**Real-Time Wind Turbine Monitoring: Rewards and Data Challenges**

Harnessing the power of clean, renewable energy, wind turbines have emerged as one of the most rapidly growing and cost-effective solutions for electricity generation. With over 350,000 wind turbines installed worldwide, boasting a combined capacity of over 650,000 MW, the demand for wind power continues to rise in the face of climate change. However, to maintain competitiveness, the industry must strive for optimal operational efficiency.

According to the Institute for Energy Research, onshore wind power already stands out as a low-cost energy source, ranging from $45 to $92 per megawatt hour. While this is reasonably affordable, operators are actively seeking ways to further reduce costs, envisioning a future where wind energy stands on its own without subsidies.

**The Life Expectancy of Wind Turbines**

Typically designed to last 20 to 25 years, wind turbines experience varying failure rates throughout their lifespan. The initial years often present higher failure rates as operators work through teething issues with new turbine models or make necessary adjustments to operational controls. Once this "break-in" period passes, turbines typically run reliably for the next 15 years. However, as they approach the end of their operational life, failure rates rise, making it crucial for operators to mitigate failures at every stage.

Wind turbines are complex machines, comprising numerous components such as electrical systems, sensors, hydraulics, rotor blades, mechanical brakes, gearboxes, generators, and more. Failures in any of these components result in varying periods of downtime. For instance, a gearbox failure, although infrequent, can lead to an average of six days of downtime, which translates into significant costs.

While electrical failures are more common, their downtime durations are comparatively shorter. To minimize downtime and associated expenses, operators primarily focus on preventing gearbox, generator, and drivetrain failures, as these tend to cause the longest periods of inactivity.

Adding to the challenge, every wind turbine is unique, situated in distinct locations and equipped with different types and brands of components. This diversity further complicates the task of effectively monitoring and maintaining wind turbines.

**The High Costs of Failures and Downtime**

Efficient turbine performance necessitates a combination of planned and unplanned maintenance activities. However, the more time technicians spend on maintenance, the greater the expenses incurred. Thus, the key lies in predicting and preventing failures before they occur. By monitoring indicators such as gearbox temperature or vibration, operators can identify potential failures in advance. Instead of relying on costly additional hardware sensors, operators leverage software solutions whenever possible, as they are more cost-effective and require less labor-intensive implementation.

Turbine maintenance stands as the most intricate and costly aspect of wind energy production. In 2019 alone, global onshore wind operations and maintenance costs reached nearly $15 billion. Within this figure, $8.5 billion was spent on unplanned repairs caused by component failures, as reported by Wood Mackenzie Power & Renewables. These staggering costs have urged wind power plant owners to prioritize operational expenditures and seek innovative solutions to improve their bottom lines.

**Enhancing Performance while Reducing Costs**

Turbit Systems recognizes the immense potential of machine learning (ML) in reducing the complexity and costs associated with operation and maintenance in the wind energy industry. This serves as just one example of how ML and real-time data analysis can be harnessed across the energy sector. Other applications include optimized energy production, weather forecasting, building-energy management, demand response, and predictive equipment maintenance, among others.

Predictive analytics has long been utilized by utilities, grid operators, transmission companies, and other entities in the electric industry to enhance operations, minimize downtime, and maximize revenues. Recent advancements in Internet of Things (IoT) sensors, stream processing technologies, and AI-based analytics

A picture containing generator, windmill, outdoor, sky

Description automatically generated