will be derived each day: one tonne of waste water sludge yields 45 to 50 kg of hydrogen. The hydrogen will be used for ***FCEVs***.

In May/June 2021, the Global Ashurst Towards Zero Emissions team will publish the first of a series of features on hydrogen for industry (***H24I*** series).

Net-zero *GHG* emission commitment update:

It is estimated that close to 1,500 corporations globally have committed to achieving net-zero ***GHG*** emissions. Depending on the carbon footprint of any individual corporation, comprising its Scope, 1, 2 and 3 emissions, the means of achieving this commitment will vary from straight-forward to complex. The means of decarbonising a footprint for each corporation is different and distinct, and it is likely to change over time.

As a general statement, there are three ways to progressing to net-zero ***GHG*** emissions: first, decarbonising the activities undertaken by a corporation, including ***GHG*** emissions arising from its own activities, and decarbonising production and use of goods and services provided by it, secondly, using carbon-off-set mechanisms (most typically, using a carbon sink to sequestrate carbon arising, directly and indirectly from the activities of the corporation); and thirdly, using capture and storage of ***CO_2*** permanently (***CCS***) or capture and use of ***CO_2*** (***CCUS***) in respect of the emission of ***CO_2*** arising from both their activities or the activities of their suppliers, for example electrical energy generation using fossil fuel and other carbon intensive sources and any process from which ***CO_2*** arises, including cement production, chemical and petrochemical production, and iron and steel production (the ***Difficult to Decarbonise Industries***).

Leaving to one side the regulation versus a carbon price debate (as noted in Edition 12 of the Low Carbon Pulse) typically a carbon price is achieved by imposing a carbon tax and introducing an emissions trading scheme, sometimes a carbon tax only. The introduction of a carbon price, will send price signals, and, if the basis of the carbon price works effectively, the carbon price will signal transition to lower or low, or no, carbon options.

At least in part, the carbon price (and as a result the carbon tax and emissions trading scheme), needs to be set to reflect the estimated costs, direct, and indirect, overtime, of the emission of ***GHG***s. In a recent paper, Mr Matthew Kotchen (an economist at Yale University) has calculated that the cost of the production and use of fossil fuels in the US economy is in the region of USD 62 billion a year. While each bases of the determination of a carbon price is subject to considerable debate, as a basis for discussion, Mr Kothchen's analysis appears sound.

See: *Fossil fuel companies get $62B a year in implicit subsidies, economist reports*

SCOPE OF *GHG* EMISSIONS	
Scope 1	***GHG*** emissions arising directly from activities and assets controlled or owned by the corporation.
Scope 2	***GHG*** emissions arising indirectly from supply of energy to the corporation, including electrical energy and heat by the corporation.
Scope 3	***GHG*** emissions arising indirectly in the supply chain of the corporation, including supply of energy.

To illustrate Scope 2 and 3 emissions, set out below is recent news:

- **Scope 2**: It has been reported that Volkswagen Group (***VAG***) is well on the way to achieving its target of deriving 100% of the electrical energy load of its European fabrication and manufacturing plants by 2023. In 2020, the *VAG* increased its renewable load from 80% to 95%.

  See: *Volkswagen's European Factories Up to 95% Powered by Renewables*

- **Scope 3:** It has been reported that the 110 suppliers of components and equipment, and fabricating and manufacturing contractors, of Apple, Inc are progressing towards 100% renewable electrical energy to the extent that their activities relate to the production of Apple components and products. What this means is the approximately 8 GW of electrical energy capacity is required to enable Apple, Inc to address its Scope 3 emissions, thereby contributing to achieving Apple's commitment to carbon neutrality by 2030. The Global Ashurst Towards Emissions team is seeing an increased focus of ***Scope 3*** emissions across many supply chains.

  See: *Apple's suppliers embrace renewable energy*

Rubber hits the road:

On April 2, 2021, Ford made an announcement in respect of each of its Scope 1, 2 and 3 emissions, with the commitment to reduce Scope 1 and 2 to 76% of 2017 emissions by 2035, and Scope 3 to 50% of 2019 emissions by 2035.

See: *Ford announces new carbon neutral targets*

(See Edition 3 of Low Carbon Pulse under ***World Business Council on Sustainable Development*** **and** ***Equinor announces its own road map to 2050 net-zero target – "every step of the way"***.)

Sweden on the move:

In addition to being an early mover in Green Steel, Sweden has reached 1 GW of installed photovoltaic renewable electrical energy capacity, and PowerCell continues to develop 100 kw fuel cell systems for use in agricultural equipment manufacturer.

See: *Sweden hits 1 GW milestone*

Publication round up:

- **Wind industry on track to install 1 TW of capacity by 2030:**

  In a recent Wood Mackenzie paper estimates that the wind industry will install 1 TW of renewable electrical energy capacity.

  See: *Global wind power installations hit record levels in 2020*

- **Net-zero stock take:**

  On March 23, 2021, the Energy & Climate Intelligence Unit published ***"Taking Stock: A global assessment of net zero targets - Scrutinising countries, states, and regions cities and companies"***.

  See: *Taking stock: A global assessment of net zero targets*

Both publications provide interesting insights.

Low Carbon Pulse - Edition 14

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to Edition 14 of Low Carbon Pulse – sharing significant current news on the progress towards net-zero emissions globally. This edition covers the period from April 5, 2021 to April 18, 2021. It is likely that Edition 15 will be published early next week to pick-up news arising from the Leaders' Summit on April 22 and 23, 2021.

Please click here for the previous edition of Low Carbon Pulse. To access the first two articles in the ***Shift to Hydrogen (S2H2): Elemental Change*** series click here and here.

GHGs concentrations increased in 2020:

In Edition 5 of Low Carbon Pulse it was reported that it was predicted that there would be a decrease of 7% in ***GHG*** emissions arising in 2020. As a result of this decrease, many may have expected that the concentration of ***GHG*** in the atmosphere would decrease. As we noted in Edition 5 of Low Carbon Pulse, a reduction in ***GHG*** emissions arising does not result in a reduction in the concentration of ***GHG*** emissions in the atmosphere immediately. On the basis of research released by the US National Oceanic and Atmospheric Administration (***NOAA***), both carbon dioxide (***CO_2***) and methane (***CH_4***) levels are now at record high levels.

See: *Atmospheric CO2 and methane levels soar to record highs despite pandemic*

CH_4 versus *CO_2*:

The increased concentration of ***CH_4*** may be regarded as the continuation of a trend that started in the mid-2000s. The global warming potential of ***CH_4*** is greater than that of ***CO_2***: over a 20-year period, one tonne of ***CH_4*** has global warming potential 84 times that of one tonne of ***CO_2***. As noted in the second article in the ***Shift to Hydrogen Series (S2H2): Elemental Change*** series, ***What needs to be decarbonised? And what role can hydrogen play?***, the majority of anthropogenic ***CH_4*** emissions arise from the agricultural activity, including raising livestock and the production of rice, and fugitive emissions arising from the mining and production of hydrocarbons for energy use. The focus on ***CH_4*** arising from these activities is important, as is the means to their reduction. While the purpose of Low Carbon Pulse is not to delve into the science of anthropogenic, and naturally, arising ***CH_4*** emissions, the following links here and here are to recent articles that provide overviews.

Face to face meetings ahead of virtual Leaders' Summit:

Edition 13 of Low Carbon Pulse reported on the Leaders' Summit convened by US President, Mr. Joe Biden, to be held on April 22 and 23, 2021. Ahead of the virtual Leaders' Summit, US Special Climate Envoy, Mr John Kerry has been meeting with a number of leaders.

Mr Kerry has met with Indian Prime Minister, Mr Mahendra Modi to discuss the prospective commitment of India to net-zero ***GHG*** emissions by 2050. As noted in Edition 13 of Low Carbon Pulse, the Global Ashurst Towards Zero Emissions team considers that in an ideal world, developed countries will commit to supporting India (and other countries) to achieve net-zero ***GHG*** emissions. It is reported that Prime Minister Modi has commented on the benefit of cooperation between India and the US in the area of innovation and faster roll-out of green technologies, including the financing necessary to achieve these. It is reported that Special Climate Envoy Mr. Kerry has tabled the provision of concessionary finance for these purposes.

In addition to meeting with Prime Minister Modi, Mr Kerry met with the ***PRC*** Climate Envoy, Mr Xie Zhenhua, in Shanghai. Clearly, given the commitment of the ***PRC*** and the energy transition already underway in the ***PRC*** (see Edition 13 of Low Carbon Pulse), this meeting focussed on the roles of the ***PRC*** and the US leading on the global response to climate change.

Also ahead of the Leaders' Summit, Brazil's Environment Minister, Mr Ricardo Salles has indicated that to achieve net-zero ***GHG*** emissions by 2050, Brazil needs USD 10 billion in aid annually from developed countries.

See: *India's Modi reaffirms Paris accord pledge in meeting with Kerry*; *China and US pledge climate change commitment*; and *Brazil needs $10bn a year in aid for carbon neutrality by 2050*

Agriculture, forestry and land use:

It may be expected that the Leaders' Summit will consider all human activities giving rise to anthropogenic ***GHG*** emissions, including those arising from agriculture, forestry and other land use (and waste).

It is becoming increasingly clear that one policy setting that is emerging is to ensure that areas of land are to be preserved completely from any land use. This fits with the basic premise of any policy setting – do no harm. It is understood that in the ***EU*** and US policy settings are being considered to ensure that at least 30% of their respective land-masses remain free of land use for human activities, or land is returned to non-use, free from human activities.

To add to the many "***30 by 30***" targets (the US's 30 GW of off-shore wind by 2030 being the most recent – see Edition 13 of Low Carbon Pulse), California intends to preserve 30% of its land mass from use for human activities by 2030. Some commentators and climate modelers have suggested the preservation of up to 50% of land-mass as a preferred outcome. One of the consequences of the preservation of land-mass from land use will be increasing urbanisation, and more intensive means of agriculture and forestry.

By 2030, it is estimated that there will be 43 cities globally with populations of more than 10 million. Amongst other things, with urbanisation comes waste heat. Ideally urban areas should be designed so as to become heat sinks. This involves the greening of the urban environment. These themes will be covered in more detailed in future Ashurst features and publications, including Low Carbon Pulse.

Japan flagging change to its NDC:

On April 13, 2021, it was reported from a number of news feeds that Japanese Prime Minister, Mr Yoshihide Suga is to announce an increase in the Nationally Determined Contribution (***NDC***) of Japan under the Paris Agreement before, or at, the Leaders' Summit: the suggestion is that the new ***NDC*** will be to reduce ***GHG*** emissions to 50% of 2013 levels by 2030. This is something of a change given previous reports suggesting an increasing in the ***NDC*** from 26% to 45%. [**Note:** In this event, it was an increase to 46%.]

On April 17, 2021, The Japan Times reported that in an interview on April 16, 2021, Environment Minister, Mr Shinjiro Koizumi said: "*It's obvious that the target will be raised from the current level… The use of renewable energy sources is the most important key*" to the reduction of ***GHG*** emissions. In this context, Mr Koizumi indicated that mandatory use of solar panels for homes in Japan was a possible policy setting.

ROK continues to maximise renewable energy:

Recently it has been reported that the government of the Republic of Korea (***ROK***) is launching initiatives to deploy solar photovoltaic projects along, and on, rail infrastructure (including embankments, tracks and on train stations) and road infrastructure so as to maximise renewable electrical energy generation in close proximity to built infrastructure.

These built infrastructure environment solar projects will be developed under 20 year concessions.

For a country with land-constraints, the maximisation of renewable electrical energy derived from close to built infrastructure and from floating photovoltaic sources allows preservation of land for agriculture, forestry and other land use initiatives (including preservation). It is to be expected that other countries will launch similar initiatives.

See: *South Korea wants to build large-scale PV along highways*

***EHB* updates its vision for the European Hydrogen back bone**

On April 13, 2021, the European Hydrogen Backbone (***EHB***) group released a press release detailing the "version of its vision for a dedicated hydrogen transport infrastructure network across Europe".

The initial version of the ***EHB*** vision was released in July 2020. The ***EHB*** comprises 12 European gas transmission system operators from 11 countries. The ***EHB*** initiative proposes a hydrogen network of 39,700 km by 2040, with a grid connecting 21 countries.

Northern European Green Industrial Revolution continues:

Edition 12 of Low Carbon Pulse outlined the ***HH-Win*** network and Edition 13 of Low Carbon Pulse outlined the ***Clean Hydrogen Coastline*** initiatives.

In addition, the ***GET H2*** consortium (comprising bp, Evonik, OGE, RWE, Salzgitter Flachstahl and Thyssengas) is developing a complete hydrogen supply chain across Northern Europe, including based on current and planned hydrogen production and use projects.

To add to these (and other initiatives), it has been announced that Engie and INEOS plan to develop the first hydrogen cogeneration plant (being a power station that generates both electrical energy and heat energy).

See: *Belgium's first commercial-scale hydrogen cogeneration plant*.

Germany plans to use gas grid to carry hydrogen:

On April 6, 2021, it was announced that a ***Hydrogen Power Storage and Solutions East Germany*** (***HYPOS***) is being developed. While relatively early, it is apparent that ***HYPOS*** is more than hypothetical.

The purpose of ***HYPOS*** is to determine how best to augment or to develop infrastructure across Germany to transport hydrogen, and whether it is possible to use existing infrastructure to deliver both hydrogen and natural gas across the existing gas grid using membrane technology that will keep the gas streams separate.

To date, thinking has tended to focus on the blending of hydrogen and natural gas. If the membrane technology works, it will have profound implications for the transportation of hydrogen using existing infrastructure, and as such the cost of progressing towards a hydrogen economy.

See: [Germany's 511,000km gas grid set to integrate hydrogen]

The UK in lock-step with Northern Europe:

It has been announced that Equinor and SSE plc plan to build two first-of-a-kind power stations: one power station will capture ***CO_2*** and store that ***CO_2*** under the North Sea and other power station will use clean hydrogen as fuel.

The carbon capture power station is reported as likely to capture up to 15% of the UK's intended carbon capture target (of 10 mtpa of ***CO_2*** by 2030) and the clean hydrogen power station use 33% of the UK's targeted production of clean hydrogen (of 5 GW of hydrogen production capacity by 2030). These targets are contained in the UK's Ten Point Plan for a Green Industrial Revolution. The two projects are to be located in the Humber region of England, regarded as a cluster of industrial activity. [**Note:** see Edition 22 of Low Carbon Pulse]

See: *SSE Thermal and Equinor join forces on plans for first-of-a-kind hydrogen and carbon capture projects in the Humber*

Second round solar tender in the Kingdom of Saudi Arabia (*KAS*) sees world record low:

The ***KAS*** has recently celebrated the development of the 300 MW photovoltaic solar Sakaka IPP, with its second renewable electrical energy project, the Dumat Al-Jandal wind project, approaching completion. The Sakaka IPP was awarded to ACWA and Gihaz on the basis of a then record low bid price.

During the inauguration for the Sakaka IPP on April 8, 2021, Crown Prince Mohammad bin Salman bin Abdulaziz announced the results of the tenders for seven large-scale solar capacity projects under Round 2 of the National Renewable Energy Program (***NREP***).

The seven new projects are to be located in Jeddah, Madinah, Quarayyat, Rafha, Rebigh, Al Shuaiba and Sudair. The 600 MW Al Shuaiba photovoltaic project is reported as being awarded on the basis of a world record low bid price for electrical energy of USD 0.0104 kWh (a little over 1 cent per kWh, or USD 10.40 per MWh). The Sudair photovoltaic project was awarded with the second lowest bid price of USD 0.01239 (1.239 cents per KWh or USD 12.39 MWh). On development, the Sudair photovoltaic project it will be the Kingdom's largest solar project, comprising around 1.5 GW of installed capacity.

Approximately 3.6 GW of energy has been contracted under Rounds 1 and 2 of the ***NREP***. It is anticipated that the Kingdom will continue to develop renewable energy resources, including for the purposes of the production of Green Hydrogen and Green Ammonia.

The ***KAS*** has recently announced plans to plant 50 billion trees (***50 BTs***) as one of a range of initiatives to reduce net greenhouse gas emissions. The ***50 BTs*** initiative (the Middle East Green Initiative) involves planting 10 billion trees in the Kingdom itself, and 40 billion trees across other Middle Eastern countries.

The ***50 BTs*** initiative may be regarded as symbolising a tree for each tonne of ***GHG*** (as ***CO_2-e***) emissions currently arising globally. The ***50 BTs*** project should not however be regarded as symbolic, it provides a negative ***CO_2*** emissions initiative that if repeated on a proportionate basis globally would have a lasting and marked impact on ***CO_2*** emissions.

See: *Saudi Arabia's second PV tender draws world record low bid of $0.0104/kWh* and *Abu Dhabi receives world's lowest tariff for mega solar farm project*

Another Hydrogen Valley and 10,000 new micro-grids:

- On April 7, 2021, it was reported that the ***New India H2 Alliance*** intends to develop a cluster allowing for the connection of producers and users of hydrogen to facilitate and to spur the development of a hydrogen industry and the broader hydrogen economy in India. The plan is to cluster around Difficult to Decarbonise industries, including cement, chemical and petrochemical (including for the production of ammonia / fertilizer), iron and steel and refining. Blue Hydrogen and Green Hydrogen would be used, and their use will be promoted by the transport sector providing freight haulage services to these Difficult to Decarbonise industries.

  The ***New India H2 Alliance*** plans to work with the Government of India to develop a national hydrogen policy and roadmap for 2021-2030, to establish a national hydrogen task force, to identify large-scale hydrogen demonstration plants, to create a national hydrogen fund for India, and to create capacity for the production, storage, distribution and transportation and use of hydrogen.

  As is the case in other countries, there is a clear recognition of the need for the private and the public sectors to work together for the purposes of developing the supply and demand side for the hydrogen industry on a coordinated basis.

- On April 15, 2021, plans were announced by the Government of India to develop 10,000 solar powered micro-grids and water pumps across the country. This is to be achieved through a partnership between government entity, CSC, and Tata Power.

See: *Energy giant Reliance Industries leads alliance pioneering Indian 'hydrogen valley'* and *Reliance, other energy majors form hydrogen coalition*

A world first in New Zealand:

New Zealand is the first country in the world to introduce legislation requiring banks, insurers and investment managers to report on the effects on their businesses on climate change. The legislation is titled ***Financial Sector*** (***Climate related Disclosure and Other Matters***), and its stated purpose is: to ensure that the effects of climate change are routinely considered in business, investment, lending, and insurance underwriting decisions; to help reporting entities demonstrate better responsibility and foresight in their consideration of climate issues; and to lead to smarter, more efficient allocation of capital, and help smooth the transition to a more sustainable, low-emissions economy.

Under the legislation the reporting requirements apply to banks with more than NZ$ 1 billion (around USD 700 million) in assets and to insurers with more than NZ$ 1 billion of assets under management.

It is expected that this legislative move in New Zealand will be followed at an increasing pace by other countries: committing to and progressing to net-zero ***GHG*** emissions is one step, the ongoing monitoring and verification of ***GHG*** emissions arising is critical to ensuring that net-zero ***GHG*** emissions are in fact achieved, and transparency through reporting across the entire economies is required for this purpose.

Time to act under a Hydrogen Act:

On April 7, 2021, Hydrogen Europe published a Hydrogen Act (***H2A***). ***Hydrogen Europe*** represents around 220 industry participants and 26 national associations. The ***H2A*** is best described as an outline of what is required to allow a hydrogen industry to develop and to be integrated into the ***EU*** economy and the infrastructure of the ***EU*** economy.

The ***H2A*** may be regarded as describing the next steps on the road to the development of the legal and regulatory framework that will allow the ***EU*** to implement its Hydrogen Strategy (***A hydrogen strategy for a climate-natural Europe – July 8, 2020***), critically during what ***Hydrogen Europe*** describes as the Ramp-up phase (2025 to 2035).

BlackRock and Temasek partner to decarbonize:

BlackRock and Temasek, two of the world's largest and most influential and respected investment houses, have announced the establishment of the ***Decarbonisation Partnership***. The ***Decarbonisation Partnership*** contemplates an initial USD 600 million capital commitment to invest in companies and proven technologies that will reduce, and potentially eliminate, ***GHG*** emissions.

Chairman and CEO of BlackRock, Mr Larry Fink said: "*The world cannot meet its net-zero ambitions without transformational innovation. For decarbonisation solutions and technologies to transform our economy, they need to be scaled. To do that, they need patient, well-managed capital to support their vital goals. This decarbonisation partnership will help define climate solutions as a standalone asset class that is both essential to our collective mission and an historic opportunity created by the net-zero transition.*"

The bed rock of the ***Decarbonisation Partnership*** is an understanding that the world carbon budget requires the reduction of 1.7 billion tonnes of ***GHG*** emissions each year to achieve net-zero by 2050. As many countries and corporations have realised around the world, the move towards net-zero emissions offers opportunities for investors.

It has been a busy period for BlackRock. In addition to the Decarbonisation Partnership: on April 8, 2021, BlackRock is reported to have closed its third global renewable energy fund at USD 4.8 billion, Global Renewable Power Fund III, and on April 7, 2021, BlackRock is reported to have agreed terms for a USD 4.4 billion borrowing facility that provides lower borrowing costs if BlackRock achieves diversity targets and broader sustainable business goals.

See: *Temasek and BlackRock launch decarbonization investment partnership* and *Decarbonization partners*

Energy efficiency first principle will inform policy settings, and guide their application in *EU*:

As noted in a number of editions of Low Carbon Pulse, and the second article in the ***Shift to Hydrogen (S2H2): Elemental Change*** series, entitled ***What needs to be decarbonised? And what role can hydrogen play***, policy makers are concerned to ensure that efficiency is optimised across all renewables, including the use of energy carriers produced using renewable feedstocks and renewable electrical energy.

It is recognised that the ***EU*** requires a massive increase in the development and deployment of new renewable electrical energy capacity to enable it to satisfy its ***GHG*** reduction targets, both to produce electrical energy as electricity and to power electrolyers to produce Green Hydrogen.

On April 13, 2021, Ms Paula Pinho, from the Directorate General Energy, at the European Commission (***EC***), noted that achievement of targets must be supported by the energy efficiency first principle: "***We believe that, first and foremost, we need to continue to apply the energy efficiency first principle, ensuring that really we make the most of out of our limited resources***".

The facts and statistics that explain the need for adherence to the energy efficiency first principle are: if the ***EU*** is to achieve net-zero ***GHG*** emissions by 2050, its electrical energy use must double, with 53% of total energy consumption in the ***EU*** to be from renewable sources and nuclear sources, with 47% of total energy consumption, to be sourced from clean or cleaner future fuels, including hydrogen.

See: *Energy efficiency must apply across all renewables, **EU** Commission says*

Open letter supports the higher sustainability standards in *EU* Taxonomy:

In Edition 13 of Low Carbon Pulse the work of the ***EC*** was highlighted, critically the meaning of *sustainable* for the purposes of ***EU*** policy settings, including funding under the European Green Deal.

On April 13, 2021, a number of leading companies and organisations penned an open letter to the ***EC*** to express "extreme concern" about proposals to lessen the emissions thresholds in respect of the production of clean hydrogen.

Signatories to the open letter include Acciona, akuo, Altenex Energy, Enel, European Energy, everoze, First Solar, fronius, GCL, Iberdrola, nel, Orsted, Renewable Hydrogen Coalition, Smart Energy, SolarPower Europe, Soltec and sunfire.

Solar round-up:

In addition to the news from the ***KAS***, solar activity continues, including:

- BloombergNEF has released conclusions from research in respect of the comparative costs of Green Hydrogen in comparison to Blue Hydrogen and natural gas. The key headline from the research is that the costs of the production of Green Hydrogen will decrease by 85% to under USD 1, allowing Green Hydrogen to compete on a like for like basis with the Blue Hydrogen and natural gas.

A key contributor to the decrease in the cost of production of Green Hydrogen is the projected continued reduction in the cost of solar sourced electrical energy, with the lower costs of solar electrical energy resulting in cost savings across the entire solar chain, including improved efficiency in manufacture costs, improved efficiency in solar cells themselves, and greater yields from solar cells, and lower renewable electrical energy costs per kg of hydrogen as a result.

See: *Hydrogen Economy Outlook: Key messages*

- Edition 13 of Low Carbon Pulse reported that Sunseap Group had commenced operations of its floating photovoltaic solar farm in the Strait of Johor. On April 7, 2021, it was reported that Krakatau Steel plans to develop a 40 MW floating photovoltaic solar farm off the island of Banten, Indonesia. It is to be expected that the straits and seas around Singapore and Indonesia will offer increasing opportunities for the development of floating solar.

  See: *Krakatau Steel to build 40MW floating solar power station*

- On April 17, 2021, it was reported that Trungnam Group has commenced operation of the Nihn Thuan Province on-shore wind farm, Vietnam's largest to date. The 151 MW wind farm is combined with a 204 MW solar farm, with the combined 355 MW of installed capacity making it the largest solar-wind farm in South East Asia.

  See: *Vietnam's largest wind power plant enters operation*

- On April 15, 2021, a report was release that modelled that as much as 76% of global electrical energy load could be matched by renewable electrical energy generated from photovoltaic solar power stations.

  The report, prepared by researchers at Lappeenranta University of Technology, Finland, contains what its authors regard as: "*the only known cost-neutral energy system transition scenario that meets the 1.5˚C climate target [**Stretch Goal**] set in the Paris … [A]greement*".

  Critically, it is understood that the model contained in the report provides for the achievement of the ***Stretch Goal*** without any increase in unit energy costs, and without the need for negative ***GHG*** emissions initiatives.

  See: *Solar could deliver 76 per cent of global energy needs, new study says*

Wind round-up:

- On April 6, 2021, it was reported that Vattenfall plans to commence construction of the 1.5 GW Hollandse Kust Zuid (***HKZ***) off-shore wind field in June. The timing of the construction illustrates one of the challenges of off-shore construction, especially in the North Sea – only the summer months provide reasonably consistent conditions to allow construction.

  See: *Offshore construction on Dutch trailblazer to start in June*

- On April 7, 2021, it was announced that the ***Norwegian Government Pension Fund*** (Norway's Sovereign Wealth Fund) is to pay a purchase price equivalent to USD 1.63 billion for a 50% stake in the Ørsted 752 MW off-shore wind field Borssele 1 &2 (***B1/B2***) project. The ***B1/B2*** project comprises 94 wind turbines, located 23 kms off-shore of the Dutch coast, and is currently the world's second largest installed off-shore wind project. As noted in previous editions of Low Carbon Pulse, Ørsted is adept at developing renewable assets and then recycling capital from them.

  See: *Norway's huge oil-backed wealth fund invests in an offshore wind farm*

- In Edition 8 of Low Carbon Pulse it was reported that the ***Offshore Act*** had entered into force in Poland, providing for the approval of development of up to 10.9 GW of off-shore wind capacity by 2027. It was understood that 5.9 GW would be auctioned by the end of June 2021, with two further tranches of 2.5 GW to be auctioned by 2025 and 2027.

  On April 8, 2021, it was announced that the Energy Regulatory Office (***ERO***) in Poland awarded a contract for differences for the 1.5 GW Baltica 2 and 1 GW Baltrica 3 off-shore wind projects. The two off-shore wind projects are being developed by Ørsted and PGE under a 50 / 50 joint venture. Final investment decisions have yet to be taken, but are expected, with Baltica 3 to commence operation in 2026, and Baltica 2 before 2030. The "strike price" for the contract for differences is reported to be equivalent to €67.93.

  In addition to Baltica 2 and 3, the 350 MW FEW Baltic II off-shore wind project is to be developed, located 50 km off shore on the north side of the Slupsk Bank in the Polish sector of Baltic Sea.

  See: *Poland awards 2.5GW Baltica 2&3 with contract for difference*

- On April 9, 2021, it was announced that NoordzeeWind has appointed Vestas and OutSmart (a Dutch German company) to operate and to maintain its Egmond aan Zee (***EaZ***) wind project in the Dutch sector of the North Sea. The ***EaZ*** wind project (100% owned by Shell, after Shell completed the purchase of Vattenfall's interest in the project in March 2021), is the first off-shore wind field project in the Dutch sector of the North Sea, comprising 36 MW wind turbines, located 18 kms off-shore of the Dutch coast.

  See: *Vestas and OutSmart to Run First Dutch Offshore Wind Farm*

- On April 11, 2021, The Irish Times reported that state-owned Electricity Supply Board (***ESB***) is to increase the scale of its renewables business and to realise its ***Green Atlantic @ Moneypoint*** program to align with Ireland's ***GHG*** emissions targets, i.e., net-zero ***GHG*** emissions by 2050.

  The plans of ***ESB*** include: **1**. upgrading the grid to allow connection of renewable electrical, **2** the development of a 1.4 GW floating off-shore wind field off the coast of Clare and Kerry with Equinor, to be developed in two stages, with the first electrical energy in 2028 (see Edition 13 of Low Carbon Pulse for the description of the success of Equinor's ***Hywind*** floating off-shore wind field off Aberdeen in the north of Scotland), and **3** the repurposing of the Moneypoint coal-fired power station, and the use of the repurposed power station to produce Green Hydrogen.

See: *ESB ready for green pivot with Moneypoint renewable energy hub*

- On April 12, 2021, it was announced that the world's largest inland fresh water wind farm has started to produce electrical energy: the 383 MW Windpark Fryslan wind field is located in Ijsselmeer Lake in The Netherlands.

  See: *First Power Flows from Windpark Fryslân*

- On April 13, 2021, it was reported that WA Offshore Windfarm Pty Ltd (a wholly owned subsidiary of UK developer Australis Energy) has submitted an application for environmental approval of the development of an AU$ 1 billion, 300 MW offshore wind field, 140 kms south of Perth in Western Australia. It is anticipated that the off-shore wind field will generate renewable electrical energy by 2026.

  While Australia has some of the best on-shore wind (and solar) resources globally, in particular in the north of Australia, Australia also has some of world's best near to nearer off-shore resources in the southern half of the country.

  In Edition 13 of Low Carbon Pulse, the landfall for Australia's first offshore wind farm, the 2 GW Star of the South (***SOTS***)Project (off Victoria), was described. As noted in Edition 13 of Low Carbon Pulse, the location of the landfall site is critical for any off-shore project, including for the purposes of the connection to the grid.

  See: *UK developer proposes $1 billion offshore wind farm for Western Australia waters*

- On April 14, 2021, it was announced that the Government of Azerbaijan (Ministry of Energy) has signed a memorandum of understanding (***MOU***) with the International Finance Corporation (***IFC***) for the purposes of a providing a framework to cooperate in the development of off-shore wind fields in the Caspian Sea.

  The activities contemplated by the ***MOU*** fall within the Offshore Wind Development Program, funded by the World Bank's Energy Sector Management Assistance Program.

  It is estimated that the Caspian Sea may realise up to 135 GW of renewable electrical energy from off-shore wind field development, 35 GW from fixed-bottom capacity and 122 GW from floating wind.

  See: *Azerbaijan's Energy Ministry Signs Offshore Wind MoU with IFC*

- On April 14, 2021, it was announced that US oil major, Chevron (***CVX***), and Norwegian corporation Moreld Ocean Wind (***MOW***) are to invest in off-shore floating wind technology. It is reported that ***CVX*** is the first US oil major to enter the off-shore wind market.

  See: *US Oil Major Chevron Enters Offshore Wind Market*

- On April 16, 2021, it was announced that Ørsted (the Danish renewable energy giant) has agreed to purchase of 100% of Brookfield Renewable's Irish and UK on-shore wind businesses. For Ørsted this is a case of back-to-the future in Europe: in 2014 DONG Energy (now Ørsted) sold its on-shore wind farm interests in Europe to concentrate on off-shore wind field developments.

  It is reported that the Brookfield Irish and UK portfolio agreed to be purchased by Ørsted has 389 MW of on-shore wind in operation and under construction, and has a development pipeline of over 1 GW. Outside Europe Ørsted has around 4 GW of on shore wind in operation and under construction in the US.

  See: *Danish energy giant Orsted is pivoting to onshore wind in new $684 million deal*

Wind scales-up:

Technological innovation, scale and scalability, are key in moving towards net-zero ***GHG*** emissions. These concepts are as long as they are broad and deep, but in the renewable energy wind industry, it is clear that the scale of turbines used in the off-shore industry is playing a role in reducing the unit cost of electrical energy production. While fixed bottom and floating off-shore wind fields are the most expensive sources of renewable energy from wind-power, off-shore wind is highly prospective, and is required if ***GHG*** reduction targets are to be achieved.

A new paper (in Nature Energy) has concluded that the contemplated increase in the scale of turbines may result in increasing electrical energy generating capacity three-fold (at asset level), with a resulting reduction in the unit cost of renewable electrical energy. The report estimates that the unit cost of renewable electrical energy from off-shore wind fields may reduce by up to 50%. Also the report estimates that up to 25% of off-shore wind fields are likely to be floating by 2035 as technology is honed and scale increased.

See: *Giant offshore turbines set to drive plummeting cost of wind power*

Scotland Near to Zero Hero:

- On April 8, 2021, it was reported that during 2020 a little over 97% of the electrical load (demand for electrical energy) across Scotland was matched by dispatch from renewable electrical energy sources. With the development of further off-shore wind capacity in the offing, Scotland will produce more electrical energy from renewable sources that it will be using, thereby contributing ever more to the net-zero commitments of the United Kingdom.

  See: *Scotland's renewable record cements its place as UK's onshore wind hub*

- On April 12, 2021, it was reported that ScottishPower, whose parent company is Spanish renewables giant Iberdrola, intends to develop a Green Hydrogen production facility in the hinterland of Scotland's largest city, Glasgow. The 20 MW electrolyser is to be located next to the largest on-shore wind farm in the UK, the 539 MW Whitelee Wind-farm. The 20 MW electrolyser is to use excess / surplus electrical energy from the Whitelee Wind-farm (i.e., lower to low cost electrical energy that it is not dispatched), and renewable electrical energy from a 40 MW solar farm to be developed close by, and a 50 MW ***BESS***. As noted in previous editions of Low Carbon Pulse, in addition to electrolyser efficiency, electrolyser utilisation and surge capacity (to take advantage of lower or low renewable electrical energy prices) are key to the economics of electrolyser projects, wherever they are located.

  See: *ScottishPower plans UK's biggest Green Hydrogen plant in Glasgow*

In the UK On Easter Monday the sun shone and the wind blew:

On Easter Monday, the UK had its "greenest of green days": it has been reported that 60% of electricity load across the UK was matched by dispatch from renewable electrical energy sources. This produced the lowest level of electrical energy carbon intensity recorded in the UK since records began in 1935.

See: *Great Britain's electricity system has greenest day ever over Easter*

In Australia the sun shines and the wind blows and new report on progress to renewable energy:

- On Sunday April 11, 2021, the National Electricity Market in Australia reached a record level of dispatch of renewable electrical energy (55.9%), and a record level of dispatch for solar and wind (53.4%).

  It remains the case that the National Electricity Market continues to rely on fossil fuel powered electrical energy generation capacity, with the peaks of renewable electrical energy dispatch tending to arise at times of lower demand. Australia is however continuing to progress net-zero capability: in 2020 around 4 GW of renewable energy capacity was installed, and in 2021 a further 4 GW of renewable capacity, and 4 GW of roof-top solar, is expected to be in installed.

- A new report from the Grattan Institute provided a keen perspective on the need for the continued development of renewable electrical energy while at the same time ensuring continued energy security.

  See: *Australia's main grid hits record renewables high of 56 per cent on Sunday*

***BESS* on-grid and off-grid:**

- **California to accelerate *BESS* installation**: On April 5, 2021, it was reported that California is to install 1.7 GW of battery electrical storage systems (***BESS***) by August 2021. It is expected that installation of ***BESS*** will continue in 2022, with 1.4 GW, and 2023 with 1.2 GW.

  See: California to install 1.7GW of battery storage in 2021 to boost grid supply

- **Australian Gas and Light and Wartsila**: On April 13, 2021, AGL and Wartsila signed an memorandum of understanding (***MOU***) in respect of the development of off-grid / behind the meter electrical energy storage systems for large users of electrical energy. It is anticipated that hybrid energy supply offerings will be available to customers with more than 20 MW of electrical energy load. It is understood that the ***MOU*** contemplates that installation of up to 1 GW of off-grid / behind the meter ***BESS***.

  See: *AGL and Wärtsilä offer onsite solar and battery solutions to big energy users*

Clean Hydrogen Round-up:

- On April 15, 2021, it as was announced that Uniper (German utility giant) plans to develop a hydrogen hub located in Wilhelmshaven (***Green Wilhelmshaven***) which is to develop a receiving terminal for Green Ammonia, then using a cracker to derive Green Hydrogen. In addition, it is planned that a 410 MW electrolyser will be developed at ***Green Wilhelmshaven***. On full development, it is estimated that the facilities at ***Green Wilhelmshaven*** will produce up to 295,000 tonnes per year of hydrogen or about 10% of the estimated Green Hydrogen demand in Germany by 2030.

  Uniper COO, Mr David Bryson, noted that while Germany intends to produce Green Hydrogen comprising 14 TWh energy, the forecast demand is 90-100 TWh. Mr Bryson noted that: "*We will be heavily reliant on imports if we want to use hydrogen to help us achieve our climate goals*".

  It is anticipated that ***Green Wilhelmshaven*** will supply industrial users as well as being connected to the infrastructure being developed in northern Europe and Europe more broadly (see above).

  (The decision of Uniper to develop ***Green Wilhelmshaven*** is reported to have ended its plans to import LNG using a floating storage and regasification unit at Jade Bay, in Wilhelmshaven.) [***Note: This may not remain the case, with the prospect of both***]

  See: *Uniper Plans to Make Wilhelmshaven a Hub for Climate friendly Hydrogen*

- On April 15, 2021, it was announced that RWE AG (German energy giant) and The Hydrogen Utility Pty (***H2U***) have agreed a memorandum of agreement (***MOA***) under which supply of hydrogen will be developed from Australia to Europe.

  It is reported that the likely location for the import of the hydrogen would be Brunsbettel. ***H2U*** is working on project developments in Australia and New Zealand, most notably, the planned Eyre Peninsula Gateway project in South Australia, at which an 75 MW electrolyser is to be developed initially, with planned expansion to 1.5 GW to 2030. The ***MOA*** aligns with the joint German – Australian supply chain feasibility study "***HySupply***" currently being undertaken.

  See: *RWE partners with H2U to bring Australian hydrogen to Germany*

- On April 15, 2021, it was reported that the Government of India is planning to use a 2 GW solar and wind capacity to facilitate the production of clean hydrogen, and to hold Green Hydrogen auctions as part of its broader plans to reduce ***GHG*** emissions. It is understood that it may be made mandatory for industrial users to source a stated percentage of the hydrogen demand from producers of Green Hydrogen located in India.

  As noted in previous editions of Low Carbon Pulse and articles in the ***S2H2*** series, policy settings are required from government to allow supply and demand to develop in tandem.

  The policy settings being contemplated by the Government of India are ideal in that they allow the Green Hydrogen industry to develop and to grow as the percentage of Green Hydrogen used by industry increases, and because of a developing supply and demand side, other users of Green Hydrogen are likely to provide further demand to support future increased supply.

  See: *Green hydrogen auctions, purchase obligations in the offing*

CCS and CCUS round-up:

- Under the Acorn Development Agreement for the 5mtpa ***Acorn CCS Project***, Storegga Geotechnologies, Shell and Harbour Energy (as equal shareholders) are planning to proceed with CCS and hydrogen projects. ***CO_2*** will be sourced from the St Fergus Gas Terminal (and from the UK and Europe) to the Port of Peterhead. The St Fergus Gas Terminal, which is near Peterhead, will use natural gas as feedstock to produce clean hydrogen (in the form of Blue Hydrogen). The Acorn CCS Project will satisfy half of the ***CO_2*** emissions target in accordance with Point 8 (including to capture and store 10 mtpa of ***CO_2*** by 2030) in the UK Government's Ten Point Plan (reported on in Edition 4 of Low Carbon Pulse).

  In early March, it was reported that Mitsui had invested in Storegga Geotechnologies. Macquarie Group and GIC are shareholders in Pale Blue Dot, the parent company of Storegga Geotechnologies.

  See: *Acorn accord: Shell and Harbour become partners in UK Blue Hydrogen and CCS project*

- It has been reported that Mitsubishi Heavy Industries and Next-Decade have executed an agreement for CCS development at Rio Grande LNG, located in Brownsville, Texas: the agreement is reported to be an engineering services agreement for the design and licensing of post-combustion carbon capture technology to be used at the NextDecade Rio Grande LNG project. It is anticipated that on full development the NextDecade Carbon Solutions CCS project will capture and store permanently around 5 mtpa of ***CO_2***.

  See: *NextDecade and Mitsubishi Heavy Industries America Execute Engineering Services Agreement for Carbon Capture at Rio Grande LNG Project in Texas*

Net-zero round up:

- On April 9, 2021, Swedish shipping giant, Stena Bulk committed to net-zero ***GHG*** emissions by 2050: each consignment of cargo carried by Stena Bulk will be carried on a carbon neutral basis. As is the case with many other corporations committing to net-zero, Stena Bulk has set itself interim targets for 2025, 2030, 2035 and 2040.

  As with other freight and transport companies, for Stena Bulk to achieve net-zero ***GHG*** emissions it needs to modify, and over time replace, its fleet to allow use of carbon-natural energy carriers to power and to propel its cargo carriers. It is likely that Stena Bulk will use carbon-offsets to achieve interim targets that it has set itself.

  See: *Stena Bulk sets 2050 net zero target*

- It has been reported that Anglo American has contracted for the provision of 100% of its electrical energy needs in South America to be matched from renewable electrical energy sources. For these purposes, Anglo American has recently contracted with Engie Energia Peru in respect of its copper mine at Quellaveco, Peru, to be supplied with the renewable electrical energy from the Engie USD 300 million, 260 MW Punta Lomitas wind farm project. In 2019, Anglo American contracted with Enel Chile in respect of its Los Bronces copper mine and its activities at El Soldado and Chagres.

  It is anticipated that world copper production will double by 2050 as decarbonisation of energy use increases. As mining companies work to achieve their own net-zero ***GHG*** commitments, it is clear that the role of renewable energy industry in the mining industry globally will increase, both to displace existing non-renewable sources, and to allow the development and expansion of new mining resources.

  See: *Anglo American inspires rise in renewables* and *Copper demand to double with decarbonisation: BHP*

- Royal Dutch Shell Plc has released its *Shell Energy Transition Strategy*, describing, at a higher level, what Shell intends as its works to become a net-zero emission energy business by 2050.

- On April 15, 2021, Apple Inc announced a plan to invest USD 200 million in fund to invest in timber-producing commercial forestry activities. The ***Restore Fund***, is a partnership between Apple and Conservation International and Goldman Sachs. The aim of the ***Restore Fund*** is to remove one million tonnes of ***CO_2*** from the atmosphere each year. This is an example of a negative ***GHG*** emission initiative.

  As noted in Edition 9 of Low Carbon Pulse and in the second article in the ***Shift to Hydrogen (S2H2): Elemental Change*** series, entitled ***What needs to be decarbonised? And what role can hydrogen play*** there is an increasing realisation of the need for negative ***GHG*** emission initiatives for countries, provinces and states within countries, cities and towns, and corporations to achieve their ***GHG*** reduction and net-zero ***GHG*** commitments.

  See: *Apple announces US$200 million forestry fund to reduce carbon*

- On April 16, 2021, Singapore's DBS Bank committed to zero thermal coal exposure by 2039. The implications of this commitment are that DBS will cease immediately to accept as a customer any organisation sourcing more than 25% of its revenue from thermal coal and from January 2026 will cease to finance any organisation that sources more than 50% of its revenue from thermal coal, other than to provide finance to such an organisation to enable it to develop non-thermal coal and renewable energy activities.

  See: *DBS Bank commits to zero thermal coal exposure by 2039*

PROGRESS TOWARDS NET-ZERO EMISSIONS
APRIL 26, 2021

Low Carbon Pulse - Edition 15

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to Edition 15 of Low Carbon Pulse – sharing significant news arising from the Leaders' Summit convened by US President Mr Joe Biden, and attended by Leaders from 40 countries, including the countries from which the greatest mass of ***GHG*** emissions arise.

As with Edition 7 of Low Carbon Pulse (to mark the inauguration of President Biden), this Edition 15 is published outside our usual two week cycle. Edition 16 will be published next week, May 3, 2021, returning us to the two week cycle.

Background:

On March 26, 2021, President Joe Biden invited 40[1] world leaders to a Leaders summit on Climate Change on April 22 and April 23, 2021(***Leaders' Summit***). All 40 world Leaders invited participated, virtually.

It is understood that US Special Presidential Envoy for Climate Change, Mr John Kerry spoke with leaders from 63 other countries in "listening sessions", but the leaders of the countries with the most progress to make, and those with most to lose, were among the 40. The first day of the Leaders' Summit, April 22, 2021, was both Earth Day and the fifth anniversary of the date on which the Paris Agreement was opened for signature.

A link is attached to the WH Gov website and its summary of proceedings.

Headlines from the Leaders' Summit:

- **Strong leadership from the US:** The US committed to increase the rate of ***GHG*** emission reductions to at least 50% of 2005 levels by 2030, and possibly by as much as 52%. This commitment resets the US' Nationally Determined Contribution (***NDC***) from the 26 to 28% of 2005 levels by 2025 committed to by the Obama Administration. This is a material commitment in global terms – the US emits the second greatest mass of ***GHG*** annually. This reset of the ***NDC*** complements the commitment to decarbonise the electrical energy sector by 2035, and to achieve net-zero ***GHG*** emissions by 2050. This increase in the US's ***NDC*** had been both hoped for and signaled.
- **Brazil committed to net-zero:** The President of Brazil, Mr Jair Bolsonaro committed to ending unlawful deforestation of Brazil by 2030 and to net-zero by 2050. Consistent with the reported comments of Brazil's Environment Minister, Mr Ricardo Salles (see Edition 14 of Low Carbon Pulse), President Bolsonaro noted the need for developed countries to provide funding to assist Brazil.
- **Canada cautious progress:** The Prime Minister of Canada, Mr Justin Trudeau, committed to increasing the rate of reductions in ***GHG*** emissions to between 40 and 45% of 2005 levels by 2030. This reset of the Canadian ***NDC*** is a 10 to 15% increase in its earlier *NDC* of 30%.

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[1] The following countries were invited: Antigua and Barbuda, Argentina, Australia, Bangladesh, Bhutan, Brazil, Canada, the People's Republic of China, Colombia. Democratic Republic of Congo, Denmark, EU Commission and Council Presidents, France, Gabon, Germany, India, Indonesia, Israel, Jamaica, Japan, Kenya, Marshall Islands, New Zealand, Nigeria, Norway, Poland, Republic of Korea, The Russian Federation, Kingdom of Saudi Arabia, South Africa, Spain, Turkey, United Arab Emirates, United Kingdom, and Vietnam. Prime Minister of Pakistan, Mr Imran Khan, was not invited initially, but was invited subsequently.

- **India Clean Energy Partership:** The Prime Minister of India, Mr Narendra Modi re-affirmed India's commitment to install 430 GW of renewable electrical energy capacity by 2030. While there had been some suggestion of India committing to net-zero ahead of the Leaders' Summit, there is clearly more work to be done before this commitment is made, including the basis on which the developed world will support India. At the Leaders' Summit, India and the US launched the India-US Clean Energy Agenda 2030 Partnership: this comprises two principal aims, first, hasten Clean Energy deployment and, secondly, to mobilise finance.
- **Japan continues to lead:** The Prime Minister of Japan, Mr Yoshihide Suga, committed to increasing the rate of the reduction in ***GHG*** emissions to 46% of 2013 levels by 2030. This is a 20% increase in Japan's ***NDC*** from 26%. In global terms this is significant: Japan emits the fifth greatest mass of ***GHG*** annually. This is a further demonstration of Japan's vital leadership. The increase in Japan's ***NDC*** had been flagged before the Leaders' Summit (see Edition 14 of Low Carbon Pulse).

Strong leadership from the *PRC* and Russia:

Both President Xi Jinping and President Vladimir Putin made key statements at the Leaders' Summit. Each President re-affirmed key existing commitments: in the case of the ***PRC***, achieving peak ***GHG*** emissions by 2030 and net-zero ***GHG*** emissions by 2060, and to exercise strict control over coal-fired electrical energy generation, and in the case of Russia to reduce "significantly" its ***GHG*** emissions over the next three decades, noting that since 1990 Russia had reduced its ***GHG*** emissions by nearly 50%.

Importantly, President Putin noted the need to reduce methane (***CH_4***): as noted in Edition 14 of Low Carbon Pulse, there is increasing concern about ***CH_4*** levels in the atmosphere as a result of its global warming potential. It is hoped that there is increased concentration on this issue ahead of ***COP-26***, in Glasgow, Scotland, in October / November, 2021. Also President Putin touched on the role of negative ***GHG*** emissions initiatives, and the potential for Russia to be a key player given its natural advantage of land mass.

Other Paris Agreement news:

In other news from the Leaders' Summit:

- Argentina will increase its ***NDC***, deploy more renewable electricity energy capacity, reduce ***CH_4*** emissions and foreclose on unlawful deforestation;
- South Africa foreshadowed an increase in its ***NDC*** and reaching peak emissions by 2035; and
- Republic of Korea (***ROK***) will increase its ***NDC***, and cease to provide government funding for coal projects.

Net-Zero Producers Forum:

The Kingdom of Saudi Arabia, Canada, Norway, Qatar and the US (each an oil-producing heavy weight) have come together to establish the ***Net-Zero Producers Forum*** to devise plans to achieve net-zero ***GHG*** emissions, including abatement of ***CH_4*** emissions arising from production of hydrocarbon products, developing and deploying CCS / CCUS technologies, and economic diversification.

For the time being at least, the United Arab Emirates and the UK are not included in the Forum.

LEAF falls in the rain forest:

The US, the UK and Norway, and major corporations, are to co-operate in a public-private initiative to preserve rain forests. The Lowering Emissions by Accelerating Forest Finance (***LEAF***) coalition was announced on April 22, 2021.

At a cellular level, ***LEAF*** is a carbon credit scheme, under which for each tonne of avoided ***GHG*** emissions, a carbon credit will arise, with that carbon credit capable of being traded to off-set carbon emission reduction commitments or obligations. ***LEAF*** is reported to have initial funding of USD 1 billion.

It is hoped that ***LEAF*** will reduce deforestation, while other policy settings reduce ***GHG*** emissions.

International Climate Finance Plan:

President Biden stated that it was critical for public and private sector finance to be deployed, both domestically and overseas.

In the context of overseas investment President Biden said that the public and private sectors from developed countries should seek to mobilise USD 100 billion a year to finance and otherwise support developing countries to reduce ***GHG*** emissions: **Public Sector funding and Private Sector investment = Net-zero *GHG* emissions**.

Strong commitment pre-Leaders' Summit:

Before the Leaders' Summit:

- the ***PRC*** and the US, the world's two largest economies, and the world's two greatest emitters of ***GHG***, had each confirmed commitment "to cooperating with each other and with other countries to tackle the climate crisis, which must be addressed with the seriousness and urgency *that it* demands" (see Edition 14 of Low Carbon Pulse);
- on April 19, 2021, the UK confirmed its position in the front rank of countries delivering on commitments to reduce ***GHG*** emission with the confirmation of an ***NDC*** of 78% of 1990 levels by 2035. (Edition 16 of Low Carbon Pulse will consider this is in more detail, and other policy settings contained in the UK's Sixth Carbon Budget); and
- on April 21, 2021, the ***EU*** confirmed agreement on the reduction of ***GHG*** emissions by at least 55% of 1990 levels by 2030; and
- the US had proposed a major infrastructure development and renewal package which includes initiatives to promote and to support progress towards net-zero ***GHG*** emissions. [**Note:** Editions 22, 23 and 25 of Low Carbon Pulse report on the progress of this initiative].

Strengthening commitments post Leaders' Summit and pre-*COP-26*:

While many countries did not increase ***NDCs*** at the Leaders' Summit, it is clear that a number of countries will do so before or at ***COP-26*** to be held in Glasgow, Scotland, between October 31 and November 12, 2021.

Also there is considerable activity ahead of ***COP-26***, including as follows:

- in late September (week that begins September 27, 2021), there will be a "Pre-COP" three day meeting in Milan, Italy;
- on May 18, 2021 the International Energy Agency (***IEA***) will publish ***The World's Roadmap to Net Zero***. This is awaited with interest - on April 23, 2021, at the Leaders' Summit, Executive Director of the IEA, Mr Fatih Birol, told Leaders that: "***Right now, the data does not match the rhetoric, and the gap is getting wider and wider***"; and
- on May 30 and 31, 2021, Republic of Korea (***ROK***) will host the ***P4G Seoul Summit***. At the ***P4G Summit***, armed with the ***IEA's World Roadmap to Net Zero***, world leaders, public and private sector, will meet to discuss, and, it is anticipated, to accelerate partnerships with developing countries to allow movement towards sustainable outcomes.

Also it can be expected that meetings of APEC (ongoing in 2021), G7 (June 2021 – see Edition 18 of Low Carbon Pulse) and G20 (October 2021) ahead of ***COP-26*** will be working hard on net-zero ***GHG*** emission reduction initiatives.

Sound-bites:

To the Global Ashurst Towards Zero Emission team, the following sound bites touch on themes that are key take-aways from the Leaders' Summit: if there was one theme arising from the Leaders' Summit it was: "*Do more, faster*":

- **President Biden**: "No single technology is the answer on its own, because every sector requires innovation".
- **President Emmanuel Macron**: "If we don't set a price for carbon, there will be no transition".
- **Prime Minister Boris Johnson**: " …the 2020s will be remembered either as the decade in which world leaders united to turn the tide [of climate change], or as a failure".
- **Chancellor Angela Merkel**: "I am delighted to see that the United States is back … the world [needs] your contribution if we really want to fulfil our ambitious goals".
- **Prime Minister Scott Morrison**: Future generations will "thank us not for what we have promised, but what we deliver".
- **President Putin**: The Russian Federation is undertaking a "… large scale campaign for environmental modernisation and greater efficiency across all economic sectors".
- **Prime Minister Suga**: "Japan is ready to demonstrate its leadership for worldwide decarbonisation".
- **President Xi Jinping**: "China looks forward to working with the international community, including the United States to advance global environmental governance".
- **President of *EU*, Ursula von der Laden**: " … this will be the 'make or break' decade for our climate. … Carbon must have its price – because nature cannot pay the price any longer".

> ***"This is our generation's moon shot"***
>
> **US ENERGY SECRETARY, JENNIFER GRANHOLM**

Low Carbon Pulse - Edition 16

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to Edition 16 of Low Carbon Pulse – sharing significant current news on progress towards net-zero emissions globally. This edition covers the period from Sunday April 18, 2021 to Sunday May 2, 2021 (inclusive of each day).

Please click here for the previous edition of Low Carbon Pulse. Please also click here and here for the first two articles in the ***Shift to Hydrogen Series (S2H2): Elemental Change*** series.

As the dust settles after the Leaders' Summit, some reflections:

Edition 15 of Low Carbon Pulse provided a summary of the key outcomes from the Leaders' Summit. As the dust settles, the following key themes have emerged and appear to be here to stay:

- the role for coal is diminishing, and this appears likely to continue absent technological change;
- each country needs to set intermediate ***GHG*** emission targets, and for this purpose to increase Nationally Determined Contributions (***NDCs***), and amend them formally under the Paris Agreement;
- solar and wind renewable energy will do most of the "heavy-lifting" to decarbonise energy use, but renewables will not be sufficient, hydrogen and negative ***GHG*** emission initiatives are needed too, and are needed quickly; and
- action on methane (***CH_4***) is required, with landfill contributing at a level not previously understood, and ***CH_4*** is arising from sources and to an extent not previously understood, including decommissioned oil wells.

EU confirms 55% reduction in *GHG* emissions by 2030 in new Climate Law:

Edition 5 of Low Carbon Pulse reported that on December 10, 2020, agreement had been reached on an ***EU***-wide ***GHG*** reduction target of ***55% by 2030*** (***55 by 30***), compared to 1990 levels. The ***55 by 2030*** was less than the 60% by 2030 that the European Parliament preferred (see Edition 1 of Low Carbon Pulse under ***European Parliament increases reductions***).

On April 21, 2021 the European Commission (***EC***) welcomed the provisional agreement on the ***European Climate Law*** reflecting ***55 by 30***. While ***55 by 30*** has grabbed the headlines, the ***European Climate Law*** also addresses what is needed to achieve net-zero ***GHG*** emissions by 2050. The ***Climate Law*** imposes limits on the extent to which carbon credits may be counted towards the achievement of ***GHG*** reductions. This may be expected to an area for continued development overtime.

EU President Ursula von der Leyen is reported to have said: "*I am delighted that we have reached an agreement on this core element of the European Green Deal. Our political commitment to becoming the first climate neutral continent by 2050 is now a legal commitment*."

On formal approval of the provisional agreement by the European Parliament and Council, the ***European Climate Law*** will enter into force. It is understood that the ***EU*** will introduce climate legislation in June 2021 for the purposes of reworking the regulatory framework so that it is aligned with achieving of ***55 by 2030***. [**Note**: This was done on July 14, 2021, and is covered in Edition 22 of Low Carbon Pulse].

See: *Commission welcomes provisional agreement on the European Climate Law*

Germany accelerating:

In the context of acceleration of ***GHG*** emission reductions, the German Parliament has decided to increase the rate at which Germany tenders for the installation of photovoltaic solar, and off-shore wind, capacity, by increasing the capacity to be reverse auctioned from 1.9 GW to 6 GW for photovoltaic, and from 2.9 GW to 4 GW.

See: *Germany expands capacity in wind, solar power auctions*

UK enshrines 78% by 2035 in law:

On April 20, 2021, the UK Government published the UK's ***Sixth Carbon Budget*** (covering 2033 to 2037). In line with the recommendations of the ***Climate Change Committee*** (see Edition 5 of Low Carbon Pulse), the UK Government has confirmed that it will legislate the reduction of ***GHG*** emissions to 78% of 1990 levels by 2035 (***78 by 35***), with the legislation to become law by the end of June 2021.

The UK is half-way to achieving net-zero ***GHG*** emissions by 2050 (see Low Carbon Pulse Edition 12 of Low Carbon Pulse). Achieving ***78 by 35*** will take the UK to the three-quarter mark on its road to achieving the reduction in emissions necessary to achieve net-zero by 2050.

As part of ***78 by 35*** the UK Government is addressing ***GHG*** emissions arising from international aviation and shipping. This is a welcome move, again indicating that the UK is at the forefront of ***GHG*** reduction policy setting.

See: *UK enshrines new target in law to slash emissions by 78% by 2035*

PRC progressing to double-digit renewable energy:

On April 19, 2021, is was reported that the ***PRC*** planned installation of solar and wind renewable energy capacity during 2021 that will increase to 11% the total electrical energy consumption that the ***PRC*** derives from solar and wind.

This represents progress towards achieving President Xi Jinping's commitment to source 25% of total electrical energy consumption from non-fossil fuel sources by 2030, consistent with achieving peak ***GHG*** emissions by 2030. National Energy Administration (***NEA***) draft plan released on April 19, 2021, indicates that this level of increase will be required in each of the next five years such that by the end of 2025 16.5% of total electrical energy usage will be derived from solar and wind resources, with the balance of electrical energy derived from other non-fossil sources, including hydroelectric and nuclear.

The ***NEA*** draft plan was open for consultation until April 25, 2021. It will be interesting to follow the finalisation of the ***NEA*** plan. It is to be expected that the ***NEA*** plan will be updated to reflect over more ambitious objectives.

Also it is understood that the ***PRC*** Ministry of Ecology and Environment is to require any corporation seeking approval for the development of a cement plant, coal-derived chemical product plant or coal-fired power station, chemical or petrochemical plant, iron and steel mill, or non-ferrous metal facility (including any aluminium smelter) to do so on the basis of a carbon-emission reduction plan consistent with the ***PRC*** achieving peak ***GHG*** emissions by 2030. The implication of this requirement should be that corporations seeking approval will have to do so on the basis of the use of low, lower or no ***GHG*** emission feedstock and fuel sources. It is reported that ***NEA*** has mandated grid connection to achieve the consumption targets.

See: *China to bring solar and wind power generation to 11% of total electricity use in 2021*, *Aluminium, cement makers are under pressure to help China achieve carbon emission goals*

TOTAL momentum continues:

On April 20, 2021, it was announced that TOTAL Eren had signed a memorandum of understanding (***MOU***) with Province Resources, to undertake a feasibility study so as to develop in joint venture the ***HyEnergy Project*** in the Gascoyne Region of Western Australia, being in reasonably close proximity to Carnarvon: see Edition 11 of Low Carbon Pulse for a description of Province Resources' ***HyEnergy Project***.

The ***HyEnergy Project*** is part of a broader Province Resources play within the Gascogne Region, in which Province Resources is also developing its industrial minerals project (***Gascoyne Mineral Sands Project***).

The Western Australian Government supports the renewable energy and future fuels industry in Western Australia in all its forms. Edition 8 of Low Carbon Pulse reported on the ***Oakajee Strategic Industrial Area*** project being promoted by the WA Government, which may include up to 1.25 GW of solar and 270 MW of wind renewable energy, including for hydrogen production. The ***Oakajee Strategic Industrial Area*** project tender process is ongoing.

See: *Total Eren teams up with Province for Australian Green Hydrogen project*

Larry Fink and Bill Gates – critical mass on Path to Net-Zero

Previous editions of Low Carbon Pulse have reported on the perspectives of Mr Larry Fink and Mr Bill Gates in respect of net-zero and climate change, each a founder of an epoch defining corporation. These two titans have recently gotten together to compare notes on net-zero, and then shared them.

As ever, their discussion is succinct (at just under 2 minutes) but punchy, as they convey the fundamental responsibilities within economies and across the global economy:

- **Mr Fink** notes [addressing climate change is] not an easy task, but .. across the board capital is moving, and is going to move very rapidly … Every hydrocarbon company in the US is now focussed on this, whereas three / four years ago they weren't … we are making change, making more rapid change, because of Bill and other people are expressing the need for change."
- **Mr Gates** notes that while in future the bulk of emissions are going to arise from developing countries: " … the responsibility to innovate rests entirely on the [developed] countries, particularly on the US …. We will not solve climate change without driving down dramatically [the costs of ***GHG*** emission reduction to make] it economic for the middle income countries who are not responsible for historic emissions [to act both on climate change while] dealing with more basic needs."

US marks the need for progress to 2035

Having determined to achieve net-zero ***GHG*** emissions from electrical energy by 2035, the US has now determined to target the achievement of 80% clean power by 2030 (***80 by 30***).

Critical to these ambitions is the analysis that the transition to clean power at this rate will not increase the cost of electrical energy or give rise to grid integrity and stability issues (each of these issues was identified as key in Edition 7 of Low Carbon Pulse).

The ***80 by 30*** target cannot be achieved at the current rate of transition to renewable electrical energy – new policy settings are needed to accelerate the development of renewable electrical energy capacity. Director of Electricity Policy, at Energy Innovation, Mr Mike O'Boyle, considers that: "***An ambitious federal Clean Energy Standard … is perhaps the most consequential climate win we could hope for from [the Biden Administration]. Clean electricity is the lynchpin of decarbonisation, and there is no time to wait***".

> **Note**: A ***Clean Energy Standard*** or ***CES*** is a policy setting that mandates the generation of a stated (minimum) percentage of electrical energy from a clean source or sources.

On the Road (and charging) with John Kerry and Jennifer Granholm:

The US Department of Energy has USD 40 billion available in its load program for the transition to clean energy.

In an interesting, and mixed, metaphor, US Energy Secretary of Energy, Ms Jennifer Granholm has commented: "I am ready to rev those engines back-up so that we can spur the next generation of innovation and deployment". The focus of the loan program appears likely to be on battery and fuel cell technology, including ***BEV*** and ***FCEV***.

In answer to the question posed by the immortal Jack Kerouac: "Whither goest thou, America, in the shiny car in the night?" Increasingly the answer will be: "Nowhere, I am going home to recharge!"

Japan continues to progress

- Following the announcement of the increase in Japan's Nationally Determined Contribution (***NDC***) under the Paris Agreement at the Leaders' Summit (see Edition 15 of Low Carbon Pulse), it is apparent that Japan is now deliberating on how best to set policy so as to achieve a reduction of 46% in ***GHG*** emissions by 2030 (***46 by 30***). It is reported that the Renewable Energy Institute considers that the revised ***NDC*** is achievable if Japan is able to increase its proportion of total consumption of electrical energy to 45% by 2030.

  It is understood that part of these deliberations centre around reducing the time taken to obtain approvals for renewable energy projects, in particular for wind projects, on-shore and off-shore. As flagged in Edition 14 of Low Carbon Pulse, the Government appears intent on expanding the use of solar on roof-tops and elsewhere (including use of floating solar), and the development of geothermal renewable energy capacity located within national parks.

  See: *Japan to Tackle Red Tape to Boost Renewable Energy*
- On April 28, 2021, is was announced that the Japanese Government (***The Ministry of Economy, Trade and Industry***, or ***Meti***) has proposed the allocation of USD 3.4 billion (¥ 370 billion) to support the development of hydrogen technologies over the next decade. This allocation would be funded from the ¥ 2 trillion fund pledged by Japanese Prime Minister, Mr Yoshihide Suga in Q4 of 2020 (see Edition 5 of Low Carbon Pulse).

  See: *Japan to subsidise hydrogen technology development*

Dial-up climate control:

There are a number of theories about the impact of achieving net-zero, for example, first, climate change is baked-in / locked-in, and will continue for some time after net-zero is achieved, or secondly, climate change will slow and cease after net-zero is achieved.

The second of the two theories has long represented the preferred science based assessment, and the theory is locked-in to the Paris Agreement. The second theory does not however mean that climate change will be reversed quickly: lower average global temperatures are likely to arise over the long term.

To accelerate lower global temperatures, ***GHG*** emissions need to be removed from the atmosphere using negative ***GHG*** emissions initiatives, thereby reducing the level of ***GHG*** emissions present in the atmosphere. To a number of commentators, on the stabilization of ***GHG*** emissions in the atmosphere, at least in theory, it will be possible to control ***GHG*** emissions, and the level of climate change.

See: *Explainer: Will global warming 'stop' as soon as net-zero emissions are reached?*

CCC / CCUS round-up:

- As reported in previous editions Low Carbon Pulse, Equinor, TOTALEnergies and Shell are developing the Northern Lights Project (see Edition 2 of Low Carbon Pulse) (as part of the broader Longship Project), and Pale Blue Dot Energy (wholly-owned subsidiary of Storegga) in joint venture with Harbour Energy and Shell, is developing the Acorn Project (see Edition 14 of Low Carbon Pulse). In addition, BP and Chevron have developed strategies for storage projects.

  To this list can be added ExxonMobil, having formed a low carbon business unit to commercialize CCS / CCUS technology, with a reported USD 3 billion to be invested by 2025.

  See: *Has Exxon Mobil turned over a new, green leaf?*
- Ahead of the Leaders' Summit, it was widely reported that ExxonMobil proposed the development of a USD 100 billion CCS / CCUS storage hub close to Houston, Texas (***Houston Hub***). If developed as proposed, the ***Houston Hub*** would capture 50 million tonnes of ***CO_2*** each year from refineries and petrochemical facilities along the Huston Ship Channel. While ExxonMobil is not proposing direct Federal funding for the ***Houston Hub***, it is

seeking tax incentives to allow the development of technology or by the introduction of a carbon price, or both (see Edition 9 of Low Carbon Pulse).

Hydrogen storage:

Edition 13 of Low Carbon Pulse, outlined the ***HYBRIT project***. On April 7, 2021, it was reported that SSAB, LKAB and Vattenfall have commenced the development of a cavern storage facility to store Green Hydrogen produced for use at the ***HYBRIT Green Steel mill***.

As noted in other editions of Low Carbon Pulse, the use of cavern storage for Green Hydrogen will provide the means to produce Green Hydrogen (or Blue Hydrogen for that matter), and to store it, providing both inventory for the facility at which it is used, and energy storage. Also as hydrogen infrastructure networks develop, surplus inventory may be sold or traded, and dispatched.

See: *HYBRIT: SSAB, LKAB and Vattenfall building unique pilot project in Luleå for large-scale hydrogen storage investing a quarter of a billion Swedish kronor*

Note: Salt Caverns have been identified for some time as a feasible and flexible storage option for hydrogen. Also there is the potential to store hydrogen in salt deposits and salt domes, and possibly in depleted oil and gas fields.

E-fuel / Future fuel round-up:

- On April 20, 2021, a 1,000 MW Green Hydrogen project was reported to be under development consideration at the deep-water port of Baton Rouge, Louisiana, located on the Mississippi River. It is reported that Gron Fuels is to make a USD 9.2 billion investment in a renewable fuels energy complex (***BRRFP***) that will produce Green Hydrogen, renewable diesel, sustainable aviation fuels and feedstock for bio-plastic production. The ***BRRFP*** will use biogenic CCS / CCUS to store CO_2 emissions arising from the fuels and feedstock derived from fossil fuel and any other carbon intensive fuels. A final investment decision is expected within 2021.

  See: *Koch units sign on to Green Hydrogen project slated for Louisiana*
- On April 21, 2021, it was reported that the Eni / HitecVision joint venture (established to develop green energy projects in Norway and the broader Nordic market), Vår Energi (70% Eni, 30% Hitec Vision), will take supply natural gas to allow Vår Energi to develop a gas-to-ammonia (***G-t-A***) plant in northern Norway. Vår Energi has the option to develop either G-t-A plant or a liquified natural gas liquefaction facility.

  See: *Groundbreaking gas-to-ammonia plant on cards in Norway's far north*
- On April 21, 2021, the Australian Federal Government announced AUD 275.5 million funding for the development of four hydrogen hubs over five years, and AUD 263.7 million for CCS / CCUS projects over the next decade.

  See: *Federal government commits a further $275m to regional hydrogen hubs, devotes similar sum to controversial technology*
- On April 22, 2021, it was reported that the Baofeng Energy Group had commenced operation of its 200 MW solar powered hydrogen electrolyser facility in Ningxia Hui. This is the world's largest installed electrolyser.

  See: *Chinese company starts commissioning 'world's largest solar-powered hydrogen' project*

Hydrogen from waste … feedstock near to production and destination:

While production has yet to commence commercially, on April 27, 2021, Hyzon Motors Inc (***Hyzon***) and Raven SR LLC (***Raven SR***) agreed to develop jointly up to 100 waste-to-hydrogen production hubs (***3 Hs***) across the US, and globally. ***Hyzon*** and ***Raven SR*** say that the waste-to-hydrogen production facilities will produce renewable hydrogen at costs comparable to grey hydrogen.

It is estimated that 100 waste-to-hydrogen hubs could convert over 5,000 tonnes of waste a day into hydrogen: each waste-to-hydrogen hub is stated to be able to process 50 tonnes of waste a day to yield production of 4.5 tonnes of renewable hydrogen a day using ***Raven SR***'s propriety technology that derives hydrogen-rich syngas from organic matter: the technology is stated not to involve combustion or catalytic conversion. It is understood that the steam reforming process comprised in the ***Raven SR*** technology uses rotary kiln technology, in the absence of oxygen, thereby avoiding oxidation (i.e. combustion). As with other rotary kiln technologies, temperature control is key to avoid ash or slag arising, and in so doing producing biocarbon (and capture CO_2 and ***CO*** arising) and synthetic biogas. The ***Raven SR*** technology while proprietary combines proven technologies.

The renewable hydrogen will be available at point of production, with fuel cells being used by garbage collection vehicles (***GCVs***) and heavy goods vehicles (***HGVs***). For *Hyzon* this avoids reliance on third party development of hydrogen refuelling infrastructure (***HRI***) and third party supply of hydrogen to the owners and operators of its ***FCEV GCVs*** and ***HGVs***.

The waste-to-hydrogen hub at landfill model is highly prospective:

- ***Hyzon*** co-founder and CEO, Mr Craig Knight, said: "***Hyzon*** *aims to be one of the first companies to supply our customers with a hydrogen fuel cell truck, including our own garbage trucks, at a total cost of ownership [****TCO****] parity with diesel-powered vehicles*".
- ***Raven SR*** co-founder and CEO, Mr Matt Murdock, said: "*Our planet produces over 5.5 million tonnes of municipal solid waste and 16.5 agricultural waste every day. Theoretically, if we convert all this waste, we could produce over two million tonnes of renewable hydrogen per day – enough to satisfy over 25% of total global oil demand*".

  See: *EGEB: Up to 100 US waste-to-hydrogen hubs will power heavy-duty trucks*

Prospectively, the implications of waste-to-hydrogen hub networks are significant because:

1. The wide spread use of hydrogen hubs co-located with existing wastewater and landfill facilities offers feedstock for the production of hydrogen close to demand in urban environments;

2. While waste-to-hydrogen hubs remain to be developed, their development would:

- divert waste from landfill achieving reduction or avoidance of the need to landfill that waste, and the surface and sub-surface benefits that arise from diversion, and reduction or avoidance of ***GHG*** emissions arising from putrescible waste in landfill; and
- in using wastewater and waste as feedstock for hydrogen production, reduce ***GHG*** emissions arising from extraction, production and use of energy carriers produced from fossil fuels.

[***Note: The capture for use of CO_2 and CO remains a matter for development***]

High Vis Hyzon.

In separate transactions:

- TOTAL Carbon Neutrality Ventures has invested in Hyzon Motors, Inc.

  See: *Total Carbon Neutrality Ventures invests in Hyzon Motors*
- NEOM has signed a memorandum of understanding (***MoU***) with Hyzon Motors, Inc and Modern Industrial Investment Holding Group for the development of a ***FCEV*** assembly facility in Neom (***FCEV Plant***). It is reported that the ***FCEV Plant*** will be sized to assemble 10,000 ***FCEVs*** a year.

  See: *Hyzon Motors, NEOM and Modern Group Plan to Collaborate on Hydrogen-Powered Vehicle Value Chain*

Wind round-up:

- Off-shore wind off the Republic of Ireland is highly prospective. In addition to the "***Green Atlantic @ Moneypoint program***" (see Edition 14 of Low Carbon Pulse), over 24 investigation applications have been received over the last eight months, and over 50 in the last 24 months for off-shore wind field developments.

  To allow easier off-shore wind field development, the Irish government continues to develop new legislation (in the form of the ***Maritime Area Planning Bill***) to address current uncertainties and the long term development timelines for projects, so as to allow certain regulation and workable timelines: the new legislation will provide an integrated one-stop planning approval and consent process.

  See: *Ireland's New Legislation to Ease Offshore Wind Development*
- In Edition 14 of Low Carbon Pulse research from ***LUT***, Finland was reported. On April 19, 2021, the result of a survey undertaken by the Lawrence Berkeley National Laboratory was reported, and is broadly consistent with the ***LUT*** research. The headlines are that the cost of wind energy will reduce by up to 35% by 2035, and by between 37% and 49% ahead of 2050. The survey considered on-shore and off-shore, fixed bottom and floating wind capacity.
- ***Oceanex Energy*** has announced plans to develop:
  - 7.5 GW of off-shore floating wind projects off the coast of New South Wales to respond to the projected decommissioning of coal-fired electrical energy generating capacity in that State; and
  - 2 GW of off-shore wind projects off the coast of Western Australia.

  See: *Oceanex eyes massive 10GW of offshore and floating wind farms in Australia*

  Pilot Energy Limited was reported in Q3 of 2020 to be undertaking feasibility of an off-shore wind field off the coast from Geraldton, Western Australia. (The ***Pilot Energy*** news arose before Edition 1 of Low Carbon Pulse.)

  See: *Pilot Energy to Take Full Control of Australian Offshore Wind Project*

Note: There are now three prospective off-shore wind field developments off the coast of Western Australia: ***Australis Energy*** (see ***Edition 14*** of ***Low Carbon Pulse***), and ***Oceanex*** and ***Pilot Energy***. This is in addition to the Star of the South project off the coast of Victoria (see ***Edition 13*** of ***Low Carbon Pulse***) and ***Oceanex***'s interest in the development of floating off-shore wind of the coast of NSW. This interest in off-shore wind field development reflects the world class off-shore wind resources around Australia as demonstrated by the World Bank's Global Wind Atlas.

- On April 22, 2021, Acciona received approval to develop the 1 GW ***MacIntyre Wind Farm Precinct*** in the Cement Hills district of the Darling Downs region of Queensland, Australia. The ***Karara Wind Farm*** (forming part of the ***MacIntyre Wind Farm Precinct***), is to be developed in partnership with CleanCo Queensland, the Queensland Government's low emission electrical energy generator.

  See: *Wind farms to generate power and jobs for the Southern Downs*
- Edition 5 of Low Carbon Pulse outlined the ***NorthH$_2$ Project***. The ***NorthH$_2$ Project*** involves the development of 10 GW of offshore wind field capacity. The renewable electrical energy generated will be used to power offshore electrolysers, with the Green Hydrogen produced to be transported to shore by a hydrogen pipeline.

  On April 26, 2021 Shell, RWE, Gasunie and Gascade announced signature of a declaration of intent (***DoI***) in respect of the ***AquaDuctus project*** to transport up to 1 mtpa of Green Hydrogen produced in the North Sea directly into northern Europe from 2035. The Green Hydrogen delivered by the **AquaDuctus project** into northern Europe will make use of the other hydrogen infrastructure development planned.

  Recent editions of Low Carbon Pulse have detailed the level of infrastructure development planned in northern Europe: Edition 12 of Low Carbon Pulse outlined the ***HH-Win network***, **Edition 13** outlined the ***Clean Hydrogen Coastline*** initiative and the ***Lacq Hydrogen Project***, and Edition 14 of Low Carbon Pulse recounted the ***Get H2*** consortium's plan to establish a hydrogen supply chain across northern Europe, the Engie and INEOS plan to develop the first hydrogen co-generation plant, and the ***HYPOS initiative***.
- Continuing the news in respect of infrastructure development and repurposing in northern Europe, on April 27, 2021, a technical pre-feasibility study was published in respect of the repurposing of existing gas infrastructure

to allow the transportation of Green Hydrogen from Holstebro, Denmark to Esbjerg, Germany. The study has been undertaken by Energinet and Gasunie Deutschland.

See: *Energinet and Gasunie publish pre-feasibility study on hydrogen infrastructure*

- On April 26, 2021, Ørsted (the global leader in off-shore wind field developments) and Enefit (a leading utility and having the largest wind portfolio in the Baltics) signed a Memorandum of Understanding to develop a business jointly that aims to be the leading off-shore wind developer in the Baltic region.

  See: *Ørsted and Enefit form partnership to deliver large-scale offshore wind in the Baltic*

- On April 26, 2021, it was reported that six consortia have been selected to progress to the next stage of the tender for the award of the 1 GW offshore wind field development 33 km off the Cotentin Peninsula, Normandy (***Cotentin Wind Field***). The off-shore wind field will be France's eighth, and the fourth using the application and competitive dialogue tender process. On ultimate selection of the preferred proponent, the ***Cotenin Wind Field*** is to be fully developed by 2028. By 2028, France will have around 12.4 GW of offshore wind field capacity either installed or under construction, being both fixed-bottom and floating – see the final item in this section.

  (Edition 9 of Low Carbon Pulse reported on the tender process being used: application, competitive dialogue phase and ultimate selection of preferred proponent.)

  See: *France Reveals Normandy Offshore Wind Tender Finalists*

- On April 27, 2021, H2 View reported on projects being undertaken by the UK's five natural gas network operators, Cadent, National Grid, Northern Gas Networks, SGN and Wales and West Utilities. The projects being undertaken go to the achievement of Point 2 in the UK Government's Ten Point Plan (*Driving the Growth of Low Carbon Hydrogen*) in a form consistent with the blueprint unveiled at the Energy Networks Association in January 2021. (The Ten Point Plan was published in November 2020.)

  See: *In focus: Transitioning the UK's gas networks to hydrogen*

- On April 30, 2021, France announced the commencement of an application and competitive dialogue tender process in respect of up to 270 MW of off-shore floating wind capacity to be installed off the Brittany coast.

  As is the case with the ***Cotentin Wind Field***, this tender process is under the Programmation pluriannuelle de l'energie (Multiannual Energy Program), under which France is seeking to contract for the development of 8.75 GW of off-shore wind field capacity by 2028.

  See: *France Launches Floating Offshore Wind Tender*

Solar and wind the way forward to net-zero:

- In a widely reported study that solar and wind resources globally have the potential to generate 5,800 Peta watt hours (PWh) of electrical energy. In 2020 the total electrical energy consumption globally was estimated to be ***27 PWh*** (or stated in more usual terms 27,000 TWh). These statistics are contained in a report from thinktank Ember-Climate.

  The report notes that Australia remains "the lucky country": "*With vast renewable potential and a low population, [Australia] is well positioned to become the battery of the world*". Africa, Australia and Russia, with huge land-mass, are well-placed too use on-shore renewable energy sources, as opposed to off-shore facilities.

- On April 22, 2021, plans to develop a 3,800 km sub-sea high voltage direct current (***HVDC***) interconnector were outlined by ***Xlinks***: the plan is to transmit renewable electrical energy from 10.5 GW of installed onshore solar (7 GW) and wind (3.5 GW) capacity in Morocco to the UK, making land-fall at Alverdiscott, Devon (England) and Pembroke (Wales). (See the final piece (headed ***Interconnection***) in Edition 3 of Low Carbon Pulse for key financial modelling issues arising on use of interconnectors of over 3,500 km in length.)

  See: *Submarine cable to connect 10.5 GW wind-solar complex in Morocco to the UK grid*

Solar round up:

- On April 28, 2021, it was reported that roof-top solar in Western Australia was responsible for matching over 65% of load across Western Australia's primary grid (the ***Southern West Integrated System*** or ***SWIS***) during early Saturday afternoon on March 13, 2021. This was a new record in Western Australia. As reported in previous editions of Low Carbon Pulse, in Australia the record levels of renewable electrical energy usage tend to occur at times of low to lowest market prices and times of low or lowest load.
- On April 30, 2021, it was reported that the wonderfully named ***Solarduck*** (Dutch floating structure specialist) has developed a smaller scale floating structure capable of hosting photovoltaic solar and electrolyser facilities. The floating structure is an integrated PV and electrolyser platform that is designed for use on inland water ways.

  See: *Offshore floating PV platform unveiled in the Netherlands*

Land Transport round-up:

- On April 20, 2021, it was reported that Hyundai Rotem has unveiled its "K-hydrogen tram". While the "K-hydrogen tram" is continuing development, it is expected that Hyundai Rotem will commence commercial production of the tram in late 2023, early 2024. The City of Changwon (where the tram is being developed), plans to use tram on its light rail network by 2030.
- On April 21, 2021, it was announced that Chevron and Toyota have signed a memorandum of understanding to develop and to build-out fuel cell infrastructure, including working together to take advantage of policy settings that allow the development of hydrogen refuelling (***HRI***) infrastructure development, and the transportation and storage of hydrogen.

  See: *Chevron, Toyota announce alliance on hydrogen technology*

- Belgium, Germany, Portugal and Spain are developing and testing a zero-emission train prototype. Toyota Motor Europe is to supply Fuel Cell modules for use in the prototype. The power and propulsion system in the prototype is a bi-modal drive system combining electrical energy from overhead supply with a Fuel Cell power pack that work independently of the overhead supply.

See: *Toyota Motor Europe to supply fuel cell modules for train prototype*

- Around April 20, 2021, there was wide spread reporting that the Wrightbus double-decker bus, procured by FirstGroup plc and Aberdeen City Council, had completed 100,000 miles of operation. Operation of the fleet of 15 buses started in January 2020. Aberdeen City Council produces the Green Hydrogen, the energy carrier used to power and to propel the buses. Re-fuelling of each bus with hydrogen is reported to take around 10 minutes, with 25 kg of Green Hydrogen reported to power and to propel a bus over 250 miles.
- On April 23, 2021, there was wide spread reporting of the arrangements for the development and testing of a hydrogen switching locomotive from diesel to ***FCEV***: the California Energy Commission provided grant funding to Sierra Northern Railway and GTI to allow the design, installation and integration of hydrogen fuel cell technology to replace diesel power and propulsion.

  See: *Sierra Northern Railway and GTI receive $4m for hydrogen switcher locomotive*
- Staying in California, on April 27, 2021, it was reported that one of the major Japanese banks, MUFG Bank, has concluded a corporate loan with FirstElement Fuel (a developer based in California) to allow FirstElement to finance the expansion of hydrogen refuelling infrastructure (***HRI***). For MUFG Bank this is a first. Also it is reported that JBIC (the Japanese policy bank) provided funding. The funding provided to FirstElement is intended to support increased sales of Toyota and Honda ***FCEVs*** in California, the most developed market for ***FCEVs*** globally.

  See: *Japanese bank finances US hydrogen fuel network*
- Also in April 2021, it was reported that Sasol and Toyota Motor Corporation are to pilot the use of ***FCEVs*** to power and to propel **HGVs** along South Africa's main road freight corridor.

  See: *Sasol and Toyota South Africa Motors form Green Hydrogen mobility partnership*

There is a continued narrative, some may say growing narrative, around the use of Fuel Cell technology – including the headline that 25% of total energy consumption could be supplied by hydrogen from renewable sources by 2050. This narrative has been added to by the narrative arising from the ***Hyzon*** / ***Raven SR*** joint venture to develop 100 hydrogen hubs. As noted, the Carbon Tracker / Ember think-tank study has provided food for thought in respect of the scale of renewable resources. The study also notes that renewable energy could displace the use of fossil fuel for the generation of electrical energy by the mid-2030s.

Shipping news forecast:

- The World Bank Group has published a report entitled ***Potential of Zero-Carbon Bunker Fuels in Developing Countries***, published on-line on April 23, 2021. In identifying ***green fuels*** – ammonia and hydrogen – "*as the most promising zero-carbon bunker fuels within the shipping industry at present*", the World Bank says that "*Liquefied natural gas (LNG) … is likely to play a limited role in the decarbonisation of the shipping sector, and countries should avoid new public policy [settings that support] LNG as a bunker fuel … and continue to regulate methane emissions to put shipping on a [Paris Agreement] aligned **GHG** emissions trajectory.*"

  Global Director of Climate Change at the World Bank, Ms Bernice Van Bronkhorst identifies the broader benefits of ammonia and hydrogen: "*Not only [do] zero carbon bunker fuels help decarbonise shipping, but they can also be used to boost domestic infrastructure needs and chart a course for low-carbon development more generally*".

  See: *Ammonia and hydrogen are key to decarbonising maritime transport, says World Bank report*
- At the Singapore Maritime Technology Conference (***SMTC***) Shell's Global Head of Shipping, Mr Grahaeme Henderson addressed directly the World Bank report. Mr Henderson noted that: "*LNG is the lowest emission fuel available at scale in the shipping sector today. It has no clear rival in this regard. … The [shipping] sector cannot afford [simply to wait] for [the development of] alternative fuels [including ammonia and hydrogen]*".

  For corporations like Shell, commitments to the reduction of ***GHG*** emissions are taken seriously: ultimately it aims to achieve net-zero ***GHG*** emissions, across Scopes 1, 2 and 3, through the reduction of ***GHG*** emissions across its reservoir to bowser supply chain is fundamental, including the reduction in ***GHG*** emissions arising from shipping. This does not mean that the use of LNG bunkers is the beginning and the end of transition for Shell: the progress towards net-zero ***GHG*** emissions is iterative and requires change, it is not immutable.

  Consistent with this theme, the Chief Responsible Investment Officer for the Church of England Pensions Board, Mr Adam Matthews, said that: "*Given Shell's progress as a result of engagement and leadership's commitment to continue meaningful on the remaining areas of the Climate Action 100+ benchmark* (see Edition 13 of Low Carbon Pulse for Climate Action 100+)*, the Church of England Pensions Board is likely to vote in support of [the Shell] Energy Transition Strategy*" (see Edition 14 of Low Carbon Pulse).

  See: *Shell defends LNG, shipping 'cannot afford simply to wait for alternative fuels'*
- On April 26, 2021, it was announced that Royal Dutch Shell is conducting a feasibility study in respect of the use of fuel cells for ships. This is reported as being a first step for Shell. The feasibility study is reported to be taking place in world shipping hub, Singapore, and will include tests involving the installation of an auxiliary power unit on a vessel currently used as a ro-ro carrier.

  For the purposes of the study and tests, Shell is working with SembCorp Marine Ltd, and LGM Marin (a wholly-owned subsidiary of SembCorp). Shell Shipping and Maritime Asia Pacific and Middle East General Manager, Mr Nick Potter, said: "*We see fuel cells and hydrogen as a promising pathway to decarbonising shipping and working with partners in this way will develop our understanding of this critical technology*".

  This news item illustrates the iterative nature of progress towards net-zero.

  See: *Royal Dutch Shell to test hydrogen fuel cells for ships*

- The International Maritime Organisation (***IMO***) is lobbying governments for the introduction of a global regime to provide a carbon price for the international shipping industry. The advantage of a global regime is that it provides a level playing field for all participants in the international shipping industry.

  The international shipping industry is responsible for up to 2% of total global ***GHG*** emissions: if the international shipping industry were a country, it would be the world's sixth largest emitter of ***GHG***s by mass.

  As outlined in Edition 13 of Low Carbon Pulse, the imposition of a carbon price allows investment decisions to be taken on that basis of a low or lower or no carbon technology options. The initiative by the ***IMO*** is most welcome, but may be regarded as likely to take some time to align countries consistently. [**Note:** see Edition 27 of Low Carbon Pulse]

  See: *Climate change: Shipping industry calls for new global carbon tax*
- It has been reported that ***Maersk Mc-Kinney Moller Center for Zero Carbon Shipping*** and ***Lloyd's Register Maritime Decarbonisation Hub*** are to undertake an assessment of the safe use of ammonia as a bunker fuel. It is reported that AP Moller-Maersk, MAN Energy Solutions, Mitsubishi Heavy Industries and TOTALEnergies are all committed to the development of best practice safety practices and guidelines for use of ammonia.

  See: *New coalition for safe ammonia bunkering*

Treeing-off – carbon-credit and carbon-offset roundup:

- **Basic principles:** Previous editions of Low Carbon Pulse have logged the likely increasing scrutiny of the use of carbon offset mechanisms, critically going to the core of the matter are two issues:
  - carbon-offset mechanisms do not reduce ***GHG*** emissions, rather they allow ***GHG*** emitting activities to continue to be undertaken applying the theory that another activity is removing an equivalent mass of ***CO_2*** from the atmosphere;
  - carbon-credit schemes may not, and, for many commentators, do not, achieve the carbon sequestration modelled, with countries and states allowing greater carbon-off-setting in respect of a greater mass of ***CO_2*** emissions than are actually sequestered by carbon credit schemes.

  It has been reported that certain countries and states have overcounted or overestimated the mass of ***CO_2*** absorbed by trees, and other means of sequestrating / sinking ***CO_2***.

As a result of these issues, there is an increasing need to formulate and to apply international standards for modelling the benefit of carbon-credit schemes, and to allow for the modification of models to reflect the actual benefits.

According to a recent study from Nature Climate Change, there is a 5.5 billion tonne discrepancy between the mass of ***CO_2*** sequestered under carbon-credit schemes and the actual sequestration of ***CO_2*** achieved (A 5.5 billion tonne discrepancy equates to over 10% of total global ***Co_2-e GHG*** emissions annually). As reporting obligations for corporations become stricter, it is likely that the private sector will respond to insist on greater accuracy, but the use of international standards for modelling will allow boards of corporations, and investors in those corporations, to draw greater levels of assurance.

See: *The math isn't adding up on forests and **CO_2** reductions*

- **Role of carbon-credit schemes and carbon-offset mechanisms:** There is a role for carbon-credit schemes and carbon-offset mechanisms, but ultimately the vast majority of the activities that give rise to ***GHG*** emissions need to be decarbonised. As is evident, there are not sufficient trees to absorb ***GHG*** emissions arising. The planting of new trees and the preservation of land-mass and returning land-mass to uncultivated use, will assist, but it is not answer.
- **World Economic Forum:**

  Recent World Economic Forum reports:
  - indicate that human activities, critically, land-clearance is actually contributing (i.e., increasing) to net ***GHG*** emissions rather than resulting in a reduction; and
  - outline the plans of Panama to restore lost rainforests by 2050 by reforestation of 1 million hectares.

  Further a World Economic Forum report is worth a read: "Why we can't afford to dismiss carbon offsetting in a climate crisis".

Summary: This feature is not an argument for ceasing to undertake negative ***GHG*** emission reduction initiatives, rather it is an argument for undertaking more of them, and to place an appropriate value on land-use to ensure that these initiatives are maximised so as to sequestrate ***GHG*** emissions. At the same time as maximising the beneficial impacts of negative ***GHG*** emission reduction initiatives, there should continue to be policy settings to price carbon-off mechanisms above the cost of transitioning to undertaking activities that give rise to low or lower or no ***GHG*** emissions at all.

Net-zero round-up:

- Amazon continues to blaze a trail making it now the largest purchaser of renewable energy globally.

  See: *Amazon is now the top corporate buyer of renewable energy in Europe*
- ANA moving to net zero by 2050.

  See: *ANA aims for carbon neutrality by 2050*

Low Carbon Pulse - Edition 17

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to Edition 17 of Low Carbon Pulse – sharing significant current news on progress towards net-zero emissions globally. This edition covers the period from Monday May 3, 2021 to Sunday May 16, 2021 (inclusive of each day).

Please click here for the previous edition of Low Carbon Pulse. Please also click here and here for the first two articles in the ***Shift to Hydrogen Series*** (***S2H2***)***: Elemental Change*** series: the *S2H2* series provides a narrative and perspective on hydrogen generally. The first feature in the ***Hydrogen for Industry*** (***H24I***) feature series has been delayed a little, but will be published this week.

The week-ahead:

- **International Energy Agency (*IEA*) - getting the message out:**

  Over the last two weeks or so, the ***IEA*** has been promoting the publication of its long awaited ***Global Roadmap to Net Zero by 2050*** (***IEA Roadmap***). The ***IEA Roadmap*** is to be published today May 18, 2021. Please click here for materials released by the ***IEA*** to promote its publication and to explain the basis of some thinking applied in modelling.

- **First UK *ETS* auction – awaiting price point:**

  The coming week sees the first ***UK ETS*** auction, and as such the first time that it will be possible to benchmark the relative prices of the ***UK ETS*** to the ***EU ETS***. The first auction will take place on Wednesday, 19 May, 2021. The ***UK ETS*** will have an initial cap of 155.7 mtpa (for 2021) with that cap reducing to 117.6 million metric tonnes per annum by 2030.

As the dust settles after the Leaders' Summit, some reflections on CH_4:

- **CH_4 reduction key theme:** Edition 15 of Low Carbon Pulse provided a summary of the key outcomes from the Leaders' Summit. Edition 16 of Low Carbon Pulse noted key themes emerging from the Leaders' Summit, including action on methane (***CH_4***).
- **Global warming potential of CH_4:** The global warming potential (***GWP***) of ***CH_4*** is greater than for ***CO_2***, and the concentration of ***CH_4*** in the atmosphere has been increasing: ***CH_4*** has 84 times the ***GWP*** of ***CO_2*** by mass over a 20 year period. The principal human activities that give rise to ***CH_4*** are the production and use (including fugitive emissions arising on production and use) of energy carriers from fossil fuels and other carbon intensive feedstocks, agriculture and farming, including raising of livestock (for meat and dairy) and production of rice using paddy fields, and the decomposition of organic waste (including waste water and putrescible organic matter in landfills). It is estimated that ***CH_4*** is responsible for up to 30% of the increase in temperature arising from ***GHG*** emissions since pre-industrial times. It appears that the rate of increase in the concentration of ***CH_4*** in the atmosphere has risen in the last 20 years, in particular since 2006.
- **UN Report affirmatory:** In a recent UN report - *Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions* - these dynamics are recognised. The report concludes that the reduction in ***CH_4*** emissions in the near to medium term (with a halving of ***CH_4*** emissions possible by 2030) is affordable, using proven technology. The UN estimates that a halving of the ***CH_4*** emissions by 2030, and their ongoing reduction, will avoid a 0.3°C increase in the average global temperature by 2045.

Lone Star Blackout Analysis:

- **Background:** Edition 9 of Low Carbon Pulse reported on the power blackouts experienced during the week of February 14, 2021, in Texas, US (the ***Lone Star State***). While early days, the prognosis at that time was that the cause of the power blackouts was the unavailability, or reduced availability, of fossil-fuel-fired electrical energy generation capacity, not the unavailability of wind, or the failure of wind, farms. At the time, the Global Ashurst Towards Zero Emissions team advocated for an increase in installed wind capacity to guard against any reoccurrence.
- **The cause of the blackout:** A report from the Electric Reliability Council of Texas (***Ercot***) confirms that the most significant cause of the blackouts was the unavailability of gas-fired electrical energy generation capacity - caused by shut-down or reduced availability, due to a shortage of natural gas. The contribution to the power blackout as a result of loss of wind (and solar) electrical energy generation capacity has been found by ***Ercot*** to be relatively insignificant. The impact would have been less significant still, had cold temperature packages been purchased, and in use, on the wind-turbines.
- **If not right first time, correct the capacity factors and try again:** An initial report from ***Ercot*** released in early April took the nameplate capacity of gas-fired generation and wind-farm capacity as the basis for the assessment of the cause of blackouts. This initial report did not apply a capacity factor to the nameplate capacity of the installed wind-farms, and as such suggested the wind-farm capacity played a more significant role in the blackouts than was in fact the case: the test applied should have been what actual electrical energy that installed wind-farm capacity could have generated during the period of severe weather (which goes to the capacity factor).

  Installed nameplate capacity of a wind farm is never used for the purposes of determining the ability of the wind-farm to generate electrical energy, rather that ability of the wind-farm to generate electrical energy is determined by the average power generated divided by the peak rate power: for example, if a 10 MW turbine generates electrical energy at an average of 4 MW, the capacity factor of that turbine is determined as 4 / 10 or 40%.

  See: *Texas grid operator confirms gas, not wind, the biggest culprit in blackouts*

Germany increases rate of *GHG* reductions:

- ***55 by 30*:** Edition 16 of Low Carbon Pulse reported that on April 21, 2021, the European Commission (***EC***) had reached provisional agreement on the ***European Climate Law***, including to reduce ***GHG*** emissions by 55% by 2030 (***55 by 30***), compared to 1990 levels. While ***55 by 30*** has grabbed the headlines, the ***European Climate Law*** addresses also what is needed to achieve net-zero ***GHG*** emissions by 2050.

  Edition 9 of Low Carbon Pulse reported on increased litigation seeking to require governments to increase the rate of reduction in ***GHG*** emissions. One the relevant governments was the German government.
- ***55 by 30*** **response to judgment of constitutional court:**

  On April 30, 2021, the Germain constitutional court determined that one of the policy settings, reflected in Germany's ***Climate Protection Act*** (intended to reflect Germany's commitments under the Paris Agreement), was unconstitutional in part because it did not deal with ***GHG*** emissions arising after 2030.

  The constitutional court said that the provisions of the ***Climate Protection Act***: *"irreversibly off-load[ed] major emissions reduction burdens onto periods after 2030 … For this target to be reached, the reductions still necessary after 2030 will have to be achieved with ever greater speed and urgency. These future obligations to reduce emissions have an impact on practically every type of freedom because virtually all aspects of human life still involve the emission of greenhouse gases and are thus potentially threatened by drastic restrictions after 2030. Therefore, the legislator should have taken precautionary steps to mitigate these major burdens in order to safeguard the freedom guaranteed by fundamental rights".*

  In response to this determination, the German Federal Government has acted. On May 7, 2021, the German Federal Government announced increased ***GHG*** reduction targets as follows: 65% ***GHG*** emission reduction by 2030 and 85-90% by 2040, both compared to 1990 ***GHG*** emissions, and net-zero ***GHG*** emissions by 2045. This is a move from the previous 55% reduction in ***GHG*** emissions by 2030, and as such moves Germany clearly ahead of the ***55 by 30*** reflected in the ***European Climate Law***, and moves Germany to a position comparable with the UK, albeit a little behind where the UK is currently.

  The challenge for Germany is how to achieve these revised targets. Japan has a like challenge, in fact a greater challenge, having increased its ***GHG*** emission reduction target from 26% to 46% by 2030 compared to 2013. A start for Germany is to accelerate the rate at which Germany tenders for the installation of renewable electrical energy capacity: this it has already done with photovoltaic solar capacity, and off-shore wind capacity, with capacity to be auctioned to be increased from 1.9 GW to 6 GW for photovoltaic solar, and from 2.9 GW to 4 GW, during 2021.

  Generally, and as noted in previous Ashurst publications, for the last 15 to 18 months, it has been apparent that countries have realised that there is a need to accelerate the rate of ***GHG*** emission reductions, and the primary responsibility for this falls on the developed countries.

  See: *Germany forced by court ruling to set world-leading net zero targets: Can it reach them?*

Northern Europe continues to cooperate at all levels:

- **Fortum and Uniper combine efforts:** On May 10, 2021, it was announced that two northern European giants, Fortum (Finland) and Uniper (Germany) have decided to cooperate strategically on "Nordic hydroelectric, physical trading optimisation, wind and solar developments, and hydrogen". The plan will allow Fortum to concentrate on hydroelectric operations, with Uniper to concentrate on wind and solar development, in each case operating the assets of both corporations in their respective areas of concentration.

  See: *Fortum and Uniper reaching first milestones in strategic "One Team" cooperation*

- **Efficient development of renewable electrical energy development is key:** The combination of Fortum and Uniper is an exciting development recognising both the scale of the development required and the shared markets in which each corporation is to compete. Emerging themes across renewable electrical energy capacity development appear to be efficiency and flexibility, including in the eyes of those developing policy settings. Edition 14 of Low Carbon Pulse noted the importance of renewable energy efficiency in the context of achieving ***GHG*** emission reduction targets.

India H2 Alliance on the road:

Edition 14 of Low Carbon Pulse reported on the establishment of the India H2 Alliance (***IH2A***), and its six-point agenda. On May 3, 2021, it was reported that the ***IH2A*** provided its agenda to the Government of India (consistent with the principles reported on in Edition 14 of Low Carbon Pulse), critically to develop a domestic hydrogen supply chain and 10 hydrogen valleys.

See: *India H2 Alliance submits six-point hydrogen agenda to Indian Government*

Increased focus of the mining sector:

- **The quiet achiever:** For some time the mining and resources sector has been something of a quiet achiever in progress towards net-zero emissions. The importance of mining and resources sector to the world economy is known, but this importance is not always recognised.

  The mining and resources sector has a strong sense of its importance and scale, and its responsibilities. This is often missed, possibly because the mining and resources sector tends to get on with the task, rather than talk about the task.

- **Increased visibility of the quiet achiever:** In a recent address, Anglo American CEO, Mr Mark Cutifani stated clearly the importance of the mining and resources industry to the world economy: in the context of a global population of 7.6 billion people, progressing to 9 billion, "*the simple fact is that the world cannot survive without mining and [its contribution] to … every aspect of modern life. In fact 45% of the world's economic activity is driven by the mining sector*" having regard to both direct and indirect sales of commodities and products derived for produced from them.

  Mr Cutifani went on to say that: "*When we talk about life-of-mine plans were are … now [also] starting to focus on the life-of-community plans, and how we can create 100 [year futures] for those communities based in the infrastructure*".

  The importance of the mining and resources industry is only going to increase. In addition to increased demand arising from population growth, the mining and resources sector needs to expand existing sources, and to develop new sources of, copper, cobalt and nickel and lithium (and precious metals gold and silver, and rare earth metals), and graphite, to allow the shift to the use of ***BEVs*** and ***BESSs*** and other metals and minerals and catalysts to allow the development of electrolysers (principally iron and steel at the moment) to produce Green Hydrogen.

  There is a helpful (and complete) publication from the ***IEA*** that outlines The Role of Critical Minerals in Clean Energy Transitions. (The full form publication is well-worth a read.) The ***IEA***'s Executive Director, Mr Fatih Birol has been active of late in communicating the need to avoid bottlenecks arising in the extraction and supply of ***Critical Minerals***.

  For those familiar with a number of industries, these dynamics are likely to provide impetus to the recovery and recycling of E-waste to derive some metals. Reflecting on this, it is not a surprise to the Global Ashurst Towards Zero Emissions team that the ***EU*** is considering mandating of the recovery of metals and minerals from E-waste so as to provide an increased level of assurance around security of supply.

- **The cost of achieving goals – corporate and global:** On May 11, 2021, it was reported that Wood MacKenzie released a report stating that the level of capital investment required by the mining industry is USD 1.7 trillion over the next 15 years so as to ensure that it is possible to achieve the ***Stabilisation Goal*** under the Paris Agreement. To achieve the ***Stretch Goal*** a higher level of capital investment is required.

  As a reminder, under the Paris Agreement the ***Stabilisation Goal*** and ***Stretch Goal*** are committed to hold: "the increase in global average temperature to well below 2°C above pre-industrial levels [***Stabilisation Goal***] and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels [***Stretch Goal***] …".

- **The mining and resources industry is going some heavy lifting:** As is the case with many other sectors, the mining and resources sector is doing some heavy lifting.

  In addition, mining and resources corporations are committing to achieving net-zero ***GHG*** emissions so as to match the expectations of investors, and so doing ensuring that they are able to access the level of capital investment necessary to enable them to extract and to deliver commodities necessary to achieve net-zero ***GHG*** emissions: supply of resources is directly linked to supply of capital, and both are necessary to achieve net-zero.

- **Not quite plain sailing:** In the case of Vale this includes the use of a wind assisted ore carrier: the carrier is a very large ore carrier (a ***VLOC***, with load capacity of around 325,000 tonnes).

  See: *Vale set to receive first-ever wind-powered ore carrier*

Japan continues to progress:

Previous editions of Low Carbon Pulse have noted that the Government of Japan and corporations in Japan appear to be in lock-step in making progress towards reductions in ***GHG*** emissions. Japanese corporations are continuing to make progress as the following news items indicate.

- **Hydrogen power and propulsion:** On May 6, 2021, it was announced that Japan Engine Corporation (***JEC***), Kawasaki Heavy Industries (***KHI***) and Yanmar Power Technology (***YPT***) have formed a consortium to pursue jointly the development of power and propulsion systems using hydrogen for coastal and ocean-going vessels. Hydrogen storage and delivery systems will be developed at the same time.

See: *Japanese trio to jointly develop hydrogen-fueled marine engines*

- ***KHI*** **scales-up** ***LHG*** **carrier:** On May 7, 2021, ***KHI*** announced that is has developed the world's largest liquid hydrogen gas (***LHG***) containment system: ***KHI*** has received approval from Classification Society, ClassNK, for a 40,000 cubic metre containment system, i.e., a tank. To be liquified, the temperature of gaseous hydrogen has to be chilled to a temperature of minus 253°C, at which temperature it is 1/800th is original volume. (This contrasts with natural gas, which has to be cooled to a temperature of minus 161°C, at which temperature it is 1/600th is original volume, and is liquefied natural gas (**LNG**).)

  A challenge in carrying any liquified "energy carrier" is the production of boil-off gas (***BOG***) caused by the liquified energy carrier converting back into its gaseous state. ***KHI*** is reported to have developed a new insulation system that maintains the temperate of minus 253°C consistently in the containment systems, and as such mitigates ***BOG***.

  Edition 2 of Low Carbon Pulse reported on the development of the Suiso Frontier (launched in December 2019) by ***KHI***. Suiso being Japanese for hydrogen. The Suiso Frontier has a 1,250 cubic metre containment system. As such the new containment system represents a 38,750 cubic metre increase in capacity, a colossal increase in ***LHG*** carrier capacity. ***KHI*** is working to develop an ***LHG*** carrier with 4 tanks or 160,000 cubic metres of carriage capacity. ***KHI*** anticipates that the ***LHG*** carrier will be commercialised by the mid-2020s.

  This is another event that illustrates the level of momentum that has been achieved, and reinforces that the momentum is increasing. The development of a 160,000 cubic metre ***LHG*** carrier creates a volumetric capacity comparable with a medium sized LNG carrier. Larger (***LHG***) carriers still can be expected.

  See: *Kawasaki Develops Cargo Containment System for Large Liquefied Hydrogen Carrier with World's Highest Carrying Capacity—AiP Obtained from ClassNK*

- **JERA sold on ammonia as energy carrier:**

  Ahead of the announcement of the tie-up between JERA and Yara (see below) JERA was signalling in The Japan Times that it was moving close to material commitment to the use of ammonia as an energy carrier. This was flagged by JERA as early as November 2020 when it announced its plans to transition its coal-fired power stations to ammonia.

  This is consistent with the development of a Roadmap for Fuel Ammonia, and the activities at various ports around Japan planning the development of ammonia import facilities.

  See: *Japan Onahama port to examine ammonia, hydrogen imports*

- **Woven City – City of the Future:** On May 10, 2021, it was announced that Japanese corporations ENEOS and Toyota Motor Company have combined resources to consider how they may work together to help in the development of Susono City, Shizuoka Prefecture, Japan – "the city of the future" or the Woven City. In a statement about the combination of ENEOS and Toyota to develop the Woven City, Toyota indicated that the plan is to test the basis of the development and implementation of a hydrogen-based supply chain, in and around (and, if you will, woven into the fabric of) the Woven City.

  See: *ENEOS and Toyota Come Together to Make Woven City the Most Hydrogen-Based Society*

BESS round-up

- **All** ***BESSED*** **up:** One of the successes over the last five years in the renewable energy sector has been the development of big batteries – battery energy storage systems (***BESSs***). Edition 10 of Low Carbon Pulse gave some examples of jurisdictions in which ***BESSs*** are being used or planned, and why. Edition 13 of Low Carbon Pulse provided an overview of the on and off-grid uses to which ***BESSs*** may be put.

  In Hawaii a big battery project is to proceed with the development of the 185 MW / 565 MWh ***Kapolei BESS*** on the island of Oahu, with Plus Power to design and construct the ***BESS*** for Hawaiian Electric Co, with completion of the construction schedule to coincide with the closure of the AES Corporation coal-fired power station in 2022.

  A policy setting issue arose in the context of the approval of the ***Kapolei BESS***: while the Hawaii Public Utilities Commission has approved the development of the ***Kapolei BESS*** it has done do knowing that the ***BESS*** will be charged by electrical energy from coal-fired power stations, not renewable energy sources: the thinking around ***BESSs*** has been that renewable electrical energy is to charge them for later dispatch, not that a ***BESS*** is charged by non-renewable electrical energy. Effectively, the ***Kapolei BESS*** has been approved, in the words of the Commission "to provide further assurance that the "lights will stay on" [on] the retirement of the AES coal plant in 2022 … ".

  In the context of the approval of the ***Kapolei BESS***, the Commission also approved the terms of power purchase agreements under which coal-fired power stations will supply electrical energy to Hawaiian Electric Co to charge the ***BESS***.

  See: *Hawaii approves massive battery storage project to help end coal power*

- **Battery of batteries:** On May 4, 2021, it was announced that Mitsubishi Power Americas, Inc. and Powin LLC have been awarded a contract to develop 640 MW of ***BESS*** capacity on two sites in California so as to assure integrity and to enhance stability of the grid, and to provide flexibility across the grid. ***BESSs*** will be installed at Southern Power's Kern County 205 MW Garland Solar Facility, 88 MW / 352 MWh of energy storage capacity, and at the 204 MW Tranquility Solar Facility, 72 MW / 288 MWh of energy storage capacity. The ***BESSs*** are expected to be installed and on-line during 2021.

  See: *Mitsubishi, Powin providing battery storage retrofits to California solar project*

- **Ready-made hall decked with batteries:** On May 7, 2021, it was announced that Greenspot plans to make use of the existing generation hall and related infrastructure at the decommissioned Wallerawang coal-fired power station just outside Lithgow, Central Western, New South Wales, Australia, to house a big battery. The AU$ 500 million ***Wallerawang 9 Battery BESS Project*** will have ***BESS*** capacity of 500 MW / 1,000 MWh.

See: *Work underway to repurpose Wallerawang power station into battery and industrial zone*

CCS / CCUS round-up:

- **Dutch Government provides grants in form of subsidy:** On May 8, 2021, it was widely reported that the Dutch Government has granted a subsidy of around USD 2.4 billion (or €2 billion) to allow the development of carbon capture and storage at the Port of Rotterdam (***Rotterdam CCS Project***).

  The ***Rotterdam CCS** Project* involves the capture of ***CO_2*** emitted from facilities and refineries located within, and in the vicinity of, the Port of Rotterdam, with the captured ***CO_2*** to be delivered into disused sub-seabed structures from which oil and natural gas have been extracted.

  The subsidy from the Dutch Government will cover the additional costs incurred by businesses undertaking activities that give rise to ***GHG*** emissions not currently captured, but which are to be captured by those businesses. This method of grant funding is reasonably well-established in Europe, and is predicated on the environmental benefit of capturing ***CO_2***.

  The Port of Rotterdam Authority is to provide the infrastructure to consolidate and to transport the captured ***CO_2*** and to deliver it into storage. It is anticipated that the ***Rotterdam CCS Project*** will achieve completion and become operational in 2024.

  The allocation of €2 billion to the ***Rotterdam CCS Project*** leaves another €3 billion of committed funding from the Dutch Government to be allocated in 2021 for technologies that will assist the Netherlands achieve its ***GHG*** emission reduction goals.

  It is becoming increasingly clear that governments have a key role to play in the development of CCS / CCUS: see Edition 2 of Low Carbon Pulse outlining the Northern Lights Project (as part of the Longship Project) – the Norwegian Government is providing USD 1.8 billion of funding for the USD 2.7 billion project.

- **Peterhead CCS Project – more demand for Acorn CCS services:** On May 12, 2021, Equinor and SSE announced the development of a new 900 MW gas-fired power station, at Peterhead, Scotland (***Peterhead Power Station***). The ***Peterhead Power Station*** is to be installed with carbon capture technology to allow the capture and storage of ***CO_2*** arising on the oxidation of natural gas used to fire the ***Peterhead Power Station*** (***Peterhead CCS Project***). The ***Peterhead CCS Project*** will have the capacity to capture and to store (on an intermediate basis) up to 1.5 mtpa of ***CO_2***.

  As reported, in the context of the policy settings of the UK Government, capture of this mass of ***CO_2*** annually would represent 15% of the target to capture 10 mtpa of ***CO_2*** by 2030. It has been noted by SSE that the ***CO_2*** captured by the ***Peterhead CCS Project*** is ideally placed to make use of the ***Acorn CCS Project*** (see Edition 14 of Low Carbon Pulse).

  Both the ***Acorn CCS Project*** and the ***Peterhead CCS Project*** have secured funding from the UK Government: from the Industrial Decarbonisation Challenge Fund, as part of Scotland's Net-Zero Infrastructure program. [**Note:** see Edition 22 of Low Carbon Pulse]

  See: *Equinor teams up with SSE for Scottish carbon capture and storage project*

E-fuel / Future fuel round-up:

- **BP, Iberdrola and Enagas** have agreed to undertake a feasibility study to firm-up plans to develop a 20 MW electrolyser project in Castellon, Valencia, Spain. The electrolyser would be located at BP's refinery in Castellon, and would be powered by renewable electrical energy from a 40 MW photovoltaic solar facility. The BP refinery currently produces and uses the greatest quantity of hydrogen within the Valencia region. The Green Hydrogen produced by the electrolyser would displace the grey hydrogen currently produced from a biofuel production process at the BP refinery.

  See: *Bp teams up with Iberdrola, Enagas on green H2 project at Spanish refinery*

- **Integrated PV Solar and electrolyser:** On May 3, 2021, Nel SA and First Solar announced that they have agreed to develop an integrated power plant control and supervisory control and data acquisition (SCADA) system as the first step to developing an integrated photovoltaic solar powered electrolyser system. This will provide a one-stop shop for developers of Green Hydrogen projects.

  See: *First Solar, Nel to develop integrated PV-hydrogen power plants*

- **Aqua nomenclature:** Edition 16 of Low Carbon Pulse reported on the ***AquaDuctus*** project, which is part of the ***AquaVentus project***: on April 26, 2021 Shell, RWE, Gasunie and Gascade announced the signature of a declaration of intent (***DoI***) in respect of the ***AquaDuctus*** project to transport up to 1 million metric tonnes per annum (***mmtpa***) of Green Hydrogen produced in the North Sea directly into northern Europe from 2035. ***AquaDuctus***' delivery of Green Hydrogen into northern Europe will deliver Green Hydrogen into the shore-based infrastructure planned for northern Europe, and detailed in previous editions of Low Carbon Pulse.

  On May 4, 2021, Offshore Wind Biz reported on the scope and scale of the entire AquaVentus project – which is intended to use renewable electrical energy from 10 GW of off-shore wind projects in the North Sea to produce up to 1 million metric tonnes per annum (***mmtpa***) of Green Hydrogen by 2035.

  The key elements of the AquaVentus project are detailed in the following table.

AQUA	KEY ELEMENTS / STAGES OF THE AQUAVENTUS PROJECT
AquaPrimus	refers to a pilot project to produce Green Hydrogen located on the island of Hegoland in the German sector of the North Sea, which project will be developed to increase capacity
AquaSector	refers to pilot scheme to achieve a "special area of energy production" for the use to produce Green Hydrogen
AquaDuctus	refers to the development of pipelines to haul Green Hydrogen from off-shore production to the mainland on northern Europe
AquaPortus	refers to the ongoing and incremental development of port infrastructure on the island of Hegoland to allow the expansion of Green Hydrogen production

- **ARENA open the hydrogen funding tray:** On May 4, 2021, the Australian Federal Government established organisation, ***ARENA*** (Australian Renewable Energy Agency), announced grant funding of a little over AU$100 million for three Green Hydrogen projects:
  - ***ATCO*** is to receive AU$ 28.7 million in respect of the development of its Clean Energy Innovation Park (***CEIP***), Waarradarge, Western Australia, at which a 10 MW electrolyser will be developed to produce up to 4 tonnes of hydrogen a day with the Green Hydrogen produced to be blended with natural gas;
  - ***Australian Gas Infrastructure Group*** (***AGIG***) is to receive AU$ 32.1 million in respect of the development of a 10 MW electrolyser at ***AGIG***'s Murray Valley Hydrogen Park, Wodonga, Victoria, with the Green Hydrogen produced to be blended with natural gas; and
  - ***Engie Renewables*** is received AU$ 42.5 million in respect of the development of its 10 MW electrolyser to produce Green Hydrogen which will be combined with nitrogen to produce Green Ammonia for the existing Yara Fertiliser facility in the Pilbara, Western Australia (this links to the MOU with JERA: see below - "***Yara and JERA leading the way from WA to Tokyo Bay***").

Elsewhere in the world:

  - **Alberta, Canada:** ATCO and Suncor are reported to be considering the development of a clean hydrogen project to produce up to 300,000 metric tonnes per annum of clean hydrogen. It is anticipated that 85% of the hydrogen produced would be used to displace fossil fuels currently used at the Suncor Edmonton Refinery; and

    See: *Suncor and ARCO Partner on a Potential World-Scale Clean Hydrogen Project in Alberta*
  - **Punggol, Singapore:** Engie was appointed by Singapore's JTC Corporation to build, own and operate the underground District Cooling System for the Punggol District of Singapore.

    See: *ENGIE wins project for the design of District Cooling System in Punggol Digital District in Singapore*

- **Amping up:** On May 4, 2021, Amp Power Australia Pty Limited, understood to be the wholly-owned subsidiary of Amp Energy (a leading Canadian energy company), has expanded into South Australia to develop the Renewable Energy Hub of South Australia (***REHSA***). The ***REHSA*** is reported to be an integrated photovoltaic and wind development with a ***BESS***. The ***REHSA*** includes the Spencer Gulf Hydrogen Energy Ecoplex, part of the South Australian Government's Hydrogen Action Plan.

  See: *Amp makes massive South Australia solar, battery, Green Hydrogen play*
- **First of a kind gas-fired power station in Australia**: On May 5, 2021, it was announced that EnergyAustralia (one of Australia's big three integrated energy companies) is proceeding to develop its 300 MW Tallawarra B peaking dual-fuel hydrogen and natural gas fired power plant. Tallawarra B will commence commercial operation fired by natural gas, but will upgrade over-time to be fired by Green Hydrogen. The New South Wales Government (the State in which Tallawarra B is located) has provided funding in the amount of AU$83 million (USD 64 million) for the Tallawarra B development.
- **Plug and SK ready to play:** On May 5, 2021, dynamic hydrogen energy companies, Plug Power, Inc., and SK Energy announced a joint venture to develop a business across ***PRC***, South Korea and Vietnam, including the manufacture of fuel cells in South Korea. (SK Energy has an existing relationship with Bloom Energy, Inc. – see Editions 3 and 4 of Low Carbon Pulse.)

  See: *Plug Power and SK Group Complete $1.6 billion Capital Investment to Build Hydrogen Economy in Asian Markets*
- **Queensland continues to be a popular destination:** On May 6, 2021, it was reported that Edify Energy (one of Australia's premier renewable electrical asset developers) plans to develop a 10 MW hydrogen electrolyser at the ***Lansdown Eco-Industrial Precinct*** being promoted and developed by Townsville City Council, in northern coastal Queensland, Australia. It is anticipated that Edify Energy will install solar capacity and a battery to provide behind the meter electrical energy to provide renewable electrical energy for the electrolyser.

  Edify Energy's plans are clear: "***Edify proposes to transform renewable energy (from the on-site solar facility) into hydrogen … to produce Green Hydrogen, which can then be utilised for … transport – trucks, locomotives and buses – for a domestic market, or potentially injected into the existing or new gas networks for domestic or export markets***". The development of the electrolyser at Townsville is the first stage in a plan to develop up to 1 GW of Green Hydrogen production capacity.

  See: *Edify Energy Lodges Development Application for Hydrogen Plant*

- **Green Hydrogen from Floating Wind:** On May 6, 2021, it was reported that Hyundai Heavy Industries (***HHI***) is to develop a 100 MW Green Hydrogen production complex. This development is consistent with the road-map that ***HHI*** released in March 2021, which included the development of a hydrogen supply chain.

  The 100 MW Green Hydrogen production complex will produce Green Hydrogen from sea-water with the renewable electrical energy to be sourced from an off-shore floating wind field (***Donghae-1 Floating Field***). The 200 MW ***Donghae-1 Floating Field*** is being developed by the Korea National Oil Corporation, Korea East-West Power, in a consortium including Equinor. The 200 MW ***Donghae-1 Floating Field*** project is part of the Korean Green Deal, and is effectively the first stage of a multi-stage development of the 6 GW off-shore floating wind field outlined below: see – "Off-shore wind fields off ROK rock".

  See: *Hyundai Heavy pursues Green Hydrogen project in Sea of Japan*

- **Great Gulf highly prospective:** On May 7, 2021, it was announced that Fusion Fuel Green (***FFG***) and Consolidated Contractors Group (***CCG***) signed a Collaboration Agreement on May 6, 2021, to provide plant design (using ***FFG*** technology) and construction (using ***CCG*** resources) to develop Green Hydrogen and Green Ammonia production capacity within the Greater Gulf region and in so doing displace current use of hydrogen derived from hydrocarbons, in the refining and petrochemical facilities across the region.

  See: *Fusion Fuel Green PLC Announces Partnership with CCC to Develop Green Hydrogen Demonstrator Plant in Middle East*

- **Yara and JERA leading the way from WA to Tokyo Bay:** On May 11, 2021, Yara International ASA (world leader in ammonia production) and JERA Co, Inc, (the largest power generation corporation in Japan, matching about 30% of total electrical energy load in Japan) announced that they had signed a memorandum of understanding (***MOU***) to work together on the production and delivery of, and supply chain development for, Blue Hydrogen and Green Hydrogen. This initiative is aligned with the policy settings of the Japanese Government, including a 46% reduction in ***GHG*** emissions by 2030 (compared to 2013) and the use of up to 3 ***mmtpa*** of ammonia by 2030.

  The Yara website reports that the ***MOU*** provides for:

  - Supply and development of new ammonia demand in Japan, including for power generation;
  - Sequestration of captured ***CO_2*** at Yara's ammonia plant in the Pilbara, Western Australia, enabling the production and supply of Blue Ammonia to JERA;
  - New clean (blue and green) ammonia project development; and
  - Optimisation of ammonia logistics in Japan.

- **Chile hot again:** On May 12, 2021, it was announced that US corporation, Tramo, and two Austrian corporations, Austria Energy Group and Ökowind, signed a memorandum of understanding for the development of a project in Chile to produce of Green Hydrogen and Green Ammonia, with the headline being the production of up to 1 ***mmpta*** of Green Ammonia. The renewable electrical energy would be provided by a 2 GW wind farm.

  In addition to the 2 GW for the Green Hydrogen and Green Ammonia project, it is reported that Chile is considering a number of other renewable projects having combined installed capacity of 2 GW: Gabriela (220 MW), Ghungnam (709 MW photovoltaic solar and 300 MW of concentrated solar), Pelequén (175 MW), Planta Solar Sol del Loa (640 MW) and Solar La Pampina (160 MW).

- **More hydrogen hub funding:** On May 14, 2021, as part of the Queen's Speech (in which the agenda and program of Her Majesty's Government is outlined), the UK Government indicated that it was providing GBP 240 to allow the development of a hydrogen production fund and the Holyhead hydrogen hub.

  See: *The Hydrogen Stream: Massive hydrogen/green ammonia project in Chile, hydrogen atlas for Germany*

- **Beautiful one day, "purefect" the next:** A previous edition of Low Carbon Pulse reported on the combination between Wildfire Energy and Pure Hydrogen. Pure Hydrogen continues to roll-out its business in Queensland with the execution an agreement with the Gladstone Area Water Board for the supply of water to Pure Hydrogen's large-scale hydrogen production facility located in Gladstone, Queensland – the ***Project Jupiter Hydrogen*** project.

- **Oakajee is OK:** Edition 8 of Low Carbon Pulse reported on the proposed development of a Green Hydrogen hub at Oakajee in Western, Australia, within a ***Strategic Industrial Area***. On May 14, 2021, the WA Government confirmed that Oakajee is an ideal location for the development of the Green Hydrogen hub.

  See: *Initial results confirm Oakajee as ideal site for Green Hydrogen*

Wind round-up:

- **Construction starts commences off Taiwan:** On May 5, 2021, it was announced that the commencement of the installation of jacket foundations was started on Ørsted's Greater Changhua off-shore wind field project, off Taiwan: the project comprises two fields, Changhua 1 and 2a, with the fields developed as one project.

  See: *Foundation Installation Starts at Ørsted's Greater Changhua OWF*

- **UK modifies policy settings – termination now a risk:** On May 7, 2021, the UK announced that the fourth round of the Contracts for Difference (***CfD***) scheme will be open to applications in December 2021.

  At the same time, the UK Government (Department for Business, Energy and Industrial Strategy), published its response to the consultation process on the changes to the standard ***CfD*** contract and the Supply Chain Plans (***SCP***).

  In the UK context:

  - a ***CfD*** is a private law contract between a ***Generator*** (being the entity developing a low carbon electricity facility) and the Low Carbon Contracts Company (***LCCC***). Under the ***CfD*** the Generator is paid the difference between the ***strike price*** (being a price on which the ***CfD*** was awarded) and the ***reference price*** (being a price reflecting the price for electricity in the UK).

– a ***SCP*** is required both to participate and to be awarded a ***CFD***.

In response to the changes to the rules applicable to ***SCPs*** there have been calls for clarification, critically arising from the right of the ***LCCC*** to terminate. This clarification may be expected well-ahead of the December 2021 allocation.

- **Off-shore wind fields off ROK rock:** Edition 9 of Low Carbon Pulse outlined the backing given to the world's largest off-shore wind fleld development: the USD 43.2 billion 8.2 GW by the Government of the Republic of Korea (**ROK** or **South Korea**).

  On May 7, 2021, the President of the Republic of Korea, Mr Moon Jae-in committed to provide funding to the first stage of a USD 32 billion, 6 GW floating off-shore wind field, off-shore of Ulsan in the south of the country.

  The development of the floating off-shore wind project will equate to half of the off-shore wind capacity to which the Government is committed by 2030. It has been reported that 80% of the electrical energy produced will be used to satisfy electrical load currently satisfied by fossil fuel fired electrical energy generation, 20% will be used to power electrolysers to produce Green Hydrogen.

  See: *South Korea unveils 6GW floating ambition*

- **Milestones no longer millstones:** In the first week of May 2021, it was reported widely that each of six off-shore wind projects in the UK have passed their respective ***Milestone Requirement***, being a key milestone in the prescribed process to the award of a ***CfD***: the six projects are Dogger Bank A, B and C (see Editions 4 and 5 of Low Carbon Pulse, being the three phases of the 3.6 GW Dogger Bank Wind Field project), Sofia (see Edition 13 of Low Carbon Pulse, the 1.4 GW project), and Seagreen (the 454 MW, Total and SSE Renewables project, on final development to have 1.075 GW of installed capacity) and Forthwind (the 12 MW project developed by Forthwind Limited off Scotland).

- **EDF to enter the Australian renewable market:** EDF announced its first wind-farm in Australia: for EDF a relatively modest 280 MW wind farm purchased from Goldwind and Lacour located in Queensland. It is reported that EDF intends to develop a portfolio of renewable energy projects in Australia, including ***BESSs***. Globally, EDF has plans to increase its current planned renewable energy capacity by 2030 from 28 GW to 60 GW.

  See: *French nuclear giant EDF unveils first wind and battery project in Australia*

- **Poseidon in good shape:** On May 11, 2021, it was reported that Zephyr Vind (a Swedish corporation, wholly-owned by Norwegian corporation, Zephyr) plans to develop the Poseidon floating off-shore wind field (***Poseidon Project***) with installed capacity of up to 1 GW (or around 5.5 TWh of generated electrical energy a year) over two fields, Poseidon North and South.

  The ***Poseidon Project*** will be located around 40 km off-shore Gothenburg, Sweden. The public consultation process for the ***Poseidon Project*** commenced on May 11, 2021, and ends on June 23, 2021, after which it may be expected that applications for permits will commence.

  See: *1+ GW Offshore Wind Farm Plan Emerges in Sweden*

- **Wind development on US Federal land approved:** On May 11, 2021, it was widely reported that the Biden Administration gave Federal approval for the USD 3 billion 800 MW Vineyard off-shore wind field project (***Vineyard Project***), south of Martha's Vineyard, off Cape Cod, Massachusetts (see Edition 13 of Low Carbon Pulse).

  The ***Vineyard Project*** is the first project to achieve approval for development in Federal sea-waters.

- **Taiwan ramps up off-shore wind field program:** On May 12, 2021, it was reported that Taiwan had released its draft policy in respect of the third round of off-shore wind developments. The headlines are that in 2022, 2023 and 2024 the Bureau of Energy will auction 3 GW of off-shore wind field capacity, for delivery of electrical energy from 2026 to 2031 at a rate of 1.5 GW a year.

  If these policy settings are achieved, it is expected that by 2031 around 14.7 GW of off-shore wind field capacity will have been installed.

  See: *'Taiwan's new policy can turn it into a major regional offshore wind hub'*

Renewables record across Californian grid record:

On April 24, 2021, at 2.30 pm on a Saturday afternoon, the California Independent System Operator has reported that 95% of the load across the Californian grid was matched by renewable electrical energy.

This outcome is consistent with experience in Australia, record levels of renewable energy are dispatched when load is lower, typically on the weekend, Saturday afternoons in particular, and at optimal times for solar generation. So it was on April 24, 2021 in California.

Solar round up:

- **Solar development on US Federal land approved:** On May 3, 2021, the Biden Administration stated that it had approved the development of the ***Crimson Solar*** project on Federal land west of Blythe, California. The USD 550 million ***Crimson Solar*** project is to be developed by Recurrent Energy, and on development will deliver renewable electrical energy to Southern California Edison.

  See: *U.S. approves massive solar project in California desert*

- **Republic of Korea – 2 GW tender:** On May 3, 2020, it was reported that the Republic of Korea Energy Agency has commenced the tender process to procure up to 2 GW of photovoltaic solar projects across the peninsula. Each preferred project will be awarded with a 20 year contract to sell renewable electrical energy to a power distributor. This is the first of two tenders to be undertaken in 2021.

  See: *South Korea kicks off 2 GW PV tender*

- **Ørsted homestead:** On May 4, 2021, it was reported that Ørsted had completed the first utility scale solar and battery storage in the US: the 460 MW solar and the 40 MW battery, as part of the ***Permian Energy Center*** project, in Andrews County, Texas. The Ørsted solar and battery facility is "located on a 3,600 acre site alongside existing oil and gas installations and will supply growing West Texas' demand for electricity". With the completion of the facility, Ørsted now has on-shore renewable electrical energy capacity of 2.1 GW, and a further 1.9 GW under construction.

  Ørsted's Chief Operations Officer, Onshore, Mr Neil O'Donovan said: "*Permian Energy Center is a significant milestone for Ørsted making it the first developer to operate the full spectrum of new renewable energy technologies at utility scale in the US – on-shore and off-shore wind, solar pv, and storage.*"

  See: *Ørsted completes US solar and battery storage facility*

- **Algeria 1 GW PV tender:** On May 6, 2021, it was reported in pv magazine that Algeria is to run a tender in June and July 2021 to procure 10 lots of 100 MW of photovoltaic solar capacity.

