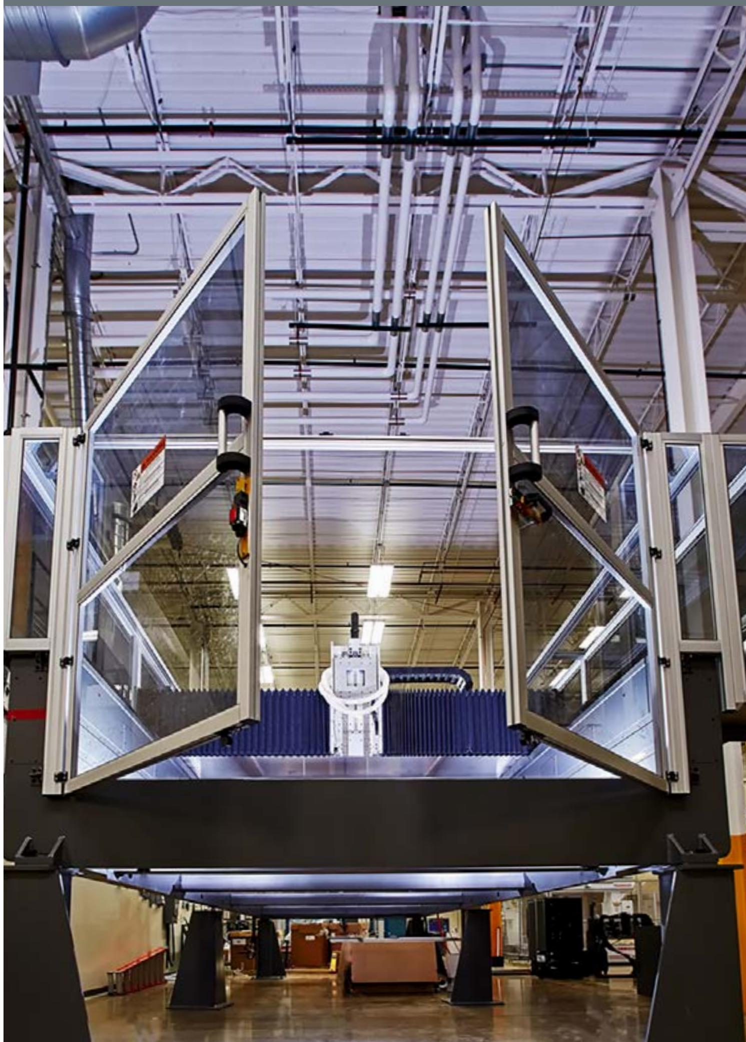
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Wind Program Newsletter

May 2016 Edition
wind.energy.gov



Oak Ridge National Laboratory has developed the Big Area Additive Manufacturing machine, which is being used to apply 3-D-printing processes to manufacture wind turbine components for use in DOE research. The groundbreaking tool is capable of printing objects that are 10 times larger at speeds up to 1,000 times faster than today's industrial additive machines. *Photo from Oak Ridge National Laboratory*

Nation Leads Wind Energy Production and Innovation

Letter from the Wind Program Director

This spring edition of the Wind Program Newsletter comes at the juncture of two important events for the wind industry: the 1-year anniversary of the U.S. Department of Energy (DOE) Wind Program's historic *Wind Vision Report* and the start of American Wind Energy Association (AWEA) WINDPOWER 2016.

We have quite a bit to celebrate this spring. Statistics released at the end of 2015 indicated that the United States was once again the world's leading wind energy producer—reaching 8.6 gigawatts for the year—pushing the country's cumulative total past 74 gigawatts, and generating enough electricity from wind to power 17.5 million typical U.S. homes!

This is great news. And yet, with wind providing approximately 5% of the nation's electrical demand, we still have a long way to go toward reaching the findings in the *Wind Vision Report* for our domestic wind industry: to supply 10% of the nation's electrical

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Wind Turbine Manufacturing Transforms with 3-D Printing

From medical devices to airplane components, three-dimensional (3-D) printing (also called additive manufacturing) is transforming the manufacturing industry. Now, research that supports DOE's Atmosphere to Electrons (A2e) initiative is applying 3-D-printing processes to create wind turbine blade molds.

