U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

2019 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
WIND ENERGY TECHNOLOGIES OFFICE

Summary Report
February, 2020

VOLUME II

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Foreword

This report is being disseminated by the U.S. Department of Energy (DOE). As such, this document was prepared in compliance with Section 515 of the Treasury and General Government Appropriations Act for fiscal year 2001 (public law 106-554) and information quality guidelines issued by DOE. Though this report does not constitute "influential" information, as that term is defined in DOE's information quality guidelines or the Office of Management and Budget's Information Quality Bulletin for Peer Review, the study was reviewed both internally and externally prior to publication. For purposes of external review, the study benefited from the advice and comments of the involved peer review chairs and U.S. Government employees.

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Volume II: Complete Evaluation Results & Appendices

This report details the results of the 2019 Peer Review for the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy's Wind Energy Technologies Office (WETO or "the Office"). The purpose of the review was to evaluate projects funded by the department during fiscal years 2017 and 2018 for their contribution to the mission and goals of the office, assess progress against stated objectives, and appraise WETO's overall management and performance.

Volume I includes Sections 1–6 of the report: the executive summary, synopses of the program- and project-level evaluation results, and WETO's response to the 2019 Peer Review findings. Volume II includes Sections 7 through 9—the complete office-level, program-level, activity-level and project-level evaluation results—as well as the report appendices.

Nomenclature

Acronym	Terminology
A2e	Atmosphere to Electrons
AEM	All Energy Management
AEP	annual energy production
AGMA	American Gear Manufacturers Association
AM	additive manufacturing
ANL	Argonne National Laboratory
ANSI	American National Standards Institute
ARESCA	American Renewable Energy Standards and Certification Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
AWEA	American Wind Energy Association
AWWI	American Wind Wildlife Institute
BAR	Big adaptive rotor
BOEM	Bureau of Ocean Energy Management
BTM	Behind the meter
BWEC	Bats and Wind Energy Collaborative
CFD	computational fluid dynamics
CWC	Collegiate Wind Competition
D3T	Defense and Disaster Deployable Wind Turbine
DG	Distributed generation
DLR	dynamic line rating
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DTU	Technical University of Denmark
DW	Distributed wind
EERE	DOE's Office of Energy Efficiency and Renewable Energy
ESA	Endangered Species Act
ESI	Energy Systems Integration
ESIG	Energy Systems Integration Group
FSI	fluid-structure interaction
FY	fiscal year
GMI	Grid Modernization Initiative
GW	gigawatt(s)
HFM	high-fidelity modeling
HPC	high-performance computing
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IECRE	International Electrotechnical Commission – Renewable Energy
IEEE	Institute of Electrical and Electronics Engineers
INL	DOE's Idaho National Laboratory
IWES	Institute for Wind Energy Systems
KPI	Key performance indicator
kWh	kilowatt-hour
LBC	land-based collaborative
LBNL	DOE's Lawrence Berkeley National Laboratory
LCCF	Low-cost carbon fiber
LCOE	levelized cost of energy
LEEDCo	Lake Erie Energy Development Corporation
LES	large-eddy simulation
LiDAR	Light Detection and Ranging
MA&D	Market Acceleration and Deployment
MMC	Mesoscale-Microscale Coupling

MOU	Memorandum of Understanding
MW	megawatt(s)
NAWEA	North American Wind Energy Academy
NDT	Non-destructive testing
NEC	National Electric Code
NERC	North American Electric Reliability Corporation
NFPA	National Fire Protection Association
NGO	Non-government organization
NPS	National Park Service
NRC	Nuclear Regulatory Commission
NREL	DOE's National Renewable Energy Laboratory
NWCC	National Wind Coordinating Collaborative
NWTC	NREL's National Wind Technology Center
OC3	Offshore Code Comparison Collaboration
OC5	Offshore Code Comparison Collaboration, Continued, with Correlation
O&M	operations and maintenance
OEM	original equipment manufacturer
ORNL	DOE's Oak Ridge National Laboratory
OSHA	Occupational Health and Safety Administration
PAW	Platform Against Wind Power
PBL	Project-based learning
PI	principal investigator
PNNL	DOE's Pacific Northwest National Laboratory
PTC	Production Tax Credit
RANS	Reynolds-averaged Navier-Stokes
R&D	research and development
RES-E	Electricity from renewable energy sources
ROI	return on investment
RRC	Regional Resource Center
SBV	Small Business Vouchers
SCADA	supervisory control and data acquisition
SECT	Self-erecting concrete tower
SIP	State Implementation Plans
SNL	DOE's Sandia National Laboratories
SOWFA	Simulator for Wind Farm Applications
SWiFT	Scaled Wind Farm Technology Facility
T2M	Technology to Market
TD	Technology Development & Scientific Research
TD&I	Technology Development & Innovation
TLP	Tension Leg Platform
TRL	Technology readiness level
TTU	Texas Tech University
UAV	Unmanned aerial vehicles
UQ	uncertainty quantification
URANS	Unsteady Reynolds-Averaged Navier-Stokes
USFWS	U.S. Fish and Wildlife Service
V&V	verification and validation
VRE	Variable renewable energy
WAC	Wind application center
WEC	Wind energy converter
WETO	Wind Energy Technologies Office
WFIP3	Word-Finding Intervention Program
WREN	Working Together to Resolve Environmental Effects of Wind Energy
WRF	Weather Research and Forecasting
WRISE	Women of Renewable Industries and Sustainable Energy

WTG	wind technology generators
WTRIM	Wind Turbine Radar Interference Mitigation

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7 Office Level Evaluation Results

Process Overview

Reviewers were asked to provide comments and numeric scores to evaluate the overall objectives and performance of WETO based both on specific office overview presentations and on general impressions from all peer review presentations. The results of the evaluation are provided in this section, along with the office's responses.

Office-Level Evaluation Criteria

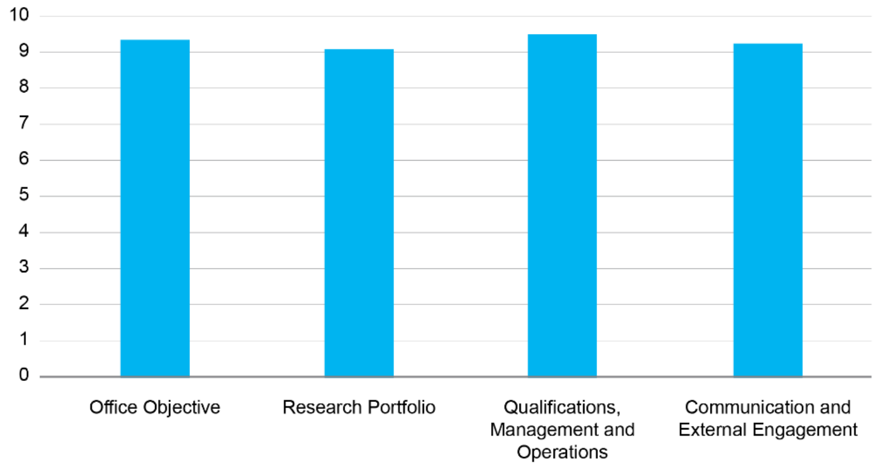
Office-level assessments were based on the four criteria listed below:

1. Office Objectives
   Overall, the office's portfolio of funded projects:
   - Reflect an understanding of the near- and long-term challenges facing industry and other wind energy stakeholders
   - Meet the needs of industry and other stakeholders in addressing those challenges in order to realize opportunities for economic growth, technical advancement, and/or dissemination of objective information
2. Research Portfolio
   Overall, the office's portfolio of funded projects:
   - Align with the stated office objectives
   - Effectively meet those objectives
   - Represent an effective use of congressionally appropriated funds
   - Meet the office's objectives by generating results of near- or long-term value to industry and other stakeholders
3. Qualifications, Management, Operations
   Overall, based on both the programmatic and project presentations, the office team:
   - Effectively manages and directs the activities needed to meet its objectives
   - Demonstrates the professional capabilities needed to identify, monitor and guide its portfolio of projects
   - Has operations and oversight procedures in place to ensure efficient direction of office activities, both internally and with project awardees
4. Communications and External Engagement
   Overall, the office:
   - Engages with industry, academia, other agencies, non-governmental organizations, and international research organizations to ensure high levels of cooperation and information exchange
   - Effectively disseminates information regarding its activities and results of its funded projects
   - Ensures that its project awardees engage in effective communication regarding project results

Numerical scores from the reviewers are based on a 10-point scale, with a 1 corresponding to an "Unsatisfactory" rating, and 10 corresponding to "Outstanding." Reviewers were also asked to provide comments on strengths and weaknesses related to each criterion, as well as recommendations that they felt that the office should consider. For reference, the office evaluation form used by reviewers is included in Appendix B of Volume II.

Reviewer Scores

This graph indicates the average reviewer scores for each of the office evaluation criteria.



Reviewer Comments

Office Objectives

Comments on Strengths

- I think the office objectives are very relevant.
- Overall, the efforts and focus of the WETO programs are outstanding and clearly working towards integrating wind affordably and reliably into the grid, while working to reduce impacts on the natural and human environment in order to eliminate barriers to deployment and lower the LCOE.
- The offices objectives are broad, primarily long-range, but includes some short-term objectives (primarily demonstrations). In general, they appear to meet the industry-requested needs, but may be based on industry's short-term focus.
- The objectives of the program are well balanced and have a significant, noticeable impact on the industry. The focus on cost reductions and mitigation of deployment barriers is appropriate and effective.
- The project portfolio reflects both the technology development issues and stakeholder issues of deployment, with a strong focus on cost reduction.
- The core activities of the office are vital to and advance the state of the industry. The national lab program is unparalleled in the world and the value created is exceptional for the taxpayer.
- The office has the right focus. Lowering LCOE is the right focus to ensure long term competitiveness and sustainability of the wind industry. Many of the projects led to new capabilities, especially in the area of high-fidelity modeling. Also, it is nice to see innovation in the floating foundation project.
- The office is built on strong objectives. The decision to reduce the cost target to 2.3 cents by 2030 was sound. This is an aggressive goal set over a mid-term time frame that will drive innovation while showcasing the maturity and cost-effective nature of this energy source. This aggressive approach has effectively invigorated industry and NGO partners and has attracted significant cost share, yielding incredible returns for taxpayers. The WETO is playing an important, centralized role in driving the future of the industry and focusing on longer-term issues that the industry doesn't have the energy to focus on, especially now as the PTC winds down.
- The three priority focus areas in the strategy are important and a valuable way to focus and tailor future activities.

- The WETO office does an incredible job of listening and attempting to meet the needs of all industry stakeholders. The competent leadership and technical expertise needed to exercise that leadership is evident in the staff and top managers in the WETO.

Comments on Weaknesses

- None that I can identify at this time other than to note that we need to arrive at cost-effective, practical wildlife solutions sooner than later. If there is an ability to ramp up funding (e.g., "moonshot" approach) to do more on the wildlife detection and deterrent system R&D—which would reduce the time needed for field verification, and, therefore, availability as trusted minimization measures—I would encourage WETO to prioritize that.
- The industry would be better served if the objectives of the office were longer-term. A2e is a good example of a longer-term objective.
- Perhaps the cost reduction target is not the only one to be focused on
- The office struggles with the non-core activities.
- DW lacks clarity, focus, and goals.
- Offshore is tracking but hasn't fully built a roadmap.
- The BAR and some other non-core programs appear to be interesting research as opposed to advancing the state of the art.
- I expect that some research will fail or result in little value. I think the key is articulating the question in advance and measuring the research against the question on a regular basis to help with focus.
- The program needs to have a clear focus on safety at all levels.
- I recommend stronger focus on using technology readiness level for funding projects. Not all projects successfully communicated how they are contributing to advancing the state of maturity of technology.
- Additional funding in the market and acceleration program would be welcome with adequate appropriations. This work is as important as the technology and development work of driving down costs and overcoming barriers to siting. These market and acceleration challenges are only expected to grow as the industry builds out, and focused attention is needed now to overcome these barriers.
- The office is understaffed.

Research Portfolio

Comments on Strengths

- The portfolio is finely aligned with the objectives.
- The current research portfolio aligns well with the office's objectives, effectively meets those objectives, represents an effective use of appropriated funds (particularly considering the private sector cost-sharing and technology investment spurred by the program efforts), and is generating results in reducing barriers to deployment and LCOE for wind energy.
- The office objectives are progressing, and results are significant considering the funding levels. Coordination between the labs to meet objectives is impressive.
- The program continues to have a big impact and continues to have a strong leadership role, bringing multiple agencies and interests together to work constructively on a broad range of relevant issues. For me, some of the highlights of the program are:
    - In the wildlife space, the WREN collaboration and Tethys are exemplary projects which are having a national and international impact. It is apparent that work conducted to mitigate wildlife issues is genuine and effective.
    - Highlights in the Grid Integration space include ESIG, collaboration with IEA Task 25, the NARIS study, and the National Wind Testing Center. It

appears there is excellent collaboration between the national labs, academia, and industry. The Wind view project is a highly focused effort successfully filling a very specific and important gap. The utility achieved for the investment is hugely positive.
    - Regarding the radar work, it appears the program has achieved a level of cooperation among a very diverse range of governmental agencies to great effect, as evidenced by a thank you note from a four-star general. Getting cooperation between multiple governmental agencies is famously difficult!
    - Finally, the commitment to an open approach to modeling and tool development is highly commendable. This is an increasing trend and the benefits for everyone are becoming obvious. Specifically, opening models and tools to the community enormously increases impact, increases confidence in and credibility of the results and in the long run will accelerate the advancement of the state of the art.
- Project portfolio is set up effectively to meet cost reduction objectives. Overall, DOE shows leadership in many areas and creates impact from the research work. The funds are distributed to different fields of research and development in a sensible way, covering all relevant areas, and are used effectively.
- The program's core is as strong as ever and has made the industry better. There are areas of research that only a national lab can conduct, and which have fundamentally improved the industry. The programs contained in this office are vital to the future of the domestic wind industry.
- Very diverse portfolio with the right focus. DOE is doing a great job leading cutting edge research programs. The projects made excellent progress toward reducing LCOE which is in line with the office's objective.
- The office's research portfolio is strong and covers key industry priorities to drive down costs and increase integration and penetration on the grid. It is impressive to see the broad reach of this research portfolio and the prioritization that DOE has undertaken to address the most pressing needs for industry.
- The portfolio of projects is broad and deep. The challenge is to continue to coordinate them all to maximize the benefits. This is done well by regular workshops and communicating with industry thought leaders.

Comments on Weaknesses

- If WETO is serious about offshore wind, the grid aspect needs to be considered and studied in depth. It is understood that because grid infrastructure is not a generation-specific issue, it doesn't fall within the remit of WETO. However, at the same time, dedicated grid infrastructure will be necessary to access the offshore resource, and experience in Europe has shown that this isn't trivial.
- On the wildlife front, some work may be required to further understand the behavior of bats, similar to that done for eagles.
- Much of the work on grid integration and modeling has been done at a high, continental U.S. or interconnection level. The NWTC is a notable exception. I wonder if there is a need for more focus on the system impacts with very high instantaneous shares of variable renewables, and how the system will behave in these situations. Studying the flexibility and adequacy of the system with an explicit representation of uncertainty is important here.
- There was little effort made in researching noise and none in icing.
- The small business vouchers do not represent a good use of taxpayer funds.
- Additional focus and vision are needed in the DW segment.
- DOE can play a bigger role to controlled sites.

- Academic collaboration should be increased. Sponsor more graduate students.
- There needs to be more focus on offshore wind as this industry is about to explode in development along the Atlantic coast. For this industry to reach its full potential, we need to anticipate and get in front of key issues now to facilitate its strong future.

Qualifications, Management, and Operations

Comments on Strengths

- Program management is very committed and competent.
- The leadership, staff, and contractors of the WETO program represent some of the best and brightest minds in the field and are top notch in my opinion. I believe that the program is being effectively run and managed and through stakeholder engagement and the peer review process ensuring that oversight of the program is being effectively maintained.
- The office's oversite [sic] and organization of the various programs and labs is clear with priority alignment communicated at all levels. These qualities are seen in well-run private organizations, and I appreciate them being so clear in WETO. It’s not surprising to see considering the professionality of the leadership team.
- Most projects were delivered on time and within budget with most delays being managed well.
- This is a team capable of leadership, careful reflection of topics from an active stakeholder engagement, and international work through IEA Wind. There is good expertise in the activity areas.
- The teams are highly qualified, engaged, and well-managed. The team overall is exceptional.
- A great and very talented team is in place.
- The office has a strong strategy of aligning various activities across the offices and within the various programs. By articulating this strategy, the office is ensuring that management and operations are advancing goals across the office. That’s driving down the cost of wind energy, and is an adequate, defensible use of taxpayers' money. In addition, it is clear that the office is staffed by incredibly competent professionals who understand key needs and priorities for the industry. In particular, the office has incredible internal capacity for modeling and analytics. This modeling has been critical to driving priorities and tailoring future activities.
- The managers in the WETO office are excellent. They have an optimal mix of patience, technical experience, vision, and leadership qualities.
- Excellent team and leadership in place. The team is very focused and well aware of priorities.

Comments on Weaknesses

- Some projects failed to deliver at the critical stage. This isn't necessarily a weakness but evidence of an appropriate amount of risk taking on the part of the program, which is important. However, perhaps there are lessons to be learned for future projects, such as the importance of functional testing of devices before field testing.
- The focus on safety and safety qualifications needs to be improved. I would encourage the team to figure out how to incorporate industry workforce participants into later stage research. Practical hands-on field experience from industry workforce participants would provide value in the practical applicability of the later stage programs.
- Need more staff to handle the breadth of projects.

Communications and External Engagement

Comments on Strengths

- Good communication of the program and its projects and activities.
- The office does a decent job through each of the projects communicating with stakeholders on the MA&D efforts.

- Communication is good.
- This is a very strong part of the office's activities and performance. In general, there is a huge amount of engagement, collaboration. and communication. Some highlights in this regard are ESIG, engagement with IEA Task 25, WREN, Tethys, and the Radar mitigation work.
- Stakeholder engagement is at an excellent level. There are dedicated resources for engaging industry and working groups with governmental agencies and other stakeholders are being proactively set up. Frequent meetings are held with industry and relevant organizations. Project results are actively disseminated.
- The program does an exceptional job.
- The communication team is doing a great job with external outreach and engaging the industry partners. Also, leadership is doing a great job engaging and seeking feedback from industry leaders.
- The communications team does a spectacular job of communicating sophisticated information to the public across various media. It was impressive to hear that DOE became a targeted resource when questions arose given the health effects of noise. The office also does a great job of communicating to key stakeholders while also communicating to the general public. One of the greatest strengths and roles of this office is its ability to disseminate and explain credible information.
- The communications staff are exceptionally skilled and committed to connecting with all stakeholders and communicating in the most effective ways. They continue to demonstrate innovation in reaching out to the industry effectively.

Comments on Weaknesses

- While I am aware of the efforts of the office in the MA&D space, it's not entirely clear to me how many others in the wind industry and broader public are. I would encourage that more focus be given to communicating the efforts and successes of the program through both traditional means and social media.
- Some projects have delays in publication of results due to lengthy review processes
- More regional specific outreach opportunities should be considered in the future similar to the RCCs.
- No weaknesses unless not having enough staff is a weakness.

Recommendations

- I strongly encourage DOE to continue supporting the efforts of the WETO program, labs and individual projects. This is a perfect example of how the federal government can engage with the private sector and serve as a catalyst and incubator for ideas and solutions to increase the viability of a critically important technology that will serve to reduce the cost of electricity for the American taxpayers while improving the quality of environment through the reduction of air and water pollution from the electric power sector. The efforts of the WETO office should remain a top priority for the DOE and in turn WETO should continue to prioritize and support the MA&D efforts being evaluated under this peer review.
- I would suggest more indirect communication (e.g., newsletters, project summaries, etc.) be broadcast, and fewer formal meetings be held.
- Study the grid aspects of offshore wind integration, particularly the dedicated offshore infrastructure required.
- Continue the commitment to an open approach to data, modeling and tool development
- Work by Ryan Wiser identified a decrease in the marginal value of wind power as shares increase. There is a large amount of work currently ongoing in the Energy Systems Integration space where increased electrification of other energy sectors such as heating and transport has the potential to

redress this fall in value. Perhaps more engagement in the Energy Systems Integration space would be relevant here as thoughts progress towards high shares of variable renewables.

- Consider investigating flexibility and uncertainty impacts in systems with high shares of renewables
- Addressing barriers and working towards cost efficient deployment will be more and more important as wind power is built to new sites and distributed closer to people. European experience also shows that addressing issues of public acceptance such as noise and risks like ice throw are important.
- The increased penetration level will have implications to deployment as risk of losing generation through curtailments increases unless integration in system operation and markets is improved. Pooling integration funding from different programs could be a good idea if it works in an effective project portfolio. If not, then wind-related integration work is essential to have as part of the wind program in the future.
- Have all team leads and above involved in any physical activity complete OSHA 30-hour training.
- I recommend that the office focus on ensuring the right mix between small, medium and, large projects, making sure to cover projects from low TRLs to high TRLs.
- Continue to engage industry partners. The office is doing a great job with that.
- The national labs are a unique asset and should continue to play a key role in advancing our R&D capabilities and boost innovation
- A greater focus on offshore wind and more investment in the market acceleration and deployment program are essential.
- Continue to get out to see the projects and visit with industry as much as possible.

8 Program Level Evaluation

Reviewers were asked to evaluate the three main WETO programs, each of the activity areas within those programs, and the individual projects within the activity areas. The results of those evaluations for the Technology Development and Scientific Research Program are summarized in this section, along with the office's responses.

The results are organized by the activity areas into which individual projects were grouped for the peer review. The outline below lists those activity areas, along with the number of the report subsection in which their respective summaries can be found.

Program:	4.2	Technology Development and Scientific Research
Activity Areas	4.3	Offshore-Specific R&D
	4.4	Atmosphere to Electrons
	4.5	Distributed Wind
	4.6	Testing Infrastructure
	4.7	Standards Support and International Engagement
	4.8	Technology to Market and Small Business Vouchers
	4.9	Advanced Components Reliability and Manufacturing

Reviewers were asked to provide comments on the programs and on the activity areas within them in response to seven questions. No numeric scores were provided at these two evaluation levels. In answering the questions, the reviewers were responding to specific program and activity area presentations but were also asked to take into account the scores and general impressions of the individual projects they reviewed within those areas.

The subsections for the overall program and for each of the activities includes a comparative table of the technical merit and performance scoring for the relevant individual projects, a summary of reviewer comments, and an office response.

Program Evaluation Results: Technology Development and Scientific Research

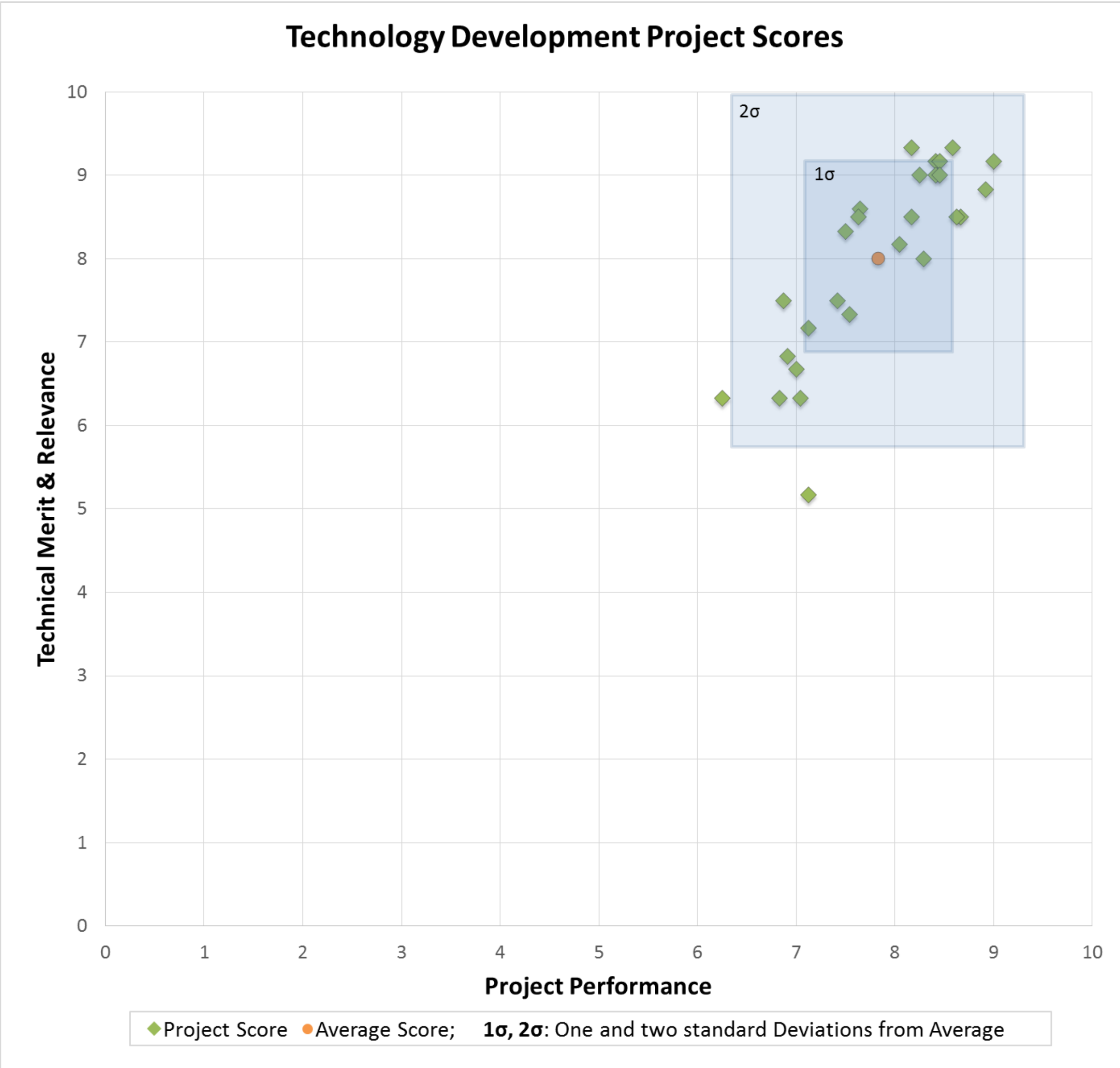
Unique ID: P03	Lead: Michael Derby
Program Level Budget (FY17 & FY18)	$184,638,224
Total Available Laboratory Project Budget	$80,391,667
Total Competitive Award Amount	$104,246,557
Total Competitive Award Cost Share	$283,611,414
Total Available Program Level Budget	$468,249,638
Total Actual Costs	$92,551,486

Program Description

Supports wind energy technology innovation and wind plant optimization through research, development, demonstration and deployment projects for the land-based wind, offshore wind and distributed wind market sectors.

Project Scores within Program Area

This graph shows the relative scores of each project in the given program area—as well as the average for all projects in the program area—with *Weighted Average Project Performance* on the X-Axis, and *Technical Merit & Relevance* on the Y-Axis. The boxes on the graph represent 1σ, and 2σ Standard Deviations from the mean average of all the scores.



Reviewer Responses and Comments

1. Are the activities and projects within this portfolio on the leading edge of work within this field?

- Yes, they are.
- Most of the program activities are industry-leading. Several of the demonstration or small-business projects would not qualify as leading edge, but appeared helpful in establishing industry capability. The A2e program specifically could not obviously be accomplished in any other way.
- No

- Many of the projects in this program are at the cutting edge of research.
- Yes. Overall, the program is diverse and valuable to the state of the art.

2. Has the rationale behind the funded Activities and Projects been effectively conveyed during the peer review?

- I think so.
- The rationale was clearly conveyed during the review. The tie to officer objectives was also stated.
- The program manager did a great job explaining the "Why" and the logic behind funding these activities.
- The motivation to continue lowering the cost of energy was very clear, and I like that it was specific.
- In general, yes. The value is clear.

3. Within this field, are thought leaders aware of the WETO-supported work?

- Yes, they are.
- Not all projects are clearly known by "thought-leaders" in the field. I'd estimate 80-90% are, but I would recommend more regular summary-level information flow to industry via emails, webinars, newsletter, etc.
- Yes. Industry leaders are well aware of those activities.
- Yes, the work is well communicated.

4. Are there important topic areas that are underrepresented or missing within the Program?

- Enabling innovation in wind by creating a common open-source control system.
- Industry concern has been stated to be equipment safety, specifically with regard to catastrophic failure. This can be addressed thru creating a closed equipment safety layer separate from the open source control layer. This is already done by some OEMs in the combustion turbine industry.
- No. The program has the right focus.
- Understanding how DW applications exist inside current research areas would increase the value of existing work.

5. Are there any notable strengths to the Program portfolio content or direction that you would like to point out?

- The coordination between labs and other government departments is impressive. Especially exemplified in the A2e program.
- The research activities are well diversified with common focus on lowering the cost of energy.
- The work currently done on floating offshore is amazing and can put the U.S. in a leadership position in this industry.

6. Are there any notable weaknesses to the Program portfolio content or direction that you would like to point out?

- Some of the Small Business Voucher topics selected seemed to be of marginal value. Consider modifying the process of selection.
- Maybe it will be helpful if there were a clearer definition on what we mean with “distributed wind.”

7. What recommendations would you like to convey to the manager(s) of this program?

- Good work. Keep on.

- Excellent work. Keep supporting floating offshore wind research and focus on both low TRL-level technologies and demonstration projects.
- The work done under A2e on high fidelity research is much needed and it is on the cutting edge of research. FAST is a good tool to keep investing in.
- Overall, the program is very well done. Understanding specific questions that specific projects are trying to answer and then measuring progress and results against those questions will help focus value. Incorporation of DW problems into existing research would add value.

Activity Area Evaluation Results: Offshore Specific R&D

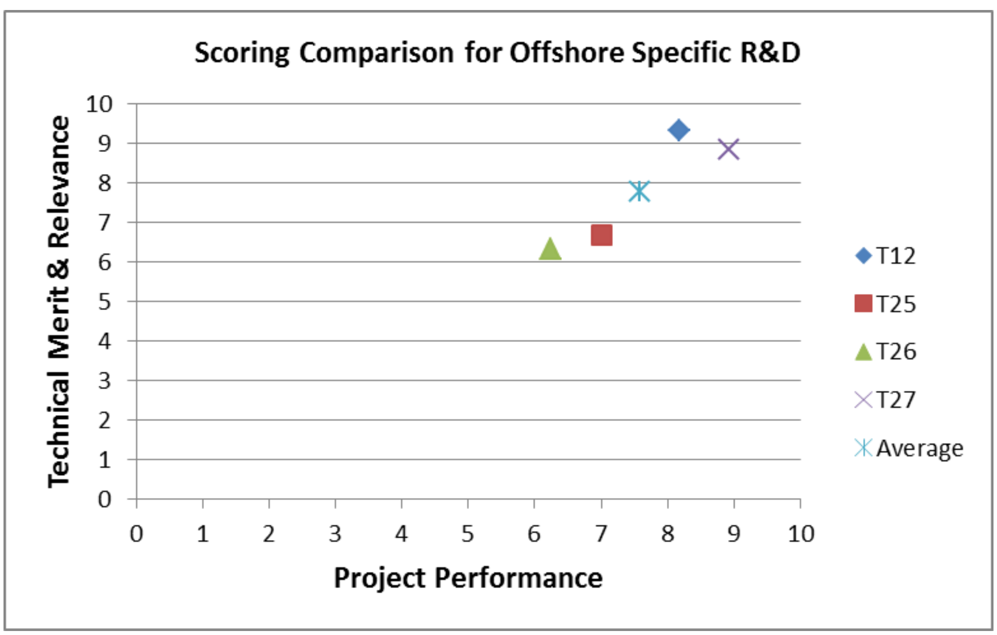
Unique ID: WETO A09	Lead: Michael Derby
WETO Program Area: Technology Development and Scientific Research	
Activity Level Budget (FY17 & FY18)	$108,146,342
Total Available Laboratory Project Budget	$3,899,785
Total Competitive Award Amount	$104,246,557
Total Competitive Award Cost Share	$283,611,414
Total Available Activity Level Budget	$391,757,756
Total Actual Costs	$38,380,918

Activity Area Description

Addresses U.S.-specific offshore wind challenges through targeted research on topics including: designing for challenging physical conditions such as hurricanes; meeting specialized vessel, port infrastructure and workforce training needs; and advancing designs for floating turbine platforms.

Project Scores within the Activity Area

This graph provides the relative scores for each project in the activity area—as well as the average for all projects in the activity area—with *Weighted Average Project Performance* on the X-Axis, and T*echnical Merit & Relevance* on the Y-Axis.



List of Projects

Unique ID	Program	Project Name	PI	Organization	Budget	Actual Costs	Project Status
T12	Technology Development and Scientific Research	Offshore Resource Characterization	Will Shaw	PNNL	$3,899,785	$592,066	Active
T25	Technology Development and Scientific Research	Cost of Energy reduction for offshore Tension Leg Platform (TLP) wind turbine systems through advanced control strategies for energy yield improvement, load mitigation and stabilization	Dhiraj Arora	General Electric	$4,417,226	$4,402,983	Complete
T26	Technology Development and Scientific Research	Project Icebreaker	Lorry Wagner	Lake Erie Energy Development Corp. (LEEDCo)	$204,054,465	$17,301,859	Active
T27	Technology Development and Scientific Research	Aqua Ventus	Habib Dagher	University of Maine	$179,386,280	$16,084,010	Active

Reviewer Responses and Comments

1. Are the projects within this activity on the leading edge of work within this field?

- This program is well targeted, both at the international and national levels. As the U.S. ramps up the offshore industry, the unique needs of the country's water conditions and regulatory system need to be established. Technology for deeper waters and hurricane tolerance need to be addressed. This program addresses these issues on multiple fronts very well. More innovation on floating platforms will meet a need that is unique to the U.S. and other non-European sites, such as Asia. Developing these floating technologies will support U.S. technology internationally.
- Yes. I find this activity showing high impact.
- Yes, although while the projects were leading edge, I can't help but think they were not far-reaching enough.
- Yes. The activity area focuses on projects that are on the leading edge of the field and critical for advancing offshore wind in the US. Work focuses on advanced controls, resource characterization, and field facilities development for full scale testing.
- Some of the projects are definitely doing cutting edge research. For example, the Aqua Ventus floating foundation is very novel.
- The projects include practical and necessary solutions, such as data collection, that advance the industry in ways that the private market will not likely do.
- Some of the projects appear to have been on the leading edge at the time they were conceived and no longer do.

2. Has the rationale behind the funded Activities and Projects been effectively conveyed during the peer review?

- The funding rationale has been well developed and is consistent with industry needs. WETO and DOE lab leadership is a key element in the success of the U.S. offshore industry. The overall WETO strategy appears to be well considered.
- Yes, with clear goals and ties to office objectives.
- Yes. Project activities have been adequately communicated and presented.
- Yes, the presentations were well done and the presenters did a great job conveying the rationale behind their work.
- While the rationale is generally apparent, I don't know that it is expressly stated in most cases. Defining the problem being solved and, at the conclusion of research, looking at how the individual project advanced the answer would be valuable and would likely help long-duration projects stay on track.

3. Within this field, are thought leaders aware of the WETO-supported work?

- All the thought leaders appear to be engaged and well aware of WETO's work. The industry is depending on WETO and the lab's leadership.
- Yes, these activities are clearly communicated to stakeholders.
- I am not really sure about this. I work in this field and I only learned about the projects funded by this activity during the review process. I knew only of the University of Maine work and activities.
- Yes. DOE did a great job keeping the research community and industry informed.
- In general, yes, but not as much as they could be. Providing a form of regular communication, such as a one-page quarterly newsletter, would be helpful. I think that some of the smaller activities are overshadowed by the flagship projects, despite the fact that the smaller projects may be more practically advancing the immediate future of the industry.