- **KAS in SA:** On May 11, 2021 it was announced that ACWA Power a corporation based in the Kingdom of Saudi Arabia is to develop a concentrated solar power (***CSP***) project 30 km from Postmasburg in South Africa's Northern Cape – the ***Redstone CSP Project***, and that the ***Project*** had achieved financial close. The ***Redstone CSP Project*** comes within the South African Renewable Energy Independent Power Producers' Procurement Program (***REIPPPP***).

  See: *Saudi power company to build R11.6 billion solar tower plant in Northern Cape* and *SA's largest renewable energy project Redstone CSP achieves financial close*

- **Tashkent tariff tumble:** On May 12, 2021, bids were opened on the IFC run procurement of the Uzbekistan Government's ***Sherabad-1 solar procurement***. UAE-based Masdar submitted the lowest bid for the planned 200 MW ***Sherabad-1 Project***. At US cent 1.8045/kWh it was the only bid below US 2 cents per kWh. The level of the bid is consistent with other low or record low bids on photovoltaic solar procurements during 2021 to date around the world, reflecting the continued fall in the cost of renewable electrical energy, in particular solar electrical energy.

  See: *Masdar submits lowest bid for Uzbekistan's Sherabad PV solar project*

Port and Land Transport round-up

- **Port of Los Angles moving to *BEVs* and *FCEVs*:** On May 6, 2021, it was announced that a Letter of Intent (***LoI***) had been signed by Nikola Corporation and the Port of Los Angeles for the supply of Total Transportation Services using 100 Nikola ***BEVs*** (30 by 2022) and ***FCEVs*** (70 by 2023).

  See: *Nikola and Total Transportation Services Inc. Sign LOI for 100 Nikola Trucks*

- **Port of Antwerp shifting to *FCEV*:** On May 6, 2021, it was announced that Air Liquide, DATS 24 and Port of Antwerp intend to deploy 300 hydrogen-powered trucks (and for these purposes to develop hydrogen support infrastructure) by 2025.

  This initiative is part of the broader ***HyTruck*** initiative to put on the roads of Belgium, western Germany and the Netherlands 1,000 hydrogen-powered trucks. (Edition 5 of Low Carbon Pulse, reporting on European Hydrogen Week, noted the initiative to deploy 100,000 hydrogen-powered trucks and 1,000 hydrogen refuelling stations.)

- **Volvo and Daimler back-into *FCEV*:** In the context of closer ties between two of the world's largest truck makers, there appears to be a complete meeting of minds: by the end of the current decade, ***FCEV*** will start to displace diesel as the preferred power and propulsion for heavy goods vehicles / trucks. Volvo anticipates that by the end of the decade half of its European sales will be of ***BEVs*** and ***FCEVs***: the truck maker anticipates a 50 /50 split between the two technologies. Both Volvo and Daimler are aiming to be net-zero by 2040. Volvo and Daimler have established a joint venture, ***Cellcentric***, to produce fuel cells (***FCs***). The production of ***FCs*** is expected to commence in 2025.

  This transition is required, indeed the transition is likely to be accelerated, as policy settings respond to the realisation that the world carbon budget needs to anticipate the growth in road freight transport (anticipated to double globally by 2050), and to mandate transition to ***BEVs*** and ***FCEVs***.

- **North Sea Port can see for miles:** On May 11, 2021, it was announced that a new Green Hydrogen project is planned within North Sea Port area at Terneuzen: Virya Energy and VoltH2 Terneuzen are reported to have signed a cooperation agreement to develop a 25 MW electrolyser to produce up to 3,600 tonnes of Green Hydrogen annually.

  The development is intended to allow the area at Terneuzen to be move to carbon neutrality in its operations, and to supply Green Hydrogen to hydrogen infrastructure facilities within the vicinity of the Port.

  The North Sea Port is a 60 km cross-border port area that extends from Vissingen on the North Sea coast in the Netherlands, 32 km in land to Ghent in Belgium. The North Sea Port is something of a hub: Ørsted plans to develop its ***SeaH2land*** 1 GW hydrogen facility (with renewable electrical energy provided from 2 GW of off-shore wind capacity) within the North Sea Port area and ArcelorMittal plans to install a new blast furnace (blast furnace B) at its Ghent steel-mill, on the Ghent -Terneuzen Sea Canal which is to use green fuels only. Arcelor-Mittal already uses world leading technology at its Steelanol project: this project captures carbon-rich gases from blast furnaces and converts those gases into bioethanol.

- **Hyundai capacity committed:** On May 13, 2021, it was reported widely that Hyundai Motor Group is committed to the development of ***FCEV***, and the facilities to produce them. Hyundai has indicated that it is committed to investing up to USD 7.4 billion by 2025 in the US.

- **US Postal Service delivery commitment:** On May 13, 2021, is was reported widely that the US has committed that at least 75% of the vehicles procured by the US Postal Service should be electric or otherwise net-zero emission vehicles. It is expected that this commitment will result in the US Postal Service spending USD 8 billion on the procurement of electric or otherwise net-zero emission vehicles.

Low Carbon Pulse - Edition 18

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to Edition 18 of Low Carbon Pulse – sharing significant current news on progress towards net-zero emissions globally. This edition covers the period from Monday May 17, 2021 to Sunday May 30, 2021 (inclusive of each day).

Please click here for the previous edition of Low Carbon Pulse. Please also click here and here for the first two articles in the ***Shift to Hydrogen Series*** (***S2H2***)***: Elemental Change*** series: the *S2H2* series provides a narrative and perspective on hydrogen generally. The first feature in the ***Hydrogen for Industry*** (***H24I***) series was published on May 28, 2021: the *H24I* series is intended to cover the role that hydrogen is playing or may play in each industry and sector, and how.

THE WEEKS AHEAD:

PRC ETS trading commencing:

The Ministry of Ecology and Environment for the ***PRC*** has indicated that work has been completed that will allow the commencement of the ***PRC***'s national carbon trading market by the end of June 2021.

Editions 6, 9 and 12 of Low Carbon Pulse provide an outline of the ***PRC ETS***.

See: *China to launch nationwide carbon trading market by June*

WHAT A WEEK!

- **IOC's under increasing scrutiny:**

  RDS judgment: Edition 17 of Low Carbon Pulse outlined the decision of the German constitutional court to the effect that one of the policy settings reflected in Germany's ***Climate Protection Act*** was unconstitutional, in part because it did not deal with ***GHG*** emissions arising after 2030.

  On May 26, 2021, the District Court in The Hague, in the Netherlands, delivered its judgment in a case brought against Royal Dutch Shell plc (***RDS***) by Mileudefensie (et al). This judgment requires ***RDS*** to reduce the net ***CO_2*** emissions of the ***RDS*** group by at least 45% by 2030, compared to 2019. The required reduction is across Scope 1, 2 and 3 emissions, not in respect of each Scope. The judgment is founded on ***RDS*** owing a duty of care to all Dutch citizens. It is expected that ***RDS*** will appeal the judgment. [**Note:** RDS appealed the decision]

  In the court of shareholder opinion:

  CVX and XOM resolutions:

  – the following resolution was passed by around 60% of the shareholders of Chevron Corporation: "*Shareholders request [Chevron substantially to reduce] the greenhouse gas (**GHG**) emissions of [**its**] energy products (Scope 3) in the medium - and long term future, as defined by [**Chevron**]*"; and
  – two new directors were appointed to the 12 member board of Exxon Mobil Corporation. The two new directors were selected from four directors nominated by ***Engine No. 1***. ***Engine No. 1*** is not a major shareholder in Exxon Mobil Corporation, but major shareholders, including BlackRock, backed the appointments.

  Each international oil company (***IOC***) is responding to the need for transition to net-zero in a manner intended to maintain shareholder value, while transforming its business from reservoir to bowser. What is becoming clear is that ***IOCs*** are facing increasing scrutiny.

  In Australia, the Federal Court found that the Federal Environment Minister has a legal duty not to cause harm to the young people of Australia by exacerbating climate change in the context of approving new or expanded coal mine projects. On the day of judgment, the concept of a legal duty of care was not determinative, but the concept may play in role in future decisions.

- **Indonesia on the road**:
  - **Phasing out coal-fired power:** On May 27, 2021, Perusahaan Listrik Negara (***PLN***) announced its intention to shutter all of its coal-fired power plants by 2056. It is reported that the shuttering will be phased: conventional plants to be shuttered by 2035 (9 GWs), "supercritical" plants by 2040 (10 GWs) and ultra-supercritical" by 2056. The shuttering is intended to be consistent with carbon neutrality by 2060.

    The shuttering of the ***PLN*** coal-fired plants may be viewed as the start of a broader move to new policy settings in Indonesia, and is certainly consistent with the decision not to develop any new coal-fired power stations.

    See: *Indonesian state utility to retire coal power plants gradually*
  - **Phasing in of renewable electrical energy and phasing out of coal-fired**: On May 27, 2021, it was reported widely that the Government of Indonesia will not approve the development of any new coal-fired power stations, recognising that coal-fired power stations under construction, and at the state of financial close, will proceed.

    See: *No new coal plants in Indonesia in another bid to cut emissions*

IEA Roadmap and G7 Meeting of Climate Change and Environment Ministers:

In Edition 17 of Low Carbon Pulse, the publication of the ***IEA Roadmap*** was foreshadowed. The key themes arising from the ***IEA Roadmap*** and the communique from the G7 Meeting of Climate Change and Environment Ministers are set out at the end of this edition of Low Carbon Pulse.

First *UK ETS* auction – no surprises:

On May 19, 2021, the ***UK ETS*** scheme commenced. As a member state of the ***EU***, the UK was part of the ***EU ETS***. On leaving the ***EU***, a ***UK ETS*** was required. Both the ***EU ETS*** and the ***UK ETS*** are cap and trade emissions trading schemes (see Edition 12 of Low Carbon Pulse for high-level outline).

Under the ***UK ETS*** there is an initial cap of 155.7 million metric tonnes per annum (***mmtpa***) (for 2021), reducing to 117.6 ***mtpa*** by 2030. The first auction of UK Allowances (***UKAs***) took place under the ***UK ETS*** on the afternoon of May 19, 2021, between 12:00 hours and 14:00 hours London time. The auction reserve price was set at GBP 22 per tonne. On the first auction, the reported clearing price was GBP 43.99, with all ***UKAs*** being auctioned successfully to 15 successful bidders. Sixteen bidders submitted bids for nearly five times the number of ***UKAs*** available in the May 19, 2021 auction. Further auctions will take place every other Wednesday until December 15, 2021, when all of the ***UKAs*** will have been offered through the auction process.

BESS round-up

- **Hot - don't touch: 16.5 GW pipeline of *BESS* under development in the UK:** On May 21, 2021, Energy Storage News provided an overview of the level of ***BESS*** activity in the UK. We include a link below to the article. It is a great article, providing a complete picture of the UK ***BESS*** market.

  See: *Large-scale battery storage in the UK: Analysing the 16GW of projects in development*
- **Compelling combination:** On May 25, 2021, it was announced that Shell Energy is partnering with the New South Wales Government and Edify (a leading independent Australian renewable energy company) to provide electrical energy to public buildings, including community and medical centres, and schools. The partnering arrangements include the development and use of 100 MW / 200 MWh of ***BESS*** to be built near Griffith, in the Riverina region of New South Wales, Australia.

  It is reported that the arrangements are reflected in a 10 year contract under which 1.8 TWh of electrical energy will be supplied each year. These arrangements are aligned with the commitment of the NSW Government to achieve net-zero ***GHG*** emissions by 2050.

  See: *Edify and Shell Energy sign a long-term services agreement to deliver a new large battery in South West NSW*
- **Big Battery Storage Map for Australia:** Leading renewable energy publication, reneweconomy, has published a Big Battery Storage Map detailing each ***BESS***. A link is included below.

  See: *Big Battery Storage Map of Australia*

Germany rounds up 62 large-scale hydrogen projects

On May 28, 2021 it was widely reported that German Federal and State Governments are to provide €8 billion in funding across 62 large-scale hydrogen projects.

The 62 large-scale hydrogen projects (selected from a reported 230 proposals) cover the entire hydrogen value chain, and reflect the oft-stated position of the German Government: "*We want to become number 1 in the world in hydrogen technologies*". This ambition, and the reported funding, is good news for all.

The funding of the 62 large-scale hydrogen projects is part of an ***EU*** initiative - ***Important Projects of Common European Interest*** (***IPCEI***) Hydrogen.

Green Metals:

Previous editions of Low Carbon Pulse have included sections on Green Steel. In light of the greening of metals, we have decided to refer to Green Metals.

- **Salzgitter update:** Edition 13 of Low Carbon Pulse provided an overview of the plans of Salzgitter to develop a direct reduced iron (***DRI***) plant able to operate using both natural gas and hydrogen. The pilot ***DRI*** plant is now under construction, with first production of ***DRI*** expected during the first half of 2022.

As noted, the ***DRI*** will be used in the blast furnace to reduce the mass of coal in pulverised coal injection form (***PCI***), and at the electric arc furnace of Salzgitter at Peine.

See: *Salzgitter begins construction of hydrogen project for low-carbon steel production*

- **Alcoa updating:** The production of alumina from bauxite uses steam as part of the process to refine bauxite to produce alumina: traditionally, the steam is derived from the use of fossil fuels to power boilers to produce steam. It is estimated that 70% of the ***GHG*** emissions arising from alumina production arise from the use of fossil fuels for this purpose.

  On May 21, 2021, Alcoa announced that it is to test the feasibility of using "mechanical vapour recompression" to electrify alumina production. This move is supported by funding from ***ARENA*** (the Australian Renewable Energy Agency).

  See: *Alcoa to investigate low emissions alumina*

- **Everfuel and Norsk to test mettle:** It has been announced that Everfuel and Norsk (formerly Norsk Hydro) signed a memorandum of understanding (***MoU***) on May 20, 2021.

  The ***MoU*** is stated to provide a basis for Everfuel and Norsk to develop a framework to allow optimisation of electrolyser use, including in the use of aluminium production, and "in the growing green mobility market in Europe". It is understood that Norsk is actively considering a number of projects for development in Norway and Europe.

  In a separate announcement, Everfuel has outlined its plans to develop hydrogen refuelling infrastructure, with 19 hydrogen refuelling stations to be in operation by the end of 2023. This is part of Everfuel's "Scandinavian Green Hydrogen fuelling strategy for trucks, buses and cars, connecting the main traffic corridors in Sweden, Norway and Denmark".

  See: Norsk and Everfuel

E-fuel / Future fuel round-up:

- **Hunter Valley to Hydrogen Valley:** The Australian states of New South Wales and Queensland have long produced both thermal coal and metallurgical coal for both domestic and export markets. In New South Wales, the heartland of coal production is the Hunter Valley.

  On May 18, 2021, advisory firm, Energy Estate, outlined plans for a Hunter Hydrogen Network (***H2N***) (echoing the Hunter Valley Coal Chain) as part of the development of the Hunter Valley to Hydrogen Valley, with the development of the Valley to involve Australian industry heavy weights AGL Energy (integrated energy company) and APA Group (Australia's largest gas pipeline company), and the UK's ITM Power (a PEM electrolyser manufacturer). As the development of the Hydrogen Valley takes shape, future editions of Low Carbon Pulse will report on it.

  See: *Hydrogen Valley: Plan unveiled to turn Hunter into a renewables hydrogen hub*

- **Blue Hydrogen and Blue Ammonia "to go", and Green Hydrogen on the go:**
  - On May 18, 2021, it was reported that policy settings in the United Arab Emirates (***UAE***) are being developed in recognition of the need to decarbonise energy production and use. Playing to the country's strengths, Blue Hydrogen and Blue Ammonia offer viable means of achieving this, through plans to develop supply to match demand.

    To commercialise these policy settings, ADQ, Abu Dhabi National Oil Company (***ADNOC***) and Mubadala Investment Co have formed a hydrogen alliance for the purposes of developing the use of Blue Hydrogen in the ***UAE*** as part of creating a hydrogen economy and positioning for export markets.
  - ***ADNOC*** **grey to blue:** produces around 300,000 tonnes of grey hydrogen a year, and intends to expand its production to around 500,000 tonnes a year. It is understood that the cost of production of grey hydrogen is between USD 1.30 and 1.50 per kg. The marginal cost of this increased production may be regarded as relatively small, with the key cost being the construction and installation of CCS / CCUS technology. ***ADNOC*** plans to increase its CCS / CCUS capacity to 5 million metric tonnes per annum (***mmtpa***) of ***CO_2*** by 2030.

    On May 24, 2021, ***ADNOC*** announced plans to develop a Blue Ammonia facility at the Ta'ziz industrial complex at Ruwais. The Blue Ammonia facility is expected to be scaled to produce 1 mpta (or 1,000 kilo-tonnes per annum).
  - **Green Hydrogen:** This does not mean that the ***UAE*** does not believe that Green Hydrogen will not be developed, quite the contrary: Masdar (owned by Mubadala) is developing a Green Hydrogen facility, and as noted below (under "**DEWA fulfils the promise of its name**") the Dubai Water and Electricity Authority has developed the first Green Hydrogen facility in the Middle East and North Africa. However, the development of Green Hydrogen supply is likely to take longer, and it appears logical to develop Blue Ammonia production in priority to Green Hydrogen given the current economics.

    See: *Masdar plans to complete design on hydrogen project this year, executive says*
  - **Green Hydrogen and Green Ammonia:** Further, on May 25, 2021, the Khalifa Industrial Zone Abu Dhabi (***KIZAD***) announced the development of a Green Hydrogen facility by Helios Industries. The Green Hydrogen facility is to be developed in phases, and on full development will produce up to 40,000 tonnes of Green Hydrogen and 200,000 tonnes of Green Ammonia per year.

    It is understood that the Green Hydrogen facility is to be powered by a 800 MW photovoltaic solar farm within ***KIZAD***. Head of Industrial Cities & Free Zone Cluster, Mr Abdullah Al Hameli, said that: "***Abu Dhabi Ports is proud to be the host of an innovative company like Helios Industries, and one of the region's first green ammonia plants with zero-carbon emissions***".

    See: *Abu Dhabi Ports announces green ammonia production project*

- **Hydrogen from sea-water :** On May 19, 2021, Gransolar announced the development of a Green Hydrogen facility (***GHF***) in the southern Spanish seaport of Port of Almeria. The ***GHF*** will use a double-reverse osmosis technology, with the deionized water being electrolysed using proton exchange membrane (***PEM***) technology, with the ***PEM*** reported to have installed capacity of 20 MW, and hydrogen production capacity of 1,000 tonnes a year. The Green Hydrogen produced is intended to provide hydrogen for ***FCEVs***. The ***GHF*** will be powered by renewable electrical energy from a 30 MW photovoltaic solar farm and 20 MWh of ***BESS***.

  The use of sea-water as a feedstock for the production of hydrogen remains an area for further development: the production of hydrogen from sea-water having desalinated the sea-water is energy intensive, and as such the economics of the ***GHF*** will depend on the cost of renewable energy and the price point for Green Hydrogen.

  See: *Solar-plus-storage to produce hydrogen from seawater*

- **E-Fuel - eMethanol:** On May 19, 2021, it was announced that Liquid Wind is proceeding with front-end engineering and design (***FEED***) in respect of its ***eMethanol*** (or renewable methanol) production facility (***eMPF***) to be located in Ornskoldsvik, Sweden. The ***eMPF*** is expected to produce 50,000 tonnes of ***eMethanol*** each year. The ***eMPF*** will use ***CO_2*** captured at a biomass-fired power plant, and combine that biogenic ***CO_2*** with Green Hydrogen. ***eMethanol*** is an e-fuel that may be used by the shipping industry, and also it may be used as a feedstock to produce chemicals (including adhesives, plastics and solvents), and in both cases its use will displace the use of fossil fuel.

  See: *Combining Green Hydrogen and biogenic CO2 to create renewable methanol*

- **Cummins welcomed:** On May 19, 2021, it was reported that the Cummins Wuhan Energy Engineering Center (***CWEEC***) had opened officially. The ***CWEEC*** is intended to provide a facility at which various technologies can be trialled, including for fuel cells and pipelines.

  For Cummins, this continues the roll-out of its global footprint in key jurisdictions, as it continues to pivot from its traditional business.

  See: *Cummins Hydrogen Energy Engineering Center Starts Operation in Wuhan, China*

- ***DEWA* fulfils the promise of its name:** On May 20, 2021 it was announced that the Dubai Water and Electricity Authority (***DEWA***) has produced Green Hydrogen within two and a half years of commencing the development of its Green Hydrogen Facility (***DEWA GHF***). The ***DEWA GHF*** derives its renewable electrical energy from the Mohammed bin Rashid Al Maktoum Solar Park (see Edition 8 of Low Carbon Pulse).

  DEWA CEO, Mr Saeed Mohammed Al Tayer has explained the thinking behind the development of the ***DEWA GHF***, fundamentally going to the role of ***DEWA***, and the flexibility of Green Hydrogen as an energy carrier: *"This is a system that allows for buffering of renewable energy production, but for fast response applications [from storage], as well as long-term storage. The [DEWA GHF] has been built to accommodate future applications and test platforms for the different uses of hydrogen, including potential mobility and industrial uses".*

  Nothing has changed since inception to completion: in 2019 Mr Al Tayer said that: "*The hydrogen produced .. will be stored and deployed for re-electrification, transportation and other uses*".

  The ***DEWA GHF*** is the first photovoltaic solar powered Green Hydrogen facility in the Middle East and North Africa.

  See: *UAE: First Green Hydrogen Plant to be Inaugurated This Week*

- **West Africa – untapped potential for hydrogen production:** On May 21, 2021, it was reported that the German Federal Ministry of Education and Research (***BMBF***) regards West Africa as a highly prospective region for the development of Green Hydrogen. Much has been written about the regions of the world with the greatest potential to produce Green Hydrogen, being regions with world class and scale renewable energy sources in the form of solar and wind.

  Rather than concentrating on solar and wind resources alone, ***BMBF*** has looked at the world class and scale hydro-electric sources of renewable electrical energy in West Africa. The work of the ***BMBF*** estimates that all three sources of renewable electrical energy in combination could produce up to 165,000 TWh of renewable electrical energy for use in the production of Green Hydrogen. The scale of these estimates is staggering.

  See: *Atlas of Green Hydrogen Generation Potentials in Africa*

- **Bell Bay ringing:** The State Government of the Australian island state of Tasmania, like a number of other states in Australia, is actively involved in promoting the development Green Hydrogen and Green Ammonia production in its State. The focus of this activity is Bell Bay, in the northwest of the island state, on the River Tamar.

  Over the last two weeks or so further steps have been taken towards the development of proposed projects at Bell Bay:

  - **Fortescue Future Industries and IHI Corporation aligned:** On May 21, 2021 it was announced that Fortescue Future Industries (***FFI***) and IHI Corporation (***IHI***) signed a memorandum of understanding (***MoU***). It is reported that the ***MoU*** provides for the exploration of "green ammonia supply chains between Australia and Japan", including from Bell Bay.

    As reported in earlier editions of Low Carbon Pulse, Fortescue Metals' green energy company, Fortescue Future Industries (***FFI***) is active globally, driven by the vision of Fortescue founder, mining magnate and green generation champion, Dr Andrew Forrest, AO. Like ***FFI***, ***IHI*** has been active globally, including in Australia, the Kogan Hydrogen Demonstration Project, and the US.

    As reported under "**IHI and JERA granted means to commence co-firing**" below, those engaging with ***IHI*** have a clear line of sight to the market into which Green Ammonia is to be sold.

    See: *Fortescue Future Industries investigating green ammonia supply chain between Australia and Japan*

- **Woodside Energy Limited and Japanese green giants, Marubeni and *IHI* aligned:** On May 21, 2021 it was reported that Woodside, Marubeni an ***IHI*** have signed a heads of agreement (***HoA***) to investigate the production and export of Green Ammonia to Japan.

  See: *Woodside, IHI and Marubeni to Study Hydrogen Exports as Green Ammonia from Tasmania*

- **New core activities for Becancour:** Earlier in 2021, Air Liquide completed the development of its Green Hydrogen facility in the City of Becancour, in Quebec, Canada. Edition 16 of Low Carbon Pulse, outlined the plan of the ***Hyzon*** and ***Raven SR*** plan to develop up to 100 waste-to-hydrogen hubs: each hub to take waste to derive renewable hydrogen from waste. (Deriving hydrogen from waste is covered in detail in *Hydrogen from Waste*.)

  On May 23, 2021, H2 V Energies announced plans to develop a hydrogen facility using a broad range of solid waste as feedstock to produce renewable hydrogen. While the project is at a relatively early stage, it seems to have strong backing.

  As is the case with other projects proposing to derive hydrogen from waste, future editions of Low Carbon Pulse will cover developments in this area, as part of broader coverage of advanced bioenergy.

- ***IHI* and JERA granted means to commence co-firing:** On May 24, 2021, it was announced that ***IHI*** and JERA have received notice of acceptance of their joint grant application to undertake a demonstration project to co-fire ammonia in the generation of thermal power.

  It is understood that the co-firing project will commence in June 2021, and continue until March 2025, with the plan to progress to commence co-firing at JERA's Unit 5, Hekinan Thermal Power Station from August to December 2021. With the rate of co-firing to increase over time, so that by 2024, co-firing will be taking place at a rate of 20% Green Ammonia, 80% coal, at Unit 4, Hekinan Thermal Power Station.

  As is a recurring theme reflected in Low Carbon Pulse, this is another world first for Japan - the first large scale ammonia and thermal coal co-firing project. The co-firing project is consistent with the policy settings in Japan.

  (The grant was approved under the New Energy and Industrial Technology Development Organization's "Development of Technologies for Carbon Recycling and Next-Generation Thermal Power Generation / Research, Development and Demonstration of Technologies for Ammonia Co-Firing Thermal Power Generation" program: an approval process likely shorter than the name of the program under which it was granted!).

  See: *JERA and IHI to Start a Demonstration Project Related to Ammonia Co-firing at a Large-Scale Commercial Coal-Fired Power Plan*

- **Cummins welcomed again:** On May 24, 2021, Cummins, Inc announced plans to develop one of the world's largest electrolyser production plants (scalable to 1 GW a year) to allow production proton exchange membrane (***PEM***) plants. The Gigafactory is to be located in the central region of Castilla-La Mancha, Spain. It is reported that the Castilla-La Mancha ***PEM*** Gigafactory project will provide the electrolysers for the planned Iberdrola Palos de la Frontera Green Hydrogen project, which is to supply Green Hydrogen to Fertiberia for the production of Green Ammonia.

  It is understood the Iberdrola has made submissions in respect of 53 hydrogen related projects to the Next Generation ***EU*** program (the program is intended to provide funding of up to €2.5 billion to achieve annual production of 60,000 tonnes a year of Green Hydrogen by 2030).

  The announcement of the ***PEM*** Gigafactory is the fourth announcement of a Gigafactory in Europe in 2021: ITM Power, McPhy and NEL each having announced plans for a Gigafactory. Haldor Topsoe has announced plans for a 500 MW plant to produce its high-efficiency solid-oxide electrolysers.

  See: *Cummins Selects Spain for its Gigawatt Electrolyzer Plant & Partners with Iberdrola to Lead the Green Hydrogen Value Chain*

- **Sinopec sites Green Hydrogen facility in Inner Mongolia:** On May 25, 2021, it was reported that Sinopec is locating its first Green Hydrogen facility in Ordos, Inner Mongolia, with production to commence in 2022. Production is anticipated to be up to 20,000 tonnes per annum.

  The Green Hydrogen produced by the project is to be supplied to Zhong Tian He Chiang Corp, a joint venture between China Coal Energy Co, Sinopec, Shenergy, and Inner Mongolia Manshi Group.

  Sinopec is the largest producer of hydrogen in the ***PRC*** (see Edition 5 of Low Carbon Pulse).

  See: *Sinopec to launch first Green Hydrogen project in 2022*

- **County Cork to go from Green to Greener:** On May 25, 2021, it was announced that ***EI-H2*** intends to develop a 50 MW Green Hydrogen facility in Aghada, County Cork, Ireland.

  See: *€120m Green Hydrogen facility planned for Co Cork*

Wind round-up:

- **Ørsted teaming for Japan off-shore wind auctions:**
  - On May 19, 2021, Ørsted announced that it is partnering with Japan Wind Development Co (**JWD**) and Eurus Energy to bid for future off-shore wind field developments as part of the auction process that closed on May 27, 2021.

    Ørsted, JWD and Eurus Energy are developing to two projects under the ***Offshore Renewable Energy Act 2018***. The two projects are the Norshiro/ Mintane/ Oga Project and the Yurihonjo Project. Both Projects are proceeding through permitting, and will then proceed to construction and installation.

    See: *Ørsted, JWD, and Eurus form offshore wind partnership in Akita*
  - On May 27, 2021, Ørsted announced that it had, with TEPCO RP, submitted a joint bid for the Choshi Offshore Wind field project.

See: *TEPCO and Ørsted sign MoU to work jointly on offshore wind projects*

- **Poland polishes off-shore wind program:** Editions 8 and 14 of Low Carbon Pulse reported on progress in the development of the Polish off-shore wind program. Edition 14 of Low Carbon Pulse reported on the award of a contract for differences for the 1.5 GW Baltica 2 and 1 GW Baltica 3 off-shore wind field projects.

  On 20 May, 2021, it was announced that the European Commission (***EC***) has approved the state-aid inherent in the Polish off-shore wind program. The state-aid in question arises from the two-way contract for differences used to provide the required revenue for the off-shore wind field projects to be developed. While the state-aid approval process is not always visible, it is nevertheless front and centre for governments providing a means of assuring revenue. *"The Polish scheme is a very good example of how competition policy can enable Member States to support green energy projects … It gives the incentive to companies to invest in such green [energy] projects where they would otherwise not have invested. We hope that we will see many such initiatives in the future, which contribute to the **EU**'s Green Deal, without unduly distorting competition in the Single Market".*

  The article in ***renewsbiz*** is well worth a read.

- **HIP in the grove:** On May 21, 2021, Hecate Independent Power Limited (***HIP***) announced that it intends to develop the ***HIP Atlantic Project*** – a USD 30 billion, 10 GW off-shore wind field project, in the North Atlantic, off Iceland: the Project will deploy both fixed and floating turbines.

  The renewable electrical energy generated from the Project will be delivered to the UK grid by high-voltage direct current (***HVDC***) subsea transmission cables.

  See: *HIP plans wind power exports to UK from pods offshore Iceland*

- **BASF and RWE proposing off-shore wind field to decarbonise chemical production:** On May 23, 2021, BASF and RWE presented a plan to develop a 2 GW off-shore wind field project in the German sector of the North Sea to supply up to 7,500 TWh of renewable electrical energy to the BASF Verbund chemical complex in Ludwigshafen, Germany, to allow the production of "***CO_2 free***" hydrogen and ***CO_2*** reduction using innovation technologies (***Offshore-to-X Project***).

  It is anticipated that the renewable electrical energy from the ***Offshore-to-X Project*** will be used as follows:

  – 80% in eCracking (renewable electrical energy to produce steam for use to produce chemicals, displacing the use of natural gas for this purpose) and in methane pyrolysis (using renewable electrical energy to achieve disintegration of methane to derive hydrogen and carbon, with the carbon captured in solid form, carbon black, with the Turquoise Hydrogen produced used to produce Turquoise Ammonia);

  – 20% in the production of Green Hydrogen for use across the north west of Germany.

  See: *BASF and RWE plan to cooperate on new technologies for climate protection*

- **Equinor, Norsk and RWE cooperate to bid for Southern North Sea 2:** Oil major (***Equinor***), aluminium giant (***Norsk***) and giant utility (***RWE***) are reported to have signed a cooperation agreement to inform the basis of a joint bid for the fixed bottom off-shore wind field auction in respect of Sorlige Nordsjo II), in the Norwegian sector of the North Sea.

  Sorlige Nordsjo II is one of two areas that the Norwegian Government has opened up for development, the other being ***Utsira Nord***, which is to be developed as a floating offshore wind field development. In respect of ***Utsira Nord***, ***Equinor*** is cooperating with Eni SPA and HitecVision.

  See: *Equinor partners with RWE and Hydro in joint bid for Norwegian offshore wind area*

- **A fair wind:** On May 25, 2021, Norseman Wind Consortium (***NWC***) announced that it has applied for a licence to develop a €3 billion, 1.4 GW off-shore wind field project off Norway, in respect of the ***Sorlige Nordsjo II*** area. The ***NWC*** comprises ASKO Fornybar, EnBw, NorgesGruppen, and Norseman Wind. The ***NWC*** business model is reported as meaning that its proposed off-shore wind field project will be developed without the need for government support of any kind: "*Our business model means that we do not need government subsidies. Thus the state's green money can rather be spent on floating offshore wind at Utsira Nord as well as on hydrogen and carbon capture*".

  See: Norseman website

Sustainable Energy round-up:

Previous editions of Low Carbon Pulse have included sections to provide a general renewables round-up. To cluster news items a little more, we have decided to do so around "sustainable energy" generally. Also this allows us to include projects that involve both solar and wind under one heading:

- ***EU* continues to accelerate:** On May 18, 2021, it was reported that the quantity of renewable electrical energy contracted under corporate power purchase agreements (or clean energy contracts) in the ***EU*** exceeded the quantity sold in calendar year 2019. By mid-May, a little short of 3.0 GW of renewable electrical energy had been contracted, compared to 2.5 GW contracted in 2019.

- **Fostering Effective Energy Transition:** The ***World Economic Forum*** published *Fostering Effective Energy Transition 2021* (***FEET***) towards the end of April 2021. In the context of providing the readers of Low Carbon Pulse with a report that gives a sense of the progress of countries towards the transition to sustainable energy outcomes, ***FEET*** provides granularity for the countries featured in it.

  In combination, ***FEET*** and the ***IEA Roadmap*** (see below) provide a guide to what has worked and where, and what still needs to be done – in combination a good report card, including on how we can all do better.

- **Bioenergy increased activity:** One of the many interesting parts of the ***IEA Roadmap*** is the analysis of the bioenergy sector, and the need for it to develop to process and to treat wastewater and waste as part of the pathway to net-zero outlined by the ***IEA***. This is touched on in the first H24I feature on Hydrogen from Waste.

On May 21, 2021, in Bioenergy Insight, there is an update on the WSSC Water and Washington Gas project to derive biogas from wastewater: the project involves increasing the extent to which ***CH_4*** can be realised from the biosolids arising from the treatment of wastewater to as to derive biomethane (***Renewable Natural Gas*** or ***RNG***) for use across the Washington Gas network.

See: *WSSC Water, Washington Gas to develop RNG project*

- **Oman goes Green by Blue:** On May 22, 2021, plans for the development of the USD 30 billion, 25 GW, Oman Green Energy Hub (***OGEH***) were announced. The ***OGEH*** is to located close to the Arabian Sea. The development of the ***OGEH*** is to be spear-headed by InterContinental Energy, in partnership with OQ (state owned Omani oil and gas company) and EnerTech (Kuwaiti based investor). The renewable electrical energy produced from onshore solar and wind farms, will allow the production of 1.8 mpta of Green Hydrogen / 10 mpta of Green Ammonia.

  Construction of ***OGEH*** is to be undertaken in phases, and is scheduled to commence in 2028, with completion of the final phase scheduled for 2038. On full development, the ***OGEH*** is to be powered by 25 GW of photovoltaic solar and wind.

  InterContinental Energy is a name that will be familiar to those following the Asian Renewable Energy Hub being developed in the Pilbara Region of Western Australia (see Edition 2 of Low Carbon Pulse).

  See: *Green fuels mega project set to make Oman world leader in Green Hydrogen and green ammonia*

- **Panasonic announces global circuit developer:** On May 24, 2021, Panasonic Corporation announced the development of the world's first "***RE100***" (***Renewable Energy 100%***) factory to be located at Kusatsu, Shiga Prefecture.

  The ***Panasonic RE 100*** factory will be powered using hydrogen fuel cells and photovoltaic solar panels, and ***BESS***, to provide 100% renewable energy at all times from within an "in-house" renewable electrical energy system to allow all activities at the factory to be undertaken without the use of any non-renewable energy source.

  See: *Panasonic to Demonstrate RE100 Solution Using Pure Hydrogen Fuel Cell Generators*

- ***RE 100* – an ever growing cohort of corporations:** It is estimated that the load of current signatories to #RE100 will reach 455 TWh by 2030. While ***RE100*** can be achieved from both on-site and off-site sources, it appears likely that most signatories will seek to achieve ***RE100*** by sourcing off-site. If the current projected demand for renewable electrical energy from signatories is realised, new corporate power purchase agreements (or clean energy contracts) will be needed for renewable electrical energy from 95 and 100 GW of new photovoltaic solar and wind capacity.

  See: RE100

Solar round up:

- **Floating solar still below the radar, but on the rise:** On May 19, 2021, it was announced that the floating photovoltaic project planned for the Cirata reservoir in West Java, Indonesia (***PVC Project***) is to proceed. The ***PVC Project*** is being developed in joint venture by Pembangkitan Jawa-Bali Investasi (***PJBI***, a subsidiary of PLN) and Masdar, using project company Pembangkitan Jawa Bali Masdar Solar Energi (***PMSE***). On development, the ***PVC Project*** will be South East Asia's largest floating photovoltaic solar project.

  See: *Decarbonizing Indonesia with Southeast Asia's largest floating solar power plant*

- **Roof-top solar below the flight path / on the radar:** On May 20, 2021, the publication, Popular Mechanics, reported that roof-tops at airports are a missed opportunity: the argument is that airports in certain parts of the world are ideal locations for roof-top photovoltaic solar panels, and possibly so too is air-side – airports are in wide-open locations in which the panels are not in locations subject to shade / shadow.

  A recent study from the Royal Institute of Technology (***RMIT University***) suggests that the deployment of roof-top solar on the 21 Federally owned airports around Australia could produce up to 466 GWh of electrical energy each year.

  See: *If We Put Solar Panels on Top of Airports, We Could Power Entire Cities*

Port and Land Transport round-up

- **President Biden makes the case:** On May 18, 2021, US President, Mr Joe Biden, outlined a USD 170 billion battery electric vehicle (***BEV***) proposal to US car-makers, encouraging them to build ***BEVs*** in the US. The case made by President Biden to encourage US investment involves "*cost-sharing grants to support new high capacity battery facilities in the United States*" and to produce parts and vehicles, and to build vehicles.

  The financial basis for the case made by President Biden is the provision of USD 100 in consumer assistance, USD 45 billion for the electrification of school and transit buses, USD 10 billion in tax credits in respect of medium to heavy duty work vehicles, and USD 15 billion to develop 500,000 ***EV*** charging stations by 2030.

  See: *Biden pitches US$174 billion EV plan in Michigan, takes truck for a spin*

- **Air Liquide to refuel Daimler trucks:** On May 17, 2021, it was reported that Air Liquide is to supply liquid hydrogen, and a refuelling system, to Daimler, as part of the Daimler heavy-goods vehicle (***HGV***) development program. The use of liquid hydrogen is considered likely to double the range of ***HGV***'s in comparison to the use of compressed gaseous hydrogen.

  As with the combination of Daimler and Volvo reported in Edition 17 of Low Carbon Pulse, these developments are telling: the issue is not if, the issue is when, ***FCEV*** will start to displace diesel as the preferred power and propulsion for ***HGVs***.

  See: *Air Liquide to support Daimler Trucks with liquid hydrogen and an enhanced refuelling system*

- **Daimler and Shell combine:** On May 20, 2021 it was announced that Daimler and Shell have signed an agreement to promote the adoption of the use of fuel cells in ***HGVs*** across the ***EU***. The simultaneous development of the supply of ***HGVs*** and hydrogen refuelling infrastructure (***HRI***) is critical to the growth of the market for ***HGV*** powered and propelled by Fuel Cells (***HGVFCEVs***), and the ability of Shell to supply hydrogen from ***HRI**,* and prescribe the use of ***HGVFCEVs*** to transport its products, to deliver on its ***GHG*** emission reduction targets, and ultimately, achieve net-zero.

  It reported that Shell intends to develop its ***HRI*** network in a way that aligns with the development of Green Hydrogen hubs, including at the Port of Rotterdam and Cologne and Hamburg. The supply of hydrogen will precede the demand for it: Shell intends to commence operation of its ***HRI*** network from 2024, with Daimler intending to make delivery of its first ***HGVFCEVs*** in 2025.

  In combination, Shell plans to expand the ***HRI*** network to 150 ***HRIs*** by 2030, with Daimler planning to have delivered 5,000 ***HGVFCEVs*** by 2030.

  This continues the initiatives from Daimler and Shell (see Edition 17 of Low Carbon Pulse); since the start of 2021, each organisation, entirely aware of the importance to the global carbon budget, is seeking to reduce use of fossil fuels in the road freight industry.

  See: *Daimler Truck AG and Shell target accelerated rollout of hydrogen-based trucking in Europe: simultaneously building truck refuelling infrastructure and rollout of fuel-cell vehicles*

- **Tracking and mapping HRIs:** On May 20, 2021, an interactive map was published to give a sense of the spread of ***HRIs*** across the ***EU*** and their location by country. It is projected that by 2030 there will be at least 60,000 commercial ***FCEVs*** across the ***EU*** and the UK, matched by at least 1,000 ***HRIs***, with at least one ***HRI*** every 200 kms. This a fertile area for involvement of government, at the very least in policy setting.

  See: *Interactive map – Truck hydrogen refuelling stations needed in Europe by 2025 and 2030, per country*

- **Hyzon Motors joins Utrecht initiative:** On May 20, 2021, it was announced that Hyzon Motors has joined a new initiative in Utrecht to deploy 300 hydrogen-powered heavy goods vehicles (***HGVs***), 1,500 lighter vehicles, two to five buses and two vessels, and up to 10 hydrogen refuelling stations by 2050. (For these purposes, Hyzon is reported to have executed the Covenant on Hydrogen Mobility.)

  This initiative is part of the broader HyTruck initiative to put 1,000 hydrogen-powered trucks on the roads of Belgium, western Germany and the Netherlands. (In Edition 5 of Low Carbon Pulse, reporting on European Hydrogen Week, we noted the broader initiative to deploy 100,000 hydrogen-powered trucks and 1,000 hydrogen refuelling stations.)

  See: *Hyzon Motors Signs Covenant to Join Utrecht, The Netherlands' 1,800 Hydrogen Vehicle Initiative*

- **Hyundai committed:** On May 24, 2021, it was reported widely that later in 2021 Hyundai Hydrogen Mobility (***HHM***) intends to deliver its new class of Xcient Hyundai HGV into the ***EU***. While ***HHM*** has been at the forefront of the development of ***HGVFCEVs*** for some time, it appears that being a front runner is likely to start to yield increasing sales.

  As noted in Edition 2 of Low Carbon Pulse, ***HHM*** entered the Swiss market in 2020. It is expected that ***HHM*** will enter Germany and the Netherlands, and then Austria, Denmark, France, Italy, Norway and Spain, responding to the demand from countries at the forefront of hydrogen infrastructure development and equipment deployment.

- **Port of Cromarty Firth to import hydrogen from Norway:** The role of sea ports in world trade is long-understood (*Ashurst Ports Compendium*). In the context of the development of the market for hydrogen, sea ports are going to be the lynch pin – they will be hubs for hydrogen production in exporting countries, and hubs for import, bunkers and distribution in importing countries.

  On May 24, 2021, the Port of Cromarty Firth, Scotland, announced that it is partnering with ***Gen2 Energy*** (Norwegian renewable energy company) to import Green Hydrogen from Norway into the UK. The Port sees this partnership as part of its broader strategy to become a hydrogen hub.

  See: *Port Of Cromarty Firth Signs Historic Green Hydrogen MoU With Norwegian Clean Energy Firm Gen2 Energy AS*

- ***EU* accelerating on transport:** On May 27, 2021, it was reported that the ***EU*** is going to accelerate progress towards net-zero for the transport sector, including a substantial acceleration to increase the pace to climate neutrality. The suggestion is that the transport sector needs to increase renewable energy sources, in fact to double them, by 2030.

  In July 2021, the European Commission will present its ***Fit for 55*** package (referring to the 55% reduction in ***GHG*** emissions by 2030 – see Edition 16 of Low Carbon Pulse). In November 2021, the ***EU*** will present energy sector specific initiatives, including decarbonisation of the gas market, and for hydrogen.

  Low Carbon Pulse will cover these initiatives as they arise.

  See: *EU to push transport sector to rapidly adopt greater use of renewables*

CO2 shipping:

On May 19, 2021, it was announced by Danish shipowners, Evergas and Ultragas that they have combined to establish ***Dan-Unity CO_2*** to develop and to supply both CCS / CCUS technology and ***CO_2*** carriers. Also, ***Dan-Unity CO_2*** is reported to have partnered with Carbfix (an Icelandic corporation) that is developing CCS / CCUS technology intended to store ***CO_2*** by "creating" stone: the process is reported to involve dissolving ***CO_2*** in water, and injecting it into the volcanic bedrock in Iceland. Carbfix estimates that up to 2,500 Gt (or 2.5 trillion tonnes) of ***CO_2*** can be stored in this way, which equates to sufficient capacity to store 50 years of global ***GHG*** emissions at current levels of annual emission.

See: *Two Danish Firms Launch CO2-Transport Shipping Line*

Global Carbon Exchange:

On May 20, 2021, plans for a new global carbon exchange were announced. The global carbon exchange is to be located in Singapore. DBS Bank, Singapore Exchange, Standard Chartered Bank and Temasek have established a joint venture, ***Climate Impact X*** (***CIX***), for this purpose. The stated intention of the ***CIX*** is to provide "*high-quality carbon credits to address hard-to-abate emissions*".

Managing Director of the Monetary Authority of Singapore, Mr Ravi Menon, noted that the ***CIX*** represented the adoption of a "twin strategy" of the reduction of ***GHG*** emissions and the off-set of ***GHG*** emissions, which provides a "practical and effective" way to achieve the Paris Agreement Goals.

See: *New global carbon exchange to be headquartered in Singapore*

Net-zero round-up:

- **MUFG to net out over time:** On May 18, 2021, Mitsubishi UFJ Financial Group (***MUFG***) made an announcement covering a number of ***GHG*** reduction initiatives, including: ***1. MUFG*** is aiming to move to net zero ***GHG*** emissions across its finance portfolio by 2050, ***2. MUFG*** is aiming to reduce ***GHG*** emissions arising from its operations to achieve carbon neutrality by 2030, and ***3. MUFG*** intends to join the ***United Nations Net-Zero Banking Alliance***.

  See: *Mitsubishi UFJ pledges net zero emissions in finance portfolio by 2050*

- **Singapore Airlines leans forward:** On May 24, 2021, Singapore Airlines (***SIA***) Group (comprising Singapore Airlines, SIA Cargo and Scoot) announced its commitment to achieve net-zero carbon emission by 2050. In announcing the commitment, ***SIA*** noted that it intended "to use multiple levers to achieve this goal … [including] investing in new generation aircraft, achieving higher operational efficiency, adopting low-carbon technology such as sustainable aviation fuels and sourcing high quality carbon offsets". Given the ***Global Carbon Exchange***, it is possible to see ***SIA*** sourcing its high quality carbon offsets from the ***Exchange***.

  See: *Singapore Airlines Group Commits To Net Zero Carbon Emissions By 2050*

- **Sydney Airport laid back:** On May 24, 2021, it was reported that Sydney Airport committed to the achieving net-zero emissions by 2030. The commitment comprise both Scope 1 and Scope 2 emissions (see Edition 13 of Low Carbon Pulse). Sydney Airport is committed to continuing its program to target Scope 3 emissions.

  See: *Sydney Airport commits to net zero by 2030*

Paris circles 11 projects to transform Paris' airports into hydrogen hubs:

On May 28, 2021, it was widely reported that 11 applicants have been chosen to contribute to the development of the ***H2 Hub Airport Project***. Publication h2-view.com provides a summary of the successful applicants, and the role of each of them.

THE WEEK THAT WAS MAY 17 TO 21, 2021:

A pathway, to some a mosaic to others crazy paving:

- **Origin and Purpose:** On May 18, 2021, the ***IEA*** published *Net Zero by 2050 – A Roadmap for the Global Energy Sector* (***IEA Roadmap***). The ***IEA Roadmap*** outlines a path to achieving net-zero by 2050 by the energy sector. As such, the ***IEA Roadmap*** relates to the sourcing, production and use of energy so as to achieve net-zero across the energy sector by 2050.

  The ***IEA Roadmap*** was prepared at the request of the UK President of COP-26 (Mr Alok Sharma). Ahead of COP-26, the ***IEA Roadmap*** sets a pathway for what needs to be done to achieve the Stretch Goal. The ***IEA Roadmap*** is stated to incorporate insights and lessons from earlier ***IEA*** publications.

  How net-zero is achieved, in fact, will differ from the ***IEA Roadmap**,* but it is reasonable to expect that many of the initiatives identified will play a role. More than this, the ***IEA Roadmap*** provides a basis for countries to develop their own policy settings and timelines to achieve their targets, and net-zero: as the ***IEA Roadmap*** states: *"Getting to net zero will involve countless decisions by people across the world, but our primary aim is to inform the decisions made by policy makers, who have the greatest scope to move the world closer to its climate goals".*

- ***IEA Roadmap*** **about energy sector only:** While the ***IEA Roadmap*** points out the need to decarbonise other sectors that give rise to ***GHG*** emissions, it does not include a pathway for their decarbonisation, critically, it does not provide a pathway for the Agriculture, Forestry and other Land Use (***AFOLU***) sector, which emits at least 12 Gt (or 12 billion tonnes) of ***GHG*** emissions per year.

- **Different models, different outcomes, but neither "nets" net-zero *GHG* emissions:** The ***IEA Roadmap*** presents two models, one based on ***specific*** **policy settings** and ***GHG*** commitments (***STEPS***), the other based on ***announced*** **pledges** (***announced pledges case*** or ***APC***).

  If the ***STEPS*** model is implemented, the ***IEA Roadmap*** signposts that ***GHG*** emissions will increase to 36 Gtpa by 2030, and remain at this level until 2050. If the ***APC*** model is implemented, the ***IEA Roadmap*** signposts that ***GHG*** emissions will fall to 30 Gtpa by 2030, and to 22 Gtpa by 2050.

  Neither model achieves net-zero by 2050. As such the ***IEA Roadmap*** provides its own ***NZE*** pathway.

- **Key themes:** The ***IEA Roadmap*** emphasises a number of a themes, most of which had emerged ahead of the publication of the *IEA* Roadmap:
  - the need for specific policy settings to support increased ***NDCs*** as soon as possible, and the implementation of those specific policy settings;
  - generally the need to accelerate implementation of specific policy settings to 2030, and to accelerate new and replacement infrastructure for these purposes;
  - the development of renewable electrical energy is at the core of the energy transition, and net-zero;

- global electrical energy demand (26,800 TWh in 2020), will increase by over 80% by 2050, with 85% of the increased in demand from developing countries and emerging market countries;
- CCS / CCUS has a key role to play, including to capture ***GHG***s arising from (**i**) production of low-carbon hydrogen production, (**ii**) industrial processes, and (**iii**) residual fossil fuel use;
- hydrogen will be a key energy carrier, with 520 Mtpa of low hydrogen production (62% Green Hydrogen & 38% using CCS / CCUS) annually by 2050: 207 Mtpa for transport and 187 Mtpa for industry;
- bioenergy is to play a key role in the decarbonisation of the energy sector, in fact it is one of the seven pillars of the decarbonisation of the energy sector.

The ***IEA Roadmap*** notes that had it made more pessimistic assumptions for CCS / CCUS or bioenergy, achieving net-zero emissions by 2050 will be more costly and difficult.

- **The Seven Pillars:** Some of the themes outlined above are best summarised in the Seven Pillars of decarbonisation of the energy sector: **1**. Energy Efficiency, **2**. Behavioural Change, **3**. Electrification, **4**. Renewables, **5**. Hydrogen and Hydrogen-Based Fuels, **6**. Bioenergy, and **7**. CCUS.
- **The benefit of the *IEA Roadmap***: The ***IEA Roadmap*** provides a framework for countries to develop plans to implement roadmaps. In addition, the ***IEA Roadmap*** provides prompts for countries, and policy makers: many matters are addressed that will require consideration by all countries, and some matters will be country specific, for example, countries reliant on tax revenue from fossil fuels will have to anticipate and to provide for the decline of that revenue overtime.
- **Net-zero without offsets and low reliance on negative *GHG* emissions initiatives:** The ***IEA Roadmap*** seeks to achieve reductions in ***GHG*** emissions by decarbonising activities, rather than the use of "offsets from outside the energy sector, and with low reliance on negative emissions technologies".
- **What is not covered in this Edition 18:** Consistent with all editions of Low Carbon Pulse, this Edition 18 does not cover the costs identified in the ***IEA Roadmap***, or the commentary and narratives from others on it. This said, we note the push-back from a number of countries around the ***IEA Roadmap*** on coal and natural gas: the ***IEA Roadmap*** provides a pathway, not the pathway, and as such the ***IEA Roadmap*** should be read in full.

REMINDER OF DEFINITIONS	
Stretch Goal: Limit the temperature increase to 1.5°C above pre-industrial levels	***Stabilisation Goal***: Limit the temperature increase to well below 2°C above pre-industrial levels
CCS: ***CO_2*** / carbon capture and storage	**CCUS:** ***CO_2*** / carbon capture, utilisation and storage

G7 – carrying forward themes:

Following the release of the ***IEA Roadmap*** and ahead of the ***G7*** leaders meeting scheduled to take place in the UK in June, ***G7*** Ministers responsible for Climate and Environment met virtually to discuss climate change on May 21 and 22, 2021. (The ***G7*** comprises Canada, France, Germany, Italy, Japan, the UK and the US.) It is reported that the ***G7*** Ministers were joined by climate and environment ministers from Australia, India, South Africa, and South Korea.

The ***G7*** Ministers' Communique is comprehensive, and while it is worth reading in full, a number of key outcomes appear to be worthy of note, as follows:

- ***G7* countries to deliver firm commitments to achieve *Stretch Goal***: The ***G7*** Ministers were aligned in the need to deliver firm commitments to reduce ***GHG*** emissions consistent with the Stretch Goal. The following is extracted from the Communique: *"… we will make ambitious and accelerated efforts to reduce emissions to keep a limit of 1.5^{O}C temperature rise within reach …".*

  Without wishing to bang an editorial drum too much, it would be good to see the ***G7*** countries increase their ***GHG*** emission reduction targets so as to achieve deeper and quicker reductions, and to assume responsibility more broadly, not just for their ***GHG*** emissions.
- **Fossil fuel development funding:** The ***G7*** Ministers have agreed to cease the direct funding of new coal-fired power stations to developing countries by the end of 2021, expressed as follows in the communique: *"We commit to take concrete steps towards an absolute end to new direct government support for unabated international thermal coal power generation by the end of 2021."*

  Much of the reporting of this commitment, has not then gone on to include the following: *"Recognising that coal power generation is the single biggest cause of global temperature increases, we commit .. rapidly [to scaling-up] technologies and policies to … accelerate … away from unabated coal capacity …"*

  This leaves open funding for abated coal-fired power generation, including those using CCS / CCUS. Also the communique states that: *"We will phase out new direct government support for carbon-intensive international fossil fuel energy".*

  While this statement does not refer to any fossil fuel energy in particular, it should be assumed that it includes all carbon-intensive fossil fuel energy, including natural gas. While this is broadly aligned with the ***IEA Roadmap***, there is an argument that natural gas is core to electrification in parts of the world developing quickly, including India, Bangladesh, Pakistan and Indonesia.

  While this policy setting has been on the agenda for a while, as it firms-up to become a reality, it is important that the ***G7*** countries provide support to allow developing countries to increase the level of electrification: effectively, funding and supporting for the development of low or no carbon technologies, and take an holistic view about energy transition, and the road to net-zero.

- **Fugitive emissions:** Consistent with themes emerging from the Leaders' Summit in April (see Editions 15 and 16 of Low Carbon Pulse), the ***G7*** Ministers recognised the "importance of ambitious and urgent action to reduce emissions and leakage of methane [(***CH_4***)] from the energy sector… [and]… the waste and agriculture sectors … in order to slow global warming". This is consistent with the ***IEA Roadmap***.
- **Land Use:** In Edition 14 of Low Carbon Pulse it was noted that: *"It is becoming increasingly clear that one policy setting that is emerging is to ensure that areas of land are to be preserved completely from any land use … It is understood that the **EU** and the US policy settings are being considered to ensure that at least 30% of their respective land-masses remain free from land use for human activities, or land is returned to non-use, free from human activities".*

  While this policy setting has been signalled for some time, it is good to see that the policy setting is now well and truly on the policy setting agenda, with the ***G7*** Ministers' communique stating that: *"We commit to champion ambitious and effective global diversity targets, including conserving or protecting at least 30% of global land and at least 30% of the global ocean by 2030 to halt and reverse biodiversity loss .. and address climate change".*

  It is reported that the decisions of the ***G7*** Ministers are to be carried forward at the ***G7*** finance ministers meeting on June 4, 2021.

PROGRESS TOWARDS NET-ZERO EMISSIONS
JUNE 15, 2021

Low Carbon Pulse - Edition 19

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to Edition 19 of Low Carbon Pulse – sharing significant current news on progress towards net-zero emissions globally. This edition covers the period from Monday May 31, 2021 to Sunday June 13, 2021 (inclusive of each day).

Please click here for the previous edition of Low Carbon Pulse. Please also click here and here for the first two articles in the ***Shift to Hydrogen Series*** (***S2H2***)***: Elemental Change*** series: the *S2H2* series provides a narrative and perspective on hydrogen generally. Please **click** here for the first feature in the ***Hydrogen for Industry*** (***H24I***): the *H24I* features provide an industry by industry narrative and perspective.

G7 Leaders' Summit Outcomes:

Over three days, June 11, 12 and 13, in Carbis Bay, Cornwall, England, the leaders of the Group of Seven (***G7***) met: the ***G7*** comprises Canada, France, Germany, Italy, Japan, the UK and the US. The Carbis Bay G7 Summit Communique, provides a summary of the agreed action agenda for the ***G7***, (and greater detail on thinking around policy settings). The agreed agenda comprises six actions.

In the context of net-zero emissions (***NZE***), there are two actions, with the ***G7*** committing to:

- " … net zero no later than 2050, halving our collective emissions over the two decades to 2030, increasing and improving climate finance to 2025, and to conserve or protect at least 30 percent of our land and oceans by 2030"; and
- "develop a new partnership to build back better for the world, through a step change in our approach to investment for infrastructure, including through an initiative for clean and green growth. We are resolved to deepen our current partnership to a new deal with Africa, including by magnifying support from the International Monetary Fund for countries most in need to support our aim to reach a total global ambition of [USD] 100 billion".

Directionally, these actions are not a surprise, having been flagged for a while (see Low Carbon Pulses 14 to 18). The aim to provide up to USD 100 billion in funding is in the nature of a re-commitment. Reflecting a continuing theme, more needs to be done, and it is hoped that ahead of ***COP-26*** in November greater momentum is achieved.

India on the road

- **India and UK:**

  Time for partnering: It continues to be a theme of progress towards net-zero emissions that developed countries that have made progress towards achievement of ***NZE*** need to be doing more, and should be working with developing countries, in particular those with more pressing needs to achieve increased electrification. It is difficult to think of two countries that fit this description better than India and the UK.

  India and UK partnering: On June 1, 2021, it was announced that India and the UK have enhanced their existing partnership to provide for cooperation in sharing thinking around policy settings, which in turn will respond to, and drive, technology development and investment as both countries progress to electrified and hydrogen economies. More broadly, and in the context of specific outcomes, the provision and sourcing of sustainable finance will be a key part of electrification and the development of a hydrogen economy, in particular clean energy and clean transport technologies and solutions, and the shift to green and to greened businesses.

  This is consistent with the projected global growth in electrical energy needs (driving electrification) and transport needs (as passenger transport levels double, and freight transport more than doubles, by 2050). In

India as above rail operations are electrified, and move to battery and fuel cell technologies, and the level of ownership of private vehicles increases, huge quantities of renewable electrical energy will be required, both to charge battery electric vehicles (***BEVs***) and to produce Green Hydrogen for fuel cell electrical vehicles (***FCEVs***) to power and to propel all modes of transport over time. As one of the developing countries most progressed to ***NZE***, the UK is well-placed, some may say, perfectly placed, to partner with India for decades to come.

Policy settings and commercial benefit: The closer partnership between India and the UK is part of continued strategic thinking from leadership in both countries.

In India, the strategic objective has been established for some time: in November 2020, Indian Prime Minister, Mr Narendra Modi, contemplated a "comprehensive National Hydrogen Energy Mission". Editions 14 and 16 noted the continued progress towards this objective. A report from the Energy and Resource Institute anticipates that "by 2050, 80% of India's hydrogen will be produced by renewable electricity and electrolysis". In this context, utility scale solar photovoltaic will be key, but roof-top solar will have an increasing role in electrification. Please also see the International Energy Agency (***IEA***) report entitled *Unlocking the Economic Potential of Rooftop Solar PV in India*.

In the UK, in November 2020, UK Prime Minister, Mr Boris Johnson, announced the ten point plan for a Green Revolution. The ten point plan provides the headlines off-which hang a full suite of policy settings and financial funding and support initiatives in the UK. Of the ten points, Driving the Growth of Low Carbon Hydrogen, Accelerating the Shift to Zero Emission Vehicles, Investing in Carbon Capture, Usage and Storage, and Green Finance and Innovation, and the underlying policy settings, appear to provide immediate opportunities for partnering.

The UK policy settings continue: on June 5, 2021 was announced that entities bidding for UK government contracts, must be committed to ***NZE***.

See: *Roadmap 2030 for India-UK future relations launched during India-UK Virtual Summit*

- **Three-wheeling:**

  On June 4, 2021, it was announced ***Hydrogen in Motion*** (of Canada) and ***h2e Power Systems*** (a producer of mobility technology, including fuel cell technology) are partnering in the development of the first hydrogen powered and propelled three wheel vehicle. This builds on the existing partnership between ***Hydrogen in Motion*** and the Government of India (specifically, the Technology Development Board) to develop hydrogen three wheel vehicles, making use of a financial funding initiative to support development of both technology and vehicles.

  The development of a three wheel vehicle powered and propelled by hydrogen makes perfect sense in the context of any country with densely populated urban centres: densely populated urban areas have demand potential, and provide a clear line of sight for the supply side to a concentrated demand side. For supply side to respond, government funding and support is likely to be required, including, possibly, to act as an intermediate buyer and supplier of hydrogen, and to act as a, or the, developer of hydrogen refuelling infrastructure (***HRI***) (which will have to be wide-spread and safe). In an environmental policy setting environment, the use of ***FCEVs*** address a trifecta - greenhouse gas emissions, air pollution and noise: three birds, one three wheeler.

  See: *Hydrogen-Powered Three-Wheeler Under Development By H2E Power Systems*

- **Carbon Pricing for India:**

  The International Monetary Fund (***IMF***) has stated that the a carbon price of USD 75 per tonne is required by 2030 to provide a suitably calibrated carbon price (as a cost) to ensure that that cost of carbon (as a negative externality) results in use of lower, low or no ***GHG*** emission technologies. In passing, it is noted that this level of carbon price was in the context of the ***Stabilisation Goal***, rather than the ***Stretch Goal***, and as such the carbon price needs to be higher to achieve the ***Stretch Goal***. Also, in passing, it is noted that if trends in some markets for carbon credits to off-set against acquittal obligations or voluntary commitments continue current trajectories, the market may prove that the suggested ***IMF*** carbon price is on the low side.

  As outlined in Edition 12 of Low Carbon Pulse (under ***Emissions Trading Schemes and Carbon Taxes*** *(each a* ***Carbon Price****)*), a carbon price is typically achieved through the use of a cap-and-trade emissions trading scheme (***ETS***) or a carbon tax or taxes to discourage the use of carbon intensive feedstocks and fuels, or both. While India does not have an ***ETS*** it does have a number of policy settings that price carbon in some contexts. The ***PRC***, ***EU*** and UK all have ***ETSs***, each of which provide clear policy settings to drive the adoption of lower, low and no carbon technologies. India has an opportunity to support its policy settings by a targeted ***ETS*** encouraging timely adoption of low and no carbon technologies.

EU **has wind in its policy setting sails:**

- **A carbon price without borders - carbon border tax taking shape:**

  Edition 12 of Low Carbon Pulse reported on the vote by the European Parliament to approve the imposition of a carbon border carbon tax as a new impost or tax on goods that are imported from jurisdictions that do not have a carbon price – the ***Carbon Border Adjustment Mechanism*** (***CBAM***). It is understood that the European Commission is to release details of the proposed ***CBAM*** on July 14, 2021.

  Further, it is understood that thinking around the ***CBAM*** includes a three year phase in, starting in 2023, completed by 2026. It is likely that the ***CBAM*** will apply to cement, fertiliser, aluminium and iron and steel: more of a whack for some, than for others. The imposition of the ***CBAM*** on these difficult to decarbonise industries is consistent with the clear underlying policy setting – to impose a carbon price for goods sourced from countries that do not have a carbon price, and as such do not have a policy setting that is driving decarbonisation of those difficult to decarbonise industries. While some commentators complain about the extraterritorial effect of the ***CBAM***, the logic of the policy is undeniable, as is the response: ***GHG*** emissions have extraterritorial effect.

The underlying commercial setting is clearer still: the production of these goods is carbon intensive, and as such not having a carbon price in the country of origin provides producers of these goods in each such country provides those producers with a unit cost advantage, and, likely, a price point advantage, over ***EU*** produced goods.

If the July 14, 2021, timeline is achieved, Edition 21 or Edition 22 of Low Carbon Pulse will cover the form and substance of the ***CBAM*** in detail, and assess its likely implications. (see Edition 22 of Low Carbon Pulse)

- **A carbon price that crosses borders:**

  In September 2020, the European Parliament voted to include vessels of more than 5,000 gross tonnes in the ***EU ETS*** by 1 January 2022. The inclusion of vessels in the ***EU ETS*** is part of broader debate about how best to decarbonise the international shipping industry.

  It has been widely reported that the Government of Japan has formally indicated its opposition to the extension of the ***EU ETS*** to international shipping, noting that the International Maritime Organisation (***IMO***) is best placed to develop measures to be applied to the international shipping industry at a global level, and that inclusion on international shipping vessels in the ***EU ETS*** may hinder progress.

  Both the ***EU*** and Japan have had the benefit of reflecting on the ***IMO*** measures agreed in late 2020. It is fair to say that the measures agreed by the ***IMO*** were regarded by a number countries as achievable, but not ambitious (enough), and, to some countries, were disappointing.

- **Time for a global carbon price on international shipping?**

  Depending on the source of information, global shipping is stated to give rise to between 1.7% and 3% of total global ***GHG*** emissions. This percentage is predicted to increase, principally as a function of increased world trade and a reduction in ***GHG*** emissions arising from the decarbonisation of other sectors and industries. Currently there is no global carbon price on international shipping, rather there is a patch-work of ***ETSs*** and carbon taxes globally, and as a result participants are affected differently.

  From a policy setting perspective, a global carbon tax would appear the soundest approach to driving decarbonisation of the international shipping industry: as is the case with any carbon tax, it should be introduced overtime to allow the industry to prepare and so as to align and to accelerate with the technological development that is required to shift to lower, low and no carbon technologies, critically, fuels.

Heavy weights on Hydrogen:

The unit cost of hydrogen (production, transportation and delivery to the point of use) may be a heavy weight slowing the development of the market for the lightest element. At the launch of the ***Hydrogen Act*** (see Edition 14 of Low Carbon Pulse) the secretary general of ***Hydrogen Europe*** (since 2016), Mr Jorgo Chatzimarkis added sparkle to the mix of thinking: "*We need capital and operating expenditure ... to bring the price of renewable hydrogen from [the price of] champagne, to [that of] prosecco, and later table water*". Some may say "tap water", noting that bottled water brought to table costs more per litre than motor spirit in many parts of the world.

The ***EU*** and its Member States are leading the world in providing funding and support for hydrogen projects, but it is likely that more is going to be needed, and there may need to be relaxation of state-aid rules (see Edition 18 of Low Carbon Pulse), and to make as many large-scale projects as possible ***Important Projects of Common Interest*** (***IPCEI***). It is difficult to counter the view that any large-scale hydrogen project is worthy of ***IPCEI*** status.

On June 11, 2021, ***EU*** Energy Ministers agreed to prolong ***EU*** support for some natural gas projects. This decision is part of wider policy setting debate and formulation, in particular the basis to classify any energy project as a project of common interest: in December 2020, the European Commission (***EC***) proposed rules to exclude natural gas and oil infrastructure.

Sinopec plans to produce 500,000 tonnes of Green Hydrogen by 2025:

- **From Grey to Green:** Edition 5 of Low Carbon Pulse outlined the position of Sinopec as a producer of hydrogen using traditional technologies, producing over 3 million metric tonnes per annum (***mmtpa***) of hydrogen. Edition 18 of Low Carbon Pulse outlined the development by Sinopec of its first Green Hydrogen facility in Ordos, Inner Mongolia, which is to start producing Green Hydrogen by the end of 2022.

  While Sinopec is the world's largest refiner of petroleum products, it has recognised for some time that there is a need to shift to low and no carbon, including to align with achieving peak ***GHG*** emissions by 2030, and net-zero ***GHG*** emissions by 2060. Sinopec is not alone among Chinese companies in responding to this imperative.

- **From production to distribution:** Chinese state owned enterprise, Sinopec, has been focused on its strategic shift to Green Hydrogen, and its wholly-owned subsidiary, Sinopec Star Co,. Ltd (***Sinopec Star***), is working towards the achievement of this shift. It is planned that ***Sinopec Star*** will develop projects to produce 500,000 metric tonnes per annum of Green Hydrogen by the end of 2025.

  In the context of developing supply and demand in tandem, at the same time as Sinopec is developing its Green Hydrogen production capacity, through ***Sinopec Star***, it is developing hydrogen refuelling infrastructure and stations (***HRI/Ss***). It is reported that Sinopec is working with Air Liquide in the roll-out of ***HRI/Ss***.

Competitiveness of Green Hydrogen assessed:

- **The Lucky Country:** A number of editions of Low Carbon Pulse have noted the advantages that certain countries and regions enjoy, and that will allow them to produce Green Hydrogen. One of those countries is Australia. Australia has world class on-shore solar and wind resources (as well as yet to be developed off-shore wind resources).

- **Build and Green:** The Chief Executive Officer of the Australian Renewable Energy Agency (***ARENA***), Mr Darren Miller, has expressed the view, for some time, that Australia has the renewable resources to become a global green energy giant. In this context, Mr Miller has expressed the view that Australia should develop its renewable energy capacity, first, to displace non-renewable electrical energy (current demand for electrical energy in Australia is less than 250 TWh annually), secondly, to produce Green Hydrogen to displace fossil fuels as energy carriers, and thirdly, to accelerate the production of Green Hydrogen for export as export markets develop.

- **The cost of Green Hydrogen:** The key to becoming a global green energy giant is the continued development of renewable electrical energy capacity, and achieving a cost of production of Green Hydrogen that is competitive with the energy carriers with which it will compete. While electrical energy produced from photovoltaic solar and from wind sources is now the lowest cost electrical energy in Australia (see a recent report by ***CSIRO*** and Australian Energy Market Operator (***AEMO***)), it is considered that the cost needs to fall further to allow acceleration of production to take place as export markets develop.
- **When might Green Hydrogen become cost competitive:** In late May 2021, the Federal Government of Australia, Advisian and the Clean Energy Finance Corporation (***CEFC***), released a report entitled *Australian hydrogen market study – Sector analysis study* (***SAS***).

  Commissioned by the ***CEFC***, the ***SAS*** is intended to provide "an appraisal of the economic gap between hydrogen supply and capacity to pay for each of the nominated demand sectors, both now and out to 2050".

  A number of key themes arise from the ***SAS*** as follows:

  – the key drivers for competitive Green Hydrogen costs include electrolyser capital cost trends, renewable energy costs and installation and operational efficiencies for electrolyser equipment;

  – the competitiveness of Green Hydrogen may accelerate as a result of broader market factors, such as the levelized costs of hydrogen being lower than forecast, fossil fuel prices being higher than forecast and the willingness of energy users to pay a premium for a clean energy alternative to fossil fuels;

  – in all sectors, low carbon hydrogen is expected to become more competitive towards 2050, due to parallel advances in production and distribution cost efficiency and end-use technology evolution;

  – in the near term, sectors that are at, or are approaching, commercialisation are line-haul vehicles, material handling and return to base vehicles (including buses), and remote power, with the expectation that mining vehicles will be commercialised towards 2030; and

  – by 2050, sectors in which hydrogen will be viable commercially are likely to include ferries, heavy rail haul, and light-haul vehicles, and natural gas networks (commercial and residential).

  SAS notes that clarification of "origin certification" expectations should be progressed as soon as possible.

  The Global Ashurst Towards Zero Emissions team did not cover the ***SAS*** in Edition 18 because it contained a summary of key themes arising from the International Energy Agency (***IEA***) report, *Net Zero by 2050: A Roadmap for the Global Energy Sector (**IEA Roadmap**).* It is fair to say that the ***SAS*** and the ***IEA Roadmap*** are both helpful, critically, it would appear that the consensus is that both appear to be based on sound modelling.

Mission Innovation – a window to innovation opened wider:

Mission Possible: Mission Innovation (***MI***) was announced at COP 21 by Mr Bill Gates. *MI* was established to provide a structure for the public and private sectors to come together to accelerate clean energy innovation to address climate change. Currently, ***MI*** has 25 members, including the ***EU***. ***MI*** links to the private sector through the Breakthrough Energy Coalition, a group of private sector investors, of whom one is Mr Gates.

The ***MI*** identified eight innovation challenges, one of which (**IC8**) is "Renewable and clean hydrogen". Members of ***MI*** reaffirmed their commitment with a second phase of ***MI***, **Mission Innovation 2.0** (***MI 2.0***).

On June 2, 2021, in Santiago, Chile, ***MI 2.0*** launched a decade of clean energy innovation to accelerate achieving the Paris Agreement Goals, including "*To increase the cost-competitiveness of clean hydrogen by reducing end-to-end costs to USD 2 per kg by 2030*", i.e., the cost delivered to bowser, not the cost of production.

In the world of hydrogen, cooperation is key: As part of ***MI 2.0***, on June 2, 2021, the ***Zero-Emission Shipping Mission*** (***ZESM***) was outlined. The ***ZESM*** is intended to accelerate international public-private collaboration to scale-up and to deploy new green maritime solutions. The Governments of Denmark, Norway and the US are to lead the ***ZESM***, working with the ***Global Maritime Forum***, and the Maersk McKinney Moller Center for Zero Carbon Shipping (see Edition 16 of Low Carbon Pulse).

The roles of Denmark, Norway and the US are key, both as shipping nations, and as countries that offer fertile ground for technological innovation. US Secretary of Energy, Ms Jennifer Granholm stated: "*Through fearless technological innovation, ambitious clean energy deployments, and constructive international collaboration, we can build a net-zero carbon economy …*".

Goals of ZESM: The ***ZESM*** has three principal goals:

1. to develop, demonstrate and deploy zero-emission fuels, ships and fuel infrastructure in a coordinated fashion along the full value chain;
2. by 2030, to have developed ships capable of running on hydrogen-based fuels (being zero-emission fuels) – such has Green Hydrogen, green ammonia, green methanol, and advanced biofuels – that make up at least 5% of the global deep-sea fleet, measured by fuel consumption; and
3. by 2030, to have at least 200 of these "well-to-wake" zero-emission fuelled ships in service and utilizing these fuels across their main deep-sea shipping routes.

Global Maritime Forum: Managing Director of ***Global Maritime Forum***, Ms Johannah Christensen (noting that the role of the ***Global Maritime Forum*** is key to the ***ZESM***) said: "*Shipping is on the verge of a clean energy revolution. To set the global maritime industry on a climate-aligned course and meet the goals of the Paris Agreement, zero-emission vessels need to be the dominant and competitive choice by the end of the [current] decade. The Zero Emission Shipping Mission will accelerate public and private efforts around the world to make a zero-emissions fleet a reality by 2030*".

Global Hydrogen Ports Coalition launched: Finally, also on June 2, 2021, at the ***Innovating to Net Zero Summit*** in Santiago, Chile, the Global Hydrogen Ports Coalition was launched. An industry, headed to hydrogen based fuels.

US, AUS and Indonesia ranges of scenarios to net-zero emissions (*NZE*):

- **Scenario nous State-side:** While it is increasingly difficult to find a fold-out paper roadmap, and nearly impossible to buy an A to Z, there is no shortage of satellite navigation products and there is no shortage of ***NZE*** roadmaps. One ***NZE*** roadmap worth navigating cyber-space for is the Princeton University, *Net Zero America Report* (***NZEA***).

  The ***NZEA*** provides five scenarios that may result in to ***NZE*** (some may call them pathways to), and the costs and benefits of each of them. The ***NZEA*** provides a helpful representation, in map form, of the current renewable electrical energy "footprint today", and the "footprint needed by 2050".

- **Scenario nous lands down-under:** In addition to attracting broad attention within the US, the ***NZEA*** has attracted attention around the world, including in Australia.

  On June 4, 2021, it was reported that Net Zero Australia (***NZAu***), a collaborative partnership among the University of Melbourne, the University of Queensland and Princeton University, and management consultancy Nous Group, is to use the nous learned from the development of ***NZEA*** to develop a similar "scenario set" for Australia. It is reported that ***NZAu*** is to continue work until 2023, and will issue interim findings along the way, with the purpose to present costs and benefits of each scenario considered by it.

  NZau is sponsored by APA Group, Dow, Future Energy Exports Cooperative Research Centre, Minderoo Foundation (settled by Forest Family interests), and Worley Parsons.

- **Scenario for *NZE* for Indonesia by 2050:** In previous editions of Low Carbon Pulse, it has been noted that Indonesia is considering committing to ***NZE*** by 2070. On May 31, 2021, a report (***Deep Decarbonization of Indonesia's Energy System*** by 2050) was published by the ***Institute for Essential Services Reform*** (Jakarta), ***Agora Energiewende*** (Germany) and ***Lappeenranta-Lahti University of Technology*** or ***LUT*** (Finland). The headline from the report is that to achieve ***NZE*** by 2050, Indonesia will have to develop 1.49 TW (or 1,490 GW) of renewable energy capacity, 80% of that renewable electrical energy being photovoltaic solar.

US roadmap taking shape …

- **may go via nuclear power stations …**

  In June 2 2021, two titans of the corporate world, Mr Bill Gates, and Mr Warren Buffet announced the development of the first Natrium (a small advanced modular reactor) (***NSMAR***) on the site of a coal-fired power station in Wyoming. TerraPower (founded by Mr Gates) and PacifiCorp (owned by Mr Buffet's investment vehicle, Berkshire Hathaway) are to co-develop ***NSMAR***. ***NSMAR*** is a 345 MW nuclear power station that will use uranium as its fuel, and, ***NSMAR***, as a salt-cooled fast reactor, will use molten salt-based energy storage.

  See: *Bill Gates' next generation nuclear reactor to be built in Wyoming*

- **… and within ear[th]shot will definitely include hydrogen of many colours:**

  The hydrogen ear[th]shot: On June 6, 2021, US Department of Energy Secretary, Ms Jennifer Granholm outlined the objectives of the US to achieve low cost Green Hydrogen – a reduction of 80% in the cost of Green Hydrogen by 2030 (***80 by 30***).

  At the Leaders' Summit in April 2021 Secretary Granholm said of achieving ***NZE*** that: "*This is our generation's moon shot*". This resonated (see Edition 15 of Low Carbon Pulse).

  The hydrogen ear[th]shot, is aimed at reducing the cost of 1 kg of Green Hydrogen to USD 1.00 by 2030, recognising the need for the deployment of people to achieve and to support this outcome.

  Clean Hydrogen: As is often the case, the phrase Green Hydrogen has been bandied around in some headlines accompanying the hydrogen earthshot.

  As described by Secretary Granholm, the hydrogen earthshot is about the use of:

  1. renewable electrical energy (being Green Hydrogen if water is electrolysed using that renewable energy);
  2. nuclear power (being Pink Hydrogen if nuclear power is used, and Purple Hydrogen if steam from nuclear power generation is used, to produce hydrogen using electrolysis); and
  3. thermal conversion (Blue Hydrogen if CCS / CCUS is used, and Turquoise Hydrogen if pyrolysis technology is used, and carbon is captured as carbon black).

  All of these technologies produce renewable hydrogen and most of them will produce clean hydrogen as described by Secretary Granholm: "*The hydrogen [earthshot] set[s] an ambitious yet achievable cost target to accelerate innovations and spur demand [for] clean hydrogen. Clean hydrogen is a game changer. … It will help decarbonise high-polluting heavy-duty and industrial sectors, while delivering good-paying jobs and realising a net-zero economy by 2050*".

  This is a positive policy target, which it is hoped will be developed further in the next short-while, critically, by the provision of guide-rails and policy settings to allow demand and supply to develop in tandem.

***BESS* round-up:**

- **Best thinking on *BESS*:** In a report (*Economic Potential of Diurnal Storage in the US Power Sector*) from the Storage Futures Study (***SFS***) from the National Renewable Energy Laboratory (***NREL***) the scale of the potential for utility-scale diurnal state is outlined. (The ***NREL*** is a valuable service of research.)

  As noted in Edition 13 of Low Carbon Pulse, factors that inform the location of, and size of, ***Battery Electric Storage Systems*** (***BESSs***), include the energy density per square kilometre: in this context, a long-range ***BESS*** (i.e., being a ***BESS*** having capacity to supply electrical energy for over 6 hours), is likely to be used less in areas of high or higher energy density.

The ***SFS*** adds to the thinking on ***BESSs***, this time on diurnal ***BESSs*** (i.e., being a ***BESS*** having capacity to supply electrical energy for up to 12 hours) finding that ***BESSs*** add most value to the grid, and deployment increases, when the overall conditions allow the provision of multiple services to the grid, and there is greater photovoltaic solar installed capacity proximate to that part of the grid. The lead author of ***SFS***, Mr Will Frazier, noted that: "*To realize cost-optimal storage deployment, the power will need to allow storage to provide capacity and energy time-shifting services*."

See: *Grid-Scale U.S. Energy Storage Capacity Could Grow Five-Fold By 2050*

- **Best current outcomes with *BESS*:** A previous Ashurst publication outlined the Alamitos Battery Energy Storage System. The backstory to the ***Alamitos BESS*** is probably less well-known, and the story is resonating globally in different jurisdictions and for different reasons: the ***Alamitos BESS*** is part of a combined choice of ***BESS*** and combined cycle gas turbine (***CCGT***) as part of a strategy that has resulted in lower demand for gas-fired electrical energy capacity on the shuttering of the San Ofre nuclear power plant. A continuing theme in decarbonization and energy transition is that the combination of technologies that is regarded as the best near to medium term outcome, may not be the ultimate net-zero ***GHG*** emission outcome.

  See: *Battery storage as peaking capacity: How Alamitos changed the game for California*

- ***BESSs* go archipelago:** On June 11, 2021, it was widely reported that Greece and the Maldives are moving to procure ***BESS***s across their island archipelagos. While the procurements are of differing scales, 700 MW (extent of storage to be confirmed) for Greece, and 40 MW (of 40 MWh) for the Maldives, the logic for their procurement and deployment is the same, progress towards the displacement of fossil fuel capacity.

Edition 20 or Edition 21 of Low Carbon Pulse will provide background on compressed air storage (***CAS***), another mooted means of energy storage that is being explored in some jurisdictions. (see Edition 21 of Low Carbon Pulse)

BECCS round-up

Bioenergy's role in *NZE*: As part of extending the coverage of Low Carbon Pulse, a greater number of news items will be included to cover the role of bioenergy in progress towards net-zero.

BECCS role in *NZE*: As many readers will know, bioenergy is not clean unless carbon is captured and stored. With the projected increase in the use of agricultural and forestry waste, and increased use of waste and waste water (see **H24I – Hydrogen from Waste**), Bioenergy with Carbon Capture and Storage (***BECCS***) will be key.

***BECCS* in practice:**

- **Better outcomes with *BECCS*:** On June 7, 2021, Bechtel (leading EPC solution contractor, with particular expertise on CCS / CCUS) and Drax (among other things, owner of the electrical energy assets in the UK, and the US, including bioenergy), announced a strategic agreement to create ***BECCS*** plants around the world.

  The announcement of this strategic agreement may be regarded as entirely consistent with Drax's conversion of its coal-fired power station in Selby, North Yorkshire, England (the UK's largest power station) (***SPS***) in to what has been described as the largest decarbonisation project in Europe.

- **Great outcome with *MHI*:** On June 10, 2021, it was announced that Drax and Mitsubishi Heavy Industries (***MHI***) had entered into a long-term agreement under which Drax is to use (under licence) ***MHI*** technology to capture carbon at ***SPS***.

By the use of ***BECCS***, Drax anticipates that it the ***SPS*** will be carbon negative by 2030: capturing and storing around 8 ***mpta*** of ***CO_2***.

(The Global Ashurst Towards Zero Emissions team includes practitioners who act on bioenergy (including bagasse and other biomass), waste, waste water projects globally. Some of those team members also work on carbon capture in the context of liquified natural gas projects and carbon neutral LNG cargoes.)

CCS / CCUS round-up:

- **Longship stretching stroke and Northern Lights starting to dazzle:** Edition 2 of Low Carbon Pulse outlined the Longship Project: the Longship Project includes the Equinor, Shell and TOTALEnergies ***Northern Lights Project*** to capture ***CO_2*** from industrial sources (cement and waste to energy), transported by ***CO_2*** carrier to the Oygarden Facility (with Equinor procuring the development of the Oygarden Facility), and then piped 100 kms for injection 2.6 km below the seabed of the North Sea.

  Ahead of the completion of the ***Northern Lights Project***, the Project is being expanded, with the development of further sub-surface storage fields, with plans to drill for a new off-shore injection well in 2022.

  See: Northern Lights *website*

- **Pointed three pronged plan from Neptune Energy:** For some time, it has been apparent that Neptune Energy has been working-up a plan to use its three depleted gas fields, the L10-A, L10-B and L10-E areas, in the Dutch sector of the North Sea, for a carbon capture and storage project. Neptune Energy has recently announced that it is undertaking a feasibility study in respect of the L10 area.

  See: *L10 Area CCS development, Dutch North Sea*

  Carbon capture, *use / utilisation* and storage: News items on CCS and CCUS tend to focus on *carbon capture and storage*, rather than the *use / utilisation* of the carbon-dioxide captured. What are the possible uses? And will products produced from CCS / CCUS be saleable? The current uses of ***CO_2*** include the production of dry ice and carbonating drinks, and for medical procedures. Also ***CO_2*** can be used to produce plastics (including containers for use to store foods, and in furniture), concrete and e-fuels / future fuels.

  If ***CO_2*** is used as a feedstock / raw material to create a product, on the production of that product the ***CO_2*** is stable, and does not give rise to ***GHG*** emissions unless that product is oxidized. In the fourth article in ***The Shift to Hydrogen (S2H2): Elemental Change*** series (for publication later in 2021), all uses of ***CO_2*** will be considered, including to produce e-fuels / future fuels.

- **Carbon neutral cement plant – Slite of hand:** On June 2, 2021, Heidelberg Cement Group (***HCG***) announced the development of the world's first carbon-neutral cement plant: this is reported to involve the augmentation and upgrade of ***HCG's*** existing cement production facility at Slite, Gotland Island, Sweden. The plant produces 1.8 mtpa of ***CO_2***. From 2030 these ***CO_2*** emissions will be captured and stored. It is understood that the Slite project will benefit from the use of CCS technology by ***HCG*** at Brevik, Norway.

  For detail about cement production and the ***GHG*** emissions arising please see *The Shift to Hydrogen (S2H2): Elemental Change – What Needs to be Decarbonised? And what role can hydrogen play?*

  See: *HeidelbergCement to build the world's first carbon-neutral cement plant*
- **Increasing *CO_2* levels need to be matched by ever increasing *CO_2* capture:** On June 7, 2021, it was reported widely that in May 2021 the level of ***CO_2*** in the atmosphere reached the highest level (419 ppm) since measurement began in the late 1950's at the US National Oceanic and Atmospheric Administration's Mauna Loa weather station, Hawaii, and is at the highest level in over 4.5 million years.

  While the rate of investment in CCS / CCUS projects appears to be increasing, the development of CCS / CCUS needs to accelerate. In the fourth article in ***The Shift to Hydrogen (S2H2): Elemental Change*** series, all forms of CCS / CCUS will be considered, as will the scale of CCS / CCUS required to be developed.
- **Gulf Coast keeps giving:** On June 8, 2021, it was reported widely that Storegga Geotechnologies and Talos Energy had entered into a joint venture to evaluate and to develop carbon capture and storage opportunities along the US Gulf Coast and in the Gulf of Mexico. The most prospective areas are along the Gulf Coast, critically, the coasts of the four States of Alabama, Louisiana, Mississippi and Texas. As has been noted in a number of editions of Low Carbon Pulse, Storegga is very much a leader in CCS / CCUS.

E-fuel / Future fuel round-up:

- **A great start to June:** On June 1, 2021, it was announced that Shell had awarded Worley Parsons (a leading engineering corporation) a contract in respect of the development of a 200 MW electrolyser as part of the development of a Green Hydrogen production facility (***GHPF***) to be located in Rotterdam, the Netherlands. From 2023, the ***GHPF*** will produce an estimated 50,000 to 60,000 kgs (or 50 to 60 tonnes) a day of Green Hydrogen. The Green Hydrogen will be used to decarbonise activities at Shell's Pernis Refinery, and it is anticipated that it will provide fuel for heavy transportation activities.

  See: *Shell awards Worley contract to help create a Green Hydrogen factory in the Netherlands*
- **Haldor Topsoe – mobilising the Green Giant:** On June 2, 2021, Haldor Topsoe announced the establishment of a Green Hydrogen business that will enable it to accelerate all aspects of its Green Hydrogen business: for example, Edition 11 of Low Carbon Pulse reported on the development of a solid-oxide electrolyser cell (***SOEC***) technology by Haldor Topose with a reported efficiency of 90% and Edition 18 of Low Carbon Pulse reported on the development of the 500 MW and up to 5 GW Gigafactory (one of four Giga-factories announced in 2021) to produce those ***SOECs***. Haldor Topsoe is expected to continue its run of successful involvement in Green Hydrogen projects.

  See: *Haldor Topsoe establishes focused Green Hydrogen organization to accelerate electrolysis business*
- **World's largest hydrogen off-take agreement signed:** On June 4, 2021, it was announced that ***SGH2 Energy*** had signed an agreement under which it is to supply 3,850 tonnes of hydrogen a year, for 10 years, to refuelling stations. The hydrogen will be produced at ***SGH2 Energy***'s planned bioenergy (biogenic from biomass) facility located in the City of Lancaster, north of Los Angeles, California: the facility is to be developed as a public private partnership (between ***SGH2 Energy*** and the ***City of Lancaster***), and will use gasification technology, and, what appears to be, enhanced plasma technology. Completion of the facility is scheduled for mid-2023.

  The hydrogen produced from the facility will be compressed, and transported using tube-tanker trailers. It is estimated that every 24 hours 11 tanker trailers will deliver compressed hydrogen to hydrogen refuelling stations across Southern California.

  Previous editions of Low Carbon Pulse have outlined the use of waste (and wastewater) to produce hydrogen in an urban setting. The first feature in the *Hydrogen for Industry* series is devoted to hydrogen to waste, including explaining the technologies that may be used, and the chemistry of each. The ***SGH2 Energy*** project may be regarded as being at the vanguard of increased use of bioenergy as a feedstock for renewable hydrogen.

  (It has been reported that the hydrogen is to be characterised as "carbon-negative" because the use of waste as feedstock avoids the landfilling of that waste, and the release of ***CH_4***: this is not an unknown analysis, but in the context of decarbonisation policy settings, a clearer analysis would be the mass of ***GHG*** produced on production of the hydrogen, rather than the mass of ***GHG*** avoided by not using landfill.)

  See: *World's largest 'Green Hydrogen' offtake deal signed in California by waste-to-H2 start-up*
- **Japan Inc to recycle *CO_2*:** A continuing theme noted in Low Carbon Pulse has been the consistent and fruitful engagement between the Government of Japan and Japanese corporations (***Japan Inc***). In early June 2021, it was reported widely that the Government of Japan is to lead a public-private initiative to use ***CO_2*** as a feedstock from which to produce low to no ***GHG*** emission fuel by 2050: the base technology involves methanation - the use of ***CO_2*** to produce ***CH_4***. As noted above, in the fourth article in ***The Shift to Hydrogen (S2H2): Elemental Change*** series, all uses of ***CO_2*** will be considered, including to produce e-fuels / future fuel.

  The Ministry of Economy, Trade and Industry (***METI***) is to establish a council to involve the private sector in this "hydrogen economy building initiative". It is understood that the council will comprise representatives from Tokyo Gas, Tokyo Electric Power Co., JFE Steel and Nippon Steel (noting that steel companies produce ***CO_2*** and can use ***CH_4*** produced from ***CO_2***), Mitsubishi Corporation, Denso (auto-parts manufacturer and supplier), and Nippon Yusen, and the Development Bank of Japan. Nineteen corporations from the private sector have been identified as being critical to this initiative.

  See: *Japan Inc enlisted to help convert carbon dioxide into methane*

- **Yara and Trafigura to navigate in tandem:** As noted in a number of editions of Low Carbon Pulse, and each of its sibling publications, the development of supply and demand in tandem is critical to the development of the market for hydrogen and for ammonia. In early June, Yara announced its collaboration with Trafigura to work together to achieve the transition to the hydrogen economy.

  See: *Trafigura and Yara Sign Memorandum of Understanding to Explore Opportunities for Joint Business in Clean Ammonia*

- **Green fields for Greenfield Green Hydrogen in Queensland:**
  - **Fields of Green:** On June 8, 2021, it was widely reported that the Queensland Government (one of the early moving and forward looking Australian's States) had agreed to the location of a 3 GW Green Hydrogen facility (***Gladstone 3G*** or ***G3G***) within the Gladstone State Development Area (***GSDA***): Stanwell Corporation (a Queensland state owned corporation) has an option in respect of the land on which ***G3G*** may be located.

    G3G is an export scale facility, reflecting the joint venture between ***Iwatani Corporation*** (a first moving and forward thinking Japanese corporation) and ***Stanwell Corporation***. The Port of Gladstone (from which coal, alumina, aluminium, bauxite, cement, and liquid ammonia are currently exported), would provide an ideal port for the liquefaction of hydrogen, and its export.
  - **Green Grid:** Given the scale of ***G3G***, given current electrolyser technologies, between 5 and 6 GW of renewable energy capacity will be required. It is expected that renewable electrical energy will be sourced from the proposed ***Central Queensland Renewable Energy Hub***, at least in part.
  - **Key to avoid grid-lock:** The support of government is key to the development of Green Hydrogen facilities, particularly on this scale. The Government of Queensland appears intent on positioning the State of Queensland as a key jurisdiction for the production of Green Hydrogen for export.
  - **Green for Greening:** On June 10, 2021, the Queensland Government announced that it will establish a AUS 1.7 billion clean energy fund "to supercharge" the continued development of the State's renewable energy industry and broader policy objective to green all sectors.

- **Canada continues to increase H_2 PC:** On June 9, 2021, the Government of Canada and the Province of Alberta announced plans to work with Air Products (one of the world's leading industrial gases companies) to develop a USD 1.3 billion net-zero hydrogen production and liquefaction facility in Edmonton, Alberta, planned to be operational by 2024. Canada continues to develop steadily its hydrogen production capacity. This project continues the progress of Canada as a leading hydrogen and hydrogen fuel based producer.

  See: *Air Products Announces Multi-Billion Dollar Net-Zero Hydrogen Energy Complex in Edmonton, Alberta, Canada*

- **Plug Power continues to plug and play:** A number of editions of Low Carbon Pulse have mentioned Plug Power, as it continues as an integrated provider of hydrogen solutions globally. On June 10, 2021, it was announced that Plug Power plans to develop a Green Hydrogen production facility in Camden Country, Georgia, US. The Green Hydrogen production facility will produce 15 tonnes of liquefied hydrogen a day to be sold for use by the transport sector. Plug Power continues to lead the way in developing merchant Green Hydrogen facilities.

  See: *Plug Power unveils plans for a liquid Green Hydrogen plant in Camden County, Georgia; one step closer to producing over 500 tonnes of hydrogen daily*

In Edition 20 or Edition 21 of Low Carbon Pulse, the prospective role of Gulf Cooperation Council (***GCC***) countries in the production of Green Hydrogen will be considered.

Green Metals:

- In late May 2021, six of the leading lenders to the steel industry, Citi, Goldman Sachs, ING, Société Générale, Standard Chartered, and Unicredit, established the ***Steel Climate-Aligned Finance Working Group*** (***SCAFWG***) to focus on, and to provide direction towards the decarbonisation of the steel industry.

  Among other things, the ***SCAFWG*** will develop a financing agreement aligned to the Paris Agreement. As might be expected, a number of initiatives are contemplated to decarbonise the steel industry, critically, electrification, energy storage, future fuels, and CCS / CCUS.

  As the financing agreement develops, future editions of Low Carbon Pulse will cover those developments. It is anticipated that the Poseidon Principles (in place for the financing of the maritime shipping industry), will guide the development of the financing agreement.

- **Blueing of the Russian steel industry:** On June 4, 2021, it was reported that Novatek and PAO Severstal have signed a memorandum of understanding to develop a pilot project for the production, and supply, of Blue Hydrogen. The Blue Hydrogen can be used as a standalone high temperature fuel or it can be blended with natural gas. In due course, it is intended that the use Blue Hydrogen will displace the use natural gas.

  See: *NOVATEK Signed Cooperation Agreement with Leningrad Region*; *Severstal and NOVATEK to partner on hydrogen and alternative energy*

Hydrogen Cities, Councils, Hubs, Infrastructure and Valleys:

Previous editions of Low Carbon Pulse have outlined the development Hydrogen Hubs, Infrastructure and Valleys. In future editions of Low Carbon Pulse, Hydrogen City, Council, Hub, Infrastructure and Valley news items will be clustered under one heading:

- **Eastern Germany mapping**: On June 1, 2021, Gascade Gastransport GmbH (a leading high-pressure gas transmission grid operator) and Ontras Gastransport GmbH (Germany's second largest gas transmission system operator) announced plans to develop a new hydrogen-hub for eastern Germany, with the hub to include a 475 km hydrogen pipeline network (***HPP***) converted from natural gas. It is anticipated that the ***HPP*** will be completed by 2026, and on completion will connect to Mecklenburg-Western Pomerania, Brandenburg, Saxony, Saxony-Anhalt and Berlin.

See: *GASCADE and ONTRAS to Launch Hydrogen Hub for Eastern Germany* and *Gascade, Ontras to establish hydrogen hub for Eastern Germany with 475km pipeline grid*

- **Italy continues infrastructure development:** On June 2, 2021, it was confirmed that a 440 km pipeline forming part of Snam's high-pressure gas transmission and distribution network in Italy is to be certified to transport 100% of its capacity as hydrogen gas. In May 2021, Snam achieved a world first - testing a 30% hydrogen, 70% natural gas, blended gas mix.

  See: *Corinth Pipeworks delivers first hydrogen-certified pipeline project for Snam's high pressure gas network in Italy*

- **Great Plains take-off:** On June 2, 2021, Bakken Energy and Mitsubishi Power Americas, Inc., announced that they had signed a strategic partnership agreement to create a clean hydrogen hub in North Dakota, US (***CHH***). The ***CHH*** is to comprise clean hydrogen production, storage, and transportation facilities, to deliver clean hydrogen to the point of use. The intention of Bakken Energy is to produce Blue Hydrogen from natural gas, so as to become, in the words of Bakken Energy CEO, Mr Mike Hopkins: "*the largest and lowest cost producer of clean hydrogen in the United States*".

  Mitsubishi has been active in the development of hydrogen hubs in the US, with the Californian Project (City of Los Angeles), Magnum Development in Delta, Utah, and the Texas Brine project.

  See: *Mitsubishi, Bakken Energy aim to develop Blue Hydrogen hub in North Dakota*

- **City for a new Future:** Edition 17 of Low Carbon Pulse reported on the Woven City – City of the Future (to be at the base of Mount Fiji, Shizuoka Prefecture, Japan).

  On June 4, 2021, Toyota Motor Company announced plans to model a city for a new future. The "city for a new future" is planned by reference to a city of 300,000 people located within the Fukushima Prefecture. Effectively the work being done by Toyota, and its partners, including Hino and Isuzu, is to develop a model for a city that is to use hydrogen, including to model the delivery of goods within the city.

  See: *Fukushima Prefecture and Toyota Begin Discussions Aimed at Building a Hydrogen-based City of the Future in Fukushima Prefecture*

- **Mission Innovation on Hydrogen Valleys**: On June 2, 2021 ***MI 2.0*** (though its Hydrogen Valley Platform) released a paper detailing the emerging use and benefit of hydrogen valleys. It is well worth a read.

- **Korean Hydrogen Council:** On June 10, 2021, Hyundai, Hyosung, and POSCO announced the launch of an industry wide body - the ***Korean Hydrogen Council***. The Council will be launched officially in September 2021 as the ***K-Hydrogen Council***. The Chair of Hyundai Motor Group, Mr Chung Euisun, stated that the goal of the K-Hydrogen Council is "*to foster the widespread use of clean energy across industries and advance a hydrogen-based society*". As was the case with the Japanese Hydrogen Association (see Editions 2 and 5 of Low Carbon Pulse for outline of JH2A), Low Carbon Pulse will report on ***K-Hydrogen Council*** on its official launch. (see Edition 27 of Low Carbon Pulse)

- **HyNet North West's net worth:** On June 11, 2021, it was widely reported that consultation has begun across the North West of England and North Wales in respect of the development of infrastructure necessary to proceed with the carbon capture and storage project in Liverpool Bay, using depleted natural gas fields operated by Eni UK Ltd. A key part of the necessary infrastructure development is the construction of a new ***CO_2*** pipeline that will connect to an existing natural gas pipeline that is to be repurposed.

  See: *Consultation begins on huge carbon capture scheme that would see 20 mile long pipeline built through Deeside*

Off-shore wind to steel:

- **Ørsted forges relationship with POSCO**: In late May 2021, it was announced that global renewable giant, Ørsted, plans to develop 1.6 GW of off-shore wind field projects off Incheon, South Korea, to the west of Seoul, in the West Sea (or Yellow Sea). South Korean steel giant, POSCO has announced that it "will support the development" by Ørsted, as part of a broader strategic objective of "*working to discover renewable hydrogen business opportunities*."

  The plans are reflected in a memorandum of understanding (***MOU***). The ***MOU*** builds on the strong existing relationship between these leading corporations. POSCO is no stranger to innovation, including the own-use import of LNG in the mid-2000's, and in March 2021 teaming with Origin Energy for the supply Green Hydrogen, likely to be sourced from the proposed project in Townsville, Queensland.

  See: *Ørsted and POSCO sign MoU to strengthen collaboration on offshore wind and renewable hydrogen in Korea*

- **Ørsted ringing the bell on the off-shore homestead:** Ørsted has been leading the way in the development of renewable energy, with 12 GW of renewable energy capacity installed. In a series of announcements during the first week of June 2021, Ørsted outlined its plans to accelerate the development of its business to 50 GW of installed renewable energy capacity by 2030.

  In outlining these plans, Ørsted has made use of the phrase "green energy major". Ørsted Chief Executive Officer and Group President, Mr Mads Nipper, said: "*Our aspiration is to become the world's leading green energy major by 2030 … it's our clear aspiration to remain the global market leader in offshore wind*".

  See: *Ørsted aims for net-positive biodiversity impact from new projects commissioned from 2030; Mads Nipper – What would the world miss if your company did not exist?*

Sustainable Energy Round-up:

- **Germany continues apace:** On June 2, 2021, it was reported that Germany is to accelerate the development of solar and wind renewable electrical energy. Reuters reported that a new draft law contemplates the expansion of planned onshore solar to 150 GW (from 100 GW currently planned, and 54.4 GW in 2020) and onshore wind to 95 GW (from 71 GW currently planned, and 52 GW in 2020) of installed capacity by 2030.

The reported planned expansion can be viewed as a direct response to the judgment of the German Constitutional Court on April 30, 2021, and reported on in Edition 17 of Low Carbon Pulse: the effect of the judgment has been to force the Federal Government of Germany to provide for increased ***GHG*** emission reduction targets leading up to 2030, having previously "off-loaded" responsibility for ***GHG*** emissions reductions to after 2030.

See: *Germany to speed up wind and solar energy expansion - draft*

- **Pumped about pumped storage:** Pumped storage has long been the mainstay of grid integrity and storage, and balancing overnight electrical load: the long-established model was to install pumped storage at strategic locations on a grid to allow response to peaking of load, and then to use electrical energy to pump water back into storage over-night. As gross-pool markets developed this continued to make sense because of the lower pool prices overnight at times of lower load, with base load coal-fired power stations dispatched.

  In the last 25 years or so, in the ***PRC***, State Grid has used pumped storage as an integral part of its grid design, allowing it to invest effectively across its grid on an integrated basis. This has continued as other renewable electrical energy load has been developed, and has facilitated that development. In effect, pumped storage, is "A Big Battery" (see Edition 6 of Low Carbon Pulse, under ***Pumped Storage – a global opportunity***.)

  With increased renewable electrical energy connected to grids, the underlying technical reasons for pumped storage remain, but the timing of the pumping water back into storage has changed. In many jurisdictions with photovoltaic solar capacity, pool prices dip during the day, and provide a window of lower pool prices to allow water to be pumped back into storage.

  As noted in another edition of Low Carbon Pulse, there is a global atlas detailing 600,000 possible locations for hydro-electric facilities (which seems to include pumped-storage). On June 8, 2021, leading Australian renewables news publication, "RenewEconomy – Clean Energy News and Analysis" published a pumped-storage map for Australia. (Also RenewEconomy has published an offshore wind field map for Australia.)

- **Damming - The Drowned and the Saved (after Primo Levi):** Just as pumped storage is part of the energy mix essential to achieving net-zero emissions, so too is the use large-scale hydroelectric energy generation, both dammed (including with pumped storage) and run of river. The generation of electrical energy from dams is achieving increasing attention in a number of jurisdictions, and in the US and Australia has achieved particular attention during the news cycle of this edition of Low Carbon Pulse.

  In the ever innovative State of Queensland, Australia, the State Government is considering whether to develop a pumped storage facility at the existing Borumba Dam, and Powerlink (a government owned corporation) is undertaking a detailed cost and design analysis.

  See: *Borumba hydro to deliver reliable supply and 2000 jobs*

Wind round-up:

- **From the land of the windmill to the sea of the windmill:** On June 3, 2021, the Netherlands announced that studies are being undertaken in respect of eight areas in the Dutch sector of the North Sea. It is understood that the areas being studied have the potential to add an additional 64.9 GW of offshore wind field installed capacity.

  See: The Netherlands Enterprise Agency (RVO) *website*

- **Is it a wind sail, a wind wall, a wind wave – no it is a *Wind Catcher System*:** On June 8, 2021 many news feeds reported on a new floating off-shore wind field project technology, with the scale of the technology presented in comparison to the Eiffel Tower, the Statue of Liberty, aircraft and cruise ships.

  The headlines for the ***Wind Catcher System*** are that it is competitive with fixed-bottom off-shore wind capital costs, and is five times as efficient as a conventional wind turbines.

- **Closing the gap by using the Gulf:** On June 9, 2021, it was widely reported that the US Department of the Interior will assess the development of off-shore wind fields on the Gulf Mexico Outer Continental Shelf (***OCS***). It is reported that the Bureau of Ocean Energy Management (***BOEM***) issued a Request for Interest (***RFI***) on June 11, 2021, relating to four of the five States with coastlines onto the Gulf, Alabama, Louisiana, Mississippi and Texas.

  As has been noted before in Low Carbon Pulse, the off-shore areas of the east and west coasts of the US, and the Gulf Coast and the Gulf of Mexico are highly prospective, and have the benefit of being close to load.

- **Floating off-shore wind for the Gulf of Roses:** On June 10, 2021, BlueFloat Energy announced its plan to develop a 1 GW floating off-shore wind field off the coast of Emporda, close to the Gulf of Roses, Catalonia.

  See: *BlueFloat Energy Plans to Build 1 GW Floating Wind Farm in Spain*

- **Bass Strait Wind Tunnel:** On June 11, 2021, plans to develop two giga-scale off-shore wind projects emerged: Brookvale Energy is planning to develop up to 2 GW of off-shore wind field capacity off Tasmania, and Floatation Energy is planning to develop up to 1.5 GW of off-shore wind field capacity off Victoria. As reported in Editions 17 and 16 of Low Carbon Pulse, off-shore wind development are relatively new in Australia, but is gathering pace.

  See: *Two massive offshore wind farms proposed for Bass Strait*

Solar round up:

On June 4, 2021, plans were announced for the development of three off-grid solar facilities in the Democratic Republic of Congo (***DRC***). The off-grid solar facilities are planned to provide electrical energy to the cities of Bumba, Gemena and Isiro. The cities are located in the north of the ***DRC***. The off-grid solar facilities are to be developed by an international consortium of corporations, AEE Power (Spain), Eranove (France) and Gridworks (UK), under a concession granted by the Ministry of Hydraulic Resources and Electricity of the DRC. The award of the concession comes under the Essor Access to Energy Initiative, to which the Government is committed.

See: *DR Congo Goes With Solar Off Grid To Power 3 Northern Cities*

Port and Land Transport round-up – shout outs to early movers:

- **Port of first call:** Editions 5 and 17 outlined the progress of the Port of Los Angeles to its greening. On June 8, 2021, it was announced that five ***FCEVs*** Class 8 trucks, developed by Kenworth Truck, using fuel cell technology developed by Toyota, and two hydrogen refuelling stations (***HRS***), developed by Shell, are now operational within the precincts of the Port.

  These initiatives are part of the ***Shore to Shore*** project (see Edition 5 of Low Carbon Pulse). While the scale of these deployments may be regarded as small in the broader context of the operation of the Port, as with other initiatives around the world, the role of first movers is critical: in addition to Shell, Toyota, and Kenworth, Tenaris and NEL are involved in the ***Shore to Shore*** project. Also, as noted in Edition 17 of Low Carbon Pulse, the Port of Los Angeles has contracted with Nikola Corporation for 30 Nikola ***BEVs*** and 70 Nikola ***FCEVs***.

  See: *Port of Los Angeles Rolls Out Hydrogen Fuel Cell Electric Freight Demonstration*

- **First Bus *HRS* in the Netherlands:** In early June 2021, Royal Dutch Shell opened its first ***HRS*** for buses. Of itself this may not appear significant, but taken with the role of Shell in developing the supply of hydrogen and ***HRS*** across Europe (Germany and UK) and North America (Canada and the US). As noted in Edition 18 of Low Carbon Pulse, Shell is working with Daimler to develop hydrogen supply and ***HRSs*** in tandem with the Daimler's development of *FCEV*s.

  See: *Shell opens its first operational hydrogen refilling point for buses in Groningen*

- **First movers, moving incrementally:** As noted frequently, supply of hydrogen needs to develop in tandem with demand for hydrogen. A number of corporations, including BP, Daimler, Everfuel, Hyundai, Hyzon, Plug Power, Shell, Toyota, and Volvo, in the transport sector, and ports, such as the Port of Los Angeles and Port of Rotterdam, are showing the importance, and effectiveness, of "in tandem" development. As such, while the absolute numbers of units sold, and ***HRSs*** opened, may appear relatively small, the demand for ***FCEVs*** and the means of refuelling ***FCEVs*** is developing at an increasing rate, being a rate that is consistent with, if not a little bit ahead of, the anticipated development of the supply and demand sides of this part of the hydrogen market.

Shipping news forecast:

- **FCT Ferries:**
  - **Who paid for the ferry, man**? On June 2, 2021, Switch Maritime announced that its ferry, MV Sea Change, will commence operation in San Francisco Bay in Q3 of 2021. The MV Sea Change will be powered and propelled by ***FCT*** using compressed hydrogen gas (at 250 bar or 3,600 pounds per square inch), and will carry 84 passengers and 246 kg of hydrogen (the mass of four average sized passengers). The ***FCT*** will produce electrical energy at 360 Kw, and battery pack will provide up to 100 KWh of additional energy.

    See: Switch Maritime *website*
  - **How is the ferryman going to be paid? By pre-baking demand:**
    - Edition 12 of Low Carbon Pulse (under ***More Northern Europe News***) outlined the agreement between Linde and Norled under which Linde was to supply liquid hydrogen and associated hydrogen storage and delivery systems in respect of the ferry, MF Hydra, which is to carry both passengers and vehicles.
    - On June 4, 2021, Caledonian Maritime Assets Ltd (***CMAL***) announced plans to develop a sea-going ferry to be powered and propelled using ***FCT***. ***CMAL*** (owned by the government of Scotland) has contracted with Aqualisbraemar LOC Group (***ALG***) to develop a concept design.

      CMAL and ***ALG*** will work together on the development of the concept design, with ***CMAL*** seeing a need for a "double-ended sea-going passenger and car ferry, with capacity for 120 passengers and 16 cars or 2 trucks". This need reflects thinking that the ferry would travel between Kirkwall and Shapinsay (both in the Orkney Islands).

      See: *Scottish-led HySeas III project aims to build Europe's first sea-going ferry powered by hydrogen fuel cells*

- **Hydrogen and Methanol:** In early June, Hydrogen Europe published a policy paper entitled *How Hydrogen Can Help Decarbonise the Maritime Sector*. The paper concludes that hydrogen and hydrogen based fuels (critically, ammonia) can contribute significantly "*to the decarbonisation and also mitigate air pollution of the worldwide [maritime fleet]*". This will not be a surprise to many readers, but tends to confirm the thinking that has developed over the last 12 to 15 months.

Airports and Aviation:

Airport solar landing strips: Edition 18 of Low Carbon Pulse (under **Solar round up**) reported in the use of airports as ideal locations for solar photovoltaic projects, including roof-top solar. On June 1, 2021 Abu Dhabi Airports and Masdar announced the completion of the use of roof-top solar at the Abu Dhabi International Airport. It is to be expected that airports around the world will install roof-top solar, including in innovative ways on, and around, car parks.

Carbon credits emission trading schemes, and off-sets:

There appears to be an ever increasing interest in the use of carbon credits to acquit obligations under emission trading schemes (***ETSs***) and other policy settings intended to achieve the adoption of lower, low or no carbon technologies (***NOs***), and to satisfy ***GHG*** emission reduction commitments assumed voluntarily, by use of offsetting (rather than decarbonisation or in combination with decarbonisation).

- **A gaggle of exchanges:** Edition 18 of Low Carbon Pulse outlined the establishment of the Global Carbon Exchange to be located in Singapore.

  On June 1, 2021, it was announced that Fortum (Finnish state-owned utility company) and Nasdaq (financial services and trading company) had agreed to develop a trading platform for trading carbon removal credits. For these purposes, Nasdaq has taken a majority stake in Puro.earth (a start-up backed by Fortum). The concept of carbon removal credits has been developed by Puro.earth, with carbon removal verified by a tradeable ***CO_2*** Removal Certificate (***CORC***). ***CORCs*** are granted in respect of technologies verified as having an effect over the long-term to remove carbon, including storage of carbon in solid structures made from industrial waste.

For Puro.earth, access to the Nasdaq network and trading platform provides access to the global market. For Nasdaq, ***CORCs*** provide corporates with high-quality carbon abatement certificates.

See: *Nasdaq and Fortum join forces to develop carbon removal market*

- **Surge in demand for high quality carbon credits:** There is clearly a demand for high-quality carbon credits (and the certificates that support them), as manifest recently by higher prices for carbon credits (including ***ETS*** certificates). Under certain ***ETSs*** and ***NOs*** it is possible to use carbon credits not issued under that scheme to acquit an obligation under it (but the ability to do so tends to be limited). As noted in Edition 16 of Low Carbon Pulse, the use of carbon credits in this way is likely to come under increased scrutiny over time.

In the next article in ***The Shift to Hydrogen (S2H2): Elemental Change*** series, the use of carbon credits and negative ***GHG*** emission initiatives (see Edition 9 of Low Carbon Pulse under ***Negative GHG Emissions … not new, but higher profile likely***) will be considered in the context of a broad analysis of the means and tools available to capture carbon and to store it.

Net-zero – a round-up and an arc:

- **DIF Capital Partners to make a DIFference:** On June 3, 2021, DIF Capital Partners committed to Net Zero by 2050. Consistent with this commitment, among other things, DIF is to measure ***GHG*** emissions and to identify pathways to achieving ***NZE*** by 2050 or sooner, and continue its global investment program in renewable electrical energy and related infrastructure.

  In addition to the commitment to Net Zero, DIF has become a signatory to the Institutional Investors Group on Climate Change (***IIGCC***). The *IIGCC* is intended to ensure that investors can maximise the contribution that they make so as to ensure that the Stretch Goal is achieved under the Paris Agreement.

  See: *DIF Capital Partners commits to Net Zero emissions today*

- **Racing on the Road to *NZE*:**

  On June 8, 2021, "visualcapitalist.com" published a really helpful visual arc detailing the commitments of countries to net-zero emissions (***NZE***). Please click here to view the visual arc.

Hydrogen Use by mode in heavy transport:

In response to requests for more detailed coverage in certain areas, future editions of Low Carbon Pulse will include narratives on those areas, and will reinstate the Zero Hero sections, covering countries that are progressing to ***NZE***.

- **Trains and hydrogen:**

  Electrification key to decarbonisation: The use of trains to transport passengers is the most efficient mode of transport, and to transport freight the second most efficient. The rail sector is estimated to give rise to 1.7% of global ***GHG*** emissions, equal to approximately 800,000 mtpa of ***GHG*** emissions.

  The decarbonisation of the transport sector may be regarded as less problematic than other sectors: the time taken to achieve electrification using electrical energy from renewable sources will be key. But there are some rail corridors on which electrification may be regarded as a less affordable / more expensive option than the use of trains powered and propelled by fuel cell technology (***FCT***), but for *FCT* to be used train operating companies will want to understand that there is a sustainable supply of hydrogen, at a sustainable price.

  As noted above (in the pieces on India), there may be a role for government as an intermediate buyer and supplier of hydrogen, and as a developer of hydrogen storage and refuelling infrastructure. Once the market is at a point of sustainability, government can of course, realise its investment, and recycle capital.

  Corridor by corridor: This is the case even in the ***EU***. While the facts and statistics relevant to each corridor will be determinative, it is possible to see the use of hydrogen to fuel ***FCT*** on freight routes in certain countries to displace the use of diesel, and in a country such as India where the electrification of its extensive network may be a task undertaken over time, and where dual powered trains can be used.

  If ***FCT*** is used, and the hydrogen used is Blue or Green, noting that ***FCT*** is agnostic as to the colour of hydrogen used, the use of ***FCT*** on a corridor is less expensive / more affordable than electrification and it is to be expected that ***FCT*** may be used. In addition, it appears increasingly likely that to allow flexibility trains will be dual powered, electrified for use on electrified corridors and ***FCT*** for non-electrified corridors, and, as is the case with ferries, it is likely that ***FCT*** will deploy electrical batteries too.

  Comparative costs: A recent Wall Street Journal article notes that the total lifetime cost (***TLC***) of ownership of trains using ***FCT*** is comparable with that of diesel and electrified corridors. Consistent with the International Energy Agency (***IEA***) report, the WSJ note that the use of ***FCT*** is "particularly useful on routes that aren't busy enough to [justify] overhead electrification". Also it is possible to retrofit with ***FCT***.

  As is noted consistently, the challenge that needs to be addressed is for the supply of hydrogen to match the demand for the use of ***FCT*** in trains. Long standing industrial gas suppliers, Air Liquide, Air Products and Linde are investing heavily in hydrogen production facilities, as are international oil companies (or more appropriately nowadays, international energy companies), including BP, Eni, Equinor, Shell and Total, with Chevron and Exxon Mobil now in pursuit.

- **Trucks and hydrogen:**

  Hydrogen has a key role to play: Global freight traffic is expected to double, and by some estimates, to increase 2.5 times, by 2050. While road freight corridors may not be as readily apparent as rail corridors, they should be – they are the major arterial roads between ports and warehousing and other consolidation and distribution hubs, and the point of delivery.

These major arterial roads are established, and the use of them known and predictable. The Oak Ridge National Laboratory, US, has studied and reported on the use of ***FCT*** for the haulage of freight by trucks, reporting that: "*Hydrogen fuel cells are ideal for the trucking industry because the refuelling time and driving range are comparable to [fossil fuel powered and propelled trucks] and travel routes are predictable, which lowers the barrier[s] for developing fuelling infrastructure*".

But supply and demand for hydrogen needs to develop: As reported in previous editions of Low Carbon Pulse, across the ***EU*** hydrogen-freight-corridors (***HFCs***) are being "developed" in the sense that hydrogen refuelling infrastructure (***HRI***) and hydrogen refuelling stations (***HRS***) are planned and are being installed on a coordinated basis so as to pre-empt the demand for their services from heavy goods fuel cell electrical vehicles (***HGFCEVs***). It is anticipated that by 2025, within the ***EU***, up to 1,500 kms of ***HFCs*** will have been developed.

It has long been understood that the useable energy in 1 kg in hydrogen is around 2.5 that of liquid fossil fuels, or stated another way, 1 kg contains useable energy equivalent to nearly 4 litres of diesel. As such hydrogen, by mass, is more efficient than fossil fuels by orders of magnitude. Also, the time taken to refuel an *HGFCEV* is comparable to the time taken to refuel a vehicle powered and propelled by an ***ICE***.

It follows that for road freight the use of ***FCT*** is likely to increase. The ever-present challenge will be development of the supply of hydrogen in tandem with the development of demand for the use of ***FCT***.

Low Carbon Pulse - Edition 20

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to Edition 20 of Low Carbon Pulse – sharing significant current news on progress towards net-zero emissions globally. This edition covers the period from Monday June 14, 2021 to Sunday June 27, 2021 (inclusive of each day).

Please click here for the previous edition of Low Carbon Pulse. Please also click here and here for the first two articles in the ***Shift to Hydrogen Series*** (***S2H2***)***: Elemental Change*** series: the *S2H2* series provides a narrative and perspective on hydrogen generally. Please **click** here for the first feature in the ***Hydrogen for Industry*** (***H24I***); *H24I* features provide an industry by industry narrative and perspective.

Edition 20 will be posted again on **July 1, 2021** to pick-up those reading later in the week.

The Week Ahead:

Trading to commence on China *ETS*: During the week beginning June 21, 2021, it was reported widely that the ***PRC***'s emissions trading scheme is to commence trading before the end of June (see Editions 6, 9 and 12 of Low Carbon Pulse). On Sunday June 27, 2021, this remained the case.

The Month Ahead:

- **The first anniversary of *A hydrogen strategy for a climate neutral Europe*** (***EUH2S***)**:** July 8, 2021, is the first anniversary of the release ***EUH2S***.

  In some ways, this edition of Low Carbon Pulse "tees-up" some of the areas in which progress has been made and in which policy settings need to be developed and firmed-up.

- ***EU* to release cat among the pigeons (also known as *CBAM*):**

  On July 14, 2021, it is expected that the ***EU*** will release the developed policy settings for the ***Carbon Border Adjustment Mechanism*** (***CBAM***) (see Editions 12 and 19 of Low Carbon Pulse).

  If the July 14, 2021, timeline is achieved, Edition 22 of Low Carbon Pulse will cover, in detail, the form and substance of ***CBAM*** in detail, and assess its likely implications. (Please click here for the link to the preliminary draft).

  While ***CBAM*** is one way of achieving the desired policy outcome, it is not the only way: everyone has a view, and for the purposes of a reasonably complete picture, see the Nova-Paper 15 outlining a tax on fossil fuels, rather than ***CO_2***, as reported in Edition 19 of Low Carbon Pulse, the International Monetary Fund proposal under which each producer of ***GHG***'s should pay a carbon price, and yet another report supports ***CO_2*** pricing so as to avoid a price cannibalisation scenario, solar versus wind.

- **Deadline for applications for ScotWind applications:** Edition 8 of Low Carbon Pulse reported on the ScotWind Leasing auction process. There is expected to be considerable activity ahead of the deadline for applications on July 16, 2021. Given the outcomes achieved by HM Treasury on February 8, 2021, in respect of Round 4 leasing program (see Edition 9 of Low Carbon Pulse), the outcome of the ScotWind Leasing auction process will be eagerly awaited.

- **UK to release its Hydrogen Strategy before July 22:** It is being widely reported that during July the UK Government will release its Hydrogen Strategy (***UKH2S***): UK Energy Minister, Ms Anne-Marie Trevelyan, has indicated that the ***UKH2S*** will be published before Parliamentary recess. Early indicators on the thinking that will inform the ***UKH2S*** are in plain-sight as part of the 10-Point Plan for a Green Industrial Revolution, including the softer target of 1 GW of low carbon hydrogen production capacity by 2025, and firmer target of 5 GW by 2030.

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In recent times the Department for Business, Energy & Industrial Strategy (***BEIS***) has indicated that while the ***UKH2S*** is likely to be agnostic as to the colour of hydrogen, it will be clearly defined on carbon intensity (like the ***EU***), and the ***UKH2S*** is likely to recognise that by 2050 final total energy consumption from low carbon hydrogen will need to be in the range of 250 to 460 TWh for the UK to achieve net-zero ***GHG*** emissions (***NZE***).

The ***UKH2S*** was published on August 17, 2021, and is outlined in Edition 25 of Low Carbon Pulse.

Japan continuing down the road to *NZE* invites ASEAN to join the journey:

- **Japan helping to drive ASEAN transition:** On June 21, 2021, at a virtual meeting of with ASEAN energy ministers (noting that ASEAN does not include Japan), the Japanese Minister of Economy, Trade and Industry (***METI***), Mr Hiroshi Kajiyama, outlined a number of suggested support measures for ASEAN countries. In recent times, Japan has been leaning forward on many policy settings (see Editions 2, 5, 6 and 12 of Low Carbon Pulse), and this is another example of Japan's broader commitment to achieving ***NZE***.
- **The AETI from METI:** The suggested support measures are proposed in the **Asian Energy Transition Initiative** (***AETI***) "as a package of Japanese support for realistic transitions in Asia towards carbon neutrality". As a prelude to news items later in this edition of Low Carbon Pulse, the ***AETI*** contemplates that projects will include the development of gas-fired power stations and liquified natural gas (***LNG***) receiving and re-gasification terminals, with natural gas (derived from *LNG*) an alternative to coal, and as a key energy transition fuel.

  See: METI *website*

India continuing down the road looking to roof-tops and micro-grids:

- **India H2 Alliance expanding:**

  Establishment of India H2 Alliance: Editions 14 and 17 of Low Carbon Pulse reported on the establishment and progress of the India Hydrogen Alliance (***IH2A***): the purpose of the ***IH2A*** is to work with the Government of India to develop a national hydrogen policy and roadmap for 2021-2030, to establish a national hydrogen task force, to identify large-scale hydrogen demonstration plants, to create a national hydrogen fund for India, and to create capacity for the production, storage, distribution and transportation and use of hydrogen.

  On June 16, 2021 it was widely reported that the membership of the ***IH2A*** has expanded, with new members including corporation JSW Steel (part of the conglomerate, JSW Group), and CSIR National Chemicals Laboratory (Government of India owned) and Scottish Development International (Scottish Government funded organisation). JSW Steel is to lead the Work Group for Steel and Cement decarbonisation, with the decarbonisation of these two Difficult to Decarbonise industries a top priority as the Indian economy and population continues to grow, and urbanise, and as such demand for steel and cement continues to increase.

- **Roof-top solar for India:**

  The International Energy Agency (***IEA***) has published a report entitled ***Unlocking the Economic Potential of Rooftop Solar PV in India*** (the ***Key Report***), developed jointly with the Council of Energy, Environment and Water (***CEEW***) and the Ministry of New and Renewable Energy (***MNRE***). The development of roof-top photovoltaic solar (***RTS***) in India is highly prospective, but has yet to achieve real momentum.

  The ***Key Report*** provides suggested policy settings that could increase the momentum to achieve roll-out of ***RTS***, including encouraging aggregation of demand for the off-take of electrical energy from ***RTS***, providing access to grant and funding options to encourage deployment of ***RTS***, and streamlining payment of subsidies (a tried-and-tested policy setting globally). The ***Key Report*** provides a walk-up to achieving and increasing momentum.

- **Micro-grids India:**

  Edition 14 of Low Carbon Pulse reported on plans to develop up to 10,000 micro-grids in India using renewable resources: the use of micro-grids will increase electrification and displace use of diesel fuel.

  On June 13, 2021, NTPC Limited (India's largest power company) commenced seeking expressions of interest globally to work with it on two pilot projects using fuel cell technology (***FCT***): one pilot ***FCT*** project is to use ***FCT*** to provide back-up electrical energy, i.e., storage, and the second pilot ***FCT*** project is to use ***FCT*** off-grid, in a captive use setting. Currently, both back-up, and off-grid, systems use diesel.

  See: *NTPC invites EoI for hydrogen fuel cell pilots*

India hosts BRICS nations Green Hydrogen Summit:

It has been widely reported that on June 22 and 23, 2021, India hosted a summit of the BRICS nations (Brazil, Russia, India, China and South Africa) to allow sharing of initiatives and policy settings about development of Green Hydrogen production capacity and use. It is reported that the Green Hydrogen Summit was organised by NTPC Limited. One of the key themes was the need for the development of common international standards for Green Hydrogen, including for safety and transportation. Each BRICS nation has the resources to be a key player globally in the Green Hydrogen market.

On June 22, 2021, the Indian Minister of Power, Mr. RK Singh, stated that under a Renewables Purchase Obligation (***RPO***), some sectors of the economy would be required to purchase Green Hydrogen.

***EU* and UK:**

- **Backbone of hydrogen demand:**

  Headline: On June 15, 2021, at the launch of the European Hydrogen Backbone (***EHB***) initiative, a report was released (***EBR***) providing a perspective on the likely size and shape of hydrogen demand by 2050. The headline is that demand for hydrogen could reach 45% of the levels of natural gas use in 2019, with final total energy consumption (***TEC***) of hydrogen equating to 2,300 TWh a year, book-ended by a low-side estimate of 2,150 TWh ***TEC***, and a high-side estimate of 2,750 TWh ***TEC***.

Consensus arising: The ***EBR*** is consistent with "established thinking" that hydrogen has a crucial role to play as an energy carrier for use in the production of cement, chemicals and iron and steel. Across these Difficult to Decarbonise industries it is estimated that 1,200 TWh of energy will be used for high-heat temperature processes, and 200 Twh for medium to high-heat temperature use: hydrogen can be used as a high-heat temperature energy carrier, able to displace fossil, and other carbon intensive, feedstocks and fuels.

In addition to use in these Difficult to Decarbonise industries, hydrogen will be used to power and to propel vehicles (particularly heavy goods vehicles / trucks) using ***FCT***. Further, it is stated that hydrogen will be used as a fuel to produce dispatchable electrical energy or, as noted in the next paragraph, Hydrogen Energy Carrier Storage (***HECS***) (up to 600 TWh)) and, in some countries, to heat buildings (up to 600 TWh), including through district heating.

Efficiency in hydrogen use and storage: The ***EBR*** notes that while it would be possible for the ***EU*** and the UK to produce sufficient Green Hydrogen to satisfy this level of projected demand, this will require considerable investment in renewable electrical energy development. While production and supply of Green Hydrogen within the ***EU*** and the UK will fulfil some of the early policy setting thinking around energy security, it is likely to prove more expensive than sourcing Green Hydrogen from countries and regions with renewable energy sources better suited to the production of Green Hydrogen and, as a result, lower cost production.

As noted in previous editions of Low Carbon Pulse, while hydrogen can be used to produce dispatchable energy, it will be interesting to see how this prospective use develops given thinking of policy settings and the thinking of development / policy banks: current trends reflect the view that hydrogen should not be used as a fuel for base load dispatchable energy, rather hydrogen (suited as it is to storage) is best used to provide ***HECS***. The ***EBR*** recognises the use of hydrogen for ***HECS*** in the context of use of hydrogen to produce dispatchable energy only, not to provide a fuel for base-load dispatchable energy.

- ***EU* pipeline of infrastructure projects eye-popping:**

  A reminder of policy settings and hydrogen roadmaps: On July 8 2020, the ***EU*** released its ***A hydrogen strategy for a climate neutral Europe*** (***EUH2S***) (contained in Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and Committee Regions). The Key Actions from the ***EUH2S*** were:

  – Create Investment Agenda for ***EU***, including supporting strategic investments in clean hydrogen from 2021;
  – Boost demand for and scale up production, including exploring demand side policy settings;
  – Design an enabling and supportive framework, including planning for hydrogen infrastructure development;
  – Promote research and innovation technologies; and
  – Develop the international dimension, critically the supply side.

