



Shifting gears: the evolution from wind energy development to operations excellence

As the wind industry matures, the focus is shifting from rapid turbine development to maximizing performance and reliability. With OEMs emphasizing standardization and efficiency, new opportunities are emerging for technologies that enhance existing assets. From advanced blade protection to predictive maintenance and technician safety, operational excellence is now the industry's top priority, and key to wind energy's long-term success.



One of the benefits of hosting the Uptime Wind Energy Podcast is the ability to connect with the wind industry's technical leaders. Over the last decade, rapid expansion coupled with accelerated growth in rotor diameters has burdened OEM engineering staff with an impossible task: to deliver increasingly complex turbines while simultaneously reducing material costs. The industry's response today is clear: to slow down development and focus on performance. OEMs are undergoing a massive internal shift towards standardization and operational excellence.

This has created unique opportunities for companies with technology or processes that can enhance existing wind turbines by squeezing out additional power while reducing downtime. Operation and maintenance (O&M) companies continue to deliver innovative solutions addressing the industry's most pressing challenges.

Advanced blade technologies

Leading edge erosion remains one of the industry's most persistent challenges. Several innovative companies now offer solutions OEMs would be wise to consider offering

directly from their factories. At least, they should provide information on those that are most compatible with their systems.

SOCOMORE has adapted Hontek's military helicopter technology to create SOCOBLADE, a durable, leading-edge protection material. According to Max LeTallec, President of SOCOMORE Canada, their polyurethane product has shown exceptional longevity, with some installations lasting eight years without requiring reapplication. This solution provides significant value for operators who might otherwise face regular replacement cycles and associated downtime.

Armour Edge has developed another innovative approach with their protective polycarbonate shielding. Armour Edge Operations Director Will Howell highlights a key advantage of their material: 'When a polycarbonate erodes, it's more like a smooth surface. It doesn't have those fissures, those gaps, that pitting. And so even during the lifecycle of the erosion on a piece of Armour Edge material, you're not seeing that same AEP (annual energy production) hit.' This means even as the protection ages, it still

maintains better aerodynamic performance than competing solutions.

Sunrez represents another breakthrough with UV-curable materials for blade repairs. These systems dramatically reduce repair time and eliminate weather-dependent application windows. This approach allows repairs in conditions that are typically unworkable with traditional two-part mixtures. The speed of curing, just 60 seconds under UV light, transforms repair logistics while maintaining structural integrity, allowing operators to return turbines to service quickly.

PowerCurve's AeroVista platform provides precise quantification of energy losses from blade aerodynamic issues. Nicholas Gaudern describes how they've analyzed 'a couple of thousand turbines now with AeroVista' to determine realistic energy production losses from leading edge erosion, typically around '1.5, 2%.' This precise quantification allows operators to prioritize repairs based on actual production impact rather than visual appearance.

The wind industry has recognized the value of collaborative approaches to blade maintenance. The Global Blade Group embodies this philosophy, conducting joint industry projects where companies voluntarily participate.

Statkraft's Birgit Junker explains their collaborative testing process: 'We focused very much on the LEP because when we started this project, we were three companies to start with: Statkraft, Vattenfall and Eon (RWE). And we tested 20 LEP projects on a rain erosion test and chose the ones that behave the best.' This approach helps operators make informed decisions without duplicating research efforts.

Innovative root bushing solutions

Blade root integrity is emerging as a critical concern for operators, and again, small companies have proven they have viable solutions.

We4Ce has developed an innovative approach using advanced materials science. Their process replaces polyester with epoxy for stronger connections: 'We tried it with polyesters and it did not work. We do it with epoxies, and it works great. It's much stronger,' Edo Kuipers explains. 'We use a drilling machine. And then once this hole in the laminate is created and the old bushing is thrown away, we're left with a clean surface ready for reinstallation.'

Gulf Wind Technology has pioneered an up-tower repair method for blade root bushing issues. David King describes the nature of the problem: 'That metal bushing that's making the physical connection to the composite has lost its pre-tension.' Their minimally invasive approach works like 'laparoscopic surgery,' allowing technicians to repair failed bushings without extensive disassembly or blade removal. 'We can, with a piece of equipment,



reach that interface with very, very minute holes and inject or create a quite significant amount of pressure, almost similar to hydraulic fracturing and achieve a repair that gets the material into this broken-down interface.'

