

Low Carbon Pulse - Edition 39

GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS



Welcome to the **Long Form Version** of **Edition 39** of Low Carbon Pulse – sharing significant news on progress towards net-zero greenhouse gas (**GHG**) emissions (**NZE**) for the period from **Friday April 1, 2022** to **Saturday April 30, 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).

Headlines:

Earth Day 2022:

Friday April 22, 2022, was **Earth Day 2022**. There was considerable coverage before, on and after Earth 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. **Edition 40** of Low Carbon Pulse will cover in detail.

The Month Ahead:

As flagged in **Edition 32** of Low Carbon Pulse, during the coming month:

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

For the author of Low Carbon Pulse, the progress made at the **Congress** will be 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 **CO₂**, i.e., its negative **GHG** emission impact.

- **May 9 to 20:** The **15th United Nations Conference to Combat Desertification** will be held in the Côte d'Ivoire. Consistent with **LDC5**, the **UN Biodiversity Conference** and the **XV World Forestry Congress**, the overarching theme that may be expected to emerge will be how to address deforestation, reforestation, afforestation, and land restoration, and land-management and land-use generally.

The Month in the rear view mirror:

- The impact of the conflict in Ukraine continues to resonate globally. The rate at which countries have committed to the development and deployment of liquefied natural gas (**LNG**) receiving terminals (floating and land based) remains a marked trend, as does the rate at which Green Hydrogen infrastructure (production and transportation facilities) is being developed. As might be expected, this activity has been particularly pronounced in Europe (see the **Europe and UK** section); and
- **Edition 38** of Low Carbon Pulse (published on **April 14, 2022**) outlined the key findings arising from [IPCC WGIII Climate Change 2022: Mitigation of Climate Change](#) report and the [IRENA World Energy Transitions Outlook 2022](#). From the number of engagements, and feedback, it seems to have struck a balance.

Vale those lost:

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

Low Carbon Pulse – Long Form Version of Edition 39 – Published on May 5, 2022.

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

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Timeline for April and May 2022:

- **IPCC WGIII conference and publication:**

- **Climate Change 2022: Mitigation:**

- On **April 4, 2022** the [IPCC WGIII Climate Change 2022: Mitigation of Climate Change](#) report (**IPCC WGIII Report**) was published. **Edition 38** of Low Carbon Pulse covered its key findings, and those of **WETO 2022**: in summary, the findings of the **IPCC WGIII Report** and **WETO 2022** are not new, but the findings are as compelling as any report so far because of their clarity and detail, around the need for immediate and urgent action to reduce **GHG** emissions, and otherwise act to mitigate the impacts of climate change.
 - **Facts and stats:** As with the lead up to the publication of the **IPCC WGII - Climate Change 2022: Impacts, Adaptation and Vulnerability** report (on February 28, 2022), during the lead-up to the publication of the **IPCC WGIII Report**, the **IPCC** provided a narrative about the number of scientists involved, comments received, and documents reviewed: 271 scientists from 65 countries were involved, 59,000 comments were received (including 21,500 comments on the first draft, and 32,500 comments on the second draft), and 18,000 publications were assessed. A mammoth undertaking, and an excellent report.
 - **Jaw, Jaw Reports:** In the lead up to the publication of the **IPCC WGIII Report** there was reporting about the lack of alignment on the findings, with the session schedule extended into **April 3, 2022** ahead of publication on **April 4, 2022**. The same issue that extended proceedings at **COP-26** (held in Glasgow, Scotland (scheduled to end November 12, 2021, running into November 13 and 14, 2021)), extended the **IPCC WGIII** session to finalise the **IPCC WGIII Report** – that issue was fossil fuels.
 - **Contention late in the day:** Given the importance of the **IPCC WGIII Report** it is understood that finalisation was contentious "because it covers the policies, technologies and finances needed to cut greenhouse gas emissions" (as reported in The Guardian).
As reported, the most contentious engagement was around the timeline to phase out fossil fuels, and, in this context, the use of technologies to extend the timeline. While the reporting around lack of alignment is no doubt accurate, the noise / static should not distract us from what needs to be done, which is known, and the means to do what needs to be done, which already exist
 - **There is no time to lose:** As noted in **Edition 37** of Low Carbon Pulse, to the author, the **IPCC WGIII Report** is the most important of the reports produced by the three **IPCC Working Groups** because it provides "how to do" "what needs to be done" outlined in the **IPCC WGI Report** (August 2021) and **IPCC WGII Report** (February 2022), which cover the extent of climate change and its impacts.

- **IPCC reports – next steps:**

- The **IPCC WGIII Report** is the third of the three Assessment reports from each **IPCC** Working Group forming part of **AR6: Working Groups I, II and III**.
 - In **September 2022**, the **IPCC** will publish the **Synthesis Report** for the purposes of **AR6**.
The **Synthesis Report** will synthesise and integrate findings and materials contained in the reports from each **IPCC Working Group**, and findings and materials contained in three Special Reports ([Global Warming of 1.5°C](#), [Climate Change and Land](#) and [The Ocean and Cryosphere in a Changing Climate](#)).
Following the tried and tested format, the **Synthesis Report** will be in two parts, the **Summary of Policymakers (SPM)** and the **Longer Report**.
 - Just as the [IPCC Working Group I Climate Change 2021: The Physical Science Basis](#) report (in particular the Summary of Policy Makers contained in it) informed discussions at and outcomes from **COP-26**, the **SPM** and the **Longer Report** (contained in the **Syntheses Report** for the purposes of **AR6**) will inform discussion of **COP-27** to be held in Sharm el-Sheikh, South Sinai, Egypt from **November 7 to November 18, 2022**.

Legal, Policy Setting and Regulatory highlights:

This section considers news items that have arisen within the news cycle of this **Edition 39** of Low Carbon Pulse in respect of laws and regulation, and broader policy settings, in each case describing substance, progress and impact.

• **IEA publications during April:**

- On **April 1, 2022**, the **International Energy Agency (IEA)** published [Direct Air Capture – A key technology for net-zero \(DAC Study\)](#). The publication provides a helpful guide to one means of carbon dioxide removal (**CDR**) from the atmosphere.

The publication of the **DAC Study** dovetailed neatly with the publication of the **IPCC WGIII Report**, particularly to inform some of the headlines arising from the **IPCC WGIII Report** about the need for **CDR** in the context of limiting global warming to a **1.5°C** or **2°C** increase in average global temperatures.

As has been noted in various editions of Low Carbon Pulse, Article 4 of the Paris Agreement contemplates **CDR**. Also as has been noted in various editions of Low Carbon Pulse, **CDR** needs to be used now (see **Edition 27** of Low Carbon Pulse and explained in full in **Edition 38** of Low Carbon Pulse).

Direct Air Capture is one of the means that will be used to effect **CDR**. There is nothing new in this, but what is new is the realisation broadly that **CDR** needs to occur immediately and at scale, rather than leaving it until mid-century. **Edition 38** of Low Carbon Pulse explains this in detail.

- On **April 17, 2022**, the **IEA** published its [Sustainable Recovery Tracker – Monitoring Progress towards sustainable recoveries from the Covid-19 crisis](#), with the key findings being:
 - As at the end of March 2022, Governments worldwide had earmarked **USD 710 billion** for sustainable recovery measures;
 - Governments of more advanced economies had ear-earmarked **USD 370 billion** for clean energy measures to be spent by the end of 2023 (consistent with the near-term spending estimated by the **IEA** as necessary to progress to achieve **NZE** by 2050);
 - There is a widening gap between the more advanced and the emerging and developing economies (with the near-term spending of emerging and developing economies estimated by the **IEA** to be at less than a quarter of the near-term spending necessary to progress to achieve **NZE** by 2050).

The latest update of the **IEA Sustainable Recovery Tracker** is available in full form on line, and details over 1,000 policy settings in the context of sustainable recovery from the Covid-19 crises.

- On **April 15, 2022**, the **IEA** published its [Gas Market Report, Q2-Analysis, including Global Gas Review 2021](#). The key finding from the report is that during the balance of 2022 global demand for natural gas is expected to decline slightly (50 billion m³, equivalent to ½ of the US exports of LNG during 2021), as a result of the disruption caused by the conflict in Ukraine.
The report references the **IEA 10-Point-Plan** (published on March 3, 2022, and covered in **Edition 36** of Low Carbon Pulse), that outlined measures that may be taken across Europe to reduce gas imports from Russia, with demand in Europe expected to reduce by 6%. The **IEA** report notes the impact on natural-gas and LNG spot prices since the start of 2022.
- On **April 20, 2022**, the **IEA** published its [Belgium 2022 – Energy Policy Review Report](#) (the **Belgium Report**). The **Belgium Report** is well-worth a read. The headlines are that Belgium needs to develop the means to increase the rate of reduction of **GHG** emissions and to reduce its reliance on energy imports.

• **IRENA:**

After a busy **March 2022** for the **International Renewable Energy Agency (IRENA)**, **April 2022** was a little quieter in terms of the number of publications, but that which was published was helpful and weighty:

- On **March 14, 2022**, the **IRENA Coalition For Action** published [Decarbonising End-Use Sectors: Green Hydrogen Certification \(Certification Paper\)](#), which provides the following recommendations: **1.** Develop a standard definition of Green Hydrogen, **2.** Certify the origin of renewable energy used to produce hydrogen; **3.** Ensure certificates contain sufficient information to address policy settings and the market; **4.** Simplify the Green Hydrogen tracking system to avoid overly burdensome administration; **5.** Implement a cost effective and efficient tracking system; **6.** Put in place control systems to avoid the consequences of any abuse or lack of transparency; **7.** Ensure interfaces between tracking and control systems work effectively, both existing, and new; **8.** Avoid double counting; **9.** Use policy setting taxonomy and green finance criteria to encourage compliance; and **10.** Promote international cooperation to establish globally accepted requirements.
- On **April 11, 2022**, **IRENA** published [Renewable Capacity Statistics 2022](#), with a helpful three page summary [Renewable capacity highlights](#);
- On **April 19, 2022**, **IRENA** published [Grid Codes for Renewable Powered Systems](#). The publication is an update on the **IRENA** publication from 2016, [Scaling Up Variable Renewable Power: The Role of Grid Codes](#). The publication is excellent, and well-worth a read;
- On **April 11, 2022**, **IRENA** published data detailing installed renewable electrical energy [Renewable Capacity Statistics 2022](#). While the content of the data is not surprising, the data is a helpful reference.

By way of reminder: During **March 2022**, in addition to **WETO 2022**, **IRENA** published the following: [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](#), with the associated publication of [Collaborative Framework on Critical Materials For The Energy Transition](#), with the [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.

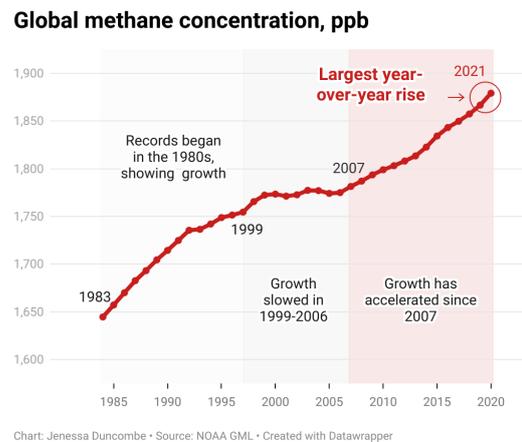
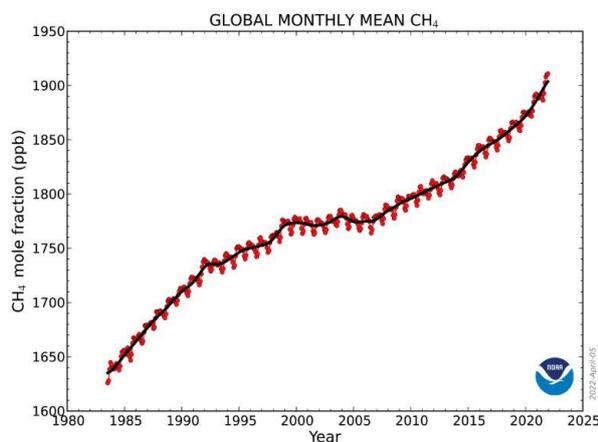
The [Collaborative Framework on Critical Materials For The Energy Transition](#) and the [Renewable Energy Market Analysis: Africa and its Regions](#) report will be considered in the **March and April Report on Reports** to be included in the Third Compendium of Low Carbon Pulse to be issued shortly.

- **European Commission's plans to publish technical regulations:** On **April 21, 2022**, it reported widely 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](#). **Edition 40** of Low Carbon Pulse will consider the parameters.
- **Denmark proposes corporate carbon tax:** On **April 22, 2022**, **Reuters** reported that the **Danish Government** proposes to introduce a uniform carbon tax, under which corporations will have to pay a levy of 1,125 Danish crowns (USD 164.21) per tonne of **CO₂** equivalent. It is understood that the carbon tax will be applicable to the energy sector and heavy industries for the most part. The **Danish Government** states that the carbon tax could reduce Denmark's carbon emissions by 3.7 million tonnes per year by 2030. Additionally, the **Danish Government** has proposed investing 7 billion Danish crowns to assist corporations to develop and implement their energy transition strategies.
- **McKinsey & Co:** On **April 26, 2022**, **McKinsey & Co** published its [Global Energy Perspective 2022](#). As ever, the publication is excellent and is well-worth a read. The key headline is that if all countries implement their [nationally determined contributions \(NDC's\)](#), **McKinsey & Co** models a **1.7°C** increase in average global temperatures: "To keep the 1.5°C pathway in sight, even more ambitious acceleration [in GHG emission reduction] is needed". As regular readers of Low Carbon Pulse will know, this is broadly aligned with other models. For the purposes of this modelling, **McKinsey & Co** models that demand for hydrogen is expected to increase by four to six fold by 2050. (For ease of reference, [links](#) are attached to previous **McKinsey & Co** reports.)

Climate change reported and explained:

*This section considers news items within the news cycle of this **Edition 39** 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.*

- **Methane emissions at highest levels:**
 - On **April 7, 2022**, the US **National Oceanic & Atmospheric Administration (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.



- **A more granular graph:** Also on **April 7, 2022**, [eos.org](#) published an excellent article (under [A Climate Mystery Warns US to Heed the Unknown](#)). The article contains the above graphic (to the right above), which continues to illustrate the point, in a more granular way.
- On **April 7, 2022**, [The Washington Post](#) published an excellent article [Methane emissions jumped by record amount in 2021, NOAA](#). In the context of the **IPCC WGIII Report**, it is worth reminding oneself that the reduction of **CH₄** is one means of buying time: by reducing the rate at which the global carbon budget of **3,000 GtCO₂** is used the better (noting that at the end of 2019 **2,400 GtCO₂** of the global carbon budget had been used). Key points that arise from the excellent article in **The Washington Post** are (each point shared by an **NOAA** scientist and reported in the article):
 1. Given that **CH₄** released to the atmosphere has up to 84 times the global warming potential of **CO₂**, but a relatively short life as a **GHG** (ceasing to have global warming potential after about 9 years according to the article), a reduction in the rate of emission of **CH₄** will allow a more effective response in the near term, relative to other **GHG** reduction initiatives;
 2. Heavy rains arising from the **La Nina** weather patterns over the last two years may have flushed large quantities of **CH₄** from wetlands.
 In addition to fugitive emissions from fossil fuel production and transportation, **CH₄** from landfills and livestock are "dominant drivers" behind the increased **CH₄** emissions monitored since 2006 / 07;

3. The "need for speed" should be motivating every climate scientist, every climate policymaker, every climate activist. Reducing and ceasing **CH₄** emissions represents the single biggest, fastest and cheapest way to reduce global warming in the near term.

Also reductions in **CH₄** emissions lower the cost "of climate mitigation and the cost adaptation, and lower reliance on learning how to remove carbon dioxide from the atmosphere" (see [Article 4](#) of the Paris Agreement, including as reported on in [Edition 38](#) of the Low Carbon Pulse and the [Anniversary Edition](#) of Low Carbon Pulse); and

4. "The effect of carbon dioxide emissions is cumulative. About 40 per cent of the Ford Model T emissions from 1911 are still in the atmosphere today".

Point 4 is sobering, and illustrates, succinctly, the criticality of the accelerated progress towards **NZE**.

• **By way of reminder:**

- [Edition 15](#) of Low Carbon Pulse reported that:

"Both President Xi Jinping and President Vladimir Putin made key statements at the Leaders' Summit. Each President re-affirmed key existing commitments: in the case of the **PRC**, achieving peak **GHG** emissions by 2030 and netzero GHG emissions by 2060, and to exercise strict control over coal-fired electrical energy generation, and in the case of Russia to reduce "significantly" its **GHG** emissions over the next three decades, noting that since 1990 Russia had reduced its **GHG** emissions by nearly 50%. Importantly, President Putin noted the need to reduce methane (**CH₄**): as noted in [Edition 14](#) of Low Carbon Pulse, there is increasing concern about **CH₄** levels in the atmosphere as a result of its global warming potential. It is hoped that there is increased concentration on this issue ahead of **COP-26**, in Glasgow, Scotland, in October / November, 2021. Also President Putin touched on the role of negative **GHG** emissions initiatives, and the potential for Russia to be a key player given its natural advantage of land mass".

- [Edition 24](#) of Low Carbon Pulse noted that the reduction in **CH₄** emissions is important because the global warming potential of **CH₄**, as a **GHG**, in terms of potency per tonne, is greater than carbon dioxide (**CO₂**): a molecule of **CH₄** has a half-life of 9 years, compared to **CO₂** with a half-life of 100 years. Over 20 years, **CH₄** traps up to 84 times as much heat energy as **CO₂**.

- [Edition 27](#) of Low Carbon Pulse reported that: "Increasing concern about increasing the concentration of **CH₄** resulted in the announcement on September 17, 2021, by the **EC** and US of the [Global Methane Pledge](#), given jointly, to reduce **CH₄** emissions by nearly a third within the next decade. At that time Low Carbon Pulse expressed: "The hope, [that] the objective of the **EC** and US now has to be to ensure, that as many countries as possible join with them in this critical initiative".

- [Editions 29](#) and [30](#) of Low Carbon Pulse reported on progress, as over 100 countries took the [Global Methane Pledge](#). In addition, [Edition 29](#) of Low Carbon Pulse reported on International Energy Agency (**IEA**) [Curtailing Methane Emissions from Fossil Fuel Operations \(CCH4R\)](#). The headline from the **CCH4R** was that the reduction in methane (**CH₄**) emissions is "among the most impactful ways to combat near-term climate change".

The **CCH4R** noted that:

"Methane has contributed around 30% of the global rise in temperature to date ... Emissions from fossil fuel operations present a major opportunity [to limit global warming in the near term] since the pathways to reduction are both clear and cost-effective".

- [Edition 34](#) of Low Carbon Pulse noted that as at February 4, 2022, 103 countries had signed the Global Methane Pledge. [Edition 34](#) also noted that: "While many countries have signed the Pledge, work needs to be done to implement the Pledge, considerable work". As of **April 30, 2022**, 131 countries have signed the Pledge.

- [Edition 35](#) of Low Carbon Pulse reported that: "On **February 8, 2022**, [nature.com](#) reported on increasing levels of methane (**CH₄**) in the climate system (under [Scientists raise alarm over "dangerously fast" growth in atmospheric methane](#)). **CH₄** concentration exceeded 1,900 parts per billion during 2021 (see [NOAA 2022 Sea Level Rise Technical Report](#)).

- **Methane Reduction and Carbon Dioxide Removal (CDR):** The author of Low Carbon Pulse notes that there is an ever increasing 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 **CH₄** reduction and **CDR**. This sharper focus is becoming ever more focussed.

While not the only initiative, the **McKinsey & Co** led [Frontier](#) initiative (announced on April 13, 2022) is illustrative of both the awareness of the need, and the means to addressing the need, for acceleration of **CDR**.

As announced, the Frontier initiative comprises an advance market commitment (**AMC**) of **USD 925 million** (over eight years) to accelerate **CDR** solutions and technologies. The purpose of **Alphabet, Shopify, Meta** and **Stripe**, working with each other and McKinsey & Co, is to support the expansion of the supply of **CDR** solutions and technologies, rather than increase competition for the supply that exists today.

For those wishing to read more on **CDR** across a range of initiatives, in February 2022, the excellent [euractiv.com](#) published a series of helpful articles framing thinking broadly across **CDR**. [Carbon removals](#); [Carbon removals: the secret to reaching net zero emissions](#); [Europe aims to scale up infrastructure for permanent carbon removals](#); [Finnish MEP: 2020s need to be 'decade of change' for Europe's depleting carbon sinks](#); [EU wants to reward farmers and foresters for nature-based carbon removals](#); [Researcher: Carbon removal technologies 'need to be upscaled quickly'](#).

Middle East including GCC Countries:

This section of *Low Carbon Pulse* considers news items within the news cycle of this **Edition 39** 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.

- **ENOWA HIDC:** On **April 1, 2022**, **ENOWA** [announced](#) that it has established the **Hydrogen Innovation and Development Center (HIDC)**. The **HIDC** is intended to contribute to the objective of the Kingdom of Saudi Arabia (**KSA**) to achieve energy carrier diversification, and as such allow the **KSA** to become a global clean energy leader.

By way of reminder: On **March 21, 2022**, **NEOM** launched **ENOWA** to lead the development and deployment of **NEOM's** world class sustainable energy and water systems, including [The Line](#), **OXAGON** (see **Editions 31** and **35** of *Low Carbon Pulse*) and [Trojena](#), and of course as a shareholder in the joint venture with Acwa Power and Air Products (**Neom Green Hydrogen**) to develop the Helios Green Hydrogen production project.

- **Oman considers Green Steel:** On **April 4, 2022**, the [Oman Daily Observer](#) reported that **Hydrogen Rise AG** (a renewable energy corporation, headquartered in Munich, Germany) had "embarked on a strategy to support the production of 'green steel' for the first time in the Sultanate of Oman". As reported, this involves plans "to trial the production of green steel at the Sohar Port complex of Jindal Shadeed Iron and Steel".

As might be expected, the trial will involve the use of Green Hydrogen as a high-heat temperature source so as to displace the use of fossil fuel in the production of iron and steel.

- **Oman progresses with the 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**.

By way of reminder: **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 **InterContinental Energy**, in partnership with **OQ** (state owned Omani oil and gas company) and **EnerTech** (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.

InterContinental Energy is a name that will be familiar to those following the **Asian Renewable Energy Hub** being developed in the Pilbara Region of Western Australia (see **Edition 2** of *Low Carbon Pulse*) [and, latterly, the **Western Green Energy Hub** in Western Australia (see **Edition 22** of *Low Carbon Pulse*)]."

- **KSA National Hydrogen Strategy:** On **April 7, 2022**, it was reported that the **National Hydrogen Strategy** for **KSA** was being finalised, and that in the context of its finalisation it is likely that the **National Hydrogen Strategy** will target up to capital expenditure **USD 36 billion** by 2030 to develop hydrogen production capacity.

It is understood the **National Hydrogen Strategy** will focus on the key elements of the hydrogen value chain, including production and export of hydrogen, and on domestic use of clean hydrogen by the infrastructure and the transport sectors.

- **NEOM progress continues:**

- **Helios Green Light:**

- **Edition 37** of *Low Carbon Pulse* reported that: "On **March 17, 2022**, it was reported widely that the USD 5 billion Helios Green Hydrogen production project (part of the development of the Neom project) is to commence construction. The Helios project is to be powered by 4 GW of renewable electrical energy. It is expected that the Helios project will be producing Green Hydrogen by 2026. The Helios project is to deploy 120 electrolysers supplied by thyssenkrupp AG. The commencement of construction is a landmark".

- On **April 5, 2022**, [energy-utilities.com](#) reported (under [Acwa Power consortium signs \\$900m EPC contract for Neom hydrogen project](#)) that Neom Green Hydrogen had signed an EPC Contract with Air Products, under which Air Products Middle East Industrial Gases is to undertake work in the **KSA** and Air Products to undertake work beyond the borders of the **KSA**.

As well as being the EPC Contractor, Air Products is an equity 33.3% participant in **Neom Green Hydrogen**, with the other equity participants being Acwa Power and Neom Company (an **ENOWA** subsidiary) with 33.3% and 33.4% equity participation respectively.

- On **April 8, 2022**, [al-Arabiya news](#) reported that **Snam** (Italian energy infrastructure operator) had contracted for the supply of equipment and plant in the context of the development of the Helios Project.

- **Progress on Helios Industries' KIZAD project:** On **April 8, 2022**, [energy-utilities.com](#) reported (under [Studies completed for \\$1 bn Abu Dhabi green hydrogen and ammonia project](#)) that financial and technical feasibility studies had been completed for **Helios Industries** in respect of the Green Hydrogen and Green Ammonia project to be located in **Khalifa Industrial Zone Abu Dhabi (KIZAD)**.

By way of reminder: Previous editions of *Low Carbon Pulse* have reported on the progress of this world scale project as follows:

- **Edition 18** reported that on May 25, 2021, the Khalifa Industrial Zone Abu Dhabi (**KIZAD**) announced the development of a Green Hydrogen facility by Helios Industries. The Green Hydrogen facility is to be developed in phases, and on full development will produce up to 40,000 tonnes of Green Hydrogen and 200,000 tonnes of Green Ammonia per year. It is understood that the Green Hydrogen facility is to be powered by a 800 MW photovoltaic solar farm within **KIZAD**. Head of Industrial Cities & Free Zone Cluster, Mr Abdullah Al Hameli, said that: "**Abu Dhabi Ports is proud to be the host of an innovative company like Helios Industries, and one of the region's first green ammonia plants with zero-carbon emissions**".

- **Edition 25** recounted the announcement of the development of a Green Hydrogen and Green Ammonia facility by Helios Industries within the Khalifa Industrial Zone Abu Dhabi (**KIZAD**), adding that on August 16, 2021, it was reported that Helios Industries had contracted with thyssenkrupp to undertake a technical study in respect of an initial production of 20,000 tonnes per annum (**tpa**) of Green Hydrogen, with production to develop overtime to 200,000 **tpa**."

As was apparent from another piece in **Edition 25** of Low Carbon Pulse (**German flagship projects – progress check**) thyssenkrupp was the ideal organisation to undertake this work: thyssenkrupp is coordinating one of the three flagship projects critical to the development of the hydrogen economy in Germany - **H2Giga**: involving the development of large-scale use of electrolyzers using renewable electrical energy to produce Green Hydrogen.

- **OPWP proceeds with W-to-E**: On **April 8, 2022**, [energy-utilities.com](https://www.energy-utilities.com) reported that **Oman Power & Water Procurement Company (OPWP)** was seeking to appoint a technical adviser to advise on the development of the **USD 1 billion waste-to-energy facility** to be located in **Barka, Oman**. The waste-to-energy facility will have between 130 and 150 MW of electrical energy generating capacity. **OPWP** has recently signed a memorandum of understanding (**MOU**) with the **Oman Environmental Service Holding Company (be'ah)**. Plans for the waste-to-energy facility were put on hold in 2020 in response to the impact of the C-19 pandemic.
- **Maldives W-to-E**: On **April 7, 2022**, there was news about the **waste-to-energy** project in the Maldives. While the Maldives is not within the Middle East, it is developing a waste-to-energy facility, with **Urbaser** (Spanish headquartered waste management corporation) using a Design Build Operate contract delivery model. The Maldives **Ministry of Environment**, with funding support provided by the **Asian Development Bank (ADB)** and the **Japan Fund for the Joint Development Mechanism**, is working with **Urbaser**. The waste-to energy facility will be located on reclaimed-land on the island of **Thilafushi, Maldives**.
- **Masdar (Abu Dhabi Future Energy Company) Kyrgyz Government MOU**: On **April 15, 2022**, **Masdar** (one of the world's leading renewable energy corporations) announced that it had signed a memorandum of understanding (**MOU**) with the **Kyrgyzstan Government** to work together to develop up to **1 GW** of renewable electrical energy projects, as planned, hydroelectric and photovoltaic solar.
- **Technology transfer**: On **April 18, 2022**, [English.aawsat.com](https://www.english.aawsat.com) reported that **Mitsubishi** intends to launch a "number of understandings" with the **KSA** to help transfer knowledge and technologies in a number of sectors, including agriculture and energy.
- **Photovoltaic solar on the near horizon**: On **April 19, 2022**, [energy-utilities.com](https://www.energy-utilities.com) reported that **Acwa Power (KSA utility corporation)** is developing plans for two photovoltaic solar projects, **Rabigh (300 MW)** and **Al Shuaiba (2 GW)**, having a projected combined installed capacity of **2.3 GW**. The projects are being developed under the second round of the renewable energy program of **Public Investment Fund**, with those plans to be submitted during May 2022. **Edition 40** of Low Carbon Pulse will cover progress.