  First anniversary approaches: As the first anniversary of the ***EUH2S*** approaches, an eye popping number of large-scale hydrogen projects have been announced. This reflects real progress, but there remain some policy settings to be developed and implemented, one of these being the interface between natural gas and hydrogen, which is a key interface as that large-scale infrastructure is developed and other infrastructure repurposed, including pipelines (see below under ***The Role of Natural Gas***).

  Getting longer in infrastructure: Attached is a link that shows the location and nature of the current and planned hydrogen projects.

  The ***EHB*** is key to the transmission and distribution of hydrogen across the ***EU***.

  Getting ready for supply and distribution:

  In recent editions of Low Carbon Pulse, the importance of the activities of early movers has been noted. In the context of northern Europe and the UK early port movers continue to move, and to look, forward to develop the means of supply to, storage and distribution from ports of import.

  – In early June 2021, the Port of Amsterdam Authority outlined plans to import up to 1 million metric tonnes per annum (***mmtpa***) of hydrogen.

    This initiative demonstrates the role of sea-ports as hydrogen hubs, and in this role, the importance of ports developing hydrogen receival, storage and send-out infrastructure ahead of the need for that infrastructure. A number of ports are leading the way, including the Amsterdam and Rotterdam, Antwerp, Hamburg, Immingham, and Los Angeles. As is noted towards the end of this edition of Low Carbon Pulse, airports are now responding to the anticipated demand and use of hydrogen, and as such, with the private sector, responding by looking to supply and to distribute.

  – In mid-June 2021 to late June, the Port of Rotterdam Authority is continuing its world leading pace setting. Key to this is the Port's development of its own backbone to allow it to be the import port of choice. On the Port's website a helpful schematic (entitled ***Hydrogen Economy on Rotterdam Starts with Backbone***) details the "backbone and nervous system" that is to distribute hydrogen from the Port to points of connection and to points of use.

  – It is not possible for Low Carbon Pulse to report on every development, but the Port of Rotterdam Authority may be regarded as leading the way in matching supply to demand and the delivery of hydrogen: within the news cycle of this edition of Low Carbon Pulse the following are noteworthy:

    - On June 15, 2021, a pre-feasibility study was released that indicated that shipping Green Hydrogen from Iceland to the Port of Rotterdam Authority would be feasible by the second half of the current decade. Landsvirkjun (the National Power Company of Iceland) and the Port of Rotterdam Authority are working on this; and

- On June 16, 2021, it was reported that the Port of Rotterdam Authority and Rotterdam Rijn Pijpleiding Maatschappij are to develop jointly a feasibility study to develop pipelines capable of carrying hydrogen (and other products), connecting the Port of Rotterdam to Chemelot and the North Rhone-Westphalia, and to the ***EHB***.

See: Port of Rotterdam *website*

Implication of *EHB:* a means to many ends:

The "launch" of the ***EHB*** was momentous both of itself, and for the discussion that it has sparked, and that will continue, including discussion around the need to develop underground storage capacity for hydrogen (including using salt-caverns and compression technologies) to provide inventory management and assurance, and security, of supply, and the development of a hydrogen market to ensure supply to match demand.

See: Uniper *website*

Germany and Australia:

- **Germany and Australia sign alliance:** On June 13, 2021, Germany and Australia signed a bilateral alliance agreement (***BAA***), a bilateral trade agreement (of sorts), relating to hydrogen production, and trade in hydrogen, and the facilitation of a renewable energy-based hydrogen supply chain between the two countries.

  The ***BAA*** recognises the commitment of Germany to the development of sources of Green Hydrogen supply to match the demand that it is anticipating will develop in response to its policy settings, and the position of Australia as a prospective supplier of Green Hydrogen.

- **Australia Guarantee of Origin Scheme:** On June 21, 2021, a discussion paper was released, entitled "***A Hydrogen Guarantee of Origin scheme for Australia***". Submissions in respect of the paper are invited by July 30, 2021.

  For Australia, as a prospective world-scale exporter of hydrogen and hydrogen-based fuels (including to Germany), an effective and accepted assurance scheme to certify the origin / source, and carbon intensity, of hydrogen and hydrogen-based fuel production is essential both for bi-lateral export contracts (to support the development projects) and to facilitate the development of a market for hydrogen and hydrogen-based fuels, including ammonia and methanol.

The Role of Natural Gas:

- **The energy mix required to achieve *NZE*:**

  A number of matters have emerged as axiomatic in the context of progress towards ***NZE***, one of them is that there is no one-size-fits-all energy mix that is going to result in the achievement of ***NZE***, globally or jurisdictionally: just as there is no one pathway to ***NZE*** (see below under ***Mid-Year Reflection on Flagship Reports***).

  While the development of renewable electrical energy (***REE***), and the displacement of coal, is going to be key to progress towards ***NZE***, the quantity of ***REE*** required to achieve electrification of existing and new electrical energy load (responding to both population growth and increased electrification to increase the access rate to electrical energy), while at the same time developing sufficient ***REE*** for the production of Green Hydrogen, touches the edges of comprehension, and as such stretches the comprehension of many as to whether it is achievable at a rate that will match the anticipated load.

  The development of ***REE*** is going to take time. The development of ***REE*** should be the key focus of policy settings. During the time taken for ***REE*** to be developed, other transitions are likely to take place, including from coal-fired capacity, to gas-fired capacity, including using CCS / CCUS.

- **Natural gas part of the energy mix required to achieve *NZE***:

  In addition to the development of ***REE***, ***BECCS*** / ***BECCUS*** (in the production of bio-energy), CCS / CCUS (in the production of Blue Hydrogen, and as such Blue Ammonia), Direct Air Capture (**DAC**), and hydrogen and hydrogen-based fuel production capacity needs to be developed (critically for Green Hydrogen, and as such Green Ammonia).

  It is to be expected that natural gas will have a role to play as feedstock for the production of Blue Hydrogen (and as such Blue Ammonia) and to remain a fuel source for gas-fired power stations, including those that over time move to fire blended natural gas and hydrogen or to co-fire. As such, natural gas is going to be part of the energy mix, albeit with its use likely to decrease (and, indeed its use must decrease) over time.

  There is a burning debate in some jurisdictions around the development of new gas-fired power stations. For many, this is a head and heartburn debate, with a tension between the need to generate electrical energy and the need to decarbonise the generation of electrical energy. What this is likely to mean in practice is that natural gas has a role to play in energy transition, but the role needs to be understood, and to the extent practicable, carbon must be captured and stored.

- **The role and use of natural gas will be subject to debate for as long as it part of the energy mix:**

  Following the meeting of ***EU*** Energy Ministers at the end of May 2021, the debate about the use of natural gas has continued. There is clear recognition that natural gas is needed as part of the energy mix, that overtime its use must decrease, and that policy settings should not prefer, or subsidise or support, new gas-fired power projects.

  In the ***EU***, natural gas continues to be needed as an energy carrier (to some a transition "bridging fuel"). Just as CCS / CCUS and hydrogen storage is on the agenda, it seems increasingly likely that underground gas storage is likely to emerge as an agenda item, critically because of the reduction in natural gas in storage during the Northern Hemisphere winter, 2020/21 as LNG was diverted to North Asia. Further, the use of natural gas a feedstock to produce Blue Ammonia remains a policy setting that remains fluid, even if the lexicon includes fossil-based hydrogen with carbon capture.

It is helpful to note that even some of the most determined and progressive countries making huge strides to achieving ***NZE*** by 2050 have not foreclosed on the use, or the role of natural gas, even in their hydrogen roadmaps, plans and strategies.

At the risk of touching the "third rail" of policy setting orthodoxy, if ***GHG*** emissions can be captured and stored permanently, or captured and used to achieve lower, low or no carbon outcomes, and there is need for electrical energy, natural gas is needed as a feedstock, and there may be a continued role of natural gas after 2050, and into the second half of this century. As noted above and below, viewing ***CO_2*** as resource has to be a key touchstone of policy settings, and will inform the role of natural gas.

Mid-year reflection on Flagship Reports:

- **The Lucky Country:** A number of editions of Low Carbon Pulse have noted the advantages that certain countries and regions enjoy, and that will allow them to produce Green Hydrogen (and Blue Hydrogen for that matter). One of the lucky countries is Australia. Australia has world class on-shore solar and wind resources (as well as yet to be developed off-shore wind resources), and States and Territories that continue to provide material funding commitment to progress to ***NZE*** (for example, NSW's AUD 380 million funding commitment announced on June 17, 2021).

  Australia is lucky for other reasons, including the amount of intellectual horse-power, and rigour, that is being applied in the context of progress to ***NZE***. In mid-June 2021, HySource published a feature article, ***Net Zero Emissions by 2050 and the Role of Hydrogen*** (***HySource Feature***), providing a really good eight page summary of the key high-level takeaways from the ***IRENA Pathway*** and ***IEA Roadmap***.

  HySource is something of a brains trust, bringing together the **Australian Hydrogen Council**, **CSIRO** (Federal Government research body and brains trust), **Future Fuels CRC** (a research centre), and **NERA** (or **National Energy Resources Australia**, an independent, not for profit, organisation funded by the Federal Government).

- **When might Green Hydrogen become cost competitive?:** in Edition 19 of Low Carbon Pulse, it was reported that in late May 2021, the Federal Government of Australia, Advisian and the Clean Energy Finance Corporation (***CEFC***), released a report entitled ***Australian hydrogen market study – Sector analysis study*** (***SAS***). Commissioned by the ***CEFC***, the ***SAS*** provides "an appraisal of the economic gap between hydrogen supply and capacity to pay for each of the nominated demand sectors, both now and out to 2050". Edition 19 of Low Carbon Pulse notes the key themes that arise from the ***SAS***.

- **Reflections on the *IRENA* and *IEA*:**

  The purpose of the ***HySource Feature*** is to reflect on the two major global flagship reports of the first part of 2050:

  - International Renewable Energy Agency (***IRENA***): ***World Energy Transition Outlook: 1.5^{O}C Pathway: Preview*** (***IRENA Pathway***) (see Edition 13 of Low Carbon Pulse); and
  - International Energy Agency (***IEA***) special report, ***Net Zero by 2050: A Roadmap for the Global Energy Sector*** (***IEA Roadmap***) (see Edition 18 of Low Carbon Pulse).

- **Reflections contained in *HySource Feature*:**

  The key reflections contained in the ***HySource Feature*** are as follows, noting that some of them will be familiar to readers of Low Carbon Pulse. Both the ***IRENA Pathway*** and the ***IEA Roadmap***:

  - are important, each representing a possible pathway to ***NZE***, not the pathway: criticism of the ***Pathway*** and ***Roadmap*** have not embraced this, it has not suited some narratives and perspectives to do so;
  - emphasize the need to increase the rate of ***GHG*** emission reduction, while remaining optimistic about the ability to progress to ***NZE*** by 2050 to achieve the Stretch Goal under the Paris Agreement remains; and
  - have different themes, but those themes can be summarized as actions that need to be taken to achieve ***NZE***: (**i**) Conversation and improved efficiency; (**ii**) Renewable electrical energy deployment required "lots of it", critically the scale and speed of deployment; (**iii**) Electrification of energy end-use sectors; (**iv**) Hydrogen and hydrogen-based fuel deployment is required, critically both Blue Green Hydrogen and Green Hydrogen are required; and (**v**) Bioenergy, and BECCS and BECCUS and CCS and CCUS are required.

"Worst is yet to come", unless greater and faster reductions:

Intentionally, Low Carbon Pulse does not take a critical view of any country or corporation, seeing any progress towards ***NZE*** as a good thing, and seeking to take a positive perspective generally. If Low Carbon Pulse has any theme or themes, however, it is that a greater mass of ***GHG*** emissions arising need to be reduced to a greater extent, and faster, than currently, and for this purpose the means of decarbonisation need to accelerate, including the development of the supply and demand for hydrogen in tandem.

The heading to this section is taken from the draft report prepared by the United Nations' Intergovernmental Panel on Climate Change (***IPCC***) (reported as leaked to Agence France-Presse (***AFP***)). ***AFP*** states that the ***IPCC*** report is not in its final form, but it is reported by ***AFP*** to contain, at over 4,000 pages, a comprehensive analysis of the impact life on earth of climate change, critically, if either Goal under the Paris Agreement is not achieved.

See: *AFP has world scoop on a draft climate science report*

[**Note*:*** AFP was right! See Edition 24 of Low Carbon Pulse]

Reporting on reports:

In the lead-up to the Northern Hemisphere Summer, reports are being published thick and fast: for the ***NZE*** follower or professional, no shortage of reading for inclusion in the holiday luggage.

While Low Carbon Pulse seeks to cover the findings of each report in summary, in future links to reports will be included at the end of each edition (as we have done in this edition), and short summaries of each report will be published outside the publishing cycle of the Low Carbon Pulse, probably at the end of each month.

***BESS* and BECCS round-up:**

- **BECCS to source *CO_2*: does this give us another acronym? BECCUS?:** On June 18, 2021 it was announced that Ørsted has identified the existing bioenergy Avedore power station (***APS***) as a source of ***CO_2***: the ***APS*** is a 100 MW straw-fired power station that is owned and operated by Ørsted. It is understood that the intention is to increase the capacity of ***APS*** to 1 GW and to capture and source up to 850,000 metric tonnes per annum (***mtpa***) of ***CO_2***.

  The captured ***CO_2*** would be used as feedstock for the production of e-fuels, e-methanol and e-kerosene, as part of the Green Fuels for Denmark (***GFFD***) policy setting thereby making this a ***PtX plant***. ***GFFD*** was recently named as an Important Project of Common European Interest (***IPCEI***), which itself is part of the broader ***EU*** policy settings consistent with the ***EUH2S***. All ***EU*** roadmaps lead from Brussels via the Paris Agreement.

  It is fascinating to see, and to reflect, on this development, consistent as it is with the development of the bioenergy industry: to many in the bioenergy industry there has been an inconvenient truth – while sourcing feedstock or fuel from a renewable source, that source is carbon intensive, with ***GHG*** emissions arising on its oxidation, or on its processing and treatment releasing ***GHG*** emissions. The capture of the ***GHG*** emissions is now firmly on the bioenergy industry radar. Also, it is becoming clear that ***CO_2*** is starting to be viewed as a resource.

  In addition, Ørsted and HOFOR (utility company serving Greater Copenhagen), have agreed to work towards the off-take by Ørsted of renewable energy electrical energy produced by HOFOR's 250 MW Aflandshage off-shore wind field project located in the Oresund Strait (***Aflandshage Project***). Also it has been agreed that HOFOR may locate a substation to step-down the electrical current from ***Aflandshage Project*** on site at the ***APS***.

  See: *Ørsted plans carbon capture at Avedøre Power Station as part of the Green Fuels for Denmark project*

- **BECCS outcomes:** In a report published on June 17, 2021 (on the ***Impact of carbon dioxide removal technologies on deep decarbonization of the electric power sector***) a finding is that: "*adding carbon removal to a mix of [already lower or] low-carbon generation technologies lowers the costs of deep decarbonization. … Bioenergy with carbon capture is selected for net-zero electric sector emissions targets, but direct air capture deployment [making sense and increasing] as biomass supply costs rise*". The report is well-worth a read, especially for those working in the bioenergy / waste industry.

  The report provides a clear headed perspective on the speed at which bioenergy projects using carbon capture and storage can be deployed, and as such is aligned to the findings of the ***IEA Roadmap***: the ***IEA Roadmap*** contemplates that bioenergy / BECCS (and CCS / CCUS) will be critical to achieving ***NZE*** by 2050.

  As noted in Edition 19 of Low Carbon Pulse, among other things, the next article in ***The Shift to Hydrogen (S2H2): Elemental Change*** series will cover BECCS and BECCUS, and all carbon dioxide removal (***CDR***) technologies, including ***DACs***.

  See: *Impact of carbon dioxide removal technologies on deep decarbonization of the electric power sector*

- **Bioenergy and BECCS and BECCUS:** Bioenergy is a term used to describe the use of renewable feedstock principally derived from waste (gaseous, liquid and solid) to derive a feedstock or fuel from which it is possible to derive or to produce an energy carrier (gaseous, liquid or solid).

  Sources of feedstock include principally, agricultural, forestry and other land use waste, the organic fracture of municipal solid waste, and commercial and industrial waste and construction and demolition waste (and other sources described in Chapters 5 and 7 the ***Ashurst – Waste to-Wealth Compendium*** and in the first feature in the ***Hydrogen for Industry*** (***H24I***) series of features, ***Hydrogen from Waste***.

  The technologies used to derive and produce energy from waste include anaerobic digestion (to produce biogas and if reformed biomethane – see Chapter 5 of the ***Ashurst - Waste-to-Wealth Compendium***), and waste to energy or energy from waste thermal treatment technologies (including mass combustion, gasification, pyrolysis, and plasma - see Chapter 2 of the ***Ashurst - Waste-to-Wealth Compendium***) (and those technologies described in Chapter 7 of the ***Ashurst - Waste-to-Wealth Compendium***. (Part 1 of Fuel and Feedstock Resource Recovery - Energy Carriers from Waste), the ***H24I*** series of features, ***Hydrogen from Waste*** and the soon to be published Part 2 of energy carriers from waste).

- **The arrival of the "battolyser":** June 24, 2021, is notable for the arrival of the **battolyser**: the word connotes the use of an electrolyser to produce hydrogen when renewable electrical energy costs are low, to store it, and when renewable electrical energy costs are high, the stored hydrogen will be used to provide electrical energy.

  See: *Dutch Hydrogen Battery Goes Commercial*

Edition 21 of Low Carbon Pulse will provide background on compressed air storage (***CAS***), another mooted means of energy storage that is being explored in some jurisdictions.

CCS / CCUS round-up:

- **Clean Air Task Force (*CATF*) tracking CCS / CCUS:** On June 14, 2021, ***CATF*** (never caught napping) released its ***Europe Carbon Capture Project Activity Map***. It is well-worth navigating.

- **From the Northern Lights Project a CCS + Initiative (*CCS + I*):** On June 16, 2021, an alliance of corporations and other entities announced the establishment and launch of the ***CCS + I*** a venture intended to leverage carbon markets, including through scaling-up decarbonisation and carbon dioxide removal: it is reported that core to ***CCS + I*** is developing accounting and technologies for CCS / CCUS, to ensure that projects are underpinned by robust cradle-to-grave life-cycle assessments (***LCA***). ***CCI + I*** comprises the North Lights Project (as part of the Longship Project), TotalEnergies, Oxy Low Carbon Ventures, South Pole, Perspectives Climate Group and Carbon Finance Labs.

  See: *New carbon market initiative to scale-up carbon capture and storage solutions*

- **Singapore chilled about CCUS and hydrogen:** On June 23, 2021, it was reported that five key agencies in Singapore are considering together the findings of two reports, one on CCUS, the other on hydrogen. The agencies are the Civil Aviation Authority of Singapore (***CAAS***), Economic Development Board (***EDB***), Energy Market Authority (***EMA***), the Maritime and Port Authority (***MPA***), and National Climate Change Secretariat (***NCCS***). They are taking an integrated approach to determine how hydrogen and CCUS may reduce Singapore's ***GHG*** footprint.

Identified next steps appear likely to be:

- **CCUS:** Considering chemical processes that allow carbon capture without underground storage (noting that Singapore does not have significant underground structures for storage), and in so doing consider capture and use, and partnering with other countries, including Australia;
- **Hydrogen (and hydrogen-based fuels):** Considering the use of hydrogen and hydrogen-based fuels, in particular in the maritime and shipping sector, recognising the constraints that exist on wide-spread adoption of hydrogen, unless and until it becomes cost competitive as an imported energy carrier.

Given Singapore's size and resources, at the moment, it seems unlikely that Singapore will produce Green Hydrogen. There may be some opportunity for the production of Blue Hydrogen. Given the need for CCUS, the need for the development of refuelling hydrogen infrastructure, the world class public transport system, and the nature of use of motor vehicles, it would appear less likely that ***FCEV*** will achieve wide-spread use in the transport sector in comparison to ***BEV*** use, other than possible specialist vehicles at ports, air and sea.

- **"An important week for "CCUS in Southeast Asia":**
  - **CCUS opportunities in SEA:** On June 23, 2021 (or thereabouts), the ***IEA*** published a technology report entitled ***Carbon capture, utilisation and storage: the opportunity in Southeast Asia*** (***CCUS Report***). The ***CCUS Report*** notes the increased activity around CCUS facility development globally, and that in SEA seven potential CCUS projects (***Seven SEA Projects***) have been identified - in Indonesia, Malaysia, Singapore and Timor-Leste. The ***CCUS Report*** frames the possible size and scope of CCUS projects (including the ***Seven SEA Projects***) opportunities within the region, and the need for cooperation.
  - **Asia CCUS Network** (***ACN***): The ***CCUS Report*** was published to coincide with the establishment of the ***ACN***. The ***ACN*** has been established to facilitate collaboration to develop and to deploy CCUS regionally. ***ACN*** was launched by ***METI*** and the Economic Research Institute for ASEAN and East Asia (***ERIA***).

  See: IEA *website*; Executive Director at IEA, Mr *Fatih Birol*.
- **Carbon Engineering (*CE*) and Storegga Geotechnologies (*SG*) sea-bed fellows:** On June 24, 2021, the MIT Technology Review reported that ***CE*** and ***SG*** are to develop a direct air capture (***DAC***) and storage (***DACS***) project likely to be located in North East Scotland, close to renewable electrical energy sources so as to allow storage of captured ***CO_2*** in sub-seabed structures. As reported, the ***DACS*** project is to be operational by 2026.

  See: *What it will take to achieve affordable carbon removal*
- ***IEA* drops DACS report:** in a particularly busy period of publication, the ***IEA*** has dropped a tracking report, entitled ***Direct Air Capture, more efforts needed***. The ***DACS Report*** ties back to the ***IEA Roadmap***.

E-fuel / Future fuel round-up:

- **Egypt to quicken the outlook:** On June 14, 2021, it was reported that the Ministry of Electricity and Renewable Energy in Egypt is committed to source 42% of total energy produced in Egypt from renewable sources by 2035. In addition, Egypt's Minister of Electricity and Renewable Energy, Mr Mohamed Shaker, has announced that Egypt is planning to invest up to USD 4 billion in a Green Hydrogen Project (***EGHP***).

  The ***EGHP*** is at feasibility stage. Work being undertaken during the feasibility stage is with the Sovereign Fund of Egypt and other key ministries, including the Ministry of Petroleum and Mineral Resources. It is reported that the feasibility work was to be presented during the week beginning June 21, 2021; as at Sunday, June 27, 2021 there was no further news on progress. Further, Mr Shaker has indicated that an area covering more than 7,000 km^2 has been identified as the location for the development of renewable electrical energy, with up to 90 GW planned.

  See: *International companies to invest in Egyptian Green Hydrogen projects, says minister*
- **The great start to June continues:** On June 17, 2021, it was announced that ***EI-H2*** (see Edition 17 of Low Carbon Pulse) had awarded Worley Parsons (see Edition 18 of Low Carbon Pulse) a contract in respect of the development of the concept design for the 50 MW electrolyser at Aghada, County Cork, Ireland, as the next step in the development of the Aghada Green Hydrogen production facility (***AGHPF***). From the end of 2023, the ***AGHPF*** will produce an estimated 20 metric tonnes per day (***mtpd***) of Green Hydrogen. For ***EI-H2*** this may be regarded as the first of an number of Green Hydrogen projects to be developed across Ireland: Ireland has high-quality renewable wind and water resources.

  Ireland (as a Member State of the ***EU***) has the resources to produce Green Hydrogen to help the ***EU*** achieve its targets for hydrogen production as part of progress towards ***NZE***, although as noted above, it likely that Green Hydrogen produced in other regions of the world is likely to be more efficient. For Worley Parsons (a leading Australian high-value design and engineering company), the award of the contract for the ***AGHPF*** continues to reflect its status as a "go-to" design and development contractor – continuing to land them from down-under.

  See: *EI-H2 Appointed Worley for 50MW Green Hydrogen Facility in Ireland, €120M Project*
- **Itochu and Future Energy:** On June 21, 2021, Australian Future Energy (***AFE***) announced that it had entered into a memorandum of understanding (***MoU***) with leading Japanese trading house, Itochu Corporation. ***AFE*** intends to develop the USD 750 million Gladstone Energy and Ammonia Project (***GEAP***), and is reportedly close to commencing front end engineering and design (***FEED***).

  It is reported that under the ***MoU***, Itochu Corporation will consider potential investment in ***GEAP*** and the role that Itochu may have in the marketing of hydrogen-based fuels produced by ***GEAP***. The ***GEAP*** is intended to produce 230,000 metric tonnes per annum of ammonia and 91,000 metric tonnes per annum of hydrogen.

- **Ground breaking development:** Edition 9 of Low Carbon Pulse reported on the development by Hyosung Corporation and Linde of a world-scale hydrogen liquefaction facility in Ulsan, South Korea, using Linde's technology to liquify hydrogen arising from the Hyosung Chemical plant. On June 21, 2021, ground was broken at site in Ulsan. On completion the facility will produce around 30 metric tonnes per day of hydrogen (and up to 13,000 metric tonnes per annum). This is an exciting development for both Hyosung and Linde, and more broadly.

  See: *Hyosung breaks ground for world's largest liquid hydrogen plant*

  As noted in Edition 19 of Low Carbon Pulse, Hyosung, along with Hyundai and POSCO, is a founding member of the ***Korean Hydrogen Council***, announced during the first part of June, and to be launched in September 2021. (see Edition 27 of Low Carbon Pulse)
- **Fortescue Future Industries (*FFI*) closer on Bell Bay:** Edition 18 of Low Carbon Pulse (under ***Bell Bay Ringing***) reported on the various Green Hydrogen and Green Ammonia arrangements being entered into by project proponents at Bell Bay, Tasmania. On June 22, 2021, one of the proponents, ***FFI*** signed an option agreement with Tasmanian Ports Corporation for ***FFI***'s proposed 250 MW Green Hydrogen project.
- **Oman's aim is true:** Edition 18 of Low Carbon Pulse (under ***Oman Goes Green By Blue***) reported on the ***Oman Green Energy Hub***. On June 16, 2021, the scale of the plans for Oman (a Gulf Cooperation Council (***GCC***) country) became clearer, in light of an interview given to S&P Global Platts, by CEO of OQ (a state owned oil and gas company), Mr Salim al-Huthali.

  Mr Salim al-Huthalia brought together the economics of using electrical energy from solar sources (the cheapest electrical energy in history in the ***GCC*** countries) rather using natural gas molecules to produce electrical energy: "*We are looking at solar projects and combined solar and wind on our plants … That will free up gas molecules that we are burning to employ into much more valuable processes rather than burning …".*

  This is at the heart of the electrons versus molecules debate broadly. (If one turns around the thinking, this informs the efficiency debate around the use of hydrogen (in particular Green Hydrogen) as a fuel to generate base-load dispatchable energy.)

  The clarity of thinking and the policy setting of moving to use renewable electrical energy to preserve molecules to produce hydrogen and hydrogen-based energy carriers is compelling.

  Mr Salim al-Huthali went on to state that OQ is developing projects to produce: "*… both blue ammonia and Blue Hydrogen .. The blue ammonia project can be accelerated … it is a matter of capturing the CO_2 and obtaining certification that it qualifies [as Blue Hydrogen and as such] as blue ammonia and can be sold to the market at blue ammonia*".

  In addition to Blue Hydrogen and Blue Ammonia, OQ is considering the development of Green Hydrogen, Green Ammonia, Green Methanol and Green Steel projects. It is anticipated that these projects will be developed with international partners, as is the case with the ***Oman Green Energy Hub***.

  See: *Oman's OQ aims to replace 40% of its 3 GW of power consumption with renewables*
- **New petroleum:** On June 24, 2021, pv magazine asked "Has the Gulf discovered the new petrol?" in an article reflecting on the record low tariffs arising from reverse auctions in the Gulf since the start of 2020, and the implications of them. The article notes (what folk in the ***GCC*** countries already know), production of Green Hydrogen and Blue Hydrogen production in the ***GCC*** region is likely to achieve cost parity sooner rather than later.

  See: *'Low-cost renewable hydrogen may already be in reach'*

Black Gold and Blue and Green Gold:

The white hot logic of OQ applies equally to each other ***GCC*** country. The black gold that has provided prosperity is to be joined (not replaced) by the Blue Gold of Blue Hydrogen and Ammonia, and the Green Gold of Green Hydrogen and Ammonia: there is gold in and on, as well as under, them there hills and dunes. As might be expected, ***GCC*** countries are agnostic as to the colour of this Gold.

In the first article in ***The Shift to Hydrogen (S2H2): Elemental Change*** series, entitled ***Why H₂? Why Now?***, the Gulf region was identified as one of the most prospective areas for renewable electrical energy production and as such for the production of Green Hydrogen and Green Ammonia.

This is proving to be the case. Also it is becoming clear that the Gulf region knows the value of its hydro-carbon reserves, and how to extract the greatest value from them. For the Gulf region, and each ***GCC*** country the road to ***NZE*** will continue to yield prosperity, if you will, a road paved with Gold.

The highly prospective outlook for the ***GCC*** countries is recognised in a recent report. While there are no surprises in the report, it consolidates thinking and provides a blue print for how to realise the promise.

See: *The Potential for Green Hydrogen in the GCC Region*

Green Metals:

- **First fossil fuel free iron and steel projection:** Editions 13 and 16 of Low Carbon Pulse reported on the development of what is billed as the world's first fossil free steel plant located at Svartoberget, in Lulea, Sweden (***HYBRIT***). The development of ***HYBRIT*** is being undertaken in alliance with SSAB, LKAB, and Vattenfall (see Editions 13 and 16 of Low Carbon Pulse). Effectively, the ***HYBRIT*** partners have developed a "mine-to-mill-to-manufacture" supply chain.
  - **Pilot to commercial scale:** The ***HYBRIT*** plant at Svartoberget, in Lulea, is a pilot plant which had proved up green sponge iron production. ***HYBRIT*** Development AB, owned by SSAB, LKAB, and Vattenfall, is developing a commercial, world scale, plant at Gallivare (see Edition 13 of Low Carbon Pulse).
  - **Production assurance:** On June 17, 2021, it was announced that to achieve more efficient storage of the hydrogen produced for use in the manufacture of Green Steel hydrogen, that hydrogen will be compressed,

and for this purpose ***HYBRIT*** has contracted with Howden Group (leading air and gas handling company) for the supply by Howden of a high-pressure diaphragm compression system.

Depending on which information source is used, the production of steel is responsible for between 7 and 9% of global ***GHG*** emissions (see second article in ***The Shift to Hydrogen (S2H2): Elemental Change*** series entitled ***What needs to be decarbonised? And what role can hydrogen play?*** for the scope, size and shape of the global steel industry.)

– **High Light – world first:** On June 21, 2021 it was announced that ***HYBRIT*** had completed the first production test of sponge iron (or direct reduction iron (***DRI***): see Edition 10 of Low Carbon Pulse), using hydrogen instead of coking coal to remove oxygen thereby avoiding the ***CO_2*** arising. This is a world first.

  See: *Howden provides hydrogen storage compression solution for the world's first pilot plant for fossil-free steel*

– **Howden and NEL frame working relationship:** On June 24, 2021, it was announced that Howden and NEL have signed a Framework Agreement under which Howden and NEL will work together to develop compression technology to compress hydrogen produced by NEL electrolysers. As noted in previous editions of Low Carbon Pulse, one of the means of transporting hydrogen efficiently is use of tube-tanker trailers from point of production to point of use. For NEL this continues its strategy of contracting with leading technology providers to enable it to contract to provide "whole Green Hydrogen project solutions": as noted in Edition 17 of Low Carbon Pulse NEL is working with First Solar to develop integrated and supervisory control systems to achieve electrical energy efficiency.

  See: Howden *website* and NEL *website*

- **Rio Tinto studies use of hydrogen in alumina refining:** Edition 19 of Low Carbon Pulse reported on the use of natural gas in the calcination process inherent in much alumina refining. On June 15, 2021, it was widely reported that Rio Tinto is to undertake a study in the use of hydrogen in alumina refining at its Yarwun refinery, Gladstone, Queensland. This study has the support of the Australian Federal Government, through ***ARENA*** grant funding. As noted in previous editions of Low Carbon Pulse, ***ARENA*** provides support for renewable technologies.

  See: *Renewable hydrogen could reduce emissions in alumina refining*

- **Rio Tinto and Schneider Electric ink clean metals deal:** On June 23, 2021, it was reported that Rio Tinto and Schneider Electric have entered into an agreement for Schneider to purchase aluminium, borates, copper and iron ore mined and produced by Rio Tinto using renewable electrical energy, and other low carbon technologies.

  See: *Rio Tinto partners with Schneider Electric to drive decarbonisation through circular and sustainable market ecosystem*

- **Volvo moving at speed:** On June 16, 2021 it was reported that Volvo (owned by Chinese car maker, Zhejiang Geely Holding Group) intends to start to manufacture cars made without steel produced using fossil fuels by 2026 (***Clean Steel***). For these purposes, as might be expected from the news items about ***HYBRIT***, Volvo has signed a letter of intent with SSAB for this purpose – a Volvo – SSAB vehicle!

  The use of ***Clean Steel*** to manufacture cars, is another step on the road to achieving Volvo's commitment to be climate neutral (across all three Scopes of ***GHG*** emissions by 2040). Consistent with this commitment, Volvo has committed itself to manufacture only battery electric vehicles (***BEVs***) by 2030, and to develop fuel cell electric vehicles (***FCEVs***) with Daimler (see Edition 17 of Low Carbon Pulse – ***Volvo and Daimler back-into FCEV***).

  See: *Volvo Cars is first car maker to explore fossil-free steel with SSAB*

- **Volvo at the double:** On June 22, 2021 it was reported that Volvo AB, with Hitachi ABB Power Grids Sweden, H2 Green Steel, Ovako AB and NEL ASA are to develop a 17 MW fossil fuel free hydrogen facility at Ovako AB's steel mill in Hofors, Sweden. (The development of the facility is distinct from other projects in which each corporation is involved, and is supported by the Swedish Energy Agency.)

  By way of reminder: February 23, 2021, ***H2 Green Steel*** was announced as a Green Steel venture (see Editions 11 and 12 of Low Carbon Pulse), proposing development of a 5 million metric tonnes per annum (***mmtpa***) Green Steel facility, with the project having Important Project of European Common Interest (***IPECI***) status. As noted in Edition 12 of Low Carbon Pulse, ***H2 Green Steel*** is backed by, among others, Mr Daniel Ek (founder of Spotify), Scania and Vargas. Other equity investors in the H2 Steel include the Agnelli, Maersk, and Wallenberg families, and Mercedes-Benz and the IKEA foundation.

- **The greening of car manufacture:** Edition 9 of Low Carbon Pulse reported on the "lower emission metal" deal between BMW and Emirates Global Aluminium. On June 16. 2021 it was reported that BMW is continuing the greening of its car manufacture with the development of its first ***FCEV*** passenger car: it has been reported that BMW has started road-testing a ***FCEV*** powered and propelled car to determine the potential of ***FCEVs***.

  See: *New Batteries for the New Class*

- **How much Green Hydrogen is needed:** The ***World Economic Forum*** (among other things, the organisation that established the Hydrogen Council), has released a report outlining steel production from 1970 to 2020. Please click here for a visual representation of global steel production.

  In 2020, 1,864 million metric tonnes (or 1.864 billion metric tonnes) of crude steel was produced globally. This is consistent with the detail in ***The Shift to Hydrogen (S2H2): Elemental Change***, which provides a sense of how much Green Hydrogen, and as such renewable electrical energy is required "to green" the production of that quantity of steel. It is estimated that by 2050, annual production of steel will increase to 2,750 million metric tonnes per annum (***mmtpa***) (or 2.75 btpa).

Hydrogen Cities, Councils, Hubs, Infrastructure and Valleys:

- **How Green is the Hydrogen Valley:** On June 18, 2021, Euractiv published an article entitled "***'Hydrogen Valley' projects sprout up across Europe***". While there is nothing new in this news, what is new, and what is news, is that a report on hydrogen valleys has been published. The report characterises hydrogen valleys (***H2Vs***), as smaller-scale, medium-scale and larger-scale. The report covers over 20 ***H2V*** projects in the ***EU*** and the UK, and 34 globally, across 19 countries. This report follows hot-on-the-heels of the report referred to in Edition 19 of Low Carbon Pulse detailing the emerging use and benefit of hydrogen valleys.

  See: *'Hydrogen valley' projects sprout up across Europe*

- **Giga-factories and hydrogen refuelling infrastructure**: Factories manufacturing electrolysers and hydrogen refuelling infrastructure and stations are critical to the development of the hydrogen economy. Future editions of Low Carbon Pulse will monitor both the levels of manufacture from factories, and the development of new factories.

  On June 22, 2021, McPhy (the French electrolyser and hydrogen station manufacturer) announced that it would increase manufacturing capacity of hydrogen stations from 20 units to 150 units a year. For these purposes, McPhy is to develop a new manufacturing facility in Grenoble (in the Grenoble-Alpes Metropole region), France.

  See: *McPhy opens a new industrial site in Grenoble and will increase its hydrogen station production capacity sevenfold*

- **Decarbonising construction sites:** Construction activity gives rise to noise, to pollution and to ***GHG*** emissions. A policy setting that is emerging is the decarbonisation of activities undertaken at construction sites: it is estimated that 10% of ***GHG*** emissions globally arise from construction activities. In Oslo, Norway, it is estimated that 7% of its total ***GHG*** emissions arising in the city arise from construction activities.

  See: *The Scandinavian way to zero-carbon construction*

- **Italian North African Hub:** Edition 19 of Low Carbon Pulse reported on the development of a pipeline network to carry hydrogen. For a number of reasons, Italy has joined Spain, in being thought of as hub between Europe, as the market for Green Hydrogen use, and North Africa, as a Green Hydrogen producing region. This is a theme that Low Carbon Pulse will follow.

- **HyNet North West's net worth increasing:** Edition 19 of Low Carbon Pulse outlined the scope of the development of infrastructure necessary to proceed with the carbon capture and storage project in Liverpool Bay, using depleted natural gas fields operated by Eni UK Ltd.

  On June 23, 2021, HyNet announced plans for the development of a zero carbon power plant in collaboration with InterGen at the site of its existing Rocksavage power station (***RPS***), a gas-fired power station in Runcorn, Cheshire, England. As announced, the intention is to blend hydrogen with natural gas at ***RPS***.

  See: *Hynet North West and Intergen Announce Plans for a Zero Carbon Power Plant*

- **Four Giga Factories For India:** On June 24, 2021, Reliance Industries Limited (***RIL***) (world scale, Indian conglomerate) Chairman, Mr Mukesh Ambani announced that the company is to develop four giga factories. Mr Ambani announced that: "Reliance will develop four giga factories which will manufacture and [integrate fully] all critical components of the new energy ecosystem".

  The development of the four giga factories is part of ***RILs*** broader plans for the new energy ecosystem. These plans include the installation of 100 GW of solar capacity by 2030, critically in the context of roof-top solar and micro-grid installations (see above ***India continuing down the road looking to roof-tops and micro-grids: Roof-top solar for India*** and ***Micro-grids for India***).

  See: Reliance *website*

Sustainable Energy Round-up:

- **Brazil at pace::** It has been widely reported that Brazil has received tender responses in respect of 1,694 projects to provide nearly 94 GW of electrical energy (including 58 GW of renewable electrical energy).

  The prize for successful tenderers is the award of long-term power purchase agreements (as part of the A5 auction process), with the term differing depending on the fuel or source: 25 years for hydro-electric power, 20 years for any fuel or source (other than hydro-electric and solar and wind), and 15 years for solar and wind.

  The A.5 auction process is scheduled for September, 30, 2021. A future edition of Low Carbon Pulse (likely marking the first anniversary of Low Carbon Pulse), will cover the outcome of the auction process.

  See: *Brazil registers nearly 58 GW of renewables for Sept 30 tender*

- **Fortescue Metals Group (*FMG*) increasing the global pace:** On September 25, 2020, Dr Andrew Forrest, AO (founder of ***FMG***) signed an agreement with the Democratic Republic of Congo (***DCR***). On June 15, 2021, it was reported that the Government of DCR announced that ***FMG*** is to develop the 4.8 GW Grand Inga hydroelectric power project.

  See: FMG *website*

- **Canadian General Fusion:** On June 17, 2021, it was reported by the BBC that Canada General Fusion (a company with backing of Amazon) intends to develop a demonstration nuclear fusion reactor in Oxfordshire, England. The BBC report follows a report on June 1, 2021, that the UK Government is planning to develop a regulatory regime to allow the development of nuclear fusion as part of its broad, and world leading, regulatory regime supporting progress towards ***NZE***, and consistent with recommendation of the Regulatory Horizons Council Report of Fusion Energy.

  See: *Nuclear energy: Fusion plant backed by Jeff Bezos to be built in UK*

- **PPT sees Global Power Synergy in renewables, and positioning globally:** On June 22, 2021, it was reported that PTT Public Company Limited (state-owned oil and gas company, known as PTT) is committing USD

635 million to renewable energy developments in Asia, including the key markets of ***PRC*** and India. PTT has set itself the target of increasing the proportion of generated power from 12% to 30%. For the purposes of making these investments, PTT has established subsidiary, Global Power Synergy (***GPS***): ***GPS*** is 75% owned by PTT.

See: *Power unit of Thailand's PTT makes $635m pivot to Asia green energy*

- **Global costs arena for renewables energy, by IRENA:** On June 22, 2021 (or thereabouts), the International Renewable Energy Agency (***IRENA***) published a report entitled ***Renewable Power Generation Costs in 2020***.

  The headlines from the ***IRENA*** report are that the:

  – global weighted-average levelized cost of electricity (***LCOE***) from new installed capacity continues to fall (compared to 2019) as follows: solar (***CSP***) by 16%, utility-scale photovoltaic solar (***USPV***) by 7%, and on-shore wind by 13%, and off-shore wind by 9%; and

  – operating costs of the existing 800 GW of installed coal-fired capacity globally are higher than those of ***USPV*** and on-shore wind: displacing coal with renewable electrical energy would reduce operating costs by USD 32 billion, and reduce annual ***GHG*** emissions by around 3 Gt (3,000 million tonnes, 3 billion tonnes).

  As might be expected, ***lower operating costs*** headline has received considerable immediate attention. It is important to note that the analysis does not deal with the unamortised / stranded capital costs of displacement.

  In the same week as the ***IRENA*** report, the ***IEA*** published its ***Statistics Report*** – ***Energy Prices: Overview – High-Quality data on end-use energy prices***. Both reports are well-worth a read.

- **Australian Federal Government slows pace on world scale project:** A number of editions of Low Carbon Pulse have reported on the proposed development of the Asian Renewable Energy Hub (***AREH***), in the Pilbara Region of Western Australian. Having been given Major Project Status by the Federal Government, to facilitate the development ***AREH***, the Federal Government has slowed the pace of progress of ***AREH*** on the basis of its prospective impact on wetlands. It is expected that ***AREH*** will take on board the concerns raised, and that ***AREH*** will proceed in a modified form.

  See: *Asian Renewable Energy Hub Revised Proposal*

- **Iran's mountains and valleys, and plains:** On June 24, 2021, Oil Price published an article entitled, ***Will Iran Emerge As A Renewable Energy Breakout Story?***. The article works at three levels, first, to provide an update on Irans's progress to ***NZE***, secondly, that climate change can affect choices of renewable energy technology, in this case run of river hydro, and thirdly, as a reminder that all countries need to progress to ***NZE***.

  See: *Will Iran Emerge As A Renewable Energy Breakout Story?*

- **Iraq and Masdar on the same plain:** On June 25, 2021, it was announced that the Government of Iraq and Masdar (Abu Dhabi Future Energy Company) had signed a strategic agreement to develop at least 2 GW of solar projects in Iraq. This may be regarded as an illustration of countries assisting each other to progress to ***NZE***.

  See: *Masdar signs strategic agreement to develop solar projects in Republic of Iraq*

- **Kazakh Invest National Company increases pace to world scale projects:** On June 25, 2021, Kazakh Invest National Company and Svevind (a privately-owned corporation, based in Germany) signed an memorandum of understanding (***MoU***) to develop mega-scale Green Hydrogen production facilities in Kazakhstan. The ***MOU*** contemplates the development of up to 45 GW of renewable solar photovoltaic and wind farms to supply electrical energy to up to 30 GW of electrolysers, to produce up to 3 mtpa of Green Hydrogen.

  See: *SVEVIND and Kazakh Invest National Company JSC sign a memorandum of understanding*

- **Sub-sea cables are live:** On June 14, 2021, it was announced that the ***North Sea Link***, connecting Norway and the UK was operational, carrying a current of electrical energy using high voltage direct current cable (***HVDC***).

  On June 24, 2021, the Australian Financial Review revisited the suggestion of the ***PRC*** President, Mr Xi Jinping (made to the United Nations) of a "global energy internet" or "submarine super-grids" using ultra-high-voltage direct current (***UHVDC***) transmission lines.

Wind round-up:

- **Tail wind for floating off-shore in Spain:** On June 14, 2021, Saitec (among other things, an off-shore technology company) presented the initial project documentation as part of the Environmental Impact Assessment process, for the purposes of gaining approval to develop a 45 MW a floating off-shore wind field project 10 kms off Bilbao, Vizcaya Province (***BOVP***). The intention for the ***BOVP*** is to be operational by 2025.

  In Edition 19 of the Low Carbon Pulse, ***BlueFloat Energy*** announced its plan to develop a 1 GW floating off-shore wind field off the coast of Emporda, close to the Gulf of Roses, Catalonia. Spain has world class renewable resources, both on on-shore and off-shore.

  See: *Saitec Unveils Floating Wind Project Off Bilbao*

- **Japan first floating off-shore wind field to progress:** On June 14, 2021, it was widely reported that the Ministry of Economy, Trade and Industry (***METI***) and the Ministry of Land, Infrastructure and Tourism (***MLIT***) had appointed a consortium to develop the 16.8 MW floating off-shore wind field project, off Goto City, Nagasaki Prefecture. The consortium (called ***Goto City Offshore Wind Power Generation LLC***) comprises Chubu Electric Power, ENEOS Corporation, INPEX, Kansai Electric Power, Osaka Gas, and Toda Corporation (the leader of the consortium).

  The appointment of ***Goto City Offshore Wind Power Generation LLC*** followed the completion of an auction process commenced in 2020 (under the Renewable Sea Area Utilization Law), and closing in late December 2020. The area off-shore of the Goto coast is one of 11 areas identified by ***METI*** and ***MLIT*** as prospective for off-shore wind field development. Edition 19 of Low Carbon Pulse reported on the Akita and Chubu area auction processes, being auctions for the development of fixed bottom off-shore wind fields, rather than floating.

See: *Toda-led group wins auction for 16.8-MW floating wind project in Japan*; METI; MLIT and Toda Corporation

- **Baltic hot spot heats-up:** Editions 8, 14 and 18 of Low Carbon Pulse have reported on the development of off-shore wind-field projects in the Baltic, with the development underpinned by the use of contracts for differences (***CFDs***). On June 16, 2021, it was reported that Baltic Power had been awarded a ***CFD***. (Baltic Power is an incorporated joint venture between PKN Orlen (a Polish based oil refiner and petroleum retailer), holding 51%, and Northland Power, Inc. (a Canadian based utility corporation), holding 49%.)

  This is the third ***CfD*** awarded in 2021 under the Offshore Act (see Editions 8 and 14of Low Carbon Pulse). As noted in Edition 18 of Low Carbon Pulse, the award of ***CfDs*** is seen as a key to enabling Poland to achieve its target of develop up to 10.9 GW of off-shore wind capacity by 2027: with auctions for 5.9 GW by the end of 2021, and two further tranches to be auctioned by 2025 and 2027.

  See: *Northland Power Achieves Key Baltic Power Milestone With 25-Year Award of Contract for Difference in Poland*

- **Open book on Empire Wind:** On June 18, 2021, it was reported widely that the Bureau of Ocean Energy Management (***BOEM***) is to conduct an environmental review of the BP and Equinor Empire Wind off-shore wind field project (***EWOP***) off the coastlines of the US states of New Jersey (17 miles east of Long Branch) and New York (12 miles south of Long Island). (BP and Equinor are reported as being 50/50 joint venturers in Empire Wind LLC.) This process starts with a notice of intent leading to the preparation of an Environmental Impact Statement of the construction and operations plan (***COP***) developed by Empire Wind LLC.

  As has been noted before in Low Carbon Pulse, among others, the off-shore areas of the east coast of the US are highly prospective, having the benefit of being close to load. Assuming approval of the ***EWOP***, its development is consistent with the policy objectives of the state of New York to have installed 9 GW of off-shore wind capacity by 2035, and the US to have installed 30 GW off-shore wind capacity by 2035.

  See: *BOEM Announces Upcoming Environmental Review for a Proposed Wind Project Offshore New York and New Jersey*

- **North and South Utsira bottom or floating forecast news:**
  - **Status check:** Edition 18 of Low Carbon Pulse reported on the ***Utsira Nord*** and ***Solige Norsjo II*** areas (known on UK shipping forecasts, as North Utsira and South Utsira) in the Norwegian sector of the North Sea. Together, ***Utsira Nord*** and ***Solige Norsjo II*** have wind resource potential of up to 4.5 GW of installed capacity. The Norwegian Government (Ministry of Petroleum and Energy) has indicated that ***Utsira Nord*** is suitable for floating off-shore wind and that ***Solige Norsjo II*** must be developed without any state-aid.
  - **BP and Aker Offshore Wind and Statkraft:** On June 14, 2021, it was announced that BP is partnering with Aker Offshore Wind and Statkraft in a consortium to apply to develop a fixed bottom off-shore wind field in the ***Solige Norsjo II*** area.

    See: *bp, Aker and Statkraft join forces for offshore wind in the Norwegian North Sea*
  - **Shell and BKK and Lyse bottom out and float:** On June 17, 2021, it was announced that Shell intends to partner with Norwegian hydro-electric companies, BKK and Lyse, to apply to develop off-shore wind field projects in both the ***Utsira Nord*** and ***Solige Norsjo II*** areas. It is understood that the partners are contemplating the development of floating off-shore wind field capacity in the ***Utsira Nord*** area, and each partner has a clear view about the quality of the wind resources in the North Sea.

    Also BBK, CEO, Ms Jannicke Hilland provided an interesting perspective on the interface between hydro-electric and wind: "*[When these off-shore wind fields produce electrical energy], we can hold back the water in our reservoirs, we can cover the demand for power by phasing in hydro-production*".

    See: *Shell, local partners to bid for wind licences offshore Norway*

- **Old acquaintances combine again for new gig:** On June 16, 2021, it was widely reported that international energy company, TotalEnergies, Green Investment Group (***GIG***), and Renewable Infrastructure Development Group are to bid jointly in the ScotWind off-shore wind field leasing round (see Edition 8 of Low Carbon Pulse). TotalEnergies and ***GIG*** are well-acquainted, having bid, and won jointly a number tenders. TotalEnergies has an existing interest in the off-shore wind project, Seagreen 1 (see Edition 4 of Low Carbon Pulse).

- **Floating Scottish Wind being funnelled:** On June 18, 2021, renewable giant, Copenhagen Infrastructure Partners (***CIP***) announced that it had revived plans to develop a 100 MW floating off-shore wind field project off Dounreay, Caithness, Scotland (the ***Pentland Off-shore Wind*** project or ***POWP***), using Highland Wind Limited (in which ***CIP*** is majority shareholder).***CIP*** anticipates financial close in 2024, and commissioning in 2026.

  Scotland, a country of high-land and hard rain (after Aztec Camera), has some of the best off-shore wind resources in the world, and is close to load. As floating wind field technology develops it is to be expected that those resources will be developed. Edition 14 of Low Carbon Pulse notes the success of early mover, ***HyWind***.

  See: *CIP Revives Floating Wind Project Offshore Scotland*

- **North Carolina looking off-shore:** On June 18, 2021, the Governor of North Carolina, Mr Ray Cooper, issued an executive order targeting the development of off-shore wind field capacity off the coast of the eastern sea-board State. Mr Cooper is targeting the development of 2.9 GW of installed off-shore wind field capacity by 2030, and 8 GW by 2040. This continues the development of the world class off-shore wind resources off the US.

  See: *Governor Cooper Commits to Offshore Wind Power as North Carolina Creates Jobs by Transitioning to a Clean Energy Economy*

- **Strong off-shore winds:** In a number of reports and editorials, the current and projected investment levels of investment in off shore wind fields globally have featured strongly, in particular in Asia: it estimated, as mid-2021 approaches, that 500 GW of off-shore wind capacity has either been installed or new capacity development announced.

See: *Report: Asia-Pacific Set to Overtake Europe in Offshore Wind Power*

Solar round up:

- **Solar on Semakau:** On June 17, 2021, JTC Corporation (a Singapore Government Agency) and Shell announced that they had signed a non-binding Memorandum of Understanding (***MOU***) to explore jointly the possible development of a solar farm on part of the Semakau Landfill, off-shore of Singapore. (The Semakau Landfill is used to landfill bottom ash and other residual material from Singapore's waste-to-energy facilities.) It is reported that the ***MOU*** is supported by Singapore's National Environment Agency and Energy Market Authority.

  See: *JTC & Shell to Explore Semakau Solar Farm to meet Singapore's Growing Clean Energy Needs*

- **Electrification of Africa: abundance of sun and rain, in search of capture:**

  The electrification of Africa has been in the news of late, principally as a number of conferences have highlighted the need to increase the rate of electrification, but in a way that is consistent with achieving ***NZE***.

  - **Solar in Mozambique:** On June 14, 2021, it was reported that the Norwegian and UK governments have provided support for a smaller scale solar and battery energy storage project in Mozambique, but nevertheless described as utility-scale. The support was provided by Globeleq (a renewables entity, owned by the Norwegian and UK Governments).

    This is the first independent utility-scale solar project in Mozambique. In addition to the backing of Globeleq, the project has received grant funding from the Private Infrastructure Development Group (***PIDG***), which is itself funded by the International Finance Corporation and the Governments of Australia, Germany, the Netherlands, Sweden, Switzerland, and the UK.

    See: *UK and Norwegian governments back solar-plus-storage in Mozambique*

  - **Solar in Tanzania:** On June 15, 2021, it was reported that an agreement had been reached by the French Government's French Development Agency (***AFD***) with the Tanzanian Government to fund the development of a 150 MW power plant in Kishapu, Shinyanga, northern Tanzania.

    The stated purpose of this project is to increase the security of electrical energy supply and to diversify the sources of supply of the Tanzania Electric Supply Company Ltd (***Tanesco***), critically to address the impact of the dry season on electrical energy sourced from hydroelectric sources available for on-grid dispatch. It is reported that 43% (561.8 MW) of ***Tanesco***'s installed capacity is hydroelectric, and 57% (693.3 MW) diesel and gas (with a further 52.2 MW of diesel capacity off-grid).

    See: *AFD to Finance the First Grid Connected Solar Photovoltaic Power Plant in Tanzania and the Modernization of Electricity Network*

  - **Solar in Africa:** A long-standing theme on progress to ***NZE*** is that at the same time as progress is made, the access rate to electrical energy needs to increase: the ***IEA*** estimates, conservatively, that around 800 million to 1.2 billion people globally do not have access to electrical energy.

    It is understood that in Tanzania the access rate is 32.7%, with 67.3% of the population (7.7 million people) without access to electrical energy. The need for electrification is particularly acute in Africa: close to 600 million people did not have access to electrical energy in Sub-Saharan Africa in 2020, projected to increase to 630 million people by 2030. The development of off-grid solar is an area in which the developed world can make a difference: as will be apparent from the next news item, that the technology exists to achieve 100% electrification off-grid.

- **100% solar at Onslow WA:** On June 18, 2021, is was widely reported that the Horizon Power (a Western Australian state-owned power company) has satisfied the load of Onslow, on the Western Australian coast, using solar and ***BESS***. This is the first successful testing of a scale, and scalable, off-grid, micro-grid.

  See: *Onslow Microgrid Powered Hydrocarbon Free*

Port News and Shipping Forecasts:

- **Ports of Auckland Limited (*POAL*) and Obayashi team:** On June 23, 2021, ***POAL*** announced that ***POAL*** and Obayashi are to joint venture with a view to the development of refuelling infrastructure at the Port to allow the displacement of fossil fuel use for port vehicles and buses within Auckland.

  See: POAL *website*

- **First Hydrogen Cargo Vessel Sails Closer:** On June 23, 2021, Statkraft and Skagerak Energi reported their appointment to supply Green Hydrogen for a vessel planned by HeidelBerg Cement and Felleskjopet. Under the Green Shipping Program, HeidelBerg Cement and Felleskjopet are planning to develop of a zero-emission bulk vessel (***ZEBV***) to transport grain from Eastern Norway to Western Norway, and gravel and rock on the return voyage: ***ZEBV*** is to be powered and propelled using Green Hydrogen and rotor sails.

  See: Statkraft *website*

- **Mid-Summer Nights Dreaming about reports:** "I have had dreams" (after Bottom) … what visions I have seen" (after Titania) from the scoop of reports in June. The pick of the scoop, is ***Hydrogen Europe's How Hydrogen Can Help Decarbonise the Maritime Sector***. The report provides a clear perspective on required policy settings, and provides a balanced perspective on the use of hydrogen, noting the importance of energy density, and the need for supply to develop in tandem with demand.

Land Transport (automobiles, buses, trains and trucks) round-up:

- **GMC on track - *BEV* for Trains:** On June 15, 2021, it was announced that General Motors Corporation (***GMC***) had entered into arrangements with Wabtec Corporation to develop a battery electric locomotive.

  See: *Wabtec and GM to Develop Advanced Ultium Battery and HYDROTEC Hydrogen Fuel Cell Solutions for Rail Industry*

- **On the high road:**
  - **Hyundai at home around Munich:** On June 25, 2021, it was announced that Hyundai had delivered to its first Elec City Fuel Cell bus for use in testing on the roads of Munich.
  - **Hyzon Motor Inc at home around Christmas Creek, Western Australia:** On June 22, 2021, it was announced that ***Hyzon***'s ***FCT*** custom-built coach had passed tests for use in the hostile mining environment of Western Australia: it is reported that Fortescue Metals Group (leading iron ore company founded by Dr Andrew Forrest, AO) has ordered up to 10 of the coaches.
  - **Woodside Energy Limited (*WEL*) joins Hyzon Zero Carbon Alliance** (***HZCA***)**:** On June 25, 2021, it was announced that ***WEL*** (leading Australian oil and gas company) had become a member of the ***HZCA***. The ***HZCA*** was launched on April 22, 2021, to drive the development of a hydrogen mobility supply chain globally. ***WEL*** joins other exceptional corporations, including Ark Energy, AXA, Bank of America, Hiringa Energy, Modern Group, NEOM, Raven SR, ReCarbon, and TotalEnergies.
  - **Nikola:** On June 22, 2021, it was announced that Nikola had acquired a stake in an Indiana Hydrogen Plant. This initiative demonstrates the need for vehicles manufacturers to be assured of supply to satisfy the demand for hydrogen that their vehicles will create, and follows the approach ***Hyzon*** and ***Raven SR*** outlined in Edition 16 of the Low Carbon Pulse.

  See: *Hyundai Motor's Elec City Fuel Cell Bus Begins Trial Service in Munich, Germany*; *Road warrior: Hyzon Motors passes durability test for Australian mining company, delivering the world's first hydrogen-powered coach fleet*; *Hyzon Zero Carbon Alliance welcomes Australia's leading natural gas producer, Woodside Energy*; *Nikola Invests $50 Million in Wabash Valley Resources to Produce Clean Hydrogen in the Midwest for Zero-Emission Nikola Trucks*

Airports and Aviation:

- **Airbus, Air Liquide and Group ADP think clean hydrogen:** On June 21, 2021, it was reported widely that Airbus, Air Liquide and Group ADP have signed a memorandum of understanding (***MoU***) under which they plan to work together to prepare for the use of hydrogen to power and to propel commercial aircraft. The ***MoU*** the deals with the production, supply, and delivery / distribution of clean hydrogen.

  Edition 18 of Low Carbon Pulse mentioned this in passing (***Paris circles 11 projects to transform Paris' airports into hydrogen hubs***). It would seem that Airbus, Air Liquide and Group ADP are going to work as part of this initiative, critically the work being done in respect of Paris-Charles de Gaulle and Paris-Orly to identify the infrastructure development requirements.
- **Airbus thinks tanks:** On June 14, 2021, it was reported that Airbus has started to work on the development of hydrogen fuel tanks. The development work is being undertaken at two Zero-Emission Development Centres (***ZDECs***), one at Bremen, Germany, the other at Nantes, France. The development of cryogenic fuel tanks is critical to the development of a hydrogen propelled (and powered) Zero-e aeroplane (***ZEA***) that Airbus is aiming to develop by 2035 (in September 2020 Airbus released a description of three hydrogen concept aeroplanes). The development work is intended to be completed by 2023 to allow a test flight of the ***ZEA*** scheduled for 2025.

  See: *Airbus Starts Work on Hydrogen Fuel Tanks for Airliners*
- ***GMC* off road, in search of flush:**

  Airborne *FCT*: ***GMC*** is known for manufacture of automobiles – on road and off-road vehicles. In addition, ***GMC*** manufactures engines and power units for maritime vessels and for trains. ***GMC*** has developed a hydrogen technology – Hydrotec fuel cell technology (***FCT***) systems. On June 18, 2021, it was widely reported that ***GMC*** is to work with Liebherr-Aerospace (part of the Liebherr Group, owned by the Liebherr family), to develop power systems for aeroplanes. (Those familiar with Low Carbon Pulse will have noted, in respect of each mode of transport, that "powering and propelling" is used, this is because all modes of transport (with the obvious exception of the bicycle) require energy to power them and to propel them.)

  Use of *FCT*: Aeroplanes have (internal) power systems to provide the energy necessary to operate "the electrics" within the aeroplane, including to operate the air-conditioning systems (including to circulate and to humidify the air within the aeroplane), the galley systems, the hydraulics, and the water systems (potable and waste). Aeroplanes have (external) propulsion systems to propel them (jet or turbo-propulsion engines). ***GMC*** and Liebherr are developing power systems to use ***FCT*** that will produce water to be used on board aeroplanes.

  Great Quote: In one of the quotes of 2021 so far, GM Executive Director of Global Hydrotec, Mr Charlie Freese provides an unforgettable factoid: "*The average aircraft takes off with two tons of water just to flush the toilet. We can now make water in flight*".

  Good Observation: The keen-eyed observer will note that ***GMC*** is charging ahead with its ***FCT*** for planes and trains, but not automobiles. The reason for this is explained by ***GMC***'s GM Executive Director of Global Hydrotec, Mr Charlie Freese: "*Having the ability to provide both [BEV and FCEV] technologies lets you see where the technology fits best, and not have to try to force a square peg into a round hole. … Batteries are great for a lot of power, and the hydrogen fuel cell is great for a lot of energy on board, and the two are great complements*". This does not mean that ***GMC*** will not develop an automobile using ***FCT***, but it will wait until the hydrogen supply is widespread. Another example of the need for supply to precede demand.

Negative Emissions Initiatives and Carbon Credits, and off-sets:

- **Sharper modelling focus at BlackRock:** Previous editions of Low Carbon Pulse have reported on the importance to BlackRock of understanding that each corporation in which it invests has a net-zero ***GHG*** emissions strategy that its board has approved and endorsed, and to which it is committed (see Editions 9 and 10 of Low Carbon Pulse). On June 17, 2021, BlackRock announced that it had acquired Baringa Partners Climate Change Scenario Model for integration into BlackRock's Aladdin Climate technology, as part of a long-term partnership. This transaction recognises that climate risk is an investment risk, micro, and macro.

See: *BlackRock to Acquire Baringa Partners' Climate Change Scenario Model Through New Long-Term Partnership*

- **Sharper definition on key issues:**
  - On June 21, 2021, a study entitled ***Asymmetry in climate – carbon cycle response to positive and negative CO_2 emissions*** was released. The key take-away from the study is that impact on average temperature of ***CO_2*** emissions and negative ***CO_2*** emission initiatives are assumed by many to be the same, with one tonne of ***CO_2*** emitted, being neutralised by one tonne captured. Any assumption of symmetry is not sound: it is not appropriate to assume that the impact on temperature of one tonne of ***CO_2*** emitted, is neutralised by the removal of one tonne of ***CO_2***. In light of this, use of negative ***CO_2*** emission initiatives is likely to be subject to closer scrutiny in respect of the use of carbon credits acquit ***CO_2*** obligations;
  - On June 22, 2021, there was some commentary that emphasised the need to understand what is meant by ***carbon neutrality*** and by ***net zero***, particularly in the context of achieving ***NZE***. As readers of Low Carbon Pulse will know, at an organisational level: (**i**) ***net-zero*** emissions is measured across each Scope of ***GHG*** emission, Scopes 1 to 3, with any positive net outcome to be off-set by negative ***CO_2*** initiatives to remove that positive net outcome, and (**ii**) ***carbon neutrality*** refers to being carbon natural across each of Scope 1 and 2, with any positive net outcome to be off-set using carbon credits to off-set.
- **World Economic Forum recirculates:** On June 17, 2021, the ***World Economic Forum*** posted an article by Sebastian Cox, that takes a different perspective on carbon, from the perspective of trees, and as such viewing carbon as a resource. The article is well-worth a read.
- **Carbon above and below ground:** On June 24, 2021, the New Scientist published an article entitled ***Global vegetation stores decade of human carbon emissions underground***. The title of the article provides a fair idea of its substance: the key finding is that on average 24% of the mass of biomass is underground - forests (22%), grasslands (67%) and scrubland (47%). Previous estimates have been within a 20 to 30% range. The research on which the article is based provides good data for negative ***GHG*** emission initiatives.

In the fourth article in ***The Shift to Hydrogen (S2H2): Elemental Change*** series, the use of carbon credits and negative ***GHG*** emission initiatives (see Edition 9 of Low Carbon Pulse under ***Negative GHG Emissions … not new, but higher profile likely***) will be considered in the context of a broad analysis of the means and tools available to capture carbon and storage of it.

Net-zero – a round-up and net-zero commitments in the round:

- **Rolls-Royce outlines plans to reach Net-Zero by 2050:** On June 17, 2021, Rolls-Royce (a leading manufacturer of power and propulsion systems) outlined plans to progress net-zero emissions by 2050.

  See: *Rolls-Royce puts net zero carbon by 2050 at the heart of future innovation and growth*
- **Awake and ready for, and on the road to *NZE*:** On June 22, 2021, Schlumberger announced its commitment to achieve net-zero emission by 2050, compared to 2019. The announcement states: "With minimal reliance on off-sets, the plan is focused on reducing Scope 1, 2 and 3 emissions across the oil and gas value chain …". In accordance with best practice, the roadmap to ***NZE*** is staged, with a 30% reduction in Scope 1 and 2 emissions by 2025, 50% reduction in Scope 1 and 2, and 30% reduction in Scope 3 by 2030, and ***NZE*** by 2050.
- **Keeping close to Racing on the Road to *NZE*:** Edition 19 of Low Carbon Pulse included a really helpful arc from the "visualcapitalist.com" detailing the commitments of countries to net-zero emissions (***NZE***). A link the visual arc is attached.

  Attached is a link to a graphic developed in respect of Fortune Global 500 companies.

Low Carbon Pulse - Edition 21

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to Edition 21 of Low Carbon Pulse – sharing significant current news on progress towards net-zero emissions globally. This edition covers the period from Monday June 28, 2021 to Sunday July 11, 2021 (inclusive of each day).

Please click here for the previous edition of Low Carbon Pulse. Please also click here and here for the first two articles in the ***Shift to Hydrogen Series*** (***S2H2***)***: Elemental Change*** series: the *S2H2* series provides a narrative and perspective on hydrogen generally. Please **click** here for the first feature in the ***Hydrogen for Industry*** (***H24I***); the *H24I* features provide an industry by industry narrative and perspective.

Edition 21 will be posted again on **July 16, 2021** to pick-up those reading later in the week.

The week that was:

On July 5, 2021, the European Commission (***EC***) outlined a new green financial plan for the purpose of supporting the initiative to achieve the goal of reducing ***GHG*** emissions by 55% across European Union (***EU***) Member states by 2030. ***EC*** Vice President Mr. Valdis Dombrovskis is reported as having said that "natural gas and nuclear energy could be the "decarbonisation pathways" that start to replace heavily polluting coal-fired power stations". Consistent with a continuing narrative across Low Carbon Pulse, it would appear more than likely that natural gas will continue to be used as a fuel to allow progress towards net zero emissions (***NZE***) in the ***EU*** and globally using technologies that reduce and capture ***GHG*** emissions.

The Week Ahead:

- ***EU* and EC releases:**
  - ***CBAM***:

    On July 14, 2021, it is expected that the ***EU*** will release the developed policy settings for the ***Carbon Border Adjustment Mechanism*** (***CBAM***) (see Editions 12 and 19 of Low Carbon Pulse). If the July 14, 2021, timeline is achieved, Edition 22 of Low Carbon Pulse will cover the form and substance of ***CBAM***, and assess its likely implications. (Please click here for the link to the preliminary draft.)
  - **Climate Change Policy Proposals**:

    In addition to the release of ***CBAM***, on July 14, 2021, the ***EC*** is scheduled to publish 2030 policy setting proposals in respect of ***NZE***, including changes to the ***EU*** Emission Trading Scheme (***EU ETS***). The changes to ***EU ETS*** are expected to attract considerable attention and comment.

    The reason for this is that ahead of the publication much modelling appears to have been undertaken, including on the appropriate price point under the ***EU ETS*** will result in decarbonisation outcomes, critically, in the transport sector.
- **Deadline for applications for ScotWind approaches:**

  There is expected to be considerable activity ahead of the deadline for applications for ScotWind Leasing Scheme on July 16, 2021. (Edition 8 of Low Carbon Pulse reported on the ScotWind Leasing Scheme auction process.)

  Given the outcomes achieved on February 8, 2021, in respect of the Round 4 leasing program auction process for sites off-shore of England and Wales (see Edition 9 of Low Carbon Pulse), the outcomes of the ScotWind Leasing Scheme auction process are eagerly awaited. It will be recalled that the original schedule for the ScotWind Leasing Scheme was delayed to avoid competing the Round 4 leasing program auction process.

Report on reports:

As noted in Edition 20 of Low Carbon Pulse, among other things, to manage the length of Low Carbon Pulse, rather than commenting on reports and publications in each edition of Low Carbon Pulse, links to them will be included in the text of and at the end of, each edition of Low Carbon Pulse. Short summaries of the reports and publications will then be developed every month or so, and published either as an appendix to Low Carbon Pulse or in a stand-alone publication.

Ahead of the *UKH2S*:

Edition 20 of the Low Carbon Pulse noted that during the third week of July 2021, the UK Government is predicted to release its Hydrogen Strategy (***UKH2S***). Early indicators on the thinking that will inform the ***UKH2S*** are in plain-sight as part of the 10-Point Plan for a Green Industrial Revolution (***TPP***), including the aim of the development of 1 GW of low carbon hydrogen production capacity by 2025, and a firmer target of 5 GW by 2030.

[**Note*:*** The UKH2S was published on August 17, 2021, and is covered in Edition 25 of Low Carbon Pulse]

Ahead of the release of the ***UKH2S***, the All-Party Parliamentary Group (***APPG***) released a report urging the UK Government to set ambitious targets both under the ***UKH2S***, and in the implementation of that strategy. While there are ten key recommendations from the ***APPG***, the most compelling headline appears to be that the UK should expand beyond the 5 GW of low carbon hydrogen production capacity contemplated in the ***TPP***, ("*Aiming for 5 GW Hydrogen production capacity by 2030 in partnership with industry*") including the use of nuclear technology to produce ***Pink Hydrogen***. A short summary of the ***APPG*** report will be included in the Ashurst July Report on Reports.

The Month Ahead:

Commencement of trading on *PRC ETS* imminent: Towards the end of June, the Shanghai Environment and Energy Exchange (the first national carbon emissions trading platform, and which is understood will handle account openings for traders and operations until a formal national carbon emissions operator is set up in the ***PRC***) provided clarity around emissions trading on the ***PRC*** emissions trading scheme (***PRC ETS***). On July 7, 2021, at an executive meeting of the State Council, Chinese Premier, Mr Li Keqiang, announced that trading on the ***PRC ETS*** would commence for power generation during July 2021. (see Editions 6, 9 and 12 of Low Carbon Pulse for background on the ***PRC ETS***.)

IRENA World Energy Transitions Outlook:

- Edition 13 of Low Carbon Pulse reported that the International Renewable Energy Agency (***IRENA***) had published its ***Preview to World Energy Transition Outlook*** (titled "Preview of World Energy – Transition Outlook – 1.5°C Pathway", and reprised the headlines and themes in Edition 20 of Low Carbon Pulse. On June 30, 2021, ***IRENA***'s ***World Energy Transitions Outlook*** (***WETO***) was published. The ***WETO*** weighs in as a heavyweight, both in terms of number of pages, and the strength of its subject matter.

  The ***WETO*** takes the same end point as its key term of reference: achieving the ***Stretch Goal*** under the Paris Agreement (i.e., to limit the increase in average global temperatures to 1.5°C above pre-industrial levels (what ***WETO*** refers to as the ***1.5°C Scenario***)). As is the case with the International Energy Agency (***IEA***) ***Net Zero by 2050 – A Roadmap for Global Energy Sector*** (***IEA Roadmap***), the ***WETO*** provides a pathway to ***NZE*** by 2050, not the pathway.

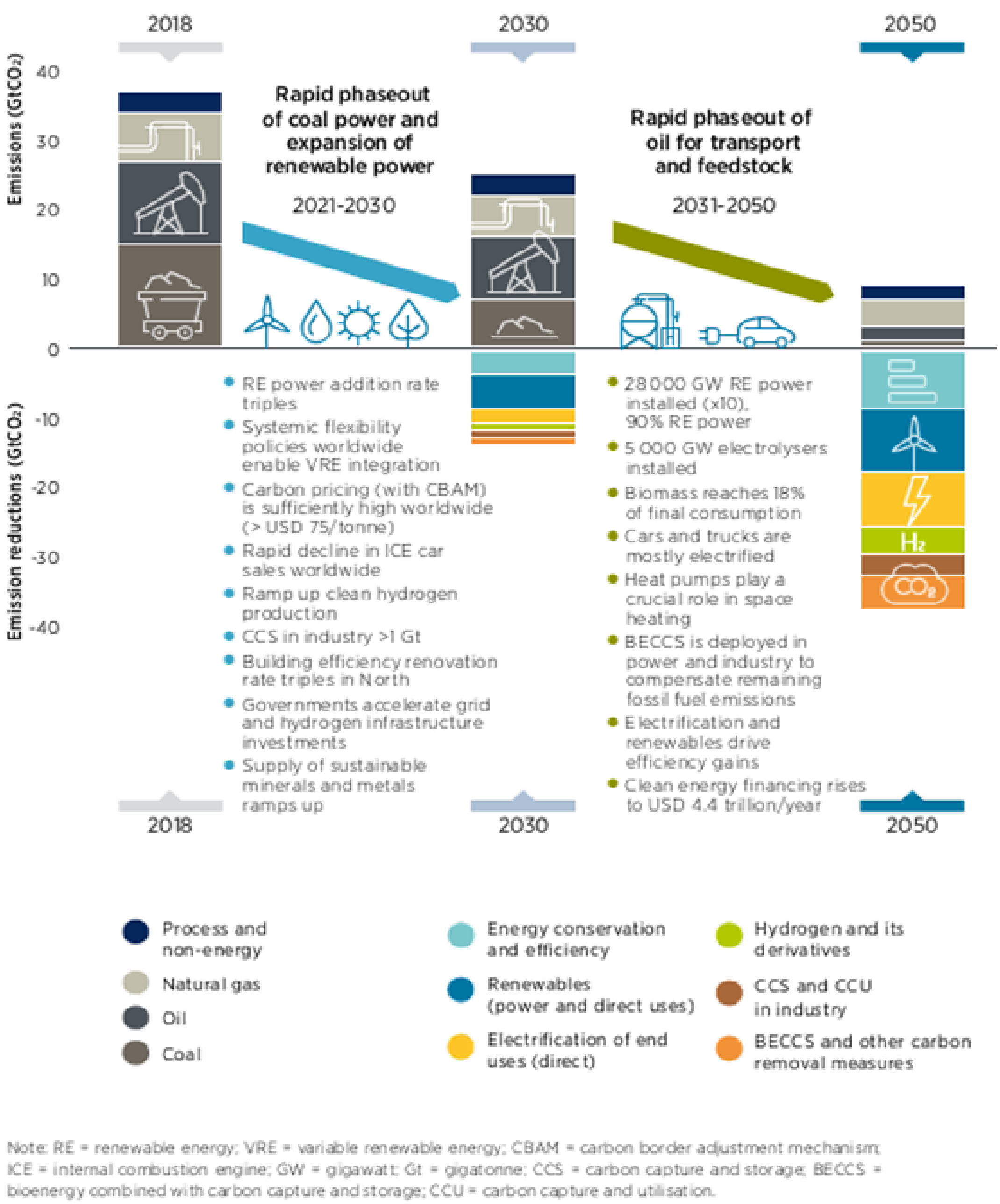
  Consistent with the intention not to report on reports in full in editions of Low Carbon Pulse, but to publish a report on reports in respect of each month, the report on reports for July will include a summary of the ***WETO***.

  To whet the appetite the following matters are key: **1**. current progress and plans to decarbonise "fall woefully short of achieving" the Stretch Goal; **2**. "time is of the essence, and a rapid decline in emissions must begin now to preserve a fighting chance of" achieving the Stretch Goal; **3**. the pressure of time, requires "careful investment and policy [setting] choices" in the current decade, and for these purposes the ***WETO*** provides a helpful graphic (Figure S.3) to convey the concepts; **4**. Hydrogen will account for 12% of final energy use by 2050 and bioenergy will represent 18% of total final energy consumption in 2050.

  Goals: On November 4, 2016 the Paris Agreement entered into force. The Paris Agreement recognises that to respond to the effects of increased ***GHG*** in the atmosphere, it is necessary to commit to hold: "the increase in global average temperature to well below 2°C above pre-industrial levels [***Stabilisation Goal***] and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels [***Stretch Goal***] …" (Article 2).

- ***WETO* is the second report from *IRENA* in short order:** While the ***WETO*** was the second publication from ***IRENA*** in short order, it has long been expected. ***WETO*** and ***Renewable Power Generation Costs in 2020*** may be regarded as compulsory reading, along with the ***IEA Roadmap*** and the ***Energy Prices: Overview – High-Quality data on end-use energy prices***. All four reports are well tagged and thumbed by the author of Low Carbon Pulse.

FIGURE S.5 Evolution of emissions with phaseouts of coal and oil, 2021-2050



New *IEA* Reports:

Edition 20 of Low Carbon Pulse reported on the number of ***IEA*** reports and studies as mid-calendar year approached. Reports from the ***IEA*** have continued to drop ahead of the Northern Hemisphere summer holiday season:

- ***Hydropower Special Market Report*** (published on June 30, 2021), reminding us that one sixth of global electrical energy generation was derived from hydroelectric power in 2020, making it the single largest source of low-carbon power, that the quantity of hydroelectric power has increased by over 70% over the last two decades, but the rate of growth needs to be increased, and absent new and recalibrated policy settings the rate of growth will not be sufficient (in particular by reference to the ***IEA Roadmap***) to achieve ***NZE***;
- ***Trends and Developments in Electric Vehicle Markets*** emphasising that there is continued development of the use of battery electric vehicles (***BEV***s) (10,000,000 at the end of 2020), and that the rate of adoption of ***BEV***s is increasing. As is the case with the ***Hydropower Special Market Report***, the ***IEA*** notes the need for new policy settings to increase the rate of adoption of ***BEV***s. One of the telling statistics from the ***IEA Roadmap*** is that the number of cars will increase from 1.2 billion to 2 billion by 2050. As ever, increased electrification requires increased renewable electrical energy, and the integrated policy settings must be in place to ensure supply of renewable electrical energy and recharging capacity is in place ahead of demand for it; and

- **Gas 2021 – Analysis and Forecast to 2024:** On July 5, 2021, the ***IEA*** released its ***Gas Market Report Q3-2-2021, including Gas 2021 – Analysis and Forest to 2024*** (***Gas Report***). As is to be expected, the ***Gas Report*** is consistent with the perspectives that inform the ***IEA Roadmap***.

  As a point of contrast, The Oxford Institute for Energy Studies (***OIES***) publication, ***Energy Transition: Modelling the Impact of Natural Gas***, is worth consideration. The ***OIES*** report provides for the use of natural gas to a greater extent than the ***Gas Report*** and the ***IEA Roadmap***. Given the timing of the release of the ***IEA***'s ***Gas Report***, the ***OIES*** report does not take account of the ***IES***'s findings. The ***OIES*** report provides for two scenarios: one resulting in slightly higher use of natural gas than currently in 2050, the other with around 60% of current levels of natural gas use in 2050. Both scenarios are intended to achieve the ***Stabilisation Goal*** under the Paris Agreement, rather than the ***Stretch Goal*** (noting that the ***IEA Roadmap*** is based on achieving the ***Stretch Goal***).

The report on reports for July will include a short form summaries of each report. (see Edition 23 of Low Carbon Pulse)

India to introduce Green Hydrogen Consumption Obligations (*GHCOs*):

Edition 20 of Low Carbon Pulse anticipated that the Government of India (***GoI***) was likely to introduce mandatory purchase obligations for Green Hydrogen, similar to their Renewable Purchase Obligations (***RPOs***). On July 1, 2021, it was reported widely that the ***GoI*** is considering proposals to impose obligations on fertiliser producers and oil refineries to procure Green Hydrogen to satisfy a percentage of their demand for hydrogen. It is understood, that the Green Hydrogen Consumption Obligation (***GHCO***) will commence in 2023 / 24, requiring the procurement of 0.15% of demand (by class of hydrogen user) for hydrogen, with the ***GHCO*** increasing to 10% over a six year period.

The use of a policy setting of this kind allows the supply side of the hydrogen economy to develop in a controlled way, achieving economies of scale, while at the same time not providing a price shock to the demand side. Further, the displacement of grey hydrogen production has immediate ***GHG*** emission reduction outcomes.

Indonesia - Proposed *Carbon Tax*:

On June 29, 2021, it was reported that the Government of Indonesia intends to introduce a carbon tax of around USD 5 per tonne of ***CO_2*** or ***CO_2-e***. The Nationally Determined Contribution of Indonesia is set to reduce ***GHG*** emissions by 29%, compared to the business as usual scenario, by 2030. To address the impact of COVID-19, the Government of Indonesia has had to reduce spending on net-zero and energy transition programs. In this context, the introduction of a carbon tax is fiscally prudent, and policy critical.

GoO on the move – Guarantee of Origin Schemes:

Edition 20 of Low Carbon Pulse reported on the discussion paper was released by the Federal Government in Australia, entitled "***A Hydrogen Guarantee of Origin scheme for Australia***". In the first week of July, 2021, Hydrogen Europe published, ***H2ero Net Zero – Different energy carriers required separate systems of guarantees of origin*** (***H2 GoO***).

The ***H2 GoO*** anticipates the review of the ***EU***'s ***Renewable Energy Directive***, and proposes that the existing GoO system should be re-worked to reflect five key principles: Traceability, Trackability, Tradability, Transparency and Trustworthiness. Key to the ***H2 GoO*** is distinct and separate GoOs for ***H_2*** derived from the use 100% renewable resources and from mixed resources, thereby providing transparency and avoiding confusion, including in respect of hydrogen produced from mixed electrical energy sources and blending of natural gas and hydrogen.

As noted in Edition 20 of Low Carbon Pulse, globally, an effective and accepted assurance scheme to certify the origin, and carbon intensity, of hydrogen and hydrogen-based fuel production is essential both for bi-lateral export contracts (to support the development of projects) and to facilitate the development of a market for hydrogen and hydrogen-based fuels, including ammonia and methanol.

Like minded giants:

On July 6, 2021, Shell Gas & Power Developments B.V (***Shell***) and Uniper Hydrogen GmbH (***Uniper***) announced that they had signed a memorandum of understanding (***MoU***) to explore how they may accelerate the development of the hydrogen economy in Europe, focusing on industrial demand and mobility demand.

It is reported that ***Shell*** and ***Uniper*** are going to work: "*backwards from [identified] customer demand to identify key opportunities to develop [supply] as the foundation of a new hydrogen economy in Europe*".

As noted in previous editions of Low Carbon Pulse, the development of supply and demand in tandem is key to the development of the hydrogen economy, with supply side needing to stay ahead of demand, so as to provide certainty of cost of supply and quantity of supply to enable demand side to develop, including to make key investment decisions to develop new infrastructure and acquire new assets (including fleets) to repurpose them.

As might be expected, the geographical focus of ***Shell*** and ***Uniper*** is going to be within the area from the Ports of Rotterdam and Wilhelmshaven to North Rhine Westphalia. As noted below (under ***Mighty Refhyne Electrolyser***), Shell's Energy and Chemicals Park Rhineland is located in this region, being the location of the first industrial scale PEM (polymer electrolyte membrane) electrolyser.

The ***Shell*** and ***Uniper*** initiative is good news, and it follows other good news involving the private sector leading the way across Europe to develop supply and demand in tandem, including the infrastructure necessary to produce, store and deliver hydrogen to the ultimate point of use.

More light than heat:

On July 6, 2021, the German Hydrogen Council released an action plan covering the period from 2021 to 2025. The action plan is aimed at facilitating the development of the hydrogen economy. The action plan is excellent, packed full of clear narratives and summaries, and clear recommendations arising from those summaries. The action plan will be reported upon in the July Report on Reports.

July 8, 2021, was the first anniversary of ***A hydrogen strategy for a climate neutral Europe*** (***EUH2S***). In the report on reports for July, progress in the first year of the ***EUH2S*** in respect of each Key Action will be considered.

More *GHG*, More Heat:

Edition 20 of Low Carbon Pulse, reported on the narrative that it is understood will emerge from the impending Intergovernmental Panel on Climate Change (***IPCC***), due in to be published. Key to the findings of the ***IPCC*** will be analysis of data from the Clouds and the Earth's Radiant Energy System (***CERES***) aboard NASA Earth-observation satellites: ***CERES*** data indicates the absorption of energy as sunlight and emission of that energy into space as infrared radiation – heat in, infrared radiation out - with the delta between the two being the energy imbalance. In a study of the ***CERES*** data from 2005 to 2019, it appears that energy imbalance has doubled in comparison to earlier years.

Energy Storage round-up (including *BESS*):

- ***BESS* to synchronise and stabilise:** For some time global mining giants have been considering how best to progress to ***NZE***, critically, how to generate electrical energy and deliver it across private grids (i.e., grids not connected to a regional or national interconnected grid) at remote mine sites using renewable sources. Iron ore mining giants, BHP, FMG and Rio Tinto, are all making progress.

  On July 2, 2021, it was announced that Rio Tinto is developing a 45 MW / 12 MWh ***BESS*** at its Tom Price iron ore mine in Western Australia: as will be deduced from 12 MWh of capacity, this ***BESS*** it is not a Big Battery, rather it is to be used as a "virtual synchronous machine" (***VSM***) to control and stabilize the electrical energy system (private grid) at Tom Price.

  While the ***BESS VSM*** at Tom Price is not the first ***VSM*** developed, it is the largest so far: others include Mt Newman (WA) (35 MW / 12 MWh) and Dalrymple North (SA) (30 MW / 8 MWh). It is reported that FMG is developing ***BESS VSMs*** for use on its Pilbara network.

  See: Rio Tinto *website*

- **Another Big Battery in Australia:** On July 5, 2021, it was announced that Maoneng Australia is to develop a 225 MW / 450 MWh utility scale battery at Gould Creek, South Australia, 20 kms south of the South Australia State Capital, and largest city, Adelaide (in the State of South Australia). It is intended that the Gould Creek Big Battery will be completed during 2023.

  See: Maoneng Australia Gould Creek ***BESS*** *website*

- **And another *BESS*, this time a stand-alone *BESS*:** On July, 2021, it was announced that TransGrid is to develop a ***BESS*** west of Melbourne, Victoria. The 300 MW ***BESS*** will be located at Deer Park, and will be used as an electrical energy storage source for metropolitan Melbourne. It is reported that financially the ***BESS*** is stand-alone in that it does not require any grant or other support initiative.

  See: TransGrid *website*

In a previous edition of Low Carbon Pulse, it was noted that Edition 21 would include a brief explanation of Compressed Air Energy Storage (***CAES***). The use of ***CAES*** is not new: in concept ***CAES*** involves the use of electrical energy at times of low or lower cost, and possibly no cost, to electrical energy, to compress air, and to pump that compressed air underground where it is stored. The compression of any gas gives rise to heat. On release of compressed air the energy released is used to drive a turbine to generate electrical energy. The extent of storage is a function of available sub-surface storage with the right geology, and as such the available capacity for ***CAES***. ***CAES*** is being considered in a number of contexts, and may be regarded as a possible alternative to ***BESS*** in some circumstances and settings. It has to be said, since the publication of the edition promising the brief explanation of ***CAES***, the proposed projects prompting the promise seem less likely to proceed – pressure, heat and markets.

BECCS / BECCUS and CCS / CCUS round-up:

- **Singapore seeks to deepen partnerships:** In Edition 20 of Low Carbon Pulse (under ***Singapore chilled about CCUS and hydrogen***) it was reported that key agencies in Singapore are considering the findings of two reports, one on CCUS, the other on hydrogen. On June 29, 2021, it was reported that those key agencies are looking to build on these findings. It is expected that the emphasis will be on seeking technology partners to capture ***GHG*** emissions arising from industrial, chemical and petrochemical processes, and the use of hydrogen and hydrogen-based fuels, to achieve low to lower, and in some cases, no, ***GHG*** emission outcomes. This is seen as important to contributing to the achievement of Singapore's enhanced Nationally Determined Contribution and Long-Term Low Emission Development Strategy, and the Singapore Green Plan 2030.

- **Equinor On Shore:** On June 29, 2021, it was announced that Equinor (leading global international energy company), plans to develop a CCS hub with US Steel (leading global steel manufacturer) in the Appalachian region of the US. For these purposes, it is reported that Equinor and US Steel have signed a memorandum of understanding (***MoU***) to explore, jointly, the potential of the development of CCU in the US States of Ohio, Pennsylvania and West Virginia. The ***MoU*** is reported to contemplate the use of natural gas to produce Blue Hydrogen. Hydrogen and hydrogen-based fuels can displace the use of fossil fuel or other carbon intensive energy carriers used in high-heat temperature production processes, including the production of steel.

  See: *U.S. Steel to Work with Equinor to Assess Hydrogen, Carbon Capture and Storage Development*

- **Petrofac and Storegga to fast track to net zero infrastructure:** On June 30, 2021, it was reported that Petrofac (leading service provider to the energy sector) and Storegga Geotechnologies (leading CCS technology corporation) entered into a Technical Delivery Alliance (***TDA***). Under the TDA, Petrofac will provide resources to allow Storegga Geotechnologies to accelerate its growing portfolio of lower, low and no carbon projects.

  For Storegga Geotechnologies, this continues progress. As noted in Edition 20 of Low Carbon Pulse, Storegga and Carbon Engineering are to develop a direct air capture (***DAC***) and storage (***DACS***) project likely to be located in North East, Scotland, close to renewable electrical energy sources so as to allow storage of captured CO_2 in sub-seabed structures. The ***DACS*** project is to be operational by 2026 and to capture up to 1 million metric tonnes per annum.

See: *Petrofac and Storegga enter strategic Alliance to fast-track net zero infrastructure*

- **Baker Hughes and Samsung move to capture:** On June 30, 2021, it was announced that Baker Hughes (leading energy technology company) and Samsung Engineering (leading engineering company) have combined "to capture" low to no emission projects, including CCUS and hydrogen production. As a team Baker Hughes and Samsung will work together to identify projects on which Baker Hughes' technologies and Samsung's engineering strengths will be leveraged.

  See: *Baker Hughes and Samsung Engineering to Collaborate on CCUS and Hydrogen Projects*

- **Pertamina looks to maximise and to capture:** On June 30, 2021, it was announced that Pertamina (with collaborators, Janus, JGC, J-Power and the Bandung Institute of Technology) is undertaking a feasibility study to assess CCUS and enhanced gas recovery (***EGR***, as a sibling of ***EOR***) at its on-shore Gundih gas field, in Central Java, Indonesia. The fundamental element of the proposed project is using ***CO_2*** to achieve ***EGR***, and for the ***CO_2*** stored to give rise to carbon credits.

  See: Pertamina *website*

- **Sinopec developing CCUS:** On July 5, 2021, China Petrochemical Corporation (***Sinopec***) announced the development of a CCUS project (reportedly the largest in the ***PRC***, megaton-scale). The project is to use the Sinopec Qilu-Shengli Oilfield for CCUS, taking ***CO_2*** arising and captured from Sinopec's Oil refinery, in Shandong province, and to inject that ***CO_2*** into 73 wells to the Qilu-Shengli Oilfield as part of an enhanced oil recovery (***EOR***). It is understood the ***Sinopec*** is considering the development of further CCUS projects.

  See: *Sinopec launches China's first megaton scale carbon capture project*

- **CCS + Initiative joined by "Big Plus":** Edition 20 of Low Carbon Pulse (under ***From North Lights Project a CCS + Initiative***) reported on the establishment of ***CCS + I***. On July 5, 2021, it was reported that the World Business Council for Sustainable Development (***WBCSD***) has joined the ***CCS + I*** advisory group.

  As reported in Edition 20, the objective of ***CCS + I*** is to leverage carbon markets, including through scaling-up decarbonisation and carbon dioxide removal. Given that the ***WBSCD*** is the umbrella organisation responsible for the Greenhouse Gas Protocol (***GHG Protocol***), the world's most widely used and accepted means of measuring and calculating ***GHG*** emissions, joining the ***CCS + I*** advisory group makes perfect sense, and may be expected to result in ongoing development of best practice measurement and calculation outcomes, which will feed into accounting and reporting outcomes.

  See: World Business Council for Sustainable Development *website*

- **Oaks and Acorn:** On July 9, 2021, it was reported that INEOS (UK based international conglomerate) and Petroineos (a joint venture between PetroChina International and INEOS) had entered into a memorandum of understanding with the equity participants in the ***Acorn Project*** (see Editions 14 and 17) for the provision of CCS services to INEOS and Petroineos.

  As is the case with many if not all CCS projects, investment is required by the corporations that are contracting with the CCS project for the provision of CCS services (***CCS service off-takers***) to enable those ***CCS service off-takers*** to develop infrastructure or install new equipment, or both, to capture carbon from their existing processing and production activities. This is the case for INEOS and Petroineos in respect of their Grangemouth operations: investment is required to enable the capture of ***CO_2*** (with the capture 1 million metric tonnes per annum of ***CO_2*** to occur by 2027, and scope to capture additional ***CO_2*** after this time).

  See: INEOS *website*

E-fuel / Future fuel round-up:

- **Equinor steps-in hydrogen production in UK:** On June 29, 2021, it was announced that Equinor (leading global international energy company), is to increase its hydrogen production targets from 0.6 GW to 1.8 GW by the addition of 1.2 GW of low-carbon hydrogen to supply Keadby Power Station, the world's first 100% hydrogen-fired power plant. See Edition 14 of Low Carbon Pulse for more background information.

  See: Equinor *website*

- **Empire State Building in Utah:** On June 30, 2021, it was reported that Utah's largest coal-fired power plant is to transition to a hydrogen-fired power plant (***the Intermountain Power Project*** or ***IPP***). Key to the transition is the storage of hydrogen in salt domes before being extracted to be oxidised to produce electrical energy. The scale of the storage contemplated is demonstrated by a graphic placing the Empire State Building within a salt dome.

  See: IPP *website*

- **Mighty *Refhyne Electrolyser*:** Edition 18 of Low Carbon Pulse reported on the development of a 10 MW PEM (polymer electrolyte membrane) electrolyser at Shell's Energy and Chemicals Park Rhineland, Cologne, Germany (***Refhyne Electrolyser***).

  On July 2, 2021, it was announced by Shell that the ***Refhyne Electrolyser*** had commenced production of Green Hydrogen. The ***Refhyne Electrolyser*** has capacity to produce up to 1,300 tpa of Green Hydrogen. It is planned to increase capacity to 100 MW by the end of 2024.

  The ***Refhyne Electrolyser*** is a PEM electrolyser manufactured by ITM Power (leading electrolyser technology corporation). Shell and ITM Power are part of the ***Refhyne*** Consortium, including SINTEF (one of Europe's largest energy research organisations), and consultants Sphera and Element Energy. The consortium was provided with funding from the ***EC*** (through the Fuel Cells and Hydrogen Joint Undertaking).

  In addition to Green Hydrogen, it is understood that there are plans to produce sustainable aviation fuel, and that a plant is in development to produce bio-LNG from biomass feedstock.

See: *Shell starts up Europe's largest PEM Green Hydrogen electrolyser*; *REFHYNE I - Building Europe's largest PEM electrolyser at the Shell oil refinery at Wesseling, Germany*

- **KHNP completes Fuel Cell Power Plant:** On July 5, 2021, it was reported that Korea Hydro and Nuclear Power had completed development of a 39.6 MW power plant at Dong-gu, South Korea. The power plant comprises 90 fuel cells (each a Doosan 440 kw design). Editions 12 and 17 reported on the development of ***FC*** projects to allow the production of electrical energy and heat in an industrial urbanised context.

  See: *KHNP completes 39.6MW hydrogen fuel cell power plant in South Korea*

- **Bio-energy – not all biomass is good biomass:** During the week beginning July 5, 2021, the Energy Transitions Commission (***ETC***) published a report entitled Bioresources within a Net-Zero Emissions Economy: Making a Sustainable Approach Possible.

  For those active in the bio-energy / bio-resources sector, the report provides a reminder of what is already known and that: "*while bioresources are in principle renewable, not all forms of biomass use are beneficial from an environmental perspective: not all biomass is good biomass. To be sustainable, biomass production should have low lifecycle **GHG** emissions, its production should take into account the 'opportunity cost' related to carbon that could be sequestered without intervention [i.e., if the biomass were to remain in situ], and must not compete with use of land for food production, trigger any land use change that could release carbon stocks into the atmosphere (especially deforestation) and negatively impact biodiversity*". The report is excellent, and will be covered in the July Report on Reports.

- **BioLNG best studied:** On July 5, 2021, it was reported that ***CMA CGM Group*** (leading global shipping and logistics company), ***EveRe*** (provider of the waste methanization technology) and ***TotalEnergies*** (leading global international energy company) are studying the development of a BioLNG production facility at the Port of Marseille using waste from households as a feedstock to produce liquefied biomethane (***BioLNG***). It appears that the intention is for ***CMA CGM Group*** to use the ***BioLNG*** to power its vessels. It is reported that: "BioLNG, combined with the dual-fuel gas engine technology developed by ***CMA CGM Group*** reduces greenhouse emissions (including carbon dioxide) by at least 67% relative to well-to-wake VLSFO [across the complete supply chain] … On the basis of tank-to-wake measurement (at vessel level), greenhouse gas emissions are reduced by 88%".

  See: *From Trash to Fuel: BioLNG Production Project Takes Shape in France*

- **Hydrogen economy developing in Egypt:** Edition 20 of Low Carbon Pulse reported that the Ministry of Electricity and Renewable Energy in Egypt is committed to sourcing 42% of total energy produced in Egypt from renewable sources by 2035. In addition, Egypt's Minister of Electricity and Renewable Energy, Mr Mohamed Shaker, announced that Egypt is planning to invest up to USD 4 billion in a Green Hydrogen Project (***EGHP***). While still at feasibility stage, it is understood that the project is likely to progress.

  On July 8, 2021, it was widely reported that Eni (leading global international energy company) has entered into an agreement with the Egyptian Electricity Holding Company (***EEHC***) and the Egyptian Natural Gas Holding Company (***EGAS***) to assess feasibility of the development of hydrogen production projects.

  It is understood that both Green Hydrogen production projects and Blue Hydrogen production projects are being considered, with ***CO_2*** arising from the production of Blue Hydrogen to be captured and stored in depleted natural gas fields. For Eni, the development of projects to produce Green and Blue Hydrogen is part of its strategy to achieve ***NZE***: as is the case for other international energy companies, Eni needs to reduce, and then remove, ***GHG*** emissions from the life-cycle of the energy carriers that it produces (Scopes 1, 2 and 3). For Egypt, this is a continuation of its strategy for progress to ***NZE***.

  Edition 20 of Low Carbon Pulse noted the key role that Italy (and Spain) were likely to play in the export of hydrogen from North Africa into Europe.

  See: *Eni signs an agreement to produce hydrogen in Egypt*

- **Self-fulfilling dynamics in UAE:** Edition 20 reported on the dynamics across the Gulf Cooperation Countries (***GCC***) in the Middle East. Edition 18 reported on four Blue and Green Hydrogen projects in Abu Dhabi, including a proposed Green Hydrogen Project at the Khalifa Industrial Zone Abu Dhabi (***KIZAD***).

  On July 7, 2021, it was reported that the Abu Dhabi National Energy Company (***TAQA***) and Abu Dhabi Ports are planning to develop a Green Hydrogen to Green Ammonia export project, the ***Abu Dhabi TAQA-Abu Dhabi Ports*** project. The planning is said to involve the installation of 2 GW of solar photovoltaic capacity to produce renewable electrical energy. The Green Ammonia produced would be used for bunkers at Abu Dhabi Ports and as the feedstock for the production of Green Ammonia for export.

  See: *TAQA Group and Abu Dhabi Ports Planning 2 GW Green Hydrogen to Ammonia Project*

- **Chile continues to speed up progress:** On July 07, 2021, it was announced that MAN Energy Solutions (***MANES***) is to supply a methanol reactor to allow the development of an E-Fuel pilot project being developed by the Highly Innovative Fuels consortium, led by AME (a corporation based in Chile), with participation from Porsche AG and Siemens Energy (***Haru Oni***). The project is located close to the evocatively named Punta Arenas, Magallanes, in Southern Chile. (***Haru Oni*** was approved by the Magallanes regional environmental agency on May 11, 2021.)

  The E-Fuels production project will use Green Hydrogen as a feedstock to produce synthetic fuels: the Green Hydrogen will be combined with ***CO_2*** captured / filtered from the air to produce Green Methanol in the ***MANES*** reactor. The plan is to scale-up production at ***Haru Oni*** from 130,000 litres a year by the end of 2022, 55,000,000 litres a year by 2024, and 550,000,000 litres a year by 2026. Porsche intends to use the synthetic E-Fuels.

  See: *MAN Energy Solutions to supply methanol reactor for Porsche AG eFuels pilot plant in Chile*

- **Common sense from Fitch, including a *KAS* pitch:** Edition 20 of Low Carbon Pulse included a narrative around the highly prospective, world-class resources that exist in the ***GCC***s (see under ***Black Gold and Blue and Green Gold***, and ***Oman's aim is true*** and ***New petroleum***), and continued above under ***Self-fulfilling dynamics in UAE***. On June 28, 2021, Fitch Solutions Country Risk & Industry Research published some themes that have emerged or are emerging.

  The publication covers 4.5 pages or so, but packs a fair punch, providing cogent perspectives and clarity around emerging themes. Building on one of the themes noted in recent editions of Low Carbon Pulse is viewing ***CO_2*** as a resource, and in this context looking to accelerate CCS / CCUS technology as having long term benefits.

  The publication provides real clarity in noting that in the context of the use of CCS:

  – for ***EOR*** (and ***EGR***): "*On a net basis, the overall CO_2 released both from production and consumption) is less, assuming the additional oil recovered would have been recovered and consumed regardless of the injection of CO_2*"; and

  – has one key challenge, and that is the need for favourable local geology, and that in this context emphasising the development of CCUS technology was critical so as to make use of CO_2 as a resource, and have the means of doing so.

  Continuing the theme around the role of ***GCC***s, in answer to a question about the role of Kingdom of Saudi Arabia (***KAS***) as a hydrogen and hydrogen-based fuel producer, the folk at Fitch provide the following pitch: " *… [KAS is] in a strong position to develop and to expand its hydrogen footprint. Its vast experience in the upstream sector along with consistent delivery of industrial and infrastructure projects gives [KAS] additional advantages in developing and operating Blue Hydrogen projects*".

- **More Green Hydrogen for the Green Isle:** Editions 18 and 20 of Low Carbon Pulse reported on the development of the ***EI-H2*** Green Hydrogen facility in Aghada, Co Cork, Ireland. On July 6, 2021, it was reported that ***EI-H2*** and ***Zenith Energy*** are planning to develop a 3.2 GW green energy facility at Bantry Bay (***GEF***) to produce Green Hydrogen and Green Ammonia. The ***GEF*** would be co-located with the Whiddy Island Terminal of Zenith Energy (which is within Bantry Bay, County Cork, Republic of Ireland). The ***GEF*** would be developed in two stages, first, a 2.7 GW Green Hydrogen facility, and secondly, a 500 MW Green Ammonia facility.

  See: *Zenith Energy and EI-H2 announce joint venture for green energy facility at Bantry Bay*

- **ADNOC continues advance**: On July 8, 2021, the Abu National Oil Company (***ADNOC***) announced that it had entered into a joint study agreement (***JSA***) with Japanese giants, INPEX, Japan Oil, Gas and Metals National Corporation, and JERA to explore the potential for the development of Blue Hydrogen and Blue Ammonia trade, and to explore possible new opportunities more broadly on climate change initiatives, including renewable energy projects.

  As noted above, and reported in Editions 5 and 18 of Low Carbon Pulse, ***ADNOC*** is one the key players in the development of hydrogen and hydrogen-based fuel market.

  See: *ADNOC and Three Japanese Companies to Explore Hydrogen and Blue Ammonia Opportunities*

Green Metals and Minerals, and the Mining Industry:

- In the last week of June, 2021, McKinsey & Co released two publications, one on mining, the other on use of negative ***GHG*** emission initiatives. Both publications are well-worth a read:

  – **Decarbonisation of mining:** In Edition 17 of Low Carbon Pulse (under ***Increased focus on the mining sector***), the decarbonisation of the mining industry was outlined. In an article entitled ***Creating the -zero carbon mine*** published on June 29, 2021, McKinsey & Company, Metals and Mining, provide an overview of the activities undertaken at mine sites, and the means of decarbonising them. The publication notes that BHP and Vale are targeting 30% reductions in Scope 1 and 2 emissions by 2030, with Rio Tinto targeting a 15% reduction, and that the means to the decarbonisation of mining activities (giving rise to Scope 1 and 2 emissions) will arise ahead of 2030. The greening of the iron and steel industry is noted as a positive development in respect of Scope 3 ***GHG*** emissions (see Edition 20 of Low Carbon Pulse, under ***First fossil fuel free iron and steel production***). See below under ***Rio Tinto and POSCO forge alliance to address Scope 3 emissions***.

  – **Negative *GHG* emission initiatives:** In Edition 9 of Low Carbon Pulse (under ***Negative GHG Emissions…not new, but higher profile likely***), the concept of negative ***GHG*** emission initiatives were outlined. On June 30, 2021, McKinsey, Sustainability, in a publication entitled ***How negative emissions can help organizations meet their climate goals***, provides a clear outline of how negative ***GHG*** emission initiatives can be used, and the required scale.

    Amongst other things, the publication outlines the three principal purposes for negative ***GHG*** emission initiatives: **1.** to off-set residual, hard-to-abate emissions (including from cement and iron and steel industries); **2.** to lessen atmospheric ***GHG*** emissions if ***GHG*** emission reductions do not occur quickly enough; and **3.** to remove historical ***GHG*** emissions from the atmosphere to provide long term assurance around a stable climate.

    To these three principal purposes might be added the net reduction of ***GHG*** emissions arising from the Agricultural, Forestry and other Land Use sector.

    As is the case with the number of pathways and scenarios around achievement of the Stretch Goal, McKinsey point out that it will be necessary to scale-up substantially negative ***GHG*** emission initiatives.

- **Rio Tinto and POSCO forge alliance to address Scope 3 emissions:** Edition 19 of Low Carbon Pulse reported on the use of natural gas in the calcination process inherent in much alumina refining, and how it may be replaced. Edition 20 of Low Carbon Pulse reported on Rio Tinto's study in respect of the use of hydrogen in alumina refining at its Yarwun refinery, Gladstone, Queensland, and that Rio Tinto and Schneider Electric have entered into an agreement for Schneider to purchase aluminium, borates, copper and iron ore mined and produced by Rio Tinto, using renewable electrical energy, and other low carbon technologies.

On July 8, 2021, it was reported that Rio Tinto (global mining giant, and leading iron ore producer) and POSCO (leading global and innovative South Korean steel producer) have entered into a memorandum of understanding (***MoU***) to develop, explore, demonstrate and deploy technologies to accelerate the transition of the iron and steel sector to lower, low and no carbon. Rio Tinto's Chief Commercial Officer, Mr Alf Barros, noted that "The [***MoU***] … complements Rio Tinto's partnerships with other customers as the industry focus" on Scope 3 emissions. For Rio Tinto, the ***MoU*** is a clear demonstration of its commitment to ***NZE*** (including in respect of Scope 3 emissions).

As noted in Edition 17 of Low Carbon Pulse (under ***Increased focus on the mining sector***) the mining sector is a quiet achiever.

See: *Rio Tinto and POSCO sign climate MOU*

Hydrogen Cities, Councils, Hubs, Infrastructure and Valleys:

- **TX to Power-to-X:** Recent editions of Low Carbon Pulse have reported on a number of proposed CCS / CCUS projects in Texas, and that the Gulf Coast Region is highly prospective for off-shore wind field development. In addition, TX has high quality on-shore renewable energy resources, and a considerable amount of built-infrastructure that might be augmented and repurposed over time. As such, it appears that TX will continue to develop as a hydrogen hub. In a report from the Center for Houston's Future and the University of Houston, these dynamics are considered. This is well-worth a read.
- **Gen2 Energy and Port of Hirtshals Hubub:** On 30 June, 2021, ***Gen2 Energy*** (a Norwegian corporation committed to the development of Green Hydrogen production and supply) and the Port of Hirtshals signed a memorandum of understanding to develop a Green Hydrogen hub in the Hirtshals region of Norway.

  The stated aim is to make the Port of Hirtshals a hub for ***Gen2 Energy***'s logistics activities and an export port for Green Hydrogen, and to supply Green Hydrogen and oxygen to users at, or in the vicinity of, the Port.

  See: *Gen2 Energy and Port of Hirtshals signs Memorandum of Understanding on Green Hydrogen*
- **Uniper and Eni exploration:** Edition 19 and 20 of Low Carbon Pulse outlined the scope of the development of infrastructure necessary to proceed with the carbon capture and storage project in Liverpool Bay using depleted natural gas fields operated by Eni UK Ltd.

  On June 30, 2021, Uniper and Eni UK Limited announced that they had signed an memorandum of understanding to allow exploration of opportunities on a joint basis for the production of low carbon hydrogen at the site of Connah's Quay Power Station in North Wales.

  As reported in Edition 19 of Low Carbon Pulse, Eni UK Limited owns and operates depleted fields in Liverpool Bay, suitable for CCS. Uniper owns Connah's Quay Power Station, which is reported to be ideally located for the production of low carbon hydrogen (using natural gas otherwise used to generate electrical energy).

  This may be regarded as a continuation of the broader decarbonisation initiatives underway in North Wales and the North West of England under the HyNet North West initiative. (see Edition 22 of Low Carbon Pulse)

  See: *Eni UK and Uniper partnering for the decarbonisation of the North Wales energy sector*
- **Everfuel and Greenstat evergreen:** On July 5, 2021, it was announced that Everfuel (see Edition 18 of Low Carbon Pulse) and Greenstat (energy and technology corporation based in Norway) have agreed to combine their efforts to develop hydrogen refuelling infrastructure projects across Norway (reported as 15 in the first instance) so as to accelerate the development of the use hydrogen as fuel.

  See: *Everfuel and Greenstat to collaborate on zero-emission mobility in Norway*; *Everfuel and Greenstat to collaborate on commercially competitive hydrogen supply for zero-emission mobility*
- **Polish Hydrogen Valleys:** While progress towards hydrogen valleys within Poland has been apparent for some time (with Hydrogen Valleys in Pomorze and Podkarpacie), for some reason the declaration establishing the Wielkpolska Hydrogen Valley appears to have captured broad attention, possibly because of the signatories to the declaration (including the region's largest cities and prestigious universities), as well as industry participants.

  See: *'Hydrogen' Valley under development in Wielkopolska region*
- **East Coast Cluster – Zero Carbon Humber and Net-Zero Teesside:** On July 9, 2021, it was widely reported that the Northern Endurance Partnership had made a submission to the UK Government seeking support for decarbonisation initiatives in the Humber and Teesside regions focussed around the Humber and Tees rivers on England's eastern seaboard. It is understood that the submission includes the deployment of CCUS and more broadly hydrogen technologies. (see Edition 22 of Low Carbon Pulse)

  See: Northern Endurance Partnership *website*

Sustainable Energy Round-up:

- **Denmark continues on shore procurement:** On June 28, 2021, the Danish Energy Agency (***DEA***) issued a technology neutral tender for the development by the private sector of a further 429 MW of renewable energy capacity. Proponents have until October 22, 2021, to submit proposals, with decisions on the procurement scheduled for the end of 2021. The successful proponents will be entitled to a feed-in premium (pegged to the wholesale price of electrical energy) for 20 years.

  See: *The Danish Energy Agency releases the time schedule and tender documents for the forthcoming Danish technology neutral tender*
- **Poland continues on-shore procurement:** On June 30, 2021, the Polish Energy Regulatory Office (***ERO***) announced the result of its solar and wind auctions held on June 8 and June 11, 2021. In the first and second auctions, around 1.2 GW and 1 GW of photovoltaic solar capacity was awarded. While around 300 MW of capacity

was set aside for on-shore wind projects, it would seem that the Polish market is developing using solar on-shore, and wind off-shore.

See: ERO *website*

- **Fortescue Metals Group (*FMG*) increasing the global pace:** On July 8, 2021, it was reported that Fortescue Future Industries Pty Ltd (***FFI***) had signed a memorandum of understanding with the State Government of Ceara to develop a Green Hydrogen Project within the Pecem Port complex and industrial precinct (***Pecem Project***). The USD 6 billion ***Pecem Project*** will produced up to 15 million metric tonnes per annum of Green Hydrogen.

  It is reported that the ***MoU*** is the fourth arrangement concluded by Ceara in respect of the Pecem Port complex and industrial precinct. ***FFI*** is a subsidiary of Fortescue Metals Group Limited, founded by Dr Andrew Forrest, AO.

  See: FMG *website*

Wind round-up:

- **Sailing in offshore Greece:** On June 29, 2021, it was announced that Copenhagen Infrastructure Partners (leading global renewable energy developer and investor), through CU New Markets Fund I and Mytilineos (major Greek conglomerate) and through its power and gas business, Protergia, are to develop off-shore wind projects off Greece.

  See: *MYTILINEOS partners with CIP for the development of offshore wind;* Copenhagen Infrastructure Partners website

- **Japan first floating off-shore wind field to progress:** Edition 20 of Low Carbon Pulse reported that the Ministry of Economy, Trade and Industry (***METI***) and Ministry of Land, Infrastructure and Tourism (***MLIT***) had appointed a consortium to develop the 16.8 MW floating off-shore wind field project, off Goto City, Nagasaki Prefecture. The consortium (called ***Goto City Offshore Wind Power Generation LLC***) comprises Chubu Electric Power, ENEOS Corporation, INPEX, Kansai Electric Power, Osaka Gas, and Toda Corporation (the leader of the consortium).

  On July 7, 2021, it was reported that ENEOS Corporation (a member of the ***Goto City Offshore Wind Power Generation LLC***, and the largest refiner, and largest distributor, of petroleum products in Japan) has signed a joint development agreement with BW Ideol (leading floating wind technology corporation) to develop a floating off-shore wind field project using BW Ideol technology.

  See: *ENEOS Signs Agreement with BW Ideol for Joint Development of Floating Offshore Wind Power Generation Project in Japan*

- **Polish sector of the Baltic Sea maintains heat:** Editions 8, 14, 18 and 20 of Low Carbon Pulse have reported on the development of off-shore wind-field projects in the Baltic, with the development underpinned by the use of contracts for differences (***CFDs***).

  On June 30, 2021, it was reported that Ocean Winds (a 50 / 50 joint venture between ***EDP Renewables*** (a Spain based renewable energy company) and Engie (world leading energy company)) had been awarded a ***CFD*** in respect of the 369.6 MW B&C-Wind off-shore wind field (***OWP***). The ***OWP*** is located around 21 kms off-shore.

  As with other off-shore wind field projects awarded ***CFDs***, the award of the ***CFD*** is a critical milestone in progress to a final investment decision for ***OWP***.

  This is the fourth ***CFD*** awarded in 2021 under the ***Polish Offshore Act*** (see Editions 8, 14 and 20 of Low Carbon Pulse). As noted in Edition 18 of Low Carbon Pulse, the award of ***CFD***s is seen as a key to enabling Poland to achieve its target of develop up to 10.9 GW of off-shore wind capacity by 2027: with auctions for 5.9 GW by the end of by 2021, with two further tranches to be auctioned by 2025 and 2027.

  See: *Ocean Winds, the 50/50 JV owned by EDPR and ENGIE, has been awarded a CfD for the `B&C-Wind´ offshore wind farm in Poland*

- **Ocean Wind and Atlantic Wind - Off-shore the Garden State:** Edition 20 of Low Carbon Pulse reported that the Bureau of Ocean Energy Management (***BOEM***) was to conduct an environmental review of the BP and Equinor Empire Wind off-shore wind field project off the coastlines of that US states of New Jersey (17 miles east of Long Branch) and New York (12 miles south of Long Island).

  On July 1, 2021, following a tender process run by the Board of Public Utilities, in New Jersey's second round of off-shore wind solicitation, it was announced that New Jersey had agreed to the development of around 2.66 GW off-shore wind field capacity:

  – **Ocean Wind II:** the Ocean Wind II (***OCII***) off-shore wind fields are to be developed by Ørsted (global leading off-shore wind corporation) and PSE&G (Public Service Electric and Gas, New Jersey's major power utility). The Ocean Wind fields are reported as to be sited to the east of Cape May, in the southern part of New Jersey. It is reported that the ***OCII*** off-shore wind-field project will be developed in three stages, starting in 2024, with completion to occur in 2028 and 2029; and

  – **Atlantic Shores:** a 1.5 GW project to be developed by EDF Renewables (a subsidiary of Electricite de France) and Shell New Energies (a division of the Royal Dutch Shell Group). It is reported that the Atlantic Shores off-shore wind-field will be developed in two stages, starting in 2024, with completion to occur in 2027 and 2028.

  As has been noted before in Low Carbon Pulse, among others, the off-shore areas of the east coast of the US are highly prospective, having the benefit of being close to load. The development of ***OCII*** and ***Atlantic Shores*** (at over 2.6 GW), together with Ocean Wind I (1.1 GW off-shore wind field project), means that New Jersey will be well-on the way to achieving its target of 7.5 GW of installed off-shore wind field capacity by 2035.

  It is reported that the consortia appointed to develop the off-shore wind field projects were the only bidders in the second round of the off-shore wind solicitation process.

  As noted in previous editions of Low Carbon Pulse, each project will need to be approved at a Federal level (as was the case for the Vineyard Wind 1 off-shore wind field project (see Editions 13 and 17 of Low Carbon Pulse)).

See: *Ørsted awarded 1,148 MW offshore wind contract in New Jersey, fully utilizing its Ocean Wind lease area*; *Atlantic Shores Offshore Wind Awarded N.J. Board of Public Utilities Contract to Develop 1,510 MW in Offshore Wind Energy, Largest Single Project in New Jersey*

- ***BOEM* starts COP on Vineyard Wind South:**

  As noted in previous editions of Low Carbon Pulse, including Edition 20 of Low Carbon Pulse in respect of Empire Wind, each project will need to be approved at a Federal level (as was the case for the Vineyard Wind 1 off-shore wind field project, see Edition 17 of Low Carbon Pulse).

  On June 28, 2021, it was reported that ***BOEM*** has started conducting a Construction and Operations Plan (***COP***) in respect of the proposed 2 GW to 2.3 GW capacity Vineyard Wind South off-shore wind field project (***VWS***). ***VWS*** is to be developed in stages off Rhode Island.

- **Off-shore wind, not the Maine game:** On July 2, 2021, it was reported that the US State of Maine had placed a moratorium on the development of off-shore wind fields within its state waters for 10 years: the moratorium is reported to be in place until March 1, 2021. The moratorium does not affect the development of off-shore wind fields in Federal waters, indeed the State is working with Aqua Ventus on a demonstration project using floating off-shore wind technology.

  See: *BOEM Announces Environmental Review of Wind Energy Project Proposed for Offshore Rhode Island and Massachusetts*

- **Giants with a following wind:** In 2020, India state-owned corporations, NTPC Limited (***NTPC***) (India's largest power generation company) and Oil and Natural Gas Corporation (***ONGC***), signed a memorandum of understanding contemplating the acceleration of renewable energy business development. At the end of June 2021, ***NTPC*** announced plans to raise funds to allow it to develop up to 60 GW of clean energy capacity by 2032. Key to achieving the business development objectives of both corporations is said to be the roll-out of an off-shore wind field program, critically using scale to realise higher efficiency levels than is possible with on-shore wind farms.

  The Ministry of New and Renewable Energy (***MNRE***) has set policy settings targeting the development of 5 GW of installed off-shore wind capacity by 2022, and 30 GW by 2030. It is reported that the coastlines off Andhra Pradesh (south-eastern coastal region of India), Gujarat (western coast of India), Karnataka (south-western India, with Arabinan Sea and Indian Ocean coastlines), Maharashtra (western coast of India) and Tamil Nadu (south coast of India) offer the most prospective off-shore wind resources.

- **Listing in the wind:** NTPC Limited's plans to develop its renewable energy business are estimated as likely to cost up to USD 35 billion. To assist in funding these costs, NTPC Limited intends to list its subsidiary, NTPC Renewable Energy Ltd during 2022. As India's largest power generation company (with the vast majority of electrical energy produced from coal-fired power stations), the scale and scope of NTPC Limited's plans are key to the decarbonisation of electrical energy generation in India.

  See: NTPC Limited *website*

- **Taiwan Teams for Two Wind Fields:** On July 6, 2021, Swancor Renewable Energy is reported to have partnered with Tien Li Offshore Wind Technology, Yeong Guan Energy and J&V Energy Technology to establish the ***Taiwan Team***. The ***Taiwan Team*** is to develop the Formosa 4 (fixed-bottom) and Formosa 5 (floating) off-shore wind fields. The establishment of the ***Taiwan Team*** means that the renewable electrical energy will be Taiwan made.

  See: *Swancor & Co. Set Up 'Taiwan Team' to Develop Two New Offshore Wind Farms*

- **BlueFloat Energy, Falck Renewables and Ørsted combine for ScotWind off-shore wind lease:** On July 8, 2021, it was reported that Ørsted (global renewable energy giant), BlueFloat Energy (pioneering off-shore wind field project corporation) and Falck Renewables (a leading renewable energy corporation based in Milan, Italy) have combined to bid in the SccotWind Leasing Scheme auction, with bids due on July 16, 2021.

  See: *Ørsted announces partnership with Falck Renewables and BlueFloat Energy to unlock floating wind potential in Scotland*

- **Swift off-shore wind mark:** On June 30, 2021, the Republic of Ireland National Marine Planning Framework (***NMPF***) was updated (see Edition 16 of Low Carbon Pulse), providing further detail of the plans to facilitate off-shore wind field development off the Republic. On July 8, 2021, it was reported that RWE (leading German international energy company) had announced its intention to develop a 900 MW off-shore wind field under the new Maritime Area Planning (***MAP***) following the establishment of ***MAP***.

  See: *RWE joins forces with Polish maritime industry to strengthen the offshore wind sector in Poland*

- **Off-shore wind-to-hydrogen:** On July 9, 2021, it was widely reported that the ***H-Wind Project*** is considering a development of off-shore wind fields off the Republic of Ireland: the Republic has world class off-shore wind resources, and the concept under consideration is the use of electrical energy derived from them for the purposes of the production of Green Hydrogen on a large scale at a number of hydrogen hubs.

  The ***H-Wind Project*** is being co-funded by the Science Foundation and the H-Wind Consortium. The H-Wind Consortium comprises Equinor (leading global international energy company) and Gas Networks Ireland (see Edition 14 of Low Carbon Pulse), Electricity Supply Board (***ESB***), and DP Energy (worldwide renewable energy company). The involvement of Gas Networks Ireland and ***ESB*** reflects that the ***H-Wind Project*** is consistent with ***EU*** policy settings encouraging the integration of energy systems.

- **World Largest On-shore Wind Farm Complete:** On July 9, 2021, SCMP (the South China Morning Post) reported that the 10 GW Jiuquan on-shore wind-farm (in the Gobi Desert, in the province of Gansu) had been completed. In the words of one local official, the completion of the project had turned: "the lifeless Gobi Desert into an unlimited chamber of treasure". To benefit from this "chamber of treasure", the provincial government is planning to expand the capacity of the wind-farm to 20 GW by 2025.

Solar round up:

- **Providence and Smartest combine for world first:** On June 6, 2021, it was announced that Marubeni Corporation (leading Japanese trading house) subsidiary SmartestEnergy (***Smartest***) has contracted with Providence Asset Group (***PAG***) to develop of 30 community-based solar photovoltaic solar farms in combination with ***BESS*** to allow Green Hydrogen production. Under the agreement between ***Smartest*** and ***PAG***, ***PAG*** will develop solar farms having 300 MW of installed capacity, generating up to 500 GWh a year. This is may be regarded as world first project, and is likely a model for the incremental development of Green Hydrogen supply.

  See: *New multi-year contract to deliver 500GWH of solar energy into the national electricity market;* Smartest *website*

- **Skies the limit:**
  - On July 2, 2021, it was reported that the Solar Energy Corporation of India (***SECI***) running procurement for 1.785 GW of solar photovoltaic projects in Rajasthan is over-subscribed by 9.3 GW. This is Tranche IV of the Rajasthan procurement process, with ***SECI*** 4.355 GW of installed capacity being procured across the Tranches.

    See: SECI *website*
  - Also on July 2, 2021, it was reported that NTPC Limited has gone to market seeking EPC contractors for 500 MW of grid-connected solar photovoltaic projects across India.

    See: NTPC Limited *website*

- **Solar in Burkina Faso:** On June 28, 2021 it was reported that the World Bank has agreed to support the Sustainable Renewables Risk Mitigation Initiative (***SRMI***) in Burkina Faso, West Africa: USD 168 million is committed, with USD 75 from the International Development Association (***IDA)*** and USD 93 million from the Clean Technology Fund (***CTF***). Among other things, it is reported that the funding support will be applied to develop Large Scale Solar and Rural Electrification, including in the context of an upcoming tender to procure solar photovoltaic capacity and ***BESS***. ***IRENA*** reported that as of 2020, Burkina Faso had 62 MW of installed solar photovoltaic capacity, with Axpo Group and Engie developing further solar photovoltaic capacity.

  See: *Scaled Up Support for Solar Energy Production and Rural Electrification in Burkina Faso*

Port News and Shipping Forecasts:

- **Wallenius and Alfa Laval combine:** In mid-2020, Wallenius Marine announced that it would develop a wind-powered vessel – Oceanbird. As reported, the dimensions of Oceanbird were world scale with capacity to carry 7,000 cars, and to cross the Atlantic in 12 days, at 10 knots. On June 30, 2021, it was announced that Wallenius and Alfa Laval have combined with the principal objective of developing a revolutionary wind power and propulsion system for the Oceanbird.

- **Maersk to methanol:** On July 1, 2021, Maersk announced that it had signed a shipbuilding contract with Hyundai Mipo Dockyards to build the world's first containership powered and propelled by carbon neutral methanol, with Maersk and Hyundai Mipo to work in collaboration. It is reported that the power and propulsion system is being developed by MAN Energy Solutions with Hyundai Engine and Machinery (the main engine) and Himsen (providing the auxiliary engine), and that the classification society will be American Bureau of Shipping.

  In February 2021, Maersk announced its intention to operate the first carbon neutral liner vessel by 2023, well-ahead of previous plans to do so by 2030, and consistent with having a carbon neutral fleet by 2050.

  See: *Maersk signs shipbuilding contract for world's first container vessel fueled by carbon neutral methanol*

Land Transport (automobiles, buses, trains and trucks) round-up:

- ***LOHC* for Trains:** As reported in previous editions of Low Carbon Pulse, battery technology (***BET***) and fuel cell (***FCT***) technology continues to be developed across the transport sector, including to power and propel trains. One if the issues with ***FCT*** is the source and carriage of hydrogen, whether in compressed or liquified form. Hydrogen can be carried in absorbed organic form in a Liquid Organic Hydrogen Carrier (***LOHC***): a ***LOHC*** absorbs hydrogen, hydrogen is then released when required. This means of carriage negates the need for compression or liquefaction, both of which are energy intensive, liquefaction in particular.

  Alstom's Coradia iLint train uses ***FCT*** and carries hydrogen in compressed gas form in tanks. Alstom's Coradia iLint train is being tested in a number of European countries, including most recently in Poland (being tested at the Railway Research Institute).

  On July 1, 2021, it was announced that Siemens Mobility is testing its Mireo Plus H train using ***LOHC*** technology, working with Helmholtz Institute Erlangen-Nuremburg. Many countries have high levels of electrification across their rail networks. High levels of electrification allow decarbonisation by the completion of electrification and development, and use, of renewable electrical energy, and on some part of the rail network to use ***BET*** or ***FCT*** or both. In countries with lower and low levels of electrification (in the US less than 1% of rail miles are electrified), it is likely that ***BET*** and ***FCT*** will be used.

  See: *Cooperation on the use of LOHC technology in rail transport planned*

- **On the high road and on overhead:**
  - **Sweden over our heads:** On July 1, 2021, it was announced that Sweden has progressed with its first overhead electrification system to power and to propel heavy good vehicles / trucks in hauling freight by road. As noted in Edition 19 of Low Carbon Pulse, logistics routes in many countries are known and understood, and in the context of use of ***FCT*** this will allow the location of hydrogen refuelling infrastructure and stations along those routes. Likewise, it is likely to make increasing sense to develop overhead electrification systems at the core of, and along, known logistics routes. The use of overhead electrification has been considered for some time, and while not as efficient as the use of electrified trains to haul freight, may be regarded as the next best thing.

- **Hyzon Motor Inc keeps trucking to deliver:**
  - On July 2, 2021, it was announced that Hyzon is to deliver a 150 tonne ***FCT*** powered and propelled heavy goods vehicle / truck (***HHT***) to an ***EU*** customer: the ***HHT*** is reported to have a range of 400 to 600 km, and has 480 kW (or 644 horse power).
  - On July 6, 2021, it was announced that Hyzon is to develop a liquid hydrogen ***FCT*** powered and propelled heavy goods vehicle / truck with a range of up to 1,000 km (***HPHDT*** or ***hydrogen-powered heavy-duty truck***). As reported in Edition 18 of Low Carbon Pulse (under ***Air Liquide to refuel Daimler trucks***), Daimler is working with Air Liquide to use liquified hydrogen gas.

  As noted in Edition 20 of Low Carbon Pulse, in addition to goods movers, Hyzon produces people movers, with Fortescue Metals Group (leading iron ore company founded by Dr Andrew Forrest, AO) having ordered up to 10 Hyzon coaches.

  See: *Hyzon Motors, Chart Industries to develop liquid hydrogen fuel cell-powered truck, targeting 1,000-mile range*

- **Hyundai finding a home in the US:** In August 2020, use of the Hyundai Xcient truck commenced in Switzerland. By the end of June 2021 the 46 trucks deployed to Switzerland had ticked (and tocked) to over 1,000,000 kilometres (621,500 miles) travelled. On July 2, 2021, it was announced that Hyundai is to turn its focus to the US market, and the design of a FCEV best suited for the US. The Hyundai Xcient is a rigid-body.

  See: *Fleet of Hyundai XCIENT Fuel Cell trucks surpass million-kilometre benchmark*

Carbon credits and Carbon off-sets, Insurance and Negative Emissions Initiatives:

- **Quote of 2021 (so far):** As has been reported previously in Low Carbon Pulse, the insurance and re-insurance industry is ceasing to provide insurance for some industries, and activities within those industries. In this context, Swiss Re has released a paper on ***The Insurance Rationale for Carbon Removal Solutions***. The paper is helpful in framing perspectives, but the most memorable part of the paper is the following:

  "The science is clear, the challenge is massive: Do our best, remove the rest! In other words: we all need to reduce, reduce, reduce, and in parallel start balancing the emissions through carbon removal"

  Senior Environmental Management Specialist, Corporate Real Estate and Services, Swiss Re – Mischa Repmann

In the fourth article in ***The Shift to Hydrogen (S2H2): Elemental Change*** series, the use of carbon credits and negative ***GHG*** emission initiatives (see Edition 9 of Low Carbon Pulse under ***Negative GHG Emissions … not new, but higher profile likely***) will be considered in the context of a broad analysis of the means and tools available to capture carbon and storage of it.

