

# Low Carbon Pulse - Edition 31

## GLOBAL DEVELOPMENTS IN PROGRESS TOWARDS NET-ZERO EMISSIONS



Welcome to **Edition 31** of Low Carbon Pulse – sharing significant current and recent news on progress towards net-zero greenhouse gas (**GHG**) emissions (**NZE**) for the period from Monday November 15, 2021 to Sunday November 28, 2021 (inclusive of each day).

Please click [here](#) for **Editions 29** and [here](#) for **30** of Low Carbon Pulse, and click [here](#) for the **Low Carbon Pulse Compendium**, which comprises **Editions 1 to 28** of Low Carbon Pulse (covering the 12 month period from October 6, 2020 to October 5, 2021). 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.

**Edition 32** (*The Magic Johnson Edition*) of Low Carbon Pulse will be published on Friday December 17, 2021. **Edition 33** (*The Larry Bird Edition*) will be published on Friday January 14, 2021, after the Christmas and western New Year holiday season. The Appendix to **Edition 33** will comprise the Report on Reports for November and December.

### Reflections on COP-26 after the dust has settled:

- **Down to earth:**

Expectations for the 26th session of the Conference of Parties (**COP-26**) of the United Nations Framework Convention on Climate Change were somewhere between heightened and sky high.

Before **COP-26**, the President of **COP-26**, Mr Alok Sharma, set out the four UK Government Goals for **COP-26** (**Four Pillars**). The next page or so outlines progress made in respect of the **Four Pillars**.

**Four Pillars:** In the working week before **COP-26**, 2021, Low Carbon Pulse published five [COP-26 Countdown features](#) describing each of the **Four Pillars**.

In short hand, the **Four Pillars** were as follows:

1. Secure global net zero by mid-century and keep 1.5 degrees within reach (**First Pillar**);
2. Adapt to protect communities and natural habitats (**Second Pillar**);
3. Mobilise finance (**Third Pillar**); and
4. Work together to deliver, including the finalisation of the **Paris Rulebook** (**Fourth Pillar**).

On the face of it, progress was made on the **Four Pillars** (see Edition [30](#) of Low Carbon Pulse for a summary of the outcomes from **COP-26**). It appears that the importance of staying tethered to a **1.5°C** average increase in global temperatures is now well and truly understood.

If three words emerged from the coverage of, and articulated the needs and outcomes from, **COP-26**, they are: ambitious, accelerated, and action, best combined in the following sentence. "**More ambitious targets, and accelerated action to achieve them, is needed to avoid the worst effects of climate change.**"

Momentum developed ahead of, and at, **COP-26** in respect of more ambitious targets. The achievement of those more ambitious targets will limit the increase in average global temperature in a range of **1.8°C** to **2.4°C** (see Edition [30](#) of Low Carbon Pulse, under **In Summary**). The range needs to be towards **1.5°C** within **1.5°C** to **2°C** (what Low Carbon Pulse has previously defined as the **Responsible Range**).

The science underpinning the **Paris Agreement** holds good.

- **Back to work:**

While those attending **COP-26** are taking a well-earned rest, there is a need to build on the **Four Pillars**. There is no doubt that the private sector is pushing on.

**Building on the Four Pillars:**

1. **First Pillar:**

*"Countries are being asked to come forward with ambitious 2030 emission reductions targets, that align with reaching net zero by the middle of the century.*

*To deliver on these stretching targets, countries will need to:*

- *Accelerate the phase out of coal [in the event, becoming the phase-down of coal];*
- *Curtail deforestation;*
- *Speed up the switch to electric vehicles;*
- *Encourage investment in renewables."*

A broader consensus arose before and during, and has consolidated after, **COP-26**: limiting the average increase in global temperatures to **1.5°C** is key to avoiding the worst effects of climate change on the climate system, and the achievement of the Stretch Goal is barely achievable, it is barely within reach. As was the case ahead of **COP-26**, acceleration of reductions in GHG emissions is critical, with greater ambition and commitment required ahead of COP-27 in Egypt.

The Administrator of the United Nations Development Programme (**UNEP**), Mr Achim Steiner, published a [summary](#) of **COP-26** on November 14, 2021, with the final paragraph containing the following: *"The road to COP-27 begins now and it is vital that we accelerate the momentum provided by COP-26. With 1.5 degrees remaining barely within reach, COP 26 must be a springboard for further commitments from countries in the immediate future"*.

The key outcome from Glasgow is that achieving 1.5 degrees is the basis for policy setting. To achieve the Stretch Goal, and **NZE** by 2050, by 2030 we must have reduced **GHG** emissions by 50%. There is a window, it remains open.

2. **Second Pillar:**

*"The climate is already changing and it will continue to change even as we reduce emissions, with devastating effects. As COP-26 we need to work together to enable and encourage countries affected by climate change to:*

- *Protect and to restore ecosystems; and*
- *Build defences, warning systems and resilient infrastructure and agriculture to avoid loss of homes, livelihoods and even lives"*.

Adaptation to climate change requires action by all countries, with some countries requiring more action than others. It is worth clicking-through on the link to the [46 Least Developed Countries \(LDCs\)](#), with a combined population of 1.1 billion people to get a sense of their location: of the 46 **LDCs**, 33 countries are African countries (including island states), four in East Asia (including Bhutan and Nepal), four in South East Asia (if one includes Timor-Leste), one in the Middle East (Yemen), and four Pacific Island nations of Solomon Islands, Tuvalu and Vanuatu, and in the Caribbean, Haiti.

Many, if not all, of the **LDCs** have contributed little, very little or not at all to climate change, yet the need for action in many of these countries is the greatest, and they are in need of the most assistance to take action to adapt. The United Nations Least Developed Country Expert Group (**LEG**), established and working under the auspices of the United Nations Framework Convention on Climate Change (**UNFCCC**), has been providing support to **LDCs** in respect of adaptation since 2001.

In Glasgow, the **LEG** reflected on 20 years of support for **LDCs** and looked forward. In looking forward, **LEG** reflected on the need for more coordination, but also on the need for **LDCs** and, other developing countries, to develop plans for adaptation, and to take those plans to developed countries, in particular the G-7 countries, and the European Union. The [third edition](#) of **Low Carbon Pulse – COP-26 Countdown** summarised what needs to be done in the near term.

3. **Third Pillar:**

*"To deliver on our first two goals, developed countries must make good on their promise to mobilise at least USD 100 billion in climate change funding a year by 2020.*

*International financial institutions must play their parts and we need to work towards unleashing the trillions in private and public sector finance to secure global net zero"*.

While attention at **COP-26** was focused on the USD 100 billion climate funding commitment each year, and some progress was made (and more organisation and coordination is required – see the [fourth edition](#) of **Low Carbon Pulse – COP-26 Countdown**), following the conclusion of **COP-26**, the common consensus is that there was more progress (and in the words of the **UNEP-WCMC**), *"more positive buzz around the redirection of trillions of \$ of private finance"*.

In this context, the [Glasgow Financial Alliance for Net Zero](#) has been welcomed warmly, and it is hoped that action will be taken *"swiftly and fairly through transparent action plans and robust near-term targets"*.

4. **Fourth Pillar:**

*"We can only rise to the challenges of the climate crisis by working together.*

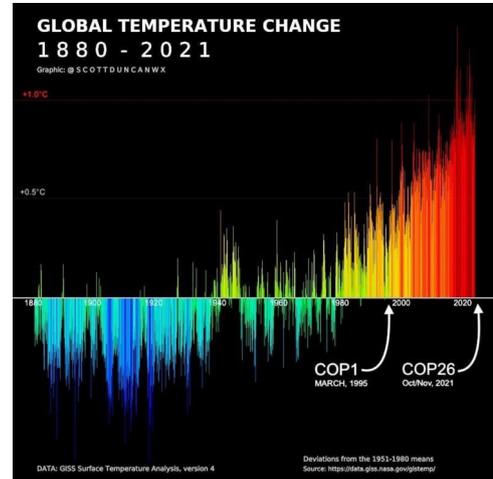
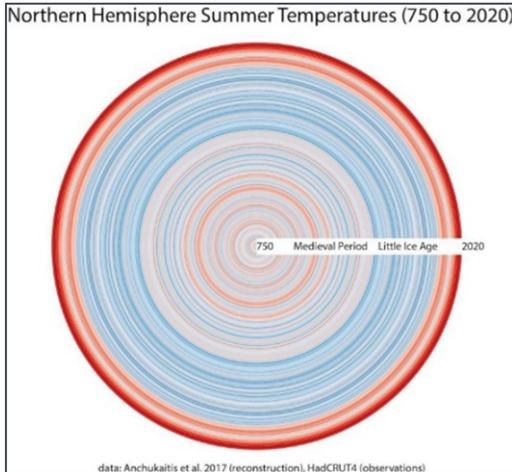
*At COP-26 we must:*

- *Finalise the Paris Rulebook (the detailed rules that make the Paris Agreement operational); and*
- *Accelerate action to tackle the climate crisis through collaboration between governments, businesses and civil society"*.

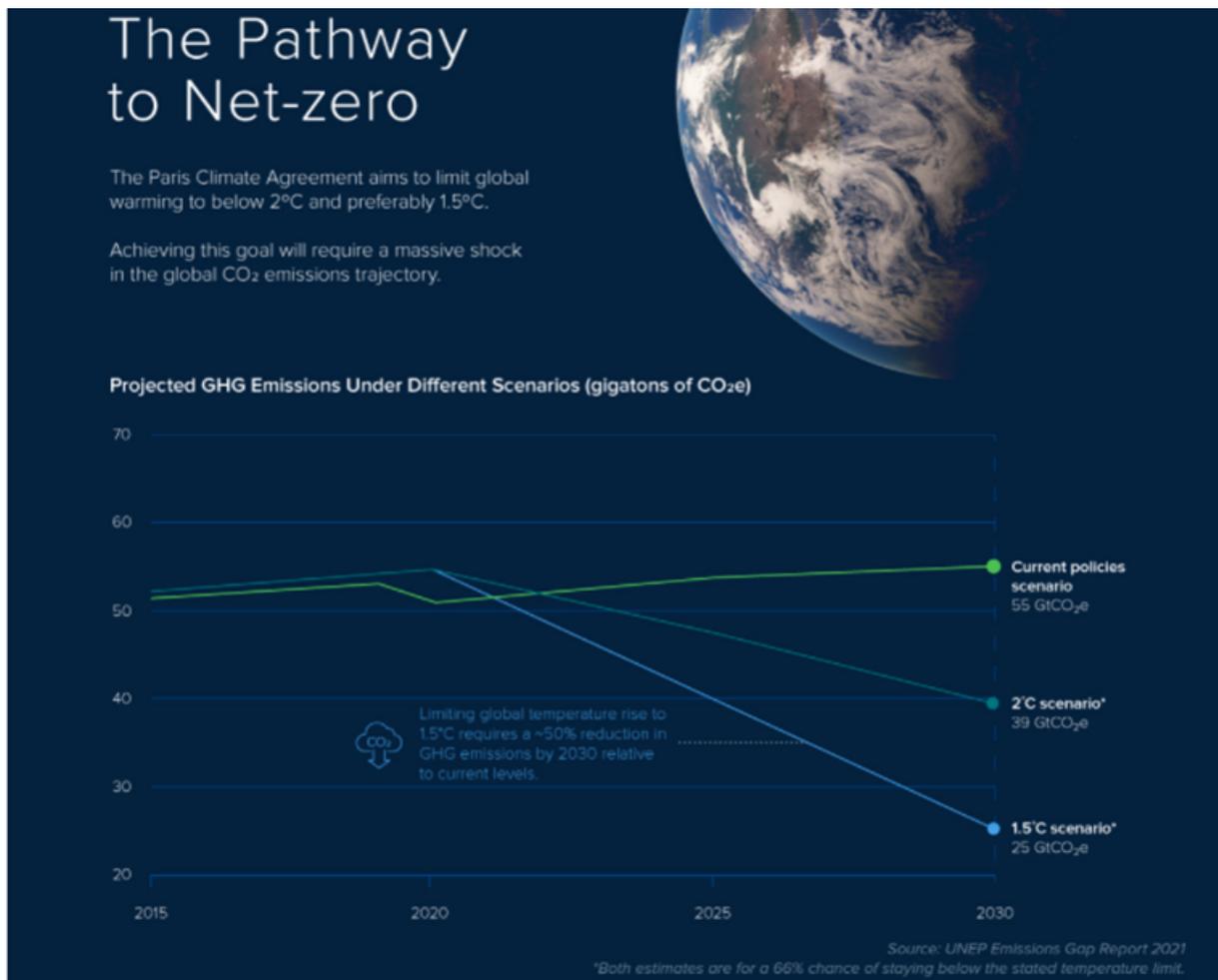
As noted in Edition [29](#) of Low Carbon Pulse, the finalisation of the **Paris Rulebook** would be a mark of the success of **COP-26**. In a standalone article, to be published early in 2022, implementation of the **Rulebook** will be reviewed.