Critical connection management

Bolt integrity represents an often-overlooked yet critical aspect of turbine maintenance. EchoBolt has revolutionized this domain with ultrasonic technology for bolt inspection. Pete Andrews explains that their approach can 'save about 90% of the cost associated with bolt maintenance by moving to an ultrasonic inspection regime.' The traditional approach of retightening 10% of bolts annually and 100% every five years costs approximately '€1.2 million per installed gigawatt per year' costs that can be dramatically reduced through ultrasonic monitoring.

IntoMachines complements this with innovations in bolt tensioning equipment. Martin Kristelijn notes: 'Today we're talking about one to two turbines a day, depending on the familiarity of the technicians and the number of technicians with the product. The labor is the major cost of those operations or the equipment needed, either ropers or the baskets.' Their automated system significantly reduces labor requirements while ensuring consistent torque application, particularly important for larger turbines with hundreds of critical bolted connections.

Enhanced monitoring and management

In the past decade, data overload has been a roadblock for operators. They simply haven't had the personnel to implement many of the useful solutions that, unfortunately, required significant time commitments for implementation, training and real-time monitoring. But predictive maintenance clearly

represents a significant opportunity for cost reduction and performance optimization. SkySpecs is one company that is making monitoring and early detection easier on operators, and more clearly advantageous.

SkySpecs' Horizon CMS is a sophisticated drivetrain monitoring platform. Their Vice President of CMS Products, Allan Larson, explains: 'It's about this early and accurate detection of ... drive train failure modes so you can take timely and appropriate action.'

SkySpecs has also developed comprehensive Vendor Management services to address the industry-wide shortage of qualified repair vendors.

Dan Partin, VP of North American Sales and Account Management, explains: 'Customers were coming to us asking not only can we help with their decision making and their prioritization, but can we also help with their management of some of these vendors? They'd ask, can we outsource some of this to you, because we don't have time to do it ourselves?' The SkySpecs Vendor Management service provides rigorous vendor qualification and comprehensive oversight, ensuring reliable execution of critical maintenance activities.

Safety and workforce development

The wind industry has always put safety at the forefront, but conditions that construction and tech workers encounter, even under 'normal' conditions, are extreme. As offshore wind development accelerates, ensuring technician safety becomes increasingly critical.

HeliService USA has developed comprehensive emergency medical services specifically for offshore wind operations. HeliService USA Founder and CEO Michael Tosi explains the

problem they're addressing: 'The US Coast Guard is not an ambulance service. And the Coast Guard serves the entire region of New England with one helicopter.'

They collaborated with Dr. Kenneth Williams from Brown University to create 'a paramedic level, fully staffed and fully equipped air ambulance that is limited to supporting the wind farm industry.' This dedicated resource ensures rapid medical response for technicians in remote offshore locations.

Meeting the industry's workforce needs requires specialized training programs, both for safety improvement and for wind's continued growth. Deutsche Windtechnik has developed comprehensive technician training initiatives. Momme Feddersen, Head of Training Center, describes their apprenticeship program and 'career changer program' for experienced professionals from other industries to 'learn to be a wind technician in about six months.' Their structured approach creates pathways for new entrants to develop the specialized skills required for wind turbine maintenance, and to be safe and successful in the field.

3S Lift has tackled one of the most physically demanding aspects of wind turbine maintenance, tower climbing. Gio Scialdone, President of 3S Lift Americas, describes their impressive adoption: 'Last year, we completed over 7,000 installations alone in 2024, and we've now got a total installed base of over 18,000, with a backlog of about 7,000.'

This remarkable growth reflects the system's significant value in reducing technician fatigue and improving productivity.

Toward excellence: the path forward

The wind energy industry's shift toward operational excellence represents a critical maturation phase. As conventional turbines reach technical plateaus in efficiency and size, the focus on extracting maximum value from existing assets will intensify. The specialists in vendor management, non-destructive testing, advanced repair methods, predictive monitoring, and workforce development will play increasingly vital roles in ensuring that wind energy remains competitive in our evolving energy landscape.

By embracing these innovative approaches to operations and maintenance, the wind industry can reduce its levelized cost of energy while simultaneously extending asset lifespans, a combination that enhances both the economic and environmental benefits of this critical renewable resource. The future of wind energy depends not only on new installations but, equally, on maximizing the performance and reliability of every existing turbine asset. Through the specialized expertise and technologies showcased by these industry leaders, excellence is on the horizon.

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