Wind turbine blade maintenance matters

BLADEFENCE®

WINDPOWER MONTHLY

Introduction

According to a study by Sandia National Laboratory in the US, a heavily eroded blade can reduce a turbine's annual energy production by up to 5%. When these output reductions are extrapolated across a utility-scale wind farm of several megawatts in size, the losses can eat into revenue and the return on investment.

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A turbine rotor is the most exposed component of a wind turbine system. The blades work in rain or shine, seven days a week, 365 days a year.

Wind turbine capacities have increased in size and continue to do so, enabled in part by larger rotor diameters. This has helped drive down the levelised cost of energy as fewer turbines are needed for the same output. This means lower capital investment is needed while installing the project, and Opex costs are lower because there are fewer machines to maintain.

What this does mean, however, is that when a single turbine is out of action the impact on the wind farm's energy production is greater.

Good maintenance practice, then, is more critical than ever – for the blades and other components.

Common causes of blade damage

Blades are vulnerable to damage even before they are fixed to the turbine on site. They need to be taken care of before the wind turbine is powered up and through their entire life cycle, right up until they need replacing or the machine is decommissioned.

Whenever a turbine's blades are hit by rain, hail, ice, salt, dust, or ultraviolet (UV) light from the sun's rays, erosion of the leading edge occurs. This creates a rough surface, causing resistance and drag as it moves through the air, reducing efficiency. Even the smallest imperfection can have an impact on a turbine's operation.

Regular checks, cleaning and targeted, small fixes to rectify any damage can help minimise maintenance costs. If problems are not detected and addressed, operations and maintenance (O&M) costs can grow exponentially.

More complex repairs take longer, increasing turbine downtime. In the worst case, the blade could need to be replaced, despite the situation being avoidable in the first place with an effective O&M regime.

Damage to the turbine blades, for example from leading-edge erosion, can also affect the finely calibrated balance of the wind turbine's three rotor blades. Eventually, this has an impact on the other components within the turbine itself, such as bearings, gearboxes and the turbine tower, resulting in additional maintenance costs.

Typically, wind-farm service providers carry out scheduled maintenance of wind turbine components, with checks at regular intervals based on standards and manufacturers' guidance.

The challenge is to ensure operational costs do not increase due to an over-reliance on planned maintenance.

What the turbine can tell you

Wind farms are extensive sources of data. Digitalisation and analysis tools enable asset owners and managers to process different sources of data, including information recorded by sensors installed on components, historical records of past inspections and repairs, and manufacturers' guidelines and standards. By combining this information, service teams can better forecast when a repair will be needed.

Recently, specialist blade O&M service providers have carried out inspections using drones and camera systems, which makes checks more efficient.

Drones or long-lens cameras can identify and prioritise areas of a blade that need repair work more urgently, without having to wait for a technician to scale the turbine.

Ultimately, inspection and maintenance activity that minimises turbine downtime reduces the impact on productivity. Wind turbines can be back in action, generating electricity and earning revenue sooner.

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Weather factors

Wind farms are, by their nature, built in windy locations. However, wild weather poses several restrictions in terms of when maintenance activity can take place.

In the northern hemisphere, the summer months are typically the best time for servicing. It tends to be when wind levels are at their lowest, making it the least productive portion of the year and minimising generation losses.

Because blades are exposed components, technicians can't usually be sheltered or protected to the same extent as if they were making inspections or repairs on drivetrain components in the nacelle or the power-conversion system inside the tower.

If wind speeds are too high, the turbine cannot be accessed, for safety reasons. Meanwhile, rain, humidity, snow and ice can also have an impact on maintenance planning and activity, as well as the effectiveness of some repairs.

The use of drones and cameras for inspections means aspects can occur without stopping the turbine, and often in higher wind speeds than is deemed safe for traditional rope-access investigations. At some point, however, technicians will be required to ascend the turbine.

For the technicians to safely access the turbine nacelle and stop the machine, based on a "lock-out, tag-out" (LOTO) protocol, this can occur in wind speeds of up to 15 metres per second (m/s) maximum. Hub and blade access require lower wind speeds, specified by the turbine manufacturer or the wind farm operator.

Rope access is the simplest way to carry out blade inspections and maintenance, in equipment terms. Based on daily rates it is often the lowest-cost approach; nonetheless, it has limitations.

Rope-access inspections or repairs can be carried out safely only at wind speeds of less than 10m/s. >>

Weather factors cont'd

<< An alternative is to provide access using a mobile elevator wind platform (MEWP), which enables technicians to safely carry out blade-maintenance work in wind speeds of up to 12.5m/s, thereby increasing the time available for repairs.

