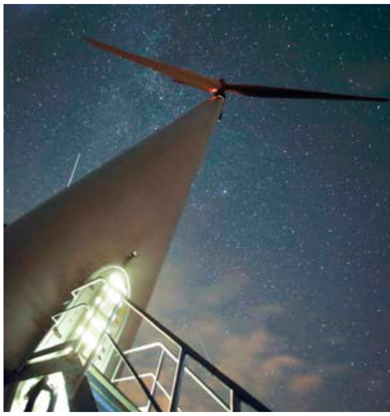
Bat Interactions with Land-Based Wind Energy: A European and North American Perspective

INTRODUCTION

Wind turbine-related fatalities of bats were first observed over 40 years ago, but it was not until the early 2000s when unexpectedly high numbers of fatality events were discovered at wind energy facilities in the eastern U.S. that the impacts of wind turbines on bats became a concern. Fatality rates vary dramatically and can range from zero to more than 100 bats/turbine/year at individual wind energy facilities. However, certain patterns are evident across the northern hemisphere. For example, fatalities are most frequent during late summer and autumn and are often concentrated during nights with warm temperatures and low wind speeds. Understanding these patterns helped in developing the first strategies to reduce fatality by altering turbine operations during the timing and conditions bats were most vulnerable.

Estimates of fatality indicate hundreds of thousands of bats are killed annually at wind turbines both in Europe and North America. Given bats are long-lived and typically only have 1 to 2 pups per year, existing fatality rates may not be sustainable for certain species. Recent studies indicate population-level declines are possible, particularly given the anticipated growth of wind energy development. However, demographic and population data are limited for most bat species, making it difficult to determine population sizes and trends. In the European Union, all bats are protected under the Habitats Directive and several species are on the IUCN Red List of threatened species. In contrast, only a few species are afforded legal protection in North America under either the United States' Endangered Species Act or Canada's Species at Risk Act.



FLYING AT HUB HEIGHT

As a group, bats are the most vulnerable animals at wind energy facilities. However, wind turbine-related fatality affects relatively few species. Those most at risk are adapted for relatively fast and straight flight in the open air and employ high-intensity echolocation for long-range detection of insects. At northern latitudes some species are also long-distance migrants and tend to roost in trees. The migrants may comprise 75–90% of the fatalities in some areas. Examples are species of *Nyctalus* in Europe and Lasiurus in North America.

Certain species are attracted to wind turbines and this increases the magnitude of the problem. However, why bats interact with wind turbines remains unclear. Several leading hypotheses explaining this phenomenon are related to bats perceiving wind turbines as a potential resource where roosts, mates or insects can be found. There is some evidence for each attraction hypothesis, but it may vary by species or habitat, or multiple attractants may work in combination. Collisions with moving rotors also may occur at random, simply because bats happen to be in the wrong place at the wrong time. This can be expected, particularly where bats congregate in large numbers, such as foraging areas, migratory corridors, or important roosts.

Bats are predominantly killed by collisions with spinning blades. Barotrauma (i.e., rapid changes in air pressure causing damage to internal organs or the auditory system) was once thought to be a major contributor to fatality. However, airflow models indicate the pressure differential necessary to cause this phenomenon is within millimeters of the blades suggesting barotrauma may only make up a small proportion of fatalities. Regardless of cause, fatality estimates are based on individuals recovered relatively near the base of wind turbines. An unknown number of carcasses may fall outside the search area or succumb to injuries beyond the wind energy facility.

RISK MONITORING AND MANAGEMENT

Our current understanding of how timing and weather conditions are associated with wind turbine-related impacts on various bat species is derived mostly from post-construction monitoring studies. Systematic carcass searches combined with statistical analyses that account for detection bias, e.g. searcher efficiency and predator removals of carcasses between searches, allow for the estimation of fatalities at a site. Continuous acoustic monitoring at the hub, using ultrasonic detectors, provides detailed information on bat activity in the zone of risk with high temporal resolution. Paired with weather data collected from the wind energy facility, these data can be used to develop risk models. Other methods and tools, such as mist-netting, radio-telemetry, radar, and thermal imaging, can provide further insight, but are not always necessary. Determining the appropriate study design and which methods to employ will depend on site characteristics, logistical constraints, and objectives of the study. Upon assessing the impact at a site, management decisions can be made regarding reducing the impact as much as practicable.

Siting wind energy facilities away from areas where bats are known to congregate is the first option to minimize risk. Yet, siting decisions can be challenging because there is no reliable way to assess the risk of a potential site prior to construction. The second option is to implement strategies to reduce bat fatalities once a site is operational. This is usually done by halting or slowing the rotors during the perceived period of risk. There are several ways to achieve this, including feathering the turbine blades (pitching them perpendicular to the wind) below the manufacturer's cut-in speed, which is typically set at 3.0–4.0 m/s, or feathering the blades up to a higher cut-in speed (e.g., 1.5–3.0 m/s above normal operations). The cost of implementing such measures, if based solely on wind speed, is high and therefore often considered unfeasible. However, if variables (e.g., time of year, wind direction, temperature, and real-time bat activity) also are incorporated in the model, the time when wind turbines need to be curtailed and the associated loss in power production will be reduced considerably. Such "smart curtailment" strategies have gained acceptance in Europe and are now used routinely in some countries and regions. Research evaluating the conservation and economic effectiveness of smart curtailment strategies are underway in North America, but have not been broadly implemented. As smart curtailment models become more complex, it will be necessary for advancements in wind turbine programming to accommodate multivariate models.

An alternative impact reduction strategy, ultrasonic acoustic deterrents, represents a mutually beneficial solution by allowing wind turbines to operate normally. This technology generates sound at the frequency and intensity used by bats and discourages them from approaching wind turbines. The efficacy of acoustic deterrents and other technologies are still being investigated.

RESEARCH PRIORITIES

1. Test and implement impact reduction strategies that address both the conservation and energy production concerns, and assess their efficiency under different climatic regimes.
2. Examine how and why bats interact with wind turbines and incorporate data to improve impact reduction strategies.
3. Develop techniques to quantify bat populations and assess the sustainability of wind energy development on bat populations.
4. Standardize monitoring protocols and fatality estimation to enhance comparability among studies and facilitate cumulative impact analyses.

For further reading, visit https://tethys.pnnl.gov/knowledge-base

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