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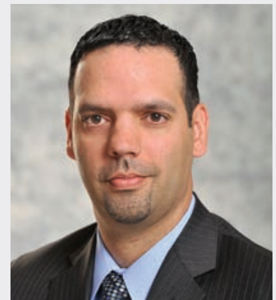
U.S. Leads Wind Energy Production and Innovation

Letter from the Wind Program Director *continued from page 1*



José Zayas, Director, Wind and Water Power Technologies Office

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demand in 2020, 20% in 2030, and 35% in 2050. Guided by the *Wind Vision*, the Energy Department's investments are aimed at improving the performance, lowering the costs, and accelerating the deployment of innovative wind power technologies.

One new example of innovation being deeply explored by DOE is 3-D printing technology, which promises to have far-reaching effects on how wind turbines and components are manufactured. DOE's Oak Ridge National Laboratory has partnered with Cincinnati Incorporated to develop a new additive manufacturing tool—the Big Area Additive Manufacturing (BAAM) machine—which is 500 to 1,000 times faster and capable of printing polymer components 10 times larger than today's industrial additive machines. The technology is also scalable, allowing us to make even larger components in the future. By applying 3-D printing to the manufacture of blade molds, it is possible to reduce costs and time associated with manufacturing, experiment with new capabilities, and improve design flexibility. Come see a section of one of these blade molds for yourself at DOE's booth 4847.

The Wind Program has a lot going on here at AWEA WINDPOWER (please see p. 3 of this newsletter for a schedule of DOE-related events). Perhaps most exciting to me personally is the U.S. Department of Energy Collegiate Wind Competition 2016. This rivalry among 12 teams of university students is located in the Education Pavilion and open to WINDPOWER visitors. Please take this opportunity to watch demonstrations of their ingenious wind turbines, talk to the students about their designs and competition strategies, and help determine the People's Choice award winner by voting for your favorite team. You're sure to be inspired by the passion and potential of these amazing students, who are our next generation of industry leaders.

Thank you for joining me in celebrating the accomplishments we're making together to promote the power of wind.

Sincerely,
José Zayas

Wind Turbine Manufacturing *continued from page 1*

This research promises to reduce the cost of blade manufacturing and wind energy overall, as blades represent one of the most expensive components of a wind turbine. The processes currently used to manufacture utility-scale wind turbine blades—which can average over 150 feet in length—are complex, energy-intensive, and time-consuming. Trends toward larger blades, coupled with the drive for global competitiveness, inspired DOE's Wind Program and the Advanced Manufacturing Office to explore new manufacturing technologies.

As part of an effort to expand the throughput and size of the additive manufacturing process, DOE's Oak Ridge National Laboratory partnered with Cincinnati Incorporated to develop BAAM. BAAM created a 3-D-printed replica Shelby Cobra automobile, which was displayed at DOE's Washington, D.C., headquarters and showcased in Paris at the United Nationals Framework Convention on Climate Change and the JEC World Conference. BAAM is capable of printing a staggering 100 pounds of polymer materials per hour, which is 500 to 1,000 times faster than conventional 3-D printers. Moreover, BAAM can print components that are 10 times larger (20 feet long, 8 feet wide, and 6 feet tall) than today's industrial additive machines.

The technology is also scalable, making the manufacture of other large components a future possibility. For now, DOE will take advantage of the availability of BAAM to evaluate whether it can simplify the manufacture of turbine blade molds. Currently, a "plug" must be manufactured and then

DOE Wind Program Presentations at AWEA WINDPOWER 2016

TUESDAY May 24

Wind Energy Technology Advancements and Cost Reductions: What Do Wind Experts Say?
1:15 p.m.–2:15 p.m.

Future technology and cost trends, including the greatest opportunities for levelized cost of energy reductions.
Ryan Wiser, Senior Scientist, *Lawrence Berkeley National Laboratory*

WEDNESDAY May 25

A New Approach to Demonstrating and Quantifying Wind's Hedge Value
12:30 p.m.–12:55 p.m.

A new and innovative framework for establishing wind's hedge value.
Mark Bolinger, Research Scientist, *Lawrence Berkeley National Laboratory*

An Analysis of the Benefits and Impacts of State RPS Programs
2:15 p.m.–3:15 p.m.