## Climate change reported and explained:

- Data Rings True:** On November 26, 2021, UN Climate Change published a graphic developed by climate scientist, Mr Kevin Anchukaitis, University of Arizona, US. The graphic described as "dataviz "Warming Rings" represent the temperatures in the Northern Hemisphere from 750 to 2020.
- Global Temperature Change – 1880 to 2021:** In another visual representation of the context in which **COP-26** took place, the following graph provides a very clear message around the rate of climate change, COP-1 to **COP-26**:



- Pathways to Net Zero:** Previous editions of Low Carbon Pulse noted that to limit the increase in average global temperatures to **1.5°C** (and in so doing achieving **NZE**) it is necessary to reduce **GHG** emissions by between 46% and 50% by 2030. The graphic below provides an assessment that requires a 50% reduction in **GHG** emissions by 2030:



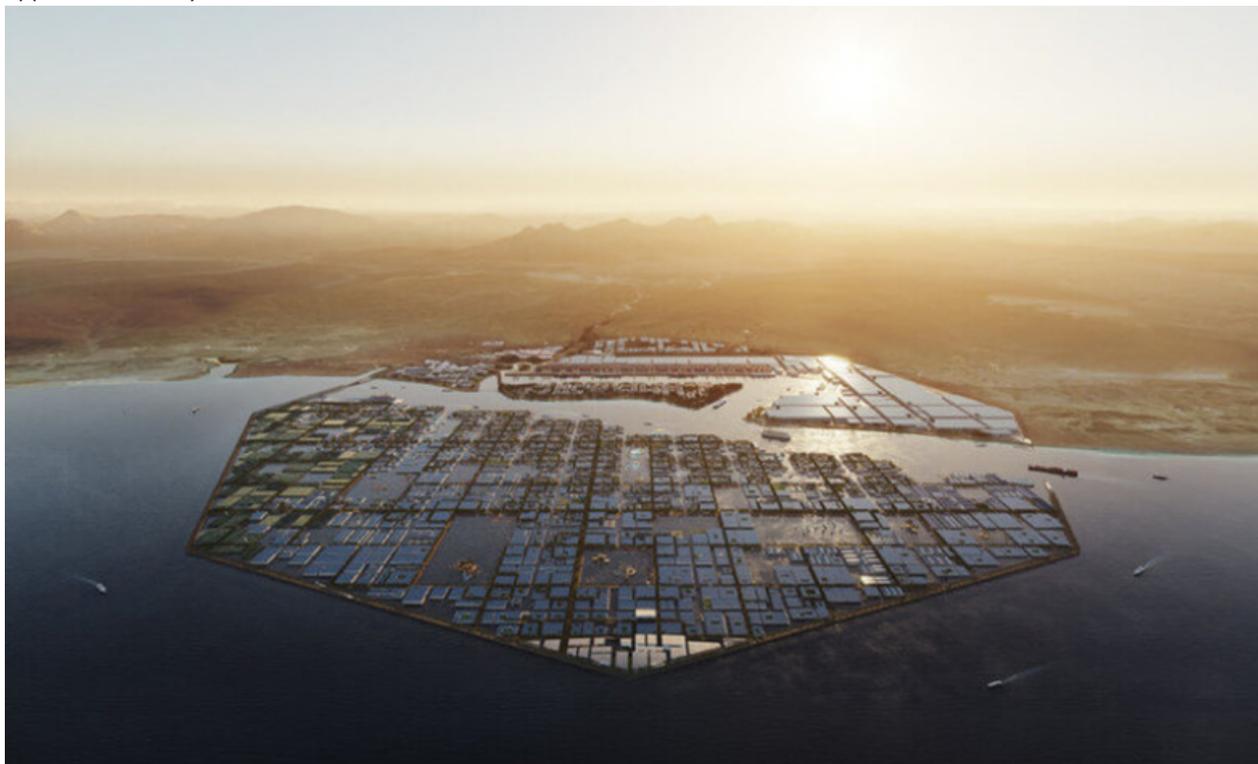
## GCC Countries:

- **ADNOC aligns with Mitsui and GS Energy:** On November 15, 2021, it was announced by the Abu Dhabi National Oil Company (**ADNOC**) that Mitsui & Co. Ltd (leading Japanese trading company) and GS Energy (leading international energy corporation head quartered in Seoul, Republic of Korea), had agreed to partner with TA'ZIZ and Fertiglobe, to develop a world scale low-carbon blue ammonia project in the TA'ZIZ Industrial Chemicals Zone in Ruwais.

His Excellency Dr. Sultan Ahmed Al Jaber, the Minister of Industry and Advanced Technology for the United Arab Emirates (**UAE**) and Managing Director and Group CEO of **ADNOC**, said: "*The strategic partnerships with Mitsui and GS Energy, two of ... Asia's global energy champions, reflect ADNOC's commitment to increase the production of low-carbon hydrogen and ammonia.*"

**See:** [Mitsui and GS Energy to Join TA'ZIZ in World-Scale Low-Carbon Blue Ammonia Project](#);

- **NEOM floats into view:** On November 16, 2021, an octagonal shaped representation of a floating industrial complex appeared in many news feeds:



The floating industrial complex is to form part of Neom, the USD 500 billion renewable city being developed by the Kingdom of Saudi Arabia (**KAS**). The floating industrial complex (**OXAGON**) includes a number of renewable energy projects, including what will be the world's largest Green Hydrogen production facility, involving Air Products and ACWA (among others, see Editions [28](#) and [29](#) of Low Carbon Pulse).

- **Emirates test flight on 100% SAF:** On November 18, 2021 it was reported widely that Emirates is preparing for a test flight using sustainable / synthetic aviation fuel (**SAF**) towards the end of 2022. The flight will use 100% **SAF** to power and to propel the aircraft being used.

- **UAE and Russia to collaborate:** The [Emirates New Agency](#) reported that the **UAE** and Russia had signed a memorandum of understanding (**MOU**) under which the countries are to explore how to work together to identify and to develop sustainable energy sources, i.e., developing hydrogen and hydrogen-based fuel projects.

The **MOU** is reported to have been signed by the Ministry of Industry and Advanced Technology for the **UAE**, and by the Ministry of Industry and Trade for Russia.

His Excellency Dr. Sultan Ahmed Al Jaber, the Minister of Industry and Advanced Technology said that: "*The MoU aligns with the strategic vision of our leadership – to build new and reinforce existing international collaboration in support of sustainable development*".

- **ADNOC closes financing for CCS and hydrogen production:** On November 21, 2021, [Energy&Utilities](#), reported widely that **ADNOC** had closed financing with the Japan Bank for International Cooperation (**JBIC**) for USD 2.1 billion, and with four Japanese commercial banks SMBC, Mizuho, MUFG, and the Tokyo branch of HSBC for USD 900 million. The USD 3 billion financing facilities are to be applied in the development and deployment of CCS / CCUS, and hydrogen and ammonia production, projects.

- **Hydrogen Projects and Production Prices:** On November 23, 2021, [futurenetzero](#) reported on new data provided by S&P Platts Analytics, which outlines that current planned hydrogen projects in the GCC countries are estimated to involve USD 44 billion in investment, with USD 35 billion to be invested in projects becoming operational by 2030.

S&P Platts Global Analytics has announced the launch of a daily information service detailing the cost of hydrogen produced in the **KAS**, Oman, Qatar and **UAE**. So far there have been no surprises – the cost of production of hydrogen derived and produced from **CH<sub>4</sub>** in **KAS** and **UAE** is lower than the cost of production in Australia and the Netherlands.

As the supply of hydrogen develops in tandem with the development of demand, one can expect transparency of production cost and delivered cost becoming key to the development of a hydrogen market.

- **UAE and AUS Business Council press print:** On November 24, 2021, the **Australian UAE Business Council** released the **Final Report of its Working Group on Renewable and Alternative Energies**. The **Final Report** will be reported on in the November and December Report on Reports to be contained in Edition 33 of Low Carbon Pulse.
- **Masdar and Armenia:** On November 26, 2021, Masdar (Abu Dhabi Future Energy Company) signed an agreement with the Government of the Republic of Armenia to develop a 200 MW photovoltaic solar plant – the Ayg-1 project. While the scale of the Ayg-1 project itself may not be regarded as significant, what is significant is that Masdar continues in its role as a "go-to" renewable energy developer and investor.

**See:** [Masdar signs agreement to develop Armenias largest solar power plant](#)

## Japan and Republic of Korea:

- **Hydrogen and ammonia for power generation:** On November 16, 2021, [rechargenews](#) reported that the Government of the Republic of Korea intends to use hydrogen and ammonia as fuel for electrical energy generation. The Ministry of Trade, Industry and Energy (**MOTIE**) plans to combine hydrogen (30%) and natural gas (70%) at all gas-fired power stations by 2035, and to combine ammonia (20%) with coal (80%) at more than half coal-fired power stations as early as 2030. As reported by [rechargenews](#), the plans to use hydrogen and ammonia will amount to the use of each of 17.7 GW and 3.5 GW of hydrogen and ammonia fired electrical energy capacity.

Given the higher heating values of hydrogen and ammonia, the capacity factors of gas-fired and coal-fired generation 50% and 77% respectively, this will equate to 1.4 million metric tonnes of hydrogen and 3.8 million metric tonnes of ammonia (derived from 670,000 metric tonnes of hydrogen). By way of a point of reference, this equates to about 2 million metric tonnes of hydrogen production a year, or the entire output from the two 10 GW mega-hydrogen projects **AquaVentus** (see Editions [16](#), [17](#) (in which described), [21](#), [23](#), [26](#) and [30](#) of Low Carbon Pulse) and **North2** (see Editions [5](#) and [16](#) of Low Carbon Pulse). See under **E-fuels and Future Fuels (increasingly "Now Fuels")** below for an update on AquaVentus.

- **East-West Power and Equinor combine:** On November 17, 2021, it was reported widely that Korea East-West Power (one of the six power generation subsidiaries of Korea Electric Power Corp (**KEPCO**)) and Equinor (leading international energy corporation) had signed a memorandum of understanding (**MOU**) under which they will cooperate in the development of 3 GW off-shore wind field projects.

Given the intended location of the off-shore wind fields, floating off-shore wind development will be required, an area in which Equinor is highly experienced. It is reported that the **MOU** reflects plans to develop 3 GW shared by Equinor in Q2 of 2021, and is consistent with the broader USD 23 billion capital expenditure plans of Equinor for the five year period 2021 to 2026.

**See:** [Stepping up Korean offshore wind plans, 3 GW collaboration with EWP](#)

This is one of the many steps that **KEPCO**, and its six power generation subsidiaries (Korea Hydro & Nuclear, Korea South-East Power, Korea Midland Power, Korea Western Power, Korea Southern Power and Korea East-West Power), are taking in progress to achievement of **NZE**. Edition [30](#) of Low Carbon Pulse noted the commitment to the phase-out of coal, with coal to ceased to be used for the generation of electrical energy by 2050.

- **Japan Decarbonising the Power Sector in Indonesia:** Edition [18](#) of Low Carbon Pulse reported that:

- **Indonesia was on the road:**

- **Phasing out coal-fired power:** On May 27, 2021, Perusahaan Listrik Negara (**PLN**) announced its intention to shutter all of its coal-fired power plants by 2056. It is reported that the shuttering will be phased: conventional plants to be shuttered by 2035 (9 GWs), "supercritical" plants by 2040 (10 GWs) and "ultra-supercritical" by 2056. The shuttering is intended to be consistent with carbon neutrality by 2060.

The shuttering of the **PLN** coal-fired plants was viewed as the start of a broader move to new policy settings in Indonesia, and is certainly consistent with the decision not to develop any new coal-fired power stations.

