PROGRESS TOWARDS NET-ZERO EMISSIONS
PUBLISHED ON JUNE 3, 2022

Low Carbon Pulse - Edition 40

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS

Welcome to the **Long Form Version** of **Edition 40** of Low Carbon Pulse – sharing significant news on progress towards net-zero greenhouse gas (***GHG***) emissions (***NZE***) for the period from **Sunday May 1, 2022** to **Tuesday May 31, 2022**. The **Short Form Version** of **Edition 40** will be published on **Monday June 6, 2022**.

Click here for the ***First Compendium of Low Carbon Pulse*** (containing **Editions 1** to **28**, covering October 6, 2020 to October 5, 2021), here for the ***Second Compendium of Low Carbon Pulse*** (containing **Editions 29** to **38**, covering October 7, 2021 to March 31, 2022), and click here for the ***Third Compendium of Low Carbon Pulse***.

Headlines:

Burning Platform:

The month of May has been a month of mixed news:

- On **May, 5 2022**, it was reported widely that in **April 2022**, the US **National Oceanic & Atmospheric Administration** (***NOAA***) observatory at **Mauna Loa, Hawaii** recorded the highest level of ***CO_2*** in the atmosphere – **420 ppm**. (For more on this news item see ***CO_2*** **at highest levels** under **Climate Change Reported and Explained**.)
- On **May 9, 2022**, the **World Metrological Organisation** (***WMO***) released a press-release reporting on the ***Global Annual to Decadal Climate Update / State of the Global Climate 2021***.

  The headline from the press-release is as follows:

  > *"There is a 50:50 [actually expressed as: "about as likely as not (48%)"] chance of the annual average global temperature temporarily reaching **1.5°C** above the pre-industrial level for at least one of the next five years – and the likelihood is increasing with time".*

The source of the headline is the ***Global Annual to Decadal Climate Update***, produced by the **Met Office** in the UK (the **Met Office** being the ***WMO*****'s** lead advisory organisation for predictions of this kind).

As reported in previous editions of Low Carbon Pulse (and sibling publications), in 2021 the global average temperature was **1.1°C** above the pre-industrial level. (For other key findings, see **Key Findings from *Global Annual to Decadal Climate Update* / *State of the Global Climate 2021*** below under **Climate Change Reported and Explained**.)

Vale those lost:

Our continued condolences for those lost in the conflict in Ukraine, and safe-haven to those displaced.

Ministers meet:

On **May 12**, and **13**, **2022**, a meeting of Ministers from more than 40 countries (convened by the Presidencies of **COP-26** and **COP-27**) took place in **Copenhagen**, **Denmark** (***May Ministerial***).

The ***May Ministerial*** marked six months since ***COP-26*** and six months until ***COP-27***, and was co-chaired by the President of ***COP-26*** **Mr Alok Sharma**, and the incoming President of ***COP-27***, **Mr Sameh Shoukry**. The communique from the ***May Ministerial*** is worth a read.

For the author of Low Carbon Pulse, the quote of the month came from **UN Climate Change Executive Secretary**, **Ms Patricia Espinosa**:

> "**COP27 must be the implementation COP**. The first COP where nations must show how they will begin putting the Paris Agreement to work in their home countries".

This quote is consistent with the increasing sentiment that the ***EU*** and the UK cannot do all the heavy-lifting.

Biodiversity Day 2022:

Sunday May 22, **2022**, was **Biodiversity Day 2022**. There were was considerable coverage before, on and after Biodiversity Day 2022 about all aspects of the environment, including the need to cease activities giving rise to degradation, and to undertake activities that will remedy degradation that has occurred. The **Blue and Green Carbon and Biodiversity** section of this **Edition 40** of Low Carbon Pulse provides some of the high-lights.

The Month in the rear view mirror:

- **May 2** to **6**, **2022**: The ***XV World Forestry Congress*** (***Congress***) was held in Seoul, Republic of Korea (***ROK***) under the theme of ***Building a Green Healthy and Resilient Future with Forests***.

  For the author of Low Carbon Pulse, the progress made at the ***Congress*** is key, both for forestry and land use. During the first four months of 2022, there has been a clear uptick in interest in the role that land-management and optimal land-use can have on increased absorption of CO_2, **i.e.**, its negative ***GHG*** emission impact.

  Outcomes from the ***Congress***:

  - Participants at the Congress endorsed the ***Seoul Forest Declaration***, identifying areas for action as a priority;
  - Ministerial Call on Sustainable Wood; and
  - Youth Call for Action.
- **May 9** to **20**, **2022**: The ***15th United Nations Conference to Combat Desertification*** (***UNCCD***) was held in Abidjanm, Côte d'Ivoire. ***COP-15*** of ***UNCCD*** was accompanied by the second edition of the ***Global Land Outlook – Land Restoration for Recovery and Resilience*** published by the **UNCCD**.

  Outcomes from ***COP-15 UNCCD***:

  - Concluded with a global pledge to boost drought resilience and to invest in land restoration for future prosperity, with agreement to establish an **Intergovernmental Working Group for 2022-2024** to consider solutions; and
  - Included the adoption of 38 decisions including on migration and tenure, highlighting the role of land in addressing the degradation that has occurred (with up to 40% of land mass degraded), including as a result of climate change.

The theme that emerged from ***XV World Forestry Congress*** and ***COP-15*** of ***UNCCD*** was how to address deforestation, reforestation, afforestation, and land restoration, and land-management and land-use generally. These matters are covered under **Carbon Accounting, Carbon Capture, Carbon Capture and Use and CDR**.

30th anniversary of UN Framework Convention on Climate Change:

May 9, **2022** was the **30th anniversary** of the adoption of the ***UN Framework Convention on Climate Change***. Considerable progress has been achieved since **May 9**, **1992**, critically the ***Paris Agreement*** and the ***Paris Rule Book*** that underpins the **Paris Agreement**.

To mark the 30th anniversary, **UN Climate Change Executive Secretary**, **Ms Patricia Espinosa** made a statement, and the following three pages convey, in short form, the essence of that statement.

The Month Ahead:

- On **June 2** and **3**, **2022**, the ***Stockholm+50*** conference will be held in Stockholm, Sweden. The ***Stockholm+50*** conference marks the **50th anniversary** of the **world's first conference** on the environment – **United Nations Conference on the Human Environment** held in Stockholm, Sweden, June 5 and 6, 1972, which gave rise to the establishment of the **United Nations Environment Programme** (***UNEP***).

  The agenda for the ***Stockholm+50*** conference is ***Immediate action for people, planet and prosperity will create a better future for all***. **Edition 41** of Low Carbon Pulse will report on **Stockholm+50**; and
- Also in June:
  - On **June 26** to **28**, the **G7 Summit** will be held at Schloss Elmau, Bavaria, Germany;
  - On **June 26** to **30**, the **World Urban Forum** will be held in Katowice, Poland; and
  - On **June 27** to **July 1**, the **UN Ocean Conference** will be held in Lisbon, Portugal.

  Edition 41 of Low Carbon Pulse will report on the Summit, Forum and Conference.

Balance of the content of this Edition 40:

Clicking on the contents list will take the reader to the section clicked:

Future Fuels article published:

As advertised in Low Carbon Pulse for some time, on **May 18**, **2022**, a standalone article on Future Fuels was published.

In September 2022, a standalone article will be published on ***NZE Waste: The recycling and reuse of waste arising on the road to NZE***. Along with plastic waste, these are areas of ever-increasing focus.

Legal, Policy Setting and Regulatory highlights, and Helpful Publications:

*This section considers news items that have arisen within the news cycle of this **Edition 40** of Low Carbon Pulse in respect of laws and regulation, and broader policy settings, in each case describing substance, progress and impact. Also this section details Helpful Publications that have been read during the month.*

- **REPowerEU detailed plans released**: As reported in **Edition** 37 of Low Carbon Pulse, on **March 8**, **2022**, the **European Commission** (***EC***) outlined its ***REPowerEU*** plan.

  On **May 18**, **2022**, the ***EC*** presented its detailed ***REPowerEU Plan***. The key points ***REPowerEU Plan*** are as follows:

  - First, the **Recovery and Resilience Facility** (***RRF***) will continue as the core of the ***REPowerEU Plan***, with the ***RRF Regulation*** to be amended to reflect the ***REPowerEU Plan***;
  - Secondly, **Energy savings** (**improved energy efficiency**) offers the cheapest and quickest means of mitigating the impacts on the energy market in the ***EU***, and to reflect this the ***EC*** will increase the **Energy Efficiency Target** under **Fit-for-55 package** from 9% to 11%. To accompany the ***REPowerEU Plan***, on **May 18**, **2022**, the ***EC*** published **EU Save Energy Communication**;

    By way of reminder: The **Fit-for-55** package was presented in mid-July 2021 (see **Edition** 32 of Low Carbon Pulse) to reduced ***GHG*** emissions by at least **55% by 2030**, compared to 1990 ***GHG*** emission levels;
  - Thirdly, **Diversifying energy imports** (**diversified supply**) is a key element to the policy settings in the ***EU***, with natural gas and LNG in the near to medium term (as a transition energy source) and hydrogen as the medium to long-term solution, as reflected in the **EU Energy Platform**. In line with editorial comment provided by Low Carbon Pulse (and sibling publications), the ***EC*** is contemplating that Member States of the ***EU*** may purchase natural gas and LNG and hydrogen jointly. In the context of the deployment of hydrogen, arrangements of this kind will accelerate the development and deployment of hydrogen capacity. The **EU External Energy Strategy** is consistent entirely with the concept of diversified supply, acceleration the commitment of the ***EU*** to the **global green and just energy transition**, critically, it addresses key actions necessary to support the reconstruction and repair of energy infrastructure in Ukraine, launching REPowerUkraine; and
  - Fourthly, **Substituting fossil fuels and accelerating clean energy transition** (**acceleration of renewable energy deployment**) is the core of progress towards ***NZE*** globally, and the ***EC*** policy settings, including the following:
    - to increase the deployment of renewable renewable from **40%** to **45%** by **2030**;
    - the **EU Solar Strategy** is to provide a pathway to **doubling photovoltaic capacity by 2025**, and to deploy **600 GW** of **photovoltaic capacity** by **2030**, with an obligation to install photovoltaic panels on new commercial, public and residential buildings under the **Solar Rooftop** initiative;
    - **Heat pump deployment** is to double, with policy settings to integrate geothermal and solar thermal energy across communal / district heating systems;
    - the **Renewable Energy Directive** is to be amended to allow the development and deployment of renewable projects at a quicker rate, and on a simplified basis;
    - targeting the production of **10 million** metric tonnes of **Renewable Hydrogen** within the ***EU*** and the import of **10 million** metric tonnes of Renewable Hydrogen into the ***EU*** **by 2030**.
    - the **Biomethane Action Plan** targeting the production of **35 billion cubic metres** of **biomethane by 2035**. The **Biomethane Action Plan** is covered in more detail below, under **Bioenergy and Heat Recovery**.

By way of a reminder: **Edition 39** of Low Carbon Pulse reported (under ***EC* considering higher renewable energy target**) that: "During **April 2022** there were a number of news items, and from the author's perspective, a number of conversations with folk in Europe, suggesting that the ***EC*** was assessing whether the ***EU*** may be able to achieve a higher renewable electrical energy target (45% by 2030), than that currently contemplated (40% by 2030).

On **April 20**, **2022**, Reuters reported that the **Deputy Director-General of the Energy Department** of the ***EC*** had stated: "*We are working on it full speed to take, first of the proposal of going from 40% to 45%, but also in the context of higher energy prices*".

While the ***EC*** may be considering the proposal at full speed, the ***EU Member States*** and the ***European Parliament*** will have to be aligned if the proposal is to become the new policy setting. There seems to be in alignment.

- ***EC* publishes technical regulations: Edition 39** of Low Carbon Pulse reported that on **May 18**, **2022**, the ***EC*** intends to publish technical regulations that will provide the parameters by which hydrogen will be classified as renewable under the ***EU RED II***.

  On **May 18**, **2022**, among other things, the ***EC*** published two **draft Delegated Acts** to clarify ***EU*** rules applicable to renewable hydrogen under the **2018 Renewable Energy Directive**. The **two Delegated Acts** are: the **Delegated Act** on the production of renewable transport fuels – share of renewable electricity (requirements) and the **Delegated Act** on renewable energy – method for assessing ***GHG*** emission savings from certain fuels. The **Delegated Acts** work together:

  A number of participants in the hydrogen industry (and the broader energy industry) have noted that the requirements for **additionality** and **coupling** may have unintended consequence of slowing the pace of development of Green Hydrogen production capacity. The form of the **two delegated acts** are open for consultation until **June 17**, **2022**, having commenced on **May 20**, **2022**. **Edition 41** of Low Carbon Pulse will consider each **Delegated Act**.

- **Green Hydrogen Organisation defines Green Hydrogen**: On **May 17 2022**, the **Green Hydrogen Organisation** or **GHO** (Swiss based not for profit organisation) published ***The Green Hydrogen Standard***: the **GHO** has defined Green Hydrogen as:

  > "*hydrogen produced through the electrolysis of water with 100% or near 100% renewable energy with close to zero greenhouse gas emissions (less than or equal to 1kg of CO_2-e per kg of H_2 taken as an average over a 12 month period*".

  The **Green Hydrogen Standard** imposes environmental, social and governance obligations on producers of Green Hydrogen, and Green Hydrogen produced must be assessed by **Independent Assurance Providers** to verify compliance. Each assessment and compliance report of **Independent Assurance Provider** will be submitted to the **Accreditation Body** of the **GHO** which will make the final determination as to compliance, and, if compliant, accredit as Green Hydrogen.

- **Clean Air Task Force framework for CCS in Europe**: On **May 10**, **2022**, the **Clean Air Task Force** or **CATF** (**an environmental organization**) published ***A European Strategy for Carbon Capture and Storage***, effectively providing a policy setting framework for carbon capture and storage across Europe.

  The policy setting framework proposed by the **CATF** provides a helpful perspective: central to the policy setting framework is the need for a coordinated policy framework that allows first-mover projects to develop to provide European wide CCS capacity. The report is well-worth a read.

- **Unlocking the hydrogen economy**: During **May** the **European Commission** (**EC**) and the **European Investment Bank** (**EIB**) published ***Unloading the hydrogen economy - stimulating investment across the hydrogen value chain***. The publication highlights the key takeaways from an investor consultation with 46 market participants conducted by the **EIB** Advisory Services Group at the request of the **EC**.

  There are six findings and seven recommendations. The publication is well-worth a read, framing as it does the dynamics across the continent with the most developed thinking and the most developed regulatory / statutory framework.

- **Kinsey & Co**: On **May 16**, **2022**, **McKinsey Sustainability** published a collection of analyses – ***Decarbonizing the world's industries: A net-zero guide for nine key sectors*** (Power, Oil and Gas, Automotive, Aviation and shipping, Steel, Cement, Mining, Agriculture and food and Forestry and land use).

  As is always the case with McKinsey publications, each analysis provides rich reading: each analysis provides a pithy piece on momentum and acceleration, underpinned by rich factual and statistical information.

- **Global CCS Institute publishes inaugural report**: On **May 17**, **2022**, the **Global CCS Institute** (a CCS "think-tank") published ***State of the Art: CCS Technologies 2022***. The publication is welcome, and very helpful.

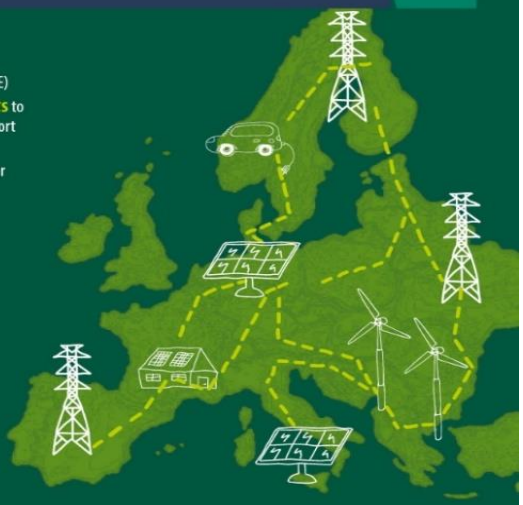
- **Council of European Union (*CEU*) revises Trans-European Networks for Energy (TEN-E) Regulation**: On **May 16**, **2022**, the ***CEU*** adopted the revised **TEN-E Regulation**. The press release (consilium.europa.eu) provides background and details on the next steps.

  The headline from the revised **TEN-E Regulation** is the introduction of mandatory sustainability criteria for all projects across the ***EU***, and the end to support for natural gas and oil projects.

  The revise **TEN-E Regulation** prioritises **11 corridors** for the **Trans-European Network**, and **three thematic** areas for development and interconnection. The following info-graphic provides a snap-shot of the thinking.

TEN-E: Europe's energy corridors

The trans-European networks for energy (TEN-E) regulation supports **cross-border projects** to link member states' energy networks and support the **integration of renewables**. It sets corridors across the EU to chart priority areas for investments.



The revised policy identifies 11 **priority corridors** focusing on:

- electricity
- offshore grids
- hydrogen and electrolysers

Three **priority thematic areas** are also defined:

- the deployment of smart electricity grids, improving the efficiency of electricity networks
- a cross-border carbon dioxide network, enabling CO_2 capture and storage
- smart gas grids, focusing on renewable and low-carbon gas sources

The TEN-E objectives are implemented mostly through **projects of common interest** (PCIs) which are financed by the **Connecting Europe Facility** for 2021-2027.

WITH THE NEW LEGISLATION, THE EU WANTS TO:

- align with the **European Green Deal objectives** and climate goals
- support more **renewables**, hydrogen and new clean energy technologies
- build more **interconnected and integrated energy infrastructure**, ensuring a more secure energy supply to isolated regions
- continue ensuring market **competitiveness, security** of supply and **affordability** of energy
- modernise rules by **simplifying procedures** and revising governance structures

THE MAIN INNOVATIONS ARE:

- compulsory **sustainability criteria** for all projects
- a new focus on **offshore electricity** and **hydrogen**
- ending support for new **oil and natural gas** infrastructure
- the acceleration of **smart grid** deployment and electrification

Council of the European Union
General Secretariat

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- **International Energy Agency (*IEA*) publications during May:**
  - On **May 11**, **2022**, the ***IEA*** published ***Renewable Energy Market Update – May 2022 – Outlook for 2022 and 2023***. The ***Update*** provides forecasts for new renewable energy capacity installation, and the development in **biofuel** demand, including for transport.
  - On **May 17**, **2022**, the ***IEA*** published ***Southeast Asia Energy Outlook 2022***. The publication provides a helpful overview of Southeast Asia generally (including the 10 member countries of the Association of Southeast Asian Nations (***ASEAN***)), and each of the ASEAN member countries, Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam.

    The ***Southeast Asia Energy Outlook 20022*** is well-worth a read: **Chapter 1**, sets the scene for across ***ASEAN***; **Chapter 2**, outlines scenarios in respect of all sources of energy and fuel (including achieving ***NZE*** by 2050), **Chapter 3**, considers investment in clean energy transition, the power sector, decarbonisation and system flexibility, low-carbon fuels and the supply of, and demand for, metals and minerals required to achieve energy transition. None of these matters are new, each of them is known (and each is consistent with narratives from ***IEA*** (and ***IRENA***) publications), and the scale and scope of what is required is known. What may be required is more detailed engagement by the ***IEA*** across ***ASEAN*** to develop workable policy settings (reflecting that no-one size fits all), including provision of funding support.

    As with each ***IEA*** publication since ***IEA Roadmap*** (***Net Zero by 2050: A Roadmap for the Global Energy Sector***), the ***Southeast Asia Energy Outlook 20022***, ties back to the ***IEA Roadmap***, critically, the policy settings that are required to limit the increase in global average temperatures to ***1.5^{O}C*** above pre-industrial levels.
  - On **May 23**, **2022**, the ***IEA*** published the ***Global EV Outlook 2022*** providing a helpful summary of the **state-of-play** across the electric vehicle market.
  - On **May 25**, **2022**, the ***IEA*** published ***Enhancing China's ETS for Carbon Neutrality: Focus on the Power Sector***, which is well-worth a read for those interested in modelling the interface of carbon taxes and ETSs.
  - On **May 25**, **2022**, the ***IEA*** published ***Renewable Energy Market Update: Key Findings***.
  - ***IEA*** publications during **April 2022**: ***Direct Air Capture – A key technology for net-zero***, ***Sustainable Recovery Tracker – Monitoring Progress towards sustainable recoveries from the Covid-19 crisis***, ***Sustainable Recovery Tracker***, ***Gas Market Report, Q2-Analysis, including Global Gas Review 2021***, ***Belgium 2022 – Energy Policy Review Report***.
- **International Renewable Energy Agency (*IRENA*) publications during May:**
  - On **May 9**, **2022**, ***IRENA*** published ***Global Hydrogen Trade To Meet The 1.5^{O}C Climate Goal – Part II – Technology Review of Hydrogen Carriers***. The publication focuses on the means, and cost, of transportation of Hydrogen Carriers from the point of production to the point of use. Below are helpful graphs, providing a summary of the current assessments of, and thinking on, costs.

FIGURE 0.1. Most cost-effective hydrogen transport pathway in 2050 as a function of project size and transport distance

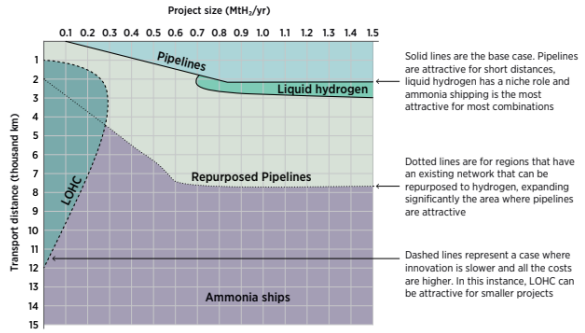
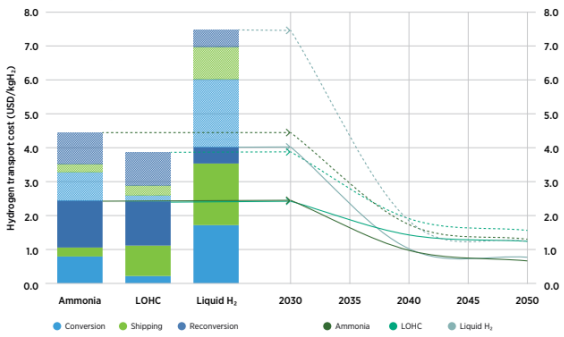


FIGURE 0.2. Transport cost breakdown by carrier and stage for 2030 (left) and evolution towards 2050 (right)



In addition, ***IRENA*** has published ***Global Hydrogen Trade To Meet The 1.5OC Climate Goal – Part I – Trade Outlook for 2050 and way forward*** and ***Global Hydrogen Trade To Meet The 1.5OC Climate Goal – Part III – Green hydrogen supply cost and potential***. ***Part III*** should be read with ***Part II***. Both ***Parts II*** and ***III*** outlined the current the possible evolution of Green Hydrogen towards to 2030 and 2050. These timelines, and the basis of assessment, follow the same path as that of ***WETO 2022*** (***World Energy Transition Outlook 2022***).

Parts I, ***Parts II*** and ***III*** will be covered in detail in the **May and June Report on Reports**, which will be included in the **Third Compendium of Low Carbon Pulse** (which will be available during June).

One of the many narratives that has emerged from the ***IRENA*** work is that the ***PRC*** will produce the world's lowest cost hydrogen followed by Chile, Morocco, Colombia and Australia.

- On **April 29**, **2022**, ***IRENA*** published ***Critical Materials for Energy Transition: Rare Earth Elements – Technical Paper 2/2022***. The publication may be regarded as compelling reading, providing an in depth analysis of demand and use and supply and source.

  For convenience, see link to ***Technical Paper 1/2022***.
- On **May 19**, **2022**, ***IRENA*** published ***Innovation Outlook: Renewable Ammonia*** (with an accompanying press release ***The Role of Renewable Ammonia in the Energy Transition***).

  The publication is excellent, and is well-worth a read for anyone interested in renewable ammonia technology and supply and demand (including as a **Future Fuel**). The publication will be covered in detail in the **May and June Report on Reports**, which will be included in the **Third Compendium of Low Carbon Pulse**.

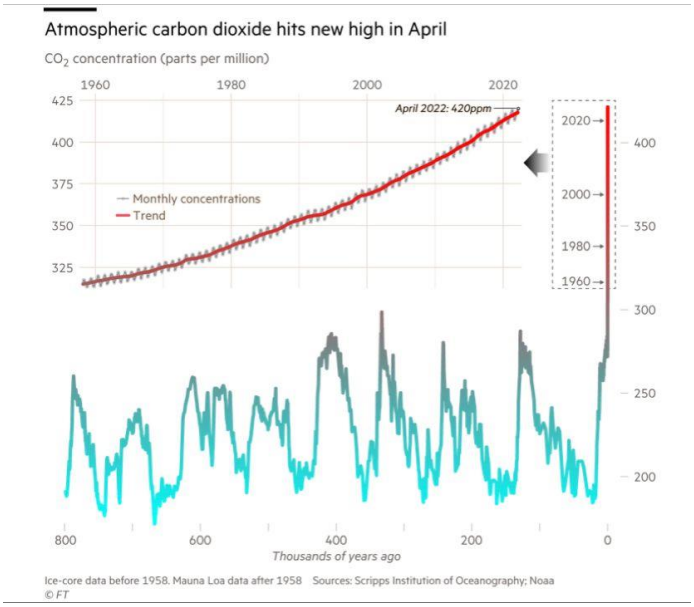
- ***IRENA*** publications during:
  - **April 2022**: ***Decarbonising End-Use Sectors: Green Hydrogen Certification*** (***Certification Paper***), ***Renewable Capacity Statistics 2022***, with a helpful three page summary **Renewable capacity highlights**, ***Grid Codes for Renewable Powered Systems*** (being an update on the ***IRENA*** publication from 2016, ***Scaling Up Variable Renewable Power: The Role of Grid Codes***), and ***Renewable Capacity Statistics 2022***. While the content of the data is not surprising, the data is a helpful reference.
  - **March 2022**: ***WETO 2022***, ***Decarbonising end-use sectors Green Hydrogen Certification***; ***Green Hydrogen For Industry – A Guide to Policy Making*** (considered in detail in **Edition** **37** of Low Carbon Pulse under **A Guide to Policy Making**), ***Collaborative Framework on Critical Materials For The Energy Transition***, ***Collaborative Framework on Critical Materials For The Energy Transition***, and ***Collaborative Framework on Critical Materials For The Energy Transition*** following like-frameworks from ***IRENA*** (including on Hydropower, Ocean Energy / Offshore Renewable Energy, Green Hydrogen, Geopolitics of Energy Transformation, Just and Inclusive Energy Transition and Enhancing Dialogues of High Shares of Renewables in Energy Systems), and the ***Renewable Energy Market Analysis: Africa and its Regions*** report.

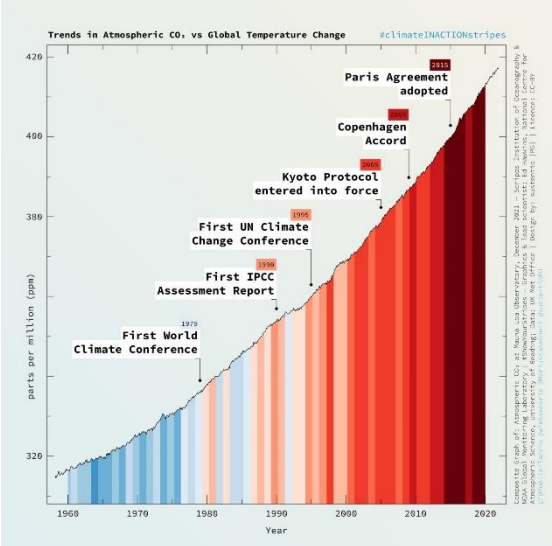
Climate change reported and explained:

*This section considers news items within the news cycle of this **Edition 40** of Low Carbon Pulse relating to climate change and its impact. The intention is to monitor significant and material data points and information, and to explain them.*

- ***CO_2* at highest levels:**

  On **May**, **5 2022**, it was reported widely that in **April 2022**, the US **National Oceanic & Atmospheric Administration** (***NOAA***) observatory at **Mauna Loa**, **Hawaii** recorded the highest level of ***CO_2*** in the atmosphere – **420 ppm**.





  On **May 14**, **2022** it was reported widely that a new daily record of **421.37 ppm** had been recorded by the **Scripps Institution of Oceanography** at the **University of California**, **San Diego**, with similar record levels confirmed by the ***NOAA***.

  Many news reports reported on the record level of ***CO_2***, accompanied by an alarming headline. It has to be noted that historically the during April and May each year ***CO_2*** levels tend to peak as a result of increased decomposition of vegetation.