The benefits and impacts of state RPS programs based on findings from a recent study.
Ryan Wiser, Senior Scientist, *Lawrence Berkeley National Laboratory*

Poster Reception 4:30 p.m.–6 p.m.

Assessing the benefits and impacts of U.S. renewable portfolio standards
Jenny Heeter, Senior Energy Analyst *National Renewable Energy Laboratory*

Estimating the economic potential of offshore wind across 30,000 sites in the United States
Philipp Beiter, Energy Markets and Policy Analyst *National Renewable Energy Laboratory*

Wheeling and banking strategies for optimal renewable energy deployment: international experiences
Jenny Heeter, Senior Energy Analyst *National Renewable Energy Laboratory*

Improving the design criteria for wind turbines and wind power plants
Paul Veers, Chief Wind Engineer *National Wind Technology Center at the National Renewable Energy Laboratory*

THURSDAY May 26

Near and Mid-term Prospects for Wind Power, Focusing on Low Wind-Speed Regions
10 a.m.–10:25 a.m.

Future development opportunities based on resource and technology trends and state-of-the-art modeling capabilities.
Eric Lantz, Senior Energy Analyst, National Renewable Energy Laboratory

used to form a mold out of which fiberglass blades can be constructed. Eliminating the plug by applying 3-D printing directly to the mold process will reduce the costs and amount of time required for blade manufacture.

In this demonstration project, DOE will partner with Oak Ridge, Sandia National Laboratories, National Renewable Energy Laboratory (NREL), and TPI Composites Incorporated to use 3-D printing in the manufacture of a mold for special scaled-down turbine blades designed to simulate the aerodynamic characteristics of a full-size turbine. These research blades will measure 13 meters (approximately 43 feet) in length and undergo static and fatigue testing at NREL. The blades will then be operated using wind turbines at DOE's Scaled Wind Farm Technology (SWiFT) facility in Texas. This effort will help researchers study wake aerodynamics—that is, the effects that turbines in close proximity to one another can have on productivity. This research will be used to understand and enhance the efficiency of a complete wind plant, comprised of numerous wind turbines.

Three-dimensional printing is just one way DOE is leading the United States toward a clean energy future and increasing our nation's competitiveness through research into new, more efficient technologies.

Visit the DOE Wind Program booth #4847 at AWEA WINDPOWER 2016 Conference & Exhibition to learn more about how wind turbine blades can be manufactured using this process.

Collegiate Wind Competition Set to Blow AWEA WINDPOWER 2016 Away

When you add passionate collegiate competitors and their pioneering wind turbine designs to America's largest wind industry event, you get a winning combination designed to spark excitement. Bringing together the next generation of wind energy professionals with today's industry leaders, the U.S. Department of Energy Collegiate Wind Competition 2016 takes place at the annual AWEA WINDPOWER Conference & Exhibition in New Orleans, Louisiana, from May 23–25.

Wind industry professionals attending the conference are invited to meet the Collegiate Wind Competition teams in the Education Pavilion. This is a great opportunity to:

- Watch as teams put their turbines to the test in an on-site wind tunnel on Tuesday, May 24.
- Talk to students about their cutting-edge turbine designs at their booths over the course of the 2-day competition. Students host a special open house on Wednesday, May 25, from 4–5 p.m.
- Attend public pitch presentations where teams convince a panel of experts of the technical underpinnings, business case, and feasibility of deploying their power system, taking place on Wednesday, May 25, in the WINDPOWER Exhibition floor theater.

Collegiate Wind Competition 2016 Teams

- Boise State University
- The California Maritime Academy
- California State University, Chico
- Kansas State University
- Northern Arizona University
- The Pennsylvania State University
- Universidad del Turabo (Puerto Rico)
- University of Alaska Fairbanks
- University of Maryland
- University of Massachusetts Amherst
- University of Massachusetts Lowell
- University of Wisconsin–Madison

"The Collegiate Wind Competition is an inspiring demonstration of the creativity and problem-solving capabilities of these remarkable students, who represent the next generation of wind industry professionals," said José Zayas, U.S. Department of Energy Director, Wind and Water Power Technologies Office. "Everyone who visits the competition at the WINDPOWER conference—from manufacturers to policymakers—will be impressed by the teams' ideas, innovations, and enthusiasm."

