

Low Carbon Pulse - Edition 32

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS



Welcome to **Edition 32** of Low Carbon Pulse – sharing significant current and recent news on progress towards net-zero greenhouse gas (**GHG**) emissions (**NZE**) for the 18 day period from Monday November 29, 2021 to Thursday December 16, 2021 (inclusive of each day).

Please click [here](#) for **Editions 30** and [here](#) for **31** of Low Carbon Pulse, and click [here](#) for the **Low Carbon Pulse Compendium**, which comprises **Editions 1** to **28** of Low Carbon Pulse (covering the 12 month period from October 6, 2020 to October 5, 2021), and click [here](#) for the **Anniversary Edition** of Low Carbon Pulse. Click [here](#) and [here](#) for the sibling publications of Low Carbon Pulse, the **Shift to Hydrogen (S2H2): Elemental Change** series and [here](#) for the first feature in the **Hydrogen for Industry (H24I)** features.

This is the final edition of Low Carbon Pulse for calendar year 2021. **Edition 33** (*The Larry Bird Edition*) will be published on Monday January 17, 2022, after the Christmas and western New Year holiday season. The Appendix to **Edition 33** will comprise the Report on Reports for November and December.

Reflections on calendar year 2021 and thoughts about 2022:

Background: It may be regarded as customary for publishers of periodicals to look back to reflect on events of the past 12 months, and look forward to the coming 12 months. Given that 2021 has been the first full year of Low Carbon Pulse (28 editions if the Anniversary Edition is counted), and given progress in 2021, it seems appropriate to follow custom.

In looking back (pages 2 to 7), the events and matters included are those that were significant of themselves, or reflected a significant trend in a general sense. With limited exceptions, corporations are not referenced. This is not to discount the significance of achievements, decisions and plans of individual corporations, rather it recognises that greater significance is to be found in policy settings and themes and trends.

In looking forward (pages 7 to 10), the observations included tend to reflect themes and trends that have emerged, and appear likely to continue or to become more significant during 2022.

Why name Editions 32 and 33 after 1980s basketball players? From August 13, 2021 to December 13, 2021, the author of Low Carbon Pulse was located in Papua New Guinea (**PNG**). While located in PNG, the author rediscovered a passion for basketball (long dormant). With the rediscovery of passion, and, more importantly, muscle memory, the satisfying sound of the *swish* returned (as the basketball touched "nothing but nylon"), so the capacity to "switch -off" was rediscovered.

With rediscovery, the author has rediscovered on "you-tube" the achievements of Earvin "Magic" Johnson and Larry Joe Bird (after whom the Twitter logo is named). No doubt reflective of the decade in which the author played basketball, Magic Johnson and Larry Joe are the author's favourite basketball players. Always have been, always will be! This does not mean that the author regards either of them as the GOAT, that accolade rests with Michael Jordan.

Both played for one franchise during their careers; Magic played No 32 for the Los Angeles Lakers and Larry Joe played No 33 for the Boston Celtics. Each franchise retired their numbers on their retirements. On the court, they were the fiercest of competitors. Off the court, they were the best of friends. They remain the best of friends.

To me, Messrs Johnson and Bird remain the embodiment of authenticity, manifest in their genuineness, and their hard fought success, wrought in application and hard work, two folk who played for their teams, cut no corners, and shared 8 championships during the 1980's. Different times, different values, well-before COP-1.

• Looking back on 2021:

Quarter 1:

- **January** (covered in Editions [6](#), [7](#), [8](#) and [9](#) of Low Carbon Pulse):

Cheapest electrical energy in history: The new calendar year started with news of record low tariffs for photovoltaic solar projects in the United Arab Emirates (**UAE**) and India, and progress of the South Fork Wind Farm in the US (the second scale off-shore wind project in the US).

Oldest first term US President in history: On January 20, 2021, US President, Mr Joe Biden, was inaugurated (marked by Edition [7](#) of Low Carbon Pulse), most memorable for [The Hill We Climb](#) by Ms Amanda Gorman. The afternoon of January 20, 2021 was memorable as President Biden signed executive orders, including one under which the US was to re-accede to the Paris Agreement, which occurred on February 19, 2021.

The "pick of publications" for January were the **Hydrogen Council's [Hydrogen decarbonisation pathways](#)**, Shell with Deloitte's [Decarbonising Road Freight: Getting Into Gear](#), and Shell's [Decarbonising Road Freight: Shell's Route ahead](#).

- **February** (covered in Editions [9](#), [10](#) and [11](#) of Low Carbon Pulse):

Long winded: The shortest month was long on news about off-shore wind tender outcomes and off-shore wind field (**OWF**) plans: in North Asia, the Republic of Korea (**ROK**) announced plans to install 8.2 GW of **OWF** by 2030, the European Union (**EU**) plans to install 60 GW of **OWF** by 2030 continued to take shape (including plans outlined by France to procure 8.75 GW of **OWF** capacity by 2028), and the UK awarded leases for 8 GW of **OWF**.

North Asia priced and regulated: During February the design and definition of the Peoples Republic of China (**PRC**) emission trading scheme (**ETS**) became clear, "going live" on February 1, 2021. Also in the first week of February, the design and definition of **ROK's** Hydrogen Law became clear as it came into effect.

Texas outages: During mid-February, the Lone Star State was impacted by power outages (see Editions [9](#), [10](#) and [17](#) of Low Carbon Pulse reported on the power outages and the causes of them). As many organisations reflected on the year, one of the more helpful reflections has come from Wood McKenzie with its article [Learning the right lessons from the Texas crisis](#) (published on December 3, 2021).

The "pick of the publications" for February were the **Hydrogen Council** and **McKinsey & Co's [report](#)** on the state of the development of the global hydrogen economy. This report appears likely to be published every six months or so: with the report for July 2021 included for convenience below. Mr Bill Gates' book, **How to Avoid a Climate Disaster** was released, providing a clear plan for the way forward to net-zero **GHG** emissions, including that reliance on renewable electrical energy alone will not allow us to reach **NZE**.

- **March** (covered in Editions [11](#), [12](#) and [13](#) of Low Carbon Pulse):

PRC ETS size and shape: During March the scope and size of, and the timing of trading under, the **PRC ETS** became clear still: first, the proposed commencement of trading nationwide in respect of emissions quotas, with quotas to be registered for trading (and transferred) overtime to allow an orderly commencement to trading, and secondly, the extension of the **PRC ETS** to include enterprises undertaking activities not included in the initial iteration of the **PRC ETS**.

UK half way to NZE: On March 18, 2021, it was reported that the **GHG** emissions arising in the UK were at 51% of 1990 levels, and at their lowest levels since 1879. In other words, the UK was half way to meeting its target of net-zero **GHG** emissions by 2050.

Elsewhere, more to do: The good news from the UK contrasted with a United Nations [report](#) which concluded that the nationally determined contributions (**NDCs**) of Parties to the Paris Agreement would result in less than a 1% reduction in **GHG** emissions from 2010 levels by 2030. UN Climate Chief, Ms Patricia Espinosa stated: "What we need to put on the table is much more radical and much more transformative than we have been being until now". This became the recurring theme of 2021 – including before **COP-26**, and after.

Quarter 2:

- **April** (covered in Editions [13](#), [14](#), [15](#) and [16](#) of Low Carbon Pulse):

KAS - electrical energy cheaper still: In the first week of April, the Kingdom of Saudi Arabia (**KAS**) announced the results of tenders in Round 2 of its National Renewable Energy Program. The results included a winning bid on one of seven project awards of a little over 1 cent per KWh (see Edition [14](#) of Low Carbon Pulse).

EU - 55 by 30: On April 21, 2021 the the European Commission (**EC**) welcomed provisional agreement on the **European Climate Law** reflecting **55 by 30**, i.e., a 55% **GHG** emissions reduction by 2030 across the **EU**.

Global Leaders: On April 22 and 23, 2021, the Leaders' Summit was held (see Edition [15](#) of Low Carbon Pulse for Summary), bringing together 40 world leaders to the Leaders' Summit, and a further 63 world leaders involved in "listening sessions". The Leaders' Summit marked the hoped for re-emergence of US leadership, and continued alignment (including on the need to reduce **CH₄** emissions), with the **PRC** and Russia involved in the Summit.

Germany – NZE by 45: As the Leaders' Summit took place, the German constitutional court determined that German legislation was unconstitutional because it did not deal with reductions in **GHG** emissions after 2030. In response to this determination, the German Federal Government announced: 65% **GHG** emission reductions by 2030 and 85-90% by 2040, both compared to 1990 **GHG** emissions, and net-zero **GHG** emissions by 2045.

- **May** (covered in Editions [16](#), [17](#), [18](#) and [19](#) of Low Carbon Pulse):

All action IEA: The **International Energy Agency (IEA) [Net-zero by 2050: A Roadmap for the Global Energy Sector](#)** (**IEA Roadmap**) was published on May 18, 2021, providing a clear sense of scale and scope of what is needed to hold the increase in average global temperature to **1.5°C** (with its key finding to be found at

the end of Edition [18](#) of Low Carbon Pulse). The **IEA Roadmap** has been a reference point for each **IEA** publication since, and has become something of a reference guide or tool-kit.

All action judiciary: On May 26, 2021, the District Court in The Hague, in the Netherlands, delivered its judgment in a case brought against Royal Dutch Shell plc (**RDS**) by Milieudefensie (et al). This judgment requires **RDS** to reduce the net **CO₂** emissions of the **RDS** group by at least 45% by 2030, compared to 2019. (**RDS** has appealed.)

All action shareholder bases: The **RDS** judgement was handed down in the same week that CVX and IOM were taken by surprise by shareholder activism at board level (see Edition [18](#) of Low Carbon Pulse).

- **June** (covered in Editions [19](#), [20](#) and [21](#) of Low Carbon Pulse):

IRENA joined IEA: The International Renewable Energy Agency (**IRENA**) World Energy Outlook (**WETO**) was published at the end of June. The **WETO** is summarised in Edition [21](#) of Low Carbon Pulse, in the Report on Report in Edition [23](#) of Low Carbon Pulse, and is compared with other reports in Edition [28](#).

A role of natural gas: The role of natural gas was coming into ever sharper focus (see Edition [11](#) of Low Carbon Pulse – **Natural Gas as a transition fuel**, and Edition [20](#) of Low Carbon Pulse – **The Role of Natural Gas**), including in light of the pathways suggested by both **IEA Roadmap** and **WETO**, and **EU** thinking around clean hydrogen, not at that time in the context of energy security.

The following table provides a high-level overview of the **IEA Roadmap** and the **WETO**. It is important to note that each is intended to achieve **NZE** while ensuring that the increase in average global temperatures are limited to **1.5°C** above pre-industrial levels. As 2021 progressed, the criticality of this became a key theme.

IEA ROADMAP AND WETO – SIX AND SEVEN PILLARS	
IEA Roadmap	The seven pillars of the IEA Roadmap are: 1. Energy efficiency; 2. Behavioural change; 3. Electrification; 4. Renewables; 5. Hydrogen and hydrogen-based fuels; 6. Bioenergy and land use change; and 7. Carbon capture, utilisation and storage.
WETO	The six pillars of the WETO are: 1. Energy Conservation and efficiency; 2. Renewables (power and direct uses); 3. Electrification of end use (direct); 4. Hydrogen and its derivatives; 5. CCS and CCUS in industry; and 6. BECCS and other carbon removal measures.

Note: By the end of Q2, the format of Low Carbon Pulse reflected the subject matter and the number of news items arising,. Country and global developments, CCS / CCUS and BECCS and BECCUS, BESS and HESS, Future / E-fuels (including Green Hydrogen and Hydrogen Based Fuels), Green Metals and Minerals, Green Hydrogen Hubs (and Carbon Clusters), Valleys, and Cities, Uses of **CO₂**, Wind and Solar and Sustainable round ups, Land Transport, Ports and Shipping and Airports and Aviation.

Quarter 3:

- **July** (covered in Editions [21](#), [22](#) and [23](#) of Low Carbon Pulse):

Fit for 55: The **Fit for 55 Package** was published by the **EC** (see Edition [22](#) of Low Carbon Pulse for detailed review), providing the means for the **EU** to reduce **GHG** emissions by 55% by 2030, including direct and indirect use of the **EU ETS**.

PRC ETS trades: The **PRC ETS** commenced trading, with 4 giga-tonnes (i.e., 4 billion metric tonnes) of **GHG** emissions covered by the **PRC ETS**, and the prospect of the application of the **PRC ETS** to be expanded to cover 8 giga-tonnes.

Two of three reasons to be cheerful around mid-2021.

What a difference six months makes: As noted above, Edition [10](#) of Low Carbon Pulse reported on the **Hydrogen Council** and **McKinsey & Co** report, dated February 17th, 2021 (**February Report**). On July 15, 2021, the **Hydrogen Council** and **McKinsey & Co** published their second report (**July Report**).

The table below shows the increased level of activity over the six month period, February to July 2021.

HIGH LEVEL COMPARISON, FEBRUARY TO JULY			
Large Scale Projects (February)	230	Large Scale Projects (July)	359
Total Investment Amount (Feb)	USD 300 billion	Total Investment Amount (July)	USD 500 billion
30% of Total Investment Amount was firm at USD 80 billion		30% of Total Investment Amount is firm, at USD 150 billion	

In November 2021, the Hydrogen Council and McKinsey & Company published **Hydrogen for Net Zero**; Chapter 3 containing the headline grabbing **Large Scale Projects > 520**, and **Total investment Amount USD 540 billion**. The November and December Report on Reports will cover **Hydrogen for Net Zero**, and the Hydrogen Council's **Policy Toolbox for Low Carbon and Renewable Hydrogen** publication in detail (the Report on Reports comprising the Appendix to Edition 33 of Low Carbon Pulse).

2°C increase not fit for purpose: On July 21, 2021, BloombergNEF published **New Energy Outlook, 2021 (NEO)**. **NEO** provided another perspective on achieving **NZE** by 2050, placing it in the context of the carbon budget that is available before reaching a **2°C** increase in average global temperatures compared to pre-industrial times, rather than **1.5°C** under the **IEA Roadmap** and the **WETO**. Based on current trends, **NEO** noted that a **2°C** increase in average global temperatures would arise by 2044.

Orthodoxy and reality has taken thinking back to the criticality limiting the increase to a **1.5°C** increase or, in the words of **COP-26** "keeping a **1.5°C** increase within reach". This thinking is no doubt underlined by the extreme weather events experienced during the months of July through September globally.

On July 22, 2021, the **IEA** published a report entitled [*Empowering Cities for a Net Zero Future- Unlocking resilient, smart, sustainable urban energy systems \(Smart Cities Report\)*](#). The **Smart Cities Report** is likely to be one of those reports that becomes more influential over time. It is one of the stand-out reports of 2021. It is summarised in the Appendix to Edition [23](#) of Low Carbon Pulse.

- **August** (covered in Editions [23](#), [24](#), [25](#) and [26](#) of Low Carbon Pulse):

Call for more action: On August 1, 2021, Ms Allegra Stratton, Climate Spokesperson for No. 10 Downing Street, said that achieving **NZE** by 2050, is "**too far away**", "**the science is clear**", and the UK must reduce its **GHG** emissions "**right now**".

Ms Stratton encouraged people to "**feel the fierce urgency of now**". Ms Stratton was right. (Revelation during the week-beginning December 6, 2021 do not lessen the power of her words in August 2021.)

At the time, Low Carbon Pulse noted that this may be regarded as one of the most telling and timely phrases of 2021: for the UK, leading the way to **NZE**, and as such acting on the science, to consider that acceleration was needed, resonated, resoundingly, and it still does. This assessment was, and remains, clear headed.

Clear need for more action: The **Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report – Climate Change 2021, The Physical Science Report (2021 Report)** was published, with the key conclusions being that: "It is more likely than not that the earth will be **1.5°C** warmer in 2050 than it was in the 19th century". The **2021 Report** finds, unequivocally, that the reason for the increase in average temperature globally is the emission to the climate system of "well-mixed greenhouse gases" (being **CO₂**, **CH₄** and **N₂O**) arising from human activities.

The **2021 Report** is summarised in Edition [24](#) of Low Carbon Pulse. The science is clear.

Call heeded in India: From the end of Q1, there was a marked increase in activity in India, at Government (including state-owned corporations) and private sector corporation level. Executive Director of the International Energy Agency (**IEA**) Dr Fitoih Birol said that: "*India is a leading country in terms of renewable energy investments ... the country has great plans to be a driver of clean energy transitions ...*". This is a good thing.