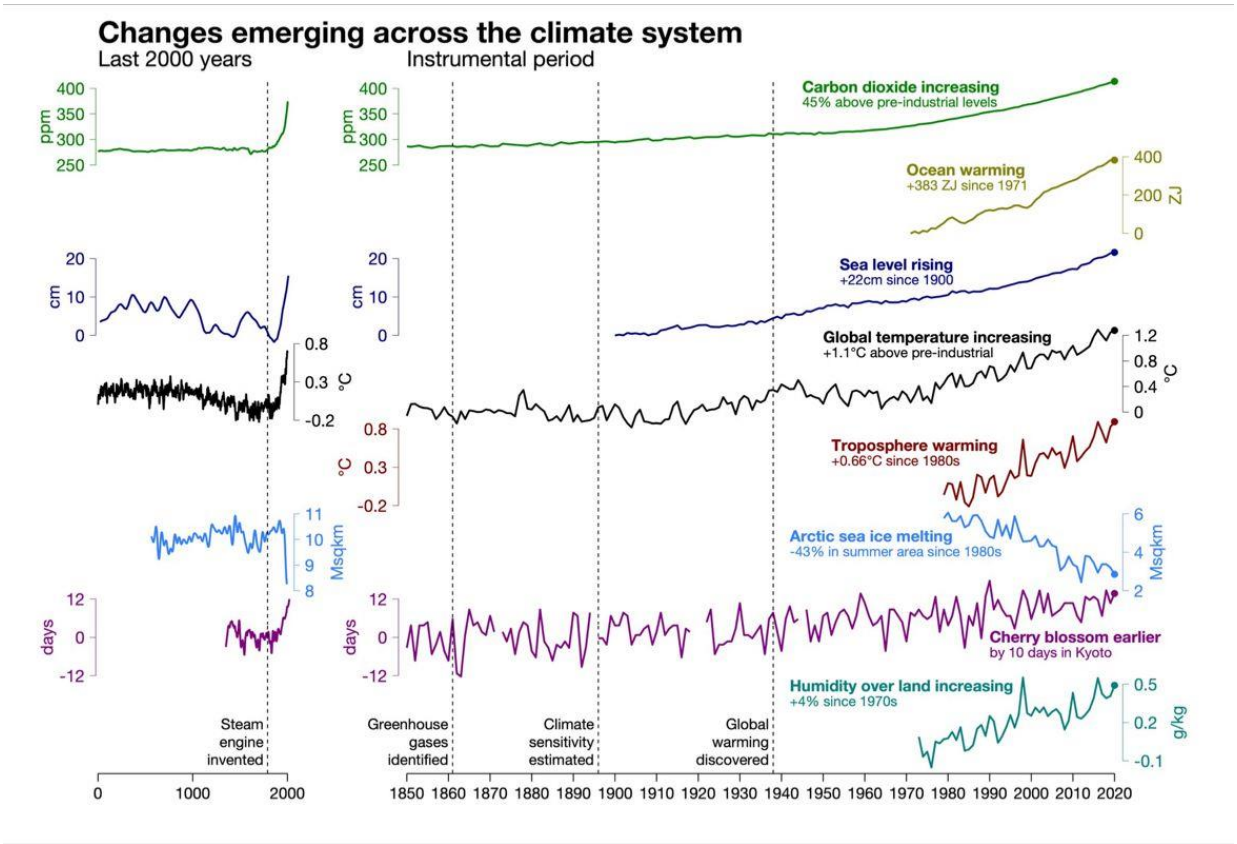
  This does not however allow us to ignore the record levels, noting that they are accompanied by record levels of ***CH_4***, but it allows them to be place in a better informed context.

- **Key Findings from *Global Annual to Decadal Climate Update***: On **May 9**, **2022**, the **Met Office UK** released ***Annual to Decadal Climate Update***, the key finding from which are:
  - The annual mean global surface temperature for each year between 2022 and 2026 is predicted to be between **1.1°C** and **1.7°C** higher than pre-industrial levels (being the average over the years 1850-1990);
  - The chance of global near-surface temperature exceeding **1.5°C** above pre-industrial levels in at least one year **between 2022 and 2026** is about as likely as not (48%). There is only a small chance (10%) of the five-year mean exceeding this threshold;
  - The chance of at least one year **between 2022 and 2026** exceeding the warmest year on record, 2016, is 93%. The chance of the five-year means for **2022-2026** being higher than the last five years (2017-2021) is also 93%;
  - The Artic temperature anomaly, compared to the 1991-2020 average, is predicted to be more than three times as large as the global mean anomaly when averaged over the next five northern hemisphere extended winters;

- Predicted precipitation patterns for 2022 compared to the 1991-2020 average suggest an increased chance of drier conditions over southwestern Europe and southwestern North America [already occurring], and wetter conditions in Northern Europe, the Sahel, north-east Brazil, and Australia;
- Predicted precipitation patterns for the **May to September 2022-2026 average**, compared to the 1991-2020 average, suggest an increased chance of wetter conditions in the Sahel, northern Europe, Alaska and northern Siberia and drier conditions over the Amazon (all of which have been covered in previous editions of Low Carbon Pulse, including their ***GHG*** emission impact); and
- Predicted precipitation patterns for the **November to March 2022/23-2026/27 average**, compared to the 1991-2020 average, suggest increased precipitation in the sub-tropics, consistent with the patterns expected from climate warming.

To regular readers of Low Carbon Pulse, none of the key findings of the **Met Office** will be of a surprise, each dynamic has been covered in one or more editions of Low Carbon Pulse. The patterns of climate change have emerged, and have been reasonably consistent. While the impact of the patterns of climate change that have emerged remain difficult to predict as to annual extent, it is clear that all patterns will continue, and, absent increased reductions in the mass of ***GHG*** emissions, will become more pronounced.

- **From then to now**: On **May 13**, **2022**, the author of Low Carbon Pulse came across an info-graphic that brings together key measures of climate change. The infographic is at once informative and sobering:



Source: Martin Gerhardt

- **Key Messages from *State of the Global Climate 2021***: On **May 19**, **2022**, the **World Metrological Organisation** (***WMO***) published ***State of the Global Climate 2021***, with the key messages including:
  - The global mean temperature in 2021 was around **1.11°C** above 1850 to 1900 levels;
  - The global mean sea level reached a new record high in 2021, rising an average of 4.5 mm a year over the period 2013 to 2021;
  - The **Antarctic ozone hole** reach a maximum area of **24.8 million km²** in 2021;
  - **Greenland** experienced an **exceptional mid-August melt**, with the first ever recorded rainfall at Summit Station;
  - Exceptional heatwaves broke records across western North America and the Mediterranean;
  - Many parts of the world were affected by **drought**, including **Afghanistan**, **Canada**, **Iran**, **Pakistan**, **Turkey**, **Turkmenistan**, and the **US**.

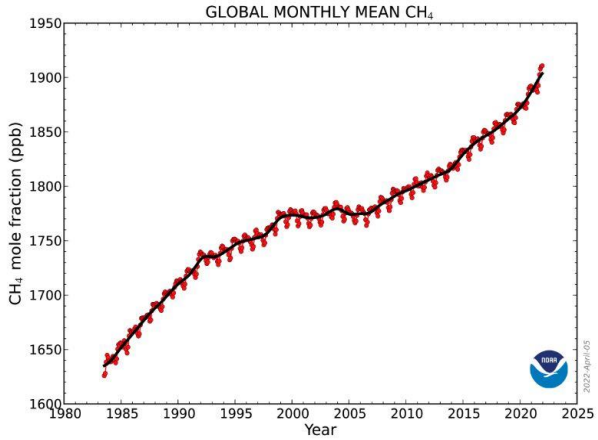
  In response to the ***WMO State of the Global Climate 2021***, **UN Secretary General**, **Mr Antonio Guterres** said: "*It's time to jump-start the renewable energy transition before it's too late*".
- **Methane Reduction and Carbon Dioxide Removal (*CDR*)**: The author of Low Carbon Pulse notes that there is an ever increasing (and continuing) focus on the reduction in methane emissions to ensure that less methane enters the atmosphere (and is emitted from the bio-sphere) and the removal of carbon dioxide already in the atmosphere, and not to ascribe carbon credits to the carbon dioxide that has been removed from the atmosphere.

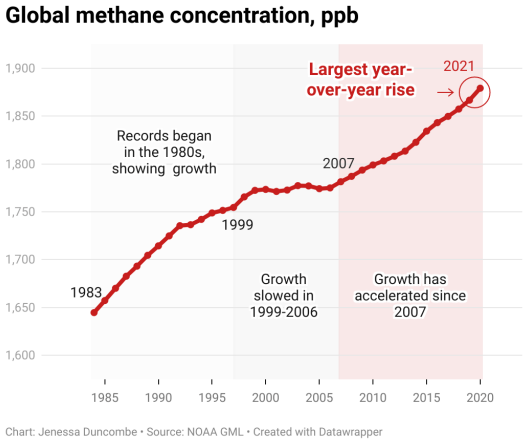
  This increasing focus was present before the publication of the ***IPCC WGIII Report***. The ***IPCC WGIII Report*** has brought into even sharper focus the need for ***CH_4*** reduction and ***CDR***. This sharper focus is becoming ever more focussed.

The record levels of ***CO2*** and their consequences follow the record levels of ***CH4*** reported in **Edition** 39 of Low Carbon Pulse as follows:

By way of reminder: On **April 7, 2022**, the ***NOAA*** issued ***Increase in atmospheric methane set another record during 2021 – Carbon dioxide levels also record a big jump***.

The following graph illustrates key dynamics reported by the ***NOAA***, critically the (steepening) upward trend.





In April, the record levels of ***CH_4*** were the subject of an excellent article in The Washington Post (***Methane emissions jumped by record amount in 2021, NOAA***). In May, the record levels of ***CO_2*** caught the attention of ***The Wall Street Journal***.

Middle East including GCC Countries:

*This section of Low Carbon Pulse considers news items within the news cycle of this **Edition 40** of Low Carbon Pulse relating to the Gulf Cooperation Council (**GCC**) Countries, being countries that are leading the way in the development of Blue Hydrogen and Green Hydrogen capacity for own use and for export.*

- **EWEC procuring 1.5 GW of photovoltaic solar**: On **May 11, 2022**, it was reported widely that **Emirates Water and Electricity Co**. (***EWEC***) was accepting expressions of interest to develop a **1.5 GW** photovoltaic solar project in Abu Dhabi (the ***AL Ajban PV*** project).
- **ADNOC and BP continue cooperation**: On **May 24, 2022**, it was reported widely that **ADNOC** (Abu Dhabi National Oil Company) and **Masdar** (Abu Dhabi Future Energy Company) had agreed to invest in **bp**'s Blue Hydrogen and Green Hydrogen projects, **H2Teesside**. **ADNOC** will work with **bp** on the Blue Hydrogen project, and **Masdar** will work with **bp** on the Green Hydrogen project (HyGreen Teesside).

  As reported in previous editions of Low Carbon Pulse, **ADNOC**, **bp**, **Masdar**, **Tadweer** (Abu Dhabi Waste Management Centre) and **Etihad Airways** are to assess the production of ***SAF*** from hydrogen and the gasification of municipal solid waste.

  By way of reminder:

  - **Edition** 27 of Low Carbon Pulse reported as follows (under ***ADNOC Group, bp and Masdar align***):

    "On September 16, 2021, it was reported widely that ADNOC Group (leading national oil company), BP (leading international energy corporation) and Masdar (Abu Dhabi Future Energy Company) entered into framework agreements. It is understood that the framework agreements provide the basis for the development of two clean hydrogen hubs, each of 1 GW, one in the UAE, the other in the UK.

    The framework agreements reflect the clear commitment of ADNOC Group and Masdar to the "Principles of the 50" and the commitment of BP to progress to ***NZE*** and the achievement of its objectives in respect of the Net-Zero Teesside project (see **Edition** 23 of Low Carbon Pulse). The development of the 1 GW Blue Hydrogen facility on Teesside (**H2Teesside**) will be facilitated by the investment of ADNOC Group and Masdar."
  - **Edition** 37 of Low Carbon Pulse (Long Form Version) reported on projects that had satisfied the eligibility criteria for progress under the UK Government **Cluster Sequencing Phase-2: eligible projects (power, CCUS, *hydrogen* and ICC)**. The following table identifies the projects that satisfied the eligibility criteria for **Phase-2**, with the **bp H2Teesside** project placed in context.

CO2 CLUSTER	POWER CCS	HYDROGEN	INDUSTRIAL CARBON CAPTURE
East Coast Cluster:	VPI Humber Zero; Whitetail Clean Energy; Net Zero Teesside Power; Alfanar CCGT Teesside; Keadby 3 CC Power Station and C.Gen Killingholme	N2NorthEast; Uniper Humber Hub Blue Project; **bp H2Teesside** and Hydrogen to Humber (H2H) Saltend	STV 1,2 and 3 Energy from Waste CC projects; Tees Valley Energy Recovery Facility Project; Altalto Immingham waste to jet fuel project; Lighthouse Green Fuels; Redcar Energy Centre; Humber Zero Refinery; Prax Lindsey Refinery; ZerCal250; Teesside Hydrogen CC; Saint-Gobain Glass CC; Norsea CC; CF Fertilisers Billingham Ammonia CCS; Teesside Green Energy Park, and North Lincolnshire Green Energy Park
HyNet Northwest	Making Net Zero Possible – Grain	Project Cavendish & HyNet Hydrogen Production Project	Viridor Runcorn Industrial CCS; Protos Biofuels and Energy Recovery; Hanson Padeswood Cement CCS; CF Fertilisers Ince CC Plant; Buxton Lime Net Zero; EssarOil UK CCU; and Emerge CCS
Scottish Cluster	Peterhead Carbon Capture Power Station	Acorn Hydrogen & Fife Hydrogen Hub	CO2 Extraction form St Fergus Gas and SAGE Terminal and Acorn Capture

- **JDA for World Scale Future Fuels project**: Previous editions of Low Carbon Pulse reported that in late 2021, **ACWA Power**, **Air Products** and **OQ** had signed a memorandum of understanding (**MOU**) in respect of an integrated photovoltaic solar, wind, and ***BESS***, Green Hydrogen production facility, and nitrogen separation facility, and a Green Hydrogen and nitrogen synthesis plant (to be located in the Salalah Free Zone, Oman) to produce Green Ammonia.

  On **May 26**, **2022**, it was reported widely that the parties to the **MOU** had progress to the execution of a joint development agreement (**JDA**). It is noted that **ACWA Power** and **Air Products** are working together on the **Neom Green Hydrogen** project in the **KSA**.

  By way of reminder: Other Green Hydrogen and Green Ammonia progress in Oman are:

  - **Oman Green Energy Hub** (***OGEH***): On **April 5**, **2022**, it was announced that **Worley** had been appointed to undertake a concept feasibility study for the ***OGEH***.

    Previously, **Edition** 18 of Low Carbon Pulse reported that: "On May 22, 2021, plans to develop a USD 30 billion, 25 GW, **Oman Green Energy Hub** (***OGEH***) were announced. The ***OGEH*** is to be located close to the Arabian Sea. The development of the ***OGEH*** is to be spear-headed by I**nterContinental Energy**, in partnership with **OQ** (state owned Omani oil and gas company) and **EnerTech Holding Company** (Kuwaiti based investor).

    The renewable electrical energy produced from on-shore photovoltaic solar and wind farms, will allow the production of 1.8 million metric tonnes per annum of Green Hydrogen and, as reported, 10 million metric tonnes a year of Green Ammonia. Construction of ***OGEH*** is to be undertaken in phases, and is scheduled to commence in 2028, with completion of the final phase scheduled for 2038. On full development, the ***OGEH*** is to be powered by 25 GW of photovoltaic solar and wind."
  - **Self-fulfilling dynamics in Oman: Edition** 22 of Low Carbon Pulse reported that: "On July 19, 2021, it was reported that Uniper (leading international energy company) has signed a cooperation agreement with the shareholders in ***Hyport DUQM*** to develop the business case for the off-take of Green Hydrogen through the negotiation of an exclusive off-take agreement for Green Ammonia and to provide related engineering services.

    As noted in previous editions of Low Carbon Pulse, there is palpable progress across the ***Gulf Cooperation Council*** (***GCC***) countries towards the development of Green Hydrogen and Green Ammonia (and Blue Hydrogen and Ammonia). **Edition** 20 of Low Carbon Pulse included a narrative around the highly prospective, world-class resources that exist in the ***GCC*** countries."
  - **Oman building on progress: Edition** 25 of Low Carbon Pulse reported that: "Uniper (leading international energy company) had signed a cooperation agreement with the shareholders in ***Hyport DUQM*** to develop the business case for the off-take of Green Hydrogen through the negotiation of an exclusive off-take agreement for Green Ammonia and to provide related engineering services.

    On August 13, 2021, it was announced that the Oman Ministry of Energy had established an alliance (***Hy-Fly***) of thirteen public and private sector organisations (including Oman LNG, OQ, BP, Shell and TotalEnergies) to work together to develop initiatives for the purposes of the production, transportation, use and export of clean hydrogen, and clean hydrogen-based fuels.
  - **OQ signs JDA: Edition** 29 of Low Carbon Pulse reported that: "On October 17, 2021, OQ (the Omani state-owned energy company) had signed a Joint Development Agreement with Dutco, Linde and Marubeni to undertake feasibility studies to assess the development of a 400 MW Green Hydrogen and Green Ammonia production facility (***SalalahH2 Project***) in Oman's Salalah Free Zone. The ***SalalahH2 Project*** will make use of OQ's existing ammonia production plant at Salalah".
  - **Oman and Siemens mapping a way forward: Edition** 30 of Low Carbon Pulse reported that: "On November 11, 2021, the Oman Hydrogen Centre (***OHC***) signed a memorandum of understanding (***MOU***) with Siemens Energy Oman to collaborate on the development and deployment of hydrogen energy projects and on hydrogen initiatives in the Sultanate of Oman".
  - **Oman and BP committed to multiple GWs: Edition** 33 of Low Carbon Pulse reported that: "On January 17, 2022, the Oman Ministry of Energy and Minerals had signed an agreement with BP (leading international energy corporation) to progress with the development of a combined renewable electrical energy and Green Hydrogen production project by 2030.

    In the near term, **BP** will assess the solar and wind resources in a 8,000 km^2 area of land that would be used to locate photovoltaic solar and wind generation capacity to provide renewable electrical energy for the production of Green Hydrogen".

Africa:

*This section considers news items within the news cycle of this **Edition 40** of Low Carbon Pulse relating to Africa. Africa remains the continent with the most developing countries, the most **Least Developed Countries** and the most countries vulnerable to climate change, and the continent with some of the lowest levels of electrification.*

- **Continued flow of Suez projects**: On **May 11**, **2022**, english.ahram.org.eg reported that Egyptian Prime Minister, Mr Mostafa Madbouly attended a signing ceremony for a memorandum of understanding (***MOU***) among the **General Authority for Suez Canal Economic Zone**, The **Sovereign Fund of Egypt**, the **Egyptian Electricity Transmission Company**, and the **New and Renewable Energy Authority**, and a consortium comprising **TotalEnergies** (global leading international energy corporation) and **Enara Capita**l (a sustainable energy investment platform).

  Under the ***MOU***, **Total Eren** (reported as TotaEnergies in some news outlets) and **Enara** (a Cairo headquartered investment corporation) will develop facilities to produce Green Hydrogen and Green Ammonia to produce up to **300,000 metric tonnes** of Green Ammonia a year initially, but with the expectation of expansion of up to **1.5 million metric tonnes** a year.
- **And another one!**: On **June 1**, **2022**, it was reported widely that the **General Authority for Suez Canal Economic Zone** (**SCZONE**) and **H-2 Industries** (developer of hydrogen storage technology) plan to develop a **USD 4 billion waste-to-hydrogen facility** at **Port Said**.

  As reported, the waste-to-hydrogen facility process **4 million metric tonnes** of **municipal solid waste** as feedstock, and produce **300,000 metric tonnes** of hydrogen annually.
- **Egyptian Future Fuel Hubbub:**

  The waste-to-hydrogen announced on **June 1**, **2022**, is another project to be developed in Egypt. The following page or so details the activity during 2022.
  - **AMEA Power to produce Green Ammonia in Egypt for export:** On **April 22**, **2022**, energy-utilities.com reported that **AMEA Power** had signed a memorandum of understanding (***MOU***) to produce Green Ammonia for export from **Ain Sokhna Industrial Zone**, Egypt. The ***MOU*** was signed with the **General Authority for Suez Canal Economic Zone**, The **Sovereign Fund of Egypt**, the **Egyptian Electricity Transmission Company**, and the **New and Renewable Energy Authority**. As reported, the **Green Hydrogen** and **Green Ammonia** production facility will produce **400,000 metric tonnes** of **Green Ammonia a year**.
  - **EDF Renewables and Zero Waste team-up in Egypt:** On **April 22**, **2022**, arabnews.com reported that **EDF Renewables** and **Zero Waste** had signed a memorandum of understanding to develop a carbon-free fuel production project working with the **Ministry of Electricity**, the **General Authority for Suez Canal Economic Zone** and The **Sovereign Fund of Egypt**. The project is to be located within **Suez Canal Economic Zone**.
  - **Hassan Allam Utilities and Masdar agree to develop Green Hydrogen production facility:** On **April 25**, **2022**, energy-utilities.com reported that **Hassan Allam Utilities** and **Masdar** had signed two memorandums of understanding (***MOU*s**) to produce Green Ammonia for export from the **Ain Sokhna Industrial Zone**, Egypt. The ***MOU*s** were signed with the **Suez Canal Economic Zone**, The **Sovereign Fund of Egypt**, the **Egyptian Electricity Transmission Company**, and the **New and Renewable Energy Authority**. As reported, the Green Hydrogen production facilities will be developed to produce up to **100,000 metric tonnes** of **e-methanol a year by 2026** (being methanol using renewable electrical energy in respect of all power required for the purposes of producing the methanol). It is reported that overtime the electrolyser capacity will increase to **4 GW** to allow increased production of e-methanol.

  As will be apparent from the following reminder, the **Ain Sokhna Industrial Zone** is going to be home to considerable **Green Hydrogen**, **Green Ammonia** and **Green Methanol** production capacity.
  - **By way of reminder Edition 36 of Low Carbon Pulse reported that:**
    - On **March 10**, **2022**, it was reported widely that **Scatec** (leading Norwegian renewable electrical energy corporation) had signed a memorandum of understanding (***MOU***) with the **Suez Canal Economic Zone**, The **Sovereign Fund of Egypt**, the **Egyptian Electricity Transmission Company**, and the **New and Renewable Energy Authority**.

      It is understood that the ***MOU*** provides for the development jointly of a **1 million metric tonnes per annum Green Ammonia** production facility (with potential to expand to 3 million metric tonnes annually).

      The Green Hydrogen and Green Ammonia production facility is to be sited in the **Ain Sokhna Industrial Zone** (itself located within the **Suez Canal Economic Zone**). The **New and Renewable Energy Authority** will allocate land proximate to the production facility to allow renewable electrical energy capacity to be installed to generate power for the production facility.
    - On **March 28**, **2022**, it was reported widely that **A.P. Moller** – **Maersk** had entered into a memorandum of understanding (***MOU***) signed by Prime Minister of Egypt, Mr. Mostafa Madbouly, under which **A.P. Moller** – **Maersk** will work with the **Suez Canal Economic Zone**, The **Sovereign Fund of Egypt**, the **Egyptian Electricity Transmission Company**, and the **New and Renewable Energy Authority** to develop green energy and green fuel production capacity.
- **Future Fuel Hubbub snap shot:** On **May 13**, **2022**, sczone.eg provided a summary and update of the memorandums of understanding that had been signed in respect of green hydrogen and green hydrogen-based fuel projects within the **Sokhana zone** (which is within the **Suez Canal Economic Zone** (**SCZONE**)).

  The **SCZONE** announcement explains that the intention is to localise green hydrogen and green hydrogen based fuels with both the **Sokhana** zone and **East Port Said**. Further, it is explained that feasibility studies are currently being undertaken in respect of each project the subject of an **MOU**, aligned to the likelihood of firmer announcements at **COP27**.

Source: Sczone

- **African Green Hydrogen Alliance launched**: On **May 20**, **2022**, it was reported widely that **Egypt**, **Kenya**, **Morocco**, **Namibia**, **Mauritania**, and **South Africa** had established the **African Green Hydrogen Alliance** (***AGHA***). The ***AGHA*** is supported by the **African Development Bank**, the **Green Hydrogen Organisation**, and the **UN Climate Change High-Level Champions**, and the **UN Economic Commission for Africa**.

  The ***AGHA*** is intended to provide a forum to set, and to increase, the pace of the development of Green Hydrogen production capacity across Africa, and as such to accelerate the transition from fossil fuels, opening up access to affordable, and clean, energy supply for all.
- **Africa Day**: **May 25**, **2022**, marked **Africa Day 2022**. **Africa Day 2022** marks the **20th anniversary** of the establishment of the **African Union**. The theme for **Africa Day 2022** was nutrition.

  One of the many interesting facts published on May 25, 2022 was that **23%** of the land mass of **Africa** comprises **forests** and **woodlands**, and that the **Congo forests** and the **Miombo-Mopane** woodlands are some of the most pristine wilderness areas in the world.
- **First of its kind BESS**: On **May 31**, **2022**, energy-storage reported that **JCM Power** and **InfraCo Africa** had announced that the **20 MW Golomoti Photovoltaic Solar** and ***BESS*** project in the **Dedza** district of **Malawi** was operational– said to be the first grid-connected utility scale co-located project in sub-Saharan Africa.

India and Indonesia:

*This section considers news items within the news cycle of **Edition 40** of Low Carbon Pulse relating to India and Indonesia, two countries with increasing populations and urbanisation, attendant increased levels of electrification, and being the countries with the third and seventh most **GHG** emissions.*

- **Hindustan Salts seeks bids for 1 GW of solar**: On **May 5**, **2022**, pv-magazine.com reported that **Hindustan Salts Ltd** (a Government of India state-owned corporation) had invited bids to develop **1 GW** of photovoltaic solar capacity located on **5,000** acres of disused land in the Indian State of Gujarat. As reported, bidding closed on **May 25. 2022**.
- **1 GW Photovoltaic solar farm at Hengjaya Mine and Industrial Park**: On **April 20**, **2022**, **ib vogt** (a solar energy engineering company and developer) and **Quantum Power Asia** (an independent power producer) announced the development of a **1 GW photovoltaic solar farm** to provide renewable electrical energy at the **Hengjaya Mine** (nickel and cobalt), contracting with **Nickel Mines Limited** for this purpose, and to provide renewable electrical energy to Morowali Industrial Park.
- **587 GW of renewable energy by 2060**: On **May 23**, **2022**, kaisel.antaranews.com reported that Indonesia plans to develop clean energy power plants with capacity of **587 GW** by 2060, including **361 GW** of photovoltaic solar capacity, **83 GW** of hydroelectric power, and **39 GW** of wind capacity. In addition, the plans include the development of **37 GW** of biomass capacity, **35 GW** of nuclear capacity, **18 GW** of geothermal capacity, and **13.4 GW** of ocean current and wave capacity. To complete the clean energy mix, there will be **energy storage capacity** of **140 GW** of ***BESS***, **52 GW** of ***HESS*** and **4.2 GW** of **pumped storage**. As reported in previous editions, the decarbonisation of the electrical energy sector will cost an estimated USD 1,177 billion (or USD 1.177 trillion).
- **Giga-factory planned by Exide Industries**: On **May 27**, **2022** Benchmark Mineral Intelligence reported that **Exide Industries** is in "advanced stages" of securing land for its first lithium-ion giga-factory. As reported, the giga-factory is to be located in the state of Karnataka, with initial production capacity of **six GWh** a year, increasing to **12 GWh** by 2030. It is understood that the giga-factory will be co-developed with **SVOLT** (leading ***PRC*** battery corporation).
- **Hybrid photovoltaic solar and wind operational**: On **May 28**, **2022**, **Adani Green** announced at adanigreenenergy.com that it had commissioned the **390 MW hybrid plant** in the state of Rajasthan. As reported, this is the first hybrid renewable energy project in India. The **Solar Energy Corporation of India** or **SOCI** (a state-owned corporation) is to off-take the renewable energy from the project with a tariff of R2.69 per KWh.
- **Large scale solar park opens in India**: On **May 30**, **2022**, **Statkraft** (Europe's largest renewable energy generator) announced that its **Nellai** photovoltaic solar farm had commenced operation. The **Nellai** solar farm is located in the southern state of **Tamil Nadu**. **Tamil Nadu** has world class solar resources, with an average of **300 days** of sunshine a year.

  While the scale of **Nellai** solar farm is not huge, it is a utility-scale solar farm, and it is likely to be the first of a number of solar farms developed by **Statkraft** using the **Indian Group Captive-model** under which customers own a minimum 26% share in the solar farm and off-take renewable electrical energy under long term power purchase agreements.
- **India Hydrogen Alliance – April 2021:** Attached is the link to the November edition of ***India H2 Monitor – April 2021***. As noted in previous editions of Low Carbon Pulse, we intend to include the link rather than repeat the content of the ***India H2 Monitor***. (The ***India H2 Monitor*** tends to be published three to five days after the end of each calendar month, and as such is not published when we publish Low Carbon Pulse – within two days after the end of each calendar month.)

Japan and Republic of Korea (*ROK*):

*This section considers news items within the news cycle of this **Edition 40** Low Carbon Pulse relating to Japan and ROK, being the countries with the fifth and tenth most **GHG** emissions, and the greatest dependence on imported energy carriers.*

- **Air Liquide and Lotte Chemical aligned strategically:** On **May 2**, **2022**, **Air Liquide** (one of the Big Three Industrial Gas Giants), announced that it had entered into a strategic joint venture with **Lotte Chemical** under which **Air Liquide** (as a 40% participant) and **Lotte Chemical** (as a 60% participant) are to co-invest though the joint venture in new generation, large-scale, hydrogen refuelling stations in the industrial basins of **Daesan** (including Seoul and Gyeonggi province) and **Ulsan** (including Busan, Daegu and Ulsan and Gyeongsang province).
- **Japan's plans to issue USD 157 billion of green transition bonds**: On **May 19**, **2022**, reuters reported that Japanese **Prime Minister**, **Mr Fumio Kishida** had outlined plans to issue an estimated **¥ 20 trillion** (USD 157 billion) of green transition bonds to assist Japan in financing the investment required to achieve carbon neutrality.

