AVEVA

WHITE PAPER

Resilient renewables: Optimizing asset performance with real-time condition monitoring

Executive summary:

As renewable energy providers work to incorporate a higher percentage of green energy into the electrical grid, many are leveraging condition-based maintenance (CBM) to combat unique maintenance challenges, lower operating costs, and improve asset reliability and availability.

Overview

Increasing reliance on renewable energy resources is critical to combatting climate change, which is why many countries and states have set net-zero targets. Meeting these targets requires power companies to increase renewable power generation and storage capabilities to ensure green energy is available during demand periods. However, large-scale, reliable renewable power generation presents a number of unique challenges.

Generating renewable energy on a large scale requires numerous, capital-intensive assets. Assets can be located on and offshore, and equipment is often distributed over large areas. The distributed nature of renewable infrastructure puts greater emphasis on efficient maintenance strategies.

Maintaining renewable energy infrastructure is expensive. The maintenance costs associated with a single wind turbine range from $42-48,000 USD per year. This means the estimated cost of maintaining Germany's 30,000 wind turbines is approximately $1.2 billion annually. In addition, solar maintenance costs are projected to hit $9.4 billion by 2025. As reliance on renewable energy increases, maintenance costs will continue to grow.

Some operators choose to respond to these challenges by focusing on a new, more efficient maintenance strategy: condition-based maintenance (CBM). CBM goes beyond calendar-based maintenance schedules to focus on the asset's actual condition using real-time operations data. CBM can eliminate unnecessary maintenance, detect and mitigate potential failures before they happen, and increase reliability and availability of resources.

The real advantages of implementing CBM go far beyond lower maintenance costs. Performing maintenance at exactly the right time can play a critical role in ensuring overall fleet availability while reducing downtime costs. By tracking asset health in real time and predicting outcomes, CBM can minimize outages and equipment failures while reducing the risk of generation losses.

This white paper examines the pressures that drive demand for more proactive maintenance strategies. Next, it will outline how CBM affects solar, wind, and thermal power plants and how CBM promotes more efficient and effective outcomes compared to planned-maintenance methodologies. The paper will also showcase CBM in action with two case studies; Iberdrola and Vattenfall Hydro.

Driving capital efficiencies through maintenance strategies

To meet decarbonization goals, many electric utilities are adding alternative energy sources such as solar, wind, and geothermal power to fleets. Given the variable performance of sustainable power sources that are dependent on weather conditions, operators must maintain a diverse combination of power sources across their fleet in order to meet demand. Plant operators must also constantly be aware of both the condition and availability of assets to reliably perform this task.

Proactive maintenance strategies use complementary corrective, preventive, and predictive processes. These strategies leverage dynamic, real-time online asset monitoring using wireless sensors and other technology. Real-time monitoring enables subject-matter experts, consultants, and OEMs to analyze data for CBM to maintain assets such as turbines, pumps, or condensers, or use predictive models to more accurately estimate asset life cycles. Predictive maintenance gives operators more time to plan capital expenditures and maximize availability.

Unlike calendar-based maintenance strategies, CBM leverages asset data to reconcile maintenance schedules with real-time asset conditions, organizational priorities, and changes in the operating environment. A CBM program begins by monitoring asset parameters, then evaluating these parameters in relation to limits, trends, and other asset data. Eventually, a successful CBM strategy ties real-time data to comprehensive work-management solutions.