4. Are there important topic areas that are underrepresented or missing within this Activity area?

- It is possible that technology innovation in mooring systems and/or mooring system deployment could use greater emphasis.
- No, I don't think so.
- Yes. Is there an offshore, full-scale test facility that makes sense?
- Resource determination should be expanded.
- Yes. High fidelity modeling that takes into account ocean waves, atmospheric turbulence, and floating structure dynamics will be critical for this activity area to realize its full potential.
- More data collection efforts would be well received by the industry. More development of the non-core technical issues, such as technical aspects of logistics and construction, will likely be necessary to help an American workforce participate in the construction of these projects. In general, America lacks many of the construction and workforce skills necessary to compete in this area.

5. Are there any notable strengths to the Activity portfolio content or direction that you would like to point out?

- The standards work and floating platform parts of the program are standout strengths.
- I think the choices of the demonstration projects were good at the time.
- The Aqua Ventus project is especially notable. This will provide invaluable data for developing high-fidelity models. Such efforts should be coupled with high-fidelity modeling to maximize impact and guide tool development toward design of floating structures.

- Programs like the floating turbine platform are well run, multiyear programs that have actively advanced the wind power industry. It is the ability to advance and share that makes for highly successful programs.

6. Are there any notable weaknesses to the Activity portfolio content or direction that you would like to point out?

- Turbine innovation to meet the challenges of large dynamic systems that are typhoon tolerant could be more emphasized.
- The size of the portfolio is rather limited. So one area for improvement is to grow resources invested in offshore wind.
- Stronger focus on sponsoring university research where more graduate students can benefit from it.
- More focus on technology maturation, not just LCOE.
- More should be done to address how long-term programs (demo projects) continue and when the taxpayer point of diminishing returns is reached. For example, both of the offshore projects have represented good initial investments, but I don't think the WETO has articulated how continued investment creates proportional advances. When non-recourse debt comes into a project, the program should ask if it is still a high-risk project that needs taxpayer funds.

7. What recommendations would you like to convey to the manager(s) of this Activity area?

- Projects that collaborate with states on deployment programs.
- Consider more data collection, especially for floating turbines.
- Develop a clear and specific plan for developing multi-scale, high fidelity engineering and modeling tools for floating turbines.
- Keep focusing on floating offshore wind.
- Try to sponsor more university led projects so more graduate students are supported.
- Keep focusing on LCOE.
- Deep water and hurricanes are issues that must be addressed in particular to US
- In order for offshore to succeed in the U.S., an entire industry of fabricators, contractors, ships, crews, and engineers has to be created in the U.S. Unlike onshore or DW, most of these skills are not present in the U.S. currently. If the U.S. is going to create this industry domestically, it should acknowledge and address its shortfalls.

Activity Area Evaluation Results: Atmosphere to Electrons (A2e)

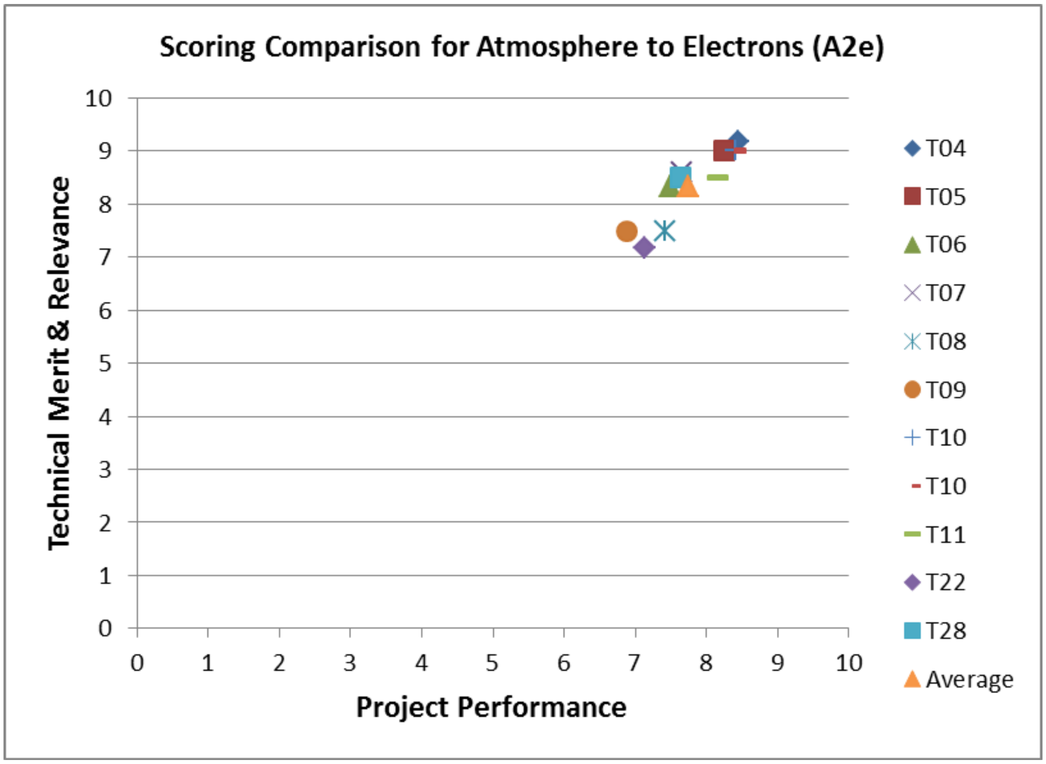
Unique ID: WETO A10	Lead: Michael Derby
WETO Program Area: Technology Development and Scientific Research	
Activity Level Budget (FY17 & FY18)	$37,631,263
Total Available Laboratory Project Budget	$37,631,263
Total Competitive Award Amount	$0
Total Competitive Award Cost Share	$0
Total Available Activity Level Budget	$37,631,263
Total Actual Costs	$29,572,298

Activity Area Description

Reduce wind energy cost by 50% by providing a better understanding of the atmospheric boundary layer interaction with wind plants and developing new technologies to maximize energy capture and optimize cost performance through integrated plant systems analysis, design and operation.

Project Scores within the Activity Area

This graph provides the relative scores for each project in the activity area—as well as the average for all projects in the activity area—with *Weighted Average Project Performance* on the X-Axis, and T*echnical Merit & Relevance* on the Y-Axis.



List of Projects

Unique ID	Program	Project Name	PI	Organization	Budget	Actual Costs	Project Status
T04	Technology Development and Scientific Research	A2e: Mesoscale Physics and Inflow: WFIP 2	Will Shaw	ANL, LLNL, NREL, PNNL	$8,773,529	$7,910,582	Active
T05	Technology Development and Scientific Research	A2e: Mesoscale Physics and Inflow: WFIP 2	Sue Haupt	ANL, LLNL, NREL, PNNL, SNL, LANL	$ 3,674,279	$2,923,357	Active
T06	Technology Development and Scientific Research	High-Fidelity Modeling	Mike Sprague	NREL, SNL	$4,304,928	$3,654,798	Active
T07	Technology Development and Scientific	Rotor Wake Measurements & Predictions for Validation	Patrick Moriarty	NREL, SNL	$10,730,881	$8,108,373	Active

	Research						
T08	Technology Development and Scientific Research	Advanced Flow Control Science for Wind Plants	Paul Fleming	NREL	$2,816,078	$2,218,862	Active
T09	Technology Development and Scientific Research	Integrated Systems Design and Analysis	Garrett Barter	NREL	$2,337,058	$1,451,808	Active
T10	Technology Development and Scientific Research	Integrated Systems Design and Analysis OSW	Amy Robertson	NREL	$1,888,656	$1,135,128	Active
T11	Technology Development and Scientific Research	A2e PRUF	Jason Fields	NREL	$ 2,242,837	$1,552,943	Active
T22	Technology Development and Scientific Research	Small Business Vouchers - WindESCo	Paul Fleming	NREL	$200,000	$131,367	Complete
T28	Technology Development and Scientific Research	Multi Physics Model Validation & UQ	Jason Jonkman	NREL	$663,017	$485,079	Active

Reviewer Responses and Comments

1. Are the projects within this Activity on the leading edge of work within this field?

- A2e is pushing the industry and DOE laboratories to develop technology for full wind plant system optimization through greater understanding of the coupled physics from large scale atmospheric drivers, which are the source of all wind energy, to the small scale, blade-attached, boundary-layer physics that drive the performance and loads acting directly on the turbine. Understanding how physics that span 10 orders of magnitude interact is key to capitalizing opportunities they present through improved forecasting of annual energy, as well as transient behavior driving wind plant power ramping events. Predicting the loads imparted as a result of these turbine-to-turbine and wind plant-to-atmosphere is key to controlling them and optimizing for lowest LCOE. Collective controls are only one of the many benefits. The industry cannot explore these opportunities without the analytical tools developed under this program. No single lab has the collective expertise needed to fully understand this wide range of physics.
- Atmospheric researchers need to be guided by the experience of the industry before they can focus on the appropriate tools. Validation of these tools is extremely important, and only DOE labs can supply this level of quality and the scope of data that is needed for industry confidence. This is a unique, world class program that is the envy of all international research programs.
- Yes. It’s hard to see how else the meso-to-micro and wake dynamics activities could be accomplished.

- This is an impressive and ambitious program both in scope and breadth. It weaves together multiple projects that address critical building blocks toward A2e's vision to develop predictive understanding of complex flows in wind plants and to provide the industry with the next generation of computational tools for reducing the LCOE.
- For the most part ongoing projects are at the leading edge of the field.
- Research done under this area is definitely at the leading edge of technology. Fantastic job with developing high-fidelity models.

2. Has the rationale behind the funded Activities and Projects been effectively conveyed during the peer review?

- The benefits and the rationale are self-evident. The WETO did a masterful job of explaining the reasons for each program, how they fit together, and the funding.
- Yes. There is a clear line-of-sight to office objectives and rationale.
- Absolutely. The rationale behind individual projects has been well thought out and presented very effectively
- The team did a great job explaining the rationale behind their work.
- Not at all. I believe that a lot of this is a shotgun approach at the interesting. This group needs to distinguish why each of these projects builds on answers to specific questions and results. Some of this research is amazing, some seems to be curiosity, and some is not relevant to the industry. On the whole, the program is valuable, but focus would be helpful.

3. Within this field, are thought leaders aware of the WETO-supported work?

- The A2e program has done an outstanding job of communicating and coordinating. All of the thought leaders are not only aware but deeply engaged.
- For the most part, thought leaders in the field should be aware of A2e. Various A2e project teams are present and visible at relevant scientific meetings showcasing the work, and publish quite extensively. Their work is adequately communicated.
- DOE did a great job engaging the research and industry communities.

4. Are there important topic areas that are underrepresented or missing within this Activity area?

- Offshore wind plant design needs might need more attention in the future. Air/sea interactions and modeling could improve load predictions, and perhaps offer greater insights into control methods for mitigating large motions of floating platforms and/or loads. Eventually, improved modeling of typhoons near the high-shear typhoon wall might be important for typhoon tolerance design.
- I feel the controls direction should be slightly shifted. As with modeling tools for industry to use to determine loads, an open source controls framework should be developed to allow the industry to experiment with various controls algorithms.
- High fidelity modeling for offshore wind turbines and plants, especially floating turbines, coupling waves, atmospheric turbulence, and structural dynamics, does not seem to be part of A2e at this point. It will be important to develop such focus soon as the offshore wind industry is advancing in the U.S.
- Creating applications where the tools can be practically applied, even at a lower accuracy, would multiply their value. Translating work between what can be done on a supercomputer and what can be done to help improve a turbine or warm design needs to be done. I am not saying to not push the limits of computing power, but understand that the work is less valuable in the next decade than lower resolution work that the industry can leverage.
- Many of these projects have DW applications that are not being properly considered or accounted for in the research or methodology. This work has the potential to make the DW market a reality and it is not being considered.

5. Are there any notable strengths to the Activity portfolio content or direction that you would like to point out?

- The modeling of the "Teraincognito" (meso/microscale atmospheric coupling) is impressive. This is an important part of understanding the coupling that impacts wind plants. Modeling of these part of the atmosphere will help forecasting transient wind conditions which drive power ramp rates.
- The coordination of various labs and DOE resources that are required to accomplish several of the program goals. Excellent work!
- I found the various measurement efforts especially impressive and critical for catalyzing progress. The SNL SWiFT project and the multi-scale atmospheric boundary layer measurements campaign were especially impressive and will yield essential data for driving the development of computational codes.
- Keep focusing on open source code development. DOE can play an excellent role in this area. A2e brings analysis to validation
- Projects like the MMC could make the DW industry transform fundamentally if properly applied.

6. Are there any notable weaknesses to the Activity portfolio content or direction that you would like to point out?

- Inter-lab coordination is hard, but A2e has succeeded remarkably in the past two years. Keeping a focus on this coordinate is important. This is not a weakness as much as a recommendation to continue the positive trend with good leadership.
- The interaction and integration between projects can be improved. I noted that while the HFM framework of A2e is the Nalu code, most of the projects are employing SOWFA. While I assume that this is the results of Nalu being in the early stages of development, it will be important to begin integrating the development of the code with effort to generate inflow conditions and enable coupling with mesoscale models.
- The development of Nalu code needs to accelerate to catch up with—and hopefully surpass—where the HFM modeling is today for land-based and offshore wind farms. The code should also leverage recent major advances in the field of HFM. This is critical for the success of the entire A2e program as HFM is at the center of the entire effort.
- The terms “high fidelity,” “medium fidelity,” and “engineering fidelity” are used loosely in different projects. It will be important to rigorously define what is meant by the various terms in the context of models.
- The program needs to develop a focus in HFM for offshore wind applications. Broaden the work to incorporate efforts previously funded by DOE which have greatly advanced.
- Sponsor more university students.
- I think that cost/benefit needs to be better considered in this program.
- I think that when research is directly translatable into immediate industry value (day ahead forecasting), the industry should support the research more. If the industry is not willing to support the research more, then the value of the research should be questioned.

7. What recommendations would you like to convey to the manager(s) of this Activity area?

- Continued, consistent funding is tremendously important. Demonstrate and report on intermediate findings often to the industry, especially the unexpected findings.
- Given the importance of HFM for A2e the program could be strengthened by diversifying its focus to consider other computational methodologies that incorporate most of the relevant physics for modeling wind farms. This is especially critical for offshore floating turbines, for which successful HFM requires advanced computational models to simulate waves, air/sea interactions, and structural dynamics. Also, experiments need to be designed and carried out for validating meso-micro scale coupling models and demonstrate the ability of Nalu to predict turbulence from the

blade boundary layer scale to wake meandering scales for a range of operating conditions and atmospheric states.

- Keep focusing on meso-micro scale coupling. This is a very complex and difficult task. A2e is in excellent position to solve this complex problem.
- Look for applications and value to DW in all areas of this research. Look at how to take the highly sophisticated research and translate it into usable information to advance both the near-term and long-term.

Activity Area Evaluation Results: Distributed Wind R&D

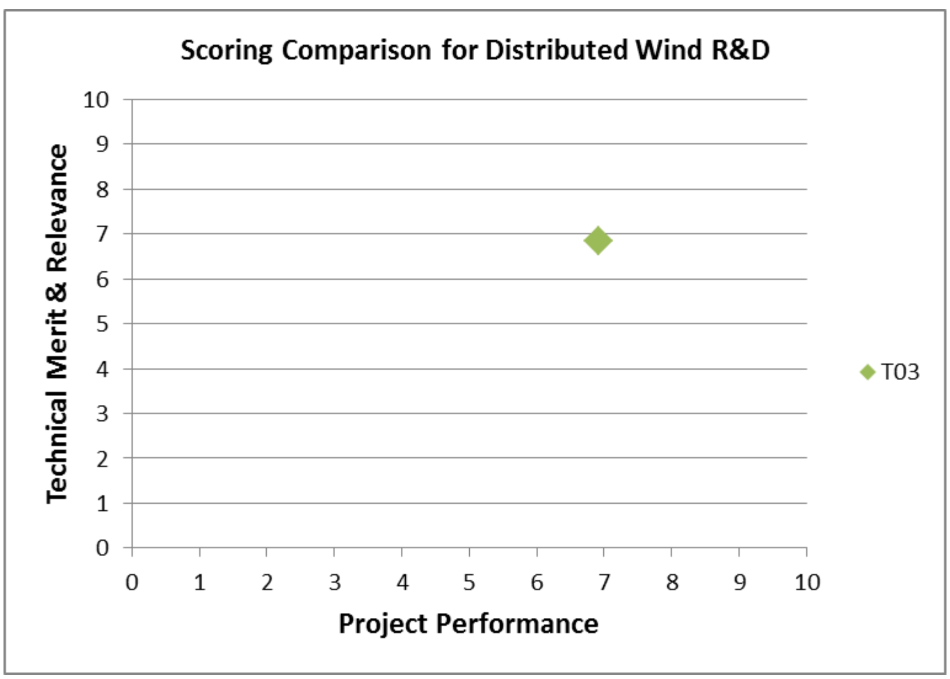
Unique ID: WETO A08	Lead: Michael Derby
WETO Program Area: Technology Development and Scientific Research	
Activity Level Budget (FY17 & FY18)	$8,752,850
Total Available Laboratory Project Budget	$8,752,850
Total Competitive Award Amount	$0
Total Competitive Award Cost Share	$0
Total Available Activity Level Budget	$8,752,850
Total Actual Costs	$3,681,505

Activity Area Description

Reduce costs and increase reliability of wind energy technology for distributed energy applications through support of innovative R&D and testing, and through analysis and stakeholder engagement to further the understanding of installed costs, market potential, and technical challenges.

Project Scores within the Activity Area

This graph provides the relative scores for each project in the activity area—as well as the average for all projects in the activity area—with *Weighted Average Project Performance* on the X-Axis, and T*echnical Merit & Relevance* on the Y-Axis.



List of Projects

Unique ID	Program	Project Name	PI	Organization	Budget	Actual Costs	Project Status
T03	Technology Development and Scientific Research	Distributed Wind Research, Development, and Testing	John Berg	NREL	$4,625,145	$3,681,505	Active

Reviewer Responses and Comments

1. Are the projects within this Activity on the leading edge of work within this field?

- This program represents a great effort to help the small and distributed wind industry with targeted market studies, resource assessment tools, and technical assistance. The challenge that small and distributed wind face is the cost of developing single units without the economies of scale that help large turbine wind plants. Marketing, distribution, installation, and long-term maintenance costs must be streamlined to overcome these challenges. Certainly, technology improvements will help, especially those that facilitate ease of installation and reliability, but they cannot overcome by themselves. Other challenges are that behind-the-meter installations tend to be in locations that have limited wind resource due to residential and commercial locations favoring low wind sites. This adds another challenge that solar does not face. Given these imbalances in challenges, the competition between solar and wind for distributed energy will be significant. WETO may want to identify the unique situations where distributed wind does not face these challenges and support work that capitalizes on these situations.
- While the portfolio is limited, given the current state of distributed wind, the work is clearly on the leading edge of the field.
- Yes, the research activities are on the cutting edge of research
- No. I don't think that this group is on the leading edge of work. This group is trying, and struggling, to describe the industry that they are studying. This lack of clarity about what the DW industry is drives the chaos in the research. The work is largely data collection, which is necessary, but will not advance anything. This group should help other areas of WETO understand how the work they are already doing applies to DW. This group also needs to figure out what questions it is trying to answer.

2. Has the rationale behind the funded Activities and Projects been effectively conveyed during the peer review?

- It appears that quite a lot of funding has gone to one OEM consistently. Should the funding focus be modified to target issues which benefit the broader distributed wind industry?
- Yes, they were.
- The program goals seem clear.
- Yes, they have been very well explained and articulated.
- Yes, the rationale was clear for the funded activities during the review sessions.
- No. The work is all over the place and has not preserved the value that the taxpayers have invested. This program is large compared to the industry and seems to be making sure everyone gets a piece, regardless of merit. Outside of data collection I do not understand what questions are being answered or how answers to those questions improve the industry.

3. Within this field, are thought leaders aware of the WETO-supported work?

- WETO support for distributed wind is legendary. All thought leaders are keenly aware of it and regularly communicate with them.
- Yes, leaders in the industry are well aware of the research activities going on under this program.
- Yes, the group has done a good job of communicating with the small number of stakeholders in the industry.

4. Are there important topic areas that are underrepresented or missing within this Activity area?

- The cost of single-installation, low-wind, behind-the-meter installations is key. More support for innovation in this area might be fruitful.
- If anything, the various projects seem to be a shotgun approach and may be diluting important areas of the program that should be focused on more to have a greater impact.
- This group needs to be more skeptical of drawing on lessons from the solar industry. While many things may appear to be logical, cross-industry fits, they are not. For example, the skills necessary to build a wind turbine, especially larger machines, are well beyond the capacity of simple certification. The focus should be on helping individuals and businesses recognize the right qualifications as opposed to helping obtain those qualifications. At this point, the breadth of the activity is quite appropriate.
- This program needs to distinguish clear areas of focus, like the onshore program, and then advance those individual areas. I submit that the key sub-topics are:
    - Small wind turbine manufacturing and associated standards
    - Project development, permitting, and installation
    - Wind resource forecasting without on-site data collection
    - Safety throughout the project lifecycle
    - Turbine operation, maintenance, and decommissioning
    - Access to capital - project finance and corporate finance
    - Electrical engineering and operating under IEEE 1547
    - Other special projects

5. Are there any notable strengths to the Activity portfolio content or direction that you would like to point out?

- Documenting the cost breakdown is helpful in focusing research on the highest impact areas. The PNNL work has been noteworthy in this area.
- The effort to understand DW resource assessment and performance in built environments and under turbulent atmospheric conditions is based on rigorous science. It is well thought out.
- Strong focus on lowering LCOE.
- Strong focus on increasing accuracy of site assessment.
- The data collection and analysis efforts are excellent, especially if you refine the definition of the industry.

6. Are there any notable weaknesses to the Activity portfolio content or direction that you would like to point out?

- U.S. OEM might be a weakness.
- It appears that some of the work was directly advantageous to a specific vendor. I would suggest looking for generic work that all interested vendors could access and utilize.
- In the end, the main issue is whether DW will be become competitive with solar. So more projects that help reduce the LCOE could benefit this activity.
- This program is not focused and does not have a logical consensus definition of DW. The current definition massively distorts the view of the industry (there is not a GW of DW). This distortion

makes it hard to measure actual impact of value of the entire program. The program is not advancing things, but rather just documenting the progress.

7. What recommendations would you like to convey to the manager(s) of this Activity area?

- Consider ramping down funding and/or a long-term strategic plan to bring distributed wind LCOE down to a level comparable to PV Solar.
- Consider if distributed wind could benefit from the other activities for onshore/offshore in an adapted form.
- Careful thought needs to be given as to whether to continue this activity as currently DW is not competitive with solar.
- Distributed wind definition can be confusing.
- Focus on accessibility as a good metric to use beside LCOE.
- This is the most high risk/high reward activity in the WETO. This program is also the most in need for refocusing. You can't fix an industry if you can't talk objectively about it. The entire industry is VERY small right now. The DW segment covers a wide range of areas.
- The best thing to do would be to conduct an honest assessment of the industry as it exists today. Then, the group needs to define the functional elements that DW projects share:
    - The project is intended to offset retail electric consumption.
    - If the systems are permitted, they are permitted at the local level, typically under zoning laws.
    - They directly interact with an electrical load.
    - They serve a single load center (which could in theory be a local microgrid acting as a single load center).
    - The utility is not selling or buying the power unless it is as acting as a facilitator of the underlying transaction.
    - If the project interconnects to the electrical grid, it is under IEEE 1547
    - The project is not driven by wholesale electric market economics

      Then, define the questions that are necessary to advance the industry.
- Additionally, this industry should have a full-time internal outreach component where it supports all of the other areas of WETO, applying their work to DW and then communicating that work to the DW stakeholders.

Activity Area Evaluation Results: Testing Infrastructure

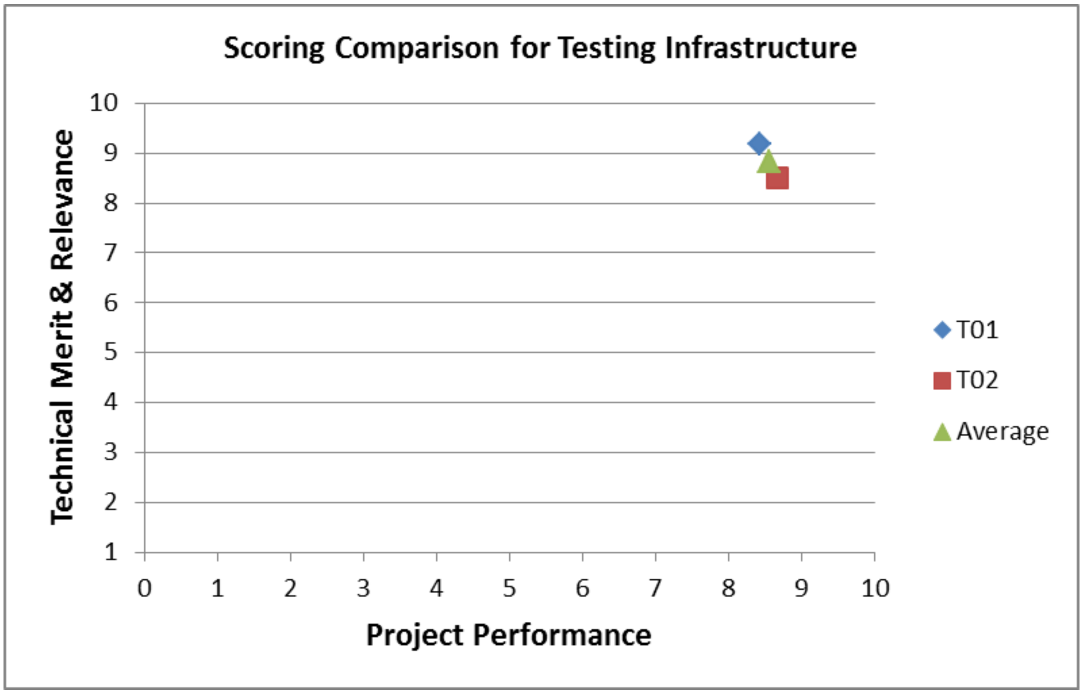
Unique ID: WETO A07	Lead: Michael Derby
WETO Program Area: Technology Development and Scientific Research	
Activity Level Budget (FY17 & FY18)	$16,466,646
Total Available Laboratory Project Budget	$16,466,646
Total Competitive Award Amount	$0
Total Competitive Award Cost Share	$0
Total Available Activity Level Budget	$16,466,646
Total Actual Costs	$11,537,763

Activity Area Description

Provide support for facilities that enable key internal programmatic research, development and testing; and meet external stakeholder needs through cooperative user agreements. Maintain unique R&D capabilities at national laboratories through specialized facility assets.

Project Scores within the Activity Area

This graph provides the relative scores for each project in the activity area—as well as the average for all projects in the activity area—with *Weighted Average Project Performance* on the X-Axis, and T*echnical Merit & Relevance* on the Y-Axis.



List of Projects

Unique ID	Program	Project Name	PI	Organization	Budget	Actual Costs	Project Status
T01	Technology Development and Scientific Research	Testing Facilities and Capabilities at NWTC	David Simms	NREL	$11,841,501	$8,138,336	Active
T02	Technology Development and Scientific Research	Testing Facilities and Capabilities at SNL: Field Test Facilities - DOE Turbine Facilities and Test Sites O&M	Jon Berg	SNL	$4,625,145	$3,399,427	Active

Reviewer Responses and Comments

1. Are the projects within this Activity on the leading edge of work within this field?

- The test infrastructure that DOE has developed over the years has placed the U.S. industry in a unique and powerful position to add quality data for model and innovation validation. These are world class facilities, unique in their capabilities. The labs have worked well with the industry to be available for technology validation.

- The facilities embody the core testing expertise and credibility needed for risk reduction. In addition to the facilities, the staff that operates them has tremendous value.
- Yes, the activities are leading edge worldwide.
- Yes. The test facilities created are almost entirely unique in the industry. (Blade and gearbox facilities may be exceptions.)
- Yes. All testing facilities included as part of this activity are at the leading edge of the field.
- Yes. The team is doing a great job with cutting edge research at both NWTC and SWiFT facility
- Yes, these facilities are unparalleled in the private sector.

2. Has the rationale behind the funded Activities and Projects been effectively conveyed during the peer review?

- The rationale for funding is very clear and warranted.
- Yes, there is a close tie to office objectives.
- Yes. Such activity is exactly what DOE needs to be doing for industry.
- The team did a good job explaining the rationale behind their work
- Yes, the need for these facilities is clear.

3. Within this field, are thought leaders aware of the WETO-supported work?

- All thought leaders are engaged and appreciate WETO support and leadership.
- Yes, they are aware. The communication is very good.
- Yes, the facilities and capabilities have been clearly conveyed in the industry.
- Yes. These are well publicized facilities within the entire community.
- Yes, the team did a good job in this area.
- Yes, the facilities and their activities are well known.

4. Are there important topic areas that are underrepresented or missing within this Activity area?

- Offshore test facilities will be an important area in the future. The PNNL buoy loan program is a good start, but more objective testing capabilities will be needed.
- Offshore testing capability is underrepresented and should be developed further in the future.
- Similar facilities need to be developed for offshore wind applications, including floating turbines.
- Including and understanding how this research can impact DW would be a positive benefit. Applications for DW do not seem to be well considered in the research.

5. Are there any notable strengths to the Activity portfolio content or direction that you would like to point out?

- Drive train testing is exemplary.
- The SWiFT facility allowing turbine-to-turbine interaction is a test facility strength.
- I am especially impressed by the SWiFT site. It provides exciting opportunities for collecting critical data and doing field testing for advancing wind plant modeling and controls.
- Fantastic job with testing facilities. Encourage them to highlight the talents.

6. Are there any notable weaknesses to the Activity portfolio content or direction that you would like to point out?

- There are clear concerns with safety and safety culture in this activity. An individual received an electrical shock, and there were clear OSHA violations in the photos presented. Leaders were not able to properly address safety questions, and it is clear that the safety culture in this activity is substandard.

7. What recommendations would you like to convey to the manager(s) of this Activity area?

- Budget for maintaining and upgrading existing facilities, and also for testing technique innovation.
- Would there be a way to cost-effectively utilize more privately operated facilities as test facilities? Data from such facilities will ultimately be used to validate the HFM efforts of A2e. The resolution of the HFM models is far greater than present measurement capabilities so plans need to be made to design experiments specific to HFM validation. This will require collecting high resolution data on turbine blades, in the near and far wake, and as accurately quantified atmospheric conditions. Such data collection strategy should be tightly integrated with high-fidelity modeling. Simulations could help identify relevant phenomena and regions of interest in the flow where experiments can zoom in to provide datasets that will enable unprecedented validation of high-fidelity models.
- Keep focusing on safety.
- Bring in industry participants to help understand and address the safety culture.
- Require all managers in the program to have OSHA 30-hour training.
- Report on first aid, recordables, lost time, and near misses monthly through the full management chain.
- Make it clear that safety performance takes precedent over technical value.

Activity Area Evaluation Results: Standards Support and International Engagement

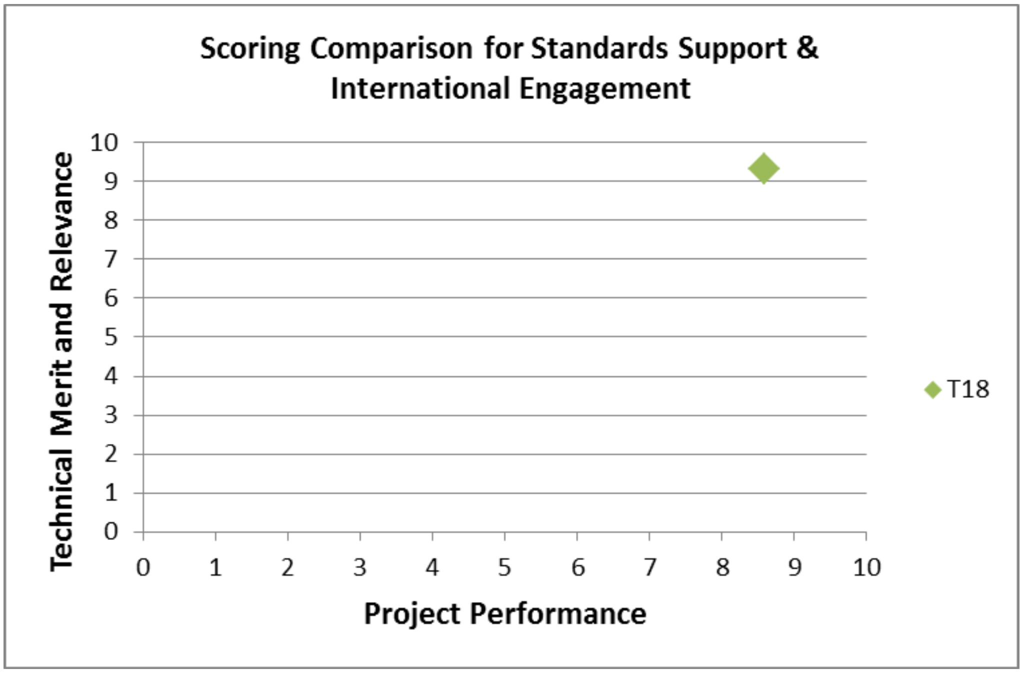
Unique ID: WETO A06	Lead: Michael Derby
WETO Program Area: Technology Development and Scientific Research	
Activity Level Budget (FY17 & FY18)	$1,842,708
Total Available Laboratory Project Budget	$1,842,708
Total Competitive Award Amount	$0
Total Competitive Award Cost Share	$0
Total Available Activity Level Budget	$1,842,708
Total Actual Costs	$1,088,926

Activity Area Description

Actively support international and domestic wind energy standards development in order to lower technical risks and costs. Play a key leadership role in the International Energy Agency Wind Technology Collaboration Program to foster global industry growth and technical collaboration.

Project Scores within the Activity Area

This graph provides the relative scores for each project in the activity area—as well as the average for all projects in the activity area—with *Weighted Average Project Performance* on the X-Axis, and T*echnical Merit & Relevance* on the Y-Axis.



List of Projects

Unique ID	Program	Project Name	PI	Organization	Budget	Actual Costs	Project Status
T18	Technology Development and Scientific Research	Wind Standards Development	Jeroen van Dam	NREL, PNNL, SNL	$1,842,708	$1,088,926	Active

Reviewer Responses and Comments

1. Are the projects within this Activity on the leading edge of work within this field?

- Critical international engagement sets design standards for the world. This is also the key DOE advanced technology transfer path.
- Both IEC and IEA engagement are critical for U.S. industry. When DOE develops new technology, it must first be tested against existing standards and, when improvements or better design methods are needed, DOE experts are in a position to introduce them to international and national standards. This helps international and national regulation, improves quality, and ultimately lowers LCOE.
- DOE experts regularly have a major influence on the standards content because they are equipped with research data to support their technical arguments. There is a natural path for technology researched and accepted internationally within IEA to become the subject for IEC standards. When appropriate, IEA should encourage the development of guides that can be used by IEC standards committees to create formal international standards.
- The standards support and activities for the wind industry are no doubt industry leading.
- The standards development project is the leading edge in this field.
- Yes. Keep focusing on standards. It is the best way to bring technology to the industry.

- By definition, no. Standards always lag behind the cutting edge. It is important to understand that this activity is anomalous to the other WETO programs and needs to be evaluated under different criteria.