By way of reminder: Edition 14 of Low Carbon Pulse reported on the Round 2 of the National Renewable Energy Program (**NREP**) as follows: "At the inauguration for the Sakaka IPP on April 8, 2021, Crown Prince Mohammad bin Salman bin Abdulaziz announced the results of the tenders for seven large-scale solar capacity projects under the **NREP**. The seven new projects are to be located in Jeddah, Madinah, Quarayyat, Rafha, **Rebigh, Al Shuaiba** and Sudair.

The 600 MW Al Shuaiba photovoltaic solar project was awarded on the basis of a world record low bid price for electrical energy of USD 0.0104 kWh (a little over 1 cent per kWh, or USD 10.40 per MWh). The Sudair photovoltaic solar project was awarded with the second lowest bid price of USD 0.01239 (1.239 cents per kWh or USD 12.39 MWh). On development, the Sudair photovoltaic solar project will be **KSA's** largest solar project, comprising around 1.5 GW of installed capacity. Approximately 3.6 GW of energy was contracted under Rounds 1 and 2 of the **NREP**.

On October 18, 2021, it was reported widely that **KAS's Renewable Energy Project Development Office (Repdo)** had shortlisted bidders for Round 3 of the **NREP**, with 1.2 GW to be contracted under Round 3. There are two categories of project in Round 3, Category A and Category B.

Category A projects are the 120 MW Wadi al-Dawasir PV IPP (**WADIPP**) and the 80 MW Layla PV IPP (**LIPP**). It is understood that TotalEnergies and Tamasuk Holding Company and the Acwa Power Consortium (comprising Acwa Power, SPIC (Huamghe Hydropower Development Company) and WEHC (Water and Electric Holding Company)) ranked first and second on **WADIPP** and Acwa Power Consortium and Alfanar ranked first and second on the **LIPP**.

Category B projects are the 700 MW Al-Rass PV IPP (**ARIPP**) and the 300 MW Saad PV IPP (**SIPP**). It is understood that the Acwa Power Consortium and Jinko Power ranked first and second on the **ARIPP** and that Jinko and Masdar ranked first and second on the **SIPP**.

As noted above, the Round 2 of the **NREP** resulted in a world record low bid price. Round 3 of the **NREP** has not resulted in new low bid prices, but the pricing is nevertheless at a level that continues the narrative about low photovoltaic solar costs. It is reported that the levelized cost of electricity (**LCOE**) bids have tariffs at the following: **WADIPP** US cents 1.9 kWh, **LIPP** US cents 3 kWh, **ARIPP** US cents 1.5 kWh and **SIPP** US cents 1.5 kWh".

- **Green Ammonia Certification**: On **April 20, 2022**, [hydrogen-central.com](https://www.hydrogen-central.com) reported that **TÜV Rheinland** (a global leading technical service provider) had **announced** the issue of the **First Green Hydrogen and Green Certificate Globally to Green Hydrogen & Chemicals SPC** for the production of Green Hydrogen and Green Ammonia from the project being developed by **ACME Group** and **Scatec ASA**. To all intents and purposes, **TÜV Rheinland** provides a green light to the effect that the proposed greenfield project will produce a Product Carbon Footprint of less than or equal to zero along with the planned production capacity of 1.2 million tonnes of ammonia in Oman.

The issue of the **Green Hydrogen and Green Ammonia Certificate (TÜV Rheinland Standard H2.21 Carbon-Neutral Hydrogen)** **TÜV Rheinland** provides evidence confirming that the ammonia and hydrogen produced at the photovoltaic solar powered Hydrogen-Ammonia plant will be from renewable sources, and will have lower levels of **GHG** emission than grey hydrogen.

By way of a reminder: Edition [37](#) of Low Carbon Pulse noted that on March 7, 2022, it was reported widely that Acme Group (Indian renewable energy company) and Scatec (Norway based renewable power producer) are to develop an ammonia production facility in Oman. The ammonia production facility is world scale, with nameplate ammonia production capacity of 1.2 million metric tonnes a year on completion of planned development and deployment.

- **Landfills to be mined:** On **April 20, 2022**, [rechargenews.com](#) reported that New York based **H₂-Industries** had signed a memorandum of understanding with the **Oman Public Establishment for Industrial Estates (Madayn)** which contemplates the development of a **USD 1.4 billion waste-to-hydrogen** production facility in **Oman**.

As reported, the feedstock for the production of hydrogen will be "mined from existing landfills" (the **urban-ore-body**). The waste-to-hydrogen production facility would be powered by **300 MW** of photovoltaic solar and **70 MW** of **BESS**.

At this stage, it is reported that rights to mine for feedstock have yet to be obtained by **H₂-Industries**. The counterparty to any right to mine contract is understood to be **Oman Environmental Service Holding Company (be'ah)**. The production of hydrogen from waste has been reported on in a number of editions of Low Carbon Pulse, a [Hydrogen for Industry](#) publication, is considered below (at [Air Liquide safe bet in Las Vegas](#) and [Seoul Sludge to Hydrogen](#)) and is considered in detail in an article entitled **Future Fuels** to be published in mid-May 2022 (the primary author of which is the author of Low Carbon Pulse).

Africa:

*This section considers news items within the news cycle of this **Edition 39** 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.*

- **Sovereign Wealth Funds align:** On **April 4, 2022**, [energy-utilities.com](#), reported that The Egyptian **Sovereign Fund of Egypt** and the Norwegian **Government Pension Fund Global** had signed a framework agreement, to which **Scatec** (leading Norwegian renewable electrical energy corporation) is also a party, under which the parties will target the development of green projects in **nine African countries - Burundi, the Democratic Republic of Congo, Djibouti, Ghana, Rwanda, Sierra Leone, South Sudan, Tanzania, and Uganda** (seven of the 46 least developed countries in the World: see [Editions 32](#) and [33](#) of Low Carbon Pulse). The framework agreement continues the marked increase in activity that the author is observing across Africa.
- **Eni and Government of Rwanda:** On **April 8, 2022**, **Eni** [announced](#) that it had signed a memorandum of understanding (**MOU**) with the **Government of Rwanda** under which **Eni** and the **Government of Rwanda** are to work together to identify opportunities to develop and to implement initiatives to promote the circular economy and to decarbonise value chains. Under the **MOU**, **Eni** and the **Government of Rwanda** will focus on the collection of used cooking oils and waste oils, waste management recycling and valorisation, with the particular fields of interest being AFOLU and bio-feedstock derivation, including for use to produce bio-fuels. This is in addition to reduction of **CO₂** in the wood-fuel value chain and the derivation of carbon credits as a result of the planned initiatives.

By way of reminder: Edition [37](#) of Low Carbon Pulse (under [Eni water PPPs](#)) reported that: "On **March 23, 2022**, [eni.com](#) announced that its subsidiary corporations, **Nigerian Agip Exploration** and **Agip Energy and Natural Resources**, and the **Food and Agriculture Organisation** of the UN (**FAO**), had commissioned 11 water schemes in the Borno and Yobe States, North East Nigeria. Each water scheme is integrated: comprising sourcing raw water from boreholes, use of electrical energy sourced from photovoltaic solar panels to pump water and to power water treatment facilities, providing water for domestic use and drinking, and for micro-irrigation purposes".

- **Namibia and Germany Joint Communique of intent:** On **April 18, 2022**, it was announced that the Director General of the Namibia's **National Planning Commission, Obeth M. Kandjoze** and the **German Federal Minister for Education and Research, Anja Karlicek**, agreed to establish a **partnership** between **Namibia** and **Germany**, and signed a Joint Communique of Intent (**JoI**). The **JoI** marks continued progress of Namibia as a major producer and exporter of Green Hydrogen.

The **JoI** notes:

"Germany will provide up to €40 million in funding from the economic stimulus package for solar power [harbouring great potential in Namibia] thanks to over 3,500 hours of sunshine per year .. We therefore think that one kg of H₂ from Namibia will cost between €1.50 and €2.00."

By way of reminder:

- **Edition 26** of Low Carbon Pulse reported (under [Green Hydrogen from Namibia](#)) that: "Germany was to partner with Namibia to allow the production and export of Green Hydrogen from Namibia and transportation and import into Germany at a price of USD 1.8 per kg. Namibia has world class renewable energy resources, with over 3,500 hours of sun each year, and strong wind resources. These world class resources are considered close to ideal for the production of Green Hydrogen at a price of between €1.50-2 per kg. Further it is estimated that up to 1.7 million metric tonnes per annum of Green Hydrogen could be produced by 2030. This mass of Green Hydrogen production delivered into Germany would be close to sufficient to decarbonise the German iron and steel industry given its current rate of production".
- **Edition 30** recounted (under [Namibia perfectly placed](#)) the consideration of the development of a Green Hydrogen project in Namibia, and reported that: "Hyphen Hydrogen Energy had been selected by the Government of Namibia to develop a large-scale Green Hydrogen project (**NH₂ Project**).

The **NH₂ Project**, to be located in the Tsau / Khaeb national park, was to produce 300,000 metric tonnes of Green Hydrogen a year. It is reported that the renewable electrical energy for the **NH₂ Project** will comprise 2 GW mixed photovoltaic solar and wind, and **BESS**, with a total capital cost of USD 4.4 billion.

The location in the Tsau / Khaeb national park is a function of: "The Tsau / Khaeb national park [being] among the top 5 locations in the world for low-cost hydrogen production, benefiting from a combination of co-located onshore wind and solar resources near the sea and land export routes to market".

The **NH2 Project** will be capable of expansion to 5 GW of renewable electrical energy and 3 GW of electrolyser capacity, with a total capital cost of USD 9.4 billion on expansion.

- **Edition 30** of Low Carbon Pulse (under **Ports connecting the dots**) reported that on November 13, 2021: "the Namibian Ports Authority (**NPA**) had signed a memorandum of understanding (**MOU**) with the Port of Rotterdam Authority (**PORA**). The **MOU** contemplates that Namport, Namibia, will become the key export port of Green Hydrogen and Green Hydrogen-based fuels produced by the **NH2 Project**. Under the **MOU**, **NPA** and **PORA** will work together to connect Namibia with the Port of Rotterdam, and as such, provide a gateway to access European buyers of Green Hydrogen and Green Hydrogen based-fuels. The development of port capacity is key in the context of any Green Hydrogen Hub".
- **Edition 34** of Low Carbon Pulse (under **Botswana-Namibia 5 GW Green Hydrogen project**) recounted the reporting from **Edition 26** of Low Carbon Pulse, reporting further that: "plans for a Green Hydrogen Project in Botswana and Namibia had expanded from 1 GW to 5 GW to be powered by photovoltaic solar electrical energy".
- **Egyptian Future Fuel Hubhub:**
 - **AMEA Power to produce Green Ammonia in Egypt for export:** On **April 22, 2022**, [energy-utilities.com](https://www.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 **390,000 metric tonnes of Green Ammonia a year**.
 - **EDF Renewables and Zero Waste team-up in Egypt:** On **April 22, 2022**, [arabnews.com](https://www.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](https://www.energy-utilities.com) reported that **Hassan Allam Utilities** and **Masdar** had signed two memorandums of understanding (**MOUs**) to produce Green Ammonia for export from the **Ain Sokhna Industrial Zone**, Egypt. The **MOUs** 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](https://www.mostafamadbouly.com), 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.

India and Indonesia:

*This section considers news items within the news cycle of **Edition 39** 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.*

- **Indonesia to supply Britishvolt giga-factory:** On **March 29, 2022**, it was [announced](https://www.britishvolt.com) by **Britishvolt** (see **Edition 33** of Low Carbon Pulse) that it had signed a memorandum of understanding with **VKTR** (a new division of Bakrie Autoparts, and as such part of Bakrie Brothers Group) to partner to develop a lower to low carbon supply chain for nickel sulphate from Indonesia to supply Britishvolt's Blyth giga-factory (in Northumberland, the north east of England) to manufacture electric vehicle batteries.
- **JSW Energy to develop hydro-electric pumped storage plant:** On **April 4, 2022**, [energy-storage](https://www.energy-storage.com) reported that **JSW Energy** (part of the Indian conglomerate, **JSW**, noting that **JSW Steel** is mentioned in **Edition 36** of Low Carbon Pulse) had signed a memorandum of understanding (**MOU**) with the **Government of Chhattisgarh** (a land-locked state in central east India) to develop a **1 GW hydro-electric pumped storage plant** – the **Hasdev Bango Pumped Storage Project (PSP)**. The integration of the **PSP**, with photovoltaic solar and wind renewable energy capacity, will allow **JSW Energy** to "provide firm dispatchable renewable power" 24/7.

The **MOU** with the **Government of Chhattisgarh** is clearly part of a well-developed strategy of **JSW Energy**: **JSW Energy** is developing a **1.5 GW PSP** in **Maharashtra**, and a **1 GW PSP** in **Rajasthan**. **JSW Energy** has expressed the view that India has the potential to develop **90 GW** of **PSP**.

- **Indonesia defers the introduction of carbon tax:** On **April 4, 2022**, it was reported widely that the **Government of Indonesia** was to defer the introduction of its carbon tax from April 2022 until July 2022 (The announcement having been made on the weekend of April 2 and 3, 2022.) Head of Fiscal Policy Agency, Ministry of Finance, **Mr Febrio Kacaribu** said:

"The [pressure on prices arising from the conflict in Ukraine] puts pressure on inflation in many countries in the world, including Indonesia. With these developments, the government is ensuring the availability and stabilization of energy and food prices in the country, including providing various forms of social protection to protect the poor and vulnerable from the impact of price increases".

At the same time as announcing deferment, **Mr Kacaribu** said that the Government of Indonesia is continuing to hone laws and regulations to implement the carbon tax, and to monitor when the economy is ready for the carbon tax, critically, the electrical energy sector. **Mr Kacaribu** noted: *"This readiness is important as the core of objective of implementing a carbon tax is to have the optimal impact"*.

The **Ministry of Finance** continues to hone regulations aimed at levelling the carbon tax, and as such the level of tariff or tariffs under the carbon tax. In addition to continuing to hone the carbon tax, work is being done to place the role and impact of the carbon tax within a carbon tax roadmap. The carbon tax roadmap will be framed by reference to intermediate and ultimate objectives (including achievement of Indonesia's nationally determined contribution and **NZE**) and key milestones. The key milestones will include decarbonisation of priority sectors, with **GHG** emission reduction targets for them, and alignment with new and renewable electrical energy development and deployment.

- **NTPC active in Green Hydrogen production and procurement:**

- **NTPC and Gujarat Gas Ltd to blend** On **April 5, 2022**, it was reported widely that **NTPC** (state owned integrated power utility) and **Gujarat Gas Limited** had agreed to blend Green Hydrogen with natural gas. While the scale of the project may not grab the headlines (Green Hydrogen produced from an electrolyser powered by the 1 MW NTPC Kawas floating photovoltaic solar project), the project is a first for India, and is significant because it will pave the way for blending of natural gas and hydrogen gas in future.

- **NTPC Renewable Energy Ltd (NREL) to electrolyse:** On **April 26, 2022**, it was reported widely that **NREL** is seeking to work with electrolyser technology corporations and developers to procure up to **1 GW** of electrolyser capacity on a turnkey basis. **NREL** has indicated that it intends for tender for **400 MW** of PEM electrolysers and **600 MW** of electrolysers using other electrolyser technologies.

- **Mitsui & Co. invests big, and early:** On **April 7, 2022**, it was reported widely that **Mitsui & Co.** (leading Japanese trading house) had invested in **ReNew** (a leading renewable energy corporation headquartered in India). While Low Carbon Pulse rarely reports on investments and acquisitions, this investment is significant, and is aligned with the plans of **JSW Energy** to develop **PSPs** detailed above.

ReNew has a power purchase agreement with **Solar Energy Corporation of India (SECI**, a state-owned corporation) to supply **400 MW** of renewable electrical energy from photovoltaic solar and wind installations across **Karnataka, Maharashtra, and Rajasthan**, and from an accompanying **BESS** (the **RTC Project**). The **RTC Project** is reported to have a capital cost of **USD 1.2 billion**, and will provide renewable electrical energy capacity 24/7.

- **PT Pertamina and Indonesian investments plans:** On **March 25, 2022**, [energyvoice.com](https://www.energyvoice.com) reported that **PT Pertamina** plans to invest up to **USD 11 billion** on renewable energy projects over the period 2022 to 2026 so as to continue making progress in energy transition, in particular to allow it to install **10 GW** of clean energy generation capacity by 2026 (**6 GW** from gas-to-power, **3 GW** from renewable energy sources, and **1 GW** from other initiatives).

On **April 4, 2022**, [energy voice.com](https://www.energyvoice.com) reported that, more broadly, Indonesia would require **USD 25.2 billion** to develop Green Hydrogen from 2031 to 2060. This is in addition to the **USD 11 billion** identified as being required to be invested by **PT Pertamina** from 2022 to 2026.

As reported, the Indonesian Government estimates that it will cost **USD 1.043 trillion (USD 1,043 billion)** to develop and deploy renewable electrical energy capacity to achieve its goal of **NZE** by 2060.

- **PLN considering importing electrical energy from BEVs:** As noted in previous editions of Low Carbon Pulse, in Europe electrical energy corporations and municipalities are importing electrical energy stored in **battery electric vehicles (BEVs)** onto their distribution networks overnight to optimise electrical energy storage within urban areas. Effectively, electrical energy stored in **BEVs** is being drawn upon to provide a multiple battery **BESS**.

During the first part of **April 2022**, it was reported widely that **PT PLN** (state-owned electrical energy corporation) is offering a 30% discount to owners of **BEVs** who charge their **BEVs** from 10 pm to 5 am.

The contrasting approaches reflect the different levels of transition from fossil-fuel electrical energy generation (base load) and renewable electrical energy generation (variable load).

- **O2 Power and Powin Energy aligned:** On **April 8, 2022**, [energy-storage.news](https://www.energy-storage.news) reported that **O2 Power** (renewables corporation, backed by Singapore's **Temasek** and Sweden's **EQT** (a global private equity firm) and **Powin Energy** (an energy storage solutions company) are to work together to advance the development and deployment of **BESS** across India.

- **PT Pertamina and Mitsui & Co:** On **April 8, 2022**, it was reported widely that **PT Pertamina** (national energy corporation) and **Mitsui & Co** (leading trading house) were to undertake jointly a study in respect of **CCUS**, critically, the pathways to the commercialisation of **CCUS** projects in Indonesia.

By way of reminder: Edition 36 of Low Carbon Pulse reported as follows: **"Indonesia to develop Green Hydrogen & Ammonia and CCUS:** On March 4, 2022, [hydrogen-central.com](https://www.hydrogen-central.com) reported that First Deputy Minister of State-Owned Enterprises, Mr Pahala Mughraha Mansury stated: "We have developed the ammonia and biomass co-firing as well as the utilisation of carbon capture technology to reduce the usage of coal at [coal-fired] power plants".

For these purposes, it was reported that on March 2, 2022, PT Pupuk Indonesia (state-owned fertiliser corporation), PT Pertamina (state-owned national energy corporation) and Mitsubishi Corporation had signed a cooperation agreement to progress the development of Green Hydrogen and Ammonia production capacity".

- **Solar Energy Corporation of India (SECI) continuing to procure:** On April 14, 2022, [energy-storage](#) reported that **SECI** had issued a **Request for Selection** document to procure **500MW / 1,000 MWh** of **BESS**. It is reported that this is expected to be the first stage of a procurement program that will procure up to **4,000 MWh** of **BESS**.
- **CATL to invest USD 6 billion in battery chain:** On April 15, 2022, [electrek](#) reported that **CATL** (leading electrical vehicle battery manufacturer, **CATL** being short form for **Contemporary Ampere Technology Co Ltd**), through a subsidiary, is to take a majority stake in five of six battery projects to be developed with **PT Aneka Tambang (ANTAM)**, being a state-owned mining corporation) and **PT Industri Baterai Indonesia (IBI)**, being a state-owned corporation dedicated to invest in battery manufacture other state-owned corporations). It is reported that the projects will include nickel mining and processing, battery materials production and manufacturing, and battery recycling.
- **Plans to supply 8% of Singapore load:** On April 19, 2022, it was reported widely that **Quantum Power** (an independent power producer based in Singapore) and **Ib Vogt** (a German solar power plant developer), through a joint venture, **Anatara**, have plans to develop renewable energy facilities within the **Riau Islands Province, Indonesia**, to supply renewable electrical energy to the Republic of Singapore, using a subsea cable. The planned development is world scale: **USD 5 billion** to develop and to deploy **3.5 GW** of photovoltaic capacity and **12 GWh** of **BESS**.
- **PLN Sub and IHI co-venture on co-firing:** On April 25, 2022, it was reported widely that **Pembangkitan Jawa-Bali (PJB)**, a subsidiary of **PLN** and **IHI Corporation** (a Japanese engineering corporation) are to work together to develop ammonia-co-firing technology to allow co-firing of natural gas and ammonia at the **PJB gas-fired power plants at Gresik**, east Java, Indonesia.
By way of reminder: Edition 18 of Low Carbon Pulse reported that IHI and JERA had announced notice of acceptance of their joint grant application to undertake a demonstration project to co-fire ammonia in the generation of thermal power. It was understood that the co-firing project would commence in June 2021 (in fact it commenced later), continuing to March 2025, the plan was 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!)"
- **Figures firming higher:** On April 27, 2022, it was reported widely that the **Ministry of Trade and Industry**, Japan had presented an estimate of the cost to the Japanese material industry of progressing to achieve **NZE** by 2050: ¥24 trillion (USD 187 billion) at the **Industrial Structure Council**, the advisory council of the Ministry. As reported, it is expected that the estimate will firm higher over time.
- **POME feedstock for clean gas:** On April 27, 2022, it was reported widely that **PT Pertamina, Inpex Corporation, JGC Holdings Corporation** and **Osaka Gas Co., Ltd** had signed a study agreement under which they agreed to work together to assess the commercial and technical feasibility of producing clean natural gas from palm oil mill effluent (**POME**). **Biogas** and **biomethane** and **bio-LNG** can be derived or produced from **POME**.

Japan and Republic of Korea (ROK):

*This section considers news items within the news cycle of this **Edition 39** 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.*

- **Hyundai Mobis invests USD 1.1 billion in FCE plants:** On April 1, 2022, it was reported widely that **Hyundai Mobis** is to develop two new fuel cell manufacturing plants, one close to **Seoul**, and the other in **Ulsan**. The two new plants will commence manufacture in Q2 of 2023 and will have capacity to manufacture up to 100,000 fuel cells a year. The fuel cells manufactured are intended for use in vehicles used in the construction and logistic mobility sectors.
- **SK to invest USD 2.5 billion in PRC plants:** During the first week of **April, 2022** it was reported widely (also having been reported at the end of March) that **SK (ROK conglomerate, and leader in energy transition technology)** is to develop a new battery factory in the **PRC** to manufacture batteries for EVs.
- **KOGAS MOU with Sempra Infrastructure:** On **April 4, 2022**, it was reported widely that **KOGAS** (the owner and operator of **ROK's** gas transmission and distribution system, and the largest single buyer of liquefied natural gas (**LNG**) in the world) and **Sempra Infrastructure** (leading North American energy infrastructure company) had signed a memorandum of understanding (**MOU**) to consider how they may work together to transition to lower-carbon and to zero-carbon fuels.
It is understood that the **MOU** contemplates that **KOGAS** and **Sempra Infrastructure** may develop projects jointly around the world, including, **LNG** projects, **CCS** projects and hydrogen infrastructure projects, as well as the off-take of lower-carbon and zero-carbon fuels from those projects.
- **Bloom Energy SOE deployed in ROK:** On **April 6, 2022**, it was reported widely that **Bloom Energy** has deployed its high-temperature solid oxide electrolyser in **Gumi, ROK**. (See **Editions 2, 4, 22** and **29** of Low Carbon Pulse for previous coverage of Bloom in **ROK**, and see **Edition 37** for a description of the principal electrolyser technologies.)

PRC and Russia:

This section considers news items that have arisen within the news cycle of this **Edition 39** of Low Carbon Pulse relating to the **PRC** and **Russia**, being countries that give rise to the most and the fourth most **GHG** emissions.

• PRC Hydrogen Plan:

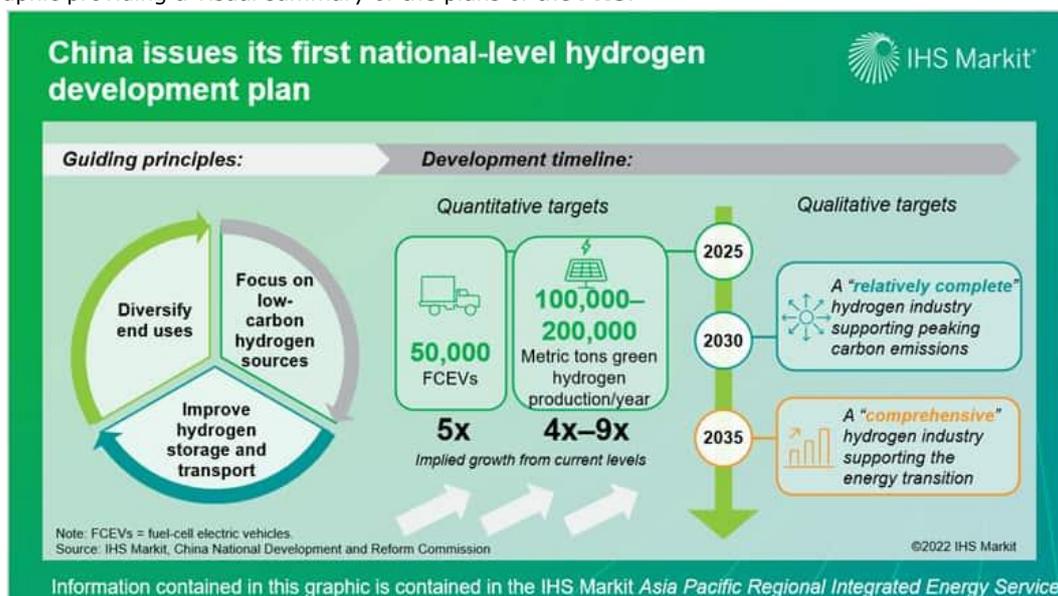
- **In words:** **Edition 37** of Low Carbon Pulse reported on: "the plans of the **PRC** for the development of hydrogen production capacity with the National Development and Reform Commission (**NDRC**) and the National Energy Administration (**NEA**) providing a roadmap to 2025, 2030 and to 2035.

In the near term, the plan is to develop hydrogen production capacity so as to produce 200,000 metric tonnes of clean hydrogen by 2025. This sits well inside the aspirations of Sinopec to have developed 500,000 metric tonnes of Green Hydrogen production capacity by 2025.

In the medium term (by 2030), the plan is to have developed a hydrogen production industry configured to produce clean hydrogen using integrated hydrogen technologies so as to maximise the reduction in **GHG** emissions arising from production, transportation, storage and use of hydrogen. In the near to medium term, the focus appears to be the decarbonisation of the mobility industry.

In the medium to longer term (by 2035), the plan is to have developed hydrogen production capacity so as to support the decarbonisation of the difficult to decarbonise industries".

- **In pictures:** On **April 4, 2022**, the good folk at **IHS Markit** (now part of S&P Global) published the following infographic providing a visual summary of the plans of the **PRC**.



