Renewables: Birds, Bats, Waste, and Noise

EPRI Investigates Environmental and Human Health Aspects of Large-Scale Wind and Solar Plants

By Chris Warren

It's becoming more common for airplane passengers to enjoy the impressive sight of vast, glassy blue "lakes" of solar panels on the earth's surface. For birds, however, these glassy lakes can be deadly.

"Birds can perceive solar photovoltaic plants as water and may attempt to land on them for a dip or drink," said EPRI Senior Program Manager Naresh Kumar. "Some limited research suggests that they can be wounded or killed by the force of the impact. There is a need to conduct additional research to fully understand the risks."

The so-called "lake effect" associated with solar panels is one of many potential environmental impacts of large-scale renewable energy plants that EPRI is examining as part of a new set of research initiatives. As countries install more solar panels and wind turbines in diverse places and habitats, the need becomes more pressing to understand these impacts, and EPRI is attempting to get ahead of the related issues.

In 2017, EPRI launched two new research steering committees focused on environmental aspects of wind and solar. They provide platforms for electric utilities to identify research priorities; share best practices and research results; and engage with experts, regulators, renewable energy companies, non-governmental organizations, and the public.

Efforts focus on quantifying environmental benefits of renewables and clearly understanding possible environmental concerns so that they can be mitigated—enabling continued deployment of these technologies.

"When people talk about solar and other renewables, they typically don't think of environmental issues. They think of them as emissions-free technologies," said Kumar. "However, we know that every new technology can have some environmental impacts. We're trying to foresee potential issues sooner rather than later so that we can identify solutions."

What to Do with Millions of Solar Modules?

The International Energy Agency (IEA) projects that global solar photovoltaic (PV) capacity will grow from 300 gigawatts at the end of 2016 to 4,500 gigawatts in 2050. China is projected to lead the way at 1,731 gigawatts, and the United States and India are expected to have 600 gigawatts each. Consider these figures along with the fact that solar modules typically last 20 to 30 years, and it's clear that in coming decades large numbers of panels must be recycled or disposed of. According to the IEA, cumulative global panel waste in 2050 could reach 60 to 78 million metric tons, well above the estimate of 43,500–250,000 metric tons for 2016.

The European Union regulates PV module recycling and disposal, with manufacturers of PV panels required to finance the collection and recycling costs. While the United States lacks PV-specific regulations for disposal or recycling solar modules, federal regulations require plant owners to determine whether the modules must be disposed of as hazardous waste, which is more expensive than shipping them to a standard landfill.

While there is still time before large numbers of modules reach the end of their life, regulatory uncertainty in the United States is driving some utilities to seek answers now. "Even though waste volumes are not yet high, they exist and are accumulating, and some utilities are eager to figure out how to deal with end-of-life issues," said EPRI Principal Technical Leader Stephanie Shaw, who is working with EPRI Senior Technical Leader Cara Libby in EPRI's Generation sector to study solar module recycling and disposal possibilities. "Because it's not clear whether panels are considered hazardous waste, utilities are seeking guidance about what to do with them."

To help inform the industry, a 2017 EPRI-Arizona State University study examined aspects of module recycling in Europe, including volumes of solar panels, how they are collected, and how recycling facilities process them.

"We highlighted what has worked and what has been challenging," said Shaw. "It's an educational piece and a potential model for a recycling system in the U.S."

In a second project, EPRI and the National Renewable Energy Laboratory collected data from European recycling facilities to evaluate the energy intensity of module recycling and expected returns from reselling glass, plastic, and other module components recovered during recycling. EPRI expects to use these data to perform a life cycle assessment for PV panels.

A third project launched this year seeks to provide clarity on whether PV modules meet the federal definition of hazardous waste. According to U.S. Environmental Protection Agency (EPA) regulations, a hazardous waste determination is made for a device by crushing a part of it, soaking it in water and acid, and measuring the concentration of metals that leach into the water.

It's not clear which part of a module should be tested: the solar cells, the electronics, the junction box, or the semiconductor material. "In this project, we're going to crush samples from different modules and test them at two test labs," said Shaw. "We're looking for variability in the results and examining what drives that variability."