2. Has the rationale behind the funded Activities and Projects been effectively conveyed during the peer review?

- This is a crosscutting program area. Standards impact every aspect of wind energy technology and market access nationally and internationally. This is highly leveraged and effective funding. Working through all the key standards organizations (IEC, IECRE, AWEA, ANSI, ASME, AGMA, etc.), DOE experts' influence is unmatched and always trusted.
- Yes. It has been effectively communicated.
- Yes, very much so. This is DOE-funded work at its very best.
- Yes, the team did a great job communicating the rational of their work
- After being pressed, yes, but initially, no. This program is about documenting the consensus edge of the industry, but not about advancing the cutting edge.

3. Within this field, are thought leaders aware of the WETO-supported work?

- Thought leaders in IEA and IEC are keenly aware of DOE support for this area. Were it not for DOE support, the U.S. would have missed opportunities to influence most of the international standards. Because of DOE support of U.S. experts and the infrastructure needed to support their participation, the U.S. has had major influence on the existing standards. They balance the leadership and dominance of European leaders. The number of U.S. committee and working group chairs is second only to Denmark.
- Within the U.S., DOE WETO support has enabled adoption of international standards and the infrastructure to coordinate U.S. input to the standards.
- Yes, it is internationally recognized.
- Absolutely. The U.S. Standards Summit sponsored by DOE is an effective method to convey the work.
- Thought leaders are very much aware of this work.
- Yes. DOE did a great job engaging the academia, standards agencies, and industry in this work.

4. Are there important topic areas that are underrepresented or missing within this Activity area?

- Most areas are well covered by this program, but technical standards tend to focus on OEM concerns to the exclusion of end users. Low end user participation in the standards has resulted in underrepresentation of siting, project development, installation, commissioning, operations and maintenance standards, and best practices. These have become more important for risk reduction for the financial community. The U.S. wind industry is dominated by end users (developers, owners, operators, banks, insurance companies). WETO should encourage end users to participate whenever possible.
- No areas are underrepresented in this work.
- This group does not appear to be participating in any workforce safety-related standards.

5. Are there any notable strengths to the Activity portfolio content or direction that you would like to point out?

- WETO support for U.S. participation in IEC standards and certification has been exemplary over many years. This consistent support has enabled the U.S. to influence international standards in major ways. Also, WETO support from ARESCA has facilitated U.S. coordination and IEC engagement dramatically.

- Many important industry players are not able to directly support standards work allowing their inputs to be heard. A method to allow the right level of industry involvement from the U.S. to the international standards process needs to continue to be supported and possibly supported further.
- Standards are important for the industry and it is exactly the kind of activity that DOE should lead.
- Fantastic job done by the team to maintain leadership on the standards committees and bring forward topics that are very relevant to our domestic market.

6. Are there any notable weaknesses to the Activity portfolio content or direction that you would like to point out?

- WETO might be able to facilitate cross-government agency adoption or acceptance of international standards as the U.S. develops the offshore wind industry. BOEM adoption of IEC standards and certification would be very helpful in accelerating offshore development. WETO might be able to help with other non-governmental organizations adoption of IEC standards such as ASME, ASCE, IEEE, NEC, NFPA and OSHA.
- Not that I have seen.
- I feel the DOE should take a more active role in gaining focused standards development activities to move industry metrics toward increased deployment, such as tying needed standards evolution to decreased LCOE.
- The DW work has caused problems for a large part of the DW industry. The work in support of small wind certification has harmed the large DW market.

7. What recommendations would you like to convey to the manager(s) of this Activity area?

- Continue to support this program area with the same forward-looking vision.
- More funding for U.S. expert involvement.
- Coordinate between U.S. supported activities and industry metrics that support industry expansion.
- This is a multi-year effort that obviously needs to be continued.
- Keep focusing on industry-like standards.
- This activity would benefit from the activity publishing its stated positions on the standards publicly and in advance. That way the industry can understand and provide commentary on the opinion since the group carries weight beyond the normal participants.

Activity Area Evaluation Results: Tech-to-Market/Small Business Vouchers

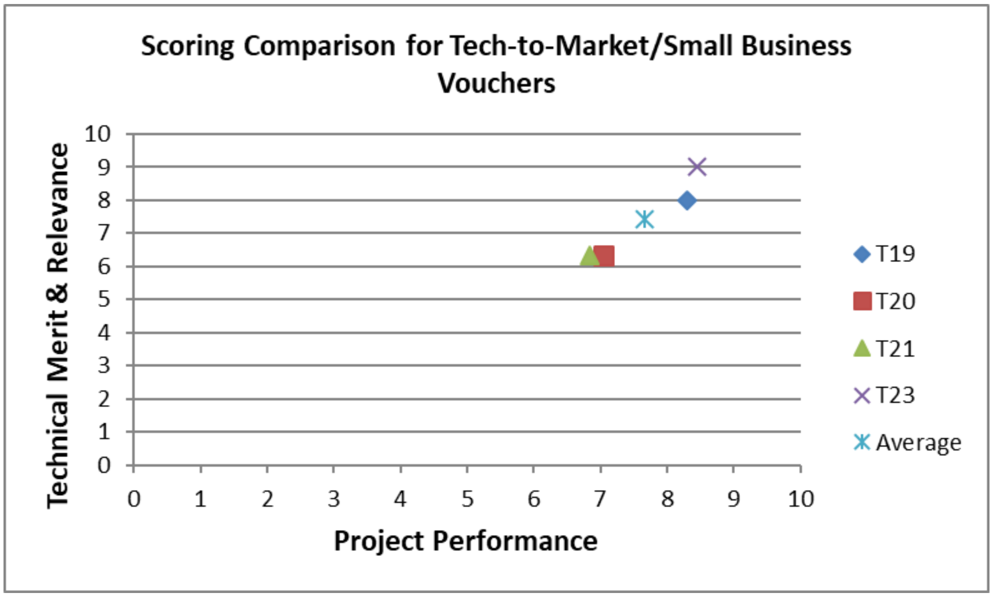
Unique ID: N/A	Lead: Michael Derby
WETO Program Area: Technology Development and Scientific Research	
Activity Level Budget (FY17 & FY18)	$1,772,082
Total Available Laboratory Project Budget	$1,772,082
Total Competitive Award Amount	$0
Total Competitive Award Cost Share	$0
Total Available Activity Level Budget	$1,772,082
Total Actual Costs	$1,511,894

Activity Area Description

Support and manage participation in two national lab focused programs: "Tech-to Market" which facilitates lab innovation by reducing barriers to market exploration; and the Small Business Vouchers program providing access to expertise and facilities of national labs for product development.

Project Scores within the Activity Area

This graph provides the relative scores for each project in the activity area—as well as the average for all projects in the activity area—with Weighted Average Project Performance on the X-Axis, and Technical Merit & Relevance on the Y-Axis.



List of Projects

Unique ID	Program	Project Name	PI	Organization	Budget	Actual Costs	Project Status
T19	Technology Development and Scientific Research	Small Business Vouchers - Micron/NIRE/SkySpecs	Joshua Paquette	SNL	$781,616	$781,616	Complete
T20	Technology Development and Scientific Research	Small Business Vouchers - Sentient	Brandon Ennis	SNL, NREL	$295,000	$181,497	Complete
T21	Technology Development and Scientific Research	Small Business Vouchers - Tower Technology	Garrett Barter	NREL	$170,000	$166,738	Complete
T23	Technology Development and Scientific Research	Technology to Market (T2M)	Alex Lemke	INL, NREL, PNNL, SNL	$525,466	$382,043	Active

Reviewer Responses and Comments: Technology to Market (Sub-activity 1)

1. Are the projects within this activity on the leading edge of work within this field?
    - This is a high-value project communicating and acting as the coordinator of industry and surveying the industry. DOE is in a unique position to coordinate industry technology focus through workshops. They are impactful and were very well organized and executed, resulting in both DOE and industry benefiting from direct feedback.

2. Has the rationale behind the funded activities and projects been effectively conveyed during the peer review?
    - This industry information-gathering is highly valuable to informing WETO's path forward; and overall, new technology to market is important, and it's important to understand where industry needs are.

3. Within this field, are thought leaders aware of the WETO-supported work?
    - The Wind Industry R&D survey seeks to identify what technology areas are important for R&D industry. This is important work, as it helps inform R&D efforts with industry needs.

4. Are there important topic areas that are underrepresented or missing within this activity area?
    - Consider communicating where potential financial benefit or total industry value was included in discussions.

5. Are there any notable strengths to the activity portfolio content or direction that you would like to point out?
    - Yes, the office does a good job at capturing inputs from the industry to better understand their R&D needs and challenges.
    - This approach is encouraging for reducing the gap between the private and public sectors and encourages them to collaborate on reducing LCOE.
    - The format of the summit and multiple presentations from differing views is a strong tool for communication. The involvement of all national laboratories is also a strong tool. The R&D survey adds similar broader value for input.

6. Are there any notable weaknesses to the activity portfolio content or direction that you would like to point out?
    - Sharing this publicly would allow for broader, non-participant feedback on the results. All communication appears to be internal, which materially decreases value.
    - It would be nice to see how the results from the survey and summit influenced the DOE roadmap or R&D focus. Recommend a continuation of building on the results of this project and make it a recurrent event.

7. What recommendations would you like to convey to the manager(s) of this activity area?
    - Findings of survey were conclusive and led to specific proposals for R&D. Barriers to successful technology transfers and areas of improvement were also identified.
    - Overall, this is a successful project and has yielded useful information for future R&D in specific technology areas. The areas identified are exciting and very forward looking.
    - The Wind Industry Partnership summit was well-organized, and engaging with industry through workshops is an excellent program and should be continued and expanded

further allowing strong communication and engagement with industry to obtain clear input for future DOE-led R&D.

Representative and Noteworthy Comments on Projects in Sub-Activity Area

Comments on Strengths (under any criterion)

- By bringing together wind industry executives and representatives from DOE and the national laboratories, these two activities offered a unique opportunity to network and engage in substantive discussions about how federally funded research can addresses the industry's R&D needs and challenges.
- Furthermore, the opportunity to gather information that directly addresses wind energy technology R&D activities that enable innovations needed to advance U.S. wind systems allowed the industry stakeholders to gain a better understanding of the DOE and national laboratory resources available to them.

Comments on Weaknesses (under any criterion)

- Sharing results publicly would allow for broader, non-participant feedback on the results. All communication appears to be internal, which materially decreases value.
- It would be nice to see how the results from the survey and summit influenced the DOE roadmap or R&D focus. Recommend continuing to build on the results of this project and to make it a recurrent event.

Recommendations

- A key driver is effective facilitation of technology handoffs, which suggests that we continue to focus on private-sector ease of access to both funding and lab resources and look to facilitation of outside the fence options.
- WETO can dive deeper into these topics and further refine survey insights and create new opportunities to convene industry representatives from across the value chain, including NGOs, who have an interest in better understanding issues related to wind deployment across the United States.
- There is an array of non-technical challenges to the shifting paradigm and future wind energy deployment that would benefit from national-level coordination where WETO is uniquely positioned to play a role. There are market acceleration and deployment challenges that these activities did not address but are deemed critical by industry stakeholders. There are coordination challenges in terms of planning, regulation and policy for electric system design, and operation where DOE, along with other agencies and organizations, could have a significant role. Future discussions will investigate the intersection of wind power industry R&D and technology development needs with DOE capabilities in wind energy technology.
- To address the short- and long-term challenges of wind energy development and operations, WETO should continue to provide wind power professionals the opportunity to share their insights on the technological, science, and deployment gaps that limit the growth of wind power capacity and generation and impede the enhancement of wind power technology and operations nationwide.

Reviewer Responses and Comments: Small Business Vouchers (Sub-activity 2)

1. Are the projects within this activity on the leading edge of work within this field?
    - Onsite manufacturing of concrete towers using a self-erecting system could be applicable to building tall towers that open up access to low-wind resource areas.
    - The projects are very relevant to help accelerate commercialization and maturation of this technology.
    - Tall tower technology is very relevant to the wind industry and has the potential to open new markets and lower LCOE.
    - Developing blade life predictive models is very relevant for the industry if it can replace the time consuming onsite visual inspections.

2. Has the rationale behind the funded activities and projects been effectively conveyed during the peer review?
    - The project team looked for innovative ways to share the information of the project while maintaining the protected nature of the work scope.

3. Within this field, are thought leaders aware of the WETO-supported work?
    - All projects were well structured and well executed. All showed clear progress toward real-world applications and demonstrate value creation for the industry; however, awareness of project existence is not widespread.

4. Are there important topic areas that are underrepresented or missing within this activity area?
    - One project was narrowly applicable to one company and one concrete tower approach. A tall tower study and/or a steel vs. concrete tower tradeoff would be more useful
    - The project was based on the premise that fatigue is a major cause of failure in wind plants. It is not clear, however, that this aligns with what plant operators experience in the field.
    - O&M using drones and artificial intelligence technology; Micron Optics fiber optic system installed and tested at the SWiFT facility; Grid controls for wind plants.

5. Are there any notable strengths to the activity portfolio content or direction that you would like to point out?
    - The SBV program is an opportunity to support short-term projects that capitalize on lab expertise.
    - All three small projects focusing on technology transfer to industry are highly relevant and clearly meet industry needs.
    - I find it relevant to support companies bridging from technology development to product development through the demonstration and validation of the technology.
    - Good progress was made in all three sub-projects of this project. Very promising results that could impact turbine inspections, turbine controls and sensing technologies, and grid controls for wind plants.
    - Operational fatigue data for a realistic turbine blade to improve detection models developed by Sentient. Project results could have a direct impact to help advance a small business. Project could be relevant to industry if repair and maintenance costs due to fatigue comprise a significant portion of O&M costs of a wind plant.

6. Are there any notable weaknesses to the activity portfolio content or direction that you would like to point out?
    - The economics and financial viability of some of these technology solutions need to be assessed prior to undertaking the research.
    - Infrared inspection has potential but needs lots of follow up to be successful. The industry is already using drone inspection and has used infrared inspection sensing as well.
    - I don't like that reports appear to lack commentary that goes beyond the selected partner. Example: Is there an inherent advantage or disadvantage with SkySpecs that makes it a better/worse platform for this type of inspection compared to industry alternatives? Adding that objective step back would complete the study and better enable the industry to advance with knowledge from the study.
    - Since the critical information obtained through this project was confidential, it had zero chance of adding value to the problem. Nothing in the applicant's information shows that the applicant is uniquely qualified to assist in or add value to solving this problem. The industry is already investing millions of private R&D funds into solving this problem. It is highly unlikely that a national lab will add value here.
    - While the work appears to have been done carefully, it is unclear that this project will have a real impact. Also, the fact that results cannot be disseminated openly makes it impossible to thoroughly assess what has been done. Such a project may not be suitable for funding by the program.
    - The applicant did not have a unique ability to add value to this problem, the data was kept confidential by the private company, and the efforts herein are de minimis compared to existing industry efforts. The project that resulted was effectively an equity contribution to a private party who took the knowledge and expanded their business in China. Nothing presented by the applicant justifies the cost.
    - Test conception by industry partner appears to be poorly conceived to validate their analytical technique.

7. What recommendations would you like to convey to the manager(s) of this activity area?
    - Technology transfer and commercialization should be more actively explored to ensure that these projects impact industry. For example, the grid integration project does not appear that it will make an impact as current PPA practices do not make it economically viable.
    - Consider integrating the improved tall tower trade off model into the balance of station model for use with different tower strategies.
    - General comments: A national lab is uniquely qualified to help create the model and resulting data set, so involvement makes sense. The model also has the potential to inform and encourage private research and advancement. The project test was not properly constructed. Not publishing the model, FEA, materials, etc. makes no sense and is not in the public interest. Nothing about the model is proprietary to the private partner. Had the model and results been shared publicly, the cost/benefit core would have been a 9.

<u>Representative and Noteworthy Comments on Projects in Activity Area</u>

Comments on Strengths (under any criterion)

- The SBV Program provided clean energy small businesses access to select national labs – making the contracting process simple, lab practices transparent, and access to the labs' unique facilities practical.

- Through SBV, selected small businesses received access to the state-of-the-art facilities and experts at participating DOE national labs, while the labs expanded their knowledge of and involvement with the private sector, helping small businesses with advanced technologies contribute to American competitiveness and economic growth.

Comments on Weaknesses (under any criterion)

- It is recognized that a mechanism to share critical information obtained though the SBV program should be communicated publicly and the results could have a direct impact to help advance a small business.

Activity Area Evaluation Results: Advanced Components, Reliability, & Manufacturing

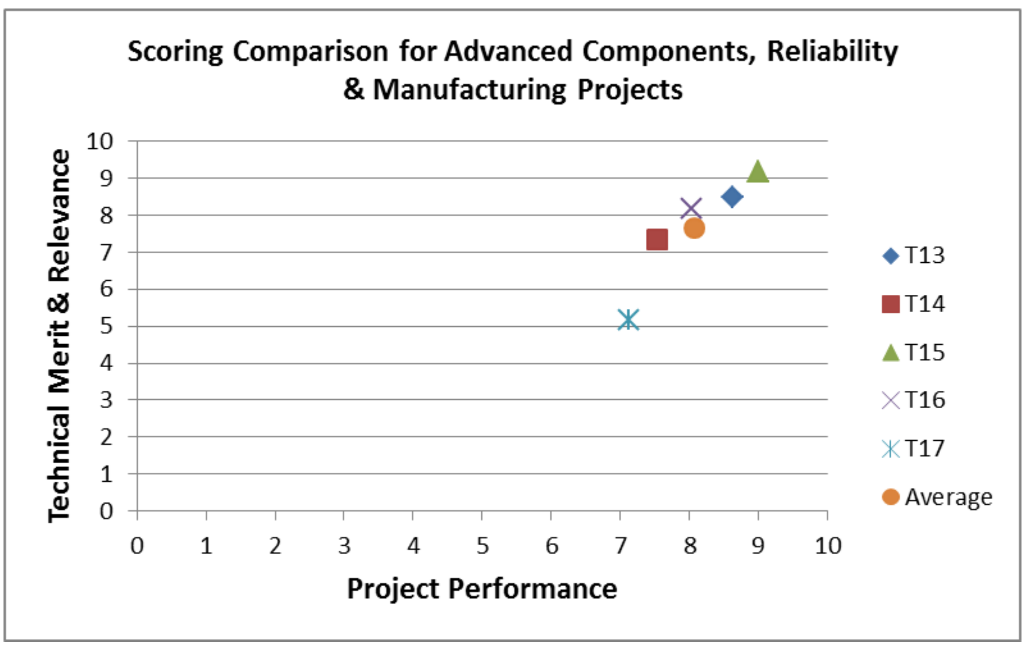
Unique ID: WETO A05	Lead: Michael Derby
WETO Program Area: Technology Development and Scientific Research	
Activity Level Budget (FY17 & FY18)	$10,026,333
Total Available Laboratory Project Budget	$10,026,333
Total Competitive Award Amount	$0
Total Competitive Award Cost Share	$0
Total Available Activity Level Budget	$10,026,333
Total Actual Costs	$6,778,182

Activity Area Description

Enable cost-effective wind energy nationwide through technology advances such as: taller towers and longer blades; overcoming transportation and logistics barriers; increasing domestic manufacturing with advanced components and materials; and improving reliability to lower maintenance costs.

Project Scores within the Activity Area

This graph provides the relative scores for each project in the activity area—as well as the average for all projects in the activity area—with *Weighted Average Project Performance* on the X-Axis, and T*echnical Merit & Relevance* on the Y-Axis.



List of Projects

Unique ID	Program	Project Name	PI	Organization	Budget	Actual Costs	Project Status
T13	Technology Development and Scientific Research	Additive Manufacturing in Wind Turbine Components and Tooling	Brian Post	NREL, ORNL	$694,295	$341,918	Active
T14	Technology Development and Scientific Research	Wind Turbine Blade Durability and Damage Tolerance	Joshua Paquette	SNL	$1,510,900	$1,117,524	Active
T15	Technology Development and Scientific Research	Wind Turbine Drivetrain Reliability	Jon Keller	ANL, NREL	$4,065,568	$3,475,387	Active
T16	Technology Development and Scientific Research	Optimized Carbon Fiber Composites for Wind Turbine Blades	Brandon Ennis	ORNL, SNL	$1,049,960	$775,585	Active
T17	Technology Development and Scientific Research	Big Adaptive Rotor	Joshua Paquette	SNL, NREL, LBNL, ORNL	$2,705,610	$1,067,768	Active

Reviewer Responses and Comments

1. Are the projects within this Activity on the leading edge of work within this field?

- This is a very high value project with multiple supported projects ranging from manufacturing innovation to improved reliability. This is one of the most productive areas of the WETO program. It funds strategic technology investigations that accelerate component development. The drive train reliability collaborative is one excellent example of continuous improvement that has improved industry's reliability
- Yes, I think this is leading edge from an industry perspective.
- In most areas, they are. The focus on tower and blade manufacturing is helping push the industry in the right areas. Although the reliability work around gearboxes is promising, I wonder if a slight tack may provide more help to the industry by lowering costs. Should we focus on technology to create lower cost repair solutions versus higher reliability?
- Yes. All projects in this activity are at the leading edge addressing major challenges in components, reliability and manufacturing. All in areas in which DOE must play a major role.
- Yes, especially the low-cost carbon fiber and 3D printed mold technology
- In most areas, yes. In other areas, this work is clearly behind (BAR).

2. Has the rationale behind the funded Activities and Projects been effectively conveyed during the peer review?

- Yes, it has indeed.
- Yes, the ties to the office objectives has been clear.
- Yes. Very well presented and articulated.
- Yes, the teams did a great job communicating the rationale behind their work.

- For the most part, yes, but not cohesively. It seems like the questions are "What are the big industry problems?" and "What is next big change?", but not all of the programs fit well into those categories. Several presenters struggled to articulate the question they were trying to answer and whether or not they actually answered that question.

3. Within this field, are thought leaders aware of the WETO-supported work?

- Excellent communication through reports and regular workshops.
- On the reliability side, communication has been clear. The manufacturing activities could use broader communication.
- Yes, DOE did a great job engaging the research and industry communities around funded research
- I personally was not aware of much of this research and that is surprising. It seems like this group is communicating well with the specific stakeholders it is targeting, but could communicate better with other stakeholders who may not be the anticipated counterparts, but may benefit from the value created by this activity.

4. Are there important topic areas that are underrepresented or missing within this Activity area?

- Perhaps more emphasis on accelerating the final resolution of the white etching problem in main bearings, and exploration of plain bearings for high load drive applications.
- I support more detailed evaluation of all the BAR options, such as advanced components.
- No, but industry input is urgently needed to guide certain projects.
- Stronger focus on structural testing programs of wind blades. This is an area were DOE can play a larger role to develop new test methods that can reduce testing time and cost.
- I think that power electronics (IGBTs), cable system fatigue, aging control systems, and tower/foundation life extension are the next big problems for the industry, yet these do not seem to be represented in any of the research.

5. Are there any notable strengths to the Activity portfolio content or direction that you would like to point out?

- The drive train reliability collaborative is an excellent project that should continue bear fruit for the industry.
- The additive manufacturing and gearbox projects are excellent. They highlight how DOE lab facilities can be brilliantly leveraged to solve problems that the industry cannot tackle, and break new ground that paves the way to onsite manufacturing.
- Excellent collaboration with industry.
- Bringing in the skills of other national labs is an excellent and high-value use of the activity. The ability to pull from other centers of excellence is way beyond the capability of the industry and has huge rewards (i.e., additive manufacturing, carbon fiber, material science for drive train).

6. Are there any notable weaknesses to the Activity portfolio content or direction that you would like to point out?

- The robotic blade inspection project appeared to lack a high-value result for the industry.
- Communication weaknesses.
- The BAR project may not be well advised. Industry is already building super large rotors.
- Encourage more collaboration with universities.
- Blade reliability is far more important in DW situations where turbines are located closer to populations. It seems like this group is responding well to known problems, but is not working on identifying the next systemic problem. While the surveys that the group conducted are valuable, they are a reflection of the present and not the future.

- The BAR program is behind industry and has already been well studied. There is no need for WETO involvement in a core area of market research. Focus on places the market is not incentivized to study.

7. What recommendations would you like to convey to the manager(s) of this Activity area?

- Continue to be open to new innovations to support and be prepared to adjust the balance of projects to fund high-value projects if necessary.
- Most of the work reported is impressive and should be expanded. Portfolio of activities should be driven by industry needs and some of the projects may not be appropriate for DOE investment.
- Keep focusing on effect of defects studies and ways to improve turbine reliability.
- Figure out what the next big problems are ahead of time. Focus on the NTP+10-, 15-, 20-, 30-year problems and how to get ahead of them.

Program Evaluation Results: Market Acceleration and Deployment

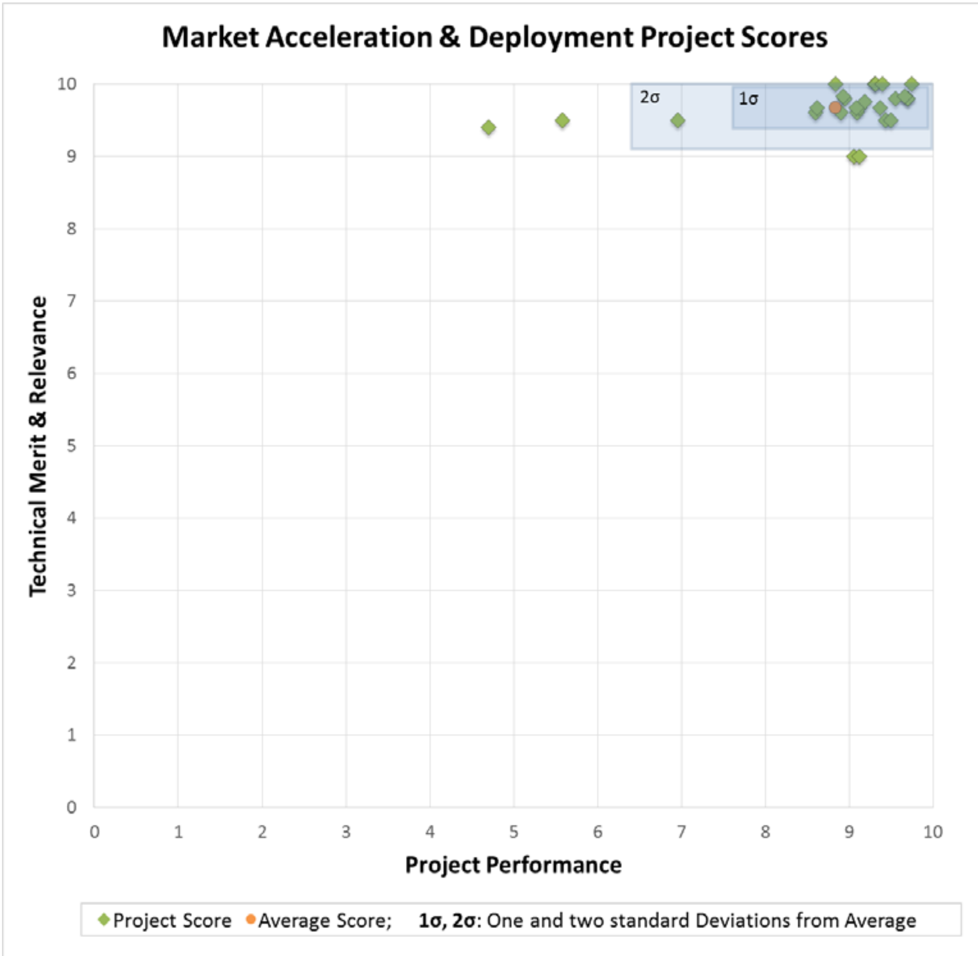
Unique ID: P02	Lead: Jocelyn Brown-Saracino
Program Level Budget (FY17 & FY18)	$33,673,508
Total Available Laboratory Project Budget	$28,563,809
Total Competitive Award Amount	$5,109,699
Total Competitive Award Cost Share	$5,915,337
Total Available Program Level Budget	$39,588,845
Total Actual Costs	$25,521,677

Project Description

The objective of this program is to reduce wind development barriers and preserve or expand access to quality wind resources. Research efforts result in tools to address wildlife, stakeholder, grid, and radar barriers to increase certainty for regulators, decrease risk for developers, and reduce cost of energy, leading to further deployment.

Project Scores within Program Area

This graph shows the relative scores of each project in the given Program area, as well as the average for all projects in the Program Area, with Weighted Average Project Performance on the X-Axis, and Technical Merit & Relevance on the Y-Axis. The boxes on the graph represent 1σ, and 2σ Standard Deviations from the mean average of all the scores.



Reviewer Responses and Comments

1. Are the Activities and Projects within this portfolio on the leading edge of work within this field?

- Absolutely. Projects within this program are directly relevant and helpful for reducing costs of wind energy and accelerating deployment opportunities. Conflicts arising from unaddressed wildlife issues, fumbled/insufficient stakeholder outreach, or a lack of local workforce engagement all drive up project costs and hold the industry back. Looking forward, it would be great to see DOE more clearly expand its scope to focus attention on these issues in the offshore context given how massive a clean energy opportunity it offers and how far we have to go in bringing it online at scale.
- The program covers Environmental impacts of bats and eagles, radar, public acceptance, workforce building, and grid integration. Most of the work presented is leading edge internationally, and, in several areas, DOE plays a vital role as a catalyst for the research.
- Yes. I believe the MA&D work is the leading edge of the work in the field and has helped significantly accelerate knowledge and investment by the private sector and others in this space.
- Yes, the activities are world class.
- Yes, the MA&D program is leading edge across a very dynamic and technical portfolio. This program is clearly leading the way in overcoming challenges associated with siting (wildlife, radar, social science) and transmission penetration. This program is leading the way in identifying the

cutting-edge strategies that will allow wind energy to deploy effectively. This work is necessary to drive down costs and expand areas viable for wind deployment.

2. Has the rationale behind the funded Activities and Projects been effectively conveyed during the peer review?

- Yes. It was very helpful to see the program overview slides up front so we could more effectively evaluate the projects relative to DOE's goals.
- The rationale of the program is very clear and focus areas have been chosen well.
- The drivers behind each of the projects has been very well communicated and is very clear
- Yes, all of the presentations were incredibly well done, and the rationale was communicated effectively.

3. Within this field, are thought leaders aware of the WETO-supported work?

- Yes. The wind-wildlife technology research is particularly valued in my field. Helping move the ball forward in identifying—and independently reviewing the performance of—wildlife detection and impact minimization strategies is critical for helping the industry overcome conflicts with wildlife, especially endangered species.
- The program is well connected with all stakeholders in the U.S. as well as internationally through IEA Wind Tasks.
- I'm not entirely certain that thought leaders in the industry are fully aware of all that WETO is doing in this space. Perhaps more could be done to promote the good efforts being undertaken by WETO.
- Yes. There is wide and effective engagement nationally and internationally to communicate the supported work, particularly through the work of WREN and engagement with IEA Wind Tasks and support of ESIG.
- Yes, the MA&D portfolio has done a tremendous job of communicating their work. More importantly, the portfolio integrates stakeholder outreach very seriously into the work across the portfolio. Every branch of this portfolio has its own well-run stakeholder outreach group (WTRIM, NWCC, ESIG, etc.). These working groups are critical to disseminating key information, leveraging resources, and driving outcomes.

4. Are there important topic areas that are underrepresented or missing within the Program?

- Offshore wind should take on an increasing focus in the years ahead. This technology holds great potential to generate a massive amount of local clean energy, produce hundreds of thousands of jobs, and bring in hundreds of millions of dollars to the federal government in the form of lease payments and rent of public waters offshore. Many challenges lie ahead in ramping up offshore wind energy, such as stakeholder concerns from fishermen to host communities for cables, significant but solvable marine wildlife impacts, and a need to rapidly but strategically develop a trained local workforce. Given that, DOE can and should play an important role in helping to accelerate the cost effective and responsible deployment of offshore wind in the U.S.
- Noise and public acceptance have somewhat low status. Barriers due to potential risks like ice throw are missing.
- The issue of grid infrastructure to support offshore wind is notably absent from the program
- More work has to be done for offshore wind across the portfolio. This technology will play a big role in future energy markets over the next decade, and we need to be laying the groundwork now to maximize this industry's full potential.

5. Are there any notable strengths to the Program portfolio content or direction that you would like to point out?

- It is really important to continue to have focus areas for environmental research, stakeholder engagement, and workforce development. These are the areas where major, often fatal, issues can come up for a project far too late in the game to be cost-effectively solved. We have all seen far too many projects delayed or blocked because of irreconcilable conflicts. Leaning into these issues and identifying strategic, precedent-setting opportunities to move the ball forward is an important role for DOE to continue playing.
- Radar, bats/birds, and integration all have excellent stakeholder networks involved that brings great impact to the activities.
- The MA&D portfolio is critical to the industry's future growth and success and WETO serves a critical role that cannot be replicated by others, particularly with radar mitigation and wildlife detection and deterrent system R&D efforts.
- WETO is playing a strong leadership role bringing multiple agencies and interests together to work constructively on a lot of issues.
- The level of national and international engagement is impressive, particularly the engagement with IEA Wind Tasks, ESIG, and IEEE
- The work in the wildlife space is impressive in its breadth, and also that it includes some very focused efforts on key challenges such as bat and bird mortality rates
- The grid integration work continues to make advances in key areas, particularly services from wind power technologies.
- The commitment, in general, to an open approach to tool development and modeling in the grid integration space.
- The strengths are many. This program particularly excels in playing a centralized role in understanding priority issues and advancing credible research to meet long term needs of the industry. The environmental research component of the portfolio has significantly advanced wind-wildlife co-existence and attracted significant matching funds. This work will surely bring significant cost savings for developers long-term and result in more efficient permitting by regulators.

6. Are there any notable weaknesses to the Program portfolio content or direction that you would like to point out?

- Yes, the limited consideration of offshore wind energy in projects with a broad focus and the overall lack of offshore wind specific projects in the portfolio. The need for technology solutions to wildlife conflicts offshore, as well as resources for effective and strategic stakeholder engagement efforts and workforce development initiatives, is significant.
- Public acceptance future topics need careful assessment of what to fund.
- Grid integration future topics need careful assessment of what to fund, how to fund it, and what can be realized through grid modernization activities in practice.
- The resources dedicated to distributed wind appear small in comparison the stated goal of making it competitive with solar. It may be that given developments in rooftop solar, distributed wind is not a strong competitor.
- More focus is needed for offshore wind.

7. What recommendations would you like to convey to the manager(s) of this program?

- DOE's WETO program plays a unique and essential role in advancing wind power for America. By focusing resources in key areas that can help reduce cost and smooth the pathway for successful projects, DOE is providing tremendous value for its investment. Looking forward, it will be great to see the program broaden its focus substantially to include offshore wind more prominently in the portfolio, given the scale of this untapped resource and the many unique economic and environmental benefits it can offer America. Done right, offshore wind power can launch a brand new U.S. industry that will bring hundreds of thousands of jobs all along the coast and inland across the local supply chain needed to support the development of such heavy energy infrastructure in our already crowded and vulnerable ocean.

- Keep up the proactive work in identifying the topics and communicating with stakeholders.
- Keep doing everything that you are doing and look for ways to promote the efforts so that the industry and general public are fully informed of all the great effort to date.
- WETO support appears to have had and is having a strong impact on the competitiveness of wind power technology. As higher penetrations are achieved nationally, operational issues in the grid integration space will require a lot more attention and this should be considered going forwards.
- Great job on managing a very diverse, highly technical portfolio. The research that DOE is investing in is yielding significant returns on investment for taxpayers.