  In addition, **Prime Minister Kishida** indicated that the Government intended to create a 10 year road map to promote green investment.
- **Japan and US align further at QUAD**: On **May 23**, **2022**, the **White House** released a ***Fact Sheet: US – Japan Climate Partnership***. The Fact Sheet outlines the increasing granularity in alignment between the Japan and the US.
- **SolarEdge opens**: On **May 25**, **2022**, energy-storage reported that **SolarEdge** has opened its **2 GW** battery cell giga-factory (**Sella 2**).

  Sella 2 has been developed by **SolarEdge**, working with **Kokam**, and is located in **Eumseong Innovation City**, Chungcheongbuk-do Province, ***ROK***. As reported, **Sella 2** will produce nickel manganese cobalt (**NMC**) pouch cells.

PRC and Russia:

*This section considers news items that have arisen within the news cycle of this **Edition 40** of Low Carbon Pulse relating to the **PRC** and Russia, being countries that give rise to the most and the fourth most **GHG** emissions.*

- **Enhancing ETS for PRC**: On **May 25**, **2022**, the ***IEA*** and **Tsinghua University** held an expert discussion in respect of how an enhanced emissions trading system in the ***PRC*** could assist in providing momentum in progress towards the achievement of ***NZE***.

  On **May 25**, **2022**, the ***IEA*** published ***Enhancing China's ETS for Carbon Neutrality: Focus on the Power Sector***. The publication analyses five policy setting scenarios for the electricity sector for 2020 to 2035, consistent with China's 14 Five-Year Plan (2021-2025), and the Long Range-Range Objectives through the Year 2035.

  The **five** policy setting scenarios are as follows: **RPS Scenario**, the **RPS-ETS Scenario**, and **three Enhanced ETS** (**ETS+**) **Scenarios**. For those interested in the modelling of ETS and carbon pricing, the publication is excellent.

  The table below provides a summary of each policy setting scenario, other than the base case **RPS Scenario**:

Table ES.1 Key outcomes by scenario, 2035

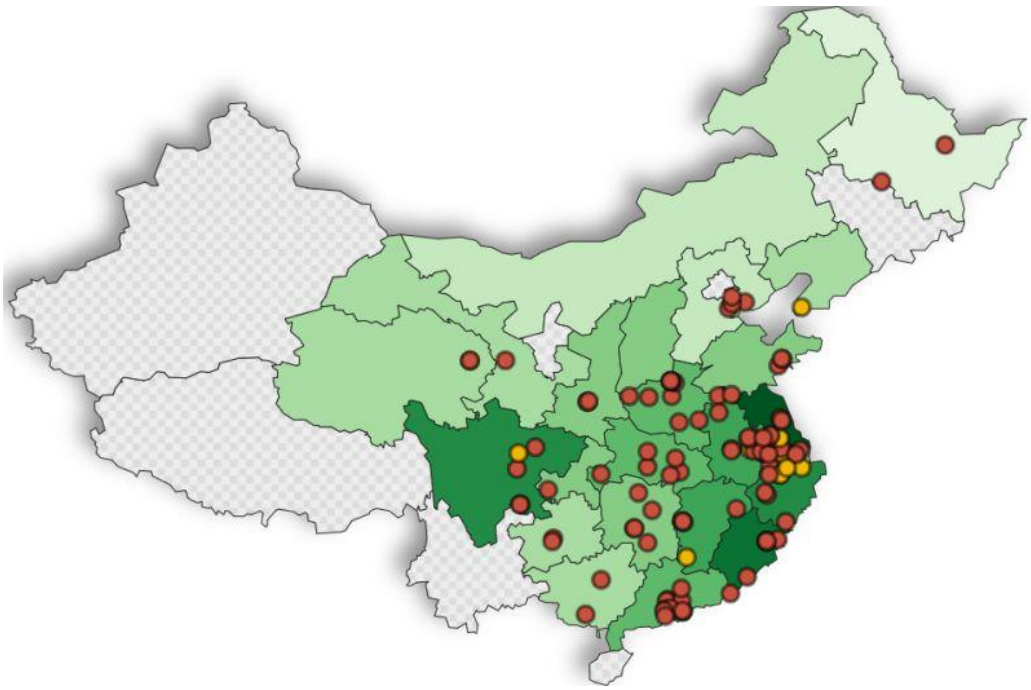
Scenario	Key ETS design features	CO_2 reduction (from 2020)	Main driver of CO_2 reductions	Increase in total system costs*	Additional renewables share**	Interaction with RPS
RPS-ETS	Intensity-based; Moderate BM tightening; Free allocation	-20%	CCUS	-/-	-/-	Low
ETS+BM	Intensity-based; Strong BM tightening; Free allocation	-38%	CCUS	5.2%	1%	Low
ETS+Auction	Intensity-based; Moderate BM tightening; Partial auctioning	-38%	Renewables CCUS	1.4%	8%	High
ETS+Cap	Cap-and-Trade; Stringent cap; Free allocation	-38%	Renewables	0%	12%	High

*Increase in total system costs relative to the RPS-ETS Scenario required to achieve given CO_2 reduction level.
**Additional share of non-hydro renewables in electricity generation mix relative to the RPS-ETS Scenario.

Source: IEA

  The **May and June Report on Reports** will consider the publication in detail, and will be published in the **Third Compendium of Low Carbon Pulse**.

- ***PRC* has 125 giga-factories**: Recent editions of Low Carbon Pulse (including this **Edition 40**) have reported on plans to develop of giga-factories across Europe and North America. The following info-graphic map provides a sense of the giga-factories across the ***PRC***.



Source: China EV map (uri.sh)

- ***PRC* NEA predicts 108 GW of new photovoltaic manufacturing capacity in 2022**: On **May 31**, **2022**, pv-magazine reported that the **National Energy Administration** (***NEA***) of the ***PRC*** expects **108 GW** new photovoltaic manufacturing capacity during 2022.

Europe and UK:

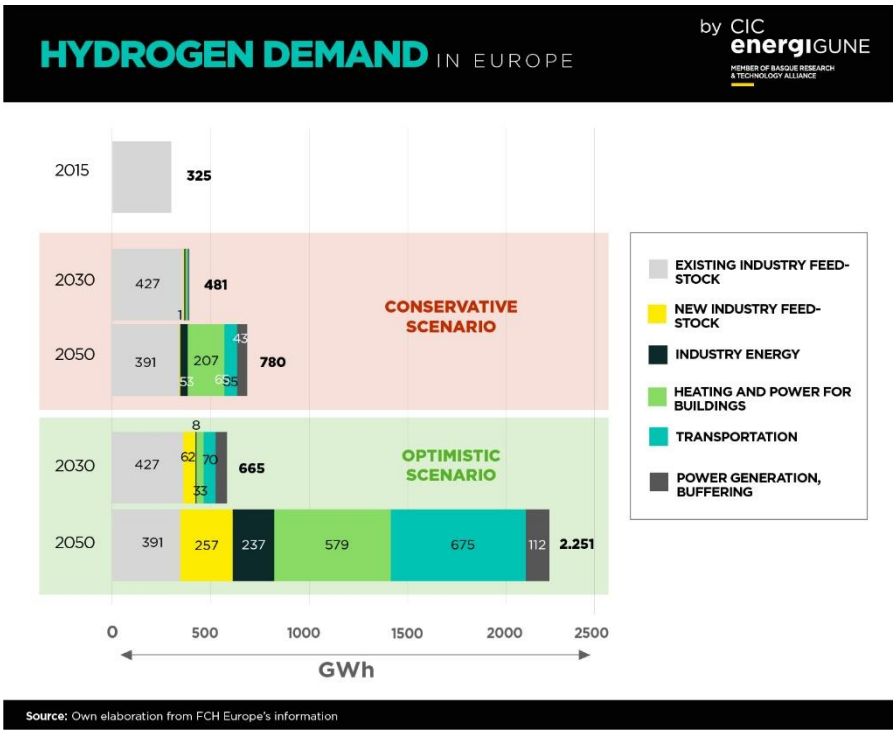
*This section considers news items that have arisen within the news cycle of this **Edition 40** of Low Carbon Pulse relating to countries within the European Union (**EU**) and the **EU** itself (as an economic bloc) and the UK given geographical proximity, and similar policy settings and progress towards **NZE**. In combination, countries comprising the **EU** give rise to the most **GHG** emissions after the Peoples Republic of China (**PRC**) and the US. The UK is a top-twenty **GHG** emitter, but has been a front-runner in progress towards **NZE**.*

- **EU will require hydrogen imports**: In the lead up to the publication of the detailed ***REPowerEU*** plan (see **REPowerEU detailed plans released** above), on **May 4**, **2022**, it was reported widely that **Mr Frans Timmermans** (Executive Vice President of the European Commission for the European Green Deal and European Commissioner for Climate Action) told the **European Parliament** that the ***EU*** would not be able to produce sufficient hydrogen to satisfy its demand:

  "*I strongly believe in green hydrogen as the driving force of our energy system of the future … And I also strongly believe that Europe is never going to be capable to produce its own hydrogen in sufficient quantities*".

  While there have been a few adverse reactions to this statement (noting however that it is not a policy setting), the statement may be regarded as both sensible and sound, recognising the capacity of the Middle East and North Africa (and other regions with world class renewable resources, in particular solar), to produce and to supply Green Hydrogen to Europe.

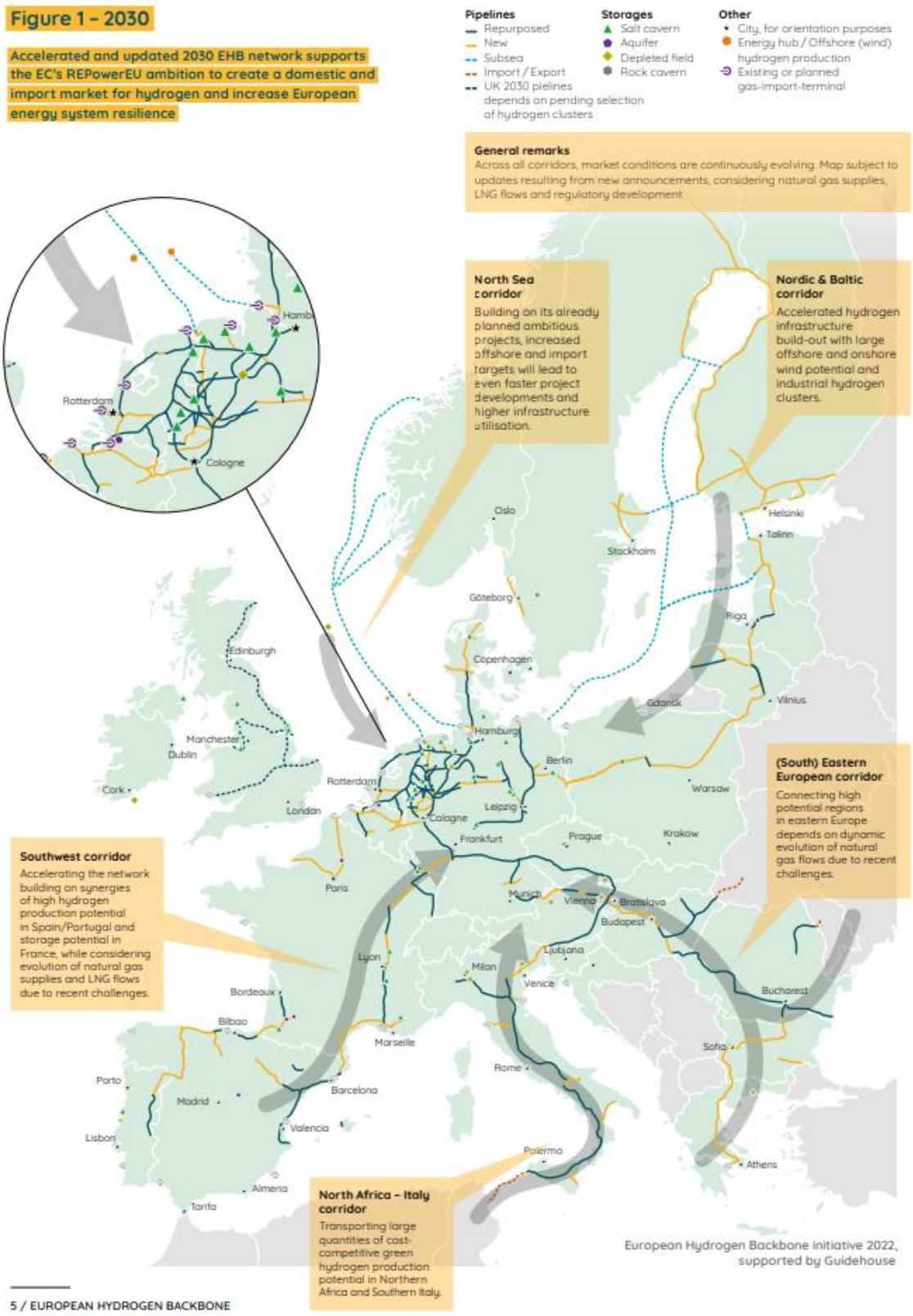
  To provide context, the good folk at **CIC energiGune** have produced the following infographic providing a sense of the possible demand for hydrogen across Europe.



Source: CIC energiGune

- **As night follows day…**: On **May 5**, **2022**, the **European Commissioner for the Internal Market**, **Mr Thierry Breton**, met with the European electrolyser manufacturers (under the ***European Clean Hydrogen Alliance***), with the result being the signature of a ***Joint Declaration*** under which the electrolyser manufacturers committed to increase electrolyser capacity **10 fold by 2025** (to **17.5 GW** of electrolyser manufacture a year). Deployment of this level of increased capacity would allow the ***EU*** to produce **10 million metric tonnes** of **Green Hydrogen** by **2030**, consistent with the ***REPowerEU*** policy settings announced by the ***EC*** in March (see **Edition** 37 of Low Carbon Pulse), and confirmed above.
- **Energy Bill**: On **May 10**, **2022**, as part of the Queens Speech (outlining the legislative agenda and program of the current UK Government), the Energy Bill was announced. Please see the Ashurst insight on the proposed Energy Bill.
- **Updated *EHB***:

  On **May 16**, **2022**, the **European Hydrogen Backbone** (***EHB***) unveiled revised plans to respond to the **REPowerEU**, with the revised plans detailed overpage.



Source: European Hydrogen Backbone

By way of reminder of the *EHB*: The following picks out from previous editions of Low Carbon Pulse the news items that demonstrate the pace at which thinking has developed around the ***EHB***, in turn reflecting the pace of the energy transition.

- On **April 5**, **2022**, the **European Hydrogen Backbone** (***EHB***) published a paper (entitled ***European Hydrogen Backbone – April 2022***) detailing the growth in the network (comprising the backbone necessary to facilitate the use of hydrogen) to meet the ***REPowerEU*** policy settings. Towards the end of April the ***EHB*** website launched a map function to detail the pipelines comprising, and to comprise, the ***EHB***.

- **Edition 37** of Low Carbon Pulse reported that in the context of the ***EHB***, what the ***REPowerEU*** means as a practical matter is that an additional **15 million metric tonnes** of hydrogen is now contemplated, which when combined with the **5.6 million metric tonnes** projected in **Fit-for-55** means that **20.6 million metric tonnes** of hydrogen is now contemplated **by 2030**, and infrastructure needs to be augmented and expanded and developed to accommodate the fourfold increase.
- **Edition 20** of Low Carbon Pulse (under **Backbone of hydrogen demand**) reported that:

  "**Headline:** On June 15, 2021, at the launch of the European Hydrogen Backbone (***EHB***) initiative, a report was released (***EBR***) providing a perspective on the likely size and shape of hydrogen demand by 2050. The headline is that demand for hydrogen could reach 45% of the levels of natural gas use in 2019, with final total energy consumption (***TEC***) of hydrogen equating to 2,300 TWh a year, book-ended by a low-side estimate of 2,150 TWh ***TEC***, and a high-side estimate of 2,750 TWh ***TEC***.

  Consensus arising: The ***EBR*** is consistent with "established thinking" that hydrogen has a crucial role to play as an energy carrier for use in the production of cement, chemicals and iron and steel. Across these Difficult to Decarbonise industries it is estimated that 1,200 TWh of energy will be used for high-heat temperature processes, and 200 Twh for medium to high-heat temperature use: hydrogen can be used as a high-heat temperature energy carrier, able to displace fossil, and other carbon intensive, feedstocks and fuels.

  In addition to use in these Difficult to Decarbonise industries, hydrogen will be used to power and to propel vehicles (particularly heavy goods vehicles / trucks) using ***FCT***. Further, it is stated that hydrogen will be used as a fuel to produce dispatchable electrical energy or, as noted in the next paragraph, Hydrogen Energy Carrier Storage (***HECS***) (up to 600 TWh)) and, in some countries, to heat buildings (up to 600 TWh), including through district heating.

  Efficiency in hydrogen use and storage: The ***EBR*** notes that while it would be possible for the ***EU*** and the UK to produce sufficient Green Hydrogen to satisfy this level of projected demand, this will require considerable investment in renewable electrical energy development. While production and supply of Green Hydrogen within the ***EU*** and the UK will fulfil some of the early policy setting thinking around energy security, it is likely to prove more expensive than sourcing Green Hydrogen from countries and regions with renewable energy sources better suited to the production of Green Hydrogen and, as a result, lower cost production.

  As noted in previous editions of Low Carbon Pulse, while hydrogen can be used to produce dispatchable energy, it will be interesting to see how this prospective use develops given thinking of policy settings and the thinking of development / policy banks: current trends reflect the view that hydrogen should not be used as a fuel for base load dispatchable energy, rather hydrogen (suited as it is to storage) is best used to provide ***HECS***. The ***EBR*** recognises the use of hydrogen for ***HECS*** in the context of use of hydrogen to produce dispatchable energy only, not to provide a fuel for base-load dispatchable energy."
- **Honing in on Northern Europe**:

  Each part of the ***EHB*** will have a local backbone. By way of illustration, the **Gasunie Hydrogen Backbone**.

- **North Sea Countries 65 by 2030 and 150 by 2050**: On **May 18**, **2022**, at the **North Sea Summit**, **Belgium**, **Denmark**, **Germany** and **the Netherlands**, consolidated their collective thinking around the development of off-shore wind field capacity development and Green Hydrogen production, with the **North Sea** the **Green Power Plant of Europe** – the thinking includes the development of **65 GW** of **OWF** capacity **by 2030** and **150 GW** of **OWF** capacity **by 2050**.

  For these purposes, each of the countries signed the **Esbjerg Declaration** (formally, **The Declaration of Energy Ministers on The North Sea as a Green Power Plant for Europe**).

ESBJERG DECLARATION - NORTH SEA OWF TARGETS			
Belgium: 8 GW by 2040	Denmark: 35 GW by 2050	Germany: 70 by 2050	The Netherlands: 21 GW by 2030

The positive reaction to the **Esbjerg Declaration** is best expressed by **CEO**'**s**:

- **Mr Mads Nipper** (**CEO** of **Ørsted**): "*It's an historic day, and the 150 GW offshore wind target is key to accelerating the transition to renewable energy. Add to that the ambitions of the UK, Norway, and other countries, and the North Sea will end up being THE power plant of Europe. To the benefit of our climate, our communities and our energy independence*".
- **Mr Roland Baan** (**CEO** of **Topsoe**): "*Witnessed history in the making at Esbjerg today, during the North Sea Summit. Heads of Government from Denmark, Germany, Belgium and the Netherlands took an enormous step toward reaching the EU's climate neutrality goal by co-signing a joint declaration that will make the North Sea a green powerhouse of Europe. Together, the four countries want to harvest at least 150 GW of offshore wind in 2050*".

Understandably, the coverage of the **Esbjerg Declaration** has been overwhelmingly positive. As noted above, it is important that in addition to progress being made in Europe towards achieving ***NZE***, that progress is made across the world, at an increasing pace.

- **Alliance Investment Management and CIP to assess feasibility of energy island**:
  - On **May 19**, **2022**, it was reported widely that **Allianz Investment Management** (**AIM**, global asset management and diversified insurance company based in the US) and **Copenhagen Infrastructure Partners** or **CIP** (global leading renewable energy investor and sponsor) had agreed to conduct a feasibility study to determine how to build an **energy island** in the **German sector** of the North Sea. As with other energy / power islands, off-shore wind field turbines will be connected to the energy / power island, with the electrical energy used both to power electrolysers to produce Green Hydrogen, then piped to northern Europe, and to dispatch electrical energy to northern Europe.
  - On **May 20**, **2022**, rechargenews.com reported that **CIP** intended to develop **BrintØ Island** (or Hydrogen Island) in the **Danish sector** of the North Sea, in the area of **Dogger Bank**, located on an extensive sandbank. As reported **BrintØ Island**, would locate Green Hydrogen production facilities, powered by renewable electrical energy from up to **10 GW** of OWF capacity, with production capacity of up to **1 million metric** tonnes of Green Hydrogen a year.

ENERGY / POWER ISLANDS IN THE NORTH SEA		
AquaVentus – Helgioland Island – Equinor, RWE and Shell	NorthH2 – Gasunie, Groningen Seaports and Shell	BrintØ Island: CIP

By way of reminder: Previous editions of Low Carbon Pulse have reported that:

CURRENT PLANNED DEVELOPMENT OF OFF-SHORE WIND			
North Sea Energy Island – 3 GW – ATP & Partners and Ørsted	Baltic Sea Energy Island – 2 GW – To be awarded	Hesselo (Baltic Sea) – up to 1.2 GW - To be awarded	North Sea Thor – 1 GW

- **Edition 5** of Low Carbon Pulse (under **Greenlights for New Green Islands**) reported that:

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

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

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

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

- **Editions 5**, **8**, **9**, **27**, **32**, and **39** of Low Carbon Pulse have reported on the green energy / power islands to be developed in the Baltic and North Seas.

- **All is well in the Kingdom of Denmark and beyond:**
  - **Topsoe (previously Haldor Topsoe)**: On **May 23**, **2022**, h2-view.com reported that **Topsoe** (leading electrolyser technology corporation) is to develop an electrolyser giga-factory capable of manufacturing up to 5 GW electrolyser capacity. It is understood that the giga-factory will manufacture solid-oxide electrolyser cells (SOEC) electrolysers (see **Edition 37** of Low Carbon Pulse and Reference Materials below for explanation of SOEC electrolyser technology.)

In addition to **Topsoe**, the consortium comprises, **Aalborg Airport**, **Aarhus Airport**, **Aarhus Havn** (Port of Aarhus), **AAU Energy**, **Alfa Lava**l, **A.P**. **Moller** – **Maersk**, **COWI**, **Crossbridge Energy**, **DLR**, **Energy Cluster Denmark**, **GreenFuelHub**, **SkyNRG** and **Steeper Energy**.

- ***TES-Wilhelmshaven project* continues to accelerate**: On **May 25**, **2022**, the ***TES-Wilhelmshaven project*** was given priority project status by the German Federal Government. The priority project status was conferred by the Acceleration Law (reported in **Edition** **39** of Low Carbon Pulse).

  By way of reminder:

  - **Edition** **39** of Low Carbon Pulse (under ***TES* Fast-tracks**) reported that ***TES*** (a green hydrogen corporation, reported on in **Editions** **36** of Low Carbon Pulse) was reported to be "fast-tracking" the development of a **green hydrogen hub** at **Wilhelmshaven** in Northern Germany (the ***TES-Wilhelmshaven project***).

    "Clean hydrogen will be used as a bridging fuel in the early years. By 2030, there will likely be a 50:50 split between clean and green hydrogen. In the initial phase, 25 [TWh a year] of green methane, from which more than half a million [metric tonnes] of [clean] hydrogen can be produced, will be imported into Wilhelmshaven. That will increase to 250 TWh [a year] and more than 5 million metric tonnes of hydrogen in a final stage. The green hydrogen will be produced using exclusively renewable sources, mainly solar in several cased wind or hydroelectricity [or both]."

  - **Edition** **37** of Low Carbon Pulse included a map-graphic outlining the plans of **TES** in visual form, for ease of reference a link to the map-graphic is included. As will be apparent from the map-graphic, clean hydrogen will be sourced from the Middle East, ***CO_2*** will be captured and shipped to the Middle East, the ***CO_2*** will be combined with hydrogen to produce green methane, which is then liquified, with the green ***LNG*** shipped to Germany. As reported, the ***TES-Wilhelmshaven project***, on full development, will comprise **six berths**, and **eight** on-site **storage tanks**, with combined storage capacity of **1,600,000 m^3**.

    On **April 25**, **2022**, ***TES*** announced that it was running an open-season process to fast-track the import of ***LNG*** to its ***TES-Wilhelmshaven project***. It is understood that under the first phase of open-season process non-binding expressions of interest are sought. The second phase will involve binding commitments, with third phase involving conclusion of the binding commitments.

Americas:

*This section considers news items that have arisen within the news cycle of this **Edition 40** of Low Carbon Pulse relating to the US, Brazil, Canada, and Mexico, being countries that give rise to the second, sixth, ninth and eleventh most **GHG** emissions.*

- **Load matched by 100% renewable electrical energy:** On **May 2**, **2022**, it was reported widely that between **2.45 pm** and **3 pm** on **April 30**, **2022**, the electrical energy load of the US State of California was matched by the dispatch of electrical energy sourced from renewable electrical energy sources. This was a first for California: load was **18 GW** and renewables electrical energy was **18.6 GW**.

  As reported in previous editions of Low Carbon Pulse, this is not the first time that 100% of a load has been matched by renewable electrical energy, but it is the first time that this has occurred across a grid the size of the Californian grid.

- **Battery funding:** On **May 2**, **2022**, the US Department of Energy (***DOE***) announced **USD 3.1 billion** of funding support under the ***Battery Materials Processing and Battery Manufacturing*** initiative and **USD 60 million** of funding support under ***Battery Manufacturing and Electric Drive Vehicle Battery Recycling and Second Life Applications*** initiative.

  These initiatives are provided for under the ***Infrastructure Investment and Jobs Act*** (***IIAJA***) also known as the Bipartisan Infrastructure Law (***BIL***). In addition to funding for these initiatives, the ***BIL*** provides for funding support of **USD 7.5 billion** for electrical vehicles charging infrastructure, **USD 5.5 billion** for electric buses, and **USD 5 billion** for clean and electric school buses. The ***BIL*** funding support is intended to accelerate the development of the supply chain for electrical vehicles in the US.

  As noted in previous editions of Low Carbon Pulse, there is USD 8 billion to provide support for **at least four hydrogen hubs** that are able to demonstrate that their development and deployment will contribute to production of clean hydrogen and to multiple uses of that clean hydrogen.

- **CCS funding:** On **May 5**, **2022**, the US ***DOE*** announced more than **USD 2.3 billion** of funding support for three initiatives to support the abatement, reduction and storage of ***CO_2*** emissions.

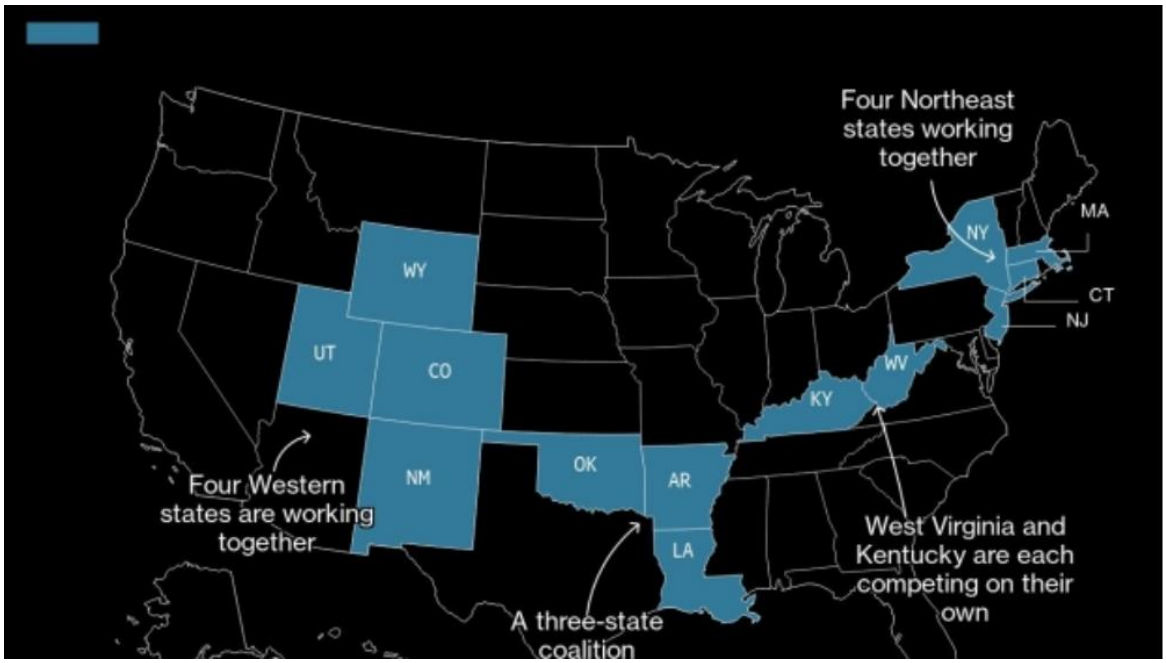
  First, **USD 2.25 billion** (under the ***BIL***) to accelerate carbon storage projects – ***BIL***: ***Storage Validation and Testing (Section 40305): Carbon Storage Assurance Facility Enterpricse (CarboSAFE) Initiative: Phases II,II.5 and IV***;

  Secondly, **USD 45** million to increase the number of ***CO_2*** storage sites – ***CarbonSAFE: Phase II -Storage Complex Feasibility***; and

  Thirdly, **USD 46** million to develop technology to remove, capture, convert and store ***CO_2*** – ***Carbon Management***.

