Operators and OEMs look to proactive blade maintenance strategies as a route to better yields

Words: David Urch, Managing Director, Armour Edge

With longer blades, faster tip speeds and harsher operating environments, early-years blade erosion is a growing challenge for onshore and offshore wind farms. This is driving new approaches, with in-warranty repairs, preinstalled blade protection and new, more durable solutions becoming more common.

The wind industry has reached a tipping point.

Early years blade erosion is becoming a more common phenomenon and operators and original equipment manufacturers (OEMs) are now adopting new strategies to avoid costly downtime and operating with sub-optimal, eroded blades, which can impact on annual energy production.

In the last decade, we have seen blade lengths increase substantially, bringing tip speeds over 200 mph.

In parallel, offshore operators are looking to more distant sites, which bring higher wind speeds, but also higher average rainfall and heavier sea states, leading to faster times to significant blade erosion, yet shorter weather windows for repair.

Onshore, there is a similar dynamic, with dust and sand combining with increased rainfall and longer blades to generate more rapid erosion times. In India and the USA, for example, onshore schemes have seen significant blade damage within two years, due to high winds and airborne sand particles.

The impact of eroded blades on annual energy production can be significant, not just to individual turbines but to whole farms through wake effects, with academic studies suggesting that leading edge erosion can reduce overall wind farm annual energy production by around 3%.

And despite the rapid advances in wind turbine technologies in the last decade, blade construction has largely stood still, with blades still made principally of glass fibre and resin. These will always erode over time, and significant erosion within five years is now not uncommon.

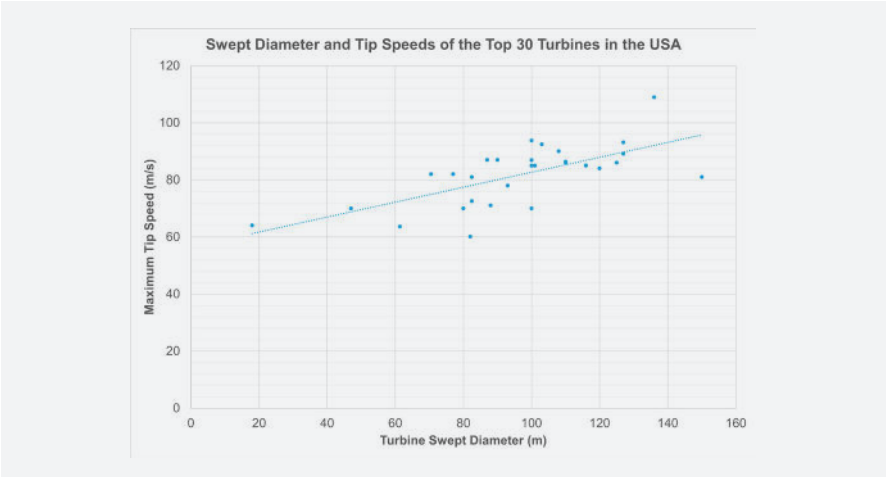
Understandably, offshore operators and OEMs are reluctant to share information on time to erode, but it is understood that in-warranty blade repairs on leading projects are not unusual.

Leading edge erosion may or may not be included within the typical five-year warranty period, it is a grey area, but irrespective of who is responsible, affected operators face either reduced energy production via a 'wait and see' approach or up-front downtime to undertake a repair.

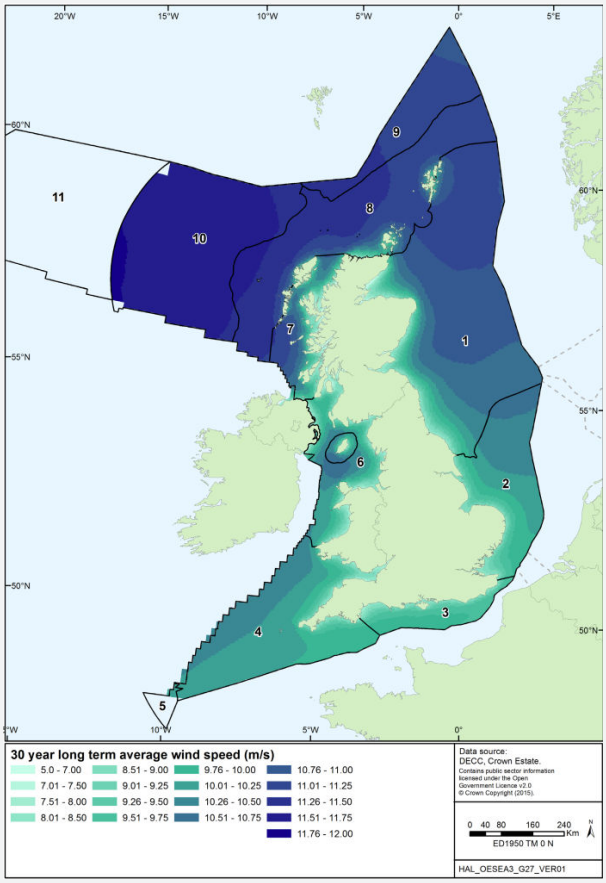
Time to repair is crucial; every day of non-production is significant in lost revenue, so minimising downtime is critical.