On August 15, 2021, India celebrated the commencement of the 75th year after its founding on August 15, 1947. Indian Prime Minister, Mr Narendra Modi, took the opportunity to announce the National Hydrogen Mission for India (**NH2M**) in his Independence Day Speech. Prime Minister Modi was to steal the show at **COP-26**.

Call not heeded on NGHGEIs: The need to remove **CO₂** from the climate system (in addition to the reduction in **GHG** emissions) is core to the Paris Agreement (recognised in Article 4). From the start of Q2, the means to the achievement of removal of **CO₂** using **net negative gas house gas emission initiatives**, received increased coverage, including in news item in Fortune magazine, under [*Net zero isn't enough. We need to get to net negative*](#). While awareness has increased, more needs to be done. **COP-26** did not move the dial significantly.

- **September** (covered in Editions [26](#), [27](#) and [28](#)) of Low Carbon Pulse):

Global Methane Pledge: As noted in the [Anniversary Edition](#) of Low Carbon Pulse, one of the most significant areas of progress from October 2020 to September 2021 was (and since has been) the recognition of the need to reduce **CH₄** emissions. Edition [26](#) of Low Carbon Pulse noted, that:

*"While there is more than 200 times more **CO₂** than **CH₄** at large in the climate system, and each **CH₄** molecule remains in the climate system for an average of ten years (not hundreds of years), **CH₄** molecules absorb and retain more radiative heat, which means that **CH₄** can have up to 84 times the global warming potential of **CO₂**. This is why in recent Government to Government engagement and reports, there has been a focus on the reduction in **CH₄** emissions: it is estimated that up to 57% of **CH₄** could be reduced by 2030, reducing the impact on the climate system by 0.25°C by 2050, and 0.5°C by 2100".*

On September 17, 2021, the EC and the US signed the **Global Methane Pledge** to reduce **CH₄** emissions by one third by 2030. Since September, 110 countries have signed the **Global Methane Pledge** (with the details of the countries that have pledged listed at www.globalmethanepledge.org).

Global Levy on shipping proposed: On September 13, 2021, the International Chamber of Shipping (**ICS**) proposed the introduction of a global levy on **GHG** emissions from shipping activities (**ICS Proposal**). On September 13, 2021, **ICS** issued a [press release](#) in respect of the **ICS Proposal**. The **ICS Proposal** would be mandatory in respect of vessels trading globally having gross tonnage exceeding 5,000 tonnes. The amount of the global levy would provide funding for the **IMO Climate Fund**.

Global get together: The week beginning September 20, 2021, saw the United Nations General Assembly in full-session. This year's United Nations General Assembly was the first since 2014 to have the benefit of an assessment report from the Intergovernmental Panel on Climate Change (**IPCC**) - the **2021 Report**. Some of the speeches from world leaders to the General Assembly were inspiring, and contributed to heightened expectations ahead of **COP-26**.

Global leaders focused: In light of the **2021 Report** and the approach of **COP-26**, the business of the United Nations General Assembly focused on climate change, and for the first time in 40 years, there was a leader-lead meeting under the auspices of the United Nations General Assembly (the **UN High-Level Dialogue on Energy**).

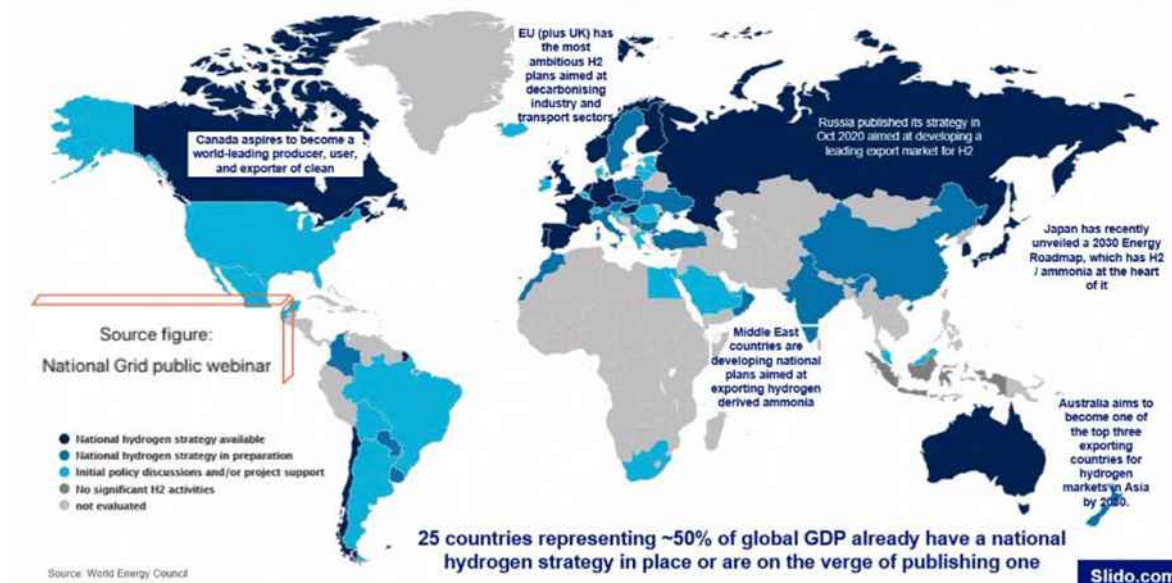
There was some good news from the United Nations General Assembly, with the **PRC** announcing cessation of support for the development of coal-fired power stations (under One-Belt-One-Road (**OBOR**)), and Turkey announcing that it was to ratify the Paris Agreement, which the Turkish Parliament did during the first week of October. (On ratification by Turkey, all G20 countries had ratified the Paris Agreement.)

After the UN General Assembly, the great and the good met in Rome, Italy in late September.

Edition [29](#) of Low Carbon Pulse noted that by the end of September the expectations for **COP-26** were somewhere between heightened and sky-high.

By the end of Q3 hydrogen plans, roadmaps and strategies were receiving increased coverage. The graphic below sets out the state of play at the end of Q3:

Status of current National H2 Strategies / Plans (Q3 2021)



Quarter 4:

- **October** (covered in Editions [28](#) and [29](#) of Low Carbon Pulse):

Mind the gap: After a busy September, and increasing optimism, two reports focused minds ahead of **COP-26**: the United Nations Framework Convention for Climate Change (**UNFCCC**) [NDC Synthesis Report](#) – reporting on the impact on climate of the implementation of **NDCs** committed to as at the end of July 2021, and the United Nations Environmental Program (**UNEP**) [Production Gap Report](#) – reporting that in setting **NDCs** countries had not taken account of planned increases in fossil fuel production and use.

The **NDC Synthesis Report** informed the UN Secretary General, Mr Antonio Guterres' use of the phrase "the **Catastrophic Pathway**" of a **2.7°C** increase in average global temperature. Mr Guterres' used the phrase in his speech to the UN General Assembly in September, and repeated it in his speech at **COP-26**.

The **Production Gap Report** informed a considerable amount of news coverage, and debate, a good deal of it well-informed and constructive, no doubt as a result of the excellence of the **Report**. Talking of excellent publications, the **IEA** published its [Global Hydrogen Review](#) during October. (The Appendix to Edition [30](#) of Low Carbon Pulse reports on the core findings of the **Review**.)

The findings in the **Production Gap Report** were underscored by US EIA's **Internal Energy Outlook** which projected a 47% increase in total final energy usage by 2050, with natural gas and oil remaining the largest sources of total final energy by 2050.

Reduce methane: The curtailment and reduction in **CH₄** continued to capture the attention of the news feeds, as awareness of the **Global Methane Pledge**, and its significance continued to increase, and no-doubt better informed by the **IEA** [Curtailling Methane Emissions from Fossil Fuel Operations](#).

Increase NDCs and commitments to NZE: In addition to publications dropping thick and fast ahead of **COP-26**, countries made announcements ahead of **COP-26**, including commitments by the United Arab Emirates (**UAE**) and the Kingdom of Saudi Arabia (**KAS**) to achieve **NZE** by 2050 and 2060 respectively, and the **ROK** committed to increasing its **NDC** to a 40% reduction in **GHG** emissions by 2030 (from 26.3%).

Ever increasing green power: The UK committed to having all green electrical energy by 2035. The [Sixth Strategic Energy Plan](#) was adopted by Japan, providing for a doubling of renewable electrical energy capacity to up to 38% by 2030, with nuclear electrical energy accounting for up to a further 22% by 2030.

A borrowed motto: By the end of October, leading into **COP-26**, Edition [29](#) of Low Carbon Pulse borrowed the extended Olympic motto "Faster, Higher, Stronger, Together" motto proposed by the President of the Olympic Committee, Mr Thomas Bach, earlier in 2020 as indicative of the action required (Mr Bach having proposed the inclusion of "Together"): "The rate of reduction in, and the rate of removal of, **GHG** emissions need to be faster and higher, and commitment stronger, together."

[**Note:** Following Edition [28](#) of Low Carbon Pulse, the Anniversary Edition of Low Carbon Pulse was posted on October 19, 2021, five pieces were published on each working day before **COP-26** and Edition [29](#) of Low Carbon Pulse covered the 26 day period to October 30, 2021. As a result two editions of Low Carbon Pulse were published during October 2021, but with a good deal of accompanying narrative ahead of **COP-26**.]

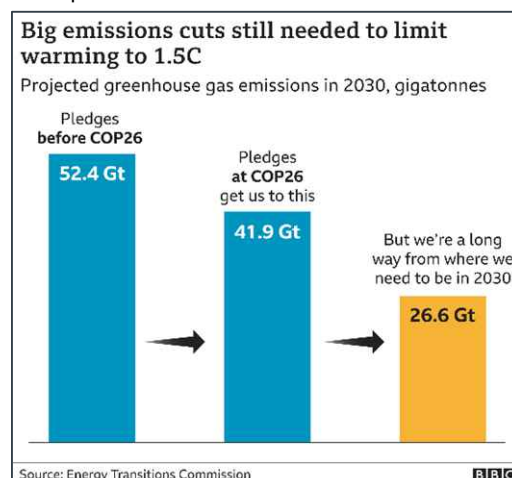
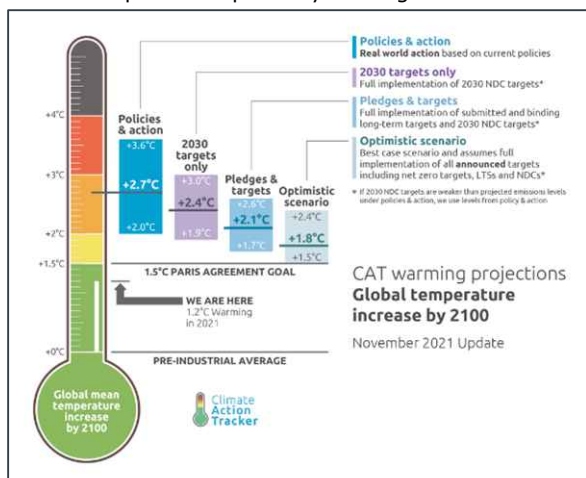
- **November** (covered in Editions [30](#), [31](#) and 32 of Low Carbon Pulse):

A measure of success: From Sunday October 31, 2021 to Saturday 13 November, 2021, **COP-26** took place in Glasgow, Scotland.

For the author, while not all of the hoped for outcomes were achieved, the key indicia of success for **COP-26** was achieved – reaching agreement on the **Paris Rulebook**. (An article on the **Paris Rulebook** and agreement in respect of Article 6 of the Paris Agreement, will be written by the author of Low Carbon Pulse during the southern hemisphere summer holiday for release early in 2022.)

An increased measure of engagement: Delegates from nearly 200 countries met at **COP-26**. For those in attendance that had attended previous COPs, there was a reported sense of urgency around what may now be regarded as a climate change emergency, and a marked increase in engagement by the private sector. Edition 30 of Low Carbon Pulse reported on the key outcomes from **COP-26**, and that reporting is not repeated here.

Graphic stories: Two telling graphics emerged during **COP-26** (each included in Edition 30), and are repeated here - indicate that if the combined **NDCs** of each country (as they stood during **COP-26**) were to be implemented, this would provide a pathway limiting increases in average global temperatures to **1.8°C**.



While this is good news, bringing us within the Responsible Range (of between **1.5°C** and **2°C**), it is not enough, progress needs to be made to limit average temperature increases to a **1.5°C** increase by mid-century, and ideally lower by the end of the twenty first century. Average global temperatures have increased by **1.1°C** since pre-industrial times, and the rate of increase has been accelerating (ever faster) since 1990.

The gap remains: Reductions of 45 to 50% in **GHG** emissions are required by 2030 to stay within the global carbon budget, and to achieve **NZE** by 2050. The modelled gap between **NDCs** and what is required is likely to remain. Action is required to close the gap, with a clear focus on the 45 to 50% reduction.

Reasons to be cheerful: As November progressed, the level and range of activity across all sectors increased, key features including increased off-shore wind field developments, planned and progressing, photovoltaic solar electrical energy continuing to be rolled-out, with the roll-out gaining pace (some may say apace), increased progress around CCS and CCUS, and **BESS** and **HESS** (and seemingly compressed air storage systems at scale), an increasing level of understanding, and definition, around both carbon credits and markets, and the prospect of a hydrogen market, a clear understanding and increasing commitment globally to green steel production, progress in the shipping industry towards decarbonisation, and the long anticipated take-off in the commitment to, and use of, **SAF** (sustainable / synthetic aviation fuel) in the aviation industry.

- **December** (covered by this Edition 32 of Low Carbon Pulse, to December 16, 2021. December 17 to December 31, 2021 to be covered by Edition 33):

Reasons not to be complacent: As reported in Edition 27 of Low Carbon Pulse, the **CSIRO** (the Commonwealth Scientific and Industrial Research Organisation, Australia's premier research institute) determined that the bushfires in Australia (elsewhere, termed wildfires) during the southern hemisphere summer of 2019 / 2020 resulted in the emission of over 715 million metric tonnes of **CO₂** to the climate system (around 1.5% of global **GHG CO_{2-e}** emissions annually) – a mass of **CO₂** equivalent to the **GHG** emissions arising from anthropogenic activities in Germany each year.

While much of the flora in Australia has evolved to grow back after bushfires (and as such absorb **CO₂**), what could not have been predicted was that up to 80 % of the **CO₂** emissions from those bushfires was absorbed by ocean algal blooms off the east- and south coasts of the island continent (principally two blooms in the Pacific Ocean and Southern Ocean, covering an area twice the size of Australia).

On December 6, 2021, the **EU's** Copernicus Atmosphere Monitoring Service **reported** (**Copernicus Report**) that around 1,760 million metric tonnes (or 1.76 giga-tonnes) of **CO₂** were released to the climate system from wildfires during 2021. Stated another way, that is a little over 3.5% of global **GHG CO_{2-e}** emissions annually, or, stated another way, closing-in on two and a half times the **GHG** emissions of Germany annually. The global carbon budget does not make allowance for **CO₂** arising from the effects of climate change!

There is a solution to most things: The **Copernicus Report** is well-worth a read, not least because it illustrates the widespread nature of the wildfires. The **Copernicus Report** read side-by-side with the **2021 Report** make salutary reading. If one were involved in managing global carbon budgeting, one would see value in accelerating global negative **GHG** initiatives to remove **CO₂**, in the near, medium and long term.

GCC countries: During the first part of December news continued to flow about decarbonisation initiatives and plans of the Gulf Council Cooperation (**GCC**) countries, and their National Oil Companies (**NOCs**).

As noted in Edition 27 of Low Carbon Pulse, decarbonisation, and, more broadly, progress to achieving **NZE** needs **NOCs** (and international oil companies (**IOCs**)). This may be an inconvenient truth to many folk, but it is the truth.