Activity Area Evaluation Results: Stakeholder Engagement, Workforce Development, And Human Use Considerations

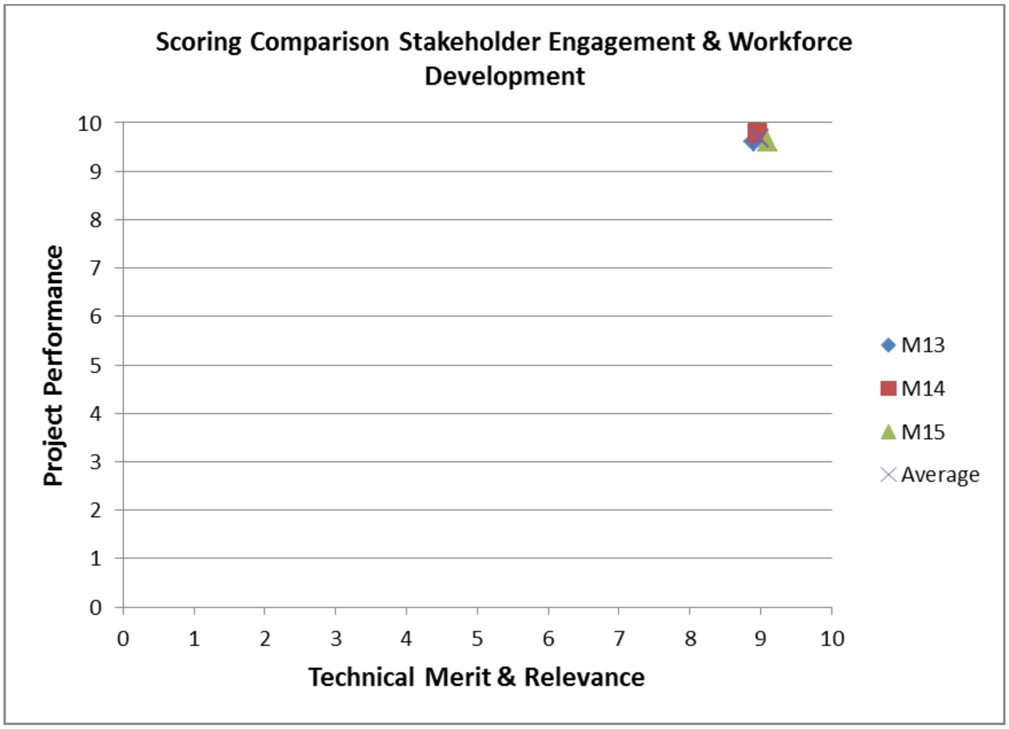
Unique ID: WETO A04	Lead: Jocelyn Brown-Saracino
WETO Program Area: Market Acceleration and Deployment	
Activity Level Budget (FY17 & FY18)	$9,287,942
Total Available Laboratory Project Budget	$9,287,942
Total Competitive Award Amount	$0
Total Competitive Award Cost Share	$0
Total Available Activity Level Budget	$9,287,942
Total Actual Costs	$5,853,246

Activity Area Description

To provide credible, unbiased information regarding wind energy, this activity supports the development and dissemination of economic, workforce, and academic programs regarding the benefits and impacts of wind energy, including community level planning and workforce development support through educational outreach efforts.

Project Scores within the Activity Area

This graph provides the relative scores for each project in the activity area—as well as the average for all projects in the activity area—with *Weighted Average Project Performance* on the X-Axis, and T*echnical Merit & Relevance* on the Y-Axis.



List of Projects

Unique ID	Program	Project Name	PI	Organization	Budget	Actual Costs	Project Status
M13	Market Acceleration and Deployment	WindExchange and Regional Resource Center	Ian Baring-Gould	NREL	$3,088,735	$2,213,842	Active
M14	Market Acceleration and Deployment	Collegiate Wind Competition	Ian Baring-Gould	NREL	$3,490,665	$1,815,696	Active
M15	Market Acceleration and Deployment	Wind for Schools	Ian Baring-Gould	NREL	$ 2,708,542	$1,823,708	Active

Reviewer Responses and Comments

1. Are the projects within this Activity on the leading edge of work within this field?

- Yes, however, expansion to include offshore wind would be greatly valuable.
- The projects address getting unbiased information to the local stakeholders to help deployment of wind, as well as developing the future workforce for U.S. wind industry. Both topics are addressed with internationally high performance.
- As best as I can tell, they are. While not reducing the industry LCOE or addressing technology needs, the work by WETO in this space is important to the continued stable growth and future of the industry. Further, I believe DOE/WETO has a unique role to play in the stakeholder engagement, workforce development, and human use considerations arenas, and those efforts are not duplicative nor would they be undertaken by any other organization.

- The need to engage the future workforce is well recognized
- The collegiate wind competition is a high impact activity utilizing state of the art facilities to leave a lasting impression on students.
- Some projects, such as Wind for Schools, WINDExchange, and Regional Resource centers, have a huge target audience with relatively small funding. It is worth considering if the scale and focus of these efforts is sufficient to achieve their goals.
- Projects targeting younger children need to be long-term in nature, and it is worth considering if the mechanisms in place can support this.
- Yes, this program really takes advantage of the three primary strengths of DOE: its reputation as an unbiased provider of information, its strength as a convener, and its ability to take a longer-term vision that is typically a challenge for industry.
- The DOE WindExchange has built tools and economic models that do not exist anywhere else. No other entity has the credibility or knowledge to assemble this data. Similarly, the RRCs are a unique entity that can provide the relationship building and tools necessary to address barriers.

2. Has the rationale behind the funded Activities and Projects been effectively conveyed during the peer review?

- This activity is tackling both the need to provide information to areas close to potential wind sites and the U.S. workforce experience difficulties.
- The rationale for all projects is very clear. There are no projects here where one is wondering where the value is. More often, it is the reverse case, where the activity is well perceived as being very valuable but of a scale where it is struggling to have the desired magnitude of impact.
- Yes, the team did a great job conveying not only the rationale, but the various and diverse strategies and tactics employed to achieve goals.

3. Within this field, are thought leaders aware of the WETO-supported work?

- Yes, the thought leaders are aware.
- Regional centers have made good outreach, and workforce development has contacts with industry.
- I am not sure they are. It would likely be worthwhile to pull together a meeting/summit to discuss who is doing what in the space, gather more input on what role DOE/WETO can/should be playing, and assess whether or not any of these efforts started by WETO would survive without continued DOE support.
- These activities are regional and domestic by nature. Increased interaction with the Department of Education may help achieve a wider reach.
- Yes, the outreach, communication and engagement of this work has been incredibly effective.

4. Are there important topic areas that are underrepresented or missing within this Activity area?

- Offshore wind is an underrepresented area.
- Regional centers do not reach all states of the U.S. and have been stopped. This may present problems for local stakeholder outreach.
- As noted in my review of the Collegiate Wind Competition, I believe there is a missing component of connecting the participating students with potential employers. More needs to be done to coordinate between AWEA and companies (OEMs and developers/owner-operators) to create opportunities for engagement at WINDPOWER or between competition years.
- Perhaps a general, broader focused effort at fostering a more positive attitude towards wind power in younger children.
- No, but regional engagement going forward is a strong need.

5. Are there any notable strengths to the Activity portfolio content or direction that you would like to point out?

- Excellent work in building web-based information systems for both WindExchange and courses for schools/colleges/universities.
- Good strategy for WindExchange to improve outreach by networks.
- This program is well designed and serves an important role in the development of young minds potentially entering the wind energy field. While not a cost-lowering or technology-based activity, this is a unique and important role for the DOE/WETO, and one unlikely to be fully replaced by others if future funding is not provided. I encourage leadership to find ways of continuing to support this work.
- The level of collaboration and personal energy that is directed into these efforts by passionate people. Particularly notable in this regard is the Collegiate Wind Power Competition.
- The collaboration and commitment to these programs are clearly one of their biggest strengths. They also fill key needs, enhancing the resources and tools of regulators, policy makers, and educators, which play a huge role in the acceleration of wind energy.

6. Are there any notable weaknesses to the Activity portfolio content or direction that you would like to point out?

- Lack of offshore wind-specific projects.
- Reaching local stakeholders, students entering the industry, and the public in general remains a challenge. New strategies are needed.
- Perhaps the one weakness is the scale of some efforts which may need to be ramped up for the desired impact. In particular, the Wind for Schools program, WindExchange, and the Regional Resource Centers.
- Advancing a larger strategy for workforce development is necessary, including increasing industry's engagement in these programs. Also, the future gap in regional on-the-ground engagement is of concern.

7. What recommendations would you like to convey to the manager(s) of this Activity area?

- This is such important and inspiring work! Helping to bring people into these critical careers has so many benefits, including bringing down costs long term as a more mature local workforce is established. Further, local information—both about wind energy opportunities as well as potential conflicts and stakeholder engagement needs—is essential for adding value to the very complex dynamics surrounding wind energy development and the many issues holding back its development. While the RRCs didn't succeed as a concept, continued efforts along these lines to help bring credible, helpful information about wind power to stakeholders and state energy decision makers is urgently needed.
- Reaching local stakeholders and the general public remains a challenge. Maybe the regional centers need to be revisited, unless other new ideas emerge.
- There still seem to lack of BS-level students reaching the industry. Collaboration between universities to share courses may be needed. Reach out to students and the industry to make sure they know about the efforts to increase wind-related education.
- This program is well designed and serves an important role in the development of young minds potentially entering the wind energy field. While not a cost-lowering or technology-based activity, this is a unique and important role for the DOE/WETO, and one unlikely to be fully replaced by others if future funding is not provided. I encourage leadership to find ways of continuing to support this work.

- The level of passion and energy from all involved is palpable. Perhaps this needs to be rewarded with more resources.
- Identify a strategy for regional engagement.
- Develop a more holistic strategy for workforce development with strong partnerships with industry, states, utilities, universities, etc.

Activity Area Evaluation Results: Environmental Research

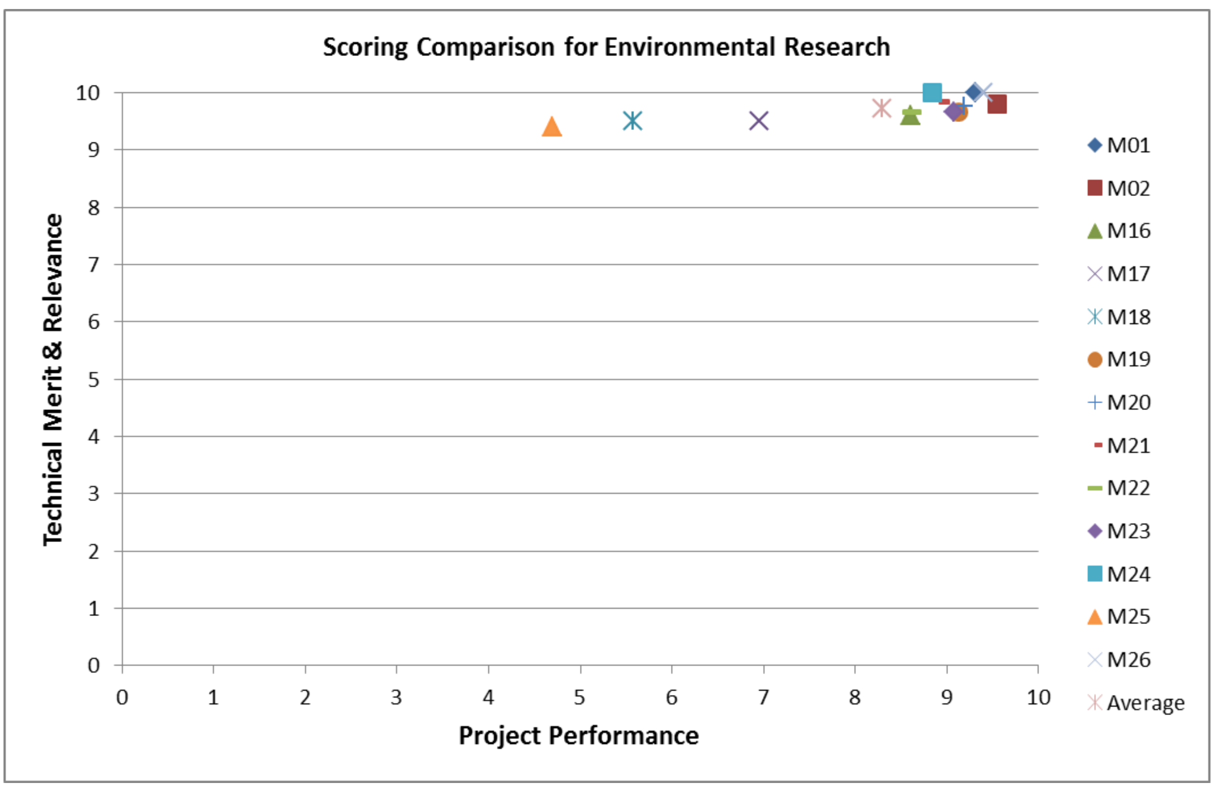
Unique ID: WETO A03	Lead: Brown-Saracino
WETO Program Area: Market Acceleration and Deployment	
Activity Level Budget (FY17 & FY18)	$10,504,541
Total Available Laboratory Project Budget	$5,394,842
Total Competitive Award Amount	$5,109,699
Total Competitive Award Cost Share	$5,915,337
Total Available Activity Level Budget	$16,419,878
Total Actual Costs	$9,594,337

Activity Area Description

The goal of this activity is to reduce wildlife barriers to wind deployment by developing informed technical solutions to wildlife impacts. The focus is on data collection and experimentation, development of wildlife monitoring and mitigation technologies, and the synthesis and sharing of results.

Project Scores within the Activity Area

This graph provides the relative scores for each project in the activity area—as well as the average for all projects in the activity area—with *Weighted Average Project Performance* on the X-Axis, and T*echnical Merit & Relevance* on the Y-Axis.



List of Projects

Unique ID	Program	Project Name	PI	Organization	Budget	Actual Costs	Project Status
M01	Market Acceleration and Deployment	Wind Operational Issue Mitigation	Cris Hein	NREL	$3,510,820	$1,534,460	Active
M02	Market Acceleration and Deployment	Wind Operational Issue Mitigation	Alicia Gorton	PNNL	$1,884,022	$992,108	Active
M16	Market Acceleration and Deployment	Biomimetic Ultrasonic Whistle for Use as a Bat Deterrent on Wind Turbines	Paul Sievert	University of Massachusetts - Amherst	$312,184	$282,363	Active
M17	Market Acceleration and Deployment	Texturizing Wind Turbine Towers to Reduce Bat Mortality	Victoria Bennet	Texas Christian University	$486,958	$486,958	Complete
M18	Market Acceleration and Deployment	Rotor-Mounted Bat Impact Mitigation System	David Cooper	Frontier Wind	$327,700	$327,700	Active
M19	Market Acceleration and Deployment	Ultrasonic Bat Deterrent Technology	Kevin Kinzie	General Electric Company - GE Power & Water	$1,464,087	$1,464,087	Complete
M20	Market Acceleration and Deployment	Evaluating the Effectiveness of Ultrasonic Acoustic Deterrents in Reducing Bat Fatalities at Wind Energy Facilities	Michael Schirm acher	Bat Conservation International	$3,086,323	$3,066,231	Active
M21	Market Acceleration and Deployment	Evaluating the Effectiveness of a Camera-Based Detection System to Support Informed Curtailment and Minimize Eagle Fatalities at Wind Energy Facilities	Taber Allison	American Wind Wildlife Institute	$1,735,391	$105,556	Active
M22	Market Acceleration and	Detection and Perception of Sound by	Jeffrey Marr	University of Minnesota	$333,660	$333,660	Active

	Deployment	Eagles and Surrogate Raptors					
M23	Market Acceleration and Deployment	Understanding the Golden Eagle Sensory World to Enhance Detection and Response to Wind Turbines	Esteban Fernandez-Juricic	Purdue University	$375,000	$242,849	Active
M24	Market Acceleration and Deployment	Evaluating the Effectiveness of a Detection and Deterrent System in Reducing Golden Eagle Fatalities at Operational Wind Facilities	Taber Allison	American Wind Wildlife Institute	$1,368,271	$177,547	Active
M25	Market Acceleration and Deployment	Eagle Take Minimization System	Eric Lauger	Laufer Wind Group, LLC	$578,598	$274,825	Active
M26	Market Acceleration and Deployment	Heterogeneous System for Eagle Detection, Deterrent, and Wildlife Collision Detection for Wind Turbines	Roberto Albertani	Oregon State University	$600,399	$305,993	Active

Reviewer Responses and Comments

1. Are the projects within this Activity on the leading edge of work within this field?

- Yes, however expansion to include offshore wind would be greatly valuable.
- DOE shows great leadership in the environmental impact research for wind power. Coordinating information collection and summaries in IEA Wind Task 34 and Bats and Eagles FOAs are giving the world new information on environmental impact mitigation.
- I absolutely believe so. The efforts of the program in this field has helped spur private sector investment and led to a rapid increase in knowledge on technology like detection and deterrent systems, which had made little advancement for years prior to DOE's involvement/investment.
- The general feeling is yes. Each of these projects is pushing forward the state of the art in different and, in some cases, overlapping domains.
- The activity as a whole supports a wide range of projects tackling different and overlapping aspects of the wildlife impacts issue. In general, the projects are complimentary and the focus consistent with the program objectives.

- Over the last two years, DOE has implemented and managed an impressive program of research. DOE has undoubtedly done more for advancing wind-wildlife co-existence than any other agency, federal or non-governmental. They have leveraged their strengths of being a credible, science-driven resource that can think longer-term to advance important research and new technologies that will advance deployment and reduce costs.
- Because of DOE's investment in this space, we now have the following outcomes:
    - At least one commercialized deterrent technology that developers are entering into with real contracts
    - The swift commercialization of Identiflight
    - An AWEA wildlife research fund (DOE showed that these investments can pay off)
    - A better understanding of eagle biology, a critical step to advancing deterrents
    - An educated and engaged stakeholder community.

2. Has the rationale behind the funded Activities and Projects been effectively conveyed during the peer review?

- All projects funded are investments most cost-efficiently made in the U.S. and will help deployment and reduce the costs for developing projects. The work really helps to bring forward environmental mitigation.
- Yes, the rationale behind all these projects is very clear. There are no projects in the activity where one is wondering if they should have been supported or not.
- Yes, the presentations were incredibly well done throughout.

3. Within this field, are thought leaders aware of the WETO-supported work?

- Yes, the thought leaders are aware.
- Yes, through nationally excellent networking and international work leading the IEA Wind Task.
- I would encourage broader self-promoting to ensure the industry and other stakeholders are acutely aware of everything being done in this space.
- Yes. Particularly in the international collaborations such as WREN, it is abundantly clear that the U.S. are thought leaders in this space, and most appear to be engaged with WETO-supported work at some level, across interest groups, industry, and academia.
- Yes. DOE has wisely included meaningful investments in stakeholder collaboration and communication to complement their research FOAs. These include BWEC, and NWCC under the land-based collaborative. This is a brilliant and well thought out strategy since the constraints surrounding wind and wildlife are much more nuanced and complicated than solely technology-related operational issues. In the technology and development space, if you increase capacity, or advance cost-effective technology solutions, there’s typically an inevitable market that will sprout. This is not the case for wind and wildlife. Often times, a marketplace in this space depends on the USFWS to drive the market through regulation because regulatory risk (rather than direct profit) is often the business reason to implement technologies or solutions. Accordingly, there could be a very effective technology available, but if it isn't 100% effective, then the technology needs to be integrated with a permitting/regulatory compliance mechanism given the risk of unlawful take.
- Moreover, understanding wildlife risk, often requires an understanding of the various other threats across the landscape. Because wind turbines are large, and the fatalities are so tangible (in contrast with more typical development-related threats such as habitat destruction) that their impact becomes a focus of communities, NGOs, and regulators even if their impact to a species is negligible.

- So the solutions in this space require so much more than simply advancing a technology. They require stakeholder buy in, fact-based communication, and a better understanding of biological processes, populations, and landscape threats.
- DOE cannot do this alone, but it has done a great job of centralizing these questions among a variety of diverse, sophisticated stakeholders and bringing a much-needed objectivity to the questions and solutions. It also has demonstrated how these programs can achieve success and have spurred so much action as a result of its leadership.

4. Are there important topic areas that are underrepresented or missing within this Activity area?

- Offshore wind.
- Protecting birds and wildlife species beyond eagles
- The focus is moving a bit towards offshore in FY2019, which is a good trend to continue.
- Fundamental research was carried out in this activity to better understand and characterize eagle hearing, vocalizing, visual abilities, and responses to stimuli. This has greatly increased the understanding of eagles and their interactions with and around turbines, which will greatly help direct the work on deterrents. It appears that this work is somewhat lacking on the bat front, where the efforts appear a little less directed and results less effective.
- Yes, prairie grouse and offshore wind energy have not received enough focused investments over the last 2-3 years. An invigorated focus is necessary.
- Supporting an NWCC for offshore should be a priority for the near-term future. Similar to the land-based experience, by kickstarting a collaborative, DOE can set the stage and be the catalyst for the future AWWIs and BWEC in the offshore space. Integrating with the fishing community should be considered when evaluating any future stakeholder group.
- More investment needs to be made in understanding risk, both quantitatively and qualitatively. For non-listed species, studies should be designed to better understand and communicate risks in terms of population-level impacts. To do this we need to enhance our monitoring capabilities offshore. North Atlantic right whales are also a priority issue to get in front of. While the wind industry is not responsible for their current perilous state, there is concern that it may disproportionately bear the brunt of their very imperiled status.
- A grouse assessment and strategy should be developed. In the interim, federal agencies and states are taking a precautionary approach and this can affect deployment opportunities in the absence of facts.
- More understanding of bat population size is important. For migratory, tree-roosting bats, this means supporting basic genetics studies.

5. Are there any notable strengths to the Activity portfolio content or direction that you would like to point out?

- Good work to screen what species need more work and checking potential issues internationally. Excellent forming of networks like National Wind Coordinating Collaborative and bats and birds' collaboratives to get stakeholders together. Helping to get access to turbines and wind power plants to test new environmental devices is valuable. Health benefits of wind are important to assess and disseminate.
- Regarding eagles, both mid TRL solutions and validation of higher TRL technology. Also, work on ability to sense and respond is important as the experience from bat projects show. And regarding bats, the activity has helped renew interest in work on deterrents, testing systems, and improving them (GE and NRG).
- Learning of knowledge gaps, like species that are difficult to influence with deterrents.
- The MA&D work is outstanding and I have no doubt it will lead to the reductions in deployment barriers and LCOE.

- The level of collaboration across industry, interest groups, and academia is world-class and truly impressive.
- The range of projects supported is impressive. Seeing how various projects have influenced one another points to the considered nature of the effort
- The eagle deterrent verification work points to a level of maturity of the effort where reliance on such systems can be considered.
- The fact that some projects failed actually suggests that a portfolio of risk was accepted and that overall it was balanced.
- DOE's foresight and strategy has been invaluable to this space. DOE has been a true visionary leader in advancing solutions and has done a good job of thinking about this portfolio holistically.

6. Are there any notable weaknesses to the Activity portfolio content or direction that you would like to point out?

- Lack of offshore wind-specific projects.
- Some projects of smaller enterprises did not manage to conclude their projects as planned. But that can be argued not to be a real drawback, as it was difficult to screen beforehand which would make it, the projects were not high in spending, and the work may be taken by others.
- At the end of the Eagle FOA, it would be great to see a summary of different approaches to tracking, and a comparison between deterrent and curtailment approaches to mitigation. Something similar perhaps would also work for bat projects.
- Some projects involving field deployment failed at this stage. Project M20 mitigated this issue by way of functional tests where the performance of turbine-mounted devices was tested prior to full scale deployment for field tests. This allowed issues to be identified and corrected prior to the field test phase. This lesson should be kept in mind for future work of this nature.

7. What recommendations would you like to convey to the manager(s) of this Activity area?

- It would be really great to see this portfolio expand given how significantly wildlife conflicts can either block, delay, or increase the cost of wind projects. Research to help advance solutions for wind-wildlife conflicts is critical for helping reduce obstacles—and therefore costs—to wind energy deployment both on and offshore.
- More on mitigation and basic population type of work funded elsewhere should be reconsidered in future. The big picture is important to get for dissemination of results, like how endangered the species are. The work for mitigation probably works for other birds as well so the work on eagles is very relevant.
- For communication, perhaps it’s not wise to highlight that eagles are a big problem if they actually are not.
- The first ideas for bat deterrents may not be the best ones in how effectively they work, but knowledge about their responses may prove useful in future work.
- Cost analysis of mitigation would be great to see when more project results cumulate, including a summary of costs for all phases.
- Could different parts of the mitigation measures be used in other projects? For example, could PNNL remote avian monitoring be used instead of radars and cameras, in more cost-efficient way?
- At the end of the Eagle FOA, it would be great to see a summary of different approaches to tracking, and a comparison between deterrent and curtailment approaches to mitigation. Something similar perhaps would also work for bat projects.

- Hopefully the ideas and materials of some of the small enterprises that did not manage to fulfill their projects could be acquired by someone else. Partnering with national labs to get support and avoid stopping promising projects may help at least to some extent.
- Review project plans to ensure separate functional tests are carried out where this is appropriate prior to full scale deployment for field tests
- Consider recommending partnering for smaller companies
- Consider a project to harvest maximum value from failed projects.
- Building off the success to date, identify priorities under a more holistic, results-chain-driven strategy for solving these complex nuanced issues.
- For example, for migratory-tree roosting bats, the development of a curtailment technology will not lead us to the collective goal of wind migratory bat co-existence on its own. This is because developers struggle to think long-term under profit-driven constraints, and, in the absence of a regulatory mandate, it will be challenging to get all of the developers to work together and voluntarily invest in a solution. And the solution will require an industry-wide approach.
- If we map out future success for overcoming concerns for hoary bats, for example, we first need to understand the level of population impacts to the species. Then we need to understand targets for the industry to meet in order to achieve what is deemed success. Understanding this will require scientists and academic study. From there, we need a regulatory vehicle to incentivize all developers to come to the table (whether through policy incentives or an actual requirement). This will require USFWS and state agency buy-in. We will also need to validate the technology in various landscapes and understand effectiveness, which will require third-party validators and industry test sites. Finally, we will need a communication and collaboration strategy to increase industry participation and get stakeholder buy-in. While not all of these actions should be funded by DOE, DOE's investments and efforts should acknowledge and consider how these consecutive results are interdependent and keep an eye on the final goal. Doing this will help DOE understand the context of their work and how they can most strategically and quickly overcome deployment barriers. In addition, this context can help its PIs better brainstorm the final application of their technology or information gathering so they can best tailor methodologies to what is needed long-term.
- DOE should not hesitate to engage in areas that extend beyond simple technology innovation, such as genetics studies for bats. DOE serves the unbiased role that many other federal agencies can't. And in this area, improving our basic understanding of wildlife biology is a critical step to reducing costs and overcoming barriers.
- DOE can play an important role in communicating facts and overcoming myths. Similar to the barotrauma paper, an effort to put eagle fatalities in context of other threats and conservation goals would be valuable. Instead of spending millions of dollars on deterrents, some of these funds may be better spent on compensatory mitigation from both a cost- and conservation- perspective.
- It is important that meaningful peer review and standardization be applied on the front end of large projects. Again, these issues are complex and multi-faceted, so the more collaboration and scrutiny on the front end will surely improve outcomes. In addition, the challenges of moving these technologies from the lab to the field was an apparent theme throughout this peer review. DOE should host a session where researchers can share their experiences and lessons learned.
- More agency engagement, communication, and coordination with USFWS and state regulators would be helpful.
- For offshore, a focus on long-term strategies and future solutions is critical to get in front of the challenges that have been experienced in the land-based context. All research investments should be made in mind of the intended endpoint.

Activity Area Evaluation Results: Siting and Wind Radar Mitigation

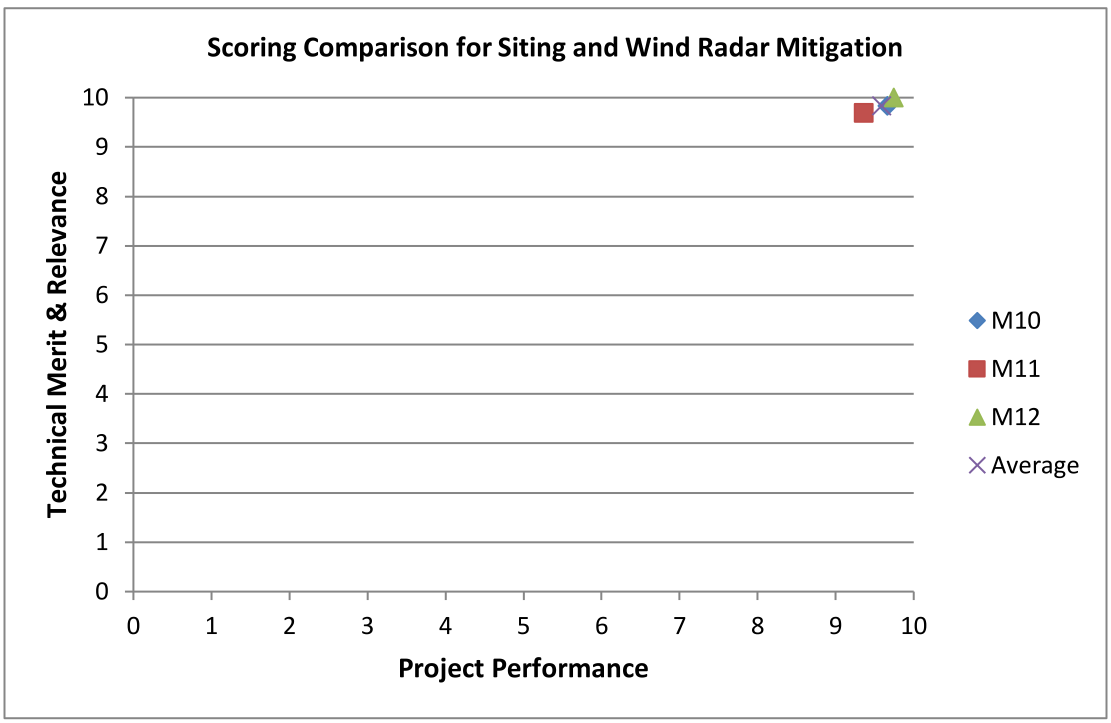
Unique ID: WETO A01	Lead: Jocelyn Brown-Saracino
WETO Program Area: Market Acceleration and Deployment	
Activity Level Budget (FY17 & FY18)	$4,483,827
Total Available Laboratory Project Budget	$4,483,827
Total Competitive Award Amount	$0
Total Competitive Award Cost Share	$0
Total Available Activity Level Budget	$4,483,827
Total Actual Costs	$2,505,152

Activity Area Description

To address conflicts between existing weather, air surveillance radar systems, and wind energy. The goal of this activity is to eliminate critical wind turbine radar interference, ensure the long-term resilience of radar operations in the presence of wind turbines, and remove radar interference as an impediment to future wind energy development.

Project Scores within the Activity Area

This graph provides the relative scores for each project in the activity area—as well as the average for all projects in the activity area—with *Weighted Average Project Performance* on the X-Axis, and T*echnical Merit & Relevance* on the Y-Axis.



List of Projects

Unique ID	Program	Project Name	PI	Organization	Budget	Actual Costs	Project Status
M10	Market Acceleration and Deployment	Siting - Radar Wind-Turbine Radar Cross-	Benjamin Karlson	SNL	$ 1,501,084	$1,125,521	Active

		Section Mitigation					
M11	Market Acceleration and Deployment	Siting - Wind Turbine Radar Interference Mitigation R&D	Jason Biddle	MIT Lincoln Labs	$1,768,294	$792,794	Active
M12	Market Acceleration and Deployment	National Wind Turbine Database and Location Impacts R&D	Ben Hoen	LBNL	$ 1,214,449	$586,837	Active

Reviewer Responses and Comments

1. Are the projects within this Activity on the leading edge of work within this field?
- Yes, in the case of radar interference, which were the only projects I reviewed in this category.
- Yes, incredibly innovative range of interesting and valuable projects.
- The radar impact mitigation is internationally at the leading edge.
- The public acceptance survey had a great general coverage of the U.S. and provided material for interesting work.

2. Has the rationale behind the funded Activities and Projects been effectively conveyed during the peer review?
- Yes, the presentations have been incredibly well done and informative.
- The two projects on radar and one more general on public acceptance had clear focus.

3. Within this field, are thought leaders aware of the WETO-supported work?
- Yes, the thought leaders are aware.
- Generally, yes, especially in the social science research and the National Wind Turbine database. The WTRIM working group is also an impressive work group and presents an important opportunity for agency stakeholders to collaborate, share ideas, and advance solutions.
- Radar work has very good coverage of national stakeholders and is disseminated internationally through IEA Wind.
- I believe so, but there could always be more communication with leaders in the wind industry, conservation community, and regulatory agencies to ensure that folks are fully aware of everything DOE is doing in this space.

4. Are there important topic areas that are underrepresented or missing within this Activity area?
- Offshore wind.
- More effort should be focused offshore across the various projects (mitigating radar siting barriers, social science, turbine location, etc.).
- Public acceptance topic including noise could have more weight. Screening of other potential barriers and risks like ice throw could be added.

5. Are there any notable strengths to the Activity portfolio content or direction that you would like to point out?

- The WTRIM, Turbine location database, and the social science research all produced such incredibly valuable outputs. I highlight these three efforts in particular since this is work product where DOE is really the only entity that could have produced such credible outputs.
- The various approaches that DOE is taking to address radar barriers is also important. Like most problems, a range of tools will be needed to address challenges across circumstances.
- The radar impact mitigation is proceeding well and is making important advancements.
- I think all the work is top notch and appreciate WETO undertaking and continuing to advance this critical work.

6. Are there any notable weaknesses to the Activity portfolio content or direction that you would like to point out?

- Lack of offshore wind-specific projects
- Addressing public acceptance with noise issues is important to capture for future work.

7. What recommendations would you like to convey to the manager(s) of this Activity area?

- Tackling siting issues that have broad applicability for multiple regions (i.e., radar) is valuable.
- Keep advancing the social science research to ask new questions and address local concerns. Local opposition is a growing barrier for siting. Understanding this opposition will be the first step to address siting challenges.
- The WTRIM is just as important as the research. Continue providing this forum and when possible engage the industry as you did with the Travis Air Force Base pilot projects.
- Identifying and supporting additional pilot projects with DOD bases should also be a priority.
- Keep doing everything you are doing in this space. Only recommendation is, to the extent you can, do more! In order to get at the answers we have all been seeking about radar-based siting impacts, I believe a "moon mission" type approach with higher funding levels and more aggressive timelines is needed.

