Interconnectors

What are Interconnectors?

Interconnectors are the high voltage cables (land and sub-sea), that connect the electrical systems of neighbouring countries together. They enable the trading of electricity between countries based on need and price and help manage and meet demand and security of supply.

This is particularly relevant for renewable energy, which is a more uncertain supply than a traditional power station and relies on local weather conditions. It enables the transfer of electricity between countries, where one may have more favourable conditions that the other at any given time. In the case of the UK-Norway interconnector for example, enabling access to hydroelectric power on days where the wind isn't blowing so strongly in the UK.

Interconnectors are usually owned by state grid operators, although private interconnectors are possible in some jurisdictions.

How Interconnectors Work in the Market

The interconnector trade is driven by the price of electricity, with traders purchasing the right to move electricity through an interconnector. This movement of electricity is how interconnectors generate revenue. The right to move electricity is sold through an auction, which can cover time periods from several years in advance, to same day sales. Electricity flows are determined for every hour of the day, ensuring electricity is transmitted to the country and grid with the greatest need.

The Benefits of Interconnectors

- Improving the **security of supply**, by increasing the access a country has to energy sources and enabling neighbouring countries to support one another.
- Maximising the amount of renewable energy a country has access to, **assisting in meeting their climate targets**. By maximising the use of renewable outputs across countries, rather than wasting any surplus due to grid or other restrictions, renewable sources are able to be used at maximum efficiency.
- Interconnectors **help countries meet sudden supply demands**, as well as utilise surplus when there are "troughs" in demand and excess is being produced. Given the difficulty in being certain of renewables' output at any given time, interconnectors help "smooth out" the peaks and troughs of demands.
- Help **keep electricity bills as low as possible** by ensuring access to electricity when it is being produced cheaper in neighbouring countries. Likewise, by selling excess electricity instead of wasting surplus.

Different Types of Interconnectors

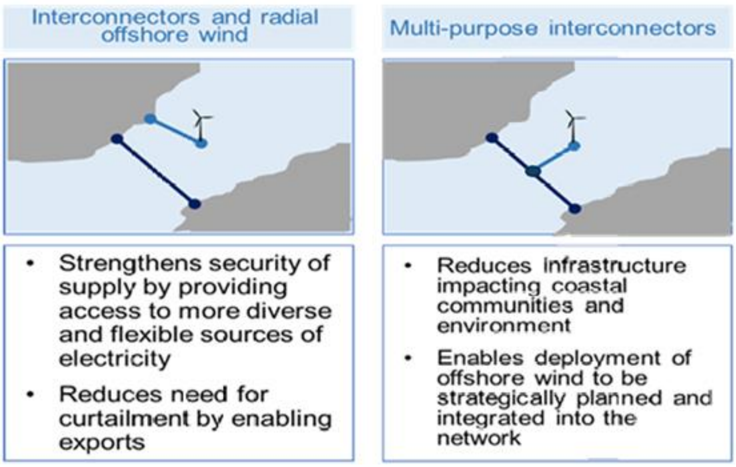
- Standard Interconnectors:

  A standard interconnector is where two countries are connected via a cable. A cable will stretch between each country, ending in a converter station, before then connecting to each country's grid. In the diagram below, a traditional interconnector is shown in green. This means that each separate windfarm must first connect to a single jurisdiction, with the electricity traded through the interconnector happening via a separate connection, with the energy to be traded needing to arrive onshore before going offshore to the other country via the interconnector.

- Multi-purpose Interconnectors (Now called Offshore Hybrid Assets to align with European naming conventions[1])

  Offshore Hybrid Assets (OHAs) are where clusters of windfarms are connected to multiple jurisdictions, without having to have an individual windfarm-to-shore connection first. This reduces costs by reducing the need for multiple interconnectors and reduces the impact onshore by having less infrastructure for each windfarm. The principle is for OHAs to become offshore connection "hubs".[2] This differs from standard interconnectors, whereby each windfarm would be connected to the shore of one country, with the electricity then going out again to other countries via interconnectors. This can be seen in the diagram below, with the OHAs the offshore "buildings" in yellow.