• A reminder of PRC plans:

On **March 5, 2022**: [Reuters](#) reported that the **PRC** had firmed-up plans to develop and to deploy 450 GW of new photovoltaic solar and wind capacity in the Gobi Desert, and other desert regions: Director of **NDRC**, Mr He Lifeng said:

"China is going to build the biggest scale of solar and wind power generation capacity on the Gobi desert in history, at 450 GW".

While the development and deployment of photovoltaic solar and wind power in the Gobi Desert has been flagged (for example, see **Edition 21** of Low Carbon Pulse) for some time, the confirmation from **NDRC** at the National People's Congress can be viewed as a firm policy setting. It is understood that the construction of 100 GW of photovoltaic solar capacity is already underway in the Gobi Desert.

As noted in previous editions of Low Carbon Pulse, the renewable electrical energy generated in the Gobi Desert, and other desert regions, will be transmitted to the load for that electrical energy using ultra-high voltage direct current transmission systems.

During the week beginning **February 28, 2022**, it was reported widely that the **PRC** plans to develop and to deploy hydrogen refuelling infrastructure at 2,000 sites across China, and for 1 million FCEV in China, by 2035.

- **Coal-fired power cancellations:** On **April 24, 2022**, [powermag.com](#) reported that the decision of the **PRC** not to finance overseas coal-fired projects had resulted in the cancellation of 15 coal-fired power plants.

The report is based on research from the **Centre for Research on Energy and Clean Air (CREA)** [released](#) on **April 22, 2022**.

Europe and UK:

*This section considers news items that have arisen within the news cycle of this **Edition 39** 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.*

- **No fool's day:** On **April 1, 2022**, seven projects were granted funding support by the **Climate, Infrastructure and Environment Executive Agency (CINEA)**, with aggregate funding support of **€1.1 billion**. Please see the following announcement for full details (<https://www.eeas.europa.eu/>). The funding support was awarded from the **EU Innovation Fund**, funded by revenues from the **EU ETS**.

While some projects are detailed elsewhere in this **Edition 39** of Low Carbon Pulse they are listed here for convenience:

- **The BECCS project:** Located in **Stockholm, Sweden**, this project is the first full-scale Bio-Energy Carbon Capture and Storage (**BECCS**) project, capturing **CO₂** and heat from an existing biomass project.
 - **The Ecoplanta project:** Located in **El Morell, Spain**, this project is a first-of-a-kind processing and production plant that processes waste (that would otherwise be landfilled), and derives / produces methanol from that waste.
 - **The Hybrit project:** Located in **Gällivare and Oxelösund, Sweden**, this Hydrogen Breakthrough Ironmaking Technology Demonstration (**Hybrit**) project will produce fossil-fuel free iron and steel.
 - **The Kairos@C project:** Located in the **Port of Antwerp**, this project is the first and largest cross-border carbon capture and storage value chain to capture, liquefy, ship, and store permanently **CO₂**.
 - **The K6 project:** Located in **Lumbres, France**, this project is a first-of-a-kind using an industrial scale-combination of airtight kiln and cryogenic carbon capture technology, with captured **CO₂** to be stored in the North Sea.
 - **The SHARC project:** Located at the **Porvoo refinery, Finland**, the Sustainable Hydrogen and Recovery of Carbon (**SHARC**) project will reduce **GHG** emissions on transition from use of fossil fuels to renewable hydrogen production.
 - **The Tango project:** Located in **Catania, Italy**, this project involves the development of industrial-scale production capacity to manufacture high-performance photovoltaic solar modules.
- **EC considering higher renewable energy target:** 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.

- **Portugal increases rate of speed of light:** On **April 4, 2022**, pv-tech.org reported that the **Government of Portugal** is to increase the rate of development and deployment of renewable electrical energy installation so that by 2026, 80% of electrical energy dispatched to match load will be from a renewable energy source.

Between 2010 and 2022 renewable electrical energy dispatched from renewable electrical energy sources increased from 41% to 58%.

- **European Hydrogen Backbone response to REPowerEU:**

- 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.
- On **April 25, 2022**, it was reported widely that the **Nordic Hydrogen Route** (part of the **EHB**) is to be developed in the **Bothnian Bay** region by **Gasgrid Finland** and **Nordion Energi**. The **Bothnian Bay** region project will comprise 1,000 km of dedicated new hydrogen pipelines. There has been a marked level of news coverage since the announcement of the **Bothnian Bay** region project.
- Towards the end of April the **EHB website** launched a map function to detail the pipelines comprising, and to comprise, the **EHB**.

By way of reminder:

- **Edition 37** of Low Carbon Pulse reported that: "On **March 8, 2022**, the **European Commission (EC)** outlined its plans to accelerate the development of renewable electrical energy capacity across the **EU**, and to increase fourfold the Green Hydrogen production capacity by 2030 (**REPowerEU**, including a **Hydrogen Accelerator**).

In short, there are two legs to **REPowerEU**, first, near to medium term energy security (through diverse sources of natural gas supply, delivered into the **EU** as liquified natural gas (**LNG**) and increased production of bio-gas and bio-methane within the **EU**) and, second, the dash to accelerate renewable electrical energy deployment."

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.

- **European Hydrogen Backbone:** The **EHB** has been covered in previous editions of Low Carbon Pulse as follows:
 - **Northern Europe Clean Hydrogen Coastline:** **Edition 13** reported:

"**Edition 12** of Low Carbon Pulse (under "**Hydrogen Republic of Germany**") lauded "as a case study in planning and integration" plans of the City of Hamburg (including the port, connected to the North Sea by the Elbe River) for the **Hamburg Hydrogen Industry Network (HH-WIN)**, and the integration of those plans with those of Bremen, Lower Saxony, Mecklenburg-Western Pomerania and Schleswig-Holstein, and the development of 500 MW of electrolyser capacity by 2025.

On March 24, 2021, a number of major industrial companies (including EWE, ArcelorMittal and FAUN Group) in Northern Germany announced plans to develop a network, spanning the Dutch, German, and Danish coastline, to develop an integrated hydrogen network (**Clean Hydrogen Coastline**) comprising 400 MW of electrolysers and storage by 2026.

In two line simple sentence CEO of steel manufacturer ArcelorMittal, Mr Reiner Blackscheck sums up what is required for industrials (including in Difficult to Decarbonise Industries) to transition of Green Hydrogen: " ... *the transformation process [requiring] the technology change in order to use Green Hydrogen in production. To do this, we need a functioning supply of hydrogen at economic costs so that we can keep the Bremen steel location competitive over the long term*".

To provide demand for "a functioning supply of hydrogen", ArcelorMittal plans to invest up to USD 1.4 billion to develop both a direct reduction iron ore (**DRI**) facility (using natural gas (predominantly **CH₄**) as the reducing gas in the first instance until the provision of Green Hydrogen from across the **Clean Hydrogen Coastline network**), and an electric arc furnace (**EAF**).

The integrated hydrogen network may be regarded as consistent with the plans outlined in a publication titled "**European Hydrogen Backbone**" outlined "How Dedicated Hydrogen Infrastructure Can Be Created". The Publication was sponsored by Enagas, Energinet, Flyxys Belgium, Gasunie, GRTgas, NET4GAS, OGE, ONTRAS, Snam, Swedegas, and Terega.

- **EHB updates its vision for the European Hydrogen back bone: Edition 14** reported:

"On April 13, 2021, the European Hydrogen Backbone (**EHB**) group released a press release detailing the "version of its vision for a dedicated hydrogen transport infrastructure network across Europe". The initial version of the **EHB** vision was released in July 2020. The **EHB** comprises 12 European gas transmission system operators from 11 countries. The **EHB** initiative proposes a hydrogen network of 39,700 km by 2040, with a grid connecting 21 countries."

- **Backbone of hydrogen demand: Edition 20** reported:

"**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 Low Carbon Pulse - Edition 20 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 **FACT**. 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."

- **Common themes – the need for common / share infrastructure and a common market:**

- On **April 5, 2022**, the [hydrogen economist](#) provided an analysis of the benefits of the development of common / shared infrastructure by Germany and the Netherlands, in particular the benefits of the development of a hydrogen backbone, with the central premise being common / shared infrastructure will increase demand, possibly even doubling the projected demand (up to 401 TWh a year by 2050).

The benefits will become self-fulfilling with higher projected demand resulting in the development of increased off-shore wind field capacity, increasing Green Hydrogen production, and therefore supply.

The project demand estimates suggest that the supply of Green Hydrogen, using renewable electrical energy sourced from off-shore wind fields in the North Sea, is achievable, but will be greatly enhanced by infrastructure providing a clear path to the point of use of the Green Hydrogen.

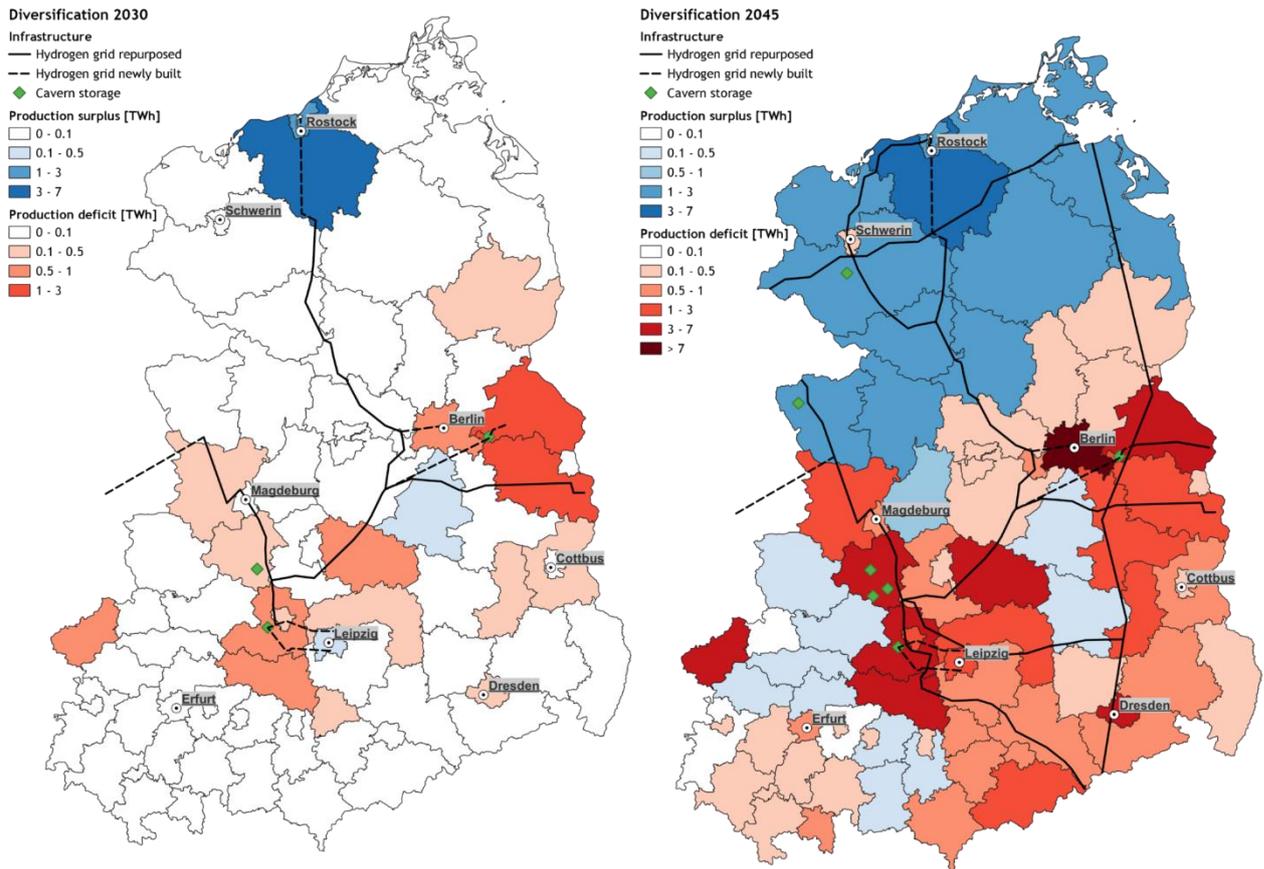
Helpfully the article identifies what needs to happen at a legal and regulatory level to allow the benefits to be realised, including:

1. the classification of Green Hydrogen as a chemical in the Netherlands;
2. the development of a regulatory framework for the development and operation of hydrogen pipeline infrastructure; and
3. the co-ordinated cross-border planning in line with the **EU's Trans-European Network for Energy (TEN-E)** and the **Ten-Year Network Development (TYND) Plan**.

In addition, the article notes that it is critical that Germany and the Netherlands develop a legal definition of Green Hydrogen, and develop a Guarantee of Origin, and accompanying certification, regime.



- **EWI Study supports needs identified above and below:** On **April 14, 2022**, **EWI** (Institute of Energy Economics at the University of Cologne) published a study, [*Development of Hydrogen Market in Eastern Germany – An Infrastructure analysis based on regional potentials and demand.*](#) The study was commissioned by **GASCADE Gastransport GmbH** (German gas transportation infrastructure company). The following map-graphic provides a number of helpful insights.



Source: [EWI](#)

• **By way of reminder:**

- **Edition 37** of Low Carbon Pulse reported that: "On **March 24, 2022**, that RWE (the German renewables electrical energy giant) and OGE (a German TSO) outlined plans to roll-out hydrogen infrastructure to produce and transport hydrogen, including a 1 GW electrolyser and a 1,500 kilometre, hydrogen pipeline system (the **H₂ercules Project**). It is reported the **H₂ercules Project** will cost around €3.5 billion.



Source: [Hydrogen fast track: OGE and RWE present national infrastructure concept "H₂ercules"](#)

- **EHB and H2ercules Project aligned:** The **H2ercules Project** will allow the import Green Hydrogen from Belgium, the Netherlands and Norway. With the developments during March 2022, it is estimated that by 2030, Germany may have 30 GW of Green Hydrogen capacity, around three times as that contemplated in July 2020 by the German Federal Government.
- **Northern Europe and Nordic countries leading the way in innovation:**
 - As noted above, of the seven projects awarded funding on **April 1, 2022 (April Fuel Day)**, three were from Nordic countries:
 - **The BECSS project:** Located in **Stockholm, Sweden**, this project is the first full-scale Bio-Energy Carbon Capture and Storage (**BECCS**) project, capturing **CO₂** and heat from the existing biomass project.
 - **The Hybrit project:** Located in **Gällivare and Oxelösund, Sweden**, this Hydrogen Breakthrough Ironmaking Technology Demonstration (**Hybrit**) project will produce fossil-fuel free iron and steel.
 - **The SHARC project:** Located at the **Porvoo refinery, Finland**, the Sustainable Hydrogen and Recovery of Carbon (**SHARC**) project will reduce **GHG** emissions on transition from use of fossil fuels to renewable hydrogen production.
 - **TES Fast-tracks:** On **April 14, 2022, Forbes** (under [German Clean Energy Hub Pivotal to Reducing Reliance on Russian Gas](#)) published an article reporting on an interview with the CEO of **Tree Energy Solutions (TES)**, Mr Otto Waterlander about green gas. **TES** (a green hydrogen corporation, reported on in **Editions 36** of Low Carbon Pulse) is 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, **CO₂** will be captured and shipped to the Middle East, the **CO₂** 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 m³**.

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.

- **All is well in the Kingdom of Denmark and beyond:**
 - **Topsoe (previously Haldor Topsoe) clusters:** On **April 1, 2022, Topsoe** (leading electrolyser technology corporation) [announced](#) that it had joined a consortium that is focused on the development and deployment of technology to produce green fuels for aircraft and ships.
 - In addition to **Topsoe**, the consortium comprises, **Aalborg Airport, Aarhus Airport, Aarhus Havn** (Port of Aarhus), **AAU Energy, Alfa Laval, A.P. Moller – Maersk, COWI, Crossbridge Energy, DLR, Energy Cluster Denmark, GreenFuelHub, SkyNRG and Steeper Energy**.
 - **Energinet hot-to-trot:**
 - As noted above, on **April 5, 2022**, the **EHB** published a [paper](#) (entitled [European Hydrogen Backbone – April 2022](#)). One of the key conclusions form the paper is that the case for the Danish-German connection has been accelerated to a 2030 timeline. In this context, **Energinet** (Danish TSO) is preparing to develop a Green Hydrogen export pipeline from Denmark to Germany to access the European market.
 - By way of a reminder:** Denmark intends to develop two power islands, the Baltic Sea Energy Island (with renewable electrical energy from 2 GW of off-shore wind field capacity), and the North Sea Energy Island (with renewable electrical energy from 3 GW of off-shore wind field capacity). (See **Editions 5, 8, 9, 27, 29, 32** Low Carbon Pulse.)

CURRENT PLANNED DEVELOPMENT OF OFF-SHORE WIND			
North Sea Energy Island – 3 GW	Baltic Sea Energy Island – 2 GW	Hesselo (Baltic Sea) – up to 1.2 GW	North Sea Thor – 1 GW

- On **April 5, 2022, Energinet** progressed with work in respect of the off-shore wind field development so as to facilitate the development of both Energy Islands, likely on an accelerated basis.
- On **April 19, 2022**, the **Danish Government** outlined plans to increase photovoltaic solar and on-shore wind farm development, as well as the energy islands and off-shore wind fields.
 - The **Danish Prime Minister, Mr Mette Frederiksen** said: "We now raise our ambitions even more with onshore wind additions, more solar panels and off-shore wind as well as more energy islands. We want to extend our renewable energy by as much as possible and in the most clever way". As outlined, the **Danish Government** plans will increase on-shore wind capacity four-fold.

- **UK Export Finance (UK EF) provides clean guarantee:** On **April 6, 2022, qtreview.com** reported that the **UK EF** had agreed to guarantee a **GBP 400 million** sustainability-linked facility provided to **Johnson Matthey** by **Bank of America, HSBC and SMBC. Johnson Matthey** is a leading developer of sustainable technologies, including for Green Hydrogen production and metals recovery and recycling. As reported, as part of the sustainability-linked facility

structure, **Johnson Matthey** has committed to reduce its **GHG** emissions and to decarbonise its energy procurement, with progress to be monitored and reported upon by an independent third party.

- **UK doubles hydrogen target and 50 by 30:** On **April 6, 2022**, UK **Prime Minister, Mr Boris Johnson** announced that the UK would double its target for hydrogen production capacity from **5 GW** by 2030, to **10 GW** by 2030.

This is one facet of a multi-faceted plan that provides that the UK will match 95% of its load for electrical energy from renewable energy sources by 2030, including deploying up to **50 GW** of off-shore field capacity by 2030.

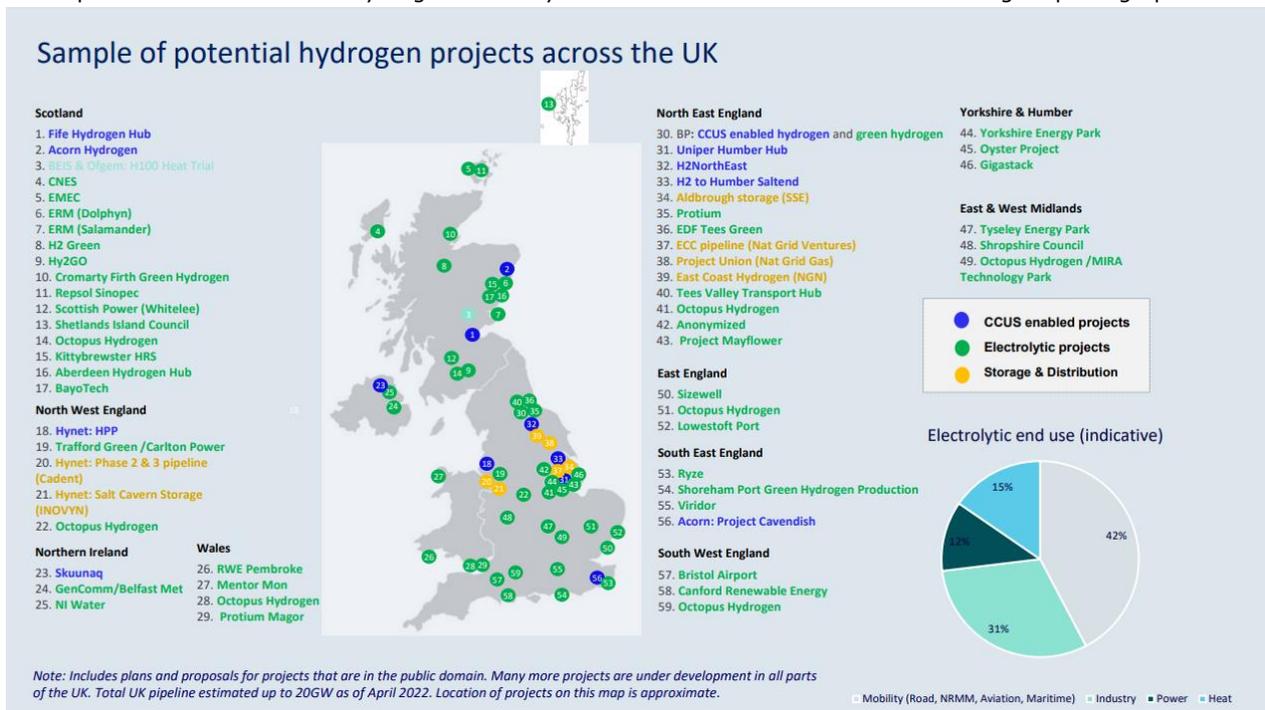
The key points of the new **British Energy Security Strategy** also include the development and deployment of eight new nuclear reactors (located at Bradwell, Hartlepool, Heysham, Hinkley, Moorside, Oldbury, Sizewell and Wylfa) and the promotion of policy settings to accelerate the installation of roof-top photovoltaic solar.

For the full form of the **Policy Paper – British energy security strategy**, please click on the attached. As ever, with publications from the UK Government, it is both clear and compelling. For an assessment of the implications of the **Policy Paper – British energy security strategy** on the power sector see the **ICIS paper, UK Energy Security Strategy: Implications for the power sector**.

- **Studied release:** On **April 8, 2022**, the UK Government **Department of Business, Energy and Industrial Strategy (BEIS)** released **Atmospheric Implications of Increased Hydrogen Use**.

The headline from the study is the importance of preventing the leakage of hydrogen into the atmosphere so as to prevent the compounding of hydrogen with other compounds and elements. The study is important and timely as governments around the world develop and progress policy settings, laws, regulations and standards to allow the development of the hydrogen economy.

- **Hydrogen Investor Roadmap:** On **April 8, 2022**, the **BEIS** published **Hydrogen investor roadmap: leading the way to net zero (HIR)**. The purpose of the **HIR** is to summarise government policies supporting the development of the low-carbon hydrogen economy in the UK. The **HIR** includes the following map-infographic:



- **CCS Investor Roadmap:** On **April 8, 2022**, the **BEIS** published **CCUS Investor Roadmap – Capturing Carbon and a Global Opportunity (CIR)**. In context, the **CIR** needs to be read with the UK Government target of capturing 20 to 30 million metric tonnes of **CO₂** a year. Many commentators and participants note that the current target is modest, as are the timelines.

- **UK Low Carbon Hydrogen Standard:** On **April 8, 2022**, the **BEIS** published **UK Low Carbon Hydrogen Standard: emissions reporting and sustainability criteria**. The publication marks considerable and marked progress since August 17, 2021, when the **BEIS** published **Designing a UK low carbon hydrogen standard**.

- **UK progressing to CfDs for hydrogen production:** On **April 11, 2022**, rechargenews.com (under **UK finalise world's first national subsidy for clean hydrogen production by the year**) reported that the **BEIS** had announced the use of contracts for difference (**CfD**) for hydrogen: described as a "variable premium price support model" subsidising any "difference between a 'strike price' reflecting the cost of producing hydrogen and a 'reference price' reflecting the market value of the hydrogen."

As reported, the UK will finalise the terms of the **CfDs** during 2022, and start to contract under them during 2023.

- **Germany and UK interconnect:** On **April 12, 2022**, [CNBC](https://www.cnbc.com) reported (under **Giant undersea cables set to give the UK and Germany their first direct energy link**) on the **NeuConnect project** which is to allow each way electrical energy supply of **1.4 GW** between Germany and the UK. The interconnector, **725** kilometres in length, has been dubbed the "invisible energy highway".

- **Gasunie hot to trot:** On **April 21, 2022**, [europeanqashub.com](https://www.europeanqashub.com) reported on the **Gasunie Hydrogen Backbone**. The following map-infographic provides a helpful overview.



- **ScotWind Clearing Round becomes clearer:** On **April 26, 2022**, it was announced by the **Crown Estate Scotland** that "a further process of Clearing has today, 26 April 2022, begun". The Clearing allows applicants that met the required standards for the **ScotWind Leasing Process** (see **Editions 22, 33, and 37** of Low Carbon Pulse), but were unsuccessful in their bid or bids for any preferred lease area to revise their application to an alternative lease area.

It is important to note that the Clearing process does not allow new applicants to participate: the process is open only to those who applied, were assessed, but were not successful in the ScotWind leasing process. The deadline for eligible applicants is May 10, 2022. **Edition 40** of Low Carbon Pulse will provide an update.

Americas:

*This section considers news items that have arisen within the news cycle of this **Edition 39** 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.*

- **Hubbub among the States:**

- **By way of reminder:**

- Under the **Infrastructure Investment and Jobs Act (IIAJA)** also known as the Bipartisan Infrastructure Law (**BIL**) 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.

Clean Hydrogen for these purposes is hydrogen that gives rise to less than 2 kg of **CO₂** for each 1 kg of hydrogen produced.

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.

- **Editions 36** and **37** reported 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 **IIAJA**;

- **Mississippi States Hub: Arkansas, Louisiana and Oklahoma** were progressing with a like initiative to create a bipartisan three-state bloc to develop a **regional clean Hydrogen Hub**;

- **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;

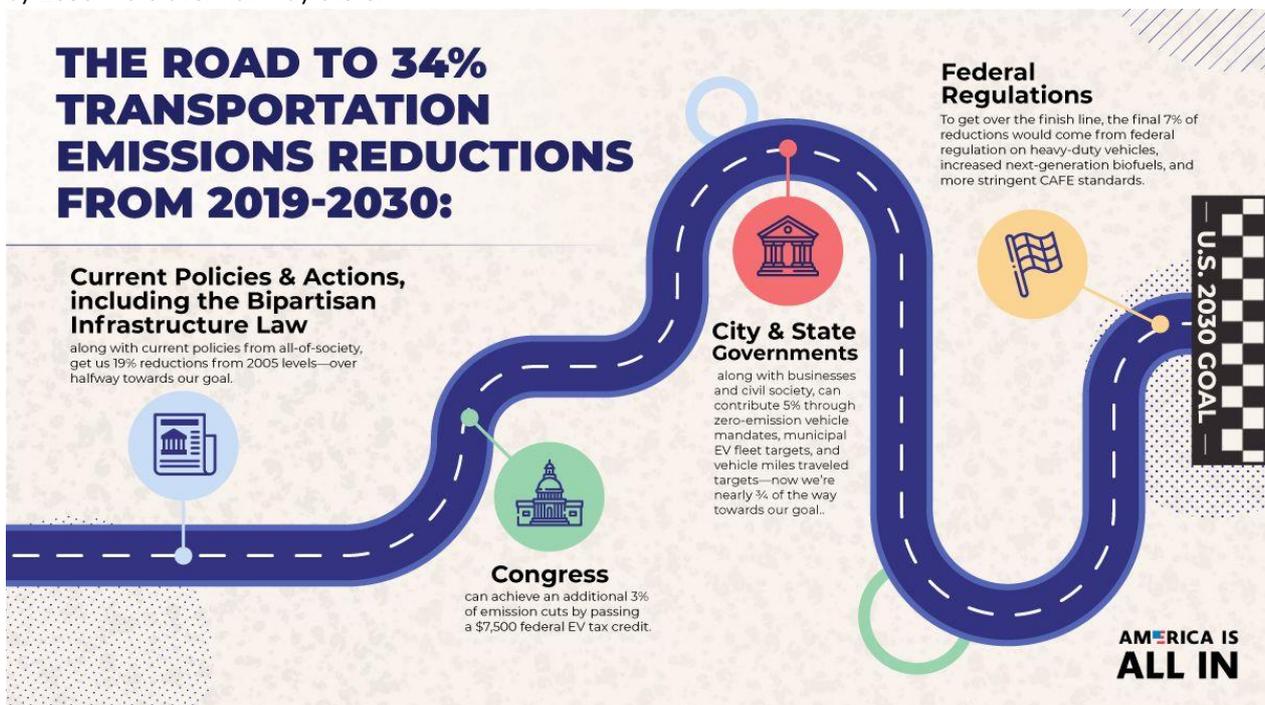
- the Governor of New York State, Ms Kathy Hochul had indicated that **New York**, together with **Connecticut, Massachusetts** and **New Jersey**, and 40 hydrogen ecosystem partners, were combining for the purposes of seeking to become one of at least four regional clean hydrogen energy hubs.

