**Increased Trend Towards Offshore Wind Farms**

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**Abstract:** Recently there has been an increase in the amount of offshore wind farms that have been built up in the last several years. Offshore wind farms provide higher electricity generation per amount of capacity installed due to the increased wind speeds and are more accepted due to reduced “not in my backyard” opposition. These offshore wind farms can exist in various bodies of water such as lakes, fjords and sheltered coastal areas as well as deeper-water areas. Most offshore wind farms employ fixed-foundation wind turbines in relatively shallow water, however as of 2020, floating wind turbines for deeper waters are in the early phase of development and deployment. These variety of options have caused offshore wind to become a more desirable form of alternative energy.

**Introduction:** Wind turbines have been a form of renewable energy for over a century. The first electricity-generating wind turbine was invented in 1888 in Cleveland, Ohio by Charles F. Brush. Since then, wind turbines have become significantly more efficient due to new technologies and cost effective due to economies of scale. This has caused wind farms to pop up all over the world. The world's first wind farm was 0.6 MW, consisting of 20 wind turbines rated at 30 kilowatts each, installed on the shoulder of Crotched Mountain in southern New Hampshire in December 1980. After wind farms started growing in popularity on land, the first offshore wind farm was built. The Vindeby Offshore Wind Farm was the first offshore wind farm in the world, erected in 1991 off the coast of the town of Vindeby on the Danish island of Lolland. It was decommissioned for cost reasons in 2017 after 25 years of generating energy. 

Figure 1: Vindeby Offshore Wind Farm

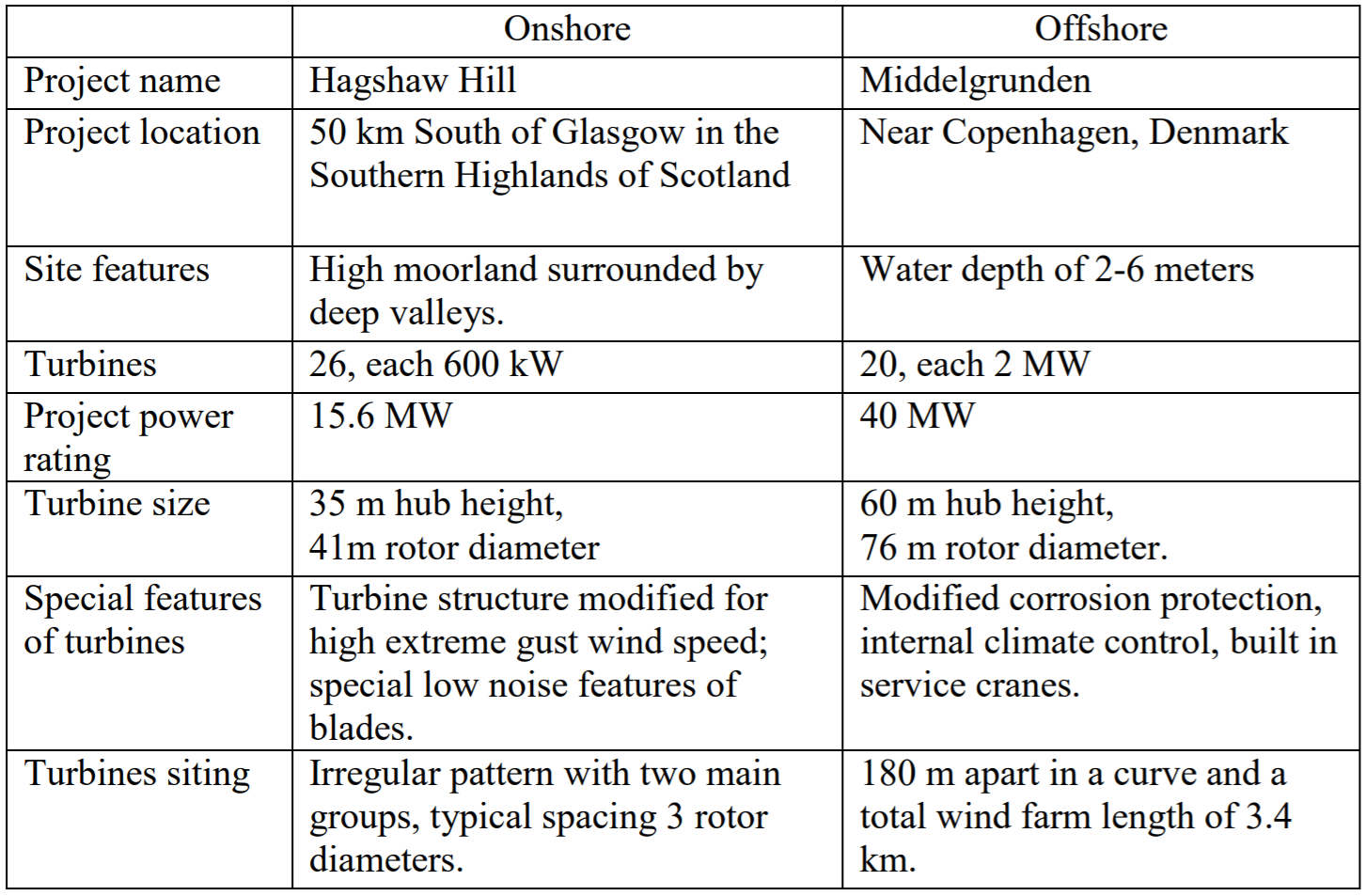
This trend to move towards offshore wind farms has only been increasing, with bigger and bigger offshore wind farms popping up all over the world.

