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Asociación Uruguaya de Energía Eólica



Preventative vs. Reactive Maintenance: When Does It Become Too Late To Repair Or Replace?

13rd June 2017

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Preventative vs. Reactive Maintenance: When Does It Become Too Late To Repair Or Replace?

The blade is the most important component in a wind turbine which nowadays is designed according to a refined aerodynamic science in order to capture the maximum energy from the wind flow. Blades are now completely made of composite materials. Composite materials satisfy complex design constraints such as lower weight and proper stiffness, while providing good resistance to the static and fatigue loading. At the same time, there is a relentless demand for lowering the cost of energy, and blades are larger and larger. Therefore the condition of the blades is of vital importance to turbine performance and revenue.

Preventative vs. Reactive Maintenance: When Does It Become Too Late To Repair Or Replace?

- *Moving towards the end of a blade's lifetime: making sense of numbers by looking at the turbine components*
- *Increasing the monitoring activity for informed and cost-effective decisions on your blades*
- *Why do regular maintenance and inspection campaigns become more and more essential towards the end of a blade's lifetime?*



Moving towards the end of a blade's
lifetime: making sense of numbers by
looking at the turbine components

The facts

Moving towards the end of a blade's lifetime

A Wind turbine contains many components all playing their part in the conversion of the wind's kinetic energy to electrical energy. Each of these components has experienced tremendous development, improvement and increase in scale in the last years to meet the requirements of increasing power energy and reducing COE, resulting in tower top weight reaching hundreds of tons and thousands of kNm.

Moving towards the end of a blade's lifetime

Blades are the most expensive component on a wind turbine and crucial to revenue generation but often neglected in the industry. During the lifetime of a wind turbine the blades are constantly exposed to wear and tear caused by the forces of nature as well as force majeure events. To ensure an optimum performance of the blades, on the technology side, manufacturers are driving down the cost of energy with longer blades, which requires more and more advanced conditioning monitoring systems in order to provide a thorough assessment of the condition of the blades. However, blade damages are often discovered too late. As result, the repair is extensive and costly with the risk of prolonged downtime. Furthermore, in areas where heavy lightning activity is, lack of intervention can cause millions of euro in damages and the impact of blade failures is increasing as wind developers reach more remote locations in the developing world.

Moving towards the end of a blade's lifetime

Even erosion, minor damages, and dirt can lead to reduced efficiency of the blade with up to 5% lost production and site specific conditions leave room for optimization where using aerodynamic upgrades can boost production up to 1.5%

Whereby, the main purpose of the inspection is to identify minor damages to the blades before they develop into more serious incidents – but also to monitor wear and tear degradation which has impact on turbine availability, safety and business profitability. Nevertheless it is very important to keep in mind that a blade in bad state is always a high risk of falling debris to the ground.



Increasing the monitoring activity
for informed and cost-effective
decisions on your blades

Value Propositions

Increasing the monitoring activity

Why?

- 1 To avoid the risk of performance losses due to blade damage at my wind power plant
- 2 Uncertainty about the current condition of my blades
- 3 Access expert knowledge on the right repair solution on my blades
- 4 A way to ensure fast blade repairs to increase my turbines' performance and enable maximum uptime
- 5 Ongoing opportunities to increase AEP and performance for my turbine
- 6 A solution to reduce risk related to wear and tear on my blades

Increasing the monitoring activity

The inspection process

- 1 Blade are inspected by means of high resolution camera - drone - rope access - etc
- 2 Damages are evaluated and compared to historical database photos. Once checked, they are then assessed and classified into damage categorization from 1 to 5
- 3 If any, repair solutions are scheduled
- 4 Once we have conducted the inspection, our technical experts analyse the collected data to identify root causes. The results are delivered in a comprehensive report.
- 5 Repairs are performed as required

1 Cosmetic	2 Similar to cosmetic	3 Non-serious damage	4 Serious damage	5 Very serious damage
No intervention needed	Intervention only done if other damage exist	Intervention done during planned WTG inspection	Intervention done within 3 months	Intervention required immediately

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Increasing the monitoring activity

Taking care of blades is not only about repairing them when damage occurs.