- On **April 8, 2022**, fuelcellworks.com reported (under **Biden's Hydrogen Hub Plan Sparks \$8 Billion Race Among US States**) that **Colorado, New Mexico, Utah** and **Wyoming; Arkansas, Louisiana and Oklahoma; Connecticut, Massachusetts, New Jersey** and **New York**, and **Kentucky** and **West Virginia** were chasing funding from the USD 8 billion earmarked by the **IIAJA**.

The following map from fuelcellworks.com illustrates the States and Groups of States chasing the **USD 8 billion** of funding.



- **Land release:** On **April, 21, 2022**, rechargenews.com reported that the **US Bureau of Land Management (BLM)** plans to green-light the development of **39 utility-scale photovoltaic solar projects**, together to have more than **29 GW of installed capacity**, on Federal lands in six western states.
- **Earth Day Executive Order:** On **April 22, 2022**, **US President, Mr Joe Biden**, signed an [Executive Order](#) to:
 - (a) safeguard mature and old-growth forests in Federal lands;
 - (b) strengthen reforestation initiatives across the US; and
 - (c) combat global deforestation, consistent with commitments made at **COP-26**;
 - (d) enlist nature to address efforts to address climate change.
- **Pennsylvania powers ahead:** On **April 22, 2022**, the **US State of Pennsylvania** (responsible for 4% of US **GHG** emissions) published regulations to require power station owners to pay for each ton of carbon that they emit. As reported, both opponents and supporters of the regulations expect delay in the application of the regulation. The regulation is reported to be part of the Regional Greenhouse Gas Initiative, including 11 north eastern US States.
- **US on the road:** On **April 24, 2022**, the **World Resources Institute** shared a publication, [America is All In](#). The infographic below provides a helpful guide: while the US needs to reduce **GHG** emissions arising from transportation by 2030 - it is over half way there.



Source: [World Resources Institute LinkedIn](#)

- **Government of Canada – Emissions Reduction Plan:** During the first week of **April 2022**, it was reported that the Government of Canada (**GOC**) has released the **2030 Emissions Reduction Plan (ERP)** targeting a 40 to 45% reduction in **GHG** emissions by 2030.

At a more granular level, zero-emissions vehicles (**ZEVs**) are to comprise 20% of car sales by 2026, 60% by 2030, and 100% by 2035. The **GOC** is providing funding support in the form of its iZEV program (CAD 1.7 billion), providing incentives to businesses and households to buy **ZEVs**, and for the development of EV charging infrastructure (CAD 400 million).

France and Germany:

*This section considers news items within the news cycle of this **Edition 39** of Low Carbon Pulse relating to France and Germany. Within the news-cycle for this **Edition 37**, the news-items have come thick and fast.*

- **France committed to 40 by 50:** On **March 31, 2022**, and in early April, it was reported widely that the French Government had committed to the development of **40 GW** off-shore wind field capacity by 2050 (**40 by 50**). As contemplated, the commitment envisages that the capacity will be installed across **50** off-shore wind fields. To reach **40 by 50**, France will have to auction a minimum of **2 GW** of off-shore wind field capacity a year from 2025. In today's Euros, the development of **40 by 50** will cost in the region **€40 billion**.

- On **March 31, 2022**, it was reported that the **Hy3 Project** study had been published jointly by **Forschungszentrum Julich, Dena**, and **TNO**. The author laid eyes on the **Hy3 Project** study in early April. As might be expected, the key finding of the **Hy3 Project** study is that cooperation between Germany and the Netherlands, in developing a common hydrogen market and common infrastructure, will boost opportunities to realise a decarbonised regional economy.

The **Hy3 Project** study is one of the best publications that the author has had the pleasure of reading in recent times: it aligns general principles to specific applications, supply and demand side driven. As such the **Hy3 Project** study is well-worth a read.

The **March and April Report on Reports** will consider the **Hy3 Project** study.

- **Germany committed to up to 215 by 30:**
 - On **April 6, 2022**, it was reported widely that Germany intended to introduce and **EEG Easter Package** to accelerate the development and deployment of photovoltaic solar capacity and wind. A key element of this is to accelerate development and deployment across open-spaces and roof-tops, with the plan to expand deployment to **22 GW** by **2023**, and then to continue to increase installed capacity (at the same rate) so as to install **215 GW** of photovoltaic solar capacity by **2030 (215 by 30)**.
 - On **April 7, 2022**, it was reported widely that Germany intended to change (as part of the **EEG Easter Package**) the targets for the installation of off-shore wind field capacity, stretching those targets to **30 GW** by **2030**, **40 GW** by **2040**, and at least **70 GW** by **2045**.

Australia:

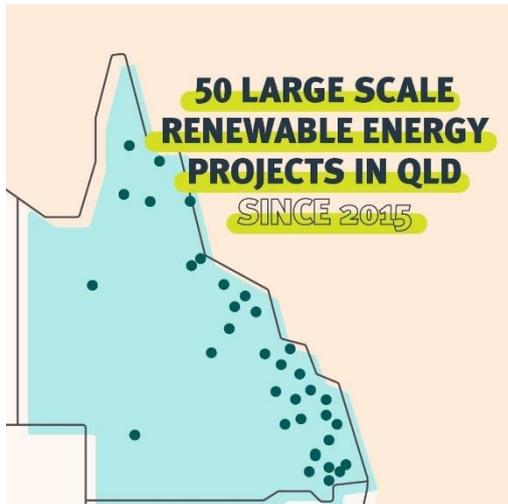
*This section considers news items that have arisen within the news cycle of this **Edition 39** Low Carbon Pulse relating to Australia, a top-twenty **GHG** emitting country, and a developed country with the highest **GHG** emissions per capita. Australia is however progressing to **NZE** at a faster 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.*

- **Federal Australian Government to fund Marinus Link:** On **April 3, 2022**, the **Department of Industry, Science and Resources** [announced](#) the funding support will be provided for the development of a 250 kilometre sub-sea interconnector between the States of Tasmania and Victoria, described as "unlocking" access to renewable electrical energy generation capacity in Tasmania, predominantly existing hydro-electric and on-shore wind.
- **Carbon Clusters and Hydrogen Hubs update:**
 - On **April 10, 2022**, it was announced that **WSP** had been appointed as the **Lead Technical Adviser** for the **Electrolysis, Ammonia Synthesis** and **Export** and **Bunkering** assessment of the feasibility study being undertaken by the **Port of Newcastle**, in partnership with Macquarie Group, **Green Investment Group**, and the Australian Federal Government, **Australian Renewable Energy Agency (ARENA)**.
 - As currently contemplated the first stage of the Hydrogen Hub at the Port of Newcastle will comprise the development of a 40 MW electrolyser, with a view to increasing electrolyser capacity to more than 1 GW overtime. The electrolyser capacity will produce Green Hydrogen and Green Ammonia for domestic use in the first instance and including export over time.
- **Federal Government of Australia announces further funding support:** On **April 19, 2022**, the Federal Government announced support for the critical minerals industry (**CMi**), the clean hydrogen industry (**CHI**) and CCS:
 - **CMi: Critical Minerals Accelerator Initiative** was announced by the **Federal Minister for Resources and Water, Mr Keith Pitt**. This announcement builds on the loan to Iluka Resources to develop Rare Earths and Elements refinery (see **Iluka to develop REE refinery in Western Australia** below);
 - **CHI:** The **Federal Minister for Industry, Energy and Emissions Reduction, Mr Angus Taylor**, announced the provision of further funding support to the clean hydrogen industry, including:
 - the **H2Kwinana Clean Hydrogen Industrial Hub** – with up to **AUD 70 million**; [arrows]
 - the **Pilbara Hydrogen Hub** – with up to **AUD 70 million**;
 - **CCS:** The Federal Government announced funding support in respect of CCS projects:
 - the **Woodside Energy multi-user CCS** hub on the **Burrup Peninsula, Western Australia** - with up to AUD 40 million;

- the **Mitsui E&P Mid-West CCS** hub – with up to **AUD 20 million**; and
- the **Buru Energy** for potential on-shore CCS – with up to **AUD 7 million**.

The Federal Government is to be commended for striking a balance between providing a helping hand, and a hand-out, to projects that are being development by the private-sector.

- **Queensland Government summarises investments in renewable energy:**



Editions 31 and **37** of Low Carbon Pulse reported on the progress of **Queensland Renewable Energy Zones - Central QREZ, Northern QREZ** and the **Southern QREZ**.

- On **April 4, 2022**, the **Department of State Development, Infrastructure, Local Government and Planning**, published details of the state of play in the sunshine state.

The headline is that:

"Queensland is invested in renewable energy"

Queensland has **50 large-scale renewable energy projects operating, under construction or financially committed**, amounting to **AUD 10.7 billion** and resulting in **5.744 GW** of renewable electrical energy capacity, which when combined with a little under **1.5 GW** of roof-top photovoltaic solar amount to **7.2 GW** of renewable electrical energy.

The attached [link](#) provides a more detailed electricity generation map for the State of Queensland.

- **AusNet renewable energy zone (REZ):** On **April 22, 2022**, it was reported widely that **AusNet (TSO)** had proposed the establishment of a **10 GW renewable energy zone** in the Gippsland region of Victoria (**GREZ**). As reported, if the **GREZ** is established it will be the first "industry-led" **REZ** in Australia.

Blue and Green Carbon Initiatives and Biodiversity

*This section considers news items that have arisen within the news cycle of this **Edition 39** Low Carbon Pulse relating to the Blue Carbon and Green Carbon initiatives and Biodiversity.*

To manage the length of this **Edition 39** of Low Carbon Pulse, **Edition 40** will include a bumper section on Blue and Green Carbon Initiatives, particularly in the context of the conferences taking place during May 2022.

Bioenergy and heat-recovery:

*This section considers news items that have arisen within the news cycle of this **Edition 39** 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.*

- **Veolia and Waga Energy deploy France's largest biomethane production facility:** On **April 1, 2022**, the author came across reports in French outlining the deployment of a 120 GW h per year biomethane production facility deriving biogas from landfill (biogas comprising **CH₄** and **CO₂**, and trace compounds), and processing that biogas to produce biomethane. This will be largest biomethane production facility in France, at least for the time being.

By way of reminder:

- **Biogas and Biomethane:** As noted in **Edition 37** of Low Carbon Pulse, there are two legs to the **RePowerEU** policy settings, near to medium term energy security (through diverse sources of natural gas supply, delivered into the EU as liquified natural gas (**LNG**) and increased production of bio-gas and biomethane within the **EU**) and the dash into renewables.

The role that biogas and biomethane has to play is likely to increase, and to do so dramatically in the near to medium term as renewable sources of feedstock are sought and used to derive or to produce biogas / biomethane as part of the means of assuring near to medium term energy security in the **EU**. By some estimates, by 2030 up to 35 billion m³ of biogas / biomethane may be derived or produced, and by 2050 up to 100 billion m³.

Continuing the theme of clear policy settings, it would make sense for the Renewable Energy Directive to contemplate the role of biogas / biomethane specifically.

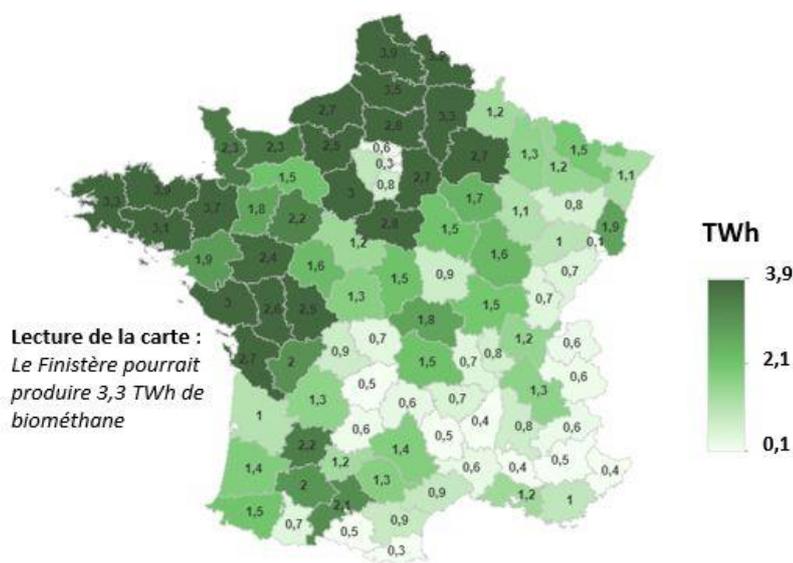
- **France's role in bio-gas and bio-methane production:** As noted in **Edition 37** of Low Carbon Pulse, the following map of France provides an indication of the potential for France to produce biogas and bio-methane.

The headline notes that France could derive up to 320 TWh of electrical energy a year from the use of various technologies to derive and to produce biogas and biomethane as follows: Methanization – 130 TWh; Pyro-gasification – 90 TWh; Hydrothermal gasification – 50 TWh; and Methanation 50 TWh.

It is understood that current natural gas energy use equates to 475 TWh a year. The sources of feedstock for the derivation and production of bigas / biomethane are organic, including from municipal solid waste, crop residues, livestock manure, agri-food industry waste, biowaste, and sludge from waste water.

Potentiel de gaz pouvant provenir de méthanisation en France

Potentiel réaliste de biométhane (en TWh) pouvant être produit par département (hors culture énergétique). Le cumul est égal à 130 TWh.



SOURCE : OPEN DATA RESEAU ENERGIE, 2022

[Note: For further information and background, please connect to the [Ashurst Waste Compendium](#)]

- **A word of caution:** On **April 1, 2022**, the [New Scientist](#) noted that care needs to be taken that progress towards bioenergy (including as contemplated by the **EU**) does not increase the area of land mass used for the growth of feedstock to derive bioenergy. This emphasises that waste of all forms should be the feedstock for bioenergy.
- **Veolia to develop world's largest biorefinery in Finland:** On **April 6, 2022**, [biofuels-news.com](#) reported (under [Veolia launches biorefinery project using alternative feedstock](#)) that **Veolia** is to develop a bio-refinery producing **CO₂-neutral methanol**. The **bio-methanol** will be produced from organic paper and wood waste sourced from the **Metsä Fibre's Äänekoski** pulp mill in Finland. It is understood that the **bio-methanol** plant will produce up to **12,000 metric tonnes of bio-methanol** a year. It is understood that production will commence in 2024. One of the strong narratives emerging from the project is: "The advantage of our industrial concept is that it is replicable at around 80% of the pulp mills worldwide. It has the potential to unlock an additional, locally generated feedstock of CO₂-neutral bio-methanol for biofuel that could be an estimated 2 million tonnes" (Ms Estelle Brachilianoff, COO, Veolia).
- **NREL on top of biogas potential:** On **April 8, 2022**, **NREL** (the **National Renewable Energy Laboratory** of the US Department of Energy) 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.

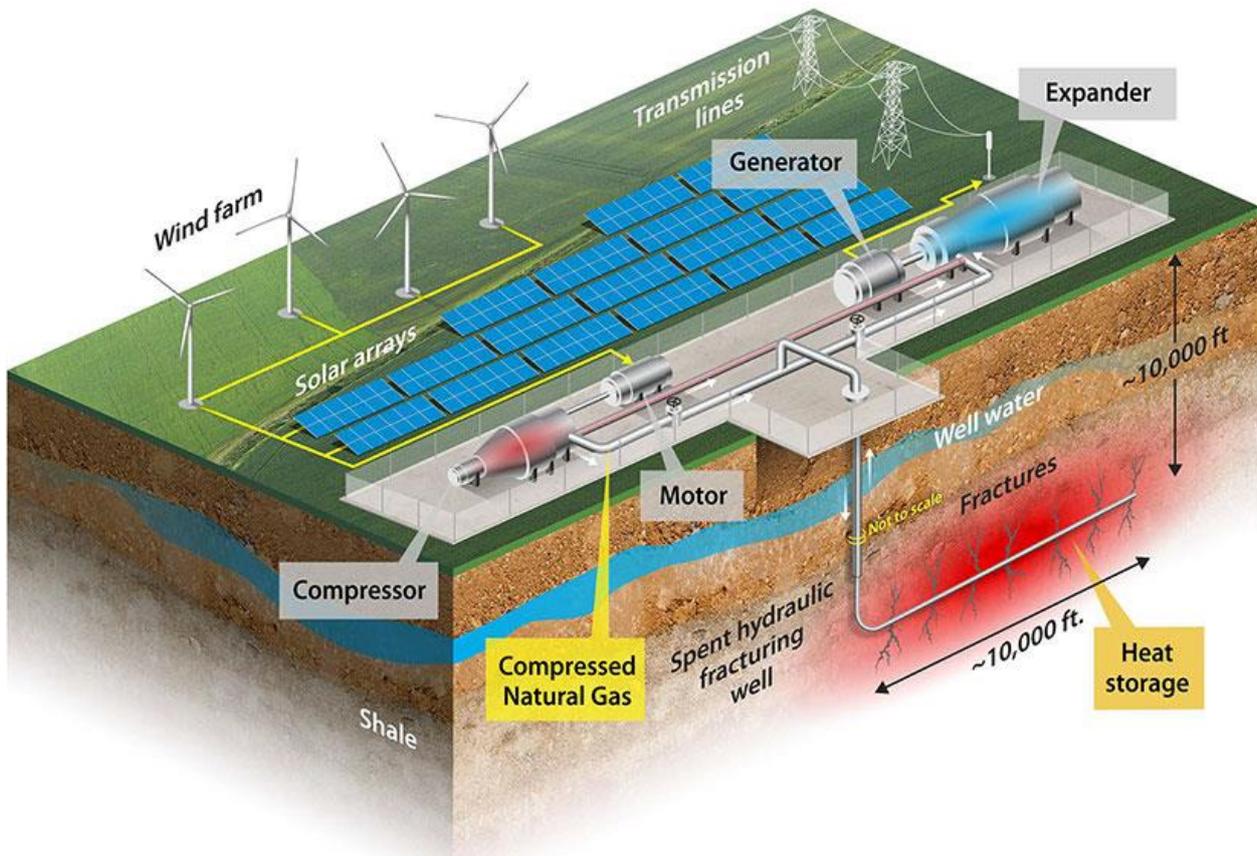
BESS and HESS (and energy storage):

This section considers news items that have arisen within the news cycle of this **Edition 39** 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](#))

- **AboitizPower proceeds with BESS:** On **April 6, 2022**, [energy-storage](#) reported that **SNAP (SN Aboitiz Power Group)** had made a final investment decision to proceed with the procurement of a **20 MW / 20 MWh BESS**, and for this purpose had contracted with **Hitachi Energy** to supply and to install the **BESS**. The **BESS** is to be installed at the **360 MW Magat hydro-electric power station in Ramon, Isabela**, in the north Philippines, and is scheduled to come on line in 2024.

- **NREL underground storage solution:** On April 8, 2022, NREL (the National Renewable Energy Laboratory of the US Department of Energy) [announced](#) (under [NREL Researchers Plot Energy Storage Under Our Feet](#)) it is considering the use of depleted oil and gas wells as a reservoir for the storage of compressed natural gas. While at an early stage, modelling suggests that this may be feasible.



Source: [NREL](#)

- **Uniper back-to-the-future:** On April 11, 2022, Uniper [announced](#) that it was to test the former Krummhörn natural gas storage facility for suitability for use at a **HES**. A demonstration **HES** is to be developed, with storage capacity of up to **250,000 m³**.
- **Market control of BESS:** On April 12, 2022, it was reported widely that **EnergyAustralia** (one of Australia's Big Three Integrated energy corporations) signed a deal with **Edify** (leading renewable energy project development corporation) to take market control of **Edify's Darlington Point (25 MW / 50 MWh)** and **Riverina 2 (65 MW / 130 MWh) BESSs** in New South Wales, Australia. (Regular readers of Low Carbon Pulse will recall that the Riverina 1 BESS is the subject of contractual arrangement with Shell: see [Edition 18](#) of Low Carbon Pulse.) **EnergyAustralia** operates **Edify's Gannawarra (25 MW / 50 MWh) BESS** in Victoria, Australia, and **Ausnet's Ballarat (30 MW / 30 MWh) BESS**, also in Victoria. **EnergyAustralia** is developing its own **BESS**, the **Wooreen (350 MW / 1400 MWh) BESS**, in the Latrobe Valley, Victoria.
- **Virtual BESS:** On April 14, 2022, **AGL** and **Neoen** [announced](#) that they had signed a virtual **BESS capacity contract (BESS CC)**. Under the **BESS CC** **Neoen** (leading renewable electrical energy corporation) provides **AGL** (one of Australia's Big Three integrated energy corporations) with **70 MW / 140 MWh** of virtual **BESS** capacity in New South Wales, Australia. The **BESS CC** allows **AGL** to charge and to dispatch the **BESS**, providing **AGL** with flexibility in respect its customer load.

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 39](#) 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 alkalisation, enhanced terrestrial weathering and direct air capture and storage (DACs) are all means of CO₂ 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 CO₂ each year through CCS, CCUS and CDR. CCS and CCUS (and BECCS and BECCUS) involve the capture at the source of CO₂, preventing release to the climate system. The following provides a helpful overview of carbon capture as things currently stand.

- **Stockholm Exergi's BECCS project receives €180 million of EU support funding:** On **April 1, 2022**, it was announced by **Stockholm Exergi** that the **Climate, Infrastructure and Environment Executive Agency (CINEA)** had committed to provide funding support, in the form of a grant, to allow the installation of **BECCS** technology for **Stockholm Exergi's** project will capture **800,000** metric tonnes of biogenic carbon dioxide a year, capturing nearly 90% of the biogenic carbon dioxide arising.

The biogenic carbon dioxide project is in addition to the existing bio-cogeneration plant in Hjorthagen, Stockholm. **Stockholm Exergi**, among other things, considers that the biogenic carbon dioxide project will be "a catalyst for establishing a market in negative emissions".

On **May 17, 2022**, the **Ashurst Global Towards Net-Zero Emissions Team** will publish an article on **Future-Fuels** (the primary author being the author of Low Carbon Pulse). Among other things, the article on **Future-Fuels** will consider the concept and practicalities of negative emissions, and as such will provide a stepping-stone to the **Carbon Credits** article due to be published by the end of June 2022.

- **Hanson CCS project and HeidelbergCement leadership:**

- On **April 6, 2022**, [constructionnews.co.uk](https://www.constructionnews.co.uk) reported that **Hanson** (part of the **HeidelbergCement Group**) is to spend GBP 400 to install carbon capture technology at its cement manufacturing plant at **Padewood**, near **Mold, North Wales (Padeswood Project)**.

The stated purpose of the **Padeswood Project** is to allow Hanson to make net-zero cement. This is explained by Hanson's Head of Process and Sustainability, Mr Iain Walpole as follows: "If you replace the [Portland] cement component with GBBS [ground granulated blast-furnace slag, which is a lo-carbon cement] ... that brings CO₂ per cubic metre of concrete down; [the **Padeswood Project**] is making the bit that is left behind net-zero".

The bit that is left behind is to be stored permanently in the **Eni UK** depleted natural gas field in **Liverpool Bay**, part of the **HyNet North West**.

- On **April 11, 2022**, **HeidelbergCement Group** announced that the **Concrete Sustainability Council** had certified **16** of its cement manufacturing plants using the new **CO₂** module. This marks further progress in transparency of monitoring and reporting on **CO₂** arising from the manufacture of cement through to the pour of concrete.
- On **April 11, 2022**, the **HeidelbergCement Group** cement manufacturing plant at which **CO₂** is to be captured and then transported for storage in the **Northern Lights Project** was featured in an article in chemindigest.com (under **Capturing Carbon Dioxide through Cement**). While the title to article may be a little confusing, the article itself is excellent, featuring the Heidelberg cement manufacturing plant at **Brevik, Norway**, and the way in which **HeidelbergCement Group** is working with **Aker Carbon Capture** and **Aker Solutions**.

- **ExxonMobil pre-FEED:** During the week beginning **April 11, 2022**, it was reported widely that **ExxonMobil** had commenced pre-FEED work to assess the potential for the use of the **Gippsland Basin** (located in the south east of Australia) for the storage of carbon. The pre-FEED work is understood to be focussing on the use of existing infrastructure to store **CO₂** in the depleted Bream field off the coast of Gippsland, Victoria, with a view to commencing operations in 2025 (subject to commercial and technical feasibility).

News of the pre-FEED work arose at the same time that **ExxonMobil** provided a strong narrative around the scale of use of CCS and CCUS, and the likely cost of CCS / CCUS. As reported by Reuters on **April 22, 2022**, ExxonMobil estimates that there will be a USD 4 trillion market for CCS by 2050.

As reported in previous editions of Low Carbon Pulse, the US **DOE** is assessing five forms of subsurface **CO₂** storage: **1.** basalt formation; **2.** oil and gas reservoirs; **3.** organic rich shales; **4.** saline / salt formations; and **5.** unmineable coal seams.

- **Technip Energies selected for Kasawari CCS project:** On **April 19, 2022**, **Technip Energies** [announced](https://www.technipenergies.com) that it and **NPCC (National Petroleum Construction Corporation)**, had been selected by **Petronas Carigali Sdn. Bhd** (a subsidiary of **PETRONAS**) to undertake **FEED** for one of the world's largest off-shore CCS projects. As reported, the CCS project, located in the **Kasawari gas field off Sarawak, Malaysia**, will process up to 3.7 million metric tonnes of **CO₂** a year, commencing in 2025.

- **CCS / CCUS Databases:**

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

- US **DOE** National Renewable Energy Laboratory (**NREL**) [Carbon Capture and Storage Database](https://www.nrel.gov/ccus/), which includes information on active, proposed and discontinued CCS projects around the world.
- US **DOE** [Carbon Storage Atlas](https://www.energy.gov/eere/energy-storage/atlantis).
- [Atlas of Carbon and Hydrogen Hubs from the Great Plains Institute](https://www.greatplainsinstitute.com/)
- **CO₂ Value** launched a [New CCU Project Database](https://www.co2value.com/), 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 39** 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).

Physical hydrogen trading: On **April 12, 2022**, hydrogen-central.com reported that during a visit to the North Sea Port in Terneuzen the Dutch **Minister of Climate and Energy** Mr Rob Jetten, had received the first certificated for Green Hydrogen from **HyXChange**.

The hydrogen exchange initiative has been developed by Gasunie, Port of Rotterdam Authority, Port of Amsterdam, Gronigen Seaports, and North Sea Port). The **HyXChange** is a trading platform that will allow the physical trading of hydrogen, with each certificate required to trade a Guarantee of Origin.

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

This section considers news items that have arisen within the news cycle of this **Edition 39** 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.

• Neste nest egg and perfect plastic:

- On **April 4, 2022**, Neste [announced](#) that it had signed a funding support agreement with the **Climate, Infrastructure and Environment Executive Agency (CINEA)** under which **CINEA** commits to provide **€88 million** in grant funding to allow Neste to continue the development and deployment of its renewable hydrogen and carbon capture and storage project (**SHARC**) at its **Porvoo refinery in Finland**. As currently contemplated, the **SHARC** will allow carbon neutral production of fuels at the **Porvoo refinery** by 2035.
- On **April 1, 2022**, it was reported widely that Neste intends to conduct a feasibility study to consider whether it was possible to process liquified feedstock derived from plastic waste at the **Porvoo refinery**.
- **Air Liquide safe bet in Las Vegas:** On **April 4, 2022**, Air Liquide (one of the Big Three industrial gas giants) announced that it is to develop a landfill gas-to biogas-to clean-gas project near **Las Vegas, Nevada** (the **Nevada Hydrogen Factory**). The **Nevada Hydrogen Factory** will produce 30 metric tonnes of liquid hydrogen (**LH2**) a day. In the first instance, it is understood that the **LH2** will be transported to California for sale into the mobility market.