PROGRESS TOWARDS NET-ZERO EMISSIONS
JULY 27, 2021

Low Carbon Pulse - Edition 22

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to **Edition 22** of Low Carbon Pulse – sharing significant current news on progress towards net-zero emissions globally. This edition covers the period from Monday July 12, 2021 to Sunday July 25, 2021 (inclusive of each day).

Please click here for the previous edition of Low Carbon Pulse. Please also click here and here for the first two articles in the ***Shift to Hydrogen Series*** (***S2H2***)***: Elemental Change*** series: the *S2H2* series provides a narrative and perspective on hydrogen generally. Please **click** here for the first feature in the ***Hydrogen for Industry*** (***H24I***): the *H24I* features provide an industry by industry narrative and perspective.

Edition 22 will be posted again on **July 30 2021** to pick-up those reading later in the week. We will endeavour to publish the July Report on Reports in Edition 23.

The two weeks that were – reasons to be cheerful:

One of the joys of authoring Low Carbon Pulse is following both the connectedness of change, and the pace of change, in progress towards net-zero greenhouse gas (***GHG***) emissions (***NZE***). As readers of Low Carbon Pulse will have noticed, the length of the last few editions has increased, reflecting ever greater change. Over the last two weeks in particular, a new coherence has emerged, built on policy setting (existing and new), and the implementation of it, and the ever increasing level of activity of the private sector.

These dynamics are demonstrated clearly by the following:

1. the release of the ***Fit for 55*** package (providing a strong set of the policy settings for the European Union (***EU***));
2. the commencement of the operation of the ***PRC ETS*** - bringing over 4 giga metric tonnes (i.e., 4 billion metric tonnes) of ***CO_2*** emissions into the ***PRC ETS***, with a further 4 giga metric tonnes to follow in the near future; and
3. the close of applications for the ***ScotWind Leasing Scheme auction process*** that will add up to a further 10 GW of offshore wind capacity field around Scotland - noticeable for the identity and the number of participants in the process, and the ability for each of them to deliver projects and the benefits of them.

While recent editions of Low Carbon Pulse have been flagging these developments, each of them, in their different ways, mark material and significant progress towards ***NZE***, both in terms of action and in terms of coherence of the policy settings, as well as providing other jurisdictions and economic blocs with a clear range of levers to pull, and options to choose, to progress to ***NZE***.

The next three pages of this Edition 22 of Low Carbon Pulse provide an outline of these developments: the intention being to provide a sense of the pace, and range, of progress.

For those with the range of reference for new wave music, there is a certain synchronicity in the reference to **reasons to be cheerful** in the heading to this section: on July 20, 1979 (40 years, and week ago to the day) "Reasons to be cheerful, one, two, three" was released by Ian Dury. In this context, the author reflected on the passage of time: in the words of the Bard, "What is past, is prologue", we start from here, and in less than 30 years we have to achieve ***NZE***.

Fit for 55 fit for purpose:

Purposes of FF55 package: On July 14, 2021 (as promised), the European Commission (***EC***) published its Fit for 55 (***FF55***) package. The overarching purpose of the ***FF55*** package is to provide the policy settings that will enable the ***EU*** to achieve a reduction in ***GHG*** emissions of 55% by 2030, consistent with the European Climate Law. For these purposes, the ***EC*** has proposed that at least 40% (up from 32%) of total energy consumption be sourced from renewable sources by 2030 (in a ***Revised Energy Directive*** or ***RED***), and 49% for the building sector.

These revised policy settings are intended to promote: "*a more energy-efficient [including 9% less energy than currently projected] and circular energy system that facilitates renewables-based electrification … the use of low carbon fuels, including hydrogen, in sector [in which] electrification is not yet a feasible option*".

Whole of economy progress: These developments represent positive and bold policy setting, ensuring that action to decarbonise all sectors of the economy is taken, not just the electricity generation sector using renewable electrical energy. In light of the proposed new carbon market for building and transport proposed by ***FF55***, distinct and separate from the ***EU ETS***, now it is clear why modelling was appearing left, right and centre on the appropriate price point under the new carbon market, critically, the price point for the transport sector.

President of the ***EC***, Ms Ursula von der Leyen provided the headlines in saying: "*The fossil fuel economy has reached its limits. We want to leave the next generation a healthy planet as well as good jobs and growth that does not hurt our nature*." In the European Green Deal (***EGD***), the ***EU*** has the design and detailed drawings necessary to construct the road to ***NZE***. While not a surprise, ***FF55*** provides reason to be cheerful.

No surprises: As foreshadowed for a while (and as covered in Low Carbon Pulse for a while), the ***EC*** has gone beyond the ***EU*** in policy setting, in particular in the context of the ***Carbon Border Adjustment Mechanism*** (***CBAM***) (see Editions 12, 19, 20 and 21 of Low Carbon Pulse), and the extension of the ***EU*** Emissions Trading Scheme (***EU ETS***). See below for the implications of each of the ***CBAM*** (under ***Tax Reform proposed and CBAM arrives***) and the ***EU ETS*** (next paragraph).

Next steps: The ***FF55*** package proposed by the **EC** needs to be approved by the European Parliament (***EP***) and the ***EU*** Member States. If approved, the legislative framework will exist for the ***EU*** to allow implementation of policy settings consistent with the ***EGD***. Approval by the ***EP*** and ***EU*** Member States could take up to 24 months, but the **EC** hopes to finalise by 2022.

Not perfect: Apart from gripes from countries whose exports will be subject to ***CBAM*** and some more logical objections from the shipping industry about the extension of the ***EU ETS*** to the shipping industry (absent initiatives from the industry itself), the ***FF55*** package has received positive reactions, and is seen as a "mammoth package", for a "mammoth task", but it is not perfect.

The gripes from countries whose exports will be subject to ***CBAM*** are outlined below. In respect of the shipping industry, it is noted that the Maersk Mc-Kinney Moller Center for Zero Carbon Shipping has stated that: "*The [**EC's**] proposals to accelerate the decarbonisation of shipping is an important first step towards the introduction of Market Based Measures (**MBM**). As long as global consensus on [**MBM**] is not within reach, the [**EU**] should take the lead. In a parallel track, the **EU** and other maritime stakeholders should continue to encourage IMO regulation on global maritime **MBM**. Shipping is global by nature and needs global regulation to avoid multiple charges*."

Tax Reform proposed and *CBAM* arrives on time, intact, and fit for purpose:

- **Taxation reform proposed to drive low carbon use:** In the ***FF55*** package, the ***EC*** proposes the revision of the Energy Taxation Directive (***ETD***).

  Consistent with the aims of the policy setting generally, energy taxation will follow the two following principles: **1**. energy taxation should be based on the environmental impact of the fuels used; and **2**. taxes on cleaner fuels should be lower than taxes on more polluting fuels, with the most polluting fuels having the highest taxes.

  So as to level the playing field for these purposes, exemptions (using free emission allowances) will be removed on the use of kerosene as aviation fuel, and heavy fuel oil for ship bunkers, used by transport within the ***EU***.
- ***CBAM* arrives on time, intact, and fit for purpose:**
  - ***CBAM Flagged:*** As noted on Editions 12 and 19 of Low Carbon Pulse, the ***EC*** flagged the introduction of ***CBAM***, and the timing for its roll-out. ***CBAM*** (pronounced: "See? bam!" as promoted / reported in some newsfeeds) duly arrived on time, intact, and fit for purpose. There were no surprises.

    The rationale for ***CBAM*** is clear: as stated in Edition 12 of Low Carbon Pulse, to impose a carbon price for goods sourced from countries that do not have a carbon price, and as such do not have a policy setting that is intended to achieve decarbonisation, and affords producers of those goods a price advantage.
  - ***CBAM* – an imputation mechanism:** The imputation mechanism is to work on the following basis: importers into the ***EU*** must acquire carbon certificates in respect of goods for a price corresponding to a carbon price that would have applied had the goods imported into the ***EU*** been produced under ***EU*** carbon pricing.
  - ***CBAM* – WTO "watertight" preventing carbon leakage:** The ***EU*** has stated that ***CBAM*** has been developed and structured so as to be consistent with the rules of the World Trade Organisation, and other international obligations, so as to prevent carbon leakage (defined below).
  - ***CBAM*** has been criticised by some countries that will be affected by it, i.e., by countries that have not introduced a carbon price (whether under an Emissions Trading Scheme or ***Carbon Tax***), and as such producers in those countries have a price advantage over goods produced (and services supplied) in the ***EU*** that have to embody a carbon price. While the criticism cannot be ignored, it is important to note that the criticism does not hold water: unlike ***CBAM*** it is not watertight.

CARBON LEAKAGE
Carbon leakage is a phrase that is used to describe a situation in which a carbon price in one country may result in a shift in production of goods to another country (with a lower or no carbon price) with the result that there is an increase in total ***GHG*** emissions in respect of the production of goods. The risk of carbon leakage is higher in industries and sectors that are fossil fuel (and feedstock) intensive and other carbon intensive fuel (and feedstock) industries and sectors.

- **Impact of *CBAM*:** As noted below (under ***EC proposes changes to the EU ETS***) ***CBAM*** is to be introduced over time, and is to be applied to imports into the ***EU*** of goods and services (in the case of electricity) that have a high or higher risk of carbon leakage, being aluminium, cement, fertiliser and iron and steel (goods) and electricity generation (as a service) (***Carbon Leakage Goods and Services*** or ***CLGS***).

  Organisations importing ***CLGS*** into the ***EU*** will have to report on the "carbon embedded" in those ***CLGS**.* If the ***CLGS*** are produced using green technologies, that reporting will reveal this and ensure that producers producing ***CLGS*** with no embedded carbon will not have to acquire ***CBAM*** certificates corresponding to the carbon price that would have been paid had those ***CLGS*** been produced in the ***EU***. It is a neat system.
- **Reflections on *CBAM*:**
  - **Rhetoric does not help, from any side:** The arguments and protestations from countries without a carbon price are at best brittle. This is not a question of forcing the hand of any country without a carbon price to introduce a carbon price: plainly and simply, it is a policy setting that levels the playing field, and that ultimately will result in the reduction and removal of negative externalities, assuring improved trade outcomes. This is economics and policy setting, and in due course trade, working perfectly "in sync".
  - **As a policy setting *CBAM* makes sense:** The draft US Federal Budget contemplates the imposition of a tax on imports from countries that have not put in place policy settings that address achievement of ***NZE*** effectively: policy settings of this kind prevent carbon leakage, and are good for free-trade and as playing fields are levelled the true cost of production, reflected in market prices, will encourage more efficient and sustainable production – if green processes are used, no ***CBAM*** liability will arise.
  - ***CBAM* and world trade:** A number of countries have protested that policy settings of this kind are "just a new form of protectionism" in the sense of favouring producers in one bloc or country, over another: good politics in some countries, but not good policy. ***CBAM*** has been structured to comply with the obligations of the ***EU*** under the World Trade Organisation (***WTO***) Rules, and neither the broad structure, nor any of the more limited (as yet) detail, appears at risk of a meaningful, let alone a sustainable challenge.
  - ***CBAM* and environmental protection:** While ***CBAM*** is not protectionist in the context of world trade, it is protectionist in the sense of encouraging producers in non-***EU*** countries to green their production processes: the greening of processes should mean that ***CBAM*** will not apply to them because there will be no embedded carbon to price. It has to be said that this is one piece of detail that needs to be front and centre, and needs to be understood, because importers of goods and services (in the case of electricity) into the ***EU*** have to report on the emissions embedded in their goods and services; if green processes are used to produce those goods and services, that will be reported, and the ***CBAM*** should not apply.

How this all fits together as part of the European Green Deal:

Among the deluge of documents accompanying the ***FF55*** package was a document entitled ***European Green Deal -Delivering on our Targets***. This is a helpful document for those seeking to understand how all the policy settings come together as part of the overarching policy concept, the ***European Green Deal***. The "honeycomb graphic" on page 9 of the document is more helpful still.

ETSs* news – *PRC* and *EU

- **Commencement of trading on *PRC ETS*:** Edition 21 of Low Carbon Pulse reported that on July 7, 2021, at an executive meeting of the State Council, Chinese Premier, Mr Li Keqiang, announced that trading on the ***PRC ETS*** would commence for power generation during July 2021.

  On July 16, 2021, the ***PRC ETS*** commenced trading. This represents a significant development in progress to ***GHG NZE*** for the ***PRC***, and globally. Given the size of the ***PRC***'s economy, it gives rise to significant ***GHG*** emissions.

  As noted in previous editions of Low Carbon Pulse, initially the ***PRC ETS*** allows trading in quotas in respect of ***GHG*** emissions arising from the power generation sector (approximately 4 Giga metric tonnes per annum (***Gtmtpa***) (4 billion metric tonnes per annum)). In the first instance, trading is undertaken on the Shanghai Environment and Energy Exchange, with other trading platforms to be introduced over time.

  In time, quotas in other sectors will be traded. As the quotas in other sectors are traded, the ***PRC ETS*** will have tradeable quotas in respect of 8,100 ***Gtmtpa*** of ***GHG*** emissions, or around 1/6th of global ***GHG*** emissions, and a little under ¼ of global ***GHG*** emissions arising from energy production and use.

  The closing price for quotas on the first day of trading (on July 16, 2021) was reported as Y 51.23 (USD 7.72).

  While the commencement of the ***PRC ETS*** may be a little behind the original schedule, and the price of quotas may not match the prices for equivalent carbon emissions allowances / permits / quotas in other ***ETSs***, the ***PRC*** has made considerable progress over the last 18 months in putting in place policy settings, and implementing them. This level of progress, gives the author another reason to be cheerful.

- **EC proposes changes to the EU ETS:** As part of the ***FF55*** package, the ***EC*** has proposed the revision of the European Union Emissions Trading Scheme (***EU ETS***). In summary, the key proposed revisions are as follows:
  - **2021:** Increase the 2030 target from minus 41% to minus 61% compared to 2030 levels (***EU ETS reduction***): this increase to the ***EU ETS reduction*** is a function of increased annual reductions to 4.2% (the ***EU ETS Rebase***) and the inclusion of the aviation sector into the ***EU ETS*** by the removal of emission allowances for the sector, i.e., the removal of the aviation sector exemption.
  - **2023:** One-off reduction (***EU ETS Rebase***) in the cap on emissions under the ***EU ETS*** by 117 million allowances under the ***EU ETS***;
  - **2023 to 2026**:
    - **2023:** Importers of specified goods into the ***EU*** will have to report, without having to acquire ***CBAM*** certificates;
    - **2025:** Establish a new carbon market, separate from the ***EU ETS***, in respect of emissions from buildings (including heating) and transport.

      This new, and separate, market will regulate the suppliers of energy and fuel suppliers, rather than households and car drivers. A cap will be set from 2026, and will reduce annually to 43% in respect of reductions across each sector by 2030, compared to 2005;
    - **2026:** Introduction of ***CBAM*** certificates under the ***EU ETS*** to give effect to ***CBAM*** (see above); and
    - **2023 to 2026:** Shipping is to be added to the ***EU ETS***, commencing in 2023, and phased in over three years.

      The owners of ships will have to acquire certificates under the ***EU ETS*** to acquit the ***GHG*** emissions arising from trade within waters, and 50% of ***GHG*** emissions arising on voyages starting and ending at a sea-port located within the ***EU***. (See the FuelEU Maritime Initiative - the EU's initiative on increasing the use of sustainable alternative fuels in European shipping and ports.)

Deadline for applications for ScotWind passes:

Applications galore: As noted in the last few editions of Low Carbon Pulse, there was expected to be considerable activity ahead of the deadline for applications for ScotWind Leasing Scheme on July 16, 2021. And so it proved: on July 22, 2021, the BBC reported that "more than 70 bids have been lodged by developers seeking the rights to develop major off-shore wind projects … around Scotland". (It is understood that 74 applications were submitted.)

Scotland on track to achieve NEZ by 2045: The ScotWind Leasing Scheme places Scotland in the first rank of off-shore global jurisdictions. The development of off-shore wind field capacity under the Scheme will accelerate progress towards ***NZE***, which Scotland is committed to achieving by 2045. These dynamics are reflected in the number and the quality of the applicants for the lease areas being auctioned, and the plans accompanying them for on-shore investment and development, further progressing to ***NZE***.

Fifteen lease areas, 10 GW: The Crown Estate Scotland is running the auction process for 15 off-shore areas: Aberdeenshire (three areas - E1, 2 and 3), Argyll (W1), Moray Firth (five areas – NE 2, NE 3, NE 6, NE 5 and NE 7), Islay (N4), Lewis (N4), Orkney (three sites off the west of Orkney, into the outer Hebrides, N1, N2, and N3), Shetland (NE1). (Edition 8 of Low Carbon Pulse reported on the ScotWind Leasing Scheme auction process, noting that it reported that the total area of the 15 sites is 8,600 km^2 or 3,320 m^2.)

Director of Marine at Crown Estate Scotland, Mr Colin Palmer, is reported to have stated: "*The high number of applications from developers shows just how much potential Scotland's seas hold for the future expansion of off-shore wind*".

Some happy folk in the New Year: The names of the successful applicants in the ScotWind Leasing Scheme auction process are expected to be announced in early 2022. The attached link shows the ScotWind Leasing Scheme lease sites. If leases are awarded in respect of each area, this will result in the development of up to a further 10 GW of installed off-shore wind field capacity. Another reason to be cheerful.

Applicants for off-shore wind leases: As noted above, 74 for applications were received by The Crown Estate Scotland. It seems likely that this reflects the number of applications received for areas by all applicants (noting that some applicants are reported to have applied for more than one area). This number is significant.

Expectations were high for the ScotWind Leasing Scheme auction process. It is fair to say that the number of applications probably exceeded expectations.

Applicants are identified below, all from reported news feeds and websites. If we have missed out any applicant, apologies:

- **ScottishPower and Shell team up:** On July 16, 2021, ScottishPower (one of the two Scottish energy company giants) announced that it and Shell (leading global international energy company) had teamed-up to make multiple applications.

  As CEO of ScottishPower, Mr Keith Anderson noted: "*Scotland is the windiest country in Europe and has the biggest and most experienced off-shore sector … Shell's knowledge, experience and expertise – combined with our extensive and successful track record in renewables – is exactly what's needed to deliver the world's first large-scale floating [off-shore wind fields] right here in Scotland*".

  See: *Scottishpower and Shell Bid to Bring Large-scale Floating Windfarms to UK Waters*
- **SSE Renewables, Marubeni and Copenhagen Infrastructure Partners (CIP) team up:** On July 16, 2021, it was announced that SSE Renewables (a subsidiary of the other Scottish energy company giant, SSE plc, formerly named Scottish and Southern Energy plc), had teamed-up with Marubeni Corporation (leading Japanese trading house, and experienced energy industry investor and asset owner and operator), and CIP (leading global renewable energy developer and investor), and are reported to have made multiple applications.

See: *SSE Renewables-Marubeni-CIP Partnership Submit Bids to 10GW Scotwind Offshore Leasing Process*

- **ESB floating applications:** On July 21, 2021, it was reported that ESB (major utility corporation based in the Republic of Ireland), had made two applications, both to develop floating off-shore wind fields, with each floating development to install up to 1 GW of capacity.

  See: ESB *website*

- **Equinor seeks to expand in HyWind environment:** On July 19, 2021, Equinor (leading global international energy company) announced that it has submitted an application for one of the off-shore leases to develop a floating wind field. As reported in Edition 13 of Low Carbon Pulse, Equinor is well-credentialed, having develop the highly efficient ***HyWind*** off-shore floating wind project off the coast of Scotland.

  See: *Equinor ready to further develop floating offshore wind in Scotland*

- **Magnora Offshore Wind submits applications:** On July 19, 2021, Magnora Offshore Wind (a joint venture between Magnora and TechnipFMC), announced that it had submitted two applications in the ScotWind Leasing Scheme auction process.

  See: *Magnora Offshore Wind, a Norwegian offshore wind developer, today announces intent to participate in the upcoming ScotWind leasing round*

- **Next Generation Off-shore Wind (NextGen)**: On July 20, 2021, it was widely reported that NextGen had participated in the ScotWind Leading Scheme auction process. As reported, NextGen is led by Maple Power (a 50:50 joint venture between the Canada Pension Plan Investment Board and Enbridge), Parkwind and Quaybridge Scotland, and comprises heavy-weight players BlackRock Real Assets and Sumitomo Corporation.

  See: *NextGen Consortium targets ScotWind success*

- **RWE:** On July 16, 2021, RWE (Germain energy giant, and leader in renewable energy, including off-shore wind field development in the North Sea) confirmed its participation in the ScotWind Leasing Scheme auction process. As a reminder, RWE was successful in applications for two leases as part of the Crown Estate and UK Treasury auction process (auctioning leases off the coast of England) announced on February 8, 2021.

  See: *RWE confirms participation in ScotWind*

As reported in previous editions of Low Carbon Pulse the following planned to make (and to our understanding made) applications:

- **BP and EnBw** (see Edition 9 of Low Carbon Pulse), have applied for an area off the east coast of Scotland (with 2.9 GW of modelled capacity), with the renewable electrical energy to be used to supply renewable electrical energy direct, and to provide renewable electrical energy to produce Green Hydrogen. As reported, the BP / EnBw application contemplated both the off-shore wind development and transformative on-shore developments. As a reminder, BP and EnBw were successful in applications for two leases as part of the Crown Estate and UK Treasury auction process announced on February 8, 2021.

  See: *bp and partner EnBW submit transformational bid for ScotWind lease*

- **Eni Rock:** Eni (leading global international energy company) and Red Rock Power Limited (Edinburgh, Scotland, based developer of energy projects) are reported to have established a 50:50 joint venture to participate in the ScotWind Leasing Scheme auction process, working with Transmission Investment. This consortium is understood to have made applications for a number of areas.

  See: *Red Rock Power and Eni partner up for Scotwind*

- **Partners GIG and TE, combine with RIDG:** As foreshadowed in previous editions of Low Carbon Pulse, Green Investment Group (***GIG***, and global leading renewable energy group), TotalEnergies (leading global international energy corporation) and Renewable Infrastructure Development Group (RIDG, Scotland based off-shore wind field developer), made applications through Offshore Wind Power Ltd (***OWPL***).

  GIG and TotalEnergies have invested heavily in off-shore projects around the UK, and globally. As a reminder, ***GIG*** and TotalEnergies were successful in respect of one lease as part of the Crown Estate and UK Treasury auction process announced on February 8, 2021.

  See: *TotalEnergies, GIG and RIDG join forces for Scottish offshore wind bid*; *TotalEnergies, Green Investment Group and RIDG join forces for Scottish offshore wind bid*; *TotalEnergies, Green Investment Group and RIDG join forces for Scottish offshore wind bid*

- **Ocean Winds:** Ocean Winds, the EDP Renewables and Engie 50:50 joint venture, is understood to have made five applications, for both fixed bottom and for floating off-shore wind developments, with three applications made in conjunction with Aker Offshore Wind.

  See: *OW and Aker Combine Experience and Heritage in ScotWind Bid*

  EDP Renewables and Engie work together on off-shore projects: Ocean Winds's 950 MW Moray East off-shore wind field development is currently under construction. Elsewhere, as Edition 21 of Low Carbon Pulse reported, Ocean Winds was recently awarded a contract for differences in respect of the B&C-Wind off-shore wind field in the Baltic Sea off the coast of Poland.

- **Ørsted, BlueFloat Energy, and Falck Renewables:** Edition 21 of Low Carbon Pulse reported on the plans of Ørsted, BlueFloat Energy, and Falck Renewables to make applications in the ScotWind Leasing Scheme auction process. It is understood that applications were made.

  See: *Ørsted announces partnership with Falck Renewables and BlueFloat Energy to unlock floating wind potential in Scotland*

- **Vattenfall and Fred Olsen**: In June 2021, Vattenfall (Sweden based international energy corporation) and Fred Olsen Renewables (wholly owned subsidiary of Bonheur ASA) announced the formation of a 50:50 joint venture to apply for leases in the ScotWind Leasing Scheme.

See: [Vattenfall partners with Fred. Olsen Renewables for ScotWind offshore leasing bid]

Reports and report on reports:

As previously noted, to manage the length of Low Carbon Pulse, rather than commenting on all reports and publications in each edition, links to them are included in the text and at the end of each edition. Short summaries of the reports and publications will then be developed every month or so, and published either as an appendix to Low Carbon Pulse or in a stand-alone publication.

- ***EU* regulators joined up:** On July 16, 2021, the ***EU*** Agency for the Cooperation of Energy Regulators (***ACER***) published a study outlining the two likely options for the haulage of hydrogen through pipelines (***ACRS***). As has been noted in Low Carbon Pulse (including in Edition 21 of Low Carbon Pulse), the development of assured hydrogen supply needs to contemplate the development of storage capacity for hydrogen. The ***ACRS*** recognises this need, identifying sub-surface sites suitable for storage.
- ***IEA* sustainable rate of reports:**

  On July 20, 2021, the International Energy Agency (***IEA***) published its flagship report ***Sustainable Recovery Tracker – Monitoring progress towards sustainable recoveries from the Covid-19 crisis (SRT)***. In 2020, the ***IEA*** developed, in collaboration with the International Monetary Fund (***IMF***) a ***Sustainable Recovery Plan*** (***SRP***). The ***SRT*** measures progress against the ***SRP***. As might be expected, there have been challenges, as countries have diverted scarce funding to address COVID.

The last couple of weeks in the in UK:

On July 14, 2021, the Department for Transport in the UK has released the Transport Decarbonation Plan (entitled ***Decarbonising Transport – A Better, Greener Britain***) outlining the policy settings and other initiatives to ensure that the UK transport sector (aviation, rail and road (cars and trucks)) achieves ***NZE*** by 2050.

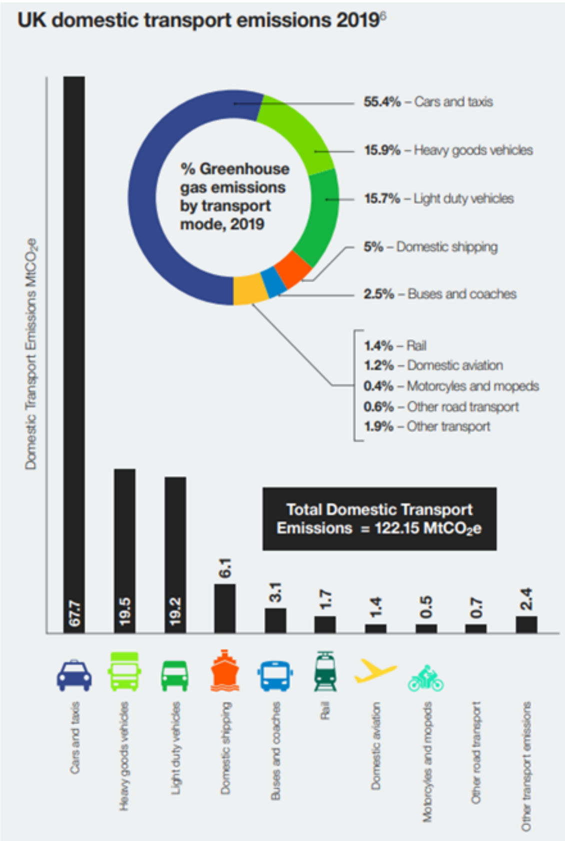
As will be apparent from the bar chart to the left below, the modes of road transportation are those that require the more intensive levels of decarbonisation to enable the UK to achieve ***NZE*** across the transport sector.

The decarbonisation of Bus and Coach and Rail transportation is likely to prove most achievable (both in terms of the scale of the task, and the existing highly developed policy settings, including the National Bus Strategy, and NetworkRail's Traction Decarbonisation Network Strategy (***TDNS***)).

The decarbonisation of the Domestic Shipping and Domestic Aviation sector may be regarded as likely to take longer, because perceived as more difficult (being reliant on the development of new bunkers and synthetic fuels, and power and propulsion systems), but the ***TDP*** acknowledges this perception, and is seeking to accelerate decarbonisation.

The ***TDP*** provides a helpful summary of existing policy settings and commitments across the transport sector.

Part 2(a) of the ***TDP*** provides a summary of the commitments and a description of what needs to be done to achieve ***NZE*** across the transport sector, and benefits of doing so. **Part 2(b)**, entitled ***Multi-modal decarbonisation and key enablers***, provides a framework, remaining to be developed fully, to allow decarbonisation, and outlines what will enable decarbonisation.



The report on reports for July will include more key facts and statistics from the ***TDP***.

Recent editions of the Low Carbon Pulse have noted that during the third full week of July 2021, the UK Government was expected to release its Hydrogen Strategy (***UKH2S***), and that ahead of this release, the All-Party Parliamentary Group (***APPG***) released a report urging the UK Government to set ambitious targets both under the ***UKH2S***.

All indications are that the publication of the ***UKH2S*** has been delayed. The Ashurst Global Towards Net Zero team will publish a flyer soon after the ***UKH2S*** is published, likely in the UK autumn / fall.

[**Note:** The ***UKH2S*** was published on August 17, 2021, and is covered in Edition 25 of Low Carbon Pulse.]

Royal Dutch Shell appealing:

Edition 18 of Low Carbon Pulse reported on the decision of the District Court in The Hague, the Netherlands on May 26, 2021. The effect the decision was to require Royal Dutch Shell plc (***RDS***) to reduce the net CO_2 emissions of the ***RDS*** Group by at least 45% by 2030, compared to 2019.

In context of the decision by ***RDS*** to appeal, the CEO of Royal Dutch Shell, Mr Ben van Beurden, is reported to have stated that "*urgent action is needed*" to reduce carbon emissions, but ***RDS*** will appeal "*because a court judgment, against a single company, is not effective*".

From the perspective of effective and coherent policy setting this has to be right. More than this, the logic expressed by Mr van Beurden may be regarded as both right and as unassailable. As the author of Low Carbon Pulse has written in an article, entitled ***Realising Reserves and Realising Capital***, "Ultimately governments must ensure that all corporations act in a way that is consistent with the Paris Agreement. This requires countries to legislate rather than to leave existential policy settings to the courts to determine".

As CEO of BlackRock, Mr Larry Fink is reported to have said back in May 2021 when the ***RDS*** decision was handed down: "*It is not about running away from the current hydrocarbon companies, it's working with them as they navigate the move forward*".

Hydrogen Council News:

- **Hydrogen Council membership continues to increase:** On July 12, 2021, it was widely reported that membership of the ***Hydrogen Council*** continues to increase, with 123 organisations now members, including on July 13, 2021, the addition of notable NOC, ADNOC. (The ***Hydrogen Council*** was established by the ***World Economic Forum*** in 2017.)
- **Hydrogen Council and McKinsey on the money, again:** Edition 10 of Low Carbon Pulse reported on the first ***Hydrogen Council*** and McKinsey & Co report, dated February 17th, 2021 (***February Report***). On July 15, 2021, the ***Hydrogen Council*** and McKinsey & Co published their second report (***July Report***).

  While there are many indicators of the speed of progress, reflecting on the five months between Reports, the ***July Report*** provides a real sense of acceleration and the scale of it since the ***February Report***. For once, the numbers proclaim: pace and scale of change!

HIGH LEVEL COMPARISON, FEBRUARY TO JULY			
Large Scale Projects (February)	230	Large Scale Projects (July)	359
Total Investment Amount (Feb)	USD 300 billion	Total Investment Amount (July)	USD 500 billion
30% of Total Investment Amount was firm at USD 80 billion		30% of Total Investment Amount is firm, at USD 150 billion	

  Key quotes in context:

  – **Mr Tom Lineberger**, CEO of Cummins and Co-chair of the Hydrogen Council: "*… 80% of the world's GDP is now located in countries that have [ambition to achieve] net-zero [emissions], up from 50% at the beginning of 2021. This is another turning point for hydrogen, the energy transition, and a clean energy future*".

  – **Mr Benoît Poitier**, CEO of Air Liquide and Co-chair of the Hydrogen Council: "*The momentum is now global. It is clear that hydrogen has become a central element of investment plans by many countries towards carbon neutrality it. While Europe remains a strong contributor, with 80% of new announced projects, other regions are stepping up, with an impressive number of hydrogen projects currently in the pipeline around the world*".

- **Just in case you missed first time around:** McKinsey & Co released two publications, one on mining, the other on use of negative ***GHG*** emission initiatives in late June, 2021. Both publications are well-worth a read: ***Creating the zero-carbon mine*** published on June 29, 2021, McKinsey & Company, Metals and Mining, providing an overview of the activities undertaken at mine sites, and the means of decarbonising them, and ***How negative emissions can help organizations meet their climate goals*** published on June 30, 2021, McKinsey, Sustainability, providing an outline use of negative ***GHG*** emission initiatives, and their required scale.

Free markets will respond to policy settings, but do not set policy:

- **Policy setting a prerequisite:** On July 17, 2021, The Guardian reported on wise words from Mr Mark Carney, the former governor of the Bank of England.

  Mr Carney, now a United Nations envoy on Climate Change, and finance adviser to the UK Government of climate change said: "*We need clear, credible and predictable regulation [covering] … air quality rules, building codes, that type of strong regulation is needed. [If you] have strong regulation for the future, then the financial market will start investing today, for the future. Because that's what markets do, they always look forward … It [won't] happen spontaneously by the financial sector … but we can't get there without the financial sector*".

  Mr Carney's perspective is to be welcomed, and, it is, hoped acted upon – policy settings are required.

  Mr Carney, in leading the Taskforce for Scaling Voluntary Carbon Markets, has recently shared thoughts on ***carbon neutral*** and ***net-zero emissions***. As noted in previous editions of Low Carbon Pulse, there is a difference, and this difference is coming into ever sharper focus, as organisations recognise that achieving ***GHG*** net-zero emissions across Scope 1, 2 and 3 is challenging, and some have taken to promoting the concept of "***carbon neutral***" (in respect of Scopes 1 and 2), and "***carbon natural*** (in respect of Scope 1 and 2) on a path to ***net-zero emissions*** (in respect of Scope 3)", with Scope 3 commitments being matched by use of carbon offsets, typically, referred to "***avoided emissions offsets***".

  Mr Carney is reported to have said that: "*There is a difference between carbon neutrality and net zero. The company should be compensating for its emissions on that pathway to net zero as well*".

- **Debating carbon neutral versus net zero:** The debate around the promotion of the concept of "***carbon neutral***" in contrast to "***net zero emissions***" is focussed on there being a difference between these familiar, and similar, terms, and ensuring that the difference is understood. This requires clarity around the use of the terms, to ensure that terminology does not get in the way of good policy setting, and implementation.

  While the debate around use of the terms may be regarded as of interest, the bigger issue is ensuring, whatever term is used, that the decarbonisation of activities occurs over time, such that carbon offsets, if used, work, and, over time, are used as a tool to bridge, what is it hoped will be, an ever narrowing gap between decarbonised activities and activities remaining to be decarbonised.

This of course, leads to the existential debate around decarbonisation being the only way to achieve sustainable slowdown in, and cessation of, the release of ***GHG*** emissions into the atmosphere. This debate appears to be developing, and is becoming ever more informed, critically by data.

- **Patience is a virtue, and patient capital has virtue:** On July 15, 2021, a World Economic Forum (***WEF***) publication was released entitled ***In emerging markets, patience is a virtue in the race to net zero***.

  The publication notes that South Asia, South East Asia and Sub-Saharan Africa have some of the lowest historic ***GHG*** emissions per person. In these areas of the world, the ***WEF*** notes that ***patient capital*** is required, provided by both the public and private sector, so as to ensure an "equitable transition to global net zero".

  In the context of an "equitable transition to global net zero", the ***WEF*** notes that capital is required to leap-frog "fossil fuels and combustion engines" to allow continued population growth and urbanisation without a concomitant increased in ***GHG*** emissions.

  For a more detailed assessment on some of the issues relevant to the ***WEF*** narrative, see ***The Geographic disparity of historical greenhouse emissions and projected climate change*** published in Science Advances on July 14, 2021.

  Both the ***WEF*** publication and the ***Science Advance*** article provide considerable food for thought.

Energy efficiency, Electrification and Renewable Energy not enough:

- **Consistent means and continuing themes:** Various editions of Low Carbon Pulse have reported on ***Net Zero by 2050 – A Roadmap for Global Energy Sector*** (***IEA Roadmap***) published by the ***IEA***, and ***World Energy Transitions Outlook*** (***WETO***) published by the International Renewable Energy Agency (***IRENA***).

  Both the ***IEA Roadmap*** and the ***WETO*** describe means to achieve ***NZE*** and in doing so conclude that achieving ***NZE*** is not possible, in any scenario, by relying solely on improving electrical energy efficiency and maximising electrification and renewable electrical energy development. Rather, other means are required, and they are required promptly. This was a developing orthodoxy before the ***IEA Roadmap*** and ***WETO***, and it is now firmly established.

- **By way of a memory jogger:** The ***IEA Roadmap*** outlines ***seven pillars***, the ***WETO*** outlines ***six pillars***, to support progress towards achieving ***NZE***.

***IEA ROADMAP* AND *WETO* – SIX AND SEVEN PILLARS**	
IEA Roadmap	The seven pillars of the ***IEA Roadmap*** are: **1.** Energy efficiency; **2.** Behavioural change; **3.** Electrification; **4.** Renewables; **5.** Hydrogen and hydrogen-based fuels; **6.** Bioenergy and land use change; and **7.** Carbon capture, utilisation and storage.
WETO	The six pillars of the ***WETO*** are: **1.** Energy Conservation and efficiency; **2.** Renewables (power and direct uses); **3.** Electrification of end use (direct); **4.** Hydrogen and its derivatives; **5.** CCS and CCUS in industry; and **6.** BECCS and other carbon removal measures.

  The seventh pillar under the ***IEA Roadmap*** is ***Carbon capture, utilisation and storage***, and one of the three key uncertainties is ***CCUS applied to emissions from fossil fuels***. The seventh pillar of the ***IEA Roadmap*** is ***Bioenergy***, and one of the three uncertainties is ***Bioenergy and land use change***. (The third uncertainty is ***Behavioural Change***.)

- **Wood for the trees:** In a recent Wood Mackenzie publication (***WMP***), dated July 9, 2021 (that did not come to the attention of the author until after the publication of Edition 21 of Low Carbon Pulse), CCS / CCUS is considered in the context of progress to achievement of ***NZE*** by 2050.

  The ***WMP*** echoes the ***IEA Roadmap*** and ***WETO***: "*Renewables alone can't resolve the net zero emissions challenge. We have to think in terms of carbon avoidance and carbon removal*".

  The ***WMP*** estimates an increase in CCS / CCUS use capacity from 56 million metric tonnes per annum (***mmtpa***) (across all forms of carbon capture in 2021) to between 4 ***Gtpa*** and 8 ***Gtpa*** by 2050: in a world of coincidences, the scale of the required CCS / CCUS matches the mass of ***CO_2*** to be subject to the ***PRC ETS***).

  If this level of CCS / CCUS is achieved, certainly towards the upper-end of the estimate, one of the key uncertainties identified in the ***IEA Roadmap*** (and echoed in the ***WETO***), or rather the consequences of not achieving the level of CCS / CCUS, will be avoided.

  The ***WMP*** emphasises the importance of the relationship between development of CCS / CCUS and a carbon price. The best estimates for a carbon price are USD 90 pt of ***CO_2***, for iron and steel up to USD 120 per tonne of ***CO_2***, and for cement up to USD 200 per tonne of ***CO_2***. As ever, the issue is whether carbon prices will result in outcomes other than the use of CCS / CCUS.

  In addition, and picking up the theme of Mr Carney (under ***Policy setting a prerequisite*** above), there are roles for Government in the development of CCS / CCUS, going beyond policy settings intended to achieve carbon prices at stated levels. Government has a role in the development of CCS / CCUS facilities itself, and to subsidise the use of CCS / CCUS, whether developed by the government or the private sector. In the Netherlands for example, subsidies are being used to support the development of carbon capture capability by industrial businesses, and the storage of that carbon (see Edition 17 of Low Carbon Pulse).

BloombergNEF releases *NEO* – current level of electrification not enough:

On July 21, 2021, BloombergyNEF published the ***New Energy Outlook, 2021*** (***NEO***). The ***NEO*** provides another perspective on achieving ***NZE*** by 2050, placing it in the context of the carbon budget that is available before reaching a ***2°C*** increase in average global temperatures compared to pre-industrial times.

The ***NEO*** notes that based on current trends, the world is on track to exceed its carbon budget, and the ***2°C*** increase in average global temperatures, by 2044.

Neither the ***IEA Roadmap*** nor the ***WETO*** (nor for that matter the ***WMP***) provide this perspective, and, as a perspective, it certainly provides the right perspective: i.e., climate change is upon us, increased action is required. [**Note:** As will be apparent from the narrative above about the ***IEA Roadmap*** and ***WETO***, the focus in ***NEO*** is on the decarbonisation of the energy sector, producing around 75% of ***GHG*** emissions annually.]

While difficult to do the ***NEO*** justice in summary form, the following may be regarded as key takeaways [**Note:** The graphics in the ***NEO*** are copy-righted, and as such we have referred to them, not reproduced them below]:

1. the carbon budget for each sector and industry is identified, as is the required rate of reduction for each sector (see graph on page 4 of the executive summary).
2. the years between now and 2030 are critical to the achievement of ***NZE***: the world needs to get back on track, and for this purpose there needs to be "an immediate, unprecedented acceleration in deployment of existing technologies, such as renewable energy and electric vehicles" at the same time as innovation and deployment of developing technologies;
3. the decarbonisation of the energy sector is key, and part and parcel of this is developing renewable electrical energy for both direct and indirect use, and the need to accelerate this before 2030 (see graph on page 5 of the executive summary); and
4. the scale of the deployment of renewable electrical energy required by 2050 is outlined under ***three scenarios***: ***Greens***, ***Gray*** and ***Red***. The scale of the deployment of renewable electrical energy has been a matter around which a few folk have now done the calculations: see the graphics on pages 3 (helpful) and 7 (compelling) of the executive summary.

Another finding in the ***NEO*** is that the shipping industry should transition to the use of ammonia. As noted in previous editions of Low Carbon Pulse (and this Edition 22), ammonia is one of a number of fuels being considered by the shipping industry (see below under ***Port News and Shipping Forecasts – Why methanol?***).

Empowering Cities for a Net Zero Future:

On July 22, 2021, the International Energy Agency (***IEA***) published a report entitled ***Empowering Cities for a Net Zero Future- Unlocking resilient, smart, sustainable urban energy systems*** (***Smart Cities Report***). As with ***IEA*** reports generally, this report is well-worth a read, and provides the context for the report: "*Cities account for more than 50% of the global population, 80% of global GDP, two-thirds of global energy consumption and more than 70% of annual global carbon emissions*".

The concentration of these factors is going to increase as progress is made towards 2050, and in this context, the role of cities in the development of energy delivery is key to achieving ***NZE***.

The report on report for July will include a summary of the ***Smart Cities Report***.

PRC study names 25 mega cities:

On July 24, 2021, Malaysia daily, The Star, reported on a new study (which the author has not sighted yet) from researchers at the ***PRC***'s Sun Yat-sen University and Guangdong Provincial Key Laboratory of Environmental Pollution and Remediation Technology in Guangzhou.

The study finds that 25 mega-cities are responsible for 52% of ***GHG*** emissions arising in an urban setting, the cities in the ***PRC***, Japan, Russia "notably singled out", including, Beijing, Handan, Shanghai, Tokyo, and Moscow.

Japan revises its 2030 energy source mix in draft plan:

- **Fewer flames from fossil fuels:** On July 21, 2021, Japan released a draft 2030 plan setting out thinking in respect of the energy source mix to allow it to move to a 46% reduction in ***GHG*** by 2030, compared to 2013. The plan is summarised below.

ENERGY SOURCE	2021 PLAN	CURRENT 2030 PLAN	DRAFT 2030 PLAN
LNG	37%	27%	20%
Coal	32%	26%	19%
Oil	7%	3%	2%
Renewable energy	18%	23%	37%
Nuclear	6%	21%	21%
Hydrogen / hydrogen based fuels	Zero	Zero	1%

There are clear implications for countries that export LNG, coal and oil to Japan, and for the development of the off-shore wind industry around Japan. The achievement of ***NZE*** requires a mammoth increase in the generation of renewable electrical energy, and otherwise zero-carbon electrical energy, and hydrogen.

As will be apparent from the draft plan for Japan, nuclear energy is seen as having a key role to play. It is unlikely that Japan will be alone in making this choice: nuclear energy is able to make a contribution to progress towards ***NZE***.

While the draft plan is about Japan's choices as an importer, it is difficult not to reflect on the fact that importers are narrowing the choices for exporters of fossil fuels, and goods that are produced using them. For countries depending on exporting fossil fuels and goods that do not have an embedded carbon price, there is a need to recognise that markets will be foreclosed over time, and how best to position to manage this transition.

- **Torches (Flames from Hydrogen)**: It is reported that the Olympic Flame, symbol of the Olympic Games, currently taking place in Tokyo, is using a hydrogen fuel source for the torch. Another first.

Energy Storage round-up (including BESS):

Iron-Air Battery Storage: On July 23, 2021, PV Magazine reported that ***Form Energy*** has secured funding for the development multi-day storage using iron-air technology.

While Low Carbon Pulse does not usually report on technology development as such, the technology is understood (from work that we have done in other contexts), and there is a clear market need for long term electrical energy storage. If this technology is commercialised, it will secure further grid integrity and stability.

See: *Form Energy Unveils Chemistry of Multi-day Storage Battery Technology*

BECCS / BECCUS and CCS / CCUS round-up:

- **Oaks to Acorn:** Edition 21 of Low Carbon Pulse reported that INEOS (UK based international conglomerate) and Petroineos (a joint venture between PetroChina International and INEOS) had entered into a memorandum of understanding with the equity participants in the ***Acorn Project*** (see Editions 14 and 17 of Low Carbon Pulse) for the provision of CCS services to INEOS and Petroineos (at Grangemouth). [**Note:** see Edition 23 of Low Carbon Pulse]

  On July 16, 2021, The Financial Times reported that ExxonMobil, Royal Dutch Shell and North Stream Midstream Partners (***NSMP***, owned jointly by the Kuwait Investment Authority and JPMorgan Infrastructure Fund) had signed provisional deals (under memorandums of understanding) with the ***Acorn Project***. The underlying business case for the ***Acorn Project*** is that CO_2 captured from natural gas processing terminals at St Fergus, Peterhead (and Grangemouth) will be stored by it. The provisional deals with ExxonMobil and Shell are in respect of their terminal and in respect of the ***NSMP*** owned terminal (with ***NSMP*** also the owner of the main feeder lines to it).

  The recent firming up of contractual off-stake for storage services in respect of the terminals at St Fergus (close to Peterhead) and facilities at Grangemouth appear likely to drive to the ***Acorn Project*** forward. The CEO of Storegga Geotechnologies (whose subsidiary, Blue Dot, in joint venture with Harbour Energy and Shell, is developing the ***Acorn Project***), Mr Nick Cooper, said that the signing of the provisional deals on the "*St Fergus* CO_2 *emissions represent[ed] a key milestone for the Acorn Project*".

  See: *Acorn Project Partners, Storegga, Shell U.K. and Harbour Energy, Sign MOU with the Owners of the Segal and Fuka Gas Terminals at St Fergus*; *ExxonMobil to participate in carbon capture and storage project in Scotland*; *NSMP Signs Memorandum of Understanding with Acorn CCS Project*

- **CCS can be a challenge:** While Low Carbon Pulse takes a positive outlook around progress towards ***NZE*** there are occasions when it is worth noting the challenges that arise. The Gorgon LNG Project (with natural gas processing, treatment and liquefaction facilities) located on Barrow Island, off-shore of Western Australia, has carbon capture and storage (***CCS***) facilities. The ***CCS*** facilities are intended to capture CO_2 associated with the production of LNG and to store that CO_2 in depleted fields around Barrow Island. It is reported that around five million metric tonnes of CO_2 has been captured and stored using the ***CCS*** facilities, being less than the licensing requirements for ***CCS*** for the Gorgon LNG Project: some of the off-shore fields from which natural gas is extracted have relatively high levels of CO_2, and as such as part of the approval and permitting process for the Gorgon LNG Project the ***CCS*** facilities were required.

  On July 19, 2021, it was reported widely that the Gorgon LNG Project is seeking to make arrangements with regulators in respect of the shortfall in CO_2 captured and stored in the ***CCS*** facilities. In the context of carbon capture and storage generally, this illustrates the key risk in respect of any CCS / CCUS project – the regulatory risk of shortfall (and the lower risk of not working at all).

CARBON CAPTURE AND STORAGE IN CONTEXT OF OIL AND GAS	
Enhanced Gas Recovery (***EGR***) (or Enhanced Oil Recovery (***EOR***)) involves the capture of CO_2 and returning CO_2 into the field from which the hydrocarbon was extracted. This may be regarded as part of good oil field practice to enhance the recovery of natural gas (or oil).	Carbon Capture and Storage in the context of the Gorgon LNG Project does not involve the return of CO_2 into the field from which hydrocarbons were extracted, rather it involves the injection of CO_2 captured (on processing of natural gas before LNG production) into depleted fields.

E-fuel / Future fuel round-up:

- **Neptune Energy in the Blue:** On July 12, 2021, it was reported that Neptune Energy has contracted for the development of a Blue Hydrogen production plant to be located at the former Theddlethorpe Gas Terminal site in Lincolnshire, England. Also it is reported that Neptune Energy has contracted with PX Group to operate the power plant that will use the Blue Hydrogen as fuel. [**Note:** see Edition 23 of Low Carbon Pulse]

  See: Neptune Energy *website*

- **A lot of investment from Lotte:** On July 13, 2021, it was widely reported that ***Lotte Chemical*** had released a roadmap (entitled ***Every Step for H2***) indicating its plans to accelerate investment in transition to hydrogen.

Every Step for H2 contemplates that Lotte Chemical will achieve carbon neutrality by 2040 having progressed to carbon neutral growth by 2030, with the production of clean hydrogen, with 160,000 metric tonnes per annum of Blue Hydrogen by 2025 (using ***CCS***), and up to 600,000 metric tonnes per annum by 2030.

See: Lotte Chemical *website*

- **Self-fulfilling dynamics in Oman:** Edition 18 reported on the ***Hyport DUQM Green Hydrogen*** project in Oman (***Hyport DUQM***) (under ***Oman goes Green by Blue***). On July 19, 2021, it was reported that Uniper (leading international energy company) has signed a cooperation agreement with the shareholders in ***Hyport DUQM*** to develop the business case for the off-take of Green Hydrogen through the negotiation of an exclusive off-take agreement for Green Ammonia and to provide related engineering services.

  As noted in previous editions of Low Carbon Pulse, there is palpable progress across the ***Gulf Cooperation Council*** (***GCC***) countries towards the development of Green Hydrogen and Green Ammonia (and Blue Hydrogen and Ammonia). Edition 20 of Low Carbon Pulse included a narrative around the highly prospective, world-class resources that exist in the ***GCC*** countries (see under ***Black Gold and Blue and Green Gold***, and ***Oman's aim is true*** and ***New petroleum***).

  See: *Hyport DUQM Signs Cooperation Agreement with Uniper to Explore Green Ammonia Offtake*

- ***NZE*: Singapore and NZ in combination:** Editions 21 and 20 of Low Carbon Pulse (*under* ***Singapore seeks to deepen partnerships*** and ***Singapore chilled about CCUS and hydrogen*** respectively) reported that key agencies in Singapore are considering the findings of two reports, one on CCUS, the other on hydrogen. On June 29, 2021, it was reported that those key agencies are looking to build on these findings.

  On July 15, 2021, New Zealand and Singapore signed an ***Arrangement regarding Cooperation on Low-Carbon Hydrogen*** (***LCH2A***). The ***LCH2A*** is consistent with the Singapore's plan to develop strategic partnerships with other countries, in particular to allow Singapore to play the role of a hub in low carbon hydrogen supply chain.

  This is seen as important to contributing to the achievement of "enhanced 2030 Nationally Determined Contribution and Long-Term Low Emission Development Strategy, and the Singapore Green Plan 2030"

- **Green Hydrogen to deliver NZ NZE:** On July 22, 2021, the Otago Daily Times, outlined plans for the development of renewable electrical energy, and use of that energy at Tiwai Point, Southland. Contact Energy and Meridian Energy (two of New Zealand's electricity generation corporations) are testing the appetite for the development of a world-scale Green Hydrogen production facility (***Southern Green Hydrogen***).

  The CEOs of Contact Energy (Mr Mike Fuge) and Meridian Energy (Mr Neal Barclay) regard the development of the ***Southern Green Project*** as "whole of economy" development, facilitating the development of domestic demand for hydrogen and allowing New Zealand to achieve 100% renewable electrical energy generation country wide. Also, it is important to read this with the initiative outlined above under ***NZE: Singapore and NZ in combination***.

- **PosHYdon pilot project progresses:** On July 22, 2021, it was widely reported that the Netherlands Enterprise Agency (***RVO***) has agreed to provide financial support (in the form of a subsidy) to allow the installation and testing of a 1 MW NEL electrolyser to produce up to 400 kg per day of Green Hydrogen, using renewable electrical energy from off-shore winds fields to electrolyse desalinated sea-water, with the Green Hydrogen blended with natural gas and delivered to shore via pipeline.

  The ***PosHYdon*** pilot project is being hosted by ***Neptune Energy*** on its Q13a-A platform, and in this regard it is a world first.

  Edition 19 of Low Carbon Pulse reported on the plans of ***Neptune Energy*** to develop CCS in the Dutch sector of the North Sea by using its three depleted gas fields in the L10-A, L10-B and L10-E areas.

- **Nuclear energy to hydrogen pilot project:** On July 23, 2021, it was reported, in Hydrogen Fuel News, that ***Rosatom*** is to run a pilot program to produce hydrogen at its Kola nuclear power plant (***Kola NPP I***), on the Kola Peninsula in north western Russia. The pilot program ties in to long plans for ***Rosatom*** to develop ***Kola NPP II***.

- **Bloom Energy and SK Energy continue progress:** On July 22, 2021, it was widely reported that ***Bloom Energy*** is to undertake the development of a combined heat and power project (***CHPP***) with ***SK Energy*** to develop the Republic of Korea's first ***CHPP*** using solid oxide fuel cell technology (***SOFC***) to derive 4.2 MW.

  See: *Bloom Energy to Power Korea's First Utility-Scale Combined Head and Power Project with Solid Oxide Fuel Cells*

- **Cromarty Firth ideal location for Green Hydrogen production facility:** Edition 18 of Low Carbon Pulse reported on the arrangements relating to the development of the Port of Cromarty as a hydrogen hub.

  On July 23, 2021, it was reported that Cromarty Firth has been identified as the ideal location for a 35 MW, Green Hydrogen production facility.

  See: *North of Scotland Hydrogen Programme feasibility study*

Green Metals and Minerals, the Mining Industry and Difficult to Decarbonise industries:

- **ArcelorMittal Green Base:** On July 13, 2021, ArcelorMittal announced that its Sestao steel mill in Spain is to be developed into a zero carbon emissions steel plant following the development of a direct reduced iron (***DRI***) plant and an electric arc furnace (***EAF***).

  The ***DRI*** and ***EAF*** projects are to proceed following the signing of a memorandum of understanding (***MOU***) by ArcelorMittal and the Spanish Government, with the development of the projects scheduled for completion in 2025, with up to 1.6 mpta of zero carbon emission steel to be produced annually. In addition to the use of renewable electrical energy to produce Green Hydrogen, it is reported that all electrical energy requirements will be sourced from renewable electrical energy, including in respect to the operation of the ***DRI*** and ***EAF*** projects.

Consistent with the greening of steel production elsewhere in the ***EU***, it is expected that ***EU*** and Spanish government support will be provided.

See: *ArcelorMittal Sestao to become the world's first full-scale zero carbon-emissions[1] steel plant*

- **Acerinox and Tecnicas Reunidas work on decarbonisation of steel production**: On July 21, 2021, it was reported widely that Acerinox and Tecnicas Reunidas are working together to assess the basis upon which Acer: inox Europa facilities, located in Cadiz, Spain, may be decarbonised. It is reported that each possible method of decarbonisation will be assessed, including renewable electrical energy, Blue Hydrogen and Green Hydrogen, bioenergy, and CCS / CCUS.

  See: *Acerinox and Tecnicas Reunidas Will Work Together on the Decarbonisation of the Acerinox Europa Plant in Cadiz*

- **Greening Glass:** During the week beginning July 19, 2021, the, as yet, sleeping giant of the difficult to decarbonise industries, glass, stirred, in both Britain and Italy, with the biggest movement in Italy. The production of glass is highly energy intensive, both electrical and heat.

  On July 20, 2021, Glass International reported that a group of Italian glass manufacturers, and furnace and energy suppliers, are collaborating to reduce ***GHG*** emissions through the use of hydrogen for the high-heat temperature processes used in glass manufacture: Italy is the ***EU*'s** second largest producer of glass. It is reported that the group comprises Bormioli Luigi, Bormioli Rocco, IFRF Italia, Rina, RJC Soft, Snam, Stara Glass, Stazione Sperimentale del Vetro and UNI.GE.

Hydrogen Cities, Councils, Hubs, Infrastructure and Valleys:

- **Siemens Smarts:** On July 12, 2021, it was announced that ***Siemens Smart Infrastructure*** has commenced construction of a Green Hydrogen production plant in Wunsiedel, Bavaria, Germany, to produce 1,350 metric tonnes per annum on Green Hydrogen (***WUN H2***), with production scheduled to commence in 2022. The ***WUN H2*** is being developed by sponsor, ***WUN H2 GmbH***, in which ***Siemens Financial Services*** holds a 45% equity share. The ***WUN H2*** is to form part of the ***Wunsiedel Energy Park***, and will be connected with Siemens' existing battery storage and industrial hub. The ***WUN H2*** continues the development of the hydrogen economy in Bavaria, and Germany, including neighbouring Czech Republic, and the ***EU*** generally.

  It is understood that the ***WUN H2*** is to offset 13,500 metric tonnes of CO_2 a year, which implies that the production of Green Hydrogen is offsetting the production of Grey Hydrogen giving rise to 10 metric tonnes of CO_2 per tonne of H_2 produced: it is not clear if this an actual or nominal decrease in CO_2 emissions.

  See: *Siemens to build one of Germany's largest carbon-free hydrogen generation plants in Wunsiedel*

- **Carbon Capture Services:** On July, 12, 2021, it was announced that ***Aker Carbon Capture*** has launched "Carbon Capture as a Service": CEO of Aker, Mr Valborg Lundegaard said: "*With our offering customers will simply pay per tonne captured CO_2. We will handle the CO_2 throughout the full value chain – from the point of emission to permanent storage*". Consistent with the sales pitch, ***Aker Carbon Capture*** will deliver and operate carbon capture facilities, transport and deliver carbon into storage.

  See: *Aker Carbon Capture launches Carbon Capture as a Service*

- **Shell proposes large-scale CCS facility in Alberta:** On July 13, 2021, ***Shell*** announced the development of a CCS project at its Scotford Complex, Edmonton, Alberta, Canada (***Scotford CCS*** or ***Polaris Project***).

  The development of the ***Scotford CCS*** would continue the development by ***Shell*** of five ***Energy and Chemicals Parks*** globally (see Editions 18 and 21 of Low Carbon Pulse for outline of the Shell Energy and Chemicals Park Rhineland, Cologne, Germany, that has developed a 10 MW PEM electrolyser ***Refhyne Electrolyser***). As announced, the ***Scotford CCS*** will have aggregate life-cycle storage capacity of 300 million tonnes of CO_2.

  See: *Shell Proposes Large-Scale CCS Facility in Alberta*

- **Clear line of sight for nuclear to *NZE*:** On July 14, 2021, the UK's Nuclear Sector Deal's Innovation Group makes a number of recommendations to allow the use of nuclear power to achieve ***NZE***. The recommendations are contained in a report entitled ***Unlocking the UK's Nuclear Hydrogen Economy to Support Net Zero***. In summary, the report outlines 10 suggested actions for industry, and 10 suggested commitments for government to consider. Whatever one's perspective on nuclear energy, the report is excellent, and well-worth a read.

- **Hydrogen Storage:** One of the key requirements for industrial users of hydrogen is the real time availability of hydrogen. For these purposes, hydrogen storage is key.

  On July 15, 2021, it was announced that Equinor (global international energy company) and SSE (Scottish energy giant) were working together to develop hydrogen storage capacity close to a cluster of industrial users. The focus of the initial work is the use of the existing Aldborough natural gas storage capacity (***Aldborough Gas Storage Facility*** or ***AGSF***) on the east coast of England, with the focus contemplating use for the storage of low carbon hydrogen by 2028 (***H2S Capacity***). (Equinor and SSE own jointly the ***AGSF***, comprising non sub-surface salt caverns, each large enough to house St Paul's Cathedral.) It is estimated that the storage capacity would equate to 320 GWh, converting salt caverns within the existing ***AGSF*** or creating new caverns.

  The development of the ***H2S Capacity*** would be part of an integrated hydrogen production, storage, transportation and supply chain: Equinor has proposed the development of 1.8 GW low carbon hydrogen (in the form of Blue Hydrogen) production capacity, comprising the 600 MW ***H2H Saltend Project*** (see Edition 14 of Low Carbon Pulse) and 1.2 GW of production capacity to supply low carbon hydrogen to the Keadby power station (see Edition 21 of Low Carbon Pulse). [**Note:** see Edition 23 of Low Carbon Pulse]

- **Clustering and hubbing:**

  The development of an integrated hydrogen production, storage, transportation and supply chain is entirely consistent with the ***NZE*** initiatives and plans in the Humber and Teesside regions on the east coast of England:

Edition 21 of Low Carbon Pulse reported on Northern Endurance Partnership's submission to the UK Government seeking support for decarbonisation initiatives in the Humber and Teesside regions.

There are a number of hydrogen hubs and carbon clusters around the UK, all of which offer the opportunity to develop integrated hydrogen production and carbon capture activities.

As Equinor has noted: "*Hydrogen is essential for decarbonisation. And there is no better place in the world for low carbon hydrogen than the Humber cluster in the UK. We have the perfect combination of natural gas supplies, renewable power generation, hydrogen production, hydrogen demand and the potential for underground hydrogen storage in salt caverns and offshore CCU*".

The Humber is a cluster with a lustre if you will!

It has to be said that this sentiment can be expressed in respect of a number of clusters and hubs around the UK. Edition 23 of Low Carbon Pulse will outline the scope of hydrogen hubs and carbon clusters around the UK, and note common themes.

See: *SSE Thermal and Equinor join forces on plans for first-of-a-kind hydrogen and carbon capture projects in the Humber*; *SSE and Equinor Developing Plans for World-Leading Hydrogen Storage Facility in Yorkshire*

Sustainable Energy Round-up:

- **Australian Energy Market Operator wants to aim for 100% renewables:** During the week beginning July 12, 2021, it was reported widely that the new CEO of the Australian Energy Market Operator (***AEMO***), Mr Daniel Westerman, considers that by 2025 grids across Australia should be able to operate with 100% of load matched by the dispatch of renewable electrical energy. Mr Westerman recognised that while this is "*unchartered territory for a large, independent grids anywhere in the world .. this must be the goal … because we know this is where we're headed!*"

  This may be regarded a measure of many things, but critically it may be regarded as a measure of the increased confidence of ***AEMO***. In 2020, ***AEMO*** was contemplating up to 75% of load matched by renewable electrical energy, but with load matched by renewable electrical energy dispatch on occasion, and over 50% on a good number of occasions, aiming for 100% of load matched by renewable electrical energy appears appropriate.

  In the week beginning July 19, 2021, it was widely reported that on April 11, 2021, new records were set in the National Electricity Market (***NEM***) for the percentage of renewable electrical energy dispatched to match load across the ***NEM***, at 57% of load at the trading interval ending 11.30 hours. A little earlier on the same morning, 7,370 MW of variable renewable energy (***VRE***) set a new record for the dispatch of ***VRE*** to match load. (As noted in previous editions of Low Carbon Pulse, these record percentage levels of renewable energy dispatch tend to occur on weekends, at times of the day when load is reduced, and there is strong solar availability.)

  In setting the 100% load target matched by renewable electrical energy, ***AEMO*** is not out on its own. In a recent survey undertaken by science alert there is support for the proposition not just on a grid by grid basis, but generally. Further, Mr Westerman's speech has resulted in a four page paper from Engevity entitled ***Australian Grid to be Capable of 100% Renewables – What does this mean?***, concluding that: "*What is abundantly clear is that overcoming the physical challenges of renewable integration is a question of when, not if*". Echoing the sentiment of Mr Westerman, "*this is where we're headed*".

  See: *AEMO CEO Daniel Westerman's CEDA keynote address: 'A view from the control room'*

- **Australian renewable energy activities continue to scale-up:**
  - During the week beginning July 12, 2021, it was widely reported that the world's largest renewable energy hub is planned for the southern coast of Western Australia. As reported in previous editions of Low Carbon Pulse, Australia has world class renewable energy resources, and south and south west coast of Western Australia has some of the best wind resources globally. As such it comes as no surprise that there are plans to develop a renewable energy hub in the region. What is a surprise is the world scale of the proposed ***Western Green Energy Hub***, which when fully developed is planned to have 50 GW of installed solar photovoltaic and wind capacity used to produce Green Hydrogen for domestic use, and for export: the production is estimated to be up to 3.5 million metric tonnes per annum of Green Hydrogen and up to 20 million metric tonnes per annum of Green Ammonia. The ***Western Green Energy Hub*** is sponsored by CWP Global and Intercontinental Energy, leading corporations developing the 26 GW Asia Renewable Energy Hub, in the Pilbara, in the north of Western Australia.
  - On July 15, 2021, Spark Renewables (a company within Spark Infrastructure Limited Group) announced plans to develop a 2.5 GW solar photovoltaic, wind and BESS integrated renewable energy hub in the south west of New South Wales, Australia (***Dinawan Energy Hub***).

  See: *Spark Infrastructure Announces Proposal to Develop a Renewable Energy Hub for up to 2.5GW in South-West NSW;* Dinawan Energy Hub website

- **NTPC to develop 4.75 GW renewable energy park:** Edition 21 of Low Carbon Pulse noted plans by NTPC (India's largest generator of electrical energy) to develop a 4.75 GW renewable energy park as part of its plans to transform its core business.

  On July 19, 2021, it was reported that the Ministry of New and Renewable Energy (***MNRE***) had approved the development of the project. The project is located at Rann of Kutch, Gujarat, India (***REP***). The ***REP*** will generate renewable electrical energy that will be used for both direct supply and as a resource of renewable electrical energy for the production of Green Hydrogen.

  See: NTPC *website*

Wind round-up:

- **Market responding to perceived need:** On July 16, 2021, it was announced that DEME Concessions Wind (***DCW***) and Zarubezhneft (Russian oil and gas corporation) had signed a memorandum of understanding (***MOU***) to provide a framework for ***DCW*** and Zarubezneft to develop jointly the €2.7 billion 1 GW Vinh Phong off-shore wind field off Vietnam (***VPOWF***). The development is to be staged, with 600 MW of capacity to be installed by 2026, and 400 MW by 2030.

See: *Zarubezhneft to proceed with the development and construction of a 1000 MW wind park in Vietnam*

- **Australian off-shore increasing prospects:** Editions 6, 14 and 16 of Low Carbon Pulse touched on the potential for the development of off-shore wind field resources around Australia. As noted in Edition 14 of Low Carbon Pulse, there are high quality off-shore wind field resources that are close to load and to existing electrical transmission and distribution infrastructure, and close to mining and electrical generation heartlands of the Hunter Valley, New South Wales, the Latrobe Valley, Victoria, and Gladstone, Queensland.

  It has been reported that the off-shore wind resources around Australia, and in these areas in particular, are truly world class, with the ability to install 2,000 GW of off-shore wind capacity within 100 km of the nearest substation on land (see *Blue Economy Cooperative Research Centre report* - published by CSIRO and the Australian Government's Cooperative Research Centre) (Australia currently has around 230 GW of grid connected electrical energy capacity.)

  While these statistics do not define an early stage business case, they do however help to crystalise early thinking around the possible use of off-shore wind resources, and their location, and the capacity that Australia has to produce Green Hydrogen if the renewable electrical energy derived from off-shore wind fields is used for that purpose.

- **California dreaming of floating off-shore wind fields:** On July 14, 2021, it was reported widely that California is considering the installation of off-shore floating wind capacity. Northern California has some of the best off-shore wind resources off the US coast. The challenge with the development of off-shore wind fields has been that fixed-bottom turbines are not practical off Northern California because the continental shelf falls away relatively close to shore, and as such will not allow realisation of the best of the wind resources.

Solar round up:

- **Expansion of solar in Vietnam:** On July 20, 2021, it was widely reported that there are plans to increase the capacity of the Xuan Thien Ea Sup photovoltaic solar project in to 2.8 GW by early 2022. This is a timely reminder that demand for electrical energy in Vietnam is increasing, and that the renewable electrical energy is likely to respond to increased demand, likely at a rate than exceeds the current planned development.

  See: *Huge Vietnamese solar park could hit 2.8 GW within a year*

- **Sunseap floating solar photovoltaic:** During the week commencing July 19, 2021, it was reported widely that that Sunseap Group (leading Singapore based, energy system developer, owner and operator) is to develop a USD 2 billion, 2 GW floating solar photovoltaic solar project (***SFSP***). The ***SFSP*** is to be developed on Duriangkang Reservoir, Batam Island (covering around 1,600 hectares). It is understood that Sunseap and the Badan Pengusahaan Batam (***BP Batam***) have signed a memorandum of understanding to allow the development of the ***SFSP***. The intention is for construction of the ***SFSP*** to commence in 2022, with completion and commencement of operation planned for 2024.

  It is understood that the renewable electrical energy generated by the ***SFSP*** will be supplied within Batam Island: Chair of BP Batam, Mr Muhammad Rudi, stated: "*This investment by Sunseap with be a timely boost for Batam's industries as they seek to reduce the carbon footprint of their operations*".

  It would seem likely that renewable electrical energy may be supplied to Singapore using a sub-sea cable, but this has not been described as going to ***SFSP*** feasibility.

  Edition 13 of Low Carbon Pulse reported on the completion and commencement of operation of the floating photovoltaic solar system developed near off-shore Singapore – another Sunseap project. Further, Edition 18 of Low Carbon Pulse reported on the increasing use of floating photovoltaic solar projects elsewhere across the Asia Pacific region, critically, off-shore the Republic of Korea, and on its reservoirs.

  It is hoped that the ***SFSP*** is the start of sustained progress towards use of floating photovoltaic solar resources across Asia.

  See: *Sunseap signs MOU with BP Batam to build world's largest floating solar farm and energy storage system*

Land Transport (automobiles, buses, trains and trucks) round-up:

As will be apparent, Low Carbon Pulse continues to report on first, or early, movers in technology development and into jurisdictions, including Ballard, Bloom Energy, Cummins, Hyundai, Hyzon Motors, Plug Power and SK Energy. While the size of the orders may not be breath-taking, the commitment to keeping moving, and finding new ways to deliver into new jurisdictions is both breath-taking and inspiring.

- **Cummins' continued pivot:** For some time, the continued pivoting of Cummins, Inc (***CMI***) to transform its business to leading provider of hydrogen solutions (including to the transportation and hydrogen production and use industry) has been marked (see Edition 18 of Low Carbon Pulse).

  On July 15, 2021, it was reported that ***CMI*** and Chevron (***CVX***) had signed a memorandum of understanding (***MOU***) to provide a basis to explore a strategic alliance. It is reported that the ***MOU*** contemplates that the two leading corporations will work together to advance public policy that promotes hydrogen as a decarbonising solution for transportation and industry, building market demand for commercial vehicles and industrial applications powered and propelled by hydrogen, developing infrastructure to support the use of hydrogen for fuel cell electrical vehicles (***FCEVs***), and to explore opportunities to leverage ***CMI's*** electrolyser and fuel cell technologies (***FCTs***), including at ***CVX*** US refineries.

  See: *Chevron and Cummins Announce Strategic Collaboration on Hydrogen*

- **Ballard rolling:** For some time, Ballard Power Systems (***BPS***) has been making progress across a number of sectors. On July 15, 2021, it was reported widely that ***BPS*** is to supply 200 kw fuel cell modules under arrangement with Siemens Mobility GmbH to power a two car Mireo Plus H passenger train trials in Bavaria, Germany (one of the hydrogen hot spots in the ***EU***). The fuel cell modules are located on the roof of the passenger train, and power and propel the train with electric battery technology located underneath the floor of the train. It is reported that that trials will start in 2022. The Mireo Plus H passenger train is designed for use on non-electrified lines at speeds of up to 160 kph.

See: *Ballard and Siemens Sign $9M Multi-Year Development Agreement For Fuel Cell Engine to Power Cutting-Edge Mireo Commuter Train*

- **On the high road and on the road overhead:**
  - **Hyzon Motors Inc keeps trucking to deliver – where there is a will there is a way:**
    - **Hyzon Motors Inc and TotalEnergies achieve deeper alignment:** Edition 16 of Low Carbon Pulse reported that TotalEnergies (leading global international energy company) had taken an interest in Hyzon Motors via a direct investment through TotalEnergies Ventures.

      On July 12, 2021, it was announced that Hyzon Motors signed a memorandum of understanding with TotalEnergies' Marketing and Services division to work together to develop hydrogen refuelling infrastructure (***HRI***) across Europe, and to continue to develop long-haul transport solutions for customers for those services across Europe. This arrangement continues to emphasise the importance of supply and demand developing in tandem. In addition, for Hyzon Motors and TotalEnergies, in a developing market, an advantage will arise in engaging with fleet owners and purchasers – assurance of both vehicle supply and hydrogen supply. (There are a number of solutions for fleet decarbonisation and these will be covered in the next ***Hydrogen for Industry*** feature.)

      This is another instance of the private sector positioning to be able to match supply to demand, and making purchasing decisions easier for other participants in the private sector. While further progress needs to be made, including Hyzon Motors being able to supply fuel cell technology vehicles with a total cost of ownership (***TCO***) equal to or less than diesel powered and propelled vehicles, it has traction.

      For TotalEnergies, this is a further piece in the three-dimensional decarbonisation jigsaw puzzle that all international energy companies are seeking to resolve from reservoir (***H_2O***) to bowser (***H_2***).

      As noted in Edition 16 of Low Carbon Pulse, TotalEnergies is a member of the ***Hyzon Zero Carbon Alliance***.

      See: *Hyzon Motors deepens strategic hydrogen mobility partnership with TotalEnergies SE*
    - **One *HHT* to Europe month:** Edition 21 of Low Carbon Pulse reported that Hyzon Motors was to deliver a 154-tonne ***FCT*** powered and propelled heavy goods vehicle / truck (***HHT***) to a customer in the ***EU***: the ***HHT*** is reported to have a range of 400 to 600 km, and has 480 kW (or 644 horse power).

      Five *HHTs* to Australia the next: On July 13, 2021, it was announced that Hyzon Motors is to deliver five 154-tonne ***HHTs*** to Ark Energy Corporation (***AEC***) and Townsville Logistics (Australian subsidiaries of Korea Zinc, reportedly the world's largest lead, silver and zinc producer). The ***HHTs*** will be used at ***AECs*** Sun Metals Corporation zinc refinery (the second largest electrical energy user in Queensland) as part of a broader plan to develop the world's first green zinc refinery. (As was noted in Edition 4 of Low Carbon Pulse, Korea Zinc has contracted with Origin Energy (one of Australia's Big Three integrated energy companies).)

      This is an exciting development for the use of hydrogen powered and propelled trucks in Australia, with the ***HHT*** to be used in road-train configuration: CEO of Ark Energy, Mr Daniel Kim commented: "*When we scoured the world for fuel cell trucks .. Hyzon Motors was the only hydrogen mobility company that could manufacture fuel cell stacks with sufficient [energy] density to meet our requirements including the ultra-heavy payload and built to Australian Design Rules*". The ***HHT*** will displace diesel powered and propelled trucks. Ark Energy will produce the hydrogen required to fuel the ***HHTs***.

      It is understood that ***AEC*** has joined the ***Hyzon Zero Carbon Alliance*** (see Edition 20 of Low Carbon Pulse). Sun Metals Corporation is a member of ***RE100*** (see Edition 18 of Low Carbon Pulse).

      See: *Hyzon Motors signs Australian subsidiary of Korea Zinc, world's largest zinc producer, as the second customer for its ultra-heavy-duty 154-ton class hydrogen truck*
- **ICE iced:** Part of the ***EC FF55*** package is the phasing out of internal combustion engines (at least powered and propelled by fossil fuels) by 2035.
- **London Buses: all aboard the Wrightbus for East Action, all stops, Oxford Circus:** On June 24, 2021, it was reported that the first ***FCT*** London Buses went into service on the East Acton to Oxford Circus route. Twenty Wrightbus vehicles (see Edition 16 of Low Carbon Pulse) are now in service.

  Lord Mayor of London, Mr Sadiq Khan, is reported to have said: *"Our investment in these hydrogen buses is not only helping us clean up London's air but is supporting jobs and local economies across the UK".*

  See: *London launches England's first hydrogen bus fleet*

Port News and Shipping Forecasts:

- **MSC and Shell well-suited:** Royal Dutch Shell Group (leading global international energy company) continues its progress towards ***NZE***. On July 15, 2021, it was announced that MSC Mediterranean Shipping Company (***MSC***) and Shell International Petroleum Limited (***Shell***) have agreed to work closely with a view to accelerating the decarbonisation of the global shipping industry, including to develop a range of competitive, and safe and sustainable, technologies. It is reported that ***MSC*** and ***Shell*** have worked together for over 10 years on a number of initiatives, including on biofuel bunkering and the trialling of very and ultra-low sulphur fuels. As is apparent from previous editions of Low Carbon Pulse, as an international energy company, ***Shell*** is leading the way across Scope 1, Scope 2 and Scope 3 emissions.

See: *MSC and Shell Sign Collaboration Agreement on Decarbonising Shipping*; *Shell and MSC Sign Collaboration Agreement on Decarbonising Shipping*

- **Why methanol?** Edition 21 of Low Carbon Pulse reported that Maersk announced that it had signed a shipbuilding contract with Hyundai Mipo Dockyards to build the world's first containership powered and propelled by carbon neutral methanol. Methanol is one of a number of e-fuels being considered by the shipping industry.

  In a global context, 12 vessels powered and propelled by methanol are in operation, with a further 10 understood to be on the order books. As such, methanol powered and propelled vessels have yet to achieve scale use. Supply and demand for methanol is around 70 million metric tonnes per annum. If supply is to develop, demand needs to develop. As discussed more broadly, leaving to one side the perspective of the World Bank (see Edition 18 of Low Carbon Pulse), LNG and methanol are being compared as bunkers, with ammonia and hydrides, and, on a longer timeline, hydrogen. [**Note:** see Edition 26 of Low Carbon Pulse]

  It occurred to the author of Low Carbon Pulse that there is a good deal of discussion around the use of methanol as a carbon neutral or low carbon fuel, without an accompanying explanation. Compared to the use of fuel oils, methanol produced from natural gas reduces CO_2 emissions in a range, the middle of which is probably around 10%, and provides reductions in ***NOx*** and ***SOx*** emissions. For methanol to be carbon neutral, it needs to be produced from a renewable resource, for example, biogas or biomass, with the electrical energy used to produce the biogas or biomass, and the methanol, being from a renewable source. This does not mean that on oxidation of methanol that CO_2 will not arise, but, in theory, because the CO_2 that arises will be absorbed into a renewable resource, with the continued growth of that renewable resource providing a carbon neutral outcome.

- **Shore to Shore (*S2S*) project continues implementation:** A number of previous editions of Low Carbon Pulse reported on the ***S2S*** project, including as related to the California Fuel Cell Partnership, involving the Port of Los Angeles and a number of first and early movers, including Shell and Nikola (***S2S Project***).

  On July 15, 2021, Shell announced that it had opened hydrogen refuelling infrastructure (***HRI***) in Southern California. The ***HRI*** comprises two heavy goods vehicle / truck (***HGVT***) refuelling stations. In addition, consistent with matching supply and demand, Shell announced the mobilisation of five ***HGVT*** as part of the ***S2S Project***.

  See: Shell *website*

- **Hydrogen from Production to Bunker:** On July 16, 2021, The Maritime Executive, published an article entitled ***Five Lessons to Learn on Hydrogen as a Ship Fuel***. The article recognises the barriers that exist to the use of hydrogen as a ship fuel or as an enabler for synthetic fuels. One of these barriers relates to the safety challenges that arise from the production, storage, transportation to port, bunkering at port and use "well to wake". To address these challenges, a consortium, led by DNV (DNV Spadeadam Research and Testing Centre in the UK), is working on the ***MarHySafe*** joint development project (***JDP***). The consortium has published a *Handbook for Hydrogen Fuelled Vessels*, providing guide to safe hydrogen operation using fuel cell technology (***FCT***) using liquified hydrogen (***LH2***). While vessels can be powered and propelled using hydrogen in absorbed organic form in a Liquid Organic Hydrogen Carrier (***LOHC***) (a ***LOHC*** absorbs hydrogen, hydrogen is then released when required), or ammonia, or blending with other fuels, the ***MarHySafe*** project is focussing on ***LH2*** using ***FCT***.

Carbon credits and Carbon offsets, Insurance, Negative Emissions Initiatives and Sustainability:

NASA surveys for Vital Signs of the Planet: On July 20, 2021, it was reported widely that a recent NASA study, undertaken by its Jet Propulsion Laboratory (***JPL***) in Southern California, had considered whether forest and savanna areas of the world were sources of carbon or sinks for carbon. In monitoring carbon sources and carbon sinks it is possible to plan the most appropriate locations to introduce negative ***GHG*** emission initiatives, including by reference to how climate change is affecting the ability of flora to absorb carbon. One of the headline grabbing by-lines from reporting of the study has been that the Amazon Basin is both a carbon source and a carbon sink, and that across the entire Amazon Basin it is close to becoming neutral. The reasons for this are many and varied, but are reported as arising as a result of deforestation, and the degradation that results, the impact of increased average temperatures, including drought and its affects.

Aviation:

As part of the ***FF55*** package, the ReFuelEU Aviation Initiative (***RFEAI***) has been hailed by a number of aviation fuel suppliers, more accurately sustainable / synthetic aviation fuel (***SAF***) suppliers. For supply side certainty of demand is required, and the ***REFAI*** provides that: by 2030, 5% of all aviation fuel used at ***EU*** airports should contain ***SAF*** and 0.7% of aviation fuel used must be ***SAF***.

Low Carbon Pulse - Edition 23

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to **Edition 23** of Low Carbon Pulse – sharing significant current news on progress towards net-zero emissions globally. This edition covers the period from Monday July 26, 2021 to Sunday August 8, 2021 (inclusive of each day).

Please click here for the previous edition of Low Carbon Pulse. Please also click here and here for the first two articles in the ***Shift to Hydrogen Series*** (***S2H2***)***: Elemental Change*** series: the *S2H2* series provides a narrative and perspective on hydrogen generally. Please **click** here for the first feature in the ***Hydrogen for Industry*** (***H24I***): the *H24I* features provide an industry by industry narrative and perspective.

The publication of the ***UK Hydrogen Strategy*** (***UKH2S***) was awaited so that Part 2 of the second article in the ***S2H2*** series (on Hydrogen Roadmaps and Strategies) would be current. Given the delayed release of ***UKH2S***, an article on carbon capture and storage and use will be published instead during August.

On August 4, 2021, members of the Global Ashurst Towards Zero Emissions team published an article entitled ***Realising Reserves and Realising Capital***. The article outlines the key dynamics for International Oil Companies (***IOCs***) and National Oil Companies (***NOCs***) in progress towards ***NZE***, and the importance of ***IOCs*** and ***NOCs*** to achieving ***NZE***.

Finally, this Edition 23 includes, as an appendix, the July Report on Reports foreshadowed in recent editions of Low Carbon Pulse: this Report on Reports was planned as a standalone Report, but having tested the preferences of a number of readers, it has been included as an appendix.

Edition 23 will be posted again on **August 13 2021** to pick-up those reading later in the week.

Progress towards COP-26:

- **IPCC 2021 Report published:** Edition 20 of Low Carbon Pulse reported on "smoke signals" (under ***"Worst is yet to come", unless greater and faster reductions***) that had emerged around messaging likely to be included in the Intergovernmental Panel on Climate Change (***IPCC***) Sixth Climate Report (***2021 Report***).

  On July 26, 2021, it was reported that the ***IPCC*** commenced final consultation ahead of the publication of the ***2021 Report*** being the first full-scale report from the ***IPCC*** since 2013 (***2013 Report***) captured in the ***Climate Change 2014, Synthesis Report***. The ***2013 Report*** provided the impetus for the Paris Agreement, with the ***IPCC*** ***special report on keeping global temperatures rise to under 1.5°C*** being published in the interim.

  It is understood that the ***IPCC*** consulted with the representatives of 195 countries on a line-by-line basis in the weeks preceding publication. The ***2021 Report***, and a summary for policymakers, was published on August 9, 2021, the day after the end of the two week cycle for this edition of Low Carbon Pulse.

  The Global Ashurst Towards Zero Emissions team will publish Edition 24 of Low Carbon Pulse outside the usual two week cycle to report on the ***2021 Report***.

  From a review of the ***2021 Report***, the themes are clear: there are five red alerts, all related: (**1**) Anthropogenic ***GHG*** emissions are responsible for climate change; (**2**). Average global temperatures will continue to increase; (**3**). It is highly unlikely that the ***Stretch Goal*** will be achieved, and this illustrates the need for immediate action; (**4**) Time is running short: it is likely that the ***Stretch Goal*** will be exceeded by 2030; **5**. Action is required to accelerate reductions in ***GHG*** emissions now.

Under the Paris Agreement, two of the principal objectives were to limit the increase in global average temperature to well below ***2.0°C*** above pre-industrial levels (the ***Stabilisation Goal***), and to limit the increase in global temperature of ***1.5°C*** above pre-industrial levels (the ***Stretch Goal***).

- **Enhanced emphasis:** In the count-down to COP-26, Low Carbon Pulse will emphasise the policy settings that work, and the policy settings that are needed (including by reference to the ***2021 Report***), to accelerate the reduction in ***GHG*** emissions as progress is made towards 2030. For the developed world, the need to accelerate ***GHG*** reductions to achieve ***NZE*** well-ahead of 2050 had emerged as a theme before the ***2021 Report***: there was recognition that policy settings need to accelerate reductions, the ***2021 Repor***t underlines the theme.

  In addition to the ***IPCC 2021 Report***, the International Energy Agency (***IEA***) has indicated that it will publish its ***World Energy Outlook 2021*** (***WEO21***) on October 13, 2021, ahead of COP-26.

  The pre-publication narrative from the ***IEA*** is that: "*With [the* ***IEA's****]* ***#NetZeroBy2050Roadmap*** *providing an integral part of the analysis,* ***#WEO21*** *is designed to serve as a handbook for* ***#COP26*** *at this vital moment for the clean energy transition & climate action*".

  (The ***IEA*** has indicated that it will publish its ***Hydrogen in Latin America*** report, in mid-August 2021. This will be summarised in the August Report on Reports. [**Note:** see Edition 27 of Low Carbon Pulse])

- **The "five red alerts" already known globally:**
  - **UK aware of need for acceleration:** On August 1, 2021, Ms Allegra Stratton, Climate Spokesperson for No. 10 Downing Street, said that achieving ***NZE*** in the UK by 2050, is "***too far away***", "***the science is clear***", the UK must reduce its ***GHG*** emissions "***right now***". Ms Stratton encouraged people to "***feel the fierce urgency of now***". This may be regarded as one of the most telling and timely phrases of 2021: for the UK, leading the way to ***NZE***, and as such acting on the science, to consider that acceleration is needed, resonates, resoundingly.
  - **Finance Industry looking to accelerate coal-fired power station retirement:** On August 3, 2021, it was reported by BBC News, Business, that Prudential Insurance is developing an initiative to accelerate the retirement of coal-fired power plants in Asia.

    The initiative involves the acquisition of coal-fired power plants, and follows from the conclusion, reached by Prudential Insurance, that: "*The world cannot possibly hit [the] Paris climate change targets unless we accelerate the retirement and replacement of existing coal-fired electricity, opening up much larger room in the near term for renewables and storage*".

    As the statement from Prudential Insurance recognises, the acquisition of coal-fired plants, and their retirement, is part of a plan, but more important in any plan of this kind is the development of generation capacity to replace the coal-fired power plant capacity to be retired, ahead of its retirement.
  - **In facts and stats – the need for acceleration in *GHG* emission reductions:**
    - **Developing world not at peak *GHG* emissions:** On August 4, 2021, the World Economic Forum (***WER***) released a short video that conveys current key dynamics, projected increases in ***GHG*** emissions, and that the current rate of progress to ***NZE*** will not be sufficient: the majority of global ***GHG*** emissions arise from countries (with over 65% of global population) that have not yet reached peak ***GHG*** emissions. The ***GHG*** emissions from those countries are projected to increase by 5 Giga metric tonnes per annum (5 billion metric tonnes per annum) by 2040.
    - **Growing population, increased urbanisation:** As noted in Edition 22 of Low Carbon Pulse (under ***Empowering Cities for a Net Zero Future***), the decarbonisation of cities has to be front and centre of policy settings: every month globally an urban area the size of New York City will be developed for the next 40 years. In this context, if the countries that have reached peak emission are to work with countries that have not, to reduce, indeed to avoid, ***GHG*** emissions, there needs to be close coordination.
    - **What does this mean?** Even if the developed countries achieve ***NZE*** by 2040, this will not achieve ***NZE*** globally to achieve either Paris Agreement Goal. This is consistent with the analysis of BloombergNEF's recent report ***Net Energy Outlook***: unless the rate of ***GHG*** reductions increases, BloombergNEF's analysis is that the world carbon budget (which does not include 5 gtpa increase noted above), will be exceeded by 2044: this will mean that neither the ***Stretch Goal*** nor the ***Stabilisation Goal*** under the Paris Agreement will be achieved. This outcome is consistent with the ***2021 Report***.
    - **Developed world needs to accelerate progress to *NZE*, home and abroad:** As noted in previous editions of Low Carbon Pulse, the rate of investment required to enable countries that have yet to reach peak ***GHG*** emissions to achieve ***NZE*** will not be achieved unless developed countries work with those countries to accelerate decarbonisation.
- **Develop world needs to adapt to changed environment: Article 2** of the Paris Agreement is best known for the ***Stabilisation*** and ***Stretch Goals*** (**Article 2.1(a)** of the Paris Agreement). It would appear that attention is turning towards **Articles 2.1(b)** and **(c)** (to many the forgotten objectives of the Paris Agreement): "*Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emission development, in a manner that does not threaten food production*" and "*Making finance flows consistent with the pathway towards low greenhouse gas emissions and climate-resilient development*". In the countdown to COP-26 it is to be expected that initiatives and policy settings will emerge in relation to each of these objectives. It is becoming increasingly clear that the science behind the Paris Agreement is incontrovertible.

Big Bill - History Made to Make Infrastructure:

- **US Bipartisan Infrastructure Deal (nearly) Done:** In the last two weeks, it has been reported that the USD 1 trillion infrastructure investment package (***IIP***), as part of the ***Build Back Better*** agenda, has been close to finalisation: the ***IIP*** includes the previously approved USD 550 billion in new Federal Government funding for infrastructure.

Colleagues in the US have penned a summary of the ***IIP***, and as such this outline looks at the ***NZE*** orientated elements of the ***IIP***. Depending on how one reads the ***IIP***, up to ***USD 114 billion*** of funding is to be made available for energy infrastructure and energy transition.

On August 6, 2021, the US Senate voted to advance the ***IIP*** infrastructure bill (the Senate having addressed procedural issues), but is yet to finalise it. Once the ***IIP*** infrastructure bill is finalised, the Senate will develop a budget framework, "to pave the way" for the infrastructure bill.

- ***NZE*** **initiatives:**
  - **Upgrading transmission grid (*UTG*):** For some time, the state of the US transmission grid has been expressed to be a concern; its integrity and stability, and the ability of the grid to allow connection of renewable electrical energy to the extent required to achieve US ***GHG*** emission reduction targets is at issue. A key element of the ***UTG*** is the allocation of USD 73 billion for infrastructure investment and a new grid deployment authority.

    As noted in previous editions of Low Carbon Pulse, the development and enhancement of grid networks ahead of connection of renewable electrical energy is critical, and given the scale of renewable electrical energy to be connected over the next 30 years, and beyond, the ***UTG*** is a "must have" policy setting.
  - **Recharging infrastructure:** develop a national network of electric recharge infrastructure (***RCI***), so as to deploy 500,000 chargers, including along highways and in rural and disadvantaged communities, to allow battery electric vehicles (***BEVs***) to recharge, and as such accelerate to the development of the ***BEV*** market. The development of the national recharging network is critical to achieving President Biden's desire for 50% of new vehicle sales to be ***BEVs*** by 2030.
  - **Renewable electrical energy and hydrogen:** In addition to the ***UTG***, the ***IIP*** provides funding support for:
    - **Electrification of school and transit buses:** As reported in previous editions of Low Carbon Pulse, electrification of school and transit buses will provide the scale and long term demand profile to encourage the private sector to develop ***BEVs*** for these (and other) functions; and
    - **Carbon capture and storage and hydrogen infrastructure:** the ***IIP*** is reported to provide support for carbon capture and storage, and carbon capture use and storage, with the likelihood of the development of ***CO_2*** pipelines the preferred means of haulage to storage and to use and storage. This is consistent with the use of CCS / CCUS for the decarbonisation of the industrial sector (for example, cement, chemical and petrochemicals, and iron and steel), rather than the power sector (with the clear policy setting preference being to decarbonise the power sector, rather than allow it to use CCS / CCUS). It is understood that around USD 8.5 billion in funding is to be provided for CCS / CCUS.

  Further information will be provided in Low Carbon Pulse as the ***IIP*** proceeds.
- **The Inconvenient Truth is true:** It is coming up for 20 years since the author of Low Carbon Pulse attended a dinner hosted by former US Vice-President, Mr Al Gore.

  The dinner was memorable for Mr Gore's literacy on the science of climate change, and because Mr Gore was a great speaker, charismatic in a way that television could never capture. The subject matter of the dinner became a book and a film. On August 2, 2021, Journal Nature Communications reported that climate change is the result of anthropogenic ***GHG*** emissions, with less than a 1% chance that climate change has occurred naturally. This is consistent with the ***2021 Report***.

  The private sector, and a number of States of the US have acted on the science that has long informed Mr Gore. Hopefully in the next short while the legislature will finalise the ***IIP*** bill, "to play catch-up".

Big Bill at the Gate:

- **Breakthrough at cost: *Breakthrough Energy*** founder, Mr Bill Gates, continues as a voice of reason, engaged with the size and shape of the task in hand: *"Every year, the world adds approximately 51 billion tons of greenhouse gases to the atmosphere trapping heat and driving up global temperatures. The only way to avoid the worst impacts of climate change is to stop adding greenhouse gases by 2050. We need to get from 51 billion tons to zero while still meeting the planet's basic needs. That means we need to transform the way we do almost everything".*

  The starting point is clear, the end point is clear, it is the bit in the middle that is the challenge!
- ***Breakthrough Energy*** **- cost so far:** One of the key tenets of Mr Gates thesis is that clean technology must be deployed and improved, noting that the development and deployment of photovoltaic solar, wind and lithium-ion batteries will continue, but those technologies need to improve, and other clean technologies allowed to develop.

  For this purpose, ***Breakthrough Energy*** provides a platform to allow accelerated development and deployment. It has been reported that Direct Air Capture (***DAC***), Green Hydrogen, Long-Duration Energy Storage (***LDES***) and Sustainable Aviation Fuel (***SAF***) are four areas of focus.
- ***Breakthrough Energy*** **- connections:** Mission Innovation (***MI***) was announced at COP-21 by Mr Gates: it was established to provide a structure for the public and private sectors to come together to accelerate clean energy innovation to address climate change. ***MI*** has links to the private sector through the ***Breakthrough Energy Coalition***, a group of private sector investors, of whom, one is Mr Gates. As reported in Edition 19 of Low Carbon Pulse members of ***MI*** reaffirmed their commitment with a second phase of ***MI***, **Mission Innovation 2.0**.

Platting Progress:

On July 26, 2021, S&P Global Platts, published its ***Platts Global Integrated Energy Model – Strategic Planning for a world in transition*** (***IEM***). The ***IEM*** provides a 30 year look back (noting the "profound transformation" in total primary energy supply), and a 30 year look forward, with some particularly helpful graphics showing the forward looking transformation by source of energy to use of energy.

As with the reports published by the ***International Energy Agency*** or ***IEA*** (***Net Zero by 2050 – A Roadmap for Global Energy Sector***), the ***International Renewable Energy Agency*** or ***IRENA*** (***World Energy Transitions Outlook***), Wood Mackenzie publication, and BloombergyNEF (***New Energy Outlook, 2021***) (and reported on in Editions 20, 21 and 22 of Low Carbon Pulse), the ***IEM*** provides a rich data set, and a strong narrative, and is well-worth a read. (The ***IEM***, with ***NEO***, is long, and strong, on data.) The August Report on Reports will summarise the ***IEM***.

Don't do too little – says Deloitte:

On July 28 / 29, 2021, a Deloitte study, entitled ***Hydrogen4EU – Charting Pathways to Enable Net Zero*** was released (***DPS***). The ***DPS*** is excellent. Framed within the European Green Deal, the ***DPS*** goes down a number of layers to provide a clear line of sight as to how hydrogen may be used in the decarbonisation of activities across each sector and industry. The August Report on Reports will summarise the ***DPS***.

The Science Based Targets Initiative:

- **Substance has to be core of action:** In Edition 22 of Low Carbon Pulse, the carbon neutral versus net zero emissions debate was canvassed. In canvassing the debate, it was noted that while the debate may be interesting, ultimately substance counted: "the bigger issue is ensuring, whatever term is used, that the decarbonisation of activities occurs over time". What "over-time" means is becoming ever clearer: global ***GHG*** emissions must be halved by 2030 to avoid the worst effects of increases in average global temperatures.
- **The Science Based Targets initiative:** As such, rather than debate, each country and organisation should consider how best to halve its carbon footprint by 2030.
- **The Economist provides straight shooting:** During the week beginning the July 26, 2021, The Economist published an article outlining possible consequences of exceeding the Stabilisation Target under the Paris Agreement. The ***2021 Report*** provides a like narrative on the imperative to act, and to act promptly.

CCS Support Framework in the Netherlands and Hydrogen import:

- **Policy setting, with an end in sight:** On July 26, 2021, a briefing (entitled ***The Industrial CCS Support Framework in the Netherlands***) was published that outlines the framework in the Netherlands to promote and to support ("carrot and stick" to some) the development of CCS / CCUS capacity, and its use.

  The ***SDE ++*** program provides support in the form of a 15 year "legal instrument" that compensates the user of CCS / CCUS for the increased costs of using CCS / CCUS compared to the counter-factual: counter-factual being, not using CCS / CCUS, and as a result incurring cost under the European Union (***EU***) Emissions Trading Scheme (see Editions 12, 19, 21 and 22 of Low Carbon Pulse) and being subject to the ***Carbon Tax*** regime in the Netherlands.

  Effectively, the ***SDE ++*** program provides a subsidy to address the negative externality of ***GHG*** emissions, the subsidy "pricing the benefit of capturing those ***GHG*** emissions". Also ***GHG*** emissions captured and stored are exempt from the ***Carbon Tax*** regime in the Netherlands.

  As currently configured, these policy settings will apply until 2035, with this support regarded as transitionary, allowing industry to move to lower, low and no carbon technologies over time.
- ***PORA*** **continues to lead the way:** Edition 20 of Low Carbon Pulse reported on leading roles of the Ports of Amsterdam and Rotterdam (under ***Getting ready for supply and distribution***). This leadership continues:
  - **Hydrogen storage facilities:** On July 28, 2021, it was reported that the Port of Rotterdam Authority (***PORA***), Chiyoda Corporation, Koole Terminals, and Mitsubishi Corporation signed an agreement to undertake a study jointly to assess the feasibility of the import of hydrogen to a Koole terminal, using proven hydrogen storage and transportation technology developed by Chiyoda.

    See: *Study for commercial-scale hydrogen imports*
  - **Ammonia import facilities:** On August 5, 2021, is was announced that ***PORA*** and Horisont Energi signed a memorandum of understanding (***MOU***) to import Blue Ammonia (produced in northern Norway, at the Barents Blue project (***BBP***)) and to store it at the Port of Rotterdam, pending distribution throughout North Western Europe. A final investment decision on the ***BBP*** is anticipated towards the end of 2022. The ***BBP*** will have production capacity of 3,000 metric tonnes per day of Blue Ammonia, or 1 million metric tonnes per annum.

    As noted in previous editions of Low Carbon Pulse, ports are critical to the export and import of hydrogen and hydrogen-based energy carriers. Blue Ammonia, a hydrogen-based energy carrier, is produced from the combination of Blue Hydrogen and Nitrogen. Currently, up to 15% of the energy carriers imported into western Europe enter Europe through the Port of Rotterdam.

    As things stand, ***PORA*** is reported as estimating that up 20 million metric tonnes per annum of hydrogen (or 100 million metric tonnes per annum of ammonia) will transit through the Port of Rotterdam by 2050. These estimates may be regarded as conservative. (See ***Port of the Future: The Importance of Hydrogen*** to get the perspective of ***PORA*** and the role of hydrogen.)

    See: *Horisont Energi and Port of Rotterdam sign memorandum of understanding regarding blue ammonia and* Port of Rotterdam website

GCC countries continued activity:

- **UAE, another week, and another week of progress:** On July 29, 2021, it was reported that the United Arab Emirates (***UAE***) had signed a strategic partnership agreement (***SPA***) with Austria. ***UAE*** Crown Prince Mohammed bin Zayed Al Nahyan and Austrian Chancellor, Mr Sebastian Kurz, signed the ***SPA*** during meetings in Vienna, Austria. At the same time it is understood that a cooperation agreement was signed in respect of the development of links to develop a hydrogen and hydrogen-based fuel value chain.

- **ADNOC exports Blue Ammonia to Japan:** On August 3 and 4, 2021, it was reported widely that Abu Dhabi National Oil Company (***ADNOC***) and Fertiglobe (a joint venture between ***ADNOC*** and OCI chemical (world leading producer of soda ash)) exported the first cargo of Blue Ammonia from the ***UAE*** to Japan. The Blue Ammonia was produced at the fertiliser plant in Ruwais. The cargo is reported to have been sold to Itochu (leading Japanese trading house). It would seem that the Blue Ammonia has been produced using Blue Hydrogen, with ***CO_2*** arising from the production of that Hydrogen being reinjected into the Bab and Rumaitha Fields to achieve enhanced oil recovery (see Edition 22 of Low Carbon Pulse under ***CCS can be a challenge***).

  It is reported that Fertiglobe is to combine in joint venture with ***ADNOC*** and ***ADQ*** (a key UEA holding company) to develop the Ta'ziz Blue Ammonia Project at Ruwais.

  See: *ADNOC and Fertiglobe Partner to Sell UAE's First Blue Ammonia to Japan's Itochu* and *Abu Dhabi's ADNOC sells its first 'blue ammonia' cargo to Japanese trading firm Itochu*

- The Oxford Institute for Energy Studies (***OIES***) has released a research paper (***ARP***) on the use of ammonia as an energy carrier and as a feedstock. The ***ARP*** is recommended. Also Renewable Energy News included an article on ammonia, entitled ***Ammonia – The Key to Unlocking Hydrogen's Potential As A Low Carbon Alternative to Fossil Fuels***. As with the ***ARP***, it is recommended.

- **PowerTap to deploy 100 hydrogen refuelling stations (*HRSs*):** On August 5, 2021, it was reported that PowerTap Hydrogen Capital is to deploy at least 100 hydrogen ***HRSs*** working with a number of governments in the Middle East. It is understood that ***HRSs*** may be co-located with existing refuelling stations.

  See: PowerTap *website*

Germany feeling the push to accelerate off-shore wind:

While it has been reported that the development of off-shore wind capacity (as opposed to on-shore wind capacity) in the German sector of the North Sea may be fallow in 2021, it is clear that this state of affairs is not likely to continue, and more broadly Germany continues to be active in the deployment of renewable energy, but there is no doubt that more off-shore wind field capacity is needed.

- On July 27, 2021, it was reported that four green giants, Equinor, Gasunie, RWE and Shell are exploring the potential for the development of an off-shore hydrogen park in the German sector of the North Sea. While this project has been in concept for a while as the ***AquaSector*** as part of the integrated ***AquaVentus*** project (see Edition 17 of Low Carbon Pulse), this project would go beyond current thinking around ***AquaSector*** (as a pilot scheme), to encompass a 300 MW electrolyser development to produce up to 20,000 metric tonnes of Green Hydrogen a year. The Green Hydrogen would be transported to the mainland of northern Europe via the ***AquaDuctus***.
- On July 27, 2021, Oil Price reported that despite a 62% increase in the installation in wind capacity across Germany in the first half of 2021, compared to 2020 (to 971 MW), this is not sufficient to achieve the national and ***EU*** wide targets for new installations. Under the Renewables Act in Germany, a little under 4 GW of wind capacity is to be installed each year.

India – the beats up:

- **SECI in beat, not wasting time:** As reported in previous editions of Low Carbon Pulse, state-owned corporation, Solar Energy Corporation of India (***SECI***) is active in the development of photovoltaic solar capacity.

  On July 26, 2021, it was reported that ***SECI*** is planning the development of a 2 GW energy storage system comprising a number of projects developed on a build-own-operate basis (each an ***ES BOO*** contract).

  Each ***ES BOO*** contract will be for a term of 25 years. It is reported that ***SECI*** will come to market later in August 2021. It might be expected that the ***ES BOO*** contracts will be awarded in tranches, each tranche reflecting the expected roll-out of the ***SECI*'s** solar development.

- **Green Hydrogen Projects:** On July 29, 2021, it was reported widely that Fortescue Future Industries (***FFI***) had signed a framework agreement with JSW Future Energy (a leading Indian power company), under which the corporations will work together to identify and to develop opportunities to use Green Hydrogen for iron and steel production and for mobility / transportation, and the production and use of Green Ammonia.

  This continues to global initiatives if ***FFI*** in a number of countries that will benefit from the capital and markets that ***FFI*** is able to unlock.

  See: Fortescue Future Industries website

- **India a leading country:** On July 30, 2021, the Executive Director of the International Energy Agency (***IEA***), Mr Fitoh Birol, addressed India's role as a country leading in clean energy.

  Mr Birol is reported to have said that: *"India is a leading country in terms of renewable energy investments … the country has great plans to be a driver of clean energy transitions …".*

Israel to introduce carbon tax:

To be phased in: On August 2, 2021, The Times of Israel, reported that Israel is to introduce a carbon tax over a five year period, 2023 to 2028.

Targeted Tax: As reported, the carbon tax:

- will apply:
  - to about 80% of the ***GHG*** emissions arising from the use of fossil fuels (coal, fuel oil, liquified petroleum gas, natural gas and petcoke) in Israel;
  - to ***GHG*** emissions arising from specified sources, including from cooling systems of all kinds, and landfill;
- will not apply to the use of diesel in the transport sector because, as reported, the excise duties on diesel in Israel are among the highest in the OECD.

Israel's NDC: As COP-26 approaches (in Glasgow, Scotland, in November), Israel has restated its national determined contribution (***NDC***) for the purposes of the Paris Agreement - 27% reduction in ***GHG*** emissions by 2030, and 85% reduction by 2050, compared to 2015. Modelling undertaken by the Environmental Protection Ministry indicates that the carbon tax will reduce ***GHG*** emissions by 67% by 2050, compared to 2015.

Japan's draft 2030 energy mix:

Pausing to consider the implications, Edition 22 of Low Carbon Pulse reported on the draft plan for the 2030 energy mix for Japan. For some, there was an initial "cat among the pigeons" or "fox in the hen house" moment following the release of the draft Strategic Energy Plan, by the Ministry of Economy, Trade and Industry (***METI***).

While there has been much analysis, possibly the pithiest assessment the author has read is that provided by Wood Mackenzie on July 27, 2021. Leaving to one side what may be regarded as stretch targets for renewables and nuclear power in the draft Strategic Energy Plan, from a policy setting perspective the draft from ***METI*** is consistent with the reduction of ***GHG*** emissions to 46% compared to 2013 levels by 2030.

ROK's energy mix dynamics:

- On July 31, 2021, The Korean Times published an article entitled ***LNG power generation poses dilemma for Korea's energy policy***. As with Japan, one of the "pause for thought" moments that has emerged in recent times in the Republic of Korea (***ROK***) is the role of LNG, in particular the use of natural gas derived from the regasification of LNG as a fuel for power generation.

  For some time, the policy settings in ***ROK*** have been oriented towards phasing out coal-fired, and nuclear, electrical energy generation. To achieve this phasing out, LNG is critical: in April 2021, power generated from firing natural gas derived from re-gasified LNG became the largest source of fuel for electrical energy generation in ***ROK***. As noted on previous editions of Low Carbon Pulse, and other Ashurst publications, LNG is regarded as a key transition fuel source because it gives rise to lower levels of ***GHG*** emissions than the use of coal.

  The policy settings in ***ROK*** reflect this role for LNG: 59 GW of electrical energy capacity sourced from LNG by 2034 (an increase of 20 GW), representing 30.6% of projected load. It is increasingly likely that these policy settings will need to be revisited.

CURRENT AND PROJECT ELECTRICAL ENERGY SOURCES IN ROK			
2019 CAPACITY (expressed as a percentage of load)		**2034 CAPACITY** (expressed as percentage of load)	
Renewables	6.5	Renewables	40.1
LNG	25.9	LNG	30.6
Coal	40.4	Coal	15.0
Nuclear	25.6	Nuclear	10.1
Other	1.4	Other	4.0

UK in consultation mode:

On July 2, 2021, the UK Government (Department for Business, Energy and Industrial Strategy (***BEIS***)) opened consultation in respect of:

- ***Carbon capture, usage and storage (CCUS): offshore decommissioning regime for CO_2 transport and storage***: the key purpose of the consultation is stated to be to seek views on ***BEIS's*** proposals for a funded decommissioning regime of ***CCUS*** projects, that satisfies the "Polluter Pays Principle", and encourages investment in the sector.

  The ***BEIS*** notes that the consultation process will be of interest to certain participants and prospective participants, including the ***CCUS***-enabled industrial regions such as South Wales, Scotland, the North West, North East and Humberside (see ***Clustering and Hubbing around the UK*** below); and
- ***Carbon capture, usage and storage CCUS: duties and functions of the economic regulator for*** CO_2 ***transport and storage***.

Policy Setting Updates:

On August 3, 2021, HyResource published ***International Hydrogen Policy Development An Update*** (***July 2021***) (***HySource Update***). The ***HyResource Update*** is a helpful publication, as was its March 2021 publication (***International Hydrogen Policies – Key Features***.

Bio-energy update:

As noted in previous editions of Low Carbon Pulse, it is anticipated that bio-energy is going to play a key role in progress to achieving ***NZE***. In recognition of this, Low Carbon Pulse will include details of bio-energy projects globally. These projects may not appear to be significant of themselves, but in combination they will reduce ***GHGs***, critically, they will reduce ***CH_4***.

- **Biogas to RNT:** On July 27, 2021, it was reported that the City of Toronto (***CoT***) is to derive renewable natural gas (***RNG***) from organics collected from its green bin system. The ***CoT*** intends to work with Enbridge Gas. The ***CoT's*** Solid Waste Management Service Division has installed infrastructure designed and constructed by Enbridge Gas, at the ***CoT's*** Dufferin Solid Waste Management Facility (which is an anaerobic digestion (***AD***) facility with capacity to take up to 55,000 tonnes of organics annually). The Enbridge Gas technology takes raw biogas arising from the anaerobic digestion of green organics, and processes that raw biogas further to scrub it, so to derive ***RNT*** or ***bio-methane*** that can then be used as pipeline gas.

- **Biogas to energy**: Towards the end of July 2021 the Santa Barbara ReSource Center is reported to have commenced operation of a materials resource recovery facility (***MRF***) and an anaerobic digester (***AD)***. As might be expected, the ***AD*** will process organics collected from the waste stream to derive biogas, with the biogas to be processed further to derive bio-methane, with the bio-methane then used to provide renewable energy.
- **Whisky delivery trucks to run on "green biogas":** On July 27, 2021, it was announced that Glenfiddich, producer and purveyor of single malt whisky, is to derive biogas from the residual material arising from the distillation of whisky to derive green biogas. The green biogas is described as "ultra-low carbon fuel gas that produces minimal carbon dioxide and other harmful emissions". In hard statistics, it is reported that the use of the green biogas reduces ***CO_2*** emissions by 95% compared to diesel. The development of the technology to produce the green biogas required parental guidance from William Grant and Sons.

  See: *Glenfiddich whisky lorries in Scotland to run on 'green biogas' made from distillery leftovers*

Blue Carbon:

- **Background:** While the author has been following with interest the concept of Blue Carbon, the narrative around possible policy settings has not developed with a coherence, and the science remains to be firmed-up to be even close to proven. The exception to this proven science is the apparently strong science around mangrove swamps.

  A report published by the Environmental Justice Foundation (***EJFR***), outlines the role that oceans and waterways have in limiting the effect of climate change through the absorption and retention of Blue Carbon.
- **Facts and Stats:** The ***EJFR*** contains some facts and statistics that assist in framing thinking, and in confirming other information gleaned over time (mangroves store up to four times more carbon per hectare than tropical rain forests).

  The ***EJFR*** is well-worth a read. This said, with the exception of the restoration and planting of mangrove swamps and other flora close to oceans and waterways, as yet the science tends to support a Socratic approach – do no harm.

BECCS and CCS and CCUS:

A number of news items in this edition of Low Carbon Pulse cover BECCS and CCS and CCUS (critically, ***Clustering and Hubbing around the UK*** below). The next edition of the ***Shift to Hydrogen (S2H2): Elemental Change*** will cover BECCS and CCS and CCUS in more detail, including in the light of the ***IPCC 2021 Report***.

***BESS*:**

- **Time for a "cold one": VBB registered with Australian Energy Market Operator (*AEMO*):** A previous edition of Low Carbon Pulse reported on the decision of Neoen (leading global renewable energy corporation) to develop the Victorian Big Battery (***VBB***): some may recall the lame joke from the author about Australia's favourite beer.

  Around July 28, 2021, it was announced the ***VBB*** had registered with ***AEMO***. As reported, from commencement of construction to registration has taken 205 days.

  This is testament to the project development acumen of the principal, Neoen, the timeliness of the supplier of batteries, Tesla, and the contractor, Downer UGL, and the role of ***AEMO*** and AusNet. To all, great outcome.

  See: Neoen *website*
- **Time for another "cold one":** In late July, 2021, it was announced that the Windoan Big Battery (***WBB***), owned by Vena Energy (leading global renewable energy corporation), had obtained its registration from ***AEMO***. The ***WBB*** is 100 MW / 150 MWh. The ***WBB*** was constructed by Doosan.

  See: Vena Energy *website*
- **UK Breaking Battery Limits:** On August 4, 2021, publication, Energy Storage, reported that there is an ever-increasing pipeline of submissions for the installation of utility-scale batteries: at the end for Q2 2021 it reported that the pipeline of submissions stands at 20 GW.

  This pipeline is expected to continue to fill, possibly not yet to its limits.
- **Big Batteries Filing In:** On August 5, 2021, it was widely reported that Maoneng (see Edition 21 of Low Carbon Pulse) has filed planning applications for the development of three new Big Batteries in Armidale (150 MW / 300 MWh), Lismore (100 MW / 200 MWh) and Tamworth (200 MW / 400 MWh) all in the New England region of New South Wales, Australia.

  See: Maoneng Group *website*

E-Fuels / Future Fuels:

- **Korean Green Ammonia Alliance:** Edition 2 of Low Carbon Pulse reported on the establishment of the ***Hydrogen Economic Committee***.

  On July 20, 2021, it was widely reported that:

  - **five public institutions:** Korea Institute of Energy Research, H2 Korea, Korea Research institute of Chemical Technology, and NETO; and
  - **thirteen private organisations:** Doosan Fuel Cell, Doosan Heavy Industries, Hanwa Solutions, Hyundai Glovis, Hyundai Heavy Industries, Hyundai Motor, Hyundai Oilbank, Hyundai Steel, Korean Shipbuilding & Offshore Engineering, Lotte Chemical (see Edition 22 of Low Carbon Pulse), Lotte Fine Chemical, POSCO and Samsung Engineering,

combined to establish the ***Green Ammonia Alliance*** (***GAA***). Members of the ***GAA*** undertake activities in each link in the ammonia supply / value chain: production, transportation, cracking (i.e., extracting Green Hydrogen from Green Ammonia) and use.

It is understood that the members intend to cooperate in the areas of ammonia production, transportation and use, including for marine use, and ammonia–coal co-fired power stations, Green Hydrogen as fuel for gas turbines, for high-temperature heat processes in the iron and steel industry, and as Green Hydrogen for ***FCT*** use, both mobility and stationary.

[**Note:** see Editions 27 and 28 of Low Carbon Pulse]

- **The nearer the destination, the more progress is made …:** On July 26, 2021, the ***World Economic Forum*** (***WER***) released a report, in collaboration with the Boston Consulting Group.

  Whether the credo or the conclusion (or possibly both), it is clear that: "*Addressing supply-chain emissions [as a whole of supply chain] enables many customer facing companies to impact [a mass] of emissions several times higher than they could if they were to focus on decarbonisation their own operations and power consumption alone – and achieving a net-zero supply chain is possible with very limited costs*".

- **It is Scotland in Chile:** Edition 21 of Low Carbon Pulse reported on the development of the ***Haru Oni Methanol Plant*** close to Punta Arenas, Magallanes, in Southern Chile. The ***eMethanol*** production project will use Green Hydrogen as feedstock to produce synthetic fuel; the Green Hydrogen will be combined with CO_2 captured / filtered from the air to produce Green Methanol. Edition 20 of Low Carbon Pulse reported on the engagement of ***Howden*** in respect of the supply of a high-pressure diaphragm compression system for ***HYBRIT***, the world's first fossil free steel plant at Svartoberget, in Lulea, Sweden. On July 27, 2021, it was reported widely that ***Howden*** is to supply hydrogen compression solutions for the ***Hari Oni Methanol Plant***.

- **Russia has a key role to play:** On July 27, 2021, in a comprehensive article Oil Price (under ***Russia Ramps Up Its Hydrogen Energy Ambitions***), the various narrative strains that have emerged over the last month or so are pulled together. The article is well-worth a read.

- **Eggs and baskets**: **Bio** is used frequently, including biogas and biomethane, bio-ethanol, bio-methanol, bio-fertiliser, and bio-LNG. Bio (effectively short for biomass) indicates that the feedstock from which the energy carrier is produced is not a fossil fuel, but is produced in whole or in part from an organic compound, i.e., comprising carbon, that on oxidation will produce CO_2, and likely ***NOx*** and ***SOx***.

  For any bio-energy carrier derived from a carbon intensive source to be carbon neutral, it needs to be produced from a renewable resource, with the electrical energy used to produce it, from a renewable source. This does not mean that on oxidation of an energy carrier that CO_2 will not arise, but rather, in theory, because the CO_2 that arises will be absorbed into another renewable resource on its growth, the continued growth of that renewable resource will provide a carbon neutral outcome. For any bio-energy carrier to be a blue energy carrier, all carbon arising on production of that energy carrier needs to be captured and stored.

  In this context the use of organic waste arising from agricultural and forestry activities and from waste collection and waste water collection is an ideal feedstock for the production of a bio-energy carrier.

- **Swiss for Hydrogen:** On July 29, 2021, it was reported that Alpiq, EW Hofe, and SOCAR Energy Switzerland are to develop, at Freienbach, Switzerland, a 10 MW electrolyser to produce 1,200 tonnes of Green Hydrogen a year. It is understood that the Green Hydrogen plant is to source renewable electrical energy to power the facility, and that the Green Hydrogen produced will be used for mobility, principally to power and propel 200 ***FCT*** light commercial vehicles.

  See: *Green hydrogen: EW Höfe, Alpiq and SOCAR Energy Switzerland mark a new milestone*

- **Hungry for Hydrogen:** On July 30, 2021, it was reported that a hydrogen production plant is to be developed (***Project Aquamarine***) in the Kardoskut Underground Gas Storage facility. Project Aquamarine has the support of the Government of Hungary.

  See: *Burckhardt Compression to Deliver H2 Diaphragm Compressor Unit for Hungarian Green Hydrogen Project*

- **Green Hydrogen to deliver NZ *NZE*:** Edition 22 of Low Carbon Pulse reported on the outline plans for the development of renewable electrical energy, and the use of that energy at Tiwai Point, Southland (location of Tawai Point aluminium smelter).

  Contact Energy and Meridian Energy (two of New Zealand's electricity generation corporations) are testing the appetite for the development of a world-scale Green Hydrogen production facility (***Southern Green Hydrogen***).

  On August 1, 2021, the Otago Times provided an update on ***Southern Green Hydrogen***, noting that production of Green Hydrogen may commence as early as 2023. The update noted the likely involvement of Fortescue Future Industries or ***FFI*** (a subsidiary of Fortescue Metals Group, founded by Dr Andrew Forrest, AO).

  On August 3, 2021, The West Australian (Western Australia being the home state of Dr Forrest, AO, and ***FFI***), picked up on the ***FFI*** interest in ***Southern Green Hydrogen***.

  On August 4, 2021, ***FFI*** announced that it had signed a collaboration agreement with Murihiku Hapu of Ngai Tahu in respect of the potential development of a large scale, Green Hydrogen production project in Southland, New Zealand.

- **Mixed combustion testing in ROK:** Edition 18 of Low Carbon Pulse reported on the plans to co-fire ammonia and natural gas in Japan. On August 3, 2021, Hanwha General Chemical and Korea Western Power Co agreed to work together to mix hydrogen and natural gas derived on the regasification of natural gas form LNG to allow co-firing of those fuels to generate electrical energy. As note previously, the higher the proportion of hydrogen in the co-fired mix, the lower the CO_2 arising on combustion, but the lower the energy density of the mixed H_2 / CH_4 stream.

  See: *Hanwha, Korea Western Power to test mixed hydrogen combustion*

- **Hydrogen power plant for Texas:** On August 3, 2021, it was widely reported that Entergy, Texas, intends to seek approval for a hydrogen and natural gas fired combined cycle gas turbine power station, to be located in Orange County, Texas (***Orange County Advanced Power Station*** or ***OCAPS***). While the details have yet to emerge from the filings for approval, it is understood that the ***OCAPS*** will be using 30% hydrogen and 70% natural gas as its fuel, converting to 100% hydrogen in the future.

  See: *Entergy Texas Plans New Generation Facility To Power Southeast Texas*

- **Spanish Hydrogen Value Chain:** On August 4, 2021, it was reported widely that Bosch, Petronor and Repsol have signed a letter of intent to work together to assess development of, and to develop, a hydrogen value chain in Spain. Each corporation regarded hydrogen as a key energy carrier for the future, in particular for the purposes of mobility (cars, buses, trains and shipping).

  See: Bosch *website*; Petronor *website*; Repsol *website*

- **Raven SR selects designers for waste to hydrogen project:** Edition 16 of Low Carbon Pulse and the first feature in the Ashurst hydrogen for industry (***H24I***) series outlined plans by ***Hyzon Motors Inc*** and ***Raven SR*** to develop up to 100 waste to hydrogen facilities to derive hydrogen from waste delivered to landfill sites across the US.

  On August 4, 2021, it was announced that ***Raven SR*** has appointed Power Engineers and Steller J Corporation to complete the final design of the first two waste to hydrogen facilities.

  See: Raven SR *website*

- **Green Hydrogen under water:** On August 5, 2021, it was widely reported that Fincantieri SpA (global leading ship building corporation) and Enel Green Power Italia (part of the global leading renewable energy corporation) agreed to explore the use of Green Hydrogen for vessels, including submarines.

  Head of Business Development for Enel Green Power, Mr Carlo Zorzoli said: "*The signing of this agreement represents a further step forward in Enel Green Power's commitment to collaborating with operators interested in developing solutions for the use of Green Hydrogen in sectors where electrification is not possible, this contributing to the energy transition process through the decarbonisation of industrial activities*".

  See: Enel *website*

- **BP inks-in Blue:** On August 5, 2021, it was widely reported that BP (global leading international energy corporation) had inked a number of agreements for the sale of Blue Hydrogen. As noted below, BP plans to develop a 1 GW Blue Hydrogen production facility on Teesside, in the North East of England, and to proceed with the development it is contracting with off-takes of Blue Hydrogen. It is reported that each of CF Fertilisers, Mitsubishi Chemical Corporation and Sembcorp Energy UK have each signed a memorandum of understanding with BP for the supply of Blue Hydrogen, and that Alfanar Company and BP have signed another memorandum of understanding for the supply of Blue Hydrogen to Alfanar at its waste to ***SAF*** (sustainable / synthetic aviation fuel) facility.

  See: BP *website*

- **Deutsche Bahn and Statkraft:** On August 6, 2021, it was reported in publication, Clean Energy Pipeline, that German rail corporation Deutsche Bahn signed a 10 year power purchase agreement with Norway's Statkraft for the supply of 190 GWh pa of renewable electrical energy.

  See: Deutsche Bahn *website*; Statkraft *website*

- **Iceland and UK killer combination:** On August 6, 2021, it was widely reported that Icelandic utility corporation HS Orka and, the UK based corporation, Hydrogen Ventures Limited are to develop a methanol production plant using Green Hydrogen as the feedstock.

  The Green Hydrogen will be produced using renewable electrical energy from HS Orka's geothermal power plant at Reykjanes. It is reported that the methanol produced will be used as mobility (for cars, vans and trucks) and as shipping fuel.

  See: HS Orka *website*; Hydrogen Ventures *website*

Green Metals and Minerals, the Mining Industry and Difficult to Decarbonise industries:

- **ArcelorMittal Green Bases:** Edition 22 of Low Carbon Pulse reported on ArcelorMittal's plans to develop its Sestao steel mill in Spain as a zero carbon emissions steel plant following the development of a direct reduced iron (***DRI***) plant and an electric arc furnace (***EAF***). The ***DRI*** and ***EAF*** projects are to proceed following the signing of a memorandum of understanding (***MOU***) by ArcelorMittal and the Spanish Government, with the development of the projects scheduled for completion in 2025, with up to 1.6 million metric tonnes per annum of zero carbon emission steel to be produced annually.

  On July 29, 2021, AcerlorMittal and the Government of Canada announced a similar investment "to green" AcerlorMittal's Hamilton, Ontario steel plant. The investment means that the Hamilton plant will transition from the use of blast furnace technology to the use, and operation of, ***DRI*** and ***EAF*** technology.

  See: *ArcelorMittal and the Government of Canada announce investment of CAD$1.765 billion in decarbonisation technologies in Canada*

- **Comment on CO2MENT:** In late July 2021, the Journal of Commerce, reported on a "first-of-its-kind" carbon capture, and use, pilot project at the Lafrarge Canada (part of LafargeHolcin, global leader in cement products), cement plant in Richmond, British Columbia (***CO2MENT Project***).

  The ***CO2MENT Project*** is using technology developed by Svante, Inc: as reported, the technology captures ***CO_2*** arising on the production of clinker and reuses ***CO_2*** (and as such stores that ***CO_2***) in cured concrete – thereby achieving the troika of "capture, use and storage".

As outlined in ***Shift to Hydrogen (S2H2): Elemental Change***, cement production gives rise to a significant mass of ***GHG*** emissions, which when added to the ***GHG*** emissions arising on transportation of limestone as feedstock, transportation of cement for concrete production, and transport of concreate to point of use, leaves a significant carbon footprint.

- **BHP Nickel West and TransAlta – global first:** Both BHP (world leading mining corporation) and TransAlta (Canadian headquartered global leading energy solutions corporation) have announced that they have contracted to transform the energy supply arrangements at BHP's Nickel West operations in Western Australia. BHP has contracted with TransAlta to effect the evolution of energy supply so as to achieve ***NZE*** over time, consistent with BHP's global commitments to achieving ***NZE***.

  As noted in previous editions of Low Carbon Pulse, the mining industry is a quiet achiever in making progress toward ***NZE***, and the BHP and TransAlta arrangements provide a blue print that may be expected to be rolled-out globally to decarbonise electrical and heat energy supply over time.

  See: *TransAlta Renewables Announces Agreement to Build a Hybrid Solar – Battery Project for BHP Nickel West in Western Australia*; *Two new solar farms and battery to help power mines at BHPs Nickel West*

- **Komatsu Greenhous Gas Alliance:** On July 2, 2021, it was reported widely that Komatsu (world leading manufacturer of yellow gear and other mining equipment), has set up an alliance with global mining giants, BHP and Rio, and Boliden and Codelco (***KGHGA***).

  It is reported that through ***KGHGA***, Komatsu will work on product development and deployment to accelerate the development and deployment of ***NZE*** mining equipment and infrastructure. It is reported that an early development prospect is the development of "power-agnostic" truck and can be powered by a range of power sources, including battery and fuel cell.

  At the risk of beating a drum too long and too loudly, the ***KGHGA*** illustrates the willingness of mining corporations to engage so as to accelerate progress towards ***NZE***.

- **UAE developing Green Steel production capacity:** On August 3, 2021, it was reported that the Abu Dhabi National Energy Company (***TAQA***) and Emirates Steel have combined in a partnership to develop a large-scale Green Hydrogen Green Steel production mill.

  As reported in Editions 13 and 21 of Low Carbon Pulse, ***TAQA*** is a key participant in the development of green utility solutions within the UEA, and the broader MENA region.

  CEO and Managing Director of ***TAQA*** Group, Mr Jasim Husain Thabet said:

  > "*TAQA is setting out to become a recognised champion of low carbon power and water, and this partnership with Emirates Steel leverages our combined expertise to lower the overall cost of production as well as reducing carbon emissions*".

  See: *TAQA Group, Emirates Steel to Enable the Region's First Green Steel Manufacturing* and Emirates Steel *website*

- **Anglo American and Salzgitter partner on the greening of iron and steel:** As covered in Editions 13 and 18 of Low Carbon Pulse, Anglo American (global leading diversified mining corporation) and Salzgitter (global leading rolled and tube steel producer) are both active in making progress to achieving ***NZE*** in their respective core businesses.

  On August 4, 2021, Anglo American and Salzgitter, announced that they had entered into a memorandum of understanding (***MOU***) to develop shared understanding of the greening of steelmaking and the use of natural gas and hydrogen as energy carriers to displace fossil fuels and other carbon intensive fuels for high-heat temperature processes to produce iron ore pellets and lump iron ores for ***DRI***.

  This is noteworthy because it illustrates that Anglo American is positioning to address its Scope 3 emissions.

  See: *Anglo American partners with Salzgitter Flachstahl to advance Green Steelmaking*; *Salzgitter AG and Anglo American cooperate in optimizing iron ore supplies for low* CO_2 *steel production*

Clustering and hubbing around the UK:

- Edition 22 of Low Carbon Pulse promised a deeper consideration of the industrial clusters and hubs around the UK which are in the process of developing, and a number of them awaiting the outcome of applications for government support in ***Track 1*** of the ***CCUS Programme*** (see second bullet point below). The ***CCUS Programme*** is consistent with key outcomes in the Ten Point Plan for a Green Industrial Revolution (***10 Point Plan***).

  Each cluster or hub is located in an area that is, or has been, dominated by industry (in some instances since the industrial revolution). Each cluster or hub hosts activities within its hinterland that contemplate a role for CCS / CCUS, with proximate storage (depleted fields) and, in the case of a number of them, the production, and likely proximate storage (salt caverns) and use, of hydrogen.

  Given the various editions of Low Carbon Pulse have touched on the development of most if not all of the clusters and hubs, it seemed timely to summarise each cluster and hub. Some clusters and hubs are more developed than others, but all are developed beyond concept.

