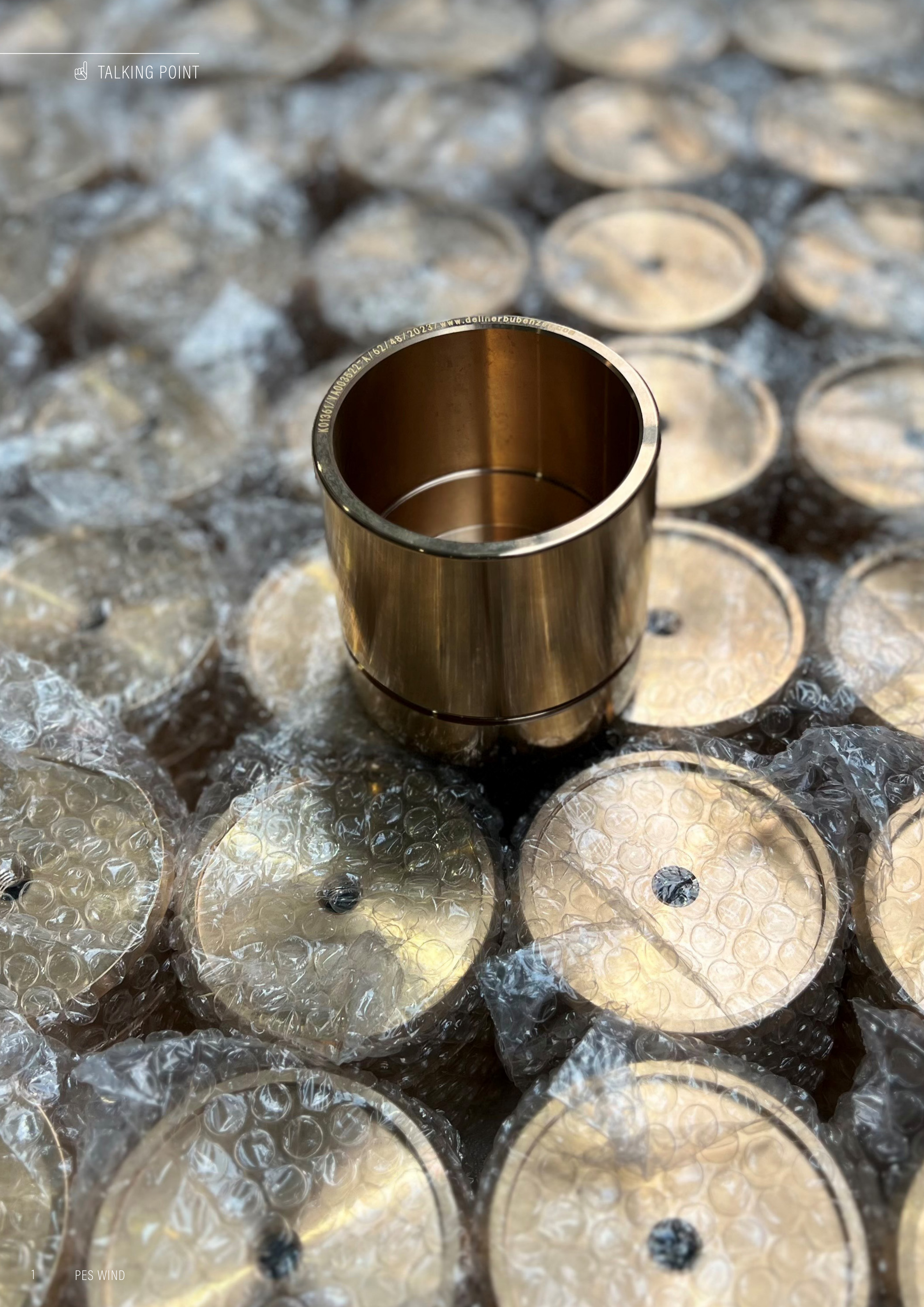
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Beyond building new turbines

The next phase of wind energy will not only be about building more turbines, but also about getting more from those already in operation. Components are at the center of that conversation, declares Joel Cox, Global Sales Director (Wind) at Dellner Wind.

As the global wind fleet matures, operators are facing a different set of priorities. The focus is shifting from increasing installed capacity to maximizing the reliability, efficiency and lifespan of assets already in operation. Turbines that once represented the latest generation of technology are now entering a phase where proactive maintenance, component availability and specialist expertise will increasingly determine their long-term value.