**See:** [Indonesian state utility to retire coal power plants gradually](#)

- **Phasing in of renewable electrical energy and phasing out of coal-fired:** On May 27, 2021, it was reported widely that the Government of Indonesia would not approve the development of any new coal-fired power stations, recognising that coal-fired power stations under construction, and at the state of financial close, will proceed.

**See:** [No new coal plants in Indonesia in another bid to cut emissions](#)

Editions [20](#) and [25](#) of Low Carbon Pulse reported on the announcement by the Japanese Minister for the Ministry of the Economy, Trade and Industry (**METI**) to provide up to USD 10 billion dollars for the Asian Energy Transition Initiative to support ASEAN countries, and the proposed "acquire to retire" program, and the possible implications.

Edition [30](#) of Low Carbon Pulse reported on the announcement by the Asian Development Bank, Indonesia and the Philippines of the Energy Transition Mechanism (**ETM**) Southeast Asia Partnership (**SEAP**).

Edition [30](#) reported that Indonesia has committed to achieving **NZE** by 2060, and to reducing **GHG** emissions by 29% by 2030 (its pre-existing commitment), or by 41% by 2030 with support from developed countries.

On November 25, 2021, leading Japanese energy corporations Tokyo Power Company (**TEPCO**), TEPCO Power Grid, JERA and Tokyo Electric Power Services agreed to work together with the Japan International Cooperation Agency (**JICA**) to develop a proposed roadmap to decarbonise the power sector in Indonesia – the "Data Collection Survey on Power Sector in Indonesia for Decarbonisation". The roadmap will identify measures that **JICA** may undertake in Indonesia to support the implementation of the roadmap.

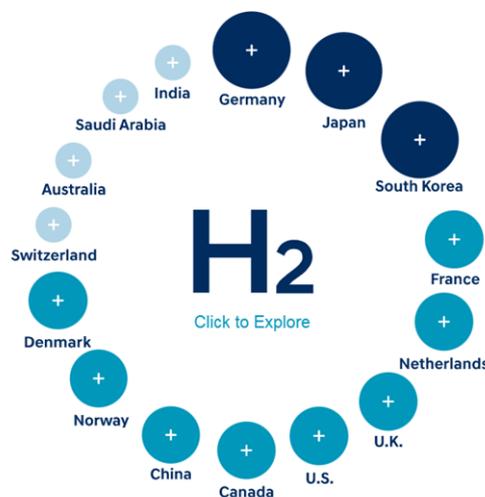
- **Republic of Korea demand for clean hydrogen by 2050:** On November 27, 2021, [S&P Platts Global](#) wrote that "South Korea will provide 27.9 million metric tonnes of "clean hydrogen" by 2050, all of which will be either green or blue hydrogen as [a] part of efforts to make it the country's number one energy source by 2050, replacing oil".

## France and Germany:

- **France to fund hydrogen:** On November 16, 2021, the President of France, Mr Emmanuel Macron, announced that the French Government will provide funding in the amount of €1.9 (or USD 2.15 billion) for the further development of the hydrogen sector in France. This funding is part of the €30 billion "France 2030" industrial investment plan. As foreshadowed in Edition [30](#) of Low Carbon Pulse, the hydrogen produced will be Pink Hydrogen predominantly, sourcing electrical energy from nuclear energy sources.
- **H2Wind within H2Mare:** Editions [22](#), [23](#), and [25](#) have reported on the three German flagship hydrogen projects to develop off-shore wind field hydrogen production and storage capacity. If hydrogen can be produced and stored at sea, the cost of submarine pipelines and beach-head connection can be avoided. In this context, the Federal German Ministry of Education and Research (**BMBF**) has provided funding to support research to be undertaken by the Fraunhofer Institute for Machine Tools and Reforming Technology (**IWU**) to develop robust electrolyzers and storage systems capable of operating conditions off-shore. The research by **IWU** is scheduled to continue until 2025.

## Investing in the Hydrogen Economy:

Bloomberg is reported to have assessed in detail the commitment and investment of 15 countries to the development of hydrogen capacity. The following graphic provides Bloomberg's assessment as things stand at the moment, before the initiatives in the lead up to **COP-26**, and since:



## Australia:

- **Queensland continuing to deliver:** In November 2021, the Queensland Government released [Consultation on the model for QREZ design and access – Delivering Queensland Renewable Energy Zones](#). The consultation is being undertaken to develop the models for the delivery of the three Queensland Renewable Energy Zones (**QREZs**), Northern, Central and Southern, with the delivery of the **QREZs** being aligned with the achievement of Queensland's commitment to reduce **GHG** emissions by 50% by 2030. There has been a good deal of comment about the consultation paper, with an apparent consensus that more than 3.3 GW of renewable electrical energy contemplated will be required. The November and December Report on Reports (to comprise the Appendix to Edition 33 of the Low Carbon Pulse) will consider the consultation paper in more detail.
- **ANU reports on Blue and Green:** On November 10, 2021, the Australian National University published a [paper](#) on the comparative **GHG** emissions and costs of the production of Blue and Green Hydrogen. The report will be considered in detail in the November and December Report on Reports comprised in the Appendix to Edition 33 of Low Carbon Pulse.
- **South Australia:**
  - **goes positive:** On November 16, 2021, the South Australian Government welcomed in the most positive of terms, the decision of the Japanese Government to provide funding support to Marubeni Corporation in respect of the development of a pilot project to produce Green Hydrogen for export to Japan. In welcoming the decision of the Japanese Government, the South Australian Government noted that the pilot project had been "show-cased" by the Japanese Ministry of the Environment at **COP-26** in a presentation entitled, **Building global supply chain of Green Hydrogen to support the energy transition toward a decarbonised society**.
  - **goes more positive still:** On November 18, 2021, it was reported widely that a new 6 GW renewable energy and Green Hydrogen Project had been proposed – the Moolawatana Renewable Hydrogen Project, to be located at Moolawatana Station, around 570 km to the north of Adelaide, South Australia's capital city.

- **goes negative:** On Sunday November 21, 2021, roof-top solar capacity resulted in two negative demand events in South Australia – reportedly a world first for a GW scale grid system. Between 12.20 and 12.50 pm and 13.25 and 13.50, demand across the SA grid was "negative" within the State, with export of electrical energy inter-state. It is understood that full effect of the "synchronous condensers" (see Edition [29](#) of Low Carbon Pulse) is now being realised: the synchronous condensers mean that synchronous generation (provided by 240 MW of gas-fired power generation), has been scaled back to 120 MW and now to 80 MW, allowing the dispatch of more renewable electrical energy to the grid in South Australia.  
On Saturday November 27, 2021 for a 72 hour rolling-period, renewable electrical energy accounted for 101% of electrical energy dispatched to the grid in South Australia. Again, reportedly a world first for a GW scale grid system.
- **NSW:**
  - **Blends Green Hydrogen with Natural Gas:** On November 18, 2021, it was reported widely that Jemena was blending hydrogen with natural gas, with the blended gas being hauled and stored across the Jemena gas distribution network.  
The Green Hydrogen is blended at Jemena's Western Sydney Green Hydrogen Hub, co-funded by the Australian Renewable Energy Agency (**ARENA**)
  - **Legislates in support of Green Hydrogen Capacity development:** On November 19, 2021, the New South Wales legislature passed the Energy Legislation Amendment Bill providing the legislative means to give effect to the [NSW Hydrogen Strategy](#).
- **Victoria goes off-shore:** On November 23, 2021, the State of Victoria and the Star of the South (Australia's first off-shore wind field project – see Editions [13](#) and [16](#) of Low Carbon Pulse), entered into a partnership agreement under which the State of Victoria agreed to provide funding to allow pre-construction development work to be undertaken.  
In addition to the Star of the South, the Victorian Government has agreed to provide funding support for a Macquarie Group 1 GW Bass Coast off-shore wind field project, and for a Flotation Energy project.
- **Australia to go off-shore:** On November 25, 2021, the Senate of the Australian Federal Parliament passed off-shore electrical energy legislation. The legislation will be subject of coverage from the Ashurst Energy Team in Australia, but in short the legislation comprises: the [Offshore Electricity Infrastructure Bill 2021](#) and the [Offshore Electricity Infrastructure \(Regulatory Levies\) Bill 2021](#).  
Renewconomy's live [map](#) identifies the 13 offshore wind field projects that may now develop under the offshore electrical energy legislation.
- **Australia and Germany on the same page:** In the lead up to **COP-26**, Low Carbon Pulse parked coverage of the HySupply State of Play Report ([The Case for an Australian Hydrogen Export Market to Germany: State of Play Version 1.0](#)) released as a consultation paper, choosing rather to wait for the final form.  
On November 23, 2021, Australia and Germany committed to strengthen bilateral cooperation on hydrogen technology (please click [here](#) for the official announcement from the Australian Government). The Australian Renewable Energy Agency (**ARENA**) is to take a lead role in a "hydrogen innovation and technology incubator", HyGATE, which will support a pilot project, and trial, demonstration and research projects for the purposes of the development of a hydrogen supply chain. The Australian Federal Government has announced that **ARENA** and the Ministry of Education and Research (**BMBF**) of the Federal German Government will open the funding support initiative in Q1 of 2022.

## US:

- **Back on track:** Edition [25](#) of Low Carbon Pulse reported on the progress of the [Infrastructure Investment and Jobs Act \(IIAJA\)](#) as follows:
  - **"US Bipartisan Infrastructure Deal Done:** Edition [23](#) of Low Carbon Pulse reported that the US infrastructure investment package (**IIP**) was nearly done. On August 10, 2021, the **IIP** "got done": by a vote of 69 to 30, the US Senate passed the [Infrastructure Investment and Jobs Act \(IIAJA\)](#).
  - **What next for the IIAJA?** From the US Senate, the **IIAJA** has made its way to the House of Representatives for adjustment to some of its provisions, those adjusted provisions to be returned to the US Senate for consolidation by the Senate before the **IIAJA** is presented to President Joe Biden for signature."
- On November 15, 2021, President Joe Biden signed the **IIAJA**.
- **Key aspects of IIAJA in context of projects to NZE:**  
USD 9.5 billion in funding support (over five years) to lower the costs of clean hydrogen and to commercialise its use, with funding to support the development and deployment of electric vehicles (**EVs**) and carbon capture and sequestration.
- **Hydrogen Gets Big Billing:** [World Energy](#) reports that the largest hydrogen program in the **IIAJA** will provide the US Department of Energy (**DOE**) with USD 8 billion to provide support for at least four hydrogen hubs that are able to demonstrate that their development and deployment will contribute to production of clean hydrogen (being hydrogen that gives rise to less than 2 kg of **CO<sub>2</sub>** for each 1 kg of hydrogen produced) and to multiple uses of that clean hydrogen.  
The **IIAJA** prescribes that at least one hydrogen hub will use fossil fuel feedstock to produce hydrogen, one will use renewables and one will use nuclear.  
The balance of the USD 9.5 billion comprises USD 1 billion in funding to lower the cost of producing Green Hydrogen with the goal of achieving a cost of USD 2 per kg by 2026, and USD 500 million to allow the award of grant funding for the purposes of research, development and demonstration (**RDD**) to develop and deliver clean hydrogen production, delivery, storage and use technologies.  
The Infrastructure Bill contemplates the development of a national hydrogen strategy and roadmap to facilitate large-scale, and wide-spread, production, delivery, storage and use of clean hydrogen.

