U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Ultrasonic Bat Deterrent Technology

Project DE-EE007035

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General Electric Company

Project Overview

Technology Impact:

- **Avoid and minimize bat fatalities with GE's bat deterrent, utilizing a unique pneumatic-powered ultrasonic jet to produce high power wide-ranging ultrasonic frequency noise**
- **To prevent lost energy production due to wind turbine curtailment**

Project Goals:

- **Advance and test GE's bat deterrent system to mitigate bat fatalities at wind turbines. Provide insights into bat behavior and ultrasonic deterrent design that had not previously been explored. This project specifically studied bat behavioral responses in the presence of ultrasonic deterrent sound fields**
  - Target deterrent effectiveness of 50% or greater reduction in estimated bat mortality with broad species applicability.
  - Research to significantly advance our understanding of how bats respond to ultrasonic sound and how bats behave around wind turbines, which collectively may stimulate other technological advances to reduce bat-wind turbine mortality
  - Conduct behavioral studies in controlled (i.e., flight room) and in small-scale (e.g., foraging areas) environments enhanced the information gathered during field testing important to eventual commercial viability of the deterrent device

Technical Merit and Relevance

Technical Merit:

- Deterrents have been explored as possible conservation tool since before 2008
- Prior to this study effective deterrents were not commercially available. Currently, the GE deterrent is available for quote.
- GE has been testing an ultrasonic deterrent at the California Ridge Wind Farm in Illinois
- 2013 and 2014 research, effectiveness of GE's deterrent was approximately 30%
- Behavioral studies are needed to determine how bats behave in the vicinity of acoustic deterrent
- Based on results of behavioral studies, GE redesigned the acoustic signal and the placement of the deterrent on turbines
- Project goal is deterrent effectiveness greater than 50% (i.e., > 50% reduction in bat mortality)

Relevance to the Wind Energy Community:

- Wind developers currently using siting and operational restrictions
- Operational restrictions include feathering blades below cut-in and possible raised cut-in speeds, up to 6.9 m/s
- Use raised cut-in speeds as a conservation strategy results in lost renewable energy production

Project Overview

Partners

California Ridge Wind Energy – Wind Farm Operator - Consultant

Texas Christian University – Technical Research – Sub-awardee

Shoener Environmental – Field Team and Data Management - Consultant

Skalski Statistical Services – Statistics and Data Analysis – Consultant

Period of Performance

Year	2015		2016		2017			
Quarter/Task	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Budget Period 1								
Flight Room Testing								
Ground Testing								
Deterrent Integration Design								
Turbine Field Study								
Budget Period 2								
Deterrent Integration Design								
Turbine Field Study								

System Overview - GE Air Jet Bat Deterrent

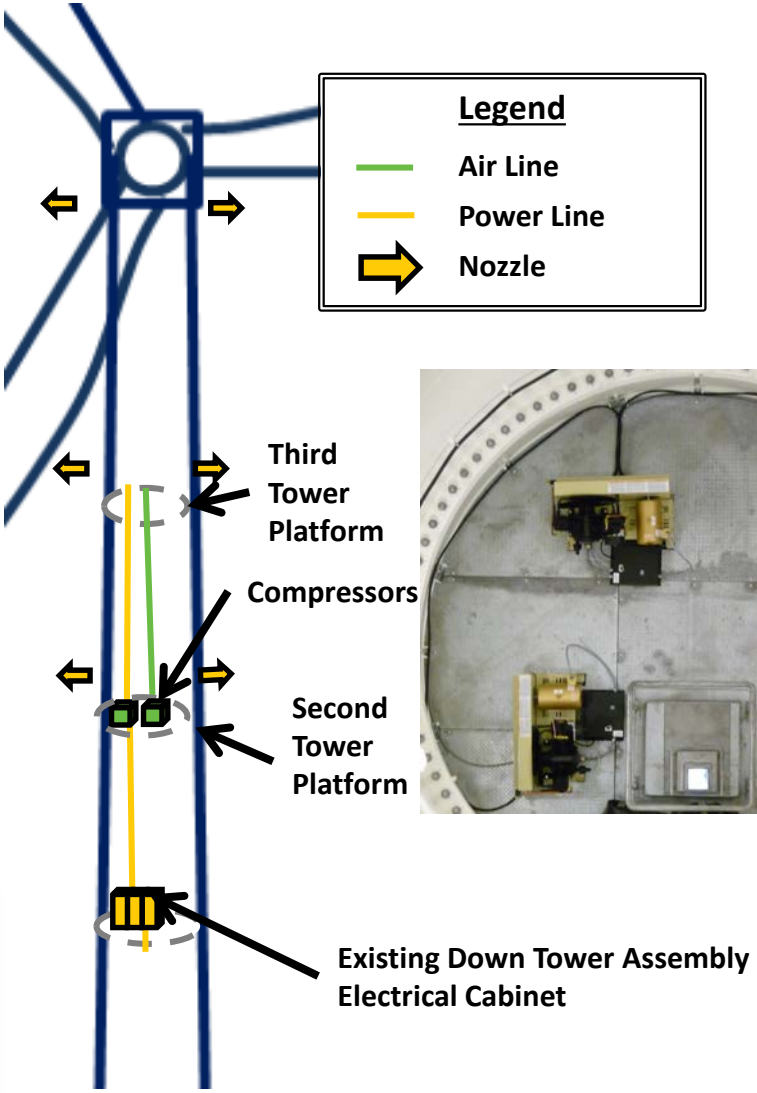
Bat deterrent ultrasonic air jet nozzles

