U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

National Wind Turbine Database and Location Impacts R&D

Project ID: M12

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FY17-FY18 Wind Office Project Organization

"Enabling Wind Energy Options Nationwide"

Technology Development

- Atmosphere to Electrons
- Offshore Wind
- Distributed Wind
- Testing Infrastructure
- Standards Support and International Engagement
- Advanced Components, Reliability, and Manufacturing

Market Acceleration & Deployment

- **Stakeholder Engagement, Workforce Development, and Human Use Considerations**
- Environmental Research
- Grid Integration
- **Regulatory and Siting**

Analysis and Modeling (cross-cutting)

Project Overview

M12: National Wind Turbine Database and Location Impacts R&D

Project Summary

U.S. wind development interacts with radar for air defense and weather, as well as human uses, which, if not handled properly, can add costs to, and delay or derail deployment. Accurate assessments require proper input data and unbiased analysis. This project produced a comprehensive quarterly-updated dataset of wind turbine locations and characteristics; a national dataset of wind neighbor survey responses; and predictive modelling results on turbine sound.

Project Objective & Impact

Provide broad-based, unbiased, and scientifically defensible information about, and data or analysis pertaining to, U.S. wind development locational impacts on radar, military operations, the surrounding landscape, and human populations. Turbine data are used widely by the U.S. Department of Defense, all branches of the military, industry, and the public. Neighbor survey and turbine sound modeling data and analysis are used widely by industry and community stakeholders. Both turbine data and public perception results are used to inform DOE R&D.

Project Attributes

Project Principal Investigator

Ben Hoen

DOE Lead

Patrick Gilman

Project Partners/Subs

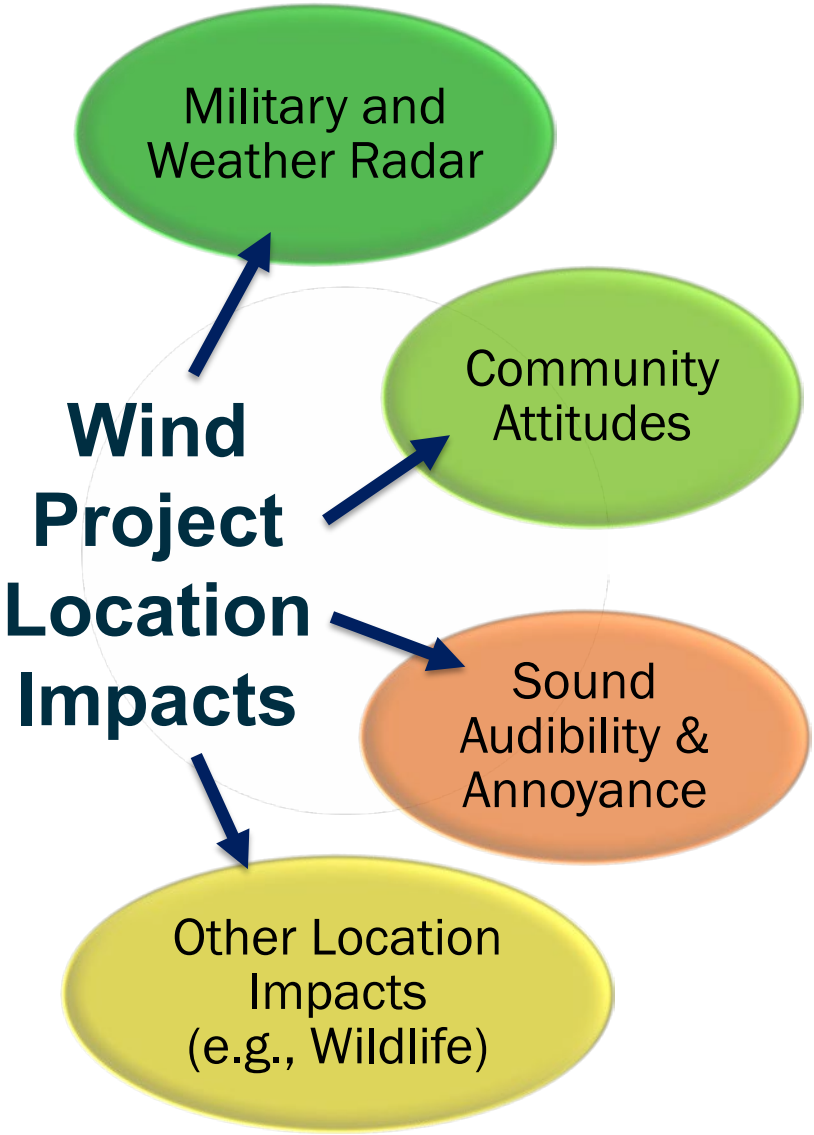
- LBNL: Joe Rand, Ryan Wiser
- U.S. Geological Survey (USGS)
- American Wind Energy Association (AWEA)
- Resource Systems Group
- University of Connecticut
- University of Delaware
- Medical School of Hamburg