The U.S. Department of Energy Collegiate Wind Competition 2016 will take place at the American Wind Energy Association WINDPOWER Conference May 23–25. Among other competition activities, student teams will test their turbines in an on-site wind tunnel. In this photo, 2014 competitors prepare their turbine for wind tunnel testing. *Photo from U.S. Department Energy*

The 2016 competition challenges teams to design and construct a wind-driven power system to supply electricity for off-grid usage. This requires each team to create a wind turbine design that is efficient and safe to operate, develop a load system that represents a real-world need that can match the power being generated, and ensure that the overall mechanical and aerodynamic turbine design is safe and reliable.

The biannual Collegiate Wind Competition is designed to attract engineering, business, marketing and communications, policy, and social science students to wind-related fields, provide them with practical knowledge and wind experience, and showcase tomorrow's promising workforce to industry leaders. Intertwining academic coursework with tangible, hands-on learning, the Collegiate Wind Competition provides valuable real-world experience as students prepare to enter the workforce.

For additional information, including profiles of the teams and a schedule of competition activities, visit *http://energy.gov/eere/collegiatewindcompetition*

Researchers Achieve Breakthrough in Solving Leading Cause of Gearbox Failures

Accomplishing a significant milestone, researchers from DOE's Argonne National Laboratory have successfully replicated the leading cause of wind turbine gearbox failures, known as white-etch cracks or axial cracks. This represents a big step forward in solving a problem that has plagued the wind industry for years.

"These results provide us with critical information to determine what causes these cracks and inform testing approaches that will allow us to understand how to actually prevent them from occurring," said Dr. Aaron Greco, principal materials scientist, Argonne National Laboratory. "Solving the white-etch crack issue in gearboxes would significantly improve turbine reliability and reduce overall wind plant maintenance costs."

White-etch cracks are thought to be caused by aspects of turbine operation, such as transient loading, electrical currents, and lubricant contamination. Argonne researchers determined that certain levels of these operating parameters lead to the formation of white-etch cracks, therefore establishing an energy threshold beyond which white-etch cracks are predicted to form.

Argonne is working with the support of DOE and several industrial partners, including SKF Group and Afton Chemical, to identify the conditions leading to white-etch cracks and how to improve bearing reliability.

Achieving a significant milestone, Argonne National Laboratory researchers have replicated white-etch cracks—the leading cause of wind turbine gearbox failures—on a test platform. This microscope image shows the surface of a test sample that failed due to white-etch cracks similar to those observed in wind turbine bearings. *Photo from Argonne National Laboratory*

"Our goal in collaborating with Argonne National Laboratory is to design a standardized test that will evaluate the ability of current wind turbine lubricants to protect against white-etch cracks," said Dr. Marc Ingram, R&D engineering specialist, Afton Chemical Ltd. "This work is leading the way for both understanding the white-etch crack phenomenon and developing solutions to this problem, in which lubricants can play a part."

Argonne is also partnering with DOE's NREL to gain insight on the conditions bearings experience in a wind turbine during events such as variable winds, grid faults, and emergency stops. This is being done by instrumenting the high-speed shaft of the gearbox in DOE's 1.5-megawatt wind turbine located at the National Wind Technology Center to measure actual loads, electrical currents, and other conditions during the turbine operation.

For its part, Argonne is focused at the material level, characterizing the failed bearings and performing benchtop testing to replicate the white-etch cracks in a controlled environment and to transfer these findings from the labs to the relevant industrial original equipment manufacturers. For more information, visit *http://link.springer.com/article/10.1007/s11249-015-0602-6*

Sandia National Laboratories Hits Milestone, Gears Up for 2016 Research

DOE's Sandia National Laboratories (SNL) recently reached a major milestone by successfully remounting a rotor on one of its heavily modified Vestas V27 turbines at the SWiFT facility in Lubbock, Texas.

