WIND ASSET MANAGEMENT IMPROVEMENT

ISSUE STATEMENT

O&M costs are a significant component of the overall cost of wind energy. Rising O&M costs and increasing downtime over the life of deployed wind turbines demonstrates that current understanding and management of materials degradation and component failure mechanisms are insufficient. New technologies, knowledge and tools are required to reduce costs and risks and increase reliability without impacting productivity.

Development of wind asset management improvement technologies will be required to reach industry targets of more than 20% reduction on onshore wind turbine O&M costs by 2020 and up to 25% for offshore by 2030 relative to 2010 levels. This includes development of on-line condition monitoring, SCADA data collection and mining, advanced NDE techniques, wind farm power prediction, operations support decision tools, enhanced Reliability Centered Maintenance (RCM), optimized wind energy components maintenance guidelines and application of new wind measurements technologies such as remote sensing (LIDAR/SODAR).

This area of research seeks to identify and foster innovative wind asset management concepts, perform feasibility analysis, testing of pilots and implement collaborative demonstration and validation projects to accelerate innovation within the wind sector. In this endeavor the involvement of leading wind turbine and component manufacturers, as well as software providers, technical consultants, services contractors and energy companies will be required.

Through this research, EPRI aims to explore and foster incremental innovations focused on cost reductions derived from wind turbines maintenance experience, use of best practices and reliability information, as well as breakthrough innovations in sensors, CM and SCADA data mining algorithms. EPRI’s target is to reduce the technological and economic risks for the early adopters and inform stakeholders of new developments on asset management and after-market technologies to accelerate its field deployment.

DRIVERS

Worldwide expansion of wind power generation, cost reduction, availability improvement and the power prediction challenges derived from the variability of the wind resource are driving the need for research into this area. Some of the key drivers are:

Worldwide expansion of wind power generation supported by regulatory and policy approaches of many types implemented around the world, has resulted in a fast double digit expansion of worldwide wind energy generation in spite of general economic crisis. Many operators realize they’ve been slow to implement asset management technologies, as well as predictive maintenance of wind operations and tools to increase operational efficiency. RD&D in this area will contribute to make wind energy production more cost effective.

Cost reduction is a key driver behind much of the existing and planned wind related RD&D. This is due to the present relatively high cost of on-shore wind and even more of offshore wind maintenance. Immediately after the 2 years of the typical initial warranty period, O&M cost more than double over the life of the project, which reflects increasing wear on the turbines and greater probability of part failures. RD&D on NDE techniques, components maintenance guidelines and application of Condition Monitoring will contribute to address this issue.

Wind turbine availability improvement also underlies many RD&D activities. Overall wind turbine availability averages around 93-95%. It is commonly accepted that turbine availability of 97% can be expected in the first few years of operation. However as wind turbine ages, failure rates of large components such as blades, gearboxes and generators increase, causing a significant downtime and reducing availability in the second decade of operation. RD&D on preventive /condition based maintenance, health monitoring and prediction and early detection of failures technologies would address this issue and...
open the option to extend the economic useful life of the Wind Turbines well beyond the typical 20 years of design.

**Wind resources variability** represents another driver since RD&D results can help to mitigate the effects of variability. RD&D on models for optimal trading of wind power in day-ahead (DA) electricity markets under uncertainty in wind power and prices will allow managing the risk of participating in the electricity markets.

Additionally as the penetration of wind energy continues to increase around the world, RD&D methodologies to achieve improved capture of ramps events for individual wind farms and portfolios are required to the large-scale integration of wind energy into electricity grids and also help the traders better understand the risk involved in trades at times of high variability.

**Wind power environmental issues** will become more important as wind energy deployment increases worldwide.

**RESULTS IMPLEMENTATION**

A comprehensive plan has been developed to address the near and longer-term research needs to identify and develop key advanced wind turbine asset management and performance improving technologies required to meet the deployment and cost reduction targets.

- Research results will be available to participants to help to evaluate the best technology options to apply to their wind projects in a cost effective manner
- Results summaries will be available to other stakeholders and the public to foster new wind power generation technology knowledge

**PLAN**

Over the next 5 years the Wind Assets Management Improvement RD&D will focus on the following technical issues:

**Wind Turbine Condition Monitoring**

The current wind energy trend is the use of larger wind turbines in remote locations, which will be increasingly offshore, for optimal wind conditions. Both the size and the location factors have led to maintenance challenges that are unique compared to traditional generation systems.

The wind energy industry typically uses a reactive maintenance approach. This form of maintenance has been shown to be the most costly O&M practice available to operators.

To move towards more efficient wind turbine maintenance, low cost on-line condition monitoring systems that predict failures and maintenance requirements and make possible to forecast maintenance activities and lower O&M costs are required.

RD&D on new CM technologies focused on low-cost, and capable to integrate control and monitoring on one platform for advanced model-based control and monitoring feedback, as well as SCADA data mining algorithms of operational signals, may provide cheap globally effective solutions to improve overall performance of wind turbines, that will translate into significant increase in revenues.