Project Duration

2 years: FY17 and FY18

(though related work began earlier and continues in FY19 in a number of areas)

Technical Merit and Relevance



- Many potential location impacts exist around wind projects
- Having comprehensive unbiased data and analyses is critical to make appropriate siting decisions
- The project developed(s) first-of-their-kind nationwide data and analysis on many potential location impacts

Approach and Methodology

LBNL Research to Measure and Mitigate Impacts

Approach & Methodological Highlights Include:

U.S. Wind Turbine Database (USWTDB): Research partnership with USGS and AWEA; advice from the Department of Defense (DOD) and Air Force on radar interference assessment needs

Baseline Public Acceptance Research: Work with AWEA to find best outreach opportunities for first-of-its-kind national 1,705 respondent wind-neighbor survey; release survey data to other researchers

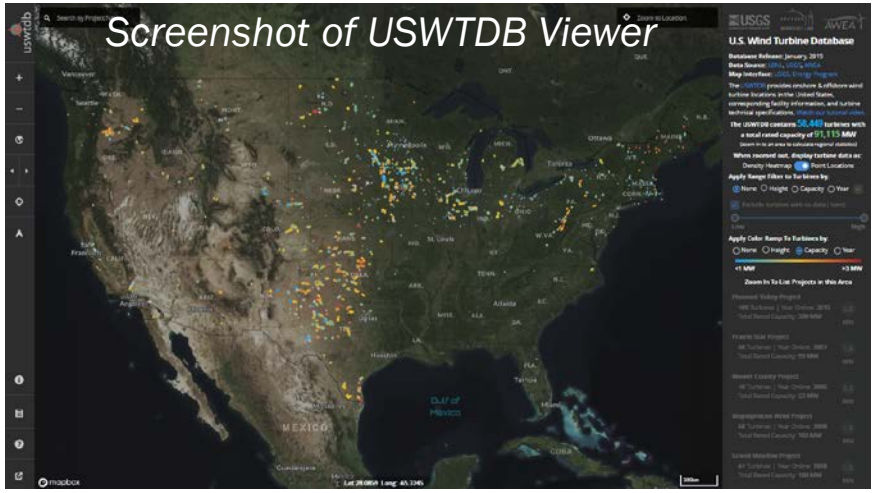
Sound Audibility and Annoyance Modeling: Leverage state-of-the-art sound models developed by leading sound-modeling firm; combine models with survey data

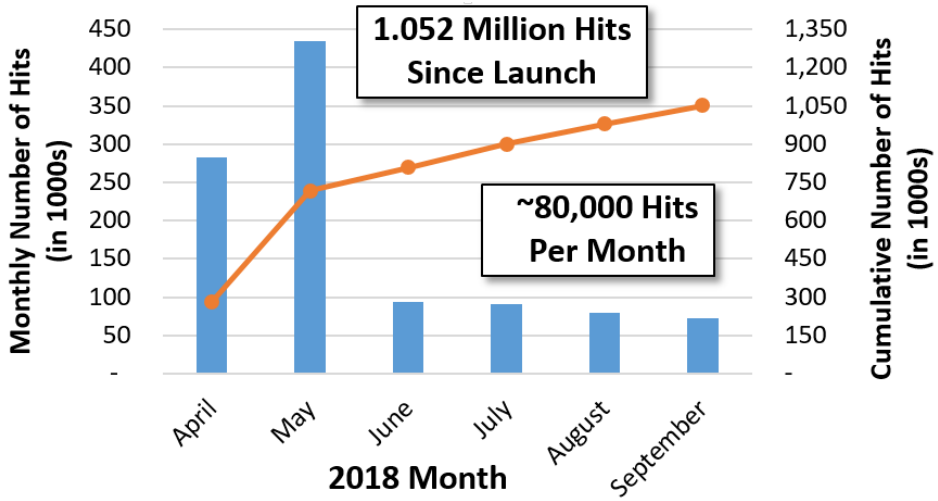
Key objective is to ensure that work is **useful and used**

