Can Hydrogen Store Aeolus's Power?

In the race to reduce carbon emissions and substitute fossil fuels using net zero technologies, over the last 20 years many initiatives have taken place all over the world to deploy greener solutions. Though impressive, the acceleration of renewable energy is insufficient to compensate fully for the levels required by our growing society. Energy transition is very complex, and COP26 highlighted the difficulties in combining countries' developments, the reduction of carbon emissions, and exposed 'political decisions' as not always taking into consideration the overall picture. That, without mentioning the post-Covid increase in energy demand, and the increased price of oil and gas forcing the reactivation of coal-powered centrals to meet the demand.

Many power designers have high hopes for the promising nuclear fusion technology, but until that technology delivers on promises, then conventional renewable energies, mainly solar and wind will continue to expand, implying the need for and the development of Long Duration Energy Storage (LDES) in order to optimize energy generated at any time being able to supply the grid in a balanced manner. LDES is a very interesting area and if we all have in mine batteries to store energy, then when considering storing multi-megawatts, other solutions must be explored and in that respect hydrogen is gaining a lot of attention (Figure 01 – next page).

From fully controlled to variable energy supply

For centuries the electricity produced by conventional power stations, coal, oil, gas, nuclear and hydro delivered stable and well controlled energy to the grid. Electricity Network Operators (ENO) were able to balance the production to meet the demand with good accuracy and stability. The introduction of sources of energy that depend on meteorological conditions modified the landscape of energy management and its predictability,

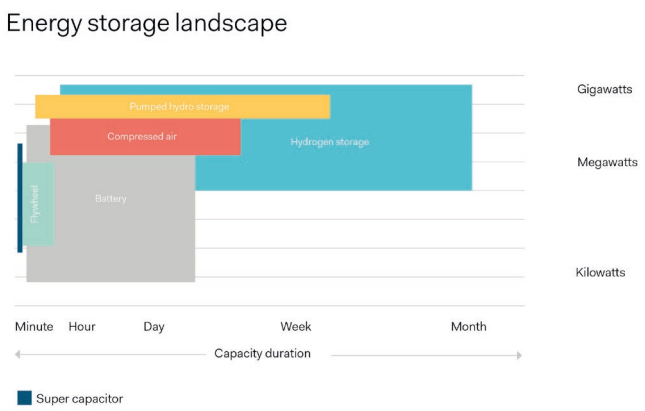

Figure 01 – Simplified energy storage landscape – Source PRBX/IEA

requiring ENO to add a variable into an equation, making 'simple', 'complex'. The complexity increased when the amount of renewable energy exceeds the demand, or when the forecasted supply does not reach expectations due to weather conditions. So what is the situation today and why do we need to consider LDES?

The Aeolus's power and Achilles' tendon!
Based on the latest International Energy Agency report, the amount of electricity generated by wind increased by almost +11% (170 TWh) in 2020, generating 1 592 TWh. This growth relies on a large deployment in China and USA, though significant projects in Europe are also taking place with many high power wind farms such as the Swedish onshore Markbygden 1101 wind farms, which when completed is expected to generate up to 3.4GW, supplying 8% of the Swedish electricity and becoming a player in green hydrogen (Figure 02).

Figure 02 – Wind-farm Markbygden 1101 up-North Sweden deploying more than 1100 wind turbines (Picture: PRBX / Courtesy of Svevind AB Markbygden 1101)

The high demand for renewable energy motivated wind turbine manufacturers to develop mega turbines for offshore wind farms. Leading wind turbine manufacturers developed gigantic generators delivering more than 14-megawatts, measuring 280 meters tall, with blades spanning of 115.5 meters, with a total height almost as taller than the iconic Eiffel Tower! Energy output from a single turbine is expected to deliver enough power to supply 20,000 households and save the equivalent of 9,000 vehicles' emissions in a year. Many projects using mega wind turbines have been approved e.g. the Dogger Bank Wind Farm located 130km from the North East coast of England, which when completed will deliver 3.6GW and will be capable of powering up to 6 million homes. Similar offshore projects are taking place in Denmark, the Netherlands, and the Baltic Sea.