Activity Area Evaluation Results: Advanced Grid Integration

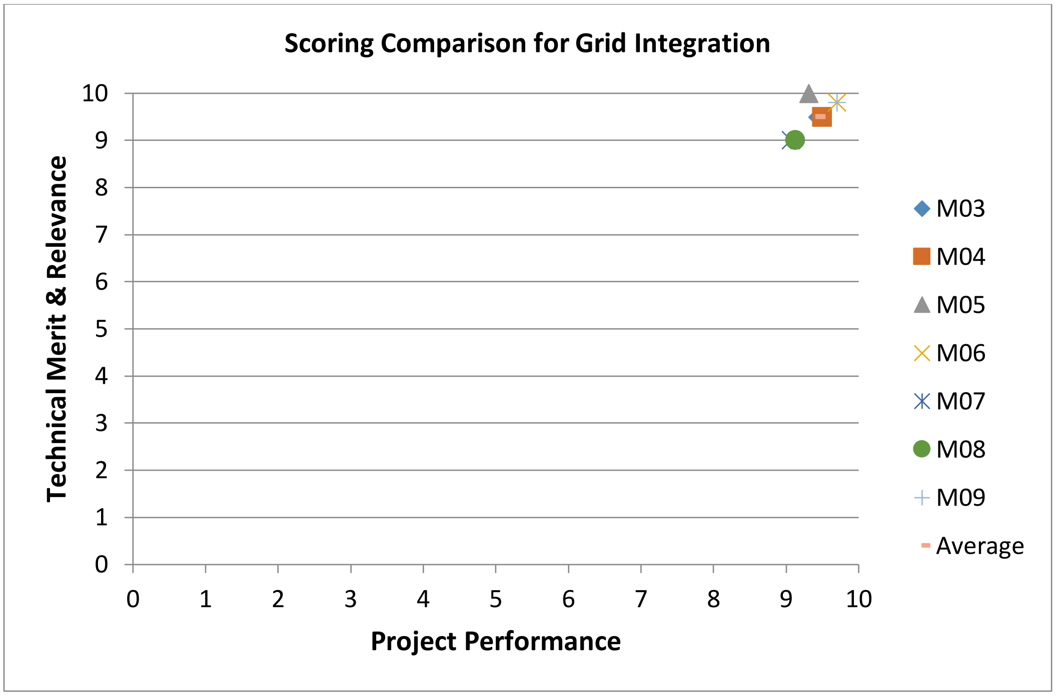
Unique ID: WETO A02	Lead: Jocelyn Brown-Saracino
WETO Program Area: Market Acceleration and Deployment	
Activity Level Budget (FY17 & FY18)	$9,397,198
Total Available Laboratory Project Budget	$9,397,198
Total Competitive Award Amount	$0
Total Competitive Award Cost Share	$0
Total Available Activity Level Budget	$9,397,198
Total Actual Costs	$7,568,942

Activity Area Description

The goal of this activity is to ensure the economic, reliable, and secure operation and planning of wind energy on the power grid through projects that address the reliability of wind energy integration, assess the value of ancillary wind energy services, and enhance power system operational flexibility.

Project Scores within the Activity Area

This graph provides the relative scores for each project in the activity area—as well as the average for all projects in the activity area—with *Weighted Average Project Performance* on the X-Axis, and T*echnical Merit & Relevance* on the Y-Axis.



List of Projects

Unique ID	Program	Project Name	PI	Organization	Budget	Actual Costs	Project Status
M03	Market Acceleration and Deployment	Operational and Strategic Implementation of Dynamic Line Rating for Optimized Wind Energy Generation Integration	Jake Gentle	INL	$1,606,371	$1,365,416	Completed
M04	Market Acceleration and Deployment	Market and Reliability Opportunities for Wind on the Bulk Power System	Jessica Lau	ANL, NREL	$1,349,127	$1,211,827	Completed
M05	Market Acceleration and Deployment	North American Renewable Integration Study	Greg Brinkman	NREL	$1,392,086	$796,483	Active
M06	Market Acceleration and Deployment	Power System Reliable Integration Support to Achieve Large Amounts of Wind Power (PRISALA)	Dave Corbus	NREL	$1,065,537	$934,696	Completed
M07	Market	Providing	Bri	NREL	$1,205,649	$1,018,257	Completed

	Acceleration and Deployment	Ramping Service with Wind to Enhance Power System Operational Flexibility	Mathias Hodge				
M08	Market Acceleration and Deployment	WindView: An Open Platform for Wind Energy Forecast Visualization	Bri Mathias Hodge	ANL, NREL	$1,168,518	$1,036,439	Completed
M09	Market Acceleration and Deployment	Understandin g the Role of Short-term Energy Storage and Large Motor Loads for Active Power Controls by Wind Power	Vahan Gevorgian	INL	$1,609,910	$1,205,824	Completed

Reviewer Responses and Comments

1. Are the projects within this Activity on the leading edge of work within this field?

- Yes. It is incredibly helpful to provide stakeholders and energy planners alike with credible information about how integration of renewable energy and wind specifically will impact the grid and ratepayers, etc. However, none of the projects take a meaningful approach to analyzing offshore wind in this context.
- For East Coast states that will be bringing over 20 GW online in the next 15 years, that seems like a glaring hole that will compromise all results in this category.
- Several very good projects funded in the grid integration activity were producing internationally leading research results.
- While I am not a subject matter expert on grid integration, this body of work is impressive and I believe does represent the leading edge of work in this field.
- Yes, in general, projects are following and/or establishing the state of the art in this area.
- Yes, the projects are incredibly innovative, and it is clear that the research funded by DOE is leading the way to better understanding how high penetrations of wind can be integrated into the grid. It not only evaluates feasibility of high wind energy penetration but also how wind energy can provide benefits to the existing grid.

2. Has the rationale behind the funded Activities and Projects been effectively conveyed during the peer review?

- A good overall set of projects addressing all topical issues in grid integration.
- Yes, the rationale is abundantly clear for all the projects which each address highly relevant issues.
- Yes, the projects were well presented.

3. Within this field, are thought leaders aware of the WETO-supported work?

- Most of the work is widely disseminated through international conferences, networks, and standardization forum.
- Yes, through ESIG and IEA Task 25 there is very good visibility of the DOE-supported work both domestically and internationally.
- Yes, there has been a variety of strong collaboration efforts including ESIG, various technical advisory groups, trainings, and conferences.

4. Are there important topic areas that are underrepresented or missing within this Activity area?

- Offshore wind is an area that is underrepresented.
- There do not appear to be any activities in the Energy Systems Integration (ESI) space. It is acknowledged that this is not a wind-specific research area, but it is very significantly driven by increased VRE ambitions. The SIP lab-directed research project at NREL is an example of something in this space that has the potential to add greatly to the WETO work by development of more agile models with greater sectoral scope. ESI and increased electrification can help mitigate the decreasing marginal cost of wind power issue identified in Ryan Wiser's work.
- There is much activity internationally looking towards 100% renewable and inverter-based power systems. This gives rise to a lot of interesting research questions that demand advanced tools and capabilities to address. In particular, the NWTC is an invaluable asset when it comes to addressing such topics. There are fundamental questions to be addressed in this space and DOE-funded labs could contribute enormously.
- In relation to offshore wind power, much of the discussion in Europe is focused around the shared grid infrastructure that is necessary to exploit offshore wind power potential. Unlike onshore wind where grid is mostly a shared asset, offshore wind power requires extensive dedicated grid infrastructure to support. It does not appear that this aspect of offshore is being considered at present.
- More analysis regarding the implications of the integration of offshore wind energy is needed.

5. Are there any notable strengths to the Activity portfolio content or direction that you would like to point out?

- Stakeholder outreach as a separate project is a good approach.
- Using the NREL test site for world leading development and validation work, combining lab tests virtually with other test sites in the U.S. and Europe.
- Developing tools to assess market design issues of future and large integration studies.
- Addressing control room practical issues with visualization techniques in collaboration with control room staff.
- The research leveraging NWTC testing facilities is particularly notable and directly addresses knowledge gaps that are impeding use of the full range of services that wind power can provide.
- The range of projects is wide and diverse.
- Having personally seen a need through my own involvement in ESIG, it’s impressive to see work in the forecast visualization space that’s very focused, specific, and of such high quality (WindView).
- The NARIS is impressive in terms of the progression across all aspects of the study, including the models, the data, the scope of the study, and the levels of VRE studied.
- The activities of ESIG have a high degree of impact in the industry and make an important link between the lab research and the frontline experience. This appears to work in both directions. The WindView project is a nice example of this.
- The support of IEA Wind Task 25 gives great international visibility of the work that DOE is supporting.

- The Dynamic Line Rating work has the potential to deliver significant additional transmission capacity for a relatively small investment.
- I was particularly impressed with the research into understanding wind energy's contributions to the grid, including transmission line cooling, ramping, and APC demonstrations.

6. Are there any notable weaknesses to the Activity portfolio content or direction that you would like to point out?

- Lack of offshore wind-specific projects.
- A gap is forming from this work ending now, and the next phase of projects not yet known.
- Plexos and ReEDS are used extensively to address these studies. Is there a need to focus on a modeling capability that is more nimble, the development of which is more under the control of the labs so that state of the art developments can be applied to meet emerging research needs?
- There are limitations to studying capacity expansion (e.g., ReEDS) and operations (e.g., Plexos) separately. For example, curtailment is not generally well captured in capacity expansion models which generally have reduced operational detail and limited chronology. Therefore, the value of variable renewable generation is often overestimated and the value of flexible resources is often underestimated. This is particularly an issue in high VRE scenarios.
- The representation of uncertainty in much of the modeling is quite limited. From what I understand, it is usually captured by use of reserves. Particularly in high VRE, explicit modeling of uncertainty using stochastic optimization can reveal increased needs for flexibility for shorter-term system balancing. Explicit representation of uncertainty is particularly important when issues of flexibility and curtailment are being addressed.
- It should be noted that these comments are mostly forward looking and mostly relevant when looking towards high VRE scenarios.

7. What recommendations would you like to convey to the manager(s) of this Activity area?

- Helping energy policy makers and planners better understand what is needed, and where, to significantly ramp up wind energy on the grid (including offshore wind in the analysis!) is essential work that no state, region, or utility can do credibly. This is a key value-add role for DOE.
- I hope that the good work can continue, and if the GMI will not bring new funding opportunities, then hopefully the wind program can take the wind related work forward.
- Especially interesting would be to see:
  - An offshore integration study at least for Eastern Interconnect.
  - Work targeting market design recommendations for wind/solar heavy systems.
- A look at how to manage hours of surplus energy from wind/solar in future systems (grid forming)
- Transmission planning. If anything like we see in Europe, this may cause a potential delay of deployment. Getting dynamic line rating to be used in transmission grids will help to get there, but transmission planning may also be addressed.
- While not within my typical area of knowledge, this work seems incredibly important to wind energy's integration in the grid. The work undertaken by WETO is well-structured and valuable. Keep up the great work.
- Consider looking at projects in the ESI and 100% renewable/inverter space.
- Consider direct investment in future modeling capability. In particular, look at explicit representation of uncertainty and consideration of increased operational detail in long term models
- Look at the grid aspect of offshore wind power deployment.

Program Evaluation Results: Analysis and Modeling

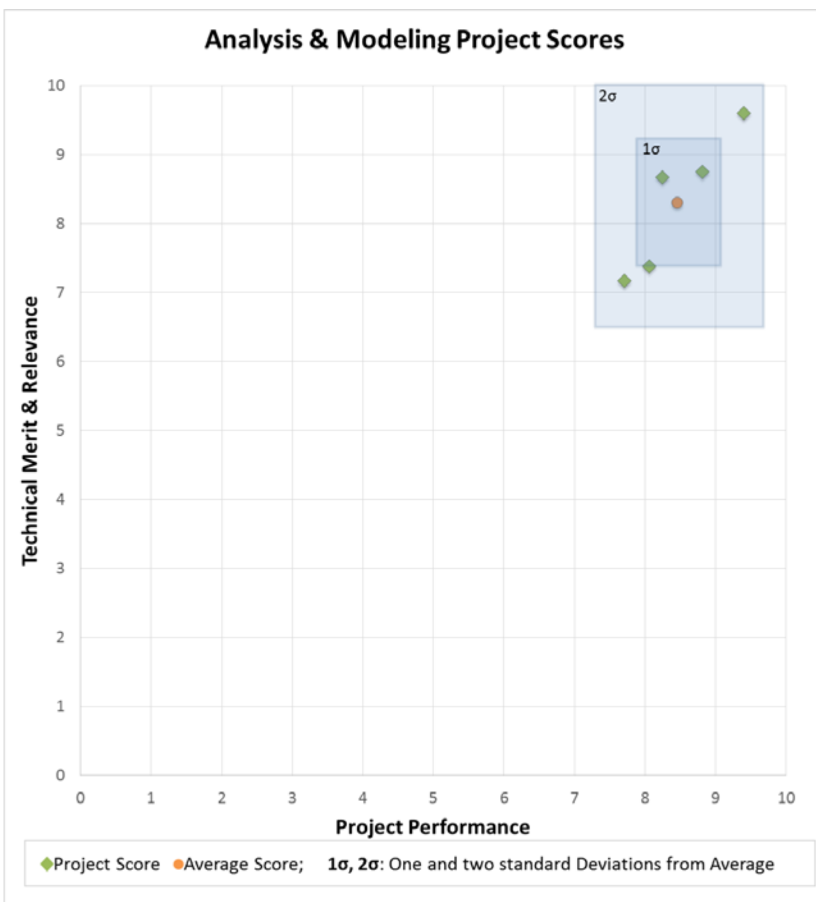
Unique ID: P0	Lead: Patrick Gilman
Program Level Budget (FY17 & FY18)	$11,391,339
Total Available Laboratory Project Budget	$11,391,339
Total Competitive Award Amount	$0
Total Competitive Award Cost Share	$0
Total Available Program Level Budget	$11,391,339
Total Actual Costs	$7,711,757

Project Description

Supports collection, analysis, and reporting of market data, R&D investment impacts, and strategic wind energy futures to ensure WETO 1) sets robust goals and tracks progress, 2) makes decisions based on a robust analytical foundation; and 3) maintains deep insight into wind's role in the electricity sector.

Project Scores within Program Area

This graph shows the relative scores of each project in the given Program area, as well as the average for all projects in the Program Area, with *Weighted Average Project Performance* on the X-Axis, and *Technical Merit & Relevance* on the Y-Axis. The boxes on the graph represent 1σ, and 2σ Standard Deviations from the mean average of all the scores.



Reviewer Responses and Comments

1. Are the Activities and Projects within this portfolio on the leading edge of work within this field?

- Yes, however expansion to include offshore wind would be greatly valuable.
- The most important and lasting contribution to wind technology and industry advancement is advancing analysis and modeling techniques and tools. This part of the WETO program spearheads that with a broad range of projects that collectively contribute to the advancing technical foundation of the industry. The industry depends on the products of this program. Academia also depends on it in educating the next generation of professionals.
- No. The work is important and time-critical, but appears to be standard activities that could be accomplished or already known (albeit, not in the public sphere) by others.
- The projects include analyses that provide new information to the field, internationally.
- Yes. The work being done in the areas of high-fidelity modeling and efficient computing is definitely at the cutting edge of technology.
- Yes, they provide valuable data collection and analysis that only this program can do.
- Yes, in general the analysis and modeling capability at the national laboratories is state of the art.
- Yes, the forward looking/driven analysis is leading our understanding of wind energy's potential and the various factors that contribute to maximizing wind energy's future potential. This is particularly the case in grid integration, resilience, and reliability as this is one of the largest barriers for advancing responsible deployment quickly.

2. Has the rationale behind the funded Activities and Projects been effectively conveyed during the peer review?

- Yes, the rationale has.
- The rationale for the funding is well described by each of the individual projects.
- In general, yes. Several of the projects though did not have a good tie.
- Analyses projects provide important information on the status and trends of different fields of wind power, both directly to DoE and to all stakeholders.
- Yes. The "Why" or the objective of the funded activities was clearly communicated.
- Yes, the goals are clear.
- Yes, in all cases the relevance and rationale for projects is very clear.
- Yes, strong presentations summarizing the value of this work.

3. Within this field, are thought leaders aware of the WETO-supported work?

- Yes, the thought leaders are aware.
- The thought leaders are aware of all the projects and respect the technical expertise of WETO leadership.
- Yes, thought leaders are aware.
- The yearly reports have attracted a wide audience globally.
- Yes. Many leaders in the industry are aware of this program and the research associated with it.
- Yes, the reports are well received and used by the industry.
- Through IEA Task 25, IEEE, and ESIG in particular, the supported work is well disseminated nationally and internationally

- Yes, DOE has done a tremendous job of circulating its well written reports and summaries broadly.

4. Are there important topic areas that are underrepresented or missing within the Program?

- Offshore wind is an underrepresented area.
- All important areas are represented.
- Changing topics cover many individual topics, sometimes including barriers may be useful.
- No area is under-represented
- I think that workforce and turbine safety issues should be included in the collection and reporting. I think that capturing systemic safety issues within a report would provide valuable insight to focus future research. For example:
    - How many turbines experienced a blade failure this year?
    - How many turbines experienced a serial defect this year?
    - How many workers died constructing wind turbines this year?
    - How many workers died operating wind turbines this year?
    - How many arc flash incidents were there this year and why?
- This information directly supports the mission of the Office.
- Some areas which may warrant study in this area are as follows:
    - Flexibility adequacy of systems under high RES-E penetration scenarios, particularly arising from uncertainty and variability.
    - Offshore grid infrastructure to support offshore wind power deployment.
- More analysis and synthesis on the state of offshore wind energy is needed, as well as understanding the predicted make up of land-based versus offshore wind and the time scale. Achieving wind deployment targets will require a better understanding of the offshore market and grid integration.

5. Are there any notable strengths to the Program portfolio content or direction that you would like to point out?

- A2e is a notable strength and well-recognized part of the program.
- The computational analysis capabilities of the DOE and labs are impressive.
- The markets and costs are well covered. Work includes also analyses of benefits that is very good.
- The national lab has amazing computing capabilities that should continue to be leveraged. Open source codes are a good focus.
- It seems the program work is excellent and the efforts of the team are viewed very favorably by AWEA and others in the industry.
- The capability of and cooperation between the national labs to deliver on complex studies and modeling needs is very impressive.
- The open approach to tool development, along with wide dissemination of methodologies and results, is a key strength.
- All work appears to be rigorous and to a very high standard.
- The market reports are incredibly well done and such an important resource and culmination of impressive analyses. Additionally, transmission-related open-source models are helping to reduce transmission-related barriers for wind energy deployment. Understanding the various public health benefits of wind innovation pathways also allows policy makers to better see the context of their investments from a broader cost benefit standpoint. The regionalized nature of this report may also benefit states and regions that are currently out of attainment for some of these pollutants as they develop their state implementation plans under the clean air act (and potentially support higher RPS targets from a policy perspective).

6. Are there any notable weaknesses to the Program portfolio content or direction that you would like to point out?

- Lack of offshore wind-specific projects.
- The content of different projects seems a bit overlapping and confusing at first, but, in the actual work, there is no significant overlap. Instead, there's very good collaboration between national laboratories. The challenge is mainly in how to communicate each project's topics in a coordinated manner.
- The definition of high-fidelity modeling needs to be better defined.
- Not sure if this is a weakness, but the reliance on Plexos for carrying out some of this work may become limiting over the longer term. Perhaps it is worth considering utilization of other models at least to compliment the analysis.
- More analysis with respect to offshore wind energy is needed.

7. What recommendations would you like to convey to the manager(s) of this program?

- Projects like the National Offshore Wind Strategy provide great value for stakeholders and policy makers alike. They are examples of work that DOE is uniquely suited to do.
- Consistent funding, especially for engineering model advancement and collaboration with high-fidelity modeling to inform the latter.
- Keep up the good work! The market reports are excellent and the global outreach is outstanding.
- The program has the right focus. Make sure the project team works close together to avoid duplicate work.
- FAST is a great tool and should continue to be supported.
- Figure out what DW is so that the reporting and analysis have more direct value. Include safety in all the reports.
- Support efforts to develop fundamental modeling capabilities particularly to address challenges associated with very high penetrations of wind power.
- Examine system flexibility requirements in very high wind power scenarios with explicit consideration of uncertainty.
- Continue the impressive work, and the analyses completed under this team is really valuable for a diverse range of stakeholders. The details in these reports matter a lot for decision making.

9 Complete Project Evaluation Results

Technology Development Projects:

Project Results - Offshore Specific R&D

Offshore Resource Characterization

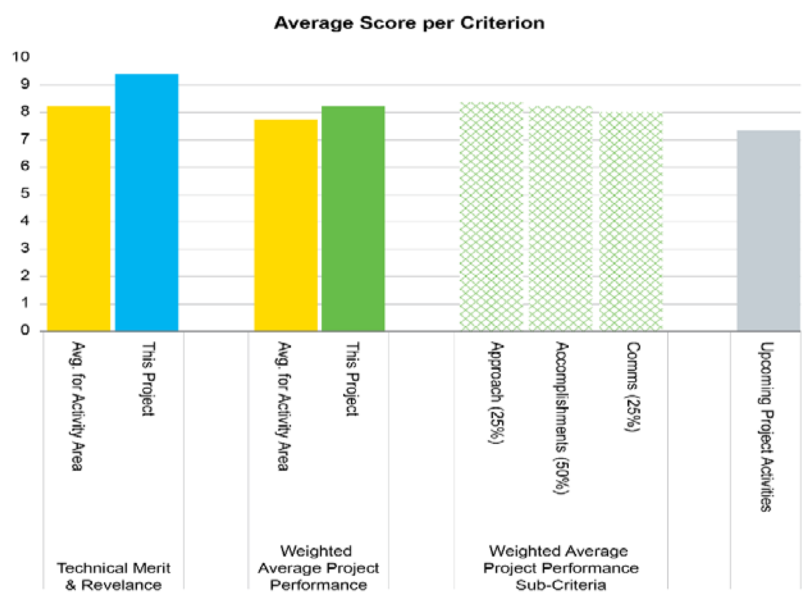
PI: Will Shaw	Unique Project ID: T12
Organization: PNNL	WETO Program: Technology Development and Scientific Research
Project Status: Active	WETO Activity Area: Offshore Specific R&D
Total Available Budget (FY17 & FY18):	$3,899,785
Actual Costs (FY17 & FY18):	$592,066

Project Description

This project enables effective deployment of DOE's two AXYS WindSentinel LiDAR buoys and the collection of hub-height offshore wind data, as well as data on other important site-specific meteorological and water conditions. Data are stored in the Data Archive and Portal developed under the A2e Initiative and freely disseminated to interested parties.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Very industry-relevant.
- The stated goal should assist offshore wind by providing high-fidelity resource information to development.
- The project will yield offshore wind and wave resource assessment data that will be invaluable to offshore wind development. Such data sets are sparse and the project will fill a major need and contribute to advancing the state of the art.
- This research has tremendous merit to the offshore industry. Wind resource characterization is essential for future model validation and demonstration activities.
- This is excellent for the industry and is highly cost effective.
- Validated floating offshore data buoy is critical for site assessment of offshore. This project develops and validates a mature system and informs partner agencies of offshore site conditions. Low-level jets discovered could significantly change design requirements and economics.
- Replacement of the weak LiDAR with a strong signal/noise LiDAR is a valuable upgrade.

Comments on Weaknesses

- Only one buoy is in use. How can DOE encourage more use and perhaps more buoy deployment?

Approach and Methodology

Comments on Strengths

- Cost-effective solution with LiDAR buoys.
- Buoy mounted LiDARs are used for wind, wave, temperature, salinity, and various other data measurements. Wind data is to be collected up to hub height. The plan for year-long deployment is a major strength of this project. Analyzing the data using theory of ocean/atmosphere coupling will help understand the physics and generalize findings.
- Strong plan in place. Strong team was in place. Strong coordination with other agencies.
- Buoy loan program with BOEM is an excellent idea.

Comments on Weaknesses

- I don't believe the approach with just two LiDARs and the later "loan" is sufficient to capture wind data offshore for the proper planning of projects.
- Only two buoys developed. Initial cost of around $1.3M per buoy.
- The project has struggled with sensing due to low power. The lessons learned are in themselves valuable. The project seems to have struggled with getting industry participation for the loan program. I am not sure that a reason for this struggle has been identified or articulated and this is critical to long-term success. It seems like this program should be able to do real-time, high-resolution collection at minimal additional cost.

Accomplishments and Progress

Comments on Strengths

- Two deployments have occurred. Buoys were deployed and recovered, and data was saved and analyzed. Buoy loan program is a great option developed.
- Significant data sets have already been collected at the Virginia and New Jersey sites. Over 15 months of data at each site can provide a wealth of information for atmospheric modelers.
- Obtaining the first full-year wind roses for the East Coast is a major accomplishment of this project.

- The team has engaged in careful analysis to ensure the quality of data and to correct for spurious signal-to-noise ratios.
- The project is going well as planned.

Comments on Weaknesses

- I don’t believe the approach with just two LiDARs and the later "loan" is sufficient to capture wind data offshore for the proper planning of projects.
- The lack of full analysis is less than ideal. This program seems to have struggled to get industry support.

Communication

Comments on Strengths

- It seems that the communication of the project has been done very broadly.
- Web pages and presentations are completed.
- Conference presentations and online material are strong.
- Good amount of presentations.

Comments on Weaknesses

- I would expect peer-reviewed journal papers from a project of this caliber.

Upcoming Project Activities

Comments on Strengths

- Project plan is described in detail.
- A clear plan is presented for collecting more data and more analysis.

Comments on Weaknesses

- It is assessed that the extent of the measurement program is not ambitious enough.
- More buoys will greatly augment the impact of this work.
- I think that this program needs to have a better self-directed vision and rely less on industry cooperation for the time being. Developing a plan to gather data in the 10–15 highest value areas and publishing and sharing that plan seem like a far better direction than trying to operate a loan program. The modification of the vision would speed up this program and produce more value.
- Are there plans for second buoy deployment?

Recommendations (Not Scored)

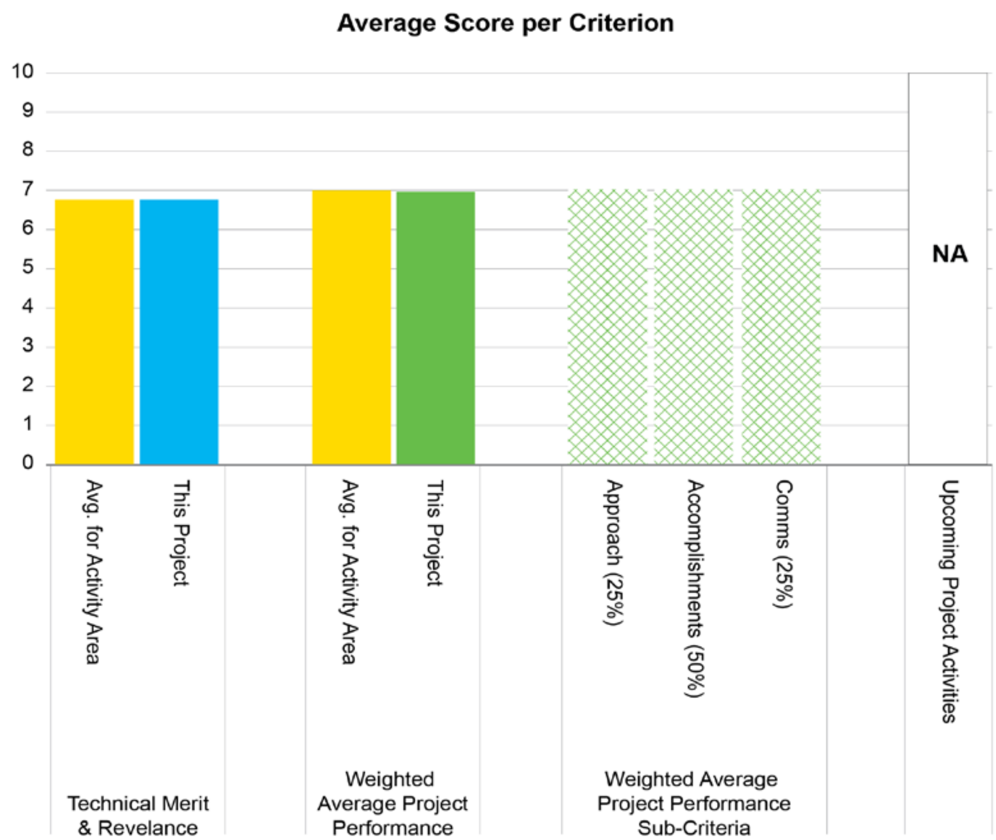
- I have scored the relevance of this project as very, very high as the measurement of wind data is key to the successful development of the offshore wind power industry in United States.
- Provide funding to develop another six more advanced (radar, etc.) buoys.
- This project is yielding important data sets for atmospheric modelers. If anything, the work should be expanded to other sites and coupled with mesoscale and high-fidelity models.
- This is a great and needed program. I think the approach of trying to work with industry and to run a loan program detracts from the value. If this was reframed as "map the U.S. offshore wind resource,” it would be far more valuable. The investment is easily justified, and the program can easily look at adding more buoys and starting to gather as much data as possible in an organized fashion.
- This program does not need industry cooperation as it currently views it. Industry will use the data to justify its own future investment.
- Continue with the program. Deploy at ongoing DOE-funded project sites like UMaine or other floating offshore sites.

Cost of Energy reduction for offshore Tension Leg Platform (TLP) wind turbine systems through advanced control strategies for energy yield improvement, load mitigation and stabilization

PI: Dhiraj Arora	Unique Project ID: T25
Organization: General Electric	WETO Program: Technology Development and Scientific Research
Project Status: Completed	WETO Activity Area: Offshore Specific R&D
Award Amount	$3,339,345
Cost Share	$1,077,881
Total Project Budget	$4,417,226
Actual Costs	$4,402,983

Project Description
Cost of Energy reduction for offshore Tension Leg Platform (TLP) wind turbine systems through advanced control strategies for energy yield improvement, load mitigation, and stabilization.

Project Scoring
Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Goals of lowering cost and reducing technical barriers to floating platforms.
- The project seeks to evaluate control strategies for reducing LCOE for floating platforms and turbines. Highly relevant to industry and at the leading edge of the state of the art.
- This research clearly advances the state of the art. All of the areas studied under this project have the potential to create value for the industry through direct innovation.
- Excellent use of FAST and BLADED on PelaStar TLP to simulate floating system loads and control impact. Use of onshore GE turbine to validate modeling is innovative.
- This is primarily an offshore controls optimization study applied to a TLP. Can the results be applied to other types of floating platforms?

Comments on Weaknesses

- It can be questioned whether product improvement of a specific WTG type and TPL concept is research that has industry-wide relevance and impact.
- Cost reduction goal of 5% seems very conservative.
- For the project to yield relevant results, it should demonstrate controls strategies for conditions relevant to offshore wind.
- I question the selection of these specific topics relative to others. Clarity on how these topics were selected would be valuable. This does not relate well to industry needs.
- Has a cost comparison between TLP and other floating options been completed?
- What are cost driving components of the TLP (vertical anchors systems, tendons, buoyancy structure)? Do these major components put the TLP at a fundamental disadvantage?

Approach and Methodology

Comments on Strengths

- Appropriate processes for simulation and validation planned.
- Controls-based approach was proposed, validated with latest simulation models of DOE. Also, various damping methods.
- Various control approaches were implemented and evaluated.
- FAST modeling and high-fidelity models were used along with field measurements on onshore turbines.
- The methods used for specific sub elements of this process appear reasonable.
- Good mix of analysis tools and experimental validation.
- The control optimization results will be applicable to types of floating platforms other than TLPs. This is a positive thing because TLP may not be cost-effective, but other types of platforms could still use the results.

Comments on Weaknesses

- Wave effects and non-linear FSI due to coupled ocean/atmosphere/structural effects will be critical for developing and assessing control algorithms. It is not clear how these were accounted for in this effort. Without such effects taken into account, the conclusions of this project should be of limited value.
- Note that even for fixed, offshore turbines, recent LES has shown that waves can affect the aerodynamics at hub height, thus impacting turbine performance. It is not clear how these effects are accounted for using land-based turbines, let alone for floating turbines where the entire structure is affected.

- The report is very light in details. It is not clear how FAST was validated with so-called higher-fidelity models. First, very few models have the sophistication required to simulate all underlying phenomena, and none of these models have been validated with data since suitable data does not yet exist.
- Statements like "Efficient Finite Element models showed reasonable correlation to field measurements" are very weak and not scientifically rigorous.
- The challenge will be in validating the potential annual energy production (AEP) gains reported.
- It appears that these specific items must have been a specific request. Studying specific items relative to underlying questions can create an illusion that these are the optimal solutions, as opposed to responses to specific questions.

Accomplishments and Progress

Comments on Strengths

- All but one milestone was met. Loads reduction and AEP increase was estimated. LCOE (stated goal) reduction of 4%–5% was estimated.
- Control strategies were tested, and their effects on loads and AEP were assessed.
- The project appears to have completed its objectives.

Comments on Weaknesses

- Identified AEP increases and CAPEX and OPEX decreases look impressive but I doubt can be validated and realized.
- Damper test was slightly delayed but did not affect overall project. Stated benefits to load reduction seemed optimistic and should be validated.
- Project findings are of limited value for offshore wind turbine controls.

Communication

Comments on Strengths

- Nine presentations were made at various offshore forums.
- One journal paper and few conference presentations and posters.
- Communication generally seems to be on par with expectations.

Comments on Weaknesses

- I think it would be relevant if more communication would have been done outside the United States, as both academia and industry (WTG and floating structures) are based in Europe.
- This is a 7-year-long project. I would expect a long stream of journal papers and conference proceedings. Few specifics are given, and, from those, the productivity seems very limited.

Recommendations (Not Scored)

- The project has tested the potential of various control strategies for reducing the LCOE for offshore turbines. While some progress has been reported, it is not clear how the results of this effort will be able to be generalized to offshore turbine controls. Testing has been done on land-based facilities without accounting for wave/atmosphere/structural coupling effects, which will be important in offshore environments. Overall, this was not a successful project. High-fidelity modeling integrated with measurements from field-scale facilities should be critical for developing relevant offshore turbine controls.
- The overall project seems to be a random shotgun blast of activity and not an organized effort to answer a question. Nothing provided in materials counters this. The cost relative to the benefit seems high, and it is hard to fully understand why this research necessitated a national lab, specifically, why a national lab provides unique value to this solution.

Project Icebreaker

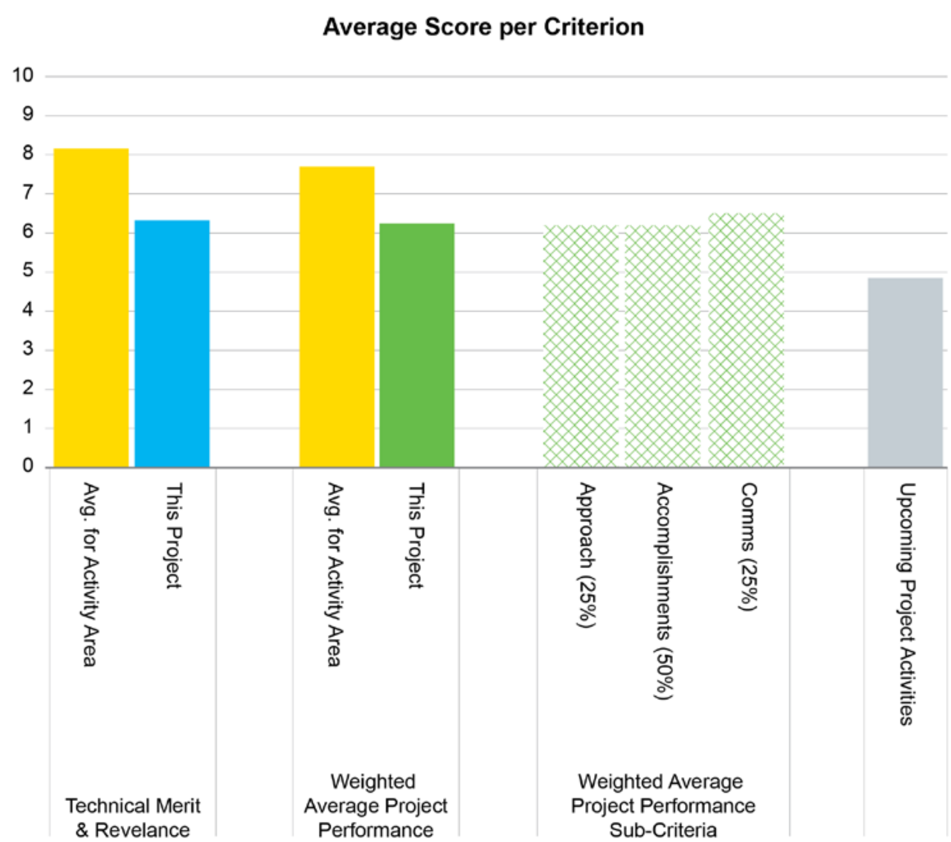
PI: Lorry Wagner	Unique Project ID: T26
Organization: Lake Erie Energy Development Corp. (LEEDCo)	WETO Program: Technology Development and Scientific Research
Project Status: Active	WETO Activity Area: Offshore Specific R&D
Award Amount	$50,405,333
Cost Share	$153,649,132
Total Project Budget	$204,054,465
Actual Costs	$17,301,859

Project Description

First-of-a-Kind Advanced Technology Offshore Wind Demonstration Project seeking to deploy an innovative offshore wind foundation technology - Monobucket (MB) - that will eliminate piledriving, minimize noise, and subsequently lower the cost of energy; reduce market barriers associated with siting and permitting; and develop a robust supply chain that will support future development and innovation.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Goal to reduce LCOE by reducing timeline and uncertainty, as well as developing technology. Use of Mono Bucket design.
- The project seeks to examine the potential of Mono Bucket foundations and address issues related to permitting for field deployment in the Great Lakes environment.
- Field demonstration projects could potentially contribute important data for the offshore wind industry.
- The technology is at TRL7, which significantly reduces the project risk.
- This project clearly advanced the understanding of development and permitting for an offshore freshwater project.
- Essential demonstration project for Great Lakes. Ice loading is the key issue. This project will demonstrate whether the inverted cone approach developed in Norway will work effectively. Suction bucket has been very expensive. This project will yield valuable experience.