Accomplishments and Progress: U.S. Wind Turbine Database

- **Goal**: Produce a quarterly-updated visually verified nationwide comprehensive dataset of wind turbine locations and characteristics
- Allows DOD, National Oceanic Atmospheric Administration (NOAA), Federal Aviation Administration (FAA) and .mil users to conduct operational assessments **and** allows public access to same data
- Over 1 million website hits in 1st six months

"The USWTDB directly supports North American Aerospace Defense Command (NORAD) by enabling us to conduct credible and meaningful analysis"
Major-General Christopher Coates, NORAD Director of Operations.

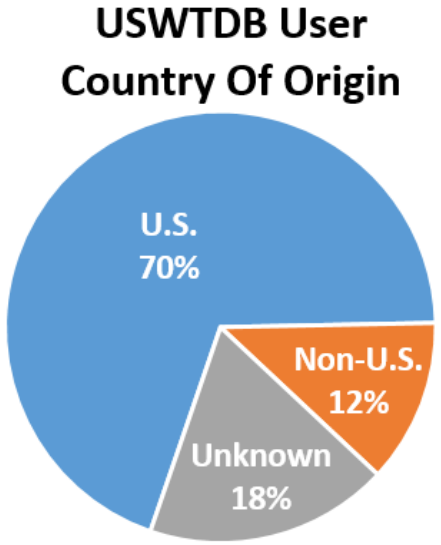




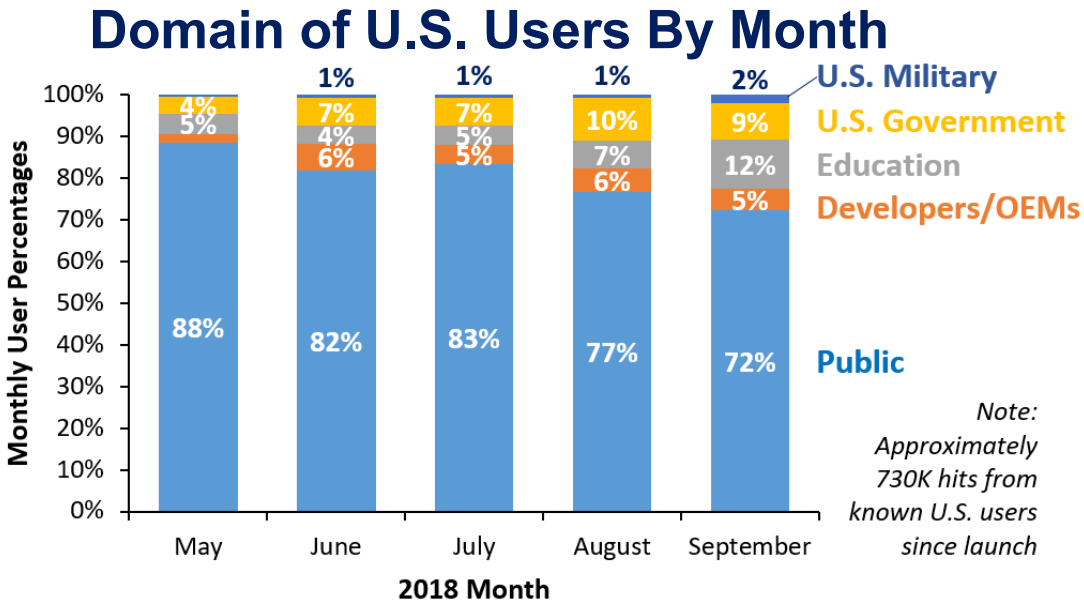
Accomplishments and Progress: U.S. Wind Turbine Database