- **California joins the hubbub**: On **May 18**, **2022**, the **State of California** announced its intention to seek funding support from the ***BIL*** to establish a renewable hydrogen hub in the State of California.

  California joins the States detailed in the following map in seeking Federal funding for a hydrogen hub.



Source: Fuelcellsworks

By way of reminder: Hubbub among the States:

- **Edition 35** of Low Carbon Pulse reported that the US ***DOE*** had "gone-live" on the implementation of the ***Infrastructure Investment and Jobs Act*** (***IIAJA***) also known as the ***Bipartisan Infrastructure Law*** (***BIL***). Going live involves rolling-out the initiatives in the ***IIAJA***. The largest hydrogen program in the ***IIAJA*** provides the US ***DOE*** with USD 8 billion to provide support for **at least four hydrogen hubs** that are able to demonstrate that their development and deployment will contribute to production of clean hydrogen (being hydrogen that gives rise to less than 2 kg of CO_2 for each 1 kg of hydrogen produced) and to multiple uses of that clean hydrogen. The ***IIAJA*** prescribes that at least one hydrogen hub will use fossil fuel feedstock to produce hydrogen, one will use renewables and one will use nuclear.
- **Edition 36** of Low Carbon Pulse reported (under ***Mountain States Hub***) that **Colorado, New Mexico, Utah** and **Wyoming** had signed a memorandum of understanding to develop a regional clean Hydrogen Hub, and in so doing, position more effectively to seek funding from the ***Infrastructure Investment and Jobs Act*** (***IIAJA***).
- **Mississippi States Hub: Arkansas, Louisiana and Oklahoma** are reported to be progressing with a like initiative to create a bipartisan three-state bloc to develop a **regional clean Hydrogen Hub**.
- **West Virginia gets in first:** On **March 22, 2022**, it was reported widely that the State of West Virginia, through the ***West Virginia Hydrogen Hub Coalition*** had submitted a proposal to the US ***DOE*** seeking funding to develop a hydrogen hub in the State.
- **Northeast Hydrogen Hub:** On **March 24, 2022**, the Governor of New York State, Ms Kathy Hochul indicated that New York, together with Connecticut, Massachusetts and New Jersey, and 40 hydrogen ecosystem partners, were combining for the purposes of seeking to become one of at least four regional clean hydrogen energy hubs.

For the **Mountain States Hub**, **Mississippi States Hub**, **West Virginia Hydrogen Hub** and **Northeast States Hub**, the development of a Hydrogen Hub represents an opportunity to take advantage of their natural advantages.

- **Extension to deadline for Civil Nuclear Credit Program**: While nuclear energy is not a key focus of the Low Carbon Pulse, Low Carbon Pulse does nevertheless covers material and significant development and support programs. On **May 19**, **2022**, the US ***DOE*** announced the extension of the deadline for applications for credit support under the **Civil Nuclear Credit Program** (established under the ***BIL***) to **July 5**, **2022**: the **Civil Nuclear Credit Program** is intended to allow nuclear reactors, that may otherwise cease operation, to continue to operate.

France and Germany:

*This section considers news items within the news cycle of this **Edition 40** of Low Carbon Pulse relating to France and Germany.*

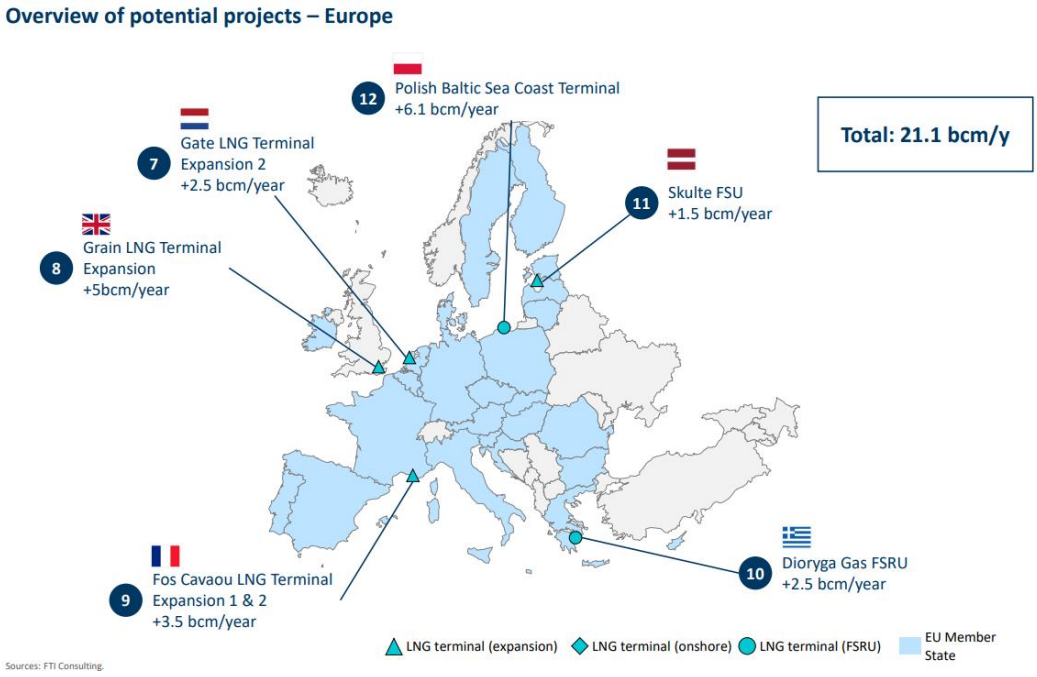
- **A progress check on FSRUs**: **Editions 37** and **39** of Low Carbon Pulse reported on the procurement of floating storage regasification units (**FSRUs**) across Europe so as to address energy security concerns by allowing the import of liquified natural gas (**LNG**). As at the end of May 2022, the situation is as follows:
  - **Germany chartering four FSRUs:** On **May 5**, **2022**, German Federal Government Economic Minister, Mr Robert Habeck announced that the **German Federal Government** had committed to charter **four FSRUs**, a commitment of **€2.04** billion (**USD 3** billion) to allow the import of sufficient LNG to provide 20% of the demand for natural gas in Germany;
  - **Gasunie chartering FSRUs**: On **May 10**, **2022**, it was reported widely that **Gasunie** (energy network operator in the Netherlands and Northern Germany) had agreed to charter an FSRU from **New Fortress Energy** to allow the import of LNG at the **EEM Energy Import Terminal**.

    The charterparty with **New Fortress Energy**, follows the charterparty signed with **Exmar** at the end of April 2022.

Both FSRUs are scheduled to arrive at Eemshaven, Groningen, the Netherlands, in August 2022. **Gasunie** subsidiary, **EeemsEnergy Terminal BV** is expanding its **EEM Energy Import Terminal**.

- **Gasrid chartering FSRU**: On **May 20**, **2022**, marinelink.com reported that **Gasgrid Finland Oy** (the Finnish state-owned natural gas transmission system operator) had entered into a 10 year charterparty with **Excelerate Energy** (a leading owner of FSRU's) to allow the import of LNG for regasification to provide natural gas to the **Baltic Sea Region**, including **Finland** and **Estonia**. In addition, Estonia plans to develop an on-shore LNG receiving and re-gasification terminal at Paldiski; and
- **Lithuania Klaipeda FSRU**: **Latvenergo** (Latvia's energy corporation) has indicated that hopes to import LNG through the Klaipeda FSRU. In addition, Latvia has indicated an intention to develop an on-shore LNG receiving and re-gasification terminal at the Port of Skulte.

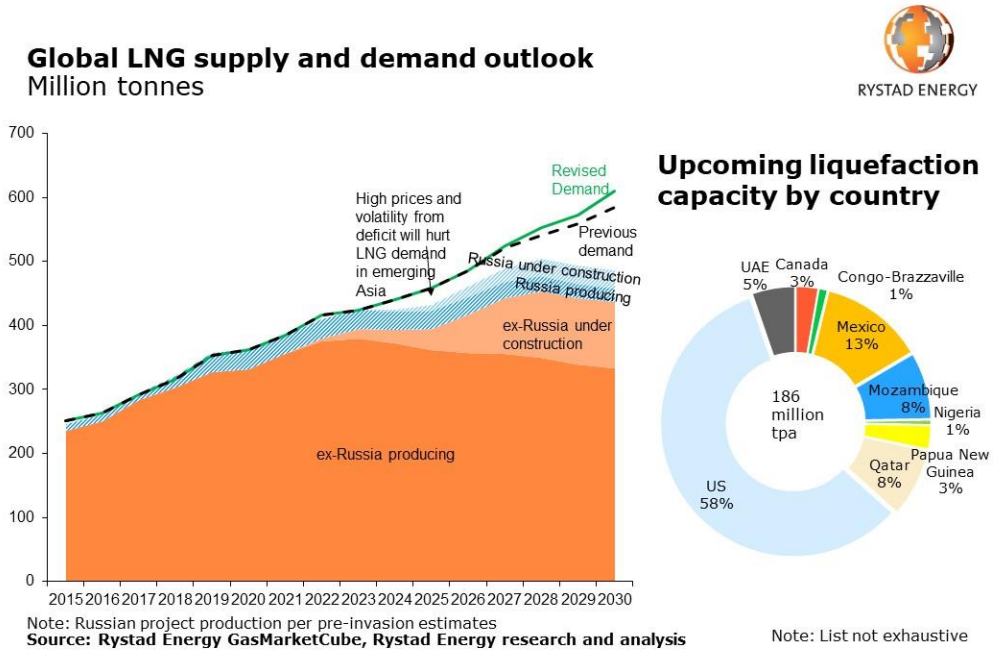
By way of background, the following map illustrates the current LNG importation terminals and regasification and send-out facilities across Europe and the UK:



Source: Global LNG Hub

- **LNG demand curve above supply curve:** On **May 9**, **2022**, the excellent folk at **Rystad Energy** published an excellent article - ***A perfect and unavoidable storm: LNG supply crisis to make landfall in winter 2022***. The title of the article says it all, but the article is well-worth a read.

  Looking past the headline and the winter of 2022, the article includes the following info-graphics in respect of Global LNG supply and demand outlook.



As noted in previous editions of Low Carbon Pulse and sibling publications (see ***The Future of LNG and Natural Gas Infrastructure***) for some time, natural gas, in the form for LNG, is key to both electrification in many countries, and to energy transition.

The critical point to note is that natural gas is not instead of renewable electrical energy, it is to bridge the gap to energy systems with ever-increasing renewable electrical energy capacity. The policy settings introduced by the German Federal Government in the last three months have demonstrated this duality perfectly.

- **France and Ireland committed to HVDC:** On **May 23**, **2022**, the irishexaminer.com reported that approval had been given for the development of the **Celtic Interconnector** allowing for the exchange of electricity between France and the Republic of Ireland using a **€1 billion 575 km subsea-cable**, from the coast of **Brittany** to the coast of **Cork**.

Australia:

*This section considers news items that have arisen within the news cycle of this **Edition 40** Low Carbon Pulse relating to Australia, a top-twenty **GHG** emitting country, and a developed country with the highest **GHG** emissions per capita. Australia is however progressing to **NZE** at a faster rate than many other developed countries, and, along with the GCC Countries, is one of four countries rich in solar resources (and wind resources) that appear likely to lead in the development of the hydrogen economy over the next five years (and beyond): Australia, Chile, the **PRC** and Spain.*

- **Three consortiums short-listed on Central-West Orana**: On **May 4**, **2022**, the **State Government of NSW** announced the short-listed tenderers to develop the **Central-West Orana REZ**.

  As announced, the short-listed consortiums are:

  1. **ACE Energy**, comprising Acciona, Cobra and Endeavour Energy;

  2. **Network REZolution**, comprising APA Group, CPB Contractors, Pacific Partnerships, and UGL; and

  3. **NewGen Networks**, comprising Elecnor, Essential Energy, Plenary Group, and Secure Energy.

  As stated by the **State Government of NSW**, the next step in the process will involve **Energy Corporation of NSW** inviting the short-listed consortiums to respond to a request for proposal, with contract award during 2023.

  By way of reminder: **Editions** 30 and 34 of Low Carbon Pulse has reported on the renewable energy zone (***REZ***) initiatives of the State Government of New South Wales, Australia as follows:

  - **Edition** 30 reported that**:**

    "**Edition** 4 of Low Carbon Pulse reported in the plans of the New South Wales Government to promote the development and deployment of renewable electrical energy in the State of New South Wales (***NSW***).

    Edition 26 of Low Carbon Pulse reported on the level of interest in ***New England Renewable Energy Zone*** or ***New England REZ***.

    "On November 1, 2021, it was reported widely that the NSW Government has invited registrations of interest for its third renewable energy zone (***REZ***) – the ***South West REZ***.

    There are three more ***REZs*** to come to market, the ***Illawarra REZ*** and the ***Hunter-Central Coast REZ***. Please click here to view the NSW Government's electricity roadmap.

NSW REZS – THE STORY SO FAR …	
Central West Orana REZ – interest expressed by the private sector to develop 27 GW of renewable electrical energy capacity	**New England REZ** – interest expressed by the private sector to develop 34 GW of renewable electrical energy capacity

    On November 11, 2021, pv magazine, reported that Australia's first coordinated renewable energy zone is to be built in the central west of NSW, the ***Central-West Orana REZ***.

    The ***Central-West Orana REZ*** will deliver up to 3 GW of renewable electrical energy into the grid. The development of the ***Central-West Orana REZ*** is aligned with the NSW Government policy setting of the development and deployment of 12 GW of renewable electrical energy and 2 GW of BESS by 2030.

    It is understood that the ***Central-West Orana REZ*** was preferred as the first ***REZ*** to be developed because of the level of investment in renewable electrical energy development already underway in the Central-West region.

    It will be interesting to follow the development of the NSW ***REZ*** initiative as Australia's most populous State progresses to the development and deployment of 12 GW of renewable electrical energy capacity across the State (see **Edition** 4 of Low Carbon Pulse)".

  - **Edition** 34 reported that

    South West REZ **interest: Edition** 30 of Low Carbon Pulse reported that:

    "On February 4, 2022, the NSW Government reported that it had received registrations of interest (ROI) for the ***South West REZ*** in respect of 34 GW of renewable electrical energy capacity.

    The CEO of the Energy Corporation of NSW, Mr James Hay said that the level of ROIs received from industry was "outstanding". Mr Hay said that: "There were 49 registrations totalling over 34 GW from potential generation and storage projects – 13 times the intended capacity for the South-West REZ, which will be no less than 2.5 GW".

    Low Carbon Pulse has noted on a number of occasions, that the States and Territories of Australia continue to blaze a trail to ***NZE***. This is another instance of this trail blazing, noting always, that the private sector is key to the continued progress to ***NZE***.

- **Port of Rotterdam Authority and State of Queensland align**: On **May 20**, **2022**, the **Queensland Minister of Energy**, **Renewables** and **Hydrogen**, **Mr Mick de Brenni** signed a memorandum of understanding (***MOU***) with the **Port of Rotterdam Authority** (**PORA**). Under the ***MOU*** the **State of Queensland** and **PORA** agree to work together to develop a hydrogen and hydrogen-based fuels supply chain.

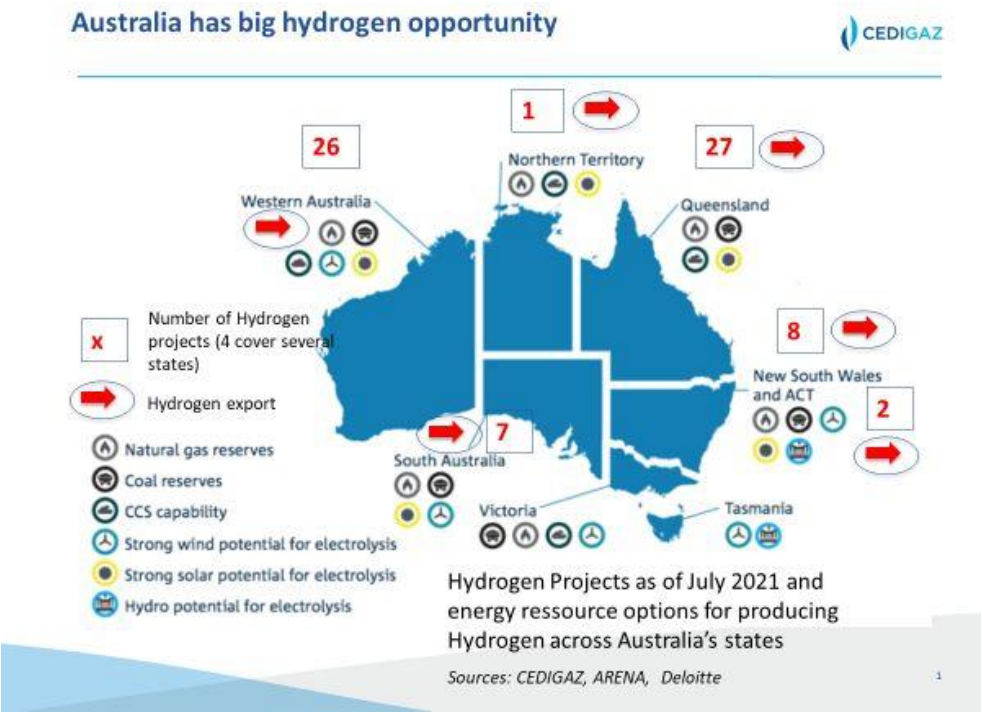
- **New Australian Federal Government**: On **May 21**, **2022**, the **Australian Labor Party** (**ALP**) was elected to form the new **Australian Federal Government**. The **ALP** stood for election on the basis of more detailed and progressive policy settings than that the Liberal and National Party government it replaces, critically a ***43%*** reduction in ***GHG*** emissions **by 2030**.
- **Monash University article on critical minerals**: On **May 24**, **2022**, monash.edu published an article outlining the critical minerals present in abundance in Australia, and that are yet to be mined so to make the most of those resources. The article notes that Australia has the world's largest deposits of **nickel**, **rutile**, **tantalum** and **zircon**, and has top five resources for **antimony**, **cobalt**, **copper**, **lithium**, **niobium** and **vanadium**. The thesis of the article is that the private and public sector needs to work more closely to maximise the opportunities for Australia, and globally.
- **Australia and Germany likely to accelerate hydrogen chain development**: On **May 27**, **2022**, Reuters (under ***Germany looks to speed up green hydrogen development in Australia***) reported that Germany wants to speed up the development of the Green Hydrogen value chain between **Australia** and **Germany**. As has been reported in previous editions of Low Carbon Pulse and this **Edition 40**, Germany will not have domestic supply capacity to satisfy its domestic demand for Green Hydrogen.

  As reported in innovationaus.com Dr Christine Falken-Grosser, a German hydrogen delegate, addressed the **National Hydrogen Conference** (in Adelaide, South Australia) on **May 31**, **2022**. This may be regarded as the culmination of the visit to Australia of a 35-member delegation to Australia (taking in the states of New South Wales, Queensland, South Australia and Western Australia). The trip by the 35-member delegation is part of the **HySupply** initiative. The delegation was led by the Federal German Government Minister of Education and Research, Ms Bettina Stark-Watzinger.

  By way of reminder: In **June 2021**, **Australia** and **Germany** signed a bilateral alliance agreement (***BAA***), a bilateral trade agreement (of sorts), relating to hydrogen production, and trade in hydrogen, and the facilitation of a renewable energy-based hydrogen supply chain between the two countries.

  The ***BAA*** recognises the commitment of Germany to the development of sources of Green Hydrogen supply to match the demand that it is anticipating will develop in response to its policy settings, and the position of Australia as a prospective supplier of Green Hydrogen (see **Edition** **20** of Low Carbon Pulse). The initiative has been badged **HySupply**.

  The info-map-graphic over the page provides a snap-shot of the scope for hydrogen production in Australia.



- **Microsoft Blue Print for Australia**: During **May 2022**, **Microsoft** published ***Accelerating the Journey to Net Zero – A Blue Print for Australia***. The publication provides a helpful overview of the progress that needs to be made in Australia.

Blue and Green Carbon Initiatives and Biodiversity

*This section considers news items that have arisen within the news cycle of this **Edition 40** Low Carbon Pulse relating to the Blue Carbon and Green Carbon initiatives and Biodiversity.*

- **May 22**, **2022**, was **Biodiversity Day**. **Biodiversity Day** is intended to increase awareness of the benefits of **biodiversity** and the importance of preserving **biodiversity**. In the broadest sense, **biodiversity** describes the variety of the fauna and flora globally, and in any particular area. At the highest level, **biodiversity** is important. The preservation of **biodiversity** is therefore a key policy setting. In this context, human activities and the clearing of land to undertake agricultural, forestry or other land use (**AFOLU**) is a key focus of policy settings. Desertification

and deforestation are key concerns (both as a result of **AFOLU**), as is the broader impact of climate change on habitats, critically, the impact on change in temperature on land and in the ocean.

There is a balance in habitats, with eco-systems that have developed overtime, and that continue to develop. The balance of habitats and their eco-systems are impacted by **AFOLU** and climate change. There are many examples, but a consistent example (that many will recognise) is the need to preserve the habitats of bees and other pollinators, and to avoid loss of bees and other pollinators. As a policy setting, the rewilding of habitats is one element of preservation, and, in some cases, restoration of eco-systems. As a broad statement, preserving wilderness areas, and rewilding of areas, and reducing old growth forestry, and afforestation and reforestation, are key to the preservation and restoration of **biodiversity**. These are policy settings over which we have control in the near, medium and long term. In addition, overtime, policy settings may extend to addressing optimal use of land, optimal in the sense of preserving or restoring **biodiversity** while at the same time addressing climate change. As always, what is needed is known. As always, the challenge is acting upon it.

Climate change will impact the effectiveness of these policy settings (in particular coastal habitats, and areas of increased drought and desertification, driven by rising sea-levels and changes in weather patterns, as a result of climate change), but they are policy settings that are necessary and need to be progressed in the near term. In addition, acting to preserve and to restore **biodiversity** is likely to yield benefits, economic and social.

As noted by the **UNEP**:

> "*Healthy, biodiverse eco-systems sustain life on Earth by providing air, wate and other essential elements. From forests to farmlands to oceans, the planet's eco-systems are the basis of resources, services and industries*".

Existing impact: It is widely understand that **75%** of the Earth's **land** and **66%** of its **oceans** have been altered by human activity, with associated impact on eco-systems. It is against this background that there is considerable anticipation of **Part 2** of the **15th meeting** of **the Conference of Parties** (***COP-15***) to the ***Convention on Biological Diversity*** (**CBD**) to be held in Kunming, **PRC**, "tentatively scheduled" for between **August 29** and **September 9**, **2022** (**Part 1** of ***COP-15*** took place virtually form **October 11** to **15**, **2021**).

COP-15 will review the achievement and delivery on the ***CBD Strategic Plan for Biodiversity 2011 – 2020***. Also it is anticipated that conclusions will be reached in respect of the **post-2020 global diversity framework**.

Previous editions of Low Carbon Pulse: **Editions** 32, 33, and 34 of Low Carbon Pulse provide detailed consideration of biodiversity in all its facets.

- "**The best time to plant a tree was 20 years ago. The second best time is now**": Ahead of Biodiversity Day on **May 22**, **2022**, **UN Biodiversity** shared a number of actions that would assist in the preservation, and contribute to restoration, of biodiversity. These actions are contained in the publication ***22 Actions for Biodiversity***.

Bioenergy and heat-recovery:

*This section considers news items that have arisen within the news cycle of this **Edition 40** of Low Carbon Pulse relating to bioenergy, being energy, whether in gaseous, liquid or solid form, derived or produced from biomass. **Bioenergy** includes any energy derived or produced from biomass (organic matter arising from the life-cycle of any living thing, flora or fauna, including from organic waste streams), whether in gaseous, liquid or solid form.*
In addition, recovered heat and waste heat (derived from any source, including waste water) has been added to this section.
*From recent activity and reporting, it appears likely that the avoidance of waste heat energy, and the recovery of waste heat energy will become a priority under the first pillar as a part of Energy Efficiency (**IEA**) and Energy conservation and efficiency (**IRENA**). By some estimates, up to 67% of energy arising is wasted. The increased awareness of sourcing heat reflects increased awareness of the energy used to heat buildings, and its source: heating buildings results in around 25% of total final energy demand, with around 75% of the feedstock used to satisfy that energy demand derived from fossil fuels.*

- **Anaergia commissions first of seven**: On **May 3, 2022**, **Anaergia** (clean energy producer using waste as a resource) announced that it had commissioned its **Easy Energia Ambiente** facility in **Pontinia, Italy**. The **Easy Energia Ambiente** facility will process organic waste to derive biogas, which will then be upgraded (by the removal of ***CO_2*** and ***CO***, and trace compounds) to produce **biomethane** or **renewable natural gas** (**RNG**). The **biomethane** will be injected into the gas pipeline network. It is understood that the **Easy Energia Ambiente** facility is the first of seven facilities to be commissioned during 2022.
- **Up to USD 2 billion committed to RNG**: On **May 12**, **2022**, S&P Global reported that:
  - **Waste Management** (US' largest waste management corporation) is to invest **USD 825** million to develop and to deploy **RNG** plants at **17** landfills across the US; and
  - **Republic Services** (US solid waste disposal company), with biofuels corporation, **Archaea Energy**, announced a **USD 1.1 billion** joint venture to develop and to deploy **39 RNG** plants across the US.

  It is estimated that there are around **2,300** biogas projects across the US, with over **2,000** deriving biogas and firing that **biogas** at site to generate electrical energy. Around **300** biogas project process the **biogas** to upgrade it to **biomethane** or **RNG**.

  By way of reminder: **Edition** 39 of Low Carbon Pulse under (***NREL* on top of biogas potential:**) reported that the US **NREL** (the **National Renewable Energy Laboratory** of the US Department of Energy) has published ***Biogas Potential in the United States (Fact Sheet), Energy Analysis***. The headline is the ***CH4*** that could be derived and produced from waste that would otherwise be landfilled, animal manure, wastewater, and organic waste streams from commercial, industrial and commercial sources is estimated to be sufficient to provide 9% of the natural gas demand of the US. The by-product of the production of biogas is digestate, which is can be used, in processed form, as a fertiliser.

BIOENERGY

Biogas and **Synthetic Gas** (or **Syngas**): arises as a result of: (**a**) the decomposition of organic material (in an oxygen free or scarce environment, explained in **Chapters 5** and **6** of the Ashurst Waste Compendium), consisting of between 60 to 70% ***CH_4*** and 30 to 40 % ***CO_2***, with other compounds and elements in gaseous form, ammonia (***NH_3***), hydrogen sulphide (***H_2S***) and nitrogen (***N_2***), and water vapour; or (**b**) the thermo-chemical treatment of organic matter to derive **Biogas**.

Biomethane: is **Biogas** that has been processed and scrubbed (referred to as "upgrading") so that it can be used as pipeline gas (i.e., complying with the specification for hauling through the applicable natural gas pipeline, including the removal of ***CO_2***, and other compounds and elements, such that the gas hauled through the pipeline is ***CH_4***). **Biomethane** is a **Biofuel**.

Biogas and **Biomethane** can be used as a fuel (typically, as a gas that is combusted / oxidised to produce electrical energy or heat energy or both) or as a feedstock. Also either may be referred to as **Renewable Natural Gas** (or ***RNG***), or in compressed form, as compressed natural gas (or ***CNG***) and in liquified form as **Bio-LNG** or, less frequently, **Renewable LNG**.

Biofuel is a fuel derived or produced from **Biomass**, whether in gaseous, liquid or solid form. In addition to **Biogas** and **Biomethane**, for example, wood products (gaseous and solid biofuels), the following may be regarded as the most prevalent **liquid biofuels:**

- **Bio-ammonia:** being ammonia that is derived or produced using H_2 derived from a renewable source that is then combined with N to produce the compound NH_3;
- **Bio-butanol:** being butanol (i.e., a synthetic alcohol) that is derived or produced from the microbial fermentation of carbohydrates (typically from corn and from agricultural waste), and is similar to motor spirit, and as such may be used as a fuel for internal combustion engines. (It is a drop-in fuel.)
- **Bio-diesel:** being diesel (i.e. synthetic paraffinic compound) that is produced typically using transesterification of animal fats and vegetable oils;
- **Bio-ethanol:** being ethanol (i.e., synthetic alcohol) that is derived or produced the microbial fermentation of carbohydrates (including from corn and sugarcane, and lignocellulosic biomass);
- **Bio-kerosene:** being kerosene (i.e., synthetic paraffinic compound and another kind of methyl ester) that is derived or produced from animal and vegetable oils (containing fatty acids);
- **Sustainable** or **Synthetic Aviation Fuel** (***SAF***), is a synthetic paraffinic kerosene. Currently most SAF is derived or produced from used animal fats and cooking oil and from the gasification of other organic waste streams (typically using some natural gas). As noted below, typically fatty acids and hydrogenated acids are used to produce synthetic paraffinic kerosene. If the feedstock is sourced from Biomass it is a Bio-kerosene;
- **Bio-LNG:** being Bio-methane that is liquified at a temperature of -161°C, with the liquified Bio-methane 1/600th the volume of gaseous Bio-methane; and
- **Bio-methanol:** being methanol (i.e., produced from CO_2 (captured or derived) and H_2 derived from Biomass) that is derived or produced from biochemical (fermentation) or thermochemical (including gasification and pyrolysis) technologies.