Comments on Weaknesses

- It is relevant to develop offshore wind power application in the Great Lakes, but is it a DOE research project? And, should it only be focused on one foundation concept?
- Mono Bucket design is not new.
- Mono Bucket technology is not novel, and it is not clear how this project will advance the industry.
- The technology is not new.
- This project does not appear to be advancing the state of the art. The foundation technology has been used, and, other than the ice interface, much of the technology is already understood globally.
- Has European ice tank testing been used to inform the loads analysis? What design standards have been used?
- What are the long-term project monitoring plans?
- What long-term value will this project add to accelerating the offshore wind industry?

Approach and Methodology

Comments on Strengths

- Proving offshore wind power project development opportunity in Lake Erie by doing the permits is a very relevant method.
- Approach involves navigating the complex multi-agency landscape and design work.
- Good plan in place to test foundation.
- This project is being well executed from a technical standpoint.

Comments on Weaknesses

- No discussion on methodology.
- Project appears to be limited in scope and lacks clarity in objective and implementation plans. It was not clear, neither from the reports nor from the presentation, what the overall objective is and what the strategy is for achieving this objective.
- Slow progress due to permits.
- The project is a new application of existing technology. The unique freshwater element of this does not make it state of the art.

Accomplishments and Progress

Comments on Strengths

- Performed quite well given the difficulty in new ground here.
- This is an ongoing project. The permitting and approval process for a Great Lakes project is being developed as an outcome of the project.
- Progress was made in obtaining permits.

Comments on Weaknesses

- No clear plan was presented as to what happens next in developing the facility. Also, no vision was presented as to exactly what this facility will accomplish.
- Some permits still haven't been obtained for demonstration.
- The project has struggled to advance through permitting.

Communication

Comments on Strengths

- Good communication and engagement.
- Public meetings were held, and web pages were developed.
- The team has done an exceptional job communicating, documenting, and sharing lessons learned.

Comments on Weaknesses

- No discussion of communication, either past or future, was shared.
- The objective and strategy for this project was not communicated adequately during the peer review.
- Not much innovation has come out of this project.

Upcoming Project Activities

Comments on Strengths

- Relevant work ahead.
- A plan is presented, but I do not see much value continuing this project.

Comments on Weaknesses

- No clear discussion on next steps to keep project moving on track.
- Future plans are weak and were not properly described and communicated.
- Big risk on the project still exists from obtaining the right permits.
- It is not clear that continuing this project will advance the state of the art.
- Slow progress.

Recommendations (Not Scored)

- I am not quite sure this activity is research in a classical view, but it is industry-relevant.
- This is not a successful project. It lacks vision and a clear plan forward. Progress to date is of limited value.
- Taking this project to this point has been a valuable exercise that has informed industry. It is not clear that advancing this project through operation is still in the taxpayers' interest.
- Wrap up the project, but do collect long-term ice loading, performance, and O&M data.

Aqua Ventus

PI: Habib Dagher	Unique Project ID: T27
Organization: University of Maine	WETO Program: Technology Development and Scientific Research
Project Status: Active	WETO Activity Area: Offshore Specific R&D
Award Amount	$50,501,879
Cost Share	$128,884,401
Total Project Budget	$179,386,280
Actual Costs	$16,084,010

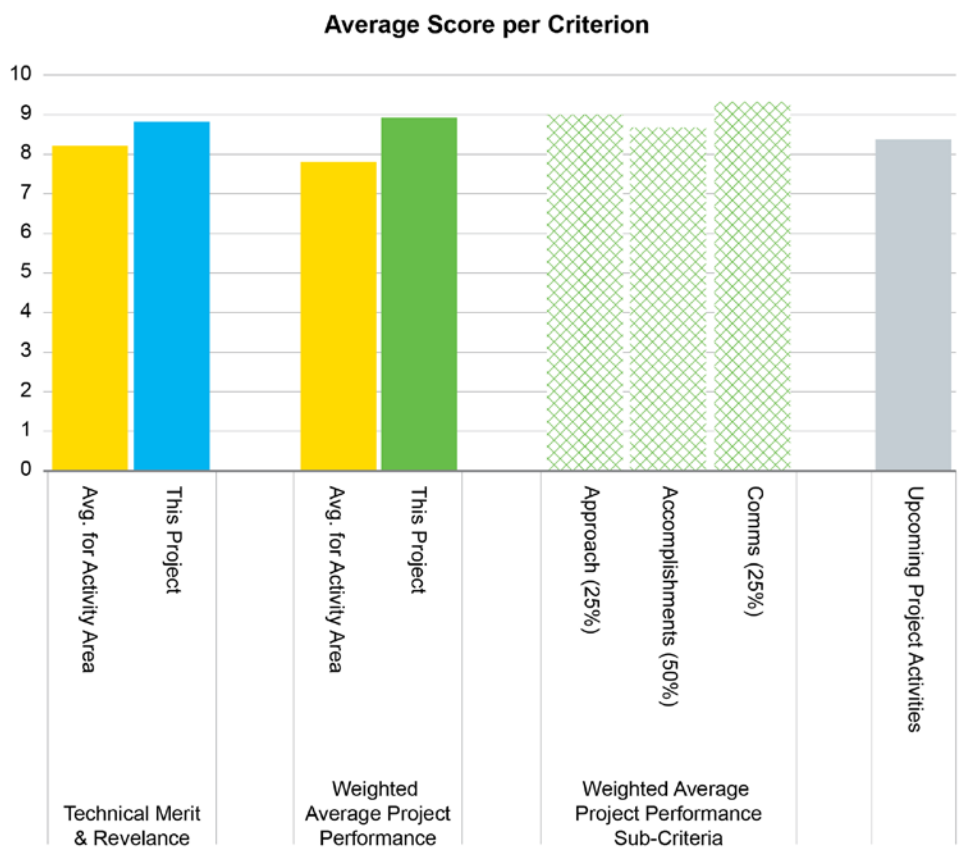
Project Description

To develop a floating concrete, semi-submersible, wind technology designed for mass production and large-scale turbines using domestic production methods.

- LCOE for utility-scale <8 c/kWh
- American Bureau of Shipping Classification received
- Demonstrated in 2013 offshore Maine at 1/8th Scale

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Project should reduce risk by showing merit of this floating concrete offshore wind technology and drive LCOE below 0.08/kWh.
- A field-scale floating turbine facility for collecting data to guide technology development and model validation does not exist. This project will fulfill this major need and will make a major impact in advancing offshore wind technology and high-fidelity predictive models for offshore wind.
- The technology seems to be scalable and can be industrialized.
- Good effort to validate FAST using floating foundations.
- Great example of how DOE funding can help accelerate and enable demonstration projects.
- The offshore problem is unique to the U.S. industry, and this project directly advances a solution.
- Economical floating offshore demonstration is key to reducing LCOE. This approach to floating platforms capitalizes on known concrete construction techniques. The systematic, modeling, certification, scale modeling, and 1:8 scale, onsite DeepCLiDAR tests all form a solid basis for the design.

Comments on Weaknesses

- Similar concern as for Icebreaker—should a publicly-funded R&D program be doing a full-scale demonstration project of one particular new floating structure technology?
- Is there an updated LCOE analysis and identification of key cost reduction path to LCOE parity?

Approach and Methodology

Comments on Strengths

- Design of floater and validation in tank and scaled model is positive.
- Basic Project Management approach. Specific high-level goals outlined.
- Implementation in four phases is well thought out to minimize risk of investment.
- Pre-stressed concrete technology for foundation design is designed to leverage existing U.S. manufacturing capabilities.
- The plan to implement a wide range of sensor and measurement technologies in the final facility is quite exciting and could yield a wealth of data that will be invaluable to modelers.
- The project takes a comprehensive approach to qualify the technology.
- A lot of data is generated to understand the environmental condition of the site.
- Strong approach toward commercialization.
- This project has utilized a well-founded and robust approach to make it this far. The combination of theoretical, laboratory, and field testing is impressive for a project of this scale.
- Systematic approach. How many graduates has this project produced? Please describe the educational program associated with UMaine's project.

Comments on Weaknesses

- The project has not fully articulated how taxpayer value is created proportional to the follow-on investments to go forward with the project. Value to date has been clear.
- Political challenges appear to have delayed progress.

Accomplishments and Progress

Comments on Strengths

- Several key goals were described. Anticipate the costs would be below 0.07/kWh.

- The project has already collected field data for resource assessment and laboratory-scale modeling for the floating turbine. Validation results using FAST have yielded promising results.
- Several patents are issued as a result of this effort.
- The data generated from the 1:8 scale is very well used to validate NREL's FAST model.
- This project has progressed well.
- Accomplishments have been noteworthy with the most challenging being non-technical.

Comments on Weaknesses

- It has taken a long time to come from scaled test and to establish full-scale test.
- Progress was notably delayed, but it now seems to be moving again.
- Progress has been slow, but not for lack of effort or creativity on behalf of the Principal Investigator.

Communication

Comments on Strengths

- The project is very well known and properly communicated.
- 30 publications generated; seven patents developed; community outreach and conferences attended.
- The team has published extensively. Their productivity is impressive.
- Over 30 publications generated.
- The project has done a good job communicating.
- Many reports to relevant industry conferences. How many graduate theses?

Comments on Weaknesses

- No weaknesses noted by reviewers.

Upcoming Project Activities

Comments on Strengths

- All outlined activities are needed to complete full-scale test.
- Future goals outlined through 2022.
- There is a clear and well-developed plan to move to Phases 3 and 4 of the project.
- There is a clear path toward demonstrating the technology at full scale.
- Strong and detailed plan in place.

Comments on Weaknesses

- I see it as difficult to realize the project's timeline with the university not having competencies and experience in project execution.
- I would like to see taxpayer value in the following phases defined more clearly.
- The expected final goal is scheduled for 10 years from start of program.

Recommendations (Not Scored)

- This is an exciting project that has the potential to make a major impact in advancing offshore wind energy in the United States. I just hope that the team continues with the same level of enthusiasm and attention to detail.
- The site has potential to be a national demonstration site for technology developers, especially after all permits are granted.
- Overall, this is a great project that is well run and is advancing the state of wind power. The taxpayer investment to date is well justified and well worth the investment.

- This project needs to articulate taxpayer value in the final phases. Consider making this a WETO test site, giving WETO the right to some equity-like upside, even if delayed. The fact that significant taxpayer capital is going into this project alongside industry equity, but is not receiving any return does not seem logical. I understand taxpayer capital being the lowest on the waterfall, but I do not understand it not being in the waterfall at all unless clear value proportional to the investment is articulated elsewhere.

Project Results - Atmosphere to Electrons

A2e: Mesoscale Physics and Inflow: WFIP 2

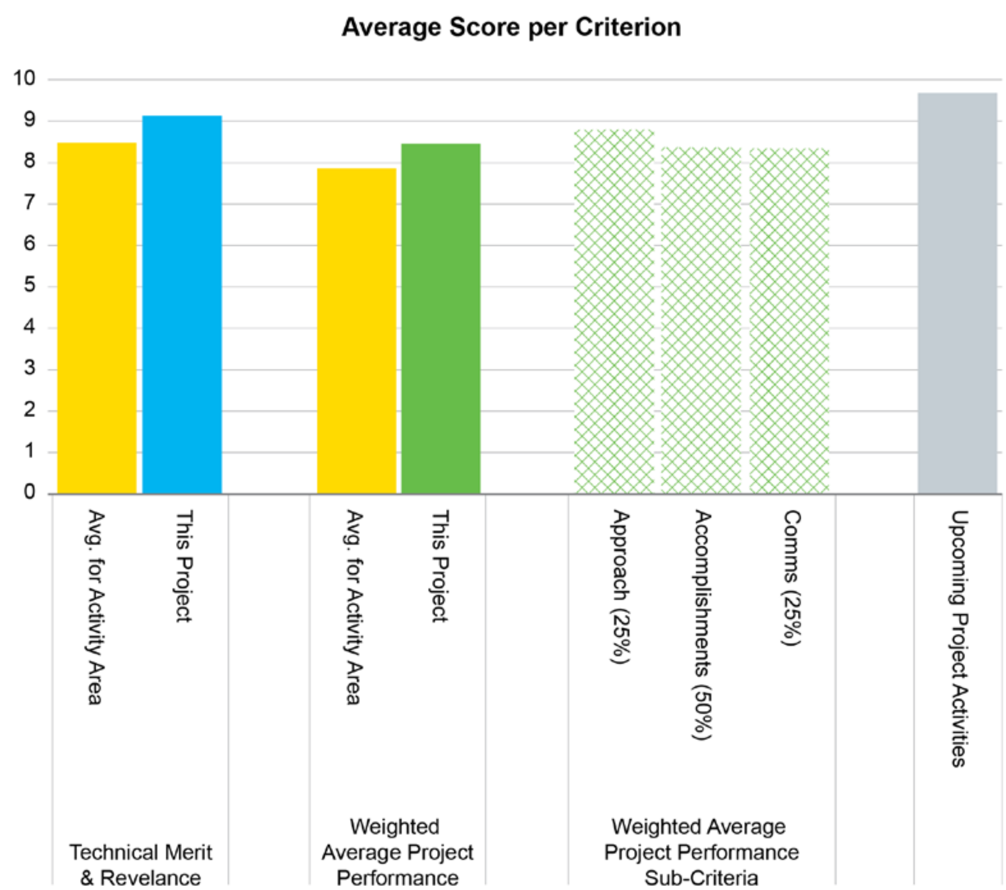
PI: Will Shaw; Dave Turner	Unique Project ID: T04
Organization: PNNL, ANL, LLNL, NREL	WETO Program: Technology Development and Scientific Research
Project Status: Active	WETO Activity Area: Atmosphere to Electrons
Total Available Budget (FY17 & FY18):	$8,773,529
Actual Costs (FY17 & FY18):	$7,910,582

Project Description

WFIP2 was a four-year, multi-institutional field and modeling study integrating industry, academia, NOAA, and DOE national laboratories in an effort to improve wind forecasts in the 0–45 hour ahead time frame. The focus area for the project was the Columbia Basin of the northwest U.S., a wind energy region in complex terrain, which poses severe challenges to forecast models.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- It was assessed as very relevant for the onshore wind power industry in the United States and, actually, in other wind power markets, too.
- Very challenging terrain to choose. Good potential to provide atmospheric and forecasting insights. Aligns well with program objectives.
- This project is of critical importance for A2e and is ultimately highly relevant for the industry. It can produce the fundamental understanding of atmospheric processes required to improve wind forecast models and reduce uncertainty in short-term energy production predictions.
- The dual focus on improving model initialization and model physics is scientifically rigorous and very much what is needed to dramatically improve the accuracy and reliability of short-term forecasts.
- The proposed work has the potential to produce major advances and lead to significantly improved mesoscale prediction models.
- DOE is best fit to fund this type of activity. It is in a unique role to provide high quality reference data.
- The project has high technical value and advances the state of the art.
- This project, perhaps more than any other, has capitalized on the unique position DOE has to pull together the best talent from all of the labs and collaborate with industry to improve the weather forecasting tools and science for the benefit of the wind industry. But it needs long term funding to make significant contributions.

Comments on Weaknesses

- Why is this high risk/high reward? The industry is well incentivized to get this right on their own. Market forces are driving them to an answer.

Approach and Methodology

Comments on Strengths

- Looks sound and well planned.
- Broad range of experienced players were engaged. Expectation of open source results is good practice.
- The approach involves multi-scale atmospheric measurements in complex terrain using state of the art instrumentation, assessment of existing models and parameterizations, and development of improved models for short-term forecast, as well numerical techniques for handling complex terrain effects.
- The research team is impressive bringing together leading researchers from DOE labs, NOAA, and universities.
- Approach is scientifically rigorous. The field experiments are impressive in scale and resolution, and are conducted with the most advanced field measurement techniques available. The approach integrates sophisticated field measurements with numerical simulations and numerical model assessment and improvement.
- The broad data approach provides a robust and valuable dataset that can be used currently and for future reanalysis.
- Understanding the physics, validating that understanding, and codifying it are exactly what the DOE supported research community does best. Deploying the codification of that deeper understanding to widely used weather models is a very efficient means for rapid technology transfer, outstanding project design, and implementation.

Comments on Weaknesses

- Duplicate projects with additional unique field sites would help accelerate the understanding of other site-specific weather anomalies.

Accomplishments and Progress

Comments on Strengths

- All objectives were accomplished. Data is available in the portal. The project has had parallel positive effects in other atmospheric modeling for NOAA.
- Significant progress (18-month-long field campaign) appears to have been accomplished on the experimental front. Measurements across a range of scales over complex terrain and under complex atmospheric conditions have been obtained and archived for use by the community.
- Some progress also appears to have been made with numerical model evaluation and assessment. I note the reference to improvements in Mellor-Yamada PBL parameterizations and the relative accuracy of terrain following vs. immersed boundary methods.
- The project appears to have completed what it intended to complete.
- This project was necessarily large and required a large number of partners across broad stakeholder base. Remarkably, the collaboration has worked very well to the benefit of the utility and operators of wind plants. All partners understand the large-scale physics much better and the impact on local wind flow, and they are better able to translate it into operational decisions. The project demonstrated a remarkable reduction in turbine level biases in predicted wind.

Comments on Weaknesses

- The measuring campaign duration was underestimated, but it seems the measurement results are sufficient for the conclusions.
- The conclusion that immersed boundary methods work well on fine LES resolution was already known. It will be useful if the team can provide specific recommendations from the measurements regarding the near-ground resolutions required to get good predictions with IB methods vs. terrain-following coordinates.
- It is not clear how such measurements will be used to improve initialization of mesoscale simulations. A plan for generalizing site-specific measurements should be developed.
- Improving wall models for mesoscale LES could be an important outcome of this project, but it is not clear if this is being pursued.
- The verification and validation formalisms are well known. It is not clear what, if anything, new was done in this project.
- Uncertainty quantification is not trivial. It is not at clear what has been done in this regard as a part of this project.

Communication

Comments on Strengths

- A lot of publications and conference presentations.
- Several venues attended to communicate results including conferences and journal articles.
- Conference presentations and journal papers have been produced by this work to disseminate the results of the project. Data has also been made available to the community. The industry has also been engaged through presentations in workshops.
- The study has been well communicated.
- Presentations at key conferences and peer reviewed journal articles are impressive.

Comments on Weaknesses

- Challenging to make data easily accessible considering the large file sizes.
- A list of papers published and under review is missing. It is not easy for this reviewer to assess how much has been actually achieved and disseminated from this project.

Upcoming Project Activities

Comments on Strengths

- Reasonable future activities outlined.
- Project is complete. Nothing to score.
- The project has ended. Proposals have been submitted by the project team to continue the work.

Comments on Weaknesses

- Project is complete. Nothing to score.
- Project has ended.
- The industry should be driving this project and future activities. This does not appear to present a compelling government interest or unique qualification to advance this beyond what the industry could do itself. Improving the overall accuracy of NOAA models is valuable, but it may not be an appropriate WETO use of funds.
- No upcoming activities listed.

Recommendations (Not Scored)

- Suggest development of WFIP3 and WFIP4. Suggest an additional onshore project and offshore project.
- This project is of critical importance for A2e and it is ultimately highly relevant for industry. It can produce the fundamental understanding of atmospheric processes required to improve wind forecast models and reduce uncertainty in short-term energy production predictions.
- The dual focus on improving model initialization and model physics is scientifically rigorous and very much what is needed to dramatically improve the accuracy and reliability of short-term forecasts. The field experiments are impressive in scale and resolution, and they are conducted with the most advanced field measurement techniques available.
- The approach integrates sophisticated field measurements with numerical simulations and numerical model assessment and improvement. Integrating such studies with the efforts on the HFM front will be critical for the success of A2e.
- $8M in cost for a study that the industry would have done anyway does not seem to be a good use of taxpayer funds. I don't see any cost sharing in the published budget. Industry should have paid DOE for this. Industry contributing plant data is de minimis, relative to the value of forecasting accuracy they will get in power sales markets.
- Do a WFIP3 for an offshore site.

MMC - Model Development & Validation

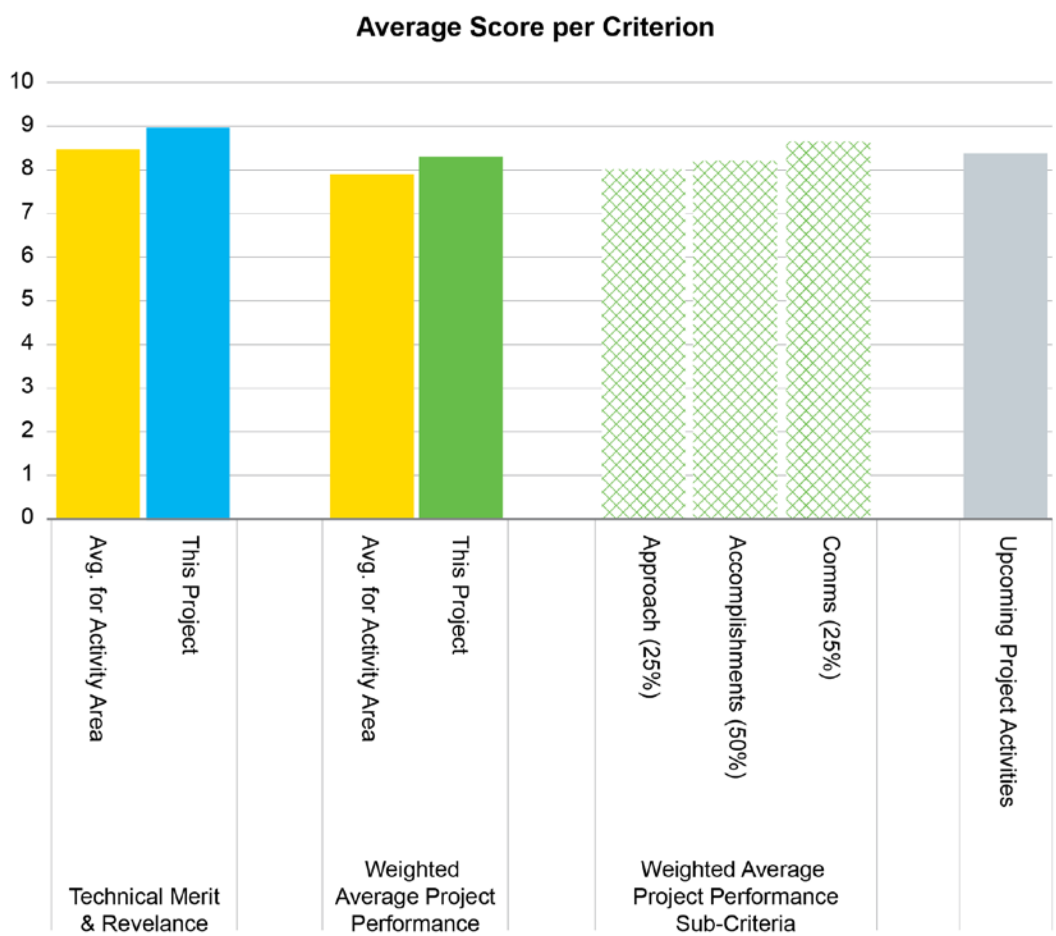
PI: Sue Haupt	Unique Project ID: T05
Organization: UCAR, ANL, LLNL, NREL, PNNL, SNL, LANL	WETO Program: Technology Development and Scientific Research
Project Status: Active	WETO Activity Area: Atmosphere to Electrons
Total Available Budget (FY17 & FY18):	$3,674,279
Actual Costs (FY17 & FY18):	$2,923,357

Project Description

The team will build new high-performance-computing-based multiscale wind plant simulation tools coupling a broad range of scales. The scale interactions enable the optimization needed to ensure the efficient, reliable production and integration of future wind-generated electricity.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- This area of work is needed to be able to bridge from weather to site wind expectations/predictions.
- Computational techniques for coupling mesoscale with microscale models in order to derive proper inflow conditions for wind-plant scale LES are of critical importance for developing accurate and reliable computational tools for wind plant simulations. This project seeks to address this important issue by integrating numerical simulations and meso-micro-coupling techniques with field experiments. As such, the project has the potential to make a significant contribution to the modeling state of the art and lead to computational tools that will be invaluable for the wind industry.
- This project clearly advances the cutting edge and it is high risk/high reward. It has the potential to transform the DG wind forecasting market.
- MMC is the biggest challenge in understanding the impact of large-scale weather on wind plant performance and forecasting accuracy for transitional conditions like storm front timing, unstable mixing, terrain influences, gravity waves, and meandering microscale phenomenon.
- If A2e is to deliver on its promise to solve poor wind plant performance due to wakes and meso scale interactions, it will be because MMC has delivered on its promise to solve the terra incognito mystery.

Comments on Weaknesses

- It is somewhat difficult for me to assess the outcome of the project for industry applications.
- Looking forward to applying new MMC knowledge to the offshore challenges, including air/sea interface coupling.

Approach and Methodology

Comments on Strengths

- As this is researching an unknown area, the approach of testing seems adequate.
- The project approach is based on using WRF as mesoscale model and developing strategies to couple it with Nalu-Wind, a code that is in parallel being adapted for wind energy applications. Experimental data from field experiments in flat and complex terrain are also utilized to validate the proposed approach and assess the effects of uncertainty.
- The project is ambitious and very challenging, but the overall approach is, at least conceptually, scientifically sound and the project team is well qualified to undertake such a project.
- The approach is robust and appropriate.
- Resolving the terra incognito behavior is a huge challenge, but creating methods to model it in practical ways for industry use is even more impressive. This is a huge contribution to all forecasting technology and operational tools used by operators.

Comments on Weaknesses

- It is somewhat difficult to understand the methods.
- Approach is somewhat unclear. Merely test and observe.
- It is not clear if the research team has sought to engage researchers beyond DOE labs from universities where similar research is being conducted to increase knowledge base and leverage what is being done elsewhere to maximize the impact of this project.
- It is stated that while WRF can account for complex terrain effects, neither SOWFA nor Nalu can; so I am confused as to why these models were selected for microscale tools. There are highly

developed open source codes that can account for complex terrain, so a better explanation regarding the rationale for making these specific micro-modeling choices will be useful.

- It is not clear if this project is designed to benefit specifically the coupling of WRF with Nalu or if the MMC approach that will be produced will be made available for other modeling options.
- I am confused by the fact that while Nalu is the model of choice for wind-farm simulations, MMC simulations in this progress report are planned using WRF and SOWFA.
- Strong team in place.
- The project needs to figure out how to provide real world validations of its work so far, in order to demonstrate the value to the market and industry. I understand the complexities in doing this, but without it, the work will not create market value. Consider looking at DG forecasting as a means to validate based on actual data.

Accomplishments and Progress

Comments on Strengths

- Seems to perform as planned.
- Terra Incognito defined: Boundary Layer Depth. Coupling method developed from mesoscale to microscale.
- The team has made progress on several fronts of this project, including selecting specific models, developing and evaluating various MMC coupling techniques, validating models over complex terrain, assessing uncertainty, etc.
- The project has accomplished what it intended to.
- The list of accomplishments is long and each one has advanced the state of the art.

Comments on Weaknesses

- Uncertain if the turbulence results at the microscale is accurate.
- In the list of accomplishments, the first two bullets are on model "down selection" where WRF and Nalu were selected. It is not clear to me why this is an accomplishment of this project. Did the team consider and evaluate other modeling options? What option other than WRF is there for mesoscale modeling?
- Yet, even though Nalu is the model of choice, progress is reported by coupling WRF with SOWFA. This is confusing, so the strategy for this project needs to be clarified.
- Many of the accomplishments appear tentative. Statements like "initiated and tested" do not help clarify what exactly has been accomplished in the all critical area of uncertainty quantification.
- It is stated that for certain cases LES results are insensitive to mesoscale resolution of the parent model. If this is true, then it is not clear what the value of this entire effort is. It is not clear if a comprehensive validation case of the MMC approach has been carried out so far. The work can benefit by designing a wind tunnel experiment with scale separation, along with appropriately designed field experiments to carefully validate the MMC approach. Without such experiments, this project will not be able to realize its full impact.

Communication

Comments on Strengths

- Nine journal publications, 15 conference presentations, quarterly webinars, and workshops conducted with the industry.
- Project findings have been reported via many journal publications, conference proceedings, and presentations.
- The information has been well communicated across industries and it has informed both wind and climate science industries.

- Regular webinars with industry are excellent idea. Conference presentations and journal articles are impressive.

Comments on Weaknesses

- Dissemination is done.
- The ultimate impact of this work to industry hinges on quantitative validation and coupling with an appropriate microscale model. It is not clear how the developments from this work are being communicated to the industry.

Upcoming Project Activities

Comments on Strengths

- I find the outlined topics for further research quite relevant when taking research to the industry.
- Very complex plan moving forward to create improved models/methods and consider offshore cases in the models.
- Remaining work will focus continuing model validation, improving MMC techniques, exploring offshore applications, and developing guidelines for MMC coupling.

Comments on Weaknesses

- Critical to the ultimate success of this project will be the comprehensive validation of the proposed MMC strategies using appropriate laboratory and field measurements. But, at this point, the team does not seem to even have a clear path as to which microscale code they will use (Nalu is mentioned yet SOWFA is used).
- It is stated that the team is ready to tackle offshore wind applications. But it is not clear that they have solved the MMC problem for land-based applications, in the sense of demonstrating the predictive ability of their approach and quantifying the uncertainty of predictions. For example, the all-important effect of mesoscale forcing on wind farm power generation and loads has not even been tackled yet for land-based wind farms.
- To make things more confusing, the team states that, in some cases, mesoscale effects do not affect microscale LES. If this is true, why continue this work? I do agree with them though that much more work is needed before such conclusions can be drawn. And, this work should explore MMC coupling with microscale tools that can account for complex terrain and turbine wake interactions and validation with laboratory and field measurements.
- Need to heavily incorporate DG activities and value.

Recommendations (Not Scored)

- I will recommend the model is validated somehow by test and validation.
- Suggest a validation experiment to determine the accuracy/relevance of the results.
- Consider how this modeling can be used to support distributed wind.
- Focus on maybe using the SWiFT site.
- Using the lessons informed here to improve other industry-valuable tools like MERRA-2 could multiply the value creation and create better local scale models that could enable distributed wind market growth. Has huge potential to improve forecasting without on-site data.
- Continue project with more funding to mature models and validate models with high fidelity reference data.

High-Fidelity Modeling

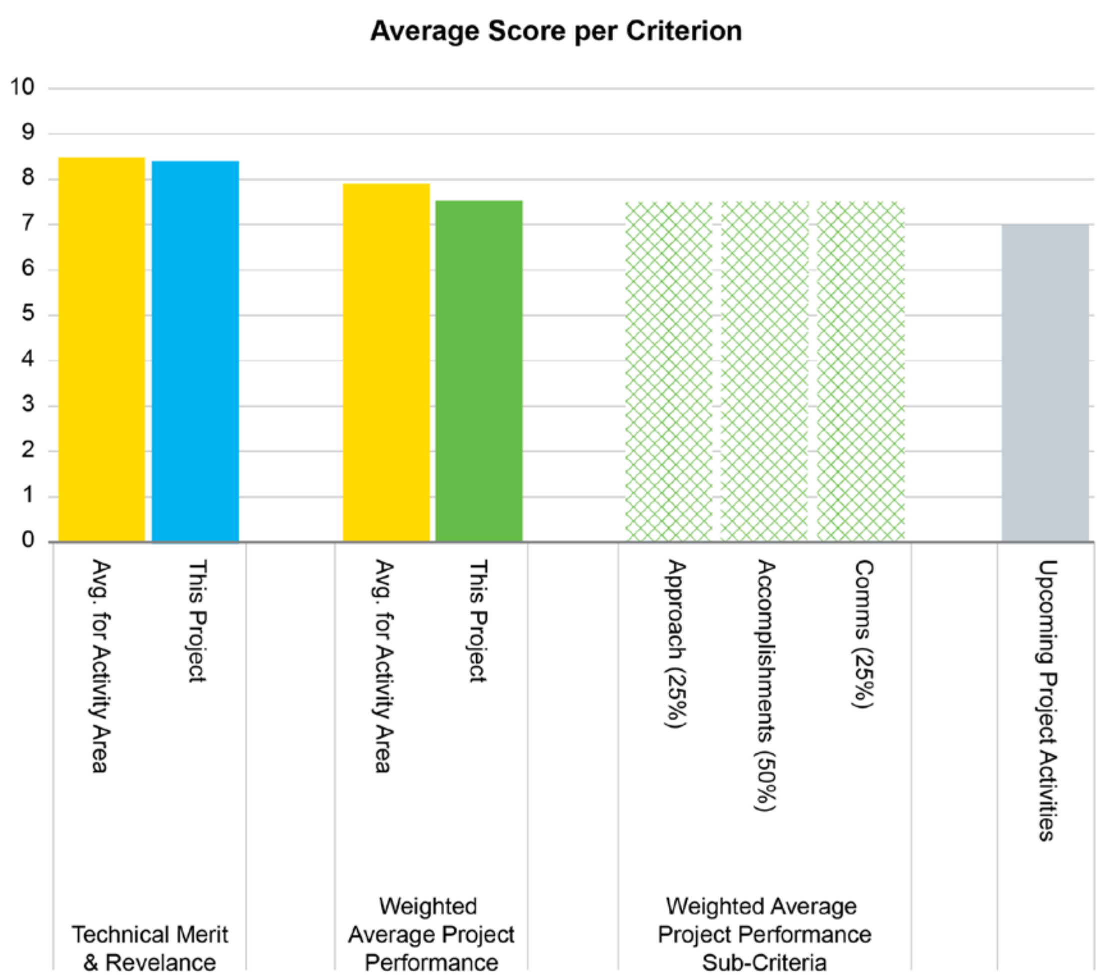
PI: Mike Sprague	Unique Project ID: T06
Organization: NREL, SNL	WETO Program: Technology Development and Scientific Research
Project Status: Active	WETO Activity Area: Atmosphere to Electrons
Total Available Budget (FY17 & FY18):	$4,304,928
Actual Costs (FY17 & FY18):	$3,654,798

Project Description

Creating an open-source, high- and multi-fidelity predictive modeling and simulation (ModSim) capability for wind turbines and plants. Performing simulations designed to create new understandings of complex flow physics and turbine dynamics.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- The outcome of the HFM effort is expected to provide insights into the fundamental behavior of wind facilities that will allow for innovations that are not currently foreseen.
- HFM models for wind plant simulations are critical for achieving A2e mission and enabling the industry to reduce LCOE and quantify uncertainties in energy production. To that end, this project has the potential to make an important contribution to the industry and advance the state of the art.
- The need for efficient high-fidelity modeling is critical to understand complex turbine behavior subject to complex wind conditions.
- The code clearly has the potential to advance the state of the art.
- HF/HFM is key to the technology transfer of complex physical understanding of MMC and all other atmospheric coupling between wind plants, wind turbines, wakes, local, and large-scale weather impacts. With improved knowledge of the atmospheric physics, but no means to transfer actionable engineering tools to industry, DOE's investment is lost.

