U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Texturizing Wind Turbine Towers to Reduce Bat Mortality

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FY17-FY18 Wind Office Project Organization

"Enabling Wind Energy Options Nationwide"

Technology Development	Market Acceleration & Deployment
Atmosphere to Electrons	Stakeholder Engagement, Workforce Development, and Human Use Considerations
Offshore Wind	Environmental Research
Distributed Wind	Grid Integration
Testing Infrastructure	Regulatory and Siting
Standards Support and International Engagement	
Advanced Components, Reliability, and Manufacturing	

Analysis and Modeling (cross-cutting)

Project Overview

M17: Texturizing Wind Turbine Towers to Reduce Bat Mortality

Technology Summary: Development of a wind turbine tower coating as a bat impact mitigation strategy that does not result in a loss of power generation.

Period of Performance: July 1, 2015 to October 31, 2018

Technology Impact: There is still a great need for the development of mitigation strategies that are economically viable and can be used alone or in combination with other options (e.g., operational minimization, acoustic deterrents) to ensure that bat fatalities are effectively reduced at wind facilities across the United States. The development of a texture coating that reduces how bats perceive and thus interact with wind turbine tower surfaces, represents one such potential mitigation strategy.

Project Goals: The goal of our project was to develop a wind turbine tower coating that 1) bats show little or no interest in approaching; 2) can be applied to currently deployed wind turbine towers and to towers as they are constructed; 3) is economically feasible to produce and apply, and 4) ultimately contributes to a reduction in bat mortality at utility-scale wind facilities.

Partners:

- Texas Christian University: study design, flight room testing, and bat behavior field studies
- NextEra Energy Resources: wind farm operation, texture coating development, and tower application

Technical Merit and Relevance

Project Rationale:

- The development of a texture coating is based on the water misperception hypothesis and the acoustic mirror effect, both of which relate to how echolocating bats identify resources in the wild. Previous research has shown that bats will repeatedly try to drink from smooth surfaces because they misperceive them to be water. Similarly, previous research has shown that detection of prey by bats can be facilitated by smooth backgrounds, such as water surfaces and leaves.
- Wind turbine tower monopoles are large, smooth surfaces and numerous studies have reported bats making close investigative approaches at turbine tower surfaces that are suggestive of drinking and foraging behavior.
- We therefore hypothesized that water misperception and foraging activity could be contributing to bat-wind turbine fatalities by increasing the amount of time that bats spend in or around the rotor-swept zone.

Technical Merit and Relevance

Texture coating

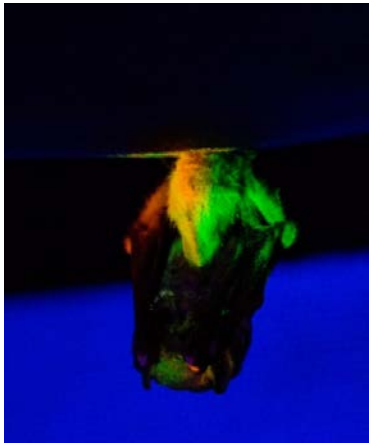
- We predict that a texture coating will contribute to a reduction in bat mortality by decreasing the amount of time bats spend investigating the tower surface within and near the rotor swept zone.
- Texture coating will have no impact on power generation.
    - Durable, one-time application to the non-moving parts of monopole turbine towers.
- Target market includes existing wind farms, turbine manufacturers, and wind farm developers.
- If successfully developed, commercialization efforts will focus on 1) geographic areas with high risk for bat mortality, and 2) areas with threatened and endangered bat species.