In addition, as sites get deeper and further from shore, overall time to repair becomes a vital consideration, repair windows may be scarce, and quicker in / quicker out will reduce onsite risk exposure.

With trained operatives, repairing a blade per day in situ is now achievable, dependent on



Sources: www.thewindpower.net & en.wind-turbine-models.com



Source: UK Government Department of Energy and Climate Change, UK Offshore Energy Strategic Assessment Appendix 1F: Climate & Meteorology, March 2016

the leading-edge protection (LEP) applied; and operators need to weigh up the relative merits of tapes versus soft shells and custom-designed products.

As part of this, operators need to think carefully about their ongoing strategy; how long will repairs take, how durable will they be and do revenue models need to bake in leading-edge repairs every, say, five years?

Proactive strategies

For operators and OEMs with operational farms, getting ahead of blade erosion is key.

Some are adopting proactive regimes, making leading-edge repairs early, 'when the sun shines', to avoid the degrading performance which will inevitably follow from a 'wait and see' approach.

Whilst developers, as always, are looking at every element of their wind farm design and operations and maintenance regime in order to reduce downtime and improve predicted yields, auction rounds are highly competitive and every developer needs to examine closely how their project can gain an edge.

Durable blades could be key

At Armour Edge we are working with OEMs to explore how factory fitting our patented blade protection system, which uses a bespoke version of INEOS's ultra-tough Luran® SC thermoplastic material, can deliver wind blades with a 50 year erosion free lifespan.

Each shield is up to one metre long and is custom formed to the exact blade type and then bonded into place by trained technicians.

Launched commercially in 2020, we now have a ten-year exclusivity deal with INEOS and a growing order book worldwide, with repeat orders from early customers including RWE and the German offshore wind farm Riffgat, with several clients now looking to increase the amount of coverage per blade.

In 2022 a series of comparative tests by The Offshore Renewable Energy (ORE) Catapult, the UK's leading technology innovation and research centre for offshore renewable energy, put three Armour Edge samples through a series of accelerated rain erosion tests at their National Renewable Energy Centre in Blyth, Northumberland.

ORE Catapult compared the Armour Edge product against a range of typical leading-edge protection systems, including tapes, coatings and softshell, using rain erosion standardised tests, conducted at 1000 rpm and 55 l/hr, equivalent to a rainfall intensity of 26.5mm/hr and droplets of around 2.4 mm, similar to what might be experienced in a thunderstorm. Blade speeds at the tip, centre and root were 125m/s, 105 m/s and 85 m/s, respectively.

In the accelerated tests, Armour Edge shields lasted an average 232 hours versus other solutions, which lasted on average between ten and 160 hours.

ORE Catapult then applied a lifetime prediction methodology based on the theoretical Springer model to industry standard DNVGL RP 0573, but using ORE Catapult's offshore rain data, to reach conclusions on the real-world durability of Armour Edge.

53 year lifespan

The model predicted the custom-made leading-edge protection would last 53.4 years, far longer than the expected lifespan of an operational wind turbine.

The report also stated that Armour Edge shields degraded much more evenly than other forms of leading-edge protection, resulting in significantly less loss of aerodynamic performance through the lifetime of the product.

This was backed up by a subsequent study by Natural Power Consultants, which examined the impact the hard shell blade protection system had on a representative turbine's aerodynamic performance.

The analysis, which was built on previous CFD analysis and wind tunnel tests by Heriot Watt University and the University of Glasgow, showed negligible impact on turbine performance at rated wind speeds and above.

New thinking

This could be a game changer for the industry.

Long-life blade protection, either pre-fitted at the manufacturing stage, or early in the operational life of a wind farm, could alter the economics of ever longer blades, removing multiple days of downtime in the life of a wind farm and significant days of lower yields as blades degrade over time.

Additionally, it may remove the likelihood of in-warranty claims and disputes and the underwriting costs these bring.

We are now seeing growing traction in the market, with numerous repeat orders in Europe and the USA and ongoing discussions with OEMs.

It does seem remarkable that multi-billion-pound wind schemes are today reliant on blades no longer durable enough to withstand the elements in which they are placed.

This is starting to change, and I anticipate we will see an increase in proactive maintenance and preinstalled long-life blade protection in the years to come.

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