A **Biofuel** is an **E-Fuel** (an **electro-fuel**) if the electrical energy used to produce it is sourced from a renewable source. Hence the use of **E-Diesel**, **E-Ethanol**, **E-Kerosene**, **E-LNG** and **E-Methanol**.

- **Biomethane Action Plan for the EU**: On **May 18**, **2022**, as part of the ***REPowerEU Plan***, the ***EU*** proposed a ***Biomethane Action Plan***, with the objective of producing **35 billion cubic metres** (***BCM***) of **biomethane** by **2030**.

  The increased derivation and production of **biogas**, and its processing to upgrade it to produce **biomethane** will require the scaling up the value chain to ensure that sufficient **biomass** (of appropriate specification) is collected to allow the derivation and production of **biogas**.

  For these purposes, a **Biomethane Industrial Alliance** is proposed by the ***EU*** as an essential means of steering cooperation between policy makers and investors and participants in the industry. This will promote the development of assured supply and the delivery of that supply via new and repurposed infrastructure. Funding support from the ***EU*** will be essential, as will long-term policy settings from the ***EU***, including ***REDIII***.

BESS and HESS (and energy storage):

*This section considers news items that have arisen within the news cycle of this **Edition 40** of Low Carbon Pulse relating to battery electric storage systems (**BESSs**) and hydrogen energy storage systems (**HESSs**). In addition to **BESSs** and **HESSs**, other forms of energy storage systems are covered, including use of compressed air energy storage (**CAES**) and pumped storage. In this context, long duration energy storage (**LDES**) is considered, being energy technology that is able to allow the off-take electrical energy out of storage for a duration of more than four hours. In the brave new world described in **Edition 13** of Low Carbon Pulse: "**BESS** storage of 10/12/24 hours is being contemplated for business users, and up to 72 hours for telecommunications companies, including to guard against the consequences of land-borne weather events".*
*The **November and December Report on Report** provides a summary of the LDES Council and McKinsey report from November 2021* (see **Second Compendium of Low Carbon Pulse**

- **Maoneng continues roll-out of *BESS*:** On **May 2**, **2022**, it was reported widely that **Maoneng** (renewable energy project developer) proposes to develop the **Merriwa Energy Hub** in the **Hunter Region** of **New South Wales**, **Australia** (located 180 kms north-west of Newcastle on the coast of New South Wales).

As reported the **AUD 1.6 billion Merriwa Energy Hub** will comprise a **550 MW** photovoltaic solar farm (1.3 million bifacial solar panels over 780 hectares) and a **400 MW** / **1,600 MWh** ***BESS***. Cannily, given the location of the **Merriwa Energy Hub**, it appears intended to provide grid integrity and stability, and to be consistent with the policy settings of the state Government of New South Wales.

- **Powin Energy powers on and up:** On **May 4**, **2022**, it was reported widely that **Powin Energy** (an energy storage solutions, and systems integration, corporation) is to supply **120 MW** / **524 MWh** of ***BESS*** capacity to Idaho Power.

  By way of reminder: Edition 39 of Low Carbon Pulse (under **O2 Power and Powin Energy aligned**) reported "that **O2 Power** (renewables corporation, backed by Singapore's **Temasek** and Sweden's **EQT** (a global private equity firm) and **Powin Energy** were to work together to advance the development and deployment of ***BESS*** across India".
- **The Future of Energy Storage**: In **May**, **2022**, the **MIT Energy Initiative** published ***The Future of Energy Storage***. As might be expected, the publication is excellent. The publication outlines each of the four basic means of energy storage, electrochemical, mechanical, thermal and chemical. The publication outlines the bases upon which energy storage will develop to store electrical energy generated from variable renewable energy (**VRE**) sources, and it provides modelling of energy storage and outlines the governance and operation of energy systems.
- **Compressed Air Storage preferred for Broken Hill**: On **May 27**, **2022**, it was reported widely that a compressed air storage solution had been chosen to provide back-up electrical energy supply at Broken Hill, New South Wales, Australia. **Hydrostor** (a Canadian headquartered corporation) with a proprietary technology – advanced compressed air energy storage (**A-CAES**). The **A-CAES** is a long duration energy storage (**LDES**) system capable of dispatching stored energy to the grid, and to help address the capacity constraints across the grid regionally.

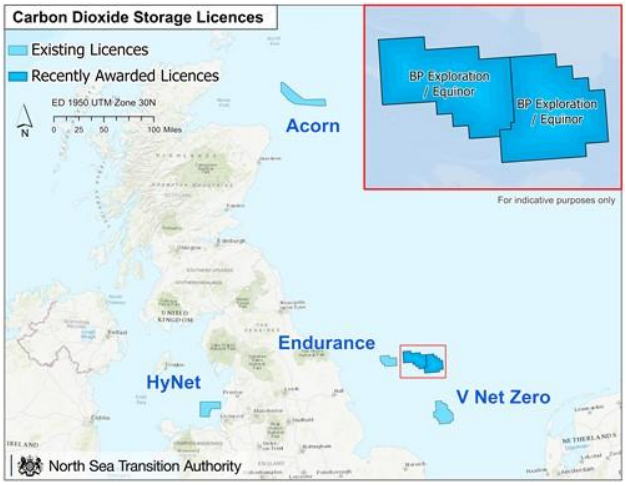
  By way of reminder: **Editions 20** and **21** of Low Carbon Pulse reported on the storage of energy using compressed air technology, and **Edition 31** reported as follows:

  > "On November 24, 2021, it was reported widely that **Hydrostor** is contemplating the development of a USD 800 million 400 MW / 3200 MWh LDES CAESS. The **Hydrostor** business model and technology involves the compression of air using off-peak, and surplus electrical, energy from the grid, to derive heat and to compress air (with the compressed air stored at a constant pressure), with compressed air and heat recombined to produce energy to drive a turbine to produce electrical energy for dispatch to the grid.
  >
  > As noted in previous editions of Low Carbon Pulse, the vital statistics of 400 MW / 3,200 MWh mean that the contemplated LDES CAESS will be able to supply 400 MW of electrical energy for up to 8 hours. **Hydrostor** is reported to have applied to the Californian Energy Commission, with the intention to commence commercial operation of the LDEC CAESS by 2026."
- ***HESS* happening**: On **May 30**, **2022**, it was reported widely that **UK Energy Storage Ltd** (**UKEn**) intends to develop an **Energy-Hub** located across two sites in **Portland**, **Dorset**, **United Kingdom**. As reported, beneath land owned by **Portland Port Limited** there are salt caverns that are ideal for the storage of hydrogen, some reporting suggesting up to **1.2 billion m³** of available capacity for hydrogen storage.

Carbon Accounting, Carbon Capture and Carbon Capture and Use and *CDR*:

*This section considers news items that have arisen within the news cycle of this **Edition 40** of Low Carbon Pulse relating to carbon accounting and carbon dioxide removal (**CDR**), including bioenergy carbon capture (**BECCs**), bioenergy carbon capture use and storage (**BECCUS**), carbon capture and storage (**CCS**), carbon capture use and storage (**CCUS**) and direct air capture (**DACS**). Effective accounting for carbon arising and **CDR** go hand-in-hand.*
*By way of background **CDR** is recognised in the 2021 Report as including: afforestation, soil carbon sequestration, bioenergy with carbon capture and storage (**BECCS**), wet land restoration, ocean fertilisation, ocean alkalinisation, enhanced terrestrial weathering and direct air capture and storage (**DACS**) are all means of **CO_2** removal.*
*The IEA pathway to **NZE** estimates that in order to achieve **NZE** it will be necessary to capture and to remove up to 7.6 giga-tonnes of **CO_2** each year through **CCS**, **CCUS** and **CDR**. **CCS** and **CCUS** (and **BECCS** and **BECCUS**) involve the capture at the source of **CO_2**, preventing release to the climate system. The following provides a helpful overview of carbon capture as things currently stand.*

- **NSTA awards carbon storage licences to BP and Equinor**: On **May 12**, **2022**, the **North Sea Transition Authority** (**NSTA**) announced in a press release that it had awarded carbon storage (**CS**) licences to **bp Exploration** and **Equinor**.



The award of the licences to **bp** and **Equinor** brings to **six** the **CS** licences that the **NSTA** is now stewarding. As stated by the **NSTA**, the current project estimates indicate the earliest injection under **CSs** could occur in 2025, given the progress being made in by HyNet, Northern Endurance's East Coast Cluster and V Net Zero Humber Cluster Projects.

- **Cross-border carbon storage**: On **May 13**, **2022**, corygroup.co.uk announced that it (**Cory Group**) had signed a memorandum of understanding (***MOU***) with **Northern Lights** (part of the Norwegian Longship CCS project) to work together to realise a major carbon capture and storage projects between **Norway** and the **UK**.

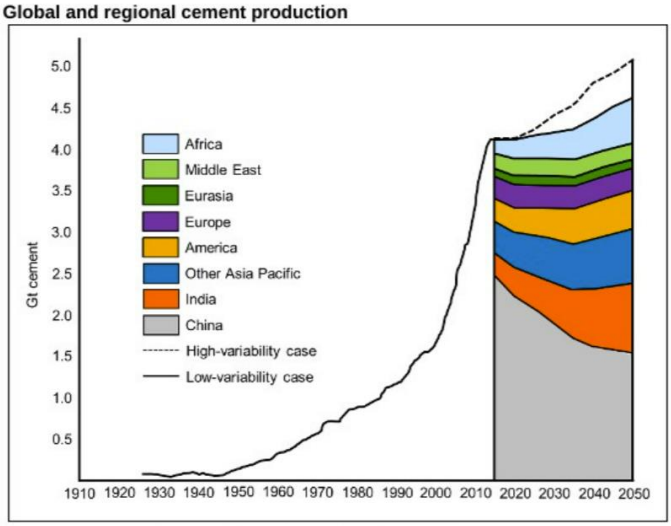
  The ***MOU*** contemplates that ***CO_2*** captured from the Cory waste-to-energy project on the River Thames, London, will be injected into sub-sea-bed storage comprised in the North Lights Project (see **Editions 11**, **20**, **26**, **31** and **34**) of Low Carbon Pulse).

  Marking the significance of the ***MOU***, and the need for government-to-government agreement, the signing of the ***MOU*** was attended by **Norwegian Prime Minister**, **Mr Jonas Gahr Støre** and the **UK Secretary of State for the Department for Business**, **Energy and Industrial Strategy** (the oft mentioned, **BEIS**), **Mr Kwasi Kwarteng**.

  The Government of Norway website, regjeringen.no, provided a positive narrative: "CO2 emissions from London's household rubbish will be captured and stored beneath the North Sea in the carbon storage facility of the Norwegian Longship CCS project".

- **Repurposing of natural gas pipeline**: On **May 18**, **2022**, upstreamonline.com reported that **Tallgrass** (US Midstream Company) is to expand the reach of its **Eastern Wyoming Sequestration Hub** to include an **ADM** (**Archer-Daniels Midland Company**) corn processing complex in **Columbus**, **Nebraska** (***ADM facility***) by the repurposing of its Trailblazer natural gas pipeline to haul ***CO_2*** captured at the ***ADM facility***. As reported, the repurposed Trailblazer natural gas pipeline (which is 400 miles / 640 kms in length) will be able to haul more than **10 million metric tonnes** of ***CO_2*** a year (in compressed form).
- **CVX launches CCS project**: On **May 18**, **2022**, **Chevron U.S.A**. **Inc**., announced the development of a CCS project at its Kern River Eastridge co-generation plant, Kern County, San Joaquin Valley, California.
- **Bayou Bend in the pink**: On **May 24**, **2022**, talos energy announced that it had executed definitive documentation with **Carbonvert**, **Inc**. and **Chevron U.S.A Inc**., to develop, in joint venture, the **Bayou Bend CCS** off-shore bub.
- **CCUS and decarbonisation of cement industry**: On **May 25**, **2022 The Oxford Institute for Energy Studies** (**OIES**) published ***The role of CCUS in decarbonising the cement industry: A German case study***. The study is well-worth a read. With one graph, the study illustrates that it is imperative to make progress in the decarbonisation of the cement industry:

Figure 1: Global and regional cement production



Source: Author's intepretation based on IEA (2018b) and USGS (2017)[9]

- **California carbon capture bills pass Senate**: On **May 27**, **2022**, Clean Air Task Force, reported that three bills passed the state Senate of California. The three bills are:

  1. **SB-905: The Decarbonised Cement and Geologic Carbon Sequestration Demonstration Act**;

  2. **SB-1399: The Carbon Capture Technology Demonstration Project Grant Program**; and

  3. **SB-1101: The Carbon Sequestration: Pore Space Ownership and Carbon Capture, Utilisation and Storage Program**.

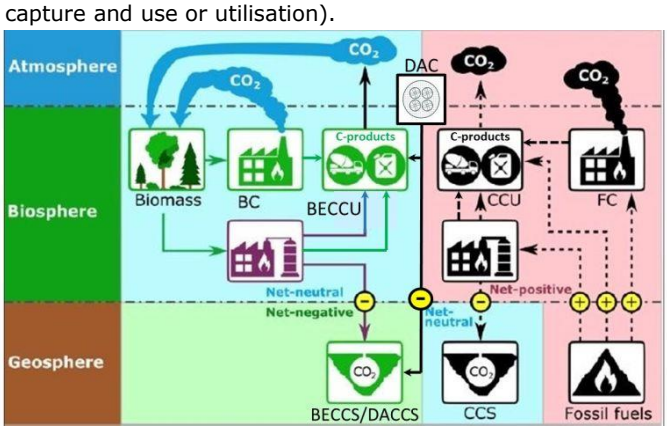
- **Carbfix basalt fix**: On **May 30**, **2022**, **Carbix** published an atlas (to be found at www.carbix.com/atlas) that provides an open-source database to favourable storage formations around the world.
- **Slite CCS Project proceeds**: On **May 30**, **2022**, HeidelbergCement announced further progress of its **Slite CCS project**. The announcement from HeidelbergCement starts with – "We're not just making concrete promises – we are also taking action". The **Slite CCS project** has passed pre-feasibility study, and the carbon capture facilities will be scaled up so as to capture **1.8 million metric tonnes** of ***CO_2*** annually by 2030.

  By way of reminder: **Edition 19** of Low Carbon Pulse reported on **Slite** as follows:

  > "On June 2, 2021, Heidelberg Cement Group (***HCG***) announced the development of the world's first carbon-neutral cement plant: this is reported to involve the augmentation and upgrade of ***HCG***'s existing cement production facility at Slite, Gotland Island, Sweden. The plant produces 1.8 mtpa of ***CO_2***. From 2030 these ***CO_2***

emissions will be captured and stored. It is understood that the Slite project will benefit from the use of CCS technology by HCG at Brevik, Norway".

- **Definition and diagram**: **Mr Reinier Grimbergen** has produced the following diagram explaining **CCS** (carbon carputer and storage), **CCU** (carbon capture and use or utilization), **BECCS** (bioenergy carbon capture and storage), **BECCUS** (bioenergy carbon capture and use or utilization), **DACCS** (direct air carbon capture and storage), and **DACCUS** (direct air carbon capture and use or utilisation).



- **CCS / CCUS Databases:**

  Previous editions of Low Carbon Pulse have included databases, which are included here for reference.

  - US ***DOE*** National Renewable Energy Laboratory (***NREL***) ***Carbon Capture and Storage Database***, which includes information on active, proposed and discontinued CCS projects around the world.
  - US ***DOE*** ***Carbon Storage Atlas***.
  - ***Atlas of Carbon and Hydrogen Hubs from the Great Plains Institute***
  - ***CO2 Value*** launched a ***New CCU Project Database***, provides reference for CCS / CCUS projects across Europe.
  - The ***Clean Air Task Force*** ***Carbon Management Tracker***, maps Middle East and North Africa CCS / CCUS.

Carbon Credits and Hydrogen Markets and Trading:

*This section considers news items that have arisen within the news cycle of this **Edition 40** of Low Carbon Pulse relating to the creation of carbon credits, the role of carbon credits, and the trading of them.*
Also this section covers the development of hydrogen markets and trading (bilateral and likely wholesale).

- ***LEAF* Coalition:** On **May 13**, **2022**, the ***LEAF* Coalition** Window for Proposals from Forest jurisdictions opened. Regular readers of Low Carbon Pulse will recall that **Edition 15** of Low Carbon Pulse reported as follows:

  "***LEAF* falls in the rain forest:**

  The US, the UK and Norway, and major corporations, are to co-operate in a public-private initiative to preserve rain forests. The Lowering Emissions by Accelerating Forest Finance (***LEAF***) coalition was announced on April 22, 2021. At a cellular level, ***LEAF*** is a carbon credit scheme, under which for each tonne of avoided ***GHG*** emissions, a carbon credit will arise, with that carbon credit capable of being traded to off-set carbon emission reduction commitments or obligations. ***LEAF*** is reported to have initial funding of USD 1 billion.

  It is hoped that ***LEAF*** will reduce deforestation, while other policy settings reduce ***GHG*** emissions."

  The mobilisation of **USD 1 billion** during 2021 was significant. As significant is the reputation that the **LEAF Coalition** has for "rigorous verification mechanisms" to verify that carbon is in fact sequestrated, and remains sequestrated. This reputation assists in the development of carbon credits trading in voluntary carbon markets.

  Critically, the **LEAF Coalition** recognises that the use of carbon credits is not a substitute for, or an excuse for any delay in, science-aligned ***GHG*** emission reductions, rather carbon credits are a means to preserve and to increase sequestration capacity to "buy time" as progress is made to achieve decarbonisation and ***NZE***.

- **Japan Carbon Credit trading platform**: On **May 13**, **2022**, asia.nikkei.com reported that the **Ministry of Economy Trade** and **Industry** (**METI**) and **Japan Exchange Group** (owner and operator of the Tokyo Stock Exchange, the Osaka Exchange, and the Tokyo Commodity Exchange) are to establish the first market for carbon credit trading in Japan.

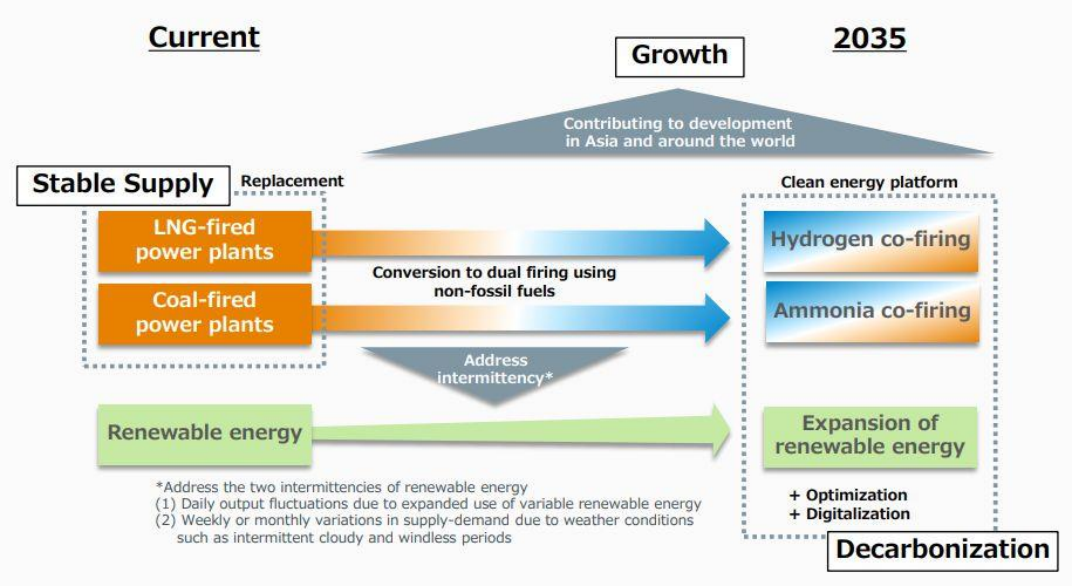
  The thinking behind the establishment of the market is to provide transparency in prices and transactions. This informs the reported scheme of the trading platform: corporations wishing to participate in the market will set ***GHG*** emission reduction targets to be achieved by 2030, with **METI** to authenticate reductions in ***GHG*** emissions by the issue of carbon credits. Corporations that do not achieve their ***GHG*** emission reduction targets will be able to acquire carbon credits on the market to acquit their shortfall.

  Also Japan has the J-Credit scheme, under which forestry and renewable energy projects are authenticated by the issue of carbon credits. Credit credits issued under the J-Credit scheme will be tradeable on the new trading platform.

  It is expected that corporations working with **METI** under the aegis of the existing GX League Basic Concept (around 440 corporations) will set ***GHG*** emission reduction targets, and participate in the market.

  As reported, the **JPX** is to set up the market in the Tokyo Stock Exchange, commencing market demonstration / pilot in September 2022, moving to full market operation at the start of fiscal year April 2023.

  On **May 13**, **2022**, **JERA Co**., **Inc**. released its updated corporate vision for 2035, including updated ***GHG*** reduction emission targets. The following graphic provides an overview of the key elements of the updated corporate vision:



Source: JERA

- **World Bank perspective**: During **May 24, 2022**, the **World Bank** published ***State and Trends of Carbon Pricing 2022***. The publication is excellent, and is well-worth a read.

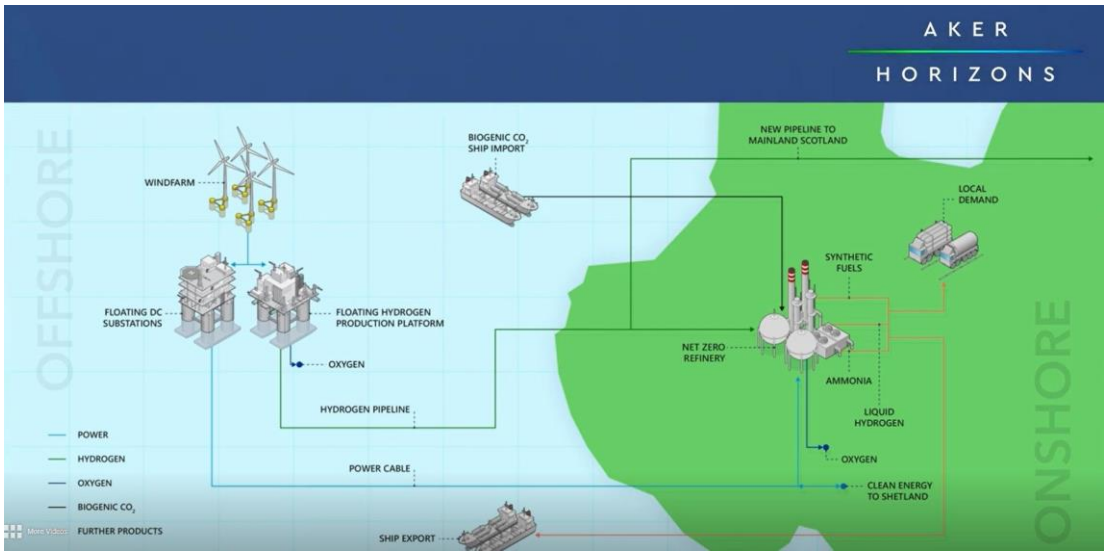
E-fuels & feedstocks / Future Fuels & Feedstocks / Now Fuels & Feedstocks:

*This section considers news items that have arisen within the news cycle of this **Edition 40** of Low Carbon Pulse relating to the development of production capacity to derive and to produce **E-fuels** (energy carriers derived or produced using renewable energy) and **Future Fuels** (energy carriers derived and produced that are characterised as clean carbon or low carbon fuels). **E-fuels** include Green Hydrogen and Green Ammonia, and **Future Fuels** include Blue Hydrogen and Blue Ammonia.*

- **Sunshine state to get Super Hybrid Hydro**: On **May 4**, **2022**, the plans of **Sunshine Hydro** were reported widely. As reported, **Sunshine Hydro** intends to develop the "world's first **SuperHydrid** project" using **renewable energy generation capacity**, **energy storage capacity** and **Green Hydrogen production capacity** to supply renewable electrical energy **24/7**, **365**, and Green Hydrogen for use within Queensland. It is understood that **Sunshine Hydro** intends to develop three **SuperHybrid** projects within the **Central Queensland Renewable Energy Zone**.
- **Jolly Green Giant**: On **May 4**, **2022**, pv-magazine-australia reported (under ***Plans for giant green hydrogen project in WA revealed***) on the scale of the planned **Murchison Hydrogen Renewables** project: while the **Murchison Hydrogen Renewables** project is not new, formal details as to its scale and scope are – the Green Hydrogen and Green Ammonia production facilities are to be powered by **3.7 GW** of installed photovoltaic solar and wind capacity, a **250 MW** to **350 MW** / **500 MWh** / **700 MWh** ***BESS***, **3 GW** of electrolyser capacity, a desalination plant (producing six-gigalitres of demineralised water a year) to allow the production of up to **2,118,880** metric tonnes of Green Hydrogen a year and up to **200** hydrogen storage vessels (each with a 680 metric tonne capacity) which together will allow the production of up to **2 million metric tonnes** of Green Ammonia a year.
- **ScottishPower and Storegga to transform highland hydrogen**: On **May 5**, **2022**, **Storegga** announced that **ScottishPower** (Scotland-based energy company and subsidiary of Spanish utility firm Iberdrola) and **Storegga** (global leading carbon capture solutions corporation) had agreed to develop, to build and to operate a **series** of **green hydrogen production facilities** across Scotland, with the first to be located in the **Cromarty Firth** region, north of Inverness (see **Edition 25** of Low Carbon Pulse), producing 20 metric tonnes of Green Hydrogen a day by 2024, with the Green Hydrogen to satisfy demand from corporations, including whisky distilleries.

  The **ScottishPower** / **Storegga** projects represent continued progress across Scotland in the development of hydrogen projects, including the **Scot2Ger project** (Scottish and German collaboration to look at potential of exporting green hydrogen from Scotland to Germany), the **Aberdeen Hydrogen Hub** (A BP and Aberdeen City Council joint venture starting with the delivery of a Green Hydrogen production and transport refueling facility powered by a solar farm), the **Acorn Project** (carbon capture and storage project and the development of Scotland's Hydrogen Coast funded by the UK and Scottish Governments and the ***EU***), the **Cromarty Hydrogen Hub** (the initial project in the North of Scotland Hydrogen Hub), the **Flotta Hydrogen Hub** (Green Hydrogen production facility on the island of Flotta in Orkney, Scotland developed by joint venture Offshore Wind Power Limited), **Gordonbush H2 project**, the **Net Zero Hub on Stornaway**, and the **Northern Horizons project**.

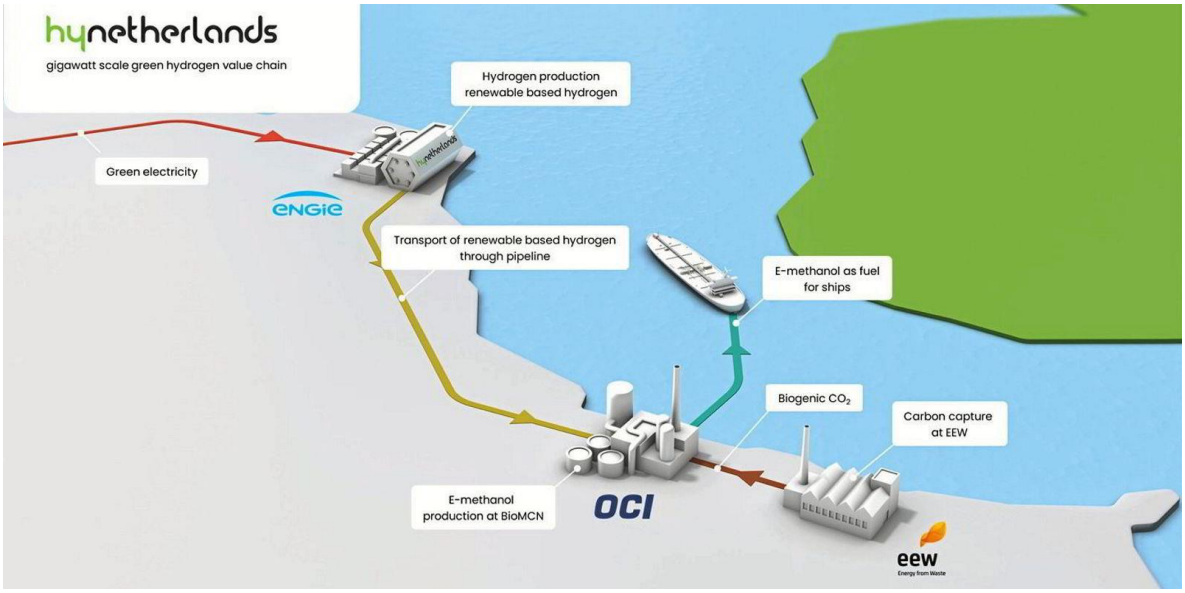
  A graphic from the Northern Horizons project provides an excellent representation of the anatomy of a hydrogen hub project powered by electrical energy sourced from off-shore wind fields.