More than this, there is an imperative for **NOCs** (and **IOCs**) to drive progress towards the achievement of **NZE**: their continued existence rests squarely with their ability to transition from producers of energy carriers derived

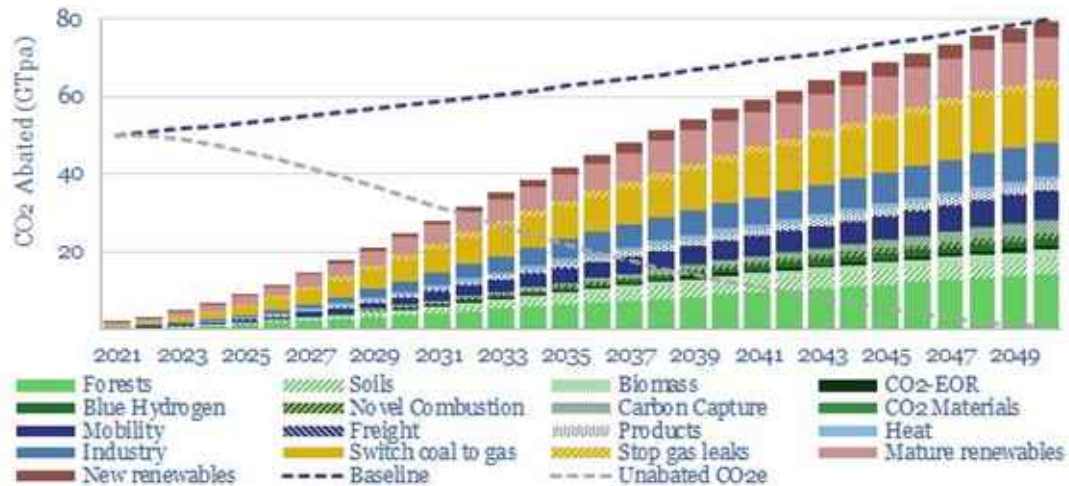
and produced from fossil fuels, to becoming producers of energy carriers derived and produced from hydrogen and hydrogen-based fuels, producers of biofuels from renewable resources (and associated carbon capture and storage and carbon capture and use), and producers of bio-feedstocks to produce bio-plastics.

Festive / Holiday Season Cheer: Not known for positively charged news streams, the [IEA Renewables 2021 Report](#) (see next news item, **under Themes and trends that emerged during 2021**) revised up its five year forecast (from 2020 on a comparative basis) for the installation of renewable electrical energy for the five years to the end for 2026.

This upward revision is a result of stronger policy settings and more ambitious Nationally Determined Contributions (**NDCs**) arising in the context of **COP-26**. The **IEA** considers that the renewable electrical energy roll-out will continue at an increased rate, notwithstanding record commodity prices that have increased the cost of development and deployment of both photovoltaic solar and wind projects.

On December 16, 2021, the ever excellent **Thunder Said Energy** published a graphic representation of the mix and means to achieving **NZE** by 2050. The associated narrative is that:

"The entire global economy can be decarbonized by 2050 at an average cost of USD40/ton ... momentum is getting exciting in five key areas: efficiency gains, under-supplied commodity bottlenecks, power-electronics, CCS and nature-based **CO₂** removals".



• Themes and trends that emerged during 2021:

The [Anniversary Edition](#) of Low Carbon Pulse, provided an assessment of, and reflection on, matters covered in Editions 1 to 28 (October 6 2020 to October 5 2021), ahead of **COP-26**, and as such sought to frame thinking ahead of **COP-26**. This section does not repeat the content of the [Anniversary Edition](#), although it does emphasise a number of matters covered in the Anniversary Edition.

- **More renewable energy installed than ever before, but not enough:** It is estimated that up to 290 GW of renewable electrical energy capacity will be commissioned during 2021, including 160 GW of photovoltaic solar capacity.

This cheering fact is reported by the **IEA** in its [Renewables 2021 – Analysis and Forecasts to 2026 – Fuel report \(Renewables 2021 Report\)](#), published on December 1, 2021. Also attached is a link to the [executive summary](#) of the **Renewables 2021 Report**.

The [Renewables 2021 Report](#) will be reported on in detail in the November and December Report on Reports (comprised in the Appendix to Edition 33 of Low Carbon Pulse), but for the time being the key headlines are:

- renewable electrical energy will be installed at a rate of around 300 GW a year over the next five years, as a main case, with between an additional 40 to 100 GW as an accelerated case;
- renewable electrical energy will account for around 95% of new electrical energy capacity installed over the next five years;
- installed renewable electrical energy will increase by 60% over the next five years, reaching 4,600 GW in 2026;
- the **PRC** will continue lead the way in the installation of renewable electrical energy capacity, with 43% of installed capacity over the next five years, followed by Europe, India and the US, with the **PRC**, Europe, India and the US accounting for 80% of the renewable electrical energy to be installed over the next five years; and
- If current rates of progress are maintained in the **PRC** and Europe, both will over-shoot their targets, and as such achieve those targets earlier than committed.

The most powerful finding from the **IEA Renewables 2021 Report** is that while there is positive news year on year from 2020, photovoltaic solar and wind roll-out needs to accelerate to close the gap between the actual rate of roll-out and the required rate of roll-out.

- **The natural solar and wind, geothermal and hydro resources exist:** The resources are matched by existing technology, albeit technology that will develop. During 2021, atlases were released or updated ([pumped storage](#), [solar](#) and [wind](#)) outlining the extent of renewable resources.

The scale and scope of renewable resources is clear; the time-frame within which a proportion of them must be harnessed to produce electrical energy is known; aligning the two is the challenge.

- **Exporting sun and wind:** One of the trends that has emerged during 2021 has been the development (so far, mostly proposed development) of high voltage direct current (**HVDC**) interconnectors to deliver renewable electrical energy from countries rich in renewable resources to countries that are not (including because they simply do not have the land mass).

In mid-June 2021, the Norway to UK **North Sea Link** (the Statnett and National Grid project) commenced transmission – the longest submarine **HVDC** in the world at around 750 km. It is to be expected that more **HVDC** projects will be developed within Europe, on-shore and submarine, with the **Greenlink** project from the Republic of Ireland to the UK progressing.

During 2021, Cyprus, Greece and Israel have progressed plans for a submarine electrical energy interconnector (the **EuroAsia Interconnector**) to enhance efficiency across grids and to allow each country to optimise renewable electrical energy capacity, particularly solar, so as to allow each country to move towards net-zero **GHG**, and to minimise the need to maintain non-renewable electrical energy. The **EuroAsia Interconnector** has achieved **EU** status as a Project of Common Interest (an **EPCI**).

The most high profile **HVDC** projects being progressed to development are the **AAPowerLink** (or **Sun Cable Project**) (700 km on-shore, 3,800 km sub-sea), from the Northern Territory of Australia to Singapore (currently contemplated as a 17 to 20 GW project), and the **Xlinks** project (3,800 km) from Morocco, North Africa to Devon, England, and to Pembroke, Wales (currently contemplated as a 10.5 GW project).

On June 24, 2021, the Australian Financial Review revisited the suggestion of the **PRC** President, Mr Xi Jinping (made to the United Nations) of a "global energy internet" or "submarine super-grids" using ultra-high-voltage direct current (**UHVDC**) transmission lines. While **UHVDC** projects are progressing to development are submarine projects, **UHVDC** projects are to be developed in the **PRC**. It seems likely that more of them will be **UHVDC**.

On December 6, 2021, Bloomberg reported on a USD 300 billion plan to bring green power to the **PRC's** megacities, over thousands of kilometres of **UHVDC** transmission infrastructure. The development and deployment of **UHVDC** is an area that is likely to develop, not least because of its relative simplicity. If one reflects that by 2030 the **PRC** will have installed 1,200 GW of renewable electrical energy in the form of solar and wind capacity (equivalent to the load of the US), there is sense in leveraging the ever-increasing scale. The **PRC** has 30 functioning **UHVDC** lines. It seems likely that there are many more to come.

- **There is a need to "crack on":** In reflecting on **COP-26**, Executive Director of the Hydrogen Council, Mr Daryl Wilson reflected that *"the strongest sentiment for [him was] the need to "crack-on" with actual implementation of climate solutions"*.

In the context of implementation, renewable electrical energy is core to implementation, followed by hydrogen: *"Hydrogen is not a panacea or silver bullet ... but it's a key solution [among] many that needs to be acted on fast ... Hydrogen for Net Zero, indicates hydrogen can make up 22% of final energy use by 2050 and deliver 85 giga-tonnes of decarbonisation along the journey to that date. That is one fifth of the job that needs to be done – a significant chunk of work"*.

If hydrogen and hydrogen based fuels are to make this level of contribution, more needs to be done to increase demand for hydrogen as an energy carrier / vector. This is particularly the case in respect of the development of demand for Green Hydrogen and Green Ammonia.

On December 6, 2021, it was reported that the Executive Director of the **IEA**, Dr Fatih Birol had noted that: *"The relative lack of demand for green hydrogen makes [the] sector's progress uncertain"*. The perspective of the **IEA** on this point is explored further in a [Recharge article](#) (dated December 6, 2021) an article that is worth reading.

European Hydrogen Week (**EHW**) took place in the week beginning November 29, 2021. European Union President, Ms Ursula von der Leyen, opened **EHW** outlining the basis to build on the [EU Hydrogen Strategy](#) in a compelling [speech](#) (for further detail see under **Europe** below).

To the author of Low Carbon Pulse, the way to increase demand for Green Hydrogen is not to make the cost of other energy carriers more expensive, rather the way forward is, and always has been, to reduce the cost per kg of Green Hydrogen. If this proposition is accepted, the focus of policy settings should be how best to increase the supply and reduce the cost of Green Hydrogen. In this context, those developing and implementing policy settings should not be confined by existing targets. For an up to the moment assessment, on December 8, 2021, Wood Mackenzie provided an [analysis](#), the headline from which is that producing Green Hydrogen for USD "1/kg is achievable in some countries by 2030".

- **While there is a need crack on globally, the EU is progressing towards achievement of targets:** On November 29, 2021, Vice-President of the European Commission, Mr Frans Timmermans said the **EU** countries and neighbouring countries are likely to exceed the installation target of 80 GW of electrolyzers powered by renewable electrical energy.

Mr Timmermans said that, *"... our aim [is]: 40 GW of renewable electrolyzers in Europe and 40 GW in Europe's neighbourhood with export to the EU. I think it's realistic to say we will probably out-perform that by 2030"*.

The question now is the acceleration in the development and deployment of Green Hydrogen, critically the policy settings that will accelerate ahead of the target. To many policy setting watchers, if it is possible to see that if a target will be achieve nine years out, that policy setting is unlikely to have been ambitious enough in the first instance, and it should be accelerated and extended.

- **There is a need for Government involvement:** There is an identified need for the development of renewable energy capacity, including to produce energy carriers, critically, hydrogen and hydrogen based fuels. The cost of capital to the Governments of many developed countries is lower than the capital costs of the private sector, and the basis of investment by the government of developed countries is different that the basis for investment of the private sector.

While many Governments are providing funding support for the private sector (both within their borders and outside them), there is an argument for government-to-government cooperation, i.e., for governments to coordinate the development of infrastructure to accelerate supply and to accelerate demand.

If it is accepted that the supply and demand sides of hydrogen and hydrogen-based fuels need to be accelerated, there is a role for Governments, certainly "book-ending" sourcing water (including possibly using desalinated water or processed and treated waste water in fresh water scarce environments) and port storage and delivery infrastructure (in the host country) and the port receiving and storage infrastructure and pipeline distribution systems (in the import country).

Historically and currently, many countries have invested in infrastructure to allow the development of industry, in most instances being circumstances in which there was not an existential concern, simply to achieve the multiplier effect of developing an industry.

- **Carbon Credits, Article 6 and the Paris Rulebook:** In contrast to the slower growth in demand for hydrogen and hydrogen-based fuels (in particular Green Hydrogen), the demand for carbon credits appears to be increasing at pace, in particular in the Voluntary Carbon Market / Voluntary Carbon Credit Market.

In a publication entitled, [Why was it so significant that COP-26 completed the Paris Rulebook?](#), a high-level summary of the significance of the **Paris Rulebook** is provided:



In the **Voluntary Carbon Market / Voluntary Carbon Credit Market**, carbon credits have value to corporations that have committed to achieving **GHG** emission reductions (and, in the longer term, **NZE** on the basis of carbon neutrality). Previous editions of Low Carbon Pulse have covered the uses of words and phrases in this context, but ultimately, decarbonisation takes time, and needs to be achieved across Scope 1, 2 and 3 emissions. To buy the time, while still reducing **GHG** emissions on a net-basis, corporations buy carbon credits.

In a stand-alone article to be published during the early part of 2022, the author of Low Carbon Pulse will outline Carbon Credits, Article 6 and the Paris Rulebook, and the near, medium and long term role of Carbon Credits, including as deforestation is curtailed and ceases, and afforestation and reforestation continues.

• **A look ahead to 2022 (and beyond):**

- **Addressing adverse pricing consequences and bottlenecks:** The **IEA Renewable Market Report** has identified increased costs of photovoltaic solar panels experienced during 2021 as likely to continue to during 2022. This becomes a problem if the rate of installation of photovoltaic solar renewable electrical energy capacity is slowed as a result of the higher costs or the bottlenecks associated with supply not being able to keep pace with demand, or both. The continued roll-out, and its rate, is critical to reducing **GHG** emissions. At the moment, by and large, the market is being left to itself, and we owe a debt of gratitude to the photovoltaic solar manufacturers, critically those in the **PRC**.

The **IEA Renewables 2021 Report** outlines the cost pressure points that have prevailed since the beginning of 2020: the price of photovoltaic grade polysilicon has increased over four-fold, the price of steel by more than 50%, aluminium by more than 80%, copper by more than 60%, and wait for it, freight costs have increased six-fold.

This is not a matter that can be ignored: the **IEA** estimates that up to 100 GW of roll-out may be delayed if commodity price shocks occur. Consistent with the continued narrative, roll-out needs to accelerate, not slow.

- **Renewable electrical energy roll-out will continue, and increase over time:** The [IEA Renewable Energy Market Update 2021](#) is timely because it demonstrates both the rate of roll-out, and that an increased rate of roll-out is required. As will be apparent from **Wind Round-up** below, a number of countries are increasing the roll-out of renewable electrical energy, aiming to progress to achieve their respective commitments to reduce **GHG** emissions by 2030 (and in some instances before), and to continue to make progress to be in position to progress to **NZE** by 2050. While no more than a hope, ideally, countries will accelerate to **NZE** well-head of 2050, in some instances by 2035. Any early indications of this will likely take shape during 2022.
- **The rate of energy transition in GCC countries is key, both for them and for the rest of the world:** The **GCC** countries will continue to develop Blue Hydrogen and Green Hydrogen projects as they accelerate their progress towards the achievement of **NZE**, both at a country level and leveraging the benefits of world class renewable energy resources at a global level. As a general statement, the **GCC** countries have the means and motivation to achieve energy transition that allows them to transition from Black Gold to Blue / Green Gold, making use of world class resources, and the ability to develop photovoltaic solar projects to provide the lowest cost electrical energy in history. Blue and green molecules are worth more than green electrons.
- **Australia, Chile, the PRC and Spain to continue to lead:** Along with the **GCC** countries, four countries rich in solar resources appear likely to lead in the development of the hydrogen economy over the next five years (and beyond) – Australia, Chile, the **PRC** and Spain. (Low Carbon Pulse has recognised the roles of Australia, Chile and Spain in editions of Low Carbon Pulse under "Net Zero Heroes".)

Each country is blessed by geography to allow production of Green Hydrogen and Green Hydrogen-based fuels (supply) and to export Green Hydrogen and Green Hydrogen based-fuels in the case of Australia, Chile and Spain to match demand overseas, and to domestic demand / use in the case of the **PRC**. Each country is also blessed by leadership, whether political or in the private sector, or both.

- **The key is to the Cities:** Ahead of, and since **COP-26**, there has been an increased focus on the greening of cities, those built and those to be built, and the buildings within them. The urban environment has become an area of greater awareness, and increasing focus: 25 mega-cities are responsible for 52% of **GHG** emissions arising in an urban setting, critically Beijing, Handan, Shanghai, Tokyo, and Moscow.

By 2030, it is estimated that there will be 43 cities globally with populations of more than 10 million. Amongst other things, with urbanisation comes waste heat. Ideally urban areas should be designed so as to become heat sinks. This involves the greening of the urban environment.

As noted above, the **Smart Cities Report** from the **IEA** appears likely to increase awareness and action:

"Cities account for more than 50% of the global population, 80% of global GDP, two-thirds of global energy consumption and more than 70% of annual global carbon emissions".

It is anticipated that decarbonising cities will become a key focus.