Improved pre-service and in-service Non Destructive Examination (NDE) Technologies for key components (rotor blades, generators, gearboxes) will be identified and developed, as well as analysis methodologies to evaluate flaws degradation impacts, to increase the wind turbines availability and reduce the risks associated with ever larger machines, and harsher environments.

EPRI’s proposed role would be to identify and evaluate technically and economically the most promising new technologies/models under development and to foster member’s participation in early collaborative pilot and demonstrations projects at host wind farms, to independently validate and share actual vs. anticipated cost-benefits and performance of the new concepts to be applied to new turbines or retrofitted to installed turbines.
Wind Farm Power Prediction and Decision Support for Operations

The rapid expansion of wind power gives rise to a number of challenges for power systems operators and electricity markets participants. There are under development several methodologies and modeling tools for the use of system operators as well as the wind power producers. A key challenge is to improve decision making under uncertainty and the understanding of the impact of uncertainty on operational decisions. At the same time it is important to continue the improvements of wind power forecasting models and to better tune them to the specific needs of the forecast users.

Probabilistic forecasting models show potential for optimal trading in day-ahead electricity markets under uncertainty in wind power and prices. Stochastic models will be important tools to control the trade-off between risk and return for wind power producers participating in electricity markets. Improved scheduling decisions and better risk management will increase the viability of wind power in the long run, and wind power forecasting models can serve as an important tool to achieve this goal.

EPRI’s proposed role would be to identify and evaluate technically and economically the most promising new models under development and to foster member’s participation in early collaborative pilot and demonstrations representative cases, to independently validate and share actual vs. anticipated cost-benefits and performance of the new concepts to be applied by wind power producers

Operating Performance Optimization

With the growing demand for green electricity worldwide, rising turbine cost and increased competition to supply green electricity to the grid, wind farms operators must improve their existing power output.

RD&D on technologies to optimize energy output and improve energy yields through application of LIDAR to turbine controls, reduction of operation and maintenance cost through improved reliability centered maintenance (RCM) application and innovative use of SCADA to identify and correct deviations in the wind turbine power curve will be required.

Additionally, strategies to repower old wind turbines retrofit blades with improved more efficient designs and upgrade electronic converters to comply with new grid integration requirement will be needed to optimize wind farm operating performance.

Technical guidelines for economic wind turbine useful life extension well beyond the typical 20 years of design will contribute to reduce the cost of electricity produced by wind farms on-shore and offshore and improve the competitiveness of wind in the electricity markets.

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Wind + PV Hybrid Plants Generation

PV-Wind Hybrid systems applications have the potential to be more cost efficient compared with PV-alone systems. In many situations the solar and wind energy potential naturally complements each other, the parallel operation of the wind/PV systems determining a higher efficiency than in separate operation. Combining wind and PV into a hybrid system may ensure an increased reliability of the electric supply delivered to the consumers at optimum quality parameters. The sizing of the power system components should be tailored to the wind/solar potential of the site.

Optimization of this type of hybrid plant, and demonstration to validate the design, capital and O&M costs as well as the integration of both technologies with the grid may pave the way to further commercial applications to distributed generation and autonomous electric power production.
EPRI’s proposed role will be to evaluate development of methodologies and algorithms for optimization of hybrid PV/Wind systems to minimize the total net present cost for the optimum configuration, including sensitivity analysis to optimize the system at different conditions, and to foster member’s participation in demonstration projects to validate and share actual vs. anticipated cost/benefits and performance at several locations.

**RISK**

Continued objective and independent research is necessary to develop the technologies required to bridge the gap in cost and deployment from the current values to the new worldwide targets for a low carbon transition in electricity generation.

This roadmap is designed to help develop and demonstrate a portfolio of cost effective wind asset management technologies for the industry to meet evolving regulatory requirements and also take advantage of expanding business opportunities. However, the successful implementation of these Roadmap activities is far from assured. A variety of factors could delay or derail some of the tasks of the plan. This includes funding constraints, regulatory delays or changes, reduction of incentives for wind energy (such as weakening of RPS’s or Investment tax credits) and technical difficulties. The same collaborative benefit that other issues have realized through a comprehensive research plan funded by many companies has not yet been fully realized in this area in the U.S. In part this may be due to the limited engagement of our utility participants in the direct development, and ownership and operation of large wind farms.
Wind Asset Management Improvement

- **Wind Turbines Condition Monitoring**
  - Technology and Cost/benefit evaluations of new concepts
  - Field assessment and demonstration Projects

- **Wind Farm Power Prediction and Decision Support for Operation Forecasting Models, Risk Management**
  - Technology and Cost/benefit evaluations of new concepts
  - Field assessment and demonstration projects

- **Operating Performance Optimization, Retrofitting, Lidar, SDM, Repowering, RCM Maintenance Guidelines**
  - Best new concepts evaluation of potential
  - Field assessment and demonstration projects
  - Issue Components Maintenance Guidelines

- **Small wind +PV Hybrid Plants for Distributed Generation**
  - Evaluation of algorithms for optimization and least cost
  - Field assessment and demonstration project

Legend
- **Funded Research**
- **Unfunded Research**