Technologies to harness wind power for net zero

The offshore wind industry has a major role to play in reducing carbon emissions, but the industry faces a number of challenges. ABB Energy Industries discusses some technology developments which are being increasingly used to tackle these for a reliable sustainable renewable source.

A combination of environmental, economic, and geopolitical factors is leading many countries to consider new forms of power generation. Combined with a growing awareness of the need for energy security and greater sustainability, there is a steadily increasing shift towards renewable sources as a means of providing the power needed for everyday life.

One such source is wind power. The world's second biggest renewable energy source after hydropower, wind power accounted for over 6% of global electricity generation in 2022, providing 837 GW of global capacity. That same year saw an extra 77.6 GW of capacity added. This is projected to rise as more countries strive towards achieving net zero carbon emissions.

A sector of the industry that has seen considerable growth has been offshore wind. Since the first units were introduced in 1991, improved performance combined with lower technology costs have seen a massive growth offshore turbine projects. The Global Wind Energy Council (GWEC) estimates that the global market for offshore wind grew by almost 22% per year between 2010 and 2020, while an additional 235 GW of new capacity is expected by 20302.

Tackling the challenges of wind

Although wind offers significant opportunities for improving both environmental performance and reducing reliance on fossil fuels, companies hoping to harness its full potential face some key challenges.

The first is wind's intermittent nature. Variability in wind conditions and the inherent unpredictability of seasonal weather means that turbines may be operating at peak efficiency when there is less demand or at low efficiency when there is high demand. Periods with low wind speeds will mean that the power from offshore turbines will need to be supplemented by other energy sources.

The challenge is to find ways to maximise output and match demand, while also reducing capital investment in the construction of the windfarm and infrastructure, as well as the facility's operating costs.

A number of technologies are helping operators meet these challenges. Improvements in offshore turbine design, including both efficiency and size and the availability of floating designs that enable

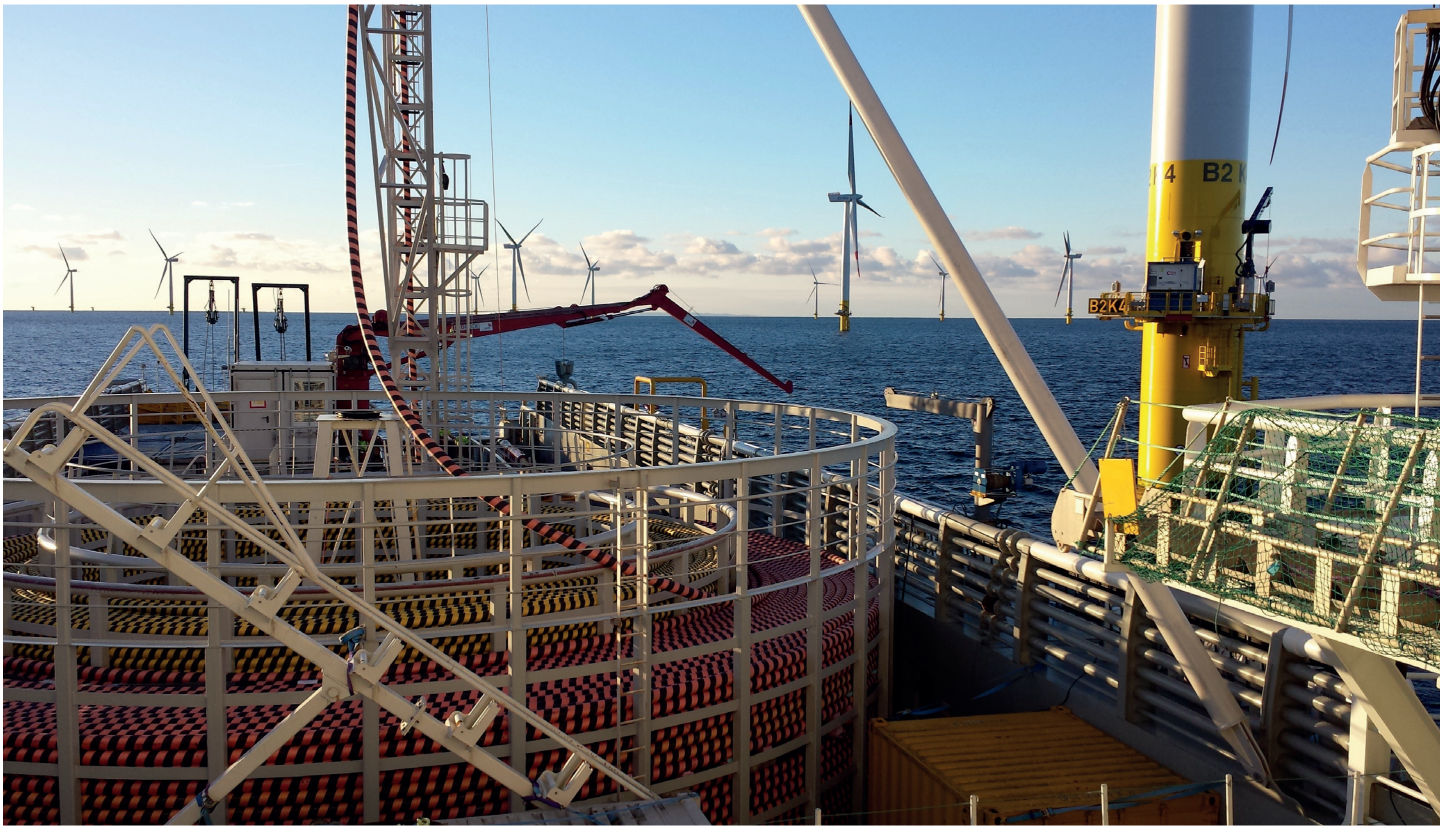

Figure 1: Using subsea power distribution and conversion technology from the oil and gas industry is helping address the cost and practicality challenges involved in transmitting power from wind turbines back to shore.