- **Increasing NDCs during 2022 ahead of COP-27:** At **COP-26** the High Ambition Coalition COP-26 Leaders' Statement [announced](#) that they were committed to increasing the **NDCs** to align with holding the increase in average global temperatures to **1.5°C (Stretch Goal)** for the purposes of commitments to be made before or at COP-27 (to be held in Egypt in 2022).

Further, all countries have agreed to update their **NDCs** ahead of COP-27. It is to be expected that countries will update their **NDCs**, and, in the case of many, it is hoped that they will stretch their **NDCs**, including to a level that is aligned to an increase in average temperatures that is lower than the **Stretch Goal** and that gets to **NZE** as soon as possible before 2050, not by 2050.

- **Final words on the look back and the look forward:**

For the author of Low Carbon Pulse, three quotes from **COP-26** are the quotes of 2021:

"Two degrees is a death sentence [for small island states]."

Prime Minister of Barbados, Ms Mia Mottley (watch Ms Mottley's speech [here](#))

"What is stopping any other heavy, hard to abate industries from doing the same [i.e., doing what FMG is doing]?"

Nothing. Just the will to make it happen!

CEO of Fortescue Future Industries, Ms Julie Shuttleworth (watch Ms Shuttleworth's speech [here](#))

"We are still knocking on the door of climate catastrophe ... it is time to go into emergency mode – or our chance of reaching net-zero will itself be net zero"

United Nations Secretary-General, Mr Antonio Guterres on the final day of **COP-26**

The quote of the year has to go to Ms Julie Shuttleworth, in particular the need for **"the will to make it happen"**. What Ms Shuttleworth said is totemic, explanatory, speaking to the application of the individual and collective will to reduce **GHG** emissions to **NZE** to achieve what Mr Bill Gates has described as, **"the hardest thing humanity's ever done"**.

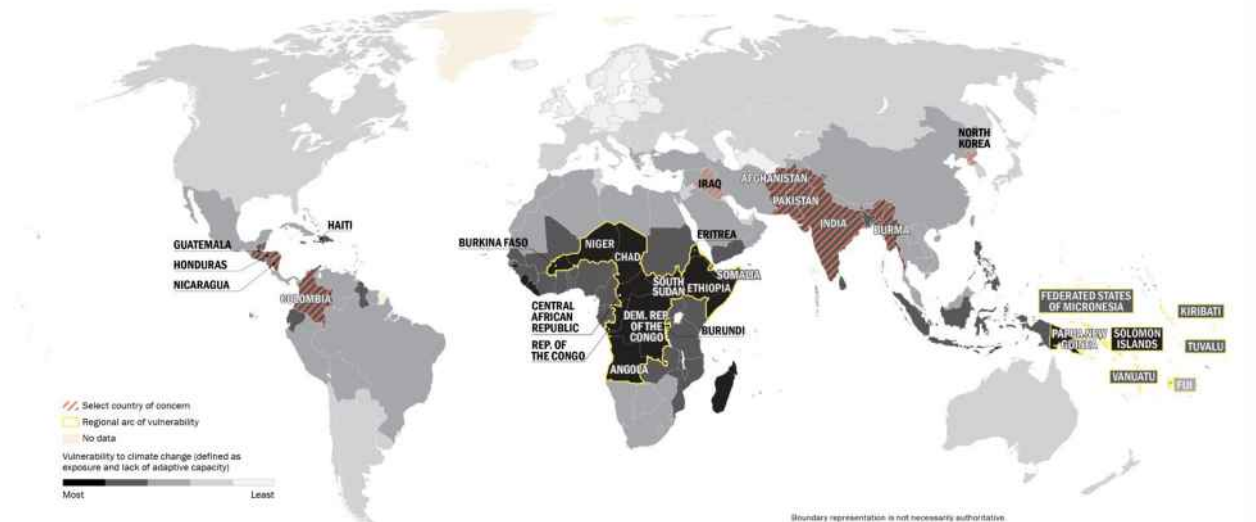
For the author, Ms Shuttleworth joins Messrs Johnson and Bird as the embodiment of authenticity, manifest in genuineness, and hard fought success, wrought in application and hard work, playing for the team, cutting no corners.

Climate change reported and explained:

- **Most vulnerable countries:** The following map provides a summary of the countries that are most at risk from the impact of climate change:

Climate Change in Select Highly Vulnerable Countries of Concern

The IC identified 11 countries and two regions of great concern from the threat of climate change. Building resilience in these countries and regions would probably be especially helpful in mitigating future risks to US interests. Two regional arcs also stand out because these groups of countries are clustered together, are relatively poor, and have little capacity to assist their neighbors.



As will be apparent, Afghanistan, Colombia, Guatemala, Haiti, Honduras, India, Iraq, Myanmar, Nicaragua, the People's Republic of Korea (North Korea) and Pakistan are considered to be the most vulnerable countries from the broader effects of climate change. The [report](#) from which the graphic is sourced, the Office of the Director of National Intelligence, outlines that climate change may result in increased political instability that may impact security.

On November 29 and 30, 2021 [CNBC](#) reported on the findings that underpin this graphic, and the fact that in some of these countries the impact of climate change on sources of energy, food, and water, and the impact on health, risk prolonged instability. The solution is to work with each of these countries to allow them to adapt to climate change, and its consequences. Given the regimes in some of these countries, for some the concept of providing help may be regarded as a challenge, but help is needed nevertheless, and help should be given.

- **Most recent National Oceanic and Atmospheric (NOAA) report:** In previous editions of Low Carbon Pulse, findings from the [monthly report](#) of the **NOAA** were reported. Over the October and November editions of Low Carbon Pulse, this reporting was missing so as to manage the length of each edition.

On December 10, 2021, the **NOAA** reported that November 2021 was the seventh warmest, eighth driest November on record for the US.

GCC Countries:

- **Emirates and GE decarb plan:** On November 29, 2021, it was reported that Emirates Global Aluminium (**EGA**) and General Electric are developing a plan to decarbonise **EGA's** activities. In January 2021, the **EGA** contracted with the Dubai Electricity & Water Authority (**DEWA**) for the supply of renewable electrical energy from the Mohammed bin Rashid Al Maktoum Solar Park (see Editions [8](#) and [18](#) of Low Carbon Pulse). The focus of the work to be undertaken by **EGA** and GE is to repurpose the current natural gas turbines to take and to use blended natural gas and hydrogen.

See: General Electric [press release](#); Emirates Global Aluminium [press release](#)

- **Masdar and Engie alliance:** On December 3, 2021, [Masdar](#) (Abu Dhabi Future Energy Company) and Engie (global leading energy company) announced a strategic alliance to explore the co-development of a UAE located Green Hydrogen hub. Masdar and Engie are contemplating the development and deployment of 2 GW of electrolyser capacity by 2030, at an anticipated cost of USD 5 billion. The strategic alliance agreement was signed by Dr Sultan Ahmed Al Jaber, UAE Minister of Industry and Advanced Technology, ADNOC Managing Director and Group CEO, and Masdar Chair, and Ms. Catherine MacGregor, ENGIE CEO.

See: [ENGIE and Masdar form US\\$5 billion strategic alliance to drive UAE's green hydrogen economy](#); [Masdar and ENGIE form US\\$5 billion strategic alliance to help drive UAE's green hydrogen economy](#)

- **Saudi Aramco and French corporations:** On December 4, 2021, Saudi Aramco announced that it signed agreements with leading French corporations as it continue to progress towards decarbonisation of its activities.

It is reported that the agreements involve Saudi Aramco: **1.** Having agreed to work with Gaussin (leading clean and intelligent transport corporation) to develop on-road and off-road vehicle solutions; **2.** Having signed an memorandum of understanding (**MOU**) with Air Liquide to develop "low carbon-hydrogen and ammonia production, logistics and back cracking technology", and an **MOU** to evaluate "carbon capture and sequestration opportunities"; **3.** Having signed an **MOU** with Alteia to develop "advanced artificial intelligence-driven geospatial imagery interpretation and processing capabilities"; and **4.** Having signed an **MOU** with Axens "to explore the local manufacturing and maintenance services and furnaces and fired heaters".

See: [Aramco announces collaboration with French companies](#)

- **ADNOC and TotalEnergies:** On December 5, 2021, it was reported widely that **ADNOC** and TotalEnergies signed a strategic alliance to work together to develop low-carbon hydrogen and carbon capture and storage projects, and to explore the development of upstream oil and gas opportunities within Abu Dhabi. The strategic alliance agreement was signed by Dr Sultan Ahmed Al Jaber, UAE Minister of Industry and Advanced Technology, ADNOC Managing Director and Group CEO, and Masdar Chair, and Mr Patrick Pouyanne, TotalEnergies CEO.
- **Air Products and thyssenkrupp write large:** On December 13, 2021, it was reported widely that Air Products had contracted with thyssenkrupp for the supply of 2 GW of electrolyzers for Air Products USD 5 billion Green Hydrogen production project to supply Green Hydrogen to Neoen to be powered by 4 GW of renewable electrical energy. While Low Carbon Pulse does not tend to cover contracts for supply of goods and services in respect of projects underway, this is a landmark contract for a landmark project for a landmark city of the future.
See: [Air Products and thyssenkrupp sign exclusive strategic cooperation agreement for world-scale electrolysis plants to generate green hydrogen](#); [One of the Largest Green Hydrogen Projects in the World: thyssenkrupp Signs Contract to Install Over 2GW Electrolysis Plant for Air Products in NEOM](#)
- **Emirates Water and Electricity Company (Ewec) – good day sunshine:** On December 13, 2021 [energy&utilities](#) reported that **Ewec** has stated procurement preparation for a 1 to 1.5 GW world-scale photovoltaic solar project to be delivered under an independent power producer (**IPP**) model.
This will be the third photovoltaic solar IPP, the first being the 1.17 GW Noor Abu IPP (that came on line in July 2019) and the 2 GW Al Dhafra IPP (that was awarded in 2020 at a then world-record low US cents 1.32/kWh).

India and Indonesia:

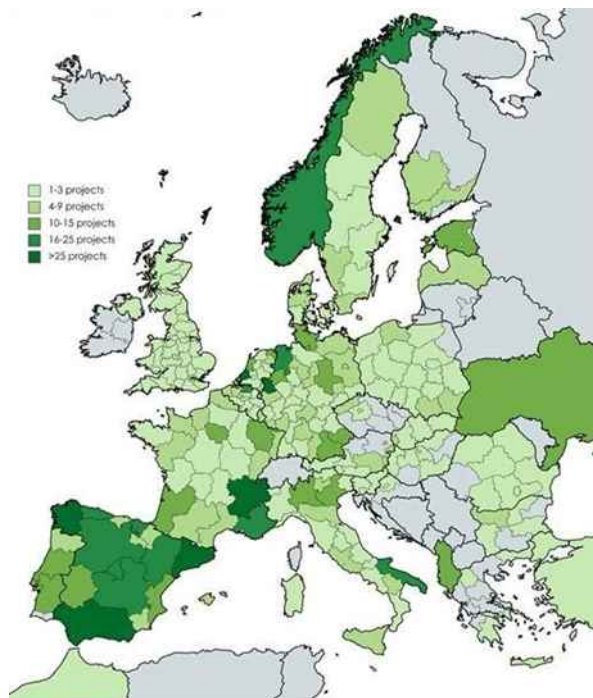
- **India Hydrogen Alliance – November 2021:** Attached is the link to the November edition of [India H2 Monitor – November 2021](#). As noted in previous editions of Low Carbon Pulse, we intend to include the link rather than repeat the context of the **India H2 Monitor**. Some of the news items have already been covered in Editions [29](#), [30](#) and [31](#) of Low Carbon Pulse because they relate to reported news items from Government and corporations.
- **Indonesia and FFI combine:** On December 10, 2021, [H2view](#), reported that Fortescue Future Industries (**FFI**) has signed an agreement with North Kalimantan Provincial Government of the Republic of Indonesia to explore the development of Green Hydrogen production capacity.
- **India's Journey to 500 GW:** On December 15, 2021 the **IEA** held a webinar titled [India's Journey to 500 GW: Reaching the Capacity and Investment Targets \(India's Journey to 500\)](#).
The background to India's Journey to 500: At **COP-26**, the Indian Prime Minister, Mr Nahendra Modi committed India to achieving **NZE** by 2050. Please click [here](#) for a transcript of Mr Modi's speech.
In addition, Mr Modi committed as follows: **1.** By 2030, India will increase its non-fossil fuel capacity to 500 GW (a 50 GW increase in this commitment from 450 GW); **2.** By 2030, India will satisfy 50% of its energy demand from renewable energy; **3.** By 2030, India will reduce its **GHG** emissions by 1 giga tonne (1 billion metric tonnes); and by 2030, India will reduce the carbon intensity of its economy to less than 45%. As has been noted in Low Carbon Pulse for some time, India is taking centre stage. This is critical globally, because the decarbonisation of India (as its population grows, the urbanisation of that population increases, and its economy develops), will be critical to the achievement of **NZE** globally.
The headlines from India's Journey to 500: On December 15, 2021, the **IEA** and the CEEW Centre for Energy Finance, held a webinar for 90 minutes. The author attends many webinars, some of which are worth it, some not. This was worth attending, click [here](#) to view a recording of the webinar.

Japan and Republic of Korea:

- **Size and Shape taking shape:** On December 1, 2021, [Recharge](#) reported that **ROK** is getting to grips with the size and shape of the supply and demand for hydrogen and hydrogen-based fuels across its economy by 2050. The Government of **ROK** has outlined (in a strategy paper), that it expects to have annual demand of 28 million metric tonnes of hydrogen, with 60% of demand being sourced from Green and clean hydrogen produced overseas.
"Hydrogen will become [ROK's] largest single energy source in 2050, which will account for 33% of the total energy consumption [within ROK]".
See Edition [31](#) of Low Carbon Pulse for details of plans to blend hydrogen and natural gas to fire gas-fired power plants and to blend ammonia with coal to fire coal-fired power plants.
The strategy paper will be considered in detail in the Report on Reports for November and December to comprise the Appendix to Edition 33 of Low Carbon Pulse.
- **Reforming Korea's Electricity Market for Net Zero:** On December 9, 2021, the **IEA** and the Korea Energy Economics Institute published **Reforming Korea's Electricity Market for Net Zero**. The report is excellent. The publication will be considered in the Report of Reports for November and December to comprise the Appendix to Edition 33 of Low Carbon Pulse.
- **Third Off-shore Wind Auction:** On December 10, 2021, Japan opened its third auction process for off-shore wind field capacity under the Renewable Sea Area Utilization Law. The auction will select a developer for up to 356 MW of installed capacity in the Happono-Noshiro zone off-shore of the Akita prefecture. The auction process will close on June 10, 2022, with the preferred bidder expected to be announced in December 2022.
By way of reminder, the Japanese Government plans to develop and to deploy 10 GW of off-shore wind field capacity by 2030, and 45 GW by 2040.
- **Another FCT power plant:** Previous editions of Low Carbon Pulse have reported on the use of fuel cell technology in the **ROK** to generate electrical energy (see Editions [4](#) and [9](#) of Low Carbon Pulse).
On December 13, 2021, [fuelcellworks](#) reported that Doosan Fuel Cell has now provided the technology for the world's two largest fuel cell technology power stations, the Shinincheon Bitdram Fuel Cell Power Plant (see Edition [23](#) of Low Carbon Pulse) and the Western Incheon Fuel Cell Phase 4.

Europe:

- **ECHA maps H2 Europe:** On December 1, 2021, the European Clean Hydrogen Alliance (**ECHA** – see Edition 5 of Low Carbon Pulse) provided an overview of prospective hydrogen projects across Europe, comprising over 750 projects across the supply / value chain, including 446 hydrogen production projects, 163 hydrogen transmission and disruption projects, 172 hydrogen for industrial application, 240 hydrogen for transport application, 143 hydrogen for energy application and 77 hydrogen for building projects. Spain is the country with the most prospective projects across Europe.



The **ECHA** was established at the same time as the [EU Hydrogen Strategy](#) in July 2020 ([A hydrogen strategy for a climate-neutral Europe](#)). The **ECHA** is a forum in which civil society, industry and public authorities come together to coordinate investment initiatives.

- **AccionaPlug map Iberian Peninsula:** On November 30, 2021, Acciona (leading infrastructure developer and investor) and Plug Power (leading hydrogen technology company) announced that they had established a joint venture to develop and to deploy Green Hydrogen production facilities across the Iberian Peninsula, both co-located with customers and stand-alone. In addition, the joint venture, AccionaPlug, will develop hydrogen supply and value chains across the Peninsula.