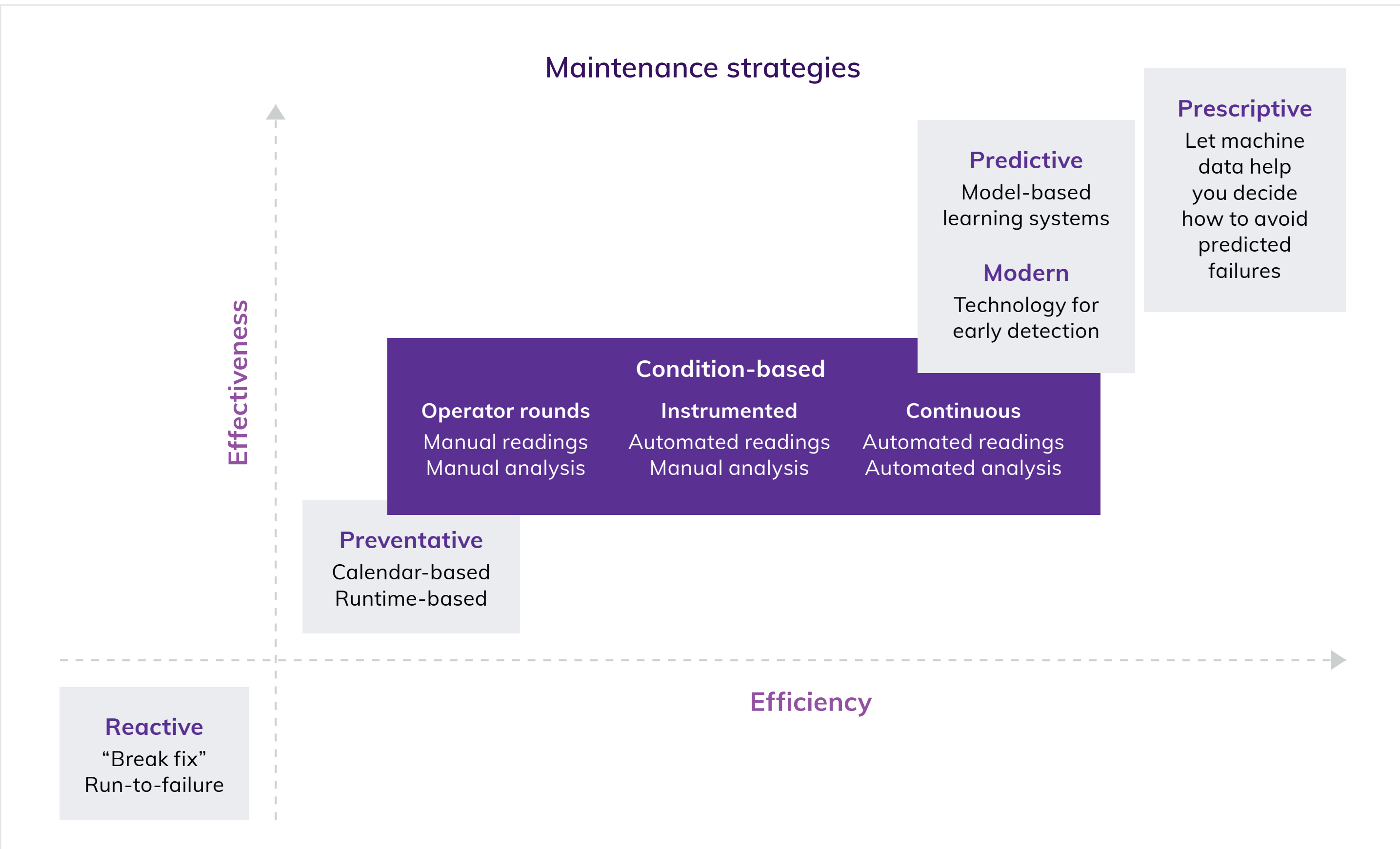

Figure 1: New maintenance strategies offer more efficient and effective alternatives to reactive approaches.

CBM enables renewables to tackle difficult challenges

Renewable-energy adoption is skyrocketing. As demand increases, so does infrastructure, creating new and unique challenges for renewable power operations. CBM strategies not only pave the path to higher availability, but these strategies also create a road map for a more sustainable future.

Preventing catastrophes at solar-power plants

The electricity generated from photovoltaic energy systems is an important renewable energy source. However, capacity is not constant or predictable, due to the stochastic nature and behavior of solar radiation. A photovoltaic system is made up of many components and reliability is related to aspects such as temperature or power losses. However, integration of photovoltaic generation within the energy-distribution network must be considered. Events such as the appearance of reverse power flow can cause voltage spikes that can affect the installation, activating protections or causing disconnects and stoppages. CBM is critical for solar power not only for system control but also for security.

Many solar plants rely on corrective maintenance or a leave-it-until-it-breaks approach. This corrective maintenance approach rarely considers manufacturer recommendations to extend asset life. However, that mentality is starting to change. Some plant operators are moving toward preventative maintenance, which focuses on maintaining and extending asset life. Beyond preventative maintenance, predictive maintenance detects the appearance of system degradation before catastrophe strikes, enabling solar plants to take corrective action.

With predictive maintenance, solar plants can reduce corrective maintenance from 60% to 20%, saving up to 50% on total maintenance costs.

In the case of photovoltaic solar plants, CBM should be applied, as a minimum, to the inverter and the transformation center. These are both highly critical and highly complex and have a high number of failure modes that can reach the systems for the PV solar plant.

Driving wind-farm maintenance efficiencies

Wind farms consist of large-scale rotating equipment often located in remote areas. Assets are expensive, and the cost of a single wind turbine, as of 2020, is approximately $1.3 million per megawatt (MW). A typical turbine capacity is 2 to 3 MW, and O&M costs are estimated at $42,000 to $48,000 per megawatt per year. It is estimated that unscheduled corrective maintenance for offshore turbines accounts for 66% of total maintenance budgets. While maintenance costs are high, the cost of failure is even higher. Power companies must detect potential problems and take action before a failure occurs.