For markets with significant onshore fleets that have been operating for more than a decade, this challenge is particularly relevant. The question is no longer simply how quickly new projects can be developed, but how effectively existing infrastructure can continue to deliver reliable power.

Managing an aging fleet requires more than having replacement parts available when something fails. It calls for a strategic approach to asset management that combines condition monitoring, engineering knowledge, effective repair processes and technical expertise.

This reflects the wind industry's transition from an emerging sector focused on proving the technology to a mature industry increasingly concerned with lifecycle performance. Owners must now consider how increasingly complex and sophisticated turbines will perform over 20, 25 or even 30 years. The objective is not simply to keep aging assets running, but to understand their condition, manage their risks and make informed decisions about how much useful life remains.

That assessment ultimately comes down to the condition and reliability of the individual components that keep a turbine operating.

The component challenge

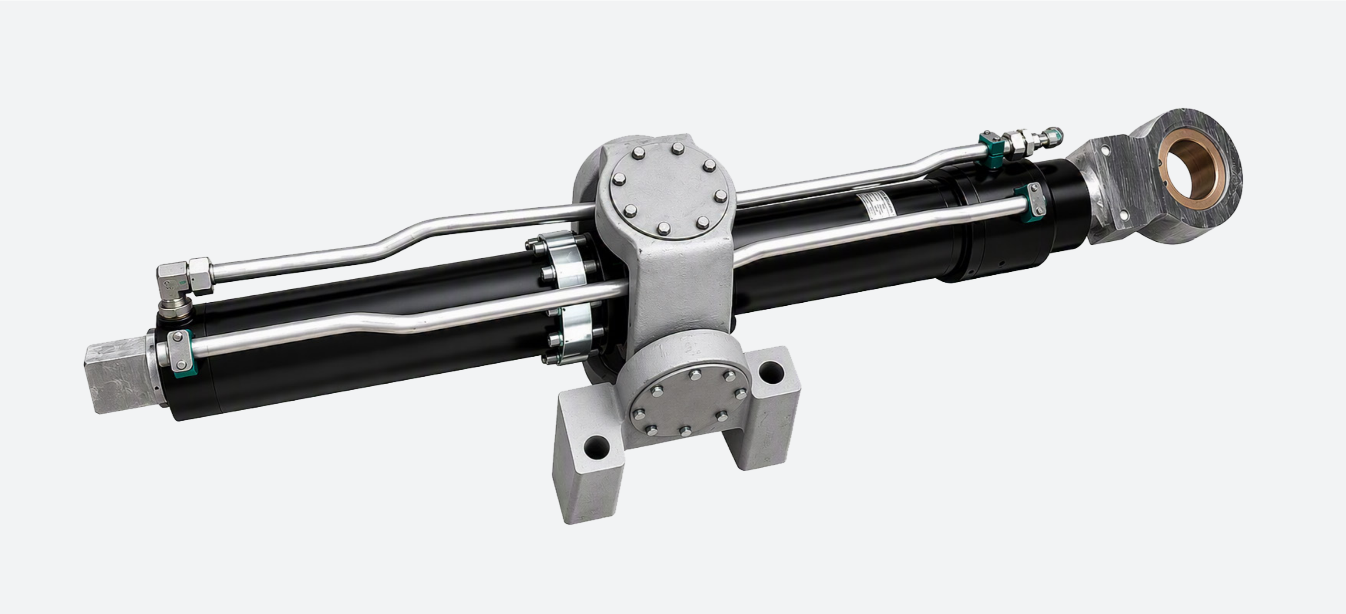
Age tends to expose weaknesses across the entire system rather than creating one universal problem component. Mechanical components naturally experience wear, but electrical and control systems can also become significant concerns as equipment ages and original components become obsolete. Braking systems, hydraulic systems, pitch equipment, bearings, gearboxes and control systems can all require increasing attention.

The important point is that these systems are interconnected. A component that appears relatively insignificant in isolation can become critical if its failure affects another part of the turbine or prevents the machine from operating safely.

Maintaining these systems becomes particularly challenging when turbines reach an age at which the components they were designed around are no longer readily available. Seals, hoses, valves, electrical components and other parts can deteriorate, while manufacturers may have discontinued original equipment or moved on to newer technologies.