See: [ACCIONA Energía and Plug Power launch AccionaPlug to address green hydrogen market in Spain and Portugal; Plug Power and Acciona Energía Launch Accionaplug to Address Green Hydrogen Market in Spain and Portugal](#)

- **EU maps carbon capture plans:** On December 1, 2021, [Reuters](#) reported that **EU** plans to capture 5 million metric tonnes per annum of CO₂, and create an **EU** system to certify CO₂ removal. The plans were published formally on December 15, 2021: [press release](#) from the **EC** under **European Green Deal: Commission proposals to remove, recycle and store carbon sustainably**, reporting on the adoption by the EC of a [Communication on Sustainable Carbon Cycles](#).

Executive Vice-President for the European Green Deal Mr Frans Timmermans said:

"Today, we set out the main principles and objectives of our work to prepare the necessary rules. These rules will ensure carbon removals are credible and have the desired effect, and help to create new business opportunities in carbon farming for, foresters, and other land managers".

By the end of 2022, the **EC** will propose a regulatory framework for the certification of carbon removal based on transparent carbon accounting and monitoring rules, allowing verification of carbon removal. The **EC** will launch a call for evidence during January 2022.

As noted above, in January 2022, the author of Low Carbon Pulse will post a stand-alone article on Carbon Credits, Article 6 and the **Paris Rulebook**, and the near, medium and long term role of Carbon Credits, including as deforestation is curtailed and ceases, and afforestation and reforestation continues. The stand-alone article will cover the carbon removal in the context of carbon credits and off-sets in the context of the **EU**.

- **Distribution map to be developed:** On December 3, 2021 it was reported widely that DNV will lead the Ready4H2 Project, which will assess how best to develop the pipeline network across Europe so as to facilitate the distribution of hydrogen across the continent.

DNV will work with 80 corporations and organisations across Europe for this purpose. At a policy setting level it is recognised that the distribution system needs to be developed so as to facilitate the development of the use of hydrogen, and to avoid any slow-down in the development.

See: [DNV to lead study on potential of European hydrogen distribution networks](#)

- **EU Green Taxonomy** adopted:

Among other things, the **EU Green Taxonomy** provides:

- What does not this mean and what is its practical application?**

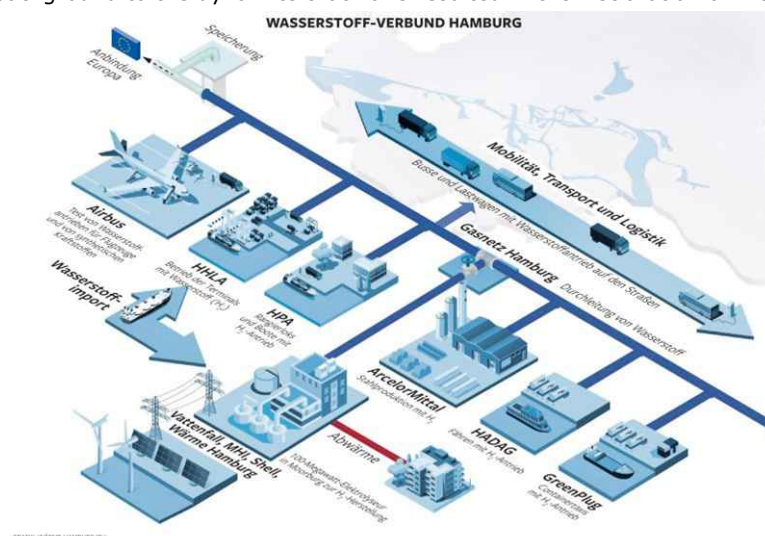
The positions of participants and stakeholders has informed the "debate" around the **CO₂-e** intensity benchmarks for some time, including around the use of natural gas and nuclear energy sources (including as sources for the production of hydrogen and hydrogen-based fuels) in the context of the **EU Green Taxonomy**.

(A link is attached to the ec.europa.eu [website](#) that contains relevant materials under **EU taxonomy for sustainable activities**.)

- The attached [link](#) provides a two page overview of the proposal from the **EC**. The November and December Report on Reports will include an outline of the proposal and the timeline for 2022 (the Report on Reports will form the Appendix to Edition 33 of Low Carbon Pulse).

Edition [30](#) of Low Carbon Pulse reported on November 10, 2021, ScottishPower (one of the two giant Scottish energy companies, the other being [SSE plc](#)) made a [press release](#) contemplating collaboration between Germany and Scotland in the production of hydrogen in Scotland and export to Germany. The contemplated collaboration is outlined in the [Draft Hydrogen Action Plan](#) released by the Scottish Government (on November 10, 2021). The **Draft Hydrogen Action Plan** sizes the potential market at €20 billion.

As reported in Editions [18](#) and [20](#) of Low Carbon Pulse, the inland port of Hamburg and the City of Hamburg want to develop as a centre of hydrogen and become a European Green Hydrogen Hub. The Hamburg News feature is well-worth a read, providing background to the dynamics that have resulted in the Declaration of Intent.



France and Germany:

On December 1, 2021, the **IEA** released [France 2021 – Analysis](#). The report provides a helpful analysis of the policy settings in France, and the progress that remains to be made in France to achieve **NZE** by 2050.

The report will be considered in more detail in the November and December Report on Reports to comprise the Appendix to Edition 33 of Low Carbon Pulse.

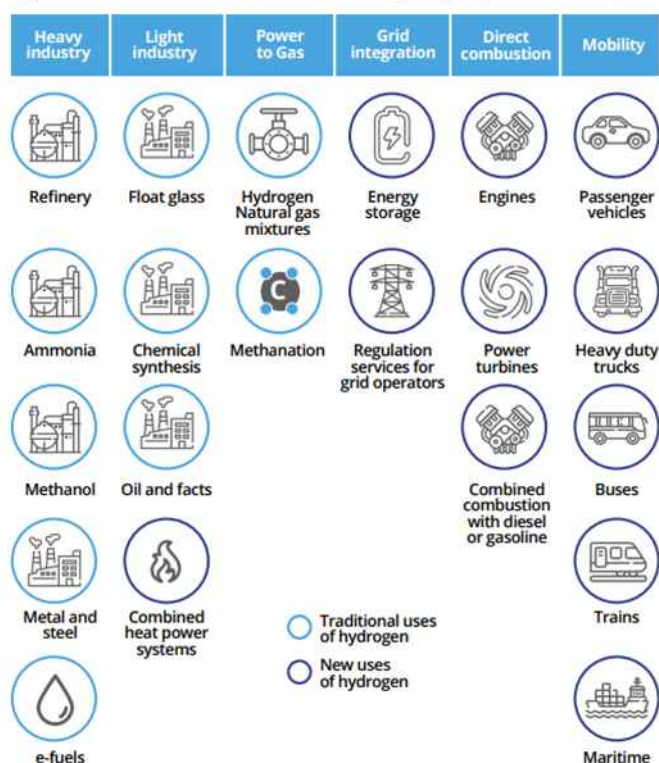
Mexico and Germany:

In December, 2021, **Green Hydrogen in Mexico: towards a decarbonization of the economy** (Volumes [I](#), [II](#), [III](#) and [IV](#)) was published (**GH2 Mex**). The report is the work of Alianza Energética Energiepartnerschaft – México – Deutschland and Cooperación Alemana – Deutsche Zusammenarbeit.

While each Volume of **GH2 Mex** is well-worth a read, Volume [I](#) sets a new benchmark for excellence in analysis of a highly prospective market, and the hydrogen industry generally. **GH2 Mex** complements the [IEA Global Hydrogen Review](#).

GH2 Mex will be considered in more detail in the November and December Report on Reports (to comprise the Appendix to Edition 33 of Low Carbon Pulse). While to be included in the Report on Reports, the following diagrammatic representation of the uses of Green Hydrogen is worth including here:

Figure 1-9. Traditional and new uses of hydrogen (Hinicio, 2020)



Australia:

- **Western Australia to Northern Europe:** On December 2, 2021, the Government of Western Australia and Port of Rotterdam announced that they had signed a memorandum of understanding (**MOU**) to develop a supply chain from Western Australia to the Port of Rotterdam, the Netherlands.

Editions [17](#), [20](#), and [21](#) have reported on the forward thinking nature of Port of Rotterdam Authority in the development of facilities and infrastructure for the import and storage of hydrogen and hydrogen-based fuel. The signing of the **MOU** may be regarded as a significant development that under-scores the clear development of supply chains from Australia to Europe.

- **New South Wales two new REZ:** Most recently, Edition [30](#) of Low Carbon Pulse reported on the Renewable Energy Zones (**REZs**) in New South Wales, Australia's most populous state. On December 3, 2021, the NSW Government sought expressions of interest for the development and deployment of new solar and wind and energy storage projects on the Central Coast and Hunter Regions of New South Wales.

The New South Wales Government announced its **REZs** plans in 2020 (see Edition [4](#) of Low Carbon Pulse), and has been progressing those plans since then. The **REZ** plans, and the policy settings supporting them, are aimed at ensuring that New South Wales halves its **GHG** emissions by 2030, and achieves **NZE** by 2050.

- **Federal Government of Australia:** On December 3, 2021, the Federal Government of Australia [announced](#) its Hydrogen Technology Cluster Australia program, with clusters to be located Townsville, Queensland, and in Gascoyne and Midwest regions of Western Australia.
- **Guarantee of Origin (GOO) Scheme to be tested and trialled:** On December 10, 2021, it was announced that the Federal Government of Australia is to start to work with participants in the hydrogen industry to test the design of its **GOO** Scheme.

Key to the assurance of origin of hydrogen and any hydrogen-based fuel is monitoring and verifying the **GHG** emissions that arise from the production of hydrogen and hydrogen-based fuels.

The Federal Minister for Industry, Energy and Emissions Reduction, Mr Angus Taylor noted that: "*Continuing our close work with industry through design and trials is critical to ensuring that an Australian Guarantee of Origin scheme is fit for purpose to support industry growth and attract investment.*"

- **State of Hydrogen 2021:** On December 10, 2021, the Department of Industry, Science, Energy and Resources (**DISER**) published [State of Hydrogen 2021](#), reporting on the state of the hydrogen industry in Australia. The **DISER** report is both informative and welcome.

The **DISER** report will be considered in the November and December Report on Reports to comprise the Appendix to Edition 33 of Low Carbon Pulse.

- **Victoria's Renewable Energy Zones:** On December 13, 2021, [reneweconomy](#), under [Victoria seeks 1.5 GW of new wind and solar in first renewable zone tender](#), reported that the Victorian Government had received more than 30 proposals in response to expressions of interest to provide new renewable electrical energy and innovative solutions to strengthen the grid.

UK and US:

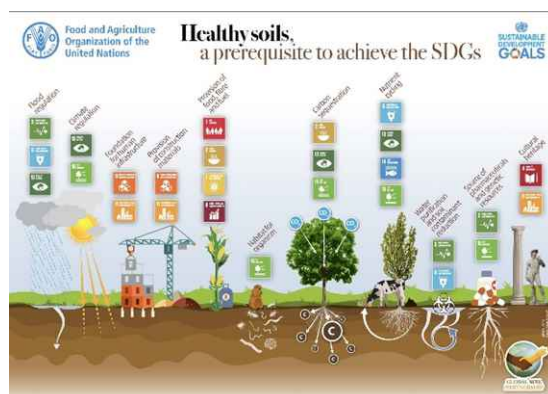
- **Largest NZE procurement:** On December 8, 2021, the President of the United States, Mr Joe Biden, signed an executive order directing the Federal Government to achieve **NZE** by 2050, 100% carbon pollution-free electricity by 2030, and 100% zero-emission vehicle acquisition by 2035. Here is a [link](#) to the Executive Order.
- **United States Hydrogen Alliance established:** On December 7, 2021, it was announced that the Western States Hydrogen Alliance had been expanded to become the United States Hydrogen Alliance. This may be expected to result in more active engagement by participants and stakeholders in the hydrogen and hydrogen-based fuel sector.
- **Off-shore wind knows no limits:** On December 16, 2021, the UK opened for applications in the fourth round of its off-shore wind field procurement process under which contracts for differences (**CFDs**) will be allocated (**fourth CFD allocation round**). Further details of the 12 GW **fourth CFD allocation round** are to be found at a press release from the UK Government, titled [Biggest ever renewable energy support scheme opens](#).

The headline for the press release is that off-shore wind will be supported by funding of GBP 200 million a year, and while fixed-bottom off-shore wind is the focus of the funding, there is specific allocation for floating off-shore, tidal. Also photovoltaic and on-shore wind is included.

By way of reminder, on February 6, 2021 HM Treasury announced the successful tenderers in the third round **CFD** allocation round (see Edition 9 of Low Carbon Pulse). Early in 2022 the successful tenderers in the **ScotWind Leasing Programme** are to be announced (see Edition 22 of Low Carbon Pulse).

Blue and Green Carbon:

- **UN Biodiversity – 5 Blue Forests:** UN Biodiversity under the auspices of the UN Environment Programme has shared an article, [5 "blue forests" that are vital to life on Earth](#). The article is well-worth a read, identifying as it does, mangroves, salt marshes, seagrass meadows, rockweed, and kelp forests as the 5 "blue forests".
On December 1, 2021, the **UNEP-WCMC (UN Environment Programme World Conservation Monitoring Centre)** shared a [piece](#) from earlier in 2021 about the importance of mangroves in Cambodia. It is well-worth a read.
On December 5, 2021, **ADNOC** announced its [Seeds of Legacy program](#) dedicated to preserving and planting more mangroves.
- **South Ocean – crucial carbon sink:** On December 3, 2021, a [study](#) published in Science, and supported by NASA (and the National Science Foundation and **NOAA**), reported on the importance of the South Ocean in absorbing **CO₂**. The study is well-worth a read.
The key findings arise from airborne measurements, with the key finding being: "*that the Southern Ocean is a stronger carbon sink that previously thought, playing a significant role in mitigating the impact of greenhouse gases*".
- **World Soil Day:** One learns something new every day: December 5 is World Soil Day. To mark 2021 World Soil Day the Executive Secretary, Convention of Biological Diversity, Ms Elizabeth Maruma Mrema issued a [statement](#) that provided a timely reminder of the importance of the health of soil: "*Soil biodiversity underpins the functioning of ecosystems that provide essential functions and services to sustain food and water security and deliver multiple benefits to ... all facets of sustainable development ... More sustainable management of soil resources through the conservation, restoration and sustainable use of soil biodiversity can play an important role in transforming our food systems*".



- **How long does it take to create a few centimetres of soil?** In the words of the song, it takes a thousand years. The European Commission (**EC**) introduced some of its coverage of the [EU Data Crunch Soil Strategy](#) in this way. The **EU Data Crunch Soil Strategy** is short, at six pages, but conveys a sense of the importance of soil. As the **EU Data Crunch Soil Strategy** says, soil is a magic carpet beneath our feet. (This has stuck with the author of Low Carbon Pulse.)

A (bad) pun (in particular for Liverpool Football Club fans) that nearly did not make it through editing: "It is important to remember that while we may walk on loam, we never walk a loam".

- **Planting trees is not the answer:** On December 8, 2021, an article was published by [physorg](#) that makes it clear that achieving carbon neutrality is not the target for which to aim; the target has to be decarbonisation. The article notes that plants and soil are absorbing considerable **CO₂**, and that in the case of rainforests there is a risk that they are at, or are reaching, saturation point.

The most telling sentence in the article is: "relying on the biosphere to store fossil carbon is ... daft when we may well need all the nature-based solutions we can find just to keep the carbon content of the biosphere stable". It is expected that this sentence will gain wide acceptance over time.

Since 1850 human activities have released 2,400 billion tonnes of **GHG** emissions to the climate system. There is around 460 billion tonnes of **GHG** emissions left in the carbon budget before average global temperatures increase by **1.5°C**. There is no short cut, decarbonisation needs to be achieved in short-order.

- **Planting sea-weed is not the answer:** [A Research Strategy for Ocean-Based Carbon Dioxide Removal and Sequestration](#) finds that current levels of **CO₂** emissions exceed greatly the ability of nature to remove it from the environment. The safest and soundest way to address levels of carbon in the climate system is to remove 10 gigatonnes of **CO₂** every year by 2050.