- **Hydrogen pipeline**: On **May 4**, **2022**, it was reported widely that **INEOS** (UK based international conglomerate) and **SGN** (British gas distribution company) intended to use a 29 km decommissioned natural gas pipeline from **Grangemouth** to **Granton** to trial the haulage of compressed hydrogen.
- **Storegga's continued progress**: On **May 16**, **2022**, it was reported widely that **Storegga** had received backing from **GIC**, **Macquarie Group**, **M&G Investments**, **Mitsui** and **Snam** to continue to develop carbon capture and hydrogen projects in Norway, the UK and the US.
- **Cromarty Firth as Greenport**: On **May 23**, **2022**, it was reported widely that **BlueFloat Energy** and **Falck Renewables** and **Ørsted** had expressed their support for the **Scottish Green Freeport** status to the **Cromarty Firth**. Scottish Green Freeport status, brings with it benefits with a package of tax reliefs, import duties exemption / holiday and other incentives like the opportunity to access seed capital funding of up to £25 million and other trade and investment support.
- **Winterhall Dea announces BlueHyNow**: On **May 5**, **2022**, **Wintershall Dea** announced plans to develop a **clean** / **low-carbon** hydrogen production facility facilities (the ***BlueHyNow Project***), at **Wilhelmshaven**, **Germany**. As announced, the ***CO_2*** arising from the ***BlueHyNow Project*** is to be transported for injection into sub-sea-bed storage in Denmark and Norway. For these purposes, it is assumed that the a ***CO_2*** liquefaction facility will need to be developed.

  As regular readers of Low Carbon Pulse will know, **Wilhelmshaven** is a hub for clean / low-carbon production and import, and LNG imports – see **Editions** **14**, **34**, **36** and **37** of Low Carbon Pulse.
- **HyNetherlands Project recast**: On **May 10**, **2022**, it was reported widely the **Engie** (global French energy company) intends to recast its **HyNetherlands Project** to produce **Green Methanol**, using **Green Hydrogen** (produced from **Engie's** planned **100 MW** electrolyser, using renewable electrical energy sourced from 200 MW of off-shore wind field capacity) as a feedstock to be synthesised with ***CO_2*** to produce low-carbon methanol in Eemshaven, the Netherlands.

  The **Green Hydrogen** produced by **Engie's HyNetherlands Project** will be synthesised with **biogenic *CO_2*** captured from the **EEW Energy** waste-to-energy facility located at **Farmsum**, at the **OCI Delfzijl Chemical Park**. The **HyNetherlands Project** will be connected with the **OCI Delfzijl Chemical Park** via the hydrogen network developed by **Gasunie**.



Source: Engie / OCI / EFW

As reported, **Engie** intends to develop its **HyNetherlands Project** from **100 MW** of electrolyser capacity to **1.85 GW** of electrolyser capacity by 2030, with the Green Hydrogen produced capable of used both as a **Future Fuel** itself and as a feedstock for the production of other **Future Fuels**.

The recast **HyNetherlands Project** is a great example of the role of Green Hydrogen in **Future Fuels** (see sibling publication, **Future Fuels** for background) and of how hydrogen hubs and carbon clusters work.

- **Iberdrola Green Hydrogen production facility opens**: On **May 13**, **2022**, it was reported widely that the King of Spain opened the **€150 million** Green Hydrogen production facility at **Puertollano**, **Spain**, owned by **Iberdrola** (a Spanish multinational electrical energy utility company). As reported in previous editions of Low Carbon Pulse, the Green Hydrogen produced will be used by **Fertiberia Group** (a fertilizer and ammonia and derivatives producer) to displace the natural gas currently used to produce ammonia. The Green Hydrogen production facility (powered by **100 MW** of photovoltaic solar power, and having a **20 MW BESS**) will produce **3,000** metric tonnes of Green Hydrogen a year.
- **Plug Power first 1 GW order**: On **May 17**, **2022**, h2-view.com reported that **H2 Energy Europe** (Swiss-headquartered joint venture between Singapore-based commodity trading firm Trafigura Pte Ltd. and H2 Energy Holding AG) had ordered a **1 GW** electrolyser system from Plug Power. The **1 GW** electrolyser system will be used to produce up to **100,000 metric tonnes** of Green Hydrogen a year to be used across northern Europe's transportation sector.
- **Uniper LoI with HIF**: On **May 19**, **2022**, **uniper** (an international energy company) announced that it has signed a Letter of Intent (LoI) with **HIF Chile** and **HIF Global** to provide a framework to negotiate binding off-take agreements for **E-Fuels** to be produced from the production facilities at **Magallanes**, **Chile**. It is understood that the negotiations will extend to the sale and purchase of up to **2 million metric tonnes** of **E-Methanol** a year.

  By way of reminder: **Edition 32** of Low Carbon Pulse (under **Total Eren swoops to develop H2 Magallanes**) reported 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 produced 800,000 metric tonnes of Green Hydrogen a year, and 4 million metric tonnes of Green Ammonia".
- **Iberdrola commits €3 billion Green Hydrogen**: On **May 25**, **2022**, it was reported widely that at the World Economic Forum in Davos, Switzerland, **Iberdrola Chair**, **Mr Ignacio Galan** announced that: "*We cannot afford to miss this train and, similarly to the test of green technologies, a stable regulatory framework is required in order to attract investment*". The ***EU*** may be regarded as well on the way to providing a stable regulatory framework.
- **JERA to accelerate NH3 and coal co-firing**: On **May 31**, **2022**, lngprime.com reported that **JERA** and **IHI Corporation** intend to accelerate the co-firing of ammonia and coal at Unit 4 of the Hekinan Power Station, co-firing of 20% ammonia to 80% coal from the start of April 1 2023, and completing the pilot project by the end of March 2024.

  By way of reminder:

  - **Edition 18** of Low Carbon Pulse (under ***IHI* and JERA granted means to commence co-firing**) reported that: "On May 24, 2021, it was announced that **IHI** and **JERA** had received notice of acceptance of their joint grant application to undertake a demonstration project to co-fire ammonia in the generation of thermal power.
    It is understood that the co-firing project will commence in June 2021, and continue until March 2025, with the plan to progress to commence co-firing at **JERA**'s Unit 5, Hekinan Thermal Power Station from August to December 2021. With the rate of co-firing to increase over time, so that by 2024, co-firing will be taking place at a rate of 20% Green Ammonia, 80% coal, at Unit 4, Hekinan Thermal Power Station.
    As is a recurring theme reflected in Low Carbon Pulse, this is another world first for Japan - the first large scale ammonia and thermal coal co-firing project. The co-firing project is consistent with the policy settings in Japan.
    (The grant was approved under the New Energy and Industrial Technology Development Organization's "Development of Technologies for Carbon Recycling and Next-Generation Thermal Power Generation / Research, Development and Demonstration of Technologies for Ammonia Co-Firing Thermal Power Generation" program: an approval process likely shorter than the name of the program under which it was granted!)."
  - **Edition 29** of Low Carbon Pulse (under ***IHI* and JERA co-firing**) reported that: "On October 6, 2021, it was reported widely that **IHI** and **JERA** had commenced co-firing of coal and ammonia at the Hekinan Thermal Power Station. The commencement of co-firing is part of a program (scheduled to complete in March 2025), with the objective of co-firing ammonia (20%) and coal (80%). As noted in **Edition 17** of Low Carbon Pulse, Unit 5 is being used to develop the co-firing burner, with Unit 4 to be used as the co-firing burner is scaled up."
  - **Edition 36** of Low Carbon Pulse (under ***JERA demand for ammonia***) reported that: "On February 18, 2022, it was reported widely that **JERA** is running a tender to procure hydrogen based ammonia as part of its plans to reduce ***GHG*** emissions arising from its coal-fired power generation. It is understood that the procurement is for the supply of 500,000 metric tonnes of ammonia from 2027 through to the 2040s, with around 30 prospective suppliers approached for the purposes of the tender."
    The tender from **JERA** is significant in providing demand that will underpin, or provide demand side support for, the development of supply side. The production of 500,000 metric tonnes of ammonia will require around 88,000 metric metrics tonnes of hydrogen, which is then combined with nitrogen. 500,000 metric tonnes of ammonia equates to 20% of the mass of fuel to fire a 1 GW coal-fired power plant – the mass of fuel required to power Unit 4 at the Hekinan coal-fired power station."

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

*This section considers news items that have arisen within the news cycle of this **Edition 40** of Low Carbon Pulse relating to the development of:*

- *areas in which: **1.** infrastructure will be developed and deployed to support the development and deployment of hydrogen production capacity and use (**Hydrogen Hubs**), the capture of carbon dioxide, and the consolidation of captured carbon dioxide for storage or use or both (**Carbon Clusters**); and **2.** technologies facilitating energy transition will be concentrated and supported (**Hydrogen Corridors and Valleys**); and*
- *giga-factories that fabricate and manufacture photovoltaic solar panels (and associated equipment), wind-turbine blades and towers (and associated equipment), electrolysers (and associated equipment), electric batteries and hydrogen fuel cells, and transmission cabling (including HVDC transmission cabling).*

*Also the section considers developments in cities to decarbonise (including using waste heat), and to cool, cities. The development of infrastructure at ports and installation and support vessels for off-shore wind developments are considered in the **Ports Progress and Shipping Forecast** section of each edition.*

- **Panasonic Corporation progresses**: **Edition 18** of Low Carbon Pulse reported as follows:

  "**Panasonic announces global circuit developer:** On May 24, 2021, Panasonic Corporation announced the development of the world's first "***RE100***" (***Renewable Energy 100%***) factory to be located at Kusatsu, Shiga Prefecture.

  The ***Panasonic RE 100*** factory will be powered using hydrogen fuel cells and photovoltaic solar panels, and ***BESS***, to provide 100% renewable energy at all times from within an "in-house" renewable electrical energy system to allow all activities at the factory to be undertaken without the use of any non-renewable energy source".

  On **May 3**, **2022**, fuelcellsworks.com reported that **Panasonic** had commenced operation of the factory located at Kusatsu, Shiga Prefecture, with the power system combining a hydrogen production facility and fuel-cell technology, photovoltaic solar, lithium-ion batteries.
- **Sila next-gen anode giga-factory**: On **May 3**, **2022**, Sila announced (at silanano.com) that it had acquired 600,000 ft^2 at Moses Lake, in Washington State, within which to house its lithium-ion anode manufacturing capacity for the use in electric battery electric vehicles. The manufacturing capacity of the facility will be up to **10 GWh** of cells when used as a full-graphite replacement, and up to **50 GWh** when used as a partial replacement.
- **John Cockerill roosts globally**: **Edition 39** of Low Carbon Pulse reported that: "The **John Cockerill Group** (leading electrolyser technology corporation) was to develop a **2 GW** electrolyser giga-factory in India in conjunction with a subsidiary of **Greenko Group** (a leading renewable energy corporation). The **John Cockerill Group** manufactures pressurised alkaline electrolysers."

  On **May 4**, **2022**, rechargenews.com reported that by 2025 **John Cockerill Group** (***JCG***) intends to increase its annual production of pressurised alkaline electrolysers to **8 GW** with new giga-factories to be developed in Europe (**2 GW**), India (**2 GW**), the Middle East (**1 GW**), and the ***PRC*** (**2 GW**), with the location of the **eighth GW** yet to be confirmed. ***JCG*** and **Nel ASA** both have significant plans to expand manufacturing capacity.
- **Sodium-ion manufacturing capacity development**: On **May 10**, **2022**, energy-storage reported on the plans of **Altris** and **Natron Energy** to develop new manufacturing facilities.
  - **Altris** (sodium-based cathode technology corporation, backed by **Northvolt**) has announced an agreement with Sandvik Materials Technology to co-locate its first manufacturing facility at a Sandvick factory in **Sandviken**, **Sweden**, called the **Ferrum facility**. The **Ferrum facility** will produce **2,000 metric tonnes** of cathode material (Ferric) a year, enabling **1 GWh** of sodium-ion battery production.
  - **Natron Energy** (sodium-ion battery manufacturer) has announced the development of a **sodium-ion battery manufacturing plant** in **Meadowbank**, **Michigan**. As reported, **Natron Energy** batteries are used primarily for critical power applications (including data centres and telecommunications networks), with the intention to achieve broader application of them, including for EVs and grid-scale ***BESS***. A number of commentators are suggesting that there will be lithium and cobalt and nickel gaps, and the sodium-ion batteries are regarded one of the most promising options.

  Consistent with other publications referenced in this **Edition 40** of Low Carbon Pulse, the following table provides an indication of the metal and mineral content of different batteries.

HOW BATTERY CHEMISTRIES DIFFER, BY MINERAL CONTENT
FOR A 60KWH LITHIUM-ION BATTERY
The name of the battery chemistry typically indicates the composition of the cathode.

	NMC811 Nickel (80%) Manganese (10%) Cobalt (10%)	NMC523 Nickel (50%) Manganese (20%) Cobalt (30%)	NMC622 Nickel (60%) Manganese (20%) Cobalt (20%)	NCA+ Nickel Cobalt Aluminum Oxide	LFP Lithium iron phosphate
LITHIUM	5KG	7KG	6KG	6KG	6KG
COBALT	5KG	11KG	11KG	2KG	0KG
NICKEL	39KG	28KG	32KG	43KG	0KG
MANGANESE	5KG	16KG	10KG	0KG	0KG
GRAPHITE	45KG	53KG	50KG	44KG	66KG
ALUMINUM	30KG	35KG	33KG	30KG	44KG
COPPER	20KG	20KG	19KG	17KG	26KG
STEEL	20KG	20KG	19KG	17KG	26KG
IRON	0KG	0KG	0KG	0KG	41KG

ELEMENTS

Source: Elements

- **Hanwha Q Cells plans US Giga-factory**: On **May 12**, **2022**, pv-magazine.com reported that **Hanwha Q Cells** has announced plans to develop a **1.4 GW photovoltaic** cell panel factory in the US. Also it was reported that **Hanwha Q Cells** intends to expand its photovoltaic cell capacity in the ***ROK*** to **5.4 GW**.
- **Corfo of Chile contracts for development of industry scale electrolyser production in Chile**: On **May 26**, **2022**, h2-view.com reported that the **Production Development Corporation** (**Corfo**) of Chile had selected **three projects** to manufacture electrolysis capacity of 388 MW. **Corfo** signed three agreements, with **GNL Quintero**, **CAP SA**, and **Air Liquide**.

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

*This section considers news items that have arisen within the news cycle of this **Edition 40** of Low Carbon Pulse relating to the extraction of metals and minerals necessary for the decarbonisation of activities to progress towards achievement of **NZE**, the use of **E-fuels** and **Future Fuels** to power and to propel vehicles used to extract and to transport metals and minerals, and the use of E-fuels and Future Fuels to process and to treat those metals and minerals. Also this section considers the Difficult to Decarbonise industries, including the iron and steel sector.*

- **Green Steel in Canada:** On **May 2**, **2022**, it was reported widely that **ArcelorMittal SA** had tested successfully the use of Green Hydrogen to reduce iron ore at its facilities in Contrecoeur, Quebec, Canada: as reported, Green Hydrogen was used to displace around 7% of the mass of natural gas ordinarily used.

  By way of reminder: The **iron and steel industry** is **carbon intensive** (responsible for between 7 and 10% of direct ***GHG*** emissions globally). Article 2 in the Shift to Hydrogen (***S2H2***): Elemental Change series (sibling publication to Low Carbon Pulse) noted that: "The production of steel may be regarded as giving rise to between 7 and 10% of global ***GHG*** emission or between 3,500 and 5,000 mmt (or 3.5 to 5 billion tonnes) of ***GHG*** emissions a year [Note: This does not include the ***GHG*** emissions arising to extract, transport to iron ore to mill, and from mill to point of use]. Global crude steel production is around 1,900 mmt (1.9 billion tonnes) a year. The best estimate is that between 1.9 and 2.1 tonnes of CO2 emissions arise in respect of each tonne of steel produced … On metrics discernible consistently, it is estimated that a little over 3,500 mmt (3.5 billion tonnes) of CO2 emissions arise each year from steel production. The ***EU*** has this higher at close to 4,000 mmt (4 billion tonnes)."

  Blast furnace technology using metallurgical coal (coking coal) "to melt" iron ore (producing "pig iron") and to remove oxygen. As might be expected, ***CO_2*** emissions arise as a result. **Direct-reduced iron** technology uses natural gas to remove oxygen and to produce sponge iron (in the form of iron ore pellets), then melted in an electric arc furnace (***EAF***).

  The use of Green Hydrogen for these purposes has been championed and lead by **LKAB**, **SSAB** and **Vattenfall** using **HyBRIT** (**Hy**drogen **Br**eakthrough **I**roning Making **T**echnology) developed jointly by them: **Edition 10** of Low Carbon Pulse reported that: "On June 21, 2021 it was announced that ***HYBRIT*** had completed the first production test of sponge iron (or direct reduction iron (DRI) using hydrogen instead of coking coal to remove oxygen thereby avoiding the ***CO_2*** arising". **Edition 25** of Low Carbon Pulse reported that (under ***HYBRIT's Clean Steel on the road***) delivered the "first fossil-free steel in the world" to Volvo Group from the ***HYBRIT*** mill, using HYBRIT technology. And that on September 1, 2021, SSAB announced that it is to partner with Daimler's Mercedes-Benz to introduce fossil-free steel to the production of vehicles.

  As reported in previous editions of Low Carbon Pulse, **ArcelorMittal SA** has announced plans to invest around USD 6.5 billion in four **Direct-reduced iron** plants (in Belgium, Canada, France and Spain).

  By way of a further reminder: Edition 37 of Low Carbon Pulse reported that the ***Green Steel Tracker*** had been released. The ***Green Steel Tracker*** has been developed by the Stockholm Environment Institute and the Leadit Secretariat. A link to the internet site with the ***Green Steel Tracker*** is included here. The ***Green Steel Tracker*** is a helpful tool for those wishing to follow green iron and steel projects globally.
- **Anglo American – nuGen™:** On **May 6**, **2022**, **Anglo American** (global mining giant) introduced its **nuGen™ Solution** – **Anglo American's Zero Emission Haulage Solution** or **ZEHS** for short ("***A solution so ambitious, it didn't exist. So we made it from scratch***".) The **nuGen™ Solution** is part of the Anglo American Our FutureSmart MiningTM programme.

  The pilot for the **nuGen™ Zero Emission Haulage Solution** is a hydrogen powered and propelled ultra-class mine haul truck: the truck is 220 tonnes, with a load capacity of 290 tonnes (with a total laden weight of 510 tonnes). The truck will be converted to hybrid power and propulsion using fuel cell and battery electric technology. The hydrogen will be produced at mine-site.

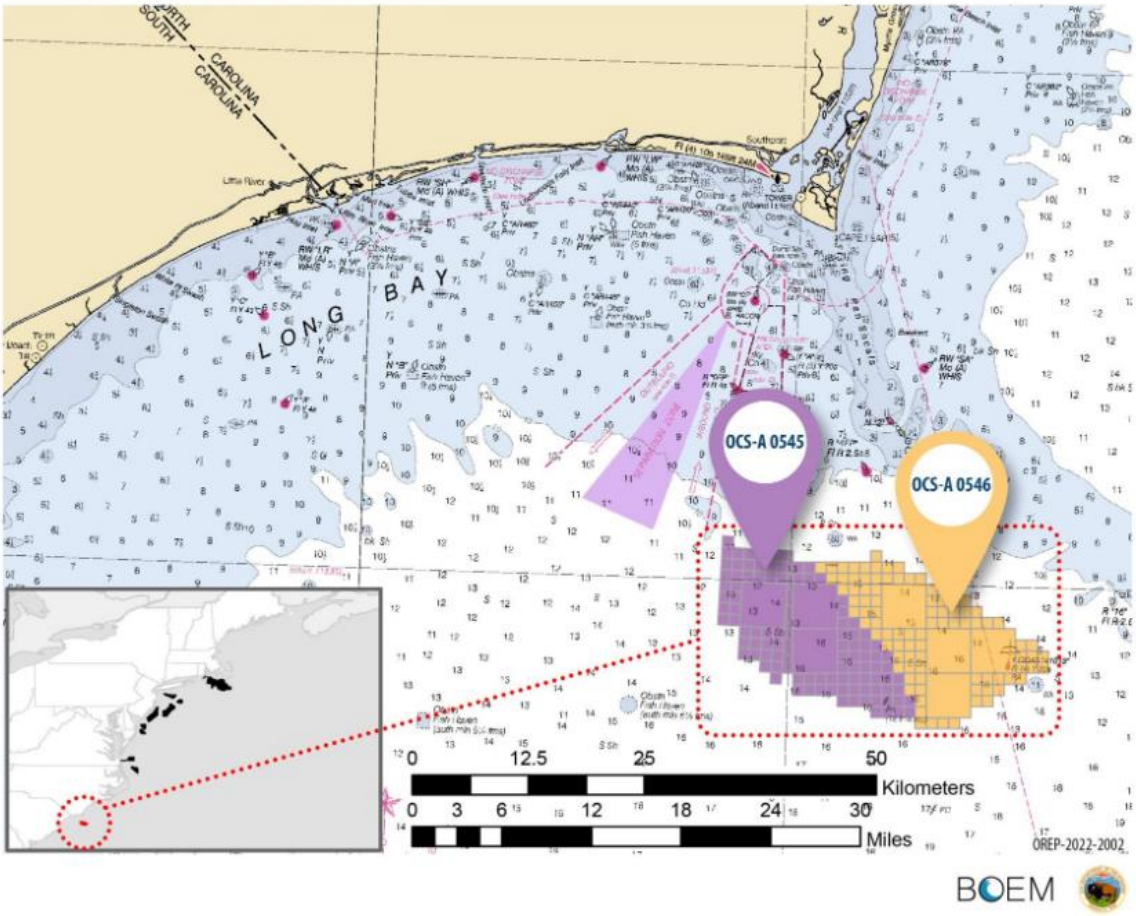
Wind round-up, on-shore and off-shore:

*This section considers news items that have arisen within the news cycle of this **Edition 40** of Low Carbon Pulse relating to the development of wind power generation capacity, on-shore and off-shore (fixed bottom and floating).*

- **Colombia Off-shore Wind Roadmap:** On **May 3**, **2022**, the **President of Colombia**, **Ivan Duque**, and the **Minister of Mining and Energy**, **Diego Mesa**, presented the Colombian ***Offshore Wind Energy Roadmap*** (***OWER***). The ***OWER*** outlines the potential for off-shore wind field capacity - **50 GW** of installed capacity over 12,000 **km^2**, with **27 GW** more suited to **fixed-bottom** installation, and **21 GW** more suited to **floating**.
- **Update on ROK offshore wind field (OWF) development:** On **May 3**, **2022**, a map was published by epj-co-kr.cdn providing a helpful snapshot of the current contemplated development of OWF. This link will give a sense of the level of activity in and around the ***ROK***.
- **US Bureau of Ocean Energy Management (*BOEM*) busy**:
  - **All cool**: On **May 6, 2022**, it was reported widely that the ***BOEM*** had completed its review of potential impacts from the development of **OWFs** in the Humboldt Wind Energy Area (***WEA***), off-shore the US State of California, the ***BOEM*** reporting a finding of no significant impact (**FONSI**). As reported, the ***WEA*** has the potential to for the installation of up to **1.6 GW** of **OWF** capacity. The ***WEA*** is off-shore of Eureka and Arcata, locations near and dear to the heart of the author (who is writing a novel based on Eureka and its surrounds);

- **All go, go, go**: On **May 11**, **2022**, the ***BOEM*** held a lease auction offering two lease areas located in US Federal Waters off-shore of **North Carolina** and **South Carolina**.

  The two lease areas (in the Wilmington East Area (**WEA**)) are located in the **Carolina Long Bay** (covering 110,000 acres) with potential to install up to **1.3 GW** of off-shore wind fields capacity across them. The lease areas are **OCS-A 545** and **OCS-A 0546**.



Source: Bureau of Ocean Energy Management

PRE-QUALIFIED BIDDERS			
547 Energy	Arevia Power	Avangrid Renewables	BP US Offshore Wind Energy
Carolina Offshore Wind	Duke Energy Renewables Wind	EDF Renewables Development	Invenergy Long Bay Offshore
Jera Renewables NA	Masdar Offshore Wind Americas	MRP Offshore Wind Farm	Ørsted North America
Ocean Winds NA Ventures	RWE Offshore Wind Holidays	Shell New Energies	TotalEnergies Renewables USA

On **May 11**, **2022**, it was announced that lease area:

- **OCS-A 0545** had been awarded to **TotalEnergies Renewables USA**, with a bid of **USD 160** million; and
- **OCS-A 0546** had been awarded to **Duke Energy Renewables Wind** with a bid of **USD 150** million.

The auction process for **Carolina Long Bay** included a 20% credit mechanism for bidders that committed to initiatives and programs supporting capacity development in the off-shore wind industry, i.e., for training and for supply chain development.

The lease auction was the second of 2022, the first being the New York Bight auction process (see **Editions** 29, 33 and 36 of Low Carbon Pulse). As was expected, the bids for **OCS-A 545** and **OCS-A 0546** did not reach the levels for the New York Bight auction process.

- **Norway to achieve 30 by 40**: On **May 11**, **2022**, the **Government of Norway** outlined its plans to promote the development of off-shore wind field capacity so as to develop **30 GW** of capacity by **2040** (**30 by 40**). The scale of the development is best illustrated by reference to the number of wind turbines currently installed and to be installed as noted by **Norwegian Prime Minister**, **Mr Jonas Gahr Støre**:

  "With this ambition we go from the two off-shore wind turbines that are in operation today to about 1,500 off-shore wind turbines".

Previous editions of Low Carbon Pulse have reported in earlier planned development and mapping of possible off-shore areas suitable for fixed-bottom and floating wind-turbine installations (see **Editions** **18**, **20** and **35** of Low Carbon Pulse).

- **California 3 by 2030, 15 by 2045 and 20 GW by 50**: On **May 11**, **2022**, the **California Energy Commission** (**CEC**) outlined plans to allow the development of floating off-shore wind field capacity **3 GW** by **2030**, **15 GW** by **2045**, and **20** by **2050**.
- **Thor hammering along**: On **May 11**, **2022**, it was reported widely the **Danish Energy Agency** (***DEA***) issued a feasibility study permit allowing progress of the **Thor Project**.

  By way of reminder:

  - **Edition** **32** of Low Carbon Pulse (under **Luck of the Thor**) 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. On December 8, 2021, S&P Global Platts provided a perspective of the competitive nature of some off-shore wind field projects".
  - **Edition** **34** of Low Carbon Pulse (**Thor'sday on a Tuesday**) reported that:" ***RWE***, announced that it had signed the concession agreement with the Danish Government for the Thor off-shore wind field (***TOSW***) project awarded to ***RWE*** on the drawing of lots on December 1, 2022".
- **Petrobras and Equinor eye 4 GW development**: On **May 18**, **2022**, offshorewind.biz reported that **Petrobras** (the national oil company of Brazil) and **Equinor** (leading international renewable energy corporation) were considering the feasibility of the development of a **4 GW** off-shore wind field. **Petrobras** and **Equinor** have been working together on the **Aracatu OWF** project since signing a memorandum of understanding in 2018.
- **Hollandse Kust West Site bids close**: **Edition** **37** of Low Carbon Pulse reported as follows:

  "**Regulations issued:** On **March 10, 2022**, offshorewind.biz reported that the Ministry of Economic Affairs and Climate Policy had issued regulations detailing rules for the upcoming licensing of Hollandse Kust (west) Wind Farm Zone, which comprises Hollandse Kust (west) VI and Hollande Kust (west) VII in the Dutch sector of the North Sea. The licence areas are located 53 kms off the west coast of the Netherlands.

  The auction for the two licenses open on April 12, 2022 and will close on May 12, 2022."

  As the close date for the auction approached, there was considerable coverage of the fact that the criteria for the assessment of bids for Hollandse Kust (west) VI and Hollande Kust (west) VII were different, in particular for:

  - Hollandse Kust (west) VI the criteria are reported as requiring bidders to consider and to address the impact of ecosystems in the North Sea (with a reported 50% weighting in respect of these criteria); and
  - Hollandse Kust (west) VII the criteria are reported as requiring bidders to consider and to address the integration on the renewable electrical energy generated (and related infrastructure) into the energy system in the Netherlands (again with a reported 50% weighting in respect of these criteria).