- **Clean Hydrogen Gets Big Tax Credit:** On November 22, 2021, [rechargenews](#) reported on the clean hydrogen tax credit of up to USD 3 per kg of clean hydrogen. The **Build Back Better Bill** (as distinct from the **IIAJA**) passed by the House of Representatives on November 19, 2021, includes a ten-year production tax credit (**PTC**) scheme under which producers of clean hydrogen are able to benefit from a USD 3 per kg tax credit. It is important to note that the **Build Back Better Bill** has yet to progress through the US Senate, and as such there is a risk that the **PTC** may not eventuate. The tax credit scheme provides a higher tax credit for cleaner hydrogen as follows in respect of clean hydrogen projects in respect of which construction commences before 2029:

CLEAN HYDROGEN TEN YEAR TAX CREDIT SCHEME		
CO <sub>2</sub> -e per kg of H <sub>2</sub>	Tax Credit of full tax credit	Impact per kg of H <sub>2</sub>
0.45 – 1.5	33.4%	USD 1.00
1.5 - -2.5	25%	USD 0.75
2.5 – 4.0	20%	USD 0.60
4.0 – 6.0	15%	USD 0.45

## Finland:

- **Finland in focus:** Edition 4 of Low Carbon Pulse included a piece on Finland as follows: "Business Finland (a public organisation directed by the Finnish Ministry of Employment and Economy) has published a **National Hydrogen Roadmap for Finland**. The **Roadmap** is clear as to historical, current and future uses: "Hydrogen has been used as an industrial chemical for more than 100 years. Today ... used to manufacture ammonia, and ... fertilizers, as well as methanol and hydrogen peroxide, both vital feedstocks for a wide variety of different chemical products ... Producing hydrogen via low or totally carbon-free ways, and using this "good" low-carbon hydrogen to replace hydrogen with a larger carbon footprint, we can reduce carbon emissions ... ." Hydrogen is seen as playing a key role in Finland's national goal of carbon neutrality by 2035. The **Roadmap** does not contain policy settings, rather it, and each initiative contemplated by it, is intended to provide a "knowledge base for further work" including shaping policy settings for Finland, and "determining the role of hydrogen in the national energy and climate policy". As with the **DOE Hydrogen Program Plan**, the Finnish **National Hydrogen Roadmap** provides a good analysis of the role that hydrogen can play across sectors, and the scale of the demand side of the prospective market for hydrogen, and in the case of the **Roadmap** the role that Finnish business can play across the hydrogen value chain." See: [Hydrogen Roadmap for Finland](#)
- **European Commission funding for CCS:** On November 17, 2021 the European Commission committed funding support, from the newly established €1.1 billion Innovation Fund, for the production of clean-hydrogen at a refinery at Porvoo, Finland, with the capture of **CO<sub>2</sub>** and its storage in the North Sea in geological formations below the seabed, with the electrical energy required being produced by renewable sources.
- **Momentum accelerating:** On November 22, 2021 it was reported widely that Finland is progressing to develop a number of initiatives that will make it a leading hydrogen economy. One initiative involves the development and deployment of large-scale hydrogen production capacity around the Gulf of Bothnia and the Baltic Sea, with the Gulf of Bothnia regarded as highly prospective for hydrogen production, storage and use and transportation.

## Sweden - European Commission Funding for Green Steel:

Previous editions of Low Carbon Pulse have reported on and described at length the Green Steel initiatives using fossil fuel free hydrogen in Gallivare and Oxelosund, Sweden.

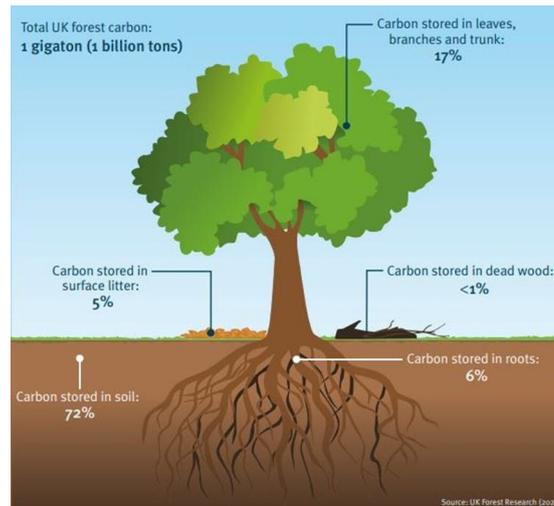
On November 17, 2021 the European Commission committed funding support, from the newly established €1.1 billion Innovation Fund, for scale development of Green Steel production in Gallivare and Oxelosund.

## Scotland:

Scotland has made and continues to make considerable progress to achieving **NZE**. The [BBC](#) has reported recently that the load for electrical energy across Scotland is being matched, or is close to being matched, by the dispatch of renewable electrical energy sources. And yet Scotland is continuing to develop sources of renewable electrical energy, allowing the export of renewable electrical energy, and the use of renewable electrical energy to produce Green Hydrogen. The potential for Scotland to be an exporter of both renewable electrical energy and Green Hydrogen is regarded as huge.

## Blue and Green Carbon:

- **A helpful picture:** UK Forest Research has developed a pictorial representation of the use of flora to absorb **CO<sub>2</sub>**, and the role of soil and root systems.

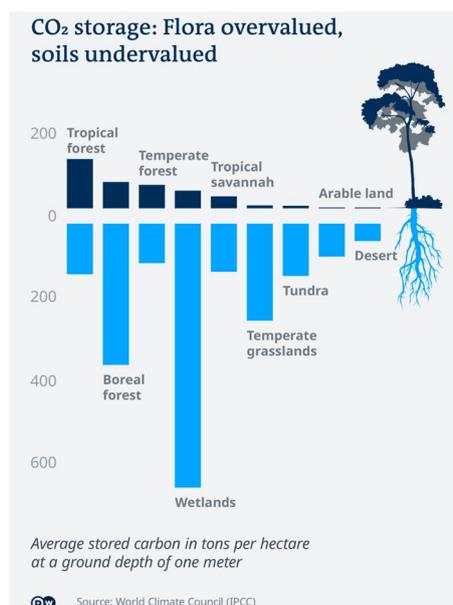


While the percentages of absorption will depend on the climate and the flora, this is a helpful picture in that it emphasises the importance of restoration of eco-systems following deforestation, and the benefits of afforestation and reforestation.

- **TotalEnergies committed to Green Carbon:** On November 19, 2021, TotalEnergies announced that it has signed an agreement with the Government of Suriname, South America, to provide support for Suriname's national strategy to reduce **GHG** emissions by preserving the forests of Suriname. The support includes a carbon credit exchange agreement.
- **A not so helpful finding:** On November 23, 2021, the [New Scientist](#), reported on a study of an area of tropical forest. The study finds that flora within the area of the study grew at a slower rate during years when nights are warmer than average or when dry-season days are unusually warm to hot. If taken as general findings, the implications are that as average temperatures increase the ability of tropical forests to absorb **CO<sub>2</sub>** may lessen.
- **Saudi Green Initiative – Plant 100 million mangroves:** One of the less reported aspects of the Kingdom of Saudi Arabia's Green Initiative is the plan to plant 100 million mangroves. As reported in previous editions of Low Carbon Pulse, mangrove forests / swamps provide a significant opportunity to restore and to improve the health of both land and sea. It is estimated that the plan to plant 100 million mangroves will result in the removal of 96 million tonnes of **CO<sub>2</sub>** from the climate system.

Continuing the theme of mangroves and Blue Carbon, and straddling the next news item, the following link is to the new Ramsar Convention on Wetlands guidance publication [The contribution of blue carbon ecosystems to climate change mitigation](#) providing for scaling up Blue Carbon.

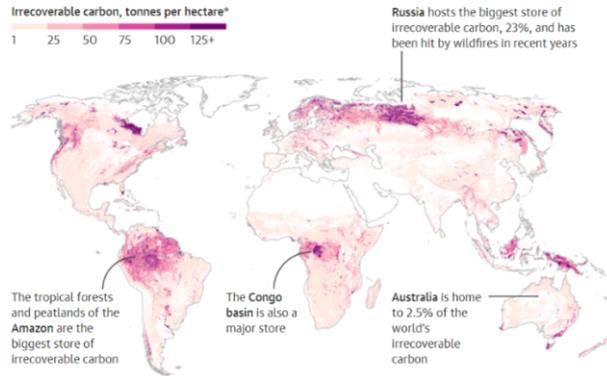
- **Grasslands, Peatlands, and Wetlands – lands of hope and glory:** Wetlands International has published a **CO<sub>2</sub>** storage graphic which illustrates the ability of grasslands, peatlands and wetlands to absorb **CO<sub>2</sub>**.



While the author of Low Carbon Pulse has not verified the information conveyed by the graphic, it is consistent with other information read by the author.

- **Irrecoverable carbon:** A new [study](#) published in Nature Sustainability has mapped what it has termed **irrecoverable carbon**, being carbon sinks that need to be preserved. The study finds that half of the **irrecoverable carbon** is in carbon sinks located on 3.3% of the world's land mass: 57% of **irrecoverable carbon** is flora, and 43% is in soils and peatlands, with peatlands storing more carbon than tropical and sub-tropical forests.

**New mapping shows the carbon-rich areas humanity cannot afford to destroy if climate catastrophe is to be avoided**



Guardian graphic. Source: Nature Sustainability. \*to 30cm depth for forests and grasslands and to 100cm depth for peat and wetlands (reflecting the different depths of typical disturbance for different ecosystems)

### Bioenergy:

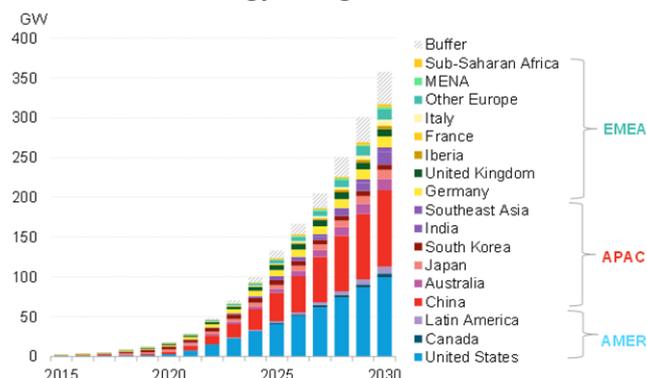
- **Australia has a bioenergy roadmap:** On November 18, 2021, the Australian Renewable Energy Agency (**ARENA**) published a [bioenergy roadmap](#) for Australia. On Friday November 18, 2021, ARENA announced funding support to help implement that roll-out of the bioenergy roadmap. This funding is in addition to funding support provided to date by the Australian Federal Government. The ARENA bioenergy roadmap will be considered in detail in the November and December Report on Reports to comprise the Appendix to Edition 33 of Low Carbon Pulse.
- **PGNiG – oil and gas to biogas and biomethane:** On November 26, 2021, [World Biogas Association](#), reported that Polish state-owned oil and gas corporation, Polskie Górnictwo Naftowe i Gazownictwo (**PGNiG**) is to develop the biogas and biomethane sector. It is reported that the **PGNiG** has agreed to take responsibility for coordinating work to develop bio-LNG, bio-CNG and biomethane, with the biomethane to be distributed using the gas distribution network as pipeline gas.

BIOENERGY	
<b>Biomass:</b> organic matter arising from the life-cycle of any living thing, flora or fauna.	<b>Bioenergy:</b> energy derived or produced from biomass, whether in gaseous, liquid or solid form.
<b>Biogas:</b> a mixture of <b>CH<sub>4</sub></b> and <b>CO<sub>2</sub></b> , arising from the decomposition of organic matter, including derived or produced from anaerobic digestion.	<b>Biomethane:</b> <b>CH<sub>4</sub></b> in near pure form, derived or produced from upgrading <b>Biogas</b> or gasification of biomass. Biogas and Biomethane are Biogases.
<b>Bio CNG:</b> Biogas or Biomethane that is compressed.	<b>Bio LNG:</b> Biomethane that is liquified.

### BESS and HESS (and now CAESS):

- **Boom in BESS and HESS:** On November 15, 2021, [BloombergNEF](#) forecast (in its [Global Energy Storage Outlook](#) report) that the 2020s would be a boom decade for the installation of energy storage – "the energy storage decade", with 1 TWh of energy storage capacity to be installed by 2030.

**Figure 1: Global cumulative energy storage installations, 2015-30**



Source: BloombergNEF. Note: MENA = Middle East & North Africa. Buffer represents markets and use-cases that we are unable to forecast due to lack of visibility.

The **Global Energy Storage Outlook** will be reported on in detail in the November and December Report on Reports to comprise the Appendix to Edition 33 of Low Carbon Pulse.

- **World's Largest HESS:** On November 17, 2021, Hefei Sinopower Technologies Co. Ltd announced that on November 13, 2021, plans to develop the Zhangjiakou 200 MW / 800 MWh HESS were progressing with the production of preliminary design for the project.

**See:** Hefei Sinopower Technologies Co. Ltd [website](#)

- **Whitelee Windfarm – first of a kind - HESS:** Edition [14](#) of Low Carbon Pulse reported on the Whitelee Windfarm, East Renfrewshire, Scotland. On November 22, 2021, [BBC](#) News reported that the UK Government is to provide funding support to allow the development and deployment of a Green Hydrogen production and storage facility to provide Green Hydrogen for public transport in Glasgow. The Green Hydrogen production and storage facility is being developed by BOC, ITM Power and Scottish Power, and involves the deployment of the UK's largest electrolyser yet, and the UK's first **HESS** (hydrogen energy storage system).

