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The end of the line for today's wind turbines

We need to start thinking today about the future of our wind turbines, according to Dr Athanasios Kolios and *María Martínez Luengo from Cranfield University.*

EDF's recent announcement that they will extend the life of 4 of their 8 UK-based nuclear power plants has focussed analyst's minds on the pros and cons of extending service life. There are numerous cost and engineering issues at play here. These obviously include balancing the initial investment cost against profits already made and the potential decreasing efficiency alongside the increasing maintenance costs in an aging facility. The issues cut across the whole energy sector, but they aren't something many of our renewable technologies have yet had to face.

Wind turbines, for example, are currently designed to be efficient and reliable for 25 years with possible extensions beyond that. According to RenewableUK, wind (and particularly offshore wind) is the UK's most promising renewable source to help meet the targets set by the EU in 2007 of obtaining 20% of total energy from renewable sources by 2020. As a result, vast numbers of turbines have already been installed on and offshore, and many more will be deployed in the next 5-10 years. What, though, will be happening in 20-25 years' time when today's turbines are reaching the end of their lives? The question of what we are doing with all of these turbines is already becoming a hot topic.

The benefits of extending the life of our current turbines seem clear cut. With a typical wind turbine costing usually a few millions per unit, extending the service life could result in a substantially greater return on investment. It also increases the overall electricity produced, and can therefore decrease the levelised cost of electricity – the cost per kWh in real terms of building and running the turbine. These are the main reasons operators will look to extend the service life, but we already know that there may be potential barriers.

The main risk is extensive degradation of one or more parts of the turbine. Rotor and blades, for example, can be impacted by lightning strikes, vibrations, corrosion and unsteady air loads. The efficiency of a wind turbine is even decreased by the smooth blade surface becoming roughened by erosion and icing to which the turbine will obviously be exposed. The tower and foundation of the turbine are also obviously critical to operation, as they can't be easily replaced. Cracks and corrosion are real threats, and while they can be modelled in design stages, exactly how a turbine will be impacted by the natural environment can't be accurately predicted. Other potential failures may lie in the electronics – responsible for 13% of failures at present – or in other crucial components like the generator, gearbox and pitch control.

Even with these risks, as today's wind turbines reach their final service life years, it can still be very beneficial to increase their service with some minor refitting. Common spare parts can cost between 5% (rotor hub) and 20% (blades) of the cost of a brand new turbine. At these prices, make do and mend makes financial sense.

Just like any consumer good, the better the turbines are cared for, the more likely it is that they will outlast their original purpose. Optimum asset management, including inspections and maintenance activities, will make turbines more efficient for longer. However, the cost of maintenance and inspection can be high – especially at offshore sites where it is costs 5 times as much as onshore activities as well as being difficult to reach and time consuming. It is a substantial but vital investment. The ideal solution to increase life span is to integrate Structural Health Monitoring and Condition Monitoring Systems. These include the use of remote sensors on the turbine, for example strain gauges or accelerometers, to provide useful data about the condition of the structure and components. This would mean a more cost effective maintenance programme that responds to condition, and allows for carefully planned activities – rather than urgent responses to component sudden failure.

Reaching the end of nominal service life, the options on the table for our turbines won't only be to extend or not. Repowering – either rebuilding a turbine in the same location replacing some parts or starting from scratch – is also a feasible alternative. And if extension or repowering is not feasible, decommissioning and returning the location to the same state it was in prior to the turbine installation comes with its own challenges and costs.

The options for repowering assume reusing part of the infrastructure from the existing wind farm to reduce the capital cost of the new one. For example, for an offshore site, most of the original subsea cables might be reused, along perhaps with the existing grid connection. The options might be to use the original tower with a new, lower capacity turbine. This may produce less electricity, but also needs less maintenance, and the tower will be less fatigued by the load as it ages. The same tower might also have a new, higher capacity turbine – producing more electricity, but the greater load may make structural integrity an issue. Or, a new tower with a new higher capacity turbine using the same site assets.

The decision on the best solution here would be based on profitability as reliability and performance decreases, the cost-benefit ratio against decommissioning the turbine totally, and the profits expectation for the life extension. However, since wind turbines tend to be in high wind sites, repowering can be lucrative. The first repowering in the UK is happening onshore imminently. RWE npower Renewables are applying it to reduce the number of turbines at the Taff Ely Wind Farm in Wales from 20 installed in 1993 to 7 higher capacity turbines which would double the output from the site each year.

When repowering or extending service life is no longer an option, decommissioning represents the final alternative. The main objective will be to return the landscape or the seabed to the state it was in before the turbines were first installed. However, all the elements of the turbine must be dissembled. Firstly blades, nacelle and the tower will be disassembled and hoisted down by crane; its posterior elements will be disjointed and reduced into smaller pieces suitable for scrap. These all need to be transferred by boat or truck to a recycling location where almost every part of a turbine can be recycled. The scale of the decommissioning operation is comparable to that of the initial commissioning! As such, this is definitely the least preferred option for the industry that should spend without the expectation for future return.

Most wind turbines shall last for about 25 years with normal inspection and maintenance. A 2014 study found that the UK's first wind turbines deployed in the 1990s are still largely profitable as their power production is about 75% of their ideal production. Those first turbines are expected to have about another five years of profitable operation. To best extend the life of our new or more recent turbines, time and money need to be wisely spent on identifying at-risk components and assessing the units' condition. The authors are of the view that the industry will need to put more efforts into planning for the end of life scenarios, especially when it relates not just to single turbines but to whole wind farms. As they get bigger and more ambitious in aspect of unit scale and number of deployed units, and the technology within the turbines as well as for monitoring structural health improves, so the issues set out here will get increasingly complex but at the same time our understanding of the assets' condition will improve. Since it is widely accepted that we can rely heavily on wind for our future needs, we need to think about the future today.

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FURTHER INFORMATION

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