Comments on Weaknesses

- The project description could be more technically descriptive of the fundamental equations or modeling methods employed, as well as the expected advantages, disadvantages, and/or assumptions that it creates in the solution.
- The HFM modeling state of the art is very advanced today with open-source HFM LES codes capable of simulating complex phenomena in wind farms with advanced actuator-based models for blades and turbine structures; accounting for terrain effects, ocean waves, and atmosphere coupling; and FSI for floating structures for offshore applications. Moreover, such codes have already demonstrated validation at utility scale and are rapidly driving forward our understanding of real-life physics. And, achieving this level of predictive ability did not require understanding the details of the boundary layers on the turbine blades.
- Developing a code that can run on exascale machines is important, but it is not clear what the vision for this code is. It was not clear to me, for instance, if the team plans to use blade boundary layer resolving stimulations to optimize utility scale wind farms. Also, there does not seem to be a clear plan for coupling this code with the MMC efforts.
- Given the resources needed to use this software, it is always a challenge to understand exactly how it translates to industry applications.

Approach and Methodology

Comments on Strengths

- A multi-lab approach is taken. The open source methodology is good as is the sensitivity to applicability of the code to current and next generation DOE hardware (supercomputers).
- The approach is based on modifying an existing code Nalu to develop a wind energy version Nalu-Wind. Nalu is a massively parallel code and this provides a framework to build to implement exascale wind simulations.
- Open source code is the way to go.
- This project is clearly developing a powerful new tool. The level of transparency used is the best path to create eventual industry value.
- It is very important for this part of the program to embrace not only the HFH/HFM, but seamlessly dovetail this modeling capability with engineering models like OPEN Fast. Together, they form a

complete package of tools that designers and researchers can use to simulate real world wind plant performance and load issues, as well as the ability to design optimize turbines, plants, and controls.

Comments on Weaknesses

- Unclear what limitations the software will have. It is mentioned that the base code being used is acoustically incompressible yet the RANS models (compressible flow) are being used. Still unsure what capabilities that code has and what its limitations are.
- Existing HFM LES codes for wind energy are far more advanced than the current state of Nalu-Wind insofar as predicting utility-scale wakes and energy production in complex terrain and offshore environments. It is not clear if the current effort is seeking to leverage what is already available. I have no doubt that this team will eventually make progress, but they have a lot of catching up to do given that current codes are very advanced both for land based and offshore wind applications.
- A strength of Nalu is that the code scales well and can be applied on exascale systems. Yet, scalability of the code (especially with all the new features added to it) is not addressed in the report.
- Figuring out how this gets used by the industry will be important to articulate in order to justify ongoing funding. If the fastest computers in the world are required to efficiently run it, then it is hard for the industry to get value out of it. The expertise appears to be in computer science and not turbine design.
- Need to coordinate with ISDA to begin seeking a deeper understanding of the physics of critical gaps in the engineering models.

<u>Accomplishments and Progress</u>

Comments on Strengths

- Although some accomplishments were delayed, the team has met all of the objectives. This shows resilience in the team and the ability to overcome obstacles.
- Early stage results have been reported. Few rotations of a single wind turbine under uniform flow conditions are presented. Also, actuator line models have been implemented and show similar results to SOWFA. Validation has been reported using URANS, but this is not an HFM approach.
- Now that Nalu finally works well, Nalu-Wind has demonstrated itself to be much faster and more efficient than the general purpose Nalu.

Comments on Weaknesses

- There is a long way to go to achieve the stated objectives of this project. I also note that no attempt to validate the code for a relevant application has been attempted yet.
- I was under the impression that this work focuses on LES or hybrid models, which is the state of the art. Yet, unsteady RANS results are reported for the well-studied-in-the-past NREL rotor pressure profile comparisons. And, the conclusions are very similar with what is already known: namely that URANS can capture torque on the blade at low speeds, but when 3D separation becomes important, large discrepancies arise.
- The team would benefit by tapping into a large body of literature on modeling complex turbulent flows. Developing tools that can resolve the blade boundary layers, and that can predict transition and separation under complex atmospheric conditions and at utility scale is extremely challenging.
- Was lagging and is not on track!

<u>Communication</u>

Comments on Strengths

- The team collaboration with DTU and across multiple DOE labs is good. Clearly providing industry information through the eight publications listed. The open source and open domain approach at this magnitude is impressive.
- The software has been built in a sustainable and transparent form.

Comments on Weaknesses

- Nothing substantial is reported regarding communication, which is understandable given the state of development of this code.

Upcoming Project Activities

Comments on Strengths

- Nice direction in developing a working group to guide verification and validation.
- The team is on track to report full turbine resolved capabilities and is ready to tackle offshore wind.

Comments on Weaknesses

- Given the current state of the project, as reported in this report, the upcoming activities do not appear to be realistic.

Recommendations (Not Scored)

- This is a complex project. The team is doing well. I challenge the team to provide more clarity and details in the working level objectives when communicating.
- Add turbulent flow modeling expertise to the team.
- Focus on single turbine modeling of realistic inflow.
- The project has the potential to make a major contribution to the industry if a tool capable of running on exascale computers AND producing physically realistic results across a range of operating conditions and atmospheric states is developed. However, the team has many challenges to overcome and it was not clear to me from the report and presentation that they fully grasp the challenges ahead.
- A viable path forward for this project would be to complete blade boundary layer resolving LES (or appropriate hybrid approaches) for a utility scale turbine with full aeroelastic FSI for different inflow conditions and various atmospheric stability states; validate the simulations with data of sufficient resolution to demonstrate the model predictive ability across the relevant scales (from blade boundary layer to turbine wake meandering); and use the computational data to refine actuator-based modeling strategies form wind farm scale simulations in complex terrain.
- Even this, however, will be a tall order given the current state of development and the monumental challenges ahead. If this is accomplished, however, the project can make an important contribution to developing the next generation of actuator surface models for HFM wind plant scale simulations.
- This has the potential of being the high-fidelity version of FAST that is available for industry and academia to use. I suggest that a gap analysis is conducted to show the difference or gap between SOWFA, FAST, and NALU.
- Creating innovative and modern software tools like this is valuable to the wind industry, has broad implications, and is an important function of national labs.
- Accelerate validation and collaboration to fill in the critical gaps in engineering models.

Rotor Wake Measurements & Predictions for Validation

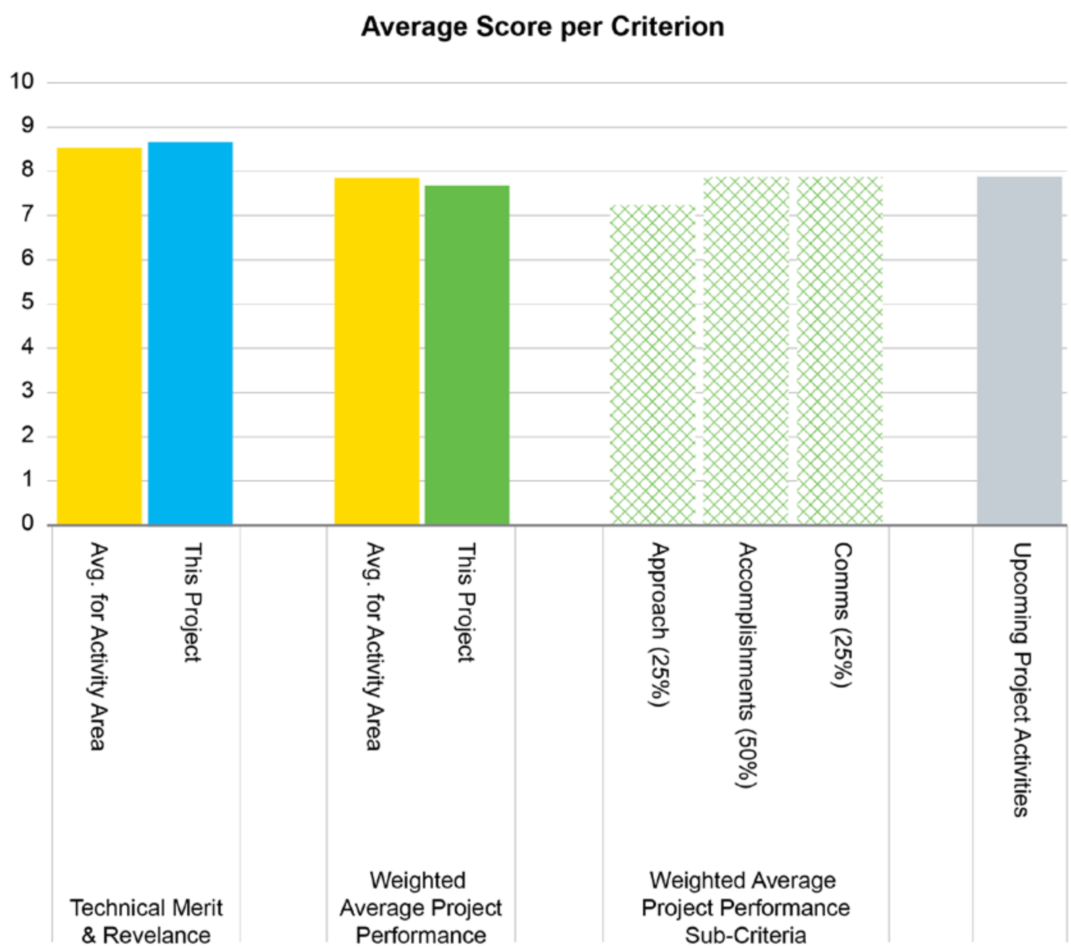
PI: Patrick Moriarty	Unique Project ID: T07
Organization: NREL, SNL	WETO Program: Technology Development and Scientific Research
Project Status: Active	WETO Activity Area: Atmosphere to Electrons
Total Available Budget (FY17 & FY18):	$10,730,881
Actual Costs (FY17 & FY18):	$8,108,373

Project Description

This project is the experimental validation hub of the DOE Atmosphere to Electrons (A2e) program, supporting multiple projects. The project is focused on the collection and application of high-fidelity validation data sets of wind plant complex flow interactions to gain a better understanding of wind farm atmospheric interactions and validation of newly developed simulation tools.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- The success of the HFM aspects of A2e hinges on the availability of high-quality measurements to validate the computational models. To that end, this project is highly relevant and can make a major impact to the state of the art and have major benefits for industry.
- Proofing wake effect in the field is very useful to demonstrate this effect. There is plenty of data to be used for future model validation.
- Understanding wakes improves multiple areas in the industry and market.
- Wakes are the source of significant poor performance of wind plants. Improving the understanding of wakes will only happen through accurate modeling of wakes and their interactions. But validated models are key to achieving that challenge, and validation can only happen with high-fidelity and high-quality measurements. This program is the source of such measurements.

Comments on Weaknesses

- DG typically has much tighter rotor spacing (2D) and, thus, wake modeling is particularly important.

Approach and Methodology

Comments on Strengths

- The project focuses on collecting data at two scales—SWiFT and utility scale—and using this data to enable model validation. Instrumentation appears to be state of the art and the team is well qualified to carry out these measurements.
- High-fidelity spatial and temporal accuracy is required to CFD validation. This is extremely difficult to perform at utility scale, open atmospheric conditions. Yet, that is what this project must do to succeed. The results so far are excellent but event greater spatial resolution is needed for CFD validation.

Comments on Weaknesses

- For such a complex validation undertaking, numerical simulations need to be tightly integrated with measurement campaigns in order to identify resolution requirements for measurements and areas of complex physics where measurements can focus. The project could be strengthened by adopting such an approach.
- If the ultimate objective is to validate HFM, then there are specific resolution requirements for such measurements—from blade boundary layer scale to wake meandering. It is not clear that the resolution of the measurements obtained by this project is fine enough to enable meaningful validation of the LES-scale models.
- Applicant should continually assess progress relative to the problem statement. In this case, it is reducing uncertainty. It is not clear that the project is solving the problem.
- Need to develop new measurement methods that capture high spatial resolution.

Accomplishments and Progress

Comments on Strengths

- The project has made good progress, obtaining both utility scale and SWiFT data. Some validation work has also been accomplished.
- SWiFT wake data from LiDAR is very impressive. Validation of wake control and quantification of the wake displacement control is a major accomplishment. Final wind plant validation of long-term performance improvement is key.

Comments on Weaknesses

- The spatial and temporal resolution of the measurements is not explained. State of the art LES models available today can resolve wake dynamics at a much finer scale than what is suggested by the reported measurement results.
- I am confused by the following statement: "These validation studies demonstrated reasonable agreement for power losses under different wind farm conditions and also highlighted improvements that can be made in the validation process e.g., ensuring that wind direction variability in the simulated inflow matches that of the observations."
- The term "reasonable" needs to be quantified across the entire wake, from near to far wake. In fact, A2e is supposed to provide much more specificity in the uncertainty of HFM predictions, so I was a bit disappointed by such a vague conclusion. Also, the fact that the wind direction variability can influence the accuracy of simulations is well known. Such experiments should strive to reduce such uncertainties as the goal is to provide validation for HFM tools.
- Need pressure-tapped blades to get validation data for HFM/HPC validation. Need wind plant performance improvement validation.

Communication

Comments on Strengths

- Results have been published and used to improve various NREL codes.

Comments on Weaknesses

- It will be useful to include a list of papers published from this work to help the reviewer assess the quality and impact of this work.

Upcoming Project Activities

Comments on Strengths

- Future work will focus on wind farm scale experiments.
- No upcoming activities listed.

Comments on Weaknesses

- The resolution issues I noted above should be carefully considered in future experiments. I would also suggest a carefully designed single turbine experiment to produce data from blade boundary layer to wake meandering scales.
- No upcoming activities listed.

Recommendations (Not Scored)

- This study is essential for the success of A2e. The project has produced promising results and very useful data sets, but more emphasis should be placed on obtaining the multi-resolution data required for validating the HFM tool of A2e. Also, validation studies need to focus on quantifying the accuracy of the simulations across the entire wake and avoid qualitative statements like "reasonable" accuracy.
- If the stated problem is improving the uncertainty, it seems like more effort should be made to quantify progress toward removing uncertainty. This modeling should also be used to look at how turbines interact with large buildings in DG applications.
- Continue with field measurements but consider complimentary test techniques to enhance spatial resolution of test data. Flow visualization? Seeding wakes with detectable particles? Nighttime thermal seeding plus thermal imaging techniques?

Advanced Flow Control Science for Wind Plants

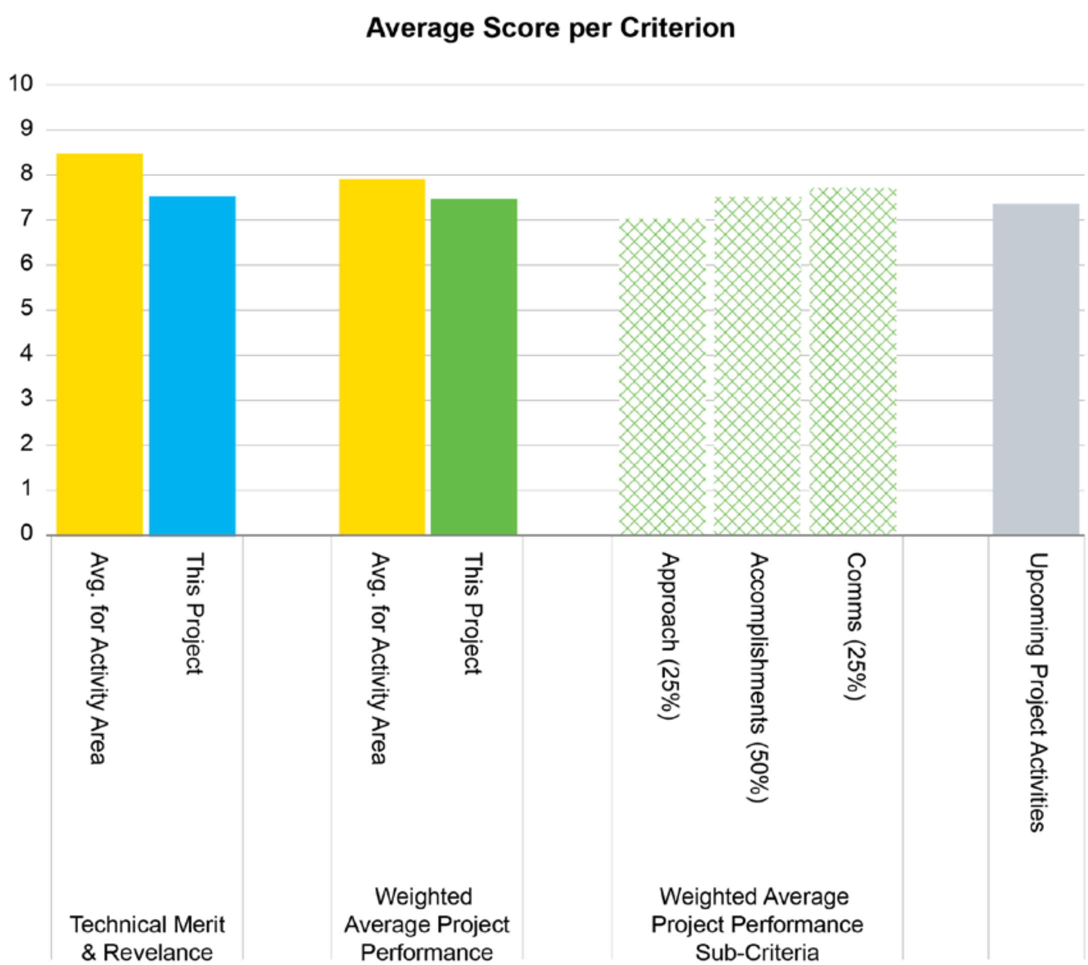
PI: Paul Fleming	Unique Project ID: T08
Organization: NREL	WETO Program: Technology Development and Scientific Research
Project Status: Active	WETO Activity Area: Atmosphere to Electrons
Total Available Budget (FY17 & FY18):	$2,816,078
Actual Costs (FY17 & FY18):	$2,218,862

Project Description

Research the science of wind farm control to produce methods and strategies to design and analyze wind farm controllers.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- The three areas of benefit outlined are a good description of the range of merit to be considered by advanced controls.
- Advanced flow control for wind plants will help quantify uncertainty, reduce intermittency in power generation, and help reduce the LCOE. As such, this project is highly relevant to industry and is of critical importance for the success of the A2e program.
- Clear high risk / high reward research.
- Wake steering is the implementation of increase knowledge of wake physics gained from HFM. This is the demonstration of the value of DOE funded A2e research. Implementing and validating this control strategy and future wind plant control strategies is the final step of tech transfer to the industry.

Comments on Weaknesses

- The project as described is too narrowly focused on wake steering. This is an important control benefit, but the described range of benefits of power production, decreasing O&M costs, and providing grid services need to be addressed with a range of potential control methods.
- Final validation will come when industry implements wake steering and sees measurable improvements in wind plant annual performance.
- Are there industry members who are planning to implement these controls?

Approach and Methodology

Comments on Strengths

- The methodology detailed from studying the physics to developing control-oriented engineering models to designing control strategies sounds solid.
- The overall approach to couple an efficient controls-level model, like FLORIS, with an LES model like SOWFA is scientifically sound and has great promise. The integration of the models with field experiments is also essential to ensuring that the approach yields physically meaningful results.
- Collaboration with NextEra is an excellent approach.

Comments on Weaknesses

- I see little effort on developing control strategies based on available actuators and sensors, and more focus on development of the physics-based models.
- There are other control strategies for wind plants. It is not clear why the project focuses exclusively on wake steering. The study could be strengthened by considering other control strategies as well.
- It is not clear how much of the wind plant physics are incorporated in FLORIS. It is stated that future work will focus on 3D effects such vortices. Does the current model incorporate only 2D phenomena? And, what "vortices" exactly need to be incorporated? How is dynamic wake meandering effects are incorporated in the model?
- The team does not seem to have a good grasp of the physics of wind plants.
- The results appear to overstate the value of the research given that modern projects are laid out to minimize project wake interactions, as opposed to 7 turbines in a straight line. This project does not focus on all of the stated objectives.

Accomplishments and Progress

Comments on Strengths

- Good success with wake steering controls has been demonstrated. The design tools for offshore controls shows good progress in this important area.
- The project has made good progress in delivering some of its goals. The field scale validation results are impressive, promising, and bode well for future applications of this approach.
- Demonstrating and quantifying the value of coordinated wind plant wake steering control.

Comments on Weaknesses

- Project did not explain how wake steering can help grid integration.

Communication

Comments on Strengths

- The team has done extremely well in collaboration with industry and academia.
- The project is developing open-source software that will be valuable to industry. Project results have been published in journals and presented in conferences.

Comments on Weaknesses

- Not very well communicated.
- There are several wind industry conferences that would I have not seen this project involved in that might benefit.
- No list of papers (journal and conferences) is included in the progress report.

Upcoming Project Activities

Comments on Strengths

- The work on floating and offshore wind turbines appears to be a pressing need.
- Future work will focus on wind plant scale control and incorporating more physics into FLORIS.

Comments on Weaknesses

- The scope of activities seems too narrow with just wake steering and offshore. I believe opportunities are being missed.
- It is not clear if the project will seek to explore other control options beyond wake steering.
- The team needs to strive to understand what coherent vortices are present in a wind plant and explain how 3D physics will be incorporated in FLORIS.

Recommendations (Not Scored)

- I would like to see more basic control strategies produced that take advantage of the physics-based model insights. These strategies should be fundamental using basic controls principles.
- The project has made good progress. More emphasis should be placed on validation with field data for wake steering and other control strategies. Also, the physics incorporated into FLORIS need to be better articulated. The statement that in the future "3D effects like vortices" will be incorporated in the model seems somewhat naive given the enormous complexity of turbine wakes. The team should engage researchers who understand turbine wake fluid mechanics.
- Aggressively explore coordinated wake steering to provide deeper understanding of turbine coupling, in order to enhance upper layer mixing to increase kinetic energy entrainment to the interior of the wind plant.

Integrated Systems Design and Analysis

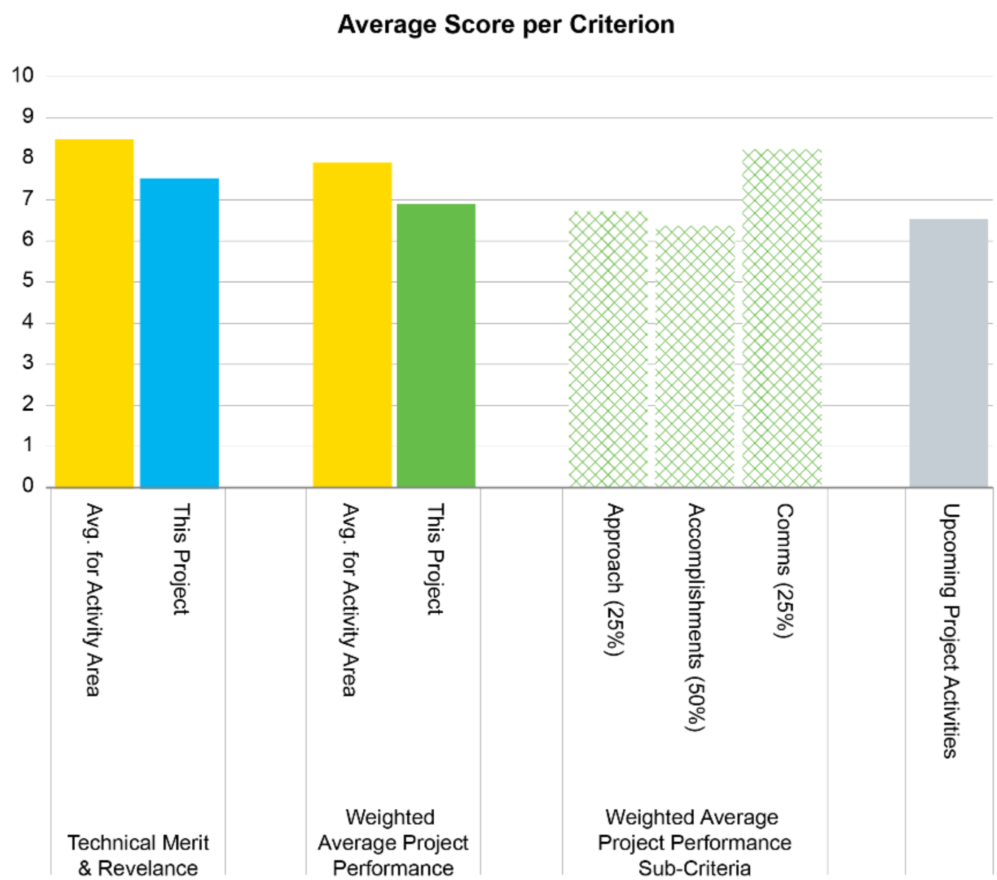
PI: Garrett Barter	Unique Project ID: T09
Organization: NREL	WETO Program: Technology Development and Scientific Research
Project Status: Active	WETO Activity Area: Atmosphere to Electrons
Total Available Budget (FY17 & FY18):	$2,337,058
Actual Costs (FY17 & FY18):	$1,451,808

Project Description

The Systems Engineering and Optimization initiative develops an analysis platform and research capability to capture full wind plant system interactions to achieve a better understanding of how to improve system-level performance and achieve system-level cost reductions The effort incorporates advances in computational algorithms, simulation methods, physics-based improvements, cost, and performance modules to assess new technology opportunities and advance the state-of-the-art and best practices in multidisciplinary design, analysis, and optimization.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Relevant research area seen from the industry.
- This project takes an integrated systems approach that focuses on wind plant level modeling, optimization, and controls. It seeks to advance an integrated systems design approach for the entire wind plant. As such, the project is timely, highly relevant to the industry, and has the potential to advance the state of the art and reduce the LCOE for future wind plants.
- The project can be viewed as the ultimate deliverable of the entire A2e effort, as it has the potential to integrate all computational modeling and experimental validation efforts of A2e to develop reliable engineering resolution tools for wind plant scale optimization and controls.
- Very powerful system optimization tools that can be used for wind plant optimization, as well as integrate all A2e physics and engineering models into the optimization process. This cannot be done by any other individual models. This platform provides a common interface protocol which enables customized optimization tools made of any DOE codes and industry proprietary codes. It is uniquely suited for wind plant modeling and is future proofed by the basic linkable code architecture.

Comments on Weaknesses

- Unclear of the benefits of the described goals. Also, not certain that the premise is accurate; that current design methods are not system level approaches.
- This is a concept that the industry is already investing in heavily. I am not sure this program fully understands where the current state of the art is, nor do I think that this program is directly advancing it.
- Need more HFM attention to engineering model physics gaps. Wake coupling? Offshore wind/wave coupling and possible coupling with floating turbine dynamics coupling might be important. ISDA might consider collaboration with MMC team to look at air/sea interface models.

Approach and Methodology

Comments on Strengths

- Well described in the material.
- The methodology integrates optimization strategies with turbine controls and modeling tools with the aim to produce wind plant. There are 3 main thrusts that need to be integrated into a single systems design framework: (1) Optimization strategies for wind plant layouts; (2) Controls using wake steering; (3) Development of engineering-fidelity modeling tools for wind plants.
- The idea to use turbines of variable size for non-heterogeneous wind plants, while not new, is promising.
- The focus on prediction of extreme loads is well advised.
- Unique areas like wake steering are worth examining if considered with all other inputs fixed.
- Very large organization and ISDA community that constantly collaborate to maximize the collective learning and industry application.

Comments on Weaknesses

- The three areas described seem to incorrectly assume that it is not done or already covered in other areas of A2e.
- The success of this project will hinge on the accuracy and reliability of the tools used for the various components and on the ability to integrate these components together into a unified framework. Validation of the various components is critical for this approach to provide reliable

results. It is not clear how this is addressed in this project. It is not clear if the team has attempted to validate their approach with real life operational data.

- The terms "high-fidelity" and "engineering-fidelity" are used loosely without clear quantifiable definition of what they mean.
- The statement regarding achieving "high-fidelity" at low cost is a somewhat surprising. You always pay for what you get and if this rule is not followed here, then much more detail needs to be provided.
- What is the LES model that is declared to be the truth? How are the turbines parameterized? What is the numerical resolution? How are inflow turbulences accounted for? Are terrain and complex atmospheric effects taken into account?
- LES models have many uncertainties and are far from the "truth" insofar as real-life wind plant flows are concerned, unless these uncertainties are carefully quantified and the predictive ability of LES is demonstrated for realistic wind plants and inflow atmospheric conditions. I am really concerned that the team will declares LES as “truth” and then proceed to develop low-fidelity models based on this assumed true state.
- Why is wake steering used as a single controls strategy? Is this the only option?
- This program seems to be attempting to include areas beyond the expertise of the national labs. The industry is already considering most of these factors and several others that are not being considered in this program. I do not see where the national labs have demonstrated any unique expertise in construction and functional cost engineering for a project. This seems to be better suited for the industry.
- ISDA collaboration with HFM and MMC teams to identify high-priority model gaps is very important. It seems that the state of each of these projects is now ready for more fruitful summit meetings. Fatigue and extreme load extrapolation design methods are outdated. Could ISDA focus on improved methods for 20-30-year load estimation?

Accomplishments and Progress

Comments on Strengths

- An approach for non-heterogeneous wind plants with turbines of various sizes has been developed.
- The WindSE model has been improved based on LES "truth".
- An efficient approach for predicting extreme loads has been developed.
- Data-driven models is a promising approach and it is encouraging that the team is pursuing it.
- The program appears to have met its schedule.

Comments on Weaknesses

- Some minor shortcomings on delivering the plan.
- Unclear of benefit of stated accomplishments. Standards and certification methods have dictated design requirements.
- It is not clear how the 3 components of this effort have been integrated together into a unified design framework.
- Validation of the models has not been addressed.
- I do not see how this project integrates well with other components of A2e. For example, HFM and field validation studies should be critical components of this project. Yet, this is not discussed.
- Declaring LES as "truth" without the caveats I mentioned before is really not a good idea.
- Even so, the comparisons of LES truth with the improved WindSE are not particularly illuminating. While the prediction improves somewhat, large discrepancies remain, and the ability to predict power generation and loads is not addressed.
- I cannot articulate what has been accomplished that has advanced the state of the art.

<u>Communication</u>

Comments on Strengths

- Very good project communication and interface to the industry.
- Detailed communication through industry conferences, workshops, and presentations.
- Several papers have been published and presented. Workshops have been organized.

Comments on Weaknesses

- I note a focus on conference papers as opposed to peer-reviewed academic journals.
- It is not clear how the industry has been engaged.

<u>Upcoming Project Activities</u>

Comments on Strengths

- All topics are very relevant areas.
- Current focus areas will continue and expand to include floating offshore among other activities.

Comments on Weaknesses

- Future proposed work scope needs to add detail to understand real-world benefit/value.
- I do not see how this project is ready to tackle real-life wind plant optimization as indicated in the plans for future work.
- This program would do better if it focused on single-variable manipulation and then communicated those results with industry to better inform industry models on whole plant design. The program has not demonstrated a unique ability to lead in the unified plant design relative to industry capabilities.

<u>Recommendations</u> (Not Scored)

- I recommend seeking collaboration with both WTG manufacturers and some of the owners, as there are tests of wake steering to optimize output ongoing in industry.
- Give clear quantifiable definitions of “high-fidelity” and “engineering-fidelity.”
- Provide details to explain how "high-fidelity" can be achieved at a low cost.
- I am really concerned that the team will develop low-fidelity models based on the declaration of LES as truth.
- The goal to extend this work to floating offshore is not realistic at this point as there is no HFM tool available in A2e right now to guide development of offshore engineering models. Development of HFM tools for floating turbines in realistic ocean environments—along with experimental data that can be collected in currently designed projects (e.g., the Aqua Ventus project)—will be critical for such a project to succeed in the future.
- The underlying assumption that the developers are not already doing much of this optimization is fundamentally wrong.

Integrated Systems Design and Analysis OSW

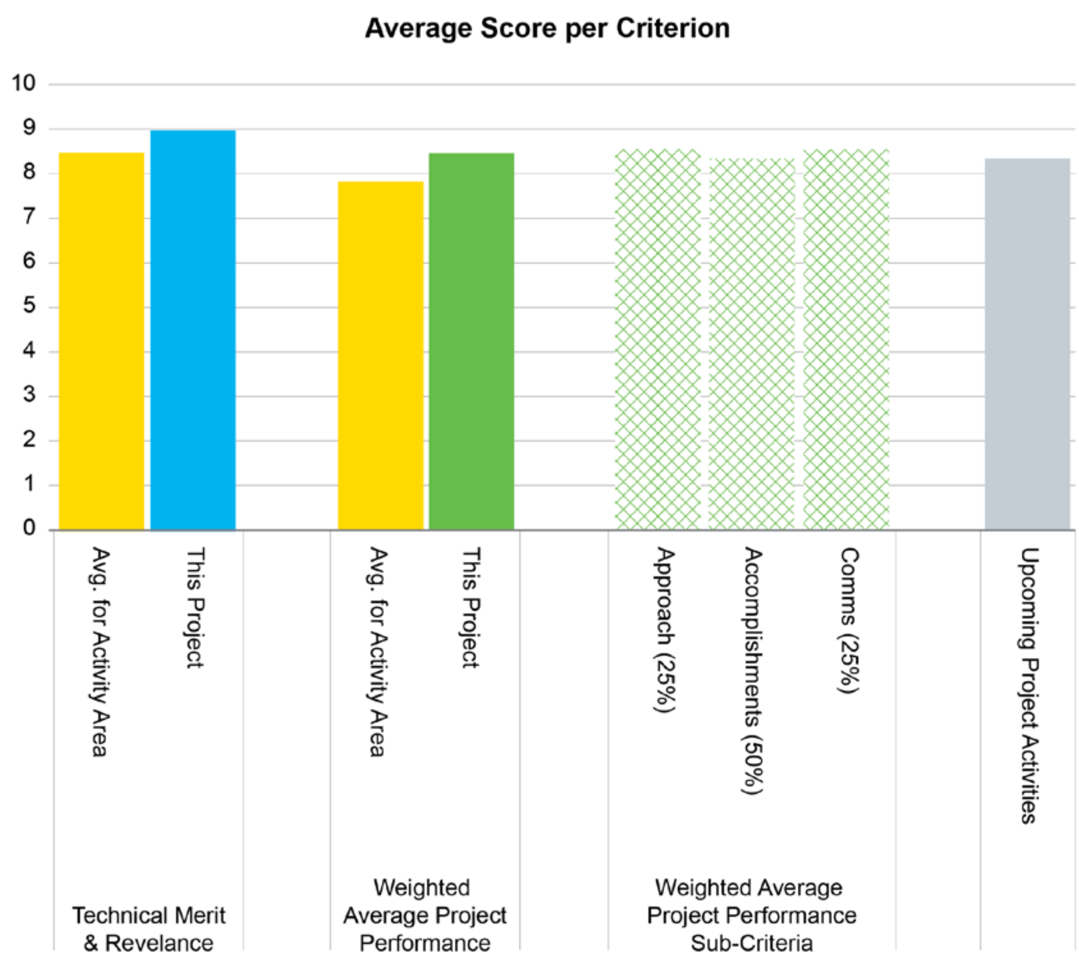
PI: Amy Robertson	Unique Project ID: T10
Organization: NREL	WETO Program: Technology Development and Scientific Research
Project Status: Active	WETO Activity Area: Atmosphere to Electrons
Total Available Budget (FY17 & FY18):	$1,888,656
Actual Costs (FY17 & FY18):	$1,135,128

Project Description

Offshore wind has a significant potential to provide power to regions of the country where other sustainable energy sources are not readily available, or where space on land is constrained. While offshore wind costs have been decreasing on a global basis, innovative and optimized offshore wind technologies have the potential to reduce costs further. Without validated design tools, rapid technology innovation and the resulting cost reduction in the offshore wind industry will not happen.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Assessed as very relevant from an offshore wind power industry perspective.
- The goals of the project will help to gain confidence in offshore wind designs and costs.
- This project seeks to collect field data from offshore wind turbine systems to validate engineering models for load prediction. Field data in real-life ocean conditions are essential for advancing modeling tools for offshore wind. As such, the project has the potential to advance the state of the art.
- Validation projects like this are valuable to the industry and directing future research.
- The continuous careful dissection of offshore codes from IEA OC3 through OC5 has delivered major improvements to all international predictive capabilities. It has been due to the constant support and leadership of NREL, with huge credit to the principle engineers for their intelligent and persistent work when collaborating with international researchers.
- Dramatic improvement in code accuracy and also isolation of the physics that cause errors in loads analysis. This informs researchers on the important areas to focus on for improvements.