UK CLUSTERS AND HUBS		
Name / location of cluster / hub:	**Participants:**	**Range of activity / production:**
Bacton Gas Terminal (*BGT*): Oil and Gas Authority (OGA) has identified ***BGT*** as an ideal location for a low carbon hub	The concept continues to develop, noting the huge potential for Blue and Green Hydrogen production	CCS / CCUS given proximity to southern North Sea Gas fields, and 5 GW of Blue and Green Hydrogen production capacity
Isle of Grain (*IOG*): The Isle of Grain, Kent, cluster / hub to comprise natural gas reforming facilities to produce Blue Hydrogen (with **CO_2** captured and stored off-shore), including to blend with **CH_4**	Arup, Cadent, National Grid, Royal Dutch Shell, SSE Thermal, SGN, Uniper and VPI National Grid sees the benefit of blending Blue Hydrogen with natural gas across its entire national network	700 MW pa (2026) and 1.75 GW pa (2030) of Blue Hydrogen to be used for power generation. 1.2 million metric tonnes per annum (***mmtpa***) (2026) and 3 mmtpa (2030) of **CO_2** captured and stored
East Coast Cluster: Comprises Northern Endurance Partnership, Zero Carbon Humber and Net Zero Teesside		
Zero Carbon Humber (*ZCH*): The anchor project is the Blue Hydrogen (**H2H**) Saltend project at PX's Saltend Chemicals Park, and use at Power Plant BECCS at Drax will capture **CO_2**, CCS at SSE Thermal 's Keadby 3 will capture **CO_2**, and CCS at Uniper's Immingham Blue Hydrogen production facility Captured **CO_2** compressed in Centrica's Easington facility	***ZCH* participants:** Associated British Ports, British Steel, Centrica, Drax, Equinor, Mitsubishi Power, National Grid, PX, SEE Thermal, Triton, Uniper, and AMRC. **Equinor across the clusters:** Equinor is a member of part of the Net Zero Teesside and Northern Endurance Partnership (***NEP***), and leads the ***ZCH*** National Grid is a partner in the ***NEP***	Humber and Teesside regions account for around 50% of UK industrial emissions. The ***ZCH*** and ***NZT*** projects are intend to capture **CO_2** from industrial activities along the Humber and Tees Valley, with 17 capture projects identified, both to reduce current **CO_2** arising currently, and to allow the development of new facilities and plants (including to allow the production of Blue Hydrogen).
Net-Zero Teesside (*NZT*) project: The intention is to capture up to 10 mmtpa of **CO_2**	BP, Eni, Equinor, Shell and TotalEnergies, with BP leading ***NZT***	In addition, four clean hydrogen / low carbon hydrogen production plants are contemplated across ***ZCH*** and ***NZT***.
Northern Endurance project: pipeline and storage infrastructure to take **CO_2** captured by ***NZT*** and ***ZCH***, it being 145 km and 85 km from each respectively	BP, Eni, Equinor, National Grid, Shell and TotalEnergies, with BP as the corporation operating the project. There is potential to expand the carbon storage capacity	There is up to 27 ***mmtpa*** of **CO_2** storage capacity in the Endurance aquifer (located in the southern North Sea), with capacity to be operational by 2030
HyNet North West:		
HyNet North West: carbon capture (industrial, bioenergy and waste to energy) and storage in Liverpool Bay, Blue Hydrogen production (of up to 3.8 GW) and sustainable / synthetic aviation fuel (***SAF***) production	Eni, Essar, Cadent, Intergen, CF Fertilisers, Hanson (Heidelberg Cement Group), and INOVYN (an Ineos company). ***HyNet North West*** is led by Progressive Energy (***PE***)	For the purposes of **CO_2** haulage, a **CO_2** pipeline is to be developed to allow **CO_2** to be delivered into storage in Liverpool Bay. ***PE*** and Essar plan to phase in hydrogen production, 3.8 GW by 2030
Scottish Cluster comprising **CO_2** source projects at Grangemouth (INEOS and Petroineos), Peterhead (Equinor and SSE Thermal CCS Power Plant), St Fergus Gas Complex (ExxonMobil and Shell, and North Stream Midstream Partners (***NSMP***)), contracting with the ***Acorn CCS Project*** and ***Acorn Hydrogen***		
Scottish Cluster carbon capture, and haulage of **CO_2** to the ***Acorn CCS Project*** that will store **CO_2** from up to nine different sources, including a DAC facility	Harbour Energy, INEOS, Petroineos, ExxonMobil and Shell, ***NSMP***, Equinor and SSE Thermal, Petrofac and Storegga, with Storegga key	***Acorn CCS Project***, with storage of 25.5 ***mmtpa*** by 2030, at a rate of 6.7 ***mmtpa***, and 500 million metric tonnes of total storage to 2050 and Acorn Hydrogen Project
South Wales Industrial Cluster (**SWIC**): carbon capture across a number of industries and Blue Hydrogen production	RWE, Tata Steel, Tarmac, and Valero.	CCS / CCUS is key to this area of the UK, and its use will contribute to decarbonisation of difficult to decarbonise industries

- On July 30, 2021, the UK Government announced five eligible projects for its ***CCUS*** (cluster sequencing) ***Programme***, detailed below:
  - **DelpHYnus Project:** a combined development from Neptune Energy to capture, haul and store ***CO_2*** from the South Humber Industrial area and the production of Blue Hydrogen at the site of the former Theddlethorpe Gas Terminal, with ***CO_2*** arising on production of Blue Hydrogen being captured, hauled and stored;
  - **East Coast Cluster:** a combination of the Equinor led Zero Carbon Humber, the BP led Net Zero Teesside projects, and the Northern Endurance Partnership (***NEP***). The ***NEP*** founding members comprise BP, Eni, Equinor, National Grid, Shell and TotalEnergies;
  - **HyNet North West**: a combination of clean hydrogen production (up to 3.8 GW by 2030, or 80% of the 5 GW target in the ***10 Point Plan***), and CCS, with storage in the Eni UK depleted gas field in Liverpool Bay. The clean hydrogen production would be phased in as follows: 350 MW, 2025, 1 GW 2026, and 3.8 GW 2030;
  - **ScottishCluster:** the ***Acorn CCS Project*** is key, as are the number of sources of ***CO_2***, nine, with eight anticipated to have capture capacity in place by 2027; and
  - **VNZ Cluster:** Harbour Energy is sole developer of the Viking Net Zero (***VNZ***) concept, developing the depleted Viking Field sourcing ***CO_2*** from the Immingham (including from EPUKI, Phillips 66, PRAX, and VPI).

  If all five eligible projects were to proceed they would provide production capacity for up to 9.7 GW of low-carbon hydrogen by 2030, 4.7 GW more than the 5 GW contemplated in the ***Ten Point Plan***. The UK is well on the way.
- On October 25, 2021, as part of the ***Track 1 CCUS Programme***, two successful clusters will be announced, as will one individual project connected to each cluster. At the same time, the process for the ***Track 2 CCUS Programme*** will be announced. The UK could accelerate by approving UK!

Hydrogen Cities, Councils, Hubs, Infrastructure and Valleys:

- **First Solar, another first:** On July 30, 2021, it was reported widely that First Solar (Arizona, US, based global leading solar corporation) intends to develop a USD 680 million, 3.3 GWdc photovoltaic solar thin film solar factory in the state of Tamil Nadu, India (***TNF***). On completion of the ***TNF***, in combination, the global manufacturing capacity of First Solar will be a little over 16 GWdc during 2024. It might be expected that this capacity will increase as further capacity is added to respond to increased demand.

  As noted across previous editions of Low Carbon Pulse, the progress to ***NZE*** is layered. Electrification is core to progress to ***NZE***. Electrification is dependent on increased manufacturing capacity, including to realise the benefits of scale and the resulting reduction in unit costs of production. Increased manufacturing capacity is dependent of the extraction and processing of metals and minerals (and production of other materials) as the raw materials for manufacturing. Increased extraction and processing of metals and minerals requires expansion and new mine development. Each requiring the deployment of capital, either from free cash flows or from borrowing, or both. Like dynamics arise in respect of the development of the Green Hydrogen supply chain.

  Decisions by the private sector to invest, involve decisions around assumption of risk, and once investment decisions are taken, development. This takes time. As noted of late, the global carbon budget does not afford the luxury of time. As COP-26 approaches (it is less than 100 days to the commencement of COP-26), the clock is ticking: the need for government policy settings and direct investment is becoming ever more pressing. What is needed, is known.
- **Battery recharging infrastructure - Australia:** Continuing the theme of infrastructure development required to achieve ***NZE***, downstream of renewable electrical energy generation (and hydrogen production) is the development of recharging infrastructure (and refuelling infrastructure). As noted in previous editions of Low Carbon Pulse, there is a role for government in the development of this infrastructure.

  On July 29, 2021, the Australian Federal Government, through the Australian Renewable Energy Agency (***ARENA***) agreed to provide support in the development of 400 fast recharging stations, from the ***ARENA*** managed, Fuel Fund and the private sector, Ampol Australia, Engie and Evie Networks. Co-funding of this kind may be regarded as ideal: the private sector is best placed to assess risk, with investment risk shared, so as to provide supply to the market for ***BEV*** to allow it to develop at a greater rate, with the attendant ***GHG*** emission reduction benefits.
- **BEVs to use recharging infrastructure – UK:** On the same day that Australia announced the development of 400 fast recharging stations working with government, seven UK corporations combined to provide a blue print to accelerate the adoption of electric vehicles across the UK. BP, BT, Direct Line Group, Royal Mail, Scottish Power, Severn Trent and Tesco, as the Electric Vehicle Fleet Accelerator (***EVFA***). The blue print is intended to accelerate progress to deliver on ***GHG*** emission reduction targets, critically in the area of road transport. The August Report on Reports will summarise the proposals.

  As noted in Edition 22 of Low Carbon Pulse, road transport in the UK accounts for nearly 90% of total ***GHG*** emission arising from the transport sector.

Wind round-up:

- **North to South:** On July 27, 2021, it was reported widely that the first Green Hydrogen scale production plant is to be developed in Hokkaido (***HGHP***) towards the end of Q1 2024. It is reported the ***HGHP*** will produce up to 550 tonnes of Green Hydrogen a year, modelled to be sufficient to fuel 10,000 ***FCEVs***. The electrical energy to power the ***HGHP*** will be sourced from an on-shore farm in the first instance, and off-shore wind fields in future to allow expansion of the capacity to 2,500 tonnes per year. It is understood that Green Power Investment, Hokkaido Electric Power, Nippon Steel Engineering and Air Water (industrial gas supplier) are participating in ***HGHP***.

  By way of a reminder, the policy settings (***Green Growth Strategy***) contemplate that by 2030 the use of hydrogen in Japan will be around 3 ***mmtpa***, increasing to up to 20 ***mmtpa*** by 2050.

- **West Coast, US:** Edition 22 of Low Carbon Pulse reported on the prospective development of off-shore wind capacity off Northern California. On July 29, 2021, it was reported in, renews.BIZ, that the US Department of the Interior's Bureau of Ocean Energy Management (***BOEM***) has called for information and nominations, by September 13, 2021, to determine interest in developing off-shore wind fields in two new areas, the Morro Bay Call Area, East and West Extensions (adjacent to the Morro Bay Call Area, which ***BOEM*** identified in 2018).

  BOEM Director, Ms Amanda Lefton said: "*Today's announcement builds on the earlier agreement between the White House, the Department of the Interior, the Department of Defense, and the State of California to advance areas for off-shore wind off the northern and central coasts of California. If approved for off-shore wind … development, these areas could bring us close to reaching this administration's goal of deploying 30 GW of off-shore wind by 2030*".

- ***Ørsted US:*** On 4 August, 2021, it was widely reported that Ørsted had completed the development of its 367 MW on-shore wind project, its largest in the US.

  See: Ørsted *website*

- **Masdar winding up:**: It has been a busy couple of weeks for Masdar with the development of the floating photovoltaic solar ***Cirata Project*** in Indonesia (see below) and the connection to the grid of the 400 MW Dumat Al Jandal (***DAJ Project***) on-shore wind farm in Saudi Arabia.

  On August 8, 2021, The National News, reported that the ***DAJ Project***, developed in joint venture between Masdar (the Abu Dhabi Future Energy Company) and EDF (global leading French electrical energy company), had produced its "first carbon-free megawatt-hours … of energy [that] will help bolster Saudi Arabia's network during the hot summer months when electricity consumption is at its peak".

  The electrical energy generated by the ***DAJ Project*** is to be supplied under a 20 year power purchase agreement to the Saudi Power Procurement Company (as subsidiary of the Saudi Electricity Company). The ***DAJ Project*** comprises 99 wind turbines, each with 4.2 MW of output. The turbines were supplied by Vestas (world leading renewable energy supplier and contractor), which also acted as the EPC contractor.

Solar round up:

- **Pertamina to develop photovoltaic solar plants:** On August 2, 2021, it was reported widely that PT Pertamina New Renewable Energy (***PNRE***), a wholly-owned subsidiary of PT Pertamina (***Persero***), is to develop 500 MW photovoltaic solar plants to be co-located with facilities that are part of the ***Persero*** Group. It is understood that ***PNRE*** has completed photovoltaic solar plants at the Badak LNG Terminal, Cilicap and Dumai Refineries. The continued development of solar photovoltaic capacity is consistent with ***Persero*** Group's objective of reducing ***GHG*** emissions by 30% by 2030.

  See: Pertamina *website*

- **Masdar floating solar commences build:** On August 4, 2021, Masdar (the Abu Dhabi Future Energy Company) announced that financial close has been achieved in respect of the 145 MW Cirata Floating Photovoltaic Power Plant Project (see Edition 18 of Low Carbon Pulse).

  The ***Cirata Project*** is the first floating photovoltaic power plant in Indonesia. It is being developed by PT Pembandkitan Jawa Bali Masdar Solar Energi (**PMSE**), a joint venture between Masdar and PT JJBI. The ***Cirata Project*** is expected to be commence operation in 2022.

  See: *Masdar joint venture reaches financial close and starts construction on Indonesia's first utility-scale floating solar power plant*

Sustainable energy round-up:

- ***WEF*** **report on US Renewables:** In another short video, the ***WEF*** reports on progress on renewable electrical energy development in the US during 2020. In 2021, 21% of electrical energy in the US was derived from renewable energy sources, second to gas fired generation capacity, and ahead of coal (in 2020, falling 20% to 20% of electrical energy generation) and nuclear. As is the case with Australia, the US has achieved this progress on the basis of State, rather than through coherent and meaningful Federal, policy settings, intended to support the development of renewable electrical energy.

- **West to East, and back again:** Previous editions of Low Carbon Pulse have reported on the proposed development of the 2 GW EuroAsia Interconnector connecting Attica, Greece, Crete, Greece, Cyprus, and Israel so as to create a means of achieving electrical energy security through access to renewable electrical energy sourced from different countries.

  It was noted that the EuroAsia Interconnector had been designated as a Project of Common Interest (PCI13,10), which allows access to ***EU*** funding and support.

  On July 27, 2021, it was reported that the Council of the ***EU*** had allocated €100 million in grant funding. It is expected that the development of the first phase of the EuroAsia Interconnector will be completed, so as to allow commissioning, by the end of 2025.

Land Transport:

Edition 21 of Low Carbon Pulse name checked "first movers" and "early movers", including Cummins Inc (***CMI***). There are of course three major corporations "that are key" to progress to development of hydrogen power and propulsion, and those corporations are Air Liquide, Air Products and Linde: all three corporations are long-standing industrial gas producers, and technology providers, key to decarbonisation across a number of sectors.

- **Global Market Leaders in complementary combination:** On July 27, 2021, it was reported widely that ***CMI*** and Air Products are to work together to accelerate the development and integration of fuel cell technology for heavy goods vehicles / trucks in the Americas, Asia and Europe. It is reported that the focus for the corporations in working together includes ***CMI*** providing ***FCT*** powertrains for use to transport Air Products industrial gases.

As with the working relationships underway among Hyzon Motors Inc and TotalEnergies (see Edition 22 of Low Carbon Pulse), the ***CMI*** and Air Products arrangements allow each corporation to play to its global leading strengths, while at the same time ensuring that its core business benefits in a complementary way from working with the other.

- **Air Liquide ROK solid:** On July 27, 2021, it was reported widely that Air Liquide had continued its run of success in South Korea, with arrangements progressing with:
  - ***Lotte Chemical*** (see Edition 22 of Low Carbon Pulse) to develop high pressure hydrogen refilling and refuelling infrastructure (***HRI***) and refuelling stations (***HRS***);
  - ***SK Energy*** (see Edition 20 of Low Carbon Pulse) to develop a scale hydrogen liquefaction plant to liquid hydrogen (***LH2***), with that ***LH2*** to be used in mobility markets; and
  - ***Yeosu City*** and ***Jeollanam-do province*** to undertake studies relating to the development of hydrogen liquefaction facilities on the south coast of South Korea, in the heartland of the refining and petrochemical industry.
- **On the high road and on the road overhead:**
  - **Hyzon Motors Inc keeps trucking to deliver:**
    - **Hyzon Motors Inc and RenewH2 align:** Edition 22 of Low Carbon Pulse reported that Hyzon Motors Inc had signed a memorandum of understanding with TotalEnergies' Marketing and Services division to work together to develop hydrogen refuelling infrastructure (***HRI***) across Europe, and to continue to develop long-haul transport solutions for customers for those services across Europe.

      On August 3, 2021, it was reported widely that Hyzon Motors Inc had signed a memorandum of understanding with ***RenewH2*** (a hydrogen production, liquefaction, distribution and delivery system corporation) to develop liquid hydrogen refuelling stations (***HRS***). It is understood that a number of ***HRS*** are to be developed and that they will be used to deliver hydrogen derived from biogenic methane, produced using gas reforming technology. The first feature in the Hydrogen for Industry (***H24I***) series featured similar plans of Hyzon Motors Inc in the context of locating hydrogen production facility and ***HRS*** at landfills.

      As has been the case with many other news items reported stories in Low Carbon Pulse, this is another instance of the private sector positioning to be able to match supply to demand, and positioning for purchasing decisions made by other participants in the private sector.

      See: *Hyzon Motors partners with liquid hydrogen production company RenewH2 to develop fueling stations* and RenewH2 *website*
    - **First Hyzon Motor Inc waste collection vehicle:** On August 2, 2021, it was reported that the City of Rotterdam has commenced use of its first Hyzon Motors Inc ***FCT*** waste collection vehicle. As noted above, ***Hyzon*** and ***Raven SR*** are in joint venture in the US to develop up to 100 hydrogen from waste facilities located across the US, with the intention to use the hydrogen derived to power and to propel waste collection vehicles.

      See: Hyzon Motors *website*
  - **Hyundai Motor Co invests in H2 Mobility:** As may be expected by one of the world's leading ***FCT*** proponents, Hyundai Motor Co has invested in ***H2 Mobility*** (a German ***HRS*** operator). It is understood that Hyundai joins Air Liquide, Daimler, OMV, Royal Dutch Shell and TotalEnergies as an investor in ***H2 Mobility***.

    See: *Hyundai becomes shareholder in H2 Mobility*
- **Scaling up first movement:** Previous editions of Low Carbon Pulse have reported on the progress that Hyundai has made in the development and deployment of fuel cell technology (***FCT***) heavy goods vehicles / trucks (***FCEVTs***) (see Editions 1, 17 and 18 of Low Carbon Pulse). Likewise, the pace-setting of Macquarie Group has been covered, including through Green Investment Group. On July 27, 2021, Macquarie Group announced that it had entered a consortium with Hyundai Motor Company to complete the deployment of 20 Class 8 ***FCEVTs*** in North America. Macquarie will own the ***FCEVTs***, and lease them to the freight transportation sector.
- **E-Highway in UK:** Edition 21 of Low Carbon Pulse reported on the first overhead electrical cable freight system (under ***On the high road and overhead***) (***E-Highway***). On July 27, 2021, it was reported that the Department for Transport, through Innovate UK, is conducting a study into the development of the UK's first ***E-Highway***. It is reported that Costain is leading a consortium to undertake the study, initially over a nine month period. If the ***E-Highway*** study proves up viability, ***E-Highways*** may be adopted in the UK during the 2030's.
- **Midlands – all change to hydrogen:**
  - **Birmingham City Council (*BCC*) takes delivery of 20 hydrogen buses:** Edition 22 of Low Carbon Pulse reported on the delivery of the first London Buses to be powered and propelled by hydrogen.

    On July 28, 2021, it was reported that ***BCC*** took delivery of its first fleet of hydrogen buses.

    See: *Birmingham gets first hydrogen bus*
  - **H2GVMids funded:** Also on July 28, 2021, it was reported that the Department for Transport is to provide funding under the Zero Emission Road Freight program to deploy heavy goods vehicles / trucks (***HGVTs***) across the Midlands in the UK for the purposes of demonstrating their use for freight transportation.
- **Miles and miles:** Edition 21 of Low Carbon Pulse reported on the approach of the first anniversary of the commencement of use of the Hyundai Xcient truck in Switzerland (August 2020), and the intention of Hyundai to extend its horizons to the US.

On July 30, 2021, it was announced that tests are to commence in California of the Hydrogen Xcient truck, based the ***FCT*** technology used in Switzerland, with the range of the ***Californian FCT*** truck to be 500 miles (or 805 kilometres) (the ***Class 8 500-mile***).

As reported in Hydrogen Fuel News (under ***500-mile range Hyundai hydrogen fuel cell semi-trucks under-go testing***), the testing program is to take place under the **NorCal ZERO project**, with grant funding from the California Air Resources Board (***CARB***) and California Energy Commission (***CEC***), together providing funding of USD 20 million, and the Alameda County Transportation Commission (***ACTC***) and the Bay Area Air Quality Management District (***BAAQMCD***), together providing funding of USD 7 million.

As the project progresses, it is reported that Hyundai intends to develop hydrogen refuelling infrastructure (***HRI***), starting with an hydrogen refuelling station in Oakland, California.

See: *Hyundai's XCIENT Fuel Cell Hitting the Road in California*

- **NorCal ZERO Project:** The NorCal ZERO project is intended to, and will, deploy the hydrogen fuel cell trucks. The Center for Transportation and the Environment (***CTE***) is working on the project, with the support of ***CARB***. In addition to ***CTE***, ***CARB***, ***ACTC*** and ***BAAQMCD***, Air Liquide, EBMUD, FE Fuel, Fielder Group, Macquarie, NorCal Kenworth, Port of Oakland, West Oakland Environmental Indicators Project, and two Berkeley based policy and research organisations, are involved in the project.
- **A Vision for Freight Movement in California – and Beyond**: On August 3, 2021, the California Fuel Cell Partnership (***CaFCP***) released its vision for the use of HD class 8 fuel cell electric trucks (***FCETs***) entitled "***Fuel Cell Electric Trucks: A Vision for Freight Movement in California and Beyond***" (***Foundational Document***).

  The ***Foundational Document*** contemplates the deployment of 70,000 ***FCETs*** and 200 hydrogen refuelling stations (***HRS***) by 2035. While trucks represent 2% by number of vehicles on California roads, they give rise to 9% of the ***GHG*** emissions, 32% of its NOx emissions and 3% of its particulate emissions. The stated intention is accelerate private sector investment in ***FCT*** as progress is made toward ***NZE*** (whether in 2045 or sooner).

  The release of the ***Foundational Document*** follows ***CARB's*** ***Advanced Clean Truck*** rule: a world first in that it requires truck manufactures to transition from diesel powered and propelled trucks and vans to electric-zero emission vehicles.

Shipping News and Forecast:

- **Best laid plans of Norled – first ferry delivered:** Edition 12 of Low Carbon Pulse reported on the liquid hydrogen supply arrangements for the world's first hydrogen powered and propelled ferry (with Linde to supply hydrogen from its Leuna Chemical Complex in Germany, using a proton exchange membrane (***PEM***) electrolyser technology).

  In late July 2021, it was reported that the first ferry had been delivered. The ferry is named ***MF Hydra***. As reported previously, the ***MF Hydra*** is 82.4 metres in length, with capacity for 300 passengers and 80 motor cars.
- **BP joins Maersk Mc-Kinney Moller Center for Zero Carbon Shipping:** Low Carbon Pulse has reported on the establishment (see Edition 16 of Low Carbon Pulse) and progress of the Maersk McKinney Moller Center (***MMMC***) (see Editions 19 and 22 of Low Carbon Pulse).

  On July 27, 2021, it was reported that BP and ***MMMC*** signed a partnership agreement, with each committing to work together over the longer-term to develop and to deploy new fuels and lower or low carbon solutions for the shipping industry.

  The partnership agreement and the resourcing and cooperation that it is intended to engender, is another illustration of the private sector combining consistently to navigate a route to ***NZE***.

  See: *bp joins the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping as a strategic partner*

EU Forest Strategy:

- **Wood for the trees and woods with more trees:** As part of the ***European Green Deal*** (see Edition 22 of Low Carbon Pulse), during the week beginning July 21, 2021, the ***EC*** released its Forest Strategy. The Forest Strategy contemplates that between now and 2030, at least 3 billion additional trees are to be planted across Europe: it is estimated that the additional trees will provide the ***EU*** with a verified carbon sink of 310 million metric tonnes of ***CO_2***.
- **Woods and well-being:** While the preservation of forests (and more generally the preservation and rehabilitation of land), is regarded as contributing to ***NZE***, it is not, and should not be, regarded as a central policy setting to decarbonisation.

  Yes, carbon credits, and their use to offset ***GHG*** emissions, are important to transition, and will be critically important as a tool to bridge (the hoped for) ever narrowing gap between decarbonised activities and activities remaining to be decarbonised (using negative ***GHG*** emission initiatives), and yet woods are linked to the well-being of fauna and flora, and humans.
- **Trees bare in the woods:** The Forest Strategy, should be viewed as, and the ***EC*** views it as, one of a number of policy settings that in combination go to the environmental and sustainability outcomes generally: the purpose of the Forest Strategy is: (**1**) for carbon storage; (**2)** Improving our health and well-being; (**3)** halting the loss of habitats and species, which in turn form part of a broad set of Sustainable Development Goals (***SDGs***).
- **Soil science = sinking feeling:** Edition 20 of Low Carbon Pulse reported on recent reporting on findings as to the percentage of flora that is underground. These findings are allowing a reassessment of the mass of ***CO_2*** stored in flora, and the mass of ***CO_2*** that can be stored in new growth flora.

On July 27, 2021, Quanta Magazine published an article entitled ***A Soil Science Revolution Upends Plans to Fight Climate Change***. There has been an orthodoxy, actual or perceived, that soil, in particular that humus, has within it carbon-rich molecules that capture and retain carbon for hundreds of years (if not thousands).

The challenge is that carbon-rich molecules are consumed by abundant micro-organisms: there is no carbon that cannot be broken down / consumed by micro-organisms, and this results in ***CH_4*** emissions.

One of the consequences of these findings is that models used to predict temperature are probably underestimating the mass of ***GHG*** emissions that will be released from soil as temperatures increase. (This leaves to one side the estimate 2,000 trillion tonnes of ***CH_4*** estimated to be contained in the permafrost.)

While soil science continues to develop, there is one takeaway: decarbonisation is the only fail-safe means of achieving ***NZE***.

EU progress in respect of the 17 SDGs:

Sustainable Development Goals, globally relevant: The ***European Green Deal*** goes to achieving some, but not all of the United Nations 17 ***SDGs***. (***UN SDGs***). Of late, there has been reporting on the ***UN SDGs***, and progress towards them. As part of this reporting round, the ***EC*** has published a helpful graphic indicating progress of the ***EU*** in respect of each of the UN ***SDGs***.

While the subject matter of UN ***SDGs*** goes beyond the usual scope of Low Carbon Pulse, it is an area that is going to get more scrutiny, critically in the context of the Paris Agreement as countries seek to adapt to the consequences of increased average global temperatures. In the context, it is to be expected that policy settings take an increasingly holistic perspective.

As Temperature Changes, policy needs to do likewise:

- **Snap shots of long term temperature change:** Edition 19 and 20 of Low Carbon Pulse included some interesting and informative arcs and circles reporting on emissions and temperatures.

  During the week-beginning July 26, 2021, another graphic (this time a time lapse graphic) came to the attention of the author showing the ***Temperature Change 1880 to 2020*** linked to over a 100 countries. The graphic conveys a compelling message in a little over 35 seconds.

- **Policy forged in heat:** On July 31, 2021, The San Francisco Chronicle (***SFC***) published an article entitled ***Carbon neutral is not good enough. California needs to be carbon negative by 2030***. The headline grabs the attention of the reader.

  The ***SFC*** notes that the mass of ***GHG*** emissions projected to be emitted in 2021 from the production, transportation and use of energy and resources is going to be in the region of 37 Giga metric tonnes (37 billion tonnes).

  This will be a record.

  This record will follow a record decline in ***GHG*** emissions during 2020 (***2020 Dip***). (Previous editions of Low Carbon Pulse have reported on the ***2020 Dip***.) Reporting and analysis of the ***2020 Dip*** continues, including in the highly respected and influential ***BP Statistical Review of World Energy 2021*** (***BPER***). The ***BPER***, with the benefit of more time and analysis, estimates a 6% decline in ***CO_2*** emissions from 2019 to 2020 (compared to earlier estimates of around 7%).

  - **Impact and Politics local:** California is drier and hotter than it was in 1990. In this context, Governor, Mr Gavin Newsom is seeking acceleration of progress on clean energy, and as such climate protection and environmental justice objectives.

  - **California has long led:** As noted in Edition 9 of Low Carbon Pulse, California (under ***Negative GHG emissions … not new, but hight profile likely***) has been ahead of the curve on policy settings, including the need to develop and to deploy negative ***GHG*** emissions initiatives. Among other things, Edition 9 of Low Carbon Pulse notes the policy setting of achieving net-zero ***GHG*** emissions by 2045.

    There are now calls for California to:

    - Reduce ***GHG*** emissions to below 80% of 1990 levels by 2030; and
    - Commence negative ***GHG*** emission initiatives to remove ***GHG*** from the atmosphere by 2030,

    in combination to achieve carbon neutrality by 2030.

    In addition, on July 28, 2021, it was reported that a bipartisan group in the Californian legislature seeking USD 300 million for the development of hydrogen refuelling infrastructure (***HRI***).

    It is no coincidence that a State experiencing the effects of climate change is responding to them.

  - **Policy settings need to be global:** As noted in previous editions of Low Carbon Pulse (and above), and as illustrated by the ***Temperature Change 1880 to 2020***, developed countries need to do more, and to do more at an accelerated pace, than countries that are not as developed.

    The calls for acceleration in California as timely: as noted above, the elephant in the room is that development countries aiming to achieve ***NZE*** by 2050 is not going to be enough to stay safely, if at all, within ***GHG*** carbon budget. The developed world needs to accelerate, thereby taking responsibility for both past emissions and because developed countries are able better to afford acceleration.

    While all politics is local, responsibility is global. Taking responsibility is manifested and delivered through policy settings, and the effective funding and implementation of them.

- **Drier and hotter = drought:** The following link provides a real time US Drought Monitor. As noted previously in Low Carbon Pulse, and in this edition, an objective of the Paris Agreement that has been forgotten is **Article 2.1(b):** Adapting to climate damage.

The extreme weather conditions in Europe and the US appear to be forcing governments (Federal, State / Provincial, City and Local) to turn their minds to the need to adapt to climate change, including, the recognition of new weather patterns, and the economic, environmental and social impact of them.

It has to be said that those familiar with the thought processes to crafting and drafting of **Article 2.1(b)** have been surprised by the lack of thinking at country by country level, other than those countries at threat because of rising sea-levels.

Carbon credits and Carbon offsets, Insurance, Investors, Negative Emissions Initiatives and Sustainability:

- **Walk the Talk: the how as well as the what:** Previous editions of Low Carbon Pulse have mentioned the Institutional Investors Group on Climate Change (***IIGCC***), and the roles of key members of ***IIGCC*** in driving ***NZE*** outcomes at a corporate level (see Edition 19 of Low Carbon Pulse). The ***IIGCC*** has recently increased the definition around what is required from corporations.

  Critically, investors are going to require corporations to disclose target reduction plans, i.e., how the particular corporation intends to achieve any announced reduction target, appoint a director or directors responsible to implement the plan, and the requirement that investors vote on progress of implementation against plan.

  Set out is the ***IIGCC's*** ***Paris Aligned Investment Initiative*** and ***Net Zero Investment Framework Implementation Guide***.

- ***NASA*** **surveys for Vital Signs of the Planet:** Edition 22 of Low Carbon Pulse reported in the NASA study, undertaken by its Jet Propulsion Laboratory (***JPL***) in Southern California.

  One of the headline grabbing by-lines from reporting of the study has been that the Amazon Basin is both a carbon source and a carbon sink, and that across the entire Amazon Basin it is close to becoming neutral. The reasons for this are many and varied, but are reported as arising as a result of deforestation, and the degradation that results, the impact of increased average temperatures, including drought and its affects.

  Edition 25 of Low Carbon Pulse will take a closer look at the findings and the implications of the ***NASA*** study, including in the light of the ***2021 Report***, and how the findings and the implications of the ***NASA*** study are core to the basis of policy setting for carbon credits, and ability to use them to off-set ***GHG*** emissions: planting trees is not sufficient.

Airports and Aviation:

Edition 27 of Low Carbon Pulse will update include an update on Airports and Aviation.

NZE **News and Facts and Statistics:**

- **Amazon and TotalEnergies firmly planted:** On July 29, 2021, TotalEnergies announced a strategic collaboration with Amazon under which TotalEnergies will contribute to Amazon's 100% renewable electrical energy commitment (474 MW of renewable electrical energy in Europe and the US under a single power purchase agreement (***SPPA***)) and Amazon will work with TotalEnergies to accelerate its digital transformation. It is expected that in time the ***SPPA*** will cover load in the Middle East and Asia Pacific.

  On its face, this may appear to be just another business to business deal, and to some extent it is, and yet it goes beyond the transactional to the transformational: President, Gas, Renewables & Power, TotalEnergies, Ms Stephane Michel stated: "… we are proud to enter into this key collaboration with Amazon and to accompany them on their journey to carbon neutrality. We are also counting on Amazon and AWS [Amazon Web Services] to help use advance our exponential shift in the speed, scale and advancement of digitalization'.

  See: *TotalEnergies and Amazon announce strategic collaboration*

- **Sunniest Cities on Earth:** In previous editions of Low Carbon Pulse, graphics have been included from the Visual Capitalist. In another great graphic, the Visual Capitalist has provided a graphic representing World Cities Ranked by Average Annual Sunshine Hours.

  For ease of reference, the Visual Capitalist graphics are included as links below:

  – Race to Net Zero: Carbon Neutral Goals by Country and

  – Visualizing the Climate Targets of Fortune 500 Companies.

Low Carbon Pulse - Edition 24 – IPCC 2021 Report Edition

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to **Edition 24** of Low Carbon Pulse. This edition reports on the Intergovernmental Panel on Climate Change (***IPCC***) ***Sixth Assessment Report – Climate Change 2021, The Physical Science Basis*** (***2021 Report***).

This Edition 24, intended as a high-level summary of the key findings in the ***2021 Report***, is divided under the following headings: ***1***. Context of the ***2021 Report***; ***2***. Conclusions from the ***2021 Report***; ***3***. What organisations need to know; ***4*** The key findings of the ***2021 Report*** (including specifically under its five models); and ***5***. Description of the subject matter of Twelve Chapters in the ***2021 Report***.

1 Context of the *2021 Report*:

- **Background:** The ***2021 Report*** is the first fully fledged report from the ***IPCC*** since its ***2013 Report*** (the Fifth Assessment Report), and the first report since the 2018-2019 Special Reports.

  The findings outlined in the ***2013 Report*** informed the provisions included in the Paris Climate Agreement (***Paris Agreement***) which entered into force on November 4, 2016. The ***Paris Agreement*** now has 195 signatories; each was consulted on the ***2021 Report***. The ***2021 Report*** is subject to further work from which a Synthesis Reports will emerge.

  The ***Paris Agreement*** recognises the science of the ***2013 Report***: the imperative of keeping the increase in "global average temperature to well below ***2°C*** above pre-industrial levels and pursuing efforts to limit the temperature increase to ***1.5°C*** above pre-industrial levels".

  For these purposes, it was agreed "to reach global peaking of greenhouse gas emissions as soon as possible", "to undertake rapid reductions thereafter … so as to achieve a balance between anthropogenic emissions by sources (***NZE***) and removals (***GHG Removal***) … in the second half of this century…", with each Party to set a nationally determined contribution (***NDC***) to the reduction in greenhouse gas emissions (***GHG***), with a stock-take to be undertaken periodically; the first undertaken in 2018, the second to be undertaken in 2023.
- **Purpose:** The purpose of the ***2021 Report*** is to provide a basis for informed progress at ***COP-26***, and to allow countries to adjust their ***NDCs*** in the lead-up to the 2023 stocktake, or before (ideally before ***COP-26***).

2 Conclusions from the *2021 Report*:

- The ***2021 Report*** confirms what was already known. All of the findings in the ***2021 Report*** tie back to the ***Paris Agreement***. The key finding is that: "*It is more likely than not that the earth will be 1.5°C warmer in 2050 than it was in the 19th century*"
- What makes the ***2021 Report*** powerful is that it is one of six Assessment Reports from the ***IPCC***, all of which have been accurate to a great extent, and all of which are based on science, and affirming that the symptoms of climate change are visible.
- The findings in the ***2021 Report*** represent the work of countless scientists, each an expert, with each finding peer-reviewed and verified. The conclusion: "What is past is prologue" - accelerate to ***NZE***.

3 What organisations need to know:

- **Key points:**
  - It is unequivocal that emissions of "well-mixed greenhouse gases", i.e., carbon dioxide (***CO_2***), methane (***CH_4***) and nitrous oxide (***N_2O***), arise from human activities, that they are the principal cause of, and continued driver of, increased climate system ***GHG*** concentrations – climate change is human-induced.
  - Every tonne of ***GHG*** emitted to the climate system contributes to an increase in average global climate system temperature - increased temperature results in climate change.
  - Reduction of ***GHG*** emissions and increased ***GHG Removal*** are the accepted and proven means to reducing climate system concentrations of ***GHG.***
  - Concentrations of ***CO_2***, ***CH_4*** and ***N_2O*** (underreported in the ***2021 Report*** because the report is based on 2019 data) contribute to climate change, and addressing ***CO_2*** reductions and removal is key.
  - More likely than not the average global temperatures will increase by more than 1.5°C by 2050, but addressing the causes of climate change is still possible, with acceleration to ***NZE*** being key.
- **The science is unequivocal, action plans are business critical:**
  - The starting point for any organisation seeking to reduce the ***GHG*** emissions arising from its activities is to identify its ***GHG*** emissions profile: which activities give rise to ***GHG*** emissions, and what mass? Both direct (Scope 1) and indirect (Scopes 2 and 3) should be included in that assessment.
  - Organisations can respond to the findings of the ***2021 Report*** by:
    1. developing a net zero strategic action plan, and to adjust that plan to respond to on-going assessment and oversight (***NZE Plan***);
    2. demonstrating that the ***NZE Plan*** is modelled as achievable and is fully-costed, and includes the impact on earnings, and distributions, from the implementation of the ***NZE Plan***;
    3. establishing data capture and measurement systems that capture all relevant data to allow effective monitoring and reporting on compliance with the ***NZE Plan*** anticipating that climate-related disclosure obligations will tighten overtime;
    4. appointing executives with responsibility for the implementation of the ***NZE Plan***, with board approval and overnight of its implementation; and
    5. engaging actively with investors and other key stakeholders on an on-going basis and expecting investors to require consultation in respect of, and, over time, approval of, the ***NZE Plan***.
  - For all corporations, there is a need to focus primarily and consistently on reducing ***GHG*** emissions (decarbonisation) across activities in Scopes 1, 2, and 3. (Ideally the acquisition of carbon credits / permits to acquit mandatory legal obligations, or assumed voluntary targets, will be a secondary focus and reduce overtime.)
- **Task Force on Climate-Related Financial Disclosures (*TCFD*)**
  - The ***2021 Report*** deals with the global action required*,* at an individual organisational level the role of the ***TCFD*** cannot be ignored and comes into (even) sharper focus. The ***TCFD*** is a global, private sector-led taskforce, that requires boards and companies to assess, and to disclose publicly, climate risks and opportunities that are material or significant. Many readers will be familiar with the work of the ***TCFD***. In the context of the ***G7*** decision in June 2021, the role of the ***TCFD*** is taking on more significance, and the leadership role of the ***TCFD*** (chaired by Mr Michael R. Bloomberg) may be expected to become more prominent, and more important.
  - Physical climate change risks are now widely understood by the international business community as financial risks that represent a critical business challenge as well as opportunity: the long-term connection between the health of the planet and the health of the world economy is accepted. The Swiss Re Climate Institute Report from April 2021 shows this clearly.
  - At the recent June 2021 meeting of the Group of Seven, comprising Canada, France, Germany, Italy, Japan, UK and US (**G7**), there was agreement on the need to require compulsory disclosure of climate-related financial risks.
  - It is clear that the ***TCFD*** understands that reporting on an activity requires an assessment of that activity, and that reporting on ***NZE*** means that ***NZE*** is an objective: the progress towards, and ultimately the achievement of, ***NZE*** across each of Scope 1, 2 and 3 emissions, is being measured.
  - All corporations require financial services, including from debt and equity markets, financial institutions providing working capital facilities, and insurers insuring the risks arising from those activities. Disclosure on progress to ***NZE*** is a key tool: even before disclosure is made compulsory, many key participants in the financial services industry want to understand how corporations are progressing to ***NZE***, and how they plan to achieve ***NZE***. The ***TCFD*** has made assessment, monitoring, analysis and disclosure a positive for organisations: key to risk assessment, capital allocation and strategic planning.
  - Access to debt and equity from the financial services industry has ceased in respect of certain activities in some jurisdictions, and the terms on which financial services are provided are increasingly differing depending on progress to, and achievement of, ***NZE***. As lawyers, Ashurst people see this on a daily basis.

4 Key findings of the *2021 Report*:

- **Background as to form of the *2021 Report*:**
  - ***2021 Report* is fact based:** The ***2021 Report*** expresses findings by reference to the ***IPCC*** "calibrated language": first, confidence expressed: very low, low, medium, high and very high, second, likelihood expressed: exceptionally unlikely, very unlikely, unlikely, about as likely as not, likely, very likely, and

virtually certain. This Edition 24 of Low Carbon Pulse reports in findings that are expressed to be high or very high or very likely (90 -100% probability) or virtually certain (99 -100% probability), unless stated otherwise.

- **Form of the *2021 Report*:** The ***2021 Report*** has a Summary for Policymakers (***SPM***) and Twelve Chapters. The ***SPM*** is drawn from the findings in the Twelve Chapters. Each of the Twelve Chapters directs: "**Do Not Cite, Quote or Distribute**". This reflects the development of the Synthesis Report.

  Given this direction, necessarily, the findings reported on in this Edition 24 of Low Carbon Pulse are derived from the ***SPM***, and conclusions are in line with the direction. Each of the Twelve Chapters is "fact packed", and replete with references. Section 5, **Description of the subject matter of Twelve Chapters in the *2021 Report***, highlights on of the parts of each Chapter that the author found to be of particular interest.

- **Every tonne of well mixed *GHG* emitted contributes to an increase in average global atmospheric temperature**: Stated another way, the root cause of climate change is the increase in temperature caused by increased mass of ***GHGs*** in the climate system, increasing the concentration of ***GHGs*** in the climate system, principally CO_2, CH_4 and N_2O.

CONCENTRATIONS OF WELL MIXED *GHG*			
Average concentration	CO_2	CH_4	N_2O
2019	410 ppm	1866 ppb	322 ppb
JUNE 2020	416.60 ppm	1876 ppb	332.7 ppb
JUNE 2021	418.54 ppm	1891 ppb	334.1 ppb

  The CO_2 concentrations are higher than at any time in the last two million years, and concentrations of CH_4 and N_2O are higher than at any time in at least 800,000 years.

  CO_2***-e*** (carbon dioxide equivalent) recognises that different ***GHGs*** have different global warming effects, with the use of CO_2***-e*** allowing a like-for-like comparison taking account of potency and time retained in the climate system. What is clear however is that CO_2 is the ***GHG*** on which ***GHG*** reduction and ***GHG*** Removal initiatives need to concentrate because globally, by mass, it is, by far, the most emitted ***GHG***. At the same time, there needs to be a near to medium term concentration on the reduction of CH_4.

- **Overview of science underpinning climate change:**
  - All readers will be familiar with the greenhouse effect. Placing the greenhouse effect in the context of anthropogenic ***GHG*** emissions and the resulting human-caused / induced climate change: ***GHG*** emissions cause net-positive radiative forcing, resulting in an accumulation of additional energy in the climate system. This energy is absorbed, and retained, by CO_2, CH_4 and N_2O molecules.
  - This is known, and the greenhouse gas effect has been known for centuries, indeed in newspapers in the early 20th century were reporting on the impact of burning increasing quantities of coal, and that in a few centuries this may become problematic.
  - The problem has eventuated: both the cause and the cure for global warming are known, and both have long been recognised, critically, by the ***IPCC***:
    - reduce ***GHG*** emissions through decarbonisation of activities that give rise to ***GHG*** emissions; and
    - increase the negative ***GHG*** emission initiatives (***NGHGEIs***) for the purpose of removing CO_2 from the atmosphere on an absolute basis, and, long term, to limit continued emission of ***GHGs*** using carbon credits / permits to off-set those continued ***GHG*** emissions.

      The policy settings that will achieve these outcomes rest with governments. As noted in Edition 22 of Low Carbon Pulse, free markets will respond to policy settings, not make them.

      Remarkable progress has been made in some countries and economic blocs, but acceleration to ***NZE*** ahead of 2050 is now required, and responsibility for this rests with all governments and economic blocs.

      One of the lesser reported findings in the ***2021 Report*** (at least over the first few days after its release), is that of itself the concentration of CO_2 in the climate system would have already resulted in an increase of greater than ***1.5°C*** in global average temperature. This has not occurred because of certain aerosols.

      There is a paradox that sits at the centre of this, the paradox emphasises the need to reduce ***GHG*** emissions. The burning of coal gives rise to both CO_2 and sulfate / sulphate aerosols, one capturing heat, the other reflecting heat. The ***IPCC*** suggests there has been a net-cooling effect of up to ***0.5°C*** due to sulfates / sulphates. The adverse effects on health of sulfate / sulphate aerosols are well-known, and as such sulfur / sulphur is removed from hydrocarbon products or captured on their use, thereby reducing the cooling effect of emission of sulfate / sulphate aerosols.

      This is not to suggest seeding the atmosphere with sulfate / sulphate aerosols (as part of a Solar Radiation Modification (***SRM***) scheme) is a solution, it suggests accelerated reduction in CO_2 and CH_4 emissions is the solution.
    - While the reduction of CH_4 emissions is not as important as a reduction in CO_2 emissions, it is still important, because of global warming potential of CH_4, in terms of its potency by tonne, is greater than CO_2. There has been a spike in the level of CH_4 emissions since the mid-2000's. A reduction of CH_4 emissions will accelerate the beneficial effects of reduced warming.

- **Observed climate change:** The graphic below is taken from the ***SPM***. It shows the findings in relation to increases in average global temperatures resulting from different ***GHGs***. Things could be worse. The fact that they are not worse is the result of luck, not judgement or knowledge.

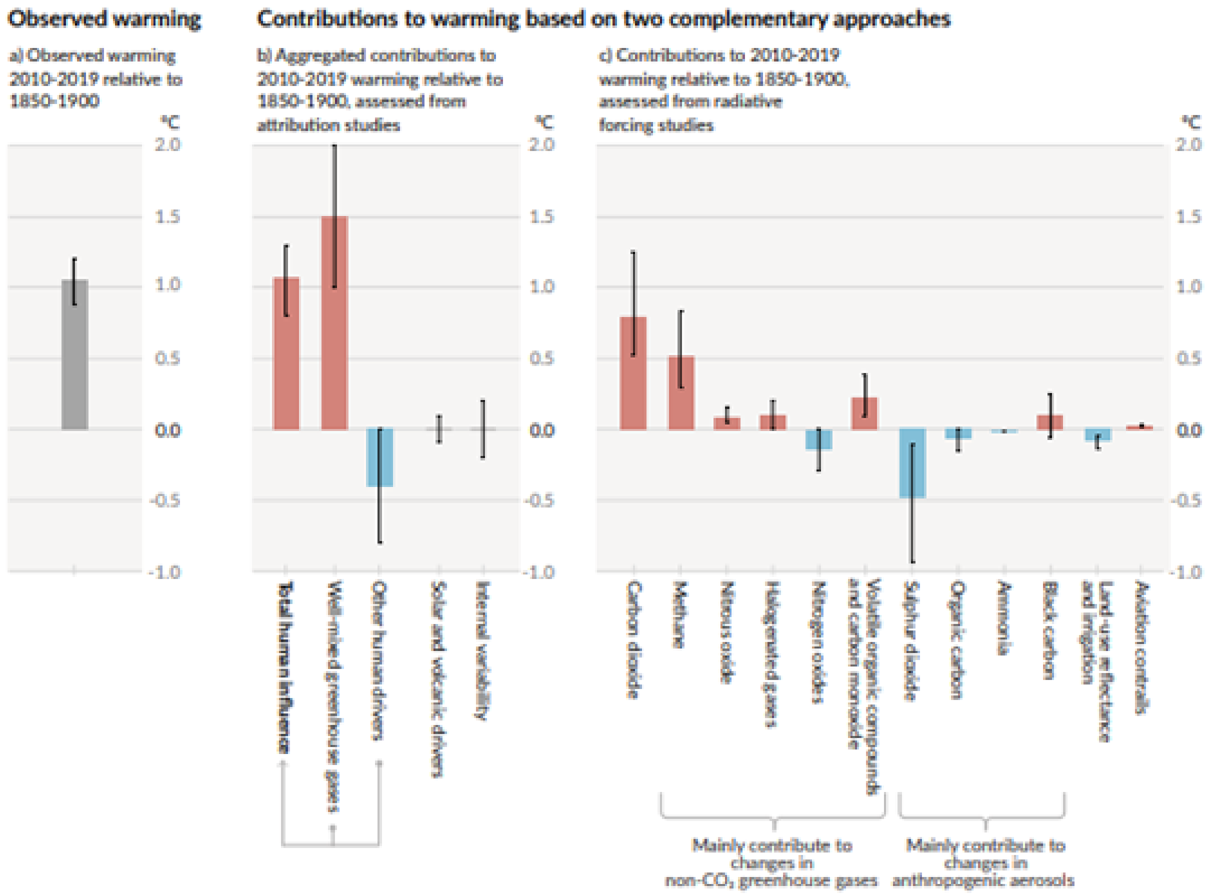


Figure SPM.2: Assessed contributions to observed warming in 2010–2019 relative to 1850–1900.

Panel a): Observed global warming (increase in global surface temperature) and its *very likely* range {3.3.1, Cross-Chapter Box 2.3}.

Panel b): Evidence from attribution studies, which synthesize information from climate models and observations. The panel shows temperature change attributed to total human influence, changes in well-mixed greenhouse gas concentrations, other human drivers due to aerosols, ozone and land-use change (land-use reflectance), solar and volcanic drivers, and internal climate variability. Whiskers show *likely* ranges {3.3.1}.

Panel c): Evidence from the assessment of radiative forcing and climate sensitivity. The panel shows temperature changes from individual components of human influence, including emissions of greenhouse gases, aerosols and their precursors; land-use changes (land-use reflectance and irrigation); and aviation contrails. Whiskers show *very likely* ranges. Estimates account for both direct emissions into the atmosphere and their effect, if any, on other climate drivers. For aerosols, both direct (through radiation) and indirect (through interactions with clouds) effects are considered. {6.4.2, 7.3}

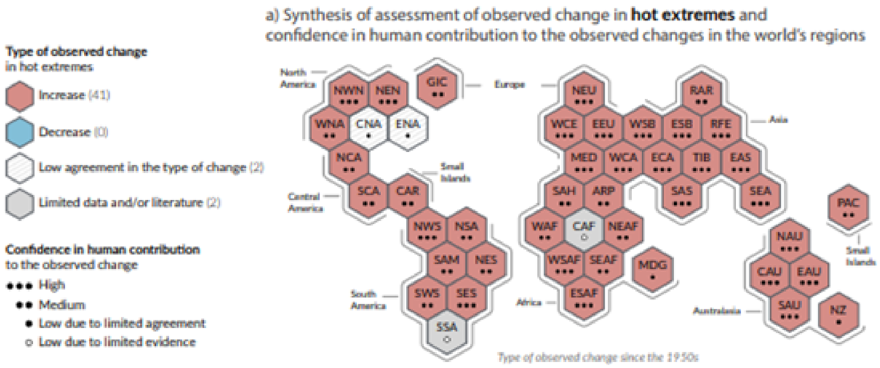
- **What is climate change for the purposes of the *2021 Report?*:** The ***2021 Report*** considers the impact of increased concentrations of ***GHG*** emissions on all aspects of the climate system, focusing on the atmosphere (air and surface temperatures), biosphere (parts of earth where life exists), cryosphere (parts of the world that are frozen) and oceans. Each of the Twelve Chapters considers these impacts.

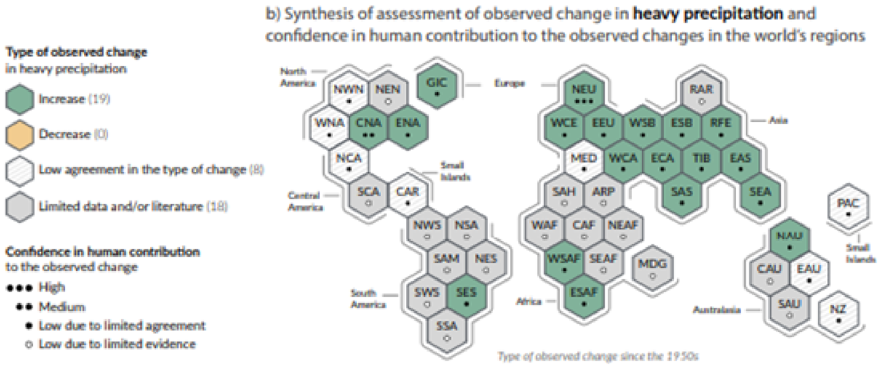
  It is necessary to emphasise that the impact of increased concentrations on ***GHG*** emissions is not the same globally, or by ***GHG***.

  The ***2021 Report*** makes it clear that climate change can result in increased ***GHG*** emissions, which in turn results in climate change: "climate-change-on-climate-change", as a result of additional biogeochemical feedbacks in the climate system, which may amplify or attenuate the impact of increasing temperature on the climate system.

- **Key changes to climate system**: The length of this Edition 24 of Low Carbon Pulse does not permit consideration of each climate impact, but the following climate impact findings are key:
  - "**It is *virtually certain* that hot extremes have become more frequent and more intense across most land regions since the 1950s, while cold extremes (including cold waves) have become less frequent and less severe, with *high confidence* that human-induced climate change is the main driver of these changes.**"
  - "**The frequency and intensity of heavy precipitation events have increased since the 1950s over most land area for which observational data are sufficient to trend analysis (*high confidence*), and human-induced climate change is likely the main driver**".

  The graphics below show the findings as to climate system change on a regional basis.



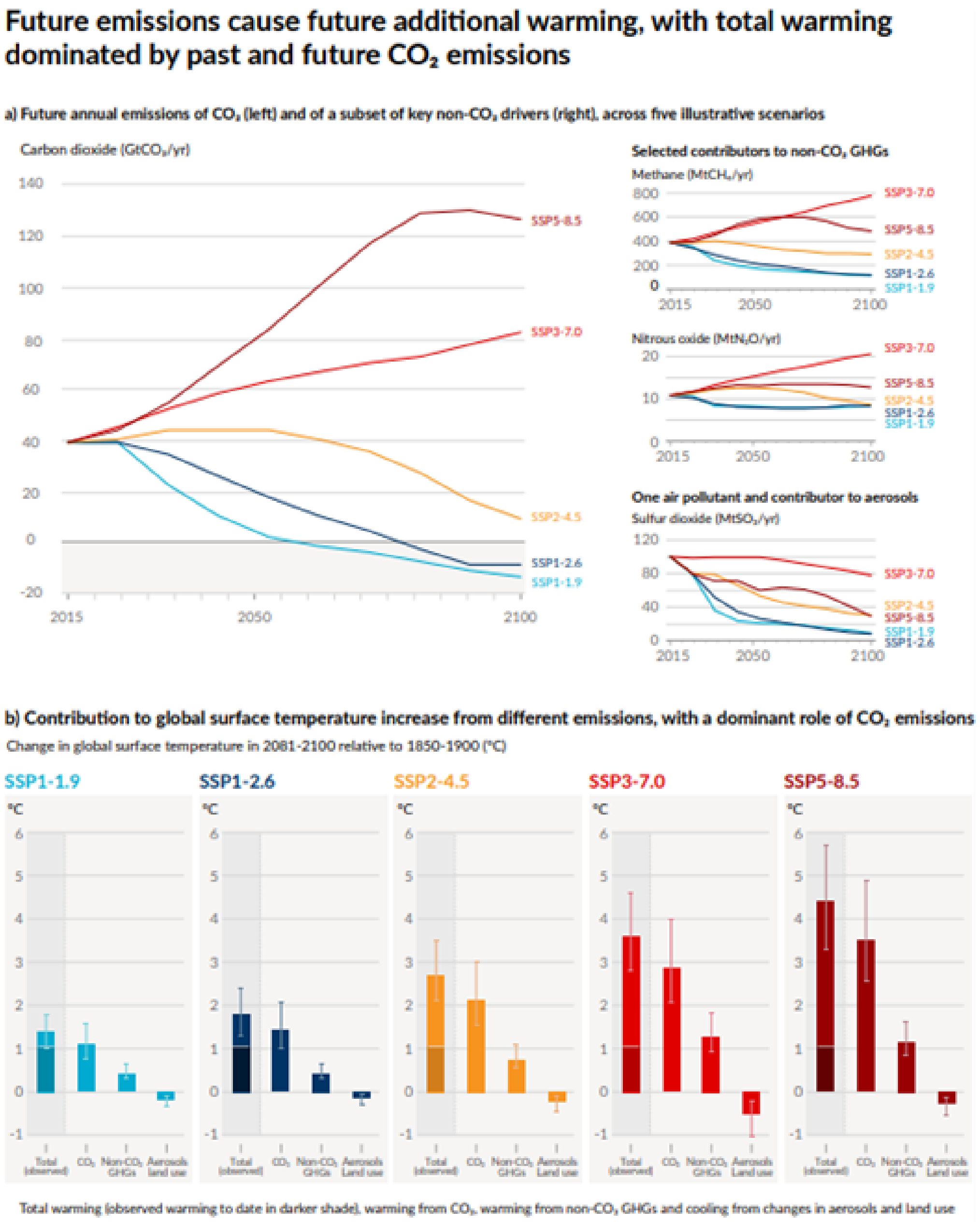


  In addition to the findings, the balance with which the findings are expressed in the ***2021 Report*** is telling, and provides the reader with considerable confidence of the analysis of the underlying data, and the calibration of the assessment of it. This may be regarded as contrasting with some of the reporting of the findings in the ***2021 Report***: it is best to go to the findings itself, rather than the reporting of any findings.

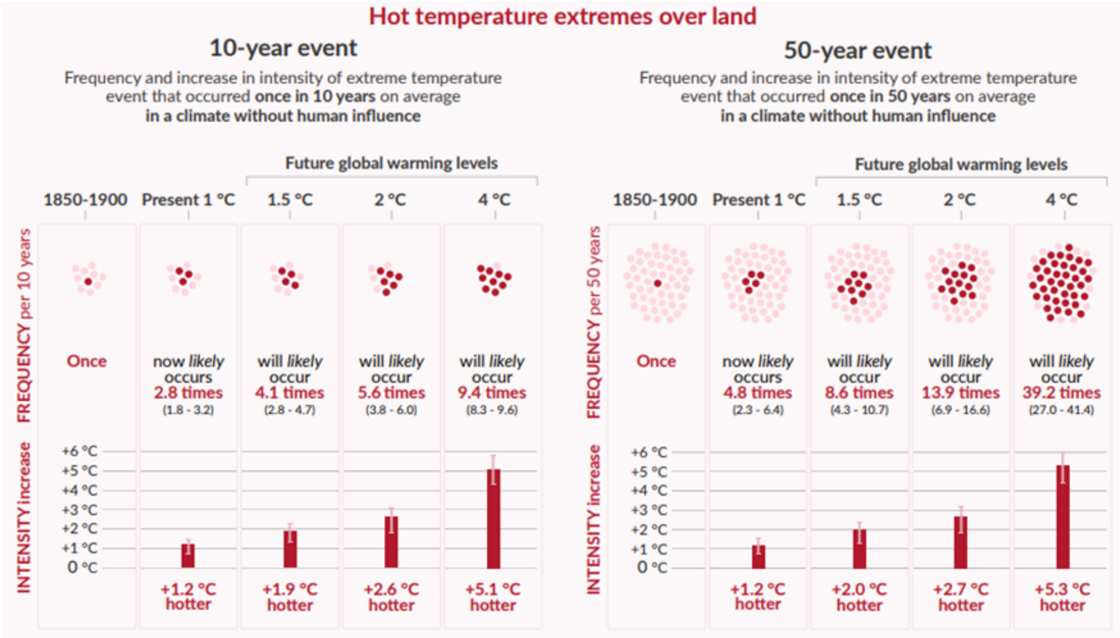
- **What might the future hold?** The ***2021 Report*** has five **SSP** models (each allowing for solar activity and background forcing from volcanic activity), with each **SSP** model making the following assumptions:
  - **SSP1-1.9**: assumes acceleration of ***NZE*** and ***NZE*** by 2050, followed by effective ***NGHGEI***;
  - **SSP1-2.6**: assumes 2050, following by varying levels of ***NGHGEI***;
  - **SSP2-4.5**: assumes that CO_2 ***NZE*** emissions staying at current levels until 2050, i.e., no increase;
  - **SSP3-7.0**: assumes that CO_2 roughly double from current levels by 2100; and
  - **SSP5-8.5**: assumes that CO_2 roughly double from current levels by 2050.

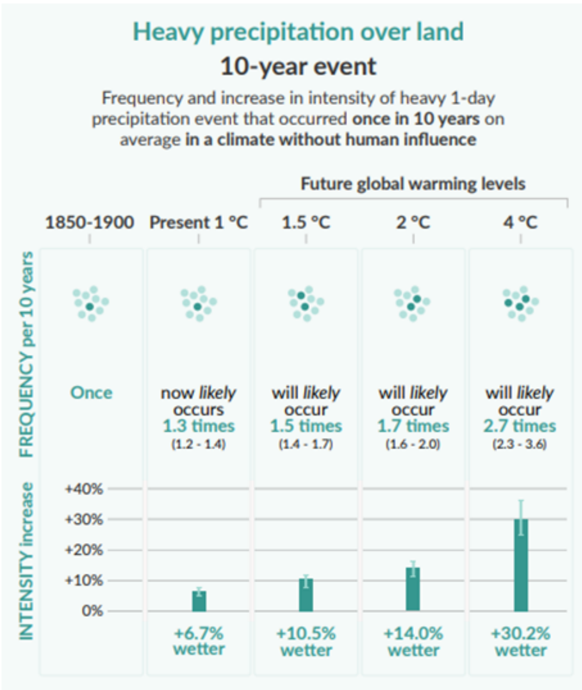
  SSP refers to Shared Socio-Economic Pathway, i.e. how society, demographics and economics might change this century.

- The projected outcome for each **SSP** model is represented graphically in the ***SPM*** as follows:



	Near term, 2021–2040		Mid-term, 2041–2060		Long term, 2081–2100	
Scenario	Best estimate (°C)	*Very likely* range (°C)	Best estimate (°C)	*Very likely* range (°C)	Best estimate (°C)	*Very likely* range (°C)
SSP1-1.9	1.5	1.2 to 1.7	1.6	1.2 to 2.0	1.4	1.0 to 1.8
SSP1-2.6	1.5	1.2 to 1.8	1.7	1.3 to 2.2	1.8	1.3 to 2.4
SSP2-4.5	1.5	1.2 to 1.8	2.0	1.6 to 2.5	2.7	2.1 to 3.5
SSP3-7.0	1.5	1.2 to 1.8	2.1	1.7 to 2.6	3.6	2.8 to 4.6
SSP5-8.5	1.6	1.3 to 1.9	2.4	1.9 to 3.0	4.4	3.3 to 5.7





- **What does all of this mean?**

  Going to the root cause of climate change, reducing ***GHG*** emissions slows the rate of increase and stabilises the ***GHG*** emissions in the climate system, there is then the need to peak and reduce and remove ***GHG***.

  Peaking and reducing: If the world passes peak ***GHG emissions*** (and it is noted that it may not), with continued reductions after the peak to a point at which the mass of ***GHG*** emissions arising is less than the mass of ***GHG*** emissions removed, there will be a decline in ***GHG*** emissions, but there will be a lag. The length of the lag will depend on the profile of ***GHG*** emissions leading up to peaking and the rate of ***GHG*** emission reductions and ***GHG Removal***. In the language of the ***2021 Report***: the accumulation of ***GHGs*** in the climate system is determined by the balance between anthropogenic emissions, anthropogenic removals and physical-biogeochemical source and sink dynamics on land and in the ocean.

  CDR: afforestation, soil carbon sequestration, bioenergy with carbon capture and storage (***BECCS***), wet land restoration, ocean fertilisation, ocean alkalinisation, enhanced terrestrial weathering and direct air capture and storage (***DACS***) are all means of ***CO_2*** removal. For these purposes, author has chosen not to include ***SRM***.

  Every organisation undertakes activities that give rise to ***GHG*** emissions, Scopes 1, 2 and 3. Every organisation can decarbonise those activities or remove ***GHG*** emissions, or both. As noted above, the starting point for any organisation seeking to reduce ***GHG*** emissions arising from those activities is to identify its ***GHG*** emissions profile: which activities give rise to ***GHG*** emissions, and what is their mass?

5 Description of the Chapters in the IPCC *2021 Report*:

Detailed below is a description of what each of the Twelve Chapters covers (**bold** and *italics* indicating Sections of interest to the author):

1. **Chapter 1 (Introduction to *2021 Report*): Section 1.1:** *Report and Chapter Overview*; **Section 1.2:** *Where are we now? How We Got here*; Section 1.4: Foundations and Concepts; Section 1.5: Major Developments since ARS 5; **Section 1.6:** *Dimensions of Integration*; and Section 1.7: Final Remarks;
2. **Chapter 2 (Changing State of the Climate System):** Section 2.1: Introduction; **Section 2.2:** *Changes in Climate Drivers*; Section 2.3: Changes in Large Scale Climate: 2.3.1: Atmosphere and Surface, 2.3.2: Cryosphere; 2.3.3: Oceans, and 2.3.4: Biosphere and 2.3.5: Synthesis of evidence for past changes; Section 2.4: Changes in Modes of Variability; and Section 2.5: Final Remarks;
3. **Chapter 3 (Human Influence on the Climate System):** Section 3.1: Scope and Overview; Section: 3.2: Methods; Section: 3.3 Atmosphere and Surfaces; Section 3.4: Cryosphere; Section 3.5: Ocean; Section 3.6: Biosphere; Section 3.7: Modes of Variability; and **Section 3.8:** *Synthesis across Earth System Components* (*of Human Influences on Atmosphere and Surfaces, Cryosphere, Ocean and Biosphere*);
4. **Chapter 4 (Future Global Climate: scenario-based projections and near term information): Section 4.1 and 4.2:** *Overview and Methodology*; **Section 4.3:** *Selected key indicators over the 21st Century*; **Section 4.4: Near Term**; **Section 4.5:** *Mid-to-long term*; **Section 4.6:** *Policy Implications*; Section 4.7: Beyond 2100; and Section 4.8; High Warming Storylines;
5. **Chapter 5 (Global Carbon and other Biogeochemical Cycles and Feedbacks):** Section 5.1: Introduction and Palaeo Context; **Section 5.2:** Historical Trends, Variability and Budgets of *CO_2 (Section 5.2.1), CH_4 (Section 5.2.2) and N_2O (Section 5.2.3)*, *Relative Importance of CO_2, CH_4 and N_2O (Section 5.2.4)*; Section 5.3: Ocean Acidification and Deoxygenation; **Section 5.4:** *Biogeochemical Feedbacks on Climate Change*; **Section 5.5:** *Remaining Carbon Budgets*; **Section 5.6:** *Biogeochemical Implications of CO_2 Removal and Solar Radiation Modification*, and Section 5.7: Perspectives on the Limits of the Assessment;
6. **Chapter 6 (Short-lived climate forcers):** Section 6.1: Importance of SLCFs for Climate and Air Quality; Section 6.2: SLCF emissions; Section 6.3: SLCF atmospheric abundance; Section 6.4: SLCF radiative forcing, climate effects and feedbacks; Section 6.5: Implications of changing climate on Air Quality; Section: 6.6: Air Quality and Climate Response to SLCF mitigation; **Section 6.7:** *Future projections of atmospheric composition and climate response in SSP scenarios*; and Section 6.8: Perspectives;
7. **Chapter 7 (The Earth's energy budge, climate feedbacks, and climate sensitivity):** Section 7.1: Introduction, conceptual framework, and advances since AR5 [i.e., ***2013 Report***]; Section 7.2: Earth's energy budget and its changes through time; **Section 7.3:** *Effective radiative forcing*; Section 7.4: Climate feedbacks; **Section 7.5:** *Estimates of ECS and TCR*; and Section 7.6: Metrics to evaluate emissions;
8. **Chapter 8 (Water Cycle Changes):** Section 8.1: Introduction; **Section 8.2:** *Why should we anticipate water cycle changes?*; **Section 8.3:** *How is the water cycle changing and why?*; **Section 8.4:** *What are the projected water cycle changes?*; Section 8.5: What are the limits for projecting water cycle changes? Section 8.6: What is the potential for abrupt change? and Section 8.7: Final remarks;
9. **Chapter 9 (Ocean, cryosphere and sea level change):** Section 9.1: Introduction; Section 9.2: Oceans; Sections 9.3, 9.4 and 9.5: Cryosphere; and Section 9.6: Sea Level, and Section 9.7: Final Remarks;
10. **Chapter 10 (Linking global to regional climate change):** Section 10.1: Foundations; Section 10.2: Observations; Section 10.3: Models; Section 10.4: Attribution and emergence; Section 10.5: Context and distillation; Section 10.6: Comprehensive examples; and Section 10.7: Final Remarks;
11. **Chapter 11 (Weather and climate extreme events in a changing climate):** Section 11.1: Framing; Section 11.2: Data and Methods; Section 11.3: Temperature Extremes; Section 11.4: Heavy precipitation / pluvial floods; Section 11.5: River Floods; Section 11.6: Droughts; Section 11.7: Extreme Storms, including tropical cyclones; Section 11.8: Compound Events; and Section 11.9: Regional information; and
12. **Chapter 12 (Climate change information for regional impact and for risk assessment):** Section 12.1: Framing; Section 12.2: Methodological Approach; Section 12.3: Climatic impact drivers and affected sectors; Section 12.4: Regional Changes to climatic impact drivers; Section 12.5: Global perspective of changes in climatic impact drivers; Section 12.6: Climatic change information in climate services; and Section 12.7: Final Remarks.

PROGRESS TOWARDS NET-ZERO EMISSIONS
AUGUST 24, 2021

Low Carbon Pulse - Edition 25

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to **Edition 25** of Low Carbon Pulse – sharing significant current news on progress towards net-zero emissions globally. This edition covers the period from Monday August 9, 2021 to Sunday August 22, 2021 (inclusive of each day).

Please click here for Edition 23 of Low Carbon Pulse. Please also click here and here for the first two articles in the ***Shift to Hydrogen Series*** (***S2H2***)***: Elemental Change*** series: the ***S2H2*** series provides a narrative and perspective on hydrogen generally. Please **click** here for the first feature in the ***Hydrogen for Industry*** (***H24I***): the ***H24I*** features provide an industry by industry narrative and perspective.

The third article in the ***S2H2*** series will be published within the next few weeks: the delay in publication of the ***UK Hydrogen Strategy*** (***UKH2S***) in July resulted in a change of plan, but the publication of the ***UKH2S*** means reversion to the original plan to publish an article on Hydrogen Plans, Roadmaps, and Strategies. An article on CCS / CCUS will follow in October.

Edition 25 will be posted again on **August 26 2021** for those reading later in the week.

Progress to COP-26:

- **Reports, reports, everywhere: lots to drink in from these fountains of knowledge and know-how:** The Intergovernmental Panel on Climate Change (***IPCC***) report, ***Climate Change 2021, The Physical Science Basis*** (***2021 Report***) was published on August 9, 2021, and reported on in Edition 24 of Low Carbon Pulse.

  Readers of Low Carbon Pulse will be aware that since May 18, 2021 the following reports have been published, earliest first, most recent last (all summarised in Low Carbon Pulse):

  – **International Energy Agency** or ***IEA*** - ***Net Zero by 2050 – A Roadmap for Global Energy Sector***;
  – **International Renewable Energy Agency** or ***IRENA*** - ***World Energy Transitions Outlook***;
  – **Wood Mackenzie** – ***How to scale up carbon capture and storage***;
  – **BloombergNEF** - ***New Energy Outlook, 2021***; and
  – **S&P Global Platts** - ***Platts Global Integrated Energy Model – Strategic Planning for a world in transition***.

- **Different reports, common themes:** While each report is different, taken together, these reports provide consistent messages and themes, foremost among them is the need for acceleration towards net-zero greenhouse gas emissions (***NZE***) at a greater rate (to many at a considerably greater rate) than is currently contemplated. Acceleration requires increased nationally determined contributions (***NDCs***) under the Paris Agreement, in particular among the countries that are progressed further than others in achieving ***NZE***, and the need for decarbonisation of activities, rather than the use of carbon credits / permits (***CCPs***), with the use of ***CCPs*** to accelerate negative greenhouse gas emission reduction initiatives (***NGHGRIs***).

- **The Causes and Cures of Climate Change are Known:** As noted in Edition 24 of Low Carbon Pulse, the causes of, and the cures for, climate change are known, critically, what is needed to slow, and to peak greenhouse gas (***GHG***) emissions and then to accelerate the reduction of ***GHG*** emissions and to remove them to as to achieve the *Stabilisation Goal* (if indeed the *Stretch Goal* is not achievable).

  As noted previously in Low Carbon Pulse, two of the three objectives in Article 2 of the Paris Agreement (all three are set out below) have tended to be forgotten (some may say neglected), at least in policy setting:

"Holding the increase in the global average temperature to well below 2°C above [***Stabilisation Goal***] pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above [***Stretch Goal***] pre-industrial levels, recognizing that this would [reduce significantly] the risks and impacts of climate change;

Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production; and

Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development".

- **Science and thinking sound:** The thinking behind these objectives is sound, with data continuing to underline that action is needed consistent with the sound thinking. It is worth recounting that all policy settings, and private sector initiatives, related to ***NZE***, can be tied back to the three objectives in Article 2 of the Paris Agreement. Those framing the Paris Agreement were aware that climate change was "along-side us", that it would have an adverse impact on us, resulting in the need to adapt to its adverse impacts, at the same time as decarbonising activities giving rise to anthropogenic ***GHG*** emissions.

  Given the extreme climate change induced events during the 2021 Northern Hemisphere summer, including droughts, floods, extreme heat waves, and forest fires (and rain falling on the summit of the Greenland Ice Sheet for the first time on record), it is to be expected that there will be a greater action on adapting to climate change, and its threat to food production.

  In Europe, with the settlement of the locations of many communities pre-dating the pre-industrial era, it has become apparent that certain locations are no longer suitable for activities undertaken at them: borrowing the language of the moment, there will be a need "to build back better" and differently. This has brought home to many the existential challenges for those with island homes.

- **Extreme weather reported and explained:**
  - On August 10, 2021, theverge, published an article (under ***A NASA scientist explains why the weather is becoming more extreme***) providing an overview of the extreme weather incidents during the 2021 Northern Hemisphere summer. The overview is from Mr Alex Ruane (one of the many scientists who contributed to the ***2021 Report***, in particular the concept of ***supercharging extreme whether events***).
  - On August 13, 2021, the US National Oceanic and Atmospheric Administration (***NOAA***) reported under *It's official: July was Earth's hottest month on record* that July 2021 was the world's hottest month recorded since records began 142 years ago.

  As a straight-talking Texan known to the author said in early June 2021: "When it rains, it rains too much, when it's hot, it's really hot, too hot. Y'all can deny the reason for it, but not the fact of it".

- ***IPCC* shares London Flood Map:** There is a tool developed by the US National Aeronautics and Space Administration (***NASA***) that makes it possible to visualise the possible levels of flooding that certain areas of the world may experience at different times based in increased sea-levels (and modelled variables).

  One of the maps that has been shared is one showing areas of London that may be subject to frequent flooding by 2030 if extreme weather events occur. For those who live or work in London, or who have done so, the Extreme Weather Flood Map brings home the adverse impacts of climate change.

- **Constant Vigilance and the Visual Capitalist:** While the ***2021 Report*** focuses on ***GHGs***, carbon dioxide (***CO_2***), methane (***CH_4***) and nitrous oxide (***N_2O***), they are not the only ***GHGs***.

  On August 18, 2021, nature.com reported on elevated levels of tetrafluoromethane (***CF_4***) and hexafluoroethane (***C_2F_6***) emissions in the climate system. The report notes that the likely sources of the elevated levels of ***CF_4*** and ***C_2F_6*** are the ***PRC*** (aluminium smelters) and Japan and Republic of Korea (semi-conductor factories).

  During the two week cycle of this edition of Low Carbon Pulse, another graphic from the Visual Capitalist (see Editions 23, 21 and 20 of Low Carbon Pulse for other graphics from the Visual Capitalist) has come to the attention of the author. This time the graphic is in the form of a globe indicating the spread of countries from which ***GHG*** emissions arise.

Big Bill makes it through the Gate:

- **US Bipartisan Infrastructure Deal Done:** Edition 23 of Low Carbon Pulse reported that the US infrastructure investment package (***IIP***) was nearly done. On August 10, 2021, the ***IIP*** "got done": by a vote of 69 to 30, the US Senate passed the Infrastructure Investment and Jobs Act (***IIAJA***).
- ***What next for the IIAJA?*** From the US Senate, the ***IIAJA*** has made its way to the House of Representatives for adjustment to some of its provisions, those adjusted provisions to be returned to the US Senate for consolidation by the Senate before the ***IIAJA*** is presented to President Joe Biden for signature.
- **What does the *IIAJA* do?** The passing of the USD 1.2 trillion ***IIAJA*** was followed quickly by consideration and some progress on the USD 3.5 trillion 2022 Budget Reconciliation legislation.

  As noted in Edition 23 of Low Carbon Pulse, the ***IIAJA*** provides for USD 550 billion of new Federal spending on infrastructure, including to upgrade the transmission grid (***UTG***), to develop recharging infrastructure, to support battery electric vehicle (***BEV***) use (including by the public school sector), and to support CCS / CCUS. The ***UTG*** initiative is particularly important to facilitate the build-out of renewable electrical energy projects across the US.

  The World Economic Forum published a helpful summary on August 18, 2021.

- **US executive providing guidance to funding:** It is understood that the US executive is guiding participants to sources of funding, in particular for recharging infrastructure and for the public school ***BEV*** buses. This makes perfect sense, because progress can be made quickly in these areas, critically to build the buses (with the Carolinas the likely States in which ***BEV*** buses will be built) and to deploy up to 12,000 of them.

- **Silver linings with grey clouds: a play book is required:** The cement, concrete, iron and steel sectors in the US are expecting high demand for their products as a result of infrastructure development under the ***IIAJA***: bridges, tunnels and roads need cement (for the production of concrete) and steel, lots of it.

  As noted in the second article in the ***S2H2*** series, the production of cement, iron and steel are the sectors that give rise to the first and second largest ***CO_2*** emission levels.

  In the US context, a study from the National Academy of Sciences estimated that 8% of ***CO_2*** emissions arising globally arise from the production of cement alone, i.e., this estimate does not count ***GHG*** emissions arising on extraction, and transportation, of raw materials to produce cement, the transportation of cement from its point of production to the point of concrete preparation, and transportation of concrete from "prep to pour".

  In the short-term, ***NGHGEIs*** are best used to neutralise the expected spike in ***GHG*** emissions, ***CO_2*** emissions particularly. The development and implementation of a ***NGHGEI*** strategy would be a valid edition to the policy settings tool kit, and in this context could be implemented through the terms on which infrastructure is procured.

- **Clean Hydrogen Energy Act proposed:** On August 11, 2021, it was reported that another bi-partisan bill had been proposed, the Clean Hydrogen Energy Act (***CHEA***). Low Carbon Pulse will report on the progress of ***CHEA***.

  The ***CHEA*** may be regarded as key to the achievement of the Hydrogen Earth-shot program: a technology agnostic policy setting seeking to achieve ***GHG*** emission free production of hydrogen at USD 1.00 per kg by 2030.

Mr Gates set for a Big Bill:

- **Breakthrough to help fund the cost:** Breakthrough Energy (***BE***) founder, Mr Bill Gates, continues both as a voice of reason, and as a source of funding. Following the passing of the ***IIAJA***, ***BE*** announced that it was working with the US Department of Energy (US ***DOE***), via the ***BE Catalyst*** project, to provide up to USD 1.5 billion of funding to accelerate the development of the ***NZE*** economy.

- **Breakthrough Energy's focus:** As noted in Edition 23 of Low Carbon Pulse, the focus of ***BE*** is to provide a platform to accelerate development and deployment of technologies in the following areas: direct air capture and storage (***DACS***), Green Hydrogen, Long-Duration Energy Storage (***LDES***) and Sustainable Aviation Fuel (***SAF***). It is no surprise that ***BE*** and ***DOE*** have announced that they will work on acceleration of technology projects to develop, in the following order: ***SAF*** , Green Hydrogen, ***DACS*** and ***LDES***.

  Funding of projects in these areas will be coordinated by ***BE*** and US ***DOE***. While these areas are not front and centre in the ***IIAJA***, it appears likely that acceleration in these areas will occur. This is a good thing, entirely in keeping with the thinking behind the establishment of ***BE*** in the first place (see Edition 19 of Low Carbon Pulse).

- **Breakthroughs seen as needed:** In a number of editorials from US publications, it has been noted in the US context that while there has been a reduction ***GHG*** emissions arising from the generation of electrical energy in the US over the last 15 years or so, and that the continued progress is being made, this is not enough if the US is to achieve its ***GHG*** emission reduction targets in progressing to achieve ***NZE***, let alone to accelerate to ***NZE***. There is an increasing recognition of the need to electrify and to decarbonise on an unprecedented scale.

Microsoft, continued focus, hard and soft:

Microsoft Corporation is leading in the areas in which it does business, and in the decarbonisation of its activities and supply / value chain, in respect of Scope 1, 2 and 3 emissions (see table below).

- **Microsoft founded but not forgetting:** Microsoft Corporation was founded in 1975 by Mr Bill Gates and, the late, Mr Paul Allen. As noted in Editions 11 and 13 of Low Carbon Pulse, Microsoft is committed to achieving ***NZE*** by 2030 and, as noted in Edition 2 of Low Carbon Pulse, to removing from the climate system a mass of CO_2-e equal to the mass of ***GHG*** emissions that it has emitted since it was founded (zero historical ***GHG*** emissions or ***ZHE***) by 2050.

  Microsoft is tying its objectives to those of the Paris Agreement (see Articles 2 and 4): first to achieve ***NZE*** then to remove ***GHGs*** from the atmosphere. Achieving ***ZHE*** is an application that Microsoft has added itself.

- **Microsoft data centres cool with Fuel Cell Technology**: At the same time that Microsoft committed to ***NZE*** and ***ZHE***, Microsoft announced that it was considering the deployment of Fuel Cell Technology (***FCT***) at its data centres. Edition 13 of Low Carbon Pulse, noted progress on this initiative.

  It is understood that considerable progress is being made in respect of this initiative. This is critical given the ever increasing importance and prevalence of data centres, and the electrical energy they require, and the criticality of the assurance as to security of supply of electrical energy.

- **Scope 1, 2 and 3 emissions:** Set out in the table below is a reminder of each scope of ***GHG*** emission.

SCOPE 1	SCOPE 2	SCOPE 3
Direct ***GHG*** emissions arising from any activity and source that are controlled or owned by an organization.	Indirect ***GHG*** emissions arising from any activity and source not controlled or owned by an organization but used by it.	***GHG*** emissions arising from any activity, not Scope 1 or 2 emissions, but part of the supply chain of that organization.

UK Hydrogen Strategy (*UKH2S*) published:

- **Soft, but sure, landing:** On August 17, 2021, the UK Government published the ***UKH2S***. The arrival of the ***UKH2S*** (expected in July 2021) was welcome, taking the author of Low Carbon Pulse by surprise, pleasantly so.

  Leaving to one side the pleasant surprise of the publication of ***UKH2S***, given consistency of intent and narrative ahead of publication (including the sibling policy setting, Energy White Paper (***EWP***), published in December 2020), the ***UKH2S*** did not contain any surprises. While some commentators who have characterised an absence of detail as surprising, it is good to have the ***EWP*** in mind when reading and reflecting on the ***UKH2S***.

- **Consistent by-line:** The by-line for the ***UKH2S*** is that: "*This strategy sets out the approach to developing a thriving low carbon hydrogen sector in the UK to meet our ambition for 5 GW of low carbon hydrogen production capacity by 2030*".

  For those familiar with UK Government policy settings, this statement is consistent with the UK Governments Ten Point Plan for a Green Industrial Revolution (published on November 18, 2020) (the ***Ten Point Plan***). Point 2 of the Ten Point Plan driving the ***Growth of Low Carbon Hydrogen*** aimed for "5 GW [of] Hydrogen production capacity by 2030 in partnership with industry".

  It is fair to say that in some quarters it was hoped that the ***UKH2S*** would increase the size of the target aimed to be achieved. As noted in Edition 21 of Low Carbon Pulse, and considered in detail in the July Report on Reports (contained in the Appendix to Edition 23 of Low Carbon Pulse), the All-Party Parliamentary Group urged the UK Government to set more ambitious targets.

- **The essentials sound:** For those familiar with the first article in the ***S2H2*** series, ***Why Hydrogen? Why Now?***, and a number of editions of Low Carbon Pulse, the need for the supply and demand side to develop in tandem, with neither being the "chicken or the egg" has long been a theme, as has the idea that to develop supply and demand, Blue and Green Hydrogen are needed.

  The ***UKH2S*** recognises these supply and demand dynamics in the same way: "*Developing a hydrogen economy requires tackling the "chicken and egg" problem growing supply and demand in tandem*". Further, the ***UKH2S*** recognises that: "When it comes to production, our "***twin track***" approach capitalises on the UK's potential to produce large quantities of both electrolytic 'green' and CCUS enabled 'Blue Hydrogen'". (see the ***EWP*** for CCUS.)

- **Continuing policy progress:** It is important to note that the UK Government has not been standing still on progress towards the hydrogen economy. As reported in Edition 23 of Low Carbon Pulse, consistent with the ***Ten Point Plan***, and, as can now be seen, aligned with the ***UKH2S***, the UK Government is already laying the foundations through its hydrogen hub / industrial cluster initiatives.

  On the day of publication of the ***UKH2S***, one of the five eligible projects announced on July 30, 2021 (see Edition 23 of Low Carbon Pulse), HyNet North West, noted that: "*The key now is for the government to build momentum by prioritising projects that are ready for development today*". It is difficult to argue with the sentiment, noting however that the sentiment straddles both the ***EWP*** and the ***UKH2S***.

  Consistent with the approach, and commitment, of the UK Government to long-term partnering with the private-sector, the private sector has been making progress ahead of final policy settings. To get a sense of the level of activity, the following graphic, from ***MapStand – Location Intelligence*** is helpful to get a sense of location, and size and shape of activity.

- **Hydrogen Hubs and Industrial Clusters:** Edition 23 of Low Carbon Pulse provided an overview of the hydrogen hubs and industrial clusters around the UK.

  The level of development and definition of these hubs and clusters is a function of the level of development and definition of UK policy settings, and the cohesion across those policy settings.

  Each hydrogen hub and industrial carbon cluster is located in an area that is or has been dominated by industry, with activities within its hinterland that give rise to the need for carbon capture (in particular arising from difficult to decarbonise industries, and, to some extent, electrical energy generators using fossil fuels or other carbon intensive fuels), and as such the storge of that carbon, or its storage and use, in proximate storage (depleted oil and gas fields), and the ability to produce hydrogen, (ncluding by virtue of proximate supply of renewable energy and water (Green Hydrogen) or natural gas (Blue Hydrogen), and likely proximate storage for (salt caverns), and use of, the hydrogen produced.

- **Headlines arising from the *UKH2S***:
  - There is room for Blue and Green Hydrogen, consistent with the low carbon hydrogen badge: the "***twin track***";
  - The low carbon badge needs to be standardised and to be consistent with ***NZE***;
  - Consistent with the initiatives in Europe, network and storage infrastructure is recognised as essential to underpin the development of a hydrogen economy;
  - Consistent with other jurisdictions, blending of natural gas (***CH_4***) with up to 20% by volume hydrogen (of the blended stream) being assessed for feasibility and modelled for the ***GHG*** emission outcomes;
  - GBP 900 million to support hydrogen projects;
  - GBP 240 million to support commercial development of hydrogen production facilities deployed through a Net Zero Hydrogen Fund; and
  - The use of a contracts for difference (***CfD***) scheme to encourage private sector investment in renewable electrical energy required to provide electrical energy to power electrolysers to produce Green Hydrogen.

- **Reaction to *UKH2S*:** A number of commentators and hydrogen industry participants have questioned the scale and speed of the development of the low carbon production capacity and the "***twin-track***" approach.
  - **Scale and speed of roll-out:** The desire to accelerate the development of low carbon production capacity is a consistent theme, both before (see Edition 21 of Low Carbon Pulse, under ***Ahead of the UKH2S***) and after (some participants suggesting that 20 GW of low carbon production capacity, rather than 5 GW, would be a more appropriate target) the publication of the ***UKH2S***.

    As noted above, the supply side and the demand side of the hydrogen economy need to develop in tandem, and acceleration is possible as supply and demand side develop, including to respond to the dynamics of the market as the cost of Green Hydrogen becomes more competitive. Further, while there is a role for government, the UK Government approach leaves space for the private sector to respond; and

- ***Twin-track* approach:** Reading the ***UKH2S*** with the ***EWP***, and considering the timelines for the progression of the policy settings, allows a conclusion that there is sufficient flexibility in these policy settings to allow a shift to Blue Hydrogen in the nearer term, and Green Hydrogen in the medium to longer term, noting that technologies used at the ultimate point of use are agnostic / indifferent as to the colour of hydrogen.

  While the UK Government has not stated expressly that the production of Blue Hydrogen and CCS / CCUS may be part of energy transition, and the policy settings as currently do not contemplate a period of transition, other jurisdictions regard Blue Hydrogen and CCS / CCUS as requiring support for a period of time, after which there is a working assumption (right or wrong) that Green Hydrogen will have become established (see Edition 23 of Low Carbon Pulse under ***Policy setting, with an end in sight***).

- **More in the pipeline:** The ***UKH2S*** contemplates that a development action plan will be launched in early 2022. Future editions of Low Carbon Pulse will cover these policy settings as they develop further.

GCC countries continued activity:

- **Clean City, UAE:** On August 9, 2021, publication H2View published an interview with acting Executive Director of Masdar Clean Energy (a leading developer and utility scale renewable energy projects), Mr Fawaz Hadi Salem Ali Al Muharrami. Masdar is celebrating the 15th anniversary of its establishment as a distinct entity, and in this context, the interview is particularly timely.

  As reported in Edition 18 of Low Carbon Pulse, Masdar is responsible for the development of a pilot project for the production of Green Hydrogen (and e-kerosene and other sustainable fuels, including sustainable aviation fuel (***SAF***)). It is expected that Green Hydrogen and ***SAF*** will be produced from the pilot project by 2022.

- **Abu Dhabi Hydrogen Alliance:** Masdar, Abu Dhabi National Oil Company (***ADNOC***) and Abu Dhabi Development Holding Company (***ADQ***) established the Abu Dhabi Hydrogen Alliance (***ADHA***) earlier in 2021. The ***ADHA*** is intended to provide a framework for each organisation to contribute to making the UEA the "trusted leader in low-carbon green and Blue Hydrogen in emerging international markets". This is bearing fruit.

  See: *Mubadala, ADNOC and ADQ form alliance to accelerate Abu Dhabi Hydrogen leadership*

- **"I" spy more Blue Ammonia to Japan**: Edition 23 of Low Carbon Pulse reported on the sale of Blue Ammonia to Itochu by ***ADNOC*** and Fertiglobe (a joint venture between ***ADNOC*** and OCI NV) to use in the production of fertiliser.

  On August 10, 2021, it was reported widely that ***ADNOC*** and Fertiglobe had agreed to sell Blue Ammonia to Idemnitsu (leading Japanese headquartered oil corporation) for use in its refining and petrochemical activities.

  On August 18, 2021, it was reportedly widely that ***ADNOC*** agreed to sell Blue Ammonia to Japan's ***INPEX*** (Japan's largest oil and gas exploration and production corporation). It is reported that the ***CO_2*** arsing from the production of Blue Hydrogen then combined with nitrogen (producing ***NH_3*** molecules) to produce Blue Ammonia is captured and stored in onshore oil fields (in which ***INPEX*** is a five percent participant). The Blue Ammonia was produced by Fertiglobe. It is reported that INPEX will use the Blue Ammonia as a fuel for the purposes of electrical energy generation.

  The development of the UAE to Japan market for Blue Ammonia reflects the policy settings put in place at both ends of the supply / value change: the UAE has a "***twin-track***" approach to the production of hydrogen and hydrogen-based fuels, and Japan is agnostic as to the colour of the hydrogen or hydrogen-based fuels imported to displace fuels and feedstocks derived from fossil, and other carbon intensive, fuels and feedstocks.

  Note: It is stated frequently that Blue Ammonia emits no carbon and no ***CO_2*** on combustion (i.e., on oxidation). This is true: it is a function of ***NH_3*** molecules containing no carbon atoms. It is important to note (Ashurst publications do), that on oxidation of ammonia (whatever its colour) ***N_2O*** arises. ***N_2O*** is a ***GHG***. This does not lessen the relative benefits of ammonia over other energy carriers, but it is important to understand.

  See: *ADNOC and Fertiglobe Partner to Sell Blue Ammonia to Japan's Idemitsu*; *ADNOC and Fertiglobe Further Strengthen UAE - Japan Low-Carbon Cooperation with Sale of Blue Ammonia to Japan's INPEX*

- **Oman building on progress:** Edition 18 of Low Carbon Pulse reported on the Hyport DUQM Green Hydrogen project in Oman (***Hyport DUQM***) (under ***Oman goes Green by Blue***). Edition 22 of Low Carbon Pulse reported that Uniper (leading international energy company) has signed a cooperation agreement with the shareholders in ***Hyport DUQM*** to develop the business case for the off-take of Green Hydrogen through the negotiation of an exclusive off-take agreement for Green Ammonia and to provide related engineering services.

  On August 13, 2021, it was announced that the Oman Ministry of Energy had established an alliance (***Hy-Fly***) of thirteen public and private sector organisations (including Oman LNG, OQ, BP, Shell and TotalEnergies) to work together to develop initiatives for the purposes of the production, transportation, use and export of clean hydrogen, and clean hydrogen-based fuels.

  The establishment of ***Hy-Fly*** by the Oman Ministry of Energy is one of the outcomes identified in the Hydrogen Economy Feasibility Study, and it is now part of the Oman Vision 2040.

  See: *Oman's hydrogen alliance to drive national hydrogen economy*

- **Solar electrical energy at pace in Saudi Arabia:** Edition 14 of Low Carbon Pulse reported on the second round of tenders for renewable projects under National Renewable Energy Program (under ***Second round solar tender in the Kingdom of Saudi Arabia sees world record low***), and the results of the second round of tenders (under which seven projects were awarded), all of which were published on April 8, 2021.

  On August 16, 2021, pv magazine, reported that the Sudair solar photovoltaic project (***SSPP***) had reached financial close, critically, on the basis of a 25 year power purchase agreement. The price under the power purchase agreement is 1.239 cents a KWh or USD 12.139 MWh, the same as the reported bid pricing in early April 2021. (The bid pricing for the ***SSPP*** was reported as being the second lowest in the second round of the National Renewable Energy Program.)

The ***SSPP*** will be the Kingdom of Saudi Arabia's largest photovoltaic solar project, with 1.5 GW of installed capacity. The ***SSPP*** is to be developed by the following leading corporations (in the following shares), ACWA Power (35%), Badeel (35%) and Saudi Aramco (30%), at Sudair Industrial City, about 120 kms from Riyadh. It is remarkable that it has taken a little over months from award to financial close.

See: *Financial close for 1.5 GW solar PV project in Saudi Arabia*

- **Green Hydrogen and Green Ammonia project progressing:** Edition 18 of Low Carbon Pulse (under ***Green Hydrogen and Green Ammonia***) reported on the announcement of the development of a Green Hydrogen and Green Ammonia facility by Helios Industries within the Khalifa Industrial Zone Abu Dhabi (***KIZAD***).

  On August 16, 2021, it was reported that Helios Industries had contracted with thyssenkrupp to undertake a technical study in respect of an initial production of 20,000 tonnes per annum (***tpa***) of Green Hydrogen, with production to develop overtime to 200,000 ***tpa***.

  As will be apparent from the piece below headed ***German flagship projects – progress check***, thyssenkrupp is the ideal organisation to undertake this work: thyssenkrupp is coordinating one of the three flagship projects critical to the development of the hydrogen economy in Germany - **H2Giga**: involving the development of large-scale use of electrolysers to electrolyse water using renewable electrical energy to produce Green Hydrogen.

  See: *thyssenkrupp supports Emirati company Helios Industry in Green Hydrogen and green ammonia value chain development*

As noted in previous editions of Low Carbon Pulse, across the Gulf Cooperation Council (***GCC***) countries, there is palpable development of Green Hydrogen and Green Ammonia (and Blue Hydrogen and Ammonia) projects.

Edition 20 of Low Carbon Pulse included a narrative around the highly prospective, world-class resources that exist in the ***GCC*** countries (see under ***Black Gold and Blue and Green Gold***, and ***Oman's aim is true*** and ***New petroleum***).

India: up-beat tempo continues:

- **India leading country for renewable energy investments:** As reported in Edition 23 of Low Carbon Pulse, the Executive Director of the International Energy Agency (***IEA***), Mr Fitoh Birol, regards: "*India is a leading country in terms of renewable energy investments … the country has great plans to be a driver of clean energy transitions …*". During 2021, this assessment appears to be accurate.
- **India progressing to energy independence:** On August 15, 2021, India celebrated the commencement of the 75th year after its founding on August 15, 1947.

  On this auspicious day, Indian Prime Minister, Mr Narendra Modi, took the opportunity to announce the National Hydrogen Mission for India (***NH2M***) in his Independence Day Speech. In the Independence Day Speech, Prime Minister Modi prompted India to give an oath to achieve energy independence before the 100th anniversary of its founding.
- **From importer to self-sufficient exporter:** Given that India imports 85% of its oil and 53% of its natural gas for domestic energy use, it was not a surprise that energy security for India ran through the narrative of the speech of Prime Minister Modi: the ***NH2M*** provides for India to become a global hub for Green Hydrogen production, both for domestic use and for export.

  The scale of the ambition is matched by the scale of the plans: from various sources, India plans to install 13.6 GW of renewable electrical energy capacity each year for the next five years, and as such up to 68 GW over that time, with 44.2 GW being utility-scale.
- **Progress continues across a number of sectors:**
  - On August 9, 2021, it was reported widely that bids have been invited by the Ministry of Railways for the provision of fuel cell technology to be used to retrofit two locomotives;
  - On August 16, 2021, it was reported widely that India's largest power company, the state-owned NTPC Limited (founded as National Thermal Power Corporation Pvt Ltd in 1975) released an expression of interest for a pilot project to blend natural gas and hydrogen across a city natural gas distribution network.

    (see Editions 21 and 22 of Low Carbon Pulse for further background on NTPC projects that relate to this initiative.); and
  - On August 20, 2021, as reported by The Economic Times (of India), ArcelorMittal is planning to invest in renewable energy (solar and wind), hydrogen production and iron and steel mills in the State of Gujarat.
- **Report on South Asia:** On August 16, 2021, **FTI Consulting** and **Teri** published a report (in the *South Asia New Energy Series*), covering many facets of the development of renewable energy capacity across South Asia.

  It is understood that a copy of the report has been provided to the Ministry of New and Renewable Energy (***MNRE***), among other things, responsible for policy settings in India. The report is well-worth a read, not least because of the focus of what is required ahead of 2030.

"Acquire to retire" program for coal-fired power station capacity:

- **Coal-fired power station efficiency an issue:** As noted below, one of the two more compelling facts reported during Q2 of 2021 is that 5% of the world's electrical energy generation capacity gives rise to 73% of ***CO_2*** emissions arising from the generation of electrical energy (see *Reducing CO2 emissions by targeting the world's hyper-polluting power plants*).

  From this report, the ten "worst polluters" were inefficient power plants, using outdated practices and technology, and lower quality coal. These power plants are located in East Asia, Europe and India, with a higher proportion of inefficient coal-fired power stations across these regions.
- **From care free to Prudential action:** As noted in Edition 23 of Low Carbon Pulse, UK insurance giant, Prudential, proposes a program to "acquire to retire" coal-fired power stations ahead of the end of their planned

life-cycles, critically, before amortisation debt and equity, and, if independent power projects, the term of power purchase agreements under which electrical energy is supplied, typically, to state-owned off-takers of electricity.

- **Prudential momentum**: On August 13, 2021, Nikkei Asia (under ***Philippines and Vietnam coal-fired power plants to retire in ADB-led plan***), reported that at COP-26, the Asian Development Bank (***ADB***) intends to announce plans to retire coal-fired powers plants in the Philippines and Vietnam, working with Prudential. As noted in Edition 23 of Low Carbon Pulse, the acquisition and retirement is half the plan, the other half is the development and deployment of new electrical energy generation capacity.

  It is understood that the ***ADB*** has a short-list of coal-fired power stations this is considered appropriate to close a decade or more before the end of their planned life-cycles. In addition to ***ADB*** and Prudential, BlackRock, CitiBank and HSBC have each been mentioned as likely to be involved in the "acquire to retire" program.

- **Convergence of policy settings:** It is possible to see a convergence of policy settings here resulting in the cessation of dispatch (in countries with gross wholesale electrical energy markets) and the retirement (in countries with power purchase agreement) of coal-fired electrical energy generation capacity coinciding with new capacity.

  As noted in previous editions of Low Carbon Pulse, reverse auctions are used to encourage cessation / retirement, with success in the case of Germany. The challenge with the replication of a reverse auction progress is that it may not result in the retirement of the most inefficient capacity.

- ***AETI* in the policy setting mix:** As noted in Edition 20 of Low Carbon Pulse, the ASEAN energy ministers met on June 21, 2021, and invited the Japanese Minister for the Ministry of the Economy, Trade and Industry (***METI***), Mr Hiroshi Kajiyama. At the meeting, Mr Kajiyama announced the USD 10 billion Asian Energy Transition Initiative (***AETI***). The ***AETI*** provides for funding support to ASEAN countries, including to promote the use of gas to power, as a means of displacement coal-fired electrical energy generation.

  It is most unlikely that the ***AETI*** would be the sole initiative (and it may be resisted in some countries), but it would be an initiative that may be regarded as forming part of other policy settings to retire inefficient coal-fired power generation capacity as quickly as possible with gas-fired electrical energy capacity best suited to integration into current grid infrastructure.

Germany flagship projects – progress check:

- **Role of BMBF:** The German Federal Ministry of Education and Research (***BMBF***) is pivotal in the development of the hydrogen economy in Germany, and further afield for that matter. For example, see Edition 18 of Low Carbon Pulse in respect of the renewable energy resources in Africa under ***West Africa – untapped potential for hydrogen production***). ***BMBF*** is key to the implementation of the German National Hydrogen Strategy.

- **The flagship projects:**

  In January 2021, the ***BMBF*** launched three flagship projects, and continues to provide funding to them. The three flagship projects are intended to undertake the necessary research and testing to enable the development of the hydrogen economy in Germany.

  The three flagship projects are:

  – **H2Giga:** dedicated to the development of large-scale use of electrolysers (using serial construction of standardised electrolyser technology) to electrolyse water using renewable electrical energy to produce Green Hydrogen. Thyssenkrupp is responsible for the coordination of **H2Giga**;

  – **H2Mare:** dedicated to investigating the use of use off-shore / off-grid renewable wind electrical energy to produce hydrogen and hydrogen-based fuels: effectively, a dedicated, integrated, closed electrical energy to Green Hydrogen production energy loop. **H2Mare** comprises four joint projects: **1**. OffgridWind, **2**. H2Wind, **3**. PtX-Wind, and **4**. TransferWind. Siemens Energy is responsible for the coordination of H2Mare.

    On August 20, 2021, it was reported widely that Siemens Energy has secured €100 million of funding for a project intend to link directly off-shore / off-grid wind capacity to electrolysers to produce Green Hydrogen. As noted in previous editions of Low Carbon Pulse, the outcomes from H2Mare will have implications for the speed of the development of Green Hydrogen production across Europe, and as such the rate at which supply is able to develop with demand; and

  – **TransHyDe:** dedicated to reaching transportation of hydrogen over short, medium and long distances, and comprising four demonstration projects: **1**. Hydrogen Transport in High Pressure Vessels, **2**. Hydrogen-Liquid Transport, **3**. Hydrogen Transport in Existing and New Gas Pipelines, and **4**. Transport of Hydrogen Bound in Ammonia or liquid organic hydrogen carrier (***LOHC***), a carrier medium. In addition to these four projects, **TransHyDe** involves five associated and relation scientific projects. Most of the work on the projects commenced in April 2021.

    On August 20, 2021, it was reported widely that a part of project 4 in the **TransHyDe** flagship project relating to ***LOHC*** was proceeding. While a number of means of transportation are being researched and tested, work is to proceed at the Mukran Project (on the island of Rugen) and Helgoland Project (on the island of the same name) in respect of ***LOHC.*** The work on Rugen and Helgoland involves consideration of the effectiveness of the transportation of hydrogen in ***LOHC*** contained in high-pressure containers.

    As reported in previous editions of Low Carbon Pulse, ***LOHC*** is being considered a carrier medium (see Edition 21 of Low Carbon Pulse).

  Note: For those readers interested in quantum physics, more specifically, the role of Werner Heisenberg in the development of quantum physics, ***Helgoland***, by Carlo Rovelli ("poet of physics"), takes the reader to the tree-less, wind-swept island of **Helgoland** in the German sector of the North Sea.

Swiss leading on a number of fronts:

- **Switzerland to mandate climate risk reporting:**
  - **Role of TCFD:** Edition 24 of Low Carbon Pulse provided an overview of the Task Force on Climate-Related Financial Disclosures (***TCFD***), and suggested that corporations would be well-advised to act on the recommendation of the ***TCFD*** ahead of legal mandating on climate-related financial disclosures. This suggestion was made in anticipation of legal mandating.
  - **Swiss to mandate climate-related financial disclosures:** On August 18, 2021, it was reported widely that the Swiss Government is to require that public companies, banks and insurance companies satisfying specified criteria (at the moment, over 500 employees, over CHF 20 million or over CHF 40 million in annual turnover), report on climate-related risks from 2024: first, the financial and investment risks related to climate change, and secondly, the impact that the activities of the reporting entity have on the environment.
- **Mammoth commitment from Mammut:** In other news from Switzerland, Mammut (leading apparel and equipment supplier) has announced that, as part of its commitment to achieving ***NZE***, it will use only shipping lines with practises that achieve ***NZE*** (or lowest carbon) outcomes in respect of its Scope 3 emissions.

  Reacting to the Mammut commitment, Climate Change Director, at Pacific Environment (an NGO), Ms Madeline Rose noted: "Mammut's commitment shows that companies have the power to end their maritime freight pollution."

  See: Mammut's *website* and its commitment *plan*.

Hydrogen in Latin America:

- **Hydrogen's role in LatAm:** On August 17, 2021, the International Energy Agency (***IEA***) published its ***Hydrogen in Latin America*** (***H2LA***) report. As with all ***IEA*** reports, the ***H2LA*** report provides a grounding in the key issues and the role that hydrogen may play in decarbonising energy use in Latin America, and the role that Latin America may play globally.
- **Six recommendations:** As is the case with most ***IEA*** papers, reports and studies, the ***H2LA*** provides recommendations for those developing policy settings in Latin American, on this occasion there is six recommendations, as follows:
  - Define a long-term vision for hydrogen in the energy system;
  - Identify near-term opportunities and supply initial deployment of key technologies;
  - Support early financing schemes and reduce investment risk;
  - Focus on R&D and skills to reap benefits beyond emission reductions;
  - Use certification schemes to incentivise the production of low-carbon hydrogen and create markets; and
  - Cooperate regionally and internationally to position Latin America in the global hydrogen landscape.

  The August Report on Reports (which will be an Appendix to Edition 27 of Low Carbon Pulse (to be published in September 24, 2021) will contain a summary of the key findings and points made in the ***H2LA*** report.

  Activity to date: As noted in previous editions of Low Carbon Pulse, a number of Latin American countries have the benefit of renewable resources that will allow the production of hydrogen at scale, in particular Green Hydrogen, and other Green Hydrogen-based fuels. See Editions 10 (under ***Brazilian government and industry caucus around Green Hydrogen Hub***), Edition 13 (under ***Green Hydrogen (and ammonia and methanol) round-up***), Edition 17 (under ***Chile hot again***) and Editions 21 and 23 (under ***Chile to speed up progress*** and ***It is Scotland in Chile***) of Low Carbon Pulse.

  Most recently, on August 11, 2021, it was announced that the Brazilian state of Rio Grande do Norte has entered into an agreement with "low-carbon energy developer" Enterprize Energy to identify, and to develop, off-shore wind fields and Green Hydrogen and Green Ammonia production.

PRC continues to lead the way:

- **Shanghai Electric and Shell China aligned:** On August 10, 2021, it was reported widely that Shanghai Electric and Shell China have signed an agreement that will allow the coordination of activities so as to deploy technologies on a timely basis in the context of achievement of the "carbon peak and carbon neutral" outcomes. It is anticipated that this will be a powerful alliance in a rapidly expanding ***PRC*** market.
- **Beijing hydrogen chain being developed:** On August 17, 2021, it was reported that the Beijing Municipal Bureau of Economy and Information Technology (***MBEIT***) released a roadmap routing the development of a hydrogen value chain in Beijing.
- **Renewable Electrical Energy for Green Hydrogen:** Editions 18 and 19 of Low Carbon Pulse reported on the development of hydrogen production facilities in the cities of Baotou and Ordos, Inner Mongolia.

  On August 18, 2021, it was reported that the development of renewable electrical energy projects (1.85 GW of solar photovoltaic and 370 MW of wind) will provide the electrical energy to allow the production of up to 66,900 ***tpa*** of Green Hydrogen. With construction to commence in October 2021, it expected that first Green Hydrogen will be produced in 2023.
- **Now that is a Forest Strategy:** On August 20, 2021, it was reported widely that ***PRC*** is to plant 36,000 square kilometres (an area that is larger than the size of Belgium) of new forest a year until 2025. By the end of 2025, over 24% of land mass in ***PRC*** will be forested. This goes beyond policy setting of preserving and returning land to ensure that at least 30% of land mass is unused for human activities (see Edition 14 of Low Carbon Pulse).

Russia continues to progress:

- **Russia has a key role to play:** Edition 23 of Low Carbon Pulse reported on a comprehensive article in Oil Price (under ***Russia Ramps Up Its Hydrogen Energy Ambitions***), in which various narrative strains that have emerged over the last few months (certainly starting in May 2021) are pulled together.
- **Russian Narrative continues:** On August 9, 2021, it was reported widely that framework plans for the development of the hydrogen economy in Russia (including for the export of hydrogen) have been approved, in principle, by the Russian Prime Minister, Mr Mikhail Mishustin. This is effectively a hydrogen strategy.

  It is understood that the framework plans contemplate the development of three clusters for the production of hydrogen: in the Northwest sector of Russia (to provide hydrogen to European countries), in the Eastern sector of Russia (to provide hydrogen to Asian countries, including into North Asia) and in the Arctic sector.

  As might be expected, the production of Blue Hydrogen (using natural gas as the feedstock, and steam methane reforming and CCS / CCUS technologies) will be the focus of each cluster, at least until the latter part of the current decade. It is contemplated also that coal may be used as a feedstock for hydrogen production.
- **Steppes Change Required:** Russia has vast resources that will enable it to be a key player in the emerging markets for hydrogen and hydrogen-based fuels and feedstocks. As is the case with all oil and gas companies globally, Russian oil and gas companies recognise the need to transition to low or no carbon energy carriers.

Bio-energy update:

- **Background:** The ***2021 Report*** does not address bio-energy in the same level of detail as any of the following.
  - **International Energy Agency** or ***IEA*****:** ***Net Zero by 2050 – A Roadmap for Global Energy Sector***;
  - **International Renewable Energy Agency** or ***IRENA*****:** ***World Energy Transitions Outlook***;
  - **Wood Mackenzie:** ***How to scale up carbon capture and storage***;
  - **BloombergNEF:** ***New Energy Outlook, 2021***; and
  - **S&P Global Platts:** ***Platts Global Integrated Energy Model – Strategic Planning for a world in transition***.

  The ***2021 Report*** recognises bio-energy as one of the means of carbon dioxide removal (***CDR***) on the basis that bio-energy being derived with carbon capture and storage (***BECCS***). ***BECCS*** is recognised is one of a number of means of achieving ***CDR*** along with afforestation, ***DACS***, enhanced terrestrial weathering, ocean alkalinisation and ocean fertilisation, soil carbon sequestration and wet-land restoration.

  For further detail on ***CDR*** (including the means of achieving enhanced terrestrial weathering, ocean alkalinisation and ocean fertilisation, soil carbon sequestration and wet-land restoration), see Chapter 5, Section 5.6 of the ***2021 Report***.
- **Bio-energy and the** ***CO_2*** **cycle**: ***CDR*** is not an instant solution in global terms (as outlined in Edition 24 of Low Carbon Pulse, it takes time), nor is ***BECCS***. For ***BECCS*** to make a contribution to a reduction in ***GHG*** emissions, it must displace another electrical energy source or energy carrier source, and, in any event, it must result in a carbon neutral outcome (rather than a carbon removal outcome) so as not to give rise to an increase in ***GHG*** emissions. The effectiveness of ***BECCS*** at a global level is more likely than not to be to achieve carbon neutrality rather than to remove carbon.

Blue Carbon update:

- **Background:** The key findings in the ***2021 Report*** in the realm of Blue Carbon are:

  > "It is *virtually certain* that the global upper ocean (0-700 metres) has warmed since the 1970s and *extremely likely* that human influence is the main driver. It is virtually certain that human-caused CO_2 emissions are the main driver of current global acidification of the surface of open ocean. There is *high confidence* that oxygen levels have dropped in many upper ocean regions since the mid-20th century … "

  This is taken from that ***Summary of Policymakers*** (***SPM***) contained in the ***2021 Report***. (The ***SPM*** is the part of the ***2021 Report*** from which it is possible to cite and to quote.)
- **Facts and Stats:** The key findings of the ***2021 Report*** support the perspective that, with the exception of the restoration and planting of mangrove swamps and other flora close to oceans and waterways, as yet the science tends to support a Socratic approach – do no harm. In fact, it is probably fair to displace "do no harm" with "do nothing at all" approach. As noted in the ***2021 Report***, it is critical to avoid activities that may increase the upper ocean temperature or that may increase acidification or reduce the level of oxygenation in the oceans.

BECCS / BECCUS and CCS / CCUS round-up:

- **World scale DACS:** On August 20, 2021, it was reported widely that on September 8, 2021, Orca, a new direct air capture and storge facility, will commence in Iceland. Orca, owned by Climeworks, will capture up to 4,000 metric tonnes per annum of ***CO_2*** from the atmosphere, and store the captured ***CO_2*** underground.

  See: *The rapid construction of Climeworks' new direct air capture and storage plant Orca has started*
- **Where has all the flour gone:** On August 21, 2021, the Australian Broadcast Corporation news developed a news item from a study that is a couple of years old from The Australia Institute (a think tank known for conducting a range of research). The news item is intended to frame the "technology not taxes" policy setting mind-set of the current Australian Federal Government. The news time grabs the attention with the headline that: "The Australian Institute says that about $4 billion of taxpayer money has been spent on CCS" since 2023.

  The ***2021 Report*** (and each of the ***IEA***, ***IRENA*** and ***BloombergNEF*** reports) contemplates the use of CCS, and that its use is critical to achieving ***NZE***, each noting that use of CCS is a less assured policy setting than others.

  Leaving to one side the purpose of the ABC news item, it is important to note that what matters is that CCS / CCUS is used and that it is used promptly, with its use to be perfected over time. It is not a question of renewable electrical energy versus CCS / CCUS, it is a matter of the deployment of both renewable electrical energy and CCS / CCUS promptly, and its perfection as soon as practicable.

See: *As carbon capture, storage spending nears $4b, what are the options for heavy industry?*

- ***DACS* viable:** On August 21, 2021, it was reported that researchers in Switzerland had released a study containing encouraging findings about the use of ***DACS*** as a means of CCS. ***CO_2*** capture was undertaken in Chile, Greece, Iceland, Jordan, Mexico, Norway, Spain and Switzerland for the purpose of the study. The key finding is that up to 97% of ***CO_2*** in the atmosphere could be captured direct-from-air using ***DACS*** technologies.

  While the study may be regarded as stating the obvious in parts ("The use of [DACS] technology only makes sense if [the emissions arising from the use of the technology] are significantly lower than the amounts of CO_2 it helps to [capture and] store"), it is well-worth a read.

CO_2 use:

On August 12, 2021, Australia's National Science Agency, the Commonwealth Scientific and Industrial Research Organisation (***CSIRO***), published its ***CO_2 Utilisation Roadmap*** (***CUR***). For the author of Low Carbon Pulse, this is timely, and, as one has come to expect, given the sustained excellence of the ***CSIRO***, the ***CUR*** is excellent.

The ***CUR*** will be considered in detail in the August Report on Reports, which will be included as the Appendix to Edition 27 of Low Carbon Pulse (to be published on September 24, 2021).

Energy Storage round-up (including *BESS* and grid forming batteries):

- **Time for the world's largest Big Battery:** On August 9, 2021, it was widely reported that AGL Energy Limited (***AGL***), one of Australia's three large integrated energy companies, is to develop the world's largest Big Battery with the development of a "grid forming" battery of 250 MW to be located at Torrens Island, Adelaide, South Australia (***GFB***). (As noted below, the title of world's largest Big Battery is unlikely to be held for long.)

  This is a continuation of ***AGL*'s** response to energy transition with big battery capacity of up to 850 MW to be developed and owned and controlled by it, to add to its established business model to contract for capacity in Big Batteries owned by other corporations, including in respect of Wandoan and two Big Batteries being developed by Maoneng (see Edition 21 of Low Carbon Pulse).

  Initially, the ***GFB*** will have one hour of storage capacity (250 MW / 250 MWh). Eventually, the ***GFB*** will have four hours of storage (250 MW / 1,000 MWh). The development of the ***GFB*** is to take place at the AGL's Torrens Island Gas Fired Power Station (***TGFPS***) as ***TGFPS*** is retired over time. Wartsila (global leading energy and battery system corporation based in Finland) is to supply the technology and construct and install the ***GFB***, and with SMA Solar Technology (leading German corporation) to supply the inverters.

  As noted in Edition 21 of Low Carbon Pulse, ***BESSs*** are able to provide virtual synchronous generation capacity.

  See: *AGL invests $180 million in Torrens Island grid-scale battery*

- **Proposal to maximise use of renewables in Big (Green) Apple:** On August 16, 2021, Energy-Storage.news reported on a proposal to develop a 150 MW / 600 MWh ***BESS*** as part of a "state-of-the-art clean energy underground highway" to transit green electrons from Upstate New York to The Big (Green) Apple.

  The background to the proposed project is the commitment of New York State to source 70% of electrical energy from renewable electrical energy sources by 2030. Upstate New York has good renewable energy resources that would support the proposed project.

  See: *New York transmission line proposal to maximise use of wind and solar includes 600 MWh of battery storage*

- **Mega-*BESSs* to hoover-up spills of renewable energy**: On August 22, 2021, CleanTechnica published a piece outlining a 1,500 MW / 6,000 MWh new energy storage facility proposed by Vistra. The proposed project would dwarf the 400 MW / 1,600 MWh Moss Landing Energy Storage Project (developed by Vistra Zero).

E-Fuels / Future Fuels:

- **Plug Power plugging away:** Edition 19 of Low Carbon Pulse reported on the plans of Plug Power to develop a Green Hydrogen production facility in Georgia, US. On August 10, 2021, it was reported that Plug Power had "broken ground" commencing construction of the facility that will produce 15 tonnes of liquid hydrogen each day.

  As noted in previous editions of Low Carbon Pulse, while the capacity of any single Green Hydrogen production facility may not appear significant, the development of production facilities are significant because of the number of them being developed, the fact that they are being developed to match supply to demand for the Green Hydrogen on an incremental market-by-market basis, and that the electrical energy used to produce the Green Hydrogen is from a renewable resource.

  See: *Plug Power breaks ground on Green Hydrogen production plant in Georgia*

- **Global Ventures and Total Eren look at feasibility:** Edition 16 of Low Carbon Pulse reported on Province Resources Limited's HyEnergy Project in Western Australia. On August 11, 2021, it was reported widely that Global Energy Ventures Ltd and Total Eren have signed a memorandum of understanding with Province Resources Limited in respect of the possible export of Green Hydrogen from the HyEnergy Project.

  See: *Global Energy Ventures hails MoU with HyEnergy project*

- **Trafford Green:** On August 11, 2021, it was reported widely that an application had been made to develop the first hydrogen fuel hub (***HFH***) in Manchester, in the Trafford area of the city, at the Trafford Low Carbon Energy Park. The ***HFH*** will produce and store Green Hydrogen. The plans indicate that the ***HFH*** will have capacity of 200 MW, making it the largest contemplated in the UK to date.

  See: *Trafford Green Hydrogen advances 200 MW renewable fuel hub in UK*

- **Everfuel ever-ready:** Previous editions of Low Carbon Pulse have reported on the activities of Everfuel (leading Scandinavian energy carrier mobility corporation) as one of the most active and forward thinking Green

Hydrogen entities in Northern Europe, including to outline the development of hydrogen refuelling infrastructure (***HRI***) across Scandinavia (see Edition 18 of Low Carbon Pulse), and production partnerships with Greenstat ASA (see Edition 21 of Low Carbon Pulse).

On August 12, 2021, it was reported that Everfuel is to develop the HySynergy Phase I 20 MW electrolyser Green Hydrogen production facility at Fredericia, Denmark. It is understood that Phase II contemplated a 300 MW Green Hydrogen production facility. This initiative builds on, and enhances, the Everfuel business model

See: *Minister of Climate, Energy and Supply Dan Jorgensen broke ground on Europe's largest power-to-x plant: the Hysynergy plant in Fredericia*

- **Pink and Purple Hydrogen:** On August 12, 2021, it was announced that NEL Hydrogen US (part of the Norwegian based NEL ASA Group, leading electrolyser technology provider) is to supply a PEM electrolyser funded by the US ***DOE*** to produce hydrogen for use at a nuclear power plant. The PEM electrolyser is to be installed at the Exelon Generation Nine Mile Point nuclear power plant in Oswego, New York State, located on Lake Ontario.

  It is not clear as yet whether the hydrogen will produce hydrogen using electrical energy from the plant (Pink Hydrogen) or steam from the plant (Purple Hydrogen).

  See: *Nel ASA: Receives contract for a 1.25 MW containerized PEM electrolyzer for DOE H2@Scale project in the US*; *Exelon Generation Receives DOE Grant to Support Hydrogen Production Project at Nine Mile Point Nuclear Station*

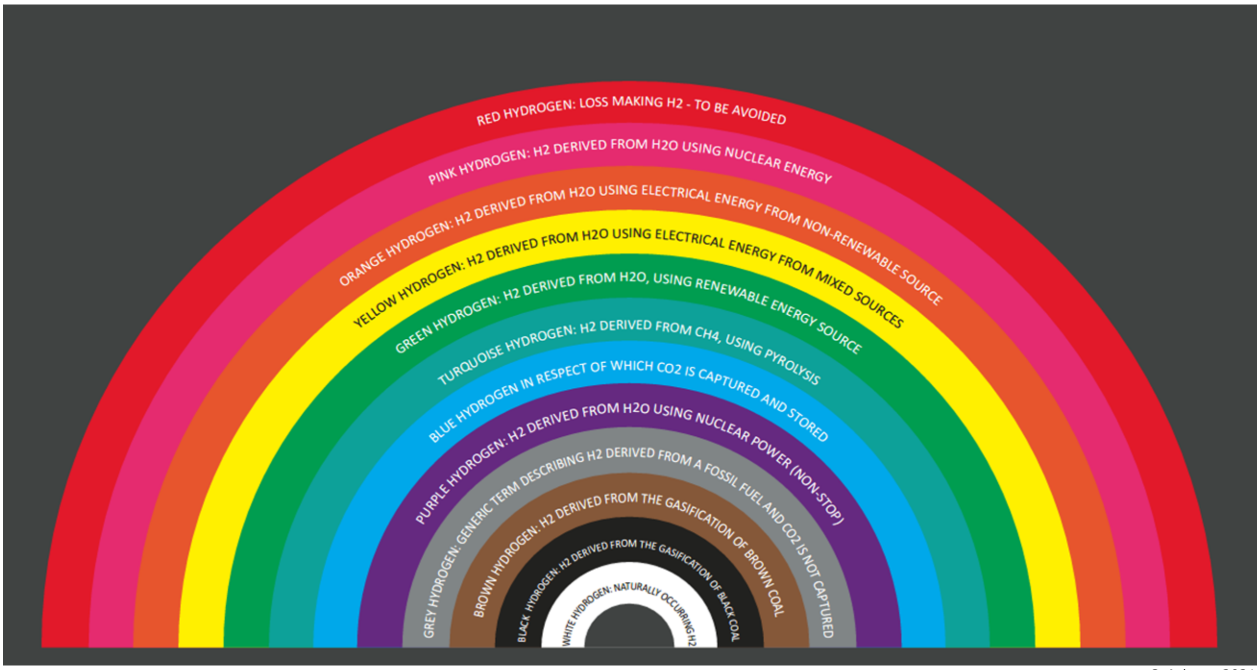
- **Ammonia Port and Carriers Heat Map and Clean Hydrogen Ladder:**

  By way of background information, attached is a link:

  – Click here for a heat map showing ports globally with an ability to handle ammonia. At least in part this heatmap explains the heat of the narrative around the use of ammonia as an energy carrier; and

  – Click here Clean Hydrogen Ladder (Version 4) of Michael Liebreich. The ladder is helpful visual reference point.

  As a point of contrast (ladder and rainbow), and for immediate reference, set out below is the ***Ashurst Hydrogen Rainbow***:



  The ***Ashurst Hydrogen Rainbow*** (a creation of the author of Low Carbon Pulse), is intended to provide an aide memoire to the reader. It is noted that the author of Low Carbon Pulse took liberties with both the colour coding of hydrogen and the spectrum: adding Red Hydrogen (at the top of the ***Rainbow***) to represent the difficulty of making a return on any early stage clean or low hydrogen project, and adding Grey, Brown, Black and White (at the bottom of the ***Rainbow***) for completeness of the colours that are used to describe hydrogen.

- **Port of Corpus Christi Authority (*PCCA*) and Howard Energy Partner pointing in the same direction:** On August 13, 2021, the ***PCCA*** and Howard Energy Partners announced plans to develop a carbon-neutral hydrogen production facility at the Javelina plant. These plans are the subject of a memorandum of understanding under which the Javelina plant will be converted to produce hydrogen, and on conversion, supply six local refineries using pipeline infrastructure.

  See: *Port of Corpus Christi responds to United Nations Intergovernmental Panel on Climate Change, Announces Carbon-Neutral (blue) Hydrogen Production Facility*

- **Any which way, Norway, ideal for Hydrogen and Ammonia, Blue or Green:**

  – **Getting in shape to be *Fit for 55***: On August 16, 2021, Aker Clean Hydrogen (a corporation within the Aker ASA Group, having diverse interests), Statkraft (leading renewable energy corporation, Europe's largest renewable energy generator) and Yara (global leading agricultural products corporation) established (each taking one-third of the equity) ***HEGRA*** (***HE***røya ***GR***een ***A***mmonia).

HEGRA involves the decarbonisation of the production of ammonia production at the current plant on the Herøya peninsula, in Porsgrunn, Norway. ***HEGRA*** will produce Green Hydrogen and Ammonia.

It is understood that ***HEGRA*** has been established with the purpose of achieving outcomes consistent with the European Commission's ***Fit for 55*** package reported on in detail in Edition 22 of Low Carbon Pulse.

In a joint statement, CEOs Oyvind Eriksen (Aker), Christian Rynning-Tonnesen (Statkraft) and Svein Tore Holsether (Yara): "*Aker, Yara and Statkfraft have established HEGRA with the ambition of creasing new industry in Norway that provides competitive advantage in a growing global hydrogen economy, establishes green jobs for the future and forms the basis for a future Norwegian export industry*".

- **Greenstat and TECO 2030 adding to the numbers:** On August 12, 2021, it was reported that Greenstat ASA and TECO 2030 had entered into a letter of intent providing for them to cooperate in the development of a complete hydrogen value chain.

  Greenstat is a leading energy corporation. TECO 2030 is a leading clean tech corporation, focused on technologies that reduce ***GHG*** emissions in the shipping and other carbon intensive industries, including through the development and deployment of ***FCT***.

  Underpinning the letter of intent is that in respect of the projects on which Greenstat and TECO 2030 cooperate, Greenstat will supply Green Hydrogen to TECO 2030.

- **More Energi up and running:** Edition 23 of Low Carbon Pulse reported on the memorandum of understanding signed by the Port of Rotterdam Authority (***PORA***) and Horisont Energi to import Blue Ammonia for ***PORA*** to use for both bunkers and distribution across Europe.

  On August 17, 2021, it was reported Horisont Energi has combined with St1 Norway (leading oil and energy sector corporation) to develop Green Hydrogen production facilities, to take advantage of the water and renewable energy resources of Norway to produce Green Hydrogen to be combined with nitrogen to produce Green Ammonia.

  In the words of the CEO of Horisont Energy, Mr Bjørgulf Haukelidsæter Eidesen: "Green hydrogen converted to ammonia unleashes the potential of renewables, ensures energy system efficiency, and enables a carbon neutral source of fuel and heat for our homes, transport, and industry, thereby making it instrumental in meeting the ***EU***'s climate objectives".

  Both Horisont Energi and St1 Norway view Green Ammonia as a key means of decarbonising transport and industry, including aviation, maritime and road freight.

  See: *St1 and Horisont Energi to collaborate on green ammonia production in Finnmark*

As will be apparent, there is a lot going on in Norway (and Denmark, Finland and Sweden for that matter). In addition to the news items noted above, attached is a link to a bulletin from SINTEF Energy Research, providing updates, among other things, on CCS / CCUS and waste to energy.

- **Green Hydrogen for Finland:** On August 16, 2021, it was reported that a P2X Solutions is to develop a 20 MW Green Hydrogen production facility (***PSP***). It is reported that the Green Hydrogen produced will be supplied to industrial users.

  Interestingly, it is reported that Green Oxygen will be used as a by-product. The derivation and use of oxygen has not tended to be the norm in the context of P2X narratives, but it may be expected that it will become part of the narrative increasingly.

  See: *First Green Hydrogen production plant in Harjavalta*

- **Bakken back plain sailing:** Edition 19 of Low Carbon Pulse reported on Bakken Energy and Mitsubishi Power Americas Inc's strategic partnership to create a clean hydrogen hub in North Dakota, US.

  On August 19, 2021, HydrogenCentral, reported (under ***Bakken Energy to Purchased Dakota Synfuels Plant and Convert to Blue Hydrogen, $ 2 B Hydrogen Hub Project***) that Bakken Energy had agreed terms with Basin Electric Power Corporation to purchase the gas assets of the Dakota Gasification Company, including its Synfuels facility.

  It is reported that Synfuels facility will be expanded and repurposed, and that it will incorporate advanced autothermal reforming (***ATR***) technology, rather than steam methane reforming (***SMR***) technology, to increase and to maximise the capture of CO_2 arising during the production of clean hydrogen (being hydrogen using carbon intensive feedstock that is then reformed).

  The ***ATR*** technology to be deployed is reported as capturing of 95% of carbon emissions arising. It is hoped that that Bakken will seek to address the 5% not covered by capture through a sequestration strategy.

- **Maersk's move to e-methanol:** On August 19, 2021, Norway's Maersk (the world's largest container shipping company) announced that it had contracted with Denmark's European Energy (and its subsidiary REIntegrate) for the development of an e-methanol production facility (***e-mpf***), and supply from it.

  The Practical: The e-methanol produced from the ***e-mpf*** (stated to be up to 10,000 tpa) will be:

  - derived from biogenic CO_2 (i.e., CO_2 captured from renewable organic feedstock); and
  - supplied to Maersk to power and to propel "the world's first container vessel operating on carbon neutral fuel".

  This initiative keeps Maersk on schedule to have: "the world's first container vessel operated on carbon neutral methanol on the water by 2023".