Bioenergy:

- **Bio-LNG in Tassie:** On November 29, 2021, Optimal Group and BOC / Elgas (a subsidiary of one of the big three industrial gas corporations, Linde), announced that they had signed a memorandum of understanding to explore jointly the development of the first bio-LNG production project in Australia at BOC / Elgas' Westbury LNG Plant, in Tasmania, Australia. Optimal and BOC / Elgas will explore the potential for Optimal to develop a waste to biogas facility.

See: [Optimal Group and BOC sign agreement to focus on development of Australia's first bioLNG facility](#); [BOC and Optimal Group sign agreement to focus on development of Australia's first bioLNG facility](#)

- **Waste-to-H₂ in Bulgaria:** On November 30, 2021, [H2view](#) reported that the City of Simtli has signed a letter of intent with Hydrogen Utopia International to develop a hydrogen production plant (the Powerhouse Energy Distributed Modular Gasification Plant), with the plant to use waste as feedstock to produce biogas and to derive hydrogen from that biogas.

- **TotalEnergies embraces Clean Energy:** On November 30, 2021, [Energy Connects](#) reported that TotalEnergies and Clean Energy are developing their first biomethane production facility, with the biomethane produced intended for use in the mobility / transport sector, and compressed natural gas. The biomethane production facility is located at the Del Rio Dairy farm, with the feedstock for the biomethane production sourced from manure supplied by the farm.

- **Power-to-X plant:** On December 6, 2021, Copenhagen Infrastructure Partners (**CIP**, leading renewable energy project developer and investor) announced that it was to develop one of the world's first commercial Power-to-X plants, to produce Green Methanol from **CO₂** derived from waste incineration.

CIP will develop the Power-to-X plant with Aalborg Forsyning and Reno-Nord. The Power-to-X plant is to be located in Aalborg, and will take up to 180,000 metric tonnes of **CO₂** a year from Reno-Nord, and produce 130,000 metric tonnes of Green Methanol.

See: [CIP announces plans to build Europe's largest Power-to-X-facility, with the support of market leaders within the agriculture and shipping industries](#)

- **WasteFuel not wasting time:** Edition [27](#) of Low Carbon Pulse reported that Maersk had invested in WasteFuel (a start-up backed in part by Mr Warren Buffett through Berkshire Hathaway subsidiary NetJets). At that time it was understood that WasteFuel processes agricultural and municipal solid waste to provide synthetic biofuel, bio-methanol for sale into the Americas and into Asia. It is becoming increasingly clear that Maersk could purchase all biofuel produced by WasteFuel, but WasteFuel sees the size of the market for biofuel as providing biofuel producers the opportunity to grow to the size of some international oil companies in a relatively short period of time.

- **Biomethane Declaration:** On December 7, 2021, the European Biogas Alliance announced that 28 corporations from across Europe presented the [Biomethane Declaration](#) to the European Commissioner for Energy, Kadri Simson. The Biomethane Declaration is worth a read.

BESS and HESS:

- **HyPSTER project progressing:** The first EU supported hydrogen energy storage system (**HESS**) project (**HyPSTER**) is proceeding in France, using salt caverns. Storenergy (a subsidiary of global leading energy company, Engie) will develop the **HyPSTER** project, with partners, Armines, Axelera, Ecole Polytechnique, Element Energy, ESK GmbH, Howden, INERIS and INVYN.

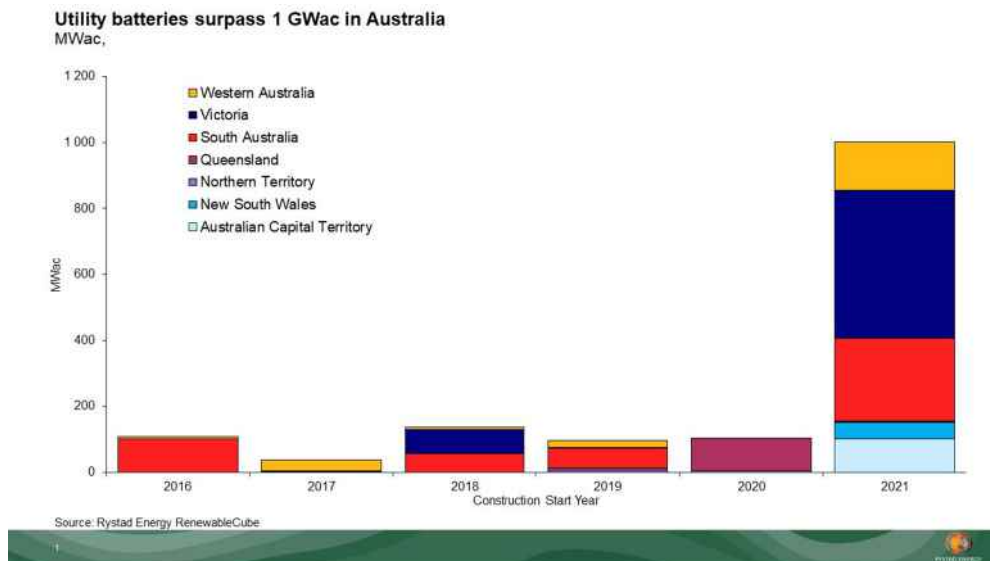
Among other things, the **HyPSTER** project will assess the position of storage in the hydrogen value chain.

See: [HyPSTER website](#)

For an article providing some background on **HESS** see [Power – Hydrogen – Want Long-Term Energy Storage? Look to Hydrogen](#).

- **Hornsedale BESS four years on:** On December 1, 2017, the Hornsdale **BESS** was launched in South Australia. Since the launch of the Hornsdale **BESS**, **BESS**'s have become a future across Australia and globally.

- **What a difference five years makes!** Set out below is a bar chart demonstrating that **BESS** has come along way since the outages in South Australia in Q3 of 2016.



- **Hazelwood BESS:** Engie and Macquarie Group's Green Investment Group are to develop and to deploy a 150 MW / 150 MWh BESS at Hazelwood, Victoria.
- **GIGA Storage Buffalo Battery:** On December 7, 2021 it was reported by [DNV – Energy](#) that GIGA Storage (a Dutch technology corporation) has achieved financial close in respect of its Buffalo Battery, the largest BESS in the Netherlands that will operate in a smart grid in the Renewable Energy Hub Flevoland.
- **Victorian Big Battery officially opened:** On December 8, 2021, the Biggest **BESS** in Australia opened officially – the Victorian Big Battery (**VBB**) – the 300 MW / 450 MWh **BESS**. The Neoen **VBB** has been developed and deployed in around 12 months. As noted in Edition [23](#) Low Carbon Pulse, from contract to connection was achieved in record time. (Also see Editions [5](#) and [11](#) of Low Carbon Pulse for progress of **VBB**.)
On December 14, 2021, Neoen announced that construction had commenced on its 100 MW / 200 MWh **BESS** close to Canberra, Australian Capital Territory – the Capital Battery.
- **North Territory – Katherine BESS:** On December 13, 2021 it was reported that Hitachi has been selected to provide a **BESS** for the iconic town of Katherine, Northern Territory, Australia (for which the author's eldest daughter is named).
The Northern Territory Government Minister for Renewables and Energy, Ms Eva Lawler, explained that: "The award of the [Katherine] **BESS** tender is a huge step in our plan for 50% renewables by 2030 – it is the cornerstone of our Darwin-Katherine System Plan".
- **US – record Q3:** During the week beginning December 13, 2021, it was reported widely that during Q3 of calendar year 2021, 1.463 GW / 3.487 GWh of **BESS** capacity was installed in the US.
- **New South Wales – Wallerawang BESS:** Edition [17](#) of Low Carbon Pulse reported that: "Greenspot plans to make use of the existing generation hall and related infrastructure at the decommissioned Wallerawang coal-fired power station just outside Lithgow, Central Western, New South Wales, Australia, to house a big battery. The AU\$500 million **Wallerawang 9 Battery BESS Project** will have **BESS** capacity of 500 MW / 1,000 MWh".
On December 15, 2021, it was reported widely that Greenspot had submitted a development application to permit it to develop and to deploy a 500 MW / 1000 MWh **Wallerawang 9 Battery BESS Project**.

BECCS / BECCUS and CCS and CCUS:

- **CCS Break-even point:** On December 1, 2021, Reuters reported that the Vice President for Global CCS Solutions at Equinor, Mr Torbjørn Fossum, had stated: "[Equinor believes] that there is a potential break even at 100 euros per tonne [of CO₂] ... Today there is a gap between what it costs to emit [the CO₂] and what it costs to implement CCS. [Equinor believes that gap is closing within the next ten years]."
In the European context the cost of emission is a function of the cost of emissions trading permits under the **EU ETS**: on December 1, 2021, €76 an emissions trading permit.
What this means in practice is that Governments should continue to develop and to implement policy settings that allow CCS to develop, while at the same time managing (down) the number of emissions trading permits (and as such lowering caps).
Critical to allowing CCS to develop is continued funding support to develop the supply of CCS capacity and services. The Northern Lights Project and the **CCUS** (cluster sequencing) **Programme** in the UK, are great examples.
- **Kasawari CCS project progresses:** On December 6, 2021, it was reported widely that Petronas' Kasawari CCS project is on the pathway to a final investment decision in 2022 with Petronas having invited bids to the award of front-end engineering and design contracts from two consortiums – Malaysia Marine & Heavy Engineering and Ranhill Worley and Hyundai Heavy Industries and Aker Solutions. Some heavy-weight players for a heavy-weight project.
- **Bifrost and Greensand Green lighted:** On December 8, 2021, [offshoreenergy](#) reported that the Danish Energy Agency (**DEA**) agreed to provide funding support for two CCS projects in the Danish sector of the North Sea. The TotalEnergies operated Bifrost, and the INEOS lead Greensand. It is well-worth clicking through to the article.

- **Polaris to progress:** On December 10, 2021 it was announced that Equinor ASA, Horisont Energy AS, and Vår Energi had entered into an agreement to collaborate on the development for the carbon transportation and storage project, Polaris off the coast of Northern Norway (see Editions [25](#) and [27](#) of Low Carbon Pulse).
The Polaris storage project is expected to have **CO₂** storage capacity of 100 million tonnes of **CO₂**, or stated another way, twice the mass of **GHG** emissions arising from activities in Norway each year. As noted in previous editions of Low Carbon Pulse, the Polaris storage project is key to the development of the Barents Blue project in Finnmark – Europe's first world-scale carbon neutral ammonia production plant.
As reported in Edition [25](#) of Low Carbon Pulse, Equinor ASA, Horisont Energy AS, and Vår Energi entered into a cooperation agreement for Barents Blue earlier in 2021.
See: [Horisont Energi, Equinor and Vår Energi enter joint development agreement on Polaris Carbon Transport and Storage Project](#); [Vår Energi enters the Barents Sea Polaris CO₂ storage joint partnership](#); Equinor ASA [website](#)
- **CCS round-up:** On December 11, 2021, [oilprice](#) published [Carbon Capture Innovations Will Play A Key Role in Net-Zero Ambitions](#). The article is worth a read, providing a clear sense of the role of CCS, including touching on the announcement by the Climate Change Committee in the UK that the use of reservoirs in the North Sea for CCS will provide the most effective means of achieving CCS in that part of the world.
- **CDR – the difference between DAC+S and CCS:** On December 15, 2021 the good folk at Climeworks posted a four page flyer clarifying DACS and CCS. A [link](#) is included for those interested in a high-level description.

Carbon credits and markets Hydrogen Markets and Trading:

Hydrogen Trading: On December 7, 2021 it was reported widely that RWE and Novatek has signed a memorandum of understanding (**MOU**) to cooperate in the supply of low-carbon and carbon-free fuels. It is reported that the **MOU** contemplates the supply of low-carbon ammonia and hydrogen. Novatek is the largest independent producer of natural gas in Russia, and to produce low-carbon ammonia and hydrogen (Blue Ammonia and Blue Hydrogen), it will be necessary for it to develop carbon capture and carbon storage facilities.

E-fuels and Future Fuels (increasingly "Now Fuels"):

- **BP tees-up:** On November 29, 2021, BP announced that it plans to develop a large-scale Green Hydrogen production facility by 2025 (**HyGreen Teesside**). The **HyGreen Teesside** facility will be located on the east coast of England. BP is leading the Net Zero Teesside projects and the Northern Endurance Partnership (**NEP**) as part of the East Coast Cluster (see Editions [22](#) and [23](#) of Low Carbon Pulse).
- **Total Eren swoops to develop H₂ Magallanes:** On December 2, 2021, it was reported widely that Total Eren (a leading renewable energy corporation part owned by TotalEnergies) plans to develop a 10 GW on-shore wind project to supply renewable electrical energy to power Green Hydrogen and Green Ammonia production facilities in the Magallanes region of southern Chile (**H₂ Megallanes**): it is reported that **H₂ Megallanes** will comprise a desalination facility, 8 GW of electrolyser capacity, and ammonia production facilities. First production is expected by 2027, with the expectation that **H₂ Megallanes** will produce 800,000 metric tonnes of Green Hydrogen a year, and 4 million metric tonnes of Green Ammonia.
See: [Total Eren Secures Lands and Launches Studies Aiming to Develop a Large-scale Green Hydrogen Project in Chile's Magallanes Region](#)
- **FFI Canadian Projects:** On December 2, 2021, Fortescue Future Industries (subsidiary of Fortescue Metals Group, founded by Dr Andrew Forrest, OA) signed agreements with three Canadian Indigenous nations with a view to assessing the viability of the development of three Green Hydrogen projects. As reported in previous editions of Low Carbon Pulse, **FFI** has contracted in many countries for the development of Green Hydrogen production facilities, and continues to do so.
See: [Fortescue Future Industries and Indigenous leaders in Canada collaborate on green hydrogen projects](#)
- **Acciona to supply renewable energy to Stanwell CQ-H₂:** On December 2, 2021, Acciona Energia announced that it has signed a memorandum of understanding with Stanwell Corporation for the supply of renewable electrical energy from Acciona Energia's Aldoga photovoltaic solar facility via a direct connection (rather than grid connection) to the Stanwell led Central 3 GW Queensland Hydrogen Project (**CQ-H₂**) – see Edition [19](#) of Low Carbon Pulse (there badged the **Gladstone 3G** or **G3G** within the Gladstone State Development Area (**GSDA**)).
See: [ACCIONA Energía signs agreement to supply clean energy to a 3GW green hydrogen plant in Queensland](#)
- **Woodside Stateside:** On December 6, 2021, Woodside Energy Limited announced that it was developing a hydrogen production project at Westport Industrial Park, Ardmore County, Oklahoma (**H₂OK**), a major node on the US road freight network. **H₂OK** will deploy an initial 290 MW electrolyser capable of producing 90 metric tonnes of hydrogen a day. The hydrogen will be liquified and will be used by the heavy mobility / transport sector. Woodside announced that it had signed an MOU with Hyzon Motors for the off-take.
As Woodside notes, **H₂OK** joins **H₂ Perth** and **H₂TAS** as its third significant hydrogen project.
See: [Woodside Expands Hydrogen Portfolio to the United States](#)
- **Trafigura pulls out in traffic:** On December 9, 2021 it was reported widely that leading Swiss metals and oil trading trader, Trafigura Group, is planning to develop a USD 540 million Green Hydrogen production facility in Port Pirie, South Australia.
- **Desert Bloom pulls H₂O out of air:** On December 13, 2021 it was reported widely (and enthusiastically) that the Desert Bloom Green Hydrogen production facility project in the Northern Territory, Australia, had been given Major Project Status.

In any Australia State or Territory in Australia, Major Project Status allows for coordination of approvals and permitting, and in so doing increases the rate at which a project is able to progress to development and deployment. Project proponent, Aqua Aerem (water air in Latin), has indicated that Major Project Status will allow a 8 MW pilot to commence in 2022, ahead of the planned 10 GW, AUS 10.75 billion, staged development.

On completion the Desert Bloom Green Hydrogen production facility will produce 410,000 metric tonnes of Green Hydrogen a year at a projected cost of less than USD 2/kg.

Desert Bloom is a game changer because it uses "air-to-water" technology: some areas of the world with world class solar resources are areas that are also subject to water stress, and as such require the use of desalinated sea-water or processed and treated waste water to provide the H₂O feedstock for the production of Green Hydrogen using electrolyzers, adding cost, both capital and operating. The "air-to-water" or "water-from-air" technology will allow arid environments to be developed for Green Hydrogen production.