The UK's Energy and Climate Change Minister, Mr Greg Hands said: "*This first-of-a-kind hydrogen facility will put Scotland at the forefront of plans to make the UK a world leading hydrogen economy ... helping to decarbonise local transport ...*".

- **ARENA for BESS:** On November 22, 2021, it was reported widely that during December 2021, the Australian Renewable Energy Agency (**ARENA**) is to launch a funding round to allow the fast-tracking of the development and deployment of grid-scale **BESS** to continue the progress being made to ensure that by 2025 the Australian east-coast grid system is able to support the dispatch of 100% renewables to match load.

**See:** ARENA [website](#)

- **Long Duration Energy Storage:** One of the organisations established or launched at **COP-26** was the [Long Duration Energy Storage Council \(LDESC\)](#), comprising, among others, BP, Rio Tinto and Siemens.

**LDES** is **BESS** (typically using lithium-ion technology), that provides eight hours or more of electrical energy storage to nameplate output. While the need for **LDES** is known, both for use behind the meter and grid-scale, it remains the case that the roll-out of LDES is taking time.

Edition [13](#) of Low Carbon Pulse reported on the development of thinking around **LDES** as follows:

"In the recent **Energy Storage Summit USA 2021**, these issues were discussed, as were the factors that will inform the size of **BESS** by location, including the energy density per square kilometre. In this context, "long-range" **BESS**, having capacity to supply for over 6 hours, is likely to be used less in areas of higher energy density than areas of lower energy density because in areas of higher energy density land use and value is likely to be at a premium. Given these dynamics, it is apparent that a broad range of multi-faceted **BESS** solutions are likely to be developed, on grid, and off-grid, at meter, and behind the meter, including micro-grids.

In this brave new world of **BESS**, **BESS** storage of 10/12/24 hours is being contemplated for business users, and up to **72** hours for telecommunications companies, including to guard against the consequences of land-borne weather events."

The **LDESC** is seeking to mobilise the development of **LDES**.

On November 23, 2021, the **LDESC** and McKinsey & Co published a [report](#) on **LDES (LDES Report)**. The reported headline from the **LDES Report** is that to achieve net-zero across power grids by 2040, **BESS** nameplate capacity of 1.5 to 2.5 TW, with **LDES** output capacity of 85 – 140 TWh of **LDES** would be required.

The **LDES Report** is well-worth a read, and will be reported on in detail in the November and December Report on Reports to be contained in the Appendix to Edition 33 of Low Carbon Pulse.

- **CAESS (Compressed Air Energy System Storage):** Edition [20](#) and [21](#) of Low Carbon Pulse reported on the storage of energy using compressed air technology, and Editions [13](#) and [25](#) of Low Carbon Pulse have reported on long-duration energy storage (**LDES**).

On November 24, 2021, it was reported widely that Hydrostor is contemplating the development of a USD 800 million 400 MW / 3200 MWh **LDES CAESS**. The Hydrostor business model and technology involves the compression of air using off-peak, and surplus electrical, energy from the grid, to derive heat and to compress air (with the compressed air stored at a constant pressure), with compressed air and heat recombined to produce energy to drive a turbine to produce electrical energy for dispatch to the grid.

As noted in previous editions of Low Carbon Pulse, the vital statistics of 400 MW / 3,200 MWh mean that the contemplated **LDES CAESS** will be able to supply 400 MW of electrical energy for up to 8 hours.

Hydrostor is reported to have applied to the Californian Energy Commission, with the intention to commence commercial operation of the **LDES CAESS** by 2026.

- **BESS at Loy Yang Power Station:** On November 26, 2021, it was reported widely that AGL Energy (one of Australia's Big Three energy corporations) had received approval for a 200 MW / 800 MWh **BESS** to be developed at the site of AGL's Loy Yang power station (**Loy Yang BESS**) in the Australian State of Victoria.

In the land of the Big Battery, the development of the **Loy Yang BESS** will provide further strengthening of grid system integrity and stability as the grid system in Australia continues to progress to a 100% renewable electrical energy network, transitioning over time from coal-fired generation capacity.

It is understood that the development of the **Loy Yang BESS** is part of the roll-out by AGL Energy of 850 MW of "grid-scale" **BESSs**, including the 250 MW / 1000 MWh **BESS** being installed at Torrens Island, South Australia, and the approved 50 ME / 100 MWh **BESS** at Broken Hill, New South Wales and the planned 150 MW **BESS** at Liddell Power Station, in New South Wales' Hunter Valley.

**See:** [AGL firms up capacity with grid-scale battery in Victoria](#)

## CCS / CCUS:

- **Freeport LNG, Storegga and Talos Energy combine:** On November 16, 2021, [The Houston Chronicle](#), reported that Talos Energy had plans to develop the first carbon capture and storage facility on the Gulf Coast, in partnership with Freeport LNG and Storegga Geotechnologies. The Gulf Coast CCS would capture **CO<sub>2</sub>** arising at the Freeport LNG liquefaction and export facility, and other sources of **CO<sub>2</sub>**.
- **Summit Carbon progresses proposed CO<sub>2</sub> pipeline:** On November 17, 2021, it was reported widely that Summit Carbon Solutions is progressing the proposed development of a **CO<sub>2</sub>** pipeline in the US State of Iowa, with a longer term intention to develop a **CO<sub>2</sub>** pipeline system across five US States. It is to be expected, that **CO<sub>2</sub>** pipelines will be developed to haul **CO<sub>2</sub>** to points of storage and use.  
**See:** Summit Carbon Solutions [website](#)
- **SK Energy and Honeywell combine:** On November 22, 2021, it was reported widely that SK Innovation and Energy (part of the leading chaebol SK Energy) and Honeywell (leading technology solutions corporation) are to undertake a feasibility study to retrofit carbon capture units to capture **CO<sub>2</sub>** arising from an SK hydrogen production facility, located at SK's refining facilities in Ulsan, Republic of Korea. The use of carbon capture units would capture up to 400,000 metric tonnes of **CO<sub>2</sub>** a year, with the captured **CO<sub>2</sub>** reportedly to be injected into depleted natural gas reservoirs.  
**See:** [SK Innovation to Use Honeywell Technology for Carbon Capture And Sequestration Feasibility Study In Korea](#)
- **Air Liquide and BASF combine:** On November 22, 2021, Air Liquide (one of the big three industrial gas producers globally) and BASF (leading chemical producer) announced plans to develop what has been described as the "world's largest cross-border Carbon Capture and Storage (CCS) value chain".  
Air Liquide and BASF will develop jointly the Kairos@C project at the chemical facilities of BASF located in Antwerp, Belgium: at its core Kairos@C will capture **CO<sub>2</sub>**, liquefy it, transport and store it in sub-surface structures below the sea-bed of the North Sea, but as with the SK Energy / Honeywell combination, Kairos@C will retrofit existing production facilities with carbon capture units. The European Union Innovation Fund is to provide funding support for Kairos@C.  
**See:** [Air Liquide and BASF welcome support from European Innovation Fund for joint CCS project](#)
- **An IEA perspective on CCS:** On November 24, 2021, the International Energy Agency (**IEA**) released a commentary entitled [Carbon capture in 2021: Off and running or another false start?](#) The commentary is well-worth a read, providing a focused and pithy overview of the current state of play in CCS / CCUS.  
The commentary notes that in 2021 more than 100 CCS / CCUS projects have been announced and that "the global project pipeline for CO<sub>2</sub> capture capacity is on track to quadruple".  
Consistent with other **IEA** publications (and ongoing Low Carbon Pulse narratives), the importance of CCS / CCUS is again emphasised: " ... without CCUS we would have limited or no solutions for tackling emissions from heavy industry sectors, including cement. CCUS also provides a key option to address emissions from existing energy assets, to support a cost-competitive scaling up of low-carbon hydrogen production, and to remove carbon from the atmosphere".
- **Norwegian Continental Shelf in demand:** Edition [27](#) of Low Carbon Pulse reported on the process underway in respect of use of geological formations on the Norwegian Continental Shelf for carbon storage. The Norwegian Continental Shelf is regarded as highly-prospective in scale for the development of carbon storage.  
On November 24, 2021, Storegga Geotechnologies announced that it had entered into an agreement with Sval Energi to explore jointly opportunities for carbon storage on the Norwegian Continental Shelf.
- **Northern Lights gets green light:** Previous editions of Low Carbon Pulse have reported extensively on the size and scope, and progress, of the Longship Project, which includes the Northern Lights Project (see Editions [2](#), [11](#), [16](#), [17](#), and [19](#)).  
On November 26, 2021, the Northern Lights Project was included in the European Commission's proposed fifth list of Projects of Common Interest (**PCIs**). **PCI's** are key infrastructure projects intended to achieve the European Union's climate objectives. The Northern Lights, as a **PCI**, is a **CO<sub>2</sub>** capture, transportation and storage project.  
**See:** Northern Lights JV [website](#)

## Carbon credits and markets and Hydrogen markets:

- **Woodmac on the money:** On November 25, 2021, the ever excellent Wood Mackenzie's, The Edge, included an article entitled [Carbon Markets' COP-26 breakthrough – Why tighter rules on carbon credits will boost prices](#). In the article, the Chairman, Chief Analyst and author of The Edge, Mr Simon Flowers, outlines the key points of a conversation with Head of Carbon Research at Wood Mackenzie, Ms Elena Belletti, to discuss the significance of agreement on Article 6 of the Paris Agreement (see Editions [27](#) and [30](#) of Low Carbon Pulse).  
The views shared are "on the money", and are driving thinking of a number of countries with high-quality resources, now determined to achieve "gold-standard" carbon credits for sale globally. The article is well-worth a read.  
Before the end of January 2022, the author of Low Carbon Pulse will publish a stand-alone article on carbon credits and Article 6 of the Paris Agreement and the **Paris Rulebook**.
- **Hydrogen market coming into focus:** In the two weeks since the end of **COP-26**, and possibly a little before, commentary in articles and new items has started to provide an early narrative around the development of a hydrogen market.  
The high-water mark of this and related narratives has been provided by five position papers from Hydrogen Europe: **1.** European Trading System; **2.** Phasing out of ETS free allowances and Phasing in Carbon Border Adjustment Mechanism (**CBAM**); **3.** The ETS and Aviation; **4.** New separate ETS for the Building and Transport Sector; and **5.** Energy Taxation Directive from Hydrogen Europe, **under H2ero Net Zero – [Hydrogen Europe Position Papers – Reforming carbon markets to enable a liquid sustainable and affordable hydrogen market.](#)**

While the Papers focus on Europe, the thinking is clear and definitional. The November and December Report on Reports will consider each position paper, and other materials in the context of both carbon and hydrogen markets. The November and December Report on Reports will comprise the Appendix to Edition 33 of Low Carbon Pulse.

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

- **Brugg, Switzerland goes mobile:** On November 15, 2021, it was announced that Axpo is to develop a Green Hydrogen production facility co-located with its Wildegg-Brugg hydro-electric power plant. It is reported that the Green Hydrogen production facility will produce up to 2,000 metric tonnes of Green Hydrogen per annum, and that Axpo has contracted with off-takers of the Green Hydrogen for use in the mobility / transport sector.

**See:** [Axpo plans new green hydrogen production plant in Swiss town of Brugg](#)

- **Hornsea Two to power 100 MW electrolyser:** On November 15, 2021, it was reported widely that ITM Power, Ørsted, Phillips 66 and Element Energy (participants in the **Giga-stack Project**) have published a report on the progress in the development to deployment of Green Hydrogen production capacity, with a final investment decision (**FID**) expected within the next 18 months, and assuming a positive **FID**, achievement of commercial operation by 2025.

In summary, Hornsea Two is the world's largest off-shore wind field, and it will provide the renewable electrical energy to the Phillips 66 Humber Refinery to displace fossil fuels currently being used to power its heaters.

- **AquaVentus joined by a further 8 corporations:** Editions [16](#), [17](#), [21](#), [23](#), and [26](#) have reported on and described in detail the AquaVentus project - the 10 GW off-shore wind field to hydrogen project.

On November 16, 2021 the AquaVentus consortium announced that it had been joined by a further eight corporations in various capacities, including GICON®-Großmann Ingenieur Consult GmbH, Heerema Marine Contractors SE, Neptune Energy, Noordgastransport B.V. (NOGAT BV and NGT BV), Ptx Development BmbH, Ramboll and Saipem.