A like-for-like replacement may sometimes be possible, but it is not always the best or even a viable solution. Understanding how the original system was designed, what may have changed during its operating life and what a modern replacement needs to achieve is therefore critical. This is where engineering knowledge and practical experience become particularly valuable.

The challenges are not the same everywhere, however. The environment in which a turbine operates can have a significant influence on component life and maintenance requirements. Cold temperatures, moisture, salt, corrosion, ice and difficult access can all introduce additional stresses, with those challenges becoming more significant as equipment ages.



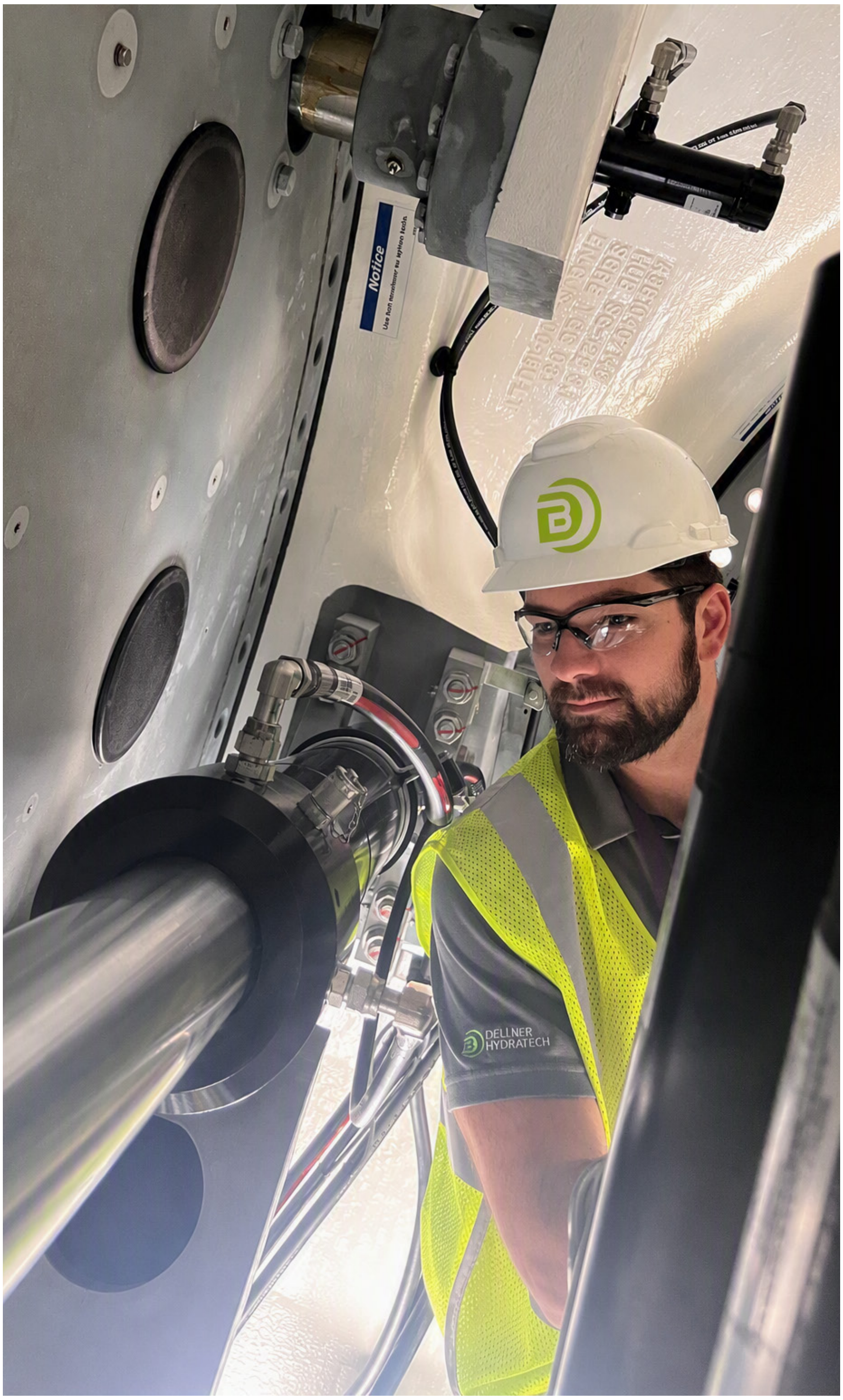
In a location such as Québec, for example, cold-weather performance and material behavior become important considerations, while offshore operators face the additional challenge of accessing equipment in a demanding marine environment.