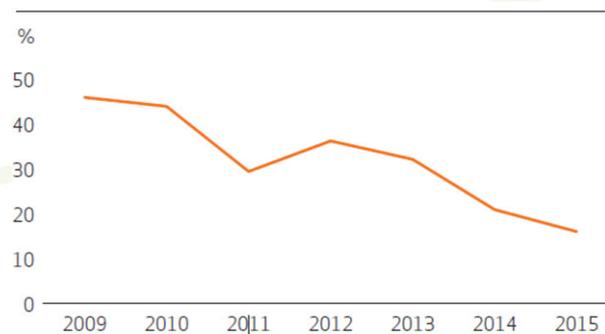
- *It is about identifying damage and intervenes before it develops into serious, failure-causing damages.*
- *Extensive blade inspections can identify all types of damage and provide a detailed status of the component with recommended solutions. In particular, experience shows that inspections significantly decrease the risk of damages developing into serious issues that require a costly repair solution and turbine downtime.*
- *To guarantee efficiency, the inspections and the subsequent repair work has to be carried out by experienced technicians. It's furthermore important to highlight the necessity of performing the repairs according to manufacturers' top-quality standards. By doing so, it is guaranteed for the full lifetime of wind farm assets a lower the Levelised Cost of Energy and an optimised performance by growing knowledge and insight.*

Increasing the monitoring activity

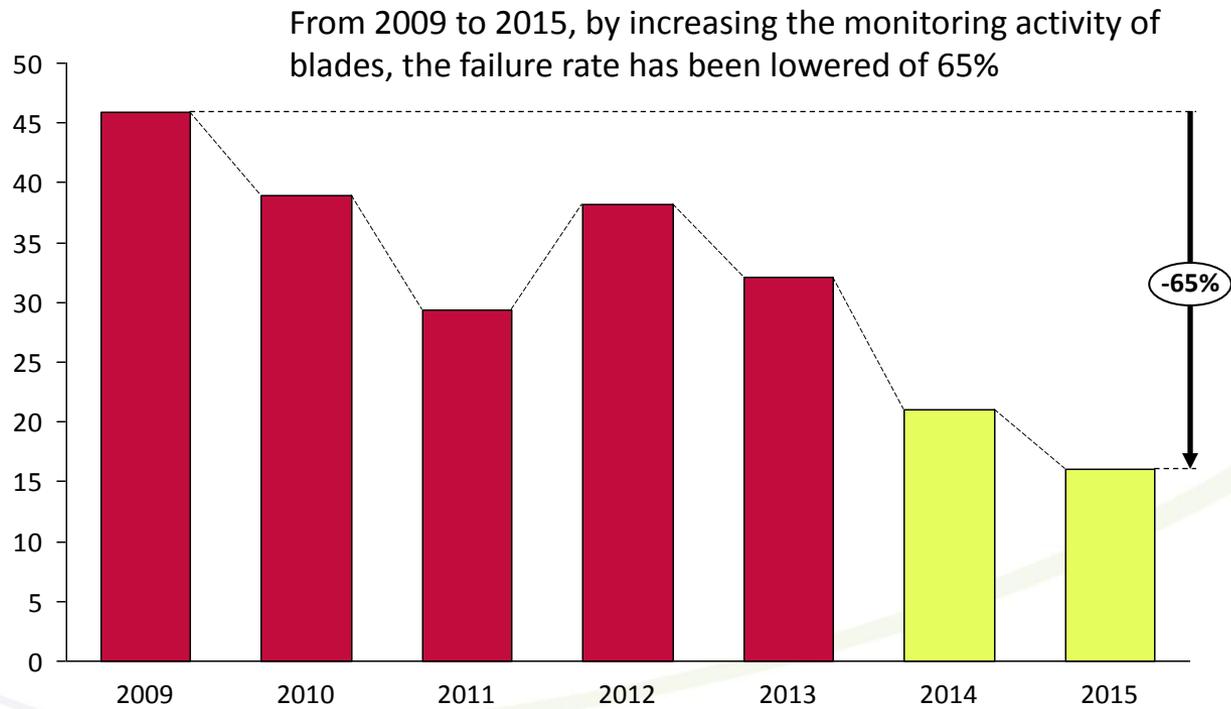
A scheduled and extensive blade inspection process helps to avoid the risk of performances losses due to blade damage at wind power plant uncertainty about the current condition of blades.

Once again, it has to be highlighting that by ensuring the access expert knowledge on the right repair solution on blades is a way to ensure fast blade repair to increase turbines' performance and enable maximum uptime.

In conclusions, blade inspection ensures an ongoing opportunities to increase AEP and performance for turbine, is a solution to reduce risk related to wear and tear on blades and an ongoing opportunity to extend lifetime of blade



