ACADEMIA | Letters

The role of offshore Wind Farms in the decarbonisation of energy systems to tackle climate change

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Background

The United Nations recently declared that we are facing a grave climate emergency with manifestations such as continuous ocean and atmospheric warming, heat waves, drier soils and rising sea levels. The effect of climate change can be catastrophic to our planet leading to vast amount of land being inhabitable leading to climate refugees. It is clear that island and coastal nations are already, and will be, disproportionately affected. The UK Committee on Climate Change has set an ambitious target to reduce greenhouse emission to net-zero by 2050. The European Union aims to be carbon neutral continent by 2050 with an economy with net-zero greenhouse emission. The United States under the new administration is also setting a similar target.

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Citation: Bhattacharya, S., Fthenakis, V., Kammen, D. (2021). The role of offshore Wind Farms in the decarbonisation of energy systems to tackle climate change. *Academia Letters*, Article 4416.
https://doi.org/10.20935/AL4416.

Energy Transition and pathways to achieve net-zero

Energy Transition must involve decarbonisation of the economy and the backbone of a modern economy is energy. A practical way to achieve net-zero target is to run the country mostly on electricity, producing energy from renewable sources without burning much fossil fuel. Another way is also to aim for an entirely clean energy-based system.

Wind power is among the established renewable energy technologies and has the potential to tackle many current technological and societal challenges, such as sustainable energy sources and air pollution reduction. Wind power has been used for centuries for sailing ships, sawing wood, grinding grains and more and it is one of the oldest sources of 'machine' power. The invention of wind-powered sawmills by Dutchman Cornelis Corneliszoon van Uitgeest in the late 16th century helped Holland increase ship production through automated wood cutting, out competing their European rivals who were relying on slow manual processes.

Modern day wind power is harvested through wind farms, either onshore or offshore. A typical offshore wind farm can generate 1GW of power, approximately equivalent to two standard nuclear power plants. A typical turbine can produce 8 to 10 MW of power and therefore 1 GW of offshore wind farm power involves 100 to 125 offshore turbines, see [1, 2] for further details. Figure 1 compares old style windmills with modern day offshore wind power.

Figure 1: Windmills and Modern-day Wind Power.

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Figure 1 - cont'd: Offshore Wind Power: Drone view of Dudgeon Wind Farm and Photo Courtesy: Jan Arne Wold, Equinor.

An offshore wind farm is scalable and relatively easy to construct due to the sea routes and vessels available to transport parts from manufacturing sites to turbine locations. The offshore Wind Energy cost is now trending toward cheaper in Europe due to the possible scale of installations and improved supply chain.

It is often said that wind does not blow all the time and when you need power, there may not be the desired wind. Also, when the wind is blowing at optimum speed, there may not be the need for the power. To combat these problems, off-shore windfarms feeding electricity and potentially Hydrogen open new avenues to decarbonize regional power systems.

The 2011 Fukushima Daiichi Nuclear Power Plant disaster was a watershed moment in history. Following the disaster, many countries such as Germany and Japan reduced their reliance on nuclear power and compensated with fossil fuels and renewables. Within the framework of global warming, and amongst others such as energy security, Japan aims to become a carbon-free country through a 'hydrogen society'. The main idea is to generate hydrogen from water through renewable energy sources such as wind, solar and hydroelectricity. Japan named it the Jidai concept, see [3].

The Jidai concept is a four-step process: (1) seawater is desalinated; (2) electrolysis is used to produce hydrogen and oxygen from water; (3) hydrogen gas is compressed to 700 bar to reduce storage volume; (4) high-pressure hydrogen gas is stored in a module-based tank system. Through existing offshore infrastructure of pipe networks, hydrogen can be transported for distribution. With the advent of hydrogen cars and trains, and the transition to H2 powered industrial hubs, such as Humber Zero Carbon industrial zone in the UK, the economy can be transformed without the need for expensive metals that are needed for battery production. For

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example, Lithium and Nickel, unlike Hydrogen, can be seen as a trading commodity like oil and gas.

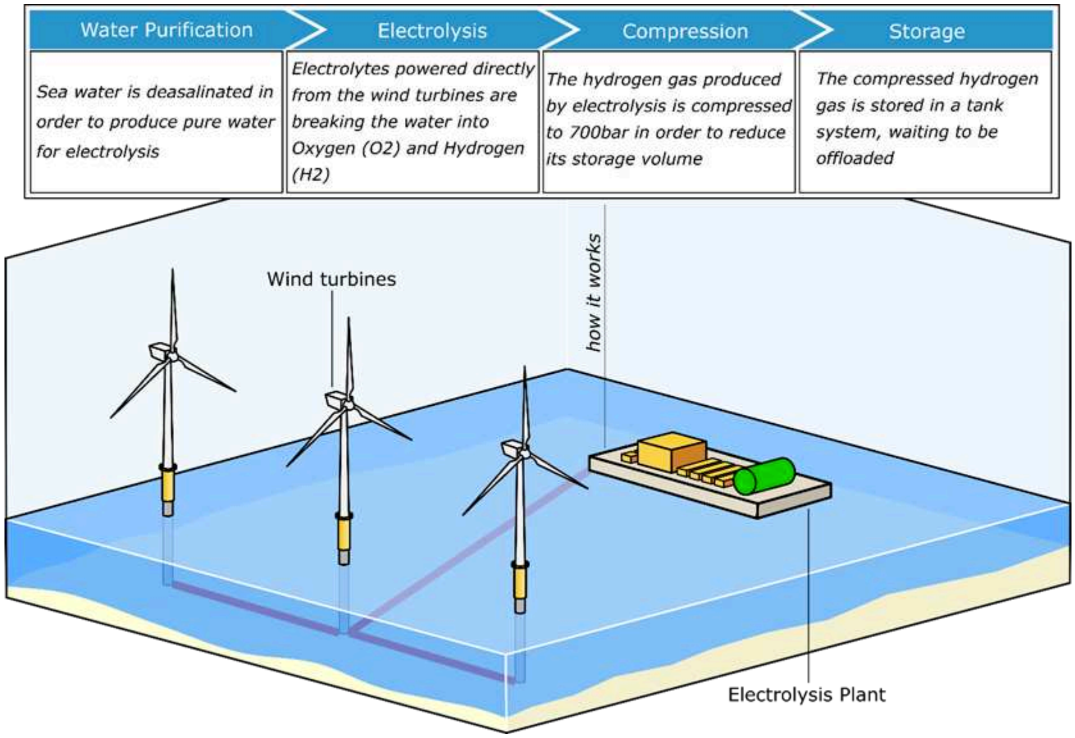

Figure 2: Green hydrogen – an application of off-shore wind

Studies are being conducted to demonstrate that a 100% hydrogen gas network can be as safe or safer than the existing natural gas system. Burning natural gas to heat homes and businesses accounts for approximately a third of the UK's carbon emissions. Hydrogen powered commuter trains are available, and it has been reported in *New Civil Engineer* [4] that 30% of the UK rail fleet could be suitable for running hydrogen powered trains.

In summary, wind power has the potential to carry the transition to low carbon energy, transforming the fossil-fuel energy landscape to a more sustainable energy future.

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