**Design Requirements for Offshore Wind Farms:** Since offshore wind farms are situated in bodies of water, there are some specific design requirements that they have to meet in order to operate safely. Offshore wind turbines need to be made of corrosion resistant material and also need to be painted with offshore grade painting systems that minimize corrosion caused by salt water and the salt in the air. The tower and nacelle also must be enclosed with a climate control system. This is typically done with dehumidifiers that maintain a constant internal humidity in order to prevent internal corrosion. Offshore wind turbines also need to have strict safety requirements. They need to have lightning protection, since there is an increased frequency of lightning strikes over open bodies of water. The turbines also need to be fitted with navigational lights and aerial warnings to warn ships and aircrafts. Rescue equipment is also available at the base of each turbine, in the event of someone from the maintenance crew falling into the water. These offshore wind turbines also need to have hair to air heat exchangers in order to regulate temperature. Since the ambient air is humid, it is only allowed to flow through the external part of the heat exchanger which regulates the nacelle enclosure climate.

**Conditions and Environment:** Since offshore wind farms are in bodies of water, it makes sense that they have to endure different conditions compared to typical wind farms. With increased wind speeds, energy from the wind is transferred into wave energy, which leads to an increase in roughness. This causes a significant variation in roughness, although the roughness is still very low compared with land surface. Obstacles such as islands and lighthouses need to be taken into account when determining where offshore wind farms are put up. With the low roughness that happens over water surfaces, the wind shear is low and the wind speed doesn’t change much. This allows for towers to have a height that is ¾ the size of the rotor diameter. Towers on land typically have heights that are equal to rotor height, so this reduction in height allows for a decrease in capital costs. The wind over water is generally less turbulent than wind on land and so offshore wind farms are subjected to less fatigue loading. This results in longer lifetimes compared to land-based turbines.

**Economics of Offshore Wind Farms:** Offshore wind farms tend to be more expensive compared to onshore wind farms. According to the Energy Information Administration (EIA), offshore wind farms are 2.6 times more expensive compared to onshore wind farms. On a kilowatt hour basis, offshore wind farms cost 22.15 cents per kilowatt hour, while onshore wind farms are estimated to cost 8.66 cents per kilowatt hour. Overnight capital costs are also 2.8 times higher for offshore wind farms compared to onshore.

**Benefits of Offshore Wind Farms:** Although offshore wind has a high upfront cost compared to onshore wind farms, there are some significant benefits that draw people towards offshore wind farms. Wind is typically much stronger over bodies of water than over land, resulting in increased power potential and efficiency. The projected power rating for offshore wind turbines can typically be 2-3 times greater than onshore turbines. Below is a comparison of the parameters of an onshore and offshore wind farms:



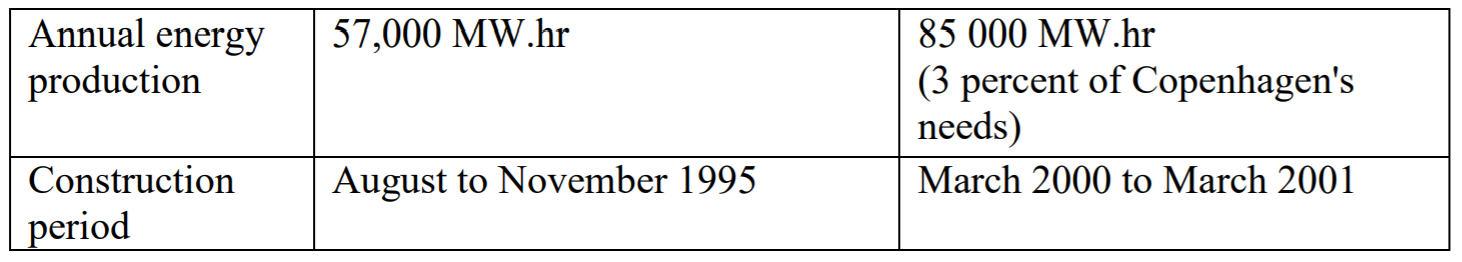
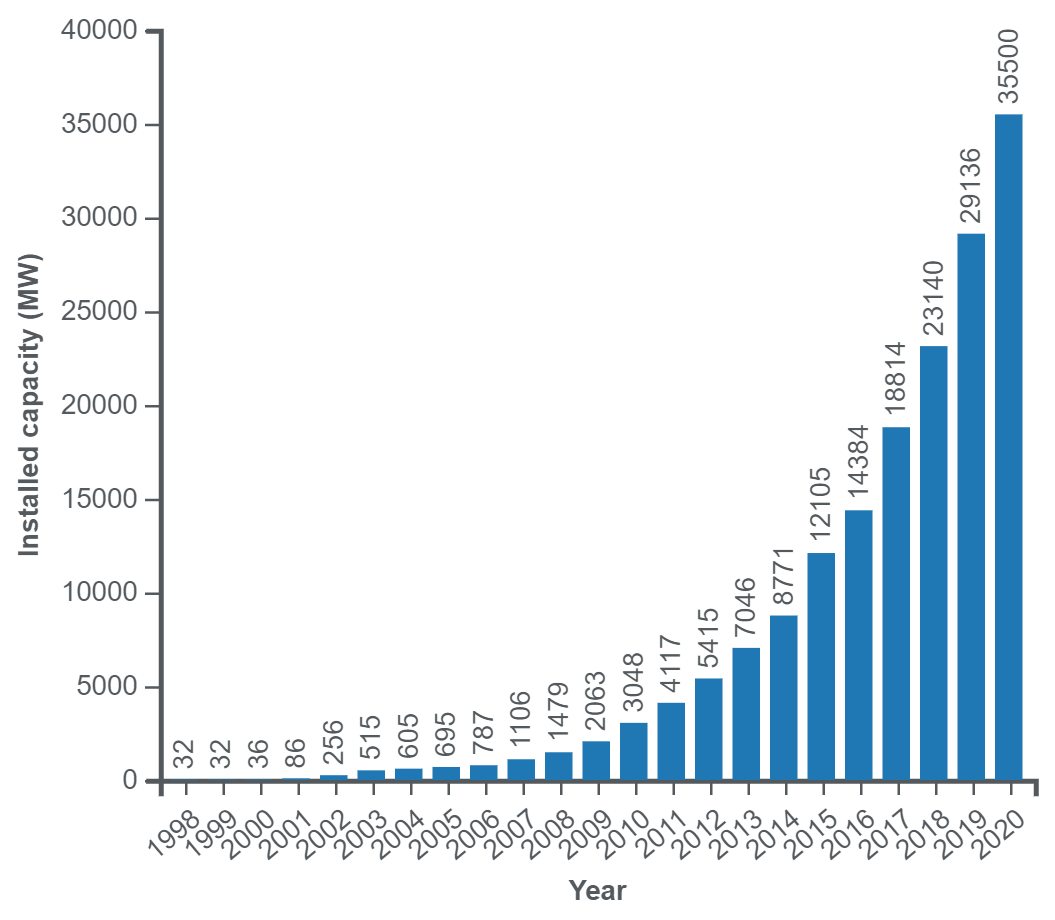


Table 1: Comparison of the parameters of an onshore and offshore wind farms

As seen above, even though offshore wind farms are more expensive, they can generate a significant amount of energy. Many coastal areas have very high energy needs. Half of the United States’ population lives in coastal areas with concentrations in major coastal cities. Building offshore wind farms in these areas can help to meet those energy needs from nearby sources. Some other benefits of offshore wind farms are the fact that they don’t take up land area or affect the human population. Due to eminent domain laws, sometimes people can be kicked out of their homes to make room for government funded projects, and sometimes those projects could be wind turbines. Offshore wind farms eliminate this issue. These are some of the main reasons there is an increased trend towards offshore wind farms.



Global cumulative offshore capacity (MW)

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