Wind engineers at SWiFT have been preparing for this event since 2014 when one of the turbines oversped and failed. Since then, SNL's Wind Energy Technologies Department has been evaluating and improving hardware, software, safety systems, procedures, training, and security at the SWiFT site. Site and process improvements include the following:

- A new generator brake system to maintain stopping capability with failure tolerance
- A new hardware-in-the-loop testbed to provide exact-replica testing of the turbine controller prior to deployment on the turbine
- A significantly strengthened hardware safety system with multiple layers
- Implementation of robust review and approval procedures
- A rigorous readiness review and change management system designed to expedite future testing efforts.

With the rotor remounted, SNL is now preparing SWiFT for a DOE Moderate Hazard Facility Readiness Review. A successful readiness review is the final DOE authorization needed for the SWiFT team to proceed with the rotational tests of the turbine commissioning, a process that will verify performance of the stopping mechanisms and power production controller. Completion of commissioning will return the facility to full operational capability and begin a wide range of wind plant research.

SWiFT is the principal wind farm research facility for investigating wind turbine wakes as part of the DOE A2e initiative, which strives to ensure that future wind farms are

Sandia National Laboratories' successful remount of a turbine rotor at the Scaled Wind Farm Technology Facility (shown here) marked the beginning of several research projects at the facility on behalf of DOE's Atmosphere to Electrons initiative. *Photo from Josh Bryant, Westergaard Solutions* sited, built, and operated to produce the most cost-effective and usable electric power.

This year, SWiFT will be the focus of a joint experiment conducted by SNL and NREL to study the use of wind farm controls to mitigate the impact of wind turbine wakes on farm performance.

At the end of 2016, the facility will fly the first blade set from DOE and SNL's National Rotor Testbed (NRT) program, which aims to demonstrate the ability to functionally scale utility rotor characteristics to the more cost-effective research scale of the SWiFT turbines. The NRT rotor will recreate the wake of a utility-scale turbine, whereas future NRT rotor designs could demonstrate wake mitigation, damage-mitigating active load control, and other innovative design concepts.

To support A2e's industrial partnership objectives, SWiFT will partner with Windar Photonics and Westergaard Solutions to investigate simultaneous feedforward/feedbackward wake control. Additionally, Pentalum Technologies, Texas Tech University, and SNL have partnered on a Binational Industrial R&D Foundation grant to further develop a new approach to light detection and ranging system technology with the hopes of leveraging that technology to develop wind plant controllers.

For information about the A2e initiative, visit *http://energy.gov/eere/wind/atmosphere-electrons*

FAST v8 Offers New Modeling and Analysis Features

Researchers at NREL recently released version 8.15 of FAST (FAST v8), an open-source, multiphysics engineering software tool used to design and analyze wind turbines. FAST v8 is also an open-source modular platform for creating, testing, and demonstrating new modeling and analysis capabilities.

The new features in FAST v8 include:

- The ability to model advanced aeroelastically tailored blades, including curved geometry, large deflections, and composite-material couplings
- A new visualization capability based on either surface or stick-figure geometry for viewing model configurations and time-series animations
- An enhanced InflowWind module, which is separated from AeroDyn and updated to support different wind-file formats and arbitrary wind directions for all wind-file types

DOE's FAST v8, the industry's premier open-source wind turbine multiphysics engineering software, has enhanced capabilities and functionality. The Siemens 2.3-megawatt turbine stationed at the National Wind Technology Center at NREL, shown in the foreground, was used to validate FAST v8 for advanced aeroelastically tailored blades.
Photo by Dennis Schroeder, NREL 25873

- A new driver for AeroDyn v15, allowing for aerodynamic analysis in standalone mode uncoupled from FAST
- Enhanced modeling of nacelle- and tower-based tuned mass dampers
- Enhanced functionality for the interface to Bladed-style dynamic link library controllers
- Checkpoint-restart capability
- Improved GNU Fortran compatibility.

FAST v8 also contains several new features specific to the modeling of offshore wind systems. Some of the new offshore features include the ability to:

- Input a wave-elevation time series, such as one measured either from a wave probe in a tank or a buoy in the open ocean
- Enter full wave kinematics (wave velocities, accelerations, and dynamic pressures) throughout the fluid domain to enable the use of external wave models
- Model the dynamics of mooring lines using two new mooring modules for floating systems
- Couple to the commercial marine-system design and analysis tool, OrcaFlex (developed by Orcina), for increased capabilities in modeling floating wind turbines.

