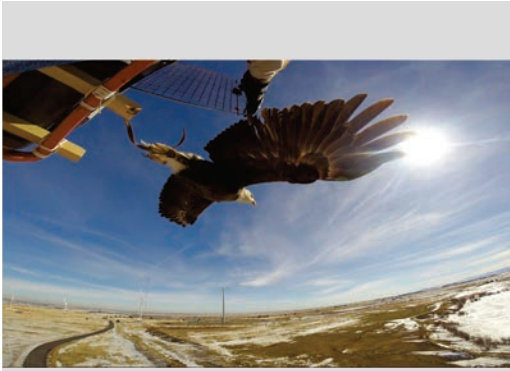


# A Summary of Recent Initiatives Conducted at the National Wind Technology Center in Support of Addressing Impacts to Birds and Bats at Wind Energy Facilities

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Bald eagle taking flight during testing of detection technology at the National Wind Technology Center (NWTC) at the National Renewable Energy Laboratory (NREL). Photo by Dennis Schroeder, NREL 35802



Wildlife detection technology testing at the NWTC. Photo by Dennis Schroeder, NREL 35743



The NWTC near Boulder, Colorado. Photo by Lee Jay Fingersh, NREL 22073

- Concerns around negative impacts to wildlife pose challenges for wind projects.
- Developers may be required to monitor projects and implement mitigation strategies to reduce fatalities even where risk parameters have not been adequately identified.
- Project developers need to know which technology solutions meet regulatory requirements in a cost-effective and reliable manner.
- Technological solutions may vary by species of interest; often a range of systems are in different stages of development and could benefit from independent testing, engineering support, and validation.
- The National Renewable Energy Laboratory (NREL) can support testing of a wide range of technologies designed to reduce bird and bat fatalities at wind energy projects.



Testing on the U.S. Department of Energy 1.5-MW wind turbine at the NWTC. Photo by Lee Jay Fingersh, NREL 19007

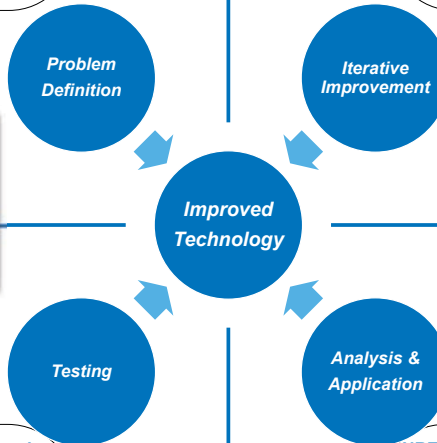
- Iterative improvement comes from working seamlessly with all stakeholders and gathering information from knowledge networks, including:
  - Land Based Collaborative - National Wind Coordinating Collaborative, Bats and Wind Energy Cooperative, the Association of Fish and Wildlife Agencies (AFWA) and NREL
  - IEA Wind Task 34, or WREN
- Knowledge sharing informs the compilation of regulatory needs, the development of protocols, and the methods used to compare testing technologies
- Iterative improvement includes identifying existing and emerging technologies that will result in statistically significant reductions in wind facility fatalities
- Accessing NREL expertise and assets can help facilitate more efficient, standardized, and cost-effective wind energy technology deployment while mitigating negative impacts to multiple species of concern across the United States.



Monitoring using a 135-meter meteorological tower at the NWTC. Photo by Lee Jay Fingersh, NREL 40950



Impact detection testing on the three-bladed Controls Advanced Research Turbine. Photo by Lee Jay Fingersh, NREL 40948



Supplier	Coverage	Range	Day/night	Low visibility	Real time	SCADA	Identification	Real time	Strike	Marine	hardened TRL
Supplier 1	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Supplier 2	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Supplier 3	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Supplier 4	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Supplier 5	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Supplier 6	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Supplier 7	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Supplier 8	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Supplier 9	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Supplier 10	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Supplier 11	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Supplier 12	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Supplier 13	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green

Comparison of detection technology performance and characteristics across vendors and technology types

- Over the past several years, NREL has participated in or led several wind wildlife testing-related initiatives, including:
- Testing camera and radar systems during the winters of 2015 and 2016. The NWTC hosted nationally recognized falcons to fly a peregrine/gyrfalcon hybrid, bald eagle, and golden eagle with GPS tracking devices to validate and refine two avian detection systems: one utilizing radar and the other stereoscopic cameras.
  - Installing thermal imagery systems, visual imagery systems, contact microphones, and accelerometers on an NWTC research turbine to evaluate technologies designed to detect bird strikes on wind turbines. Bird strikes were simulated using tennis balls thrown from the nacelle at varying distances and heat configurations and by firing tennis balls from the ground using a pneumatic cannon. Two separate full-week test campaigns were completed.
  - Monitoring thermal camera imagery collected on two NWTC research wind turbines of different sizes. This research support to the U.S. Geological Survey has been ongoing.



Visual, infrared, and thermal monitoring test from one turbine to a neighboring turbine at the NWTC. Photo by Lee Jay Fingersh, NREL 40949

- NREL has participated in or led several wind wildlife analysis-related initiatives, including:
- Analyzing technologies to help an offshore wind farm developer meet pending permit requirements (performed as part of one of the U.S. Department of Energy's Offshore Demonstration Projects); the table above summarizes a comparison of various technological solutions to best meet regulatory requirements
  - Hosting a workshop focused on eagle detection and deterrent mitigation solutions with experts in biology, policy, and technology from across the globe
  - Hosting an AFWA and Bats Conservation International workshop in support of bat impact mitigation and wind energy including three separate landscape classes, transect set up, training in field monitoring, review of different detection technology, and classroom lecture/hands-on training
  - Convening wildlife statisticians, biologists, and engineers to develop testing protocol to determine the effectiveness of emerging avian and bat detection and deterrent technologies.