- 4 nozzles mounted to tower for the continuous system
- Additional two nozzles mounted to nacelle for pulsed system in 2016

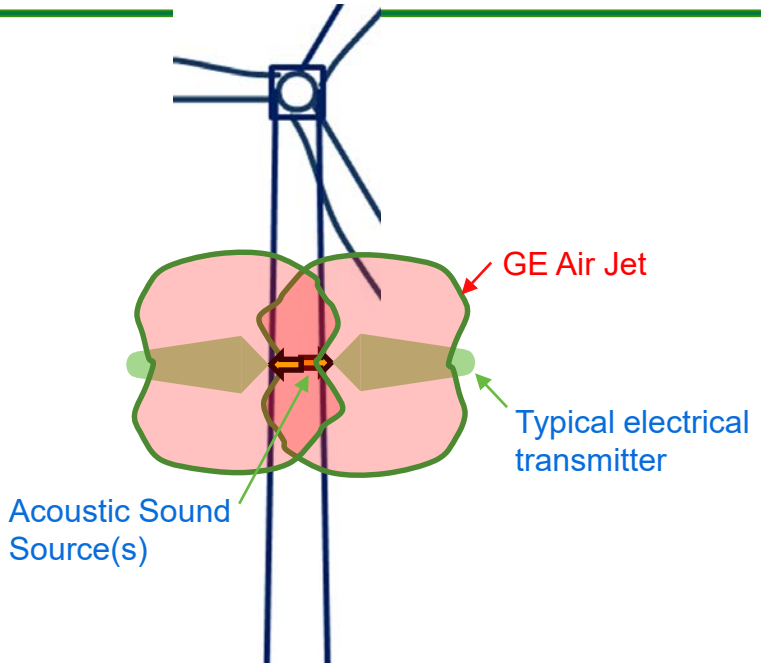
2 compressors located on platform

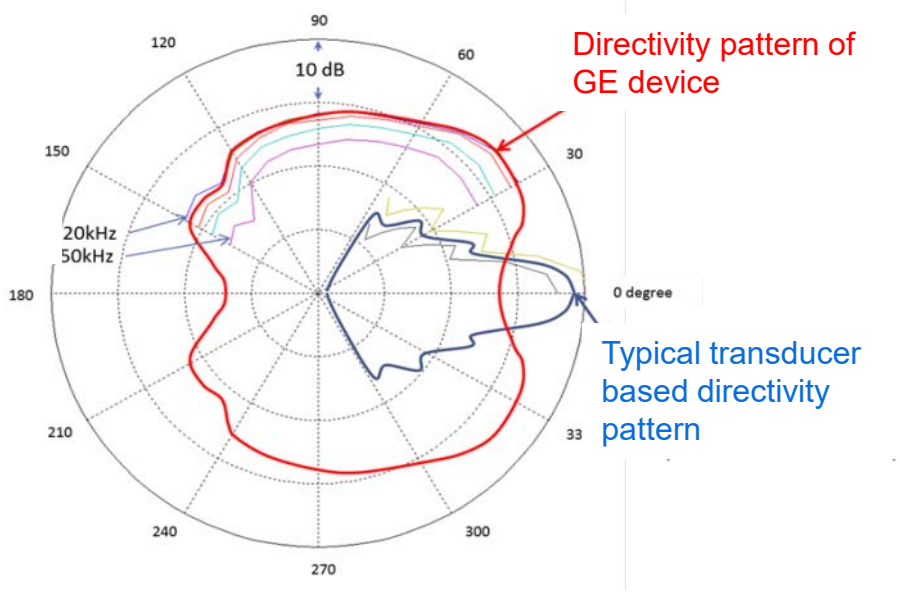
- Uses 400V AC power
- 2 compressors supply
- Controller located on tower platform
- Monitored remotely via SCADA