These features increase accuracy in predicting the behavior of offshore wind systems, expand the ability to validate FAST v8 against measurements of offshore wind systems tested either in a tank or open water, and ultimately enable the development of more innovative and cost-effective offshore wind turbine designs.

FAST v8 has undergone the first phase of validation for advanced aeroelastically tailored blades, which provides new understanding of and confidence in the tool's modeling capabilities. NREL researchers, in collaboration with Siemens Energy engineers, compared FAST v8 results against:

- Experimental measurements from the heavily instrumented Siemens 2.3-megawatt turbine stationed at the National Wind Technology Center at NREL
- Results generated by BHawC (turbine modeling software developed by Siemens).

These comparisons demonstrated that FAST v8 predictions agree consistently with those of BHawC and the measured data, building confidence in applying FAST v8 to the design and analysis of innovative rotor technology.

The latest public release under the FAST modularization framework, FAST v8 is available for download at *https://wind.nrel.gov/forum/wind/viewtopic.php?f=38&t=652&start=15*

Using Weather Data to Improve Capacity of Existing Power Lines

When it comes to increasing the efficiency of 160,000 miles of U.S. high-voltage transmission lines, the answer might be blowing in the wind.

In fact, when the wind blows just the right way on a high-voltage line, the line cools enough to safely increase the amount of current between 10% and 40%.

Under DOE's Grid Modernization Initiative, Idaho National Laboratory (INL) is receiving $2.35 million over 3 years to further develop Dynamic Line Rating tools that maximize the capacity of power lines. Using weather data, customized algorithms, and advanced computer modeling, INL is improving the accuracy and reliability of these tools at a lower cost.

As part of this work, researchers from INL and Idaho Power have teamed up to install weather stations on more than 450 miles of transmission line in a windy part of southern Idaho.

"Our greatest challenge was to come up with a standard design that didn't cost a fortune," said Phil Anderson, project leader for Idaho Power. As it turned out, with INL's help, Idaho Power was able to create Dynamic Line Rating weather stations and loggers by retrofitting some of the power quality meters it had developed in-house. The team plans to have all 47 weather stations mounted and operational this year.

The next challenge was finding software that could offer a complete view of the electrical and environmental conditions spanning all 450 miles, taking into account topography rife with rocks, canyons, and vegetation.

INL discovered a company called WindSim, which has the ability to incorporate multiple weather stations in a single computational fluid dynamics model. This custom software program, when combined with INL's General Line Ampacity State Solver, analyzes airflow, ambient temperature, and solar irradiation to provide a real-time picture of conditions along the line.

These tools will help INL give planners, designers, and control-room operators the data they need to keep the lines running at maximum efficiency.

To increase the amount of electricity delivered from wind farms, researchers from DOE and Idaho National Laboratory are investigating the effects of weather on transmission lines using weather stations and loggers, which are visible near the base of the utility pole on the right. *Photo from Idaho National Laboratory*

"Having reliable weather data and accurate models to predict line ampacity is where this truly becomes impactful," said INL Project Lead Jake Gentle.

As utilities work to replace aging infrastructure and incorporate renewables from remote locations, unlocking extra capacity within existing transmission lines is proving essential. The culmination of this work promises to be a more robust and efficient electricity grid.

Simulation Toolkit Promises Better Wind Predictions, Increased Farm Production

Wind farm production frequently falls short of expectations. Poor forecasts of low-altitude winds, suboptimal wind plant design and operation, and higher-than-expected downtimes and maintenance costs all undermine project profitability. Each of these issues results from industry reliance on insufficient computational approaches for simulating wind farm inflow and plant behavior under realistic operating conditions. These tools largely neglect the influence of changing weather conditions and other environmental impacts, such as terrain characteristics, on simulated flows at turbine heights.

To address these shortcomings, DOE's Lawrence Livermore National Laboratory (LLNL) is creating a multiscale atmosphere/wind farm simulation toolkit that incorporates the full spectrum of weather, environmental, and turbine impacts to better predict wind farm flows. This toolkit will address industry needs, including resource characterization, inflow prediction, siting, design, and operations, and will apply to challenging environments with complex flows and terrain.

