# Increased returns by robotized wind turbine inspection and maintenance

With the increasing size of wind farms and the turbines themselves, the scale of inspection and maintenance challenges faced by the wind energy industry is also growing. Servicing the blades has become more difficult, whereas turbine failure and downtime are more costly. Additionally, growing risks related to increased lightning damage due to towers and blades reaching ever higher in the sky further strengthen the importance of preventive maintenance, structural repairs, and other turbine upkeep.


Wind turbines are getting bigger. The once giants of the early 2000s, with a rotor diameter of 50 meters generating less than 1 MW, have been dwarfed by today's behemoths, which have tripled in both size and capacity. Still larger turbines are coming, and while there may be debate about the upper limits of turbine size, the consensus is that we've still got a way to go before reaching it.

How are wind farm operators reacting to this? Until recently, the majority weren't, as there were no solutions available for efficient inspection and maintenance services. They had to rely on increasingly ineffective traditional human-centric inspection and maintenance practices, while hoping that insurance would help mitigate some financial losses, which they end up paying for themselves through higher premiums. Due to this, there was a perception that inspection and maintenance was slow and expensive. And, admittedly, it was, to the point where doing it preventively at scale was not viable.

However, this is no longer true because the robots are here and the scales have tipped in favor of maintenance. Today, with the advent of robotics for inspection of maintenance, the cost-benefit equation has been rebalanced. By automating, accelerating, and streamlining various key maintenance elements through the use of robots, there is now a strong financial incentive to take better care of your turbines. This is a fact that the majority of the industry is slowly waking up to, but perhaps too slowly.

With robots that operate inside and outside of the turbine, it's now possible to carry out external visual inspections, speedy internal blade inspections, lightning protection system (LPS) inspections, ultrasound inspections, and more; all remotely from the comfort and safety of the ground. And the robots are not only capable of performing inspections, but also safe and fast repairs, such as cracks and leading edge erosion, ice-phobic coating application, as well as drainage, tower, and blade cleaning.

This has completely changed the playing field for inspection and preventive maintenance, allowing wind park owners to make better decisions and more efficient use of their labor. Of course, all while massively reducing downtime, idle stay, and service costs.

Take LPS inspection, for example. Even just a few years ago, it was an expensive and slow process that meant an entire day of turbine downtime and labor hours. Now, with Aerones' robotic tools, wind turbine owners can inspect the health of the LPS in one or two hours. In addition to standard inspection, the robot is also capable of detecting conductor damages, allocating the issue placement, and repairing the oxidation in the lightning protection system wires.

As a result, wind park owners are discovering that up to 30% of turbines in their wind parks have broken LPS and are better informed to make optimal decisions regarding preventive maintenance.

In a similar vein, robot-powered internal inspections can reveal critical issues, such as the real and precise scale of cracks, by providing data that would otherwise be either incomplete or costly to gather. For instance, a blade crack typically starts on the inside, yet a drone inspection may only reveal the scale of damage on the outside; it may look like a minor 30 cm issue on the surface when in reality it already stretches 1.5 m within.

Moreover, due to the compact size of the robot, it can penetrate far deeper down the blade, which will be invaluable as blades keep growing in size. The cost-effective availability of this type of data puts decision-makers in a far better position to see the real picture and react accordingly.

Oil cleaning is another task that will, within a few years, be completely taken over by robots. It can take three rope access technicians three to six days to complete such a menial job, whereas a robot can complete it in a single day. In a time when skilled technicians are among the most in-demand professionals in the world, they should be spending their time on more value-added activities such as structural repairs.

This is to say nothing of the massive savings generated by less downtime and the reduced impact on the environment through the collection and recycling of wastewater when cleaning is performed by robots.