**See:** AquaVentus [website](#)

- **Proposed 1.3 GW hydrogen export facility in Sarawak, Malaysia:** On November 16, 2021, [pvmagazine](#), reported that H2X and Thales New Energy (both Australian based corporations) had signed a memorandum of understanding (**MOU**) with the Sarawak Economic Development Corporation subsidiary, SEDC Energy.

It is reported that the **MOU** contemplates the establishment of an incorporated joint venture to develop the Samalaju Hydrogen Production Facility, with a reported capacity of 1.3 GW and as such the ability to produce as much as 170,000 metric tonnes of hydrogen a year, or 970,000 metric tonnes of ammonia.

- **Shelling out for Largest Green Hydrogen Facility:** On November 19, 2021, [hydrogen central](#) reported that Shell wants to develop the largest Green Hydrogen production facility in the world at Maasvlakte. The design of the facility is what has captured the headlines.



- **Vision and Energy:** On November 22, 2021, it was reported widely that Vision Hydrogen and Virya Energy have been granted approvals to develop a Green Hydrogen production facility in the Port of Terneuzen, the Netherlands. It is understood that initially the production capacity of the facility will be 26 MW (3,500 metric tonnes of Green Hydrogen a year) with the intention to increase the production capacity to 75 MW (10,500 metric tonnes of Green Hydrogen a year).

**See:** [Vision Hydrogen And Virya Energy Awarded Permits For Scalable 25-75 MW Green Hydrogen Production Facility](#)

- **Indian Oil Corporation Limited (IOCL) to green refining:** On November 22, 2021 it was reported widely that **IOCL** (state-owned oil and gas corporation) is to procure Green Hydrogen production facilities to be located at its refineries at Mathura, Uttar Pradesh and Panipat, Haryana. One of the principal uses of grey hydrogen produced currently is for the purposes of refining oil.

**See:** IOCL [website](#)

- **Redefining recycling thinking:** On November 23, 2021, it was reported widely that Shell is to develop and to deploy a pyrolysis upgrader unit to take plastic waste as feedstock to derive chemicals. While this technology is proven, its use to apply pyrolysis may be regarded as progress. It is reported that that the pyrolysis upgrader unit is part of a broader development to establish a Shell Energy and Chemical Park in Singapore.

The development of the Shell Energy and Chemical Park, and bio-based fuels and feedstocks to be derived and produced there, reflects the Sustainable Jurong Island [initiative](#) published by the Singapore Economic Development Board on November 23, 2021. The initiative includes the capture of 2 million metric tonnes of carbon capture by 2030. It would be wonderful for a partnership or a series of partnerships to develop between Shell and Governments to target the collection of plastics for use as feedstock.

**See:** [Investment in Shell Energy and Chemical Park Singapore to Bring Circular Chemicals to Asia Pacific Customers](#)

- Rehydned thinking:** On November 24, 2021 the Refhyne project (among others, see Editions [21](#) and [22](#) of Low Carbon Pulse) reported on economic findings and policy setting thinking following the development and deployment of 10 MW electrolyser at the Shell Refinery.
 

The core of the published findings are of no surprise: "*Electrolysers face a trade-off-between high fixed cost and low load factors and high electricity cost at high load factors*".

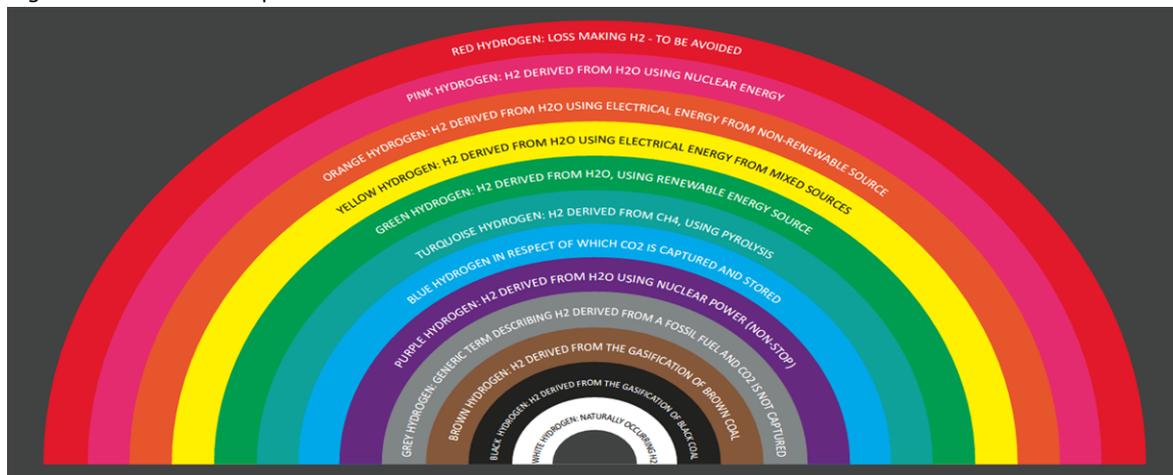
The central conclusion is that for the economics of an electrolyser to be sustainable the electrolyser must be able to run at base load to be able to achieve a €4 per kg of hydrogen produced (assuming zero levy or tax on the electrical energy used).

**See:** [Brief summary report on initial policy implications of the bulk electrolyser model](#)
- Edify and Port of Townsville:** On November 24, 2021, it was reported widely that Edify (leading renewable energy project developer) and the Port of Townsville had signed a memorandum of understanding (**MOU**) for the purpose of working together to investigate the export of hydrogen.
 

It is expected that the work under the **MOU** will concentrate on the export of Green Hydrogen produced by Edify's proposed, and recently approved, 1 GW electrolyser, with capacity to produce up to 150,000 metric tonnes per annum of Green Hydrogen (see Edition [17](#) of Low Carbon Pulse). Edify's Green Hydrogen production facility is to be located in the Lansdown Eco-Industrial Precinct, 46 km south of Townsville.

**See:** [Edify's MoU with Port of Townsville to advance Hydrogen Export](#); [Hydrogen Export Plans Boost for Jobs](#)
- UK considering hydrogen from nuclear:** As noted under, **Hydrogen Gets Big Billing**, above, the US is to use nuclear power and likely steam to produce hydrogen.
 

On November 26, 2021, [H2-view](#), reported that the UK is considering the introduction of "nuclear derived hydrogen" in the context of policy setting decisions to be made on the role of hydrogen in buildings (ambient and water heating). The National Nuclear Laboratory (**NNL**) and DNV are working together to discern the basis on which nuclear derived hydrogen could be scaled up the GW scale.



- EQTEC and Wood ink blue:** Previous editions of Low Carbon Pulse have reported extensively on projects to derive and to produce hydrogen and natural gas, and sibling publication, [Hydrogen for Industry \(H24I\) Feature 1: Hydrogen from Waste](#), outlined the use of waste and waste water to derive and to produce hydrogen. As noted in the **H24I** feature, waste (and waste water) provides a viable source of feedstock for the derivation and production of hydrogen and biogas (and further processed biomethane).
 

On November 26, 2021, it was reported widely, that EQTEC and Wood had concluded a strategic collaboration agreement to pursue waste-to-hydrogen and waste-to-synthetic natural gas (**SNG**) developments.

**See:** EQTEC [website](#); Wood [website](#)
- Tokyo Gas and Mitsubishi Corporation combine:** On November 26, 2021, [hydrogen central](#), reported that Tokyo Gas Co. Ltd. (**TG**) and Mitsubishi Corporation (**MC**) had announced that they were exploring joint feasibility in the procurement and supply of synthetic methane, i.e., synthetic natural gas. It is understood that **TG** and **MC** are focusing on the feasibility of synthetic methane produced using the combination of Green Hydrogen and **CO<sub>2</sub>**.
 

The background to this is policy based: for Japan to achieve **NZE** by 2050, among other things, the heating industry needs to be decarbonised. In this context, Japan's Strategic Energy Plan contemplates the replacement of natural gas with synthetic methane. Of course, while the production of synthetic methane may be **GHG** emission free (depending on the source of the **CO<sub>2</sub>**), the combustion / oxidation of synthetic methane is not **GHG** emission free.

## Green Metals / Minerals, Mining and Difficult to Decarbonize industries:

**Miners pursue green coals:** In November 2021, TotalEnergies posted [Saft magazine # 42 – Sustainable Mining](#). A link to the Saft is attached. The article focuses on the role, in fact the increasing role, of energy storage systems at mine sites, and the progress towards the displacement of diesel generation capacity.

## Hydrogen - Cities, Clusters and Hubs, Giga-Factories, and Valleys:

- Hydrogen Hub at the Port of Newcastle:** On November 15, 2021, it was reported widely that Macquarie Group (through its Green Investment Group), Jemena and Snowy Hydro are considering the feasibility of the development of a Green Hydrogen Hub in the New South Wales, Australia, City of Newcastle.

It is understood that the feasibility study will assess the viability of the development of a Green Hydrogen Hub, using a 40 MW electrolyser in the first instance, but assessing expansion of Green Hydrogen production capacity of up to 1 GW by 2030. The Australian Renewable Energy Agency (**ARENA**) is providing funding support for the feasibility study.

- **Aberdeen to be world's first 100% hydrogen powered city:** On November 19, 2021, [energyvoice](#) reported on plans to make Aberdeen the world's first hydrogen powered city by 2030. Gas network corporation, SGN, has published a roadmap outlining the role that clean-fuel can play in decarbonising energy, and sets out an accelerated pathway for Aberdeen.
- **Ballard, Caterpillar and Microsoft combine:** On November 22, 2021, it was reported widely that Ballard Power Systems, Caterpillar Inc and Microsoft are to demonstrate a back-up power system that will use fuel cell technology to provide reliable and sustainable back-up power systems for data-centres. Ballard Power will provide the fuel cell technology, Caterpillar the control systems and Microsoft the data-centre design team.

**See:** [Ballard teams up with Caterpillar & Microsoft to demonstrate megawatt-scale hydrogen fuel cell backup generator system for datacenters](#); [Caterpillar to Launch Demonstration Project Using Hydrogen Fuel Cell Technology for Backup Power at Microsoft Data Center](#)

## Off-shore wind round-up:

- **Morro Bay, California designated for OWF:** Edition [23](#) of Low Carbon Pulse reported on the likely designation of Morro Bay, California for the development of off-shore wind field development. On November 15, 2021, the Bureau of Ocean Energy Management (**BOEM**) designated an area of 376 square miles in Morro Bay for the purposes of the development of off-shore wind field capacity. The area is around 20 miles off the coast of California.
- **Italy awash with floaters:** Edition [30](#) of Low Carbon Pulse reported on the highly prospective off-shore wind field resources in Italian waters. On November 22, 2021, it was reported widely that the Ministry of Ecological Transition had received 64 expressions of interest (**EOI's**) to develop and to deploy off-shore floating wind field projects. It is reported that 55 **EOI's** were received from corporations, three from environmental protection organisations, and seven from other organisations.
- **71,000 GW opportunity:** On November 23, 2021, the author of Low Carbon Pulse came across a representation conveying the scale, and the size of the prize, of the development of off-shore wind capacity. The headline accompanying the graphic is: "**When you work in #Offshorewind the world looks like this: 115 countries with a 71,000 GW opportunity to combat #climatecrises!**".



- **Singapore Enterprize Energy energizes overseas:** On November 22, 2021, it was reported widely that Singapore based off-shore wind field developer, Enterprise Energy, intends to develop a USD 10 billion wind field off the Republic of Ireland.
- **Germany to increase offshore wind field development:** Edition [23](#) of Low Carbon Pulse reported that during 2021, installation of off-shore wind field capacity had stalled. On November 24, 2021, the new coalition government (comprising Social Democrats, Greens and Free Democrats) announced plans to increase the targets for the installation of offshore wind field development as follows: 30 GW by 2030 (an increase of 10 GW from the previous 20 GW), 40 GW by 2035, and 70 GW by 2045. In addition to offshore wind field capacity development, 200 GW of photovoltaic solar is planned by 2030, and 2% of the land mass of Germany is to be designated for onshore wind farm development.
- **Thor Offshore Lottery:** On November 25, 2021, the Danish Energy Agency (**DEA**) announced that the award of the 1 GW Thor offshore wind field (**Thor OWF**) project will be decided by a lottery. It is understood the multiple bidders, including heavy weight consortiums, Copenhagen Infrastructure Partners and SSE, Iberdrola and Total Energies, Ørsted and RWE, Swan Wind (Eneco and European Energy) and Vattenfall, are to draw lots for the award. The **Thor OWF** project is to be developed by the winner of the lottery without any Government support in the form of a subsidy. The **DEA** announced that: "*More than one bidder has offered to build Thor offshore wind farm with a capacity of 1,000 MW at the minimum price of Dkr0.10 / MWh, and the tender will therefore, in accordance with the tender conditions, be decided by drawing lots*". The drawing of lots will take place on December 1, 2021.
- **Second US Off-shore approval:** On November 25, 2021, it was reported widely, that the US Department of the Interior (**DOI**) has approved the construction and the operation of Ørsted Offshore North America and Eversource's 132 MW South Fork off-shore wind field project, off the coast of Rhode Island (see Edition [8](#) of Low Carbon Pulse).