The toolkit is being implemented within the Weather Research and Forecasting (WRF) model, a widely used, publicly available atmospheric modeling framework that supports simulations ranging from global weather to large eddies of turbulent flows. Development of the toolkit within the popular WRF model enables easy collaboration among industry, academia, and DOE laboratories. It also provides a direct patch for incorporating future capabilities and improvements contributed by the worldwide community of WRF users and developers.

Toolkit Features

Accurate multiscale simulation requires proper physics parameterizations, numerical methods, and model configurations. The LLNL simulation toolkit addresses these requirements by providing:

- Actuator models for wind turbine and farm simulation
- Advanced turbulence subgrid models for better large-eddy simulations
- Algorithms to improve downscaling, both from mesoscale to large-eddy simulations and within large-eddy simulations
- Ensemble-based forecasting to provide uncertainty bounds
- Vertical mesh refinement for multiscale simulation
- Immersed boundary methods for improved simulations over complex terrain.

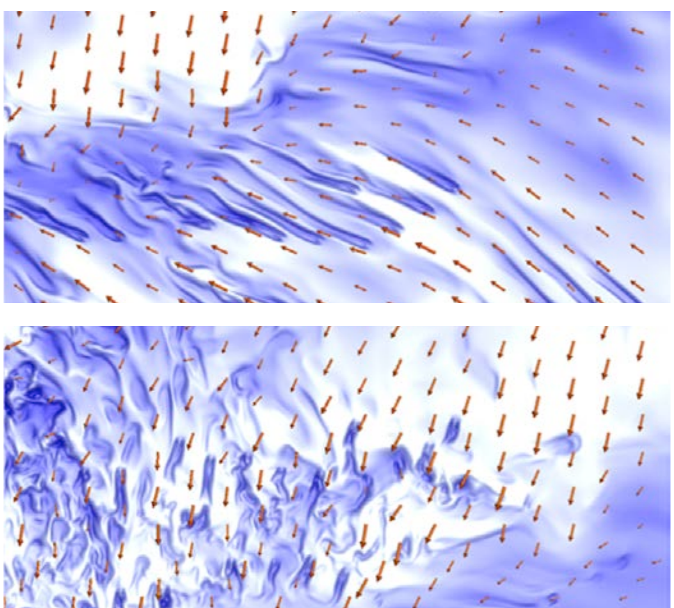
Simulating Weather-Turbine Interactions

The toolkit's turbine models are embedded in a large-eddy simulation, which resolves turbine/turbulence interactions. Next, the simulation is nested within larger-scale simulations that model weather effects, therefore capturing atmospheric and environmental characteristics, such as weather features, that impact both the plant inflow and turbine response.

The multiscale simulation in these graphics shows a weather front just before (top) and after (bottom) passing through an array of actuator turbine models using LLNL's WRF-based wind farm simulation toolkit. Color contours show wind speed, with the darkest colors indicating the lowest values. Turbine wakes appear as pairs of dark blue streaks extending downstream from the actuator models. Arrows show wind speed and direction. Note the change in wind direction and impacts on turbine wakes during the frontal passage.

Obtaining accurate simulations of flow over complex terrain is a continuing challenge for the wind energy industry. The immersed boundary method eliminates numerical errors caused by grid distortion in simulations over complex terrain. In combination with vertical grid nesting, the immersed boundary method extends LLNL's advanced multiscale simulation capability to flows over arbitrarily complex terrain, providing more accurate wind simulations for the challenging environments in which many wind farms operate.

These efforts support projects within the DOE A2e initiative. More information is available online at *https://www-gs.llnl.gov/about/energy-security/windpower*



Lawrence Livermore National Laboratory's multiscale atmosphere/wind farm simulation toolkit will improve weather forecasting to increase wind farm production. Shown here is a simulated weather front passing through a wind farm. *Photo from Lawrence Livermore National Laboratory*

The Lawrence Livermore National Laboratory multiscale simulation toolkit can be applied to a wind farm in complex terrain like the one shown here, using vertical nesting, immersed boundary method terrain, and actuator turbine models. *Photo from Lawrence Livermore National Laboratory*

