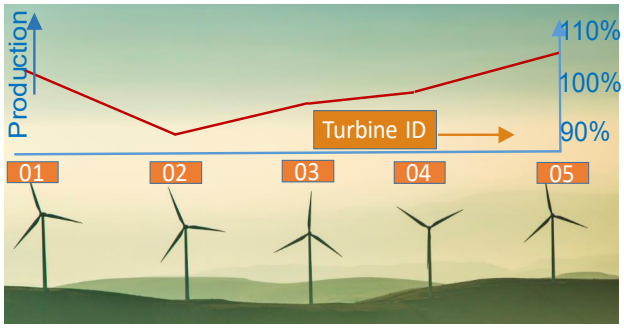
Wind Turbine Performance Monitoring Demonstration



- Analyze individual wind turbine performance that can change over time non-uniformly, affecting production and LCOE
- Classify wind turbines based on their performance trends
- Highlight under-performing wind turbines and recommend actions to increase production

Key Research Question

A standardized method for one-time measurement of wind turbine performance (the "power curve") is described in IEC 61400-12-1. This method is the only one widely accepted for measuring absolute wind turbine performance in the field, but it is typically only used on a few "perfect" turbines in the first year of operation. This method is not certain enough nor cost-effective to use on each and every wind turbine, or for an extended time period. Over time, component misalignment and wear/tear and performance shortfalls can occur non-uniformly across a wind farm. Other, not yet standardized, techniques may be needed to monitor the performance of wind turbines at realistic site operating conditions.

Objective

The goal of this project is to improve wind turbine production and reduce Levelized Cost of Electricity (LCOE) by tracking performance using turbine operational and maintenance (O&M) data, filters, and the techniques proposed in EPRI Report 3002011955. EPRI intends to conduct a performance assessment on individual turbines in the same farm with the goal of increasing wind farm power production. This work includes:

- Assess individual wind turbine relative performance
- Measure precision and repeatability of performance tracking techniques to use as thresholds for action
- Classify wind turbines based on their performance trends. Identifying under-performing wind turbines and recommend actions to increase production
- Demonstrate and quantify the benefits of performance monitoring and validate future performance improvements.

Approach

The project tests performance analytics techniques on wind turbines over different periods of time to evaluate repeatability and variability.

Wind turbine performance analytics techniques evaluation (under Task 1) and demonstration effort (under Task 2) consists of the following five steps:

Step 1: Collect Data: Typical 10-minute SCADA, met tower data, site data, and fault/alarm events are mandatory input for the performance analytics model. O&M events are used to track the turbine health and maintenance activities. Participants will transfer three years of historic data to EPRI's secure servers.

Step 2: SQL Database Build and Quality Assurance (QA): Data collected, typically in csv format, from Step 1 will be refined by removing anomalous data and identifying gaps for upload on EPRI's secure SQL database. Erroneous data could be due to turbine hardware (such as anemometers) and/or software malfunction (such as SCADA data logger).

Step 3: SCADA and Fault Data Analytics: Conduct data analytics to identify issues related to individual turbine performance, including identifying time and energy lost due to turbine faults. Conduct data analytics for various turbine conditions (such as unavailability, icing, invalid data, derating, and high-wind hysteresis) to create clean power curves for comparison purpose, and to quantify energy losses due to each issue.

Step 4: Analyze and Visualize: Compare performance analytical techniques with varying time windows and quantify variability of:

- Energy estimates from nacelle-based power curves
- Neighbor comparisons of energy estimates from nacelle power curves
- Neighbor comparisons of actual energy output over time
- Neighbor comparisons of other metrics (pitch angle, RPM, etc.).

Step 5: Prediction and Confirmation: Track historical performance over time for each turbine at the wind farm. Apply one or more performance analytics methods with least variability from Step 4. Hypothesize any power performance shortfalls if found.

Step 6: Actions and Financial Impact: Classify turbines based on their performance trends. Highlight under-performing turbines and recommend actions. Assess potential cost benefit of performance issues uncovered. Participants can utilize these turbine-specific actions to improve performance and increase production.

The project will culminate with a collaborative meeting to share and learn from results (Task 3).

Research Value

Wind turbine performance analytics is one piece of EPRI's focus on collaborative research with industry partners to improve performance and reliability while reducing cost of wind energy for participants and the public.

As the wind industry matures, there is an increased focus on the optimization of wind farm operations. Whether through improving the performance of wind turbines, reducing downtime and service and maintenance costs, or extending the life of the assets, there is an increasing trend of leveraging advanced analytics to reduce the LCOE.

Proper periodic and accurate wind turbine performance analysis provides the following benefits:

- Immediate increases in generation and revenue and, in severe cases, reduced wear and tear.
- Better financial projections for both operating wind farms and wind farms in development.
- Reduction in failure rates and O&M costs.

Deliverables

Participants will receive a final report including project results and key findings. The report will include details on repeatability of performance tracking techniques and relative wind turbine performance.

Price of Project

The cost of this project is $50,000 per participant for up to 100 wind turbines at one wind farm. Contact EPRI for specific pricing for additional turbines. This project qualifies for Tailored Collaboration (TC) and Self-Directed Funding (SDF).

Project Schedule

A 12-month schedule is anticipated per site, providing the requisite data is obtained.

Task No.	Description	Est. Schedule
1	Evaluation of performance analytics techniques	2 months from kickoff
2	Performance evaluation of one wind farm	4 to 6 months from kickoff
3	Collaboration and results review	12 months from kickoff

Who Should Join

Utilities and companies that own/operate wind projects and desire to improve production and reduce O&M costs could benefit from participation in this project.

Contact Information

For more information, contact the EPRI Customer Assistance Center at 800.313.3774 (askepri@epri.com).

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