The Record of Decision (**ROD**) issued by the Bureau of Ocean Energy Management (**BOEM**) contains the terms of the decision to approve South Fork.

In March 2021, the **DOI** approved the first off-shore wind field – the 804 MW Vineyard Wind 1 project (see Editions [12](#) and [13](#) of Low Carbon Pulse), and on November 19, 2021 was reported to have held a ground breaking ceremony, at Covell's Beach, Barnstable.

While noted before in Low Carbon Pulse that the US is not as progressed as some other countries in off-shore wind field development this appears to be changing, at a rate of knots: US Secretary of the Interior, Ms Deb Haaland is reported to have said:

*"Just one year ago, there were no large-scale off-shore wind projects approved in federal states of the United States. Today there are two, with several more on the horizon".*

## Solar and sustainable:

- **EDF afloat in Laos:** On November 16, 2021, [pvmagazine](#) reported that EDF (leading energy cooperation headquartered in France) intends to develop a 240 MW floating photovoltaic solar farm to be located on the largest hydroelectric dam in Laos, providing water for the Nam Theun hydro-electric power station. The 240 MW photovoltaic project, the Nam Theun 2 Solar Project, will cover an area of 3.2 km<sup>2</sup> less than 1% of the area of the water dammed.
- **Buffett and Gates go nuclear:** Edition [19](#) of Low Carbon Pulse reported on the plans of industry and investment titans Warren Buffet and Bill Gates to develop a nuclear power plant in Kemmerer, Wyoming. Subject to obtaining all approvals, TerraPower is to develop a USD 4 billion 345 MW nuclear power plant, about 130 miles northeast of Salt Lake City, Utah. The nuclear power plant, deploying a relatively small Sodium reactor, based on the technology used in nuclear submarines, will have a short build period, be cheaper to build, and both cheaper and safer to operate than larger conventional nuclear power plants.
- **ADB and PetroVietnam alignment:** On November 18, 2021, [vietnamplus](#) reported that the Asian Development Bank (**ADB**) and the Vietnam Oil and Gas Group (**PetroVietnam**) had signed a Memorandum of Understanding (**MOU**) to establish a strategic partnership, covering the period 2021 to 2024, to promote clean and renewable energy development and deployment, and in so doing assist **PetroVietnam** achieve **GHG** emission reduction targets, principally **NZE** by 2050.
- **Geothermal – A Summary:** In November, 2021, the Global Geothermal Alliance, IDB and IRENA published, [Geothermal: The Solution Underneath](#). The publication provides a useful summary. The publication will be summarised in the November and December Report on Reports, to be contained in the Appendix to Edition 33 of Low Carbon Pulse.
- **A mix of Oil and Sun:** On November 23, 2021, [Africanews](#), reported that TotalEnergies is to develop 500 MW of photovoltaic solar capacity in Libya, working with the Libyan Government.
- **Enel to add 84 GW of renewables by 2030:** On November 24, 2021, Enel (leading international renewables corporation) announced that it was to invest around €70 billion (USD 78 billion) to scale up its renewable electrical energy and **BESS** portfolio by 2030, and in doing so develop 84 GW of new renewable capacity, such that by 2030 Enel will have a total of 129 GW of renewables capacity. Of the additional 84 GW of new renewable capacity, 43 GW is to be photovoltaic solar, with 9 GW of **BESS**.

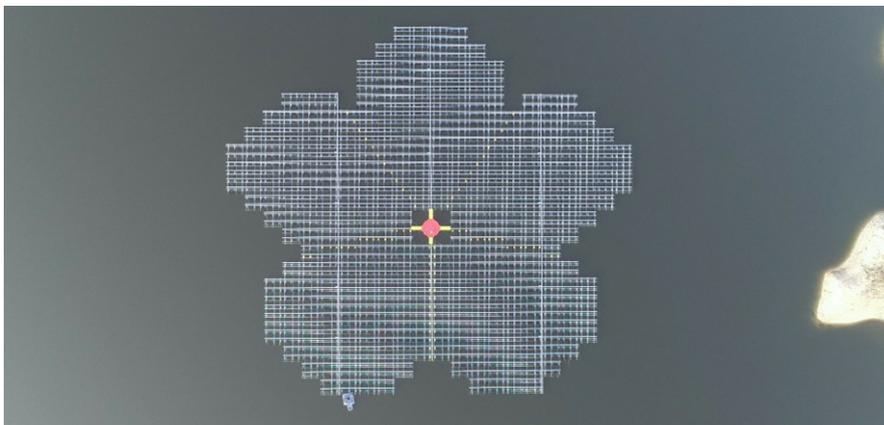
**See:** [Enel, the road to 2030 in the 2022–2024 Strategic Plan: powering investments towards zero emissions with focus on the electrification of customer energy demand](#)

- **Vinci verges green:** Edition [14](#) of Low Carbon Pulse reported on plans in the Republic of Korea to develop photovoltaic solar facilities along linear transport routes. On November 24, 2021, Vinci Group announced plans to install photovoltaic solar facilities along unused areas for land along freeways / motorways in France. It is reported that Vinci Group will partner with Tryba Energy to develop and to deploy the facilities.

As with the initiative in the Republic of Korea, the Vinci Group initiative is significant in that land is being used to generate renewable electrical energy, and the development and deployment of like initiatives consistently along linear transport routes more broadly will deliver significant additional renewable energy capacity at speed.

**See:** Vinci Autoroute [website](#)

- **Scotra flowers:** Edition [12](#) of Low Carbon Pulse reported on the development of floating photovoltaic solar projects across the Republic of Korea. On November 26, 2021, [pv magazine](#), reported that South Korea's largest floating photovoltaic solar facility had come on line. Scotra (the South Korean developer), using solar modules provided by Hanwha Q-Cells, has deployed the 41 MW floating photovoltaic solar facility. The floating facility is configured in the shape of a flower.



The floating flower facility is the largest floating facility deployed in the Republic of Korea. Scotra developed the 24 MW floating photovoltaic solar facility on a reservoir in Goheung county, Jeollanam-do, and the 500 kW pilot floating facility on Hapcheon.

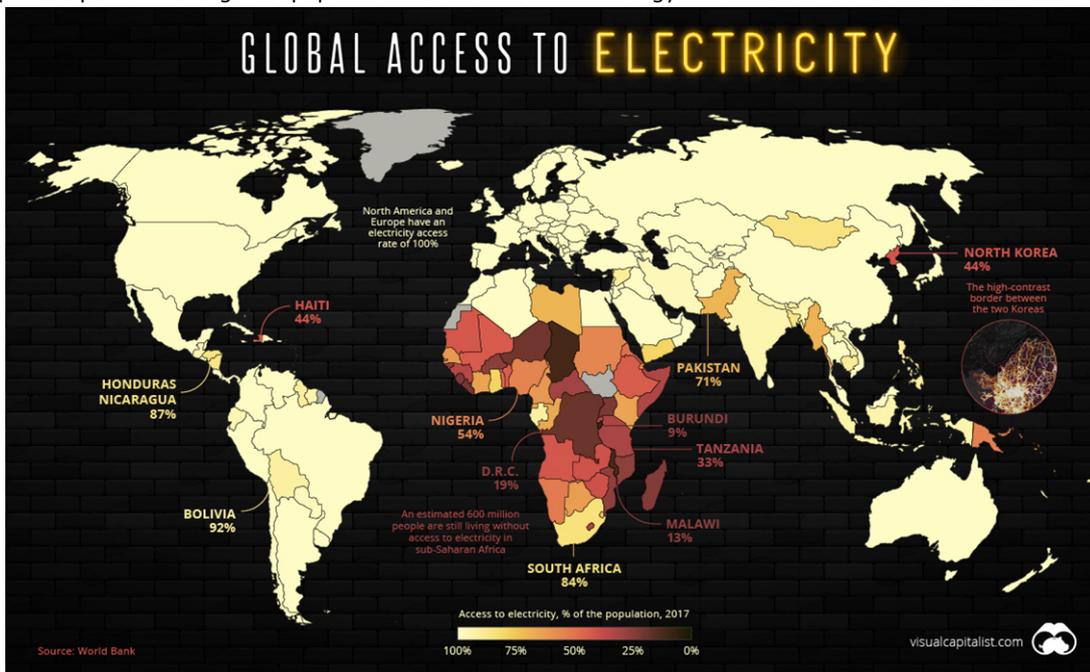
- **BASF Goes Green:** On November 26, 2021, [rechargenews](#), reported that BASF has formed its own renewables business to allow effective management of its projected increased demand for green energy / power.
- **Continued electrification:** One of the tensions that exists around the achievement of progress towards **NZE** is that at the same time that renewable electrical energy capacity is being developed and deployed to displace existing fossil fuel capacity and to allow the production of Green Hydrogen and hydrogen-based fuels, the population of the world continues to increase and to urbanise.

While confronting, it is often helpful to reflect upon the scale of the task to develop renewable electrical energy capacity:

1. to retire fossil fuelled power generation capacity and to replace it with renewable electrical energy capacity;
2. to develop and to deploy renewable electrical energy to derive and to produce hydrogen and hydrogen-based fuels; and
3. to develop and deploy renewable electrical energy to those in the world that currently do not have it.

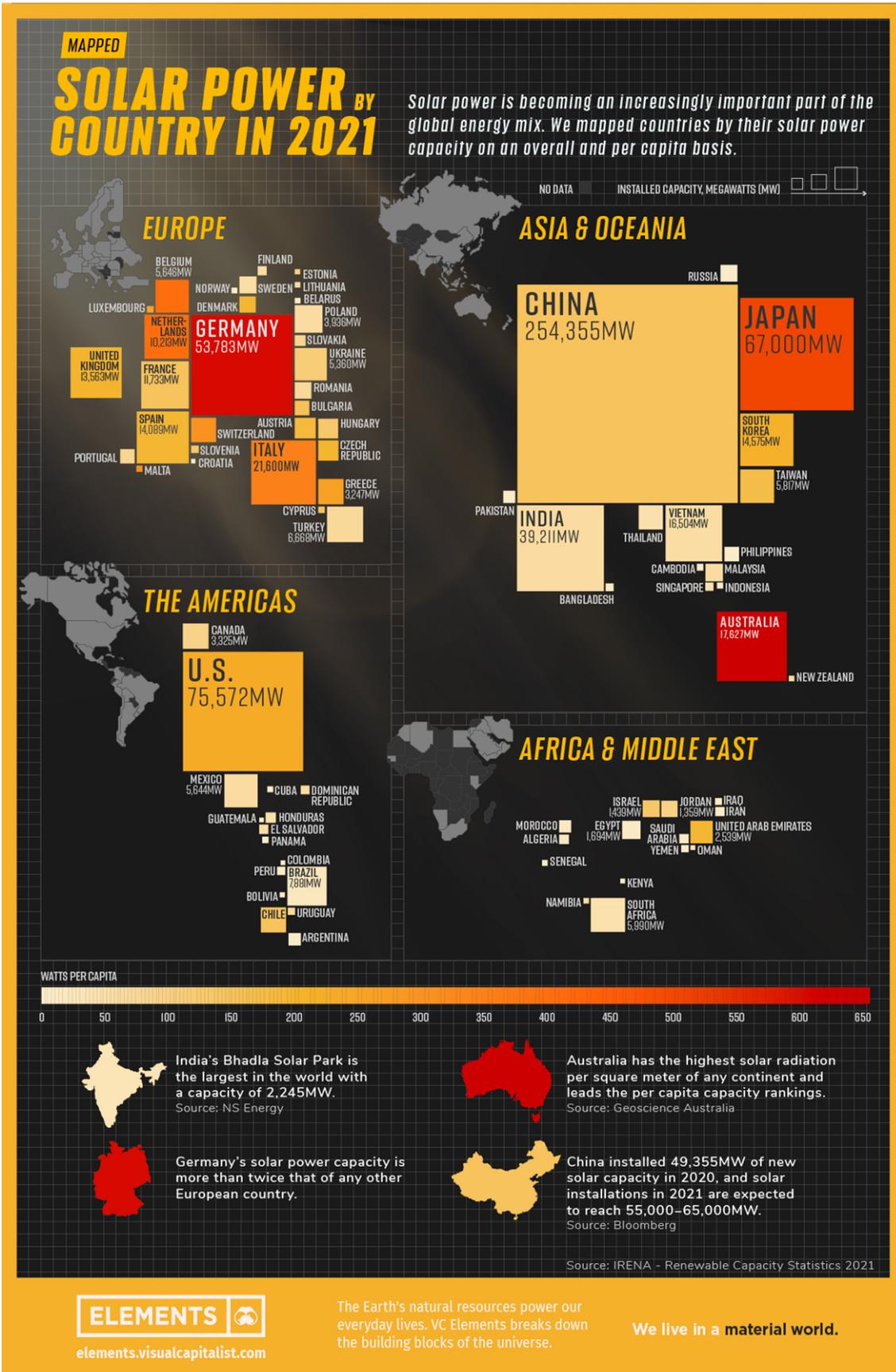
With the increase in population, the number of people without access to electrical energy will increase. At the moment, there are a number of estimates of how many people currently do not have access to electrical energy with a range of between 800 million to 1.2 billion from different sources.

