Wind Energy Technology

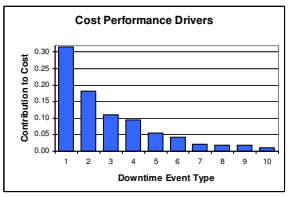
Sandia National Laboratories

Help our nation secure a peaceful and free world through technology.

SANDIA'S WIND ENERGY PROGRAM

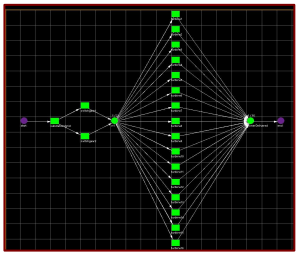
Sandia National Laboratories (SNL) conducts applied wind energy research aimed to increase the viability of wind technology by improving wind turbine performance, reliability, and reducing cost of energy. SNL specializes in all aspects of wind-turbine blade design, manufacturing, and system reliability. By partnering with both universities and industry, Sandia focuses on advancing the state of knowledge in the areas of materials, structurally efficient airfoil designs, active-flow aerodynamic control, and sensors. Researchers at the laboratory are currently investigating integrated blade designs where airfoil choice, blade platform, materials, manufacturing process, and embedded controls are all considered in a system perspective. By collaborating with operators, developers, and manufacturers, Sandia evaluates known reliability problems and develops tools and methods to anticipate and investigate future reliability issues.

SUMMARY OF PROGRAM ACTIVITIES



Reliability Database & System Analysis

In order for wind generated energy to reach high penetration levels in the electrical market, continued confidence in the quality, durability, and reliability of wind turbines throughout the fleet is imperative. SNL's reliability effort aims to ensure high fleet operating performance levels, judged both by energy delivery and low operating costs. This task will measure, analyze, document and publish current and future turbine and wind farm availability, as well as target potential reliability issues as early as possible. To accomplish this, the program has initiated a national reliability database, which will be used to gather and store wind farm operations data. This data will be analyzed and baseline statistics on the reliability of the fleet will be reported. The program will use these analyses to initiate technology improvement projects where critical reliability issues are discovered. Manufacturers are key stakeholders and will be invited to participate in addition to wind plant owners and operators. Building from the Sandia-sponsored public Wind Turbine Reliability Workshops of the past two years, Sandia will continue to build partnerships across the industry and facilitate information exchange to bridge the gaps between operators, developers, turbine suppliers and component vendors.

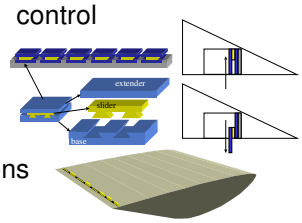


Large Turbine Technology: Wind Turbine Blades

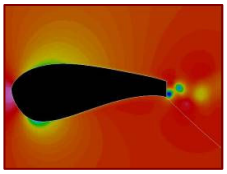
Blades are the only wind turbine component designed and manufactured uniquely for wind energy applications. The challenge is to create the scientific knowledge base and engineering tools to enable designers to maximize performance at the lowest possible cost. Activities at Sandia seek to produce research results, tools, and prototype evaluations necessary for the successful implementation of advanced design concepts into large innovative utility-grade blade designs. By focusing on improvements in blade technology through improved materials and manufacturing, optimized sensors, improved aerodynamic and structural codes, and enlarged rotors made possible by adaptive techniques, Sandia is providing innovative solutions to the industry.

- ***Materials & Manufacturing***
  Wind turbine blades constitute a significant portion of the cost of a modern, utility-scale, wind turbine. These blades are comprised of relatively low-cost composite materials and current manufacturing processes are very labor-intensive. To facilitate the incorporation of larger blade designs into new turbines, Sandia studies composite materials and manufacturing processes targeted at developing innovations that will help reduce the nonlinear growth in blade weight. The objective of this effort is to provide innovations in materials, manufacturing processes, and embedded sensor technologies.

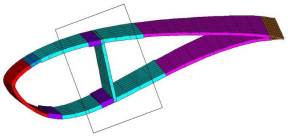
- ***Innovative Concepts***
  As wind turbines become larger and heavier, blades that incorporate small load control devices (similar to but smaller than flaps on an airplane wing) and embedded sensors to alleviate fatigue loads offer the potential for significant weight savings. Efforts are focused in three primary areas: 1) analysis of the aerodynamic performance 2) development of advanced controls and 3) calculation of the maximum potential cost of energy reductions that can be reasonably achieved through reductions in fatigue loading.



- ***Aerodynamic Tools and Aeroacoustics***
  SNL continues to develop and utilize computational fluid dynamics codes to improve understanding of the highly 3-D flow fields under which wind turbine rotors operate. By leveraging the High Performance Computing (HPC) capability of the laboratory, these tools provide the necessary information needed to develop the next generation of wind turbine blades that maximize both structural and aerodynamic efficiency. Additionally, SNL will continue to develop aeroacoustics emission and propagation prediction codes that provide the capability to estimate the noise characteristics of wind turbine rotors. As part of that effort, the aerodynamic performance and acoustic emissions of a rotor with blunt trailing edge airfoils will be compared to those of a similar rotor with conventional airfoils and the effects of various blunt trailing edge treatments on these characteristics will be investigated. This comparison effort is supported by wind tunnel tests to compare the measured noise generation and propagation of a traditional sharp trailing edge airfoil and a structurally efficient flatback airfoil.



- ***Design Tools & System Modeling***
  Sandia will continue its efforts to develop computational tools to significantly improve the structural and aeroelastic analysis capability available to the wind industry. These analytical capabilities may be used to guide the design of new blades as well as to verify/improve the design of existing blades. The validity of the tools will be demonstrated by continuing a comprehensive design, analysis, build, test, and validation program. A major focus is being placed on better integration of the structural analysis and aeroelastic codes. This effort will result in a reduction in design time and lead to better and more efficient designs for future wind turbine hardware.



- ***System Performance and Blade Testing***
  Full scale testing of prototype wind turbine blades is vital to asses the structural and aerodynamic performance of advanced concepts. Recently, Sandia has developed three advanced blade designs which are in the process of being evaluated by a series of structural and aerodynamic tests. SNL will continue to conduct both laboratory and field testing of advanced blades in the future, and provide the necessary results to industry to ensure the viability of the unique features of the designs. Additionally, results from the blade testing provide the critical information needed to validate and improve our design codes.

Integration Technology Assessment & Support

Though wind turbine systems continue to improve, the success of wind energy in the marketplace increasingly depends on the ability to integrate wind effectively into the existing power grid and address the barriers associated with large scale deployment. In order to address some of these challenges, Sandia supports several research activities aimed at determining and mitigating the effect of wind turbines on civilian and military radar systems, and providing the analysis necessary for successful wind integration. Sandia will continue to provide support to the wind integration analysis effort by collaborating with the appropriate utilitiy/grid operators and relevant stakeholders. Sandia is actively participating in DOE's Transformational Energy Action Management (TEAM) initiative through the analysis of an on-sight 30 MW wind farm that would tie into the Sandia distribution network and be utilized by both Sandia and Kirtland Air Force Base.

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