Compressed air and electrical lines bundled with existing cables along tower



Characteristics of GE Bat Deterrent



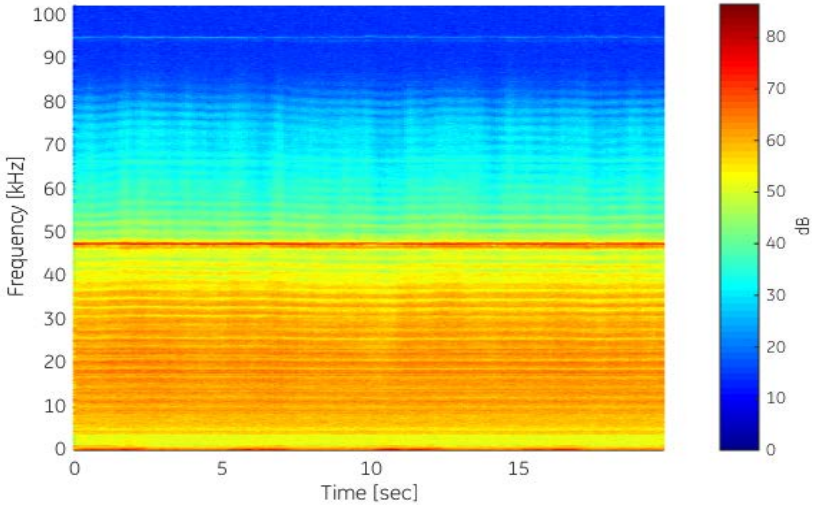


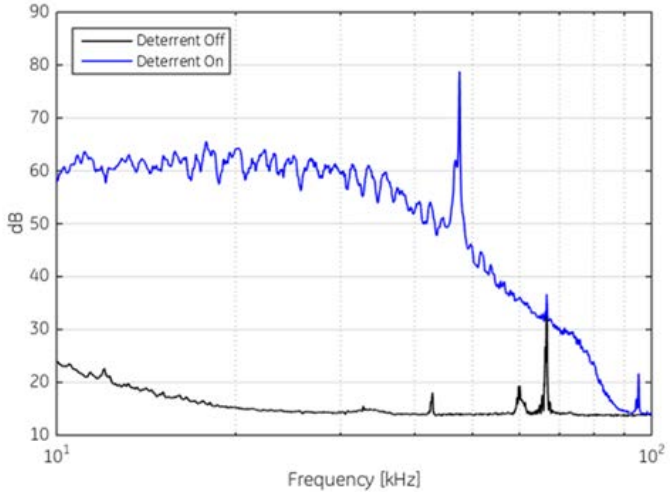
High speed air jet device provides wide frequency range, broad coverage, and reliability

- 10x more airspace volume covered for each deterrent device compared to transducer based system
- No electronics exposed to weather
- Simple hardware mechanisms with easy operations and maintenance
- Proper deterrent operation easily verified with standard instrumentation
- Broadband ultrasonic emission with a wide directivity field
- Compact; easily mountable on turbine system
- Robust and easy maintenance
- Capable of installation on non-GE turbines