  The Theory: As noted in previous editions of Low Carbon Pulse (most recently in Edition 22 of Low Carbon Pulse, under ***Why methanol?***), while the oxidation of e-methanol (and any other bio-organic sourced fuel) is not CO_2 free, "the theory is that the CO_2 that arises will be absorbed into a renewable resource, with the continued growth in that renewable resource providing a carbon neutral outcome". This is the theory, noting that the science is still more theoretical than firm.

From the other end of the "growth-to-emission cycle", the US Environmental Protection Agency has stated that ***CO_2*** emissions arising from biogenic sources are "emissions that come from natural sources".

See: *Maersk secures green e-methanol for the world's first container vessel operating on carbon neutral fuel*

- **HyP SA closes in on commissioning:** Previous editions of Low Carbon Pulse have reported on the development of the Hydrogen Park South Australia (***HyP SA***).

  On August 20, 2021, it was reported that ***HyP SA*** is closing on the final stages of commissioning of the hydrogen production facility, and will commence the supply of hydrogen to Whyalla, South Australia, shortly.

  See: Hydrogen Park South Australia *website*

- **Naftogaz and RWE to cooperate:** On August 21, 2021, Naftogaz and RWE signed a memorandum of understanding to work together to identify opportunities in the Green Hydrogen market, principally developing Green Hydrogen and Green Hydrogen-based fuels (including Green Ammonia) production facilities in Ukraine and supply in Germany and Europe more broadly.

  See: *Naftogaz and RWE sign memorandum of understanding on hydrogen*

Green Metals and Minerals, the Mining Industry and Difficult to Decarbonise industries:

- **Tomago Aluminium to switch to renewable electrical energy**: Recent editions of Low Carbon Pulse have noted moves by a number of alumina and aluminium producers to green their production processes. On August 11, 2021, Australia's largest aluminium smelter owner, Tomago Aluminium, announced that it is to procure electrical energy from renewable sources from 2028. This decision will displace the use of electrical energy currently sourced from coal-fired sources.
- **Bluescope Steel prefers Green Steel:** On August 16, 2021, Australian headquartered Bluescope Steel Limited (***BSL***) announced that it is committed to ***NZE*** for its Scope 1 and Scope 2 emissions. ***BSL*** is to achieve this ***NZE*** commitment using renewable electrical energy, and Green Hydrogen, rather natural gas (***CH4***), whether alone or blended with hydrogen.

  As has been reported in a number of editions of Low Carbon Pulse, a number of steel makers are moving to sourcing high-temperature heat using ***CH4*** (rather than coal), with the intention to move to Blue or Green Hydrogen overtime, including using blending. ***BSL*** is not taking this approach, and as such the transition to Green Steel production may take longer as the supply side of the Green Hydrogen industry develops.

  In any event, ***BSL*** recognises that achievement of its ***NZE*** commitment is not going to be easy, and that reductions in ***GHG*** emissions will occur, gather pace, after 2030.

  See: *BlueScope to Pursue Net Zero by 2050*

- ***HYBRIT's*** **Clean Steel on the road:**
  - **The concept:** Previous editions of Low Carbon Pulse (see Editions 13 and 16, and summarised in Edition 20, of Low Carbon Pulse) have reported on ***HYBRIT Development AB's*** (established and owed by SSAB (steel mill owner and operator), LKAB (iron ore supplier) and Vattenfall (state-owned energy company, producer and supplier of Green Hydrogen)) development of a "mine-to-mill-to-manufacture" supply chain, including the development of a pilot plant at Svartobret, in Lulea, billed as the world's first fossil free steel plant, using hydrogen for high-temperature heat processes to produce steel, rather than metallurgical coal.
  - **The execution:** Edition 20 of Low Carbon Pulse reported that SSAB and Volvo Group had entered into a letter of intent for the supply and purchase of Green Steel, and on the production of the first sponge iron at the pilot plant in Lulea. In July 2021, SSAB rolled the first steel using the ***HYBRIT*** technology.

    On August 18, 2021, it was widely reported that SSAB had supplied the world's first 100% fossil free steel to Volvo Group. President and CEO of SSAB, Mr Martin Lindqvist, said: *"The first fossil-free steel in the world is not only a breakthrough for SSAB, it represents proof that it's possible to make the transition [and reduce significantly] the global carbon footprint of the steel industry."*

    As noted in Edition 13 of Low Carbon Pulse, the ***HYBRIT*** technology is to be deployed at the Gallivare Green Steel mill, to have Green Steel production capacity of up to 2.7 million metric tonnes per annum by 2030.
  - **The significance:** As noted in Edition 22 of Low Carbon Pulse, one of the joys of authoring Low Carbon Pulse is "following both the connectedness of change, and the pace of change".

    Following the progress of the ***HYBRIT*** partnership, and technology, illustrates this perfectly.

    Why is this significant? Article 2 in the ***S2H2*** series, it was noted that: *"The production of steel may be regarded as giving rise to between 7 and 10% of global **GHG** emission or between 3,500 and 5,000 mmt (or 3.5 to 5 billion tonnes) of **GHG** emissions a year [**Note:** This does not include the **GHG** emissions arising to extract, transport to iron ore to mill, and from mill to point of use]. Global crude steel production is around 1,900 mmt (1.9 billion tonnes) a year. The best estimate is that between 1.9 and 2.1 tonnes of CO2 arises in respect of each tonne of steel produced … On metrics discernible consistently, it is estimated that a little over 3,500 mmt (3.5 billion tonnes) of CO2 arise each year from steel production. The **EU** has this higher at close to 4,000 mmt (4 billion tonnes)."*

    Progress towards the decarbonisation of the iron and steel industry is to be welcomed, warmly.

  See: *The world's first fossil-free steel ready for delivery*

Hydrogen Cities, Councils, Cluster and Hubs, Infrastructure and Valleys:

- **Second Hydrogen Hub planned for Canada:** A previous edition of Low Carbon Pulse reported on the establishment of the first hydrogen hub in Canada, at Edmonton.

  On August 13, 2021, plans for a second hydrogen hub were announced in Southeast Alberta (***SEAH2H***). For the purposes of assessing whether and, if so, how to develop the ***SEAH2H***, the Southeast Alberta Hydrogen Task Force has been established.

- **Getting busy in Cities:**
  - Edition 22 of Low Carbon Pulse reported that:
    - the International Energy Agency (***IEA***) published a report entitled [***Empowering Cities for a Net Zero Future- Unlocking resilient, smart, sustainable urban energy systems***] (***Smart Cities Report***). The July Report on Reports contained further detail on the ***Smart Cities Report*** (see the Appendix to Edition 23 of Low Carbon Pulse for the July Report on Reports, being Edition 1 of Ashurst Report on Reports); and
    - researchers at the ***PRC***'s Sun Yat-sen University and Guangdong Provincial Key Laboratory of Environmental Pollution and Remediation Technology in Guangzhou found that 25 mega-cities globally are responsible for 52% of ***GHG*** emissions arising in an urban setting, with cities in the ***PRC***, Japan, Russia "notably singled out", including, Beijing, Handan, Shanghai, Tokyo, and Moscow.
  - **Paris – City in Light**: On August 17, 2021, CleanTechnica included a piece entitled ***Cities Like Paris May Be Optimal Urban Form For Reducing Greenhouse Gas Emissions*** (this piece in turn was based on a piece in ***npj*** entitled ***Urban Sustainability***), which highlights the balance to be struck between energy efficiency and ***GHG*** emissions arising in the built environment of an urban setting, and a whole-of-life assessment of the carbon footprint, including an assessment of both energy efficient and ***GHG*** emissions.

    Current thinking appears to be that density of buildings is required, but not height. "So it seems that the world needs more Parises and fewer Manhattans … in the next decade".

    These findings matter, and ideally will be spotlighted by those devising and implementing policy settings.
  - **Cities of Green:** On August 18, 2021, it was reported that Athens is modelling the use of green oases in the urban setting to develop pocket parks throughout the sitting, to sink carbon and to provide cooling by lowering air temperature.

    Similar initiatives are either on the agenda or underway in:
    - Bangkok (developing 11 new parks, including using mangroves);
    - Nairobi (returning parts of the city to park-land, and in so doing, doubling the green areas since the start of the pandemic); and
    - Paris (removing half its car parking spaces, reported as being up to 70,000 spaces, and developing the Champs-Elysees into an "extraordinary garden").
- **Assessment and planning – follow the facts:** Over the last quarter or so, two facts have resonated more than others, as follows:
  - Cities account for more than 70% of ***GHG*** emissions arising from global energy consumption; and
  - Five percent of 5% of the world's electrical energy generation capacity gives rise to 73% of ***CO_2*** emissions arising from the generation of electrical energy.

  In the context of reducing ***GHG*** emissions at a greater rate than currently contemplated, certainly at a rate greater than combined ***NDCs*** contemplate, policy settings need to progress on a basis largely informed by these statistics. In this context, the built urban environment is a pressing an area for action to reduce ***GHG*** emissions as any other. Future editions of Low Carbon Pulse will include a feature on policy settings in this area.

Note: A feature edition of Low Carbon Pulse will include a feature on giga-factories - those recently opened and those planned. Given recent activity, a feature of this kind had been planned for this edition, but space became a premium (seeking to limit each edition of Low Carbon Pulse to 15 pages of narrative / 13,000 words).

Wind round-up:

- **GIG and TotalEnergies secure EBL:** On August 16, 2021, it was reported widely that the Green Investment Group Limited (***GIG***) and TotalEnergies has been granted an electricity business licence (***EBL***) from the Ministry of Trade, Industry and Energy. The grant of an ***EPL*** allows the development, and exclusive basis, of the first phase (504 MW) of the three phase 1.5 GW off-shore floating wind field project off Ulsan, South Korea.

  See: *GIG & TotalEnergies Obtain EBL for Korea's First Floating Offshore Wind Farm*
- **Cromarty Firth ideal location for Green Hydrogen production facility:** Edition 18 of Low Carbon Pulse reported on the arrangements relating to the development of the Port of Cromarty as a hydrogen hub. On July 23, 2021, it was reported that Cromarty Firth has been identified as the ideal location for a 35 MW, Green Hydrogen production facility (see Edition 22 of Low Carbon Pulse).

  As reported in Edition 22 of Low Carbon Pulse, the ***ScotWind Leasing Scheme*** auction process is going to result in the award of leases to allow the development of offshore wind fields, fixed bottom and floating. In this context, there is going to be a need for the provision, on-shore to off-shore, of manufacture and fabrication, and installation, service industry development. The need is recognised, how best to satisfy the need is now the focus of attention.

  On 19 August, 2021, an independent report prepared for the Scottish Offshore Wind Council (***SOWEC***), chaired by Sir Jim McDonald, has come out strongly in favour of the development of a floating wind port cluster in the North of Scotland (see ***Scottish Offshore Wind Strategic Investment Assessment: An Independent report to the Scottish Offshore Wind Energy Council***), with Cromarty Firth the most suitable area in Scotland for platform manufacture and fabrication.

  Within the Cromarty Firth and Moray Firth area, the two ports of Invergordon and Nigg (in East Ross) are regarded as being suitable for manufacture and fabrication locations, with their use for this purpose requiring significant increased capacity at each port. Other ports that may expect to gain from the next wave of off-shore wind field development are Aberdeen, Dundee and Leith, and Hunterston (Ayrshire), and Loch Kishorn (Wester Ross).

[**Note:** The news items on Cromarty Firth could be been included in the usual ***Ports and Shipping Forecast*** section, is included under ***Wind round-up*** for convenience.]

Solar and Sustainable Energy Round-up:

- **Solar-assisted hybrid gasification of biomass and urban wastes**: On August 9, 2021, Pollution Solutions on line published an article outlining the potential for hybrid solar and bio-energy projects in Pakistan using gasification technology to derive biogas and biomethane.
- **Solar eclipses coal:** On August 21, 2021, electrical energy dispatched from solar sources exceeded the electrical energy dispatched from coal fired power stations across the national electricity market in Australia.

Land Transport (automobiles, buses, trains and trucks) round-up:

After a flood of new items on land transport in recent editions of Low Carbon Pulse, the two news cycle for this Edition 25 of Low Carbon Pulse has seen far fewer news items, and they will be included in Edition 26 of Low Carbon Pulse, noting however that some land transport news items are included elsewhere within this Edition 25.

Aviation and Airports:

Edition 27 of Low Carbon Pulse will include the promised feature on development of ***NZE*** initiatives in the Aviation and Airports sector.

Low Carbon Pulse - Edition 26

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

This edition was first published on September 7 2021.

Welcome to **Edition 26** of Low Carbon Pulse – sharing significant current news on progress towards net-zero greenhouse gas (***GHGs***) emissions globally. This edition covers the period from Monday August 23, 2021 to Sunday September 5, 2021 (inclusive of each day).

Please click here for Edition 25 of Low Carbon Pulse. Please also click here and here for the first two articles in the ***Shift to Hydrogen Series*** (***S2H2***)***: Elemental Change*** series: the ***S2H2*** series provides a narrative and perspective on hydrogen generally. Please **click** here for the first feature in the ***Hydrogen for Industry*** (***H24I***): the ***H24I*** features provide an industry by industry narrative and perspective.

The third and fourth articles in the ***S2H2*** series will be published before the end of November 2021. The third article will be on Hydrogen Plans, Roadmaps, and Strategies, and the fourth article will be on CCS / CCUS.

Progress to *COP-26*:

- ***GHG* emissions budget – a reminder:** As noted in Edition 25 of Low Carbon Pulse, since mid-May 2021, a number of reports have been published outlining pathways to ***NZE***. The report with the most impact, certainly on first reading, was the BloombergNEF ***New Energy Outlook*** (***NEO***). It packs a punch. Edition 22 of Low Carbon Pulse reported on ***NEO***: ***NEO*** is worth reading, and viewing, noting that the graphics are compelling.
- **How long until we reach *2°C* increase?** As reported in Edition 22 of Low Carbon Pulse, a key message from ***NEO*** was: "*based on current trends, the world is on track to exceed its carbon budget, and the 2°C increase in global average temperatures compared to pre-industrial times, by 2044*".

  Given the ***Sixth Assessment Report – Climate Change 2021, The Physical Science Basis*** (***2021 Report***) of the Intergovernmental Panel on Climate Change (***IPCC***), and the increasing frequency of extreme weather events, the focus has switched to the shared socio-economic pathway (***SSP***) in the ***2021 Report***. One pathway, ***SSP1-1.9***, assumes an accelerated reduction in ***GHG*** emissions and achievement of ***NZE*** by 2050. ***SSP1-1.9*** emphasises the importance of staying as close as possible to a ***1.5°C*** increase in global average temperatures.
- **How long until we reach 1.5°C increase?** The question being asked increasingly is how much longer do we have until the carbon budget is exceeded and we reach a ***1.5°C*** increase, or until we enter the ***1.5°C*** to ***2°C*** range. The ***2021 Report*** suggests that we are likely to exceed a 1.5°C increase by 2040 (but we may do so earlier). The Chief Economist of BloombergNEF, Mr Seb Henbest, has noted: "*As soon as 2028, we will have exhausted the emissions budget to stay within 1.5* °C *of warming*".

  However the ***GHG*** emission carbon budget is represented, it hoped that at ***COP-26*** there is a collective realisation of the need to provide more funding to reduce ***GHG*** emissions so as to replenish the global carbon budget.
- **Roles to be played to reduce *GHG* emissions:**

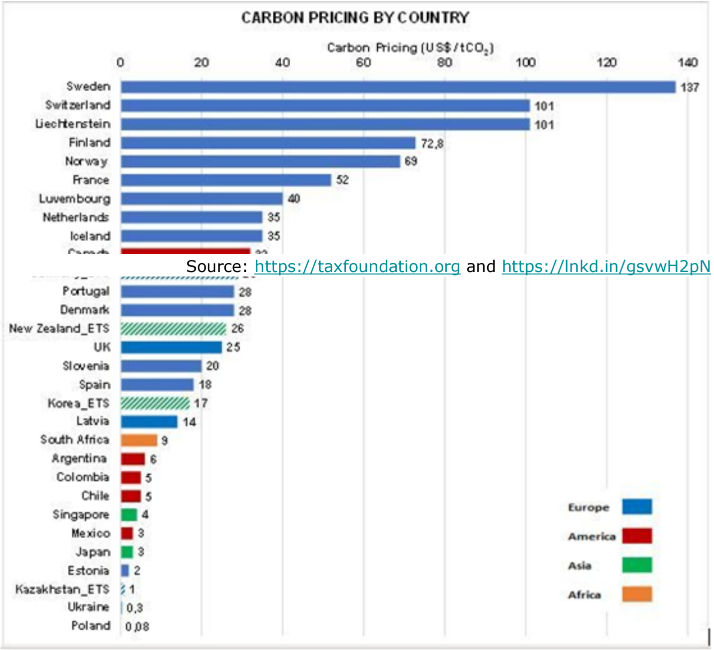
  As foreshadowed in previous editions of Low Carbon Pulse, ahead of ***COP-26***, current and relevant matters will be considered. This Edition 26 of Low Carbon Pulse covers the roles of Central Banks, ***Carbon Price*** and the Courts in the context of reductions in ***GHG*** emissions generally and ***NZE*** specifically.
  - **A role for Central Banks:** The roles of governments and government agencies and institutions are being scrutinised increasingly, both in terms of policy settings (including the need for them, and changes to them) and in terms of the extent and range of duties and obligations.

Recent narratives have emerged around the role of Central Banks, including direct and indirect criticism of the role that Central Banks are playing currently in the context of progress towards achieving ***NZE***. The key focus at the moment appears to be on the role of Central Banks in the funding of the fossil fuel industry.

There is a debate to be had around a role for, and functions of, Central Banks in progress towards achieving ***NZE***, with any role and function to be aligned with the policy settings within the particular country or economic bloc reflecting a clear mandate. While a full frontal fusillade against the fossil fuel industry may be appealing to many, of itself, it is not a fix. Mandates for Central Banks should be aligned to avoiding the financial consequences of climate change, and calibrated to respond promptly to the risks of climate change.

- **A role for a *Carbon Price*:** Edition 25 of Low Carbon Pulse noted that "***Causes and Cures of Climate Change are Known***". Likewise, the policy settings that work are known: emissions trading schemes (***ETS***) and carbon taxes price carbon, and depending on the carbon price, they encourage lower, low and no carbon outcomes. Edition 12 of Low Carbon Pulse (under ***Emissions Trading Schemes and Carbon Taxes***) explains how ***ETS*** and carbon taxes work.

  Not all countries put a price on carbon, and no two countries (with limited exceptions) have the same carbon price. No carbon price or different carbon prices may result in a shift of production from one country to another. Any shift in production results in carbon leakage such that policy settings in countries with a carbon price or a higher carbon price may be circumvented by shifting production to a country with a lower or no carbon price. The European Commission (***EC***) has proposed the introduction of the Carbon Border Adjustment Mechanism (***CBAM***), under which importers of goods into any European Union (***EU***) must acquire carbon certificates in respect of goods with embedded carbon - a carbon price to be applied in respect of that embedded carbon (see Edition 22 of Low Carbon Pulse).



Source: https://taxfoundation.org and https://lnkd.in/gsvwH2pN

  On September 1, 2021, the ***EU ETS*** carbon price (the price of one ***Emission Allowance Unit*** or ***EAU***) hit a new high of €60 per tonne (having hit a new high on over 40 occasions, and increased by 85%, since the start of 2021). The reasons for these higher prices may be regarded as near term, but it might be expected that they will result in medium to long term lower, low or no carbon technologies to avoid the higher carbon price. Carbon credits will be considered in Edition 27 of Low Carbon Pulse, including in both mandatory and voluntary settings, as will the various carbon credits and permits, and the basis for their issue and use.

- **A role for courts:** Editions 17 and 18 of Low Carbon Pulse reported on court decisions in respect of reductions in ***GHG*** emissions and ***NZE***: the German constitution court, the District Court, The Hague and Federal Court in Australia.

  On August 26, 2021, the Land and Environment Court (***Court***) New South Wales (***NSW***) Australia, handed down its decision in an action brought against the ***NSW*** Environment Protection Authority (***EPA***). The ***Court*** decided that the ***EPA*** must seek to ensure protection from climate change in developing environmental quality objectives, guidelines and policies required of it under the *Protection of the Environment Administration Act 1991* (NSW) (***Bush Fire Case***). While the ***Bush Fire Case*** has been welcomed by many commentators, the key take-away for the ***EPA*** will be how to respond to the decision in practice.

  In previous editions of Low Carbon Pulse (and other Ashurst publications), the colours of the author have been "nailed to the mast": it is for governments to devise and to implement policy settings (through legislation and regulation as necessary), it is not appropriate for governments to leave it to courts to respond to specific circumstances and facts to impose duties or to extend duties, critically, on a case by case basis. If there is a role for courts, it is the role undertaken by the German constitutional court as to compliance by government.

- **The role of hydrogen and hydrogen-based fuels:**

  In an opinion piece, Wood Mackenzie notes that hydrogen is likely to play a crucial role in energy transition, and that ***COP-26*** will be the acid test for the development of hydrogen (and hydrogen-based fuels).

  Wood Mackenzie notes that ***COP-26***: *must go far beyond setting new emissions targets. Ensuring that hydrogen is not just a "fuel for the future", but a fuel that needs to be … implemented into global society from today [and] should be top of the agenda*."

  The Wood Mackenzie opinion piece goes on to the outline why hydrogen is vital. The opinion piece is excellent. The underlying theme is that the production, and use, of hydrogen (and hydrogen-based) energy carriers, in particular energy carriers that are green, needs to increase, promptly. This theme is echoed in ***Reclaiming Hydrogen for a Renewable Future***, from Earthjustice, and the ***DNV Report*** (see ***DNV Report*** on this page).

It is difficult to overstate the need for government involvement in the development of renewable electrical energy capacity to allow the development of Green Hydrogen capacity as soon as possible.

As ever, the challenge is the amount of renewable electrical energy that is needed for this, and the related matter of land and the location of that land. Also, the mass of water required, and its sources and its storage (in addition to current water use), are critical. As such, there is a role for Government in the development of off-shore wind fields to be dedicated to the production of Green Hydrogen (and as such allowing for the production of Green Ammonia and Green Methanol), using electrolysers located off-shore (noting the Siemens off-shore electrolyser pilot as part of ***H2Mare***: see below under ***German progress continues, home, on the seas, and overseas***). Also there is likely a role for Government as wholesale buyer and seller of Green Hydrogen.

Climate change reported and explained:

- ***NOAA* news**: Each month the US National Oceanic and Atmospheric Administration (***NOAA***), among other things, reports on findings for the previous month. In the second edition of Low Carbon Pulse each month, we will cover latest data from the ***NOAA*** report for the previous month.
- **Royal Metrological Society *State of the UK Climate 2020* report (*2020 Report*):** On August 31, 2021, CNBC reported on the publication of the ***2020 Report***. A headline from the ***2020 Report*** is that 2020 was the UK's third warmest year since records began in 1884. As noted in Edition 12 of Low Carbon Pulse, on 24 March 2021, human-activities in the UK were giving rise to the lowest level of ***GHG*** emissions since 1879. This illustrates that the temperature graph is trending up, and the ***GHG*** emissions graph, down, reflecting the need to accelerate the reduction of ***GHG*** emissions.
- **Extreme weather and extreme weather events:** As a straight-talking Texan known to the author said in early June 2021: "*When it rains, it rains too much, when it's hot, it's really hot, too hot. Y'all can deny the reason for it, but not the fact of it*".

  In the reporting on climate change at the moment, many commentators have picked up on the term "extreme weather event", possibly in the context of the ***2021 Report***. As is often the case, the term is used loosely. For ease of reference it means: "*an event that is rare at a particular place and time of year, normally rare means rarer than the 10th or 90th percentile of a probability density*". The paradox is that the greater the frequency of "extreme weather events", by definition the fewer of them there will be!

DNV Report:

- **Another report, same themes:** On September 1, 2021, ***DNV*** (the Norwegian headquartered classification society) released its annual report (***DNV Report***).

  While the ***DNV Report*** will be considered and summarised in the August Report on Reports as an Appendix to Edition 27 of Low Carbon Pulse. The headline from the ***DNV Report*** is that it is close to certainty, even if there was the renewable electrical energy to required levels installed today, that there is no prospect currently of achieving ***NZE*** by 2050 absent a massive increases in hydrogen deployment.
- **Carbon Budget for *1.5°C* increase exceeded by 2030:** The findings in the ***DNV Report*** are aligned with those of Chief Economist of BloombergNEF, Mr Seb Henbest, effectively that by 2030 the available carbon budget to stay within the ***1.5°C*** average global temperature increase will have been exceeded.
- **Carbon Budget** is used frequently, and in different contexts, but in this context it is used to refer to the maximum aggregate mass of all ***GHGs*** in the atmosphere that must not be exceeded to ensure that a stated increased in average global temperature will not be exceeded.

A.P. Moller – Maersk: fleet of foot:

Background: The following news item has been steaming towards us for a while: Edition 25 of Low Carbon Pulse reported on ***Maersk's move to methanol*** and Edition 21 of Low Carbon Pulse reported that A.P. Moller – Maersk had signed a ship-building contract with Hyundai Mipo Dockyards, the first methanol powered and propelled container vessel.

Previous editions of Low Carbon Pulse (and sibling publications of Low Carbon Pulse, *Global Ports, **Port Liability Regimes**),* have reported on the progress of the shipping industry towards decarbonisation, including "*achieving zero-emission vessels as the dominant and competitive choice by the end of the [current] decade*" (see Edition 19 of Low Carbon Pulse under ***Global Maritime Forum***), and the initiatives of some countries and economic blocs to achieve this outcome, including the extension of the ***EU ETS*** to the shipping industry (see Edition 22 of Low Carbon Pulse).

- **Move to low carbon methanol:** Edition 25 of Low Carbon Pulse reported on the move by Maersk (the world's largest container shipping company) to contract with Denmark's European Energy (and its subsidiary REIntegrate) for the development of an e-methanol production facility to supply low carbon methanol.

  The headline being that the initiative kept Maersk on schedule to have: "*the world's first container vessel operated on carbon neutral methanol on the water by 2023*".
- **Giant step to low carbon methanol:** On August 24, 2021, A.P. Moller – Maersk announced that Maersk had accelerated the rate of its fleet decarbonisation with an order for eight container vessels capable of being powered and propelled using carbon neutral methanol. With each container vessel costing USD 175 million, this is a USD 1.4 billion commitment.

  The eight container vessels are to be built by Hyundai Heavy Industries (***HHI***) and delivered in 2024. The multi-vessel shipbuilding contract with ***HHI*** gives Maersk an option for four additional container vessels. As would be expected, the engines will be dual fuel, to allow the use of both low carbon methanol and low sulphur heavy fuel oil. As noted in previous editions of Low Carbon Pulse, ***HHI*** has been working on the dual fuel technology for some time with MAN ES and Alfa Laval (see Edition 21 of Low Carbon Pulse).

  The CEO of A.P. Moller – Maersk, Mr Soren Skou said: "*The time to act is now, if we [are] to solve shipping's climate challenge. This order [for the eight container vessels] proves that carbon neutral solutions are available* *today across container vessel segments and that Maersk stands committed to the growing number of our customers who look to decarbonise their supply chains*."

As is the case with all sectors of the transport industry, a decision needs to be taken as to when to invest in new fleet, and when to refurbish and retire existing fleet. These decisions may be regarded as pressing for the container shipping industry, and the broader shipping industry.

- **Giant step to addressing Scope 3 emission ambitions of Maersk customers:** As noted in Edition 25 of Low Carbon Pulse (see under ***Mammoth commitment from Mammut***), many corporations are seeking to decarbonise their supply / value chains, increasingly seeking commitments from shipping lines to achieving ***NZE***.

  For global corporate sustainability leader, A.P. Moller – Maersk, with strong ties to other corporate sustainability leaders (including Amazon, Disney, H&M Group, HP Inc, Levi Strauss & Co., Microsoft Inc., Novo Nordisk, Protor and Gamble, PUMA, Schneider Electric, Signify, Syngenta and Unilever), this commitment may be regarded as part of a new sustainability pact.

  As will be apparent from the announcement from A.P. Moller – Maersk, customers of Maersk are delighted by the commitment.

SCOPE 1	SCOPE 2	SCOPE 3
Direct ***GHG*** emissions arising from any activity and source that are controlled or owned by an organization.	Indirect ***GHG*** emissions arising from any activity and source not controlled or owned by an organization but used by it.	***GHG*** emissions arising from any activity, not Scope 1 or 2 emissions, but part of the supply chain of that organization.

- **Giant signal to low carbon / e-fuel market, supply side:** Possibly the most stated and restated theme in Low Carbon Pulse (and sibling publications relating to hydrogen and hydrogen-based fuels) is the need for supply and demand for hydrogen and hydrogen based energy carriers to develop in tandem.

  In the announcement of the order for the eight container vessels, Mr Soren Skou noted that: " .. *this is a firm signal to fuel producers that sizeable market demand for the green fuels of the future is emerging at speed*".

  It is understood that Maersk will use ***carbon neutral e-methanol or sustainable bio-methanol*** as soon as possible. Also it is understood that in the near to medium term, the supply of low carbon methanol is likely to be challenging. To address this challenge, it should be expected that A.P. Moller – Maersk will increase demand from corporations with which it has existing supply arrangements, and contract with other corporations for supply.

  Hitherto it has not been necessary to take a deeper dive into the facts and statistics of methanol in Low Carbon Pulse, but given the commitment made by A.P. Moller – Maersk, and readily available information from the Methanol Institute (of which more later in this Edition 26 of Low Carbon Pulse), and other sources, a greater level of factual and statistical background seems appropriate. (The fourth article in the ***S2H2*** series, ***CCS and CCUS***, takes a deeper dive, critically in the context of use of ***CO_2***).

- **Methanol as an E-Fuel / Future Fuel:** A.P. Moller – Maersk has signalled for some time that it is likely to prefer ***carbon neutral e-methanol*** **or** ***sustainable bio-methanol*** over other energy carriers for its shipping fleet.

  One of the key decision points for A.P. Moller – Maersk will have been the energy density of methanol (compared to other low carbon fuels), energy density being one the three key characteristics identified in the excellent Hydrogen Europe publication ***How Hydrogen Can Help Carbonise the Maritime Sector*** (***HE FF Paper***) as being key for any decision on use of low carbon fuels. The other two key characteristics are ***availability and security of supply*** (of which A.P. Moller – Maersk is clearly aware) and ***GHG neutrality "from well to wake***" (see Edition 16 of Low Carbon Pulse, and below under ***Wake up to well-to-wake accounting***).

- **Background information on methanol:** In 2020, global methanol production was estimated to have been around 100 million tonnes. Coincidently, this is around the same mass of grey hydrogen produced in 2020. Methanol is used as feedstock for the production of olefins (and, in turn, plastics) and for the production of chemicals, and as an additive to motor spirit (i.e., gasoline or petrol).

  Currently, the vast majority of methanol (***CO_3OH***) produced is derived from synthesised gas (***syngas***): carbon monoxide (***CO***) combined by hydrogen (***H_2***) derived from the application of steam methane reforming (***SMR***) of natural gas (and possibly gasification of coal) to produce ***CO_2***: in chemical shorthand, ***CO_2*** is produced by the hydrogenation of ***CO*** using a catalyst (comprising compounds of copper, alumina, magnesia and zinc oxide). ***SMR*** is the same technology used to derive grey hydrogen from natural gas.

  If the electrical energy for hydrogenation is renewable, the ***CO_3OH*** is an energy carrier with embedded carbon that will give rise to ***CO_2*** on oxidation, but the ***CO_2*** that arises, in theory at least, will be absorbed into a renewable resource, with the continued growth in that renewable resource providing a carbon neutral outcome.

Edition 27 of Low Carbon Pulse will include a piece on phrases and words used to seek to convey lower or low carbon fuels and feedstocks. In passing, it is noted that this news item could have been included in either the **E-Fuel / Future fuel round up** or **Port News and Shipping Forecasts** section of this Edition 26 Low Carbon Pulse, but given its significance, it is contained in a standalone section.

Other possible E- Fuels / Future Fuels for the shipping sector:

- **Background:** Low carbon methanol is one of the E-Fuels / Future Fuels being considered to power and to propel the shipping sector. As the ***HE FF Paper*** notes, given current technologies, all of the practical low carbon, carbon neutral or all zero-emission fuels (***EF Fuels***) contemplated by the shipping sector are derived or produced from hydrogen, including low carbon methanol.

- **Other *EF Fuels*:** Each of the following is being considered as a possible fuel to power and to propel vessels so as to decarbonise the shipping industry: **1**. Hydrogen (***H_2***); **2**. Ammonia (***NH_3***); **3**. Bio / E-diesel; **4**. Bio / E-kerosene; **5**. Bio / E-LNG. The ***HE FF*** Paper provides a summary in respect of each of them.

Ammonia and LNG are regarded as being the most prospective for the purpose of powering and propelling vessels. Ammonia and methanol are regarded as the most likely, each being produced using proven technologies and there being existing standards and law and regulations.

Green Hydrogen is the only fuel that does not give rise to ***GHG*** emissions on production or oxidation (it contains no carbon atoms). Green Ammonia does not give rise to ***GHG*** emissions on production, but does give rise to N_2O on oxidation (see Edition 25 of Low Carbon Pulse).

- **Green Hydrogen needs renewable electrical energy:** As noted in previous editions of Low Carbon Pulse (normally in the context of reporting on ***NZE Reports***), the mass of hydrogen production required "to green" energy carriers so as to displace fossil fuels tests the bounds of comprehension. It is not just hydrogen as a energy carrier that needs to be produced, it is hydrogen as a molecule to be synthesised to produce hydrogen-based fuels.

  To help illustrate this, the following table describes each hydrogen-based fuel.

BIOENERGY / HYDROGEN-BASED FUEL TERMINOLOGY	
Bioenergy: energy derived or produced from biogas or biomass, whether in gaseous, liquid or solid form	**Biofuel:** a subset of Bioenergy, being any energy carrier that is derived or produced from biogas or biomass for use as a fuel
Biogas: a mixture of CH_4 and CO_2 (and trace elements of other gases), arising from the decomposition of organic matter, including derived or produced from anaerobic digestion	**Biomethane** (or Renewable Natural Gas (***RNG***)): CH_4 in near pure form, derived or produced from upgrading **Biogas** or gasification of biomass. Biogas and Biomethane are Biogases
E-Fuel (or electro-fuels)**:** any energy carrier that is derived or produced using renewable electrical energy, incl. energy carriers derived and produced from renewable and non-renewable sources, including each of the **E-Fuels**	**E-Fuels:** include **E-diesel**, **E-kerosene**, **E-LNG**, **E-methanol** the derivation or production of each of which requires the synthesis of H_2 with CO_2 (hence synthetic fuel). **E-Ammonia** requires the synthesis of H_2 with N
Ammonia compound of H_2 with N (NH_3) that can be used in direct combustion, in fuel cells to derive electrical energy, or as a medium to carry hydrogen	**Methanol** (methyl alcohol) is a compound of carbon, hydrogen and oxygen (CH_3OH) that can be used in direct combustion to power and to propel vehicles and vessels

- **Advantages of Ammonia and Methanol:** Both Ammonia and Methanol are existing chemical commodities with existing laws and regulations (and standards) covering production, storage and transportation, and proven means of compression / pressurisation and refrigeration (in the case of Ammonia). Ammonia or Methanol derived from fossils fuel using CCS / CCUS is Blue Ammonia or Blue Methanol. Ammonia or Methanol derived from biogas or biomass using BECCS / BECCUS is likely Low Carbon Ammonia or Methanol. It is fair to say that the synthesis of CO_2 and H_2 using CO_2 captured by CCS or BECCS is receiving increased interest.
- **Low or No Carbon, but not *GHG* emissions free:** It is important however to note that on oxidation, neither Ammonia nor Methanol derived or produced from any source (or whatever the colour code) are ***GHG*** emission free: Ammonia gives rise to N_2O and Methanol gives rise to CO_2.

UK Hydrogen Economy developing:

- **UK Hydrogen Strategy not defining progress:** Edition 25 of Low Carbon Pulse (under ***UK Hydrogen Strategy*** (***UKH2S***)) outlined the scope of the UK Hydrogen Strategy (***UKH2S***) published on August 17, 2021. The publication of ***UKH2S*** was both welcome, and generally stated, well received.
- **Progress at HyNet North West:** Edition 23 of Low Carbon Pulse outlined (under ***Clustering and hubbing around the UK***) the background to each of the clusters and hubs in the UK. One of the clusters / hubs is HyNet North West, led by Progressive Energy Ltd (***PE***).

  On August 23, 2021, HyNet North West announced a world first: leading glass maker, Pilkington Glass, commenced trials to produce float (or sheet) glass using hydrogen for the high-heat temperature processes.

  As is the case with other difficult to decarbonise industries using fossil fuels to achieve the required high-heat temperatures, industrial glass manufacture uses natural gas (which is predominantly CH_4), which on oxidation gives rise to CO_2 (and gives rise to fugitive emissions on extraction, processing and transportation).

  See: *World first as 100% hydrogen fired at Pilkington UK, St-Helens*
- **Blue Hydrogen "blow back":** Leaving to one side the pleasant surprise of the publication of ***UKH2S***, given consistency of intent and narrative ahead of publication (including the sibling policy setting, ***Energy White Paper*** (***EWP***), published in December 2020), the ***UKH2S*** did not contain any surprises. While some commentators who have characterised an absence of detail as surprising, it is good to have the ***EWP*** in mind when reading and reflecting on the ***UKH2S***.

  One area of some criticism that has emerged is that Blue Hydrogen is contemplated in the ***UKH2S***. A number of editorials and news items have reported that the "twin-track" of Blue Hydrogen and Green Hydrogen will allow the scaling up of hydrogen production more quickly. A good thing, and necessary to allow supply and demand to develop in tandem. Accompanying this narrative is one to the effect that Blue Hydrogen is not zero-carbon as is the case with Green Hydrogen, because the CCS / CCUS used to produce Blue Hydrogen does not capture 100% of the CO_2 emissions arising.

It is important to frame thinking on this: CCS / CCUS facilities are being developed to capture CO_2 emissions arising currently from industrial processes around the UK, critically industrial clusters. The capture of CO_2 from these processes requires CCS / CCUS, and the capture of CO_2 and the payment for CCS / CCUS services is going to underpin CCS / CCUS. This is a good thing.

The use of those CCS / CCUS services to capture and to store or to capture and to use CO_2 arising from Blue Hydrogen production is an opportunity that may be regarded as essential to the development of supply and demand for hydrogen. While not stated expressly, the "twin-track" is likely to become one track as the Green Hydrogen industry develops, and Green Hydrogen is used to decarbonise the high-temperature heat processes currently giving rise to CO_2 that is to be captured and stored. There are shades of Blue and Green, but overtime expect Green Hydrogen and Green Hydrogen-based energy carriers to prevail.

GCC counties update:

- **Masdar aims being fulfilled, globally:** Recently the inauguration ceremony was held for the 100 MW Nur Pavoi Solar Project in Uzbekistan (the ***Nur Pavoi Solar Project*** or ***NPSP***). The ***NPSP*** is significant for a number of reasons: it is the first independent power producer project to be financed in Uzbekistan and it is the country's first utility scale solar project. It is understood that the ***NPSP*** is the first of up to a planned 1 GW of renewable energy projects in Uzbekistan.

  For Masdar it is another step on its path as a member of the elite club of global "go to investors" in the renewable energy sector.

- **Oman's aim straight and true:** Edition 20 of Low Carbon Pulse (under ***Black Gold and Blue and Green Gold*** and ***Oman's aim is true***), reported on the progress that Oman is making in embracing Green Hydrogen as a carbon neutral energy source. Editions 18 and 25 of Low Carbon Pulse have reported on the ***Hyport DUQM*** project. This strong narrative is continuing. On September 1, 2021, the Oman Daily Observer, Business, reported on the continued progress, critically that the Oman Society for Petroleum Services (***OPAL***), the umbrella organisation for energy and energy services corporations in the Sultanate, is working closely with OQ (the global integrated energy group of the Sultanate of Oman) and EJAAD (the leading member-ship based government, industry and research and development organisation).

  As noted in Edition 25 of Low Carbon Pulse, the establishment of ***Hy-Fly*** (National Hydrogen Alliance) under the auspices of the Ministry of Energy and Minerals, has been recognised quickly as a gamechanger. It is understood that additional projects are likely to be announced in the near to medium term. It is reported that one of the members of ***Hy-Fly***, Shell, is progressing with a number of renewable energy projects.

India: up-beat tempo continues:

- **India realising capital:** In a recent sibling publication (***Realising Reserves and Realising Capital***), members of the Ashurst Global Towards Zero Emissions team outlined trends to realise reserves and to realise capital, among other things, to fund progress towards ***NZE***.

  On August 23, 2021, it was reported that the Government of India (***GoI***) intends to monetize up to USD 81 billion of assets under long-term leasing arrangements (one of the means of releasing capital outline in the ***Realising Reserves and Realising Capital*** article) to enable recycling of capital (***Recycling Program***).

  Edition 22 of Low Carbon Pulse (under ***Patience is a virtue, and patient capital has virtue***), reported on a World Economic Forum (***WER***) publication entitled ***In emerging markets, patience is a virtue in the race to net zero***. Chief Executive of ***GoI*** think tank, NITI Aayog, Mr Amitabh Kant, said: "*The strategic objective of the program is to unlock the value of investments in brownfield public sector assets by tapping institutional and long term patient capital which can thereafter be leveraged for further public investments*".

  While there has been focus on assets in the natural gas pipeline and power transmission sector, it appears likely that the rail and road sectors are likely to yield most for the ***Recycling Program***. This said, natural gas assets and power transmission sector assets will yield significant capital for the ***Recycling Program***. As those advising on any long-term leasing program will know, it will be critical for the long-term leases to ensure that ***GoI*** is able to continue to develop new infrastructure, and to augment existing infrastructure, including the assets subject to the long-term leases, to progress to ***NZE***, this is critical for the power transmission sector as renewable electrical energy is developed and becomes the pre-dominant source of electrical energy over time.

- **Biogas to biomethane to hydrogen:** On August 25, 2021, H2VIEW, reported a project of GPS Renewables and HyGear (see below under ***Hydrogen Production Hub***) to capture landfill gas (comprising CO_2 and CH_4) and to process the organic waste stream from municipal solid waste to derive biogas. The biogas will be processed further to derive bio-methane, and that biomethane will be reformed to derive hydrogen (***3 G Project***). The first of the ***H24I*** features (entitled ***Hydrogen from Waste***) provides an outline of projects of this kind.

  In the Indian context, the ***3 G Project*** will be a first, and hopefully the first of many. As has been noted in a number of editions of Low Carbon Pulse (and covered again in this Edition 26 of Low Carbon Pulse below), bio-energy with carbon capture (***BECCS***) and bio-energy with carbon capture and use (***BECCUS***) are key to reduction in ***GHG*** emissions globally. Further, given the developing nature of the waste management system in India, and the amount and the nature of organic waste arising, there are a number of technologies that may be used to derive bio-gas and to use it to produce electrical energy or heat, or both, and to process it further to produce bio-methane or to reform it to produce hydrogen.

- **Electrical energy demand growth:** On August 25, 2021, it was reported widely that during the first six-months of calendar year 2021, 72% of the increase in demand for electrical energy in India was matched by increased solar and wind capacity. This said there was an increase in coal capacity too. In neighbouring Bangladesh the increase in electrical energy demand was matched entirely by coal-fired capacity.

  Edition 25 of Low Carbon Pulse reported on the **FTI Consulting** and **Teri** report (in the ***South Asia New Energy Series***), covering many facets of the development of renewable energy capacity across South Asia. The continued development of coal-fired power is addressed in the report. It is hoped that the findings in the report and other initiatives will be acted upon promptly.

- **ArcelorMittal steely resolve in Gujarat and Rajasthan:** On August 31, 2021, it was reported that world leading steelmaker ArcelorMittal intends to develop USD 6.8 billion of solar, wind and hydrogen facilities in the state of Gujarat and to develop a USD 2.5 billion, 4.5 GW solar facility in the state of Rajasthan. While these developments have yet to proceed to permitting and planning stage, it understood that they will be doing so.

  See: Arcelor Mittal *website*

- **British and Indian Climate Change initiative energised:** On September 2, 2021, it was announced that the CEO of Macquarie Bank, Ms Shemera Wikramanayake has been appointed as co-chair of a British and Indian climate change initiative. The Governments of the UK and the India, together with the Climate Finance Leadership Initiative are going to provide valuable guidance. The appointment of Ms Wikramanayake is significant because of the leading role that Macquarie Bank has globally in respect of the development and financing of renewable energy projects.

German progress continues, home, on the seas and overseas:

- **Flagship projects – more funding, this time for H2Giga and H2Mare:**
  - **The flagship projects:**

    The German Federal Ministry of Education and Research (***BMBF***) is pivotal in the development of the hydrogen economy in Germany.

    On August 23, 2021, it was reported that further funding for **H2Giga**, one of the three German flagship projects, is to be awarded to allow the start the production of large-scale electrolysers.

    On September 2, 2021, it was reported that Siemens Energy (coordinating **H2Mare**) is to receive funding for pilot projects for the development of combined off-shore wind fields and electrolysers. It is understood that two of the pilot projects will be installed at the AquaPrimus project, part of the AquaVentus project (see Edition 17 of Low Carbon Pulse for detail of AquaVentus, and each element of it).
  - **Quick reminder:** Edition 25 of Low Carbon Pulse reported on further funding for **H2Mare** and **TransHyDe**. Together, the three flagship projects are intended to undertake the necessary research and testing to enable the development of the hydrogen economy in Germany.

    The three flagship projects are:
    - **H2Giga:** dedicated to the development of large-scale use of electrolysers (using serial construction of standardised electrolyser technology) to electrolyse water using renewable electrical energy to produce Green Hydrogen. Thyssenkrupp is responsible for the coordination of **H2Giga**;
    - **H2Mare:** dedicated to investigating the use of use off-shore / off-grid renewable wind electrical energy to produce hydrogen and hydrogen-based fuels: effectively, a dedicated, integrated, closed electrical energy to Green Hydrogen production energy loop. **H2Mare** comprises four joint projects: **1**. OffgridWind, **2**. H2Wind, **3**. PtX-Wind, and **4**. TransferWind. Siemens Energy is responsible for the coordination of **H2Mare**.
    - **TransHyDe:** dedicated to reaching transportation of hydrogen over short, medium and long distances, and comprising four demonstration projects: **1**. Hydrogen Transport in High Pressure Vessels, **2**. Hydrogen-Liquid Transport, **3**. Hydrogen Transport in Existing and New Gas Pipelines, and **4**. Transport of Hydrogen Bound in Ammonia or liquid organic hydrogen carrier (***LOHC***), a carrier medium.
- **Role of *BMBF*:** As noted in Edition 25 of Low Carbon Pulse, the role of ***BMBF*** extends beyond Germany. For example (as outlined in Edition 18 of Low Carbon Pulse) the ***BMBF*** has funded work in respect of the renewable energy resources and hydrogen production in Africa under ***West Africa – untapped potential for hydrogen production***). ***The National Hydrogen Strategy*** of the Federal Government of Germany, published in July 2020 contemplated that €2 billion of funding support would be made available to support Green Hydrogen projects in developing countries.
- **Green Hydrogen from Namibia:** On August 25, 2021, RECHARGE, reported that Germany is to partner with Namibia to allow the production and export of Green Hydrogen from Namibia and transportation and import into Germany at a price of USD 1.8 per kg. Namibia has world class renewable energy resources, with over 3,500 hours of sun each year, and strong wind resources. These world class resources are considered close to ideal for the production of Green Hydrogen at a price of between €1.50-2 per kg. Further it is estimated that up to 1.7 million metric tonnes per annum of Green Hydrogen could be produced by 2030. This mass of Green Hydrogen production delivered into Germany would be close to sufficient to decarbonise the German iron and steel industry given its current rate of production.
- **Helmholtz Cluster** (***HHC-H2***) **established:** On September 2, 2021, it was announced that a new hydrogen cluster had been established in the Rheinische Revier of North Rhine-Westphalia, Germany. The accompanying narrative to the announcement is that: "*The Helmholtz Cluster for Sustainable and Infrastructure and Infrastructure-Compatible Hydrogen Economy will form a central nucleus … with its focus on hydrogen logistics using chemical hydrogen carriers*".
- **New Innovation and Technology Centres:** On September 3, 2021, the German Federal Ministry of Transport and Digital Infrastructure (***BMVI***), identified three new centres, located in Chemnitz, Duisberg, and Pfeffenhausen, to focus on founders, start-ups and small to medium sized corporations to develop fuel cell and hydrogen technologies for mobility applications. In addition, Bremen / Bremerhaven and Stade will combine as the fourth centre.

PRC **continues to lead the way:**

- **Sinopec continues to lead:** Previous editions of Low Carbon Pulse have reported on the activities of China Petroleum & Chemical Corporation (***Sinopec***) in progress towards ***NZE***, in particular its leading role in respect of hydrogen.

  On August 30, 2021, ***Sinopec*** announced plans to spend a considerable amount on various hydrogen energy initiatives, reservoir to bowser, between now and 2025. ***Sinopec*** plans to supply hydrogen for the mobility market is underpinned by plans to deploy hydrogen refuelling infrastructure capacity for 200,000 tonnes of hydrogen by 2025, involving the development of up to 1,000 hydrogen refuelling stations. (***Sinopec*** is reported as having developed 20 hydrogen refuelling stations to date, with a further 60 being developed.)

  The deployment of refuelling infrastructure capacity provides a distribution network for ever increasing hydrogen production capacity, with plans to have produced 1,000,000 tonnes of Green Hydrogen between 2021 and 2025.

- **CNNOC commences CCS project:** On August 30, 2021, it was reported by Reuters, that China National Offshore Oil Corporation (***CNOOC***) (global leading oil and gas corporation, and one of the Big Three ***PRC*** oil and gas corporations, with ***Sinopec*** and China National Petroleum Corporation (***PetroChina***)) has commenced the first off-shore CCS project, in the South China Sea, 118 miles southeast of Hong Kong.

Japan and Russia to cooperate:

- **Russia making progress**: Edition 25 of Low Carbon Pulse reported on framework plans for the hydrogen economy in Russia, critically the development of three clusters for the production of hydrogen, with one of the three in the Eastern sector to provide hydrogen to Asian countries, including into North Asia.
- **Statement of Cooperation:** On September 2, 2021, it was announced that Japanese Industry Minister, Mr Hiroshi Kajiyama, and Russian Energy Minister, Mr Nikolai Shulginov, signed a statement of cooperation under which the two countries agree to work together to develop hydrogen and ammonia production capacity.
- **Memorandum of Cooperation:** On September 2, 2021, it was announced that Ministry of Economy Trade and Industry (***METI***) and Novatek (Russia's largest producer of LNG) signed a memorandum of cooperation in respect of the supply of hydrogen and ammonia (and recognising the use of CCS and CCUS).
- **Source agnostic:** Consistent with the perspectives of both Japan and Russia, each country is agnostic as to the source of hydrogen, and as such the statement of cooperation is said to contemplate both CCS and CCUS (i.e., contemplating Blue Hydrogen and Blue Ammonia).

Nepal has a Green Hydrogen Plan:

- **Countries with the heavy lifting:** The keen-eyed reader of Low Carbon Pulse will have noted that recent editions of Low Carbon Pulse have grouped news items about the ***EU***, India, Japan, South Korea, ***PRC***, Russia and the US. The thinking behind this is that these countries are critical to progressing to ***NZE***, and as such the activity in these countries is critical. Also Germany, UK and the GCC countries are key, with Germany and the UK leading the way in terms of policy settings, and the GCC countries being key to the shift to hydrogen. While these countries have the heavy lifting to do, other countries need to make progress too.
- **Countries with lifting to do:** On August 30, 2021, Hydrogen Fuel News, reported that Nepal, currently highly dependent on fossil fuels (coal, diesel, LPG and motor spirit) is developing a strategy to allow it to produce domestically hydrogen to displace fossil fuels as part of its decarbonisation plans.

Bio-energy (including BECCS and BECCUS) update:

- **Background:**
  - **Key role to play:** As noted in a number of editions of Low Carbon Pulse, bio-energy is regarded by the **International Energy Agency** and the **International Renewable Energy Agency** (and key analysts, including **Wood Mackenzie, BloombergyNEF** and **S&P Global Platts**), as having a key role to play in progress to achieving ***NZE***.

    The ***2021 Report*** recognises **bio-energy** as one of the means of carbon dioxide removal (***CDR***) on the basis that bio-energy is derived with the carbon arising being captured and stored (***BECCS***) and bio-energy is derived with the carbon arising being captured and used, and in use, stored (***BECCUS***).
  - **What is bio-energy?** As noted above, **bio-energy** is energy derived or produced from biogas or biomass, whether in gaseous, liquid or solid form. Bioenergy is derived from organic matter, but not fossilised organic matter. Organic matter contains carbon.

  Given the key role that bio-energy with carbon capture has to play, we have combined the bio-energy and ***BECCs*** / ***BECCUS*** sections of Low Carbon Pulse: this combined section will cover bio-energy projects with and without ***BECCs*** / ***BECCUS***.

  Note: Carbon Dioxide Removal (***CDR***) is not an instant solution in global terms (as outlined in Edition 24 of Low Carbon Pulse, it takes time), nor is ***BECCS***. For ***BECCS*** to make a contribution to a reduction in ***GHG*** emissions, it must displace another electrical energy source or energy carrier source, and, in any event, it must result in a carbon neutral outcome (rather than a carbon removal outcome) so as not to give rise to an increase in ***GHG*** emissions. The effectiveness of ***BECCS*** at a global level is more likely than not to achieve carbon neutrality rather than to remove carbon.
- **Bio-energy projects**:

  In addition to the news item above (under **Biogas to biomethane to hydrogen**):
  - **BP and CleanBay packed:** On August 24, 2021, BP and CleanBay announced that they had entered into a 15 year contract for the supply of renewable natural gas (***RNG***) derived from the biogas arising from an anaerobic digestion of poultry litter. It is expected that the ***RNG*** will be compressed / pressurised and that BP will market in the US mobility / transportation sector.

See: BP *press release*; Cleanbay *press release*

- **Bright-markings for Chevron:** On August 25, 2021, Brightmark and Chevron announced the extension of their existing joint venture to develop 10 further biomethane projects across the US. Biomethane is regarded as a renewable natural gas (***RNG***). Chevron will purchase the ***RNG*** and market it in the mobility sector as compressed natural gas (***CNG***). Chevron (and each other corporation with existing distribution networks for hydrocarbon products) is ideally placed to off-take and to market ***RNG*** from bio-energy projects.

  See: Brightmark *press release*; Chevron *press release*

- **Bright marks along the road in Denmark:** On August 25, 2021, Frode Laursen and REMA 1000 Danmark announced the intention to deploy 10 trucks powered and propelled by biogas, the biogas having been derived from "garbage and livestock manure". The biogas is to be compressed (***CBG***).

  As is often the case, the announcement from Frode Laursen and REMA 1000 Danmark was accompanied by a statement that the effect of the use of ***CBG*** "will save up to 100% ***CO_2*** emissions". Statements of this kind need to be read in the broadest sense, and to avoid being misleading, in a legal sense, generously: this statement could be read as intended to mean that "the use ***CBG***, rather than a fossil fuel, will result in a reduction of 100% in the ***CO_2*** emissions from the use of fossil fuel, if all ***CO_2*** emissions arising in deriving the biogas are captured and all ***CO_2*** arising on the oxidation of the ***CBG*** are absorbed by renewable sources."

  See: *Orkla in cooperation with Frode Laursen*

- **Bright sparks in water research in Australia:** On August 25, 2021 (and for some time before), it was reported widely that Water Research Australia (comprising Melbourne Water, Southeast Water, Water Corporation and Yarra Valley Water) and Monash University, Melbourne, is undertaking a pilot project to determine the feasibility of deriving hydrogen from wastewater. This concept was examined in ***H24I – Feature 1: Hydrogen from Waste***.

  In the Australian context (with scarce water supplies in many parts of the country), to use of wastewater to derive hydrogen has particular relevance. As noted in ***H24I – Feature 1: Hydrogen from Waste***, hydrogen derived from waste water is not Green Hydrogen, Blue Hydrogen or Turquoise Hydrogen, absent the capture of ***GHG*** emissions which in the case of waste water comprise ***CH_4*** predominantly.

- **Raven SR, Inc., ... continued progress:** Edition 16 of Low Carbon Pulse outlined the plans by Hyzon Motors Inc., and Raven SR, Inc., to develop up to 100 waste to hydrogen facilities across the US, each facility to be co-located at landfill, with the hydrogen produced at landfill to be used to power and to propel waste collection vehicles delivering municipal solid waste the landfill. The first of the facilities is located at Republic Services' West Contra Costa Sanitary Landfill in Northern California.

  See: *Hyzon Motors' partner Raven SR Inc. announces its first waste-to-hydrogen* hub

- **First 100% *RNG* powered truck:** On August 26, 2021, it was reported, in a Global Gas Mobility article, that on September 8, 2021, Dourogas GNC will commence use of refuelling facilities at its Santo Antonio dos Cavaleiros refuelling station, to supply biomethane in compressed natural gas form (***CNG***), the ***CNG*** comprising ***RNG*** derived from biogas arising from the anaerobic digestion of organic matter.

  The Global Gas Monthly article reports that recently deriving biogas from sludge arising from waste water treatment is being considered, with that biogas then processed further to produce biomethane.

- **Biodiesel / Renewable Diesel:** On August 26, 2021, Imperial Oil (Canadian oil corporation) announced plans to develop Canada's largest renewable diesel complex at its Strathcona refinery in Edmonton, Alberta. Imperial Oil has produced a helpful graphic demonstrating the path from "farm yard to tractor" tank. The Imperial Oil plan is an integrated plan to seek to develop a carbon neutral means of producing diesel from an organic source, rather than from a hydrocarbon.

- ***CH_4* fugitive emission avoidance and *CO_2* capture key:** As will be apparent from the above narrative, biofuels and biogas are derived from ***CH_4*** intensive sources, and on oxidation those biofuels and biogases give rise to ***CO_2*** (or ***N_2O*** if ammonia).

  While there is more than 200 times more ***CO_2*** than ***CH_4*** at large in the climate system, and each ***CH_4*** molecule remains in the climate system for an average of ten years (not hundreds of years), ***CH_4*** molecules absorb and retain more radiative heat, and at which ***CH_4*** can have up to 80 times the global warming potential of ***CO_2***.

  This is why in recent Government to Government engagement and reports, there has been a focus on the reduction in ***CH_4*** emissions: it is estimated that up to 57% of ***CH_4*** could be reduced by 2030, reducing the impact on the climate system by 0.25°C by 2050, and 0.5°C by 2100. These estimates seem to have been determined on a gross basis, rather than net.

  While some abatement measures naturally lead to a gross outcome, some do not, for example, the use of organic matter to derive or to produce biofuels and biogases, and the ultimate use those biofuels or biogases will not. As such, for these reductions to be achieved, any ***GHG*** emissions arising in deriving or producing biofuels or biogases need to be captured. The capture of the life-cycle of ***CH_4*** is achievable, at least in the context of deriving biofuel and biogases from organic matter.

- **Waste Arising and Required Infrastructure:** On September 3, 2021, the Infrastructure Australia released the ***Australian Infrastructure Plan*** (***AIP***). The ***AIP*** identifies waste as a priority area.

Blue Carbon and Ocean update:

- **Background:** The key findings in the ***2021 Report*** in respect of the warming of the oceans (and in the realm of Blue Carbon) are:

  "It is *virtually certain* that the global upper ocean (0-700 metres) has warmed since the 1970s and *extremely likely* that human influence is the main driver. It is virtually certain that human-caused ***CO_2*** emissions are the main driver of current global acidification of the surface of open ocean. There is *high confidence* that oxygen levels have dropped in many upper ocean regions since the mid-20th century … "

- **Impact:** The warming of oceans has given rise to "warmer spots" (or "ocean blobs") in certain areas. The Journal of Climate has noted that there are ocean blobs east of New Zealand in the south Pacific ocean, and that human influence has contributed to these ocean blobs (at least in part). Areas of the ocean covered by the blobs is now ***1.5°C*** warmer than 40 years ago, and areas surrounding the blobs are ***0.2°C*** to ***1°C*** warmer.

  These increased ocean temperatures have resulted in warmer winds, which in turn have affected rainfall in Chile. These impacts may impact activities that Chile wishes to undertake as part of its energy transition, with possible impact on water availability for any hydrogen production, hydroelectric electrical energy generation, and negative ***GHG*** emission initiatives.

CCS / CCUS round-up:

- **World scale DACS matched to World Scale Insurer:** Edition 25 of Low Carbon Pulse reported that the Orca project, a new direct air capture and storage (***DACS***) facility, is commencing operation in Iceland. Orca, owned by Climeworks (a Swiss corporation), will capture up to 4,000 ***tpa*** of ***CO_2*** from the atmosphere, and store the captured ***CO_2*** underground.

  In the context of the next section (headed **CO_2 use**), ***CO_2*** captured by the Orca ***DACS*** is captured only, it is not to be "stored" in any medium or to be used to produce any product. Mr Jon Gernter, in YaleEnvironment360 (published on August 25, 2021), considers the Orca ***DACS*** project in context and in detail.

  On August 26, 2021, Climeworks announced that it had signed a 10 year carbon dioxide removal purchase agreement worth USD 10 million. To the knowledge of the author of Low Carbon Pulse, this is a world first.

  As Swiss Re notes: "*Both the length of the term of 10 years and the total value of USD 10 million are so far unmatched in the voluntary market for this type of high-quality carbon [dioxide] removal, sending an important to demand signal to developers, investors and other buyers*".

  See: *Swiss Re and Climeworks launch partnership by signing world's first ten-year carbon removal purchase agreement*; *Climeworks and leading risk knowledge company Swiss Re sign the world's first and largest 10-year purchase agreement for direct air capture and storage of carbon dioxide*

- **Talos Energy wins offshore CCS project:** On August 25, 2021, it was announced that Talos Energy and Carbonvert had been successful in their bid for the planned 225 to 275 million tonne capacity CCS project in the Texas Gulf Coast. Given the scale of the CCS project, this is an exciting development for CCS in the US and globally.

  See: *Talos Energy selected as winning bidder for carbon capture and storage site*; Carbonvert website

- **Hyundai Heavy:** On August 31, 2021, it was announced that Hyundai Heavy Industries and Korean National Oil Corporation have developed an off-shore platform to allow the storage of ***CO_2*** in sub-ocean floor geological structures.

  See: *Hyundai Heavy develops offshore carbon dioxide storage platform*

***CO_2* use:**

Later in 2021, the fourth article in the ***S2H2*** series will be published, entitled, ***CCS and CCUS***. Ahead of that publication, and more generally, it seemed appropriate to start to map the uses of ***CO_2***, and to frame some of the building blocks of CCS / CCUS, and the terminology that is used.

- ***CO_2* primer:**
  - **Capture:** There is ***DACS*** (involving the capture of ***CO_2*** direct from the air) and there is point source capture or ***PSC*** (involving the capture of ***CO_2*** at the point at which it arises or within the facility within which it arises);
  - **Interface with decarbonisation:** The use of capture (and storage and use) does not decarbonise the activities from which ***CO_2*** arises, as such, policy settings for CCS / CCUS and decarbonisation need to be aligned;
  - **Clusters and Hubs:** As noted in a number of editions of Low Carbon Pulse (most recently Edition 23 of Low Carbon Pulse), CCS and CCUS projects tend to be located around clusters or hubs of activities that give rise to ***CO_2*** and may use it;
  - **Demand and Supply:** As with many aspects of progress to ***NZE*** supply and demand side need to develop in tandem, CCS and CCUS (and use of ***CO_2***) are no different: CCS projects are dependent on customers with ***PSC*** contracting for the provision of storage services, and CCUS project dependent on sufficient ***CO_2*** arising;
  - **Transportation:** Once captured, using ***DACS*** or ***PSC CO_2*** needs to be delivered to the point of storage (in a sub-surface structure) or to the point of use. Depending on the distances, pipelines or shipping or both will be used;
  - **Points of Use and Use:** At the moment at least, the reinjection of ***CO_2*** arising from oil (typically as part of enhanced oil recovery or ***EOR***) and gas (typically as part of enhanced gas recovery or ***EGR***) extraction is regarded by some as use, but not by others. In some jurisdictions, from a regulatory perspective, this is relevant.
  - **Uses of *CO_2*:** As will be apparent from the narrative above (under **Other possible E-Fuels / Future Fuels for the shipping sector**) ***CO_2*** is used in the production of methanol, but on oxidation of that methanol (as is the case with other biofuels or biogas containing carbon atoms) ***CO_2*** arises. As such, storage of ***CO_2*** in methanol is not permanent.

    Other uses will be considered in more detail in the Appendix to Edition 27 of Low Carbon Pulse under the summary of the ***CO_2 Utilisation Roadmap*** (***CUR***), published by Australia's National Science Agency, the

Commonwealth Scientific and Industrial Research Organisation (***CSIRO***). One of the uses is cement / concrete.

- ***CO_2* storage in concrete:** Edition 25 of Low Carbon Pulse reported, with enthusiasm, on the greening of the iron and steel sector (under ***HYBRIT's Clean Steel on the road***). The cement and concrete industry gives rise to a greater mass of ***GHG*** emissions than the iron and steel industry: between 3,500 to 4,000 billion tonnes of ***GHG*** emissions arise each year from the production of cement.

  In an article in Fast Company, Mr Mark Wilson provides an overview of the possible storage of ***CO_2*** in concrete. This concept will be considered in the August Report on Reports (in the summary of the ***CUR***) as the Appendix to Edition 27 of Low Carbon Pulse.

Energy Storage round-up (including *BESS* and grid forming batteries):

On September 3, 2021, EDF Renewables North America (part of leading global energy company, EDF) and Clean Power Alliance (***CPA***) signed a 15 year power purchase agreement in respect of renewable electrical energy supply from the 300 MW solar project and a 600 MWh ***BESS*** (***Desert Quartize Solar-plus Storage*** or ***DQS+S*** project). The ***DQS+S*** project is located in Riverside Country, California on Federal land of the Bureau of Land Management (***BLM***), the ***BLM*** having designated this area as a Solar Energy Zone and Development Focus Area. ***CPA*** is expected to commence off-take for its customers in Los Angeles and Ventura counties in February 2024.

See: *EDF Renewables North America and Clean Power Alliance Sign Power Purchase Agreement for Solar-plus-Storage Project*

E-Fuels / Future Fuels:

- **Egyptian Green Hydrogen Project:** Edition 21 of Low Carbon Pulse reported on the anticipated development of a Green Hydrogen project in Egypt. On August 24, 2021, Siemens Energy announced its plans to develop a hydrogen project of export scale and capacity. The first stage of development is 100 MW to 200 MW of electrolyser capacity. This progress follows the signing of a letter of intent by the Egyptian Electricity Holding Company (***EEHC***) and Siemens Energy at the start of 2021.

  See: *Siemens Energy supports Egypt to develop Green Hydrogen Industry*

- **ENEOS and Origin Energy teaming:** On August 27, 2021, it was announced the ENEOS Corporation (leading hydrocarbon importer and refiner into Japan) is teaming with Origin Energy (one of the three big integrated energy companies in Australia) to undertake jointly a study of the hydrogen and hydrogen-based energy carrier supply chain starting at the Origin Energy Green Hydrogen facility at Gladstone, Queensland, Australia and terminating at the ENEOS refineries in Japan. It is understood that ENEOS is considering the use of Green Hydrogen to produce methylcyclohexane (***MCH***). The accompanying diagram (included in the link below) with the ENEOS announcement contemplates that hydrogen will be transported as ***MCH*** (see the first article in the ***S2H2*** series for background).

  See: *ENEOS Begins Joint Study with Origin for Development of a Japan-Australia CO2-free Hydrogen Supply Chain in Queensland*

- **Power-to-X plant in Denmark:** On August 30, 2021, it was announced that H2 Energy Europe (a Swiss corporation) is to develop a 1GW Green Hydrogen production facility in Esbjerg, Denmark.

  See: Ministry of Foreign Affairs of Denmark *website*; H2 Energy Europe *website*

- **MMEX Resources progressing with hydrogen production facilities**: On August 31, 2021, it was reported that MMEX Resources Corporation had secured tenure in respect of additional land in Texas to allow it to continue to progress with the development of its Blue Hydrogen and Green Hydrogen projects.

  See: *MMEX Resources Corp. Advances Sites for Hydrogen and Clean Energy Projects August 2021*

- **Green Whisky:** On August 30, 2021, The Guardian reported that Bruichladdich Distillery, located on the isle of Islay, has set itself the target of progressing to ***NZE*** by 2025 using Green Hydrogen.

- **Plugged in to power:** Edition 11 of Low Carbon Pulse reported on STAMP. On September 2, 2021, it was reported that Senator Charles ("Chuck") Schumer has continued his support for STAMP and its precincts with the creation of the ***WNY STAMP Campus*** as the next global hub for clean energy industries.

Green Metals and Minerals, the Mining Industry and Difficult to Decarbonise industries:

- **Giants' Pilot:** On August 25, 2021, Rio Tinto (world leading mining company) announced a partnership with Sumitomo Corporation (leading Japanese corporation and infrastructure investor) to develop a pilot project to produce hydrogen, as part of the ***Gladstone Hydrogen Ecosystem***.

  The pilot project is to be located at Rio Tinto's Yarwun alumina refinery, Gladstone, Queensland. Edition 20 of Low Carbon Pulse (under ***Rio Tinto studies use of hydrogen in alumina refinery***) reported on Australian Federal Government funding for a study in the use of hydrogen. As noted in previous editions of Low Carbon Pulse, hydrogen is a likely replacement for natural gas used in the calcination process inherent in alumina refining. This is exiting news and continues the narrative that the mining industry is the quiet achiever in ***GHG*** emission reductions and progress to achieving ***NZE***.

  See: *Rio Tinto and Sumitomo Corporation to assess hydrogen pilot plant at Gladstone's Yarwun alumina refinery*

- **Alumina and Aluminium – a progress and technology check**: Previous editions of Low Carbon Pulse have noted moves by a number of alumina and aluminium producers "to green" their production processes. On August 11, 2021, Australia's largest aluminium smelter owner, Tomago Aluminium, announced that it is to procure electrical energy from renewable sources from 2028. This decision will displace the use of electrical energy currently sourced from coal-fired sources.

- **Green Iron Ore:** On August 30, 2021, it was reported widely that Dr Andrew Forrest, AO (founder of Fortescue Metals Group (***FMG***)), has outlined the next steps that the ***FMG*** (including Fortescue Future Industries (***FFI***)) intends to take: "*The really big steps for the creation of the steel delivered to customers to be decarbonised has to be the first one – create green iron ore*".

A key part of taking "the really big steps" is the decarbonisation of activities undertaken at mine site (and the mining fleet used at site), including to extract iron ore, to haul iron ore to rail, to haul iron ore by rail to port, and the loading and unloading of iron ore, and activities associated with this, and, of course, the use of renewable electrical energy. On August 30, 2021, it was reported that off-road haul trucks at ***FMG*** mine sites had started to test the use batteries to power and to propel those trucks.

See: Fortescue Future Industries *website*; Fortescue Metals Group *website*

- **Caterpillar on track to deliver 100% H_2 solution:** On September 1, 2021, Caterpillar announced that it was on target to deliver electrical energy generation solutions using 100% hydrogen by the end of 2021. At the moment, Caterpillar generation solutions allow for the use of 25% hydrogen and 75% natural gas blended fuels.

  See: *Caterpillar to Expand Hydrogen-Powered Solutions to Customers*

- **Clean Steel a thing:** Edition 25 of Low Carbon Pulse reported that (under ***HYBRIT's Clean Steel in the road***) SSAB delivered the "first fossil-free steel in the world" to Volvo Group from the ***HYBRIT*** mill, using ***HYBRIT*** technology. On September 1, 2021, SSAB announced that it is to partner with Daimler's Mercedes-Benz to introduce fossil-free steel to the production of vehicles. As a reminder, ***HYBRIT*** is a shortening of Hydrogen Breakthrough Ironing Making Technology, developed jointly by LKAB, SSAB and Vattenfall.

  See: *SSAB to deliver fossil-free steel to Mercedes-Benz*

Hydrogen Cities, Councils, Cluster and Hubs, Infrastructure and Valleys:

- **BlackRock backing acceleration of *BEVS*:** On August 25, 2021, it was announced that BlackRock, Inc. has taken an interest in JOLT Charge. JOLT Charge plans to develop up to 5,000 battery recharging stations across Australia. In addition to taking an interest in JOLT Charge, BlackRock is to provide up to USD 72 million in development funding.

  See: BlackRock Australia *website*

- **Giga-factory update:** It was the plan to include a feature on giga-factories in this Edition 26 of Low Carbon Pulse. Given the weight of other news, this feature will be include in Edition 27 of Low Carbon Pulse. Also Edition 27 of Low Carbon Pulse will include an update on charging and refuelling infrastructure.

Wind round-up:

- **Wind turbine size better understood:** Edition 14 of Low Carbon Pulse reported on research revealing a better understanding of the benefits of larger wind turbines. During the week beginning August 23, 2021, MingYang Smart Energy announced the development of the MySE 16.0-242 (***My Mega***). As the full name suggestions, the ***MyMega*** is colossal: a 16 MW capacity, 242 metre (794 feet) wind-turbine, with each blade 118 metres (387 feet), with a sweep of 46,000 m^2.

  The resulting output from the dimensions of the ***My Mega*** is a wind-turbine capable of providing renewable electrical energy to 20,000 homes if it is operating at capacity. Allowing for the fact that the ***My Mega*** will not operate at capacity at all times, it is stated that it will generate 80 GWh of electrical energy per year.

  The resulting benefit of the use of ***My Mega*** (and, no doubt other, yet larger, off-shore wind turbines) is that the cost of off-shore wind projects will continue to fall. As reported previously in Low Carbon Pulse, the capital costs of off-shore wind fields is higher than other forms of renewable electrical energy (and non-renewable sources) translating into USD 120 per MWh cost profile, before funding support, direct or indirect. These costs are falling.

  As noted in Edition 19 of Low Carbon Pulse (under ***Wind round-up***), larger structures than the ***My Mega*** are being contemplated, including the ***Wind Catching System*** or ***Windcatcher***. On August 23, 2021, the **Wind Catching System** was back in a number of news feeds, it being reported that development is proceeding. At the risk of repeating earlier reporting, the ***Windcatcher*** comprises 300 metre framework with around 120 turbines.

  As with the ***My Mega***, it might be expected that ***Windcatcher*** will result in lower electrical energy costs, and as such make off-shore wind more competitive with other sources of electrical energy, or in any event allow an energy cost that will result in a reduction in the level of funding support required from Government.

  See: *Leading innovation: MingYang Smart Energy launches MySE 16.0-242, the world's largest offshore Hybrid Drive wind turbine*

- **Kansai and RWE aligned:** On August 23, 2021, it was reported widely that Kansai Electric Power (***Kansai EPCO***) and RWE Renewables (***RWE***), both leading energy corporations (and ***RWE*** a leading off-shore wind field player), agreed to undertake jointly a study of the feasibility of large-scale floating off-shore wind field development.

  For both ***Kansai EPCO*** and ***RWE***, there is clear alignment with policy settings in Japan, the ability to leverage ***RWE's*** experience and know-how elsewhere, and, ultimately, to allow development of off-shore floating wind field capacity at a cost that reflects utility rates of return.

  See: *Kansai EPCO and RWE team up for floating offshore in Japan*; Kansai Electric Power *press release*

- **Door opens for unsolicited off-shore wind proposals:** On August 23, 2021, it was reported that the Danish Energy Agency (***DEA***) has opened a technology agnostic tender (***TAT***) for renewable electrical energy. This is the third ***TAT*** for ***DEA***. A total of €162 million is available to support the developments of hydropower, solar, wave and wind (on-shore and off-shore) in this ***TAT*** round. The support is provided under a contract for difference (***CfD***) model. Under the ***DEA's CfD*** model, successful proponents will have the benefit of a fixed settlement price for 20 years under the ***CfD***. Responses to the ***TAT*** have to be submitted by October 22, 2021.

  Proposals for off-shore wind field development may be made in respect of the developments of areas identified by the proponent on an unsolicited basis. As will have been apparent from previous editions of Low Carbon Pulse (most recently in Edition 23 of Law Carbon Pulse in respect of ***ScotWind Leasing Scheme***, under ***Deadline for***

applications for ScotWind passes) it is usual for proponents to bid in respect of areas identified by Government, not by proponents. In this unsolicited proposal model, any proponent that identifies an off-shore area on an unsolicited basis that is successful will be granted a permit to undertake a feasibility study.

See: Danish Energy Agency *website*

- **US Off-shore developments continue:** On August 25, 2021, it was reported widely that the Port of Virginia in Virginia in the United States, has leased part of its Portsmouth Marine Terminal to Dominion Energy (***DE***) for the purposes of the development of the 2.6 GW Coastal Virginia Off-shore Wind (***CVOW***) project. Currently, ***DE*** has two turbine off-shore wind pilot projects.

  In early 2020, Virginia enacted the Clean Economy Act (***CEA***). The ***CEA*** targeted the development of off-shore wind, with 5.2 GW of capacity to be installed by 2034, with the longer term target of 100% carbon free electrical energy generation by 2045.

- **Marine Scotland scouting for sites:** On August 26, 2021, it was reported that Marine Scotland had opened a consultation process to identity new areas and sites within which to locate further off-shore wind capacity for oil and gas and decarbonisation projects. It is understood that the period of consultation will close on October 20, 2021. For information, the following is the link to the ***Sectoral Marine Plan for Off-shore Wind for Innovation and Targeted Oil and Gas Decarbonisation*** (***INTOG***).

- **New England Energy Zone experiencing overwhelming interest:** Edition 4 of Low Carbon Pulse reported on the plans of the state of New South Wales, Australia, to promote the development of renewable electrical energy in five areas the across the state. One of those areas was the New England region of the state (***NEREZ***), designated nominally to be the location of up to 8 GW of new renewable solar, wind and battery storage facilities.

  On August 26, 2021, NSW Energy Minister, Mr Matt Kean, stated that expressions of interest were received from over 80 interested entities in respect of the opportunity for new solar, wind and energy storage projects within the ***NEREZ***. Without hyperbole, Mr Kean said: "*The overwhelming response shows that is a once in a generation opportunity to attract enormous investment into regional areas, cementing NSW's renewable energy future*".

  As noted in previous editions of Low Carbon Pulse, the states and territories of Australia continue, with the private sector, to make progress towards the achievement of ***NZE*** (see Edition 6 of Low Carbon Pulse ***under Australian States and private sector***). In contrast, the Australian Federal Government has yet to introduce policy settings aligned with the achievement of ***NZE***.

- **US off-shore wind progressing with wet sail**: On August 31, 2021, offshoreWIND.biz reported on the ***Off-shore Wind Market Report*** (***US OWF Report***) (prepared by the Department of Energy, National Renewable Energy Laboratory). The US off-shore wind field pipeline for projects now stands at 35.324 GW of developments at various stages, including 15 projects at permitting stage. The increased activity is a function of lower offshore development costs, the action of the US Federal Government, and commitments at US state-level. Eight US states have targets for off-shore wind field development, with those targets totalling 39.298 GW of installed capacity by 2040.

- **Shell joins Ulsan Off-shore wind (*OWF*):** On September 1, 2021, Shell Overseas Investment B.V. announced it has combined in joint venture with CoensHexicon Co. Ltd, with Shell a 80%, CoensHexicon, a 20%, equity participant, to develop and then to operate the 1.4 GW Ulsan ***OWF*** project (the ***MunmuBaram Project***). It is understood that the ***MunmuBaram Project*** plans to apply for the Electricity Business Licence (***EBL***) during this month, September 2021.

- **Australia chomping at the bit:** On September 2, 2021, the Australia Federal Energy Minister, Mr Angus Taylor, tabled in the Australian Federal Parliament legislation to unlock investment in offshore wind-fields around Australia. This is an exciting development in the Australian context.

  Within state waters around Australia, a number of off-shore wind field projects are under development and being planned (for example, see Editions 19 and 17 of Low Carbon Pulse).

  The use of Federal waters for off-shore wind farm developments might be expected to increase further the level of investment, including for the purposes of the development of hydrogen production capacity.

Solar and Sustainable Energy Round-up:

- **Solar and Wind progress strong:** On August 25, 2021, Solar Power World, reported that during the first half of calendar year 2021, over 90% of new utility-scale electrical energy generating capacity in the US was solar or wind. The reporting is based on data from the monthly ***Energy Infrastructure Update*** from the Federal Energy Regulatory Commission (***FERC***): ***FERC*** reports 5.279 GW of new solar installed capacity and 5.617 GW of new wind. Renewable energy now represents 25.1% of the total available installed generating capacity in the US.

- **Solar Station Expansion:** Editions 2 and 3 of Low Carbon Pulse reported on the planned development of the 10 GW capacity solar photovoltaic project at Newcastle Water Station (***Solar Station***), Powell Creek, within the Barkly region of the Northern Territory, Australia. The capacity was then increased to 14 GW. The ***Solar Station*** is to export renewable electrical energy via a high voltage direct current cable (***Australia-ASEAN Power Link***) of 3,800 kms in length from Darwin to Singapore (with a 750 km high voltage transmission network to carry the electrical energy from the ***Solar Station*** to Darwin). Edition 18 of Low Carbon Pulse reported on the development of a photovoltaic panel factory.

  On August 22, 2021, it was announced that Sun Cable (Singapore based renewable energy company) plans to increase the installed capacity at the ***Solar Station***, and to install a Big ***BESS*** (with 33 GWh of storage).

  See: Sun Cable *website*

- **Solar Atlas:** In the August 26, 2021 edition of pvmagazine, Mr Philip Wolfe has updated his solar atlas detailing the largest solar power stations in the world. In 2019, when the solar atlas was first published, there were no solar power stations with over 1 GW of installed capacity.

- **Solar build out continues across France:** On August 31, 2021, it was reported widely that during the first half of calendar year 2021, 1.36 GW of utility-scale solar photovoltaic capacity had been installed in France.
- **Solar build out continues across Germany:** On August 31, 2021, it was reported widely that during the first half of calendar year 2021, 2.8 GW of solar photovoltaic capacity was installed in Germany, with a further 430 MW installed during July.
- **Australia planning for 100% renewables:** Edition 22 of Low Carbon Pulse reported that the CEO of the Australian Energy Market Operator (***AEMO***), Mr Daniel Westerman, was anticipating that Australia was moving towards a 100% of load across the grid that it operates being matched by dispatch by renewable electrical energy.

  On August 31, 2021, ***AEMO*'s** Electricity Statement of Opportunities (***ESOO Report***) contemplates that "*there could be up to 100% instantaneous penetration of renewables as certain times of the day throughout the year by 2025*". Supporting this outcome, the ***ESOO Report*** anticipates that a further 10 GW of large-scale utility solar and wind capacity will be installed by 2025.
- **World record low bid in hot Chile**: On September 2, 2021, it was reported widely that a world record low bid USD 0.01332 kWh had been successful in the current renewable electrical energy reverse auction process being run by the Chilean National Energy Commission. Also it reported that SolarReserve bid USD0.0399 / kWh using concentrated solar power (***CSP***) technology.

  See: SolarReserve *website*

Land Transport (automobiles, buses, trains and trucks) round-up:

- **Automobiles:**

  While some commentators and battery electrical vehicle (***BEV***) manufacturers have dismissed the use of fuel cell technology (***FCT***) for automobiles, this does not mean that automobile manufacturers are not progressing with the development of vehicles using ***FCT*** (***FCEVs***):

  - On September 2, 2021, Toyota Motor Corporation announced that it would be manufacturing two ***FCEVs***, Corolla and Prius ***FCEVs***; and

    See: Toyota Motor Corporation *website*
  - On September 3, 2021, Hyundai Motor Company announced that its Genesis Motors brand would be powered and propelled by both batteries and ***FCT*** by 2030.

  This said, it remains likely that ***BEVs*** will tend to be preferred in the daily drive market.
- **Buses:**
  - **Dublin up for Hy:** On August 26, 2021, H2View, reported that double-deckers (is that Dublin Deckers?) are being trialled in Dublin, Republic of Ireland. The trials are part of the final phase of the ***Low Emission Bus Trial*** of the Department of Transport. The Department of Transport has worked with Go-Ahead Ireland, BOC Gases (part of the Linde Group, one of the big three industrial gas giants, with Air Liquide and Air Products), and Byrne Ó Cleirigh.
  - **Liverpool:** Across the Irish Sea, on August 27, 2021, it was reported by Alexander Dennis Limited that it had received an order for 20 of its Enviro400FCEV buses powered and propelled by ***FCT*** module supplied by Ballard Power Systems.

    See: *Liverpool city region is first to select ADL's H2.0 second-generation hydrogen bus with order for 20 double deckers*
- **Keeping track of rolling stock**:
  - **Two Seas Railway Green Now Between:** On August 25, 2021, it was reported that the trains running on the railway between Sansepolcro and Sulmona (in the Apennines) are to be powered and propelled by Green Hydrogen (***Two Seas Rail Project***).

    AECOM and Iberdrola are reported to have signed a memorandum of understanding (dated August 24, 2021) under which they are to work to replace the existing diesel locomotives powered and propelled trains with ***FCT***. It is reported that the ***Two Seas Rail Project*** is part of a larger project to rejuvenate (to Newby?) the Central Apennines.

    See: *Iberdrola mobilises Green Hydrogen in the Apenine railway hub in Italy*
  - **Sweden deploys hydrogen passenger train:** On August 25, 2021, it was reported widely that an Alstom Coradia iLint passenger train had been deployed in Östersund, Sweden. The Alstom Coradia iLint passenger train is powered and propelled using ***FCT*** (that oxidises hydrogen to generate electrical energy).

    Alstom Coradia iLint trains have been deployed in Austria, Germany and the Netherlands, and are to be deployed in Italy.

    See: *Alstom's Coradia iLint hydrogen train runs for the first time in Sweden*
- **Hy Road for Track:**
  - **Great Wall of Hydrogen Trucks:** On August 23, 2021, it was reported widely that Great Wall Motors (leading Chinese manufacturer of road vehicles of all kinds) had delivered a fleet of 100 ***FCT*** electric vehicles (***FCEVs***) for use in the haulage tasks for the Xiong'an New Area constructure project. Each ***FCEV*** has a 111 kw fuel cell engine, and uses hydrogen stacks and hydrogen storage, developed by Great Wall Motors.

    See: Great Wall Motors *website*
  - **Scottish Hydrogen Fuel Cell Freight Trial (SHyFT):** On August 24, 2021, it was reported that the Scottish Wholesale Association and Arcola Energy (an original equipment manufacturer (**OEM**) and, as such,

technology provider), with funding from the Department of Transport's ***Zero Emission Road Freight Programme***, are undertaking an assessment of the uses for ***FCT*** in powertrains for road freight haulage.

While this may be regarded as relatively early stages, this approach is to be commended because it will provide an understanding of the size and scope of the demand side, with the findings to be tested with fleet testing. Scottish Power (one of two Scottish energy company giants, and whose parent company is Spanish renewable giant Iberdrola) and BOC Gases (part of the Linde Group) are providing advice on production, supply and refuelling requirements. Again, this is to be commended: as noted in previous editions of Low Carbon Pulse (most recently in Edition 25 of Low Carbon Pulse under ***The essentials sound*** and in this Edition 26 of Low Carbon Pulse) supply and demand for hydrogen needs to develop in tandem.

- **H2Accelerate:** On August 24, 2021, ***H2Accelerate*** (established by Daimler, IVECO, Volvo Group, OMV, Shell and TotalEnergies), outlined its expectations in a publication titled ***Expectations for the fuel truck market*** (***Expectations Paper***)). The ***Expectations Paper*** outlines three phases for development of ***FCEVs*** and concomitant support:

  1. **Learning and Development:** with this phase having commenced and to continue until 2025;
  2. **Industrial Scale up:** this phase will commence from 2025 and continue until 2028, and will involve the deployment of thousands of ***FCT*** heavy goods vehicles and trucks, with refuelling infrastructure to continue to develop, critically along key transport corridors; and
  3. **Sustainable Growth:** the third phase from 2028 and continuing thereafter will become self-sustaining as economies of scale arise and are maintained across each aspect of the supply and value chain.

  Until the **Sustainable Growth Phase**, ***H2Accelerate*** expects public funding support to be required, but the need for it to decline as economies of scale are realised on a sustained basis.

  Spokesperson for ***H2Accelerate***, Mr Ben Madden, said: "*It has never been clearer that actions to enable the decarbonisation of road freight must be set in motion immediately if climate targets are to be achieved. The latest whitepaper from … H2Accelerate … demonstrates the commitment from participants to invest in scaling up this vital sector, and support policymakers to take the necessary steps to catalyse these investments*".

  As noted in previous editions of Low Carbon Pulse, key participants in the freight industry are taking the lead in the development of technology and infrastructure. (see Editions 18, 19, and 22 of Low Carbon Pulse for illustrative examples.)

- **Toyota Kentucky expansion:** On August 25, 2021, Toyota Motor Company announced plans to develop a dedicated production line to manufacture dual fuel cell modules (***DFCMs***) at its plant in Kentucky. The ***DFCMs*** will deliver up to 160 kW. The Toyota powertrains in which these ***DECMs*** will be installed will have a 300 mile range, and a full load weight of 80,000 lbs (36,287 kg), and as such are intended for use in the Class 8 heavy duty truck segment of the market.

  See: *Toyota to Assemble Fuel Cell Modules at Kentucky Plant in 2023*

- **Mercedes Benz trialling its GenH2 Truck:** On August 26, 2021, it was reported by Mercedes Benz that it was trialling its GenH2 Truck, and that Mercedes Benz is closing in on customer trials. Mercedes Benz is in the **Development** part of the ***H2Accelerate*** **Learning and Development** phase.

Port News and Shipping Forecast:

In addition to the A.P. Moller – Maersk news (see under **A.P. Moller – fleet of foot** above), over the last two weeks there has been some interesting news across the Ports and Shipping sector as follows:

- **CH-2 Ship on the medium horizon:** Edition 18 of Low Carbon Pulse reported on the development of a vessel to carry compressed ***CO_2***.

  As noted above (under **CO_2 use**), one of the key technologies that needs to be developed to facilitate the development of CCS (and to a lesser extent CCUS) is the development of a vessel that can transport ***CO_2*** in compressed / pressurised or refrigerated form.

  On August 24, 2021, it was reported widely that Global Energy Ventures Limited has submitted vessel specification engineering and drawings, stability analysis and tank design calculations to the American Bureau of Shipping (one of the foremost international vessel classification societies) for Approval in Principle (***AIP***). An ***AIP*** provides an expert assessment of the basis for development of a vessel.

- **Trials for Bay Area Ferry:** Edition 23 of Low Carbon Pulse reported on the proposed development of a ***FCT*** powered and propelled ferry for the Bay Area, San Francisco, California. It is understood that the 70 foot, 75 passenger, ferry is close to completing testing and trialling at Bellingham, Washington, and that it will be launched in the Bay Area in the fall.

- **Zero crew, zero emissions:** On August 26, 2021, it was announced that later in 2021 a cargo vessel journey between two Norwegian ports. The cargo vessel with be piloted remotely - it will have no crew. The cargo vessel is powered and propelled by electrical energy stored in batteries. The thinking behind the development of the cargo vessel is to displace road freight from the Norwegian road system, thereby reducing congestion and ***GHG*** emissions.

- **Mitsubishi and TotalEnergies developing CO_2 carriers:** On August 27, 2021, Mitsubishi Shipbuilding (part of Mitsubishi Heavy Industries (***MHI***)) announced that it has partnered with TotalEnergies (global leading international energy company) to undertake a feasibility study for the development of a liquified ***CO_2*** (***LCO_2***) vessel.

  As noted above , the development of this technology is required to allow scaling-up of the ***CO_2*** storage, transport and use. As Vice President at TotalEnergies, Mr Bruno Seihan noted: "*[LCO_2] vessels will be key to accommodate the expected surge in transported CO_2 volumes for geological storage triggered by the acceleration in net zero carbon targets worldwide and to meet world industrial emitters needs [for carbon storage]*".

On September 2, 2021, ***MHI*** announced that the cargo tank system to be mounted in the ***LCO_2*** vessel had been granted Approval In Principle (***AIP***) from the French Classification Society, Bureau Veritas. As noted above, an ***AIP*** provides an expert assessment of the basis for development. This is exciting news, and again illustrates the pace at which the private sector is making progress in the development of technologies needed to progress to ***NZE***.

- ***CO_2* carriers need arms:** On September 2, 2021, it was announced that the North Lights Project (see Editions 2 and 20 of Low Carbon Pulse) had contracted with Technip Energies to supply ***CO_2*** loading arms. ***CO_2*** loading arms are required to take ***CO_2*** (captured and stored) and to load that ***CO_2*** on the ***CO_2*** carrier.
- **Wake-up to "well to wake" accounting:** On August 30, 2021, the Methanol Institute (***MI***) called for maritime policy makers to adopt a ***well-to-wake*** approach to accounting for fuel use. ***Well-to-Wake*** emissions (life-cycle emissions) are the sum of upstream (***Well-to-Tank***) and downstream (***Tank-to-Wake***) emissions. The current ***Tank-to-Wake*** approach is regarded as placing the burden of decarbonisation on shipowners.

  The use of standardised accounting for fuel use is regarded as a key element of decarbonisation of the shipping industry: the standards would provide measurement and monitoring of ***CO_2***, ***CH_4***, and ***N_2O GHG*** emissions, from ***Well-to-Wake***, and as such place the burden / focus across the fuel chain.
- **Going large on LNG Bunker Barge:** On September 1, 2021, it was announced that Crowley Maritime Corporation (***CMC***) and Shell NA LNG, LCC, have concluded a long-term time charter under which ***CMC*** will build a new LNG Bunker Barge, 416-foot-long barge (***LBB***). The ***LBB*** will provide LNG bunkers to LNG-fuelled ships that call at port on the US East Coast.

  See: *Crowley and Shell to Build and Charter Largest LNG Bunker Barge in US*
- **Going large on Ammonia Bunker "Terminal":** On September 2, 2021, it was announced that funding support will be provided by the Government of Norway (through the Norwegian Green Platform Initiative) for the development of an Ammonia Fuel Bunkering Network (***AFBN***).

  The ***AFBN*** will provide new solutions for ammonia bunkering allowing receipt of ammonia from barges, ships and trucks, in compressed / pressurised or refrigerated state. It is contemplated that both shore-based and floating solutions will be provided. There are nine partners in ***AFBN*** (detailed in the link below).

  See: *Ammonia bunkering technology company Azane Fuel Solutions and project partners receives public funding for World's first green ammonia bunkering terminal*

Aviation and Airports:

Edition 27 of Low Carbon Pulse will include a round-up of news items on the aviation and airports industries.

Low Carbon Pulse - Edition 27

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

This an updated version of Edition 27 of Low Carbon Pulse which includes, as an appendix, the August Report on Reports. Edition 27 was first published on September 21 2021.

Welcome to **Edition 27** of Low Carbon Pulse – sharing significant current news on progress towards net-zero greenhouse gas (***GHGs***) emissions globally. This edition covers the period from Monday September 6, 2021 to Sunday September 19, 2021 (inclusive of each day).

Please click here for Edition 26 of Low Carbon Pulse. Please also click here and here for the first two articles in the ***Shift to Hydrogen Series*** (***S2H2***)***: Elemental Change*** series: the ***S2H2*** series provides a narrative and perspective on hydrogen generally. Please **click** here for the first feature in the ***Hydrogen for Industry*** (***H24I***): the ***H24I*** features provide an industry by industry narrative and perspective.

The third and fourth articles in the ***S2H2*** series will be published with the next six to eight weeks. The third article will be on Hydrogen Plans, Roadmaps, and Strategies, and the fourth article will be on CCS / CCUS.

Progress to *COP-26*:

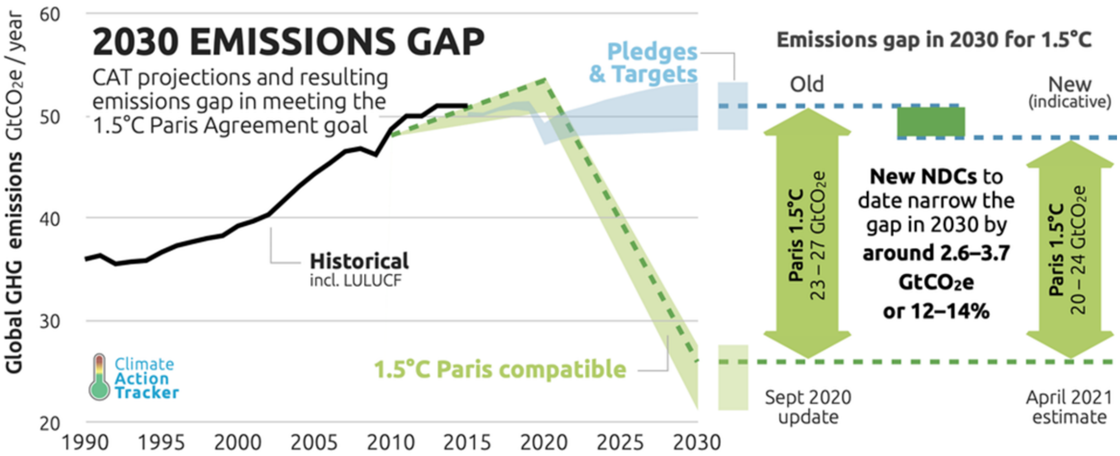
- **Trending issues:**
  - ***GHG* emissions budget:** As noted in Edition 26 of Low Carbon Pulse, there is a real and ready understanding that it is going to be a challenge to peak and then to reduce ***GHG*** emissions so as to limit global temperature increase to ***1.5°C*** above pre-industrial levels (what Low Carbon Pulse has called the ***Stretch Goal***).
  - **How long until we reach *1.5°C* increase?** Edition 26 of Low Carbon Pulse, reported on the best estimates of how much longer we have until the carbon budget is exceeded and we reach a ***1.5°C*** increase is reached (exceeding the ***Stretch Goal***) or until we enter the ***1.5°C*** to ***2°C*** range (the ***Stabilisation Goal***).

    The ***Sixth Assessment Report – Climate Change 2021, The Physical Science Basis*** (***2021 Report***) suggests the ***Stretch Goal*** will be exceeded by 2040. Chief Economist of BloombergNEF, Mr Seb Henbest, has noted: "*As soon as 2028, we will have exhausted the emissions budget to stay within 1.5* °C *of warming*".

    While the papers, reports and studies published tend to emphasise different points, and to focus on either the ***Stretch Goal*** or the ***Stabilisation Goal***, there is a bandwidth of messaging, which is illustrated by two publications the appeared during the week beginning September 13, 2021: the achievement of the ***Stretch Goal*** is nearly out of reach, and the achievement of the ***Stabilisation Goal*** is "touch and go" at best.
  - **Climate Action Tracking:**
    - On September 15, 2021, Climate Action Tracker published a paper (***CAT Paper***) outlining whether the policy settings of sample countries (activities in those sample countries currently gives rise to 80% of global ***GHG*** emissions) were aligned with achieving the ***Stretch Goal***.

      While the sample size is limited to 37 countries, all twenty of the G20 countries were included in the sample.

      Based on current policy settings, the ***CAT Paper*** finds that none of the G20 countries is on track to achieve the ***Stretch Goal*** (more accurately reductions so as to achieve its proportionate share of the ***Stretch Goal*** globally). This is not a surprise: even the UK (in many ways leading the way), recognises that more needs to be done, and at an increased rate. The ***CAT Paper*** supports the argument that the rate of ***GHG*** emission reductions needs to increase, and those increased reductions need to be acted on in the near term.



- On September 16, 2021, Nature magazine published an article entitled ***Wave of net zero emission targets opens window to meeting the Paris Agreement***. The sample size for the analysis undertaken for the purpose of the article was 131 countries (contrasted with the sample size of 37 for the ***CAT Paper***, which countries cover 72% of current global ***GHG*** emissions). The headline from the article is that based on the implementation, in full, of current commitments to reduce ***GHG*** emissions, the best estimate of the global average temperature increase is ***2°C*** to ***2.4°C*** by 2100.

  The estimates and findings of these recent publications emphasise that acceleration of ***GHG*** emission reductions is needed, including to lock-in a 45% reduction in ***GHG*** emissions by 2030, or even a 50% reduction. This would have a material and significant beneficial effect on the climate system and bring us back within the ***Stabilisation Goal***, or, possibly, the ***Stretch Goal***.

– **Keep Tracking to *Stretch Goal*?** While not yet a fully-fledged debate, some analysts and commentators have raised whether the ***Stretch Goal*** should be adjusted on the basis that it may not be achieved, or, to some, cannot be united.

  As analysts and commentators have worked out the scale of the task required to achieve the level of ***GHG*** emission reductions necessary to achieve the ***Stretch Goal***, a number have questioned whether or not the scale of the task is achievable. For example, Rystad Energy has noted that the solar manufacturing industry needs to quadruple in size by 2035, so as to increase annual manufacturing capacity to 1.2 - 1.4 TW from the current manufacturing capacity of 330 GW.

  While this is a valid policy debate to have, ultimately it is a debate better had about moving the ***Stabilisation Goal*** towards the ***Stretch Goal*** rather than the increasing the ***Stretch Goal*** to limit the global average temperature increase to say 1.7°C above pre-industrial levels.

  The debate around achievability tends to focus on the need to increase the rate of extraction of raw materials to allow the renewable energy manufacturing sector to manufacture for installation the necessary renewable electrical energy equipment. During the week commencing September 13, 2021, a Venn diagram (see right) came to the attention of the author. It is a helpful reminder of the metals and minerals required.

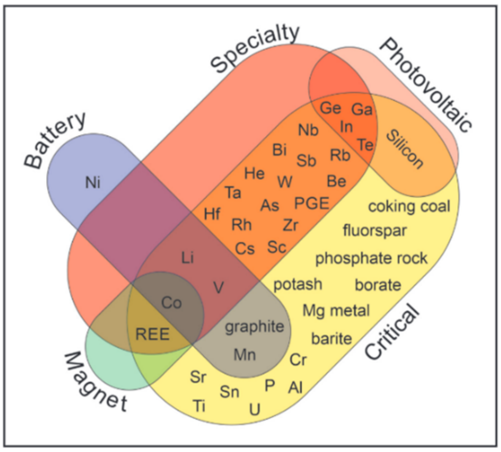


Figure 7. Examples of overlapping material categories. Terms 'battery', 'magnet', and 'photovoltaics' are used here in *sensu lato* (as used by industrial users, exploration companies, banks, and government organizations). For example, cobalt (Co) is currently considered as one of the specialty materials but may be referred to as a 'critical', 'battery', or 'magnet' metal.

– **Developments in CH_4 policy:**

  - **Background:** As noted in previous editions of Low Carbon Pulse, the rate at which the ***GHG*** emissions budget is being spent means that increased reductions in ***GHG*** emissions are required, promptly.

    As noted in Edition 24 of Low Carbon Pulse, the reduction in ***CH_4*** emissions is important because the global warming potential of ***CH_4***, as a ***GHG***, in terms of potency per tonne, is greater than carbon dioxide (***CO_2***): a molecule of ***CH_4*** has a half-life of 9 years, compared to ***CO_2*** with a half-life of 100 years. Over 20 years, ***CH_4*** traps up to 84 times as much heat energy as ***CO_2***.

  - ***CH_4* avoidance is key:** As noted in Edition 26 of Low Carbon Pulse (under ***CH_4* fugitive emission avoidance and *CO_2* capture key**) avoidance of ***CH_4*** emissions is key in particular the avoidance of fugitive emissions: "*While there is more than 200 times more **CO_2** than **CH_4** at large in the climate system, and each **CH_4** molecule remains in the climate system for an average of ten years (not hundreds of years), **CH_4** molecules absorb and retain more radiative heat, which means that **CH_4** can have up to 84 times the global warming potential of **CO_2**.*

*This is why in recent Government to Government engagement and reports, there has been a focus on the reduction in **CH_4** emissions: it is estimated that up to 57% of **CH_4** could be reduced by 2030, reducing the impact on the climate system by 0.25°C by 2050, and 0.5°C by 2100.*"

In this regard there was some good news during the week beginning September 13, 2021. The week started with news reports that the European Commission (***EC***) and the US were working to agree to reduce ***CH_4*** emissions by 30% within the decade. While reductions in ***CO_2*** are the long-game, the short-game of ***CH_4*** emission reductions will result in a material and significant reduction in ***GHG*** emissions by 2030.

On September 17, 2021, the ***EC*** and US announced a pledge (the ***Global Methane Pledge***), given jointly, to reduce ***CH_4*** emissions by nearly a third within the next decade. The hope, and the objective of the ***EC*** and US now has to be to ensure that as many countries as possible join with them in this critical initiative.

See: *Joint EU-US Press Release on the Global Methane Pledge*

- **Good news feed needs to continue:** From all of the papers, reports and studies, one target emerges at the core of policy settings - the need to reduce ***GHG*** emissions by at least 45% by 2030 if the global climate system is to avoid the ever-increasingly serious impact of increased concentrations of ***GHG*** emissions. Unfortunately this target sits alongside trends that indicate an increase in ***GHG*** emissions of 15% by 2030.

  This is one of the key policy settings to watch out for ahead of, during, and after, COP-26. The G-7 countries (Canada, France, Germany, Italy, Japan, the UK and the US) need to take a clear lead on this, with the remaining G-20 countries in tandem, both in terms of their own targets and in working with other countries.

  World Trade and accompanying agreements globally need to reflect that policy settings that achieve reductions in ***GHG*** emissions are now key to cooperation, trust and sustainable trade. In the absence of this alignment, more Carbon Border Adjustment Mechanisms (***CBAMs***) are needed, and less state policy avoidance mechanisms (***SPAMs***). More ***CBAMS***, less ***SPAMS***.

- **High level observations on current high energy prices:** Global prices of natural gas (including LNG) have increased significantly of late, a function of gas markets, including spot prices. For example, Asian spot LNG prices are trading at ten times the prices seen in mid-2020, and Henry Hub gas prices reaching their highest level since 2014, with expectations of still higher prices as the Northern Hemisphere winter in Asia, Europe and the US approaches. The high energy prices (gas prices in particular) in Europe in particular have focussed attention on the need to run economies while at the same time decarbonising the generation of electricity essential for everyday activities.

  It is not possible to detail each factor contributing to these high prices, but at its most basic the price of natural gas is a function of supply and demand. Over-time, and having already started, as international and national oil and gas companies respond to policy settings that reduce the benefit to them of exploration and new sources of production of natural gas, the supply side becomes constrained. At the moment more supply, including more reliable supply, is needed.

  As noted below (under **We are not there yet … !**), planning is required. Natural gas is different from coal, and has a role to play in transition. To provide sufficient supply, certainty of demand is required. The more certainty there is around demand, the more certainty there will be around supply, including the development of new sources. This is an area where pragmaticism is required in policy settings, including from policy banks.

- **Roles to be played to reduce *GHG* emissions:**

  As foreshadowed in previous editions of Low Carbon Pulse, ahead of ***COP-26***, current and relevant matters will be considered in Low Carbon Pulse, including the roles of Governments and institutions, and policy settings.

  This Edition 27 of Low Carbon Pulse covers the roles of Policy Banks and Carbon Credits / Permits in the context of reductions in ***GHG*** emissions generally and ***NZE*** specifically, and the role of Government in the context of the development, in tandem, of supply and demand for hydrogen and hydrogen-based fuels. These are significant matters, which are considered over the next three pages or so, if only to scratch the surface.

  - **A role for Policy Banks:**
    - **Background:** Policy Banks are distinct from Central Banks and Commercial Banks. Policy Banks provide funding support to assist the development objectives of areas and countries of the world that need that support, and in the absence of which development would not occur or would occur slowly and less soundly, and more recently in areas and countries to support decarbonisation initiatives.
    - **Possible future role for Policy Banks:** Edition 25 of Low Carbon Pulse outlined the "acquire to retire" program proposed by the Asian Development Bank (***ADB***) aimed at acquiring, and then retiring, coal-fired power stations in Asia Pacific to reduce ***GHG*** emissions, in particular to acquire and to retire less efficient coal-fired power stations. The "acquire to retire" program has received considerable attention, and it is expected that further details of the program will be described and explained at ***COP-26***.

      The "acquire to retire" program illustrates an ideal role for a Policy Bank, in particular if accompanied by a staged and realistic program for the development of electrical energy generation to replace the retired coal-fired capacity. If the "acquire to retire" program progresses in this way it will be a good thing.

      In terms of the form, substance and timing of any progress of the "acquire to retire" program, it is important to recognise the role that Policy Banks have in supporting renewable energy projects, and that this role needs to increase. Further, in the context of the "acquire to retire" program this may result in by-passing the use of natural gas, and move straight to renewable electrical energy outcomes.
    - **Scrutiny and Criticism:** As is the case with Central Banks, narratives have emerged around the role of Policy Banks, including direct and indirect criticism of the role that policy banks have played in funding fossil fuel developments in the past, and are playing, or not playing, currently in the context of progress towards achieving ***NZE***.

Clearly, the "acquire to retire" program would be a good thing on the basis that retirement is coordinated with lower, low or no carbon generation capacity, or more likely a mix of all three. For countries with low or lower rates of electrification, there is a balance to be struck between avoiding the development of coal-fired power stations, and yet increasing rates of electrification and electricity system development and integrity and stability as increased renewable energy is connected to the system. Depending on the source used, it is estimated that between 0.8 billion and 1.2 billion people globally do not have access to electricity.

- Policy **Banks have had a role in reduced investment in coal-fired power generation:** It should be noted that while some Policy Banks have continued to provide funding support for coal-fired power generation development, over the last five years or so, since the Paris Agreement, the level of funding support has reduced, contributing, at least in part, to fewer coal-fired power generation developments.

  A recent report from E3G, Global Energy Monitor and Ember published on September 13, 2021, reports that: "*Only five years ago, there were so many new coal power plants planned to be built, but most of these have now been either officially halted, or paused and unlikely ever to be built*".

  Consistent with other reporting in Low Carbon Pulse, Associate Director of E3G, Mr Chris Littlecott says: "*increasingly [coal-fired power generation is] uncompetitive in comparison to renewable energy, while the risk of stranded assets has increased*". The risk of stranded assets is already a risk being realised in a number of developed economies.

- **Clear mandates:** While there is a debate around the investment mandate of Policy Banks in facilitating progress towards achieving ***NZE***, it is important to understand that the investment mandates of Policy Banks are a function of the policies of the countries that provide funding to the Policy Banks.

– **A role for Carbon Credits / Permits:** Previous editions of Low Carbon Pulse have considered matters relevant to Carbon Credits / Permits; these are not repeated here.

- **Current Framework for Policy Settings:** In some ways what follows is closer to opinion than is typical in Low Carbon Pulse, and reflects the perspective of the author from a policy setting perspective.

  The intention of this editorial is to frame thinking around Carbon Credits / Permits in the context of COP-26, critically, to ensure that thinking is focussed on the core of the Paris Agreement objectives and how to achieve them, and over time the removal of obstacles to their achievement:

  - the decarbonization of activities giving rise to ***GHG*** emissions – the means to achieving the ***Stabilisation Goal*** or the ***Stretch Goal*** in Article 2; and
  - the removal of ***GHG*** emissions from the climate system (referred to by many as ***Carbon Dioxide Removal*** or ***CDR***), by the use of negative ***GHG*** emission initiatives (***NGHGIs***) – a means to achieving reductions under Article 4.

CORE OBJECTIVES OF THE PARIS AGREEMENT	
Article 2: (a) Holding the increase in global average temperatures to well below 2°C [***Stabilisation Goal***] above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C [***Stretch Goal***] above pre-industrial levels, recognising that this would significantly reduce the risk and impacts of climate change.	**Article 4:** In order to achieve the long-term temperature goal set in Article 2, Parties aim to reach global peaking of greenhouse gas emissions as soon as possible, … and to undertake rapid reductions thereafter in accordance with best available science, so as to achieve a balance between anthropogenic emissions by sources and removals to sinks in greenhouse gas in the second half of this century …

  Note on Article 4: Article 4 contemplates "*peaking of greenhouse gas emissions as soon as possible and to undertake rapid reductions thereafter*". This should not be read to preclude removal of CO_2 (to sinks) to achieve reductions before peaking or before achievement of ***NZE***, in particular to preclude use of ***NGHGIs*** at any time.

- **Achievement of these objectives:** If these objectives are to be achieved, value needs to be ascribed to ***NGHGIs*** globally, outside any existing Carbon Credit / Permit regime (through ***NGHGIs Value Certificates*** or ***NVCs***). Any ***NVC Regime*** should be global, placing value on absolute ***CDR***, rather than net-***CDR***.

  To achieve this, any ***NVC Regime*** should be "ring-fenced" to ensure that absolute ***GHG*** emission removal initiatives do give rise to Carbon Credits / Permits that can be used to off-set CO_2 emissions arising from activities that continue to be undertaken rather than being decarbonised. This approach will maintain and underpin the integrity of the objective of the Paris Agreement, and accelerate ***NGHGIs***. Any ***NVC Regime*** should be funded by G20 countries, and any other country that wants to participate.

  In the thinking of some (it has to be said based on the wording of Article 4 of the Paris Agreement to some extent), ***NGHGIs*** are to be undertaken following the achievement of ***NZE***. From a policy and scientific perspective, it is not possible to conclude that this is a logical or sustainable position, nor, it has to be said, from an interpretive perspective. While the Paris Agreement calls for the achievement of "*a balance between anthropogenic emissions by sources and removals to sinks in greenhouse gas in the second half of this century*" there is a need to "cut-through" this – there is a need for ***NGHGIs*** to commence now, and ***NGHGIs*** should be a top three agenda item at COP-26.

- **Policy Settings need to be brought into absolute alignment:** It is acknowledged that this is easily said, and difficult to do. This is why it should be a top three agenda item at COP-26. While easily said, it is not said often enough. The reason for this may be that thinking has been clouded with the passage of time: the thinking that informed the development and use Carbon Credits / Permits was to put a price on carbon so as to encourage and over time, effectively, to force adoption of lower, low and no carbon.

In a number of countries, policy settings embraced the use of Carbon Credits / Permits to support what may be referred to as notional reductions in ***GHG*** emissions so as to be able to be counted towards the achievement of ***GHG*** emission reduction targets through the use of sequestration and sink schemes (***Sink Schemes***).

There is nothing wrong with ***Sink Schemes*** that are sustainable and that achieve verifiable capture and storage of ***GHG*** emissions on a "permanent" basis.

The challenge with ***Sink Schemes*** is that many of them are neither sustainable nor are the reductions in emissions verifiable, and a good number of them are susceptible to climate change itself, most obviously ***Sink Schemes*** based on the development of forests. More than this, the activities that give rise to ***GHG*** emissions continue.

Policy setting to the practical: Providers of debt and equity in financial markets increasingly expect ***NZE*** plans and overtime, they will be mandated. It is increasingly likely that the use of Carbon Credits / Permits under ***Sink Schemes*** will be scrutinised more closely, including whether or not the use of Carbon Credits / Permits from ***Sink Schemes*** is part of a transition to decarbonisation or a means to avoid or to postpone decarbonisation of activities, and the risks associated with avoidance and postponement strategies. This is why financial markets are looking closely at these Carbon Credits / Permits, and this explains why exchanges (like the global carbon exchange in Singapore, Climate Impact X or CIX) are looking for "high-quality carbon-credits to address hard-to-abate emissions (see Edition 18 of Low Carbon Pulse, and Editions 16, 19 and 20 of Low Carbon Pulse).

- **Sink Schemes become *NGHGIs***: In any event, from a policy setting perspective ***Sink Schemes*** should continue, effectively becoming ***NGHGIs*** over time for so long as they remove ***CO_2*** from the climate system, but the ability to use Carbon Credits / Permits to off-set mandatory or voluntary ***GHG*** reduction targets should have a shelf-life, being a shelf-life that is aligned with the adoption of lower, low or no carbon consistent with ***NZE*** based on activities undertaken that are described as carbon neutral.
- **Application of Article 6 of the Paris Agreement**: On a related issue, there is debate about the application of Article 6 of the Paris Agreement (allowing voluntary cooperation initiatives (***VCIs***)), in particular whether the use of voluntary Carbon Credit / Permits arising under ***VCIs*** should be counted towards the achievement of the nationally determined contributions (***NDCs***) of the country in which the ***GHG*** emission reduction arises or the country in which the Carbon Credit / Permit is used to off-set ***GHG*** emissions, or in both countries.
- As a matter of principle, it is clear that the use of any Carbon Credit / Permit to off-set ***GHG*** emissions does not result in an absolute reduction in ***GHG*** emissions, and as such there is a strong argument for not counting it towards the achievement of any ***NDC***. If to be counted towards the achievement of any ***NDC***, it should be the country in which the ***GHG*** emission reduction arose, not in the country in which it is used to off-set ***GHG*** emissions. It will be interesting to see how this debate develops and, ultimately, how it is resolved. Future editions of Low Carbon Pulse will report on this.

– **A role for Government in the development of supply and demand for hydrogen:**

- **With *NGHGI* a top three agenda item:** Edition 26 of Low Carbon Pulse reported on an excellent opinion piece from Wood Mackenzie. The opinion piece noted that ***COP-26*** will be the acid test for the development of hydrogen (and hydrogen-based fuels) as part of the pathway to decarbonisation and progress to achieving ***NZE***.

  The Wood Mackenzie opinion piece notes that ***COP-26***: "*must go far beyond setting new emissions targets. Ensuring that hydrogen is not just a "fuel for the future", but a fuel that needs to be … implemented into global society from today [and] should be top of the agenda*".
- **Government needed to guide to achieve timely development:** Edition 26 of Low Carbon Pulse noted that it is difficult to overstate the need for Government involvement in the development of renewable electrical energy capacity to allow the development of Green Hydrogen capacity as soon as possible.

  At the core of the development of the hydrogen economy in any country is the central (both establishing and sustaining) challenge of the development of supply and demand for Green Hydrogen in tandem.

  The key elements for the development of the supply side for Green Hydrogen are the:

  - quantity of renewable electrical energy needed, and, unless off-shore wind field capacity is to be used, the related matter of land and the location of that land;
  - mass of water required, and its sources and its storage, and how the sources are best realised, delivered and stored, and how associated infrastructure is best developed and funded;
  - use of fresh water sources and the use of osmosis to desalinate saltwater, and the sources are balanced with activities / business as usual for each sector of the economy;
  - development of electrolyser technology and transportation technology; and
  - price of Green Hydrogen, including any role for the Government as a wholesale buyer of Green Hydrogen in the near to medium term.
- **Coordination is needed at country level and globally:** Editions 25 and 26 of Low Carbon Pulse have outlined the role that the German government is taking in the development of the supply side for Green Hydrogen. The German model is to be commended in the highest terms, and it is likely that globally the benefit of the work being done in Germany will be leveraged with German developed technology playing a key role in the development of the Green Hydrogen economy.

Among other things, Edition 28 of Low Carbon Pulse will cover **trending issues** and consider the role of bioenergy and CCS / CCUS, including the role of Government, critically to facilitate the production of Blue Hydrogen.

Climate change reported and explained:

- ***NOAA* news**: Each month the US National Oceanic and Atmospheric Administration (***NOAA***), among other things, reports on findings for the previous month. In the second edition of Low Carbon Pulse each month, we will cover the latest data from the ***NOAA*** report for the previous month.

  During the metrological summer (June, July and August) of 2021 in the US:

  – the temperatures were:

    - 2.6°F (or 0.8°C) above the average for the 20th century; and
    - the hottest ever, and as such hotter (by 0.01°F or 0.018 °C) than the Dust Bowl Summer in 1936;

  – the rate of temperature increase was greater than had been anticipated in previous modelling;

  – 18% of the 48 contiguous States experienced their hottest average summer temperatures; and

  – California, Idaho, Nevada, Oregon and Utah experienced their hottest average summer temperatures, and 16 other States experienced temperatures within their top five hottest summer temperatures.

  The ***NOAA*** August report notes that August 2021: "*brought Hurricane Ida, numerous wildfires and floods, capping off a summer of record heat and rainfall for many states throughout the [US]*". As reported in Edition 25 of Low Carbon Pulse, the ***NOAA*** report for July 2021, reported that it was the hottest month recorded since records began 142 years ago.

  As a straight-talking Texan known to the author said: "*When it rains, it rains too much, when it's hot, it's really hot, too hot. Y'all can deny the reason for it, but not the fact of it*". The reasons are known.

- **World Bank Report:** During the week commencing September 13, 2021, a number of news items reported that by 2050 up to 216 million people may be forced to migrate globally as a result of the effects of climate change. This news items has picked up on the conclusion of the second part of the *Groundswell report* from the World Bank. The following graphic illustrates the possible source of migration.

- **Weather Hazards Map:** Space does not permit consideration of all of the Northern Hemisphere summer weather hazards and extreme weather and extreme weather events. To provide a high-level summary, please view this link for a map indicting weather hazards for the Northern Hemisphere during the summer of 2021.

- **Extreme weather and extreme weather events:** Edition 26 of Low Carbon Pulse reflected on reporting of climate change, in particular the use of "extreme weather event". In the light of recent extreme weather, and extreme weather events, what is clear is that the private and the public sector are having to get to grips with how to adapt to the effects of climate change, however they may be described.

  Edition 28 of Low Carbon Pulse will consider the ways in which countries and areas within countries are adapting to the effects of climate change, and the medium to long term consequences of adaptation by reference to the Paris Agreement and the ***2021 Report**.*

Visualisation Platforms and Tools:

- ***ENTSOG* Visualisation Platform:** On September 13, 2021, ***ENTSOG*** (the ***European Network of Transmission System Operators for Gas***) launched its Europe wide visualisation platform for hydrogen projects along transmission lines, aka value chains. The platform is a great tool, detailing hydrogen projects of all kinds across Europe (greenfield and brownfield), and accompanying data.

- **Dairy and Meat Emissions:** On September 8, 2021, EcoWatch (Ohio, US based, long-time leader in science derived reporting on environmental issues) published a graphic and article detailing the ***GHG*** emissions arising from the activities of the five largest dairy and meat producers globally.
- **Food System gives rise > 30% of anthropogenic *GHG* emissions:** On September 13, 2021, a study was released that suggested that the food system (including production, processing transportation and disposal of waste), gives rise to about 35% of global ***GHG*** emissions. Nine crops provide 75% of the calories consumed by humans, maize, rice and wheat (50%), with the balance from barley, palm oil, potatoes, soy and sugar.

  It will not be a surprise that the study finds the ***GHG*** emissions arising from animal-based food production is twice that of ***GHG*** emissions arising from plant-based food production. While not a surprise, what this finding illustrates is that it is necessary to find a solution to ***GHG*** emissions arising from the food system in its entirety, with the focus on reduction across the food system.
- **Industrial heat close to 30% of final energy demand:** On September 13, 2021, BloombergNEF and the World Business Council for Sustainable Development published a helpful report outlining the current levels of global energy demand arising from industrial heat use, and which of the G20 countries may be regarded as the leading countries, in the sense of being able best to respond to that demand by deployment of low carbon solutions.

  The leading countries for these purposes are listed as the ***PRC***, France, Italy, Germany, South Africa and the UK. There is a helpful map in the report comparing these leading countries to other G20 countries.

AFOLU GHG emission reductions and waste to biofuels:

Future editions of Low Carbon Pulse will report on, and consider, ***GHG*** emissions arising from agriculture, forestry and other land use (***AFOLU***), and the food system generally. The role of ***BECCS*** and ***BECCUS*** (bioenergy carbon capture and storage, and bioenergy carbon captured use and storage) will be considered in detail, and how ***AFOLU*** waste, and waste arising from the food system can be used as a feedstock to produce biofuels.

At the moment, the reduction of the ***GHG*** emissions arising from ***AFOLU*** activities and the food system may be regarded as the most difficult to address as a front-end issue, but addressing ***GHG*** emissions arising from these sectors as a back-end issue (through processing waste) will realise ***GHG*** emission reduction benefits, because most of the ***GHG*** emissions from ***AFOLU***, and the food system and waste, are CH_4.

This said, it is important to recognise the need to achieve balance in the use of nitrogen in fertiliser (NH_3), with over 100 million metric tonnes per annum of nitrogen applied annually. The dynamics in the application of nitrogen are considered in a recent study from the International Institute for Applied Systems Analysis, Wageningen University, the Netherlands, and Zhejiang University, China.

(To provide some background, links are attached to publications written by members of the Global Ashurst Towards Zero Emissions team. **See**: *Aerobic and Anaerobic digestion waste projects*; *Fuel and Feedstock Resource Recovery – Energy Carrier from Waste*; *Hydrogen for Industry*.)

Global Carbon Levy:

- **Background:** It is estimated that between 2% to 3% of global anthropogenic ***GHG*** emissions arising annually arise from the activities of the shipping industry (the estimates vary between 1.8% and 3%).

  As reported in Edition 16 of Low Carbon Pulse, there is a level of consensus across the shipping industry of the need to decarbonise the shipping industry. The issue is how best to do this.

  Edition 19 of Low Carbon Pulse (under ***Global Maritime Forum***) reported on the progress of the shipping industry towards decarbonisation, including the aim of "*achieving zero-emission vessels as the dominant and competitive choice by the end of the [current] decade*", and the initiatives of some countries and economic blocs to achieve this outcome.

  Edition 22 of Low Carbon Pulse reported on the proposed extension to the European Union Emission Trading Scheme (***EU ETS***) to cover shipping trade to and from ***EU*** member states.

  Edition 22 of Low Carbon Pulse noted the reaction of Maersk McKinney Moller Center for Zero Carbon Shipping (the epitome of balance and good sense) to the proposed extension of the ***EU ETS***: "*The [**EC's**] proposal to accelerate the decarbonisation of shipping is an important first step towards the introduction of Market Based Measures [(**MBM**)]. As long as global consensus on [**MBM**] is not within reach, the [**EU**] should take the lead. In a parallel track, the **EU** and other maritime stakeholders should continue to encourage IMO regulation on global maritime **MBM**. Shipping is global by nature and needs global regulation to avoid multiple charges*".

  On September 13, 2021, the UK Government "nailed its colours to the mast", proposing to "chart a course" to achieve ***NZE*** across the shipping industry by 2050.

  The introduction of a truly global carbon levy would be significant, and for this reason the next two pages are devoted to it, not least because the devil will be in the detail, critically the price point, and its application.
- **Global Carbon Levy proposed:** On September 13, 2021, the International Chamber of Shipping (***ICS***) proposed the introduction of a global levy on ***GHG*** emissions from shipping activities (***ICS Proposal***). On September 13, 2021, ***ICS*** issued press release in respect of the ***ICS Proposal***.

  The ***ICS*** is the representative organisation for the national ship-owning associations (with over 80% of the global merchant shipping fleet members of those associations). The ***ICS Proposal*** was provided to the International Maritime Organisation (***IMO***) during the week ending September 12, 2021. The ***ICS Proposal*** would be mandatory in respect of vessels trading globally having gross tonnage exceeding 5,000 tonnes. The amount of the global levy would provide funding for the ***IMO Climate Fund***.

  It is not difficult to deduce the cause and effect of the proposed extension of the ***EU ETS*** to the ***ICS Proposal***. The ***ICS*** press release addresses the interface between the two proposed policy settings: "*ICS believes that a mandatory global levy based **MBM** is strongly preferrable over any unilateral, regional application of **MBMs** to* *international shipping, such as that proposed by the European Commissions which wishes to extend the [**EU ETS**] to international shipping*".

The interface between the two proposed policy settings is a matter for discussion (possibly at COP-26).

If the price point for the global carbon levy (***Global Carbon Levy***) proposed by the ***ICS*** is:

- equal to, or is greater than, the price point achieved by the extension of the ***EU ETS***, the ***EC*** may be regarded as likely to allow the ***Global Carbon Levy*** to prevail because there will be an alignment on the required outcome from the policy setting; or
- less than the price point achieved by the extension of the ***EU ETS***, the ***EC*** may regard this as likely to result in carbon-leakage, and as such not achieve the broader outcomes that it is seeking to achieve.

- **Book-ending with balance and good sense:** Just as the Maersk McKinney Moller Center for Zero Carbon Shipping welcomed the extension of the extension of the ***EU ETS*** (in the absence of global maritime ***MBM*** to price carbon), it welcomed the ***ICS Proposal***, picking up on the (all-important) price point in the second sentence: "*Global regulation is a critical driver of the transition towards zero carbon shipping and essential to close the price gap between fossil fuels and zero carbon fuels. As a next step, we need a firm carbon price to enable timely transition*".
- **Global bunker build out:** The ***IMO Climate Fund*** would be used to fund the development and deployment of bunkering equipment and infrastructure for lower, low and no carbon hydrogen and hydrogen-based fuels (including ammonia and methanol). This reflects the desire of the ***ICS*** to ensure that equipment and infrastructure is developed and deployed as widely is possible.

  The ***ICS Proposal*** is significant because of the:

  - acceptance of a new cost, the ***Global Carbon Levy***;
  - acceptance that the ***IMO Climate Fund*** is to be used to develop and deploy new bunker equipment and infrastructure; and
  - most significantly, acceptance of the need to replace or to refurbish existing fleet so as to switch to lower, low or no carbon fuels.

- **Global fleet replacement / refurbishment:** As noted in Edition 26 of Low Carbon Pulse, as is the case with all sectors of the transport industry, a decision needs to be taken as to when to invest in new fleet, and when to refurbish and retire existing fleet. These decisions may be regarded as pressing for the merchant shipping industry. The ***ICS Proposal*** will place increased purpose on decisions to replace and to refurbish fleets.
- **Giant signal to lower, low and no carbon supply side:** The ***ICS*** press release notes the need for the supply side for lower, low and no carbon fuels to develop.

  The most stated and restated theme in Low Carbon Pulse (and sibling publications relating to hydrogen and hydrogen-based fuels) is the need for supply and demand for hydrogen and hydrogen based energy carriers to develop in tandem.

- **The form and application of the Global Carbon Levy will shape supply and demand:** As noted by the Maersk McKinney Moller Center for Zero Carbon Shipping, the next step is a "*firm carbon price*".

  The key feature of the Global Carbon Levy will be that "*firm carbon price*" and whether it is payable in respect of any fuel that is not a "*zero carbon fuel*". It would seem more likely than not that the ***Global Carbon Levy*** will recognise fuels in respect of which it is payable, and fuels in respect of which it is not payable, and in respect of which variable rates may be payable.

  The sooner the amount of the "*firm carbon price*", and its application, is clear, the better, assuming, of course, that the price point encourages (or the price points encourage) lower, low, and no carbon fuel usage. Also, the form and application may encourage progress overtime to "*zero carbon fuel*". Carbon neutral fuel contains carbon, with any CO_2 arising on use being balanced / matched by the growth of renewable resources from which that fuel was derived and produced notionally to absorb the CO_2 arising on its use, or CO_2 or N_2O is captured.

  (While some abatement measures naturally lead to a gross reduction in ***GHG*** emissions, some do not, for example, the use of organic matter to derive or to produce biofuels and biogases, and the ultimate use of those biofuels or biogases will not. As such, for these reductions to be achieved, any ***GHG*** emissions arising in deriving or producing biofuels or biogases need to be captured. The capture of the life-cycle of CH_4 is achievable, at least in the context of deriving biofuel and biogases from organic matter.)

- **Current spread of lower, low and no carbon / nitrogen fuels:** At the moment ammonia (NH_3) and LNG (predominantly CH_4) are regarded as being the most prospective for the purpose of powering and propelling vessels, noting however that in the absence of matching off-sets, LNG (while a lower carbon fuel than heavy fuel oil) is less likely other fuels to be exempt from the ***Global Carbon Levy***.

  As noted in Edition 26 of Low Carbon Pulse, methanol (CO_3OH) is a viable lower or low carbon fuel. The decision by AP Moller – Maersk to order eight dual fuel container vessels appears to have increased interest in methanol as a bunker fuel, and the size of the potential demand for methanol is as yet unmatched by supply. On a rough and ready basis, eight container vessels will have an annual demand of between 300,000 and 360,000 metric tonnes a year. For a "deeper dive" see the S&P Global feature from September 16, 2021 - ***Methanol bunkers in the limelight after Maersk's latest ship orders***.

  Ammonia and methanol may be regarded as more than likely to be exempt from, or subject to a lower ***Global Carbon Levy*** rate, than LNG. Also both ammonia and methanol are existing chemical commodities with existing laws and regulations (and standards) covering production, storage and transportation, and proven means of compression / pressurisation and refrigeration (in the case of ammonia).

  As will be apparent from the above narrative, biofuels and biogas are often derived and produced from CH_4 intensive sources, and on oxidation those biofuels and biogases give rise to CO_2 (or N_2O if ammonia).

- **A reminder of the dynamics:**
  - **If carbon or nitrogen atoms are present, *GHG* emissions will arise on oxidation:** It is important to note that on oxidation, neither ammonia nor methanol derived or produced from any source (or whatever the colour code) are ***GHG*** emission free: ammonia gives rise to N_2O and methanol gives rise to CO_2 on oxidation.
  - **Green Hydrogen is a no *GHG* emissions fuel:** Green Hydrogen is the only fuel that does not give rise to ***GHG*** emissions on production or oxidation (it contains no carbon atoms). As such, Green Hydrogen may be regarded as an ideal fuel, but its energy density is lower than both ammonia and methanol.