[3]



[4]

Alternative diagram: Standard interconnector in the left, OHA on the right

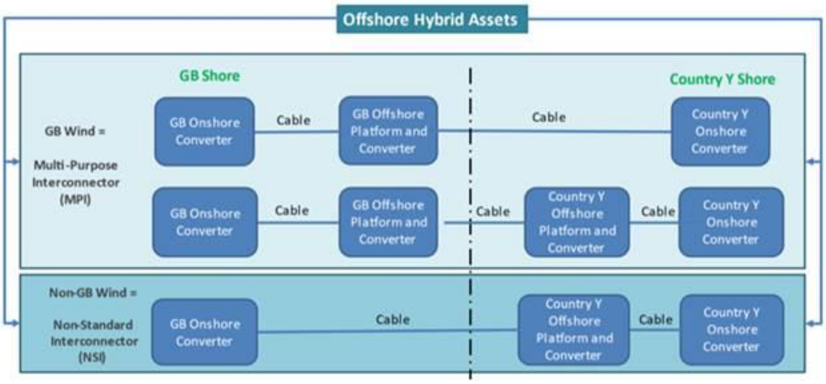
The “Kriegers Flak Combined Grid Solution” was the first example of an OHA. The Danish “Kriegers Flak” windfarm and the German “EnBW Baltic 2” windfarm, situated next to each other, were connected together, as well as with connections to each of the separate countries. It also acts as a connection between Denmark and Germany to transfer electricity, even without the windfarms in operation.

The first UK project of this kind is the “LionLink” between the UK and the Netherlands, a 1.8GW OHA. A similar 1.4 GW project between the UK and Belgium, called “Nautilus”, is also being planned.

- Non-Standard Interconnectors

  Specific to UK regulation, a non-standard interconnector (NSI) is where the interconnector is combined with offshore wind generation in non-Great British waters and where the interconnection occurs in both GB and the neighbouring jurisdiction, but with offshore transmission only occurring to the neighbouring jurisdiction (i.e. where the energy is only transferred to the neighbouring country but the interconnector joins both jurisdictions together).[5] This differs from a multipurpose interconnector (now OHA), in that OHAs are defined as an interconnector combined with wind generation in GB waters and where the offshore transmission arrives in GB, with the option to also allow transmission to the neighbouring jurisdiction.[6]

Figure 5: Highlighting possible asset permutations



[7]

- Cables

  There are two types of cables that can be found. Array cables and export cables. Array cables connect the wind turbines together and then transmit power from the windfarm to an offshore substation, typically rated at 66kV (likely up to 132kV in the future). Export cables are of a higher capacity, typically 220kV, and take the power from the offshore substation to the onshore substation for distribution via the grid. Sometimes with smaller wind farms there is no offshore substation, and the array cable goes straight to an onshore substation. There are static and dynamic array cables, with the static being found in fixed-bottom wind farms and dynamic used in floating windfarms.[8]

- Energy Islands

  Energy Islands are natural or artificial islands used to facilitate the production of offshore energy and to support windfarms much further from the coast. There are numerous energy islands planned, including the artificial Princess Elisabeth Island off the coast of Belgium, and (natural) Energy Island Bornholm, off the coast of Denmark, which will have a high voltage converter station built to transmit the energy from two windfarms to Zealand, in

Denmark. These Islands both help facilitate infrastructure for the windfarms and for OHA interconnectors but also offer the potential for large-scale hydrogen production, for example Helgoland, which is planned to be connected to a 10GW offshore wind farm, to be entirely used for hydrogen production, partly for the Island's own use.[9]

[1] ESO "ESO Offshore Coordination Quarterly Update" (December 2023) p5

[2] National Grid "Offshore Hybrid Assets"

[3] National Grid "Offshore Hybrid Assets"

[4] Ofgem "Consultation on the Regulatory Framework for Offshore Hybrid Assets: Multi-Purpose Interconnectors and Non-Standard Interconnectors" (2 June 2023) p9

[5] Ofgem "Consultation on the Regulatory Framework for Offshore Hybrid Assets: Multi-Purpose Interconnectors and Non-Standard Interconnectors" (2 June 2023) p22

[6] ESO "ESO Offshore Coordination Quarterly Update" (December 2023) p5

[7] Ofgem "Consultation on the Regulatory Framework for Offshore Hybrid Assets: Multi-Purpose Interconnectors and Non-Standard Interconnectors" (2 June 2023) p30

[8] Offshore Wind Scotland "Fact sheet 4: Cables and accessories"

[9] DNV "Are offshore energy islands the future of hydrogen and e-fuel production?"