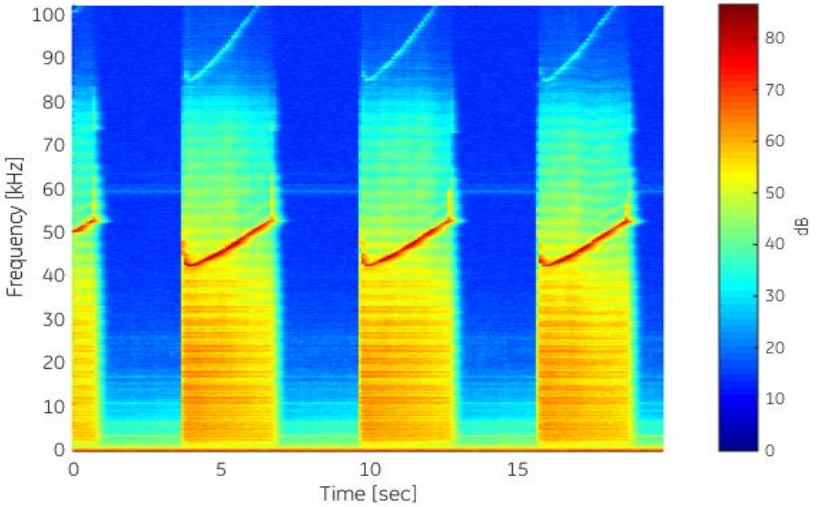
Acoustic Signal Characteristics

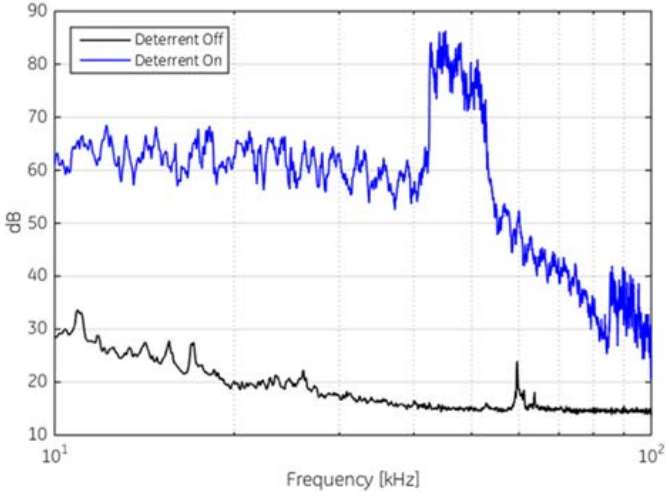
Steady Signal





Pulsed Signal





Approach and Methodology

1) Develop causal bat behavioral characteristics to understand:
   - How bats respond to various ultrasonic stimuli
   - Deterrent effectiveness on different species and in different bat environments (i.e. foraging, near turbines)
   - How bats interact with operating wind turbines with and without the deterrent operating using video imaging and 3D flight mapping

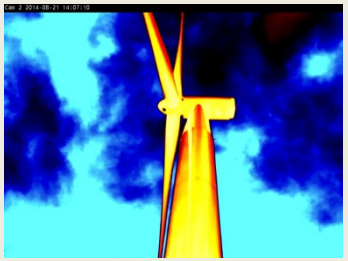
2) Redesign the GE deterrent system based on new behavioral and technology learnings and test the efficacy in a operating wind farm

Designed by Industry Leading Turbine Manufacturer
Tested at Major US Wind Farm
Evaluated by World Class Biologists and Statisticians