Aqua Aerem is majority owned by Sanguine Impact Investment.

- **South Africa continues to buzz:** On December 15, 2021, it was announced that an ammonia production plant is to be developed on Nelson Mandela Bay. The USD 4.6 billion ammonia production project is to be developed by Hive Hydrogen and Linde Africa (Linde being one of the three industrial gas giants globally, with Air Liquide and Air Products), and it is understood on completion, will produce up to 780,000 metric tonnes of ammonia a year.

See: [World's Largest Green Ammonia Plant for Nelson Mandela Bay, South Africa](#); Linde [website](#)

- **Macquarie and Nobian – giants combine:** On December 15, 2021, it was reported widely that Macquarie Group's Green Investment Group, and Nobian have formed the Hydrogen Chemistry Company (**H2CC**) to focus on supply to the difficult to decarbonise industries, including the chemical and petrochemical and iron and steel industries, and to the aviation sector.

It is understood that the **H2CC** is to develop and to deploy up to 400 MW of electrolyser production capacity to produce Green Hydrogen, including a 250 MW electrolyser to be located in Rotterdam, the Netherlands, a 100 MW electrolyser proximate to Amsterdam, and a 60 MW electrolyser dedicated to the production of Green Hydrogen to be used as feedstock to produce methanol and aviation fuel.

See: [Nobian and GIG join forces to launch leading green hydrogen company HyCC](#); Nobian [press release](#)

Green Metals / Minerals, Mining and Difficult to Decarbonise Industries:

- **Possible pivot:** On December 1, 2021, the ever excellent BloombergNEF published an article on the prospects for, and costs of, decarbonising the iron and steel production industry globally by 2050, together with an accompanying report. Both the [article](#) and the [report](#) are well-worth a read.
- **Iberdrola and H2 Green Steel combine:** On December 2, 2021, Iberdrola (leading international energy company) and H2 Green Steel (**H2GS**, and see Editions [11](#), [12](#), [13](#), and [20](#) of Low Carbon Pulse) announced plans to develop a Green Hydrogen production facility on the Iberian Peninsula to provide Green Hydrogen for use in the production of Green Steel (which with the use of Green Hydrogen gives rise to 95% less **CO₂** emissions).

The planned Green Hydrogen production facility would be the world's largest with electrolysis capacity of 1 GW. To provide sufficient renewable electrical energy to power the electrolyser, Iberdrola plans to invest around €800 million, with the total cost estimated at around €2.3 billion. It is understood that the intention is for production of first Green Steel in 2025 to 2026.

See: [Iberdrola and H2 Green Steel sign 2.3 billion euros green hydrogen deal](#); [H2 Green Steel and Iberdrola announce €2.3 billion Green hydrogen venture](#)

- **BSL and Shell combine:** Edition [25](#) of Low Carbon Pulse reported that Bluescope Steel Limited (**BSL**) announced that it is committed to **NZE** for its Scope 1 and Scope 2 emissions. **BSL** indicated that it would achieve its **NZE** commitment using renewable electrical energy, and Green Hydrogen, rather natural gas (**CH₄**), whether alone or blended with hydrogen.

On December 6, 2021, **BSL** announced that it had signed an MoU with Shell to develop and to deploy a renewable hydrogen pilot project at **BSL's** Port Kembla Steelworks, and to explore, with other organisations, the development of an Illawarra Hydrogen Hub (aligned with the recent policy settings of the New South Wales Government).

See: [BlueScope and Shell join forces to develop renewable hydrogen projects in the Illawarra](#)

- **Firm commitments:** On December 8, 2021, [De Tijd newspaper](#) reported on the signing of a Declaration of Intent by ArcelorMittal and the Federal Government of Belgium and the Government of Flanders in respect of the investment of €1 billion to produce Green Steel (**Ghent Declaration of Intent** or **GDOI**).

The **GDOI** provides that the two blast furnaces at ArcelorMittal's Ghent steel works will be replaced by direct reduced iron (**DRI**) facilities which will provide **DRI** / sponge to the electric arc furnaces. (Low Carbon Pulse has reported previously on the investment of €700 for the purposes of Joint Venture Finocas.)

Hydrogen – Cities, Clusters, and Hubs and Corridors and Valleys, and Giga-Factories:

- **Geelong Hydrogen Hub:** On November 30, 2021, it was reported widely that Geelong Port, Victoria, Australia, is to develop the Geelong Hydrogen Hub (**GHH**). The **GHH** is to involve the development and deployment of a biomass gasification project from which biogas will be produced from biomass, and that biomass will be used to derive clean hydrogen (see [Hydrogen For Industry \(H24I\) Feature 1: Hydrogen from Waste](#)), using technology developed by CAC-H2.

See: [GeelongPort establishes the Geelong Hydrogen Hub](#)

- **Blending State-wide:** On December 6, 2021 it was reported widely that APA Group (leading Australia natural gas transmission and distribution pipeline owner and operator) is developing the first blue-print for state-wide hydrogen blending in the State of Victoria across the Victorian Transmission System. Rightly, APA CEO and Managing Director, Mr Rob Wheals said: "This landmark study proposes to assess the Victorian gas transmission network to transport safely hydrogen blends, which could put Victoria in the box seat to achieve the least cost, fastest, and most efficient transition to a low-carbon future".

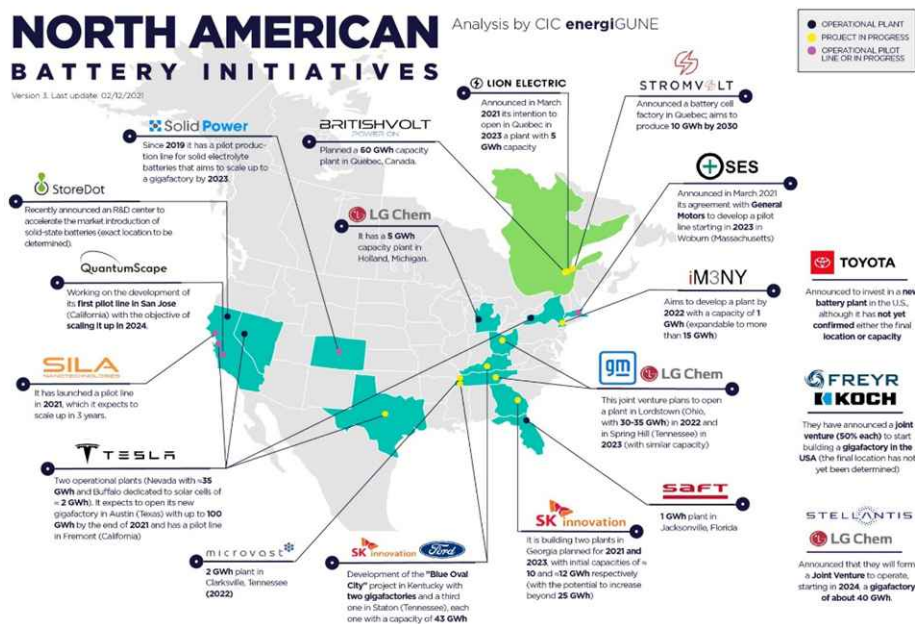
See: [Developing Australia's first blueprint for state-wide hydrogen blending](#)

- **AGL Energy and FFI to develop the Hunter Energy Hub:** On December 8, 2021, AGL Energy and **FFI** announced plans to develop an energy hub at the sites occupied by the AGL Energy Liddell coal-fired power station (that is to close in 2023) and Bayswater coal-fired power station. The detail of the plans will become clearer over time, but this is an exciting development for AGL Energy and for **FFI**, and for the Hunter region of New South Wales, Australia.
- **The new UK Hydrogen Hubs – Southampton and Inverness:** On December 8, 2021, it was announced that ExxonMobil, Macquarie Groups Green Investment Group (**GIG**) and SGN are contemplating the development of Southampton Hydrogen Hub, to decarbonise industrial activities being undertaken in the region.

In the days since the announcement, news items have covered the proposed development in more detail with [rigzone](#) reporting that the three corporations have signed a memorandum of understanding under which they will explore the use of hydrogen and carbon capture to reduce **GHG** emissions in the industrial cluster around Southampton. An initial feasibility study undertaken by **GIG** and SGN is reported to have indicated the hydrogen demand may be up to 37 TWh in electrical energy equivalent terms.

On December 14, 2021, it was reported that H2 Green (a Getech business) and SGN had agreed to progress with plans for the development of Green Hydrogen production facilities; SGN to use its former gas-holder site.

- **Battery of factories:** The map below details the development of battery factories across the US:



Wind round-up, on-shore and off-shore:

- **MunmuBaram licensed:** On November 29, 2021, it was reported widely that the joint venture, **MunmuBaram** (80% Shell Overseas Investment B.V. and 20% CoensHexicon Co. Ltd – see Edition 26 of Low Carbon Pulse) had been granted an Electricity Business Licence (**EBL**) for the floating off-shore wind field project off the coast of Ulsan, **ROK**.

The **EBL** allows **MunmuBaram** to progress with the first stage (420 MW), of the three stage (1.3 GW), project (generating up to 4.2 TWh a year).

See: [Munmubaram Secures Electricity Business License for Floating Offshore Wind Project in South Korea](#)

By way of reminder: Edition 26 of Low Carbon Pulse reported that, "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."

- **RWE and Ulsan City aligned:** On November 29, 2021, it was reported that Ulsan Metropolitan City (major manufacturing city in the **ROK**) and RWE (leading international energy corporation) had signed a memorandum of understanding under which Ulsan City and RWE are to cooperate to develop up to 1.5 GW of floating off-shore wind field renewable electrical energy.

See: [South Korea: RWE and Ulsan City cooperate in floating offshore wind](#)

- **High Wind in Turkey:** On November 29, 2021, [Daily Sabah](#), reported that for the first time the largest source of dispatched electrical energy across the grid in Turkey (operated by the Turkish Electricity Transmission Corporation (**TEIAS**)) was dispatched from wind farms, with 22.6% of load matched by electrical energy from wind farms. This was a record.
- **New Zealand looking off-shore:** On December 1, 2021, the [taranaki daily news](#), reported that BlueFloat Energy (a leading off-shore wind field corporation), Energy Estate (established renewable energy project developer) and Elemental Group (a pioneer in the New Zealand off-shore wind field sector).
- **"Luck of the Thor":** Edition 30 of Low Carbon Pulse reported that on December 1, 2021, the successful tenderer would be determined by the drawing of lots, with the successful tenderer to develop the 1 GW Thor off-shore wind field.

On December 1, 2021, the Danish Ministry of Climate, Energy and Utilities and the Danish Energy Agency announced that Thor Wind Farm I/S (owned by RWE AG, RWE Renewables GmbH, and RWE Renewables Management UK Limited) was the successful tenderer.

See: [Success in offshore auction: RWE secures concession for 1,000-megawatt wind farm off the Danish coast](#)

On December 8, 2021, [S&P Global Platts](#) provided a perspective of the competitive nature of some off-shore wind field projects. The by-line is: "It's no longer enough to bid zero for offshore wind concessions – now you have to pay for the privilege of securing valuable sea acreage".

While the concept of no subsidiary is not new, the competitive nature of off-shore and on-shore renewable energy projects in some parts of the world is becoming challenging for some participants.

- **Ørsted takes FIDs:** On December 1, 2021, Ørsted announced that it had taken final investment decisions (**FIDs**) on two German off-shore wind field developments – Gode Wind 3 (242 MW) and Borkum Riffgrund 3 (900 MW), which together will comprise 1.142 GW of installed capacity. The **FID** decisions are supported by the power purchase agreements that Ørsted has concluded with Amazon, BASF, Covestro, Google and REWE Group.

See: [Ørsted takes final investment decision on two German offshore wind farms](#)

- **Dogger Bank C Banked:** Editions 4 and 5 of Low Carbon Pulse reported on FID for Dogger Bank C and financial close of Dogger Bank A and B. Construction of Dogger Bank A and B is underway.

On December 2, 2021, financial close of Dogger Bank C was reported widely. Total investment in Dogger Bank A, B and C is projected to be around GBP 9 billion.

See: [Equinor](#) website; [eni](#) website; [SSE](#) website

- **RWE cements further relationship with Asia Cement Corporation:** On December 6, 2021, RWE announced that it had reinforced its strategic partnership with Asian Cement Corporation (ACC) to develop fixed bottom and floating off-shore wind field projects off Taiwan, in waters off Hsinchu, Taichung and Changhua.

See: [Taiwan: RWE reinforces strategic partnership with ACC](#)

- **Dutch off-shore wind progress:** During the second week of December 2021 it was reported that the Dutch Government intends to expand its off-shore wind capacity, possibly through the development of a further 10.7 GW by 2030, from 11.5 GW to 22.2 GW, with newly designated zones in 1, 2 and 5-East (to accommodate an additional 8 GW), the Ijmuiden Ver North (2 GW) and Hollandse Kust (700 MW). The development of this further capacity would align with the **EU's** commitment to reduce **GHG** emissions by 55% by 2030.
- **Denmark off-shore wind progress:** No sooner had the hammer fallen on the Thor drawing of lots(!), than the Government of Denmark committed to procure a further 3 GW of off-shore wind field capacity to be installed before 2030. Currently Denmark is committed to adding 7.2 GW of off-shore wind field capacity by 2030.

CURRENT PLANNED DEVELOPMENT OF OFF-SHORE WIND

North Sea Energy Island – 3 GW	Baltic Sea Energy Island – 2 GW	Hesselo (Baltic Sea) – up to 1.2 GW	North Sea Thor – 1 GW
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A number of players have asked that the process for the additional 3 GW does not include the drawing of lots next time around.

- **Alinta Energy power to Portland:** On December 7, 2021, it was reported widely that Alinta Energy has proposed the development of a 1 GW off-shore wind field, off the coast of Victoria, Australia, to provide 100% renewable electrical energy to the Alcoa alumina smelter at Portland, Victoria (the **Spinifex Off-shore Wind Project**).

See: Alinta [Website](#)

- **Vattenfall Vesterhav FID:** On December 14, 2021, it was reported widely that Vattenfall (leading European energy corporation) had taken a final investment decision in respect of its Vesterhav €769 million North and South off-shore wind field complex off the coast of Denmark.

See: [Vattenfall has taken the final investment decision for Vesterhav Syd and Vesterhav Nord adding 344 MW of fossil free electricity capacity to the Danish energy system towards 2023](#)

Solar and Sustainable:

- **World -scale dedicated Photovoltaic Solar Project:** On November 30, 2021, it was reported widely that Sinopec (one of the big three **PRC** oil and gas corporations) is to develop and to deploy a world scale photovoltaic solar project dedicated to the production of Green Hydrogen.

Located in Kuqa City, in the north western region of Xinjiang, the 300 MW photovoltaic solar facility will supply renewable electrical energy to allow the production of up to 20,000 tonnes of Green Hydrogen a year. It is reported that the Green Hydrogen production facility will have a 210,000 m³ hydrogen storage tank, and will have a hydrogen pipeline with capacity of hauling 28,000 m³ of hydrogen an hour.

See: Sinopec [website](#)

- **Greentailing in Australia:** On December 6, 2021 it was reported widely that global leading renewable energy corporation, Enel Group has been granted an energy retail licence and intends to offer a "green-tailer" product within the Australian market, combining the supply of renewable electrical energy, virtual power plants and EV charging facilities to customers.

See: [Enel launches 'greentailer' business in Australia backed by Enel Green Power and Enel X](#)

- **Solar Power – the Fastest Growing Energy Source:** So declares a [slide deck](#) from Statkraft. While the article does not tell us anything that we do not know, the covering piece on LinkedIn does grab the attention: "Every year, the Earth received 15,000 times more energy than the entire global population consumes". While it is possible only to recover a relatively small proportion of that energy, there is sufficient energy that is capable of capture to generate sufficient renewable electrical energy from the sun.

NZE Waste:

Edition 31 of Low Carbon Pulse introduced a section titled **NZE Waste**. To manage the length of this Edition 32 of Low Carbon Pulse, Edition 33 of Low Carbon Pulse will include news on **NZE Waste** from Monday November 29, 2021, to Sunday January 16, 2022.

In addition, Edition 33 of Low Carbon Pulse will include the long-promised section on Giga-Factories.