    As noted in ***How Hydrogen Can Help Decarbonise the Maritime Sector*** (***HE FF Paper***) from Hydrogen Europe, one of the three factors around the choice of fuel is energy density. The other two factors (in the ***HE FF Paper***) are: availability and security of supply and ***GHG*** emission neutrality "from well to wake". "From well to wake" describes the source of the feedstock for the production of that applicable fuel (well) to the result of the use of that fuel (the wake of the vessel).

    (For completeness, Green Ammonia does not give rise to ***GHG*** emissions on production, but does give rise to N_2O on oxidation (see Edition 25 of Low Carbon Pulse).)
  - **Lower, Low and No *GHG* emission fuels**: By way of a reminder, the following table describes each relevant hydrogen and hydrogen-based fuel.

BIOENERGY / HYDROGEN-BASED FUEL TERMINOLOGY	
Bioenergy: energy derived or produced from biogas or biomass, whether in gaseous, liquid or solid form	**Biofuel:** a subset of Bioenergy, being any energy carrier that is derived or produced from biogas or biomass for use as a fuel
Biogas: a mixture of CH_4 and CO_2 (and trace elements of other gases), arising from the decomposition of organic matter, including derived or produced from anaerobic digestion	**Biomethane** (or Renewable Natural Gas (***RNG***))**:** CH_4 in near pure form, derived or produced from upgrading **Biogas** or gasification of biomass. Biogas and Biomethane are Biogases
E-Fuel (or electro-fuels)**:** any energy carrier that is derived or produced using renewable electrical energy, incl. energy carriers derived and produced from renewable and non-renewable sources, including each of the **E-Fuels**	**E-Fuels:** include **E-diesel**, **E-kerosene**, **E-LNG**, **E-methanol** the derivation or production of each of which requires the synthesis of H_2 with CO_2 (hence synthetic fuel). **E-Ammonia** requires the synthesis of H_2 with ***N***
Ammonia compound of H_2 with ***N*** (NH_3) that can be used in direct combustion, in fuel cells to derive electrical energy, or as a medium to carry hydrogen	**Methanol** (methyl alcohol) is a compound of carbon, hydrogen and oxygen (CH_3OH) that can be used in direct combustion to power and to propel vehicles and vessels

GCC counties update:

- **ADNOC Group, bp and Masdar align:** On September 16, 2021, it was reported widely that ADNOC Group (leading national oil company), BP (leading international energy corporation) and Masdar (Abu Dhabi Future Energy Company) entered into framework agreements. It is understood that the framework agreements provide the basis for the development of two clean hydrogen hubs, each of 1 GW, one in the UAE, the other in the UK.

  The framework agreements reflect the clear commitment of ADNOC Group and Masdar to the "Principles of the 50" and the commitment of BP to progress to ***NZE*** and the achievement of its objectives in respect of the Net-Zero Teesside project (see Edition 23 of Low Carbon Pulse). The development of the 1 GW Blue Hydrogen facility on Teesside (***H2 Teesside***) will be facilitated by the investment of ADNOC Group and Masdar.

  See: *bp, ADNOC and Masdar to form strategic partnership to provide clean energy solutions for UK and UAE*; *ADNOC, bp and Masdar agree to expand UAE-UK new energy partnership*; *ADNOC, bp and Masdar agree to expand UAE-UK new energy partnership*
- **ENI and Mubadala Petroleum align:** On September 8, 2021. it was reported widely that Eni (leading international energy corporation) and Mubadala Petroleum (a wholly-owned subsidiary of Mubadala Investment Company) signed a memorandum of understanding (***MoU***) outlining the basis for cooperation in respect of potential opportunities in the Middle East, North Africa, and South East Asia, and Europe, and other regions of mutual interest.

  The ***MoU*** is intended to identify opportunities in respect of energy transition, including CCS / CCUS, hydrogen production projects and REDD + initiatives (***REDD*** being an acronym **Reducing Emissions from Deforestation and Forest Degradation**), and as those opportunities are developed to allow each of Eni and Mubadala Petroleum to achieve their respective ***NZE*** targets. By way of remainder, for Eni this means ***NZE*** for Scope 1 and Scope 2 from upstream ***GHG*** emissions by 2030, and all activities by 2040, and ***NZE*** across ***GHG*** life-cycle emissions for Scopes 1, 2 and 3 by 2050.

  See: Eni *press release*; Mubadala Petroleum *press release*

India: up-beat tempo continues:

- **State of Kerala's ambitions:** Edition 25 of Low Carbon Pulse reported on the Independence Day speech of Indian Prime Minister, Mr Narendra Modi, in particular the announcement by Mr Modi of the National Hydrogen Mission (***NHM***). It understood that details of the ***NHM*** are being developed.

During the week beginning September 13, 2021, a number of reports appeared to the effect that the State of Kerala is "getting ahead of the curve", and is developing its own strategy.

For these purposes it is being reported that Kerala has started to engagement with energy giants, BPCL (Bharat Petroleum Corporation Limited), GAIL Limited (Government of India owned natural gas corporation), IOC (India Oil Corporation Ltd) and NTPC Limited (India's largest integrated energy corporation), and others, including for the development of a Green Hydrogen facility within the vicinity of the Cochin Airport.

- **Reliance Industries' ambitions:**
  - Chair of Reliance Industries, Mr Mukesh Ambani, has devised the "1-1-1" plan to achieve a price point of USD 1 per kg of hydrogen by 2030 (or soon after).

    See: Reliance *website*
  - Reliance and BP have combined to establish BluSmart, the first and largest electric (including ***BEV*** and ***FCEV***) ride-hailing platform, as part of plans to invest USD 10 billion over the next three years on clean energy. BluSmart will provide a platform for the use of all clean energy forms.
- **Tata Steel achieving ambitions:**

  On September 15, 2021:
  - Tata Steel announced that it had commissioned its carbon capture facility at its Jamshedpur steelworks. The carbon capture technology captures directly CO_2 arising from the blast furnace high-temperature heat processes required to produce pig iron.

    The CO_2 is captured using an amine-based technology, and is then used on-site, and as such is not stored permanently. It is understood the Carbon Clean is providing technological support. Initially the five tonnes of CO_2 will be captured each day. This is a first for iron and steel production in India.

    See: *Tata Steel commissions India's first plant for CO2 capture from Blast Furnace gas at Jamshedpur*
  - Tata Steel announced that it had committed to the introduction of direct reduced iron (***DRI***) technology in one or more electric arc furnaces at its Ijmuiden steelworks. This initiative is part of the plan to reduce CO_2 emissions at Ijmuiden by 5 mpta by 2030. This will be achieved by the use of hydrogen, rather than fossil fuels to produce ***DRI*** / sponge iron.

    See: *Tata Steel, the leading international steelmaker, has announced plans to pursue a fully sustainable future for its steelworks in IJmuiden, the Netherlands, by adopting a hydrogen route*

IRON AND STEEL	
Blast Furnace: a high-pressure, high-temperature heat environment, using metallurgical coal, in which iron ore is smelted to produce pig-iron	**Electric Arc Furnace:** high-voltage electrical energy is applied to graphite electrodes creating a high-temperature environment in which iron ore or scrap metal is melted
Pig Iron: The crude iron used to produce steel	**DRI / Sponge Iron:** Iron reduced directly from iron ore, using carbon monoxide and hydrogen derived from natural gas or coal

  - Tata Steel's ammonia cracker at Ijmuiden was in the news as being integral to plans to import Green Ammonia projects in Latin America, and through use of Tata Steel's cracker to [dehydrogenate] the ammonia to derive Green Hydrogen.

    See: Tata Steel *website*
- **Clean energy car incentives:** On September 16, 2021, Energyworld reported that India is to introduce USD 3 billion in funding support: "*to leapfrog to environmentally cleaner, electric vehicles and hydrogen fuel cell vehicles. It will herald a new age in higher technology, more efficient and green automotive manufacturing*". The funding support is to be provided to automobile and drone manufacturers over a five year period. Further detail is expected to follow within the next quarter.

Japan and Australia – continued cooperation at corporate and G-to-G level:

On September 15, 2021, Stanwell Corporation (a Queensland State government-owned corporation with a power generation business) with APA Group (leading natural gas pipeline network owner and operator in Australia) announced that a feasibility study was to be undertaken for the purposes of assessing plans to develop a large-scale Green Hydrogen Hub in Queensland.

The feasibility study will be undertaken by Stanwell Corporation, and APA Group and a number of leading Japanese corporations, including Iwatani Corporation (see Edition 5 of Low Carbon Pulse), Kansai Electric Power Corporation, Kawasaki Heavy Industries and Marubeni Corporation.

The feasibility study has the backing of the Queensland State Government and the Australian Federal Government (through the Australian Renewable Energy Agency (***ARENA***)) and the Japanese Government, through funding provided by the Ministry of Economy, Trade and Industry (***METI***).

German progress continues, home, on the seas and overseas:

- **Germany is role model:** Edition 25 of Low Carbon Pulse (under ***Germany flagship projects – progress check***) and Edition 26 of Low Carbon Pulse (under ***German progress continues, home, and on the seas and overseas***) has reported on the initiatives in Germany, and that Germany and the UK are leading way in terms of policy settings.

In another material and significant development, on September 8, 2021, the German Transport Ministry announced the development and deployment of overhead electric contact lines along the A5 and A9 motorways to allow the use of electrical energy to power and to propel vehicles (and to allow recharging of vehicles) transporting freight. In addition to the deployment of overhead electric contact lines, battery recharging infrastructure will be developed and deployed.

- **Role model remodelled:**

  As noted in previous editions of Low Carbon Pulse, the perspective taken in Low Carbon Pulse is forward looking and positive – no policy setting or resulting outcome is perfect, and there will be continuous improvement in progress towards ***NZE***. This is why negative news items are not included in Low Carbon Pulse.

  In the recent past, there has been some negative comment around the ability of Germany to achieve ***NZE*** by 2045. More often than not, negative comments are not accompanied by other means of achieving progress towards ***NZE***.

  On September 10, 2021, there was positive comment and a clear means of achieving progress. McKinsey & Company published a report (***McKinsey Report***) that outlines how Germany "can become carbon neutral by 2045 – at net-zero costs".

  The ***McKinsey Report*** notes that: "*To master decarbonisation we need to accelerate at least at a factor of 3 … using a fact-based plan and 10 major initiatives - among the rapid build-up the hydrogen infrastructure 10 - 15 mt of clean hydrogen will be needed*".

  In recent times there have been cautionary narratives around the increased production of hydrogen other than Green Hydrogen, and the importance of the use of Green Hydrogen as efficiently as possible, for example. Further, the focus should be on the electrification of the building and transport sectors in the long term.

  Please see a report from Earthjustice for more details. There is considerable cross-over with the findings of Professor Ronnie Belmans and Pieter Vingerhoets: in short, hydrogen is not used efficiently in buildings or cars or for short distance transport.

- **The Flagship Program sound, *McKinsey Report* accelerates**: The ***McKinsey Report*** builds in the framework of the Flagship Program already underway. While included in Editions 25 and 26 of Low Carbon Pulse, for ease of reference, by way of a quick reminder, the three Flagship Projects in the Flagship Program are:

  - ***H2Giga*****:** dedicated to the development of large-scale use of electrolysers (using serial construction of standardised electrolyser technology) to electrolyse water using renewable electrical energy to produce Green Hydrogen. Thyssenkrupp is responsible for the coordination of ***H2Giga***;

  - ***H2Mare*****:** dedicated to investigating the use of use off-shore / off-grid renewable wind electrical energy to produce hydrogen and hydrogen-based fuels: effectively, a dedicated, integrated, closed electrical energy to the Green Hydrogen production energy loop. ***H2Mare*** comprises four joint projects: **1**. OffgridWind, **2**. H2Wind, **3**. PtX-Wind, and **4**. TransferWind. Siemens Energy is responsible for the coordination of ***H2Mare***.

  - **TransHyDe:** dedicated to reaching transportation of hydrogen over short, medium and long distances, and comprising four demonstration projects: **1**. Hydrogen Transport in High Pressure Vessels, **2**. Hydrogen-Liquid Transport, **3**. Hydrogen Transport in Existing and New Gas Pipelines, and **4**. Transport of Hydrogen Bound in Ammonia or liquid organic hydrogen carrier (***LOHC***), a carrier medium.

- **We are not there yet … !**

  - **Background:** During the week beginning September 13, 2021, it was reported widely that during the first six months of calendar year 2021, coal-fired electrical energy generation in Germany exceeded that of electrical energy sourced from wind. The increased use of coal has not been restricted to Germany, it has been experienced in other countries in Europe too, along with increased energy prices.

  - **Reversion to fossil fuel:** The reversion to coal-fired power generation is a result of a number factors, including the price of energy, including to respond to weather events consistent with climate change. The recent reversion to coal is not an argument for near, medium and long term reliance on coal, rather it is an argument for increasing the rate of development of renewable energy capacity, and energy storage solutions.

  - **Pragmatic planning is required:** As importantly, the experience in Germany indicates the level of planning that is required to retire coal-fired (and other fossil fuel) generation capacity while developing renewable energy capacity: Germany has a well-developed and world leading reverse auction process to retire coal-fired power generation capacity, and yet circumstances have conspired to result in the need to continue to use coal-fired power generation capacity.

    The application of the reverse auction process in Germany has been well-planned and executed. This serves to emphasise the need for planning to ensure coordination between the development of renewable energy and transmission system augmentation and enhancement and expansion to ensure system integrity and stability, in tandem with (and as such a little ahead of) the retirement of coal-fired power generation.

    The experience in Germany provides a good case study for "acquire to retire" policy settings and "reverse auction to retire" schemes, and, given recent experience, the need to ensure that there is sufficient lower or low carbon fuel available as energy transition is achieved over time.

  - **Natural Gas as a transition fuel:** There is a saying in the fossil fuel industry (in particular the natural gas industry), that the "best cure for high prices is high prices": a competitive market that sees high prices, responds by developing new energy sources to take advantage of those high-prices.

    In the context of progress towards the achievement of ***NZE***, international energy companies and national oil companies may be regarded as less likely to respond in this way, because in the medium to long term there is a risk of not achieving the required return of, and on, capital. As a result, higher to high prices will continue.

PRC continues to lead the way:

- ***PRC* leads in off-shore wind installation:** On 9 September, 2021, the Global Wind Energy Council (***GWEC***) released the ***Global Offshore Wind Report 2021*** (***GWEC 2021 Report***).

  Of the 6.1 GW of offshore wind capacity installed in 2020 (slightly down on the 6.24 GW off-shore wind capacity installed in 2019), ***PRC*** led the way with more than 3 GW. The ***GWEC 2021 Report*** anticipates that 7.5 GW of off-shore wind capacity will be installed during 2021, again with ***PRC*** leading the way (driven in part by installing capacity to get the benefit of the current feed-in-tariffs).

  Other key findings from the ***GWEC 2021 Report*** are contained in the **Wind Round-up** below, critically, that more off-shore wind capacity needs to be installed, up to 2,000 GW of off-shore wind capacity needs to be installed by 2050 if global average temperatures are not to exceed 1.5°C. This level of installed capacity is consistent with the models used by the International Energy Agency (***IEA***) under its ***Net Zero by 2050 – A Roadmap for Global Energy Sector*** and the International Renewable Energy Agency (***IRENA***) under its ***World Energy Transitions Outlook***.

- ***PRC* leads in production and export of solar panels:** Previous editions of Low Carbon Pulse have noted the importance of the ***PRC*** to the solar panel industry. On September 8, 2021, pv magazine reported that in the first five months of 2021, the ***PRC*** had exported more than 37 GW of solar panels, based on reports from the China Photovoltaic Industry Association (***CPIA***).

  See: *China exported 37 GW of panels in five months*.

- ***PRC* leads in installation of solar photovoltaic:** The National Energy Administration in the ***PRC*** has reported that during the first eight months of calendar year 2021, 9.52 GW of solar photovoltaic capacity was installed in the ***PRC*** (including 1.85 GW installed in August).

- **Golmud City leading on hybrid solar project:** On September 17, 2021, pv magazine reported that the Government of the City of Golmud, Qinghai province has announced that state-owned China Green Development Group has commenced the development of a 3.3 GW hybrid solar photovoltaic and concentrated solar power (***CSP***) project: 3 GW of solar photovoltaic, 300 MW of ***CSP***, and 520 MW of energy storage (in the form a ***BESS***).

Republic of Korea (ROK) News:

- **Port of Townsville and Korea Zinc ink *MoU*:** On September 7, 2021, it was reported widely that the Port of Townsville (being a port in Queensland, Australia) had signed a memorandum of understanding (***MoU***) with Sun Metals owned by Korea Zinc (Sun Metals being a sibling of Ark Energy, and the owner of the Sun Metals zinc refinery in Townsville). It is reported that the ***MoU*** will allow for the export of Green Hydrogen, with it being anticipated that ultimately up to 200,000 metric tonnes of hydrogen may be exported annually.

- **Korean H_2 Business Summit**: Edition 2 of Low Carbon Pulse reported that a number of leading corporations and organisations in the Republic of Korea (***ROK***)intended to establish the Green Ammonia Alliance (***GAA***).

  On September 8, 2021, the establishment of the ***Korean H_2 Business Summit*** was reported. The members of the ***Korean H_2 Business Summit*** are understood to include: Doosan, E1, GS, Hanwha, Hyosung, Hyundai Heavy Industries, Hyundai Motor Company, IL Jin, Isu, Lotte, KOLON, Korea Zinc, POSCO and SK Energy. It is understood that the members of the ***Korean H_2 Business Summit*** will meet regularly to develop detailed implementation plans, and that the members will come together every September for an annual conference.

  In the week before the first ***Korean H_2 Business Summit***, four ***ROK*** corporations joined the RE100 (see Edition 18 of Low Carbon Pulse for background): KB Financial Group (the leading financial services provided in the ***ROK***), Korea Zinc, Mirae Assets Securities and SK (in respect of technology). There is increasingly broad and dedicated commitment across corporations in ***ROK*** to clean power, and ***GHG*** emission reductions generally. The commitment of the Government to achieve ***NZE*** by 2050, and its Green New Deal.

- **HyStation on station:** On September 10, 2021, it was reported widely that a new corporation had been established in the ROK to construct and to operate a hydrogen refuelling infrastructure (***HRI***) across ROK to provide hydrogen for public bus fleets. HyStation is the name of the new corporation. It is understood that the first ***HRI*** will be operational by the end of 2022.

  HyStation is a joint venture among Hydrogenic Energy Fund, Hyundai Rotem, Industrial Bank of Korea, KOGAS, Samsung C&T and Woodside Energy Limited. The Korean Development Bank has agreed to provide debt funding for HyStation.

  See: Hyundai Rotem *website*; Industrial Bank of Korea *website*; KOGAS *website*; Samsung C&T *website*; Woodside Energy *website*

- **Siemens Energy and KOGAS tee up Green:** On September 14, 2021, Siemens Energy AG (a leading international energy company) announced that it had signed a memorandum of understanding with Korea Gas Corporation (***KOGAS***) to work together in the production of Green Hydrogen for use in hydrogen fuelled turbine power generation.

  See: *Siemens Energy and KOGAS sign MoU to collaborate on Green Hydrogen projects*

- **Hydrogen Port Ecosystem on the hydro-carbon coast:** On September 14, 2021, the ***ROK*** Ministry of Oceans and Fisheries and SK Group announced plans to develop a hydrogen port ecosystem (***HPE***) in the Yeosu Gwangyang Port on South Korea's southern coast (deep in the heart of oil refining and petrochemical, and own-use LNG importation territory). The heart of the ***HPE*** is a 200,000 to 300,000 metric tonnes per year Blue Hydrogen production facility. The Blue Hydrogen produced will be used for port mobility / transportation and shipping.

  As is the case with Germany and Japan, the private sector in the ***ROK*** continues to work closely with Government in achieving progress to reduction in ***GHG*** emissions, and ***NZE*** by 2050. Minister of Oceans and Fisheries, Mr Moon Seong-hyeok summed up the approach perfectly: the Government will "spare no effort in administrative and policy support" so that "corporate investment on hydrogen ports" is achieved.

See: SK Group *website*

Finland Has a New Improved Hydrogen Plan:

- Edition 26 of Low Carbon Pulse reported on the plans of Nepal to achieve ***NZE***, in particular that it is developing a strategy for the production and use of hydrogen to displace the use of fossil fuels.
- As noted in Edition 26 of Low Carbon Pulse, the purpose of including Nepal was to illustrate that a number of countries are progressing towards the achievement of ***NZE*** even though not one of the countries required to do the heavy lifting in terms of reducing ***GHG*** emissions.
- In a report issued on September 15, 2021, by Hydrogen Cluster Finland (***HCF***), ***HCF*** suggests the creation of a hydrogen production and export industry. The report, and the plan contained in it, would allow Finland to achieve ***NZE*** by 2030, and, through the export of hydrogen, Finland would help other countries achieve ***GHG*** emission reductions.

Update on the US in Edition 28:

Edition 28 of Low Carbon Pulse will include a summary of the policy settings, and state of play, in the US.

Bio-energy (including BECCS and BECCUS) update:

- **Background:** As noted in Edition 26 of Low Carbon Pulse, **bio-energy** is energy derived or produced from biomass, whether in gaseous, liquid or solid form. Bio-energy is derived from organic matter, but not fossilised organic matter. Organic matter contains carbon, and as such bio-energy is not a zero emission energy.

  Note: Carbon Dioxide Removal (***CDR***) is not an instant solution in global terms (as outlined in Edition 24 of Low Carbon Pulse, it takes time), nor is ***BECCS***. For ***BECCS*** to make a contribution to a reduction in ***GHG*** emissions, it must displace another electrical energy source or energy carrier source, and, in any event, it must result in a carbon neutral outcome (rather than a carbon removal outcome) so as not to give rise to an increase in ***GHG*** emissions. The effectiveness of ***BECCS*** at a global level is more likely than not to achieve carbon neutrality rather than to remove carbon.

Bio-energy projects:

Maersk invests in WasteFuel: On September 8, 2021, CNBC reported, that Maersk had invested in WasteFuel (a start-up backed in part by Mr Warren Buffett through Berkshire Hathaway subsidiary NetJets). It is understood that WasteFuel processes agricultural and municipal solid waste to provide synthetic biofuel, bio-methanol for sale into the Americas and into Asia.

Edition 26 of Low Carbon Pulse reported on the decision of AP Moller Maersk to order eight dual fuel container vessels, capable of being power and propelled by methanol. In reporting on this decision it was noted that AP Moller – Maersk was aware of the need to continue to procure supplies of methanol.

See: *Maersk invests in WasteFuel to develop green bio-methanol production in the Americas and Asia*

Blue Carbon and Ocean update:

- **Ocean absorption:** On September 13, 2021, Nature, published an article entitled ***Projected ocean warming constrained by observation record***. The key finding of the article is that: "*The ocean absorbs most of the excess heat from anthropogenic climate change, causing global ocean warming and sea-level rise … By 2081-2100, under [a high emission scenario], the upper 2,000 m of the ocean is likely to (>66% probability) to warm by 1,546-2,170 ZJ relative to 2005-2019, corresponding to a 17-26 cm sea-level rise from thermal expansion.*"
- **Alignment with *2021 Report*:** This finding builds on the findings in the *2021 Report* in respect of the warming of the oceans (and in the realm of Blue Carbon): "It is *virtually certain* that the global upper ocean (0-700 metres) has warmed since the 1970s and *extremely likely* that human influence is the main driver. It is virtually certain that human-caused CO_2 emissions are the main driver of current global acidification of the surface of open ocean. There is *high confidence* that oxygen levels have dropped in many upper ocean regions since the mid-20th century …".

CCS / CCUS round-up:

- **World scale DACS matched to World Scale Insurer:** Editions 25 and 26 of Low Carbon Pulse reported that the Orca project, a new direct air capture and storage (***DACS***) facility, owned by Climeworks (a Swiss corporation) that will capture up to 4,000 metric tonnes per annum of ***CO_2*** from the atmosphere (storing the captured ***CO_2*** underground), and Climeworks had signed a 10 year carbon dioxide removal purchase agreement with Swiss Re worth USD 10 million to Climeworks. On September 8, 2021, to considerable news coverage, Orca commenced operations.

  See: *Climeworks begins operations of Orca, the world's largest direct air capture and storage plant*
- ***Aramis CCC Project:*** On September 8, 2021, Energie Beheer Nederland BV (a leading natural gas corporation), Gasunie (energy network operator in the Netherlands and northern Germany), Shell Nederland and TotalEnergies announced that they have concluded a joint venture arrangement to develop transport infrastructure to allow the storage of ***CO_2*** captured in carbon industrial clusters.

  See: *TotalEnergies, Shell Netherlands, EBN and Gasunie form partnership to develop an offshore CCS-project: Aramis*
- ***Bifrost CCS Project*:** On September 10, 2021, Noreco (Norway-based oil and gas company) announced that it had entered into a joint venture arrangement to develop the ***Bifrost CCS Project*** involving the proposed use of the depleted Harald off-shore gas field located in the Danish sector of the North Sea. It is estimated the ***Bifrost CCS Project*** has storage capacity of up to 3 million metric tonnes of ***CO_2***.

  The joint venture arrangement is with Ørsted, the Technical University of Denmark and the Danish Underground Consortium (***DUC***). ***DUC*** comprises TotalEnergies (as operator), Noreco and Nordsøfonden. It is understood that the joint venture is seeking funding support from the Energy Technology Development Demonstration Program

(***EUDP***), and that the funding support sought includes funding to assess the possible use of additional depleted fields in the North Sea. The work undertaken under the ***EUDP*** would include assessment of the use of existing pipeline infrastructure haul ***CO_2*** from Denmark, and in so doing establish Denmark as a consolidate hub for CCS Hub.

See: *Noreco announces the CCS partnership Project Bifrost*

- **Interest in Norwegian Continental shelf:** On September 10, 2021, the Ministry of Petroleum and Energy in Norway announced that application could be made for two areas for injection and storage of ***CO_2*** on the Norwegian continental, under the ***CO_2 Storage Regulations*** (***CO_2 SRs***). The ***CO_2 SRs*** provide a process to allow the development of ***CO_2*** storage facilities to allow the storage of ***CO_2*** in sub-ocean floor geological structures. The deadline for the applications is stated as noon on December 9, 2021.

  On September 13, 2021, Horisont Energi announced that it had made an application for a licence to establish the Polaris ***CO_2*** storage facility of the coast of Finnmark. The Horisont Energi application is intended to store the ***CO_2*** arising from the production of Blue Hydrogen at the Barents Blue facility (to produce Blue Hydrogen and Blue Ammonia) (***Barents Blue***) reported in Edition 23 of Low Carbon Pulse - Horisont Energi, Equinor and Vår Energy have entered into a cooperation agreement to develop ***Barents Blue***, and the Polaris ***CO_2*** project has long been an integral part of the thinking around the development of ***Barents Blue***.

  See: *Announcement of areas related to CO2 storage* and Horisont Energi website

- **Acceleration of CCS roll-out required:** On September 10, 2021, Professor Jon Gibbins commented on a paper from Messrs. Welsby, Price, Pye and Ekins entitled ***Unextractable fossil fuels in a 1.5°C world***. Both the paper and the commentary from Professor Gibbins are telling, and both make it clear that CCS / CCUS requires planning and development by Governments globally to ensure that sufficient CCS / CCUS is available, and being available, Governments can mandate its use. As noted above, Edition 28 of Low Carbon Pulse will consider this is more detail.

- **Bayu-Undan CCS project takes next step:** On September 14, 2021, Santos announced that it had signed, as the operator of the Bayu-Undan Joint Venture, a memorandum of understanding (***MoU***) with the Timor-Leste regulator Autoridade Nacional do Petroleo e Minerals (***ANPM***) as the next step in the development of a CCS project to store ***CO_2*** arising from the development of the Caldita Barossa field in the depleted Bayu-Undan reservoir in the Timor Sea. This is a significant development in this key CCS project.

  See: *MOU signed on Bayu-Undan carbon capture and storage*

CO_2 storage and use:

- **A circular and interconnected world:**
  - ***CO_2* absorbed from Australia bush fires absorbed by algae:** On September 15, 2021, the New Scientist published an article titled ***Most CO_2 from Australia's megafires has been offset by algal blooms***. As with all articles in the New Scientist related to climate and the environment, the article is well-worth a read. The article reports on a study from CSIRO (Commonwealth Scientific and Industrial Research Organisation).

    The article notes that over the Southern Hemisphere summer of 2019 and 2020, over 70,000 square kilometres of Australian bush and scrub land was burned (an area the size of the Republic of Ireland). As a result, approximately 715 million tonnes of ***CO_2*** were released to the climate system (a mass of ***CO_2*** equivalent to the ***GHG*** emissions arising from anthropogenic activities in Germany each year). The article suggests that up to 80% of that mass of ***CO_2*** has been absorbed by ocean algal blooms (principally two blooms in the Pacific Ocean and Southern Oceans, covering an area twice the size of Australia).
  - **Shortage of manufactured *CO_2*:** One of the impacts of the high natural gas prices (see **High Level observations on current high energy prices** above) is that facilities producing fertiliser (the primary feedstock for which is natural gas (predominantly ***CH_4***)). As readers of Low Carbon Pulse (and sibling publications) will know, one of the by-products of the production of hydrogen from natural gas (then combined with nitrogen to produce ammonia) is ***CO_2***.

    Among other uses (in addition to beer and fizzy drinks), one of the uses for manufactured ***CO_2*** is to stun animals in abattoirs. This is the second time in three years in which the UK (and Europe) have experienced shortages of manufactured ***CO_2***. As a result of the shortage of manufactured ***CO_2***, news items have focussed in on the causes of increased natural gas prices, and the knock-on effect on energy prices and broader implications.
  - **In a world of connected carbon:** The two news items above illustrate the circular and interconnectedness of how nature can respond to the consequences of bush / scrub fires (forest fires in most parts of the world) and the impact that higher energy prices can have on other activities in an economy.

    There is not much we can do about nature, but the impact of the shortage of manufacture ***CO_2*** on food security is something to which policy settings can respond, including to provide further impetus to Government funding support for CCUS.

Spotlight on CVX:

- **CVX New Energies ACES it:** Edition 19 of Low Carbon Pulse mentioned in passing the development of the Advanced Clean Energy Storage (***ACES***) project in Delta, Utah, developed by Mitsubishi Power Americas and Magnum Development. The project contemplated will comprise a 1 GW electrolyser facility, producing 450 metric tonnes per day of clean hydrogen, with salt-caverns to store hydrogen. On September 10, 2021, Chevron New Energies (***CNE***) announced that it intends to acquire an equity interest in ***ACES***.

  See: Chevron *press release*

- **CVX tracks Caterpillar:** On September 8, 2021, Chevron Corporation (global leading international energy corporation) and Caterpillar (global leading heavy equipment manufacturer) inked an agreement under which they will work together to develop hydrogen demonstration projects to enable participation in the mobility /

transportation markets (including the use of hydrogen in the rail freight and shipping), and in the stationary power sector (in both instances for primary power). It is understood that Chevron and Caterpillar are to commence work to demonstrate hydrogen powered and propelled locomotives and hydrogen refuelling infrastructure (***HRI***).

Edition 26 of Low Carbon Pulse reported that on September 1, 2021, Caterpillar announced that it was on target to deliver electrical energy generation solutions using 100% hydrogen by the end of 2021. At the moment, Caterpillar generation solutions allow for the use of 25% hydrogen and 75% natural gas blended fuels.

See: Chevron *press release*

- **CVX on the move:** On September 14, 2021, it was reported widely that Chevron Corporation (***CVX***), leading international energy corporation (and one of the super-majors), is committed to the development of 150,000 tonnes per year of hydrogen production by 2030. Consistent with other announcements of late, ***CVX*** is targeting the supply of hydrogen to the mobility / transportation sector, and power.

  As noted in previous editions of Low Carbon Pulse (for example, Edition 26 of Low Carbon Pulse), ***CVX*** is increasing its production of renewable natural gas (***RNG***) and renewable fuels (principally in the form of biofuels), and has a CCS / CCUS and carbon offset trading business.

  For these purposes, CVX has ear-marked USD 10 billion in capital expenditure by 2028. For the time being, however, ***CVX*** has indicated that it does not intend to apply any of this capital expenditure to the development of renewable electrical energy capacity.

  See: *Chevron Accelerates Lower Carbon Ambitions*

E-Fuels / Future Fuels:

- **For richer, for PORA, green inked in:** On September 6, 2021, Port of Rotterdam Authority (***PORA***) and Uniper (leading global energy company head-quartered in Germany) announced that they had entered into an agreement to develop a 100 MW electrolyser facility (***Maasvlakte Facility***) to be located at Maasvlakte (a site occupied by Uniper), with aspirations to expand to a 500 MW electrolyser. It is understood that the electrolyser will source renewable electrical energy generated from off-shore wind fields.

  The ***Maasvlakte Facility*** will connect to the ***HyT Pipeline***. Edition 20 of Low Carbon Pulse reported on the background to the development of the HyTransport RTM pipeline (***HyT Pipeline***).

  See: *Cooperation Uniper and Port of Rotterdam Authority in production Green Hydrogen*

- **BP weighing up Kwinana Energy Hub:** On September 7, 2021, it was reported widely that BP Australia is undertaking a feasibility study to produce Green Hydrogen at the site of its Kwinana refinery, working with leading renewables energy and hydrogen adviser and participant Macquarie Group. While this may be regarded as early days, the repurposing of the Kwinana site, and the supportive policies of the Western Australian Government, may be regarded positively, including the possibility of the development of Kwinana as a hydrogen hub and carbon cluster.

  See: *bp Australia is undertaking a feasibility study into the production of Green Hydrogen at its Kwinana site in Western Australia, in partnership with Macquarie Capital and with funding from the Western Australian Government*

- **JERA commences hydrogen firing:** Previous editions of Low Carbon Pulse have reported on the plans of JERA Co., Inc. (***JERA***) to test the use of hydrogen combined with natural gas to generate electrical energy.

  On September 7, 2021, it was reported widely that, from October 2021, ***JERA*** (leading Japan based energy company) intends to commence testing the use of hydrogen at power plants currently fired by natural gas sourced from the import of liquid natural gas (***LNG***). The testing and evaluation of the use of hydrogen will continue from October 2021 to March 2026.

  On the basis of the results of testing and evaluation, ***JERA*** will make a decision as to the development of facilities to allow co-firing of hydrogen and natural gas (30% to 70%) by 2025.

- **Danish Green Island Green Light:** Edition 9 of Low Carbon Pulse reported on the development of a Green (Power) Island (***Green Island***) in the Danish sector of the North Sea. In early September 2021, it was reported that the Danish Parliament had agreed upon the way forward for the development of the ***Green Island***.

  Under the final agreement, the Danish State is to retain a 50.1% interest in the ***Green Island***, and the criteria for the development are clear, including that the terms of development must provide the lowest prices to Energinet (the Danish national energy system operator). It is understood that this agreement will pave the way for the release in 2022 of a tender to develop the ***Green Island***.

  Following the announcement of the agreement of the Danish Parliament, prospective tenderers are emerging, including Ørsted and ATP.

- **Porsche on the road:** Edition 21 of Low Carbon Pulse reported on the development of the Haru Oni project at Punta Arenas, Chile (***Hari Oni Project***), to produce synthetic methanol (E-Methanol in this instance) from Green Hydrogen, called Green Methanol (as an E-Fuel). On September 10, 2021, Porsche AG announced that construction of the ***Hari Oni Project*** has commenced with a ground breaking ceremony at site.

  See: *Construction begins on world's first integrated commercial plant for producing nearly CO2-neutral fuel in Chile*

- **Ukraine route to new markets:** On September 8, 2021, it was reported widely that Eustream (Slovakian based natural gas pipeline network owner and operator) has joined a joint venture to develop a supply chain from Green Hydrogen production facilities in Ukraine to Austria and Germany, and other central European markets (***H2EU+Store***). ***H2EU+Store*** comprises key players, including Bayerngas GmbH, Bayernets GmbH, Eco-Optima LLC, Open Grid Europe GmbH and RAG Austria AG.

- **Giants aligned:** On September 8, 2021, it was reported widely that Mitsubishi Corporation (leading Japanese engineering, manufacturing, and infrastructure and trading corporation) and Shell Canada signed a memorandum of understanding to produce low-carbon hydrogen.

  See: *Mitsubishi Corporation and Shell sign MoU to collaborate on hydrogen plans in Alberta*

- **Two more Giants aligned:** On September 10, 2021, ENEOS Corporation (leading hydrocarbon importer into, and refiner in, Japan) and Petronas (the national oil company of Malaysia) signed a memorandum of understanding (***MoU***) for the development, jointly, of a competitive clean hydrogen supply chain between Malaysia and Japan.

  The press release from Petronas states: "*The MoU will see both parties embark on a technical -commercial joint-study of hydrogen production and transportation of methylcyclohexane [(**MCH**)] form, where hydrogen is converted from its original gaseous state into a liquid form to enable large volume deliveries*".

  Edition 26 of Low Carbon Pulse reported that ENEOS Corporation and Origin Energy had agreed to undertake jointly a study to develop a hydrogen and hydrogen-based energy carrier supply chain from Origin Energy's Green Hydrogen facility at Gladstone, Queensland, Australia and terminating at ENEOS Corporation refineries in Japan. Part of the study includes the use of Green Hydrogen to produce ***MCH***.

  See: *PETRONAS and ENEOS Expand Energy Partnership To Include Hydrogen Business*; *ENEOS Begins Collaborative Studies and Researches with PETRONAS Group toward the Development of a CO2-Free Hydrogen Supply Chain*

- **Low Carbon Hydrogen Hub Plans accelerate:** On September 13, 2021, it was announced that plans of Essar Oil UK to derive increased quantities of hydrogen from its Stanlow Manufacturing and Refining Complex at Ellesmere Port, Cheshire, England, were progressing with a planning application lodged which if granted (as expected) will allow the introduction of natural gas and oxygen to derive 3 TWh of clean hydrogen from 2025. This level of production is planned to increase to 9 TWh by 2030 , equivalent to 80% of the UK Government target of 5 GW of low carbon hydrogen production capacity by 2030. Essar Oil is working with Progressive Energy Limited, which is leading the HyNet North West project (see Edition 25 of Low Carbon Pulse for details).

  See: Essar Oil *website*; Progressive Energy *website*; HyNet North West *website*

- **Shelling out:** On September 16, 2021, Royal Dutch Shell announced plans to develop a 820,000 metric tonne per year biofuels plant in Rotterdam, the Netherlands, as part of its commitment to progress to achieving ***NZE*** by 2050. The biofuels plant is scheduled to commence production in 2024.

  It understood that the biofuel plant will produce sustainable or synthetic aviation fuel (***SAF***), accounting for around 50% of its production capacity, with the balance being renewable diesel. It is intended that the feedstock for the production of the bio-fuels will be waste vegetable fuels, waste animal fats, and other residual waste materials, with feedstock derived from fuel crops (including rapeseed) to be used to supplement feedstock derived from waste.

  See: *Shell to build one of Europe's biggest biofuels facilities*

Green Metals and Minerals, the Mining Industry and Difficult to Decarbonise industries:

In addition to the news item above about ***CVX*** and Caterpillar, **Giants aligned:** On September 14, 2021, Engie (leading international energy corporation) and Liebherr (leading high value engineering and manufacturing corporation) announced that they are partnering to offer carbon neutral solutions to the mining industry, based on the deployment of hydrogen use.

The two corporations bring distinct and market leading strengths, in particular in the remote mine site sector of the industry: Engie brings remote renewable electrical energy expertise and hydrogen and hydrogen-based supply chain know-how, and Liebherr brings its market leading reputation of heavy-duty mining equipment supply.

See: *Liebherr and ENGIE partner to offer carbon-neutral solutions for the mining industry*

Hydrogen Cities, Councils, Cluster and Hubs, Infrastructure and Valleys:

- **Green Hydrogen Valley:** On September 15, 2021, it was announced that three new hydrogen production facilities were to be developed, with a combined capacity of 220 MW, as part of broader plans to develop a Green Hydrogen Valley in the Foggia area of the Puglia region of Italy (***Puglia Green Hydrogen Valley***). Each of Brindisi (60 MW), Cerignola (80 MW), and Taranto (80 MW) to site one of the hydrogen production facilities.

  Leading Italian corporations, Alboran Hydrogen with 30%, Edison with 30%, Saipam with 10%, and Snam with 30%, have combined resources to establish a single purpose vehicle (***GHSPV***). The ***GHSPV*** will develop the Green Hydrogen production facilities, with the hydrogen to be used in the local mobility / transport market, by local industry, and to for blending with natural gas into the Snam natural gas pipeline network.

  See: *Edison and Snam alongside Saipem and Alboran for the Green Hydrogen valley project in Puglia region*; Alboran Hydrogen *website*; Edison International *website*; Snam *press release*

- **Giga-factory update:** It has been the plan for a while to include a feature on giga-factories in an edition of Low Carbon Pulse. Given the space and word count taken by outlining trends and matters of policy ahead of COP-26, Editions 25 and 26, and this Edition 27, of Low Carbon Pulse have been weighty. A future edition of Low Carbon Pulse will include a feature on both giga factories and charging and refuelling infrastructure.

Wind round-up:

- **Iberdrola positions for Taiwan 6 GW off-shore wind pipeline:** On September 9, 2021, Iberdrola (leading global energy company) announced that it was establishing itself formally in Taiwan to facilitate its participation in "the Zonal Development offshore wind procurement". Iberdrola has invested in work ahead of the "Zonal Development" auction rounds under which offshore wind procurement will be undertaken. For these purposes, Iberdrola has undertaken work in respect of the Da-Chung By, Guo-Feng and Ju-Dao off-shore wind field areas. It is understood that the water depths will allow a choice of fixed-bottom or floating off-shore wind technologies.

See: *Iberdrola expands in Asia-Pacific with development of 6GW pipeline in Taiwan*

- ***GWEC 2021 Report*:** As noted above, the Global Wind Energy Council has released the ***GWEC 2021 Report***. The highlights of ***GWEC 2021 Report*** are as follows: **1.** 2020 was a good year for the installation off-shore wind installation despite COVID-19, with the second highest level of installations, following the record high of 2019; **2**. Off-shore wind is regarded as having the greatest growth potential, and that to realise this potential, new and improved policy settings are needed; **3.** Currently installed off-shore wind capacity is 2% of the level required for there to be assurance of achieving ***NZE*** by 2050; and **4.** Currently is it possible to project the installation of a further 235 GW of off-shore wind capacity by the end of the current decade.
- **UK provides basis for "biggest ever" auction::** On September 13, 2021, the UK Government announced details in respect of the fourth round of its award of ***contracts for differences*** or ***CfDs*** (see Edition 17 of Low Carbon Pulse for an explanation of ***CfDs***). Of particular interest in the announced from the Department of Business, Energy & Industrial Strategy is the backing for off-shore wind field development, both fixed-bottom and floating.

  As reported in Editions 9 and 13 of Low Carbon Pulse in respect of third round for the award of ***CfDs***, this resulted in the successful auction of areas for off-shore wind field development around the coast of England and Wales. The use of ***CfDs*** as a policy setting has been the key factor in the development of renewable electrical energy capacity within the UK.
- **Ocean Winds (*OW*) and Aker Offshore Wind (*AOW*):** On September 14, 2021, energyvoice, reported that ***OW*** and ***AOW*** had shared details of their planned development of a 6 GW floating off-shore wind field in the Outer Moray Firth, off the east coast of Scotland. It is understood that the details shared reflect the terms of the ***OW*** and ***AOW*** response to the ScotWind Leasing Scheme. The scale of the planned development would revolutionise the floating off-shore wind industry.

Land Transport (automobiles, buses, trains and trucks) round-up:

- **Automobiles:**
  - **NY zeros in:** On September 8 2021, New York Governor, Ms Kathy Hochul signed legislation requiring cars and light duty trucks / vans to be zero-emission from 2035, and medium and heavy trucks to be zero-emission by 2045. As such New York becomes the second state to commit in these terms, after California. Earlier in September 2021, Los Angeles City committed on similar terms.
  - **Mercedes-Benz and Volkswagen decision**: Both Mercedes-Benz and Volkswagen have indicated that they do not intend to develop fuel cell electrical vehicles (***FCEVs***). This reflects the view that ***FCEVs*** do not achieve the required level of efficiency when used to power and to propel cars.
- **Buses:** As reported in Edition 22 of Low Carbon Pulse, Lord Mayor of London, Mr Sadiq Khan, announced the commencement of the use of fuel cell technology (***FCT***) buses in London. On September 18, 2021, it was reported widely that Mr Khan announced that all buses procured for use in London would be zero-emission vehicles.
- **Keeping track of rolling stock**:
  - **France deploys hydrogen passenger train:** Edition 26 of Low Carbon Pulse reported that on August 25, 2021, an Alstom Coradia iLint passenger train had been deployed in Östersund, Sweden. The Alstom Coradia iLint passenger train is powered and propelled using ***FCT*** (that oxidises hydrogen to generate electrical energy). Alstom Coradia iLint trains have been deployed in Austria, Germany and the Netherlands, and are to be deployed in Italy.

    On September 6, 2021, the Alstom Coradia iLint passenger train debuted on French railways. Some of the coverage of the debut was interesting, allowing the casual reader to assume that this was the second coming of the steam engine.

    See: *Alstom's Coradia iLint hydrogen train runs for the first time in France*
- **Hyundai on the road:**

  To being carbon-neutral road for 2045: On September 6, 2021, Hyundai Motor Company (***HMC***) announced that it planned to become carbon-neutral by 2045. For these purposes, ***HMC*** noted its intention to place emphasis on the hydrogen value chain and the scaling up of ***FCEV*** technology and production. As noted in previous editions of Low Carbon Pulse, ***HMC*** is at the forefront of the development and deployment of ***FCEV***, and as such this announcement may be regarded as a natural next step.

  In addition to progressing to carbon-neutrality, ***HMC*** has announced its Vision 2040 to popularise the use of hydrogen for "Everyone, Everything and Everywhere". As noted above, ***HMC*** is one of the founding members of the KHA.

  See: *Hyundai Motor Presents Carbon Neutral Commitment at IAA Mobility 2021*
  - **And ports side with a drone:** On September 9, 2021, HMC unveiled the e-bogie. The e-bogie is a hydrogen powered and propelled container transportation system with the ability to steer front and back, and to move sideways. The e-bogie is intended for use port side and in confined urban environments. The e-bogie is able to transport alone or in a cluster with other e-bogies.

    See: *Hyundai Motor Group Presents Its Vision to Popularize Hydrogen by 2040 at Hydrogen Wave Forum*
- **Hyzon busy sales continue, and listing achieved:**
  - **500 FCEV sold to Shanghai:** On September 9,2021, Hyzon Motors Inc. announced that it had signed a memorandum of understanding (***MoU***) for the supply of 500 hydrogen powered fuel cell technology trucks to Shanghai Hydrogen HongYun Automotive. It is understood that the ***MoU*** contemplates firm orders by the end of 2021 for the delivery of 100 ***FCEVs***, and orders in 2022 for a further 400 ***FCEVs***.

    See: *Hyzon Motors to supply up to 500 hydrogen fuel cell electric vehicles to Shanghai logistics company*

- **HoA to VSA:** Edition 22 of Low Carbon Pulse reported on a heads of agreement between Ark Energy Corporation (a subsidiary of Korea Zinc) for the supply of five 154 tonne ***FCT*** trucks. On September 14, 2021, Ark Energy Corporation announced that it had entered into a vehicle supply agreement with Hyzon Motors, Inc. for the supply of five 140 tonne ***FCT*** trucks by the end of 2022 to haul to and from the Sun Metals Corporation zinc refinery.

- **IVECO and Nikola**: Previous editions of Low Carbon Pulse reported that IVECO was committed to the development of ***FCT*** trucks. On September 16, 2021, IVECO and Nikola (leading fuel cell technology corporation) announced the development of a new ***FCT*** truck manufacturing facility in Ulm, Germany. The first ***FCT*** truck to be manufactured at the Ulm facility will be the Nikola Tre battery-electric and ***FCT*** powered and propelled truck, based on the IVECO S-Way track and incorporating Bosch-designed components. Earlier in September, Nikola agreed a licencing agreement with Bosch.
- **KIA to provide Military Hydrogen Fuelled Electric Vehicle:** On September 14, 2021, it was announced that Kia Motors (Korean vehicle manufacturer) had developed military ***FCEV***, and that it is to launch non-military ***FCEVs*** in 2028.

Port News and Shipping Forecast:

- **Windship head of wind:** Edition 21 of Low Carbon Pulse reported on the development of the windship. On September 6, 2021, it was reported widely that Windship Technology had received Approval in Principle (***AIP***) from international shipping classification society, ***DNV***. An ***AIP*** provides an expert assessment of the basis for development of a vessel.
- **BP and NYK Line align on F/Fuels:** On September 15, 2015, it was reported widely that BP (leading international energy company) and NKY Line (leading global shipping company), had agreed to cooperate in relation to the development of future fuels, including hydrogen and hydrogen-based fuels. It is understood that LNG and biofuels are being considered, and potentially ammonia and methanol.

  See: *bp and NYK Line join forces to help decarbonise hard-to-abate sectors;* NYK Line *press release*
- **Hydrogen and hydrogen based fuels from Tromsø:** On September 16, 2021, H2view, reported that Magnora ASA, Prime Capital and Troms Kraft are to develop a large-scale Green Hydrogen production facility in Tromsø. As might be expected, the Green Hydrogen produced at the facility will be used as a feedstock for the production of Green Ammonia, and possibly other hydrogen-based fuels, to be used as bunkers.

Aviation and Airports:

The purpose of this section of Edition 27 of Low Carbon Pulse is to provide an update of news items within the last two weeks (***Recent News***) and from the start of July (***Past News***). Given the word count and length of this Edition 27 of Low Carbon Pulse, ***Recent News*** is outlined. Edition 28 of Low Carbon Pulse will include ***Past News***.

- **Recent News:**
  - **100% Sustainable Aviation Fuel by 2050:** On September 9, 2021, the Biden Administration announced plans to achieve "a fully zero-carbon aviation sector by 2050". This will be achieved incrementally, with the production of at least 3 billion gallons of sustainable fuel that will enable aviation emissions to drop 20% by 2030, when compared to business as usual. The key policy settings to support these targets include the new and ongoing funding opportunities to support sustainable aviation fuel projects and fuel production of up to USD 4.3 billion;
  - **Continuous Lower Energy and Noise Program:** On September 10, 2021, it was reported widely that the Federal Aviation Administration (***FAA***) has committed to grants worth more than USD 100 million for the purposes of making aviation more environmentally sustainable (through the reduction of ***GHG*** emissions) and less noisy;
  - **Hyzon Motors Inc. flying:** On September 10, 2021, it was reported widely that ZeroAvia has contracted with Hyzon Motors Inc. for the supply of fuel cell stack systems for trucks to allow assessment of their use as part of its zero-emission aircraft development program. The attraction of the Hyzon full cell stack system is its energy / power density by volume of 6.0 kW per litre of hydrogen; and
  - **Stuttgart, Germany, to Melbourne, Australia on 18 tonnes of fuel:** On September 15, 2021, it was reported widely that, based on modelling by easy-jet and the German Aerospace Centre, an Airbus A320 could fly from Stuttgart to Melbourne on 18 tonnes of liquid hydrogen.

Low Carbon Pulse - Edition 28

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Business as usual: Welcome to **Edition 28** of Low Carbon Pulse – sharing significant current news on progress towards net-zero greenhouse gas (***GHGs***) emissions globally. This edition covers the period from Monday September 20, 2021 to Sunday October 3, 2021 (inclusive of each day).

Please click here for Edition 27 of Low Carbon Pulse. Please also click here and here for the first two articles in the ***Shift to Hydrogen Series*** (***S2H2***)***: Elemental Change*** series: the ***S2H2*** series provides a narrative and perspective on hydrogen generally. Please **click** here for the first feature in the ***Hydrogen for Industry*** (***H24I***): the ***H24I*** features provide an industry by industry narrative and perspective.

The third and fourth articles in the ***S2H2*** series will be published over the couple of months. The third article will be on ***Hydrogen Plans, Roadmaps, and Strategies***, and the fourth article will be on ***CCS / CCUS***.

Edition 28 of Low Carbon Pulse will be posted again on **October 8, 2021** for those reading later in the week.

An anniversary: Edition 1 of Low Carbon Pulse was published on October 6, 2020, covering the seven day period from September 27, 2020 to October 4, 2020. To mark the anniversary of Edition 1, the ***Global Ashurst Towards Zero Emissions*** team is preparing a review of the last 12 months, and a preview of the next 12 months, looking at key themes and trends. The review will link to Editions 1 to 28, consolidated into the ***Low Carbon Compendium***, and to each paper, report and study referenced in Low Carbon Pulse.

Progress to COP-26:

- **A Climate Week:**
  - **UN General Assembly:** The week beginning September 20, 2021, saw the United Nations General Assembly in full-session (alongside Climate Week NYC). This year's United Nations General Assembly is the first since 2014 to have the benefit of an assessment report from the Intergovernmental Panel on Climate Change (***IPCC***), the ***Sixth Assessment Report – Climate Change, The Physical Science Basis*** (***2021 Report***). While the ***2021 Report*** will not have changed the agenda, it has added a sense of urgency.

    In light of the ***2021 Report*** and the approach of COP-26 from November 2 to November 12, 2021, the business of the United Nations General Assembly focussed on climate change, and for the first time in 40 years, there was a leader-lead meeting under the auspices of the United Nations General Assembly (the ***UN High-Level Dialogue on Energy***).

    There was some good news from the United Nations General Assembly. The Peoples Republic of China (***PRC***) announced that it will cease to provide support for the development of coal-fired power stations (under One-Belt-One-Road (***OBOR***)), and Turkey is to ratify the Paris Agreement (and on ratification all of the G20 countries will have ratified the Paris Agreement).

    For a number years now, Climate Week NYC has been a fixture in the calendars of the great and good, coinciding with the United Nations General Assembly sessions.
  - **Climate Week NYC:** Ahead of COP-26, this year's Climate Week NYC (***CWNYC***) may be regarded as a pre-COP-26 meeting, and of particular significance given the expectations ahead of COP-26. As will be apparent from the piece on **Trending Issues** (below) we have touched on some of the subject matter emerging from ***CWNYC***.

    As ***CWNYC*** drew to a close many organisations and publications provided their assessment of the week, and the actions and themes arising from it. Rather than seek to summarise the many actions and themes, a selection of links is included: breakthrough energy, canarymedia, GeekWire, ING, World Resources Institute, Impakter, GSK.

During ***CWNYC***, the following came to the attention of the author of Low Carbon Pulse: National Grid (US electrical energy, natural gas and clean energy corporation, with networks across Massachusetts, New York and Rhode Island) shared its thinking on how best to develop the hydrogen economy in New York, including the use of Long Island as a hydrogen hub (see *Developing the Hydrogen Economy in New York*).

- **One week NYC, the next Milan:** As the United Nations General Assembly and ***CWNYC*** concluded their climate change agenda, the focus ahead of COP-26 increased with a formal three day Pre-COP-26 meeting the following week in Milan, Italy (noted in Edition 15 of Low Carbon Pulse). It is clear that there is an ever increasing weight of expectation, ahead of COP-26.

- **Trending Issues:**
  - **Tracking to 2.7°C:** UN Secretary General, Mr Antonio Guterres pulled no punches in his address to the United Nations General Assembly. Mr Guterres expressed extreme concern, critically, that the world is on a catastrophic pathway to a ***2.7°C*** increase in average global temperatures compared to pre-industrial times (***Catastrophic Pathway***) without significant and immediate increases in the rate of ***GHG*** emission reductions. As is readily apparent from the science based reports: greater ***GHG*** emission reductions are needed, and the rate of those reductions needs to increase. No matter the direction from which discussion is approached, the discussion needs to coalesce around "greater and faster reductions".
  - **Keeping fossil fuels in the ground:** It appears likely that at COP-26 an alliance will be established called the ***Beyond Oil and Gas Alliance***: an alliance of countries that will seek to persuade other countries not to develop oil and natural gas reserves, even those proposing to use CCS and CCUS. At the moment, Costa Rica and Denmark are co-leading the move to establish the ***Beyond Oil and Gas Alliance***. In December 2020, Denmark committed to cease licensing natural gas and oil exploration. Both Costa Rica and Denmark recognise the magnitude of the task to persuade countries to take the same step taken by Denmark.
  - **Natural gas, in or out or in until phased out?**
    - **High prices driving debate:** The role of natural gas in progress towards the achievement of ***NZE*** has been a matter of debate for some time. That debate is now front-and-centre ahead of COP-26.
    - The central position assumed by the debate is a function of the high price of natural gas as both a fuel and a feedstock in global markets, the resulting impact on electrical energy prices, and, in some markets, the impact of a downturn in fertiliser production, and the reduction in manufactured carbon dioxide as a by-product of fertiliser production (see Edition 27 of Low Carbon Pulse under ***CO_2* storage and use**.)
    - As noted in Edition 27 of Low Carbon Pulse, the reasons for the current high levels of natural gas prices are multiple, and multi-faceted. There are many papers, reports and studies (and theories) about natural gas prices. On September 30, 2021 and October 1, 2021 LNG spot prices and natural gas prices in Europe reached record levels. The Oxford Institute for Energy Studies publication, ***Why Are Gas Prices So High?*** (***OIES Report***) is a dispassionate take on the dynamics, including the context.
    - **Natural gas and *GHG* emissions:** The extraction, processing, transportation, and use of natural gives rise to methane (***CH_4***) and carbon dioxide (***CO_2***) emissions. Progress towards achievement of ***NZE*** requires the reduction in ***CH_4*** and ***CO_2*** emissions: this is achieved as human activities are decarbonised, which in turn requires the installation of up to 10,000 GW of dispatchable renewable electrical energy and the production of up to 600 million metric tonnes per annum (***mmtpa***) of hydrogen (as fuel and as feedstock for hydrogen based fuels), and storage solutions for renewable electrical energy (***BESS***) and hydrogen and hydrogen-based fuels (***HESS***). The required build-out of renewable electrical energy capacity is going to take time, and there is a role for natural gas in the meantime.
    - **Natural gas integral to energy transition:** For some time, Global Ashurst Towards Zero Emissions team members have held the view that natural gas is a transition fuel. Among other things, this is informed by the everyday roles that those team members have working on natural gas and LNG project developments around the world, while at the same time working on the development of renewable electrical energy projects, and hydrogen and hydrogen-based fuel and feedstock projects.
    - Three members of the Global Ashurst Towards Zero Emissions team authored an article in August 2020 entitled ***The Future of LNG and Natural Gas Infrastructure***, expressing the view that natural gas should be regarded as integral to energy transition to achieve ***NZE***. The basis for this assessment is outlined in that article, but at its core is the need to continue electrification, the role of natural gas fired power generation in "filling the gap" until sufficient renewable electrical energy and hydrogen and hydrogen-based fuel and feedstock capacity has been developed, and the impact of any foreclosure on the use of natural gas as a matter of policy – increased tightness in the supply of natural gas, and the price pressure that will result.
    - **Tightening and tight natural gas supply:** Given the medium to long term sentiment around the use of natural gas, including as manifest in some existing policy settings, the supply side of the market will not respond to the current and prospective tightness in supply by the development of new natural gas resources, rather the supply side will use the higher natural gas prices to invest in progress towards ***NZE*** (and to generate healthy rates of return to shareholders).

      In the context of the Ashurst August 2020 publication, and since, the perspective of the author of Low Carbon Pulse is that pragmatism is required, because natural gas is required for electrical energy generation and as a feedstock to produce Blue Hydrogen. The issue is, for how long.

      At various points, Low Carbon Pulse has expressed this perspective. In the context of keeping the lights on, accelerating development of renewable electrical energy, and continuing in the context of the development of supply of and demand for hydrogen and hydrogen-based fuels in tandem, the role for Government, both as policy setter and as participant, has been noted (most recently in Edition 27 of Low Carbon Pulse under ***Roles to be played to reduce GHG emissions***). Over the weekend of October 2 and 3, the UK Prime Minister Mr. Boris Johnson "hit the nail on the head": accelerate the rate of development of renewable electrical energy, and the faster this is done, the shorter the transition for natural gas.

The policy settings and the role of Government as a participant need to be woven into broader energy strategies. This is known, and is happening in a good number of countries with increasing success, but there seems to be a blind spot or reluctance to look to see a role for natural gas.

- **Pragmatism required, critically from Governments:** There is not a right or wrong in this debate, it is a debate from which pragmatic policy setting and market definition needs to emerge, including encouraging the development of lower to low carbon intensive natural gas resources (reservoirs with lower or low ***CO_2***), carbon capture and storage or carbon capture and use, as part of Government CCS / CCUS sponsored developments, continuing, and accelerating the increased regulation of fugitive emissions (including monitoring, and carbon pricing signals), and having an integrated, and clear, energy plan on a country by country, and, as appropriate, on an economic bloc by economic bloc, basis.

  The role of CCS / CCUS in extracting and processing of natural gas, and in production of liquified natural gas (***LNG***), is an area that offers considerable potential to reduce ***GHG*** emissions, at least in respect of Scope 1 emissions. In respect of ***GHG*** emissions arising on use of natural gas, this is a policy setting best left for the country in which the natural gas is used, including through a carbon price and other policy settings, including the use of negative ***GHG*** emission initiatives (***NGHGIs***). Continuing a narrative commenced in Edition 27 of Low Carbon Pulse, deployment of ***NGHGIs*** is an area for immediate action, with the use of ***NGHGIs*** to lessen the impact of natural gas, and, as the role of natural gas lessens through energy transition, the benefit of those ***NGHGIs*** will be realised globally on an ongoing basis.

- **Energy Planning required:** As noted above, broader energy strategies are needed. As noted by Mr Mark Carney, former Governor of the Bank of England, and currently a United Nations Envoy on Climate Change, it is the responsibility of governments to set policy to achieve the required response to climate change through "clear, credible and predictable regulation" (see Edition 22 of Low Carbon Pulse, under ***Free Markets will respond to policy settings, but do not set policy***). The imperatives of energy markets are not energy transition to achieve ***NZE***, while ensuring energy security!

  On September 25, 2021, the CEO of ENI SpA, Mr Claudio Descalzi is reported to have told La Republica newspaper that the European Union (***EU***) needs a long term energy plan, critically, to achieve energy security. It is difficult to argue with this. (ENI SpA is a leading global international energy corporation.)

  Among other things, any energy plan could provide certainty for the supply of natural gas in a way that provides natural gas producers with certainty under term supply contracts, and that dovetails with the development of renewable electrical energy and ***BESS***, and hydrogen and hydrogen-based fuel and feedstock and ***HESS***, and ultimately the phasing out of natural gas use, other than in circumstances in which its production and use achieves outcomes consistent with ***NZE***.

  In the evolutionary chain of progress to ***NZE***, there is a missing link, an energy plan, implemented by "clear, credible and predictable regulation".

- ***UN High-Level Dialogue on Energy*****:** On September 24, 2021, the ***UN High Level Dialogue on Energy*** took place, the first meeting of its kind in 40 years. While it was high energy, the general consensus from the news feeds was that the energy levels need to increase in the lead up to and at COP-26.

  In the context of the ***UN High Level Dialogue on Energy***, it is reported that USD 400 billion of new commitments were announced to increase the level of renewable electrical energy development, and new electrical technologies (including for cooking). The following link is to the United Nations, UN News, Climate and Environment, coverage, and a high-level summary of the new commitments.

  As noted in previous editions of Low Carbon Pulse, the focus of Low Carbon Pulse is not to track the achievement of the UN Sustainable Development Goals, but a key feature of the ***UN High Level Dialogue on Energy*** was the achievement of Sustainable Development Goal 7 (clean energy access for all by 2030).

  This is relevant both from the economic and social development perspective and from the ***NZE*** perspective: at the same time as countries are progressing to reduce ***GHG*** emissions, the level of electrification needs to increase globally, to provide electricity to the 800 million to 1.2 billion people who currently do not have access to electrical energy. (The author notes that the 800 million figure is used most frequently.)

  It is important to understand that the transition from fossil fuel to renewable sources of electrical energy is taking place at the same time as hundreds of millions of people will have access to electrical energy for the first time.

  In other words, in a world seeking to achieve ***NZE***, this is not a zero sum game of itself, because at the same time that we are trying to replace fossil fuel electrical energy generation with renewable electrical energy generation capacity, we are trying to increase access to electrical energy to those that do not have access. Add to this the likely role of natural gas, and it is not a zero-sum game in terms of being able to use renewable electrical energy to achieve these outcomes.

  In this context, natural gas appears likely to have a key role to play in the electrification of developed and developing countries with increasing population growth and urbanisation (including countries like Bangladesh and Pakistan) where the deployment of gas-fired powered stations may be regarded as more likely achieve a balance between electrification and ***GHG*** emissions on a planned basis, not to the exclusion of renewable electrical energy, but alongside it.

- **Increased reductions and rate of them:** As noted in Editions 26 and 27 of Low Carbon Pulse, there is a real and ready understanding that it is going to be a challenge to peak, and then to reduce, ***GHG*** emissions so as to limit the increase in average temperature globally to ***1.5°C*** above pre-industrial levels (what Low

Carbon Pulse has called the ***Stretch Goal***), and, currently, it is more likely that we will enter the ***1.5°C*** to ***2°C*** range (the ***Stabilisation Goal***). In other words, the achievement of the ***Stretch Goal*** is nearly out of reach, and the achievement of the ***Stabilisation Goal*** is "touch and go" at best.

As noted above, UN Secretary General, Mr Antonio Guterres (in pulling no punches in his address to the United Nations General Assembly) said that the world is on a catastrophic pathway to a ***2.7°C*** increase in average temperature globally (***Catastrophic Pathway***).

In the context of the ***Stretch Goal***, ***Stabilisation Goal*** and the ***Catastrophic Pathway***, a S&P Global Sustainable Report (drawing on Platts Analytics Future Energy Outlooks analysis), emphasises what is required to be able to achieve medium and longer term targets: it is necessary to concentrate on what needs to be done in the near term, and to granularize it.

In the twilight zone between near and medium term, the S&P Global Sustainable Report provides examples of what is required by 2025 to achieve the ***Stabilisation Goal***: for example, relative to 2019, by 2025, electrical energy from solar and wind sources need to increase by 98% and 133% respectively, the electrical energy sector and the transportation sector need to reduce ***GHG*** emissions by 7% and 1%, and on a country by country basis, the ***PRC*** needs to reduce ***GHG*** emissions from coal-fired electrical energy generation by 6%, and the US needs to reduce ***GHG*** emissions from coal by 2%, natural gas by 11%, and oil by 8%.

These metrics are illustrative and, on their face, the achievement of them may appear straight-forward. Each sector and country needs to achieve reductions in ***GHG*** emissions by 2025. If the required reductions in ***GHG*** emissions are to be achieved by 2025, consistent with the achievement of targets by 2030 through 2050, we may avoid the ***Catastrophic Pathway***.

- ***NZE* not enough, *CDR* required now:** Edition 27 of Low Carbon Pulse covered the role of Carbon Credits / Permits. Boiling down the narrative in Edition 27 to its essentials, there is a need to commence negative ***GHG*** emission initiatives (***NGHGEIs***) as soon as possible.

  NGHGEIs should be used to achieve absolute reductions in ***GHG*** emissions (i.e., there are fewer ***GHG*** emissions in the climate system as a result of the initiative than before, hence the naming negative greenhouse gas emission initiatives).

  To achieve and to sustain absolute reductions, the reductions arising from any ***NGHGEI*** should not be capable of being used to off-set ***GHG*** emissions elsewhere.

- **Point to reflect upon:** The *reduction* in ***GHG*** emissions is distinct from the *removal* of carbon dioxide (or Carbon Dioxide Removal (***CDR***)): the reduction in ***GHG*** emissions involves the decarbonisation of activities that would give rise to ***GHG*** emissions emitted to the climate system, but for that decarbonisation, ***CDR*** involves the removal of ***GHG*** emissions that have been emitted to the climate system. Both ***GHG*** emission reductions and ***CDR*** are contemplated in Article 4 of the Paris Agreement.

  The need for ***NGHGEIs*** reflects that fact that the achievement of ***NZE*** is not going to be sufficient to achieve the core objectives of the Paris Agreement (see the italicised text in respect of the extract from the text of Article 4).

CORE OBJECTIVES OF THE PARIS AGREEMENT	
Article 2: (a) Holding the increase in global average temperatures to well below 2°C [***Stabilisation Goal***] above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C [***Stretch Goal***] above pre-industrial levels, recognising that this would significantly reduce the risk and impacts of climate change.	**Article 4:** In order to achieve the long-term temperature goal set in Article 2, Parties aim *to reach global peaking of greenhouse gas emissions as soon as possible*, … and to undertake *rapid reductions thereafter in accordance with best available science*, so as to achieve a balance between anthropogenic emissions by sources and *removals to sinks in greenhouse gas in the second half of this century* … .

(**Note on Article 4**: Article 4 contemplates "peaking of greenhouse gas emissions as soon as possible and to undertake rapid reductions thereafter". This should not be read to preclude removal of ***CO_2*** (to sinks) to achieve reductions before peaking or before achievement of ***NZE***, in particular to preclude use of ***NGHGIs*** at any time.)

- **Ahead of COP 26:** As COP-26 approaches, certainly since the start of August 2021, this long standing objective, and the means to its achievement, ***NGHGIs***, has received increased news coverage, including recently a news item in Fortune magazine, under ***Net zero isn't enough. We need to get to net negative***.

  It is important to note that while the increased news coverage is new, the objective is not. Awareness of the need to achieve ***net negative gas house gas emissions*** is increasing, but it still appears to be filed in the "to do tray".

  As COP-26 approaches, the need for "net negative initiatives" appears to be moving from the "to do tray" into "pending". Hopefully, during COP-26, it will moved to the "do today tray". It is certainly on the agenda.

- **Roles to be played to reduce *GHG* emissions – Role of *IECs* and *NOCs***
  - **Concentration of *IECs* and *NOCs*:** As foreshadowed in previous editions of Low Carbon Pulse, ahead of COP-26, current and relevant matters will be considered in Low Carbon Pulse, including the roles to be played by key players.

    This Edition 28 of Low Carbon Pulse covers the roles of International Energy Companies (***IECs***) (formerly international oil and gas companies (***IOCs***)) and National Oil Companies (***NOCs***).

    This reflects their importance. While there are multiple roles to be played, by multiple players, in achieving progress towards ***NZE***, without the transition, some may say transformation, of the businesses of ***IECs*** and ***NOCs***, it is not possible to achieve ***NZE***. It is important to recognise that ***IECs*** and ***NOCs*** have a central role to play. To provide a balanced view, it is the world's use (a function of supply and demand) of hydrocarbon fuels that has contributed to climate change. This remains the case.
  - **Background: *IECs*** and ***NOCs*** have long been essential to the production of energy carriers from hydrocarbons, including motor spirit (gasoline and petroleum) from oil to power and to propel motor vehicles and natural gas to heat homes and to fuel gas-fired power stations. Many of the world's largest corporations have been, and remain, oil and gas corporations. ***IECs*** and ***NOCs*** recognise that energy transition is upon them, and is critical to progressing to ***NZE***. Around 75% of global ***GHG*** emissions arise from the extraction, production and use of fossil fuels, principally, coal, and oil and natural gas.

    IECs and ***NOCs*** have the established infrastructure and supply chains (including means of distribution) to transition from the production and delivery of energy carriers derived and produced from hydrocarbons to hydrogen and hydrogen-based fuels as energy carriers. Also ***IECs*** and ***NOCs*** have the financial resources to affect energy transition over time: in part, this is a function of their sheer size and global reach. The ability of ***IECs*** and ***NOCs*** to raise and to deploy capital is essential to achieving progress towards ***NZE***.

    As noted in previous editions of Low Carbon Pulse, the Global Ashurst Towards Zero Emissions team favours policy settings to define the role and the rate of transition required of ***IECs*** and ***NOCs*** (and energy companies more broadly). As noted in Edition 26 of Low Carbon Pulse, courts have a role, but the role is best fulfilled in determining whether policy settings are constitutional and whether corporations have complied with laws and regulations effecting those policy settings.
  - ***IECs* and *NOCs* key to achieving *NZE*:** The CEO of BlackRock, Mr Larry Fink, had it right when he commented in the context of the District Court in The Hague, the Netherlands finding that the Royal Dutch Shell Group must reduce its ***GHG*** emissions across Stages 1, 2 and 3 by at least 45%, by 2030, compared to 2019 (***RDS Case***): *"[The **RDS Case**] doesn't change the global footprint, that's not a solution. We are doing a lot of greenwashing because we're not changing the carbon footprint of the world. We may change the carbon footprint of a company. What I worry about is that we're going to put all [the] pressure on public [bourse / stock exchange listed] companies and very little on the private [companies]."*

    Mr Fink went on to state that: *"It's not about running away from the current hydrocarbon companies, it's working with them as they navigate the move forward"*.
  - ***IECs* and *NOCs*** - **there at the start and at the finish: *IECs*** and ***NOCs*** have supplied hydrocarbons to match the demand side that consumes hydrocarbons.

    The production *and* use of hydrocarbons has contributed to climate change. ***IECs*** and ***NOCs*** have produced those hydrocarbons, and many ***IECs*** and ***NOCs*** are listed as "top polluters" (click here for a piece on the "top 20" global polluters since 1965). It is however too simple to blame the supply side. Pollution is a function of supply and demand, with the resulting use giving rise to the greatest contribution to ***GHG*** emissions. It is not time to demonise, it is time for collective responsibility, and accelerated action to reduce ***GHG*** emissions.

    NOCs account for more than 50% of global production of natural gas and oil production (and associated petroleum products) with the vast majority of the balance from ***IECs***. In many countries, the revenue from ***NOCs*** is vital, and as such the realisation of that revenue is critical. Also the royalties and taxes paid by ***IECs*** to host Governments is vital.

    The Gordian Knot is ensuring that there is sufficient supply of hydrocarbons while at the same time progressing to ***NZE***. On September 30, 2021, Executive Vice-President at Equinor, Mr Al Cook published a "clear sighted" article entitled ***Why National Companies are key partners in fighting climate change***.

    Key to achieving this balance is the investment by ***NOCs*** (and ***IECs***) in renewable energy projects.
  - **The same in many ways, but different in others:** The core role of ***IECs*** and ***NOCs*** is to produce energy carriers. The core role will not change, but ***IECs*** and ***NOCs*** will expand (and many are already doing so) their business to include the development of renewable electrical energy capacity, both to supply electrical energy as electricity to the ultimate user of that electricity and to derive and to produce hydrogen and hydrogen-based fuels (while at the same time continuing to produce hydrocarbon energy carriers).

    In some areas of the world, ***IECs*** and ***NOCs*** are making material investments in the development of renewable electrical energy capacity in the form of photovoltaic solar and wind (on-shore and offshore).

    As might be expected, the patterns of development, and the thinking behind them, differ from corporation to corporation, and country to country. For example, in a number of countries within the Gulf Cooperation Council (***GCC***) countries, there is a clear recognition that photovoltaic solar is key to realising the value of hydrocarbons (including the production of Blue Hydrogen and Blue Ammonia) and the production of Green Hydrogen and Green Ammonia.
  - **Check on progress:** Different ***IECs*** and ***NOCs*** are progressing at different rates, but each is responding to the policy settings to which it is subject. Each ***IEC*** listed on a bourse / stock-exchange is subject to scrutiny of the shareholders / stockholders, and their perspective on its direction of travel, and the speed at which it is travelling.

As has been noted in previous editions of Low Carbon Pulse, the investors (institutional and "mums and dads"), are aware of the need for corporations in which they invest to have a plan to address the risk that arises from climate change, and in this context how that risk is being avoided or managed.

The CEO of BlackRock, Mr Larry Fink, said back in February 2021, that:"*Given how central … energy transition will be to every company's growth prospects, we are asking companies to disclose a plan for how their business model will be compatible with a new -zero economy … We are asking how this plan is incorporated into [each company's] long term strategy and reviewed by [the] board of directors.*"

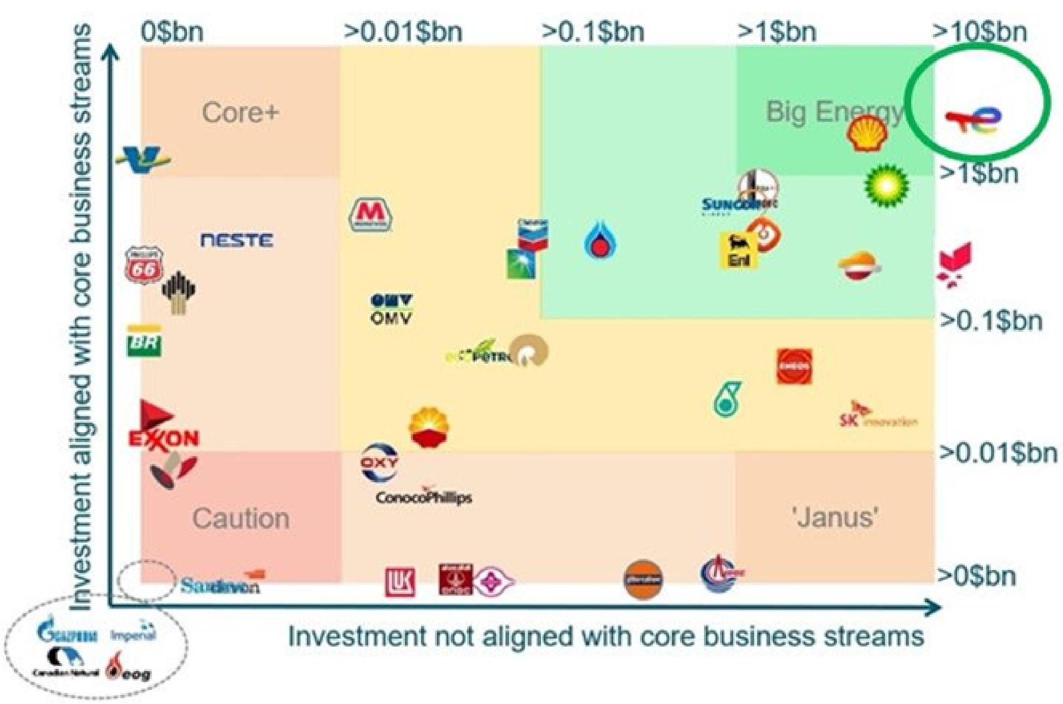
"*We know that climate risk is investment risk … But we also believe that climate transition presents [a] historic investment opportunity.*"

More broadly of course, ***IECs*** are subject to the court of public opinion and any impact on reputation that may arise from any adverse publicity on the direction and speed of travel.

BloombergNEF recently benchmarked a number of ***IECs*** and ***NOCs*** by reference to their investment strategies, broadly reflective of positioning in progress towards ***NZE***. The purpose of including this benchmarking is not to "call-out" any corporations, but to emphasise the progress that has been made.

As ever, the benchmarking is backward looking, covering, as it does, the period from 2015 through to June 30, 2021. As such, recent announcements about commitments are not included: for example, the recent Chevron Corporation commitment of USD 10 billion capital investment by 2030 is not reflected.

Oil and gas low-carbon investment strategies, 2015 to 1H 2021



– **Measuring and monitoring and reporting on progress:** While many ***IECs***, and ***NOCs***, measure and monitor ***GHG*** emissions (and many countries require them to do so), it is becoming increasingly clear that disclosure and reporting are going to be key, including in the context of any carbon border adjustment mechanisms to address carbon leakage, and to level the playing field.

– **Conclusion:** ***IECs*** and ***NOCs*** have a transformational role to play in progress to achieving ***NZE***, they are essential to it, in terms of the transition of their business models from hydrocarbon reservoirs to water reservoirs, with the ultimate destination remaining the bowser (or other point of ultimate delivery) and resulting transition from energy carriers derived and produced from hydrocarbons to energy carriers derived and produced from hydrogen (absent the carbon atoms), either as hydrogen or as a hydrogen based fuel.

Among other things, Edition 29 of Low Carbon Pulse will cover trending issues and consider the role of Government in decarbonising ***AFOLU*** and the development of bio-energy and BECCS and BECCUS (including bio-energy from waste), critically to facilitate the production of Blue Hydrogen and clean hydrogen, and the roles of Government and the private sector in working together. Edition 30 of Low Carbon Pulse will cover trending issues and consider the role of carbon credit trading and coal.

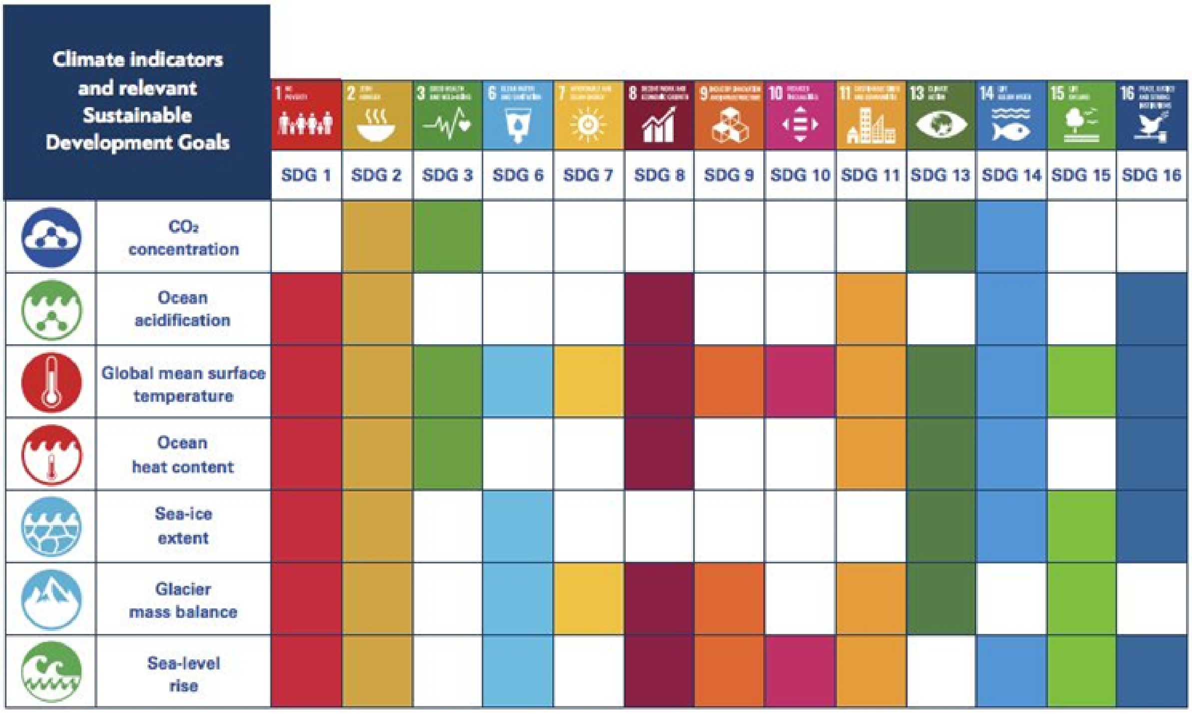
Climate change reported and explained:

- ***WMO Report***: As noted in Edition 27 of Low Carbon Pulse, each month the US National Oceanic and Atmospheric Administration (***NOAA***), among other things, reports on findings for the previous month. In the second edition of Low Carbon Pulse each month, we will cover the latest data from the ***NOAA*** report for the previous month. New data from the September ***NOAA*** report will be included in Edition 29 of Low Carbon Pulse.

  The World Meteorological Organization (***WMO***) has released a report (entitled ***Climate Indicator and Sustainable Development: Demonstrating the Interconnections***) on the impact of climate change. The ***WMO Report*** highlights the interconnected impact of increased ***CO_2*** concentration in the climate system, average temperatures, ocean acidification and increasing temperature, sea-ice extent, sea-level rise and glacier mass balance. Like the ***2021 Report***, the ***WMO Report*** is science based, with analysis based on observation.

The ***WMO Report*** goes further than the ***2021 Report*** in that it emphasises the cascading impact of climate change on achievement of sustainable development goals (***SDGs***). The ***WMO*** Secretary-General, Professor Petteri Taalas is quoted as having said: "*Increasing temperature will result in global and regional changes, leading to shifts in rainfall patterns and agricultural seasons. The intensification of El Niño events is also generating more droughts and floods*".

The ***WMO Report*** is notable for the visual representation of its findings and the impact on the achievement of each of the ***SDGs***. The visual representation set out below, entitled ***Climate Indicators and relevant Sustainable Development Goals*** is an illustration of the power of a visual representation.



The ***WMO Report*** will be considered in detail in the September Report on Reports (to be contained in Edition 30 of Low Carbon Pulse as an Appendix).

- **Climate and weather monitoring:** On September 28, 2021, in an excellent article in Politico (entitled ***Climate and weather monitoring from space: key to safeguarding lives and infrastructure***), it is noted that: "*Our planet and its people have been battered by extreme weather events throughout 2021: record temperatures, intense storms, floods, fires and droughts*" (see Editions 25, 26 and 27 of Low Carbon Pulse for the related facts and statistics, the meaning of "extreme weather event", and the projected consequences, of rising sea-levels).

  The Politico article reports that from 2010 to 2019, weather related events have displaced, on average, an estimated 23.1 million people each year. The article reminds us that the 15th Edition of Global Risks Report from the World Economic Forum considers that climate change (and the associated consequences of it) is one of the top five risks in terms of likelihood of occurrence. Edition 27 of Low Carbon Pulse reported on the World Bank report which provides a forward looking estimate that by 2050 around 215 million people may be forced to migrate globally as a result of the effects of climate change (See *Groundswell report* from the World Bank).

  In the context of the facts and statistics, Politico, notes the importance of the collection of data, and the importance of that data being made available to allow informed planning and responses to the observed impacts of climate change. On 27 September 2021, one of the key organisations responsible for data collection and sharing, EUMETSAT, published its new strategy, *Destination 2030*.

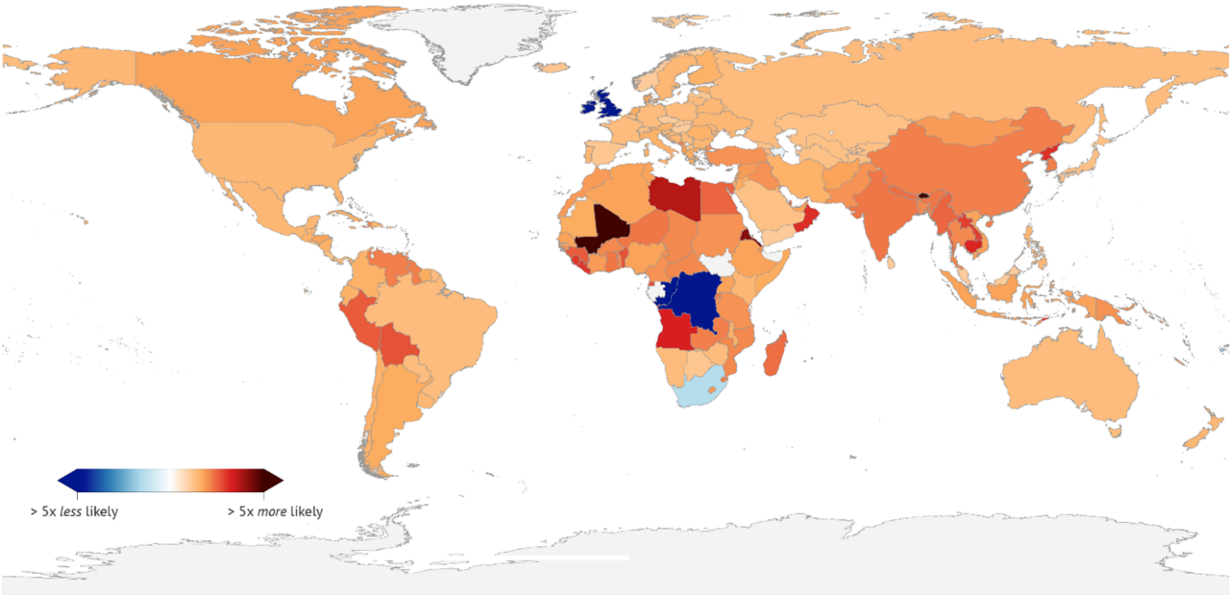
  As a straight-talking Texan known to the author said: "*When it rains, it rains too much, when it's hot, it's really hot, too hot. Y'all can deny the reason for it, but not the fact of it*". The reasons are known.

- **So what is 0.5°C among the global population:** Or asked another way, what is **0.5°C** among friends. In a helpful graphic from the World Wildlife Fund, the key differences are explained. This link takes you to the graphic. It is worth clicking on the link.

- **Extreme weather and extreme weather events:** Editions 26 and 27 of Low Carbon Pulse reflected on reporting of climate change, in particular the loose use of "extreme weather event".

  In light of recent extreme weather, and extreme weather events, there has been a focus on what this might mean for current, and future generations. The journal, Science, has recently reported on a new study that finds that extreme weather and extreme weather events are going to be experienced with greater frequency by younger generations, with children born in 2020 likely to experience extreme weather events, on average, two to seven times more frequently than those born in 1960. As might be expected, and, unfortunately, as we have come to expect, younger generations in lower income countries will be affected to the greatest extent.

The projections appear to the author of Low Carbon Pulse to be based on assumptions consistent with those of UN Secretary General, Mr Antonio Guterres' ***Catastrophic Pathway*** of up to a ***2.7°C*** increase in average temperatures globally, but it is noted that the ***2021 Report*** is used as a point of reference. Whatever the basis of the assumptions, those born in 1960 can no doubt reflect from memory on the increase in extreme weather events, and extreme weather more generally. If the memory fails, the science does not.



Multiplication factor of extreme weather events in a world where current nationally determined contributions (NDCs) are met, and a world at 1.5°C warming. Dark red shows extreme weather events will be five or more times more likely. Dark blue shows extreme weather events will be five or more times less likely. Note for heatwaves the scale is x10. Interactive by Joe Goodman for Carbon Brief based on data from Thiery et al (2021).

- **Climate change tops the list of the concerns of insurers:** As the world progresses to some level of normality, the risks associated with climate change have returned to the top of the risks that concern insurers.

  Edition 27 of Low Carbon Pulse noted that Edition 28 of Low Carbon Pulse would consider the ways in which countries and areas of countries are adapting to the effects of climate change, and the medium to long term consequences of adaptation by reference to the Paris Agreement and the ***2021 Report****.* Edition 30 of Low Carbon Pulse will cover this.

Visualisation and Listening Platforms and Tools, and useful materials:

- **Visual Capitalist – Green Corporations:** The following link shows the top ***50 US corporations that use the most Green Power*** (as a percentage of their power use), with the associated article. (The data for the bar chart from the Visual Capitalist is the Environmental Protection Authority in the US.)

  The key takeaway is the number of US corporations already sourcing 100% of their power use from Green Power (as a subset of renewable energy), and that a number of corporations are sourcing more than 100% of their power use from Green Power. Sourcing Green Power is one part of the jigsaw puzzle for each corporation to achieve ***NZE*** across Stage 1, Stage 2 and Stage 3 emissions. The achievement of ***NZE*** across all Stages is the more challenging jigsaw puzzle.

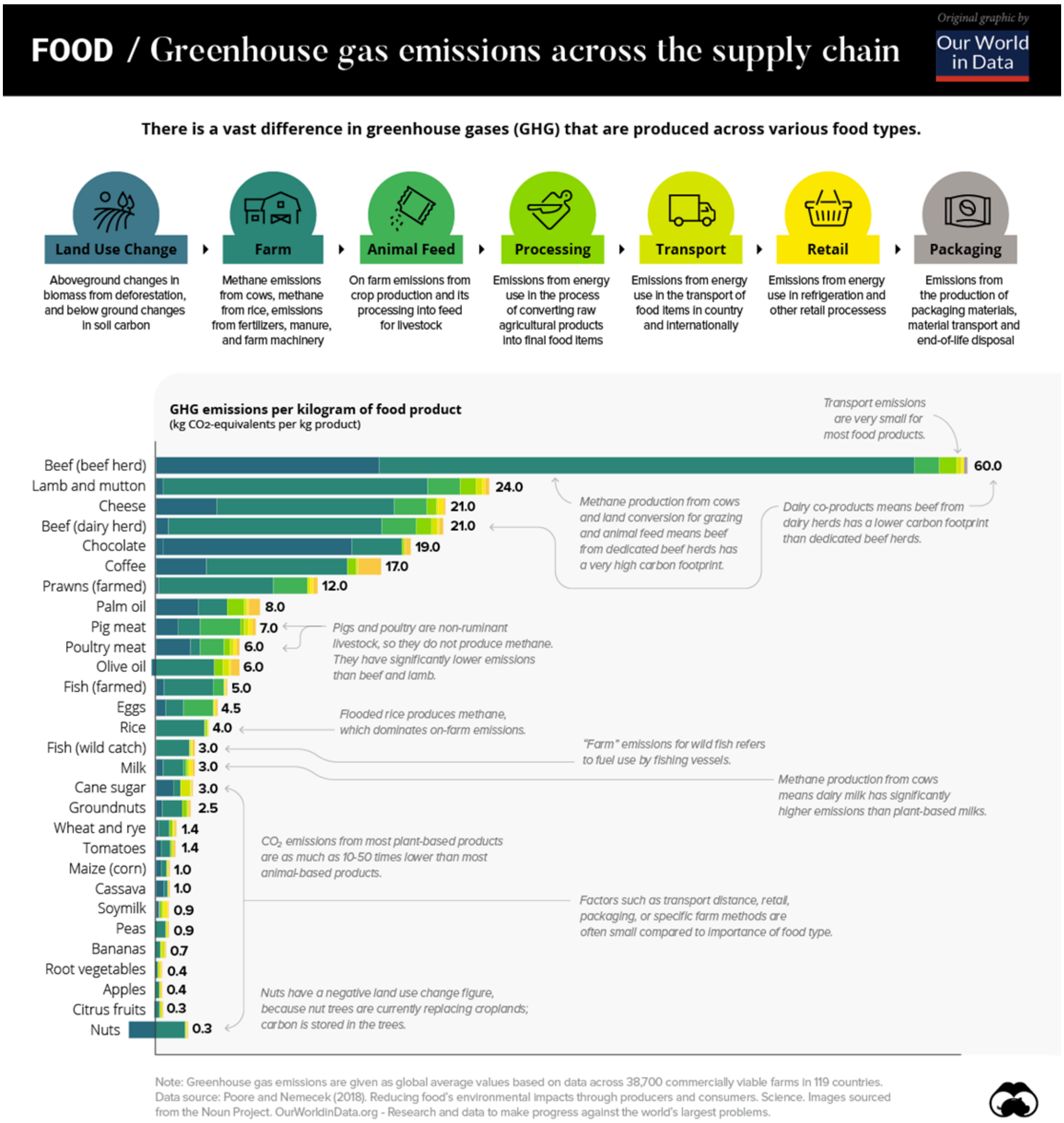
- **Hydrogen Europe – source of information:** Hydrogen Europe (***HE***, representing industry participants and national association members from across the entire hydrogen chain) has established the **#FCHObservatory** (Fuel Cells and Hydrogen Observatory). The **#FCHObservatory** is data rich: for example, it provides up to date information on established hydrogen refuelling infrastructure and stations across Europe. The membership of ***HE*** continues to grow: logo page.

- **The *1.5°C* series:** This section of Low Carbon Pulse is fast becoming the location of information sources that the author finds interesting and useful. Shell has an energy podcast series to which the author listens. The Shell podcast ***The world and 1.5°C: what will it take to … transform the energy system*** is well worth a listen.

- **COP-26 Materials:** Ahead of COP-26, Low Carbon Pulse will include reference materials that the author has come across that may be regarded as helpful reading for those attending COP-26 or following progress: ***The Oxford Institute for Energy Studies – Oxford Energy Forum - September 2021: Issue 129***; and ***COP-26 Presidency Compilation of 2021-2025 Climate Finance Commitments***.

***AFOLU GHG* emission reductions and waste to biofuels:**

- ***AFOLU* – hard to decarbonise:** Edition 27 of Low Carbon Pulse noted that future editions of Low Carbon Pulse would report on, and consider, ***GHG*** emissions arising from agriculture, forestry and other land use (***AFOLU***), and the food system generally. To set the scene for consideration of ***GHG*** emissions arising from the food system, there is a useful graphic (from Our World in Data) that provides a high-level depiction of the Carbon Footprint of the Food Supply Chain. Edition 29 of Low Carbon Pulse will delve deeper.



- **Deadwood stage coming on over the hill:** On September 20, 2021, scitechdaily.com, reported (under ***Deadwood Releasing 10.9 Gt of Carbon Every Year – More Than All Fossil Fuel Emissions Combined***) that decaying wood releases around 10.9 Gt (10.9 billion tonnes) of carbon worldwide a year. The report is based on the findings from a study undertaken by a team at the Australian National University (***ANU***). It is important to note that the ***GHG*** emissions from deadwood are not counted within the 50 Gt of ***CO_2***-e emissions arising each year, but illustrates that a change in the forests of the world can impact climate change.

  While the implications of the study are still being digested, it is clear that "climate change and the loss of insects have the potential to alter the decomposition of wood, and therefore, carbon and nutrient cycles".
- **Decarbonising agriculture:** In many countries, some may say in most countries, agriculture has cultural, political and social significance. In the interests of food security and political expediency, in many countries agriculture receives direct and indirect funding support, including policy settings intended to ensure value to certain crops.

  Given these dynamics, the decarbonisation of the agriculture sector is best regarded, and is best calibrated, on a country by country, area by area, basis. At the core of decarbonisation of agriculture is land use, raising livestock and growing crops best suited to the environment in which they are grown, including the return of land to the wild (and paying for the benefit of doing so) and ceasing to grow crops other than for food. Also, collection of waste from livestock and crops is key.

  Key to decarbonising is achieving a balance between ***GHG*** emissions arising from agriculture and using negative ***GHG*** emission initiatives such that ***GHG*** emissions arising are matched by ***GHG*** emissions removed from the climate system. This approach avoids or mitigates the need to introduce some of the more challenging policy settings that may go to cultural, political and social dynamics that may limit progress.
- **Bio-energy as part of decarbonising *AFOLU*:**
  - **The role of bio-energy:** The Global Ashurst Towards Zero Emissions team notes that both the International Energy Agency (***IEA***) ***Net Zero by 2050: A Roadmap for the Global Energy Sector*** (***IEA Roadmap***) and

the International Renewable Energy Agency (***IRENA***) ***World Energy Transition Outlook*** (***WETO***) see bio-energy as a key part to achieving progress towards ***NZE***.

The ***IEA Roadmap*** saw the development of the use of bio-energy as a key risk in the implementation of its ***IEA Roadmap***, on the basis that achieving the proportion of world energy use assumed by the ***IEA Roadmap*** from bio-energy was regarded as less likely, more difficult than other sources contributing to the **Sources of feedstock:** Bio-energy can be derived and produced from any biomass, including agriculture (crop and livestock) waste, food system waste (including arising from the food industry and at the point of commercial or domestic consumption) and wastewater.

Ever mindful of health, safety and welfare, and environmental protection, policy settings are required to maximise the waste that can be used as feedstocks from which to derive bio-energy.

- **Regulation of feedstock and reduction of methane:** In the ***EU***, use of waste as a feedstock requires the Renewable Energy Directive (***RED***) to recognise a particular source of waste as a renewable energy feedstock. The ***EU*** is a key reference point.
- **Methane reduction:** Depending on the technology used, the production of bio-energy from biomass can reduce methane (***CH_4***) emissions. This importance of the reduction in ***CH_4*** emissions in explained in Edition 27 of Low Carbon Pulse. Reflecting this, the ***EU*** and US have recently committed (in the ***Global Methane Pledge***) to reduce ***CH_4*** emissions by a third within the next decade (see Edition 27 of Low Carbon Pulse).

The broader ***AFOLU*** and waste and waste water sectors are estimated as giving rise to up to 95% of anthropogenic ***CH_4*** emissions globally. Given the impact of ***CH_4*** emissions on climate change, there is an immediate and present reason to capture the life-cycle of carbon in the broader ***AFOLU*** and waste and waste water cycles. This is best framed and achieved through Government collection and consolidation initiatives. These will include the derivation and production of biogas, and biomethane for pipeline gas, from waste to displace natural gas over time. Further, if ***CO_2*** arising on the production and use of biogas or any other biofuel is captured and used, and matched by new growth biomass to absorb an equivalent mass of ***CO_2*** arising on oxidation / use of that biogas or other biofuel, the promise of bio-energy will realised.

In the agricultural sector, policy settings of this kind become the core of an environmentally and economically sustainable sector, including by use of the digestate arising from the derivation and production of bio-gas, and the use of cover crops and perennial crops. As noted in a publication from the European Biogas Association, the use of digestate offers a means of soil improvement both for crops and for rehabilitation. The parts of a closed loop exist; policy settings need to facilitate the closing of the loop.

GCC counties update:

- **United Arab Emirates and UK aligned:** Edition 27 of Low Carbon Pulse reported that ADNOC Group (leading national oil company), BP (leading international energy corporation) and Masdar (Abu Dhabi Future Energy Company) entered into framework agreements. It is understood that the framework agreements provide the basis for the development of two clean hydrogen hubs, each of 1 GW, one in the UAE, the other in the UK.

  During September 2021, the UAE and the UK signed a memorandum of understanding (***MOU***) to accelerate cooperation between the UAE and the UK. Dr Sultan Al Jaber, Minister of Industry and Advanced Technology (and chair of Masdar), for the UAE, and Mr James Cleverly, Minister of State for Middle East and North Africa, for the UK, signed the ***MOU***.
- **UAE perfectly placed for hydrogen production:** Managing Director and group chief executive of ADNOC, Dr Sultan Al Jaber is a busy person.

  Dr Sultan Al Jaber has emphasised the current infrastructure advantage that the UAE has for the production of Blue Hydrogen: "*By leveraging our existing gas infrastructure and commercial scale CCUS capabilities, the UAE can and will become a major player in the emerging blue hydrogen market*".

  The UAE has no shortage of natural gas reserves from which to produce Blue Hydrogen. Dr Sultan Al Jaber notes: "*Today, gas provides almost one quarter of the world's energy supply and will continue to play a critical roles in the global energy system*". As noted in sibling publications of Low Carbon Pulse, producers of LNG can become producers of LNG and Blue Hydrogen.
- ***KAS*, major investor in renewables:** On September 22, 2021, thenationalnews, Business Section, reported (under ***Saudi Arabia to channel 50% of investments into renewable energy, PIF governor says***) that the Kingdom of Saudi Arabia (***KAS***) plans to deploy 50% of its investments in renewable electrical energy, and sustainable energy sources.

  Chair of the Public Investment Fund and of Saudi Aramco, Mr Yasir Al Rumayyan noted "*the [**KAS**] aims to deploy 50 per cent of its investments in renewable and sustainable power sources, more than two-thirds from investments. We are one of the most efficient countries when it comes to sustainability and renewable energy*".

  As noted above, to achieve progress towards ***NZE***, it is necessary for ***NOCs*** (and ***IECs***) to invest in renewable projects, and sustainable projects.
- **"A" Team:** On September 28, 2021, it was reported widely that Saudi Aramco (the world's largest corporation by value), ACWA Power (leading developer, investor and owner operator of power and water assets) and Air Products (one of the big three leading global industrial gas corporations, with Air Liquide and Linde) have established a joint venture company (***JVC***) to develop a new project to produce hydrogen and electrical energy at Jazan Economic City (Jazan, also Jizan, is a port city).

  The ***JVC*** will contract with Saudi Aramco to purchase assets from Saudi Aramco, with Saudi Aramco supplying feedstock to the ***JVC***, with the ***JVC*** producing electrical energy, heat and steam, and hydrogen.

  The hydrogen produced will be used across Saudi Arabia. It is expected that completion of the sale and purchase of the assets, and funding for the project, will occur during October 2021. It is understood that the Saudi Industrial Development Fund and 23 lenders (domestic and international) are providing USD 7.2 billion.

India moves to centre stage:

- **India and US Hydrogen Task Force:** In the lead up to the Leaders' Summit in April 2021, US Special Presidential Envoy for Climate Mr John Kerry was a busy fella. In the lead up to the Leaders' Summit, Mr Kerry met with Indian Prime Minister, Mr Narendra Modi. At that time, closer cooperation was flagged.

  On September 27, 2021, the two countries launched a new public-private task force to increase the rate of development of renewable electrical energy. It is understood that the Hydrogen Task Force will soon be joined by the Biofuels Task Force. Both task forces are to be enabled by the Indian Strategic Clean Energy Partnership (***SCEP***) and the US Department of Energy (***DOE***).

- **Indian Prime Minister Centre Stage:** On September 25, 2021, Indian Prime Minister, Mr Narendra Modi addressed the United Nations General Assembly in New York. Mr Modi confirmed the commitment given by India to install 450 GW of renewable electrical energy capacity by 2030, and to develop and to implement the National Hydrogen Energy Mission so as to scale up production to 1 million metric tonnes of hydrogen a year by 2030.

  In addition to these existing commitments, commitments to the Production Linked Incentive Scheme were announced, adding 10 GW of photovoltaic manufacturing capacity by 2025, 15 million metric tonnes per annum of compressed natural gas, sourced from biogas by 2024, and to achieve 20% ethanol blending by 2025/26.

- **India Centre Stage for inbound investment:** On September 21, 2021, The Economic Times (of India) reported that Petroleum Nasional Berhad (***Petronas***), Malaysia's national oil company, is looking to invest in renewable energy projects in India for a "substantial" proportion of its planned development of 3 GW of renewable energy by 2024.

  Head of New Energy at Petronas, Mr Jay Mariyappan said that: "*Our overall target is three gigawatts by 2024 in terms of capacity; a substantial part of that will be within India*".

  It is understood that ***Petronas*** has had discussions with Tata in respect of possible renewable energy projects. Edition 20 of Low Carbon Pulse reported on plans of PTT (PTT Public Company Limited, Thai state owned oil and gas corporation) to invest in the renewable and sustainable energy sector in India.

- **India Centre Stage for private sector domestic investment:** On September 22, 2021, it was reported widely that Adani Group intends to invest up to USD 20 billion over the next 10 years. On October 2, 2021, Adani Green Energy reported its acquisition of 5 GW of photovoltaic solar and wind assets from SB Energy India for USD 3.5 billion.

  With Adani, Reliance and TATA each now committed materially and significantly to reduce ***GHG*** emissions, and the investment necessary to achieve this, it is clear that the might of India's private sector is now very much aligned with the public sector, including state owned corporations.

  See: Adani Group *website*

- **Indian economy continues to need to grow:** In delivering a presentation on hydrogen to one of the Seven Sisters in February 2021, the author of Low Carbon Pulse was asked to identify the biggest challenge to progress towards achieving ***NZE***. The author responded to note that countries like the ***PRC*** and India needed to continue to grow so as to achieve continued economic development, while at the same time seeking to decarbonise the means of that growth. This response was conditioned to note that the challenge could be overcome.

  On September 27, 2021, Chair of India Oil Corp (***IOC***), Mr Shrikant Madhav Vaidya, announced ***IOC*** plans to increase its refining capacity within India. It has long been known that India would need to add around 100 million metric tonnes per annum (***mmtpa***) to its refining capacity, currently around 250 ***mmtpa***.

  The increased production of hydrocarbons using increasing refining capacity will result in increased ***GHG*** emissions. Mr Vaidya intends to seek to mitigate the extent of increased ***GHG*** emissions arising from the use of the new refining capacity by the use of renewable electrical energy to provide electrical energy required for that production.

  See: IOC *website*

- **India, Japan, US and Australia climate change announcement:** On September 24, 2021, following a meeting of the leaders of India, Japan, the US and Australia (the so-called Quad), it was announced that the Quad countries are: **1**. to cooperate to allow the development of a green-shipping network, with each country to work with each other country to reduce ***GHG*** emissions arising from the shipping value chain; **2**. to establish a Clean Hydrogen Partnership, including for the purposes of technology development and scaling up of hydrogen production on an efficient basis, with the intention to stimulate demand to accelerate trade in clean hydrogen in the Indo-Pacific region; and **3**. to increase the Indo-Pacific region's resilience to climate change by improving climate change information sharing and disaster-resilient infrastructure.

  See: The White House's communique: *Fact Sheet: Quad Leaders' Summit*.

Australia – A Curate's Egg:

- **Background:** Australia is the lucky country, blessed with two of the three key creators of wealth in real economies: agricultural capacity and natural resources (the third key creator of wealth being manufacturing capacity). Traditionally, natural resources have included metals and minerals (including iron ore), fossil fuels (including coal (thermal and metallurgical) and natural gas (liquified and exported).

  Natural resources now include Australia's natural renewable resources - world class solar and wind (on-shore and off-shore) resources. These natural renewable resources are now the focus of the progress made by Australia. Australia is progressing to matching 100% of load with dispatch from renewable energy sources. Also Australia is the source of renewable energy sources that will export renewable electrical energy into South East Asia (using HVDC interconnectors) and drive electrolysers to produce Green Hydrogen and Green Ammonia.

- **Scrutiny of Australia:** And yet, the Federal Government of Australia has yet to commit to meaningful ***GHG*** emission targets or to ***NZE*** by 2050. As a result, for some time, the Federal Government of Australia has been under scrutiny by the international community and its own citizens. At once, both the lucky country, and the recalcitrant country, a country that could lead, but a country that chooses not to do so.

As is often the case, things are not always as they seem: the Commonwealth of Australia is a federation of States and Territories, and those States and Territories are progressing with their own ***GHG*** emission reduction targets and are committed to achieving ***NZE***.

Most recently, New South Wales (***NSW***), Australia's most populous State, announced that it would increase its reductions in ***GHG*** emissions by 15% from 35% to 50% by 2030 compared to 2050, with the eye catching prediction that ***NSW*** would attract AUD 35 billion in investment as a result. It was a busy week for policy setting in ***NSW*** with the release of a report entitled ***Development of a hydrogen industry in New South Wales*** on September 30, 2021. (The September Report on Reports will consider the report.)

The State of South Australia remains the stand-out performer in terms of solar, wind and battery (***SWB***). Throughout 2021, South Australia has demonstrated that 100% ***SWB*** matching load is becoming a reality across a GW-scale grid. On Saturday 2, 2021, at 11.10 am, photovoltaic solar (roof-top and utility) achieved 106.1% of the load across South Australia, and continued to match load for nearly an hour.

Key to the development of ***SWB*** across Australia has been the role of the private sector, with both domestic and international investment key to progress the development of the renewable electrical energy industry with the original Federal Government policy settings (to encourage the development of the renewable electrical energy industry) having long-since passed their "use by dates".

- **Balance being struck:** The oft stated reason given by the current Federal Government for not committing to meaningful ***GHG*** emission reduction targets or to ***NZE*** is that Australia is committed to the means of achieving ***GHG*** emission reduction, through technology and funding support, and that Australia does not need to commit to achieve ***GHG*** emission reductions or ***NZE***.

  Whatever one's view of this stated logic, were the Federal Government of Australia to commit to increase ***GHG*** emission reductions and to achieving ***NZE***, the level of private sector investment would increase, perhaps, borrowing a phrase, that investment would be turbo-charged. This said, the Federal Government of Australia is providing funding support across a number of technologies.

  On September 30, 2021, the Federal Energy Minister, Mr Angus Taylor announced AUD 250 million (circa USD 180 million) in funding for the development (AUD 150 million) and deployment (AUD 100 million) of CCS as part of the Emissions Reduction Fund. More generally, the Federal Government of Australia provides funding support, including through the Australian Renewable Energy Agency (***ARENA***), see Edition 17 of Low Carbon Pulse (under ***ARENA opens the hydrogen funding tray***), the Clean Energy Finance Corporation (***CEFC***) and the National Australia Infrastructure Facility (***NAIF***).

- **From No Target to Big Targets:** Where the Federal Government of Australia has been non-committal, some of its high-profile and most successful business leaders are developing renewable energy projects domestically and internationally, including for the purposes of the development of Green Hydrogen and Ammonia production.

  First among equals is Dr Andrew Forrest, AO, (founder of Fortescue Metals Group, one of the Big Three Australian iron ore producers). Dr Forrest continues to lead, at pace, and its doing so both within Australia and overseas.

  During the week beginning September 27, 2021, Dr Forrest and, former Prime Minister of the Commonwealth of Australia, Mr Malcolm Turnbull combined to establish the Green Hydrogen Organisation (***GH2***), with Mr Turnbull as its inaugural chair and Dr Forrest a founding member of the ***GH2*** board. This is a high powered duo.

- **Unlocking Australia's hydrogen opportunity:** On September 27, 2021, the Australian Hydrogen Council (comprising energy corporations, infrastructure investors and vehicle manufactures promoting the role of hydrogen as an energy carrier) released a publication entitled, ***Unlocking Australia's hydrogen opportunity***. The September Report on Report will cover the publication in detail.

German progress continues, home and on the seas:

- **Germany rolls out model:** During the week-beginning September 27, 2021, the Ordinance on the Allocation of Other Energy Production Areas in the Exclusive Economic Zone (***SoEnergieV***) entered into force. The ***SoEnergieV*** allows for the testing of hydrogen produced off-shore (and ultimately development).

  SoEnergieV states the bases for the allocation of areas within the exclusive economic zone for production of hydrogen using off-shore wind. Under the ***SoEnergieV***, the German Federal Maritime and Hydrographic Agency is responsible for allocation.

  It is understood that areas will be allocated through tender processes, starting in 2022. Successful tenderers will be granted a right to apply for zoning within the area the subject of the grant to allow development.

  SoEnergieV may be regarded as being born of the three Flagship Projects undertaken by the German Federal Government, amongst other things, which have proved up the viability of the production of hydrogen off-shore.

- **Importance of framework and funding support:** Editions 25 to 27 of Low Carbon Pulse have covered the approach taken by the German Federal Government, with three Flagship Projects (in its Flagship Program) at the core of the development of a framework within which Government and the private sector are dedicated to developing the hydrogen economy:

  - **H2Giga:** the development of large-scale use of electrolysers (using serial construction of standardised electrolyser technology) to electrolyse water using renewable electrical energy to produce Green Hydrogen. Thyssenkrupp is responsible for the coordination of **H2Giga**;

  - **H2Mare:** investigating the use of use off-shore / off-grid renewable wind electrical energy to produce hydrogen and hydrogen-based fuels: effectively, a dedicated, integrated, closed electrical energy to Green Hydrogen production energy loop. **H2Mare** comprises four joint projects: **1**. OffgridWind, **2**. H2Wind, **3**. PtX-Wind, and **4**. TransferWind. Siemens Energy is responsible for the coordination of **H2Mare**; and

- **TransHyDe:** reaching transportation of hydrogen over short, medium and long distances, and comprising four demonstration projects: **1**. Hydrogen Transport in High Pressure Vessels, **2**. Hydrogen-Liquid Transport, **3**. Hydrogen Transport in Existing and New Gas Pipelines, and **4**. Transport of Hydrogen Bound in Ammonia or liquid organic hydrogen carrier (***LOHC***), a carrier medium.

- **Glass and silver demand:** On September 29, 2021, pv-magazine.com, in an article titled ***How much glass is needed for a terawatt-scale PV***, reported on the findings of researchers in Germany who determined how much glass and silver would be required to allow the installation of photovoltaic capacity under two scenarios: **1**. 20 TW by 2050, and 80 GW by 2100; and **2**. 80 TW by 2050 and 170 by 2101. For those who want to get to grips with the scale of a key part of progress to ***NZE***, the article is well-worth a read.

PRC continues to lead the way:

- **PRC pulls back from development of coal-fired power:** On September 22, 2021, President of the ***PRC***, Mr Xi Jinping announced to the United Nations General Assembly, by video, that the ***PRC*** would cease to fund and to develop coal-fired power stations as part its ***OBOR*** assistance program.

  At the same time as making the commitment to cease funding coal-fired power stations developments, Mr Xi said that the ***PRC***, would "*step up support for developing countries in developing green and low carbon energy*".

- **Asian Infrastructure Investment Bank (*AIIB*) and *IRENA* aligned:** On September 22, 2021, it was reported widely that ***AIIB*** and ***IRENA*** had signed a memorandum of understanding under which they commit to work with each other to support energy transition across Asia and to mobilise private sector capital for this purpose.

  See: ***AIIB***'s *press release*; ***IRENA***'s *website*

- **China Three Gorges and TOTALEnergies combination:** On September 28, 2021, it was reported widely that China Three Gorges Corporation and TotalEnergies had established a joint venture to develop electric mobility infrastructure across Hubei and Wuhan provinces, with plans to develop and to deploy 11,000 high-power battery electric charging points (***BCI***) for use by battery electric vehicles (***BEVs***). As is noted below, the PRC is leading the world in many aspects of ***BEVs***.

  The intention is to have developed and deployed the ***BCIs*** by 2025. Each ***BCI*** is to comprise 60 kW and 120 kW charging points, with hosting capacity for between 20 to 50 ***BEVs***.

  As noted in previous editions of Low Carbon Pulse, TOTALEnergies has been developing and deploying ***BCI*** (and hydrogen refuelling infrastructure) globally: the 11,000 ***BCI*** in Hubei and Wuhan join deployed and planned deployment of ***BCI*** as follows: Amsterdam, 22,000, Antwerp 3,000. London, 1,700, Paris 2,300, and Singapore, 1,500 (following the recent acquisition).

  See: *TotalEnergies joins forces with China Three Gorges Corporation to Develop More than 11,000 High Power Charge Points for Electric Vehicles in Wuhan and Hubei Province*

- **IEA's perspective on achieving carbon neutrality in PRC:** On September 30, 2021, the International Energy Agency (***IEA***) published ***An Energy Sector Roadmap to Carbon Neutrality in China*** (***IEA PRC Roadmap***).

  The headline from the ***IEA PRC Roadmap*** is that the ***PRC*** has the means to accomplish: "*fast clean energy transition … and [in so doing] increase the world's chances of limiting the rise in global [average temperatures] to 1.5°C*".

  The ***IEA PRC Roadmap*** will be covered in detail in the September Report on Report (to be included as an Appendix to Edition 30 of Low Carbon Pulse).

- **Wood Mackenzie:** In addition to the ***IEA***, Wood Mackenzie published new research (entitled ***China wind power outlook 2021-2030***) and an opinion piece entitled ***Wind power to play a key role in achieving China's carbon neutral goal***.

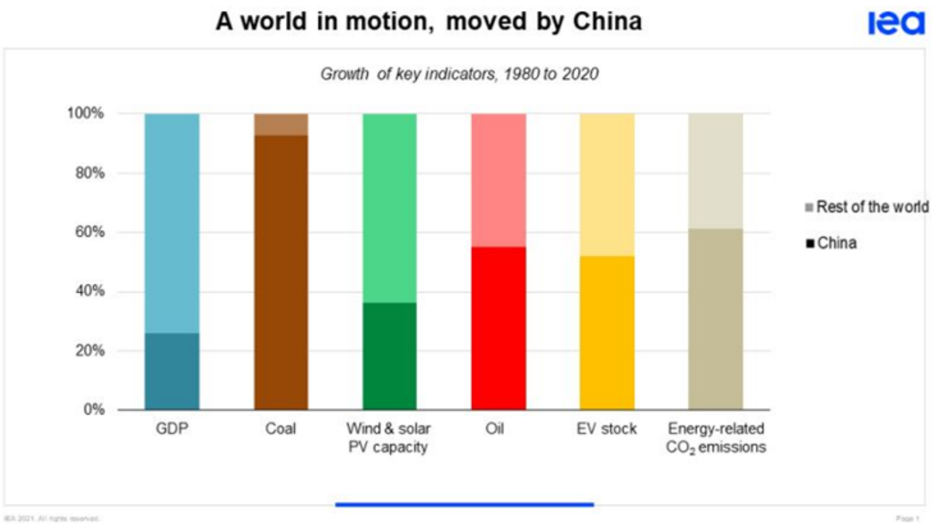
  The Wood Mackenzie research concludes that by 2030 the ***PRC*** will have cumulative grid-connected wind capacity of 689 GW, accounting for 67% of the then installed wind generation capacity, as things stand. This will require the installation of a further 408 GW of wind capacity between 2021 and 2030.

  As always, the research from Wood Mackenzie is excellent, and well-worth a read. As is the case with ***the IEA PRC Roadmap***, the September Report on Reports will include detailed coverage of the Wood Mackenzie research.

- ***PRC* belting along the road:** The economy of the ***PRC*** has become a behemoth over the last 40 years: with 25% of global growth, more than one third of photovoltaic solar installation, 50% of all ***BEVs*** and 70% of ***BEV*** manufacturing.

  The growth has been fuelled by 90% of the net increase in demand for coal (thermal and metallurgical), 50% of the increase in global demand for oil, resulting in 60% of the total growth in ***GHG*** emissions.

The bar chart below is illustrates these facts and statistics:



- **Singing the praises of the battery electric:** The list of corporations below provides a snap shot of the current leading manufacturers of batteries:

RANK	CELL SUPPLIER	EV MAKER SERVED / UNDER CONTRACT	GWH	% MARKET SHARE	% GROWTH, 2016 - 2020
1	**Contemporary Amperex Technology Co. (CATL)**	BMW, Dongfeng Motor Corp., Honda, SAIC Motor Corp., Stellantis, Tesla, Volkswagen Group, Volvo Car Group	21.6	26	3,400
2	**LG Energy Solution**	General Motors, Groupe Renault, Stellantis, Tesla, Volvo, VW Group	21.4	26	1,193
3	**Panasonic**	Tesla, Toyota	14.1	17	214
4	**Samsung SDI**	BMW, Ford, Stellantis, VW Group	5.5	7	399
5	**BYD Co.**	BYD, Ford	5.5	7	113
6	**SK Innovation**	Daimler, Ford, Hyundai, Kia	3.4	4	226
7	**China Aviation Lithium Battery (CALB)**	GAC Motor, Zhejiang Geely Holding Group Co.	2.7	3	321
8	**Gotion High-Tech**	Chery Automobile Co., SAIC, VW Group	1.4	2	23
9	**Automotive Energy Supply Corp. (AESC)**	Groupe Renault, Nissan	1.4	2	46
10	**Ruipu Energy Co. (REPT)**	Dongfeng, Yudo Auto	0.6	1	100

Sources: Adamas Intelligence, BusinessKorea, Electrive, BMW, Ford, Honda, Volvo

US Update:

- **Background:** As noted in Edition 26 of Low Carbon Pulse, the front section of each edition of Low Carbon Pulse has been dedicated to news items on policy settings consistent with progress towards the achievement of ***NZE*** among the countries that emit the greatest mass of ***GHG*** emissions.

  Countries with the greatest mass of emissions have the heaviest lifting to do to achieve ***NZE*** by mid-century, or, as is becoming increasingly clear, before 2050 in the case of G7 and the G20 countries.

  These countries, and in the case of the ***EU***, these blocs, include the ***PRC***, ***EU***, the US, Russia, Japan, India, and Republic of Korea.

Having reacceded to the Paris Agreement on January 20, 2021, the US has made considerable progress. Edition 30 of Low Carbon Pulse will include, as part of the September Report on Reports, details of all material developments. This Edition 28 of Low Carbon Pulse, outlines the most recent and material initiative, and progress on the passage of the USD 3.5 trillion Budget Reconciliation legislation.

- ***EPA* freezes out *HFCs***: The Environmental Protection Agency (***EPA***) announced on September 24, 2021, a requirement to reduce ***GHG*** emissions that have the highest global warming potential – the hydrofluorocarbons (***HFCs***), a group of industrial chemicals used primarily for cooling and refrigeration. The ***HFCs*** reduction requirement imposes an obligation to phase down (85% within 15 years from the introduction of the requirement) and then phase out the production and use of ***HFCs***.

  The ***HFCs*** reduction requirement is to be implemented using an allowance and trading program: from October 1, 2021, corporations are allocated allowances to produce and to import of ***HFCs*** and ***HFC*** related products. The ***EPA*** estimates that from implementation to 2050, the ***HFC*** reduction requirement will avoid 4.5 gt of ***CO_2-e*** to the climate system, or, stated another way, on current facts and statistics, a mass of ***CO_2-e GHG*** emissions equal to three years of ***GHG*** emissions from the US power generation sector. Interestingly, the ***HFC*** reduction requirement has been welcomed across the board in the US.
- **Headline progress on US 3.5 trillion bill:** Editions 23 and 25 of Low Carbon Pulse covered the progress and passage of the Infrastructure Investment and Jobs Act (***IIAJA***), and anticipated that the passage of the IIAJA was to be followed by the USD 3.5 trillion 2022 Budget Reconciliation legislation.

  As has been reported widely, the passage of the USD 3.5 trillion Budget Reconciliation legislation is proving to be a challenge. As at October 3, 2021, the Democratic Party leaders were seeking to pare-back the amount of the Budget, and, as such, some of the initiatives to address climate change.

Republic of Korea (ROK) News:

Korean H_2 Business Summit and Korean Hydrogen Council: Edition 27 of Low Carbon Pulse reported that on September 8, 2021, the ***Korean H_2 Business Summit*** had been established. Edition 19 of Low Carbon Pulse reported that the Korean Hydrogen Council would be established in September, 2021. The ***Korean H_2 Business Summit***, is the Korean Hydrogen Council - they are one and the same. The author could have made this clearer in Edition 27 of Low Carbon Pulse.

Bio-energy (including BECCS and BECCUS) update:

- **Background:** As noted in previous editions of Low Carbon Pulse (and touched on above), **bio-energy** is energy derived or produced from biomass, whether in gaseous, liquid or solid form. Bio-energy is derived from organic matter, but not fossilised organic matter. Organic matter contains carbon. (For background on biomass see this article by Iman Ghosh.)

  Note: For the production of bio-energy to be carbon-neutral, it must be combined with carbon capture and storage, ***BECCS***, or with carbon capture and use or storage, ***BECCUS***. For ***BECCS*** to make a contribution to a reduction in ***GHG*** emissions, it must displace another electrical energy source or energy carrier source, and, in any event, it must result in a carbon neutral outcome (rather than a carbon removal outcome) so as not to give rise to an increase in ***GHG*** emissions.
- **Importance of these dynamics:** The purpose of repeating these dynamics is to ensure that it is understood that the use of bio-energy as an integral part of progress to achieving ***NZE*** is about effective collection systems for bio-energy feedstocks (all carbon intensive), the capture and storage of ***CO_2*** arising from the production of them, and ensuring, through monitoring and verification, that the ***CO_2*** arising on use of bio-fuels is absorbed by renewable biomass growth. This is the basis of achieving carbon-neutrality in fact, rather than in concept.

  There are many sources of biomass. One of the most fertile grounds is waste arising from the growth of crops, the rearing of livestock, waste arising in the food supply chain (from field to fork) and waste and waste water.
- **Bio-energy projects**:
  - **Smaller scale in South Australia:** A key feature of bio-energy projects is that they come in all shapes and sizes. On September 24, 2021, The Port Lincoln Times, covering news relevant to the town of Port Lincoln, in South Australia reported on the signing of a memorandum of understanding (***MOU***) between Eyre Peninsula Cooperative Bulk Handling (***EPCBH***) and H2U, under which EPCBH and H2U will assess options for the production locally of Green Hydrogen and Green Ammonia;
  - **Shell and TOTALEnergies:** In many ways, Shell and TOTALEnergies may be regarded as two of the ***IECs*** making most progress towards achievement of ***NZE*** across their Stage 1, 2 and 3 ***GHG*** emission profiles, and this progress includes the development of bio-fuels as part of part of broader bio-energy initiatives. The starting point for the commitment to biofuels is that depending on source and technologies used to derive and to produce them, they result in up to 50% less ***CO_2*** in production.

    IECs are well-placed to produce biofuels because that have existing refining infrastructure that is able to be repurposed to produce biofuels, and the understanding of how to develop biofuel refining facilities;
  - **Shell – on the moove:** On September 29, 2021, Shell announced that it had produced renewable natural gas (***RNG***) from cattle / cow manure and other agricultural residues. The ***RNG*** is processed further to derive biomethane (suitable for injection into pipeline systems as pipeline natural gas) and subject to compression to produce compressed natural gas (***CNG***) or renewable compressed natural gas (***R-CNG***). Shell is developing two like facilities;

    See: *Shell starts production at Shell New Energies Junction City, its first US renewable natural gas facility*
    - **TOTAL moved in:** TOTAL Energies is in the process of making this transition, including in 2019 at Le Mede, and with the commencement of production of Grandpuits refinery in 2024; and

- **Biomethane enters GRDF network:** On September 30, 2021, injection of biomethane into the GRDF Network commenced. The biomethane meets the specification for pipeline natural gas, but is not fossil fuel derived, it is derived from organic waste to produce biogas, then processed further to produce biomethane.

CCS / CCUS and difficult to decarbonize round-up:

- ***OEIS* on CCS:** On September 24, 2021, the Oxford Institute of Energy Studies (***OIES***) released a paper, entitled ***Carbon Capture and Storage: The Perspective of Oil and Gas Producing Countries***.

  As is always the case with ***OIES*** publications, the perspectives and findings are thought provoking, and as such it is well-worth a read. At a high-level the key findings are: CCS could play a central role for oil and natural gas producing and exporting countries, the cost of CCS could be shared between producers and users, there is a need for policy settings that encourage the deployment of CCS on the basis of a clear cost outcome for users, direct and indirect, and a clear revenue outcome for owners and operators of CCS, with the Paris Agreement having a key role to play (in particular Article 6).

- **Woodmac on CCS:** On September 28, 2021, Wood Mackenzie provided an update on the cost of CCS, in an opinion piece, entitled ***Carbon capture and storage: how far can costs fall?*** which provides access to the proprietary report. Wood Mackenzie emphasises again the need to reduce ***GHG*** emissions by 1.8 Gtpa of ***CO_2-e*** a year for 30 years to achieve ***NZE*** and to limit the increase in average temperatures globally to ***1.5^oC*** (to meet its ***Accelerated Energy Transition*** scenarios). As reported in previous editions of Low Carbon Pulse, Wood Mackenzie's view is that between 4 and 6 Gtpa of ***CO_2*** needs to be captured and stored for these purposes.

  As is becoming increasingly apparent, the use of carbon clusters is going to be key to achieving a price point that will make CCS affordable and encourage the use of CCS. For these purposes, Wood Mackenzie provides levelized costs for carbon cluster CCS projects and standalone CCS projects.

- ***CO_2* to Storage:** The city of Houston is committed to achieving ***NZE*** by 2050. Leading oil, natural gas, petrochemical and refining corporations, Calpine, Chevron, Dow, ExxonMobil, INEOS, Linde, LyondellBasel, Marathon Petroleum, NRG Energy, Phillips 66 and Valero, have stated jointly (see ExxonMobil's press release here) that the key to achieving ***NZE*** by 2050 is the use of CCS.

  On September 23, 2021, Mr Erik Oswald, in energyfactor (by ExxonMobil) has written a clear and direct piece noting that to develop and to deploy CCS is going to require support from Government, at all levels, including policy settings to regulate the safe injection of ***CO_2*** to ensure that capture is permanent, to provide and extend funding support to encourage development (likely based on tax credits, rather than direct grant funding), and to provide funding support in respect of the development or repurposing of shared infrastructure. What Mr Oswald is describing is not unique to the development of CCS in the US: these policy settings are required around the world, within countries, and in some areas, across countries.

- **California mandates 40% reduction in carbon-intensity of cement:** During the week beginning September 20, 2021, California Governor, Mr Gavin Newsom, signed SB 596 which mandates the reduction of carbon emissions per ton of cement produced by 40% by 2035, compared to 2019.

  In addition, SB 596 requires the California Air Resources Board to develop a net-zero emissions strategy to decarbonise the production of cement completely by 2050. The second article in the Shift to Hydrogen (***S2H2***) series provides details on the mass of ***GHG*** arising from the production of cement and concrete globally.

  The cement production industry needs to decarbonise the production of clinker as the process of producing clinker releases ***CO_2***. Decarbonisation of the production of clinker can be achieved by the use of high-heat temperature non-fossil fuels, and the capture of ***CO_2*** arising naturally from the limestone used to produce the clinker.

  The decarbonisation of the cement industry requires the displacement of fossil fuels with high-heat temperature non-fossil fuels or non-carbon intensive fuels, such as hydrogen. ***CO_2*** arises from the production of clinker as follows: ***CO_2*** arises from both the use of fossil fuels or carbon intensive fuels and the production of clinker from limestone, i.e., calcium carbonate (***$CaCO_3$***) – for every molecule of **$CaCO_3$** used to produce cement, one molecule of ***CO_2*** arises. As such cement requires both the reduction in carbon intensive fuels and the capture of ***CO_2***.

  On October 1, 2021, Nicole Kobie published an article entitled ***Concrete is a climate disaster. It's time to clean it up***. The article's facts and statistics are consistent with ***S2H2***, but the narrative is forward looking in terms of reducing the mass of ***CO_2*** arising from cement production, and the injection of ***CO_2***.into concrete.

