Sandia National Laboratories

Energy, Climate, & Infrastructure Security

High-Performance Computing to Support Wind Energy Development

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Sandia National Laboratories hosts many DOE EERE research efforts to improve the efficiency, energy density, reliability, and durability of wind energy systems. Researchers leverage DOE-funded Sandia high-performance computing (HPC) assets, built to support national defense research activities, to accelerate wind energy innovation and provide greater insight into design and manufacturing processes. This research seeks to improve design efficiency and help industry develop cost-effective, reliable products.

HPC has broad applications for wind research and development from turbine design, to single-turbine and wind plant performance modeling, to wind forecasting and meso-scale weather modeling. By using DOE-funded HPC capacity, national laboratory researchers can provide the wind industry the data they need to make informed decisions to solve critical wind-energy design issues, while remaining cost effective. Sandia also maintains strong partnerships with several academic institutions, which affords them access to large-scale HPC assets, which they might not otherwise have.

Vision

To enhance the nation's security and prosperity through sustainable, transformative approaches to our most challenging energy, climate, and infrastructure problems.

HPC Evaluation of Wind Turbine Blades with Flatback

Challenge

Optimizing wind turbine blade design is a complex, delicate balancing act. Blades must be light, but also strong and durable; they must efficiently harvest wind energy and be manufactured reliably and cheaply. Manufacturers could develop dozens of prototype designs with potential and test them over years to develop the data needed to support the next-generation design, but that would increase costs and result in lengthy delays.

In partnership with UC Davis and TPI Composites, a provider of composite wind blades, Sandia conducted extensive studies of "flatback" airfoils. A flatback airfoil has a thick, blunt trailing edge, unlike the sharp trailing edge of a conventional airfoil. At the time, flatback airfoils were a new blade technology with the potential to provide several structural and aerodynamic performance advantages. The research focused on quantifying two potential disadvantages of the design—increased drag and increased noise generation—both of which would decrease a design's commercial viability (noise generation is a particularly important factor in community acceptance of wind farms).

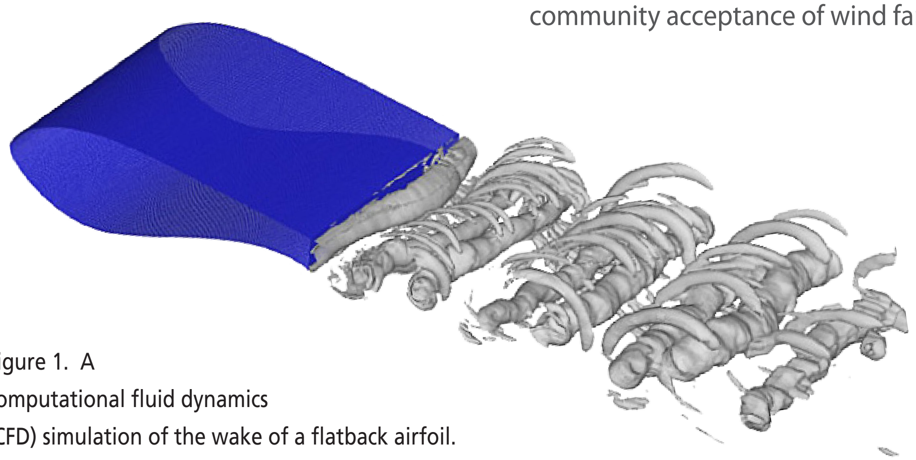

Figure 1. A computational fluid dynamics (CFD) simulation of the wake of a flatback airfoil.

U.S. DEPARTMENT OF ENERGY

Approach

The research team collected data from wind tunnel experiments and other tests and designed a model to quantify blade noise and drag. Using the Sandia-developed Red Sky Thunderbird Cluster to analyze the problem, over 20 simulation runs were performed using the SACCARA computational fluid dynamics (CFD) code on 384 Red Sky cores/processors. This simulation effort took ~480 hours of real time to run and simulated several tenths of a second of a rotating flatback blade. The fluid dynamical effects that lead to drag and noise generation operate on millisecond time scales, so this result captures enough cycles to provide for in depth statistical analysis of the relevant drag/acoustic sources.

Figure 2. An example of Siemens' Quantum Blade design, which incorporates flatback airfoil technology.

Figure 3. A Sandia researcher inspects a component board in one of the many cabinets that make up Sandia's Red Sky supercomputer.

Impact

The study showed that the flatback design was viable—that its drag and noise fell within acceptable limits—and the technology has been adopted by industry. Siemens has incorporated flatback technology into its new Quantum Blade design, which is advertised as being lighter than previous models but retaining excellent strength. GE has reportedly developed a 4 MW prototype turbine with blades incorporating flatback airfoils.

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