Key USWTDB Fields

- **Geo-rectified x/y coordinates**
- Turbine OEM
- Turbine Model
- Hub Height
- Rotor Diameter
- Total Height
- Capacity
- Year of Installation
- Project Name
- Project Number of Turbines
- FAA IDs

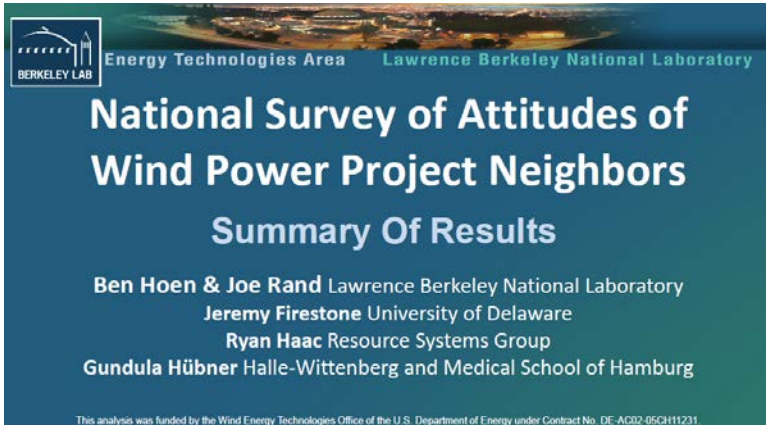


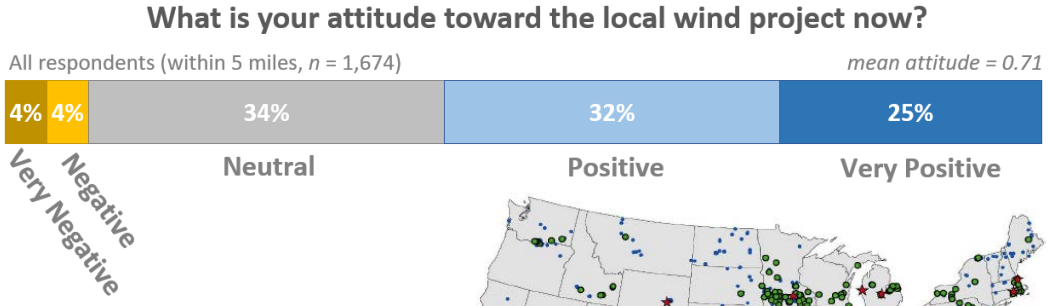
> 1 Million User Hits Since Launch



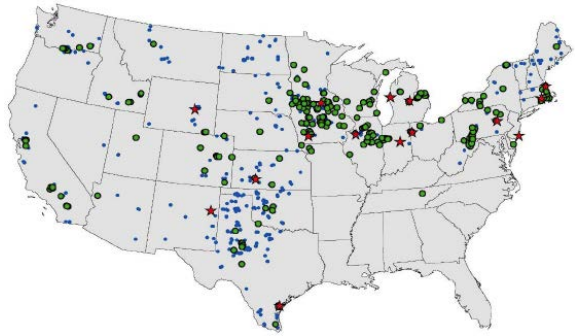
Accomplishments and Progress: Baseline Public Acceptance Research

- **Goal**: Finalize four-year FY15-FY18 Baseline Public Acceptance survey research by submitting **five** journal papers (see next slide), conducting outreach, and releasing data to other researchers
- Conduct webinar series with ~ 700 total attendees
- Conduct ½ day seminar and working session of results at AWEA's Siting Conference in 2018
- Conduct 19 other presentations
- Release de-identified version of data to other researchers





Survey of >1,700 Wind Turbine Neighbors



Accomplishments and Progress: Baseline Public Acceptance Research

Five Research (Journal Paper) Areas

1. *North American wind public acceptance literature review*
2. *Overall analysis of attitudes and their correlates*
3. *Examination of perceived fairness of wind siting and permitting procedures*
4. *Comparison of U.S. and EU wind neighbor annoyance results*
5. *Prediction of turbine sound audibility and annoyance*