By way of reminder [Edition 36](#) of Low Carbon Pulse reported that:

- "**Air Products** (one of the Big Three industrial gas giant globally, with Air Liquide and Linde) is to develop a 10 metric tonne a day liquid hydrogen (**LH₂**) production facility in **Casa Grande, Arizona**, with the **LH₂** to be used in the California mobility market. The **LH₂** production facility will comprise two **thyssenkrupp nucera electrolyzers** to produce gaseous hydrogen and **Air Products** technology to liquify to produce **LH₂**"; and
- "**Samsung Ventures** had joined **Chevron Corporation, Itochu Corporation** and **Ascent H2 Fund** in backing **Raven SR** in respect of its first waste to hydrogen plant in northern California. Under the deal between **Samsung Ventures** and **Raven SR**, **Raven SR** is to work with **Samsung C&T** (a sibling corporation of Samsung Ventures) to "advance the scalability" of the **Raven SR** technology to develop and to deploy it in the Asian market.
- "**Raven SR** was to develop a hydrogen from waste facility in **Aragon, Spain**. As reported, the facility will treat 75 metric tonnes of organic waste a day to produce 1,600 metric tonnes of hydrogen a year".

It is clear that hydrogen from landfill gas is "now a thing": click [here](#) for the first feature in the **Hydrogen for Industry (H24I)** features published in June 2021. As noted in previous editions of Low Carbon Pulse, the technologies used to derive and to produce hydrogen from waste in landfill or the landfill gas arising from waste in landfill, gives rise to **CO₂** unless that **CO₂** is captured and stored for captured and used, and as is not carbon neutral of itself.

• Bakken Energy and Mitsubishi Heavy Industries continue to progress:

- On **April 5, 2022**, [asia.nikkei.com](#) reported (under [Mitsubishi Heavy taps US partner for \\$2 bn hydrogen project](#)) that **Mitsubishi Heavy Industries** was continuing to work with **Bakken Energy** develop the largest clean hydrogen project in North America to date, the **300,000 metric tonnes** a year. The feedstock for the production of clean hydrogen is natural gas (the **North Dakota Clean Hydrogen Hub Project**).
- On **April 10, 2022**, [asia.nikkei.com](#) updated early reporting (under [Mitsubishi Heavy's U.S. hydrogen hub to receive \\$90 million in aid: governor](#)) that the US State of **North Dakota** was to provide USD 90 million of funding support, including subsidies and low-interest financing for the development of the **North Dakota Clean Hydrogen Hub Project**.

By way of reminder:

- **Edition 19** of Low Carbon Pulse reported:

"**Great Plains take-off:** On June 2, 2021, Bakken Energy and Mitsubishi Power Americas, Inc., announced that they had signed a strategic partnership agreement to create a clean hydrogen hub in North Dakota, US (**CHH**). The **CHH** is to comprise clean hydrogen production, storage, and transportation facilities, to deliver clean hydrogen to the point of use. The intention of Bakken Energy is to produce Blue Hydrogen from natural gas, so as to become, in the words of Bakken Energy CEO, Mr Mike Hopkins: "the largest and lowest cost producer of clean hydrogen in the United States".

[Mitsubishi](#) has been active in the development of hydrogen hubs in the US, with the Californian Project (City of Los Angeles), **Magnum Development** in **Delta, Utah**, and the Texas Brine project".

- **Edition 25** of Low Carbon Pulse reported:

"**Bakken back plain sailing:** **Edition 19** of Low Carbon Pulse reported on Bakken Energy and Mitsubishi Power Americas Inc's strategic partnership to create a clean hydrogen hub in North Dakota, US.

On August 19, 2021, HydrogenCentral, reported (under [Bakken Energy to Purchase Dakota Synfuels Plant and Convert to Blue Hydrogen, \\$ 2 B Hydrogen Hub Project](#)) that Bakken Energy had agreed terms with Basin Electric Power Corporation to purchase the gas assets of the Dakota Gasification Company, including its Synfuels facility.

It is reported that Synfuels facility will be expanded and repurposed, and that it will incorporate advanced autothermal reforming (**ATR**) technology, rather than steam methane reforming (**SMR**) technology, to increase and to maximise the capture of **CO₂** arising during the production of clean hydrogen (being hydrogen using carbon intensive feedstock that is then reformed).

The **ATR** technology to be deployed is reported as capturing of 95% of carbon emissions arising. It is hoped that that Bakken will seek to address the 5% not covered by capture through a sequestration strategy".

- **Mitsubishi and Shell aligned:** On **April 7, 2022**, [h2-view.com](#) reported that **Mitsubishi Corporation** (Japanese conglomerate) and **Shell** plc (leading global international energy corporation) had agreed to work together to develop

and to deploy **Green Hydrogen** production capacity using renewable electrical energy sourced from **4 GW** of off-shore wind fields off the Netherlands.

As currently contemplated, together **Mitsubishi** and **Shell** plan to produce **400,000** metric tonnes a year of Green Hydrogen by 2030, and is expected to be used for fertiliser production and for heating. Mitsubishi Corporation will invest through its subsidiary Eneco Groep N.V.

- **Atura Power on the move:**

- **Niagara Falls to produce Green Hydrogen:** On **April 8, 2022**, [h2-view.com](https://www.h2-view.com) reported (under **Niagara Falls to integrated a Hydrogen Centre with 20 MW capacity**) that **Atura Power** (Ontario gas producer) plans to develop the **Niagara Hydrogen Centre** to house a **20MW** electrolyser to produce Green Hydrogen.

The Green Hydrogen produced by the **Niagara Hydrogen Centre** may be used to balance the Ontario, Canada, electricity grid in real time.

- **HES:** On **April, 21, 2022**, it was reported widely that **Atura Power** and **Plains All American** had signed a memorandum of understanding to work together on FEED to analyse the commercial and technical feasibility of the development of a **20 MW** electrolyser, the hydrogen from which would stored in a **HES** in a subsurface structure – the **Windsor salt-cavern**.

- **Lhyfe aligned wpd and Mitsui:**

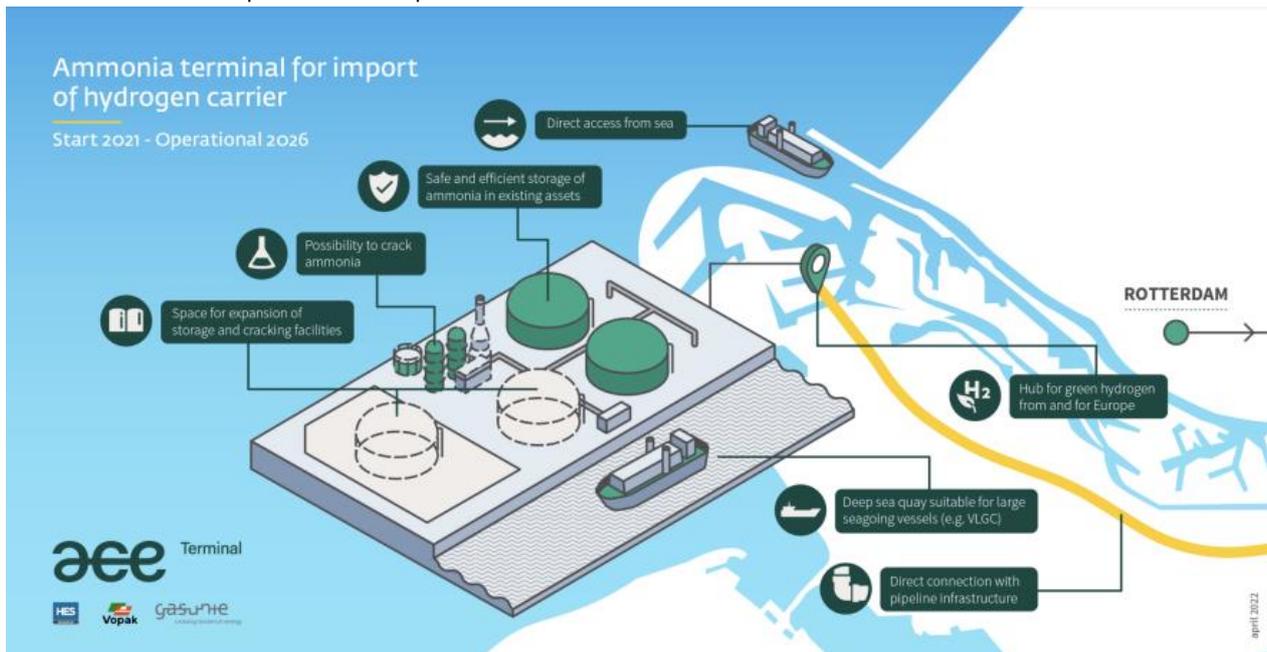
- On **April 11, 2022**, [h2.view.com](https://www.h2-view.com) reported that **Lhyfe** (French green hydrogen producer) and **wpd** (German wind and solar energy producer) have agreed to work together to develop and to deploy a large-scale Green Hydrogen production facility, of up to **600 MW**, using renewable electrical energy sourced from a planned **1 GW** off-shore wind field.

The agreement is reflected in a memorandum of understanding (**MOU**), and it is understood contemplates connection to the **Nordic Hydrogen Backbone**.

- On **April 13, 2022**, **Mitsui & Co., Ltd** [announced](#) that it had invested in **Lhyfe**, on the basis that it is aligned the sustainability goals of **Mitsui**, critically, to allow **Mitsui** to import Green Hydrogen into European markets.

- **ACE Terminal progressing:** On **April 11, 2022**, **Vopak** provided an update in respect of the **ACE Terminal**.

The **ACE Terminal**, being developed by **Gasunie** (energy infrastructure company in the Netherlands and Germany), **HES International B.V.** and **Vopak**, the Green Ammonia import terminal being developed in the Port of Rotterdam. The **ACE Terminal** is planned to be operational from 2026.



- **Gladstone to get another hydrogen production facility:** On **April 12, 2022**, it was reported widely that **The Hydrogen Utility (H2U) Group** (Australian green hydrogen infrastructure developer) and **Orica** (explosives supplier) are to assess the first stage of the development of a **3 GW Green Hydrogen Hub**, capable for producing up to 5,000 metric tonnes of Green Hydrogen a day, the electrolysers powered by renewable electrical energy sourced from photovoltaic solar and wind sources.

- **Desert Bloom progresses:**

- On **April 11, 2022**, it was reported widely that **Osaka Gas** had agreed to develop **Desert Bloom** jointly with Aqua Aerem (air-to-water technology developer). The involvement of **Osaka Gas** is telling, providing support for both the project and the technology.

- **By way of reminder:**

Edition 32 of Low Carbon Pulse reported on **Desert Bloom** as follows:

"On December 13, 2021, it was reported widely (and enthusiastically) that the Desert Bloom Green Hydrogen production facility project in the Northern Territory, Australia, had been given Major Project Status.

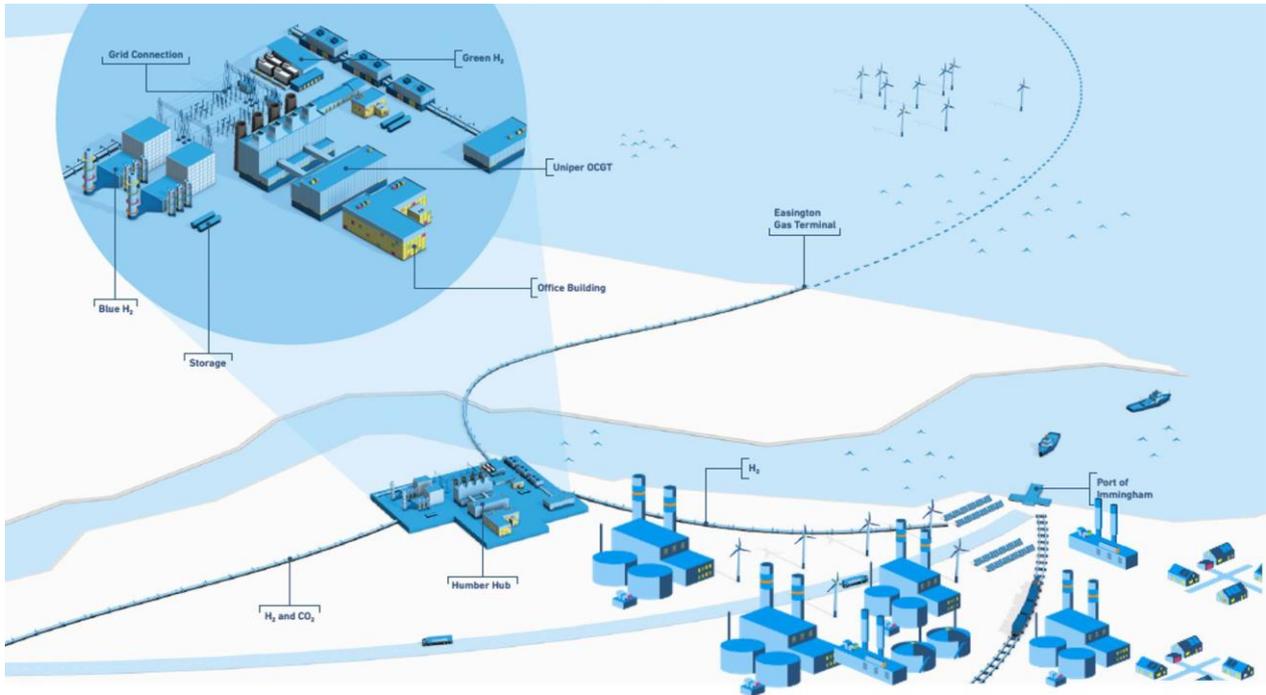
In any State or Territory in Australia, Major Project Status allows for coordination of approvals and permitting, and in so doing increases the rate at which a project is able to progress to development and deployment. Project

proponent, Aqua Aerem (water air in Latin), has indicated that Major Project Status will allow a 8 MW pilot to commence in 2022, ahead of the planned 10 GW, AUS 10.75 billion, staged development.

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

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

- **Shell and Uniper progress:** On **April 12, 2022**, **Shell** [announced](#) (under [Shell and Uniper to work together on Blue Hydrogen production facility in the UK](#)) the signature of a cooperation agreement with **Uniper** to progress plans for low-carbon hydrogen production at Uniper's **Killingholme Site** in North Lincolnshire, England.



Source: [Uniper LinkedIn](#)

As contemplated, the low-carbon hydrogen produced will be used by heavy industry, land transport mobility, and heating and power across the Humber region (and beyond). As noted in **Edition 37** of Low Carbon Pulse, the project satisfied the eligibility criteria for the Phase-2 carbon capture, usage and storage Cluster Sequencing Programme.

- **Seoul Sludge to Hydrogen:** On **April 12, 2022**, it was reported that **Seoul Water Recycling Corporation** is working with **Plagen** (a pyrolysis and renewable fuel production corporation) to develop jointly technology to source biogas from the sludge arising from waste water treatment to derive or to produce hydrogen.

In addition to outlining the production of hydrogen from waste, **Hydrogen for Industry (H24I)** (entitled [Hydrogen from Waste](#)) feature published in June 2021 outline the production of hydrogen from waste water.

As noted in previous editions of Low Carbon Pulse, if water, derived from the waste water, is electrolysed, the hydrogen produced will be Green Hydrogen. If biogas is derived from the waste water and is subject to steam methane reforming or pyrolysis the hydrogen derive or produced will not be Green Hydrogen, because as a matter of chemistry **CO₂** will arise even if in the form of carbon black in the case of the use of some pyrolysis technologies.

- **Total Eren chilled:** On **April 14, 2022**, it was reported that **Total Eren** is progressing with the development of its **8 GW** Green Hydrogen production facility in the **Magallanes** region, Southern Chile (see **By way of reminder below**) with the reported appointment of Wood (leading global consulting and engineering corporation) to undertake conceptual design and engineering work.

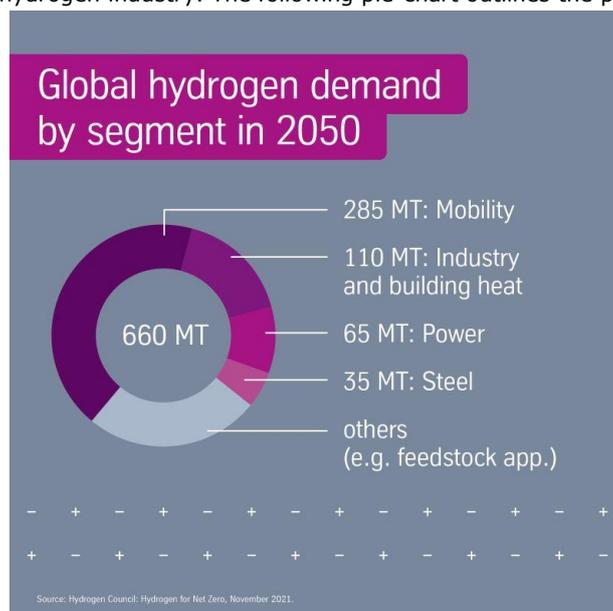
By way of reminder: Edition 32 of Low Carbon Pulse reported that: "Total Eren (a leading renewable energy corporation part owned by TotalEnergies) plans to develop a **10 GW** on-shore wind project to supply renewable electrical energy to power Green Hydrogen and Green Ammonia production facilities in 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".

- **Project Global Hydrogen Supply by 2030:** On **April, 13, 2022**, **EDF Group** (global leading electrical energy corporation) [announced](#) (under [The EDF Group launches a new industrial plan to produce 100% low-carbon hydrogen](#)) that it aims to develop "3 GW of electrolytic hydrogen projects worldwide by 2030. These projects will involve between €2 and €3 billion of investment, will be developed and co-financed through industrial partnerships and by drawing on national and European support mechanisms". The hydrogen produced will be both Green and Pink.

- Sun Cable continues to progress:** On **April 20, 2022**, the Australian Broadcasting Corporation (**ABC**) on-line news feed, abc.net.au reported that the **environmental impact assessment (EIS)** for **Sun Cable** had been lodged. As regular readers of Low Carbon Pulse will know, the **Sun Cable** (and the **Australia-Asia PowerLink**) projects have been covered in Low Carbon Pulse from the earlier editions (see **Editions 2, 3, 13, 26, 28, 32**). As reported by the **ABC**, the **EIS** identifies a range of potentially negative environmental impacts, characterised as minor to moderate.
- CIP and Madoqua Renewables progress in Portugal:** On **April 20, 2022**, renews.biz reported that **Copenhagen Infrastructure Partners' Energy Transition Fund** is working with **Madoqua Renewables** and **Power2X** to develop a **€1 billion 500 MW** Green Hydrogen and Green Ammonia production facility to be located in **Sines, Portugal** (the **MadoquaPower2X** project). The **MadoquaPower2X** project will produce **50,000** metric tonnes of Green Hydrogen and **500,000** metric tonnes of Green Ammonia a year.
- Advanced Methanol Rotterdam (AMR):** On **April 24, 2022**, as reported the **AMR** facility will produce up to **90,000** metric tonnes of renewable methanol a year from feedstock comprising **180,000** metric tonnes of non-recyclable waste, currently being treated thermally. The **AMR** facility will capture all **CO₂** arising, and it will be used in local greenhouses, and the bottom ash will be used for cement production, with other residual streams (including ammonia and salts) to be sold.
- Aker Horizons and Nordkraft shape the north:** On **April 25, 2022**, it was reported widely that **Aker Horizons** and **Nordkraft** plan to develop, in joint venture, a large-scale hydrogen production facility in **Narvik, Norway**. It is understood that common use infrastructure will be developed to provide sites for energy intensive industries. A key driver for the development of the hydrogen hub in **Narvik** is the surplus renewable electrical energy that arises regionally, that will allow relatively low-cost renewable electrical energy to power electrolyzers for Green Hydrogen production.
- Permacand and RES to develop Green Hydrogen production facility:** On **April 25, 2022**, it was reported widely that **Permacand** (an electrode supplier) and **RES** (a global renewable energy company) had signed a letter of intent (**LOI**) to develop a Green Hydrogen production facility in **Alby, Ånge Municipality, Sweden**.
- US DOE lends to the Advanced Clean Energy Storage Hub Project:** On **April 26, 2022**, it was reported that the **US DOE Loan Program Office** had committed, conditionally, to provide up to **USD 504.4** million of debt funding in respect of the **Advanced Clean Energy Storage Hub Project**. The **Advanced Clean Energy Storage Hub Project** is to be developed by **Magnum Development LLC** and **Mitsubishi Power Americas Inc**, and it expected to the commence operations in 2025.

On **April 27, 2022**, it was reported that **Black & Veatch** had been selected as a EPC provider for the Project.

By way of reminder: Edition **19** of Low Carbon Pulse reported on the **Advanced Clean Energy Storage Hub Project** as follows: "Advanced Clean Energy Storage (**ACES**) project in Delta, Utah, developed by Mitsubishi Power Americas and Magnum Development. The project contemplated will comprise a 1 GW electrolyser facility, producing 450 metric tonnes per day of clean hydrogen, with salt-caverns to store hydrogen".
- Approvals to energise HyEx Project:** On **April 28, 2022**, renewablesnow.com reported that **Engie Latam SA** (ammonium and nitrate producer) and **Enaex SA** (explosives supplier) had received environmental approval to commence their complementary Green Hydrogen production facility and Green Ammonia synthesis facility in the city of **Tocopilla, Antofagasta, Chile**. While the **HyEx Project** it is not world scale of itself, it provides a model project in terms of participants and replicability.
- Projected Global Hydrogen Demand by 2050:** Various editions of Low Carbon Pulse have reported on the estimated projected demand for hydrogen by 2025. A **Hydrogen Council** report (published on **November 2021**) provides estimates from the hydrogen industry. The following pie-chart outlines the projected demand by sector:



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 39** 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), electrolyzers (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.

- **Enel receives funding support for expansion of giga-factory:** On **April 1, 2022**, the **Enel Green Power** (subsidiary of Enel, leading international renewables and utility corporation) [announced](#) that it had signed a grant agreement with the **Climate, Infrastructure and Environment Executive Agency (CINEA)** under which it will receive **€118 million** to be contributed to the cost of the expansion of its 200 MW bifacial photovoltaic module factory in Catania, southern Italy, into a 3 GW Giga-factory. The total cost of expansion is understood to be **€600 million**.
- **John Cockerill and Greenko Group roost:** On **April 11, 2022**, [rechargenews.com](#) reported the **John Cockerill Group** (leading electrolyser technology corporation) is 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 alkaline electrolysers. [Recharge news](#) notes that this is the 14th Giga-factory for electrolyser manufacture in the past year or so, and the second in India after Ohmium.

ELECTROLYSER GIGA-FACTORIES				
Cummins 1 GW x 2 *	FFI – 2 GW	ITM Power – 5 GW	McPhy – 1 GW	NEL – 2GW +
Ohmium – 0.5 to 2 GW \$	Plug Power 1 GW x 2 #	Siemens Energy – 1 GW	Sunfire – 1 GW	Thyssenkrupp – 5 GW

* Cummins has announced two Giga-Factories, one with Iberdrola, and one with Sinopec,

Plug Power has announced two Giga-Factories, one in the US, one in ROK.

\$ Ohmium International announced on April 18, 2022 that it is to increase electrolyser manufacturing capacity to 2 GW by the end of 2022 at its giga-factory in Bangalore, India.

+ NEL ASA announced on April 20, 2022, that its fully automated electrolyser manufacturing facility in Herøya, Norway, was on-line.

- **Republic of Ireland's first Hydrogen Valley:** On **April 14, 2022**, [renews.biz](#) reported that the **Port of Galway** and **SSE Renewables** (leading developer and operator of renewable energy across the UK and Ireland) had unveiled plans for Ireland's first Hydrogen Valley (the **Galway Hydrogen Hub**).

The **Galway Hydrogen Hub** was announced by An Taoiseach, Mr Micheál Martin.

In addition to the **Port of Galway** and **SSE Renewables** and other members of the **Galway Hydrogen Hub** are reported to be Aer Arann Islands, Aran Islands Ferries, Bus Eireann, CIE Group, Lasta, and NUI Galway. It is understood that a Green Hydrogen production facility will be developed at Galway Harbour to produce Green Hydrogen for use within the Hydrogen Valley, the primary use being to fuel private and public transport.

- **100 cities to participate in EU Missions:** On **April 28, 2022**, the **EC** announced the [100 EU cities](#) that will participate in the [EU Mission](#), the so called **Cities Mission**.

The cities comprise cities located in the 27 Member States and 12 other cities associated with the EU research and innovation programme. As noted in previous editions of Low Carbon Pulse, urban areas are home to 75% of EU citizens.

Globally cities consume over 65% of energy and give rise to more than 70% of GHG emissions.

EU CITIES



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

This section considers news items that have arisen within the news cycle of this **Edition 39** 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.

- **Highlight for HYBRIT:** On **April 1, 2022**, **LKAB**, **SSAB** and **Vattenfall** [announced](#) the signature of the funding support agreement with the **Climate, Infrastructure and Environment Executive Agency (CINEA)**, in the form

of a grant. The funding support is to allow the scaling up and commercialisation of the value chain for the use of hydrogen to produce green iron and steel.

By way of reminder: Low Carbon Pulse has covered the **HYBRIT** project as follows:

- **Edition 13:** "On March 24, 2021, it was announced that **HYBRIT** is to develop a new Green Steel mill in Gallivare, Sweden, to produce fossil-free sponge iron (also known as direct reduction iron). The Gallivare Green Steel mill will have a total steel-making capacity of 2.7 million metric tonnes per annum by 2030. The Gallivare Green Steel mill will join the pilot Green Steel mill at Lulea that has proved up the technology. In addition, there are plans to develop an underground storage facility to store Green Hydrogen. The project is part of an integrated supply chain, from "mine-to-mill-to-manufacturer", among the **HYBRIT** partners (LKAB, SSAB and Vattenfall), to transform their respective businesses: for LKAB as the supplier of iron ore, SSAB as the steel mill owner and operator, for Vattenfall as a producer, and retailer, of electrical energy and heat, and the producer and supplier of Green Hydrogen. (Vattenfall is ultimately a Swedish state-owned company.) **Hybrit Development AB**, owned by LKAB, SSAB, and Vattenfall, was established to develop technology to enable the production of steel using hydrogen, rather than coal. Significant support has been provided by the Swedish Energy Agency, through *Industriklivet*".
- **Edition 16:** "**Edition 13** of Low Carbon Pulse, outlined the **HYBRIT project**. On April 7, 2021, it was reported that SSAB, LKAB and Vattenfall have commenced the development of a cavern storage facility to store Green Hydrogen produced for use at the **HYBRIT Green Steel mill**. As noted in other editions of Low Carbon Pulse, the use of cavern storage for Green Hydrogen will provide the means to produce Green Hydrogen (or Blue Hydrogen for that matter), and to store it, providing both inventory for the facility at which it is used, and energy storage. Also as hydrogen infrastructure networks develop, surplus inventory may be sold or traded, and dispatched".
- **Edition 20:** "**Editions 13** and **16** of Low Carbon Pulse reported on the development of what is billed as the world's first fossil free steel plant located at Svartoberget, in Lulea, Sweden (**HYBRIT**). The development of **HYBRIT** is being undertaken in alliance with SSAB, LKAB, and Vattenfall (see **Editions 13** and **16** of Low Carbon Pulse). Effectively, the **HYBRIT** partners have developed a "mine-to-mill-to-manufacture" supply chain.
 - **Pilot to commercial scale:** The **HYBRIT** plant at Svartoberget, in Lulea, is a pilot plant which had proved up green sponge iron production. **HYBRIT Development AB**, owned by SSAB, LKAB, and Vattenfall, is developing a commercial, world scale, plant at Gallivare (see **Edition 13** of Low Carbon Pulse).
 - **Production assurance:** On June 17, 2021, it was announced that to achieve more efficient storage of the hydrogen produced for use in the manufacture of Green Steel hydrogen, that hydrogen will be compressed, and for this purpose **HYBRIT** has contracted with Howden Group (leading air and gas handling company) for the supply by Howden of a high-pressure diaphragm compression system. Depending on which information source is used, the production of steel is responsible for between 7 and 9% of global **GHG** emissions (see second article in **The Shift to Hydrogen (S2H2): Elemental Change** series entitled [What needs to be decarbonised? And what role can hydrogen play?](#) for the scope, size and shape of the global steel industry.)
 - **High Light – world first:** On June 21, 2021 it was announced that **HYBRIT** had completed the first production test of sponge iron (or direct reduction iron (DRI): see **Edition 10** of Low Carbon Pulse), using hydrogen instead of coking coal to remove oxygen thereby avoiding the **CO₂** arising. This is a world first".
- **Edition 25:** Under **HYBRIT's Clean Steel on the road:**
 - **The concept:** Previous editions of Low Carbon Pulse (see **Editions 13** and **16**, and summarised in **Edition 20**, of Low Carbon Pulse) have reported on **HYBRIT Development AB's** (established and owned by SSAB (steel mill owner and operator), LKAB (iron ore supplier) and Vattenfall (state-owned energy company, producer and supplier of Green Hydrogen)) development of a "mine-to-mill-to-manufacture" supply chain, including the development of a pilot plant at Svartobret, in Lulea, billed as the world's first fossil free steel plant, using hydrogen for high-temperature heat processes to produce steel, rather than metallurgical coal.
 - **The execution:** **Edition 20** of Low Carbon Pulse reported that SSAB and Volvo Group had entered into a letter of intent for the supply and purchase of Green Steel, and on the production of the first sponge iron at the pilot plant in Lulea. In July 2021, SSAB rolled the first steel using the **HYBRIT** technology.