Land Mobility / Transport:

• Cars:

- **Nissan charging on:** On November 29, 2021, it was reported widely that Nissan Motors (leading vehicle manufacturer) is to invest GBP 13 billion over the next five years, with a view to having developed 23 "electric vehicle" models by 2030, with 15 of those vehicle models being electric, and 8 of those vehicles being hybrid. This investment is consistent with the plans of Nissan to sell electric vehicles 75% in Europe, 55% in Japan, and 40% in PRC by 2026, and 40% in the US by 2030.

See: Nissan Motors [website](#)

- **Toyota taking the hy road:** On December 2, 2021, it was reported widely that Toyota Motor Corporation had adapted the internal combustion engine (**ICE**) of a Yaris to combust hydrogen rather than motor spirit. The adapted **ICE** is reported to give rise to "almost zero emissions", "while retaining the acoustic and sensory sensations of" an **ICE**. This adaption is for use in motorsport, at least for the time being.

See: [Toyota showcases experimental hydrogen-powered GR Yaris](#)

• Industry and Trucks:

- **Hyzon to Foshan:** On December 2, 2021, Hyzon Motors Inc (leading supplier of zero-emission fuel cell vehicles) announced that it had delivered eight dump trucks to the Foshan Dump Truck Association, with the intention being to lease the trucks to the Association on completion of successful trials of them.

Foshan Municipality is located in Guangdong Province is a designated "Hydrogen Energy Demonstration City" for the purposes of the United Nations Development Program.

See: [Hyzon Motors delivers eight dump trucks to trial customers in Foshan Municipality](#)

- **Hyzon to Shanghai:** On December 8, 2021, Hyzon Motors Inc announced that it had delivered 29 fuel cell technology trucks to the PRC, through Shanghai Hydrogen HongYun Automotive Co.

See: [Hyzon Motors delivers 29 hydrogen fuel cell electric heavy duty trucks to reduce carbon emissions in the steel industry](#)

- **Hyzon to Taiwan:** On December 13, 2021, it was reported widely that Hyzon Motors Inc and MiTac-Synnex Group (a leading industrial conglomerate) had signed a memorandum of understanding (**MOU**) to develop jointly hydrogen-powered commercial vehicles for the Taiwan market.

- **Giga Carbon Neutrality (GCN) mega order:** On December 13, 2021, clean commercial transportation and technology corporation, Giga Carbon Neutrality (**GCN**) announced that it is to supply 200 hydrogen and electrical vehicles to the **PRC**, together with associated engineering equipment and machinery.

The order for the supply is from the Peoples' Government of Ejina Banner, and administrative division of Ordos City, in the Inner Mongolia Autonomous Region in the **PRC**.

Regular readers of Low Carbon Pulse will recall Ordos City. Editions [18](#) and [19](#) of Low Carbon Pulse reported on the development of hydrogen production facilities in the cities of Baotou and Ordos City, Inner Mongolia. On August 18, 2021, it was reported that the development of renewable electrical energy projects (1.85 GW of solar photovoltaic and 370 MW of wind) will provide the electrical energy to allow the production of up to 66,900 **tpa** of Green Hydrogen. With construction to commence in October 2021, it is expected that first Green Hydrogen will be produced in 2023 (see Edition [25](#) of Low Carbon Pulse).

- **Switzerland setting a pace:** Switzerland was a first mover in the import and use of hydrogen fuel cell technology trucks (**FCT**) (see Editions [1](#), [18](#), [22](#) and [23](#) of Low Carbon Pulse). By the end of 2021, around 50 **FCTs** will be in use, with nine hydrogen refuelling stations. By the end of 2022 around 20 hydrogen refuelling stations will be deployed. By the end of 2025 it is anticipated that 1,500 **FCTs** will be in use.

• Trains:

- **Giants combine:** On November 29, 2021, it was reported widely that Alstom (global leader in sustainable mobility technology) and Liebherr Aerospace & Transportation SAS (see Edition [20](#) of Low Carbon Pulse) had signed a collaboration agreement to optimise fuel cell technology, in particular to optimise hydrogen fuel cell systems, including to improve durability and reliability of fuel cells and increasing energy density.

See: [Alstom and Liebherr sign a collaboration agreement, in order to optimise hydrogen fuel cells](#)

- **Alstom and MOL on track to explore:** On December 3, 2021, it was reported widely that Alstom and MOL (the leading oil and gas company in Hungary) had signed a memorandum of understanding (**MOU**) to explore the use of hydrogen technology in rail transportation.

The **MOU** may be regarded as part of the decarbonisation of the rail transport network in Hungary, certainly to displace trains powered and propelled using diesel.

See: [Alstom and MOL sign agreement to explore use of hydrogen technologies for rail transport in Hungary](#)

- **CZ Loko:** Czech locomotive manufacturer, CZ Loko, is developing a fuel cell technology locomotive.

- **More giants combine:** On December 14, 2021, it was reported widely that BNSF Railway, Caterpillar and Chevron had signed a memorandum of understanding to develop a demonstration locomotive powered and propelled by fuel cell technology.

For each corporation, the demonstration locomotive project provides an outcome aligned with its broader progress in decarbonising activities, and the role that each corporation sees for itself in energy transition.

Ports Progress and Shipping Forecast:

- **First methanol-fuelled towboat:** On November 29, 2021, [Marine Log](#), reported that the M/V Hydrogen One (being developed by ABB, the Elliot Bay Design Group and e1 Marine), will be available for charter from 2023 to meet the increasing "demand for sustainable towboat operations". The M/V Hydrogen One will be IMO 2030 compliant and have an operational range of 500 miles between refuelling.
- **Switch presses on:** Editions [19](#) and [26](#) of Low Carbon Pulse have reported on the development and prospective deployment, and testing, of the hydrogen powered and propelled ferry in San Francisco Bay Area - the Sea Change. On November 30, 2021, it was reported by Switch Maritime that in commissioning and trials of the ferry, that refuelling had been undertaken successfully. Also it was reported that BAE Systems was the supplier of the propulsion system for the Sea Change. The fuel cell technology for Sea Change is supplied by Zero Emission Industries, and the BAE propulsion system will interface with the fuel cell technology, providing an all-electric powered and propelled vessel.
See: BAE Systems [website](#); Zero Emission Industries [website](#)
- **Puerto San Antonio to use Green Hydrogen:** On December 1, 2021, it was reported that Puerto San Antonio, Chile, is to work with [Solek Group](#) (a leading renewable energy corporation) to develop Green Hydrogen production facilities at the port. It is expected that renewable energy facilities will be developed and deployed to provide electrical energy for the port, and for the Green Hydrogen production facilities, with the Green Hydrogen being used to power vehicles used at the port.
See: Puerto San Antonio [website](#); Solek [website](#)
- **Fuel Cell and Ammonia Cracker approved:** On December 1, 2021, it was reported that DNV had provided Approval in Principle (**AiP**) for the ZeroCoaster ammonia fuelled cargo ship designed by AFC Energy. The technology approved is an alkaline fuel cell with ammonia cracker and fuel storage. The design approved will allow the use of green ammonia in the shipping industry.
See: DNV [website](#); AFC Energy [website](#)
- **Fuel cell powered drivetrain passes test:** On December 2, 2021, it was reported that Kongsberg Gruppen (Norwegian engineering corporation) had achieved a world first in testing a hydrogen fuelled fuel cell powered drivetrain propulsion system as part of its HySeas program developing hydrogen propulsion systems for vessels.
- **Kawasaki Heavy to transport light:** On December 3, 2021 it was reported widely that the MV "Suiso Frontier" (see Editions [2](#), [8](#), [10](#) and [17](#) of Low Carbon Pulse) built by Kawasaki Heavy Industries Limited (**KHI**), and owned by HySTRA is likely to travel to Australia during December 2021 to take load, to transport and deliver to Kobe, the first cargo of liquid hydrogen (**LH2**) as the Hydrogen Energy Supply Chain project progresses (see Editions [10](#) and [12](#) of Low Carbon Pulse). The development and scale-up of **LH2** carriers will be key to the development of the hydrogen export industry.

Managing Director of Capra Energy Group, Mr Tamir Druz, posted photographs of the Methane Pioneer (the first LNG carrier) and the Suiso Frontier (the first LH2 carrier). The photographs are included, as are the vital statistics for those involved in the sale and purchase of LNG and **LH2**, MMBtu of the cargo.

Methane Pioneer in 1959
1st Commercial LNG Carrier



Suiso Frontier in 2021
1st Commercial Liquefied H₂ Carrier



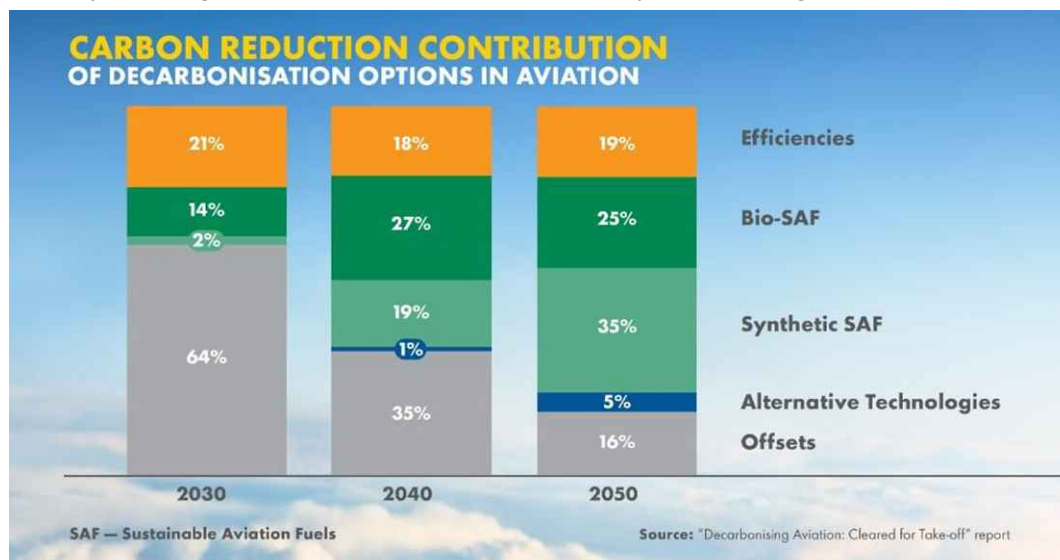
Carrying Capacity (cubic meters)	5,000 m ³ LNG	1,250 m ³ liquid H ₂
Cargo Size (mmbtus)	116,900 mmbtus	11,900 mmbtus

Edition 17 of Low Carbon Pulse noted that **KHI** is developing **LH2** carriers with a 40,000 m³ containment system, i.e., tank, with the intention of **KHI** to develop **LH2** carriers with four such tanks, i.e., 160,000 m³ of capacity (by volume).

- **Panama Canal announces GHG emission fee:** On December 3, 2021, [splash.247.com](#) reported that the Panama Canal Administrator had announced plans for a green vessel classification system that will include a **GHG** emissions fee. The **GHG** emissions fee will be applied to make the operations of the Panama Canal carbon-neutral.
As reported, the green vessel classification system will classify all vessels with an overall length exceeding 38.1 metres by reference to their energy efficiency, applying three factors: **1.** The vessel's Energy Efficient Design Index score; **2.** The vessel's use of efficient operational measures; and **3.** The vessel's use of biofuels or carbon neutral fuels.
- **Port Authority of Valencia paves the way:** On December 6, 2021, [fuelcellworks](#) reported that the Head of Strategic Planning and Innovation at the Port of Valencia (**PAV**), Mr Juan Manuel Diez, announced that the **PAV** would be the first port in Europe to incorporate hydrogen technologies to reduce the environmental impact of terminal machinery operations.

Airports and Aviation:

- History made:** On December 1, 2021, United Airlines made history by completing the first passenger flight using sustainable (or synthetic) aviation fuel (**SAF**). While Federal Aviation Authority regulations in the US allow use of a blend of 50% of **SAF** and 50% fossil fuel, approval and clearance for take-off were required to use 100% **SAF**.
See: United Airlines CEO Scott Kirby's LinkedIn [Post](#)
 Research by the US Department of Energy (**DOE**) Bioenergy Technologies Office helped to develop the 100% **SAF** (derived and produced from biofuel). While a quiet achiever, the US biofuel industry continues to lead the world.
 As ever with many if not most news items relating to progress towards decarbonisation and **NZE**, one does not have to look too far for the involvement of Government, research and funding support for the most part, to understand the critical role that Government has to play.
- American Airlines and Aemetis aligned:** On December 1, 2021, it was reported widely that American Airlines and Aemetis had agreed a **SAF** supply agreement, with Aemetis to produce **SAF** at its Riverbank **SAF** production facility.
- British Airways and Phillips 66 aligned:** On December 3, 2021, it was reported widely that British Airways and Phillips 66 had agreed a **SAF** supply agreement, with Phillips 66 to produce **SAF** at its Humber Refinery.
See: [British Airways and Phillips 66 Agree First Ever UK Produced Sustainable Aviation Fuel Supply](#); [British Airways, Phillips 66 Limited sign sustainable aviation fuel supply agreement](#)
- Aerospace Technology Institute UK flying hy:** On December 6, 2021, it was reported widely that the UK's Aerospace Technology Institute is to undertake a project (the **FlyZero Project**) that will allow the use of hydrogen to power and to propel an aeroplane to any global location with one stop.
 The aeroplane is a concept aircraft of 279 passengers (with a range of 5,250 nautical miles), that will use a range of advanced technologies, including storage of liquid hydrogen in the fuselage, rather than in the wings (i.e., a dry winged aircraft), cryogenic hydrogen tanks and fuel systems and fuels cells to provide electrical energy to power the power systems (as opposed to the propulsion systems), and hydrogen gas turbines.
 Consistent with the theme of Government involvement, the **FlyZero Project** is backed by the UK Government.
- Shell Aviation ... continued narrative:** Edition [30](#) of Low Carbon Pulse contained the September and October Report on Reports in the Appendix, which reported on **Decarbonising Aviation: Cleared for Take-off – Industry Perspectives** from Royal Dutch Shell.
 On December 7, 2021, Shell Aviation posted a short, but interesting piece on the carbon reduction options for the aviation industry, including the role of carbon credits, and their importance through 2030.



- Air New Zealand perspective:** On December 8, 2021, the CEO of Air New Zealand, Mr Greg Foran, provided a perspective that is a helpful contrast with that provided by Shell Aviation, effectively that decarbonisation of the carbon footprint is the aim of Air New Zealand, rather than the use of carbon credits as a means to offset **GHG** emissions.
- Airbus article of assurance:** As noted in previous editions of Low Carbon Pulse, Airbus aims to develop the first zero-emission commercial aircraft by 2035. On December 10, 2021, Airbus published an article [How to store liquid hydrogen for zero-emission flight](#). The article is well-worth a read.
 The article outlines the challenges of use of hydrogen as an energy carrier: " ... storing hydrogen on board an aircraft poses several challenges. Hydrogen may provide more energy by mass than kerosene fuel, but it delivers less energy by volume." It is all a matter of energy density.
 The liquefaction of hydrogen (at a temperature of minus **253°C**) increases the energy density by volume: in liquified form 4 litres of hydrogen is equivalent to 1 litre of kerosene (in liquid form at normal temperature and pressure). The development of cryogenic storage tanks is fundamental to the development of an aircraft that is able to use hydrogen to power and to propel that aircraft.

NZE reports:

At the end of each Low Carbon Pulse, publications reviewed are listed, by organisation, title / subject matter, and link.

ORGANISATION	TITLE / SUBJECT MATTER
Alianza Energética Energiepartnerschaft – México – Deutschland and Cooperación Alemana – Deutsche Zusammenarbeit	<i>Green Hydrogen in Mexico: towards a decarbonization of the economy</i> (Volumes I , II , III and IV)
BloombergNEF	<i>New Energy Outlook 2021</i>
Department of Industry, Science, Energy and Resources (DISER)	<i>State of Hydrogen 2021</i>
IEA	<i>Renewable Market Report</i>
IEA	<i>Renewable Energy Market Update 2021</i>
IEA	<i>France 2021 – Analysis</i>
National Intelligence Council	<i>Climate Change and International Responses Increasing Challenges to US National Security Through 2040</i>
The National Academies of Sciences Engineering Medicine	<i>A Research Strategy for Ocean-Based Carbon Dioxide Removal and Sequestration</i>
Science	<i>Strong Southern Ocean carbon uptake evident in airborne observations</i>

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