  At the risk of missing those that bid in the action process (and apologies in advance if anyone is missed), from news reports the following bidders have been reported: **BASF** and **Vattenfall** are reported to have bid jointly in respect of Hollandse Kust (west) VI, and **Vattenfall** is reported to have bid on Hollande Kust (west) VII; **bp** is reported to have bid for both Hollandse Kust (west) VI and Hollande Kust (west) VII; **Brookfield** and **SSE Renewables** are reported to have bid for Hollandse Kust (west) VII; **Eneco** and **Shell** are reported to have bid for both Hollandse Kust (west) VI and Hollande Kust (west) VII; **Ocean Winds** (the **EPD Renewables** and **Engie** 50:50 joint venture) is reported to have bid for Hollandse Kust (west) VI; **Ørsted** and **TotalEnergies** are reported to have bid jointly for both Hollandse Kust (west) VI and Hollande Kust (west) VII; and **RWE** is reported to have submitted bids for both Hollandse Kust (west) VI and Hollande Kust (west) VII.
- **Noatun Nord and Noatun Syd**: On **May 20**, **2022**, it was reported by offshorewind.biz that **OX2** (leading off-shore wind field developer) and **Ålandsbanken Fondbolag Ab** (an investment management firm) had agreed to progress to develop multi-giga watt off-shore wind field projects, **Noatun Nord** and **Syd**, off of the **Åland Islands** in the **Baltic Sea**. Both OWF projects are at early development phase.

  By way of reminder:

  - **Edition** **36** of Low Carbon Pulse (under ***OX2 given legs offshore shore***) reported that: "OX2 had applied for a Natura 2000 permit to develop the 1.8 GW Triton off-shore wind field, located within the economic zone off the coast of Skåne, Sweden, and that OX2 had been granted exploration permits for two off-shore wind fields in the Gulf of Bothnia Exclusive Economic Zone (EEZ): the permits were granted at a plenary session of the Finnish Government, and are in respect the Halla project (approximately 35 km off-shore the city of Raahe) and Laine project (approximately 30 km off-shore of the adjacent cities of Kokkola and Pietarsaari)".
  - **Edition** **37** of Low Carbon Pulse (under ***Continued activity for OX2 in the Baltic Sea***) reported that: "OX2 had applied for a Natura 2000 permit to develop the 5.5 GW Aurora off-shore wind field, located 20 kilometres south of Gotland and 30 kilometres east of Öland, within the Swedish Baltic Sea Exclusive Economic Zone. The application by OX2 marks its continued progress, with three major off-shore wind field developments at various stages of develop ment / progress".
- **BlueFloat Energy and Falck Renewables floating off-shore Sardinia**: On **May 20**, **2022**, rechargenews.com reported that **BlueFloat** (leading off-shore wind developer) and **Falck Renewables** (leading Italian renewable energy developer) planned to develop **975 MW** of off-shore wind capacity, off the northeast coast of **Sardinia**, **Italy**, the **Tibula Energia**.

  As reported an application for a maritime concession was made on May 6, 2022, with approval sought for up to 62 floating wind turbines with an annual generation capacity of up to **3.4 TWh**. For the projects to proceed, among toher things, a maritime concessions must be granted by the Ministero delle Infrastructurre.

(**Editions** **28**, **29**, **30** and **31** of Low Carbon Pulse have tracked progress to date in the development of off-shore wind field projects in Italian waters.)

By way of reminder:

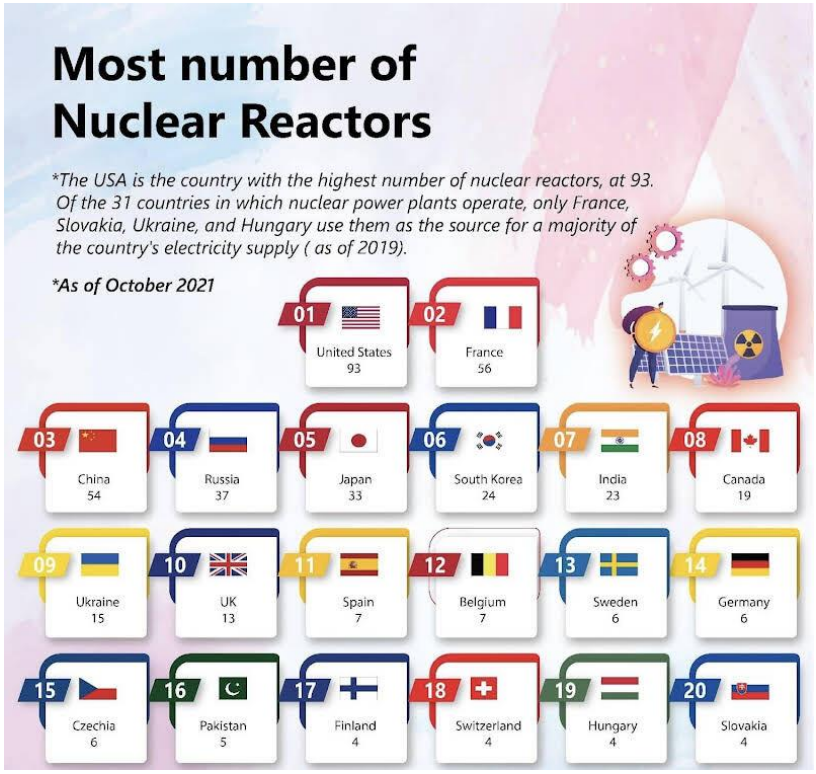
BlueFloat and **Falck Renewables** have been working together in the OWF sector offshore Italy for coming up to 12 months:

- **Edition** **28** reported that **BlueFloat Energy** and **Falck Renewables** had announced that they have entered into a 50:50 joint venture for the purposes of developing off-shore wind field (**OWF**) projects off the coast of Italy
- **Edition** **37** reported that **BlueFloat Energy** and **Falck Renewables** had been granted a 40 year maritime concession to allow the development of the **1.35 GW Orda Energia** floating off-shore wind field project (***Orda Energia OWP***). The ***Orda Energia OWP*** is to comprise 90 turbines located in waters with depths of 100 to 200 metres.
- **Current projects progressing:** By the reckoning of the author, **BlueFloat** and **Falck Renewables** are progressing four other OWF projects : the **675 MW Minervia Energia** project in the **Gulf of Squillace**, **1.4 GW Nora Energia 1** and **2** wind fields in **Gulf of Cagliari** and **1.2 GW Kailia Energia** off Brindisi.

Solar and Sustainability (including *NZE* Waste):

*This section considers news items that have arisen within the news cycle of this **Edition 40** of Low Carbon Pulse relating to the development of solar power generation capacity, on-shore (photovoltaic and concentrated) and floating.*
*Also this section covers news items relating to the development of facilities and technologies to process and to recycle **NZE Waste**. Also this section considers the treatment of residual **NZE Waste**.*

- **Superstores can match half load with roof-top solar:** On **May 2**, **2022**, a report (entitled ***Solar on Superstores: Big roofs, big potential for renewable energy***) from Environment America Research & Policy Center and Frontier Group came to the attention of the author of Low Carbon Pulse. The report estimates that retail superstores across the US had sufficient area of useable roof space to install photovoltaic solar arrays to generate **50% of** their **electrical energy load**. The report is based on data compiled by the **National Renewable Energy Laboratory** (***NREL***). ***NREL*** estimates that around **2**/**3rds** of the roof space on large buildings across the US is suitable for the installation of photovoltaic solar arrays.
- **Nuclear reactors**: There is increased activity in the development and proposed development of nuclear reactors, both to replace aging reactors and to decarbonise the generation of electrical energy. On **May 3**, **2022**, the author of Low Carbon Pulse came across the following infographic detailing nuclear reactors globally.



Source: Power System Operation's LinkedIn

In passing, it is noted that Germany, Spain and Switzerland have announced that they intend to phase-out the use of nuclear reactors.

On **April 29**, **2022**, nei.org published (***Nuclear Needs Small Amounts of Land to Deliver Big Amounts of Electricity***). The facts and stats (which in broad terms align with the understanding of the author of Low Carbon Pulse) are that for an equivalent amount of electrical energy, nuclear power plants take 31 times less land than photovoltaic solar, and 173 times less than on-shore wind farms. In addition, nuclear plants can be located anywhere, whereas photovoltaic solar and on-shore wind farms have to be located in areas of renewable resources. While these facts and stats are not an argument of nuclear power, they are worth understanding.

- **Solar Juice and Sungrow position for C&I and residential renewable electrical energy equipment market**: On **May 7**, **2022**, as reported in pv-magazine-australia.com, **Solar Juice** (Australian wholesale solar distributor) and **Sungrow** (Chinese power inverter manufacturer) signed a long-term distribution contract in respect of up to **2 GW** of capacity. The long-term distribution contract reflects the confidence in the continued growth of the C&I and residential market for photovoltaic solar capacity.
- **Increasing focus on waste as a resource:** On **May 8**, **2022**, the **BBC** published an article entitled ***Mine e-waste, not the Earth, say scientists***. The article is worth a read. In the context of the progress that needs to be made to reduce ***GHG*** emissions to progress to ***NZE***, it is critical that all sources of resources are "mined".

  In addition to the elements identified in previous editions of Low Carbon Pulse (including aluminium, cobalt, copper and gold, lithium, manganese, and nickel, the price of each commodity having reached record levels in recent times), **e-waste** contains elements, some of which are in increasingly short supply, including arsenic, gallium, indium, tantalum and yttrium.

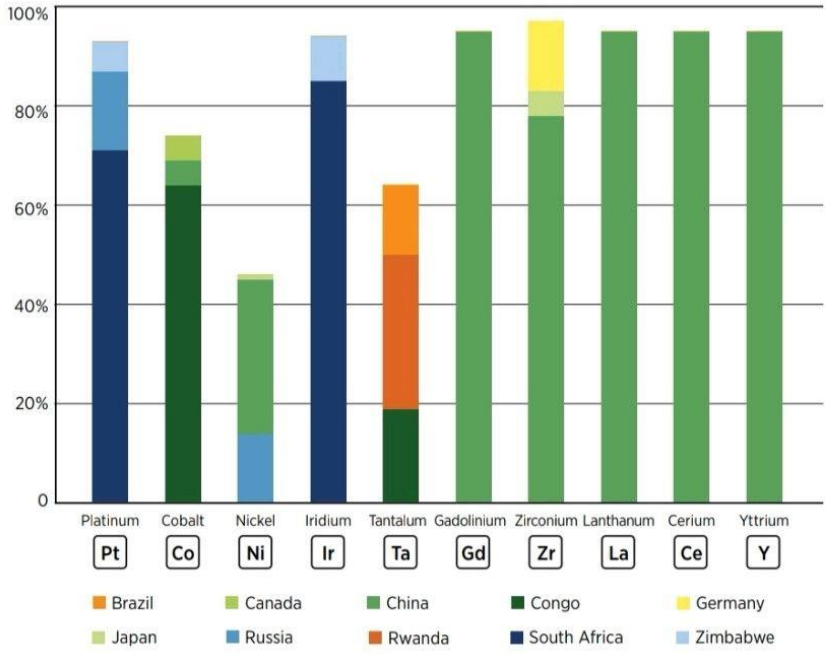
  This will be the subject of a standalone article from the author of Low Carbon Pulse in coming months (title ***NZE Waste and Recovery***). In the interim, it is clear that policy settings are needed to allow collection and consolidation of **e-waste** to allow the elements within in to be recovered and recycled. The role of government is central, including because overtime electronical goods from which **e-waste** arises will be manufactured in more sustainable ways, and the mass of **e-waste** may decline.

  By way of reminder: There are **17 rare earth elements** (***REE***, sometimes referred to a **rare earth metals** or **rare earth oxides**), including the following ***REE*** which are key for the purposes of energy transition: cerium, dysprosium, europium, gadolinium, lanthanum, neodymium, praseodymium, samarium, scandium, terbium, and yttrium.

  In passing, the value of recycling of metals and minerals appears to gathering momentum: on **May**, **11**, **2022**, it was reported widely that **Glencore AG** (global metals and minerals giant) had agreed to provide **USD 200** million of funding to **Li-Cycle** (leading Canadian battery recycling corporation), under which **Glencore** will have access to the lithium recovered by **Li-Cycle**, and **Glencore** will provide reagents used in the recovery of metals and minerals. More of **L-Cycle** shortly.

LANTHANIDE REES								
Light REE	cerium	Europium	gadolinium	lanthanum	neodymium	praseodymium	promethium	samarium
Heavy REE	dysprosium	Erbium	holmium	lutetium	terbium	thulium	ytterbium	
NON – LANTHANIDE REES								
Scandium				Yttrium				

The **International Energy Agency** (***IEA***) has been highlighting the need for sufficient supply of metals and minerals necessary for progress towards to ***NZE*** (***critical minerals*** in the lingua franca of the ***IEA***), and in **March 2022** the ***IEA*** determined to deepen its work on ***critical minerals***. The ***IEA*** has released the following bar chart indicating the scale of price increases across some ***critical minerals***.



Source: International Renewable Energy Agency (IRENA)

The standalone article, ***NZE Waste and Recovery***, will cover the mass of ***NZE Waste*** arising globally, and the recovery of inorganic materials from it, critically, ***critical minerals*** and ***REES***.

- **Westinghouse to house pumped-storage**: On **May 9**, **2022**, energy-storage reported that on **May 5**, **2022**, **Westinghouse Electric Company** (US head-quartered power corporation) had signed a memorandum of understanding with **Bulgarian Energy Holding** to develop **two pumped thermal energy storage** (***PTES***) units. It is understood that the Westinghouse ***PTES*** technology allows dispatch over 10 hours (or more), and has a design-life of 50 years. The ***PTES*** units provide Long-Duration Energy Storage (***LDES***), which will assist in providing grid system integrity and stability in Bulgaria. As reported, **Westinghouse** has partnered with **Echogen Power Systems** (a waste-heat recovery and electro-thermal energy storage technology corporation).
- **BP stake in Asian Renewable Energy Hub (*AREH*)**: On **May 9**, **2022**, it was reported widely that **BP** (leading international energy corporation) intended to invest in ***AREH*** (see **Editions 2**, **18**, **20** and **37** of Low Carbon Pulse). This may be regarded as providing a clear pathway for Green Hydrogen and Green Ammonia projects, with an international energy corporation providing a cornerstone investment, and the ability to contract for off-take.
- **Portugal First Floater**: On **May 10**, **2022**, **Reuters** reported that on **May 9**, **2022**, two tugboats moved an array of **12,000** (**5 MW**) photovoltaic solar panels to their mooring on the **Alqueva** reservoir, ahead of the start-up of what will be Europe's largest floating photovoltaic (**FPV**) solar park in July 2022. The floating photovoltaic solar park has been developed by **EDP**. While the floating photovoltaic solar park may be regarded as having relatively low electrical energy generation capacity, the cost and ease of development is likely to mean that it will form a model of increased use of floating photovoltaic solar.
- **DNV on FPV**: On **May 13**, **2021**, pv-magazine.com reported that **DNV** (Norwegian classification society) is developing recommended practices (**RPs**) for the design, development and operation of **FPV** arrays.
- **Richer at PORA**: On **May 13**, **2022**, the **Port of Rotterdam Authority** (**PORA**) reported the development of the first **e-waste** and **battery waste recycling plant** in the Netherlands. As noted above, batteries use the metals and minerals cobalt, lithium and nickel, each of which is increasingly valuable.

  The **PORA** is in the vanguard, indeed is the frontrunner, of ports globally, in embracing all facets of progress required to decarbonise activities to reduce ***GHG*** emissions to achieve progress towards achievement of ***NZE***.

  The ***NZE Waste*** recycling plant is being developed by **TES** (Singapore based e-waste recycling company).
- **Northvolt recycling voltage**: On **May 15**, **2022**, **Northvolt** (Swedish battery developer for electric vehicles) announced and **Norsk Hydro** announced that the **Hydrovolt AS** (a joint venture between **Northvolt** and **Norsk Hydro**) recycling plant, located in **Fredrikstad**, **Norway**, had commenced operation.

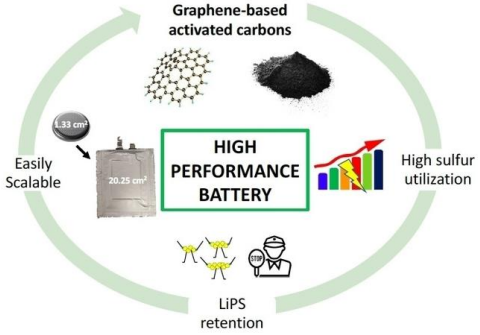
  The fully automated **Hydrovolt** recycling plant has capacity sufficient to recycle the entire end-of-life battery pack market in Norway, i.e., **12,000 metric tonnes** of **battery packs** from BEVs annually (around 25,000 battery packs) recovering up to **95%** of the materials comprising each battery pack.

  It is to be expected that **Hydrovolt** will expand to recycle end-of-life battery packs across Europe.
- **ACE Green Recycling plant**: On **May 16**, **2022**, pv-magazine.com reported that **ACE Green Recycling** (US based recycling technology company) plans to develop a lithium-ion and lead-acid battery recycling plant in Texas. As reported, the recycling plant will be able to recycle up to **100,000 metric tonnes** of **lead-acid** batteries, and up **20,000 metric tonnes** of **lithium-ion** batteries, annually.
- **Li-cycle Corporation (Li-cycle) third spoke turning**: On **May 17**, **2022**, it was reported widely that **Li-cycle** (leading lithium-ion battery recovery and recycling corporation) had commenced commercial operation at its recovery and recycling plant in **Gilbert**, **Arizona** (**Arizona Spoke Facility**).

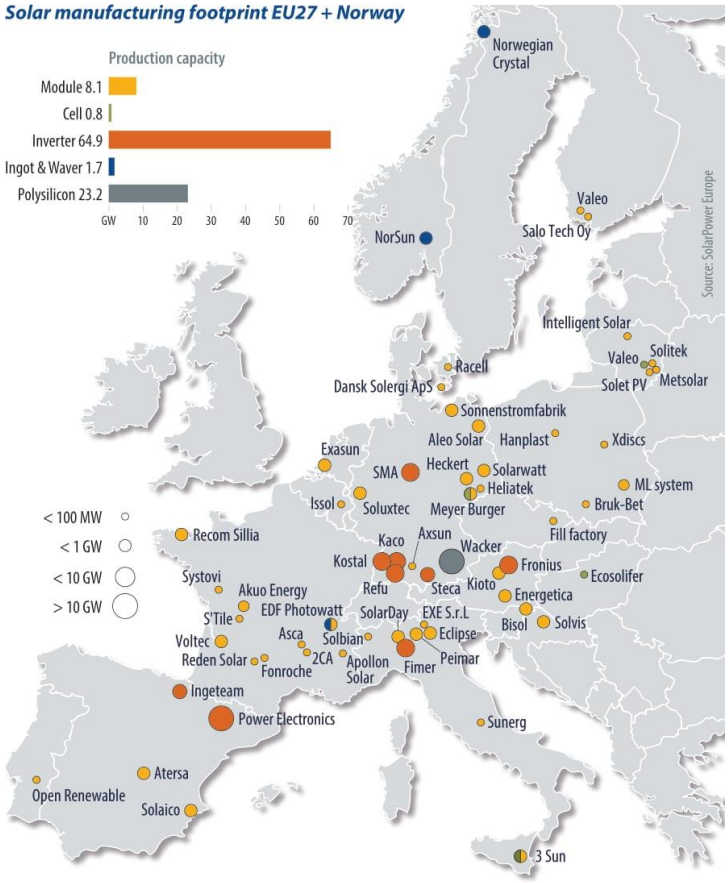
  The **Arizona Spoke Facility** recovers metals and mineral from full battery packs from **BEVs**, having capacity to recover up to **30,000 metric tonnes** annually. **Li-cycle** anticipates that it will have capacity to recycle up to **65,000 metric tonnes** of battery packs in Europe and North America by the end of 2023.
- **Second life and recycling**: **Edition 39** of Low Carbon Pulse reported on the **CIC energiGUNE** map-graphic (entitled ***Second Life and Recycling – Companies in Europe***) providing a snap shot of the battery recycling plants across Europe and the UK.

  The recycling of all forms of ***NZE Waste*** is critical: in a future standalone article dedicated to ***NZE Waste***, the author of Low Carbon Pulse will provide an in depth analysis of each form of ***NZE Waste*** arising currently, and as estimated.

  As a forerunner of the article on ***NZE Waste***, it is worth reflecting that **by 2050** it is estimated that from **lithium-ion** batteries up to **2.5 million metric tonnes** of ***NZE Waste*** may arise a year, from **wind-turbines** up to **45 million metric tonnes** of ***NZE Waste***, and from **photovoltaic solar panels** up to **80 million metric tonnes**.
- **Xlinks progresses**: On **May 20**, **2022**, it was reported widely that **Xlinks** plans to proceed to develop the Morocco to UK sub-sea **HVDC** renewable electrical energy project. **Edition 16** and **28** of Low Carbon Pulse reported on Xlinks.
- **CIC energieGUNE paper on Graphene-based Activated Carbon Composites for High Performance**: On **May 31**, **2022**, the good folk at **CIC energieGUNE** published an excellent article on graphene based activated carbon composites. The following graphic provides an overview of the key messages from the article.

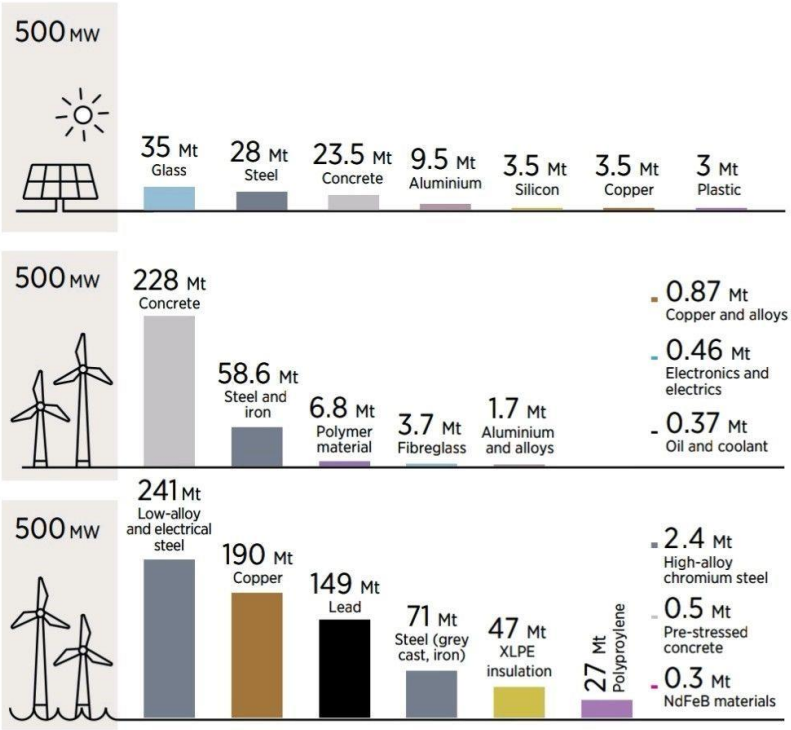


- **European photovoltaic solar manufacturing capacity**: On **May 25**, **2022**, the following info-graphic-map from pv-magazine provided a snap-shot of the current photovoltaic solar manufacturing capacity across Europe.



Source: SolarPower Europe

- **Insight to what is in sight:** The following infographic provides a sense of the materials required to manufacture photovoltaic solar and wind renewable power generation capacity. For those in the recycling industry, and for all, the need for recycling capacity is upon us. As noted above, a future standalone article from the author of Low Carbon Pulse will consider all aspects of the recycling industry.



- **MENA Climate Week: Edition 37** of Low Carbon Pulse reported that: "From **March 28** to **March 31**, 2022, the first-ever Middle East and North Africa Climate Week (***MENACW***) conference took place in Dubai, United Arab Emirates, under the auspices of the UNFCCC.

  On **March 31**, **2022**, the UN released the following press release (titled ***MENACW Galvanises Regional Momentum for COP-27***). At the half way point between ***COP-26*** and ***COP-27***, ***MENACW*** is reported to have built on one (held in Glasgow, Scotland), and prepared for the next (to be held in Sharm El Sheikh, South Sanai, Egypt).

  In the context of ***COP-27***, the Foreign Minister of Egypt, and incoming ***COP-27*** President, Mr Sameh Shoukry said:

  > "*Holding the Climate Week for the first time in the Arab region has been clear evidence of the priority that the countries in the region give to international climate action and ways to combat the negative effects of a phenomenon that has seen its repercussions and impacts extend to multiple aspects of life in our countries. Egypt seeks to make the twenty-seventh session of the United Nations Framework Convention on Climate Change a milestone in the field of international climate action, in which pledges and promises are transformed into actual implementation on the ground*".

  The press release provides the facts and stats around the number of participants, meetings and sessions.

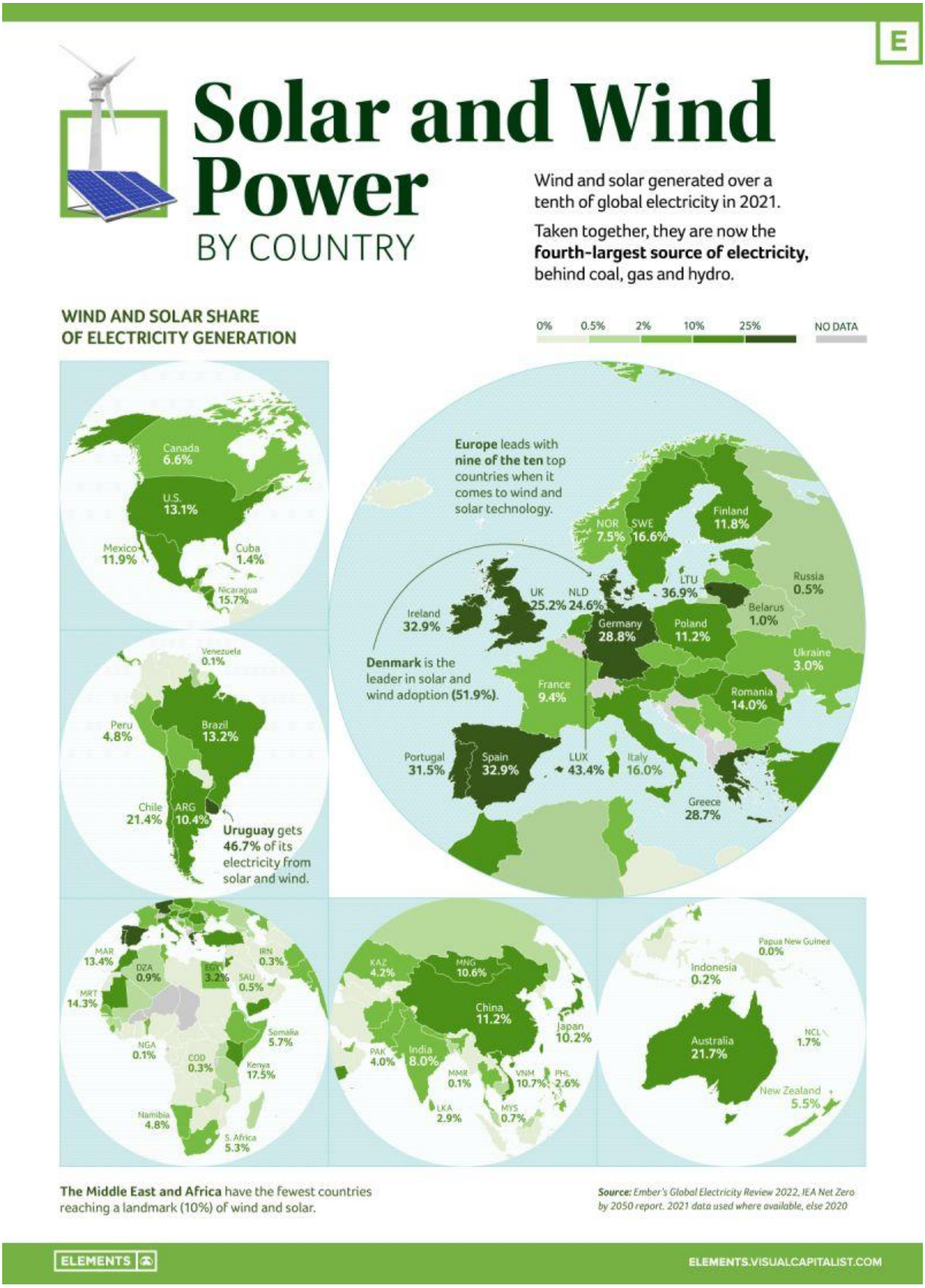
  Edition 30 of Low Carbon Pulse reported on the **UN High Level Climate Action Champions** initiative, and in Dubai the ***COP-26*** Champion, Mr Nigel Topping, and the ***COP-27*** champion, Mr Mahmoud Mohieldin, announced their vision.

  Previous editions of Low Carbon Pulse have noted that as the ***MENACW 2022*** outcomes are published, Low Carbon Pulse would report on them. Three key areas of focus are reported to have emerged as follows:

  - The need to integrate ambitious actions across key sectors of each country;
  - The need to adapt to climate risks through the development of resilience as part and parcel of actions across key sectors; and
  - The need to promote and to accelerate the development of breakthrough solutions, innovation and technology, so as to be able to apply incremental and transformational innovations, solutions and technologies to guard against and to overcome the impacts of climate change.