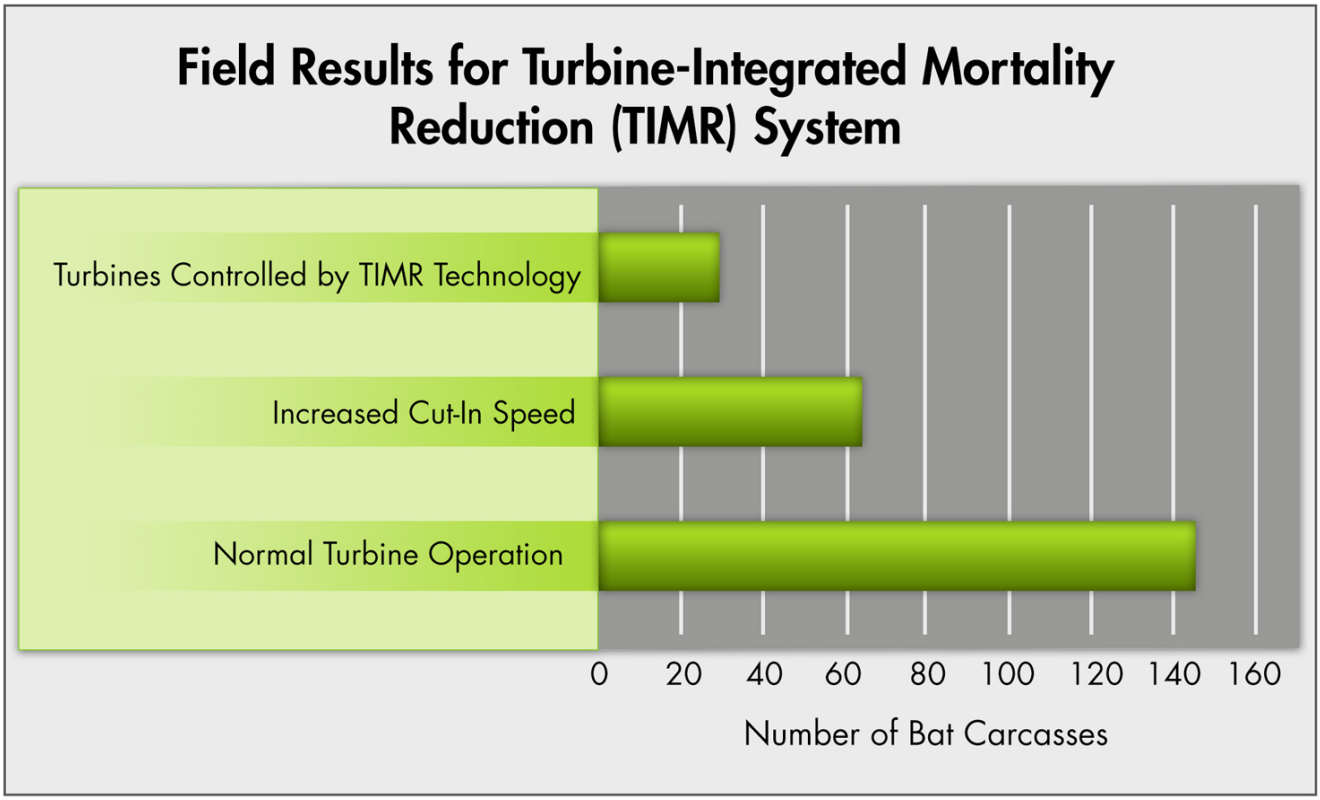
Making Wind Farms Bat-Friendly

A recent academic study* estimated that collisions at wind energy facilities in the United States and Canada killed 840,000–1.7 million bats between 2000 and 2011. Bats are important pollinators and help control insect populations, providing significant economic value to agriculture. In addition, a disease known as white-nose syndrome has caused certain bat populations to collapse, increasing the possibility that more bat species will require federal protection under the Endangered Species Act. These factors, along with a U.S. Department of Energy study that envisions wind energy supplying 35% of the nation's electricity by 2050, have prompted increased concern about bat mortality at wind farms.

EPRI and Normandeau Associates developed a technology that can shut down individual turbines briefly when a large number of bats are nearby. The Turbine-Integrated Mortality Reduction (TIMR) system determines the risk of bat mortality by combining weather data with real-time information on bat activity. It uses ultrasonic microphones mounted on a turbine's nacelle to detect bat calls. Bats are most active at low wind speeds.

"High bat activity is what leads to high mortality rates at turbines," said EPRI Principal Technical Leader John W. Goodrich-Mahoney. "By linking real-time bat calls with weather conditions, the software can determine if the risk of bat activity is high and shut down a turbine for 30 minutes. If the risk stays high, the turbine will continue to shut down in 10-minute increments. The turbine starts up automatically when the risk falls below a certain level."