As already mentioned, managing renewable energy to match demand is very complex and in addition to weather conditions, ENO are facing price challenges in a very competitive market. We've all noticed wind turbines in standby when wind conditions are excellent and asked ourselves why is that? This often happens when supply exceeds demand, dropping the price below the break even level, or when the grid is unable to accommodate an excess of supply. Also, at night when the demand is low and wind is good, conventional wind farms are operated at low efficiency, which of course is a pity. In such conditions, it would be much better to store the excess of available energy or convert it into hydrogen.

It's taken for granted that the wind will always blow and be enough to generate gigawatts of electricity, but that may no longer be the case. From April to September 2021, Europe experienced a long period of dry conditions and low wind speeds. A UK-based power company stated that their renewable assets produced 32% less power than expected, and Germany was forced to switch on several coal power stations. It's too early to determine if this is an effect of climate change, but research conducted by H C Bloomfield and its team in 2018 raised concerns about the possible impact on renewable energy produced from wind. This is another reason to consider LDES but here we are talking about many gigawatts for a long, to very long period, for which conventional batteries are not suitable or far too expensive.

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Hydrogen for Long Duration Energy Storage

All 27 EU member states made a commitment to turning the EU into the first climate neutral continent by 2050. To get there they pledged to reduce emissions by at least 55% by 2030, compared to 1990 levels. The so-called European Green Deal is for sure aiming to reduce carbon emissions but also to reduce external energy dependency. This implies the acceleration of electrification, and Europe is going to see a surge in electricity demand as it transitions towards climate neutrality. In the EU demand for electricity will more than double from 3,000 TWh today to 6,800 TWh by 2050. Renewable energy sources will be very important, and wind energy will be central to this transition. Today wind is 16% of Europe's electricity mix and is forecast to be 50% by 2050.

To meet this goal, generating electricity is not enough and LDES must be considered. As stated in the EU report 'Contribution to the security of the electricity supply in Europe' energy storage is very important to make the bridge between renewable energies and users. Large EU projects to develop Hydrogen Valleys e.g., NorthH2 demonstrated the possibility of generating green hydrogen from renewable energy sources to store high volumes of hydrogen in caverns dug out of salt deposits, then distributed as raw material to users including electricity production via fuel cells (Figure 03).