- **Decarbonisation of cement production in Lancashire, England:** On September 30, 2021, it was reported in the constructionindex.co.uk, that Hansen Cement has produced clinker using a 100% net zero mix of heat-temperature fuels in its cement kiln.

  The 100% net zero mix comprised 39% hydrogen, 12% meat and bone meal (***MBM***) and 29% glycerine. The hydrogen used was Grey Hydrogen. It was noted that while Grey Hydrogen was used to provide up the use of the 100% net zero mix, Green Hydrogen would be used over the long term.

  As will be apparent from this Edition 28 of Low Carbon Pulse, and previous Edition 27 of Low Carbon Pulse, the concept of 100% net zero mix needs to be approached with care.

Energy Storage round-up (including BESS and grid forming batteries):

Edifying site: On September 22, 2021, Edify Energy (leading renewable energy project developer) was granted approval to develop a Green Hydrogen production facility of up to 1 GW, and a behind the meter, photovoltaic and ***BESS*** facility at the Landsdown Eco-Industrial Precinct, in Townsville. As is the case with most Green Hydrogen production facilities, the Edify Energy project will start with a 10 MW pilot facility.

E-Fuels / Future Fuels:

- **Plug Power, keeps plugging away:** On September 20, 2021, it was reported widely that one of the first movers in the development of supply side Green Hydrogen, Plug Power Inc., is continuing its roll-out of Green Hydrogen production capacity in the US with the development of a production facility in Fresno County, California

(***Fresno Facility***), in California's Central Valley, which, while an agricultural heartland, is increasingly water stressed.

It is reported that the ***Fresno Facility*** will produce up to 30 metric tonnes of Green Hydrogen a day (***30 mtpd***), using renewable electrical energy from a 300 MW photovoltaic solar farm, and using Plug Power PEM electrolysers. It understood that the **Fresno *Facility*** will make use of water from a waste water treatment plant in the city of Mendota, Fresno County.

As noted in previous editions of Low Carbon Pulse, while a ***30 mtpd*** facility may not appear significant in a global context, what is significant is the Plug Power is continuing to develop Green Hydrogen production facilities to provide supply to match demand on an area by area basis across the US. Further, the combination of Green Hydrogen production with the development of waste water treatment plant is about as good as it gets at the moment. As noted in previous editions of Low Carbon Pulse, the use of waste and waste water as a feedstock for the production of hydrogen has material and significant potential globally. The ***Fresno Facility*** underscores this.

This is a wonderful model: kudos to all, and a "shout out" to Plug Power Inc., whose CEO, Mr Andy Marsh said: "*Plug Power is … committed [fully] to a green hydrogen future and is investing heavily on building a green hydrogen ecosystem to support our customers' efforts to achieve their sustainability goals*".

This is a demonstration, at micro-level, of the need to develop supply and demand in tandem, with supply a little ahead of demand, (completing the metaphor) supply occupying the front-seat of the tandem, demand the back. Plug Power is demonstrating that a private sector corporation is able to lead the way, developing and deploying incrementally in the medium term, which 2030 appears to have become, to produce 1,000 ***mtpd*** across its US network of hydrogen production facilities, and such close to 400,000 metric tonnes a year.

See: *Plug Power to Build Largest Green Hydrogen Production Facility on the West Coast*

- **Paraguay – a place in the sun:** Edition 25 of Low Carbon Pulse reported on the release of the International Energy Agency (***IEA***) report on the development of hydrogen capacity in Latin America, entitled ***Hydrogen in Latin America***. The report was considered in further detail in the August Report on Report (as an Appendix to Edition 27 of Low Carbon Pulse). On September 21, 2021, the International Renewable Energy Agency (***IRENA***) released a report entitled ***Renewables Readiness Assessment Paraguay*** (***Paraguay Report***).
- **INEOS continues progress to *NZE*:** Previous editions of Low Carbon Pulse (see Editions 22 and 23 of Low Carbon Pulse for most recent coverage) have reported on the commitments made by ***INEOS*** (UK based international conglomerate) and PetroChina International, including commitments to capture at least 1 million metric tonnes of ***CO_2*** from activities at Grangemouth petrochemical and refining facilities (***Grangemouth Facilities***) in Scotland.

  These activities are significant of themselves, and because of their importance to the ***Scottish Cluster*** (see Edition 23 of Low Carbon Pulse), including the ***Acorn Project***. The carbon capture and other initiatives are intended to reduce ***GHG*** emissions from the ***Grangemouth Facilities*** by 60% by 2030.

  On September 22, 2021, ***INEOS*** announced plans to augment the ***Grangemouth Facilities*** to allow use of hydrogen as a feedstock and fuel. This augmentation will require the investment of GBP 1 billion. ***INEOS***'s stated intention is to progress to ***NZE*** by 2045, in line with the policy setting of the Scottish Government.
- ***PORA* richer for DOI:** On September 24, 2021, Port of Rotterdam Authority (***PORA***) and the DeltaPort Niederrhainhä fen (the combined activities of these two inland ports providing leading a logistics hub), EON (international energy company), Kreis Wesel (a district of Germany), Nordfrost (leading logistics service provider) and Thyssengas (gas pipeline operator) announced entry into an declaration of intent (***DOI***) to enable inland ports in North Ruhr to act as a regional hub for the import of hydrogen from the Port of Rotterdam.

  North Rhine-Westphalia Minister for Economic Affairs, Innovation, Digitalisation and Energy, Mr Andreas Pinkwart noted: "*That the significance of this project goes way beyond our region*". ***PORA*** Commercial Director Mr Emile Hoogsteden said: "*We want to help [in] developing a Cool Corridor, a regular inland shipping connection for reefer containers between Rotterdam and the Ruhr area*".

  The ***DOI*** is consistent with the development of North Rhine-Westphalia as the focal point of hydrogen hubbing.
- **Eustream tripling up:** Edition 27 of Low Carbon Pulse reported that Eustream (Slovakian based natural gas pipeline network owner and operator) has joined a joint venture to develop a supply chain from Green Hydrogen production facilities in Ukraine to Austria and Germany, and other central European markets (***H2EU+Store***). ***H2EU+Store*** comprises key players, including Bayerngas GmbH, Bayernets GmbH, Eco-Optima LLC, Open Grid Europe GmbH and RAG Austria AG.

  On September 24, 2021, it was reported widely that Eustream, EP Infrastructure, NAFTA and RWE are assessing the use of their gas transmission pipelines to haul Blue Hydrogen from a Blue Hydrogen production facility in Slovakia. The repurposed Eustream gas transmission system would be used to haul the Blue Hydrogen into Austria and Germany. This assessment will be combined with the work being done on ***H2EU+Store***, and ***CEHC*** (see next paragraph) and work will be done in Austria, Czech Republic, Germany and Ukraine as the key jurisdictions. The thinking is that the Blue Hydrogen haulage will precede that of Green Hydrogen, with blending of Blue Hydrogen with natural gas during 2023.

  The combination of gas transmission operators, or TSOs (comprising Eustream, Gas TSO (Ukraine TSO), Net4gas (the Czech TSO) and OGE (a German TSO) has been christened as ***Central European Hydrogen Corridor*** (***CEHC***). From various sources, it is stated that the ***CEHH*** will be able to haul up to 120 GWh per day by 2030 from Ukraine via Slovakia and the Czech Republic, delivering hydrogen to areas of high demand for hydrogen.
- **MingYang mega-wind turbine factory:** Edition 26 of Low Carbon Pulse reported on the development of the MingYang MySE 16.0-242 (***My Mega***) wind turbine. On September 24, 2021, MingYang announced plans to develop a factory in Germany. If these plans come to fruition, this would be a first for a ***PRC*** company, and it would be great boost for the wind turbine industry generally.

See: MingYang *website*

- **Repurposing of infrastructure and use of established designs:** On September 24, 2021, it was reported widely that Viscofan (world leading supplier of casings / containers, for meat products) had conducted tests successfully using Green Hydrogen to displace natural gas as the fuel source in one of its boilers in Cáseda Spain. The use of Green Hydrogen to displace natural gas is an integral part of the plans of Viscofan to decarbonise its activities. The challenge for Viscofan is the supply of Green Hydrogen to allow it to effect decarbonisation.

  See: Viscofan *website*

- **Great Interest in Southern Green Hydrogen project:** Editions 22 and 23 of Low Carbon Pulse reported on the Tiwai Point, Southland, New Zealand, ***Southern Green Hydrogen project***, proposed to be developed with the Tiwai Aluminium Smelter in Invercargill on New Zealand's South Island.

  As noted in Edition 22 of Low Carbon Pulse, Contact Energy (***CE***) and Meridian Energy (***ME***) are proposing to develop the ***Southern Green Hydrogen*** project. Having been advised by McKinsey & Co of the potential of the project, ***CE*** and ***ME*** have tested the market for interest, and the market is reported to have responded in a way that demonstrates considerable interest for the Green Hydrogen that may be produced at the project, and as such provide a basis to underpin it.

- **A world first in French Guiana – prospective global application:** On September 29, 2021, Fuelcellsworks.com, reported under ***HDF Energy Breaks Ground on World's Largest Green Hydrogen-Power Project*** that HDF Energy (global pioneer in hydrogen power), and its equity partners, Meridiam (infrastructure fund) and SARA (petroleum operator and member of the Rubis Group) broke ground on the development of the CEOG Renewstable®Power Plant (***COEG***). ***COEG*** is reported to be the world's first multi-megawatt hydrogen power plant, and the largest Green Hydrogen intermittent ***HESS*** (with 128 MWh of energy storage capacity).

  The ***COEG*** is significant because it can be replicated globally – it is the right scope and scale, and it is dispatchable 24/7. It has been project financed on the basis of a credit worthy off-taker of the renewable electrical energy from ***COEG*** under a 25 year power purchase agreement, ***EDF***, a first tier engineering procurement and construction (***EPC***) contractor, Siemens Energy, and a first tier electrolyser technology supplier, McPhy (French headquartered, leading supplier of electrolysers and associated technology). The electrical energy to power the electrolyser is sourced from photovoltaic solar capacity.

  COEG is being duplicated in 20 countries, including Australia, Indonesia, Mexico, and South Africa.

- **Mitsui, Wesfarmers, Japan Oil and Metals National Corporation combine for feasibility study:** On October 1, 2021, it was reported widely that Mitsui & Co. (leading Japanese trading house, through its extended Australian group) and Wesfarmers Chemicals Energy and Fertilisers (leading Australian diversified conglomerate, which includes energy and fertiliser production interests), with Japan Oil and Metals National Corporation, are undertaking jointly a feasibility study to assess the development of low carbon ammonia supply chain.

  The study will consider the use of natural gas to produce Blue Hydrogen, with a depleted natural gas field in Western Australia to be used to store ***CO_2***, with the Blue Hydrogen then used as feedstock to produce Blue Ammonia. The electrical energy required would be sourced from photovoltaic solar and wind sources. The headline is that the feasibility study will consider the potential to produce up to 1 ***mmtpa*** of Blue Ammonia.

  See: Mitsui *website*

- **In late news**: As Edition 28 of Low Carbon Pulse was being finalised on October 4, 2021, the ***IEA*** released its ***Global Hydrogen Review 2021***. The ***Global Hydrogen Review 2021*** will be considered in detail in the September Report on Reports, to be included as the Appendix to Edition 30 of Low Carbon Pulse. Also, ENOES and Fortescue Metals Group and Fortescue Future Industries reported that they are working on the development of a Japan-Australia ***CO_2***-free hydrogen Supply Chain, and the Ammonia Energy Association reported on the scope of the potential of Mexico to produce green maritime fuels.

Hydrogen Cities, Councils, Cluster and Hubs, Infrastructure and Valleys:

- **Greenlink Interconnector:** On September 22, 2021, it was reported that Greenlink Interconnector Limited (the developer of the 500 MW, 190 km, high voltage direct current (***HVDC***) ***Greenlink Interconnector*** between the Republic of Ireland and the UK) had signed a design, procurement and construction contract with Siemens Energy and Sumitomo Energy under which Siemens and Sumitomo will deliver the ***Greenlink Interconnector***.

  While not yet a trend, the use of ***HVDC*** interconnection between sources of renewable electrical energy and load for that electrical energy appears to provide a means of developing world scale projects in parts of the world that do not have sufficient load to parts of the world that do.

  As noted below, the ***Sun Cable Project Making Progress*** and ***The X-Factor***, interconnectors of 3,500 kms in length are being developed.

  See: *Siemens Energy and Sumitomo Electric awarded EPC contract for Ireland-UK interconnector*

- **Gasunie Salt Cavern Storage:** On September 23, 2021, Gasunie announced that it completed successfully the conversion of a portion of a salt cavern used for natural gas storage into a hydrogen storage facility.

  While further testing is to be undertaken, Gasunie is to continue the development of storage in salt caverns. It is anticipated that the first salt cavern will be operational by 2026 for commercial use.

  As noted in previous editions of Low Carbon Pulse, the development of hydrogen storage facilities is required as a key element to the commercial use of hydrogen by large users (including for the high-heat temperature process undertaken by the cement, chemical, petrochemicals and refining, glass and iron and steel industries) and to allow the use of hydrogen across networks.

  Gas Infrastructure Europe (***GIE***) released a study entitled ***Picturing the value of underground gas storage to the European hydrogen system / Guidehouse study*** (***GIE Study***). The ***GIE Study*** confirms what has been known for some time, that for the hydrogen economy to be established at a functional level hydrogen storage is required.

See: *Successful start of hydrogen storage demonstration project strengthens hydrogen development*

- **Giga-factory update:** It has been the plan for a while to include a feature on giga-factories in an edition of Low Carbon Pulse. Given the space and word count taken by outlining trends and matters of policy ahead of COP-26 Editions 25, 26 and 27, and this Edition 28, of Low Carbon Pulse have been weighty. A future edition of Low Carbon Pulse will include a feature on both giga factories and charging and refuelling infrastructure.

Wind round-up:

- **Australia winds-up**: A number of editions of Low Carbon Pulse have covered the highly prospective nature of the development of the off-shore wind industry (***OWI***) in Australia, and the recognition of the Federal Government of Australia of the need for legislation to allow the development of the ***OWI***. As noted, while Australia has some of the best renewable energy resources in the world on-shore, it has world class off-shore wind resources as well. This section picks up on the emerging news from the increasingly prospective ***OWI***.
  - **Australis Energy winds-up:** On September 20, 2021, is was reported widely that Australis Energy subsidiary SA Offshore Windfarm has submitted an application for the development of a 600 MW off-shore wind field development off the coast of South Australia (approximately 10 kms off the South Australian coast). This follows the application in June for the development a 495 MW off-shore wind field off the coast of Victoria, and the application in April (see Edition 14 of Low Carbon Pulse) for a 300 MW off-shore wind field development off the coast of Western Australia; and
  - **Oceanex Energy quantifies the potential:** During the week beginning September 27, 2021, the results of a report commissioned by Oceanex Energy were shared, informing its decision to develop two 2 GW off-shore wind field developments, one off the coast of the Hunter Valley, the other off the coast of the Illawarra (two coal producing areas in NSW). This announcement coincided with the announcement by the NSW Government to reduce ***GHG*** emissions across the State of NSW by 50% by 2050 (see ***Australia – the Curates Egg***).
- **Another floating off-shore wind commissioned:** On September 21, 2021, it was reported widely that the Kincardine Offshore Windfarm Ltd (***KOWL*** project sponsor of the ***Kincardine Project***) had commenced the dispatch of electrical energy under its power purchase agreement with Statkraft (leading renewable energy generation corporation) which has agreed to purchase 100% of the renewable electrical energy from the ***Kincardine Project***, reported to be the world's largest floating off-shore wind field project.

  See: *Statkraft helps world's largest floating wind farm find its customers*
- **Ørsted outlines its development plans submitted in ScotWind Leading program:** Edition 27 of Low Carbon Pulse reported details of the development plans of Ocean Winds (an EDP and Engie 50:50 joint venture) and Aker Offshore Wind for a 6 GW floating off-shore wind field in the Outer Moray Firth, off shore of Scotland.

  During the week commencing September 20, 2021, it was reported widely that Ørsted (global renewable energy giant) intends to progress its floating off-shore wind field development plans with expenditure plans of up to GBP 12 billion. Ørsted is a consortium with BlueFloat Energy (leading off-shore wind developer) and Falck Renewables (leading Italian renewable energy developer).

  It is understood that the details shared reflect the terms of the Ocean Winds, Aker Offshore Wind and Ørsted responses to the ScotWind Leasing Scheme (bids for which closed on July 16, 2021, which are covered in Edition 22 of Low Carbon Pulse).

  See: Ørsted *website*
- **SSE Renewables scoping Berwick Bank:** On September 26, 2021, The Scotsman, published under an article entitled ***Giant offshore wind farm in Fourth would be the UK's largest and could power all Scottish homes twice over***. A big headline, for a big story, about a big project. The Scotsman reported that SSE Renewables is planning a 4.1 GW off-shore wind field project (***Berwick Bank Super Project*** or ***BBSP***) within the Firth of Forth, 40 kms off the East Lothian and Fife coastlines.

  The ***BBSP*** is reported to combine the earlier Berwick Bank and Marr Bank proposals, covering a combined area of 1,313 km^2. The location of landfall, and connection to the grid, has been secured at Branxton, near Torness, in East Lothian. If the ***BBSP*** is consented to by the Scottish Government in Q1 of 2022, it is anticipated that the ***BBSP*** could be operational by 2026.
- **Ørsted outlines its development plans for Swedish wind:** On September 29, 2021, Ørsted announced that it plans to proceed with the development of the 1.5 GW Skåne Havsvingpark off-shore wind field project (***Skane Havsvingpark*** Project or ***SHP***) off the coast of Sweden, in the Swedish sector of the Baltic Sea, 22 km south of Skåne. On development of the ***SHP***, it will be capable of suppling half the current electrical load of Skåne. For the purposes of proceeding with the ***SHP***, Ørsted has submitted an environmental impact assessment. The Baltic Sea is considered to highly prospective for the development of off-shore wind fields: Ørsted considering that the Baltic Sea region has the potential for up to 90 GW of off-shore wind field capacity.

  See: Ørsted *website*
- **From Scotland to Italy:** On October 1, 2021, Falck Renewables (leading Italian renewable energy developer) and BlueFloat Energy (leading off-shore wind developer) announced that they have entered into a 50:50 joint venture for the purposes developing off-shore wind field (***OWF***) projects off the coast of Italy.

  It is reported that the first project is a 1.2 GW ***OWF*** off Brindisi (***Kailia Energia Project***), with projected annual generation dispatch of up to 3.5 TWh. For the ***Kailia Energia Project*** to proceed, authorisation will have to be obtained from the Ministero per la Transizione Ecologica and a maritime concession granted by the Ministero delle Infrastructurre and the Port Authority of the Southern Adriatic Sea.

  See: BlueFlat *press release*; Falck Renewables *press release*

Solar and Sustainable Energy Round-up:

- **Kaban Green Power Hub achieves Financial Close:** On September 20, 2021 it was reported widely that Neoen (global leading renewable energy company) had achieved financial close for its AUD 370 million, 157 MW and 320 km transmission line project (***Kaban Green Power Hub*** or ***KGPH***) within the Northern Queensland Renewable Energy Zone. It is understood that this will enable Neoen to supply renewable electrical energy to Cleanco (Queensland state government renewable electrical energy consolidation company). It is reported that BNP Paribas, HSBC, MUFG, NAB and Nord L/B have provided project finance for the ***KGPH***.
- **Lord Howe Island milestone:** On September 20, 2021, renweconomy, reported that the micro-grid on Lord Howe Island (off Australia), comprising a photovoltaic solar facility and a ***BESS*** (a Tesla Powerpack), has been operating for six months. It is reported that the use of the micro-grid has reduced diesel use on Lord Howe Island by two-thirds. While the scale of the micro-grid is not significant in a global sense, the installation of the micro-grid and its use has implications for other islands within the Asia Pacific region.
- **Sun Cable making continued progress:** Previous editions of Low Carbon Pulse have reported on the development of the ***Sun Cable Project*** (see Editions 2, 3, 13 and 26 of Low Carbon Pulse): currently the size and shape of the ***Sun Cable Project*** is as follows: 20 GW of installed photovoltaic solar capacity and between 36 and 42 GWh of ***BESS***, with the electrical energy dispatched and delivered through a high voltage direct current (***HVDC***) cable from Darwin to Singapore. For these purposes the ***HVDC*** cable has to be laid through the territorial waters of the Republic of Indonesia, and this requires the approval of the Government of Indonesia.

  On September 23, 2021, it was announced by Sun Cable that it had been granted approval by the Government of Indonesia (in the form of a sub-sea cable permit), for the proposed route of the ***HVDC*** through Indonesian territorial waters. The ***Sun Cable Project*** and the Australia-Asia PowerLink (***AAPowerLink***) continues to make progress to realisation of the planned first dispatch date of 2028.
- **The X-Factor:** Edition 16 of Low Carbon Pulse reported on the proposed development of a 10.5 GW photovoltaic solar (7 GW) and wind (3.5 GW) renewable energy and a 5 GW / 20 GWh ***BESS*** project (***Morocco Project***) proposed by Xlinks (a renewable energy development corporation based in the UK) to be located in Morocco, North Africa, with the electrical energy generated by the ***Morocco Project*** to be transmitted to the UK using a 3,800 km ***HVDC*** (***Morocco UK Interconnector***). It is stated that the ***Morocco UK Interconnector*** will be able to deliver 3.6 GW for an average of more than 20 hours a day.

  The length the ***Morocco UK Interconnector*** is similar to the length of the ***AAPowerLink*** from Darwin to Singapore (noting that the electrical energy from the ***Sun Cable Project*** is to be transmitted 700 km from a 17-20 GWp solar farm with approximately 36-42 GWh battery energy storage located near Elliott, NT, to Darwin before going sub-sea). The ***Morocco UK Interconnector*** would trace the Moroccan and Spanish coasts, crossing the Bay of Biscay, and the English Channel, making land-fall at Alverdiscott, Devon, England, and possibly Pembroke, Wales.

  Edition 3 of Low Carbon Pulse (under ***Interconnection***) outlines the key financial modelling issues arising from the use of ***HVDC*** cables for interconnection, in particular if over 3,500 kms in length.
- **Africa WindPower established:** On September 30, 2021, Global Wind Energy Council (***GWEC***) announced a regional body to represent the wind industry, Africa WindPower (***AWP***). The purpose of ***AWP*** is to provide a platform for dialogue between Government and industry stakeholders across Africa.

  According to an International Finance Corporation report, Africa has 59,000 GW of wind resources (on shore and off-shore combined), and as such the potential to match 250 times over the current load across Africa. As reported in previous editions of Low Carbon Pulse, Africa is similarly blessed with solar and hydroelectric and pumped storage potential. As is the case with all reports in respect of renewable energy resources, the reports provide reason for confidence, but the reason for confidence has to be firmed up against the practical, in particular the location of the resources and the location of the load.

Land Transport (automobiles, buses, trains and trucks) round-up:

- **Engine technology:** While there tends to be focus on battery electric vehicles (***BEVs***) and fuel cell electric vehicles (***FCEVs***) in the context of progress towards achievement of ***NZE***, it is apparent that the internal combustion engine (***ICE***) may have a new lease of life using hydrogen as a fuel. On September 23, 2021, Cummins announced that it is progressing its ***ICE*** program to develop 6.7-litre (for use in medium-trucks) and 15-litre ***ICEs*** (for use in heavy-duty, long-distance trucks).

  The development program is proceeding with funding support from the UK Government's Advanced Propulsion Centre initiative. Cummins President of Engine Business, Mr Srikanth Padmanabhan places the ***ICE*** development program in context with ***BEV*** and ***FCEV***: "*Reducing well-to-wheels carbon emissions requires innovation of both energy sources and power solutions. While cases for battery electric and fuel cell electric powertrains are promising, the pairing of green hydrogen in the proven technology of internal combustion engines, provides an important complement to future zero emissions solutions*".
- **Cummins is not alone:** On September 27, 2021, Kawasaki Heavy Industries (***KHI*** being one of the highest value and largest scale engineering corporations leading the transition across the hydrogen economy, as is the case with Cummins), is working on the development of hydrogen-fuelled ***ICEs***. As reported by H2View on September 27, 2021, by Executive Officer at ***KHI***, Dr Motohiko Nishimura hydrogen-fuelled ***ICEs*** may be regarded as "superior to fuel cells" for some uses: "*In terms of durability and reliability [hydrogen-fuelled **ICEs** are superior to fuel-cells, making [hydrogen-fuelled **ICEs**] suitable for heavy-duty use on ships, heavy machinery and long distance buses and trucks*."
- **Keeping track of rolling stock**: Edition 27 of Low Carbon Pulse reported that the Alstom Coradia iLint passenger train debuted on French railways. On September 24, 2021, in the publication, The Local, Martin Greenacre (in an article entitled (***5 things to know about hydrogen trains coming to France***), outlines the implications of the use of Coradia ILint passenger train in France.

Mr Greenacre provides historical background, noting that Alstom has been developing fuel cell technology (***FCT***) for use in trains since 2013 and providing some current facts and statistics: that SNCF has ordered ***FCT*** trains for use on its regional and slower, non-electrified, lines, that the Coradia iLint is assembled at Salzgitter, Germany, that the two ***FCT*** trains are in use in Germany, with another 41 to begin regular service in Germany during 2022 and 2023, and finally that the ***FCT*** trains are in use in Austria, Italy, the Netherlands and Sweden.

The article is worth a read.

- **Taking the hy-road:**
  - **MANing up:** MAN (leading engine technology, bus heavy and goods vehicle / truck corporation, and a subsidiary of Volkswagen Audi Group) announced that it is transitioning from diesel to electric drive buses and heavy goods vehicles / trucks by 2024.
  - **Mercedes Benz and Daimler trucks splitting up:** On October 1, 2021, Daimler announced that its truck division is to split from Mercedes Benz. It anticipated that the split will be effected from February 1, 2022. Daimler is expected to become named Mercedes-Benz Group AG with the truck division to become Daimler Trucks. The split may be regarded as consistent with the increased focus of Daimler Trucks on fuel cell electric technologies (***FCT***) and fuel cell electric vehicles (***FCEVs***), including the tie up with Volvo reported in Edition 17 of Low Carbon Pulse and the tie-up of Shell in respect of the development of hydrogen refuelling infrastructure (***HRI***), with Shell to develop and to deploy 150 ***HRI*** by 2030, and Daimler's plan to have delivered 5,000 heavy goods vehicles / trucks using ***FCT*** by 2030 (see Editions 17 and 18 of Low Carbon Pulse).

Aviation and Airports:

- **Airbus, Air Liquide and VINCI Airports H2 Airport :** On September 21, 2021, Airbus, Air Liquide and VINCI Airports announced plans to develop a pilot project at the Lyon-Saint Exupery airport. As noted in previous editions of Low Carbon Pulse, hydrogen has considerable potential airside and landside, and airborne. The planned pilot project is understood to involve the development and deployment of hydrogen storage and delivery systems. If the pilot project proves feasible, VINCI Airports across Europe are likely to adopt the storage and delivery systems overtime.
- **Airbus reports hydrogen the aviation fuel of tomorrow:** Airbus has released a report on the use of hydrogen in the aviation industry (***Hydrogen: An energy carrier to fuel the climate-neutral aviation of tomorrow***). Chief Operating Officer of Airbus, Mr Mark Bentall is reported as having said: "Hydrogen offers us the biggest potential to reach that zero emissions target and our net zero ambitions".
- **Shell and Deloitte, from road to air:** Shell and Deloitte have produced a paper entitled ***Decarbonising Aviation: Cleared for Take-off, Industry Perspectives*** (***Cleared for Take-off***). The September Report on Reports will cover the key findings from ***Cleared for Take-off***.

NZE reports

Please see below a list of reports that have been reviewed for Editions 1 to 28 of Low Carbon Pulse. This list includes the publishing organisation, title / subject matter, and link.

ORGANISATION	TITLE / SUBJECT MATTER	EDITION
Edition 1		
McKinsey & Company	*Road Map to a US Hydrogen Economy: Reducing Emissions and Driving Growth Across the Nation*	1
Edition 2		
International Energy Agency (***IEA***)	*CCUS in Clean Energy Transitions*	2
International Energy Agency (***IEA***)	*World Energy Outlook 2020*	2
The International Council on Clean Transportation	*Liquid hydrogen refueling infrastructure to support a zero-emission U.S.–China container shipping corridor*	2
World Energy Council	*International Hydrogen Strategies: A study commissioned by and in cooperation with the World Energy Council Germany*	2
Edition 3		
Ministry of Economic Affairs and Climate Policy (Netherlands)	*A Hydrogen Exchange for Climate*	3
Edition 4		
Business Finland	*Hydrogen Roadmap for Finland*	4
Department for Business, Energy & Industrial Strategy	*The ten point plan for a green industrial revolution*	4
Foreign, Commonwealth & Development Office (UK)	*Sectors that are Challenging to Decarbonise*	4
International Energy Agency (***IEA***)	*Renewables 2020*	4
World Economic Forum	*Top 10 Emerging Technologies of 2020*	4
Edition 5		
BBC	*Climate change: Temperature analysis shows UN goals 'within reach'*	5
Coalition for Urban Transitions	*Climate Emergency, Urban Opportunity*	5
McKinsey & Company	*How the European Union could achieve net-zero emissions at net-zero cost*	5
United Nations Environment Programme	*UNEP Emissions Gap Report 2020*	5
Edition 6		

ORGANISATION	TITLE / SUBJECT MATTER	EDITION
Australian Energy Market Operator Limited	*South Australian Electricity Report*	6
Global Alliance Powerfuels	*POWERFUELS in a Renewable Energy World: Global Volumes, Costs, and Trading 2030 to 2050*	6
Nature Climate Change	*Greater committed warming after accounting for the pattern effect*	6
Edition 7		
International Energy Agency (***IEA***)	*Driving Down Methane Leaks from the Oil and Gas Industry*	7
Edition 8		
Deloitte and Shell	*Decarbonising road freight: Getting into gear: An industry perspective*	8
Hydrogen Council	*Hydrogen Decarbonization Pathways*	8
Shell	*Decarbonising Road Freight: Shell's Route ahead*	8
United Nations	*Adaptation Gap Report 2020*	8
Edition 9		
BloombergBEF	*1H 2021 Corporate Energy Market Outlook*	9
Lawrence Livermore National Laboratory	*Lawrence Livermore National Report*	9
United Nations	*Global Climate Change Litigation Report*	9
Wood Mackenzie	*2050: The Hydrogen Possibility*	9
Edition 10		
Hydrogen Council and McKinsey & Company	*Hydrogen Insights: A perspective on hydrogen investment, market development and cost competitiveness*	10
Hydrogen Utilization Study Group (***H2SG***)	*Summary of Activities for Hydrogen Utilization in Chubu in 2030*	10
Nuclear Hydrogen Association	*Hydrogen Roadmap*	10
Edition 11		
International Energy Agency (***IEA***)	*Japan 2021: Energy Policy Review*	11
United Nations	*NDC Synthesis Report*	11
Wood Mackenzie	*Carbon capture and storage 2021*	11
World Economic Forum	*We can end routine gas flaring by 2030. Here's how*	11
Edition 12		
Environment America	*Offshore Wind for America*	12
Institute of Energy Economics and Financial Analysis (***IEEFA***)	*Australia's Opportunity to Plan Ahead for a Secure Zero-Emissions Electricity Grid*	12
Nature	*Food systems are responsible for a third of global anthropogenic GHG emissions*	12

ORGANISATION	TITLE / SUBJECT MATTER	EDITION
Edition 13		
Climate Action 100+	*Net-zero Company Benchmark*	13
International Renewable Energy Agency (***IRENA***)	*World Energy Transitions Outlook*	13
Energy & Climate Intelligence Unit	*Taking stock: A global assessment of net zero targets*	13
Edition 14		
Grattan Institute	*Go for net zero: A practical plan for reliable, affordable, low-emissions electricity*	14
Hydrogen Europe	*Hydrogen Act*	14
ScienceDirect	*Low-cost renewable electricity as the key driver of the global energy transition towards sustainability*	14
Edition 16		
Carbon Tracker	*The Sky's the Limit: Solar and wind energy potential is 100 times as much as global energy demand*	16
Nature Climate Change	*Critical adjustment of land mitigation pathways for assessing countries' climate progress*	16
World Bank	*The Potential of Zero-Carbon Bunker Fuels in Developing Countries*	16
World Economic Forum	*Why we can't afford to dismiss carbon offsetting in a climate crisis*	16
Edition 17		
Department for Business, Energy & Industrial Strategy (UK)	*Contracts for Difference (CfD): changes to Supply Chain Plans and the CfD contract*	17
International Energy Agency (***IEA***)	*The Role of Critical Minerals in Clean Energy Transitions*	17
United Nations Environment Programme	*Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions*	17
Edition 18		
G7 Research Group	*G7 Climate and Environment: Ministers' Communiqué*	18
International Energy Agency (***IEA***)	*Net Zero by 2050 – A Roadmap for the Global Energy Sector*	18
World Economic Forum	*Fostering Effective Energy Transition 2021*	18
Edition 19		
CSIRO	*GenCost 2020-21*	19
Federal Government of Australia, Advisian, and the Clean Energy Finance Corporation (***CEFC***)	*Australian hydrogen market study – Sector analysis study*	19

ORGANISATION	TITLE / SUBJECT MATTER	EDITION
Fuel Cells and Hydrogen Joint Undertaking	*Hydrogen Valleys: Insights into the emerging hydrogen economies around the world*	19
Hydrogen Europe	*How Hydrogen Can Help Decarbonise the Maritime Sector*	19
International Energy Agency (***IEA***)	*Unlocking the Economic Potential of Rooftop Solar PV in India*	19
Institute for Essential Services Reform	*Deep decarbonization of Indonesia's energy system: A Pathway to zero emissions by 2050*	19
National Renewable Energy Laboratory	*Storage Futures Study: Economic Potential of Diurnal Storage in the U.S. Power Sector*	19
Princeton University	*Net Zero America Report*	19
The Energy and Resources Institute	*The Potential Role of Hydrogen in India: A Pathway for Scaling-up Low Carbon Hydrogen Across the Economy*	19
The White House	*Carbis Bay G7 Summit Communique*	19
Edition 20		
Commonwealth Government of Australia, Advisian and the Clean Energy Finance Corporation (***CEFC***)	*Australian hydrogen market study – Sector analysis study*	20
Dii & Roland Berger	The Potential for Green Hydrogen in the GCC Region	20
Electric Power Research Institute	*Impact of carbon dioxide removal technologies on deep decarbonization of the electric power sector*	20
European Hydrogen Backbone	*Analysing future demand, supply, and transport of hydrogen*	20
Hydrogen Europe	*Hydrogen Europe's How Hydrogen Can Help Decarbonise the Maritime Sector*	20
Hydrogen Valley Platform	*Hydrogen Valleys: Insights into the emerging hydrogen economies around the world*	20
Hysource	*Net Zero Emissions by 2050 and the Role of Hydrogen*	20
International Energy Agency (***IEA***)	*Unlocking the Economic Potential of Rooftop Solar PV in India*	20
International Energy Agency (***IEA***)	*Net Zero by 2050: A Roadmap for the Global Energy Sector (IEA Roadmap).*	20
International Energy Agency (***IEA***)	*Energy Prices: Overview – High-Quality data on end-use energy prices*.	20
International Energy Agency (***IEA***)	*Carbon capture, utilisation and storage: the opportunity in Southeast Asia*	20
International Renewable Energy Agency (***IRENA***)	*World Energy Transition Outlook: 1.5^{O}C Pathway: Preview*	20

ORGANISATION	TITLE / SUBJECT MATTER	EDITION
International Renewable Energy Agency (***IRENA***)	*Renewable Power Generation Costs in 2020*	20
KBR	*Study of Hydrogen Imports and Downstream Applications for Singapore*	20
Navigant	*Carbon Capture, Utilisation and Storage, (CCUS): Decarbonisation Pathways for Singapore's Energy and Chemicals Sectors*	20
Regulatory Horizons Council	Regulatory Horizons Council Report of Fusion Energy	20
Zickfeld, K., Azevedo, D., Mathesius, S. et al.	*Asymmetry in climate – carbon cycle response to positive and negative CO_2 emissions*	20
Edition 21		
All-Party Parliamentary Group (***APPG***)	*The role of hydrogen in powering industry*	21
Energy Transition Commission	*Bioresources within a Net-Zero Emissions Economy: Making a Sustainable Approach Possible*	21
European Commission	*A hydrogen strategy for a climate neutral Europe*	21
Hydrogen Europe	*H2ero Net Zero – Different energy carriers required separate systems of guarantees of origin*	21
International Energy Agency (***IEA***)	*Energy Prices: Overview – High-Quality data on end-use energy prices*	21
International Energy Agency (***IEA***)	*Hydropower Special Market Report*	21
International Energy Agency (***IEA***)	*Trends and Developments in Electric Vehicle Markets.*	21
International Renewable Energy Agency (***IRENA***)	*World Energy Transitions Outlook*	21
International Renewable Energy Agency (***IRENA***)	*Renewable Power Generation Costs in 2020.*	21
McKinsey & Company	*Creating the -zero carbon mine*	21
McKinsey & Company	*How negative emissions can help organizations meet their climate goals*	21
NASA and NOAA	*Satellite and Ocean Data Reveal Marked Increase in Earth's Heating Rate*	21
Swiss Re Group	*The Insurance Rationale for Carbon Removal Solutions*	21
The Oxford Institute for Energy Studies	*Energy Transition: Modelling the Impact of Natural Gas).*	21
University of Houston and the Center for Houston's Future	*Houston: The Low Carbon Energy Capital*	21
Zickfeld, K., Azevedo, D., Mathesius, S. et al.	*Asymmetry in climate – carbon cycle response to positive and negative CO_2 emissions*	21
Edition 22		
European Union Agency for the Corporation of Energy Regulators (***ACER***)	*Transporting Pure Hydrogen by Repurposing Existing Gas Infrastructure: Overview of existing studies and reflections on the conditions for repurposing*	22

ORGANISATION	TITLE / SUBJECT MATTER	EDITION
Hydrogen Counsel and McKinsey & Company	*Hydrogen Insights: An updated perspective on hydrogen investment, market development and momentum in China*	22
National Nuclear Laboratory	*Unlocking the UK's Nuclear Hydrogen Economy to Support Net Zero*	22
International Energy Agency (***IEA***)	*Empowering Cities for a Net Zero Future- Unlocking resilient, smart, sustainable urban energy systems*	22
Jet Propulsion Laboratory	*Changes in global terrestrial live biomass over the 21st century*	22
International Energy Agency (***IEA***)	*Sustainable Recovery Tracker*	22
All-Party Parliamentary Group	*The role of hydrogen in powering industry*	22
Edition 23		
European Union Agency for the Corporation of Energy Regulators (***ACER***)	*Transporting Pure Hydrogen by Repurposing Existing Gas Infrastructure: Overview of existing studies and reflections on the conditions for repurposing*	23
Hydrogen Counsel and McKinsey & Company	*Hydrogen Insights: An updated perspective on hydrogen investment, market development and momentum in China*	23
National Nuclear Laboratory	*Unlocking the UK's Nuclear Hydrogen Economy to Support Net Zero*	23
International Energy Agency (***IEA***)	*Empowering Cities for a Net Zero Future- Unlocking resilient, smart, sustainable urban energy systems*	23
Jet Propulsion Laboratory	*Changes in global terrestrial live biomass over the 21st century*	23
International Energy Agency (***IEA***)	*Sustainable Recovery Tracker*	23
All-Party Parliamentary Group	*The role of hydrogen in powering industry*	23
Edition 24		
Intergovernmental Panel on Climate Change (***IPCC***)	*AR6 Climate Change 2021: The Physical Science Basis* (2021 Report)	24
Intergovernmental Panel on Climate Change (***IPCC***)	*Climate Change 2013: The Physical Science Basis* (2013 Report)	24
Intergovernmental Panel on Climate Change (***IPCC***)	Special Report: *Climate Change and Land*	24
Intergovernmental Panel on Climate Change (***IPCC***)	Special Report: *Global Warming of 1.5 °C*	24
Intergovernmental Panel on Climate Change (***IPCC***)	*2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*	24

ORGANISATION	TITLE / SUBJECT MATTER	EDITION
Intergovernmental Panel on Climate Change (***IPCC***)	*Special Report on the Ocean and Cryosphere in a Changing Climate*	24
Edition 25		
International Energy Agency (***IEA***)	*Net Zero by 2050 – A Roadmap for Global Energy Sector;*	25
International Energy Agency (***IEA***)	*Hydrogen in Latin America*	25
International Energy Agency (***IEA***) or International Renewable Energy Agency (***IRENA***)	*World Energy Transitions Outlook;*	25
Wood Mackenzie	*How to scale up carbon capture and storage*	25
BloombergyNEF	*New Energy Outlook, 2021*	25
S&P Global Platts	*Platts Global Integrated Energy Model – Strategic Planning for a world in transition.*	25
FTI Consulting and Teri	*South Asia New Energy Series*	25
Intergovernmental Panel on Climate Change (***IPCC***)	*Sixth Assessment Report – Climate Change 2021, The Physical Science Basis (2021 Report)*	25
Commonwealth Scientific and Industrial Research Organisation	*CO_2 Utilisation Roadmap*	25
Edition 26		
BloombergNEF	*New Energy Outlook*	26
The Met Office (Royal Metrological Society)	*State of the UK Climate in 2020 (2020 Report)*	26
DNV	*Energy Transition Norway 2020 (DNV Report)*	26
Office of Energy Efficiency & Renewable Energy	*Off-shore Wind Market Report (US OWF Report)*	26
Australian Energy Market Operator	*Electricity Statement of Opportunities Report (ESOO Report)*	26
H2Accelerate	*Expectations for the fuel truck market*	26
Edition 27		
BloombergNEF and wbcsd	Hot Spots for Renewable Heat: Decarbonising Low-to-Medium Temperature Industrial Heat Across the G-20	27
Climate Action Tracker	Climate target updates slow as science ramps up need for action	27
E3G	No New Coal by 2021: The Collapse of the Global Coal Pipeline	27
Global Wind Energy Council	*Global Offshore Wind Report 2021*	27
H2 Cluster Finland	*A systemic view on the Finnish hydrogen economy today and in 2030 – Our common playbook for the way forward*	27

ORGANISATION	TITLE / SUBJECT MATTER	EDITION
Intergovernmental Panel on Climate Change (***IPCC***)	*Sixth Assessment Report – Climate Change 2021, The Physical Science Basis*	27
Lancaster University	*The real climate and transformative impact of ICT: A critique of estimates, trends, and regulations*	27
National Centers for Environmental Information	*Global Climate Report – August 2021*	27
World Bank	*Groundswell Part 2: Acting on Internal Climate Migration*	27
Edition 28		
Airbus	*Hydrogen: An energy carrier to fuel the climate-neutral aviation of tomorrow*	28
Australian Hydrogen Council	*Unlocking Australia's hydrogen opportunity*	28
Gas Infrastructure Europe (***GIE***)	*Picturing the value of underground gas storage to the European hydrogen system / Guidehouse study*	28
International Energy Agency (***IEA***)	*Hydrogen in Latin America*	28
International Renewable Energy Agency (***IRENA***)	*Renewables Readiness Assessment Paraguay*	28
Nature	*The contribution of insects to global forest deadwood decomposition*	28
NSW Parliament Legislative Council	*Development of a hydrogen industry in New South Wales*	28
Shell and Deloitte	*Decarbonising Aviation: Cleared for Take-off, Industry Perspectives*	28
Oxford Institute for Energy Studies	*Why Are Gas Prices So High*	28
Oxford Institute for Energy Studies	*Carbon Capture and Storage: The Perspective of Oil and Gas Producing Countries*	28
World Meteorological Organization	*Climate Indicator and Sustainable Development: Demonstrating the Interconnections*	28

Edition 1 – July Report on Reports

Welcome to **Edition 1** of **Report on Reports** – sharing summaries of papers, reports and studies published in respect of net-zero emissions (***NZE***), and related matters. This edition covers paper, reports and studies published during July 2021, and some from June (noting that the Report on Reports idea arose in July 2021). As noted in recent editions of Low Carbon Pulse, each Report on Reports is intended to provide a summary of key findings.

All reports and studies in this Edition 1 of Report on Reports, were covered in the editions of Low Carbon Pulse published during July 2021: Edition 21, click here, and Edition 22, click here.

The table following table details each paper, report and study covered in this July Report on Reports, and has a link to it:

REPORTS AND STUDIES COVERED IN DETAIL JULY REPORT ON REPORTS			
REPORT / STUDY	**LINK**	**REPORT / STUDY**	**LINK**
APPG Report	*The role of hydrogen in powering industry*	***IEA – CCS / CCUS SEA Report***	*Carbon capture, utilisation and storage: the opportunity in Southeast Asia*
DB Plan	*Decarbonising Transport – A Better, Greener Britain*	***IEA Hydropower Report***	*Hydropower Special Market Report*
ETC Report	*Bioresources within a Net-Zero Emissions Economy: Making a Sustainable Approach Possible*	***IEA Smart Cities***	*Empowering Cities for a Net Zero Future- Unlocking resilient, smart, sustainable urban energy systems*
EHB Report	*Analysing future demand, supply, and transport of hydrogen*	***IRENA – WETO***	*World Energy Transitions Outlook*
H2E GO Paper	*H2ero Net Zero: different energy carriers require separate systems of guarantees of origin*	***IRENA – RP Report***	*Renewable Power Generation Costs in 2020.*
H2E Maritime Paper	*How hydrogen can help decarbonise the maritime sector*	***OIES ET Report***	*Energy Transition: Modelling the Impact of Natural Gas.*

***APPG* - Hydrogen report:**

- **Title, and provenance, of report: *[The role of hydrogen in powering industry](#)*** (***APPG Report***)**:** The All Party Parliamentary Group (***APPG***) in the UK published the ***APPG Report***. The ***APPG Report*** was researched by Connect, and was funded by Baxi, Bosch, Cadent, EDF Energy, Energy and Utilities Alliance, Equinor, Johnson Matthey, National Grid, Northern Gas Networks, SGN and Shell (all key players in UK energy markets).

  Neither ***APPG*** nor the ***APPG Report*** have formal standing in the UK Parliamentary context, including in a policy setting context, but the members of ***APPG***, and the organisations funding the ***APPG Report***, make the publication, and the contents, of the ***APPG Report*** significant.

- **Purpose of *APPG Report*:** To identify "*measures that can be taken to support the overall delivery of decarbonising industry through hydrogen, and establishing the UK as a global leader in hydrogen technology*". (The concept of establishing the UK as a global leader in hydrogen technology, informs at least one of the recommendation contained in the ***APPG Report*** (i.e., the third recommendation).

- **Findings: Ten recommendations:**

  1. The UK Government must continue to expand beyond its existing commitments to 5 GW of low-carbon hydrogen production capacity by 2030;

  2. Any forthcoming policies must be complementary of the wider UK low-carbon commitments.

  Comment: This may be read as a "motherhood statement", it is not if read with the detail that sits beneath it: which detail notes that it is critical to co-ordinate and to streamline policy settings and implementation;

  3. The UK Government must commit to incentivising hydrogen production within the UK as opposed to importing hydrogen.

  Comment: This recommendation is consistent with the purpose of the ***APPG Report***, but overtime it is likely to succumb to lower cost imports of hydrogen, in particular Green Hydrogen;

  4. The UK Government must align hydrogen production pathways with nuclear technology to enhance hydrogen production.

  Comment: The UK Government's *Ten point plan for a green industrial revolution* (***Ten Point Plan***), provides for the development of the nuclear power sector (Point 3 of ***Ten Point Plan***), a low-carbon source of electrical energy, that may be used to produce hydrogen. In this context, the recommendation is a good one;

  5. A UK wide hydrogen network to support the transport sector is required, include a larger-scale implementation of hydrogen refuelling stations.

  Comment: *[Decarbonising Transport – A Better, Greener Britain](#)* states that close to 90% of ***GHG*** emissions arising from the transport sector in the UK arise from road transport, and as such development of refuelling stations, and recharging stations, is key;

  6. Industrial clusters will be key catalysts for driving forward the UK's decarbonisation of industry using CCS / CCUS and hydrogen and should be an immediate priority for the UK Government.

  Comment: This recommendation is a good one, and in many ways reflects what is already happening, with six clusters (some may say seven) identified and being developed by the private sector (including some of the organisations funding the ***APPG Report***), with five clusters and hubs identified on July 30, 2021 (see Edition [23](#) of Low Carbon Pulse) as eligible for the Track 1 CCS Programme;

  7. Changes in regulation by the UK Government are required to support hydrogen's role in powering industry.

  Comment: This recommendation is a good one, and like Recommendations 5 and 6, it is a recommendation "at home" in any jurisdiction globally: each country and economic bloc needs to develop laws and regulations that provide safety and certainty;

  8. For hydrogen to expand in the UK, a technology neutral approach is required for all types of energy systems.

  Comment: This recommendation goes to the core of Blue Hydrogen versus Green Hydrogen, and one being preferred over the other. The recommendation is a good one, not least by Blue Hydrogen, using subsidised CCS / CCUS, is needed to develop the supply side for hydrogen, with Green Hydrogen likely to displace Blue Hydrogen;

  9. Significant and long-term financial support is required for the development, deployment and operation of hydrogen technologies:

  Comment: Like Recommendations 5, 6, 7 and 8, this is a recommendation that is at home in any country, with support required for CCS / CCUS to produce Blue Hydrogen, and a likely role for Government to allow the deployment of Green Hydrogen production and storage technologies; and

  10. Ofgem must ensure that the hydrogen market is subject to effective competition to drive down prices for consumers.

  Comment: This is a laudable recommendation, but it is likely "to care of itself" as choices will exist for consumers in respect of many consumer choices, critically, the price of energy for the daily drive.

Department for Transport: Decarbonising Transport – A Better, Greener Britain:

- **Title, and provenance, of report:** ***[Decarbonising Transport – A Better, Greener Britain](#)*** (***DB Plan***)**:** The Department for Transport in the UK released the ***DB Plan*** on July 14, 2021 (the same day as the European Commission released its **Fit for 55** package (see Edition 22 of Low Carbon Pulse)). The ***DB Plan*** may be regarded as a consolidation of initiatives and plans already developed to provide the policy setting framework for the decarbonisation of the UK's transport sector.
- **Purpose of *DB Plan*:** To act as a point of consolidation for decarbonisation commitments across the transport sector, and more importantly, to outline the key enablers to decarbonisation. Edition 22 of Low Carbon Pulse outlined the key enablers, and they are considered in more detail below. Rather than report further on the ***DB Plan***, the key facts and statistics are the focus.
- **Scale of Decarbonisation required:**

  Total *GHG* emissions: In Q1 of 2021, the UK passed the half way mark to achieving ***NZE***: the reporting in the ***DB Plan*** has yet to catch up with this achievement. So as to provide a like-for-like comparison with the facts and statistics it is necessary to use the 2019 statistics in the ***DB Plan***. In 2019, human activities in the UK gave rise to 414.1 million tonnes CO_2 equivalent ***GHG*** emissions (414.1 $MtCO_2$-e): at that point, a 48.8% reduction in the mass of ***GHG*** emissions arising was required compared to 1990. By any measure, a first rank performance. But a performance that is likely to be accelerated.

  Total Transport sector *GHG* emissions: On the basis of the same source data, in 2019 the UK domestic transport emissions were 122.15 MtCO2-e, a little short of 30% of all ***GHG*** emissions. It is likely that the absolute mass of ***GHG*** emissions arising in 2020 was lower because of the impacts of Covid-19, but it may be that the percentage of ***GHG*** emissions arising from the transport sector has increased slightly. The transport sector in the UK may be regarded as more difficult to decarbonise than other sectors of the economy. The UK is not the only country in which this the case, but it is eminently achievable in the case of the UK.

  UK domestic transport emissions 2019: The following graphics outline the 2019 level of ***GHG*** emissions arising from each segment of the transport sector, and the profile of reductions in ***GHG*** emissions to achieve ***NZE***. To achieve ***NZE***, policy settings need to be finalised, funded and implemented.

Decarbonising Transport domestic transport *GHG* emission projects, versus the baseline:

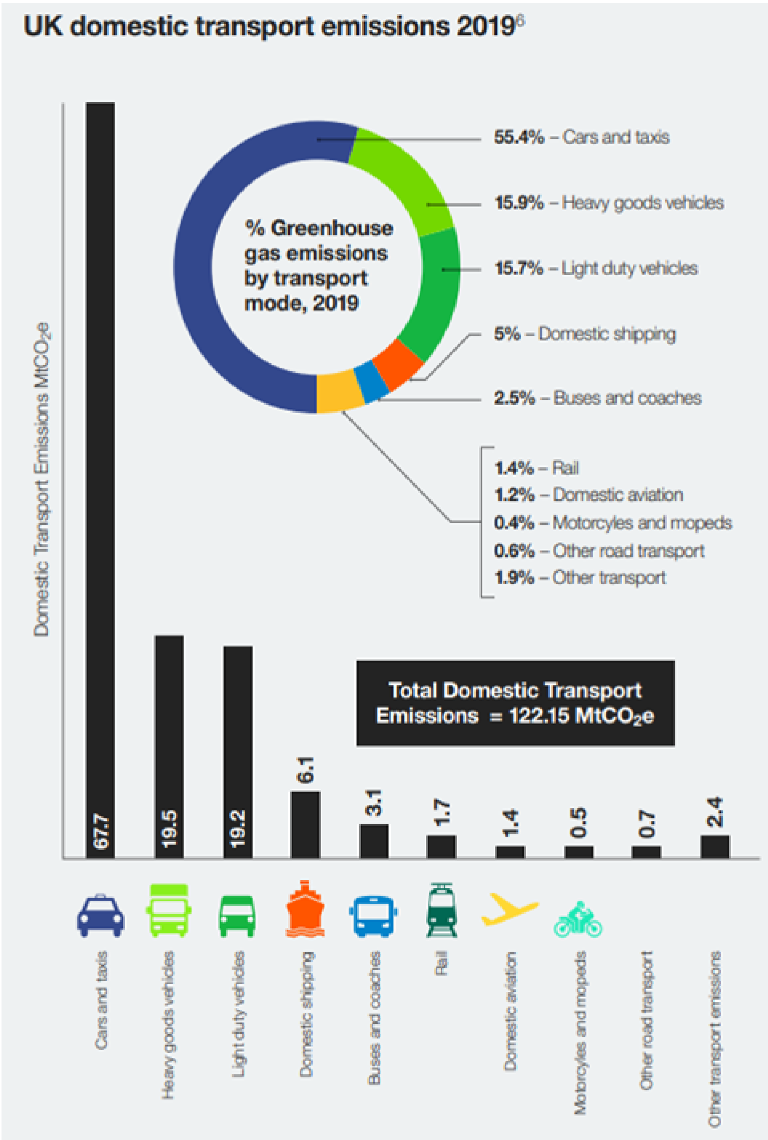
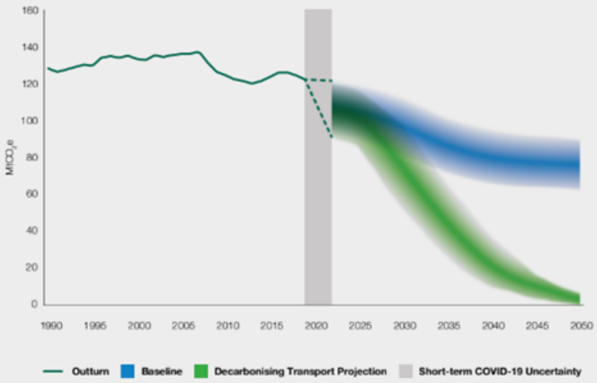
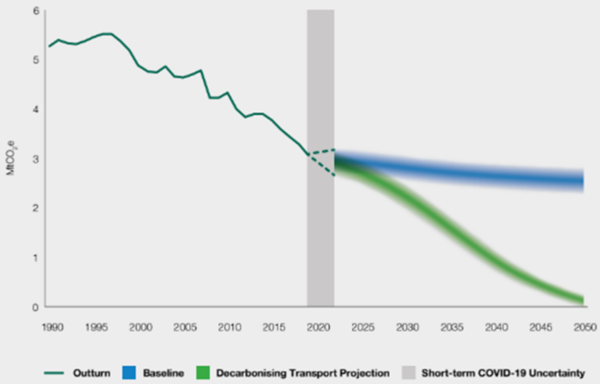


Figure 2: Decarbonising Transport domestic transport GHG emission projections, versus the baseline*



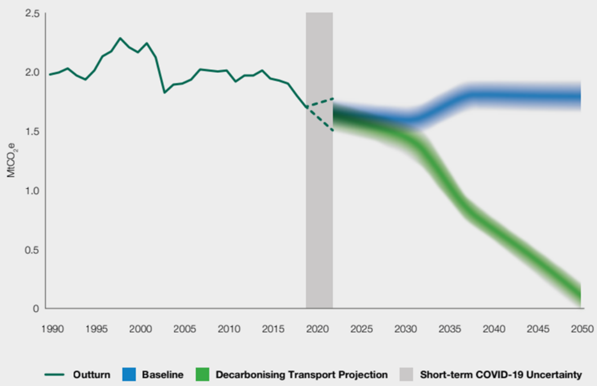
* Historic emissions are from published Her Majesty's Government (HMG) GHG statistics. Our projections are produced using a range of models, including the National Transport Model (road transport), and Traction Decarbonisation Network Strategy (rail), and Aviation model, adjusted for decarbonising transport measures. The shipping baseline and projections are based on the latest analysis by the CCC (https://www.theccc.org.uk/publication/sixth-carbon-budget/), which drew on research commissioned by DfT. Given the emerging nature of zero emission shipping fuels, the projections should be interpreted as possible scenarios for meeting the net zero goal that the government has announced for the UK maritime sector rather than estimates of the impact of specific policies. Baseline forecasts are not consistent with the 2019 BEIS Energy and Emission Projections (EEP), as these use different methodologies. Where feasible, uncertainty in projections reflects uncertainty on policy design, GDP, fuel prices, trip rates, and historic volatility in emissions. The range in the policy line declines as we move out to 2050, due to a higher proportion of zero emission vehicles. Transport emission projections exclude military aircraft and shipping.

Figure 5: Decarbonising Transport bus and coach GHG projections, versus the baseline*



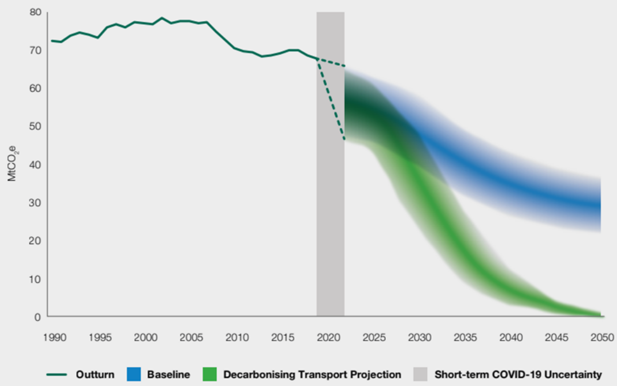
* Historic emissions are from published GHG statistics. Future bus and coach emissions are modelled using the National Transport model and adjusted for Decarbonising Transport measures. Bus and coach service levels in the central case are estimated based on 2015 levels. The uncertainty bands around projections reflect uncertainty on the form of final policy and uncertainties on future demand for road transport – related to future trends in travel, uptake of connected and autonomous vehicles, fuel prices, GDP growth, and historical volatility. Carbon savings are driven by Decarbonising Transport policies and ambitions. Modelling assumes zero emission technology is available for all buses and coaches. There is significant uncertainty about future business models for the bus and coach fleet (e.g. mobility as a service), which are not factored in these projections.

Figure 7: Decarbonising Transport rail GHG projections, versus the baseline*



* Historic emissions are from published GHG statistics. Carbon savings have been estimated using TDNS analysis. The uncertainty bands around projections reflect uncertainty on the form of final policy, and on historic volatility in rail. Emission reductions are primarily driven by rail electrification, but also from the deployment of battery electric and hydrogen trains on difficult to electrify sections of the rail network. Modelling assumes successful implementation of battery or electric trains.

Figure 9: Decarbonising Transport car GHG projections, versus the baseline*



* Historic emissions are from published GHG statistics. Future car and van emissions are modelled the using the National Transport model and adjusted for Decarbonising Transport measures. Uncertainty bands around projections reflect uncertainty on the form of final policy and uncertainties on future demand for road transport – related to future trends in travel, uptake of connected and autonomous vehicles, fuel prices, GDP growth, and historical volatility. Carbon savings are driven by Decarbonising Transport policies and ambitions. The range of uncertainty in emissions projections falls in the policy line as the proportion of miles by zero emission vehicles increases. From 2040 the lower end of policy projections includes emission reductions from speculative scenarios to get emissions to zero.

Figure 10: Decarbonising Transport van GHG projections, versus the baseline

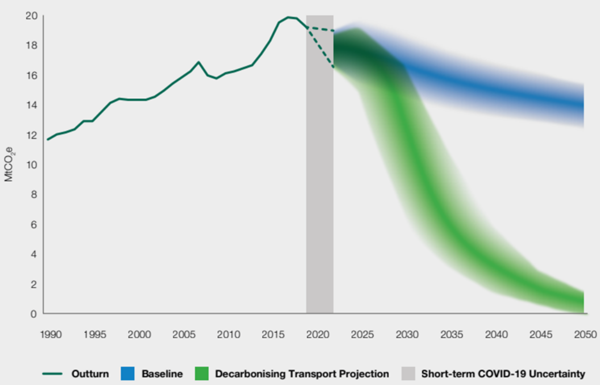
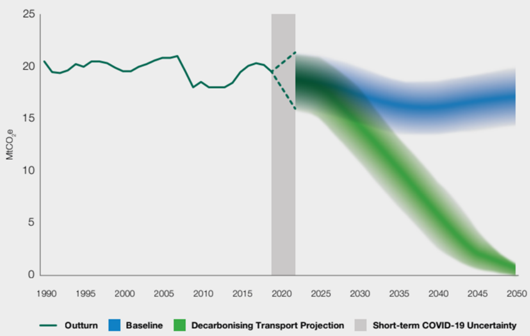


Figure 13: Decarbonising Transport HGV GHG projections, versus the baseline*



* Historic emissions are from published GHG statistics. Future HGV emissions are modelled using the National Transport model, adjusted for Decarbonising Transport measures. The uncertainty bands around projections reflect uncertainty on the form of final policy and uncertainties on future demand for road transport – related to future trends in travel, uptake of connected and autonomous vehicles, fuel prices, GDP growth, and historical volatility. Carbon savings are driven by Decarbonising Transport policies and ambitions. The range of uncertainty in emissions projections falls in the policy line as the proportion of vkms by zero emission vehicles increases – this modelling assumes successful implementation of zero emission HGVs for all categories of HGV.

ETC on Bioresources within a Net-Zero Economy report:

- **Title, and provenance, of report: *Bioresources within a Net-Zero Economy : Making a Sustainable Approach Possible*** (***ETC Report***)**:** The Energy Transitions Commission (***ETC***) is a global coalition of leaders from across the energy sector (producers and users). The ***ETC*** publishes reports from time to time. (In addition to the ***ETC Report***, in April 2021 the ***ETC*** published the excellent, *Making Clean Electrification Possible: 30 Years to Electrify the Global Economy* and *Reaching climate objectives: the role of carbon dioxide removals*).
- **Purpose of *ETC Report*:** To assess the extent of the role of the use of bio-resources to provide energy carriers on a sustainable basis. This is in the context of increased interest on bio-energy sector, with most if not all reports on studies on pathways to achievement of net-zero emissions (***NZE***) contemplating a material role of bioenergy in the mix by 2050, for example, each of the International Energy Agency (***IEA***) and the International Renewable Energy Agency (***IRENA***), contemplate that bio-energy is a pillar to decarbonisation.
- **Findings:**
  1. "**Not all biomass is good biomass**": There is a working assumption that any bio-resource (i.e., biomass) is a renewable resource, and that the use of any renewable resource to derive or to produce energy (electrical or heat) or an energy carrier (gaseous, liquid or solid) is a good thing. All bio-resources contain carbon. Decomposition of carbon gives rise to CH_4 and oxidation (partial or complete) of carbon gives rise to CO_2 (and NOx and SOx: each a ***GHG***).

     If ***GHG*** emissions arising during production of energy or an energy carrier are captured and stored, and renewable electrical energy is the source of all electrical and heat energy to produce an energy carrier, on use, ***GHGs*** will arise. The theory is that the ***GHGs*** produced on use will be absorbed because bio-resources will be grown to absorb those ***GHGs***. As a matter of theory, this is a little rough-and-ready, and by no means sound in all instances. As a matter of practice, this is rougher-and-readier, and not sound in many instances.
  2. **Bioresources should have low lifecycle emissions and growth must comply with three rules:** For the theory to be firmer, production of bio-resources should take into account the "opportunity cost" related to carbon that should be absorbed without intervention. Critically, there are three rules, growth of any bio-resource, must not: (**a**) compete with use of land for food production; (**b**) trigger any land use change (direct or indirect) that could release absorbed carbon into the atmosphere; and (**c**) impact biodiversity negatively.
  3. **Use of bioresources for bioenergy:** On the basis of compliance with the three rules on a strict basis, the ***ETC Report*** estimates that by 2050 on a sustainable basis it will be possible to derive up between 40 and 60 EJ pa from bio-energy. (The ***ETC Report*** outlines the conditions to deriving more than 60 EJ from bio-resources as bio-energy.)

Report Card on *EC* - A hydrogen strategy for a climate neutral Europe:

- **Title and provenance:** July 8, 2021, was the first anniversary of the publication of the ***Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – A hydrogen strategy for a climate-neutral Europe*** (***EU Hydrogen Strategy***). In Edition 21 of Low Carbon Pulse, it was noted that the July Report on Reports would include a piece assessing progress.

  Given that many of the actions in the ***EU Hydrogen Strategy*** contemplate achievement in 2021, the thought is to assess progress at the end of 2021, likely as part of the fourth article in the ***Shift to Hydrogen (S2H2): Elemental Change*** series on ***Hydrogen Plans, Roadmaps and Strategies*** (publication of which has been deferred until the UK Hydrogen Strategy is published).
- **Purpose of *EU Hydrogen Strategy*:** To set out a vision of how the European Union (***EU***) can turn clean hydrogen into a viable solution to decarbonise different sectors of the economy over time, including installing at least 6 GW of renewable hydrogen electrolysers in the ***EU*** by 2024 and 40 GW by 2030. The production of Green Hydrogen is the subject to specific targets, the reference to clean hydrogen (see the note below) does not limit the ***EU Hydrogen Strategy*** to Green Hydrogen.

  The use of hydrogen to decarbonise is an integral part of the European Green Deal.

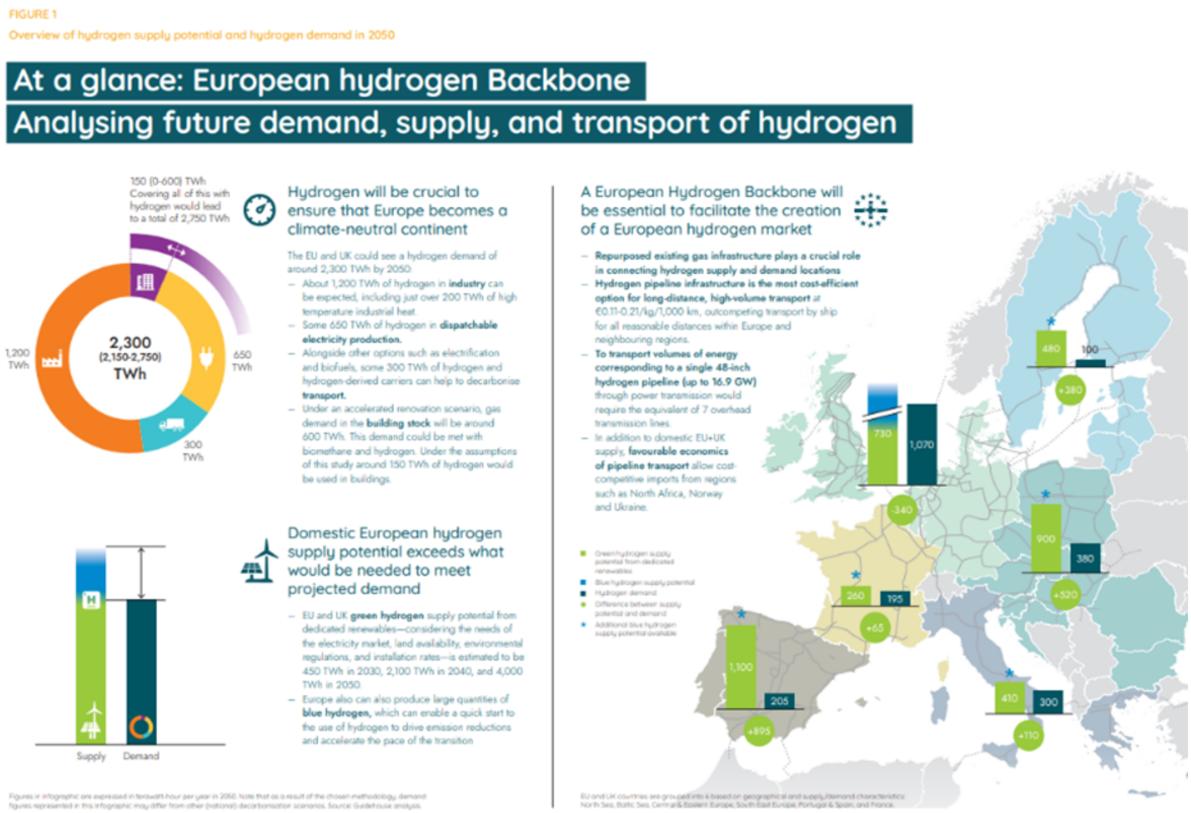
  (**Note:** For these purposes, **clean hydrogen** means renewable hydrogen, i.e., "hydrogen produced through electrolysis of water (in an electrolyser, powered by electricity), with electricity stemming from renewable resources. The full life-cycle of greenhouse gas emissions of the production of renewable hydrogen are close to zero. Renewable hydrogen may [also] be produced through the reforming of biogas (instead of natural gas) or biochemical conversion of biomass, if in compliance with sustainability requirements".)

European Hydrogen Backbone – Analysing future demand, supply, and transport of hydrogen:

- **Title and provenance:** The European Hydrogen Backbone (***EHB***) is an initiative of European Gas Transmission System Operators (***TSOs***) (the ***Initiative***): it covers 23 ***TSOs***, with gas networks across 19 ***EU*** member states.

  In June 2021, the ***EHB*** launched a paper entitled *Analysing future demand, supply, and transport of hydrogen* (***EHB Study***).

  In June 2020, the ***Initiative*** published a paper outlined an initial vision of the ***EHB***. An updated report was published in April 2021. These papers outline the physical assets and infrastructure that are available for use to haul hydrogen across Europe, anticipating assets and infrastructure across 21 ***EU*** members states will comprise the ***EHB*** as currently contemplated.
- **Purpose of the *EHB Study***: The ***EHB Study*** (intended to complement the existing papers from the ***Initiative***) considers the development of supply and demand of hydrogen across the continent, as part of progress to achieved "a climate-neutral continent". The ***EHB Study*** considers both Blue and Green Hydrogen.
- **Findings:** Key findings of the ***EHB Study*** were reported in Edition 20 of Low Carbon Pulse, in terms of demand and supply.



Hydrogen Europe (*H2E*)– Different energy carriers required separate systems of guarantees of origin:

- **Title, and provenance, of paper:** ***Different energy carriers require separate systems of guarantees of origin*** (***H2E GO Paper***)**:** Hydrogen Europe (***H2E***) is an organisation drawing its membership from across the private and the public sector, providing thought leadership and direction for the hydrogen industry in Europe, viewing hydrogen as "the other leg of the energy transition – alongside renewable electricity". ***H2E*** represents the interests of the European Hydrogen industry, and it publishes papers, reports and studies from time to time.
- **Purpose of *H2E Paper*:** To assess the current Guarantees of Origin (***GO***) system under the Renewable Energy Directive (***RED***), including to assess any shortcomings in its design.
- **Findings: Four recommendations** as follows, each of which feeds into the design and architecture of the ***RED*** as it relates to ***GOs***:

  1. Create a distinct hydrogen ***GO***, separate from electricity and gas.

  2. Encourage the use of ***GOs*** to prove the renewable character, and ***CO_2*** intensity, of electricity procured for the production of renewable hydrogen.

  3. Initiate the development of a global system of Hydrogen Guarantees of Origin (***H2GOs***), with track-and-trace and auditing functionality.

  4. Set clear ground rules that avoid false or misleading claims. Enable the cancellation of ***H2GOs***, and the issuance of a natural gas ***GO*** when physical volumes are blended.

  These recommendations are carried forward through detailed recommendations on four ***T*'s**: Traceability and Trackability, Tradability, and Transparency.

H2E – How Hydrogen Can Help Decarbonise The Maritime Sector:

- **Title, and provenance, of paper:** ***How Hydrogen Can Help Decarbonize The Maritime Sector*** (***H2E Maritime Paper***). As noted above, ***H2E*** represents the interests of the European Hydrogen industry. As might be expected, ***H2E*** is seeking to promote the development of the hydrogen industry, critically, in each area that may be regarded as difficult to decarbonise. In the area of shipping, ***H2E*** has been advocating that the ***EU*** takes the lead in the absence of the International Maritime Organisation (***IMO***) doing so. The ***H2E Maritime Paper*** provides helpful background on ***GHG*** emissions arising from the shipping industry, and ***IMO*** initiatives.
- **Purpose of *H2E Maritime Paper*:** To assess the potential of hydrogen and hydrogen-based fuels to contribute to the decarbonisation of the maritime sector, noting there are challenges, and, in the context of those challenges, to identify what the ***EU*** can do to address them. In this context, ***H2E*** notes the importance of the ***EU*** taking the lead, for example, the inclusion of "the maritime sector in the European Union Emission Trading Scheme [***EU ETS***]". As reported in Edition 22 of the Low Carbon Pulse, the shipping has been included in the ***EU ETS***.
- **Findings:** The key points that arise from the ***H2E Maritime Paper*** are as follows:
  - the choice of the fuel of the future for the shipping industry is uncertain. Factors that need to be balanced are:
    - cost and ease of storage on board, including volume, noting that energy density is a key factor;

    - for smaller vessels and short distance vessels, pure hydrogen is convenient, and cheaper than other future fuels, for larger vessels and longer distance vessels, ammonia is the cheapest future fuel; and
    - a considerable amount of clean hydrogen will be required, which goes to assurance, cost and quantity, and timing, of supply development;
  - the choice of Green Hydrogen as the future fuel enables a 100% reduction of Well-to-Wake (***WTW***) ***GHG*** emissions;
  - the choice is not simple, and certainly not a Green Hydrogen only choice: there is a range of choices:
    - Green Hydrogen or Green Ammonia (combination / synthesis of H_2 and ***N***);
    - E-Fuels (or Bio-fuels): e-diesel, e-kerosene, e-LNG and e-methanol; and
    - Blue Hydrogen and Blue Ammonia.

  The ***H2E Maritime Paper*** considers each possible future fuel for the shipping industry, and each facet that arises.

IEA Reports:

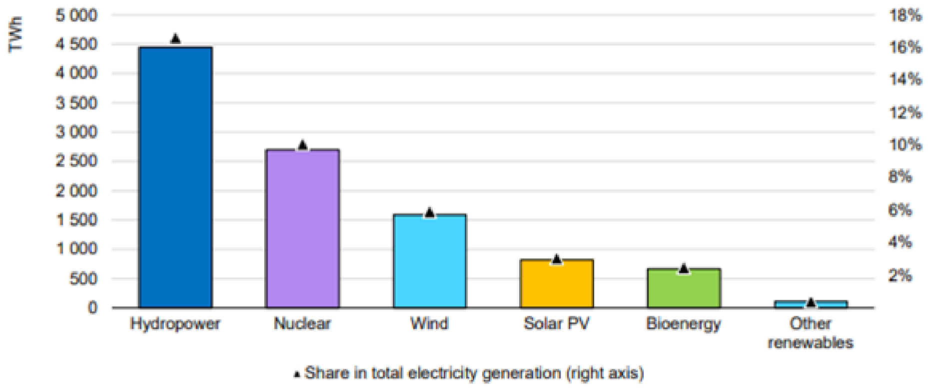
The International Energy Agency (***IEA***) was established in 1974 as a response to the oil price crises during that year. The ***IEA*** now comprises 30 member countries, and 8 association countries.

The ***IEA*** has become one of the leading energy data collection and analysis organisations, and from this key to information provision and to research globally.

- ***IEA* Reports during July, 2021** (and late June)**:**
  - Energy Prices: Overview;
  - Carbon Capture, Utilisation and Storage: The Opportunity in Southeast Asia (***CCS / CCUS SEA Report***);
  - Hydropower Special Market Report – Analysis and Forecast to 2030 (***Hydropower Report***);
  - Trends and developments in electric vehicle markets;
  - Empowering Cities for a Net Zero Future: Unlocking resilient, smart, sustainable urban energy systems (***Smart Cities Report***); and
  - Sustainability Tracker: Monitoring Progress towards sustainable recovery from Covid-19 crisis.
- For the purposes of this July 2021, Report on Reports, the ***CCS / CCUS SEA Report***, the ***Hydropower Report*** the ***Smart Cities Report*** are reported upon in more detail, with headlines only included in respect of the other reports, first those headlines:
  - **Energy Prices**: ***Overview***: Rightly the ***IEA*** regards monitoring end-use energy prices as critical for the purposes of understanding markets, and framing policy settings, and as end-use energy prices increasingly cease to be regulated, this monitoring becomes ever more important, and relevant. The ***Overview*** is commended because it looks at energy prices and energy taxes;
  - **Trends and development in electric vehicle markets**: The ***IEA*** notes that in 2020 "the global electric car stock hit the 10 million mark": this is 1% of total global car stock, but in 2020, 3 million new battery electric vehicles (***BEVs***) joined the global stock. Low Carbon Pulse will continue to cover developments in ***BEVs***.
  - **Sustainability Tracker: *Monitoring Progress towards sustainable recovery from Covid-19 crisis***: The Sustainability Tracker provides a report card against the *IEA Sustainable Recovery Plan* (***IEA SRP***) from 2020. The high level summary is that governments, globally, have committed to spend an additional USD 350 billion a year between 2021 and 2023, but this is 35% of the amount envisaged as required by the ***IEA SRP***, which is the amount that the ***IEA*** considers necessary to put the world on track to achieve ***NZE*** by 2050.
- ***CCS / CCUS SEA Report*:**
  - **Purpose**: It is recognised that CCS / CCUS has a key role to play in clean energy transition in Southeast Asia: CCS / CCUS may capture emissions from existing chemical, petrochemical and power production, and other industrial activities, including cement, glass, and iron and steel. Regional cooperation to store CO_2 captured will accelerate capture and storage, and transportation, development.
  - **Findings and strategic priorities:** To facilitate the development of CCS / CCUS regional co-operation is required as is the development of legal and regulatory frameworks consistent with policy settings, including incentives under those policies. The key findings from the ***CCS / CCUS SEA Report*** are the strategic priorities for CCUS in Southeast Asia as follows:
    - **Increase regional cooperation and collaboration:** to identify and to develop opportunities for shared infrastructure development, and to develop CCS / CCUS capabilities;
    - **Identify and develop on-shore and off-shore CO2 storage resources** in parallel with the development of robust legal and regulatory frameworks for safe and secure storage of CO2, and in this context to leverage support available from policy banks;
    - **Encourage early investment in CCUS projects**, critically, pilot projects to demonstrate feasibility and scalability, and to make use of industrial hubs as hubs for carbon capture; and
    - **Build International support and financing for CCUS in Southeast Asia**, critically, to access grant and loan support, noting that on-going subsidy support (of the kind that is provided in Europe) is less likely to be feasible, and as such upfront grant and loan support is to key.

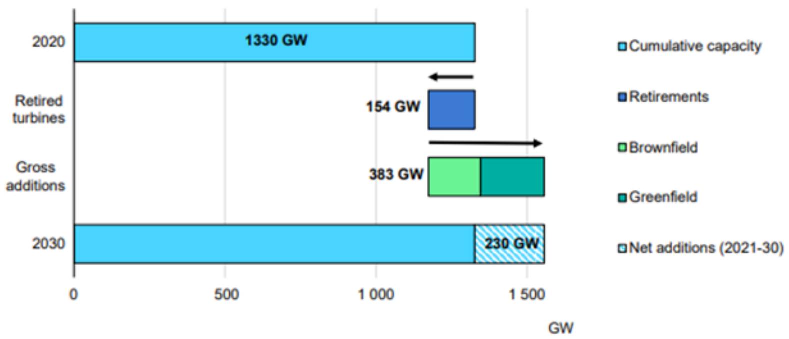
- ***Hydropower Report***:
  - **Purpose:** It is recognised that hydropower (pumped storage, reservoir and run-of-river) capacity has grown significantly since 2000, and that the growth of the sector needs to continue as part of progress towards ***NZE***. In this context, the ***IEA*** presents forecasts for the potential for growth. The ***IEA*** reminds the reader that hydropower is the backbone of existing low-carbon electricity generation, providing almost half of the low-carbon electricity generation.

Figure 1.1 Low-carbon electricity generation by technology and shares in global electricity supply, 2020



  - **Findings and priority areas:** It is recognised that hydropower has a key role to play, and a greater role to play in progress towards ***NZE***. Looking forward to 2030, the bar chart below indicates that headline hydropower capacity is projected to increase by 230 GW (net, taking account of retirement of existing capacity).

Figure 3.1 Global hydropower capacity forecast, retirements, and gross and net additions, 2020 and 2030

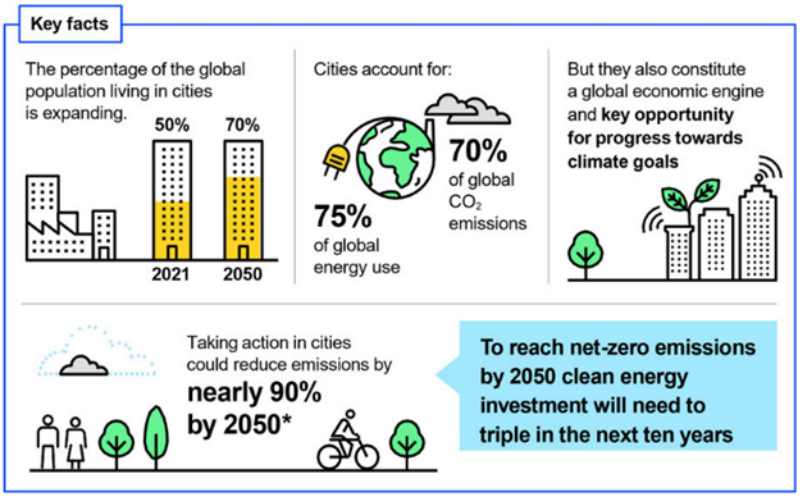


While this represents a 17% increase 2021 to 2030, it is a slower rate of increase than occurred 2010-2020. The ***IEA*** considers that this slower rate of increase will be a missed opportunity. In this context, the ***IEA*** identifies seven priority areas for governments so as to avoid missing the opportunity:

- Move hydropower up the energy and climate policy agenda;
- Enforce robust sustainability standards for all hydropower development with streamlined rules and regulations;
- Recognise the critical role of hydropower for electricity security and reflect value through remuneration mechanisms;
- Maximise the flexibility capabilities of existing hydropower plants through measure to incentivise their modernisation;
- Support the expansion of pumped storage hydropower;
- Mobilise affordable financing for sustainable hydropower development in developing economies; and
- Take steps to ensure to price in the value of multiple public benefits provided by hydropower plants.

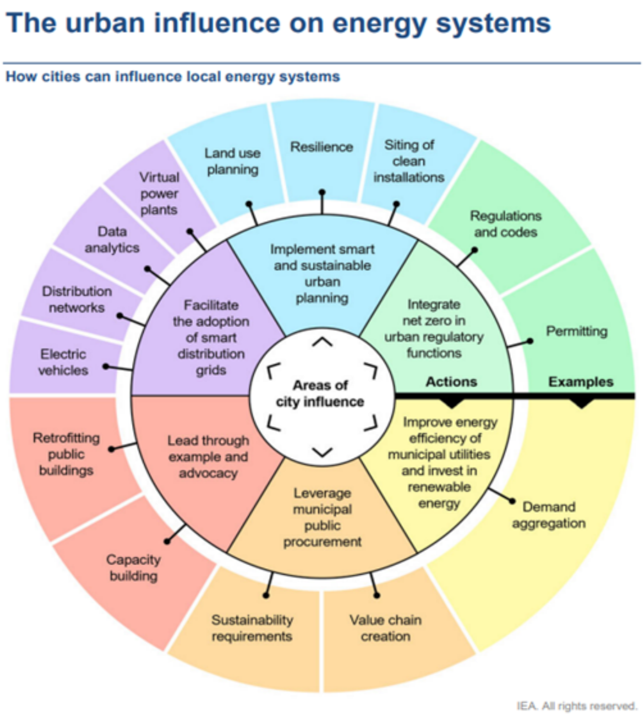
The ***Hydropower Report*** is well-rounded, and it considers the challenges of hydropower, including cost.

- ***Smart Cities Report***:
  - **Purpose:** It is recognised more than 50% of the world's population lives in cities, and that this concentration will increase as the pace of urbanisation increases, and the standards of living increase, overtime in countries whose populations are continuing to grow, with 70% of the world's population expected to live in cities by 2050. Currently, 70% of CO_2 emissions arise from activities undertaken in cities, and as the number of cities increases, and the populations of them increases, the reduction of ***GHG*** emissions arising from cities will be critical to the reduction of over 80% of the ***GHG*** emissions arising globally so as to achieve ***NZE***. In this context, energy production, transportation and use is central to policy settings in the urban setting.

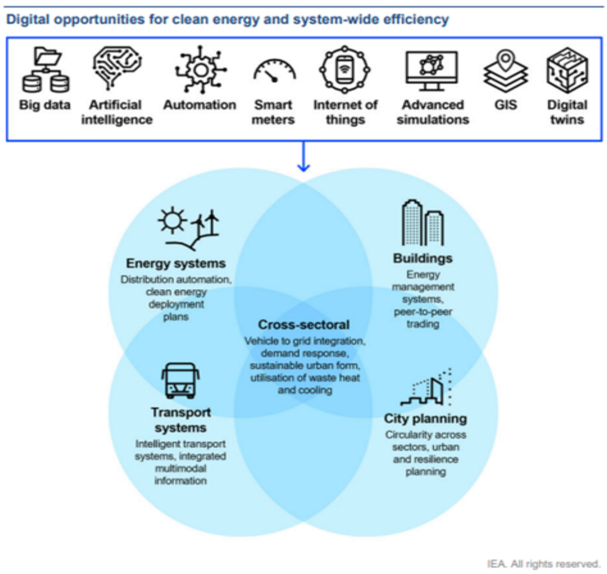


*Notes: Taking action in cities could reduce emissions by nearly 90% by 2050, compared to Coalition for Urban Transition's 2050 business-as-usual reference scenario.

  - **Findings and recommendations:** It is recognised that improved efficiency of energy use is critical in the built environment as is the reduction in ***GHG*** emissions arising from urban transport, and of course the increased electrification and the use of low-carbon or no carbon energy carriers, including hydrogen and hydrogen-based fuels.



Digitisation is seen as a key means of improving efficiency of energy use across all sectors and industries.



The ***IEA*** makes six recommendations:

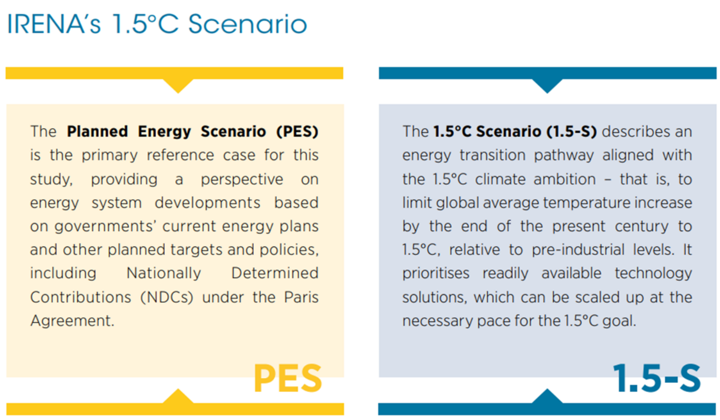
- Design inclusive policies and programmes with people at their core;
- Build capacity across digitalisation and energy;
- Ensure timely, robust, transparent access to data;
- Ensure the availability of finance and promote financial innovation;
- Promote the development and uptake of international standards and benchmarks; and
- Create opportunities for sharing and learning.

While the findings and the recommendations of in the ***Smart Cities Report*** are not surprising, the ***Report*** is helpful in collating research, and outlining what needs to be done.

IRENA Reports:

The Intentional Renewable Energy Agency (***IRENA***) is an intergovernmental organisation supporting countries in the transition to renewable / sustainable energy, and is reported to be actively engaged with more than 180 countries in this endeavour.

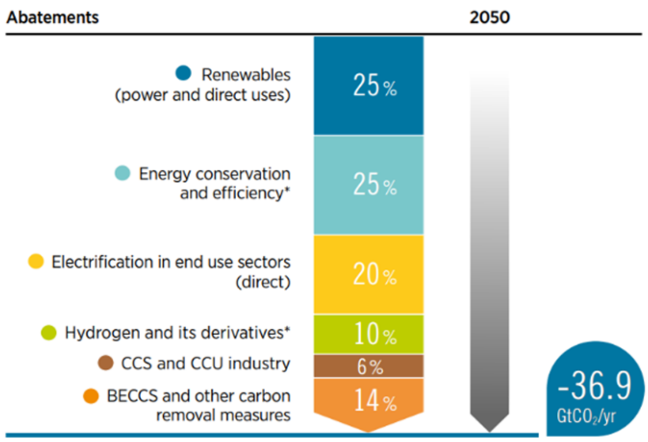
- ***IRENA* Reports during July, 2021 (and late June)**
  - *World Energy Transition Outlook: 1.5^{O}C Pathway* (***WETO***); and
  - *Renewable Power Generation Costs in 2020* (**RP Report**).
- ***WETO***: The ***WETO*** was long-awaited, not least because it was previewed in Q1 of 2021 (***Preview to World Energy Transition Outlook***, and reported on in Edition 13 of Low Carbon Pulse). Editions 21 and 22 of Low Carbon Pulse provide high level summary of the key elements of ***WETO*** (and comparison with the ***IEA Net Zero by 2050 – A Roadmap for Global Energy Sector***, the ***IEA Roadmap***). In this report on report, the key facts and statistics are extracted, and presented:
  - **Purpose of *WETO***: The purpose of ***WETO*** is to provide "an energy transition pathway aligned with the 1.5^{O}C climate ambition" (i.e., to limit global average temperatures increase to 1.5^{O}C above pre-industrial levels), and in so doing to provide a tool-kit for those developing and implementing policy settings in countries and economic blocs globally.



Throughout ***WETO*** the Planned Energy Scenario (***PES Scenario***) and the 1.5^{O}C Scenario (***1.5-S***) models are considered side by side. This is different from the ***IEA Roadmap***, which uses the specific policy setting model (***STEPS***) and the announced pledges model (***APC***).

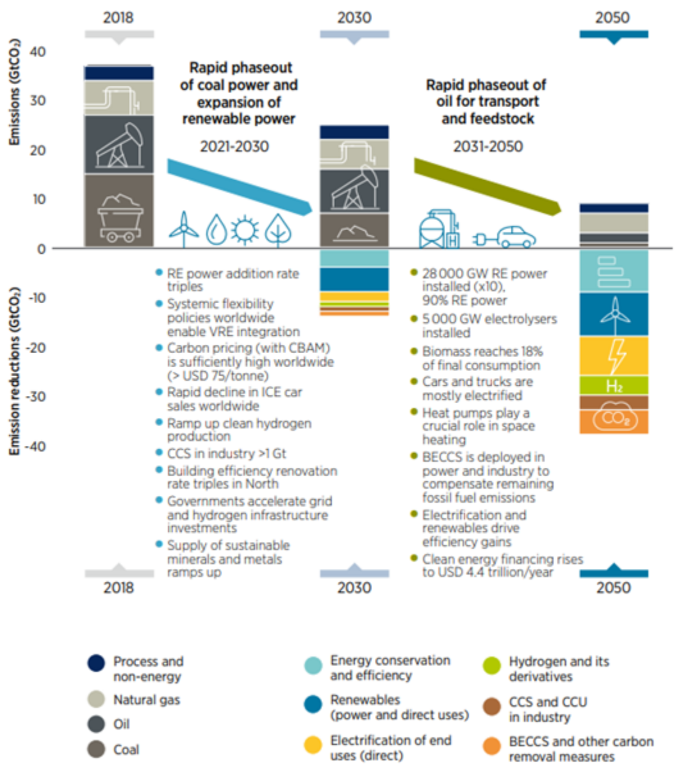
- **Findings:** The findings of ***WETO*** are many and varied, and the findings are best summarised in the following graphic that identifies ***IRENA's*** assessment of the sources of abatement of ***GHG*** emissions to achieve ***NZE*** across the energy sector.
  - Abatement as modelled:

FIGURE S.4 Carbon emissions abatements under the 1.5°C Scenario (%)



The graphic needs to be read with the next graphic, which outlines the progress required to reduce ***GHG*** emissions arising from the use of the current mix of technologies, with abatement of ***GHGs*** from the use of other the technologies (and other means).

FIGURE S.5 Evolution of emissions with phaseouts of coal and oil, 2021-2050

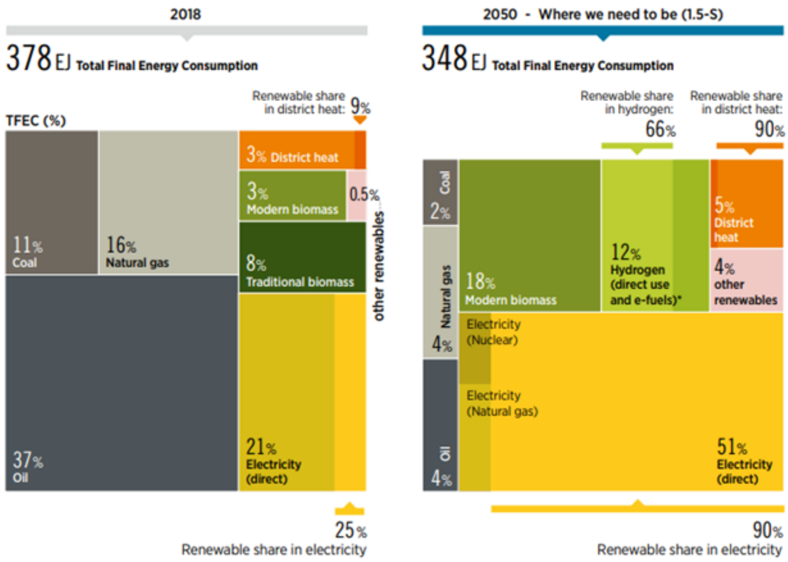


Note: RE = renewable energy; VRE = variable renewable energy; CBAM = carbon border adjustment mechanism; ICE = internal combustion engine; GW = gigawatt; Gt = gigatonne; CCS = carbon capture and storage; BECCS = bioenergy combined with carbon capture and storage; CCU = carbon capture and utilisation.

- **How much energy now and then?**

  The concepts that arise from the above graphics, are explained equally plainly by reference to total final energy consumption as follows:

FIGURE 2.4 Breakdown of total final energy consumption (TFEC) by energy carrier in 2018 and 2050 (EJ) in the 1.5°C Scenario



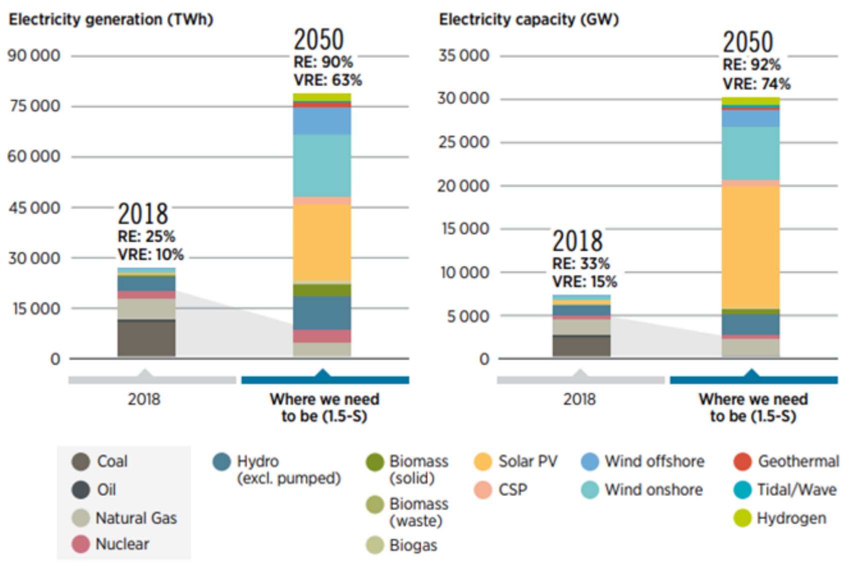
Note: The figures above include only energy consumption, excluding non-energy uses. For electricity use, 25% in 2018 and 90% in 2050 are sourced from renewable sources; for district heating, these shares are 9% and 90%, respectively; for hydrogen (direct use and e-fuels), the renewable energy shares (*i.e.*, green hydrogen) would reach 66% by 2050. The category "Hydrogen (direct use and e-fuels)" accounts for total hydrogen consumption (green and blue) and other e-fuels (e-ammonia and e-methanol). Electricity (direct) includes all sources of generation: renewable, nuclear and fossil fuel based. 1.5-S = 1.5°C Scenario; EJ = exajoule.

- **How much electrical energy now and then?**

  The core of energy transition under any model is the need to increase electrical energy from renewable sources, both for direct supply and for the derivation and production of energy carriers (including hydrogen, and hydrogen-based fuels).

  The following graphic explains this graphically!

FIGURE 2.5 Electricity generation and capacity by source, 2018 and 2050 (TWh/yr and GW) in the 1.5°C Scenario



Note: 1.5-S = 1.5°C Scenario; CSP = concentrating solar power; GW = gigawatts; PES = Planned Energy Scenario; PV = photovoltaic; RE = renewable energy; TWh/yr = terawatt hours per year; VRE = variable renewable energy.

If there is one graphic in all the papers, reports and studies published in recent times that conveys the magnitude of the level of electrification required, it is this.

While other papers, reports and studies may have provided statements that are different (invariably higher) as to the electricity generation and capacity required, this graphic speaks loudly to the scale of what needs to occur in electrical energy generation capacity and electrical energy generated.

The hard numbers, reflect how hard the task is going to be.

- **How?**

  Six Pillars: ***WETO*** provides six pillars to frame thinking and development policy setting and its implementation: (**1**).. Energy Conservation and efficiency; (**2**) Renewables (power and direct uses); (**3**) Electrification of end use (direct); (**4**) Hydrogen and its derivatives; (**5**) CCS and CCUS in industry; and (**6**) BECCS and other carbon removal measures.

  While the **IEA** ***Roadmap*** has seven pillars, whether six or seven, pillars cover the activities that needed to achieve ***NZE***. In some ways, the pillars are more helpful than the detailed modelling, because they allow the framing of thinking and policy setting and implementation while at the same time showing that certain activities will require more government support than others, because there is differing execution risk.

  Government role: In addition to government policy settings, governments need to take an active role, critically in respect of the right policy settings to encourage the development of renewable electrical energy and grids, ahead of load, the development of CCS / CCUS projects to achieve scale use as quickly as possible, both to capture ***GHGs*** and to allow the development of Blue Hydrogen production capacity, to fund or co-fund the development of infrastructure, including recharging and refuelling infrastructure, and critically to consider whether it becomes a "forward-buyer" of hydrogen and hydrogen-based fuels to allow government to provide the right supply and demand side mix, and as such the right price point.

(As is the case with the ***IEA Roadmap*** *and* ***BloombergNEF's New Energy Outlook***, ***WETO*** assesses the pathway through energy transition to ***NZE*** across the energy sector. As such, not all activities giving rise to anthropogenic ***GHGs*** emissions are covered: in short, abatement of ***GHG*** emissions arising from Agriculture, Forestry and other Land Use (***AFOLU***) and from waste and waste water is not covered in ***WETO***).

- ***RP Report***: In what has become an annual event, in July 2021, ***IRENA*** released its ***Renewable Power Generation Costs in 2020***. Edition 20 of Low Carbon Pulse reported on the headlines from the ***RP Report***. Those reading the ***RP Report*** tend to focus on the comparative cost of renewable energy versus fossil fuel.

  The ***RP Report*** provides a consistent lens through which to consider and to analyse the development of the renewable energy sector, critically, the scale of development from 2000 to 2020, from 754 GW to 2,799 GW. The accurate and consistent reporting provides confidence in the broader analysis undertaken by ***IRENA***, critically ***WETO***.

  At the risk of labouring the point made above as to the scale of development of renewable electrical energy required on the road to achieving ***NZE***, for those who have followed the ***IRENA Renewable Power Generation Costs*** reports, the scale of development required has been visible for a while.

OIES – Energy Transition: Modelling the Impact on Natural Gas

- **Title, and provenance, of paper:** The ***Energy Transition: Modelling the Impact on Natural Gas*** (***OIES Report***) was prepared by The Oxford Institute For Energy Studies (***OIES***), a non-governmental organisation that operates as a research organisation and think tank.
- **Purpose of *OIES Report*:** To share two scenarios on the possible role of natural gas, both stated to have been developed and modelled to be consistent with the sustainable development model of the ***IEA***, which is fully aligned with the Paris Agreement to hold the rise in global average temperature to "well below 2^{O}C … and pursuing efforts to limit [it] to 1.5^{O}C". Each of the two scenarios is compared to business as usual. The ***OIES Report*** is helpful as a counter-point to other reports, critically, those that may be regarded as understating the role of natural gas as progress towards ***NZE*** is made. Further, the report takes a regional perspective, which may be regarded as critical because the use of natural gas will differ by region.
- **Findings:** The key finding is that in Asian markets the use of natural gas will continue to grow as part of energy transition.

ALL PAPERS, REPORTS AND STUDIES COVERED IN LOW CARBON PULSE DURING JULY 2021	
Organisation	**Title / subject Matter**
All-Party Parliamentary Group (***APPG***)	*The role of hydrogen in powering industry*
Commonwealth Government of Australia, Advisian and the Clean Energy Finance Corporation (***CEFC***)	*Australian hydrogen market study – Sector analysis study*
Dii & Roland Berger	The Potential for Green Hydrogen in the GCC Region

Electric Power Research Institute	*Impact of carbon dioxide removal technologies on deep decarbonization of the electric power sector*
Energy Transition Commission	*Bioresources within a Net-Zero Emissions Economy: Making a Sustainable Approach Possible*
European Commission	*A hydrogen strategy for a climate neutral Europe*
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European Union Agency for the Corporation of Energy Regulators (ACER)	*Transporting Pure Hydrogen by Repurposing Existing Gas Infrastructure: Overview of existing studies and reflections on the conditions for repurposing*
Hydrogen Counsel and McKinsey & Company	*Hydrogen Insights: An updated perspective on hydrogen investment, market development and momentum in China*
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Jet Propulsion Laboratory	*Changes in global terrestrial live biomass over the 21st century*
KBR	*Study of Hydrogen Imports and Downstream Applications for Singapore*

McKinsey & Company	*Creating the -zero carbon mine*
McKinsey & Company	*How negative emissions can help organizations meet their climate goals*
NASA and NOAA	*Satellite and Ocean Data Reveal Marked Increase in Earth's Heating Rate*
National Nuclear Laboratory	*Unlocking the UK's Nuclear Hydrogen Economy to Support Net Zero*
Navigant	*Carbon Capture, Utilisation and Storage, (CCUS): Decarbonisation Pathways for Singapore's Energy and ChemicalsSectors*
Regulatory Horizons Council	Regulatory Horizons Council Report of Fusion Energy
Swiss Re Group	*The Insurance Rationale for Carbon Removal Solutions*
The Oxford Institute for Energy Studies	*Energy Transition: Modelling the Impact of Natural Gas).*
University of Houston and the Center for Houston's Future	*Houston: The Low Carbon Energy Capital*
Zickfeld, K., Azevedo, D., Mathesius, S. et al.	*Asymmetry in climate – carbon cycle response to positive and negative CO_2 emissions*

Edition 2 – August Report on Reports

Welcome to **Edition 2** of **Report on Reports** – sharing summaries of papers, reports and studies on published on net-zero emissions, and related matters. This edition covers papers, reports and studies published during August 2021. As noted in recent editions of Low Carbon Pulse, each Report on Reports is intended to provide a summary of key findings.

While a good number of papers, reports and studies have appeared during August, the nature of them and their findings has been such that they have been covered in Low Carbon Pulse. Further, new Hydrogen Plans, Roadmaps and Strategies are the subject of a separate publication from the Global Ashurst Towards Net Zero Emissions Team.

All reports and studies in this Edition 2 of Report on Reports, were covered in the editions of Low Carbon Pulse published during August 2021: Edition 23, click here, and Edition 25, click here. Edition 24 of Low Carbon Pulse, as an out-of-cycle edition, covered the ***Sixth Assessment Report – Climate Change 2021, The Physical Science Basis***.

The following table details each report and study, and has a link to it:

REPORTS AND STUDIES COVERED IN DETAIL IN AUGUST REPORT ON REPORTS			
ORGANISATION	**PAPER / REPORT / STUDY**	**ORGANISATION**	**PAPER / REPORT / STUDY**
CSIRO	*CO_2 Utilisation Roadmap*	***IEA***	*Hydrogen in Latin America*
IEA	*Key World Energy Statistics - 2021*	***S&P Global Platts***	*Platts Global Integrated Energy Model*

CSIRO – CO_2 Utilisation Roadmap:

- **Title, and provenance, of report: *[The CO_2 Utilisation Roadmap]*** (***CSIRO Roadmap*****):** The Commonwealth of Australia leading research organisation, Commonwealth Scientific Industrial Research Organisation (***CSIRO***) published the ***CSIRO Roadmap***. The ***CSIRO Roadmap*** was sponsored and supported by the Federal Australian Government, Department of Industry, Science, Energy and Resources, and Advisian, apa, Federal Australian Government Australian Trade and Investment Commission, CO_2 Value Australia, BHP, KBR, Mineral Carbonation International, Santos, Victoria State Government, Wesfarmers Chemicals, Energy and Fertilisers and Woodside.
- **Purpose of *CSIRO Roadmap*:** "To lay the pathway to ***CCU*** opportunities for Australian industries, and the Australian economy". It is recognised that "***CCU*** is an emerging area of science and technology, and further work is required to bring down costs, but international interest in this technology continues to grow". Recognising this, the ***CSIRO Roadmap*** "aims to provide a framework for discussion about how Australia could become a leader in this area, and reduce emissions, but not the profits from [Australian] industries".

  While these concepts inform the subject matter of the ***CSIRO Roadmap***, the ***CSIRO Roadmap*** is reasonably wide ranging, and as such worth a read for general information.

  The ***CSIRO Roadmap*** defines ***CCU*** as the conversion of ***CO_2*** captured from emissions sources or the atmosphere into valuable lower or zero emission products.
- **Key recommendations:**

  The ***CSIRO Roadmap*** makes the following key recommendations based on its findings:

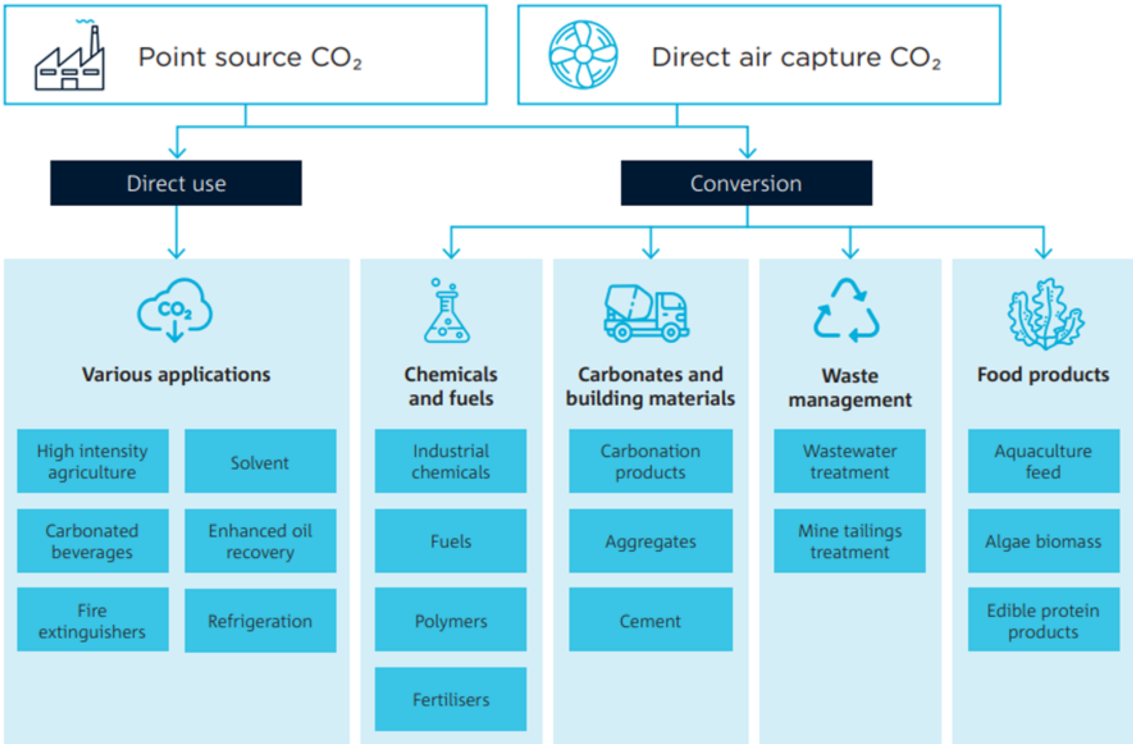
  1. Diversify and engage across the value chain and multiple ***CCU*** applications;
  2. Use ***CCU*** as part of a portfolio of decarbonisation solutions;
  3. Explore incentives and minimise barriers to entry; and
  4. Use ***CCU*** to support or to de-risk investment in existing and planned infrastructure.

  While the ***CSIRO Roadmap*** was developed with Australia in mind, it has implications for many other countries seeking to develop means of using ***CO_2***, including the renewable energy and land requirements for the production of feedstock and fuels if ***CO_2*** is to be combined with hydrogen to produce an e-feedstock or e-fuel, and the challenges of over-reliance on carbon offsets (a continuing theme throughout Low Carbon Pulse, and seemingly receiving increased attention ahead of COP-26).
- **Findings:**

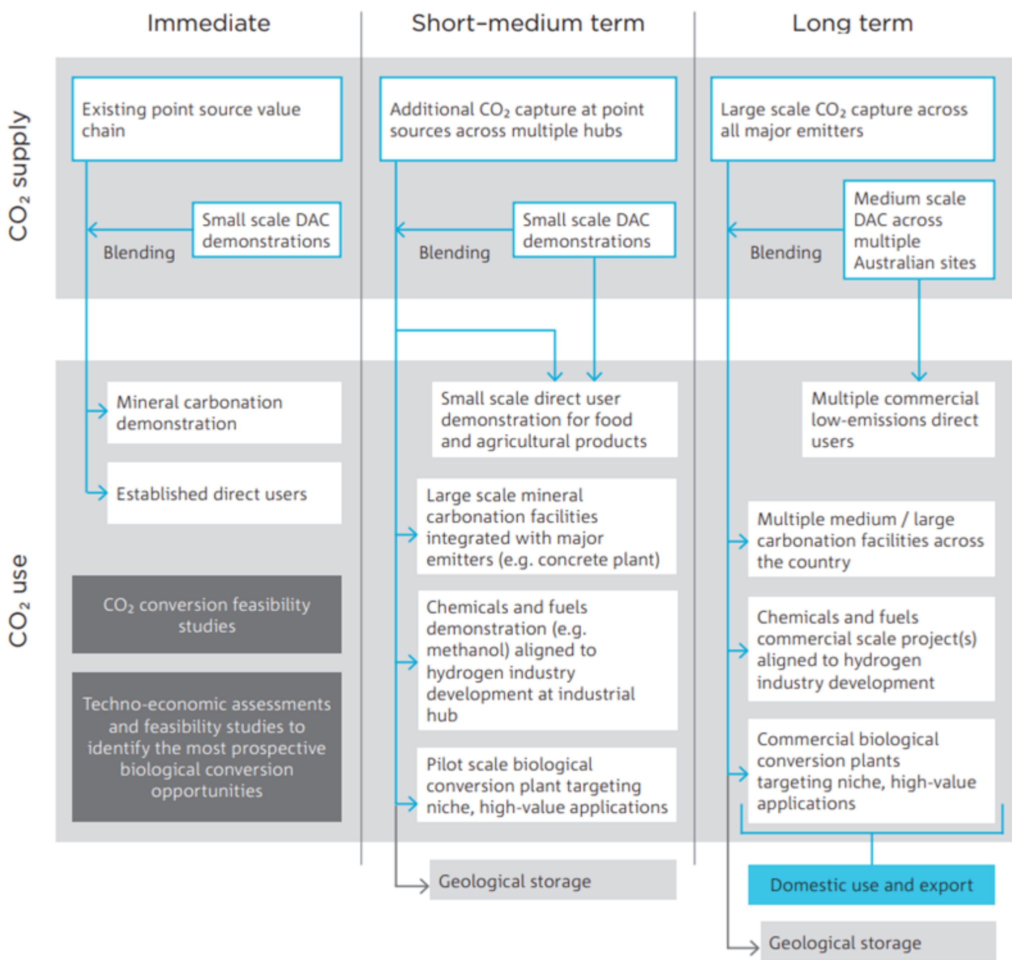
  The ***CSIRO Roadmap***:

  - contains general findings about the use of ***CCU*** as an opportunity to capture ***CO_2*** emissions and to convert ***CO_2*** into products (in respect of both capture of ***CO_2*** from industrial waste streams and from the climate system through direct air capture (***DAC***) technologies);
  - identifies the advantages that Australia has to support the role that ***CCU*** is to play:
    - bilateral ***CCU*** collaborations: Australia has established bilateral agreements including with Japan and Singapore;
    - large volumes of feedstock: Australia has capacity to produce large volumes of hydrogen and industrial waste streams, particularly within industrial hubs and precincts;
    - project low cost of renewable electrical energy;
    - track record for exporting resources;
    - decarbonisation commitments across hard-to-abate industries; and
    - commitment to growing the manufacturing base of Australia, including through the Modern Manufacturing Strategy.
  - The uses of ***CO_2*** captured for use:
    - **direct use of *CO_2*:** leverage established demand to use ***CO_2*** captured;
    - **mineral carbonation:** leverage ***CO_2*** captured from industry and mining as a source of permanent ***CO_2*** storage;
    - **conversion of *CO_2* into chemical and fuels:** leverage the emerging hydrogen industry in Australia to provide hydrogen feedstock to produce chemicals (olefins) and fuels (methanol and sustainable aviation fuel); and
    - **biological conversion of *CO_2***: leverage ***CO_2*** captured to produce food export opportunities.
- **Point of source *CO_2* and direct air capture:**

  The following graphic provides a high-level visual representations of means of capture and use:



- **Immediate, short to medium term and long term opportunities:**
  The following graphic illustrates the nature of the current uses of ***CO_2*** captured.

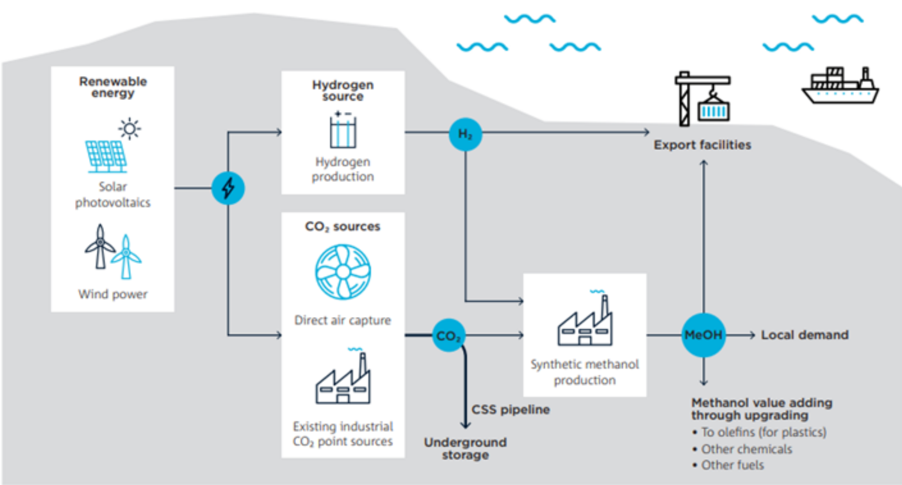


- **Carbon clusters and hydrogen hubs:**

  All of the publications from the Global Ashurst Towards Net Zero Emissions team have focussed on the location of sources of CO_2: Point Source CO_2 needs to be relatively close to the point of use (or the point of storage), and as such it might be expected that clusters will emerge around activities that give rise to CO_2 and if that CO_2 is to be used to derive or to produce a feedstock or fuel, that in the same vicinity as a Carbon Cluster arises, a Hydrogen Hub will arise: CO_2 needs to be combined with hydrogen to produce lower or low carbon fuels such as methanol.

  The following graphic provides a sense of these Carbon Cluster / Hydrogen Hub Dynamics.

Methanol hub: Scale-up alongside existing/planned infrastructure to complement and de-risk investment



- **Emerging CO_2 capture technologies:**

  As noted above, the ***CSIRO Report*** is well-worth a read for anyone interested in getting a general background on carbon capture technologies. Set out below is a table detailing an assessment of emerging CO_2 technologies.

Table 2: Emerging CO_2 capture technologies

TYPE	TECHNOLOGY	TRL[55]	DESCRIPTION
Point source	Calcium (carbonate) looping[56]	6	In calcium looping, a cycle of calcination and carbonation produces a pure stream of post-combustion CO_2, using a reversible reaction. The pure CO_2 stream is extracted for use or storage. An advantage of this technology is the relatively low cost of calcium carbonate compared to other sorbents, such as monoethanolamine (MEA).
	Chemical looping combustion[57]	6–7	Chemical looping combustion uses a reversible reaction of solid metal oxide to provide the oxygen for fuel combustion. The process is similar to oxyfuel combustion, where there is limited contact between air and fuel, providing a near pure CO_2 stream which can be utilised or stored. Input metals include Fe, Mn, Cu, Co and potentially others. Advantage of this method over alternatives (such as oxyfuel combustion) is improved energy efficiency of the oxygen input.
	Electrochemical separation	7	CO_2 is separated from flue gases via electrochemical reactions. This is commonly conducted via electrodialysis, using a liquid electrolyte as a medium to absorb and release the CO_2, or via direct separation with an electrochemical cell (e.g. in a polymer electrolyte membrane electrolyser).[58] This method allows for high selectivity and does not require large pressure gradients or high temperatures, potentially reducing energy costs.
	Cryogenic separation	6	In cryogenic distillation, flue gases are separated by a series of compression and cooling steps to produce liquid CO_2. Obtaining liquid CO_2 is potentially useful for storage and transport, or for use in specific applications such as enhanced oil recovery. However, the process is more energy intensive than other technologies, as it requires high CO_2 pressure input gas to be effective.[59] Modelling has shown this process can be more cost-effective than traditional amine systems.[60]
	Biological systems for capture	1–9	Biological capture systems may offer cheaper and simpler systems for specific point source options. Although various microbes capture CO_2, RD&D is needed to transform laboratory systems into scalable technologies. Overcoming barriers, such as catalysts that do not require costly cofactors and are able to operate at the higher temperature of flue gas streams, are important to commercialising biological capture systems.[61] Some biological capture systems could instead be used to capture CO_2 directly from the air
Direct Air Capture	Hydrogels	3–4	'Hydrogels' increase the contact surface area between CO_2 and the amine sorbent to speed up the rate of reaction, while using low cost readily available materials.[62]
	Solution-based absorption and electrodialysis (no heat)	5	CO_2 is absorbed by an aqueous hydroxide solution, such as sodium hydroxide (NaOH). In the case of NaOH, the CO_2 reacts to form sodium carbonate (Na_2CO_3) solution, which is then acidified using sulfuric acid (H_2SO_4) to release near-pure CO_2. The NaOH and H_2SO_4 are then regenerated through electrodialysis to be used again. Only electricity is required for the process.[63]
	Metal organic frameworks (MOFs)	3–4	CO_2 is adsorbed through the pores of a MOF. The MOF can then be regenerated at temperatures of approximately 80°C.[64] A key advantage of MOFs is their tunability to CO_2 uptake, selectivity and heat of adsorption.[65] The technology remains at small scale, with CSIRO's Airthena technology able to capture 2 tonnes of CO_2 per year.[66]
	Membrane-based DAC		As in membrane-based separation for point source CO_2 capture, membranes could be applied for direct CO_2 capture from air. Currently membranes are only suited to separate CO_2 from high concentration streams, such as post-combustion gases, and are unlikely to be considered for DAC at their current state of development. However, if membranes with higher gas permeance and selectivity were achieved, CO_2 capture could become efficient enough to render membranes suitable for direct air capture.[67]

***IEA* Reports – Hydrogen in Latin America and Key World Energy Statistics 2021:**

The International Energy Agency (***IEA***) was established in 1974 as a response to the oil price crises, now comprising 30 member countries, and 8 association countries.

The ***IEA*** has become one of the leading energy data collection and analysis organisations, and from this a key information provision and research function globally.

- ***IEA* Reports during August 2021:**
  - Energy Prices: Overview;
  - Carbon Capture, Utilisation and Storage: The Opportunity in Southeast Asia (***CCS / CCUS SEA Report***);
  - Hydropower Special Market Report – Analysis and Forecast to 2030 (***Hydropower Report***);
  - Trends and developments in electric vehicle markets;
  - Empowering Cities for a Net Zero Future: Unlocking resilient, smart, sustainable urban energy systems (***Smart Cities Report***); and
  - Sustainability Tracker: Monitoring Progress towards sustainable recovery from Covid-19 crisis.
  - Evolving Energy Service Companies in China;
  - Cola Information: Overview;
  - Hydrogen in Latin America;
  - Natural Gas Information: Overview;
  - Oil Market Report – August 2021;
  - Greenhouse Gas Emissions from Energy: Overview;
  - Oil Information: Overview;
  - World Energy Balances: Overview;
  - Renewables Information: Overview; and
  - Electricity Information: Overview.
- For the purposes of this August 2021, Report on Reports, the ***Hydrogen in Latin America Study*** is reported on in more detail:

  ***Hydrogen in Latin America Study*:**

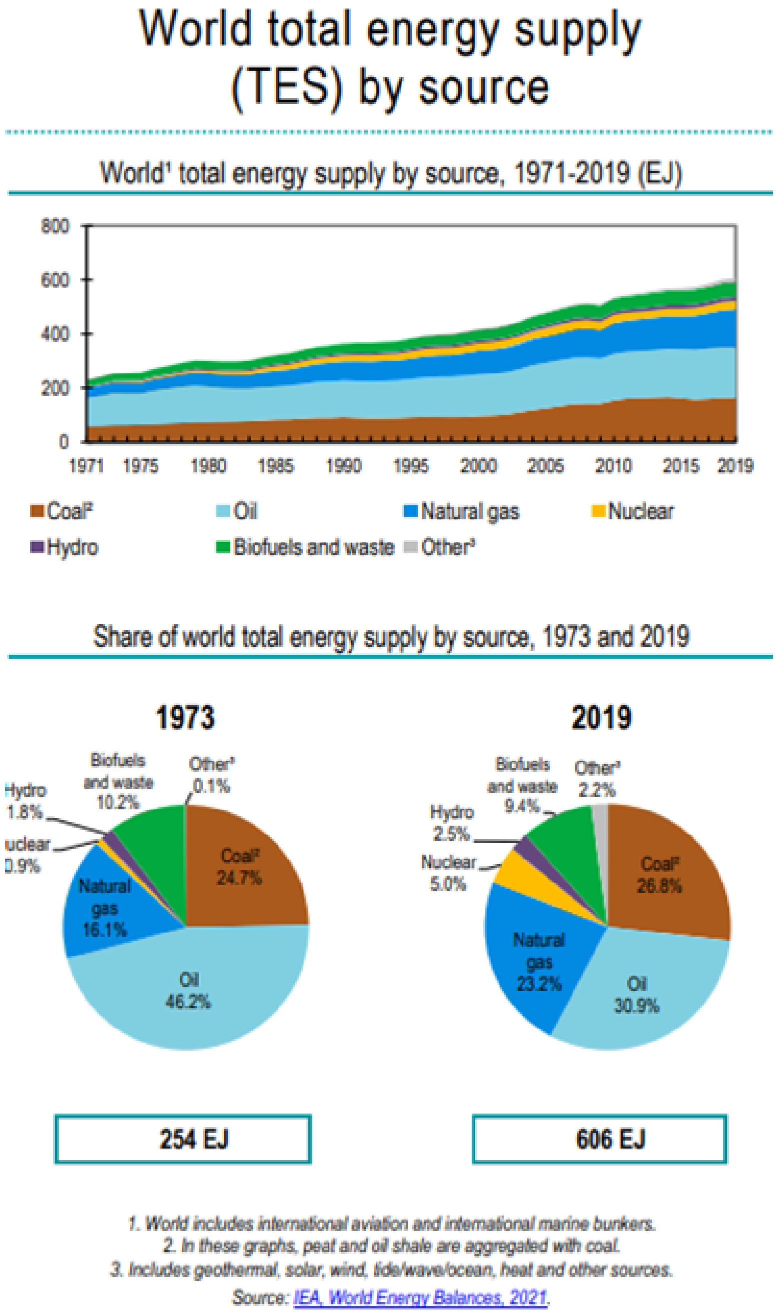
  - **Purpose**: It is recognised that Latin America has a key role to play globally in the production of lower, low and no carbon hydrogen solutions. The ***Hydrogen in Latin America Study*** considers the near term to long term opportunities to develop and to deploy hydrogen production and use.
  - **Recommendations for policy makers:**
    - define long term vision for hydrogen in the energy system;
    - identify near-term opportunities and support initial of key technologies;
    - support early financing schemes and reduce investment risk;
    - focus on research and development to reap the benefits beyond emission reductions;
    - use certification schemes to incentivise the production of low-carbon hydrogen and create major opportunities; and
    - cooperate regionally and internationally to position Latin America in the global hydrogen landscape.

    Comment: While these recommendations may appear high-level, it is important to reflect that what lies beneath is complex. The ***Hydrogen in Latin America Study*** recognises this in its findings. In Report on Reports 1, the findings in respect of the ***CCS / CCUS SEA Report*** were more granular, because the focus of that ***CCS / CCUS SEA Report*** was different.
  - **Findings from the *Hydrogen in Latin America Study*:**
    - **low-carbon hydrogen has the long term potential to reduce emissions and unlock new trade opportunities:** The opportunity for development of lower, low and no carbon hydrogen production, and its use, is different across Latin America: Latin America is not Europe, it does not have common policy settings that inform and regulate activities provided by an equivalent of the European Union. There is no one size fits all blue-print, and as such the potential of Latin America is a country by country proposition;
    - **deploying low-carbon hydrogen in Latin America will be a complex challenge:** at the core of this complexity is a result of the need to develop each aspect of the lower, low or no carbon hydrogen industry simultaneously (including the development of enabling infrastructure, such as new or enhanced electrical energy transmission networks), to the extent that anything is capable of development simultaneously, and as such the multifaceted nature of this development task; and
    - **the next decade will be crucial to secure the long-term potential of low carbon hydrogen in Latin America:** this finding may be regarded as of global application. As noted above, Latin America is not Europe with European Union commonality, but where it is possible to achieve commonality, for example, certification and standardisation, coordination will be key.

  Key World Energy Statistics 2021:

  - **Purpose:** The purpose of the ***Key World Energy Statistics 2021*** report is to provide an overview of global energy supply by source, and region.

For the purposes of this August Report on Reports, we commend the ***Key World Energy Statistics 2021***, but in the context of the approach of COP-26, the graph and pie charts below provide context of world total energy supply and source trend from 1971 to 2019, and in supply source in 1973 and 2019:

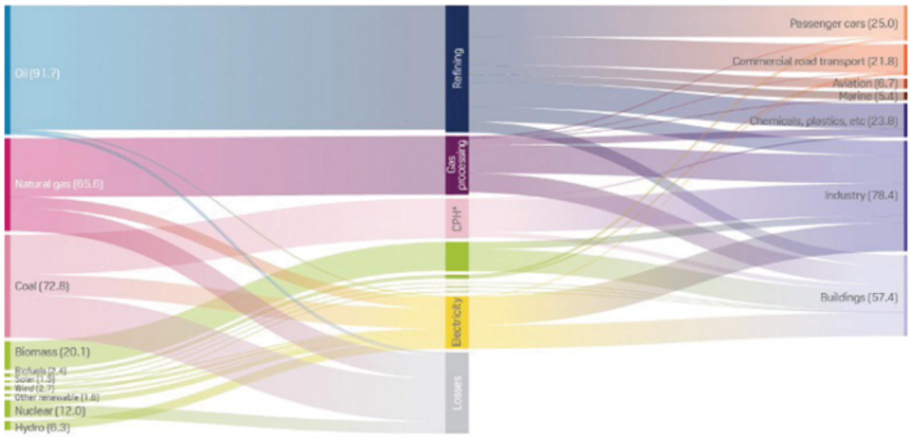


– **Context ahead of COP-26:** As will be apparent from the above graph and pie-charts, the fossil fuel sources of supply continue to provide over 70% of the total energy supply globally. Ahead of COP-26, it is important for Governments and policy makers to get to grips with the size of the task to decarbonise the sources of supply of energy to achieve net-zero emissions.

S&P Global Platts – Platts Global Integrated Energy Model:

- **Title, and provenance, of model – *Platts Global Integrated Energy Model*** (***Platts Global Model***)**:** Platts Global is one of the leading global information, research and modelling organisations across the entire energy sector.
- **Purpose of *Platts Global Model*:** To provide a comprehensive energy transition modelling tool that will allow users of it to adjust assumptions and inputs overtime. Visit spglobal.com/giem.
- **Findings from the *Platts Global Model*:** The ***Platts Global Model*** is a model rather than a paper, report or study, and as such it does not contain findings. The reporting of the Model has however provided a wonderful graphic that builds on information that has informed the ***Key World Energy Statistics 2021*** report to explain what energy transition means for fossil fuels from 2020 to 2050.

2020 (million boe/d)



2050 (million boe/d)

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Organisation	**Title / subject Matter**
Australian Energy Market Operator	*Electricity Statement of Opportunities Report* (*ESOO Report*)
BloombergNEF	*New Energy Outlook*
BloombergNEF and wbcsd	Hot Spots for Renewable Heat: Decarbonising Low-to-Medium Temperature Industrial Heat Across the G-20
Climate Action Tracker	Climate target updates slow as science ramps up need for action
Commonwealth Scientific and Industrial Research Organisation (***CSIRO***)	*CO_2 Utilisation Roadmap*
DNV	*Energy Transition Norway 2020* (*DNV Report*)
E3G	No New Coal by 2021: The Collapse of the Global Coal Pipeline
FTI Consulting and Teri	*South Asia New Energy Series*
Global Wind Energy Council	*Global Offshore Wind Report 2021*
H2Accelerate	*Expectations for the fuel truck market*
H2 Cluster Finland	*A systemic view on the Finnish hydrogen economy today and in 2030 – Our common playbook for the way forward*

Intergovernmental Panel on Climate Change (***IPCC***)	*Sixth Assessment Report – Climate Change 2021, The Physical Science Basis (2021 Report)*
International Energy Agency (***IEA***)	*Key World Energy Statistics - 2021*
International Energy Agency (***IEA***)	*Hydrogen in Latin America*
International Energy Agency (***IEA***)	*Net Zero by 2050 – A Roadmap for Global Energy Sector;*
International Renewable Energy Agency (***IRENA***)	*World Energy Transitions Outlook;*
The Met Office (Royal Metrological Society)	*State of the UK Climate in 2020* *(2020 Report)*
Lancaster University	*The real climate and transformative impact of ICT: A critique of estimates, trends, and regulations*
National Centers for Environmental Information	*Global Climate Report – August 2021*
Office of Energy Efficiency & Renewable Energy	*Off-shore Wind Market Report* (*US OWF Report*)
S&P Global Platts	*Platts Global Integrated Energy Model*
Wood Mackenzie	*How to scale up carbon capture and storage*
World Bank	*Groundswell Part 2: Acting on Internal Climate Migration*
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Regulatory Horizons Council	Regulatory Horizons Council Report of Fusion Energy
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