Wind down

With first-generation offshore wind farms coming to the end of their active lives, what is the best way for operators to decommission them?

Eva Topham

Since the first offshore wind farm was built in 1991 in Vindeby, Denmark, the industry has focused on the development and growth of the sector, giving little thought to the end-of-life phase for turbines. Most are designed and certified for a 20–25-year service life: nearly 30 years after Vindeby, only five projects have been decommissioned, and this has been done by trial and error because there are still no clear guidelines or regulations. To date, this has resulted in lengthy, expensive processes.

Decommissioning should be considered in the design phase of projects so that structures may be easily disassembled at the end of their life, and to ensure that the funds are available to decommission them. Numerous factors make decommissioning a challenge, such as:

- the hostile marine environment
- the difference between the estimated and actual turbine life
- the technical restrictions of vessels
- the absence of dedicated regulations
- the need to plan decades in advance.

Because each site is unique, every project will need to be decommissioned in a different way. End-of-life decisions will be critical in the next few years as around 20,000 offshore wind turbines will reach the end of their originally planned service life between 2030 and 2040. Owners need to decide whether to extend the asset's life by repowering the site — which can range from refurbishing or replacing components to installing new turbines, while trying to re-use as much of the existing infrastructure as possible to reduce costs — or decommissioning. The decision will be highly dependent on the condition of the assets as well as economic constraints: maintenance costs may be high enough to make it less profitable or even unfeasible.

Decommissioning process

Because of the lack of spare parts and the rapid upscaling of turbine size and numbers, decommissioning is often the preferred option. There is no one solution or established process, but reducing time, costs and environmental impacts are the main considerations. The lifetime of turbines is also crucial: if projects do not perform as predicted, this will have a considerable impact on the economics of the project and its decommissioning plan.

The availability of specialised vessels is another crucial factor. The variable price of oil makes predicting future vessel costs challenging. Even if oil prices stay low, future demand for such vessels will remain high because they are solicited for oil and gas decommissioning as well as the installation, operation and maintenance, and decommissioning of offshore wind.

Minimising the length of the operations is important to reduce costs, but the time taken for the process will vary with the type of vessel chartered, the disassembly technique and the number of lifts used, as well as the transportation strategy. Water depth is a key factor, because deeper water requires longer monopiles, which makes operations more difficult and will have a direct impact on the foundation design and weight of the project to be decommissioned. In addition, these processes rely on good, consistent weather conditions.

The UK Department of Trade and Industry initially estimated the cost of dismantling offshore wind turbines as £40,000/MW, but recent studies show it can exceed £200,000/MW. To reduce this, vessels should be chartered in advance and there should be a clear strategy, including what to do with components once removed.

Even though prioritising reduction ahead of re-use and only then recycling should be the aspiration, the two main scenarios for offshore wind turbines are recycling and, if this is not possible, disposal. Most turbines installed to date are gearboxed, mainly comprising metals such as steel, cast iron

This turbine at Egmond aan Zee offshore wind farm in the Netherlands, installed in 2006, is one of the 1,800 due to reach the end of their lives by 2030

and copper, which are used in the tower, gearbox, main shaft, generator, castings, bearings and parts of the nacelle and hub. This means that nearly 95 per cent of the total weight of turbines could be recycled.

Most foundations are monopiles, which are also made of steel and embedded into the seabed. Therefore, decommissioning involves cutting a few metres into the seabed and lifting the piles out. Where offshore wind turbines sit on monopile foundations, a recent study showed that if everything were recycled, decommissioning costs could be reduced by 20 per cent. However, this figure is highly dependent on the current scrap metal price, which is volatile. Disassembling the structures into all the distinct components is challenging.

The remaining five per cent can be found in the power electronics, lubricant and cooling substances, and polymers that are mostly used in the blades. To date, blades remain problematic to recycle and they are mostly shredded, incinerated or go to landfill. Research around this continues because of the number of turbines, both onshore and offshore, that will need decommissioning in the next few years.

As turbines continue to increase in size and capacity, there will be a transition to direct-drive turbines, which do not require gearboxes, and this is supposed to reduce failure rates as well as operation and maintenance costs. In addition, as turbines become larger more raw materials are being used. Two smaller turbines need fewer raw materials than a single large turbine of the same rated power, so even though larger turbines would produce more and should be more competitively priced, using increased resources for the same capacity makes them unsustainable. This makes recycling and re-using raw materials essential.

Before decommissioning, companies should consider all options: both partial and full repowering, which generally depend on the status of the asset and the technical limitations of any new turbines being installed on the foundations, or the electrical system being re-used. This approach supports a flourishing market offering second-hand components and even turbines at a reduced price.

Once the asset stops operating, the owner is required to leave the site as it was before the project was installed to prevent environmental damage. However, because the regulations are unclear, there is an argument for leaving the structures in situ as new marine habitats may have flourished around them and the environmental impact may be increased if they are removed. This would also benefit the project owners by reducing their decommissioning costs. Safety conditions apply — for instance, cutting the foundations to allow secure navigation, ensuring that cables are well buried and so on. If owners do not estimate their decommissioning costs realistically, the worst case could be that they abandon the project leaving the public to pay the bill.

Decommissioning is a complex procedure full of uncertainty, and currently challenging because of the sector's limited experience and lack of specific regulations. Detailed regulations and guidelines with clear liabilities for the owners are necessary to minimise impacts, as well as encouraging sustainable decommissioning from the design phase that targets re-use and recycling of materials.

Eva Topham is project engineer at DNV GL Renewables Advisory (Spain) and is a PhD researcher at the University of Strathclyde
eva.topgon@gmail.com

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