Solway Firth Partnership

Renewable Energy Framework

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Introduction

The Solway Firth is a body of water lying between the coastlines of Cumbria in the north west of England, and Dumfries and Galloway in the southwest of Scotland. This location puts the Solway coast in a very interesting position for the generation of renewable energy. An aspect of this location that is advantageous for the generation of renewable power is the various interconnectors that connect the electricity grids of Scotland, England, and Northern Ireland which exist nearby. An additional advantage of this area is that the local grid has been used for high voltage generation in the past, the grid around the old nuclear power plant at Chappelcross was designed for generation and at the current time is not used for such [1]. Another advantage of the location is the existence of a large commercial port at Cairnryan, as well as both Whitehaven and Workington, this would allow for the transport of materials for offshore projects to be transported more easily.

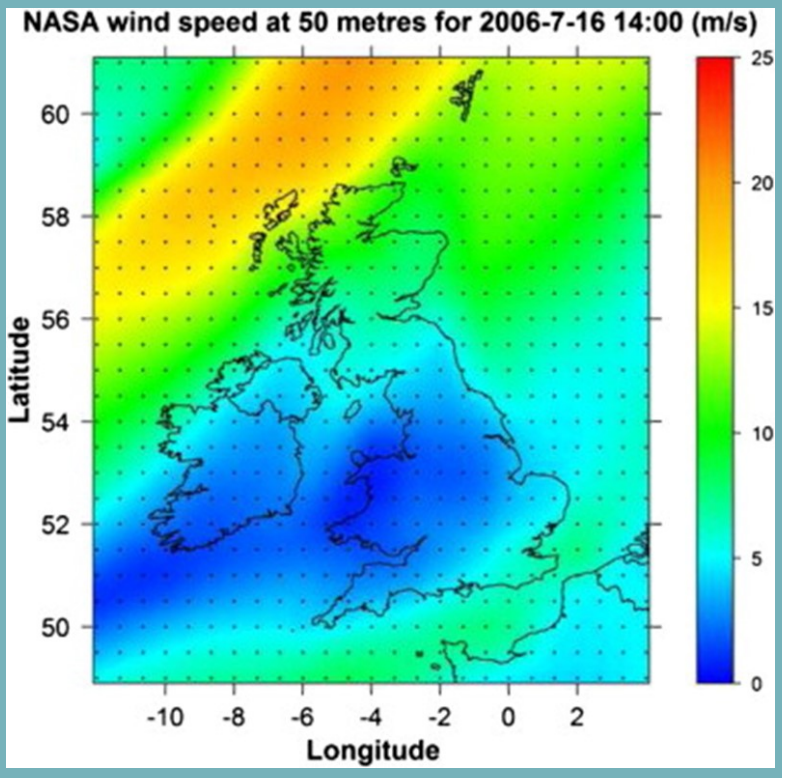
There are a number of different renewable energy technologies that potentially could be put in the Solway Firth or on the Solway coast, these have different levels of viability and their potential in engineering terms is discussed below. The impact on the environment, biological and commercial resources are not considered here as this would be dependent on the specific sites chosen for these technologies. As a result the impact of each proposed scheme would need to be considered individually.

Wind Energy

Wind turbines can be split into various categories, for different reasons. Here they will be split by location (on-shore, and offshore), and basic turbine type (vertical axis, and horizontal axis).

For any wind turbine the wind resource in the specific area it is to be sited needs to be investigated. However, the average wind speed in the Solway coast area is considered to be somewhere between 6 and 8 m/s at a height of 50 m above the ground [2].

All of the various types of wind turbines work in fundamentally the same way, in which a moving column of air contains an amount of energy of which a certain proportion can be extracted. The amount that can be extracted is based upon the speed of the flow (i.e. the wind) and the type of turbine being used.



https://www.researchgate.net/figure/Colour-map-showing-the-interpolated-wind-speeds-for-a-given-hour-over-the-British-Isles_fig5_261600738