Figure 2: **Increasing numbers of offshore windfarms coming online require people and facilities to deliver and maintain them.**

wind farms to be situated further offshore to take advantage of higher quality wind conditions, are helping achieve steady increases in capacity of 40 to 50% and more. This improved efficiency is seeing offshore turbines exceeding the capacity performance of other renewables such as onshore wind and solar power.

Developments in energy storage are also helping to provide added stability. Various technologies can be used, including batteries and thermal storage.

Other concepts include bladders on the seabed. Here, excess power is used to pump water from underground reservoirs into the bladders. When demand for power rises, water from the bladders is routed through hydro turbines to generate electricity.

Another technique is to use power from wind to help produce hydrogen, a low carbon power source that can be used widely for anything from electric vehicles and shipping through to heavy industries. With around 70 million tonnes of hydrogen currently produced using fossil fuels, offshore wind offers huge potential to make significant savings in CO_2 emissions.

Yet another challenge is how to get the power produced from the turbine back to shore efficiently. Depending on the distance involved, this has been achieved using either HVAC or HVDC connections. For both techniques, subsea power distribution and conversion technology originally developed for the oil and gas industry have substantially reduced the cost and eased the practicalities of transmission. By eliminating the need for surface infrastructure, this technology is opening new opportunities for transmitting power over long distances whilst simultaneously reducing emissions. It also offers scope for improved control and operation through digitalisation and the use of remote monitoring.

Other techniques are also becoming increasingly viable, including floating substations that share design and assembly ideas from the buoyant platform structures being deployed for floating offshore wind turbines.

Matching supply to demand

As more offshore wind farms come online, there is a growing requirement for the people and facilities needed to deliver and maintain them.

The high initial capital costs involved in building sea-based wind farms and their associated transmission networks means there are currently a limited number of operators in the market with the ability and resources to build, operate and maintain large scale wind farms.

Engineering resources are becoming increasingly stretched as more wind farm programmes get underway. Companies across the power generation value chain, from operators through to suppliers, have had to find ways to make best use of existing resources.

This can mean using tools to help get more out of available engineering hours. One of the key tools is remote operation, which allows operators to understand what is happening and then using the data to make decisions to improve performance. Advances in smart digital technology are delivering expanded possibilities for remote and unmanned assets. As well as making them easier and more efficient to deploy and operate, they increase the speed and quality of information sharing, allowing better decision making and faster rollout of modifications.

Getting practical data from remote assets is important for safe functioning of remote assets – the greater autonomy made possible by digitalisation also reduces the need for manpower at the asset sites.

Do more with less

Digitalisation allows engineers to do more whilst making better use of available time. Some of the tasks made easier include condition monitoring, fault tracing, incident handling, cybersecurity patching and modifications.

Many maintenance and inspection tasks, for example, can now be performed remotely. These can be done either via real-time control and communications networks or using technologies such as drones to inspect components at height or in otherwise hard to reach areas.

Developments in predictive maintenance technologies especially are also helping to improve turbine performance. Identifying problems in advance allows operators to decide how best to rectify them, either deploying engineers to the turbine or, if possible, applying the fix remotely.

Digital simulation has also helped to reduce a lot of the work involved in planning new offshore installations. These tools can allow operators to assess turbine performance and potential electrical output before installation. By testing a turbine installation under multiple conditions, operators can use the data produced to help develop the best real-world solution, reducing risks and speeding up deployment.

Partnerships in power

Another way to address the limitations of the available skills base is to work in partnership with other players in the supply chain.

This approach offers several advantages. Foremost amongst these is the exchange of new ideas. For example, ABB has an extensive portfolio of electrical solutions and has developed expertise from delivering hundreds of offshore applications, including projects located in some of the world's harshest waters. This means it can offer new perspectives on meeting many of the challenges inherent in offshore wind projects. As an example, its experience gained in building subsea transformers for oil and gas since the 1990s is now being used to provide the building blocks for subsea networks that collect, convert, and distribute power from floating wind turbines.

This expertise can be used to create networks that can help to ensure grids can meet peak demand whilst also delivering peak reliability by finding ways to supplement wind power during periods of low demand. Experience can also be used from a supplier's involvement in other

Figure 3: Improvements in offshore turbine design, in relation to size and efficiency and the availability of floating designs, enable wind farms to be situated further offshore to take advantage of higher quality wind conditions.

forms of energy generation and distribution, such as hydrogen production, storage and transmission projects. This makes it well placed to advise operators on how to supplement generation networks using alternative power sources that are powered by offshore wind.

The same advances in digital maintenance technologies can also be used to help deliver remote service and support. This can range from digital simulation through to augmented reality tools that can be used by engineers to remotely guide colleagues on site to resolve problems.

The growing convergence between information (IT) and operational (OT) technologies allows new opportunities for collaboration. The huge variety of data from equipment, processes, plants and business systems can be integrated and shared between the different parties involved in building, running and maintaining offshore wind farms.

By sharing information about operational status and asset performance, including analysing varying performance between different wind assets and wind farms, allows better decision-making within the operating company. Sharing performance information among the vendors in the wind generator industry also allows new equipment and techniques to be developed that can benefit everyone.

Maximising potential

The growing need for affordable low carbon technologies will see all forms of renewable power being used to supplement and eventually replace fossil-fuel based power generation.

The potential of offshore wind as an effective power source has increasingly been recognised as technology has advanced and ways have been found to tackle issues such as variability and intermittency.

As the industry addresses issues through continued developments in electrical system design, offshore wind will increasingly take its place as a major enabler of the global transition from fossil fuels to renewable power.