On August 18, 2021, it was widely reported that SSAB had supplied the world's first 100% fossil free steel to Volvo Group. President and CEO of SSAB, Mr Martin Lindqvist, said: "The first fossil-free steel in the world is not only a breakthrough for SSAB, it represents proof that it's possible to make the transition [and reduce significantly] the global carbon footprint of the steel industry."
 - **The significance:** As noted in **Edition 22** of Low Carbon Pulse, one of the joys of authoring Low Carbon Pulse is "following both the connectedness of change, and the pace of change".

Following the progress of the **HYBRIT** partnership, and technology, illustrates this perfectly.

Why is this significant?

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

Progress towards the decarbonisation of the iron and steel industry is to be welcomed, warmly.]; and

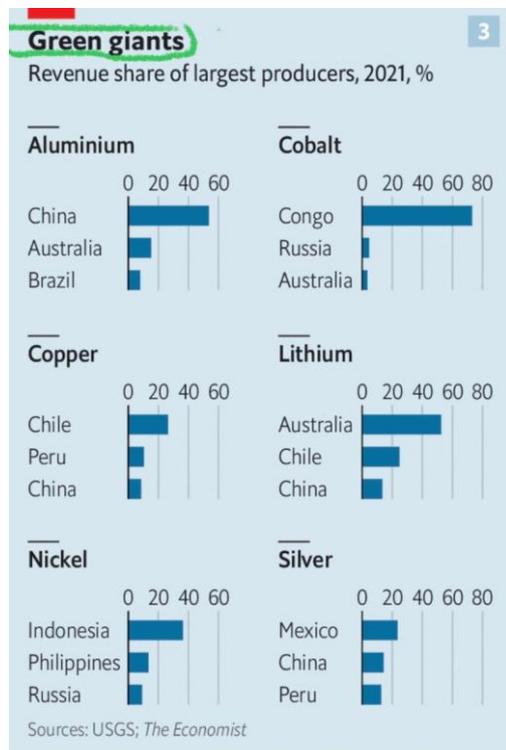
- **Edition 26:** "**Edition 25** of Low Carbon Pulse reported, with enthusiasm, on the greening of the iron and steel sector (under **HYBRIT's Clean Steel on the road**). The cement and concrete industry gives rise to a greater

mass of GHG emissions than the iron and steel industry: between 3,500 to 4,000 billion tonnes of GHG emissions arise each year from the production of cement.

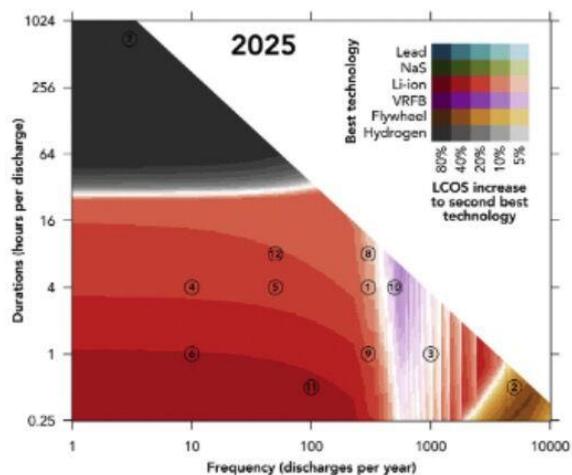
In an [article](#) in Fast Company, Mr Mark Wilson provides an overview of the possible storage of CO2 in concrete. This concept will be considered in the August Report on Reports (in the summary of the CUR) as the Appendix to **Edition 27** of Low Carbon Pulse.

Clean Steel a thing: **Edition 25** of Low Carbon Pulse reported that (under **HYBRIT's Clean Steel on the road**) SSAB delivered the "first fossil-free steel in the world" to Volvo Group from the **HYBRIT** mill, using HYBRIT technology. On September 1, 2021, SSAB announced that it is to partner with Daimler's Mercedes-Benz to introduce fossil-free steel to the production of vehicles. As a reminder, **HYBRIT** is a shortening of Hydrogen Breakthrough Ironing Making Technology, developed jointly by LKAB, SSAB and Vattenfall".

- **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.
- **POSCO and Hancock testing feasibility of HBI plant:** On **April 1, 2022**, the author picked up on reporting in the **ROK** press that **POSCO** had announced the execution of a memorandum of understanding (**MOU**) between **POSCO** and **Hancock** to Produce Low Carbon Steel Raw Materials, with the **MOU** focusing on testing the feasibility of a **hot briquette iron (HBI)** production facility, and, depending on the outcome of the testing of feasibility, the development of an iron ore mine to provide dedicated iron ore to produce **HBI**. To some with long memories, and longer in the tooth, **HBI** has long been a good idea the time for which may be nigh.
- **Critical metals and minerals:** The bar chart below illustrates how metal and mineral prices performed during 2021. The message is clear – higher demand = higher prices, the best sure for higher prices, is increased supply. As such, as has been clear for a while, it seems likely that a mining boom is ever-more likely.



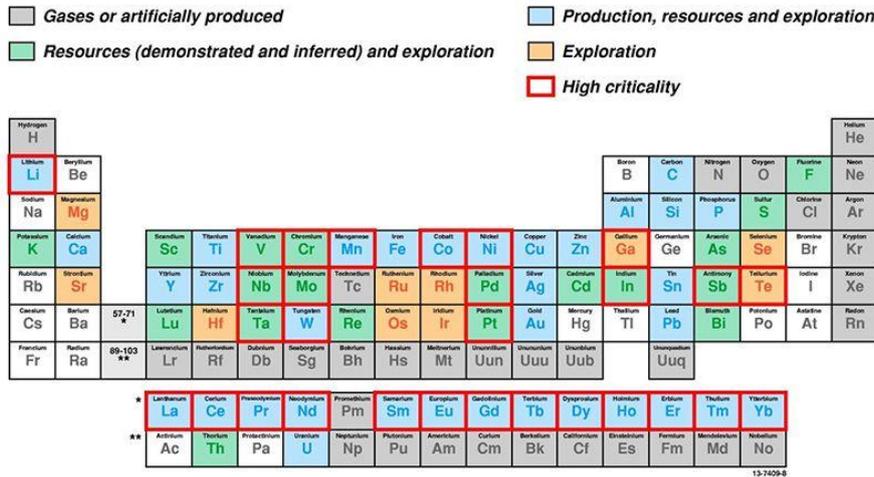
The Economist



- **Battle of the batteries - BEV versus FCEV:** The dynamics and thinking informing the debate around the use of **BEV** and **FCEV** is becoming more nuanced, helped by ever more research and work. The above graph (at the right hand side), prepared by the team at **Imperial College, London**, demonstrates that frequent and rapid recycling tends to prefer the use of **Li-ion** technology **BEV** technology, whereas less frequent and more extended cycles tend to prefer the use of **FCEV** technology.

This has been the instinctive, possibly intuitive, sense for many, but the Imperial College, team have provided a firm basis for the use of both technologies.

- **Iluka to develop REE refinery in Western Australia:** On **April 3, 2022**, **Iluka Resources** [announced](#) that the Australian Federal Government had approved an **AUD 1.25** billion loan to allow **Iluka Resources** to develop a rare earths and elements (**REE**) refinery. As many readers will know, Australia is a leading miner of bauxite (for alumina and aluminium), cobalt and nickel, copper and gold, iron ore, lead, lithium, manganese, and zinc, it also has the potential to be a leading miner and producer of **REEs**.



Source: [Pedram Danesh-Mand LinkedIn](#)

- **Green Steel expansion awaiting Green Hydrogen:** On **April 8, 2022**, [InnovationAus.com](#) reported that aluminium and iron and steel magnate, and chair of the **GFG Alliance**, **Mr Sanjeev Gupta**, speaking at an AmCham meeting in Adelaide, South Australia, announced the intention to expand iron and steel production capacity, to increase capacity by up to 2.5 million metric tonnes a year. To facilitate the expansion Mr Gupta encouraged Australia, to become "a world leader in .. clean hydrogen, not on by exporting green hydrogen, but using it to produce green projects such as steel".
- **Rio Tinto to strengthen social licence:** On **April 10, 2022**, it was reported widely that **Rio Tinto** is to focus on mining metals and minerals that are key to the achievement of energy transition, critically, copper, lithium and nickel, alongside the continued mining of iron ore.
- **The urban ore body / urban mining:** Back in the early days of waste projects (2000), the author used to work with **Dr John White** who coined the phrase, the "urban ore body" to refer to the waste that arose in urban environments. In recent months the author has read a number of pieces referring to "urban mining". In passing, this section could be included in most sections of Low Carbon Pulse, because waste includes organic and inorganic material, in gaseous, liquid and solid form. The piece headed **Landfills to be minded** provides an example of "urban mining". Bringing thinking together, it is clear that policy makers are moving towards acceptance of waste as a resource. Those involved in the waste collection and management industry have long regarded waste of all kinds as a resource. In this context there is a role for government in providing or supporting that development of waste collection infrastructure to maximise the capture of waste arising in the urban environment to allow maximisation of recycling and reuse of all waste streams arising in an urban context.

The policy settings need to be developed with policy settings that reduce the amount of waste arising, and that maximise the prospect of recycling and reusing the waste streams that do arise. For example, **Edition 36** of Low Carbon Pulse reported as follows:

"With the presentation of the **Circular Economy Action Plan**, the **EC** is proposing [new regulations and rules](#) in respect of good and products, including to addressing energy efficiency over the life-cycle of those goods and products, and to design their recycling and repurposing at the end of their design life. In addition, the EC presented proposals in respect of textiles, construction materials and products, and to ensure that customers are informed fully as to the sustainability of the goods and products."

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

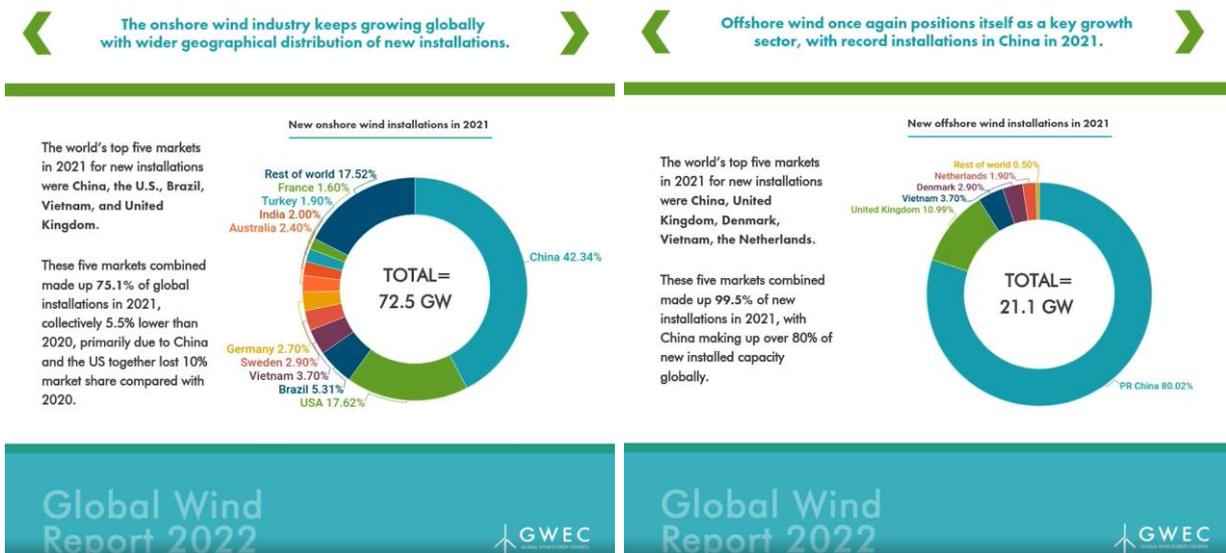
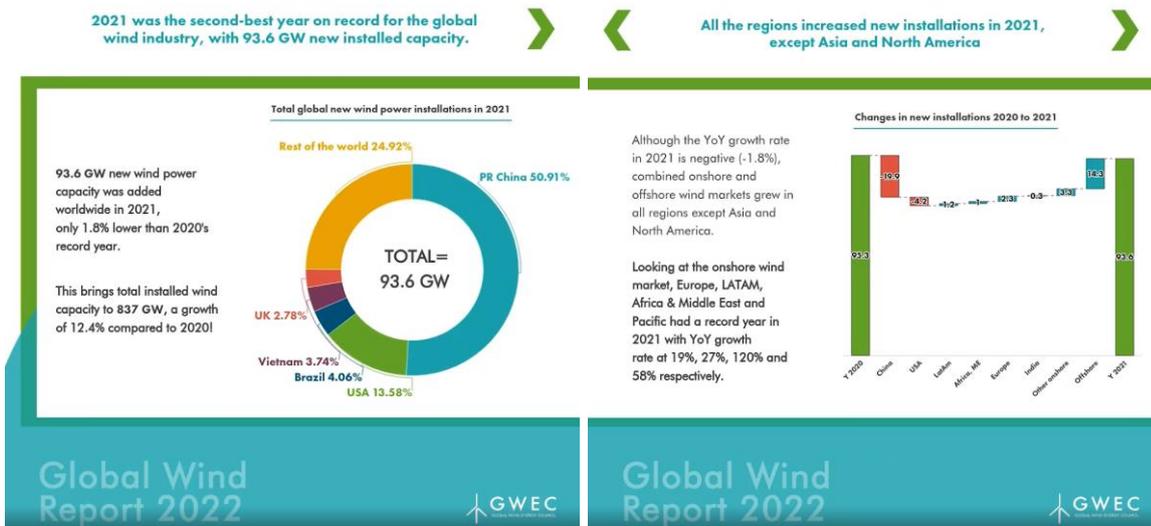
*This section considers news items that have arisen within the news cycle of this **Edition 39** of Low Carbon Pulse relating to the development of wind power generation capacity, on-shore and off-shore (fixed bottom and floating).*

- **Lithuania moves to off-shore:** On **April 1, 2022**, it was reported widely that on **March 31, 2021**, the **Lithuanian Parliament (Seimas)** had approved laws to allow the development of the off-shore wind field capacity in the **Lithuanian sector** of the **Baltic Sea**. The laws will enter into force on signature of the President. As reported, the first off-shore wind field progress to development during Q3 of 2023, and is to have **700 MW** of installed capacity, with first electrical energy in **2028**.
- **Australia's first off-shore wind project starts heavy lifting:** On **April 1, 2022**, it was reported widely that the developers of the **2.2 GW Star of the South** Project, off the coast of **Victoria, Australia**, were progressing to undertake detailed ground investigations (with work starting on April 4, 2022) along the route of the on-shore transmission route. See **Editions 13, 14, 16** and **31** for earlier reports on the **Star of the South**.
- **GWEC – Global Wind Report:** On **April 4, 2022**, the **Global Wind Energy Council (GWC)** released the [Global Wind Report 2022](#).

The headlines from the Report are:

- The global wind industry had its second-best year in 2021, with almost 94 GW of capacity added globally, trailing behind the 2020's record growth by only 1.8%.
- Europe, Latin America and Africa & Middle East had record years for new onshore installations, but total onshore wind installations in 2021 were 18% lower than the previous year. The decline was driven primarily by the slow-down of onshore wind growth in the world's two largest wind power markets, China and the US.

- 21.1 GW of offshore wind capacity was commissioned last year, three times more than in 2020. making 2021 the best year in offshore wind history, bringing its market share in global new installations to 22.5% in 2021.
- China made up 80% of offshore wind capacity added worldwide in 2021, bringing its cumulative offshore wind installations to 27.7 GW. This is an astounding level of growth, as it took three decades for Europe to bring its total offshore wind capacity to a similar level.
- Total global wind power capacity is now up to 837 GW, helping the world avoid over 1.2 billion tonnes of **CO₂** annually – equivalent to the annual carbon emissions of South America.
- Wind auction activities bounced back in 2021 with more than 88 GW of wind capacity awarded globally, 153% higher than in 2020.
- After a year in which net zero commitments gathered global momentum, coupled with renewed urgency for achieving energy security, the market outlook for the global wind industry looks even more positive. 557 GW of new capacity is expected to be added in the next five years under current policies. That is more than 110 GW of new installations each year until 2026.
- However, this growth needs to quadruple by the end of the decade if the world is to stay on-course for a **1.5°C** pathway and net zero by 2050.



By way of reminder: Edition 37 of Low Carbon Pulse (under **Global Wind Energy Council (GWEC) highlights five countries**) reported as follows: "On **March 11, 2022**, the **GWEC** published **Floating Offshore Wind – a Global Opportunity** identifying five countries as comprising the chasing pack (in the sense of chasing to catch France, Japan, **ROK** and the UK), Ireland, Italy, Morocco, the Philippines and the US, being five countries that are likely to spearhead the next wave of floating off-shore wind field developments".

- **Eni and CIP JV proceeds to floating off-shore:** On **April 6, 2022**, it was reported widely that **Plentitude** (a joint venture between **Eni SpA, CDP Equity** and a fund managed by **Copenhagen Infrastructure Partners**) was to proceed to develop **two floating off-shore wind fields** off the coast **Marsala, Italy**, in combination the two off-shore wind fields will comprise **750 MW** of installed capacity. This continues the on-going progress of the development

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

By way of more recent reminder: Edition 37 of Low Carbon Pulse reported on **BlueFloat** and **Falck Renewables** as follows:

- **Orda Energia Concession Granted:** On **March 8, 2022**, it was reported widely 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.

As will be apparent from the below, this is the fifth off-shore wind field development of BlueFloat Energy and Falck Renewables in off-shore Italy.

- **By way of reminder:** Previous editions of Low Carbon Pulse have reported on the plans of BlueFloat (leading renewable energy corporation) and Falck Renewables to develop off-shore wind field capacity off the coast of Italy as follows:

- **Edition 29** reported that the first project between Falck and BlueFloat was the 1.2 GW OWF project off Brindisi (Kailia Energia Project), with projected annual generation dispatch of up to 3.5 TWh.

On October 26, 2021, it was reported widely that the joint venturers are not seeking a permit in respect of a further 1.3 GW of OWF projects off the southern coast of the province of Lecce. For the projects to proceed, authorisations will have to be obtained from the Ministero per la Transizione Ecologica and maritime concessions granted by the Ministero delle Infrastrutture and the Port Authority of the Southern Adriatic Sea.

- **Edition 28** of Low Carbon Pulse reported that Falck Renewables (leading Italian renewable energy developer) and BlueFloat Energy (leading off-shore wind developer) 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.

- **Current projects progressing:** By the reckoning of the author, the following off-shore wind field progress are progressing: 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 of Brindisi.

- **Floating off-shore hydrogen production facility:** On **April 7, 2022**, [pv-magazine.com](https://www.pv-magazine.com) reported (under **Renewable offshore floating hydrogen production**) that **Scottish Development International** and **J-DeEP** (Japan Offshore Design and Engineering Platform Technology Research Association) plan to develop a **floating off-shore Green Hydrogen production facility** off the coast of Scotland.

For these purposes, **ClassNK** (ship classification society) had issued an approval in principle (**AiP**) for a floating off-shore hydrogen production facility. The hydrogen production facility will be powered by renewable electrical energy arising as surplus electrical energy from off-shore wind fields, and will use desalinated sea-water as feedstock for the electrolysers.

- **Equinor unveils USD 23 billion plans:** On **April 22, 2022**, [maritime-executive.com](https://www.maritime-executive.com) reported that **Equinor** (leading global international energy corporation) intends to invest **USD 23 billion** in off-shore wind projects in the near term (over the next five years), with the intention of having **16 GW** of installed off-shore wind field capacity by 2030.

- **Iberdrola approval for next phase of USD 4 billion project:** On **April 25, 2022**, [rechargenews.com](https://www.rechargenews.com) reported that **Iberdrola** (leading global international energy corporation, and renewable energy giant) had received approval from the **Federal German Government** authorities to develop the second of three off-shore wind field projects in the **German sector** of the **Baltic Sea**. The Federal German **Maritime and Hydrographic Agency** approved the development of the **476 MW Bald Eagle project**.

- **Dutch continuing to double-up:**

- On **April 13, 2022**, it was reported widely that the ruling political parties in the Netherlands (WD and D66) want the Netherlands to more than double its goal for the production of **Green Hydrogen**.

In the **2019 National Climate Agreement of the Netherlands**, the commitment was to establish **4 GW** of **Green Hydrogen** production capacity by 2030, the **increase to 8 GW** would go hand in hand with the planned increase scaling up of off-shore wind field capacity.

The sentiment to double Green Hydrogen production capacity is entirely consistent with the news items reported in **Edition 37** of Low Carbon Pulse (under **Double Dutch**) as follows: "The Dutch Government had doubled its forecasts for off-shore wind field capacity: an additional 10.7 GW of off-shore wind field capacity is to be installed, doubling current planned capacity, to 21 GW of installed capacity by 2030".

- **Edition 37** of Low Carbon Pulse 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 Hollandse 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".

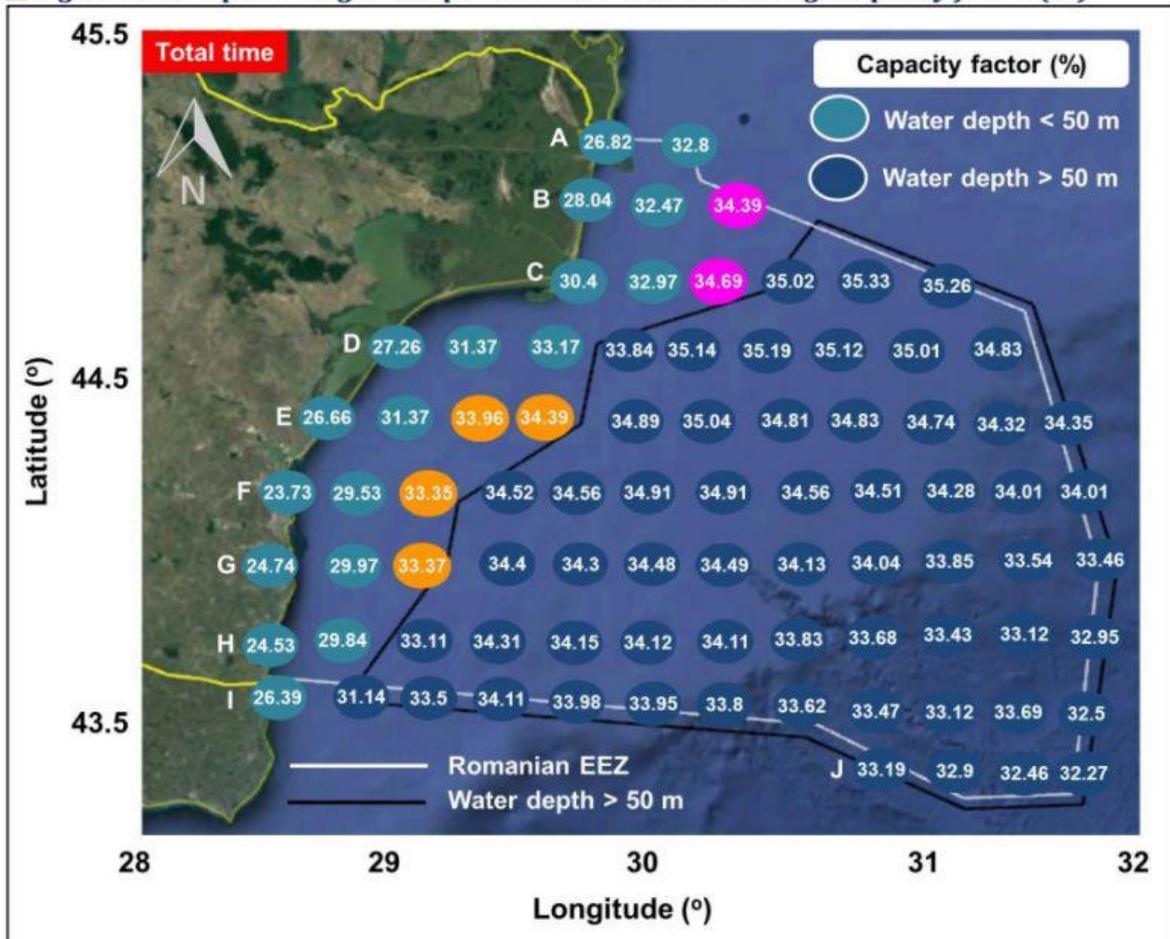
The **auction** for the **two licenses** opened on **April 12, 2022** and will close on **May 12, 2022**. There have been many news items reporting on the level of interest in the licensing, including on the likely bidders and bidding combinations. **Edition 40** of Low Carbon Pulse will report on the outcome of the licensing.

- **Enefit Green progress in Estonia:** On **April 29, 2022**, [offshorewind.biz](https://www.offshorewind.biz) reported on the progress being made towards the development of the **1.1 GW Hiiu** (or **Loode-Eesti**) off-shore wind field development to be located 12 kms north of the second largest island in the Estonia sector of the Baltic Sea (**Hiiumaa**).

For regular readers of Low Carbon Pulse, this project will not ring any bells, because it has been a project that has taken time to develop, and will continue to take time to develop, with construction by 2030. The author has been following the project for over 10 years. Recent developments in progress towards the realisation of the project are significant, including the environmental impact survey being close to finalisation, and the appointment of Ramboll to undertake preliminary design work.