Horizontal Axis wind Turbines

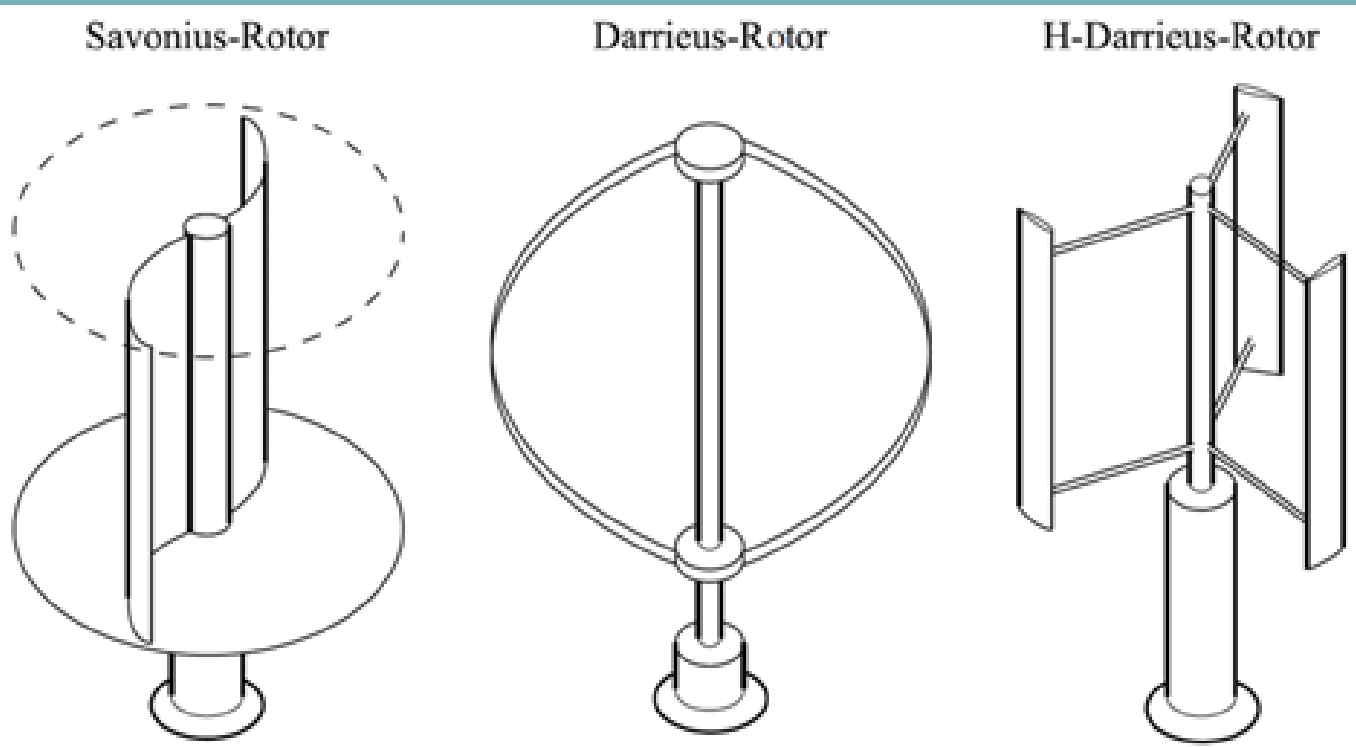
The standard design for a horizontal axis turbine is the three bladed design. Three blades are used as this design is the best optimised for tip speed ratio and stall [3]. In very simplified terms, this tip speed ratio will be more efficient, with these turbines having a peak efficiency between 6 and 10m/s. As a result of this, these are the type of turbine that are currently installed in the Solway coast area, both on and off shore.

This is proven profitable technology and it would be likely that these would continue to be the most efficient of the current standard wind turbines to be installed.

https://en.wikipedia.org/wiki/Robin_Rigg_Wind_Farm

Vertical axis wind turbines

There are several different types of vertical axis wind turbines. These include various different types of turbine including Darrieus and Savonius turbines. In general, these wind turbines are most efficient at dealing with varying wind speeds and strong gusty winds [4]. As a result these are not currently the most effective type of turbine for use in the Solway coast area.



https://www.researchgate.net/figure/Standard-types-of-vertical-axis-wind-turbines-13_fig6_323589645