Extreme temperatures or icy and wet conditions are not safe for technicians to work in, either. In wet weather, the health and safety risk for slips, trips and falls increases substantially. Other risks include electrical shocks from power tools, and reduced visibility.

Weather waiting factor

Even in the summer months there are periods of inclement weather. Operators have to consider a 'weather waiting factor' – the additional hours when technicians are waiting during periods of bad weather, due to rain or high winds, for instance.

Costs relating to the weather waiting factor are a financial calculation of weather-related risk that operators need to incorporate into budgets for blade O&M. These risks can be mitigated to an extent by interrogating historical weather data for a given wind farm's location.

> A mobile elevator wind platform (MEWP) enables technicians to safely carry out blade-maintenance work

Weather-related risks and costs can be reduced further by ensuring that technicians are able to undertake blade-maintenance and repair work in conditions that might otherwise be challenging or impractical if planning to use rope or MEWP access.

Advances in blade-repair products

One of the most common and time-consuming aspects of blade-repair activity is the application of new layers of coatings to protect these composite structures against further erosion.

Traditional wet lamination techniques and materials can be difficult and messy to apply when using rope or platform access. They have to be applied above a certain temperature and require significant time to cure by heating with a dryer.

Composite materials used for repairing blades do not perform as required in extreme temperatures. Typically, an epoxy repair resin requires 15°C-25°C and a maximum relative humidity of less than 70% to set effectively.

While there are composite materials on the market, designed for emergency repair in the marine market, that are usable in wet conditions, these are not yet approved by wind-turbine manufacturers or industry certification bodies such as DNV GL.

Advances in UV curing materials designed for the wind industry's needs have resulted in new coatings. Examples include Gurit's RENUVO system, which can be applied in a wider temperature and humidity window (min 5°C and up to 90% RH). The UV curing process takes just a few seconds.

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For wind farm operators with an eye on the bottom line, maintenance work that can be carried out in the most efficient and fastest way possible translates into reduced turbine downtime, optimising productivity.

The Bladefence proposition

Developed during 2018 and introduced in 2019, Bladefence is making the case for a disruptive approach to blade maintenance. The Bladefender system is designed to provide technicians with a safe, protected and comfortable environment all year round.

Using Bladefender reduces weather waiting factors, due to high humidity and rain, by 47% (see table below).

It creates a covered climate-controlled platform and allows full access around the blade. This means work can occur in rain and humid conditions, as well as when temperatures are very high or low, opening up the window for blade repair and maintenance and reducing sub-optimal operation and downtime.

Bladefence's product allows the technician to create an environment to suit materials used for the repair when the external temperatures are between -5°C and 30°C, compared with rope or MEWP access, where the temperature has to be between 15°C and 25°C.

Technicians are also able to spend more time on maintenance jobs and less time on the ground waiting for good weather conditions.

Wind farm asset owners benefit from a reduction in weather waiting hours, as this lowers maintenance budgets. Technicians can complete maintenance activities more quickly and turbines can be brought back online sooner thereby generating revenue once again.

Project	Access	Total project hours (working hrs + weather waiting hrs)	Weather waiting hours	Weather waiting hours suitable for Bladefender deployment (due to humidity/rain)	Reduction of weather waiting time (%)
Repair project, Southern Sweden	MEWP	827.5	310.75	80	26%
		185	73.5	45	63%
		95.5	39.5	25.5	65%
		86	43.5	16	37%
		168.5	79	35	44%
TOTAL		**1362.5**	**546.25**	**202.5**	**47% AVERAGE**

Bladefender details

- The modular design of Bladefender allows for fast and simple on-site installation.
- The internal environment can be adjusted to support application of rapid-curing UV-based blade coatings, such as RENUVO.
- Using Bladefender reduces weather waiting factors, due to high humidity and rain, by 47%.
- Developed in partnership with the MEWP OEM, Bronto Finland, the system has a maximum load of 350kg and a 12.5m/s wind-speed limit.
- Bladefender allows the technician to easily control the work-area temperature and humidity, with a dehumidifier and heater included as part of the system.
- Bladefender allows maintenance work to be carried out more quickly and efficiently than rope- or MEWP-enabled access.
- The system is provided with safety documentation, risk assessment and evacuation plan.

About Bladefence

Bladefence offers the most sophisticated methods to maximise the performance and endurance of wind turbine blades. Founded in 2010, our focus is firmly on offering high-quality blade service and changing the common practice of reactive and expensive wind-turbine blade repairs towards shared risks, preventive maintenance and fixed fees.

Get in touch

+358 9 8553 8585 (Europe)

+1 647 339 2924 (Canada)

info@bladefence.com

bladefence.com