Capability

Wind Turbine System State Awareness

Applications:

- Operational wind turbines

Benefits:

- Optimize wind turbine performance in the field.
- Prevent damage and related maintenance costs.
- Predict consequences of existing component damage

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Summary:

Researchers at the Los Alamos National Laboratory (LANL) Intelligent Wind Turbine Program are developing a multi-physics modeling approach for the analysis of wind turbines in the presence of realistic wind loading. This first-of-a-kind simulation tool will decipher connections between wind events and compromising/damaging load configurations, providing a synthetic environment for preliminary evaluation of changes in operating loads and for testing control algorithms. This work is expected to provide key design and operational guidance for defining turbine design criteria and to enhance wind farm energy production.

This capability is being developed to fill the wind industry's need for a fast and reliable approach to optimize wind turbine operations in real world conditions. Wind turbines operate with too many variables to explore that may, and probably do, affect wind turbine performance in the short and long term. The potential cost is manifested in many ways, including 1) extensive R&D to understand how to increase performance and mitigate turbine damage in the field and 2) maintenance miscalculations that compromise optimal energy production in multiple operational scenarios due to lack of on-location guidance.

This new technology will integrate multi-scale monitoring of both local and global conditions with a validated, predictive simulation capability, advanced diagnostics, and data extraction and interrogation, with the goal of both creating system state awareness for production enhancement and damage mitigation in the field and accelerating the pace of significant discoveries to optimize current design parameters in multiple field scenarios.

Successful implementation of this multi-scale monitoring will result in a system capable of predicting the behavior of damaged components in wind turbines and its consequences on system performance. Developing a validated, predictive capability to support the design and analysis of intelligent wind turbines will require integration on an unprecedented scale (See HIGRAD/WindBlade and Wind Turbine Structural Health Monitoring). Elements to be integrated include simulations, finite element models, adjoint optimization, resulting data products, and uncertainty inherent in field experiments. The decision-making framework will articulate a strategy to manage these simulations, experiments, and results via a combination of prognostics and exploratory and explanatory visual analysis.

Status: The integration framework is being developed from a suite of software analysis tools in conjunction with the world-famous LANL High Performance Supercomputing facilities. This framework incorporates elements from codes that are used to test the reliability of nuclear weapons and other reality based scenarios that require fast and accurate predictive capabilities to scenarios that change quickly.

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