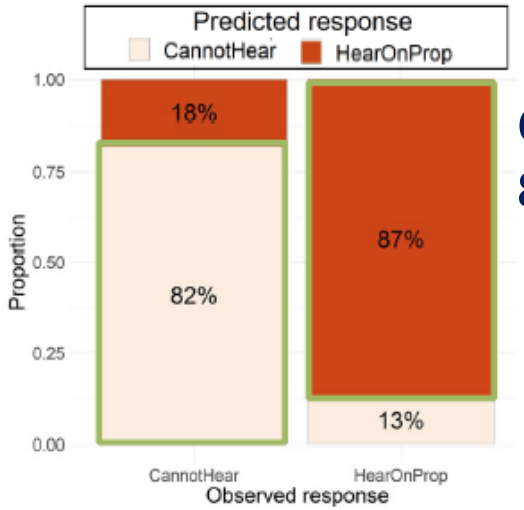
Some Key Findings

- *Wind neighbors are overwhelmingly positive*
- *Distance from turbines not correlated with attitudes; perceptions of planning process is*
- *Over time neighbors become more positive*
- *Demographics does not matter*
- *There is a silent majority of positive support*
- *Sound annoyance is not correlated with sound output but audibility is*

Accomplishments and Progress: Sound Audibility and Annoyance Modeling

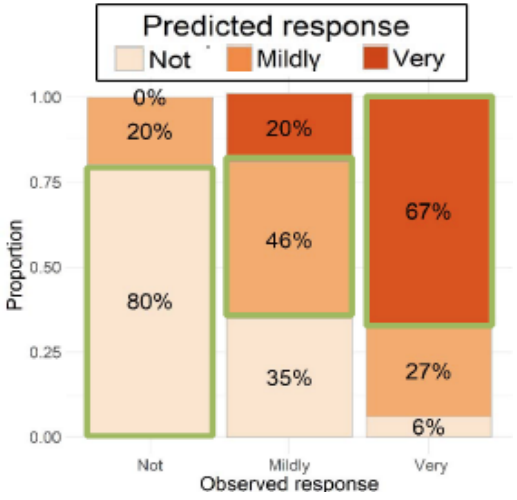
- **Goal**: Use survey data collected from Baseline Project to develop models to predict audibility and annoyance of wind turbine sounds by wind project neighbors
- Develop first-of-their-kind models using actual receiver data
- Account for turbine technology to inform DOE R&D
- Clarified audibility based on turbine sounds **but** annoyance is not, instead it's based on subjective variables and compensation

Audibility Model



Correctly Predicts 83% of Responses

Annoyance Model



Correctly Predicts 64% of Responses

Accomplishments and Progress:
Other Activities and Accomplishments

Wind Turbine Radar Interference Mitigation (WTRIM) Working Group

- Member of the steering committee of the DOE-led WTRIM group conducting innovative turbine radar interference mitigation research
- Provide WTRIM members and other federal agencies dataset of to-be-built turbines derived from FAA data sets

International Energy Agency (IEA) Task 28 – Public Acceptance of Wind Energy

- Collaborate with a set of IEA member countries on pushing state-of-art research on wind energy and public acceptance

European Union Funded Renewable Energy and Social Acceptance Projects

- Help develop successfully funded €4.2 MM project to train the next generation of thought leaders in social acceptance called MISTRAL: **M**ulti-sectoral approaches to **I**nnovative **S**kills **Tr**aining for Renewable Energy & Soci**al** Acceptance. Serve as Chair of expert advisory committee
- Serve as an advisor to Wind2050 a Danish effort to examine social acceptance issues for wind energy in that country

Wind Energy and Property Value Impacts

- Continue to serve as technical expert supporting past wind energy and property value impacts research

Technical Assistance

- Provide technical assistance to numerous parties, including the DOE, academic researchers, state and federal decision-makers, and a variety of wind and community stakeholders on USWTDB, social accptance and other work as requested

Milestones and Schedule: FY17–FY18

- **Formal milestones listed in narrative summary of project and therefore not repeated here**
- **Milestones reflect formal annual operating plans established annually**
- **All projects required extensive coordination with external partners including USGS, AWEA, WTRIM and multiple academic and private researchers**
- **All milestones met on time except one, which was delayed but completed within fiscal year**
  - One FY17 milestone (the submission of five journal papers) was delayed because of external partners' issues
- **All go/no-go decision points achieved go decisions :**
  - FY17: LBNL will prepare for DOE, in memo form, a summary of feedback from interested parties on the "draft" USWTDB, to determine the value of that product: Go
  - FY18: LBNL and WETO will decide whether to allow the release of the Public Acceptance Baseline Analysis dataset to academic researchers: Go