The consequences of component failure can therefore vary significantly depending on where a turbine is located. A problem that might be relatively straightforward to address onshore can become a major logistical and commercial event offshore, where weather conditions, vessel availability and access can all affect how quickly an intervention can be carried out.

Maintenance strategies consequently need to consider not only the condition of the component, but also the environment in which it operates and the consequences of failure.

Strategic approach

There has historically been a strong emphasis on new installations because they are visible, measurable projects with clear investment cycles. But an enormous installed base still has to generate electricity, presenting a different set of challenges. Maintaining an aging turbine may not look as attractive on paper as installing a new one, but it can be critical from an asset owner's perspective.



A properly maintained turbine can continue to deliver significant value, while deferring maintenance can ultimately make keeping that asset operational far more costly.

Operators also have far more information available to them, allowing maintenance to become increasingly data-driven rather than purely calendar-based. At the same time, many fleets have moved beyond their original design life, changing the questions owners need to ask. It is no longer about whether a component is functioning today, but how much useful life remains, what the consequences of failure could be and whether the component can realistically support the turbine for the remainder of its operational life. That demands a more strategic approach to maintenance.

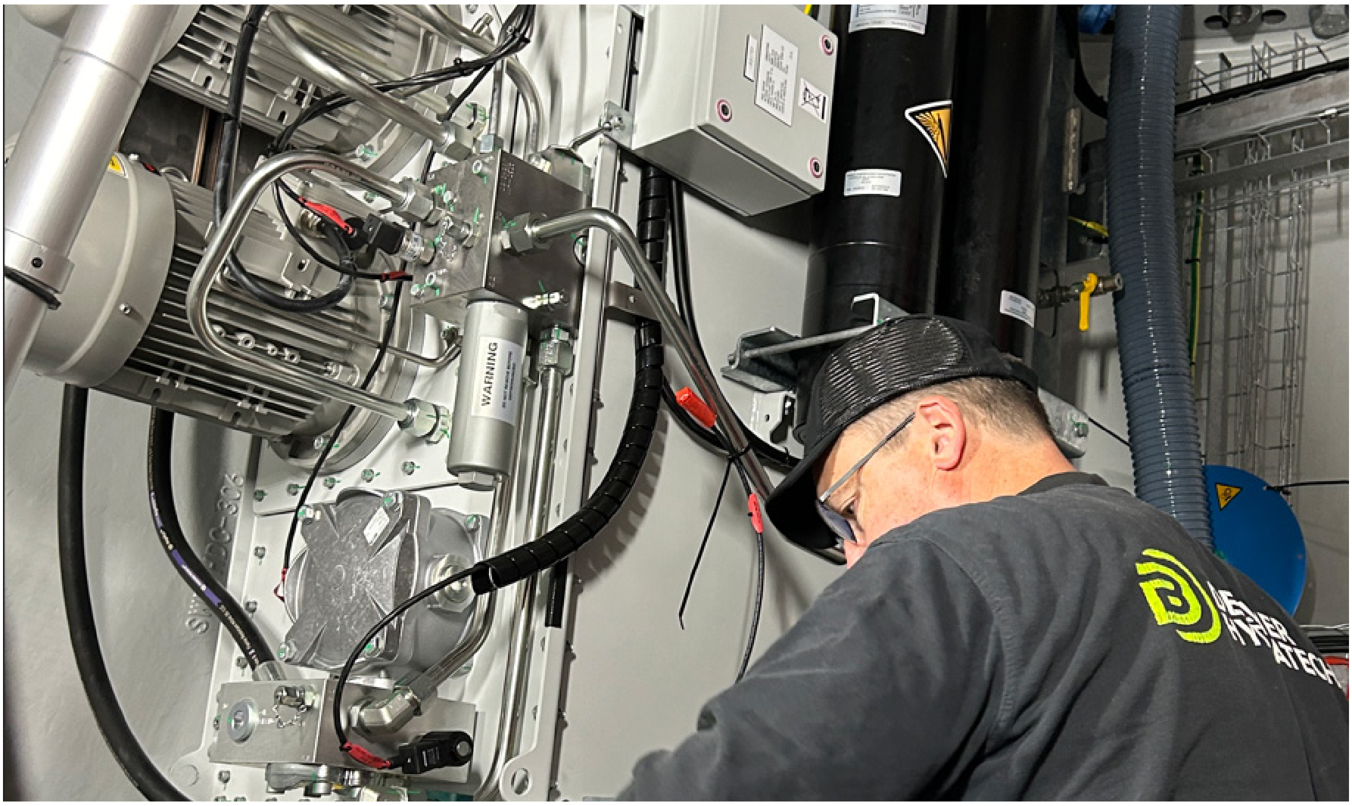
Data meets experience

Historical data is an important part of managing an aging turbine, but it is only useful if it can be interpreted in the right context. Knowing what has failed previously, what has been replaced and how often particular components have required attention can help identify recurring problems and anticipate future issues. Without that history, decisions can end up being based on assumptions rather than evidence.

That does not, however, mean that more data automatically leads to better decisions. Even with today's connected, data-rich turbines, engineering judgment remains critical. Data can indicate that something has changed, but it does not necessarily explain why or determine the most appropriate response. Recognizing when an indication is a symptom rather than the underlying problem requires an understanding of the equipment, its operating environment and its potential failure modes.

The most effective approach is therefore to combine data with experience. Operational and historical data provide valuable evidence, while engineering experience provides the context needed to interpret it and decide what action to take. For aging turbines in particular, that combination can be critical in determining whether a component should be monitored, repaired, replaced or upgraded and ultimately whether an intervention is justified by the remaining value of the asset.

All of this ultimately depends on having the right people to act on the information



available. Skilled technicians remain critical to long-term asset performance because technology can monitor a turbine, identify trends and generate alarms, but people still have to inspect, diagnose, repair and make decisions. A technician's experience is not necessarily captured in a manual or software platform. They know what normal looks like, recognize subtle changes and can identify when something does not make sense.