### An industry on the precipice of a paradigm shift

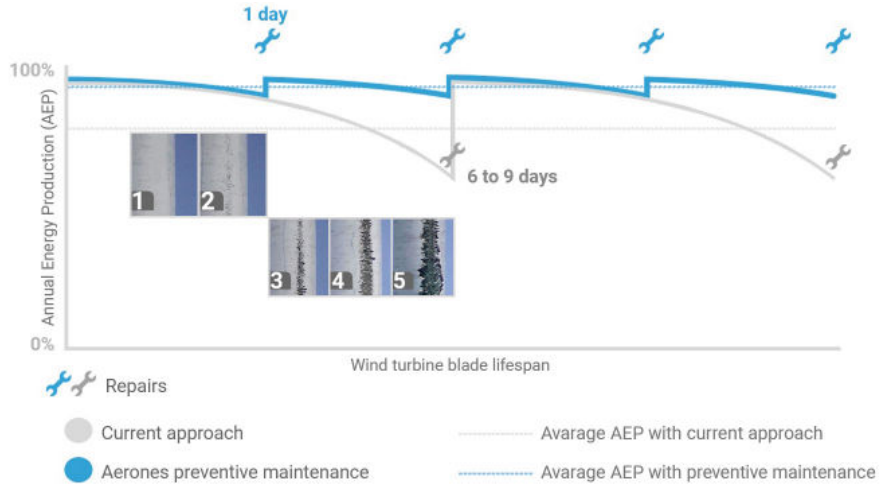
Beyond the few practical examples offered above, robotics also offer more general advantages, such as the ability to operate in wider weather windows, in wind speed of up to 15m/s, and may serve as a scalable solution to the talent shortage. The training of technicians operating robots can be done in less than a month, as opposed to the one to two years it takes for a rope access technician.

To say that robotics will redefine the entire wind industry is no exaggeration. Their impact will be so significant that it will even change what we consider maintenance and repairs.

For example, in the future, we will view wind blade leading-edge renewal the same way we see an oil change for a car, as casual upkeep. Currently, it's a costly and slow type of repair, which is why it's postponed until level 5, the most critical state of erosion. But with Aerones' robots being able to do automatic level 5 repairs twice as fast, level 4 repairs up to three times faster, and preventive level 2 maintenance 10x faster, it will become a cheap, quick, and automated task that won't even be counted as repairs, but rather standard upkeep.

That said, the industry is not there yet and we don't mean in terms of technology, that's already available. Rather, in terms of mindset. The adoption of robots requires going against decades of established practices and many operators exhibit reluctance to do so. Sending your technicians up there may be getting less effective, but they're still getting the job done and doing it predictably.

Still, as fleets expand and turbines grow in size, the returns of manual wind turbine inspection and maintenance are diminishing. There should come a turning point when




ignoring robotics is no longer possible. The question is, when?

### What will it take to change this mindset?

Three core factors may prove critical in pushing automation adoption: regulations, cost efficiency, and snowballing social proof.

The least likely is regulations. The wind industry has a long history of regulations impacting its modus operandi, particularly as far as safety is concerned. Unfortunately, these typically come in the form of reactive national responses to some tragic event. Today, with the wind industry at the center of attention, any mishap is likely to amplify and elicit concern about why routine maintenance is still manual and subjects in-demand professionals to safety risks. Particularly when alternative modes of inspection are available. However, it's unlikely that we'll see governments act proactively.

A far more likely catalyst for the adoption of automation is cost considerations. We've already touched on a deluge of factors, the diminishing productivity of manual maintenance, talent shortages, the necessity for more frequent inspections, inefficient use of human resources, and the rising cost of downtime. As these inefficiencies converge and costs mount, they will become impossible to ignore.

Considering all of the factors, we already see that in most cases the cost of robotic services is lower than the cost of traditional services. The question is when will that become obvious in the industry?

Finally, and by far the most impactful of the factors in changing the industry's mindset, social proof. Once a sufficient mass of early adopters will have demonstrated the clear advantages of robotics in practice and implemented such solutions on a permanent basis, the tides will turn. This will be further accelerated by a changing insurance landscape.

Once preventive maintenance at scale gains widespread traction, certain types of damages will be deemed the result of negligence and become too costly to insure, compared to available alternatives, namely, the use of robotics.

### This has happened before, albeit on a smaller scale

The wind industry went through a similar shift, with the same resistance and impact, with the advent of drones. Despite presenting clear benefits for visual inspection in a time when it was still done with pen and paper by rope access technicians, operators were skeptical and hesitant to modernize their methods. Now, drone use for inspection is just short of ubiquitous, and the benefits are obvious.

Why expend considerable resources and specialist time when it can be done by a drone in 15 minutes, and analyzed by artificial intelligence? The on-ground technicians must merely confirm what the computer has advised.

Though the answer may seem self-evident now, it took years and hordes of early adopters to convince others to follow suit. Today's status quo is yesterday's uphill battle, and it's clear that a few years from now, we'll be looking back at the advent of automation and robotics the same way we look at drones; and ask ourselves, what took so long?

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