- **Black Sea off-shore wind field development:** On **April 29** and **30, 2022**, it was reported widely that the Bulgaria and Romania intend to develop jointly off-shore wind fields in the Black Sea. The following map provides an indication of the prospective scope of the development:

Figure 6. Most promising development areas based on average capacity factor (%)



Source: EPG assessment

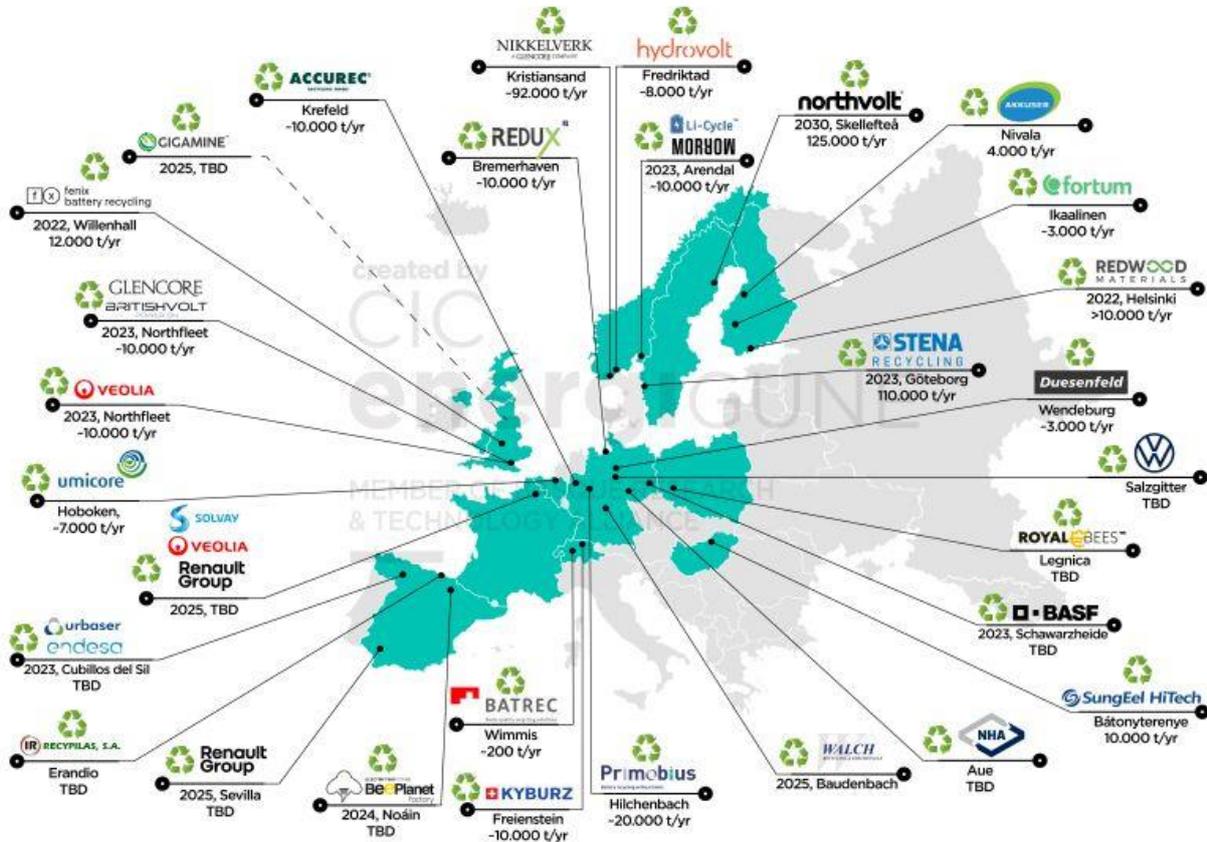
Solar and Sustainability (including NZE Waste):

This section considers news items that have arisen within the news cycle of this **Edition 39** 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**.

- **Second life and recycling:** On **April 7, 2022**, **CIC energiGUNE** published a map-graphic (entitled [Second Life and Recycling – Companies in Europe](#)) providing a snap shot of the battery recycling plants across Europe and the UK. As ever, thanks to the good folk at **CIC energiGUNE**.

SECOND LIFE & RECYCLING COMPANIES IN EUROPE

by CIC energIGUNE
MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE



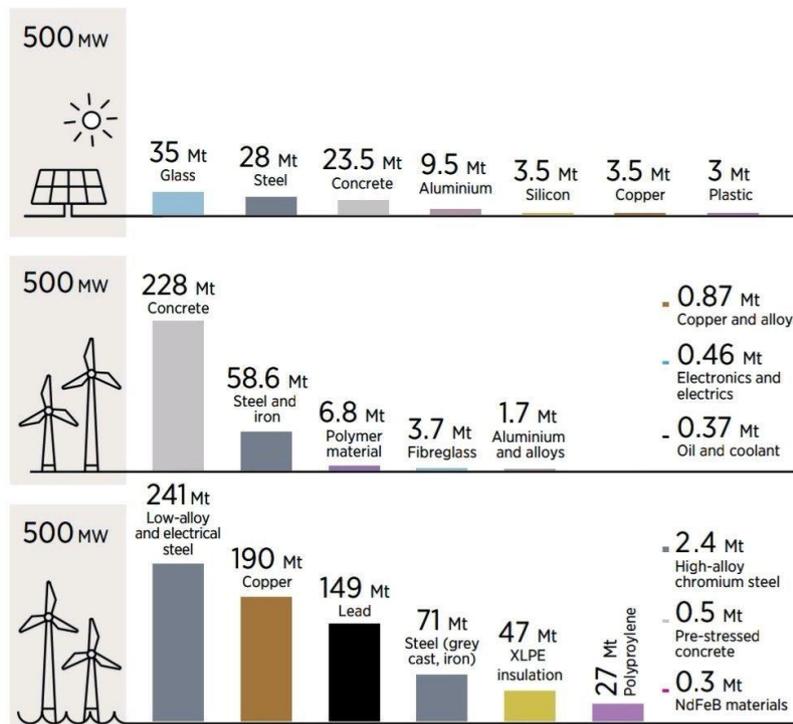
Source: Own elaboration from public information

- **ENEOS and TotalEnergies aligned:** On April 13, 2022, it was reported widely that **ENEOS** (leading hydrocarbon importer and refiner in Japan) and **TotalEnergies** (leading global energy corporation) had established a **50:50 joint venture** to develop up to **2 GW** of decentralised photovoltaic solar capacity over the next five years. It is contemplated that the joint venture will contract business-to-business for the supply of renewable electrical energy (principally to commercial and industrial customers).
- **Chile tenders nearly 2,800 hectares:** On April 14, 2022, pv-magazine.com reported that Chile's **Ministry of National Property** announced a tender for nearly **2,800 hectares** of land located in the **Commune of Santa Elena**, 27.5 km northwest of **Quillagua**, in the **Antofagasta** region of **Chile**. Those interested in tendering for the land must do so by May 25, 2022. The land must be used to develop large-scale renewable energy generation capacity.
- **Gemini Project closes:** On April 26, 2022, rechargenews.com reported on financial close of the US's largest-ever photovoltaic solar-plus **BESS** project (the **Gemini Project**): the **Gemini Project** comprises **690 MW** of photovoltaic solar and **380 MW / 1,417 MWh** of **BESS**.

Primergy Solar (leading renewable electrical energy project developer) and **Quinbrook Infrastructure Partners** (leading infrastructure investor, headquartered in Australia) are reported to have closed the **USD 1.9 billion** construction debt (circa **USD 1.3 billion** in debt) and tax equity financing for the **Gemini Project** to be located in the **Mojave Desert, Nevada**.

The four coordinating lead-arrangers are **Bank of America**, **KeyBanc Capital Markets**, **MUFG Bank** and **Norddeutsche Landesbank Girozentrale**. It is reported that **Bank of America** and **Truist Bank** provided **USD 532 million** in tax equity financing, believed to be the largest tax equity financing for a photovoltaic solar project in the US.

- **JERA to deploy 1 GW of photovoltaic solar:** On April 27, 2022, rechargenews.com reported that it intends to develop and to deploy up to **1 GW** of photovoltaic solar by 2025 to provide electrical energy to **JERA's** domestic market.
- **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. A future standalone article from the author of Low Carbon Pulse will consider all aspects of the recycling industry.



- **Recycling in the shipping to steel industry:** On **April 7, 2022**, **A.P. Moller – Maersk** announced that it had joined **SteelZero**, a global initiative that brings together leading organisations to accelerate transition to a net-zero steel industry in partnership with **ResponsibleSteel**. The basis for the initiative is clear: "Global ship recycling volumes are projected to double by 2023, and quadruple by 2033. Recycled steel will be recognised progressively as a viable raw material for steel consumers with net-zero emission targets".
- **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](#).

As the **MENACW 2022** report on outcomes is published, a future edition of Low Carbon Pulse will report on them.

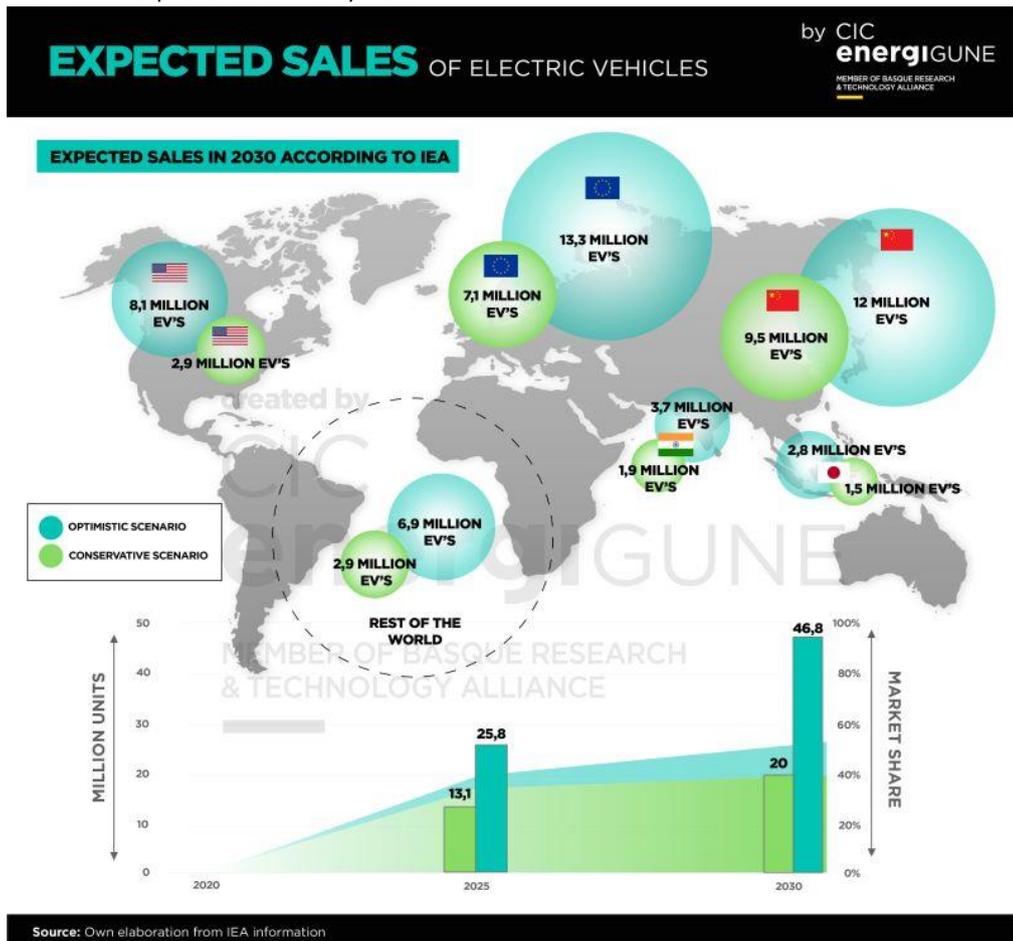
Land Mobility / Transport:

*This section considers news items that have arisen within the news cycle of this **Edition 39** 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:**
 - **Solaris Bus & Coach continues its roll:** During **April 2022**, **Solaris Bus** and **Coach** continued to agree sales of its **Solaris Urbino** electric bus with the following sales: **12** electric buses to **JGSP Novi Sud** (Serbian bus operator), and accompanying supply of electric charging infrastructure; **17** electric buses to **MZK Grudziądz** (Polish bus operator in the City of Grudziądz); **10** hydrogen buses (Urbino) are to mobilised for use by two operators (five to each), **Busreisen Ettenhuber GmbH** and **Martin Geldhauser GmbH & Co. KG**.
 - **NY School Buses electric by 2035:** On **April 8, 2022**, it was reported widely that **Governor Ms Kathy Hochul** is to propose legislation to require 100% of all school buses to be electric by 2035 in the State of New York.
 - **Spain's hydrogen fuel celled buses:** On **April 8, 2022**, it was reported widely that **Transports Metropolitanas de Barcelona (TMB)** begun operating a **CaetaniBus** powered and propelled by fuel cell technology. In addition, it is understood that another seven **CaetaniBuses** will enter into service by the end of 2022. The hydrogen to fuel the fuel cell buses is to be supplied by **Iberdrola** (Spanish renewable energy company).

- **German operator receives grant funding:** On **April 11, 2022**, fuelcellbuses.eu reported (under [RVK received grant of 108 hydrogen-powered fuel cell hybrid buses](#)) that a German public transport operator, **Regionalverkehr Köln GmbH (RVK)**, is to receive funding support from the German Federal Government Ministry of Digital Affairs and Transport. The funding support will allow the mobilisation of 108 hydrogen-powered and propelled buses, which will be added to the **RVK** fleet by 2024.
RVK provides public transport services in the areas surrounding Bonn and Cologne. The 108 buses will comprise 79 individual buses in the first procurement phase (with the first 20 buses on target for delivery in December 2022), and 29 articulated buses in the second phase.
- **BEV Bus Depot:** On **April 13, 2022**, the **Government of Queensland**, Australia, [announced](#) (under [A one-way ticket to low-emissions public transport](#)) that **Australia's first 100%** electric bus depot was now open, and would be providing battery charging for **30 electric buses**.
[Note: The author recognises that there have been other news items in respect of the mobilisation of buses and coaches, and that as such this news items included is a representative sample]
- **Cars (including taxis and air-taxis):**
 - **Airborne taxis and airports:**
The author is still working out whether to include new items about air-taxis in this section or in the **Airports and Aviation** section (of Low Carbon Pulse). For the time being, the author has decided to leave in this section. Since the start of 2022, the number of news items on air taxis has increased, and April 2022 saw an increase in the level of coverage. The author has chosen two articles from April that illustrate the progress being made:
 - **Hyundai plans hydrogen powered and propelled air taxis:** On **April 1, 2021**, it was reported widely that **Hyundai** is progressing with plans to develop and to deploy air-taxi by 2030 – using advanced air mobility technology, and having established an **Advanced Air Mobility Unit** to develop the **eSTOL** aircraft.
 - **AFC Energy fuels cells showcased:** On **April 29, 2021**, hydrogen-central.com reported (under [AFC Energy Hydrogen Fuel Cell to be Showcased at Flying Taxi Airport](#)) that "one of the hydrogen batteries" of **AFC Energy PLC (AFC Energy)** "will be used to charge Air One's fleet of electric vehicles" based at "the flying taxi airport that opened in Coventry" during April 2022. The flying taxi airport is the location of the world's first fully operational hub for electric airborne vehicles (the **Urban-Air Port**).
 - **Paris electrolysis:**
 - **Edition 4** of Low Carbon Pulse reported that: "In Paris, over 500 fuel cell electric vehicles (**FCEV**) provide taxi services, using hydrogen supplied by **Air Liquide** via 4 hydrogen re-fuelling stations (**HRS**). On November 11, 2020, the **European Network of Transmission System Operators for Electricity (ENTSO-E)**, announced a proposal to develop **10** hydrogen storage facilities at locations around Paris. The proposed €1 billion project would provide total storage for up to 11 GWh of hydrogen. As a result of the project, Parisian transport company, **Societe du Taxi Electrique Parisian**, estimates that **50,000** taxis could provide taxi services using **FCEV** technology. The Paris **HRS** project is one of 25 energy storage projects and schemes identified by **ENTSO-E** across the **EU**".
 - On **April 4, 2022**, **Cummins Inc.** announced that its affiliate, **Hydrogenics Europe N.V.**, had signed a contract to supply a **2.5 MW** electrolyser to **Hysetco** (a mobility corporation owned by **Air Liquide, Korous, TotalEnergies** and **Toyota**) to allow production of hydrogen in **Paris, France**. The **hydrogen** will be **delivered** to **12** sites with hydrogen refuelling infrastructure. The electrolyser is a 2.5 MW HyLYZER®-500 PEM, capable of producing 380 metric tonnes of hydrogen a year.
 - On **April 25, 2022**, euractiv.com published an article (under the excellent title, **Fleets of hydrogen taxis are picking up across Europe**) focussing on the activity in France, both policy setting and private sector progress. It is noted in the article that hydrogen is an ideal source for "random intensive uses like taxis". The article notes that France has introduced a law mandating the procurement and use of low-emission vehicles (whether **BEV** or **FCEV**). Also the article mentions that **EU** initiatives are supporting initiatives across Europe, including initiatives resulting in the progress that has been made with the **ZEFER** project (see below under **Hike in taxi plans**).
 - **BMW Group to use cast aluminium wheels:** On **April 11, 2022**, it was reported the **BMW Group** is to use cast aluminium wheels cast and manufactured using renewable electrical energy for its **BMW** and **MINI** brands starting in 2024.
 - **Hike in taxi plans:** On **April 21, 2022**, [zefer](https://zefer.com) reported that two pan-European projects have worked together to bring zero-emission hydrogen taxis and hydrogen refuelling infrastructure to the **Copenhagen**. The two pan-European projects are: **ZEFER** (Zero Emission taxi Fleets for European Rollout) and **H2ME2** (Hydrogen Mobility Europe), funded by the **EU** Clean Hydrogen Partnership, and they have mobilised **100** zero emission taxis.
- **Fuel Cell and Battery Supply and Technology:**
During **April 2022**, the author had not come across any news items that may be regarded as material or significant in the area of fuel cell and battery supply and technology. Then on **April 30, 2022**, it was reported widely that **Stellantis** (an automotive manufacturing corporation, and see [Edition 37](#) of Low Carbon Pulse) planned to invest **€30 billion** by the end of 2025 to support electrification and software strategies. The statement from Stellantis is well-worth a read.
- **Industrial Vehicles and Trucks:**
 - **Wholesale switches:**
 - On **April 2, 2022**, it was reported widely that **Lidl** (retail giant) is transitioning its entire battery electric fleet (used in its logistics centres) to fuel cell technology, using Green Hydrogen.
 - On **April 20, 2022**, **Plug Power** announced that it had agreed with **Walmart** to supply Green Hydrogen (in liquid form) to power and to propel material handling lift trucks across the **Walmart distribution and fulfilment centers** in the US.

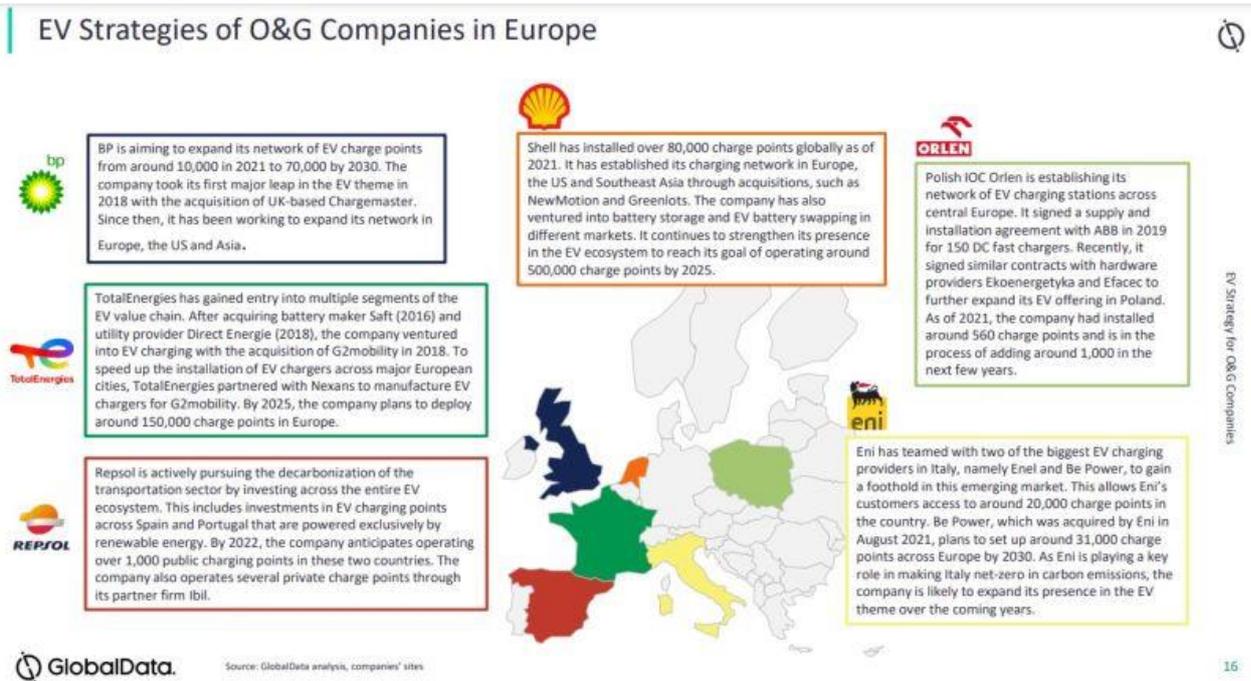
- Scania and Cummins aligned:** On **April 8, 2022**, it was announced that **Scania** (Swedish manufacturer of commercial heavy vehicles) is working with **Cummins, Inc** (leading primary mover manufacturer and electrical generator technology corporation) to develop 20 fuel cell electrical trucks to be fuelled by Green Hydrogen (for the **HyTruck Project**).
Scania (part of the Volkswagen Audi Group) will manufacture the trucks, and Cummins will supply and install the fuel cells. The trucks will be delivered to **Air Liquide** and the **Port of Rotterdam Authority (PORA)** for deployment and use as part of the **HyTrucks Project** undertaken jointly by **Air Liquide** and **PORA**.
By way of reminder: Edition **18** of Low Carbon Pulse outlined the **HyTruck Project** as follows: "The **HyTruck Project** involves putting 1,000 hydrogen-powered trucks on the roads of Belgium, western Germany and the Netherlands.
 (Edition **5** of Low Carbon Pulse, reporting on European Hydrogen Week, noted the broader initiative to deploy 100,000 hydrogen-powered trucks and 1,000 hydrogen refuelling stations.)
- Edmonton International Airport to convert to hydrogen:** On **April 27, 2022**, flyeia.com reported **Edmonton International Airport** was to participate in the **VEXSL Hydrogen Project** using **Hydra Energy's** retrofit solution and technology to convert trucks powered and propelled by diesel power plants to co-combust with hydrogen.
- On EVs expected by 2030:** On **April 14, 2022**, the good folk at **CIC energigUNE** published the following infographic estimated expected sale EVs by 2030.



- Recharging and refuelling infrastructure:**

- Eni and Linde aligned:** On **April 15, 2022**, it was reported widely that **Eni** (leading international energy corporation) has opened the first hydrogen refuelling station in **Venice, Italy**, with equipment and infrastructure supplied and installed by **Linde** (on the Big Three industrial gas giants).
- Ever active Everfuel:**
 - Everfuel to develop heavy-duty hydrogen station in Germany:** On **April 8, 2022**, it was reported widely that **Everfuel GmbH** had been awarded the contract to develop and to deploy hydrogen refuelling infrastructure (including stations) to serve a fleet of fuel cell buses. The contract was awarded following a Europe wide procurement process involving an open tender. The contract is between **Everfuel GmbH** and **WSW mobil GmbH**. WSW mobil GmbH is one of the pioneers in the deployment of fuel cell buses in public transport in Germany (and Europe for that matter).
 - Everfuel to develop largest HRS in Denmark:** On **April 21, 2022**, Everfuel [announced](#) that, with Taulov Dry Port, it was to expand the green logistics hub at Fredericia to establish the largest hydrogen refuelling station in Denmark.
- Electric Charging Ahead:** On **April 27, 2022**, the following infographic was published summarising progress made by major oil and gas corporations in the development and deployment of electrical charging / recharging

infrastructure across Europe. The infographic illustrates the criticality of oil and gas corporations to energy transition.



The infographic illustrates the rate of progress being made, both in terms of the number of charging points and their geographical spread.

- **BP and VW launch strategic roll-out:** On **April 28, 2022**, **BP** and **Volkswagen Group** announced (click [here](#) for bp's press release; click [here](#) for Volkswagen's press release) that they are to work together to boost the use of electric vehicles (**EVs**) across Europe, and to mark this opened the first EV charging station in Dusseldorf, Germany.
- **On BEVs and battery manufacturers:** On **April 13, 2022**, the good folk at **CIC energigune** published an excellent article, [Major Automakers Behind Giga-factory Projects](#). The article is well-worth a read. The article contains a great infographic providing an overview of who is who, with the [attached link](#) connecting to it.
- **Trains:**
To manage the length of this **Edition 39** of Low Carbon Pulse, **Edition 40** of Low Carbon Pulse will include two months' of new items on trains.

Ports Progress and Shipping Forecast:

*This section considers news items that have arisen within the news cycle of this **Edition 39** 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:**
 - **Electric on blue:** On **April 1, 2022**, [Norwegian Ship Design](#) reported **Cemre Shipyard** and **Torghatten Nord** As had entered into a contract to build a new ferry for the Bognes – Lødingen route, in northern Norway. The new ferry will be powered and propelled by battery technology, and is configured as a double-ended car and passenger ferry (each end having its own power and propulsion with system), with capacity for 399 passengers. The new ferry will have back-up bio-diesel power and propulsion.
 - **Training dressed in blue:** On **April 6, 2022**, it was reported widely that a training vessel, **Ab-Initio**, is in development by **Concordia Damen** and **STC Group**. The **Ab Initio** is a 67 metre training vessel, powered and propelled by hydrogen fuel cell technology, and it to be used to train maritime professional in the navigation and operation of fuel cell technology vessels.
 - **Sea Change edging closer to the water:** On **April 21, 2022**, it was reported widely that the launch of the **Sea Change** was ever closer, with a launch date of mid-May 2022 reported.
By way of reminder:
Editions 19 and **26** of Low Carbon Pulse reported on the development and prospective deployment, and testing, of the hydrogen powered and propelled ferry in San Francisco Bay Area - the Sea Change.
Edition 32 of Low Carbon Pulse reported that Switch Maritime was commissioning and undertaking trials of the ferry, that refuelling had been undertaken successfully.

Also it was reported that BAE Systems was the supplier of the propulsion system for the Sea Change. Further, it was reported that the fuel cell technology for Sea Change is supplied by Zero Emission Industries, and the BAE propulsion system will interface with the fuel cell technology, providing an all-electric powered and propelled vessel.

- **Green Ports:**

HyTransPortRTM get first customer: On **April 14, 2022**, it was reported widely that **Shell** is the first customer for the **hydrogen transportation pipeline** in the **Port of Rotterdam** – the **HyTransPortRTM**. **Shell** is developing a **Green Hydrogen production facility** at the **Conversion Park, Maavlakte** (see [Edition 27](#) of Low Carbon Pulse for the most recent coverage), with the Green Hydrogen will be transported through the **HyTransPortRTM** to allow the delivery of Green Hydrogen into the national and international networks to deliver Green Hydrogen to customers.

- **Green Corridors:**

- **Australia to East Asia Green Corridor LoI:** On **April 6, 2022**, it was reported widely that a letter of intent had been signed by **BHP, Rio Tinto, Oldendorff Carriers** and **Star Bulk Carriers Corp** to assess the development of a Green Corridor between Australia and East Asia, with the assessment being led by the **Global Maritime Forum**.

By way of a reminder:

- **Edition 19** of Low Carbon Pulse included the following narrative, providing the broader context of the **Global Maritime Forum** and **Green Corridors**.

"In the world of hydrogen, cooperation is key: As part of **MI 2.0**, on June 2, 2021, the **Zero-Emission Shipping Mission (ZESM)** was outlined. The **ZESM** is intended to accelerate international public-private collaboration to scale-up and to deploy new green maritime solutions. The Governments of Denmark, Norway and the US are to lead the **ZESM**, working with the **Global Maritime Forum**, and the Maersk McKinney Møller Center for Zero Carbon Shipping (see [Edition 16](#) of Low Carbon Pulse). The roles of Denmark, Norway and the US are key, both as shipping nations, and as countries that offer fertile ground for technological innovation. US Secretary of Energy, Ms Jennifer Granholm stated: "Through fearless technological innovation, ambitious clean energy deployments, and constructive international collaboration, we can build a net-zero carbon economy ...".