As the installed fleet gets older, that practical knowledge will become more valuable, particularly as technicians encounter equipment with years of operating history, modifications and repairs behind it. At the same time, the workforce will need to become more technically diverse, combining mechanical, electrical, hydraulic, control and braking expertise with the ability to work with condition-monitoring data and digital tools.

Developing that breadth of knowledge, and giving technicians the training and career opportunities needed to build experience, will be essential as the global fleet continues to age.

That experience also needs to feed back into the maintenance process. An effective repair loop starts with understanding what failed and why, rather than simply replacing a component and returning the turbine to service. The affected equipment needs to be inspected, the root cause established, the component repaired or refurbished and the result properly tested.

Crucially, what is learned needs to be captured and fed back into future maintenance decisions. If the same problem occurs again without anything having been learned from the first failure, an opportunity has been missed.

A well-managed repair loop continually feeds practical experience back into engineering, maintenance planning and component selection.

Deciding what comes next

Knowledge becomes particularly important when deciding what to do with an aging asset. Repair, refurbishment, replacement and repowering all have a place, but the right choice depends on the condition of the turbine, its remaining useful life, component availability, the cost and duration of the intervention and its expected future revenue.

Refurbishment can make good sense when the fundamental asset remains sound, but individual systems or components are approaching the end of their useful life. Addressing those weaknesses can extend the productive life of a turbine without the cost and disruption of replacing the entire asset. The key is to be realistic about what refurbishment can achieve rather than using it simply to postpone an inevitable replacement.

Getting those decisions wrong can be expensive. The true cost of a maintenance decision extends beyond the price of a component or repair to include downtime, lost generation, emergency mobilization, expedited parts and potentially much greater secondary damage.

Replacing a component unnecessarily ties up capital that could have been better deployed elsewhere, while delaying a necessary intervention can turn a manageable repair into a major failure. The objective therefore has to be to assess the total cost and risk over the remaining life of the asset, rather than focusing solely on the immediate expenditure.

Ultimately, aging should be treated as a lifecycle management issue rather than a deadline. Reaching an original design life does not automatically mean an asset has reached the end of its useful life, just as remaining technically operational does not necessarily mean it makes commercial sense to keep it running.

The industry needs to continually assess condition, history, risk, available technology and the economics of extending an asset's life. Done properly, that approach can support better decisions about repair, refurbishment, replacement and repowering.

The opportunity is significant. The next phase of wind energy will not be defined solely by how quickly new turbines can be built, but by how effectively the industry can maintain, optimize and extend the productive lives of turbines already in operation. Getting more from the existing fleet is not simply a maintenance challenge; it is a central part of delivering the next generation of wind energy.

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