To test the technology, EPRI organized a 2015 field study at We Energies' 145-megawatt Blue Sky Green Fields Wind Energy Center. To maximize generation while reducing bat mortality, researchers configured the software to communicate with the SCADA system that operates the turbines, automatically triggering turbine shutdowns when there was a high risk of significant bat activity. During the summer and fall bat migration seasons, 10 turbines operated normally, 10 used the TIMR system, and 10 operated at increased "cut-in" speeds. There is evidence that raising cut-in speeds reduces bat mortality because bats typically don't fly during high winds.



The team compared bat mortality among the three sets of turbines and found that the set equipped with the TIMR system saved the most bats by far. "Compared to the normally operating turbines, the system reduced bat mortality by 83%," said Goodrich-Mahoney. "For the endangered *Myotis* species, the reduction of mortality was 90%. It was the first time that particular species had experienced such a steep reduction."

Over the four-month study, all turbine curtailments occurred between July 15 and September 30 when bat activity was high. With the TIMR system, the turbines operated nearly 50% longer than if their operations had been curtailed at certain wind speeds—a common practice among some utilities to reduce bat mortality.

EPRI is collaborating with the American Wind Wildlife Institute to help make wind power operators aware of the technology. EPRI plans to test the technology at other wind facilities.

Health Impacts of Wind Turbine Noise?

Concerns regarding human health impacts of wind turbine noise have been significant enough that press coverage now uses the term "wind turbine syndrome." Originally coined in a non-peer-reviewed book describing anecdotal evidence of health effects related to noise exposure, the term refers to a collection of symptoms that includes headaches, nausea, dizziness, and sleep problems.

Despite the emergence of the "syndrome," there is no credible evidence that wind turbine noise can lead directly to health problems. "The scientific literature clearly shows that it can be associated with annoyance," said EPRI Principal Project Manager Annette Rohr. "Indirect health effects are possible. There's some evidence that turbine noise can disrupt sleep, which can lead to health problems."

Rohr says that specific research is needed to understand potential connections between turbine noise, annoyance, and health problems. "Past research shows that many factors influence whether an individual is annoyed," she said. "It's difficult to isolate the impacts of turbine noise."

For example, some studies indicate that financial benefit can reduce annoyance. "If residents have turbines on their property and are benefiting financially from them, they are less likely to be annoyed," said Rohr. "But they may be annoyed if they're not getting that benefit and at the same time feel a loss of control over their environment."

For the New York State Energy Research and Development Authority, EPRI examined potential links between turbine noise and health impacts at a 126-megawatt wind facility in Wethersfield, New York. Researchers monitored turbine noise inside and near the facility for nine months and surveyed nearby residents on their reactions to the noise. Noise measurements about three miles from the farm served as a control.

The results indicated that noise levels in and near the farm were at times higher than in rural areas without turbines. They varied considerably, depending on wind speed and seasonal conditions, but generally were within limits recommended by the World Health Organization and the EPA. Louder noise did not correlate with greater

annoyance reported by residents. A total of 12 survey participants (about 20% of all respondents) reported being concerned about the health effects of wind turbine noise and attributed symptoms such as headaches, fatigue, stress, and sleep disturbance to the noise. However, as with annoyance, researchers found no relationship between the sound intensity experienced by participants and the likelihood of concern about health effects. New York and other states may use the results as they consider siting new facilities and adjusting noise ordinances.

Rohr hopes to launch a study examining health effects of extremely low-frequency sound known as infrasound that has been hypothesized to drive symptoms. The work would use a controlled laboratory environment to expose people to wind turbine noise with and without infrasound, while monitoring blood pressure and heart rate variability.

Insights on potential health impacts of wind turbine noise can inform state and local noise ordinances that specify permissible wind facility locations. “The potential ramifications for both new and existing wind facilities could be significant,” said Rohr.

*Arnett, E. B. and E. F. Baerwald, “Impacts of Wind Energy Development on Bats: Implications for Conservation.” In *Bat Evolution, Ecology, and Conservation*, 2013.

This article has been amended to correct data cited from Arnett and Baerwald.

Key EPRI Technical Experts

Naresh Kumar, Stephanie Shaw, Cara Libby, John Goodrich-Mahoney, Annette Rohr