Researchers at the Pacific Northwest National Laboratory collaborated with the National Oceanic and Atmospheric Administration to add three new radar wind profilers—one every 150 miles—along the Oregon and Washington coast. The profilers measure the speed and direction of oncoming wind patterns, providing wind plant operators and utilities more accurate wind energy forecasts.
Photo from Pacific Northwest National Laboratory

Making Wind Energy Predictable: New Profilers Provide Hourly Forecasts

Balancing the power grid is an art—or at least a scientific study in chaos—and DOE is hoping wind energy can take a greater role in the act. Yet, the intermittency of wind—sometimes it's blowing, sometimes it's not—makes adding it smoothly to the nation's electrical grid a challenge. If wind energy were to become more predictable, use of this clean, renewable power source stands to increase.

As nice as it would be, controlling the wind eludes us. It is possible, however, to get better at predicting it, which is what DOE's Wind Forecast Improvement Project (WFIP) seeks to accomplish. Under the second phase of this project (WFIP 2), some of the world's best scientists are working together to gain a better understanding of the physical processes that drive the wind in complex terrain. Collaborators on this project include researchers from several DOE national laboratories, the National Oceanic and Atmospheric Administration (NOAA), and Vaisala (whose subcontractors include the University of Colorado, the University of Notre Dame, and the National Center for Atmospheric Research).

Recently, researchers at the Pacific Northwest National Laboratory, along with NOAA, added three new radar wind profilers—one every 150 miles—along the Oregon and Washington coast. These profilers project continuous radio signals nearly 5 miles into the atmosphere. By measuring changes in the radio waves caused by air movement, the speed and direction of oncoming wind patterns is determined.

Each profiler site also includes a radio acoustic sounding system that uses sound waves to measure temperature changes. For part of each hour, the radar tracks the sound waves to measure their speed. As the speed of sound varies depending on the temperature of the air, the system is able to detect how temperature changes with height.

By measuring speeds and temperatures of air blowing into the West Coast and feeding this information in real time to weather prediction models operated by NOAA, the profilers give the models a more accurate starting point for the forecasts. These models then provide wind farm operators and utilities with more accurate wind energy forecasts a few hours to a day ahead. Such forecast improvements allow wind farms to be more efficient and pave the way for greater integration of wind energy into the grid. If a utility company knows in advance a wind front will coincide with peak hours, it can call on wind farm operators to power up turbines and scale back on baseload power sources.

In addition to supporting weather forecasts, the data are also being used by WFIP 2 researchers to investigate local variations in turbine-height winds as air flows over the Cascade Mountains and through the large wind farms in eastern Oregon. Data from these new profilers are combined with data from four additional profilers along the California coast. With the West Coast lined with profilers where weather systems move from, the accuracy of weather information flowing into wind models and forecasting will improve.

For more information on the DOE Wind Program's resource assessment and characterization activities, visit *http://energy.gov/eere/wind/wind-resource-assessment-and-characterization*

Wind Events

Wind Turbine Design & Construction
Stevens Point, Wisconsin
June 6–11, 2016
https://www.midwestrenew.org/civicrm/event/info?id=854&reset=1

Small Wind Conference 2016
Stevens Point, Wisconsin
June 13–15, 2016
http://smallwindconference.com/

AWEA Wind Resource & Project Energy Assessment Conference 2016
Minneapolis, Minnesota
September 27–28, 2016
http://www.awea.org/events/event.aspx?eventid=41840

International Offshore Wind Partnering Forum
October 2–4, 2016
Newport, Rhode Island
http://www.2016ipf.com/

North American Society for Bat Research Meeting
October 12–15, 2016
San Antonio, Texas
https://www.nationalwind.org/event/nasbr-meeting/?instance_id=417

AWEA Offshore WINDPOWER 2016
Warwick, Rhode Island
October 25–26, 2016
http://www.awea.org/events/event.aspx?eventid=43770

AWEA Wind Energy Fall Symposium 2016
San Antonio, Texas
November 15–17, 2016
http://www.awea.org/events/event.aspx?eventid=41842

Stay current on important wind energy events around the United States by receiving the Wind Program Newsletter by email. Subscribe at *wind.energy.gov/subscrib.html*

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