On-shore wind turbines

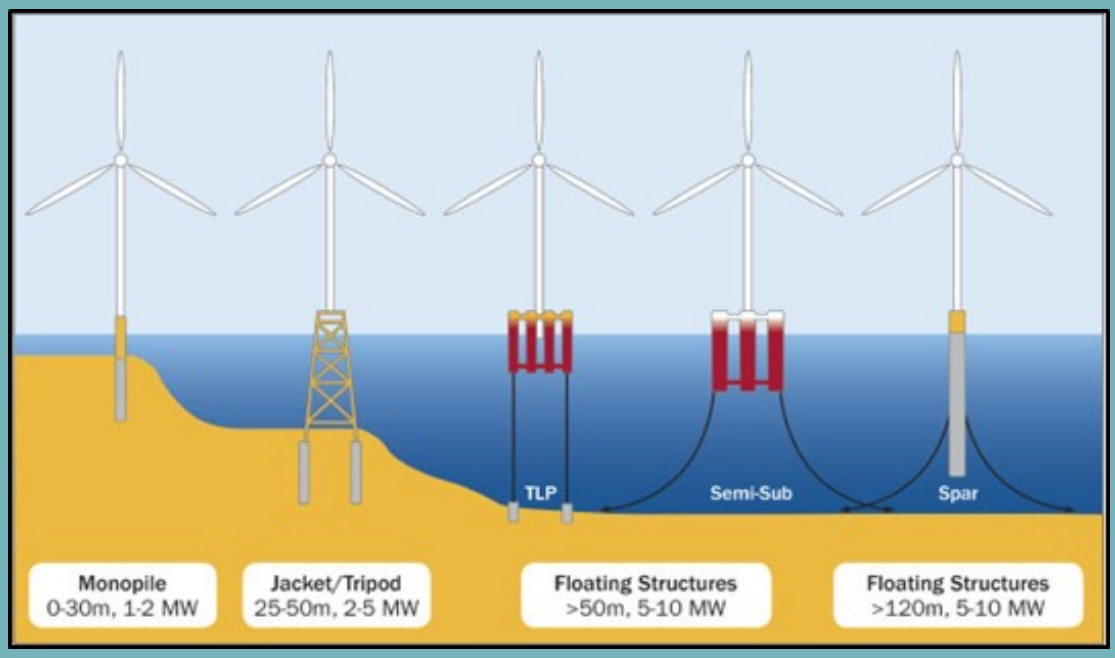
The main advantage of on-shore wind is that it is easier to construct the turbines. As the underlying ground conditions are easy to determine it is much simpler to prepare the foundations for the installation [5].

On the other hand there are some issues with onshore wind. These are mainly related to wind speed. This can vary more significantly on land than on water and various terrains can slow the wind speed down significantly. Additionally, the maximum size of the turbines is limited by a range of factors such as transport. This is an issue as the size of the turbine varies with energy output squared. As a result the larger the turbine the more efficient the wind farm as whole.

http://www.siemens.co.uk/en/news_press/index/news_archive/siemens-reaches-3gw-wind-power-generation-uk.htm

Off-shore wind turbines

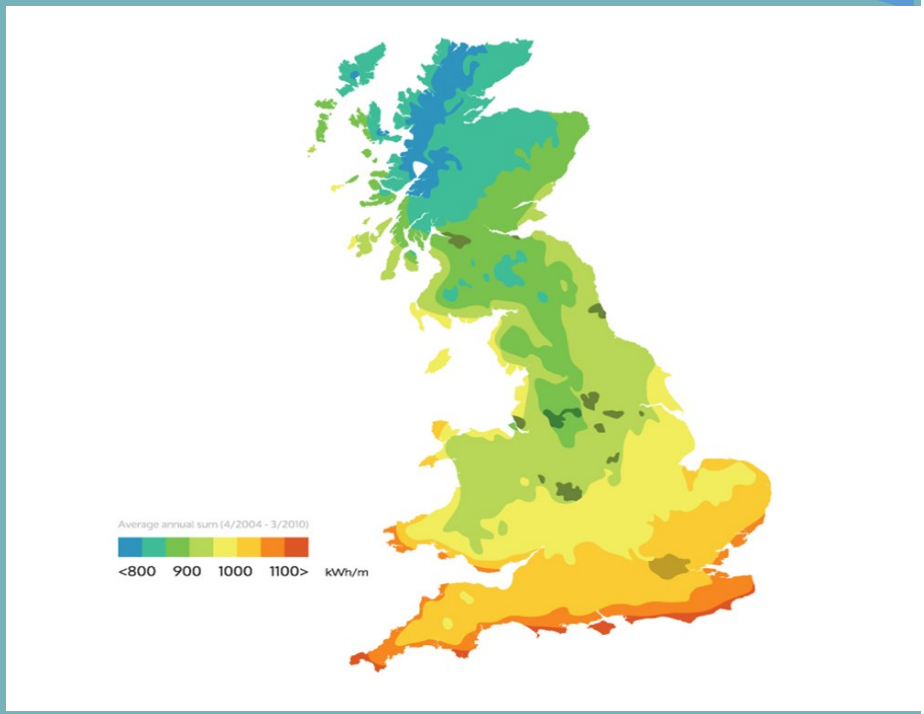
The main advantage of offshore wind is that the turbines can be significantly larger and thus more efficient than on-shore schemes (see above). However there a number of potential issues with the installation of off-shore wind turbines. One such issue is the fact that it can be very difficult to prepare foundations for the installation. This can have an effect on the cost efficiency of the scheme, and its long term structural integrity. Some of the time however there are effective alternatives to this such as floating turbines, however these are mainly used in areas of water that are much deeper than that of the Solway Firth [6]. Another factor that may be detrimental to the development of off-shore wind could be the strong currents within the Solway coast area as this may increase costs when installing the connected power lines.