Without wishing to debate the actual number of people, the graphic below provides a fair representation of the geographical spread of the global population without electrical energy.



- **Progress check around the world on photovoltaic solar installation and plans:**
  - The new coalition Government in Germany has indicated that it intends to develop and to deploy an additional 143.5 GW of photovoltaic solar capacity by 2030;
  - The Polish research institute, Instytut Energetyki Odnawialnej, has estimated that Poland will have developed and deployed 30 GW of photovoltaic solar capacity by 2030;
  - In the first nine months of 2021 around:
    - 2 GW of photovoltaic solar capacity has been deployed in France; and
    - 2.82 GW of photovoltaic solar capacity has been deployed in the Republic of Korea; and
  - In Belgium, the EnergyVille, has reported that the potential for roof-top photovoltaic solar is close to 100 GW.
- **Community Energy Toolkit:** In November 2021, the International Renewable Energy Agency (**IRENA**) published a paper, entitled [Community Energy Toolkit: Best practices for broadening the ownership of renewables](#) that outlines how communities may participate actively in energy decision-making around the world, and in so doing harness the benefits of the energy transition.

- Photovoltaic solar mapped by country:** In one of the clearest and cleverest graphics from the good folk at the Visual Capitalist, the following map graphic provides a summary of the photovoltaic solar capacity installed by countries in 2021.



## NZE Waste:

- **The concept of NZE Waste:** Edition 29 of Low Carbon Pulse introduced the concept of Net Zero Emission Waste **NZE Waste**, being waste that: "arises from the extraction, manufacture, transportation and use of equipment and infrastructure developed for the purposes of reducing **GHG** emissions, including on the extraction of metals and minerals used in the manufacture of solar panels and wind towers and turbines, and energy storage systems (including BESSs) on the manufacture of those panels, towers and turbines, and systems, and on recovery and recycling of resources from them at the end of their life-cycles, and the means of disposal of any material that cannot be recovered or recycled".

While **NZE Waste** is not yet as recognised as a term of art, and named as such, the need to develop an effective **NZE Waste** management system is recognised. In recognition of the need to develop an effective **NZE Waste** management system, this edition (and future editions of) Low Carbon Pulse will include a section on **NZE Waste**.

While it is unlikely that the **NZE Waste** section of Low Carbon Pulse will contain the same level of content as other sections, it is nevertheless important – if you will, book-ending the news items on green mining and giga-factories.

- **The Dark Side of Solar Power:** In June 2021, the Harvard Business Review, contained an insightful article from authors Atalay Atasu, Serasu Duran and Luk N. Van Wassenhove, with the article entitled [The Dark Side of Solar Power](#). The article takes a clear perspective, and it is well-worth a read. Among, other things, the article refers to the International Renewable Energy Agency Report (**IRENA**) from 2016 that anticipated the need to address the [End-of-life management Solar Photovoltaic Panels](#). Of course the effective waste management of photovoltaic solar panels, is but one part of the effective management of **NZE Waste**.
- **Northvolt recharging:** In November 15, 2021, it was announced that Northvolt produced a lithium-ion battery using recycled metal. Northvolt has announced that it is able to recover up to 95% of metals from a battery, and in so doing reducing demand for newly mined metals.

**See:** [Northvolt produces first fully recycled battery cell – looks towards establishing 125,000 ton/year qiga recycling plant](#)

- **Aker Offshore Wind recycling wind-blades:** On November 24, 2021 it was announced that a pilot project is to commence to provide the UK with its first wind blade turbine recycling plant.

Aker Offshore Wind, working with researchers from the Advanced Composites Group and Lightweight Manufacturing Centre at the University of Strathclyde (part of the National Manufacturing Institute Scotland Group) and trade body Composites UK, are to oversee the development of a viable solution that can be implemented commercially at scale. The oversight group will work with other partners from Cubis (composite part manufacturer), GRP Solutions (composite distributor), Nottingham University and global waste management company SUEZ.

## Land Mobility and Transport:

- **California Energy Commission (CEC) backs Hydrogen Infrastructure:** On November 16, 2021, the CEC approved a USD 1.4 billion funding support plan to allow the development and deployment of zero-emission mobility / transport infrastructure and manufacturing with hydrogen as the focus. Among other things, the funding support is intended to enable California to achieve its recharging and refuelling targets by 2025.



## Ports Progress and Shipping Forecast:

- **Shoreham aligns with Getech:** On November 15, 2021 it was announced that Shoreham Port, UK had contracted with Getech subsidiary, G2 Green, with G2 Green to develop all of the port-based hydrogen and ammonia production and storage facilities, and associated renewable electrical energy capacity at the Port of Shoreham.

**See:** Shoreham Port [website](#)

- **Yara first:** 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".

The Yara Birkeland was developed in collaboration with Kongsberg Group and was built by VARD, and will transport mineral fertiliser between Porsgrunn and Brevik.

**See:** [Yara to start operating the world's first fully emission-free container ship](#)

- **Shanghai Port first:** On November 25, 2021, it was reported widely that Shanghai Port has commenced trials of the first mobile crane powered and propelled using hydrogen fuel cell (**FC**) technology.

- **Port of Narvik first:** On November 25, 2021, it was reported widely that the Port of Narvik, Norway, is seeking to work with project partners to develop a high-speed workboat powered and propelled by **FC** technology from TECO 2030 and built by Grovfjord Mekaniske Verksted.

- **Gaussin and Nexport moving goods south:** Edition [1](#) of Low Carbon Pulse reported as follows: "The French corporation, Gaussin, has unveiled two new vehicles for use in logistics ports – the ATM-H2 and the APM-H2. Vehicles used in logistics and port hubs are viewed as being more than likely to transition from the use of fossil fuels to hydrogen. The ATM-H2 has a towing capacity of 38 tonnes (for use in logistics hubs) and the APM-H2 has a pulling capacity of 75 tonnes (for use in the movement of containers at container terminals). These vehicles use a fuel cell that combines hydrogen with oxygen to produce electrical energy."

On November 25, 2021, it was reported that GAUSSIN and Nexport had signed a joint venture agreement to allow exclusive licensing and manufacturing to supply of zero-emissions vehicles (**ZEVs**) and systems and technology into the Australian and New Zealand markets, including **ZEVs** to be supplied for use at airports, logistics hubs and terminals and at port terminals.

- **Reflections on COP-26 for the Shipping Sector:** On November 26, 2021, Head of Regulatory Affairs at the Mærsk Mc-Kinney Møller Center for Zero Carbon, Mr Jan-Christoph Napierski published [Global decarbonisation after the COP – new hope for zero by 2050?](#), detailing the four central take-aways from COP:

1. Global zero as a new target for IMO;

2. The continued activity of private stakeholders in the shipping sector, reflecting in the activity before COP, including the [Getting to Zero Coalition](#), and the [Cargo Owners for Zero Emission Vessels](#);

3. The [Clydebank Declaration](#) (see Edition [30](#) of Low Carbon Pulse); and

4. The broader engagement of the shipping sector with particular progress around the Zero Emission Shipping Mission within the framework of Mission Innovation (see Editions [19](#) and [30](#) of Low Carbon Pulse).

As with all thought-leadership from Mærsk Mc-Kinney Møller Center for Zero Carbon, the reflections of Mr Napierski are clear and direct, including the following summary:

"COP 26 in Glasgow was a landmark for the decarbonization of shipping. The formal agreement may seem thin but many other initiatives have created a global momentum that cannot be ignored anymore. This creates hope, also for the heavy discussions on Market Based Measures going on right now in the IMO's 77th session in the Marine Environment Protection Committee".

- **A.P. Moller – Maersk looks to hydrogen:** Edition [26](#) of Low Carbon Pulse (under **A.P. Moller – Maersk: fleet of foot**) reported, in detail, on the decision by A.P. Moller-Maersk to procure container vessels powered and propelled by dual fuel engines, fuel oil and low-carbon methanol.

On November 26, 2021 it was reported widely that A.P. Moller-Maersk was seeking to secure supplies of Green Methanol (noting that Edition [26](#) stated that the supply of low-carbon methanol was critical), and is assessing the use of hydrogen as a fuel to power and to propel vessels in its fleet.

Head of Future Fuels at A.P. Moller-Maersk, Ms Maria Strandesen, noted that Green Methanol remained the decarbonisation fuel of choice, and that hydrogen could be used for certain vessels: "We are looking at our vessels that have a maximum roundtrip of 2,000 km – we don't have many of those – but we do have a few there [and] we are ... looking [at] whether hydrogen could be used as fuel."

For longer activities hydrogen by deep-sea going vessels hydrogen is not regarded as a viable option because the energy density of hydrogen is such that it will take up valuable cargo space. Ms Strandesen noted that hydrogen would take up as much as 15 times the tankage of current fuels.

## Land Mobility and Transport and Airports and Aviation lite:

As has been the case in respect of other Editions of Low Carbon Pulse, while there are news items relating to **Land Mobility and Transport** and **Airports and Aviation** in the period covered by this Edition 31 of Low Carbon Pulse, in order to manage the length of this Edition 31, Edition 32 will combine those news items with news items arising to December 17, 2021, the date on which Edition 32 will be published.

## NZE reports:

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

ORGANISATION	TITLE / SUBJECT MATTER
Australian Renewable Energy Agency	<a href="#"><u><i>Australia's Bioenergy Roadmap Report</i></u></a>
Global Geothermal Alliance, IDB, and International Renewable Energy Agency ( <b>IRENA</b> )	<a href="#"><u><i>Geothermal: The Solution Underneath</i></u></a>
Hydrogen Europe	<a href="#"><u><i>Reforming carbon markets to enable a liquid, sustainable and affordable hydrogen market</i></u></a>
HySupply	<a href="#"><u><i>The Case for an Australian Hydrogen Export Market to Germany: State of Play Version 1.0</i></u></a>
International Renewable Energy Agency ( <b>IRENA</b> )	<a href="#"><u><i>Community Energy Toolkit: Best practices for broadening the ownership of renewables</i></u></a>
Journal of Geophysical Research: Biogeosciences	<a href="#"><u><i>Annual Tropical-Rainforest Productivity Through Two Decades: Complex Responses to Climatic Factors, [CO<sub>2</sub>] and Storm Damage</i></u></a>
Long Duration Energy Storage Council and McKinsey & Co.	<a href="#"><u><i>Net-Zero Power: Long duration energy storage for a renewable grid</i></u></a>
Nature Sustainability	<a href="#"><u><i>Mapping the irrecoverable carbon in Earth's ecosystems</i></u></a>
Queensland Government	<a href="#"><u><i>Consultation on the model for QREZ design and access – Delivering Queensland Renewable Energy Zones</i></u></a>

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