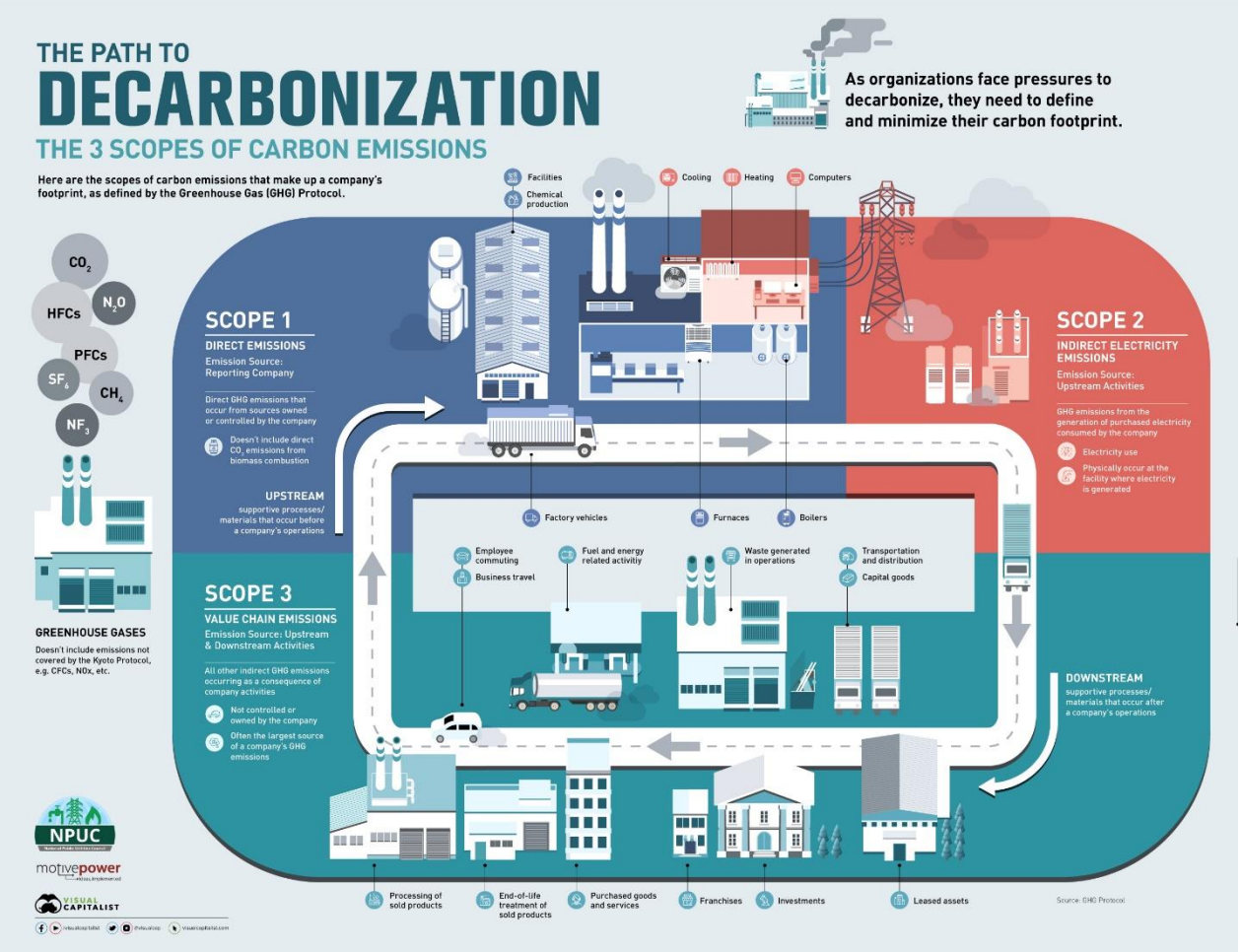
  MENACW 2022 encouraged participation in UN initiatives, ***Race to Resilience*** and ***Race to Zero***.

- **Solar and Wind Power By Country**:
  By way of a reminder, the following infographic provides a helpful summary of the installed solar and wind power capacity by country.



Source: Gavin Mooney's LinkedIn

- **Decarbonisation infographic**: The following info-graphic places each scope of decarbonisation in context.



Source: Visual Capitalist

Land Mobility / Transport:

*This section considers news items that have arisen within the news cycle of this **Edition 40** of Low Carbon Pulse relating to the development and deployment of land vehicles, buses and coaches, cars, industrial vehicles and trucks, and trains.*

- **Buses and coaches:**
  - **Bonn / Köln fuel cell fleet:** On **May 3**, **2022**, **Dutch Hydrogen Magazine** reported that the region of Bonn / Koln in Germany is to procure a fleet of **108 fuel-cell technology buses**. By the reckoning of the author of Low Carbon Pulse, this is the largest single procurement to date of fuel-cell technology buses.
  - **Volgren and Wrightbus look to Australian market**: On **May 11**, **2022**, **Wrightbus** (global leading fuel-cell technology bus manufacturer) announced that it was working with **Volgren** (leading bus body manufacturer) to manufacture **two zero-emission** hydrogen single deck **fuel-cell technology** buses for the Australian market. The two fuel-cell technology buses will be powered and propelled by the Wrightbus' **NexGen fuel-cell powertrains**.
  - **Maine Street**: On **May 17**, **2022**, electrek.co reported that the first of four **Proterrra ZX5** 35 foot battery electric buses had entered service in **Portland**, **Maine**. Greater Portland Metro and Biddeford Saco Old Orchard Beach Transit purchased the electric busses using funding support from both Federal and State Governments.
  - **NSW first hydrogen bus**: On **May 25**, **2022**, **Transport NSW** announced that the State of New South Wales would commence trials of its **first fuel-cell technology electric bus** on the Central Coast of New South Wales later in 2022. The thinking is that fuel-cell technology electric buses are likely to be better suited to use in regional and outer metropolitan areas.
  - **Wrightbus right for Germany**: On **May 27**, **2022**, h2-view.com reported that **Wrightbus** is to supply **60** zero-emission hydrogen-powered-and-propelled buses to Germany. German bus operator, **Regionalverkehr Köln GmbH** (**RVK**) is the purchaser. As reported, this is the first order for left-hand drive versions of Wrightbus' Kite Hydroliner.
- **Cars** (including taxis and air-taxis):
  - **Taking the Scenic route - Renault to manufacture BEV and fuel cell family cars**: On **May 19**, **2022**, it was reported widely that **Renault** is to manufacture a battery electric vehicle (**BEV**) family car, and a hydrogen powered and propelled family car (using fuel-cell technology) for the European car market. **Renault** is reported as intending to use its **Scenic** model vehicle, manufacturing a **BEV** family car in **2024**, and a **fuel-cell technology** family car by **2030**.

- **Great Wall Motor to manufacture fuel cell cars**: On **May 27**, **2022** (or thereabouts), it was reported widely that **Great Wall Motors** or **GWM** (***PRC*** giant vehicle manufacturer) is to manufacture a number of hydrogen powered and propelled family vehicles. **GWM** manufactures **BEV** cars already (the ORA and WEY).
- **Western Australian police trialling fuel police cars**: On **May 31**, **2022**, it was reported widely that the **Western Australian** (**WA**) **Police Force** was to commence trials of a fuel-cell technology vehicle. For these purposes, the **WA Police Force** is using a **Toyota Mirai** fuel-cell technology vehicle.

- **Battery, Fuel Cell and ICE Technology**:

  Cummins Inc ICE: On **May 9**, **2022**, **Cummins Inc** (global technology leader) announced the debut of its 15-litre hydrogen engine at ACT Expo in Long Beach, California. As stated: "The engine is built on Cummins' new fuel-agnostic platform, where below the head gasket each fuel type's engine has largely similar components, above the head gasket, each has different components for different fuel types".

  It is understood that Cummins intends to manufacture engines with 15 litre and 6.7 litre capacity.
- **Industrial Vehicles and Trucks**:
  - **Hyundai to expand in the US**: On **May 9, 2022**, Hyundai Motor Company announced plans to increase its participation in the US commercial vehicle market with the introduction of its **XCIENT Fuel Cell** trucks into the US market.
  - **Emergency services roll-out**: **Edition 30** of Low Carbon Pulse reported on the use of **fuel-cell technology** to power and to propel ambulances. On **May 11**, **2022**, hydrogen-central reported hydrogen fuel-cell technology pioneer, **ULEMCo** is working with **Oxfordshire County Council** and its **Fire and Rescue Service** to assess and to determine the basis upon which fuel-cell technology may be used to power and to propel fire engines.
  - **Scania expands to match growing interest in biogas trucks**: On **May 12**, **2022**, **Scania** announced that it is responding to increased customer interest in biogas (more correctly, **biomethane** or **renewable natural gas**) with new specifications and tanks, with ranges of **1,400 km** now possible.
  - **Volvo Trucks using Fossil-free Steel**: On **May 24**, **2022**, it reported widely that **Volvo AB** is now manufacturing trucks comprising **Fossil-free Steel**.

    This marks continued progress in the decarbonisation of steel used in vehicle manufacture, and continued progress of **SSAB** producing **Fossil Free Fuel** from the ***HYBRIT*** mill, using ***HYBRIT*** technology.

    Edition 25 of Low Carbon Pulse reported that (under ***HYBRIT's Clean Steel in the road***) SSAB delivered the "first fossil-free steel in the world" to Volvo Group from the ***HYBRIT*** mill, using ***HYBRIT*** technology.

    Edition 25 of Low Carbon Pulse reported that on September 1, 2021, SSAB announced that it is to partner with Daimler's Mercedes-Benz to introduce fossil-free steel to the production of vehicles. As a reminder, ***HYBRIT*** is a shortening of Hydrogen Breakthrough Ironing Making Technology, developed jointly by LKAB, SSAB and Vattenfall.
- **Recharging and refuelling infrastructure:**
  - **Green for Greece**: On **May 18**, **2022**, it was reported widely that the first hydrogen refuelling station (***HRS***) had commenced operation in Greece. The ***HRS*** is located in **Athens**, **Greece**, and will be used to refuel light duty vehicles (bikes and scooters) in the first instance. The technology deployed at the ***HRS*** is noteworthy: hydrogen is produced using a hydrogen compression system (derived from metal hydrides) being noise-free and using water as the means for both cooling and heating.
  - **HRS opens in Antwerp, Belgium**: On **May 30**, **2022**, it was reported that **Colruyt Group** (Belgian family owned retail group) and **DATS 24** (energy and fuel supplier) has opened a new ***HRS*** on the **A12** in **Wilrijk**, **Antwerp**, **Belgium**. As reported, this is the first of five new ***HRS*** in Belgium (the other four stations to be located in Erpe-Mere, Hassrode, Herve and Ollignies). **DATS 24** is a first mover, having opened the first ***HRS*** in Belgium in 2018, located in **Halle**, **Belgium**.
- **Trains:**
  - **ATCO Group to supply to Canadian Pacific:** On **May 4**, **2022**, **ATCO Group** announced that it had contracted **Canadian Pacific** to develop and to deploy two hydrogen production facilities and hydrogen refuelling infrastructure – the facilities and infrastructure are to be developed at the railyards of Canadian Pacific in **Calgary** and **Edmonton**, in the province of **Alberta**, **Canada**. The development of the facilities and infrastructure is key to Canadian Pacific continuing implementation of its Hydrogen Locomotive Programme.
  - **Deutsche Bahn and Siemens Mobility present new hydrogen train and hydrogen storage tank trailer**: On **May 5**, **2022**, it was reported widely that **Deutsche Bahn** and **Siemens Mobility** had presented the newly developed **Mireo Plus H** and a newly designed mobile hydrogen storage tanker. The **Mireo Plus H** is intended to replaced diesel powered and propelled trains.

Ports Progress and Shipping Forecast:

*This section considers news items that have arisen within the news cycle of this **Edition 40** of Low Carbon Pulse relating to the development and deployment of production and storage capacity, and infrastructure, at ports for **E-Fuels** / **Future Fuels** (including **Hydrogen Hubs**) and to capture and to store or to use carbon, or both (including **Carbon Clusters**), and the connection of port infrastructure to the hinterland.*
Also this section considers news items that relate to the development of infrastructure at ports, including to allow the development of off-shore wind fields.

- **Ferries and other craft:**
  - **ADB (Asian Development Bank) funds E-Smart Ferries Project**: On **April 27**, **2022**, **ADB** announced that it had agreed to provide funding support (from its Clean Technology Fund) to **Energy Absolute Public Company Ltd** to assist in the funding required to develop and to deploy an electric ferry fleet for mass rapid transport in Bangkok, Thailand. This initiative is part of the E-Smart Bangkok Mass Rapid Transit Electric Ferries Project, which

contemplates the deployment of up to 27 E-Ferries along the Chao Phraya River, that runs through Bangkok, each ferry having capacity for up to 250 passengers.

- **Gladstone – Curtis Island Shuttle**: On **May 9**, **2022**, pv-magazine-australia.com reported that **SeaLink Marine & Tourism** had received a funding support commitment from the **Government of Queensland**, Australia (under its Hydrogen Industry Development Fund) to develop a ferry powered and propelled by **fuel cell technology**. The ferry will provide shuttle services between **Gladstone** and **Curtis Island** (the location of world scale LNG facilities), having capacity for up to 200 passengers, and having a range between refuelling of 50 nautical miles.
- **Workboats afloat**: On **May 11**, **2022**, **CMB.TECH** (technology corporation) and **Windcat Workboats** (the Netherlands based operator of offshore crew transfer vessels, in the European offshore wind sector) announced that they have developed as the world's first hydrogen-powered (and propelled) crew transfer vessel (***CTV***) – the **Hydrocat 48**. The **Hydrocat 48** uses dual-fuel **MAN Engines**, retrofitted by **CMB.TECH** with a hydrogen injection system, and is to undertake bunkering and sea-trials. As a ***CTV***, the **Hydrocat 48** will be used by the marine and off-shore wind industries.
- **Chase Zero on the water**: On **May 13**, **2022**, hydrogenenergy reported that chase boat, **Chase Zero**, had been tested in Hauraki Gulf, Auckland, New Zealand. The **Chase Zero** is a hydrogen powered and propelled chase boat, and during testing it reached a little over 50 knots (58 mph or 93 km/h). The **Chase Zero** is a foiling boat, developed by the Emirates Team New Zealand for use in the America's Cup, and powered and propelled by **fuel cell technology** developed by **Toyota**.

- **Green Ports (including infrastructure):**
  - **Gasunie and Vopak**: On **May 2**, **2022**, **Vopak** announced that **Gasunie** (European energy-infrastructure corporation) and **Vopak** (global leading energy infrastructure corporation) had agreed (under a cooperation agreement) to work together jointly to develop **open access** hydrogen import terminal infrastructure at **Dutch** and **German** ports to allow the import of hydrogen and hydrogen-based fuels into **northwest Europe**.

    As announced, the cooperation agreement includes import terminal projects for green ammonia, liquid hydrogen and liquid organic hydrogen carriers (for further details of these energy carriers, see **Future Fuels** a sibling publication of Low Carbon Pulse).

    Gasunie and **Vopak** are used to working together to develop major import terminal infrastructure they have been working together on the **Gate LNG regasification terminal** at the Port of Rotterdam since 2011. More recently, as reported in **Edition 39** of Low Carbon Pulse, Gasunie and Vopak are working with HES International to develop the ACE Terminal in the Port of Rotterdam. **By way of a reminder**: "The **ACE Terminal**, being developed by **Gasunie**, **HES Internationa**l **B.V.** and **Vopak**, is the Green Ammonia import terminal being developed in the Port of Rotterdam. The **ACE Terminal** is planned to be operational from 2026."
  - **Port of Rotterdam Authority (PORA) continues to lead the way**: On **May 10**, **2020**, a number of news items covered the size and shape of what **PORA** and 70 corporations will be able to achieve, represented most consistently by a representation of a hydrogen molecule marked with "**4.6 mega tonnes hydrogen in 2030**" and "**Rotterdam Europe's Hydrogen Hub**". The news items and the photo-opportunities arose ahead of the presentation of **REPowerEU** on **May 18**, **2022**. While the news items and the photo-opportunities were jolly, the underlying message is clear – for the ***EU*** to achieve the objectives of **REPowerEU** production and import capacity has to be increased at ports (has hydrogen hubs), across Europe.

- **Green Shipping:**
  - **Design for 37,500 m_3 liquified hydrogen carrier:** On **May 3**, **2022**, it was reported widely that **C-Job Naval Architects** has provided high-level details of its **141 metre**, **37,500 m_3**, liquid hydrogen (***LH_2***) carrier.

Source: C-Job Naval Architects' website

Critically, the design of the ***LH_2*** carrier allows transportation of ***LH_2*** without the need for ballast, with the containment system at deck-level. Also the containment system will allow a lower level of boil-off than currently.

The news item has drawn considerable comment, much of it enthusiastic. Of particular interest has been comment around the use of the ***LH_2*** carrier to facilitate the trade in ***LH_2*** between Scotland and Germany, delivering 100

metric tonnes (scaling up to 300 metric tonnes) of ***LH_2*** a day, on a "milk-run". The intention is that ***LH_2*** carrier will be commissioned at least six months before the first scheduled loading of ***LH_2*** in 2027.

- **First truck to ship hydrogen bunkering successful**: On **May 5**, **2022**, **Ekinetix** announced that the **Hydrocat** (a hydrogen-powered vessel used as a support vessel for off-shore wind field developments) had been bunkered with hydrogen using its mobile refueler and bunkering process.
- **ONE orders 10 13,700 TEU container vessel**: On **May 31**, **2022**, offshore-energy reported that Singapore-based **Ocean Network Express** (**ONE**) had order the build of 10 eco-efficient very large container vessels (**VLCS**). As reported, five **VLCS** will be built by **Hyundai Heavy Industries** and five by **Nihon Shipyard**. The new **VLCS** are planned for **Ready Notation** or **Approval in Principal** to use **ammonia** and **methanol** as fuel, and to deploy **carbon capture** and **storage**.

- **Carbon price on shipping emerging:**
  - **Japan supports carbon tax in the shipping sector**: On **May 3**, **2022**, **The Financial Times** reported that Japan had informed the International Maritime Organisation (**IMO**) that it would support a carbon tax to raise more than **USD 50 billion** a year. As proposed, the shipping industry would have to pay **USD 56** per metric tonne of ***CO_2*** from **2025** to **2030**, increasing to **USD 135** per metric tonne of ***CO_2*** from **2030**. The money raised would be made available to fund the decarbonisation of the shipping industry, both the world shipping fleet and the infrastructure and fuels that it uses.

    The shipping industry gives rise to at least 3% (around one billion metric tonnes of ***CO_2-e***) of ***GHG*** emissions arising globally each year.

    As regular readers of Low Carbon Pulse will know, there continues to be a debate as to how best to decarbonise the shipping industry. From a policy setting perspective, decarbonisation is best undertaken on a global basis, rather than on a jurisdiction-by-jurisdiction basis or economic bloc basis.
  - **International Maritime Organisation** (***IMO***) **consensus**: On **May 23**, **2022**, climatechangenews reported that the ***IMO*** (the agency of the United Nations responsible for regulating shipping) had reached consensus that a carbon price was required to decarbonise the shipping industry: the meeting of the ***IMO*** took place during the week beginning May 16, 2022, and the conclusion was that "as part of a basket of mid-term measures", with support to adopt a "well-to-wake" approach – providing a carbon price for production of fuel for shipping, and for use of fuel by shipping.

    The ***IMO*** consensus arose as the ***EU*** approved the **Fit-for-55 package**, including shipping in the ***EU ETS*** (see **Editions** 22, 27 and 32 of Low Carbon Pulse for background).

Airports and Aviation:

*This section considers news items that have arisen within the news cycle of this **Edition 40** of Low Carbon Pulse relating to the development and deployment of technology a airports and in the aviation sector to decarbonise the airports and the aviation industry.*

- ***SAF* continues to find, and to expand, market:**
  - On **May 19**, **2022**, it was reported widely that **Neste** (leading renewable chemical and fuel supplier) and **United Airlines** had signed a three year sale and purchase agreement under which **Neste** is to sell and **United Airlines** is to purchase up to **160,000 metric tonnes** (**52.5 million gallons** or **### million litres**) of **Neste**'s **MY Sustainable Aviation Fuel**, with the SAF to be used to power and to propel United's flights from Schiphol Airport, Amsterdam.
  - On **May 27**, **2022**, **Neste** announced that **Neste** and **ITOCHU** were celebrating the **first delivery**, in Japan, of **Neste**'s **MY Sustainable Aviation Fuel** to **Etihad Airways**, with ***SAF*** to be delivered to Etihad Airways at Narita International Airport, Toyko. Japan is committed to the use of ***SAF*** to satisfy 10% of total use of aviation fuel by 2030.

Reference Materials:

The purposes of this Reference Material section is keep live, reference material that readers may find most useful on an ongoing basis without the need to search for that material:

- **Background on electrolysers:**

  At the moment around 61% of electrolysers use ***AE*** technology and around 30% use ***PEM*** technology.

ANATOMY OF AN ELECTROLYSER	
Alkaline electrolysers (***AE***) produce H2 using a liquid electrolyte, using nickel electrodes and stainless steel for the stack.	***AEs*** and ***PEMs*** have similar electrical energy efficiency, with the consumption of electrical energy being almost the same. PEM's operate at a higher electrical current, and as such are more productive per unit of stack mass.
Polymer Electrolyte Membrane or Proton-Exchange Membrane (***PEM***) electrolysers operate in an acidic environment, using iridium coated anodes and platinum coated cathodes, both the anode and cathode are made from titanium.	

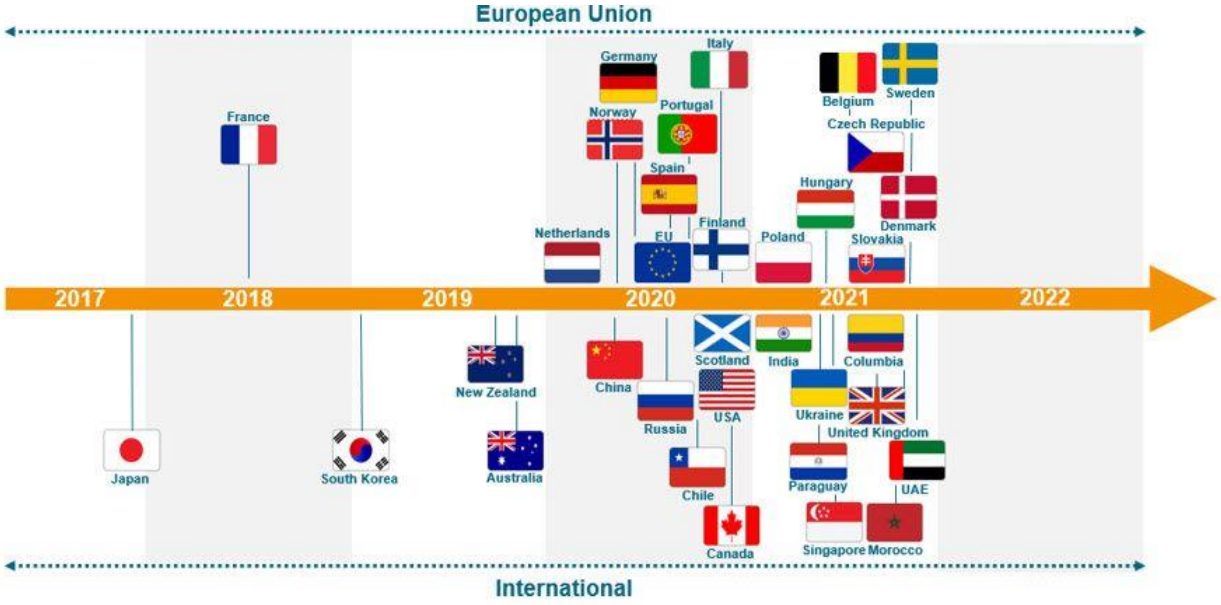
In addition to ***AE*** and ***PEM*** electrolyser technologies, there are what may be regarded as emerging technologies of anion exchange membranes (***AEM***) and solid oxide electrolysis cells (***SOEC***).It is fair to say that ***SOEC*** electrolysers are emerging more quickly, and more developed, than ***AEM***.

SOLID OXIDE ELECTROLYSER CELLS (*SOECS*)
SOECs operate at high temperatures and with high electrical efficiencies of 79-84% (LHV), and require a heat source to produce steam. Therefore if ***SOEC*** hydrogen were used to produce synthetic hydrocarbons (power to liquid and power to gas) it would be

possible to recover waste heat from the synthesis processes to produce steam for further ***SOEC*** electrolysis. Nuclear power, solar thermal and geothermal heat systems, as well as industrial waste heat, could provide heat sources for ***SOEC***s.

SOEC electrolysers can be operated in reverse mode as fuel cells, to convert hydrogen back into electrical energy (again, distinct from ***AE*** and ***PEM***.) Combined with hydrogen energy storage systems (***HESS***), ***SOEC***s can provide balancing services to grids, increasing the overall use of the ***SOEC***. ***SOEC*** can be used for co-electrolysis of steam and CO_2 so as to create a synthetic gas mix comprising ***CO*** and H_2 for conversion into synthetic fuel.

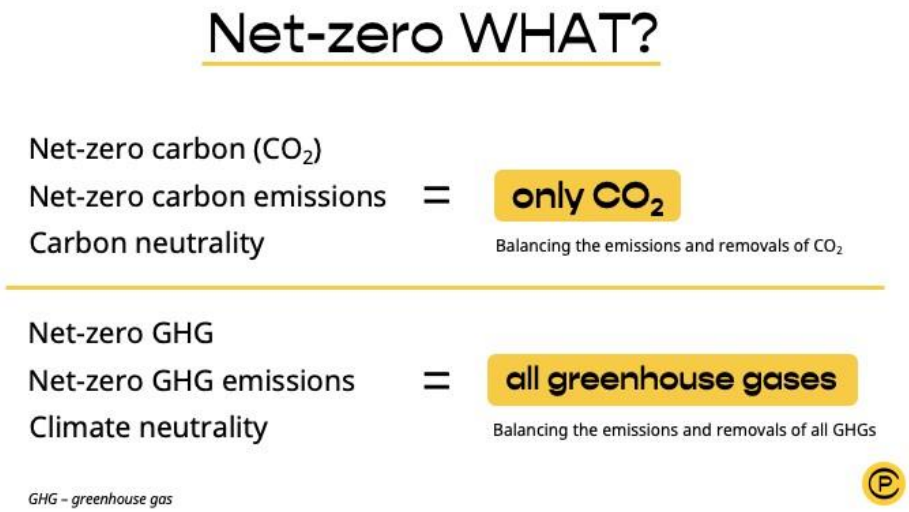
- **A reminder of countries with Hydrogen Plans, Roadmaps and Strategies:**



- **S&P Global Platts – Atlas of Energy Transition:** On **February 22, 2022**, S&P Global Platts published its ***Hydrogen Price Wall***, mapping hydrogen prices across means of production and regions of use. The ***Hydrogen Price Wall*** is to be found in the updated ***Atlas of Energy Transition***.

  While Low Carbon Pulse does not report on the cost or price of hydrogen, the S&P Global Platts ***Hydrogen Price Wall*** (as part of the ***Atlas of Energy Transition***) provides a helpful point of reference.

  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.
- **A reminder:** On **March 26, 2022**, the author of Low Carbon Pulse came across the following simple reminder of the nomenclature of carbon neutrality and net zero:



NZE Publications:

At the end of each edition of Low Carbon Pulse, publications mentioned or reviewed in the edition are listed, by organisation, title / subject matter, and link:

ORGANISATION	TITLE / SUBJECT MATTER
Clean Air Task Force (***CATF***)	***A European Strategy for Carbon Capture and Storage***
European Commission (***EC***)	**EU Save Energy Communication**
European Commission (***EC***)	**draft Delegated Acts**
European Commission (***EC***) and the European Investment Bank (***EIB***)	***Unloading the hydrogen economy - stimulating investment across the hydrogen value chain***
Global CCS Institute	***State of the Art: CCS Technologies 2022***
Green Hydrogen Organisation	***The Green Hydrogen Standard***
International Energy Agency (***IEA***)	***Renewable Energy Market Update – May 2022 – Outlook for 2022 and 2023***
International Energy Agency (***IEA***)	***Global EV Outlook 2022***
International Energy Agency (***IEA***)	***Southeast Asia Energy Outlook 2022***
International Energy Agency (***IEA***)	***Enhancing China's ETS for Carbon Neutrality: Focus on the Power Sector***
International Energy Agency (***IEA***)	***Renewable Energy Market Update: Key Findings***
International Renewable Energy Agency (***IRENA***)	*Global Hydrogen Trade To Meet The 1.5OC Climate Goal – Part I – Trade Outlook for 2050 and way forward*
International Renewable Energy Agency (***IRENA***)	***Global Hydrogen Trade To Meet The 1.5^{O}C Climate Goal – Part II – Technology Review of Hydrogen Carriers***
International Renewable Energy Agency (***IRENA***)	***Global Hydrogen Trade To Meet The 1.5OC Climate Goal – Part III – Green hydrogen supply cost and potential***
International Renewable Energy Agency (***IRENA***)	***Critical Materials for Energy Transition: Rare Earth Elements – Technical Paper 2/2022***
International Renewable Energy Agency (***IRENA***)	***Innovation Outlook: Renewable Ammonia***
Microsoft	***Accelerating the Journey to Net Zero – A Blue Print for Australia***
MIT Energy Initiative	***The Future of Energy Storage***
National Renewable Energy Laboratory (***NREL***)	***Biogas Potential in the United States (Fact Sheet), Energy Analysis***
The Oxford Institute for Energy Studies (***OIES***)	***The role of CCUS in decarbonising the cement industry: A German case study***
World Bank	***State and Trends of Carbon Pricing 2022***
World Metrological Organisation (***WMO***)	***State of the Global Climate 2021***

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