https://www.researchgate.net/figure/Types-of-offshore-wind-turbine-foundations-reproduced-from-ref-102-source-Principle_fig4_266086383

Solar power

For locations like the Solway coast where the total surface area available is limited the most effective option for the installation would be a photovoltaic setup. These are solar panel that will directly convert certain wavelengths of light into electricity. Whilst this can provide a decent amount of electrical energy the main issue with solar power generation in the Solway area and Scotland in general is that the density of the resource (sunlight per collecting area) means that other options are almost always more viable[7].



https://www.evoenergy.co.uk/wp-content/uploads/2015/04/irradiance-map.jpg

Tidal power

Tidal stream

Tidal stream systems could be simply described as under water wind turbines. There are however a number of differences between tidal and wind turbines. In particular, the tidal turbine will turn significantly more slowly but with a lot more power. This is due to the fact that water is 1,000 times denser than air. Thus although more power can be generated it can lead to potential gearing issues. Other difficulties include design problems such as basic material problems that arise from the saltwater environment in which the device will be placed [8].

Tidal range

Tidal range systems work by extracting the potential energy difference due to the height difference between the low and the high tide levels. This can be carried out in a number of different ways. To date, this is normally done by building a barrage to hold the water at the high tide level in order to maximise the difference between the water levels. Another proposed system is to create lagoons out in the middle of the water [8]. These are the types of system that have the greatest potential in the Solway coast area due to its very high tidal range [8].

Experimental technologies

There are number of different experimental technologies that have potential applications in the Solway these include but are not limited to:

-Wave power (extensively lab tested but as yet not commercially viable)

-Underwater energy storage (undergoing early testing stages)

-Floating solar (an area that is expected to see huge growth in the coming years)

-Venturi powered tidal bridges - a type of tidal system that uses a pressure difference rather than flow or height difference (one of these systems has already been proposed within the Solway area)

Storage systems

One way of improving the overall effectiveness of a renewable energy system is to add some form of storage to it. This allows for the system to avoid the largest issue with renewable energy systems , the fact that you cannot control the supply/demand of electricity. The main issue with the current technology is that they are not consider to be financially viable [8]

Sources

[1] https://magoxsites.com/site/chappelcross
[2] https://www.researchgate.net/figure/Colour-map-showing-the-interpolated-wind-speeds-for-a-given-hour-over-the-British-Isles_fig5_261600738
[3] http://perso.bertrand-blanc.com/Resume/Experience/Energy/index.html
[4] https://aip.scitation.org/doi/abs/10.1063/1.5024099
[5] https://www.peikko.co.uk/products/wind-turbine-foundation-system/overview/
[6] https://www.researchgate.net/figure/Types-of-offshore-wind-turbine-foundations-reproduced-from-ref-102-source-Principle_fig4_266086383
[7] https://www.evoenergy.co.uk/wp-content/uploads/2015/04/irradiance-map.jpg
[8] Attached report