Increasing the monitoring activity



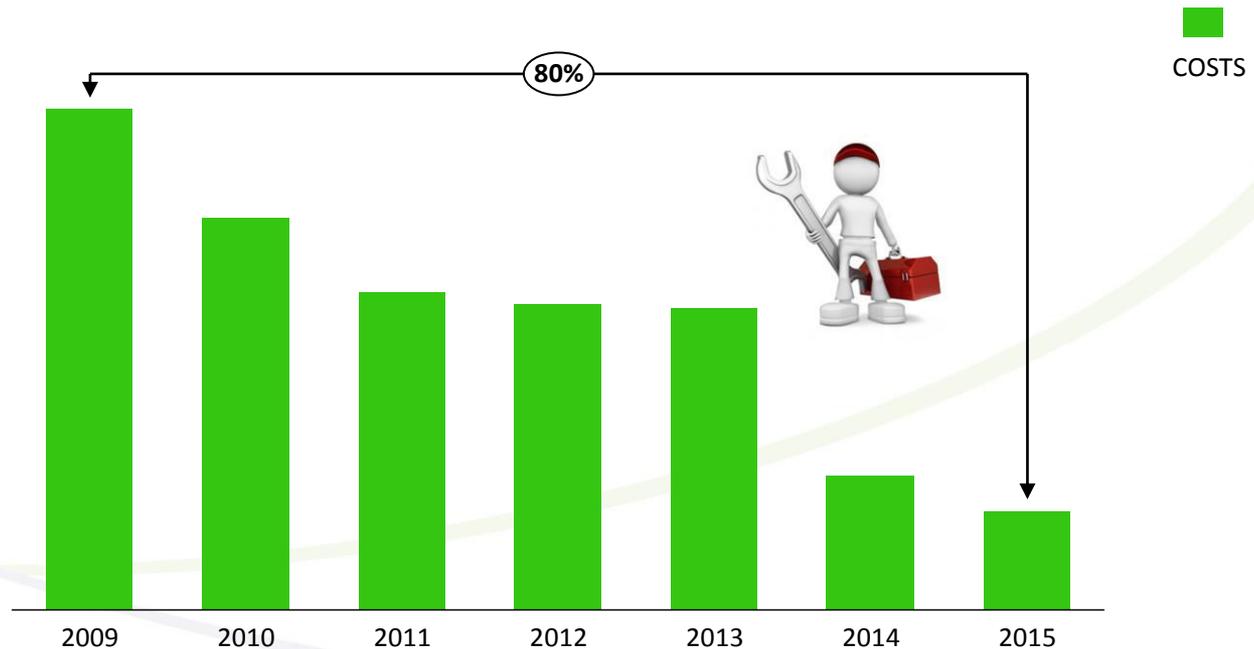
Why do regular maintenance and inspection campaigns become more and more essential towards the end of a blade's lifetime?

Furthermore, the results analyzed during the last years of frequent inspections, showed how since 2009, there has been a 80% reduction of average costs for interventions, since

- Repair solutions have been improved;*
- Blade access method have been improved;*
- Scheduling of the repair has been improved.*



Why do regular maintenance and inspection campaigns become more and more essential towards the end of a blade's lifetime?





Why do regular maintenance and inspection campaigns become more and more essential towards the end of a blade's lifetime?

Prevent critical blade damages with high quality and flexible inspection methods

Why do regular maintenance and inspection campaigns become more and more essential towards the end of a blade's lifetime?

- 1 You get the best and most cost efficient blade service in the market
- 2 We offer fleet wide inspections to enable you to always know the condition of your blades
- 3 We deliver high quality and fast blade repairs to increase your turbines' performance and enable maximum uptime
- 4 We have designed blade specific upgrades for complete blade protection
- 5 We offer aerodynamic performance upgrades to increase your AEP
- 6 All of our tasks and execution incorporate safe, globally released methodology, ensuring your blades are addressed in a SAFE and consistent way.

Why do regular maintenance and inspection campaigns become more and more essential towards the end of a blade's lifetime?

Early discovery of potential damages contributes to the extension of turbine lifetime to exceed the original 20 year life design and ensures turbine availability when it is most profitable. Inspection is a proactive, preventive process that detects premature damages before they develop into critical issues that will demand costly repair or exchange solutions.

During the inspections frequent issues can be found and most ongoing research on failure modes for blades uses to summarizing them as follows

- *Leading edge erosion*
- *Lightning damages*
- *Cracks*
- *Severe contamination*



Why do regular maintenance and inspection campaigns become more and more essential towards the end of a blade's lifetime?

Once the inspection is conducted, the collected data have to be analyzed by technical experts in order to identify root cause and define the repair solution, if any. Furthermore, the results have to be stored in a comprehensive report, which includes a clear outline of any damages and recommended solutions based on the most cost-effective repair solutions and industry-leading upgrades. The report will also include detailed images of all blade areas, defect clarifications. Moreover, the reports and images have to be stored to follow the development of blades and inform decision making. The above is crucial to remove wear and tear cost uncertainty, minimize LPF caused by suboptimal blade conditions and fully integrate into a streamlined repair process.

Why do regular maintenance and inspection campaigns become more and more essential towards the end of a blade's lifetime?

Missing a blade care program can cause several losses in damages and energy interruption.

Several lessons have been learned in the last years within the wind sector. It has been seen for example how the good status of the blades is of vital importance in keeping unchanged the turbine performances and in reducing the wear and tear phenomenon.

It has been also found that accurate data management and detailed technical reporting support the owner in keeping a constant and updated condition monitoring of blade, and therefore of the wind turbine generator, allowing and ensuring an effective and an efficient asset management.

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