Often, when a wind turbine fails, a crane is deployed for maintenance. Given the remote nature of wind turbines, crane deployment is expensive and time-consuming, especially for offshore turbines. With CBM strategies, wind farms can easily see whether any other components are near end of life and maximize each crane deployment. Such efforts can save as much as $100,000.

Thanks to low-cost wireless sensors, CBM has become a more affordable solution for wind farms. As real-time asset data from multiple points informs maintenance strategies, wind farms can operate more efficiently and take preventative action before a catastrophe occurs. In addition, utilities can integrate weather forecasting information, maintenance crew schedules, and financial data to best determine optimal maintenance timing as well as all associated costs.

Iberdrola: Centralized maintenance management to optimize maintenance

Iberdrola is one of the largest power generation companies in the world. Specializing in wind power generation, the company uses its CORE Toledo program to monitor and control assets all over the world. Underpinned by AVEVA™ PI System™, CORE monitors over 6000 wind turbines, 200 wind farms, 200 electric substations, and more.

Prior to deploying CORE, all wind farm monitoring was performed on-site. If a turbine stopped working outside of normal business hours, no one was there to fix it. The company was also losing money because turbines were not always running when there was wind.

Now, CORE uses aggregated, real-time data from PI System to monitor Iberdrola's assets from one centralized location. Operators are on-call 24-hours per day and can see real-time information, including any incidents and alarms. This real-time streaming information enables them to quickly fix issues and get turbines back up and running, no matter what day or time.

Not only has CORE reduced Iberdrola's operating and maintenance costs, the company has used the solution to improve asset availability and maximize profitability. By making real-time, data-driven decisions, Iberdrola reworked its curtailment strategies, which increased energy generation by an average of 30% while mitigating mechanical wear on turbines and preventing catastrophic or urgent repairs.

Comprehensive maintenance insights in thermal power plants

Thermal power plants, whether fired with coal, natural gas, or nuclear reaction, are under tremendous financial pressure from renewable generation, microgrids, and distributed generation. Moving up the maintenance hierarchy from reactive to predictive maintenance can yield significant O&M savings for a conventional power plant.

Outside of efficiency improvements, which are often hard and or expensive to realize, O&M and inventory costs are the major controllable expense at thermal power plants. These costs can run from around $10 million at a small, combined cycle plant to well over $100 million at a nuclear site.

The ability to push back time-based maintenance and overhaul expenses on equipment operating acceptably can lead to millions of dollars in savings a year at large thermal power plants.

Real-time data delivers real-time insights

In any facility, unexpected failures are the most catastrophic. Not only do failures present the greatest risk to availability, but these failures are also the most expensive to repair. In a CBM/proactive system, early detection of performance degradation not only reduces or eliminates the unexpected and unplanned costs associated with a reactive-maintenance approach, plant personnel also have more opportunities to plan maintenance activities and manage costs.

The core of CBM is real-time condition monitoring. This strategy supports preventative maintenance and can determine the overall health of assets. When an organization begins collecting real-time data for specific equipment parameters, the actual condition of the asset is always known and validated.

In proactive maintenance strategies, real-time asset behavior and context drive maintenance requirements. Condition monitoring is performed while the asset is operating, enabling managers to detect an impending failure and plan accordingly.

Maintenance personnel collect multiple pieces of data from an asset, analyze the data by looking at rates of change or comparing values to a norm, and create an algorithm for a group of assets based on multiple indicators. By comparing maintenance histories of similar assets, plant operators can make confident, data-driven recommendations that reduce inventory costs, prevent over-servicing, and improve overall operational variability. Real-time operations data collection can be highly useful not only for maintenance programs, but also for guiding future capital expenditures, maximizing renewable production, or defining work-prioritization schedules.

With industrial data-management software, such as PI System, power generation companies can further use model tools for advanced pattern recognition (APR) developed by third parties to leverage the data collected by real-time systems. By automatically analyzing large amounts of data, these APR tools can reduce the need for manual monitoring, detect anomalies in critical equipment very early in the performance-degradation process, and help support operations by avoiding equipment failures and optimizing maintenance schedules.

Faster detection enables rapid action

How do CBM and proactive maintenance strategies contribute to higher availability? In calendar-based maintenance strategies, asset replacement or repair is driven by vendor recommendations or internal experience. These recommendations have historically been time-based. If an asset's lifecycle runs outside the historical projections, utilities and power generation facilities run the risk of increasing costs by replacing or repairing the asset too soon, or worse, too late. A catastrophic failure can cause anything from a safety issue to a major system outage.