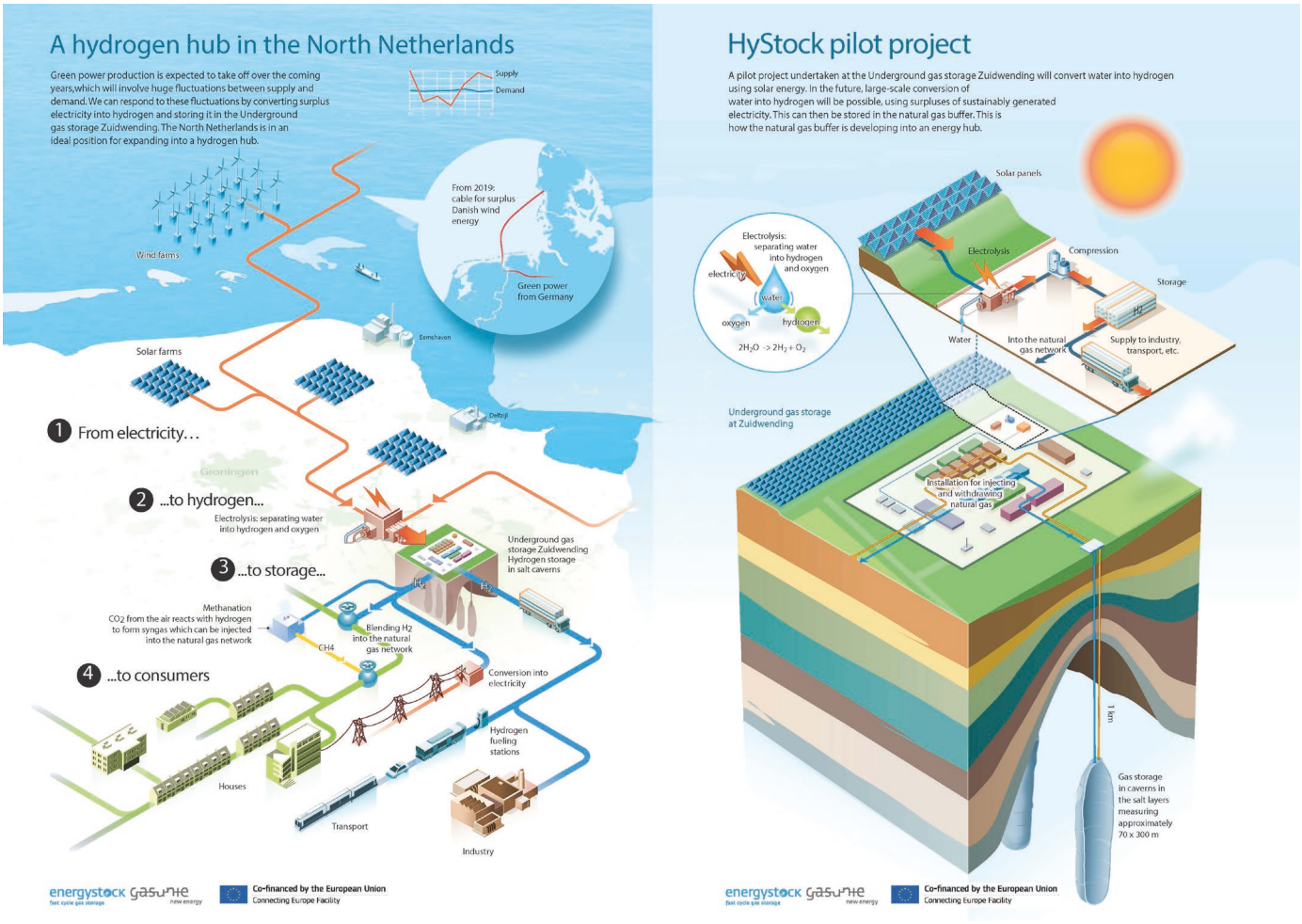

Figure 03 – Hydrogen Valley example, producing hydrogen from wind and solar farms, storing in tanks and caverns in salt layers, delivering and transforming to H2 Ecosystem. (Picture: PRBX / Courtesy of Gasunie)

If converting electricity to hydrogen then to back to electricity seems to be a low efficiency solution, we should consider the overall ecosystem and the overall cost. Because similarly, having gigawatt wind farms in standby is inefficient, and being unable to deliver energy during 'wind-droughts' is very expensive, with the added risk of needing to keep coal-power generation alive for a long time. Fuel cells and gas turbines are solutions being considered to generate electricity from hydrogen and there is no doubt that will become a major contributor in the EU transition towards climate neutrality. We are only at the early beginning of the H2 adventure and it's going to be a major brick in the wall towards Net Zero.

Note:
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https://www.powerelectronicsnews.com/

References:
Powerbox (PRBX):
https://www.prbx.com/

Svevind wind farms and Markbygden 1101
https://svevind.se/en/projects/

Dogger Bank Wind Farm
https://doggerbank.com/

Gasunie
https://www.gasunie.nl/en/expertise/hydrogen

EU Green deal energy storage to help decarbonisation
https://www.europarl.europa.eu/news/en/agenda/briefing/2020-07-08/10/green-deal-boost-energy-storage-to-help-decarbonisation

About Powerbox
Founded in 1974, with headquarters in Sweden and operations in 15 countries across four continents, Powerbox serves customers all around the globe. The company focuses on four major markets - industrial, medical, transportation/railway and defense - for which it designs and markets premium quality power conversion systems for demanding applications. Powerbox's mission is to use its expertise to increase customers' competitiveness by meeting all of their power needs. Every aspect of the company's business is focused on that goal, from the design of advanced components that go into products, through to high levels of customer service. Powerbox is recognized for technical innovations that reduce energy consumption and its ability to manage full product lifecycles while minimizing environmental impact. Powerbox a Cosel Group Company.

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Chief Marketing and Communications Officer for Powerbox, Patrick Le Fèvre is an experienced, senior marketer and degree-qualified engineer with a 40-year track record of success in power electronics. He has pioneered the marketing of new technologies such as digital power and technical initiatives to reduce energy consumption. Le Fèvre has written and presented numerous white papers and articles at the world's leading international power electronics conferences. These have been published over 450 times in media throughout the world. He is also involved in several environmental forums, sharing his expertise and knowledge of clean energy.

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