Communication, Coordination, Commercialization

5 Lab reports

5 Journal article submissions

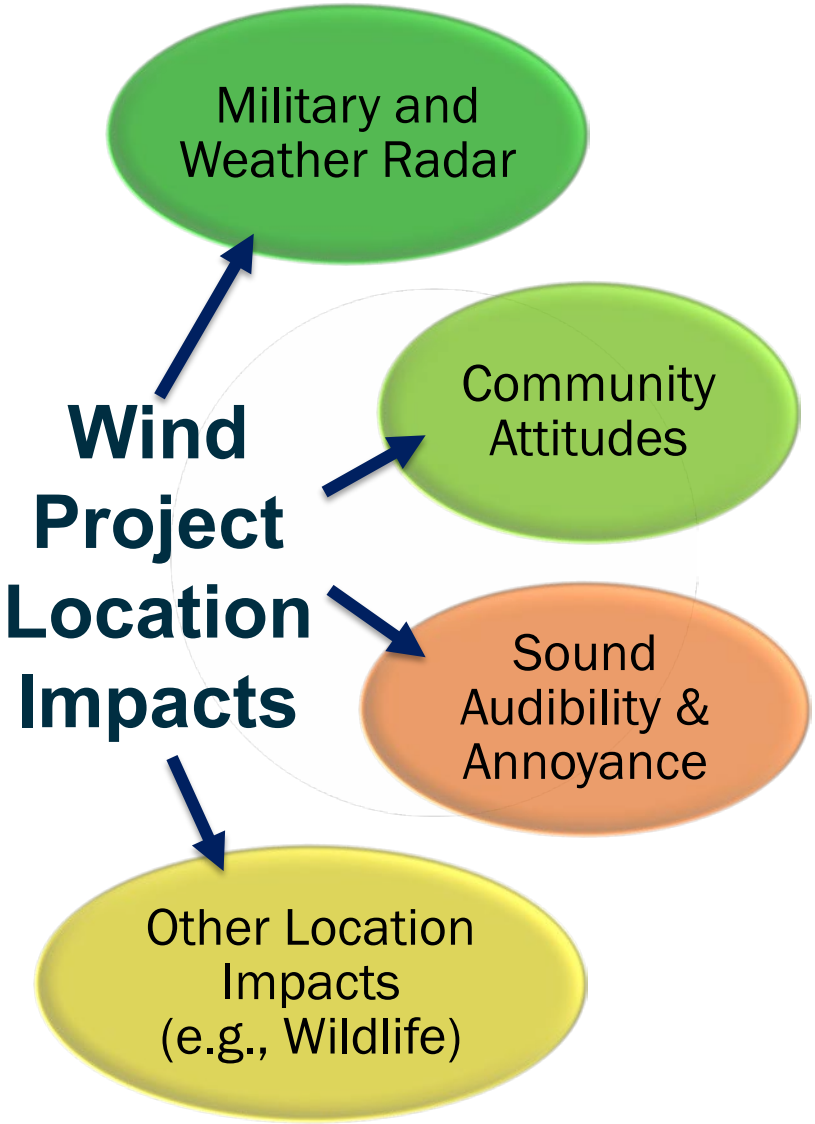
1 Conference paper

[see: https://emp.lbl.gov/publications]

Media Hits	Presentations	Webinars
38	32	7

Worked on communications with DOE, USGS, AWEA, DOD and other partners where appropriate. Repeatedly invited to present at industry conferences.

Upcoming Project Activities



FY19 Research Scope:

- Continue to update USWTDB and expand data access options in concert with WTRIM advisors
- Conduct first-of-its-kind analysis of wind project impacts on school district revenue and student outcomes
- Apply wind sound modeling insights to future turbines to predict deployment impacts
- Continue to support past work and push state-of-the-art via technical assistance and involvement with international projects
- FY19 milestones and budget on track