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The P-F curve in Figure 2 shows typical asset behavior as it nears failure. Point P represents the first possible point on the curve when plant personnel can detect any performance deviations. This point can be detected by tracking any number of asset characteristics, such as a slight change in temperature, a higher-than-normal vibration rate, or a change in power usage. Point F represents the point of equipment failure. The time between those two points is the opportunity window for the organization to proactively prevent failure. The further up the curve point P occurs, the more time maintenance personnel have to replace the asset, order parts or labor, or schedule an outage before the equipment fails.

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Moving left up the curve (things you can do with AVEVA PI System)

- Rate of change
- Actual vs. design
- Pattern recognition alarm
- Efficiency
- Count and rate of operations
- Operation limits (maximum T, vibration, or load)
- Dynamic threshold hi/lo limit notification

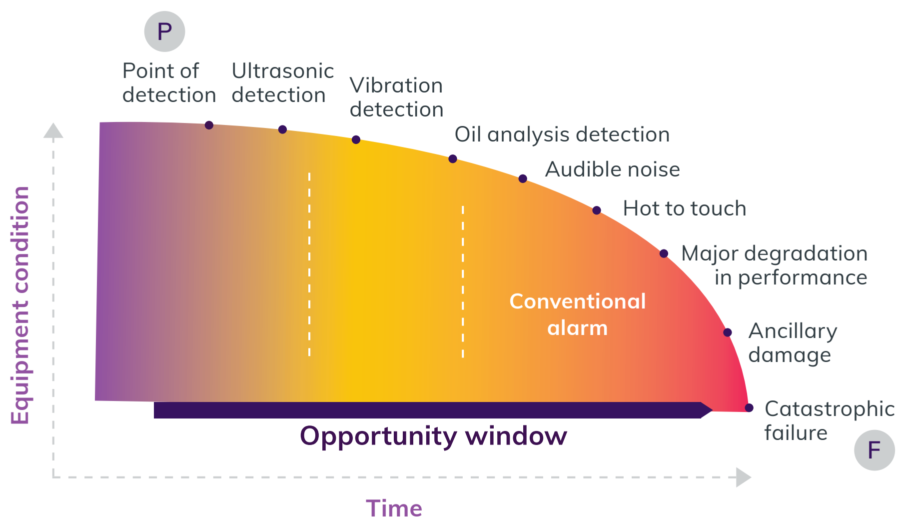

Figure 2: Initial failure detection depicted on a curve. The earlier point P occurs, the more time plant personnel have to solve the problem.

Vattenfall Hydro: From static to dynamic maintenance strategies

Vattenfall Hydro is the third-largest hydro power provider in Europe. The company has leveraged CBM for 15-20 years, but the company relied on an old system that used static data based on periodic inspections, tests, and a historian. Information was not available in real time, so Vattenfall's maintenance practices were often reactive. The company needed to move to a real-time condition-monitoring solution to reduce operational costs.

The company piloted a AVEVA PI System project to capture data from modern DCSs, analog DCSs, a dam-instrumentation system, and a vibration-monitoring system. In addition, Vattenfall imported its existing Conwide maintenance data into PI System.

With this information, the Vattenfall team began performing trend analysis on approximately 25 basic conditions for each unit. The team used Asset Framework templates to perform trend analyses and create new elements. Operators now visualize operating conditions using AVEVA™ PI Vision™ and receive email notifications if a unit performs outside of set parameters.

Not only was the pilot program a huge success, PI System also successfully replaced Vattenfall's Conwide maintenance system. Early projections indicate that Vattenfall will reduce overall maintenance costs by 1.5% by minimizing unplanned maintenance events.

Conclusion

Renewable energy is critical to the environment and a future without climate change. While renewable energy assets present a number of unique challenges, real-time data holds the key to optimized, condition-based maintenance strategies. With CBM, utilities can increase asset availability and reliability, all while preventing catastrophic failures. When assets are running at optimal levels, utilities can increase generation efforts and work towards a carbon-free future, one kilowatt at a time.

About AVEVA PI System

AVEVA PI System manages more than two billion sensor-based data streams that enable better operations management and outcomes. For example, plant operators can spot problems with a remote pump before it fails. Environmental scientists can predict the accumulation of harmful elements in city water before it is tainted, while process engineers can finetune production variables to increase profitability. With PI System's high-quality curated data, data scientists can rapidly construct smarter AI algorithms, and executives can review dashboards that inform better business decisions.