Assessment over assumptions: how to hardwire the right approach into repowering a wind farm

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Repowering is the process of upgrading or replacing components of a wind turbine to improve efficiency and capacity. There are two main types of repowering, full and partial. It is estimated that, on average, full repowering can double the generation of capacity in MW and triple the electricity output, because the new turbines produce more power per unit of capacity. A partial repower typically increases energy production by 10 to 30 percent. We've seen a lot of repowers across the major OEMs, and primarily, the economic reasons are attractive. But repowering doesn't only make financial sense, it makes environmental and health, and safety sense too.

Around 10 to 18 years ago, large numbers of 1.5 MW turbines in the US were deployed. These older turbines have a broad range of hardware conditions that owners could replace, as well as possible future issues which could cause downtime, such as cracked bedplates, deteriorating blades, and aging drivetrains.

However, many strategies to maximize turbine life are challenging. Tower and foundation challenges can present themselves in wind projects built before around 2010. There is a potential risk of failure due to deterioration that may not be visible or routinely inspected. Operators therefore need to investigate the severity of the damage and decide whether the turbine can continue to be safely operational or be repaired or retrofitted. In discerning the right repowering approach for a wind farm, hard data and realistic expectations are key.

What is repowering and who is doing it?

Full repowering involves the near-complete dismantling of an old wind farm and replacing almost all turbine components with new ones. This is common when the project is mature and none of the components are suitable for reuse. Full repowering is popular in a state like California, where many projects consist of legacy turbines with no feasible options for a partial repower. Often, existing power purchase agreements can be leveraged in the negotiation of a new agreement or even an extended one. At a minimum, the reuse of land reduces construction challenges compared to a greenfield project. High energy prices justify the extra cost of a full repower.

In European wind markets such as Spain, where assets are highly matured, full repowering is less common. The economics favor life extension over the high investment costs of a full repower. Owners tend to continue operating their wind farms with minimal additional investment as long as power production is continuing rather than shell out capital on life extension procedures.

Partial repowering, on the other hand, involves replacing only a portion of the project components while keeping others like the substation, distribution lines, turbine foundations, and usually the towers, in place. This is often done to improve the capacity factor of the wind farm by installing a larger rotor with improved controls that can generate energy over a wider range of wind speeds, thus increasing the project efficiency and overall generation. In the broader US market, partial repowering is popular due to a tax incentive that allows owners to requalify for the production tax credit (PTC) if they spend 80% of the asset's net present value on repowering.

How can operators make the right repowering decisions?

Condition monitoring systems (CMS) are useful for both full and partial repowering. For full repowering, CMS can help owners receive actual measurement to understand the state of their components and make financial decisions before repowering that does not rely on future-gazing simulations, which can often underestimate the remaining useful life.

Similarly, for partial repowering, the CMS can clarify the condition of components. Owners are therefore empowered with accurate data that enables them to make informed decisions about what needs to be repaired. This can prevent owners from paying for costly upgrades, such as foundation retrofits, on a site-wide basis and allows them to focus on only addressing needed improvements.

Even in situations outside of repowering, condition-based maintenance can avoid replacing and servicing components on a predetermined schedule that does not take into account whether components are performing better than would otherwise be anticipated. Clearly, this extends the component life-cycle and avoids unnecessary expenditure on non-essential replacement.

Conclusion

Operators of wind assets have made a lot of progress in implementing data management strategies across their portfolios in recent years, and 2023 is set to be another big year. With greater onus being placed on renewable energies it is vital that we maximize the efficiency and longevity of the hardware which makes that energy possible, the wind turbines.

ONYX Insight is well placed to help wind operators manage their assets effectively as they look towards repowering their fleets. Offering a deeper understanding of hardware, software and engineering to all, ONYX Insight provides operators with a clear vision of their asset's health. This is becoming vitally important as the whole sector expands, with those in the industry thinking hard about how they can safeguard their fleets moving forward.

We must have advanced controls and refined suitability assessment methods that are part of the risk reduction that comes with repowering using newer technologies. Technology adoption and digitising are essential in the future of repowering. Not only is it cost-effective, but data integration and an engineering approach could be the answer to understanding how to implement a repowering strategy and maintain it optimally.

Advanced sensing technologies and monitoring of towers, foundations, and blades, plus complete turbine predictive maintenance, have a crucial role in providing accurate analytics across and supporting visual inspections to enable owner-operators to make the best decisions.

Condition monitoring systems provide real-world, analytical insight that helps owners make informed data-driven decisions about maintenance, repairs, strengthening, and replacement.

High-quality data and forward-thinking investments, instead of sweeping assumptions and the by-products of simulations, are key to making sure repowering strategies leave neither megawatts nor dollars behind. At the end of the project lifecycle, it all adds up.

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Ian Prowell has worked professionally in multiple engineering disciplines. Since 2008 his primary focus has been on structural engineering in wind energy.

He received his BS degree in Engineering from Harvey Mudd College and completed his MS and PhD degrees in Structural Engineering at the University of California, San Diego.

Dr Prowell's PhD research focused on experimental and numerical research into the seismic behavior of wind turbines and has informed updates to both IEC 61400-1 and IEC 61400-6, among other wind energy standards.

His expertise includes structural design, dynamic modeling, soil-structure interaction, and physical measurement.

He has worked in onshore and offshore wind, solar, and other novel structures.

ONYX Insight

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ONYX Insight is an award-winning global, renewable, technology business. We bring unbiased predictive analytics underpinned by real-world engineering expertise to owners and operators of renewable energy assets via seven global offices and 10 patents.

We work collaboratively with our customers, at every stage of the asset life cycle to provide efficiency-driven, cutting-edge solutions across thousands of wind turbines that optimize asset performance while minimizing downtime.