Flight Room Behavioral Testing to Document Response to Ultrasonic Signals

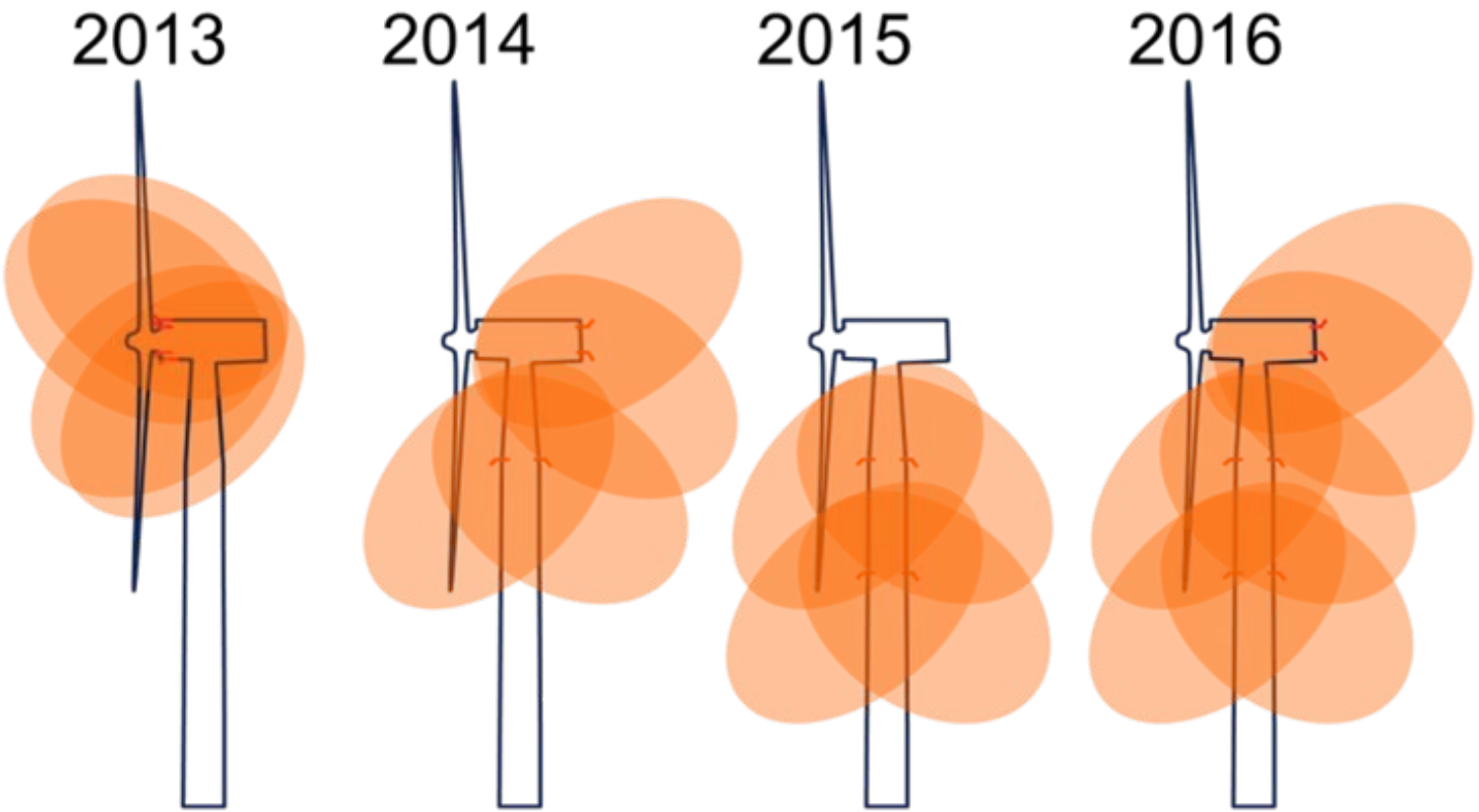
Ground Based Testing for Demonstration of Redesigned Deterrent