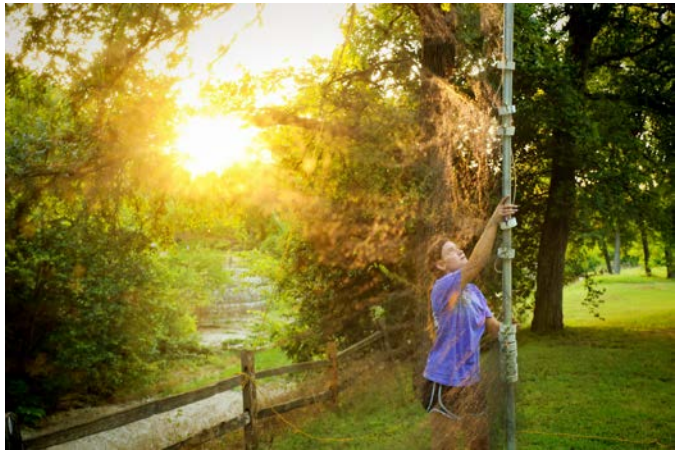
Approach and Methodology

- Our hypothesis is that echolocating bats perceive wind turbine tower surfaces to be one or more resources, such as water, and that this may contribute to bat-wind turbine fatalities.
- Bat mortality at wind turbines is a significant challenge for wind farm operations and development.
- There is a pressing need for technological solutions that do not reduce power generation.

BP1: Tasks 1 and 2

- Texture coating development
- Behavioral experiments with wild-caught bats in a flight facility – part I





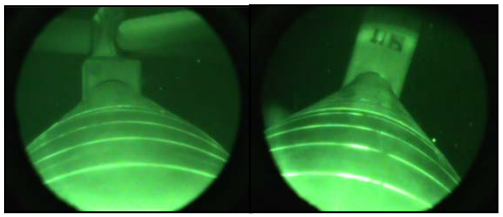
Approach and Methodology

BP2: Tasks 3 and 4 (2016)

- Behavioral experiments with wild-caught bats in a flight facility – part II
- Feasibility study at smooth turbine towers

BP2: Tasks 5, 6, and 7 (2017)

- Coating application to turbine towers
- Bat activity surveys at smooth and texture-treated turbines
- Final analysis and report writing



Accomplishments and Progress

Tasks 1, 2, and 3:

- Successfully completed 2 rounds of experiments with wild-caught bats
  - Bat activity differed between the smooth and texture-treated surfaces
  - Bats made contact with smooth vertical surfaces in the flight facility
- Developed a commercially-ready texture coating and application plan for turbine towers

Task 4:

- Observed free-flying bats interacting and contacting smooth tower surfaces in feasibility study

Project milestones and deliverables (Tasks 1-4):

- Completed on time
- Scope of Work for BP2 was modified during the Go/No-Go decision phase
  - Added a second round of flight facility testing (Task 3)
  - Added the feasibility study (Task 4)
  - Modified the field study to observe bat activity and behavior at an operational wind facility (Task 6)
  - Extended the project length by one year

Accomplishments and Progress

Task 5:

- **Applied texture coating to operational wind turbine towers**
  - Application target date was moved from April to June 2017 due to weather delays and challenges sourcing equipment to apply the coating
  - Given budgetary constraints, we successfully applied the coating to fewer turbine towers than planned (2 instead of 3-5)

Task 6:

- **Completed acoustic and video surveys of free-flying bats at smooth and texture-treated turbine towers**

Task 7:

- **Completed data analysis and submitted final report**

Project milestones and deliverables:

- **Completed on time, with the exception of the delay in Task 5**

Accomplishments and Progress

Award Date: July 1, 2015 **Notification of Award: July 21, 2015 with pre-award costs approved by the DOE** **Go Decision: August 10, 2016**		**Budget Period 1**			**Budget Period 2**						
		Q1 Jul-Sept 2015	**Q2** Oct-Dec 2015	**Q3** Jan-Mar 2016	**Q4** Apr-Jun 2016	**Q5** Jul-Sept 2016	**Q6** Oct-Dec 2016	**Q7** Jan-Mar 2017	**Q8** Apr-Jun 2017	**Q9** Jul-Sept 2017	**Q10** Oct-Dec 2017
Task 1	**Testing Behavioral Response of Bats to Textures in Flight Room**										
1.1	Make Textured Surfaces for Flight Facility										
1.2	Behavioral Study in Flight Facility										
Task 2	**Texture Coating Development, Field Study Design, and Application Plan**										
2.1	Texture Coating Development										
2.2	Field Study Design										
	G1 Go/No-Go Decision Point										
2.3	Texture Coating Application Plan										
Task 3	**Testing Behavioral Response of Bats to Textures in Flight Room – Part II**										
Task 4	**Feasibility Study at Control Turbines at Wolf Ridge**										
Task 5	**Application of Coating to Turbines at Wolf Ridge**										
Task 6	**Bat Activity Surveys at Control and Texture-treated Turbines at Wolf Ridge**										
Task 7	**Data Analysis and Final Reporting** Final Report: 7/24/2018; Accepted 10/31/2018										

Accomplishments and Progress

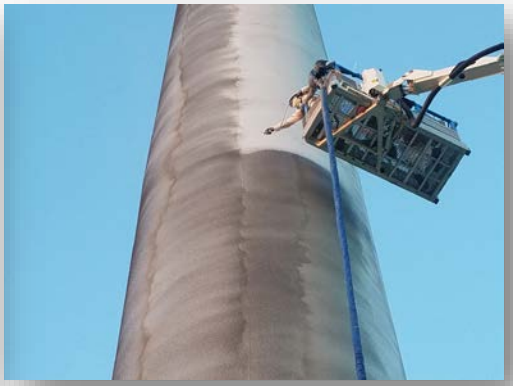
Significant major findings:

Task 3

- We found a significant reduction in bat activity <1 m from smooth vertical surfaces in the final flight facility experiment with the vertical test surfaces.
- The results of this experiment clearly indicated that a texture coating could be an effective mitigation strategy at reducing close-range bat activity at wind turbine tower surfaces, which in turn could lead to a reduction in the amount of time bats spend within the rotor-swept zone of wind turbines.

Task 7

- The results of the field test were inconclusive, perhaps due in part to one of the tower coatings (the first tower coated in Pair 1) not being applied to our specifications. The small number of towers that we were able to observe (during one season) presented another challenge when interpreting the results of the field test.



Accomplishments and Progress

Recommendations for next steps:

- We recommend that additional survey work should be conducted at these turbine towers before determining whether or not a texture coating could be an effective mitigation strategy.
- The lessons learned from the texture coating application process would lead us to take a different strategy if we were given another opportunity to test a texture coating on operational wind turbine towers in the future.
  - Retrofit - coating could be manufactured as a film, wrap, or laminate that could be quickly applied to the tower monopoles.
  - Manufacturing stage – uniform textured surface could be applied during painting stage.
- More research is needed on bat responses to textured surfaces prior to developing a commercialization plan.

Communication, Coordination, and Commercialization

TCU Master's Theses:

Brynn E. Huzzen, MS Environmental Science, expected May 2019, Bat behavior at smooth and texture-treated wind turbine towers.

Christina R. Bienz, MS Environmental Science, 2016, Surface texture discrimination by wild-caught bats: implications for reducing mortality at wind turbines.

Luyi Z. Jarzombek, MS Environmental Science, 2016, Aerial-hawking bats can glean prey items from surfaces similar to wind turbine towers: implications for reducing bat fatalities at wind facilities.

Brad R. Yuen, MS Environmental Science, 2015, Surface texture differentiation using synthetic bat echolocation calls: implications for reducing bat fatalities at wind turbines.

Conference Presentations:

2018

12th NWCC Wind Wildlife Research Meeting, St. Paul, MN.

98th Annual Meeting of the American Society of Mammalogists, Manhattan, KS.

2017

4th Conference on Wind Energy and Wildlife Impacts, Estoril, Portugal.

Annual Meeting of the Ecological Society of America, Portland, OR.

2016

96th Annual Meeting of the American Society of Mammalogists, Minneapolis, MN.

2015

45th Annual Meeting of the North American Society for Bat Research. Monterey, CA.