Goals of **ZESM**: The **ZESM** has three principal goals:

- 1.** to develop, demonstrate and deploy zero-emission fuels, ships and fuel infrastructure in a coordinated fashion along the full value chain;

- 2.** by 2030, to have developed ships capable of running on hydrogen-based fuels (being zero-emission fuels) – such as Green Hydrogen, green ammonia, green methanol, and advanced biofuels – that make up at least 5% of the global deep-sea fleet, measured by fuel consumption; and

- 3.** by 2030, to have at least 200 of these "well-to-wake" zero-emission fuelled ships in service and utilizing these fuels across their main deep-sea shipping routes.

Global Maritime Forum: Managing Director of **Global Maritime Forum**, Ms Johannah Christensen (noting that the role of the **Global Maritime Forum** is key to the **ZESM**) said: "*Shipping is on the verge of a clean energy revolution. To set the global maritime industry on a climate-aligned course and meet the goals of the Paris Agreement, zero-emission vessels need to be the dominant and competitive choice by the end of the [current] decade. The Zero Emission Shipping Mission will accelerate public and private efforts around the world to make a zero-emissions fleet a reality by 2030*".

Global Hydrogen Ports Coalition launched: Finally, also on June 2, 2021, at the **Innovating to Net Zero Summit** in Santiago, Chile, the Global Hydrogen Ports Coalition was launched. An industry, headed to hydrogen based fuels.

- **Edition 30, Clydebank Declaration:** On November 10, 2021, the [Clydebank Declaration](#) was agreed at **COP-26**. The **Clydebank Declaration** emphasises the importance of limiting "the increase in global average temperature to **1.5°C** above pre-industrial levels", expressed great concern that if "no further action is taken, international shipping emissions are expected to represent 90% to 130% of 2008 emissions levels by 2050", and recognised that "a rapid transition in the coming decade to clean maritime fuels, zero-emission vessels, alternative propulsion systems, and the global availability of landside infrastructure to support these, is imperative for the transition to clean shipping". In addition the signatories to the **Clydebank Declaration** commit to facilitate the development of **Green Corridors**, with at least six **Green Corridors** by "the middle of this decade ... [and] many more corridors ... by 2030". A **Green Corridor** is a route between two or more ports that are "zero-emission maritime routes".

The signatories to the **Clydebank Declaration** are: Australia, Belgium, Canada, Chile, Denmark, Fiji, Finland, France, Germany, Republic of Ireland, Italy, Japan, Republic of the Marshall Islands, Morocco, the Netherlands, Norway, Spain, Sweden the UK, and the US".

- **Chilean Green Corridors Network:** On **April 14, 2022**, **Maersk McKinney Møller Center for Zero Carbon Shipping** [announced](#) that it had signed a formal agreement with the **Ministerio de Energía Chile** (Ministry of Energy In Chile) to establish a network of Green Corridors allowing for green maritime transportation of goods in and out of **Chile**. **Chile** was among the first countries to sign the **Clydebank Declaration**.

Maersk McKinney Møller Center for Zero Carbon Shipping is to undertake and to complete by the end of 2022 the assessment and mapping of the most promising Green Corridors, and will route the way for the development of **Green Corridors** identified.

- **Green Shipping:**

- **The World Bank values carbon:** On **April 1, 2022**, **The World Bank** published [Carbon Revenues from International Shipping: Enabling an Effective and Equitable Energy Transition-Technical Paper](#).

The **Technical Paper** asks and answers the following **four questions**, the **first question setting-up questions 2, 3 and 4**.

- 1. Question:** Why a technical paper on the use, recipients, and management of, carbon revenues from shipping?
Answer: Because it is likely that revenue will arise from policy settings intended to decarbonise the International Shipping industry. See **Editions 19** and **27** of Low Carbon Pulse.
- 2. Question:** What could carbon revenues from International Shipping be used for?
Answer: This question is answer fully, and summarise in the following table:

TABLE 1: REVENUE USES, THEIR POTENTIAL ALIGNMENT WITH THE INITIAL IMO GHG STRATEGY AND OTHER SELECTED DESIRABLE KEY FEATURES

CRITERIA		① FINANCING IN-SECTOR CLIMATE CHANGE MITIGATION	② ENHANCING MARITIME INFRASTRUCTURE AND CAPACITY	③ FINANCING BROADER CLIMATE AIMS	④ FINANCING BROADER DEVELOPMENT AIMS	⑤ FINANCING THE GENERAL BUDGET	⑥ COVERING ADMINISTRATIVE AND ENFORCEMENT COSTS	⑦ IMPLEMENTING A REVENUE-NEUTRAL FEE/BATE
Potential Alignment with the Initial IMO GHG Strategy Principles	Narrow CBDR-RC*	Green	Amber	Green	Amber	Red	Green	Red
	Broad CBDR-RC*	Green	Green	Green	Amber	Green	Green	Red
	Avoiding DNI	Green	Green	Red	Red	Red	Amber	Red
	Remedying DNI	Green	Green	Green	Green	Green	Green	Red
	Polluter Pays	Green	Amber	Green	Amber	Red	Green	Red
	Highest Possible Ambition	Green	Amber	Green	Amber	Red	Green	Amber
Selected Desirable Key Features	Potential Climate Benefits**	Green	Amber	Green	Amber	Red	Green	Amber
	Potential Development Benefits**	Green	Green	Green	Green	Amber	Green	Amber
	No Need for Active Management	Red	Red	Red	Red	Red	Amber	Green
	Political Feasibility – Industry Perspective	Green	Green	Amber	Red	Red	Amber	Green
	"Unique value proposition"	Opportunity to lower the carbon price level needed to decarbonize shipping	Extension of the options to address DNI through sector-specific but not necessarily climate-related financing	Highest potential climate benefits	Highest potential development benefits	Greatest flexibility for recipient countries to use carbon revenues	Instrumental for proper functioning of carbon pricing instrument	Only option that does not require active management of revenues

* "Broad CBDR-RC" is understood as encompassing "narrow CBDR-RC". Thus, any carbon revenue use that satisfies the latter appears also aligned with the former.

** Note: The results presented in this table describe the potential of each revenue use option to deliver climate and development benefits and align with the Initial IMO GHG Strategy under the assumption that carbon revenues are adequately spent (e.g., corruption and poor governance do not lead to carbon revenue misuse).

Under a Red-Amber-Green (RAG) matrix, options are marked, with green indicating a more positive evaluation, red a less positive evaluation, and amber an evaluation between green and red. Green = highly aligned | Amber = partially aligned | Red = less aligned.

Source: [Carbon Revenues from International Shipping: Enabling an Effective and Equitable Energy Transition- Technical Paper](#)

3. Question: Who could be the recipients of carbon revenues from International Shipping?

Answer: Three groups of potential recipients are identified: **1.** Governments, **2.** The shipping industry, and **3.** The private sector in a broader sense. The basis of distribution of carbon revenues are stated to be best determined applying the following principles: achieving maximum climate and development outcomes, supporting an equitable transition, and ensuring an adequate function of the medium terms measure and distribution of revenues.

4. Question: How could adequate governance and management of carbon revenues from International Shipping be implemented?

Answer: This question is considered as follows: **1.** Whether revenues should be disbursed by an existing fund or a new fund; **2.** The role of the IMO in the governance of carbon revenues from shipping; **3.** How to address challenges of managing carbon revenues; **4.** If a new fund is established, how to select revenue distribution criteria, and **5.** How to ensure that no country is left behind in the distribution of carbon revenues.

The author is chosen not to seek to summarise the answers, they are nuanced. The **Technical Paper** is well-worth a read, both for specific consideration of the International Shipping industry, in the context of policy settings generally.

- **Bulk: Cement and Grain: Edition 20** of Low Carbon Pulse reported on the development of a bulk carrier to transport cement for **HeidelbergCement** and grain for **Felleskjøpet AGRI**. **Egil Ulvan Rederi AS** is to build the bulk carrier.

On **April 5, 2022**, it was announced by **HeidelbergCement** and **Felleskjøpet AGRI** that **ENOVA** (Norwegian government enterprise owned by the Ministry of Climate and Environment) had provided funding support for these purposes. (see ENOVA [press release](#)): this means that Egil Ulvan Rederi will build the zero-emission cargo ship **With Orca**. A cargo ship that will sail under a long-term contract for HeidelbergCement and Felleskjøpet Agri, and is scheduled to be put into operation in 2024.

In addition to the funding support for the build of the bulk carrier, **ENOVA** has provided support for the development and deployment of the bunkering solution and technology provided by **Statkraft** and **Skagerak Energi** (hydrogen will be stored in compressed form in replaceable containers, with bunkering taking place by lifting empty containers off the ship, and replacing them with containers full of compressed hydrogen).

By way of reminder: Edition 37 of Low Carbon Pulse reported that "**Egil Ulvan Rederi AS** had received Approval in Principle (**AiP**) from Lloyds Register for its zero-emission self-discharging hydrogen-fuelled bulk carrier – the **With Orca**. The **With Orca** is designed by **Norwegian Ship Design**."

As reported, the **With Orca** will be powered and propelled by hydrogen, with propulsion and energy capture provided by two rotor sails as well as hydrogen. The hydrogen will be stored in the **With Orca** in compressed form and a hydrogen combustion engine for use in higher load conditions, and a fuel cell electric system for use in lower load conditions. The hydrogen is to be supplied by Statkraft (global leader in hydropower and Europe's largest generator of renewable electrical energy)".

- **Nordic Roadmap being developed:** On **April 7, 2022**, **DNV** (global leading advisor for the maritime industry) [announced](#) that it had been appointed by the **Norwegian Ministry of Climate and Environment** to develop a roadmap for the introduction of **sustainable zero-carbon fuels** across the Nordic region (the **Nordic Roadmap**), with the focus being the **sustainable zero-carbon fuels** from "**Well-to-Wake**". **DNV** will work with **Chalmers, IVL, Litehauz Aps, MAN Energy Solutions** and **Menon Economics** in the development of the **Nordic Roadmap**. The DNV announcement is well-worth a read.

The **Nordic Roadmap** will plot the means, and the basis to accelerate, the transition to **zero-carbon fuels**, including by identifying any barriers to accelerated transition, and how to avoid, navigate or remove them. The **Nordic Roadmap** is centred around the establishment of a **Nordic Cooperation platform** to facilitate: **1.** Sharing of knowledge; **2.** Undertaking of pilot projects; **3.** Establishment of Green Corridors; **4.** Development of enabling infrastructure.

- **DSME LCO2 carrier headed for the water:** On **April 8, 2022**, [Ingprime.com](#) reported that **Daewoo Shipbuilding & Marine Engineering (DSME)** that **DSME** had received classification society basic design approval for its 250 / 44 metre dimensioned vessel to carry **liquid carbon dioxide (LCO2)**. The basic approval in principle is understood to make the **DSME** vessel the largest dimensioned **LCO2** carrier to receive approval in principle to date, with containment tank capacity stated to be **70,000 m³**.
- **Ammonia and LCO2 carrier updates:** On **April 14, 2022**, the **Ammonia Energy Association** posted an [update](#), including the following **Approvals in Principle (AiP)**: the concept design for a **50,000 m³** ammonia and **LCO2** carrier from **Mitsui O.S.K Lines, Ltd.** and **Mitsubishi Heavy Industries**, the **AiP** from **DNV** for an ammonia powered and propelled **7,000 car** carrier designed by **China State Shipbuilding Corporation**, and the **AiP** for the **7,500 m³** ammonia carrier, the **MS Green Ammonia**, designed by **Grieg Edge** and using a Wärtsilä W25dF ammonia engine.

The development of ammonia and **LCO2** carriers has become a particular focus of a number of participants in the shipping industry, reflecting the perspective of likely cargoes, **LCO2** into storage, and ammonia to export markets.

- **NZE emission carriers:** In addition to the cargoes that are to be carried, the carriers carrying those cargoes are progressing to become **NZE** emissions carriers. **Mitsui O.S.K Lines, Ltd** is reported to be aiming to deploy 110 **NZE** carriers by 2035.
- **Yara bookends the month of April:**
 - **Yara International pacesetting:** On **April 1, 2022**, [h2-view.com](#) reported than **Yara International** was continuing to develop the world's first carbon-free ammonia fuel bunker network in Scandinavia. As will be apparent to regular readers of Low Carbon Pulse, ammonia is a **Future-Fuel**, which is being considered by the international shipping industry as one of a number of fuels to displace heavy fuel oil.
On **May 17, 2022**, the **Ashurst Global Towards Net-Zero Emissions Team** will publish an article on **Future-Fuels** (the primary author being the author of Low Carbon Pulse).

- **Yara Birkeland wetted:** On **April 29, 2022**, the **Wilhelmsen Group** [announced](#) the official christening of the **Yara Birkeland**, the world's first autonomous and zero-emission container vessel: the **Yara Birkeland** was developed in collaboration with Kongsberg Group and was built by VARD, and will transport mineral fertiliser between Porsgrunn and Brevik.

By way of reminder: [Edition 31](#) of Low Carbon Pulse reported that: "On November 19, 2021, the Yara Birkeland departed for its maiden voyage – the Yara Birkeland is the first container vessel to be powered and propelled by electric technology. CEO of Yara, Mr Svien Tore Holsether said: "[Yara is] proud to be able to show case the world's first fully electric and self-propelled container ship. It will cut 1,000 tonnes of CO2 and replace 40,000 trips by diesel-powered trucks a year".

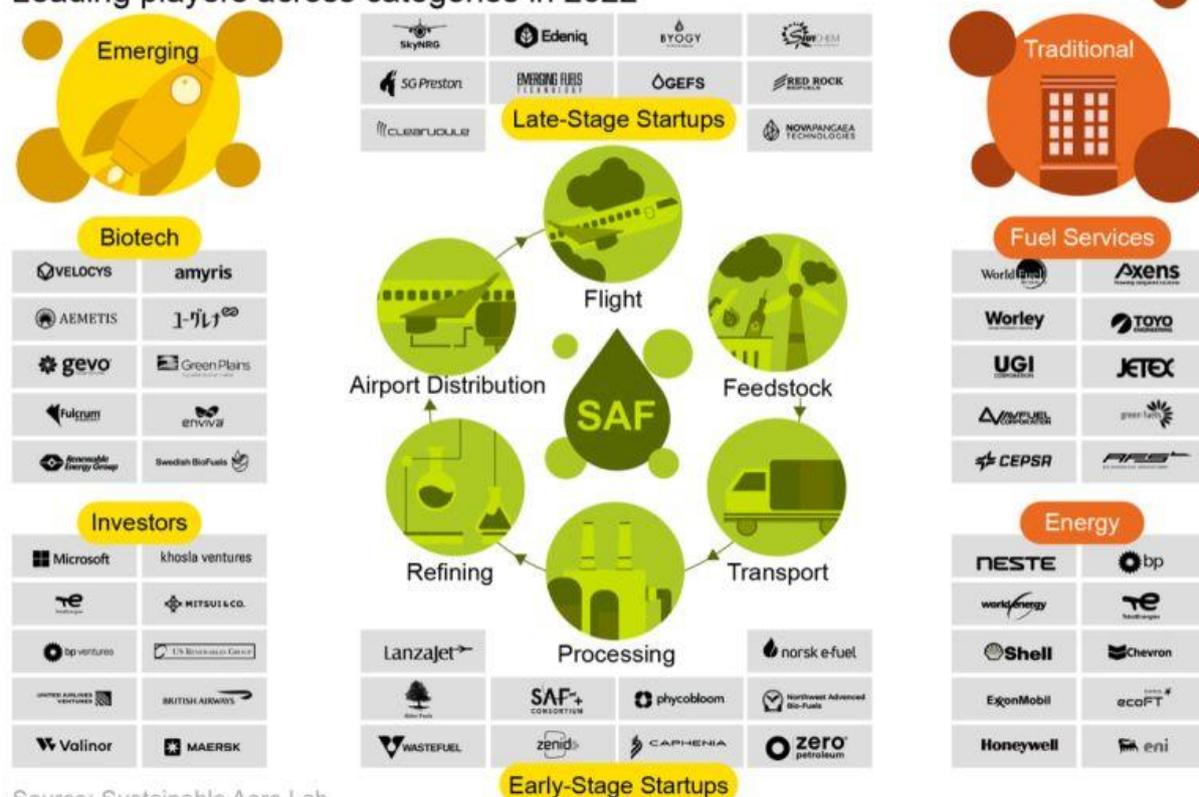
Airports and Aviation:

This section considers news items that have arisen within the news cycle of this **Edition 39** of Low Carbon Pulse relating to the development and deployment of technology at airports and in the aviation sector to decarbonise the airports and the aviation industry.

- **SAF represented in infographic:** The following infographic provides a snap-shot of the **SAF** ecosystem:

THE ECOSYSTEM ADVANCING SUSTAINABLE AVIATION FUEL

Leading players across categories in 2022



Source: Sustainable Aero Lab

- **HyPoint – another high point:**
 - [Edition 37](#) of Low Carbon Pulse reported that: "**HyPoint** (technology corporation) had developed a need technology that would allow the carriage of liquid hydrogen (**LH2**) using ultra-light weight fuel tanks". This news item has received considerable further coverage throughout April as the implications of the development of this technology are reflected upon.
 - In early **April 2022** it was announced that **HyPoint** had agreed to work **Gloyer-Taylor Laboratories (GTL)** to integrate **HyPoint's** ultra-light weight fuel tanks with **Gloyer-Taylor Laboratories (GTL)**.
- **Airbus Industries and Kawasaki Heavy Industries aligned:** On **April 12, 2022**, it was reported widely that **Airbus** and **Kawasaki** have agreed to work together to develop supply hydrogen supply chains to deliver hydrogen and hydrogen-based fuels to airports, and to develop the accompanying hydrogen eco-system. For these purposes, the two global giants, signed a memorandum of understanding (**MOU**). Through working together **Airbus** and **Kawasaki** will develop jointly a roadmap to address the challenges and define an advocacy plan to ensure the timely development of hydrogen supply and demand, and delivery, for the aviation industry.
- **ENEOS and TotalEnergies align:** On **April 14, 2022**, [biofuel-news.com](#) reported that **ENEOS Corporation** (a Japan-based integrated energy company) and **TotalEnergies** (global leading international energy corporation) had

agreed to work together to assess the feasibility of a **SAF** production facility at **ENEOS' Negishi** refinery in Japan. (**ENEOS** and **TotalEnergies** had previously commenced studies on supply).

As reported (and as will be familiar to regular readers of Low Carbon Pulse), the feedstock for the **SAF** would be animal fats and cooking oils (and possible other residues and waste), with the intention to produce up to **300,000 metric tonnes** of **SAF** a year.

- **Air Products, Honeywell and World Energy SAF and sound:** On **April 25, 2022**, it was reported widely that **Air Products** (one of the Big Three industrial gas corporations), **Honeywell** (a leading solutions and technology corporation) and **World Energy** (a producer and supplier of **SAF**) are to work together to develop North America's first commercial scale **SAF** production facility in **Paramount, California**.

The **USD 2 billion SAF** production facility (with current nameplate production capacity of **340 million gallons** a year is to be located at the production hub of **World Energy**, using hydrogen supplied by **Air Products**, with **Honeywell** continuing to work with **World Energy** to continue to develop more efficient and new processes.

As a reminder, **Edition 35** of Low Carbon Pulse noted in respect of **SAF**:

1. commercial aircraft are not permitted to use **SAF** on its own to propel aircraft (a maximum blend ratio of 50% fossil fuel to 50% **SAF** is permitted);

2. the process to produce **SAF** – there is only one commercially scalable production process – the use of fatty acids and hydrogenated acids as feedstock to produce synthetic paraffinic kerosene. As such, while there are seven approved means of production of **SAF**, only one means is currently commercially scalable; and

3. there is limited available feedstock (i.e. fatty and hydrogenated acids) from which to produce **SAF**. The primary sources of feedstock are animal fats and used cooking oils. As a result, current supply (200,000 metric tonnes of **SAF** annually) is a drop in the ocean of demand for aviation fuel (300 million metric tonnes annually). There is a market for **SAF**, not least because the aviation industry gives rise to around 1 billion metric tonnes of **CO₂-e** each year.

In addition to the reports in **Edition 35** of Low Carbon Pulse on **SAF** on the use of animal fats and used cooking oil, Stuttgart Airport and Schwenk Zement and SkyNRG are progressing with plans to develop synthetic aviation fuel, in the form of synthetic kerosene. The feedstock to produce this **SAF** is **CO₂**, captured from the production of cement, combined with **H₂**.

- **Future publications:**

- **Carbon Credits, Article 6 and the Paris Rulebook:**

The demand for carbon credits is increasing at pace in the **Voluntary Carbon Market / Voluntary Carbon Credit Market**. In the **Voluntary Carbon Market / Voluntary Carbon Credit Market**, carbon credits have value to corporations that have committed to achieving **GHG** emission reductions and, in the longer term, **NZE**, on the basis of carbon neutrality.

In a stand-alone article, the author of Low Carbon Pulse will outline Carbon Credits, Article 6 and the Paris Rulebook, and the near, medium and long term role of carbon credits, including as deforestation is curtailed and ceases, and afforestation and reforestation continues, and possible regulation of the **Voluntary Carbon Markets / Voluntary Carbon Credit Markets**.

- **E-Fuels / Future Fuels, including derived from biomass and bioenergy:**

The focus on fuels that are not derived or produced from fossil fuels is increasing. Low Carbon Pulse covers E-Fuels / Future Fuels and bio-energy. In addition to the focus on hydrogen and hydrogen based fuels (including ammonia and methanol), including hydrogen derived from biomass, there is a focus on the derivation and production of Renewable Natural Gas (**RNG**), derived from biomass, including biogas / biomethane, both for use as pipeline gas and for use as bio-compressed natural gas (**Bio-CNG**) and bio-liquified natural gas (**Bio-LNG**).

In a stand-alone article, Michael Harrison and Richard Guit will outline the sources of fossil fuels and non-biomass fuels (including crop fuels), and the feedstocks and technologies used to produce each E-Fuel / Future Fuel, and each form of bio-energy, and of course the **GHG** arising from their derivation and production, and use.

- **EU Taxonomy:**

The format of Low Carbon Pulse does not allow detailed coverage of the various regulations relevant to progress to **NZE** across the **EU**. In anticipation of the expiry of the four month scrutiny and objection period (which started at the end of January 2022) expiring without an effective objection to the **Taxonomy Complementary Climate Delegated Act**, the author of Low Carbon Pulse will provide a summary of the key regulations and their effect over coming months in a standalone article hopefully by the end of June 2022.

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 electrolyzers:**

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

ANATOMY OF AN ELECTROLYSER	
Alkaline electrolyzers (AE) produce H ₂ 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) electrolyzers operate in an acidic environment, using iridium coated anodes and platinum coated cathodes, both the anode and cathode are made from titanium.	

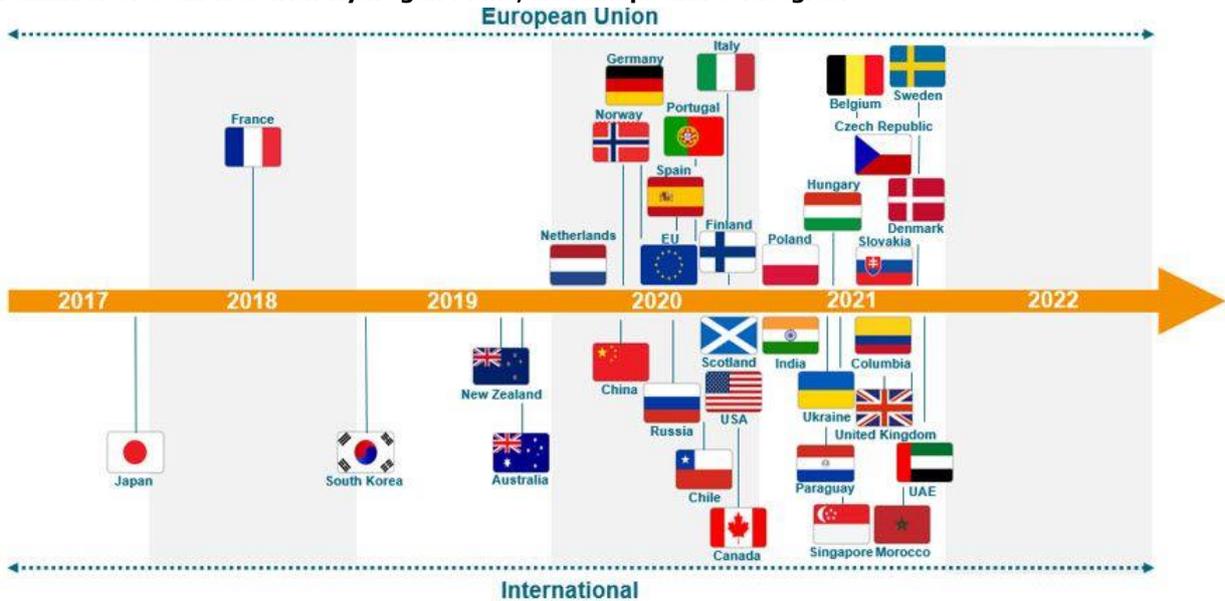
In addition to **AE** and **PEM** electrolyser technologies, there are what may be regarded as emerging technologies of anion exchange membranes (**AEM**) and solid oxide electrolysis cells (**SOEC**). It is fair to say that **SOEC** electrolysers are emerging more quickly, and more developed, than **AEM**.

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 **SOECs**.

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**), **SOECs** can provide balancing services to grids, increasing the overall use of the **SOEC**. **SOEC** can be used for co-electrolysis of steam and **CO₂** so as to create a synthetic gas mix comprising **CO** and **H₂** 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:

Net-zero WHAT?

Net-zero carbon (CO₂)

Net-zero carbon emissions = **only CO₂**
 Carbon neutrality = Balancing the emissions and removals of CO₂

Net-zero GHG

Net-zero GHG emissions = **all greenhouse gases**
 Climate neutrality = Balancing the emissions and removals of all GHGs

GHG – greenhouse gas



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
Department of Business, Energy and Industrial Strategy (BEIS)	<u><i>Atmospheric Implications of Increased Hydrogen Use</i></u>
Department of Business, Energy and Industrial Strategy (BEIS)	<u><i>Hydrogen investor roadmap: leading the way to net zero</i></u>
Department of Business, Energy and Industrial Strategy (BEIS)	<u><i>CCUS Investor Roadmap – Capturing Carbon and a Global Opportunity</i></u>
Department of Business, Energy and Industrial Strategy (BEIS)	<u><i>UK Low Carbon Hydrogen Standard: emissions reporting and sustainability criteria</i></u>
European Hydrogen Backbone (EHB)	<u><i>European Hydrogen Backbone – April 2022</i></u>
Global Wind Energy Council (GWC)	<u><i>Global Wind Report 2022</i></u>
Government of United Kingdom	<u><i>Policy Paper – British energy security strategy</i></u>
Institute of Energy Economics at the University of Cologne (EWI)	<u><i>Development of Hydrogen Market in Eastern Germany – An Infrastructure analysis based on regional potentials and demand</i></u>
International Energy Agency (IEA)	<u><i>Direct Air Capture – A key technology for net-zero</i></u>
International Energy Agency (IEA)	<u><i>Sustainable Recovery Tracker – Monitoring Progress towards sustainable recoveries from the Covid-19 crisis</i></u>
International Energy Agency (IEA)	<u><i>Gas Market Report, Q2-Analysis, including Global Gas Review 2021</i></u>
International Energy Agency (IEA)	<u><i>Belgium 2022 – Energy Policy Review Report</i></u>
International Renewable Energy Agency (IRENA)	<u><i>Decarbonising end-use sectors: Green hydrogen certification</i></u>
International Renewable Energy Agency (IRENA)	<u><i>Renewable Capacity Statistics 2022</i></u>
McKinsey & Co	<u><i>Global Energy Perspective 2022</i></u>
National Renewable Energy Laboratory (NREL)	<u><i>Bioogas Potential in the United States (Fact Sheet). Energy Analysis</i></u>
The World Bank	<u><i>Carbon Revenues from International Shipping: Enabling an Effective and Equitable Energy Transition-Technical Paper</i></u>

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