3D Flight Mapping of Bat Motion Around Turbine

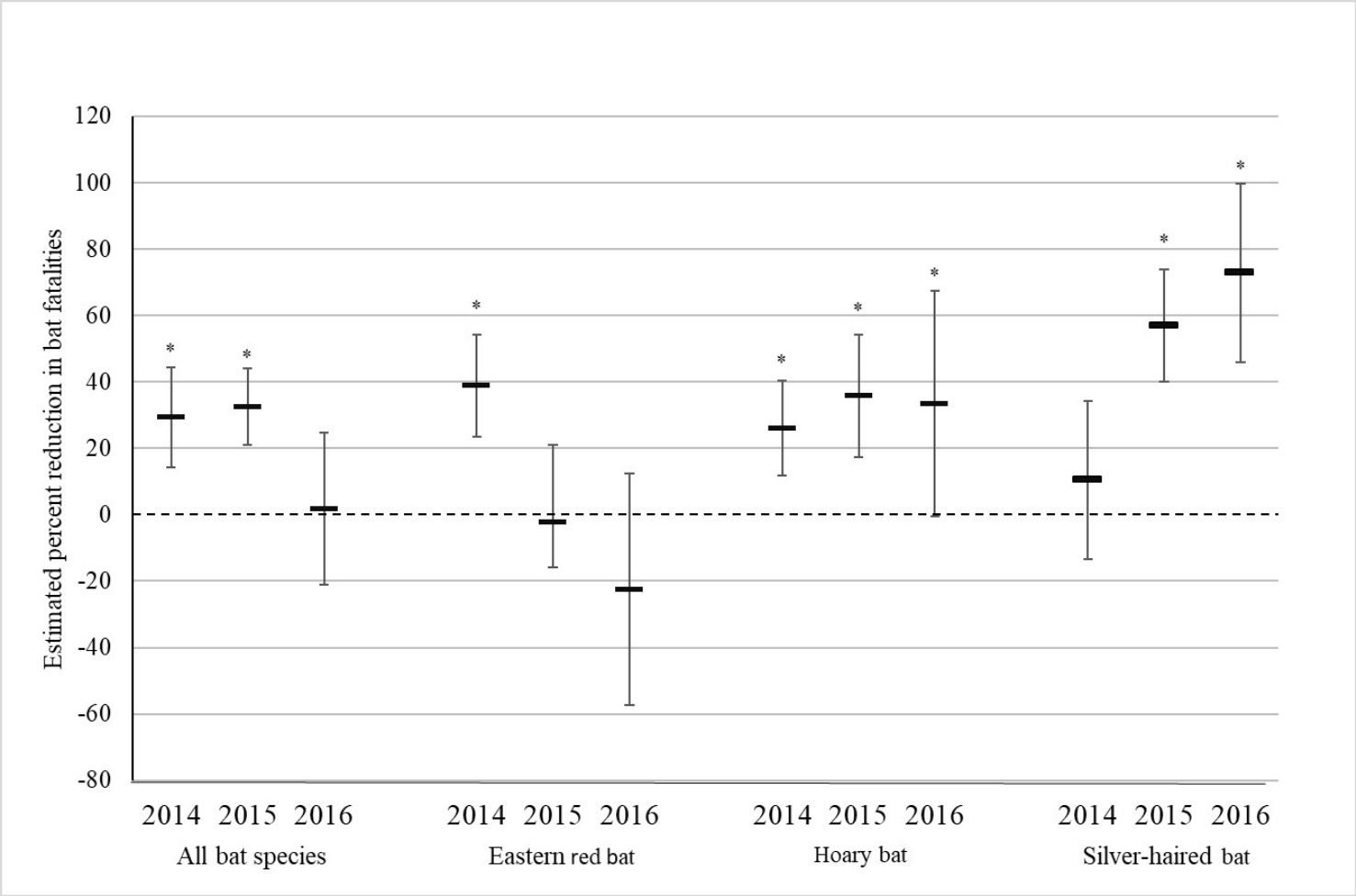


Field Testing of Redesigned Deterrent Installed in Operating Wind Farm

Nozzle Deployment Configurations, California Ridge Wind Farm Tests



Reduction of Bat Fatalities
California Ridge Wind Farm, Illinois

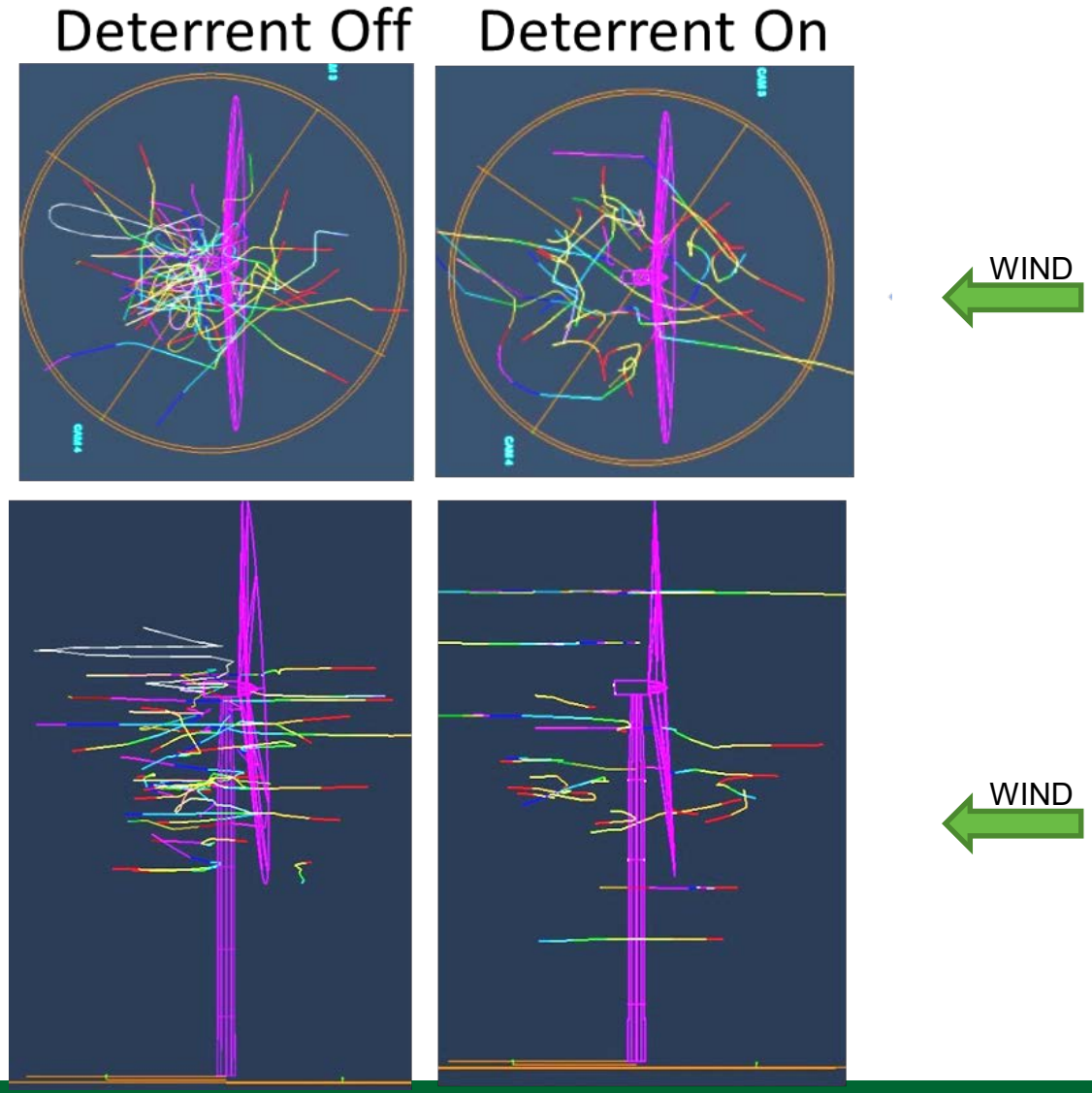


* = estimated reduction in bat fatalities significantly greater than zero effectiveness ($p < 0.05$, one-tailed); Based on T-distribution

Error bars represent 90% confidence intervals

All research turbines were feathered below manufacturers' cut-in

2016 Flight Path Mapping
California Ridge Wind Farm, Illinois



Communication, Coordination, and Commercialization

Communication and Coordination

- Manuscript for publication in peer-reviewed scientific journal – in revision
- Numerous presentations at professional meetings, including, but not limited to bat deterrent technology workshop at National Renewable Energy Laboratory, Wind Wildlife Research Meeting XII, and 2019 AWEA Wind Project Siting and Environmental Compliance Conference
- TCU portion used as partial fulfilment of requirements for graduate degree
- Based on feedback from extensive outreach with the U.S. Fish and Wildlife Service, Illinois Department of Natural Resources, and wind energy developers/owners/operators, lead to GE applying and being selected for award negotiations for a DOE grant to evaluate the relative effectiveness of ultrasonic deterrence versus wind turbine curtailment for different bat species
- Final Technical Report: https://www.osti.gov/biblio/1484770-ultrasonic-bat-deterrent-technology

Commercialization

- The GE Bat Deterrent System is available for full-scale deployment
- System is capable of installation on GE and non-GE wind turbines
- GE's bat deterrent system is commercially available for quote