Low Carbon Pulse - Edition 26

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

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 October 2021. The third article will be on Hydrogen Plans, Roadmaps, and Strategies, and the fourth article will be on CCS / CCUS.

Edition 26 of Low Carbon Pulse will be posted again on **September 10, 2021** for those reading later in the week.

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^{O}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^{O}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^{O}C increase in global average temperatures.
- **How long until we reach 1.5^{O}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^{O}C increase, or until we enter the 1.5^{O}C to 2^{O}C range. The ***2021 Report*** suggests that we are likely to exceed a 1.5^{O}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 ^{O}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:**

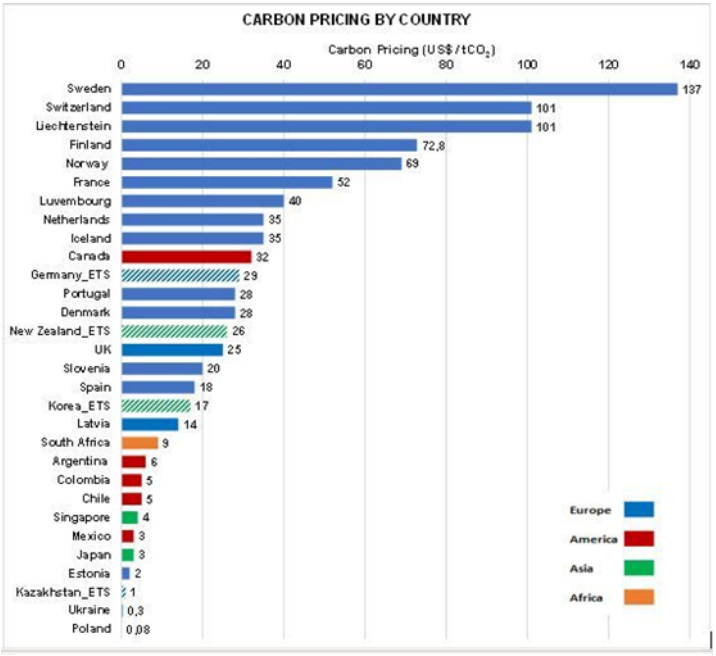
  As foreshadowed in previous editions of Low Carbon Pulse, ahead of COP-26, current and relevant matters will be considered. This Edition 26 of Low Carbon Pulse covers the roles of Central Banks, Carbon Price and the Courts in the context of reductions in ***GHG*** emissions generally and ***NZE*** specifically.

  - **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.

    Source: https://taxfoundation.org and https://lnkd.in/gsvwH2pN

    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).

    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^{O}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^{O}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 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 ***mtpa*** 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^{O}C by 2050, and 0.5^{O}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^{O}C warmer than 40 years ago, and areas surrounding the blobs are 0.2^{O}C to 1^{O}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 storge (***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.

- **CO2 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 a ***Tank-to-Well*** 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.

NZE reports:

As noted above, at the end of future editions of Low Carbon Pulse, reports that have been reviewed for the purpose of that edition of Low Carbon Pulse will be listed, by organisation, title / subject matter, and link.

ORGANISATION	TITLE / SUBJECT MATTER
BloombergNEF	***New Energy Outlook***
The Met Office (Royal Metrological Society)	***State of the UK Climate in 2020*** ***(2020 Report)***
DNV	***Energy Transition Norway 2020*** ***(DNV Report)***
Office of Energy Efficienty & Renewable Energy	***Off-shore Wind Market Report*** **(*US OWF Report*)**
Australian Energy Market Operator	***Electricity Statement of Opportunities Report*** ***(ESOO Report)***
H2Accelerate	***Expectations for the fuel truck market***

The author of (and researcher for) Low Carbon Pulse is Michael Harrison.

Key Contacts

We bring together lawyers of the highest calibre with the technical knowledge, industry experience and regional know-how to provide the incisive advice our clients need.

Michael Harrison
Senior Partner, Energy, Resources and Infrastructure

M +65 9728 8562 /+61 439 512 384/ +61 414 968 707
michael.x.harrison@ashurst.com

Richard Guit
Global Co-Head, International Projects

T +65 6602 9153
M +65 9728 7943
richard.guit@ashurst.com

Daniel Reinbott
Partner

T +65 6416 9529
M +65 9728 8672
daniel.reinbott@ashurst.com

Peter Vaughan
Partner

T +61 8 9366 8173
M +61 412 909 489
peter.vaughan@ashurst.com

Dan Brown
Partner

T +61 7 3259 7149
M +61 401 564 654
dan.brown@ashurst.com

Paul Curnow
Partner

T +61 2 9258 5738
M +61 434 074 591
paul.curnow@ashurst.com

Michael Burns
Partner

T +44 20 7859 2089
M +44 7717 840 646
michael.burns@ashurst.com

Anna-Marie Slot
Global Environmental, Social and Governance Partner

T +44 20 7859 3724
M +44 7788 710 892
anna-marie.slot@ashurst.com

Antony Skinner
Partner

T +44 20 7859 1360
M +44 7917 635 974
antony.skinner@ashurst.com

David Wadham
Office Managing Partner, Tokyo

T +81 3 5405 6203
M +81 90 4828 5191
david.wadham@ashurst.com

Eleanor Reeves
Partner

T +44 20 7859 1210
M +44 7823 340 854
eleanor.reeves@ashurst.com

Andrew Roche
Partner

T +65 64160272
M +65 97287452
andrew.roche@ashurst.com

Keep up to date

Sign up to receive the latest legal developments, insights and news from Ashurst. By signing up, you agree to receive commercial messages from us. You may unsubscribe at any time.

Sign up here

ashurst

www.ashurst.com