Comments on Weaknesses

- OC5 represents the best example of a transparent proficiency test of different modelers abilities. It should be the basis for certification proficiency assessment. Could a streamlined OC5 type proficiency assessment be defined for IECRE Certification Body assessment?

Approach and Methodology

Comments on Strengths

- Very relevant methods for validation.
- The approach seems clear and simply stated, which helped us gain insights and improve the models.
- Field data collection under realistic conditions is proposed and coupled with validation efforts to identify predictive capabilities of engineering models. The central premise of this project is solid, provided that data sets for turbine systems that can be accurately replicated by models can be obtained.
- Systematic dissection of all international codes has born huge benefits.

Comments on Weaknesses

- IP issues and data sharing conflicts have created difficulties in this project. This is understandable given the industry challenges, but without data sets for systems that can be accurately prescribed as input to models, it is difficult to have meaningful validation studies.
- Engineering models are inherently incapable of accounting for the non-linearities arising in real life ocean conditions and the coupling of atmospheric turbulence with waves and structural dynamics. Without a high-fidelity model to provide guidance, I am skeptical about how much progress can be made.

Accomplishments and Progress

Comments on Strengths

- Assessed as a rather successful accomplishment.
- Several testing campaigns have been performed.
- Data has been collected. Validation studies with several engineering models have been carried out.

- While some promising results have been reported, significant discrepancies between model predictions and measurements were identified. The project made an excellent contribution because it clearly illustrated the importance of non-linear effects in such systems and exposing limitations of engineering models.
- Many publications from many of the international collaborators.
- Demonstrated reduction of prediction variability.

Comments on Weaknesses

- The setup with NREL and IWES had many, many participants and seemed rather bureaucratic. Did it really work well?
- Unsure of how the results aided tool improvements.
- The lack of adequate input data posed a major difficulty for achieving the project objectives from the start. The conclusions are thus not surprising. Engineering models showed deficiencies, but uncertainties in input data and flow conditions made it difficult to draw more useful conclusions.
- It is unlikely to make major progress without incorporating in the validation effort a high-fidelity model that can couple wind, waves, and FSI of turbine structures.
- Measurements using a turbine system from which data can be shared with modelers is essential for future progress.

Communication

Comments on Strengths

- Looks as if the outcome reached a lot of stakeholders.
- Several papers and presentations have been shared.
- The project has led to improvements for industry design tools and guidelines on how to approach offshore wind modeling. Conference and journal papers have been published.
- The project is coordinating a large group of stakeholders well.
- Public platform for information from OC3 through OC5 is very valuable for the public technical community.

Comments on Weaknesses

- It was unclear which improvements have been found or performed.

Upcoming Project Activities

Comments on Strengths

- Very relevant.
- They clearly described additional activities.
- The OC6 four-year project has already begun. The data will help better understand hydrodynamic loading and will further improve engineering models.
- Wind/wave tunnel tests of the floating system being conducted in Italy with robotic forcing are very high value and will be a major contribution.

Comments on Weaknesses

- The objectives for OC5 and OC6 are unclear.
- Data collected in systems that can be fully shared with modelers will be important for future progress to minimize uncertainties in validation studies. Also, a high-fidelity model coupling waves, atmospheric turbulence, and FSI of floating structures will be critical for future progress.
- The limitations of engineering models are well known when applied to such non-linear systems. Major progress can only be made by validating HFM models with such experiments and by using the results to improve engineering models.

Recommendations (Not Scored)

- Clearly show what benefits have been provided to tools from the project.
- Be clearer with the goals of the future activities.
- Consider leveraging the future data that will be generated by the work done under the two demonstration projects funded by DOE: AquaVentus and Project Icebreaker.
- Develop a transparent modeling proficiency process with public reference turbines, support structures, wave inputs, etc., for certification assessment and industry academic use.

A2e PRUF

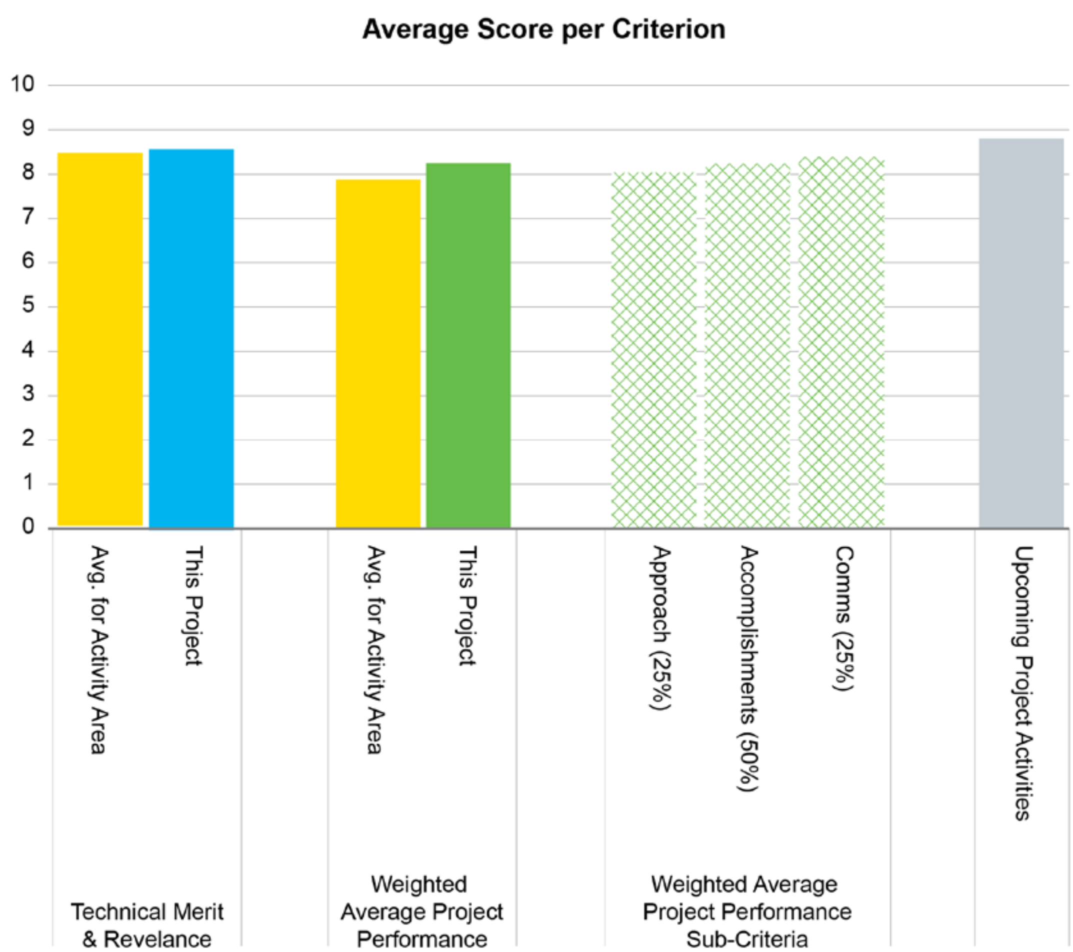
PI: Jason Fields	Unique Project ID: T11
Organization: NREL	WETO Program: Technology Development and Scientific Research
Project Status: Active	WETO Activity Area: Atmosphere to Electrons
Total Available Budget (FY17 & FY18):	$2,242,837
Actual Costs (FY17 & FY18):	$1,552,943

Project Description

PRUF identifies and reduces risk and uncertainty factors that impact long-term operation and profitability of wind power plants. Improving the predictability and reliability of wind power generation and operations increases investor confidence and boosts returns for wind plant owners, both of which are critical for robust and organic industry growth.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- The current focus of PRUF (WP3) supports the goal of reducing LCOE and uncertainty.
- This project can reduce LCOE, increase annual energy production, and accelerate technology transfer. It is of critical importance for the wind industry and can bring much needed quantitative insights to decisions guiding investment and wind development.
- Huge value to work toward establishing a benchmark; DOE is in a great position to play an unbiased role in providing such benchmark.
- The broad industry collection of data sets has the potential to be hugely valuable if properly used.
- AEP shortfalls have plagued the wind industry for many years. Isolating the cause has largely been assumed by the independent engineers who make the predictions. This has prevented transparency as to the cause. PRUF is the first objective transparent research analysis and quantification. DOE is in a unique trusted position to perform the task. It is critical for investor confidence. The industry needs this trusted benchmark.

Comments on Weaknesses

- There are other factors (levers) that can more dramatically positively affect LCOE.
- While every consultant will want to protect their privacy, the value of this report is entirely dependent on how the results are reported. The applicant does not fully explain how it will communicate results. Seeing results by contractor, by project, by turbine predicted vs. actual results, is key. It is also important to understand how the annual operational data is normalized.
- Has there been an analysis as to the causes for some participants being more accurate than others? This kind of analysis is important to lead to long-term reductions in uncertainty.

Approach and Methodology

Comments on Strengths

- The stepwise approach is clear with its specific project deliverables and goals.
- Large buy-in from the U.S. industry has created an unprecedented size database of wind projects to design a statistically significant test to verify pre-construction energy yield assessments.
- Data sets will be used to validate pre-development predictions and improve prediction models.
- This project could lead to exciting results which would benefit the entire industry. And equally importantly, it would contribute to advancing an industry culture for sharing data as a means to advance the state of the art.
- I very much like the idea of using machine learning and AI.
- The collection of data and the goal of a competition clearly has the potential to provide an objective assessment of the industry's capabilities.
- OpenOA is very valuable tool for the industry; for independent benchmarking and validation of internal tools.

Comments on Weaknesses

- This project requires a continuing approach over time as the more projects are added, the better the prediction methods will be.
- The geographic diversity of projects should be carefully considered as it will be important to account for various region-specific conditions in cost estimate predictions.
- The industry does not have a broad agreement on normalizing operating data, so the methods used to compare operational assessments to predictions still introduces debated uncertainty. This

analysis needs to be on a per turbine basis to truly understand precision vs. accuracy of the assessments.
- More transparency and analysis of the causes would be valuable.

Accomplishments and Progress

Comments on Strengths
- The results of the effort to date have been good.
- Phase 1 with 10 projects on simple terrain has been completed.
- OpenOA is a great way to engage the community.
- This has been an excellent and groundbreaking data collection effort.
- Very productive and successful collaboration with the industry.

Comments on Weaknesses
- Types of projects selected for future inclusion in the database will be critical for the success of this effort. Geographic variability to consider simple and complex terrain situations will be important factors, and it will need to be carefully considered to have a general bias-free predictive framework.

Communication

Comments on Strengths
- Good approach to have in both internal and external communication plans.
- Conference papers and reports have been published. The development of OpenOA is a significant accomplishment for the industry and needs to be aggressively communicated.
- The results so far are already industry transforming.
- This project requires very careful communication, plus protection of confidential information. This project has accomplished that.

Comments on Weaknesses
- Although publications and presentation forums are top rated, the communication could be better if a wider swath of industry publications and forums were engaged. It was too focused on finance- and resource-specific venues.
- The value of this report to affect the market is entirely dependent on the quality of the reporting and communication.

Upcoming Project Activities

Comments on Strengths
- Upcoming activities are deemed appropriate for the continuation of this work.
- Strongly encourage introducing the OPEN AO to IEC 61400-15 standard as an annex or IECRE certification system as an assessment tool.

Comments on Weaknesses
- The project must communicate data the financial market needs, which includes individual turbine analysis as well. The more transparent this is, the more it will move the industry.
- No upcoming activities listed.

Recommendations (Not Scored)
- Suggest PRUF explore and at least catalogue all levers that effect LCOE, even if the main focus is WP3.

- This project can reduce LCOE, increase annual energy production, and accelerate technology transfer. It is of critical importance for the wind industry and can bring much needed quantitative insights to decisions guiding investment and wind development.
- Types of projects selected for future inclusion in the database will be critical for the success of this effort. Geographic variability to consider simple and complex terrain situations will be important factors and need to be carefully considered to have a general bias-free predictive framework.
- This is the foundation for a game changing project, but the value will only exist if the analysis and reporting is done well. This project needs to look at per turbine, and not just per project basis, to be fully valuable. This project is only going to move the financial market if the data is shared.
- Continue funding! This needs long-term support by DOE. DOE is the only objective and trusted group with no conflict of interest. Publish public reference energy assessment tool.

Small Business Vouchers - WindESCo

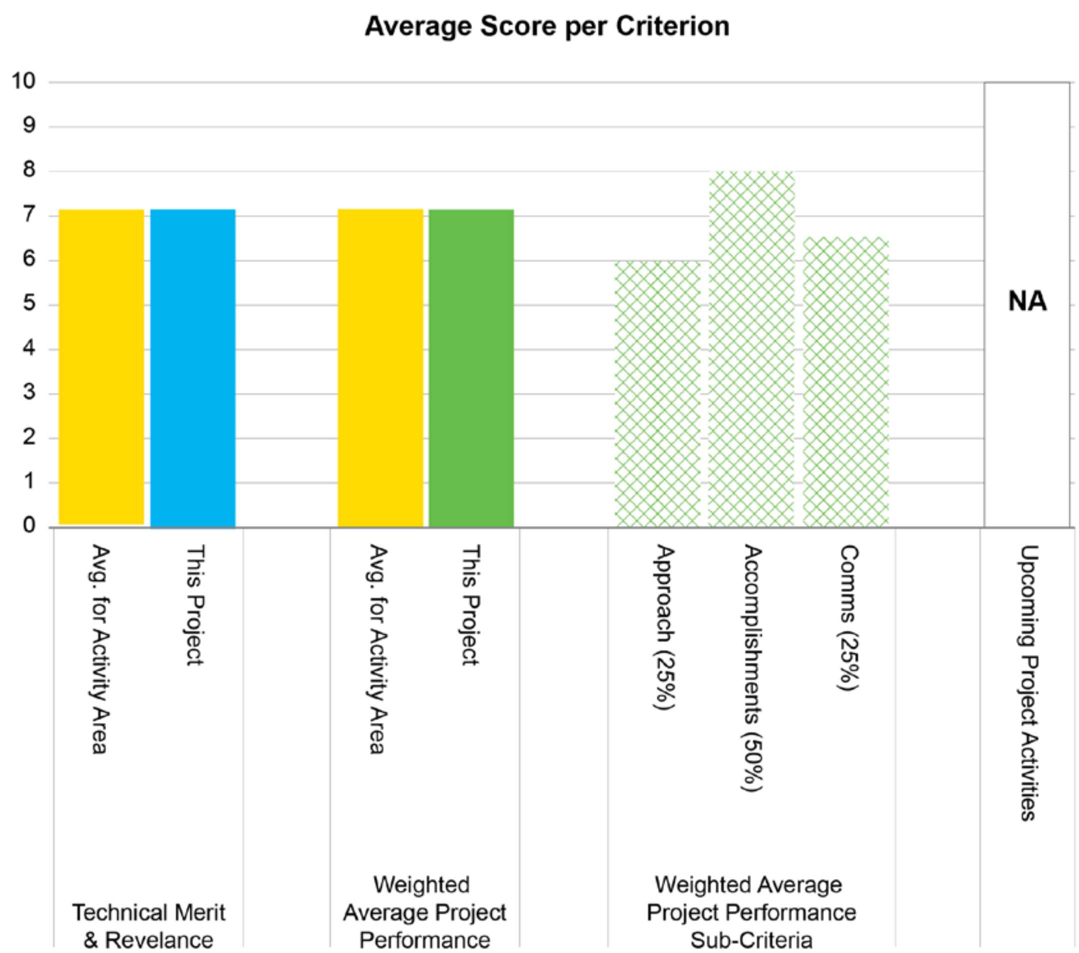
PI: Paul Fleming; Jennifer King	Unique Project ID: T22
Organization: NREL	WETO Program: Programmatic Support
Project Status: Completed	WETO Activity Area: Atmosphere to Electrons
Total Available Budget (FY17 & FY18):	$200,000
Actual Costs (FY17 & FY18):	$131,367

Project Description

NREL and WindESCo investigated the application of NREL's consensus yaw control at a site where WindESCo hardware for wind farm control is being deployed. A hybrid analysis using data collected by WindESCo showed the potential for a more than 2% increase in AEP if consensus control is deployed.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Great to see some practical work on consensus controls. It can be a practical method to deal with individual turbine issues.
- Consensus control is a promising idea that has the potential to increase energy production by aligning wind turbines in wind farms. The project is relevant to industry.
- Very relevant to lowering the cost of energy. The technology has strong potential to increase AEP, and therefore lower the LCOE.
- Solving or advancing the yaw problem has broad market value.
- This is a very simple wind plant control technique that capitalizes on SCADA data to correctly orient errant wind turbines based on their neighbors within the plant. The surprising result of 2% AEM improvement represents a no-cost control strategy. Even if it isn't implemented as a control strategy, it seems it should be implemented as a SCADA-based operations quality control test of wind turbine performance, along with other such turbine to turbine performance tests.

Comments on Weaknesses

- I do not see this as really relevant for the industry.
- How do we know that the consensus control is not masking actual variation versus a specific turbine issue?
- Challenges may arise from the implementation of consensus control algorithms in the field due to data resolution and noise.
- This report is very narrow in scope, and it is hard to determine overall application to the yaw problem.

Approach and Methodology

Comments on Strengths

- The overall idea to develop some kind of "collective intelligence" in a wind farm by enabling turbine-to-turbine communications to achieve alignment with wind direction is quite interesting.
- The projects used real-life wind farm data to demonstrate potential of the technology.
- Analysis on yaw cycle times is informative.
- Conducting this project with a private company that plans to commercialize it was a good strategy for accelerated technology-to-market transfer.

Comments on Weaknesses

- The methodology employed is not clear. The section reads as merely a log of the steps executed. Unsure if the steps were the appropriate, thought-out method.
- Implementation of this idea in the field could be challenging, especially as the size of the wind farm grows. And, it is not clear that the team has been able to demonstrate with certainty that consensus control has been achieved.
- Yaw misalignment does not appear to be considered, nor does turbine self-orientation knowledge. Most turbines do not have a dynamic source of North, so the process of determining how the specific turbine Norths were set may materially alter the conclusions of the report. Most are set by a technician trying to use a compass, which is unreliable; the turbines may all have been pointing the same direction without knowing it.

- The paper and algorithm are academic in approach and will suffer signifying practical shortcomings: technology, yaw misalignment, north misalignment, and lack of a local vs. consensus self-check step.

Accomplishments and Progress

Technical Merit and Relevance

- Very positive results are described. Lower yawing time and increased AEP.
- The project sought to demonstrate the effectiveness of consensus control on wind farms using SCADA data. The reported results are certainly promising, and given the overall size of the project, I consider progress to be satisfactory. The results certainly demonstrate that the idea has merit and should be further investigated.
- Results are very clear and demonstrate the potential of the technology.
- They accomplished what they intended to accomplish.
- Short and simple project implemented on time.

Comments on Weaknesses

- Unsure how real the accomplishments are as this is a desktop exercise.
- It is not clear that consensus control has been objectively achieved using the data and overall approach used in this work.

Communication

Technical Merit and Relevance

- Results are clearly described and presented.
- Good to see a plan to discuss with a broader audience. (I've seen separately that a paper is planned for WindPower 2019).
- Very minimal communication has been done.
- A report was created and shared with stakeholders.

Comments on Weaknesses

- Description of communication plan is thin.
- Very minimal communication has been done.
- Not sure if they have submitted invention disclosures or patents.
- I do not see how this report/information was communicated to non-project stakeholders.

Recommendations (Not Scored)

- It is a promising approach overall, but an idea that requires turbine-to-turbine communications in wind farms can be tricky to implement and demonstrate. Given the relatively small size of this project, however, I consider this to be a successful project as the work has yielded promising results.
- Team up with a wind farm operator to validate AEP gain.
- As best I can tell, it cost $130k to do some data analysis. The conclusions are beyond the capability of the dataset.
- Continue with validation, plus explore other big data control applications, which capitalize not only on synchronized wind plant measurements, but also historical performance, fault, and maintenance data.

Multi Physics Model Validation & UQ

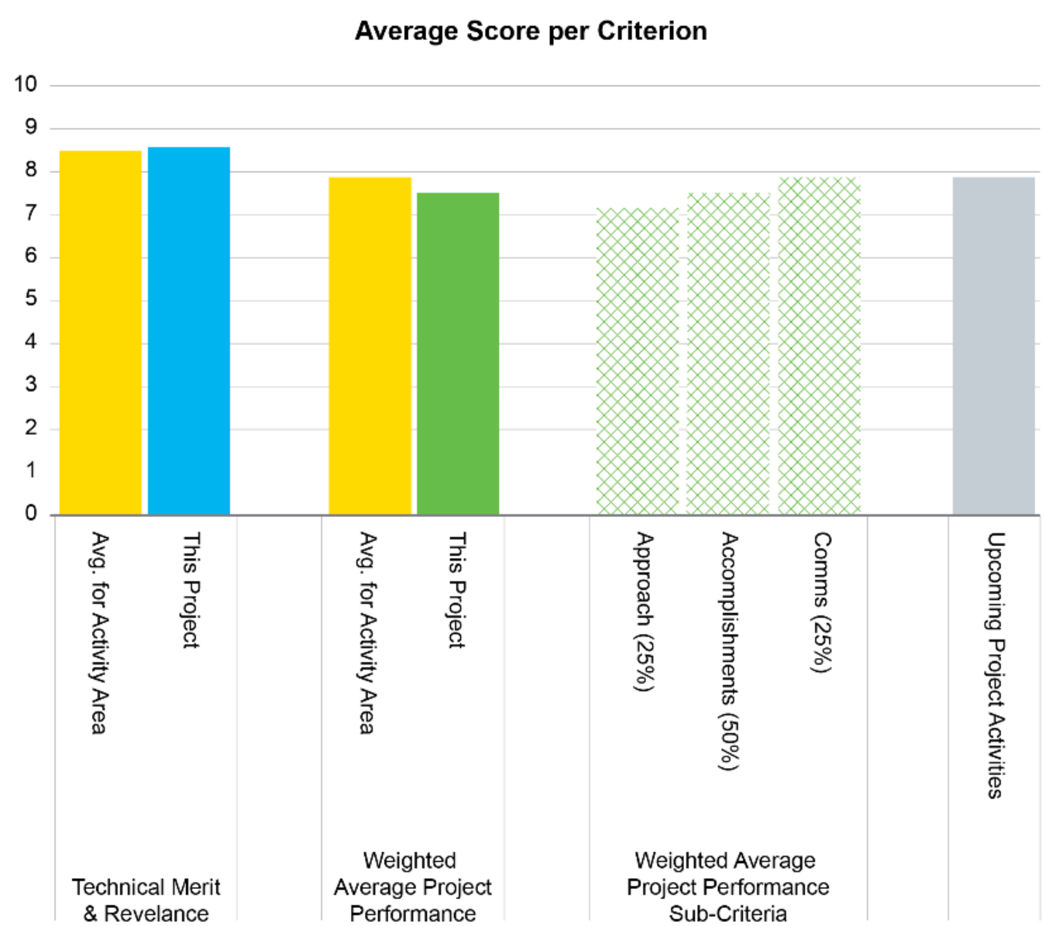
PI: Jason Jonkman	Unique Project ID: T28
Organization: NREL	WETO Program: Technology RD&T and Resource Characterization
Project Status: Active	WETO Activity Area: Atmosphere to Electrons
Total Available Budget (FY17 & FY18):	$663,017
Actual Costs (FY17 & FY18):	$485,079

Project Description

Enable the development of advanced wind-plant technology by leveraging knowledge, data, and high-fidelity modeling (HFM) results from the broader Atmosphere to Electrons (A2e) initiative to verify and validate (V&V) and improve physics-based engineering tools at both the turbine and plant levels

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Very impactful goal to get research results into modeling tools for industry to utilize.
- Project seeks to develop physics-based, mid-fidelity design tools for fast and reliable load calculations, as well as to carry out V&V efforts and develop uncertainty quantification framework. This project is critical for next-generation turbine design, and the project has the potential to dramatically advance the state of the art. Highly relevant to the industry.
- Specific efforts to validate long-term DOE efforts are very important. Projects like this are cost effective and valuable.
- A2e was originally designed to gain a better understanding of the physics of mesoscale and microscale atmospheric effects on wind turbines in wind plants. But the real impact will be how it improves the understanding and informs engineering models that can be used to improve turbine designs, reduce LCOE, and improve wind plant controls.
- This project demonstrates how A2e has already improved the engineering models, but the engineering models (FAST.Farm) have been used to inform Nalu-Wind what space is important to investigate because Nalu cannot be used to explore all analysis space.
- Excellent work!

Comments on Weaknesses

- I find it difficult from the materials really to understand the outcome of the project and how that can be applied in the industry.

Approach and Methodology

Comments on Strengths

- The project approach with workshops seems appropriate for the purpose.
- A physics-based, "mid-fidelity" model FAST.FARM is developed using LES data as the "truth" to gauge predictive ability and identify areas of improvement.
- The approach of using HFM data to develop mid-fidelity tools is scientifically rigorous and provides a clear path for developing the next generation of engineering tools.
- I very much like the effort to systematically assess the sensitivity of aeroelastic models to various parameters.
- The design load case/parameter sensitivity study was an excellent way to identify the most important physics that A2e must focus on. This project demonstrates the powerful value of having a continuum of code/modeling fidelity.

Comments on Weaknesses

- The approach seems very soft and nonspecific.
- It is not clear how wakes are modeled in FAST.FARM, as well as how new physics are incorporated in the model.
- The entire project is based on the premises that SOWFA is the "truth." Yet, SOWFA has its own uncertainties, and it is not applicable to complex terrain and offshore environments. The project could benefit by broadening the focus to consider interfacing with other models that incorporate a wider range of wind farm physics.
- The terms “high-fidelity,” “mid-fidelity,” and “low-fidelity” need to be precisely quantified for the benefit of this and ALL projects.
- The materials do not explain this project or the value to the industry well.

Accomplishments and Progress

Comments on Strengths

- It is shown to be working.
- The steps outlined in the approach have been executed.
- Progress has been made on several fronts of this project: (1) workshops to plan how A2e can benefit industry; (2) improvements of FAST.FARM using SOWFA as ground truth; (3) assessment of sensitivity of load predictions to various model parameters; (4) V&V of FAST with data from utility scale; and (5) validation of turbulence models.
- Impressive demonstration of isolating the important physics for HFM to focus on. This sensitivity analysis is a perfect demonstration of the power of engineering models informing HFM.

Comments on Weaknesses

- Several items presented as accomplishments did not seem directly related to the goals or approach defined.
- I just do not see how the accomplishments relate to the goals of this project.
- I do not understand how turbulence models were evaluated and how such effort fits within the current project. This project has several pieces, and it is not clear how they all connect together.

Communication

Comments on Strengths

- Assessed to be good and ensuring sparring with different stakeholders.
- Workshops were conducted.
- Journal papers, conference papers, and reports have been published. Open-source software is downloaded at very high rate every year. Workshops organized to engage the industry.

Comments on Weaknesses

- Unclear what communication actually occurred other than to DOE internally.
- A list of papers published is not included.

Upcoming Project Activities

Comments on Strengths

- Topics listed are fine for further research, though not very industry application oriented.
- I very much like the future focus on assessing the effects of inflow conditions on wind plant predictions and turbine loads.

Comments on Weaknesses

- Unclear what the future activities will produce.
- Integration with HFM activities will be critical for future work to expand and refine the capabilities of FAST.FARM.

Recommendations (Not Scored)

- FAST.FARM could be an important contribution of A2e, as such a tool could serve as the work horse for industry simulations and wind plant optimization.
- The success of the project, however, hinges on its integration with HFM and validation efforts. The goals of this project need to be better defined and articulated. Presently, pieces seem to be a bit disconnected. A2e will benefit a great deal by clearly defining what various fidelity levels mean to this and all other teams of A2e. Also, considering SOWFA as the LES-truth should be carefully reconsidered.

- Uncertainty quantification is an important aspect of this project, but validating FAST.FARM using a so-called LES-truth introduces all of the uncertainties of the LES in this model, making UQ even more difficult and "uncertain."

Project Results - Distributed Wind

Distributed Wind Research, Development, and Testing

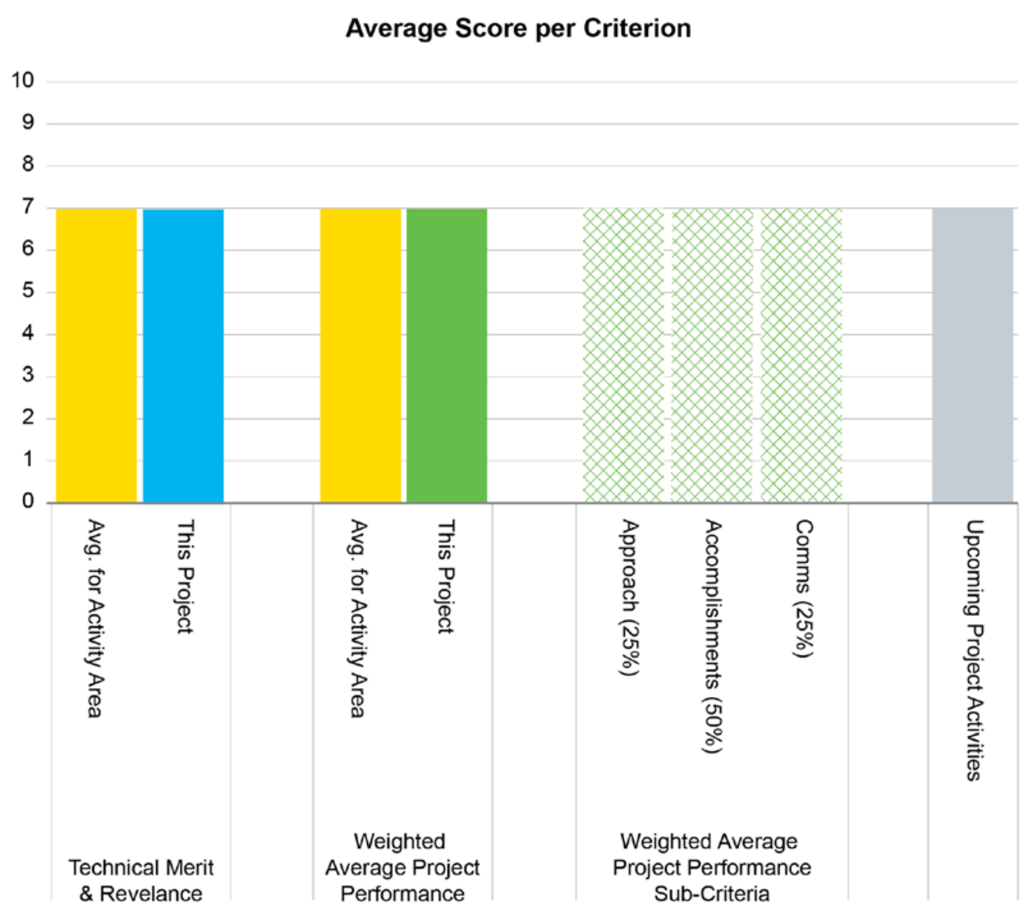
PI: Ian Baring-Gould	Unique Project ID: T03
Organization: NREL	WETO Program: Technology Development and Scientific Research
Project Status: Active	WETO Activity Area: Distributed Wind
Total Available Budget (FY17 & FY18):	$8,752,850
Actual Costs (FY17 & FY18):	$3,681,505

Project Description

Support innovative R&D and testing of wind technologies designed for distributed energy applications through the Competitiveness Improvement Project request for proposals, research, analysis, and stakeholder engagement to develop a fundamental understanding of the installed costs, market potential, and R&D challenges limiting market development

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Possibly easy wins if large wind lessons were brought down to distributed wind.
- This is an important project as DW has the potential to make a significant impact in wind energy production for a number of sectors, including rural, commercial, and industrial applications.
- There is a clear need for a comprehensive research effort to improve turbine technology, perform systematic resource assessment, understand and mitigate market barriers, and perform economic analysis. This project tackles all of these issues and, to that end, has the potential to be very impactful.
- Very relevant to diversify the electricity generation portfolio.
- I agree that the BTM wind market has significant potential for growth.
- Benchmarking and detailed project cost breakdowns provide material value to inform the market and new business plans.
- Great effort to help the small and distributed wind industry with targeted market studies, resource assessment tools, and technical assistance.

Comments on Weaknesses

- I assess distributed wind power as a non-industry. Why not do PV?
- Distributed wind will most likely be less competitive than solar.
- I question if any of the current programs and methods imposed by T3 will result in achieving the stated goal of improving and enabling the market. The views do not appear to conform to current market forces, making the market complicated. Where is cost benchmarking for turbine OEMs to inform new and successful business plans? What positive market results (in dollar value) have been realized through this program?
- The D3T may be interesting, but it is motivated by non-market disaster and defense needs, and it is thus not appropriately grouped into this project, which is focused on market-driven applications.
- The MIRACL program is borderline for being appropriately included in this program. It has not been shown that this is a compelling need for the market right now, and, even if successful, that the program will materially affect the DG wind market.
- The cost breakout seems to highlight the challenge small and distributed has in overcoming the outsized cost of installation compared to the cost of the turbine. The turbine cost is almost the only part that the manufacturer can control. It seems very difficult to see how PV Solar will not dominate the market.

Approach and Methodology

Comments on Strengths

- Cost reduction analysis is valuable, and takes lessons learned from distributed solar. Resource information is a good and needed direction.
- The approach is multi-pronged as required for a project of this nature. It involves providing cost-shared projects to the industry to improve technology, and it also involves conducting research by NREL staff to support the other aspects of this effort.
- The effort to understand DW resource assessment and performance in built environments and under turbulent atmospheric conditions is based on rigorous science and is well thought out.
- Strong support for turbine innovation. Identifies opportunities for market growth. Understands the cost drivers and identify opportunities for lowering the LCOE. Tools for better site resource assessment.
- Excellent collaboration with the industry to get them what they want and the tools they need.

Comments on Weaknesses

- Approach regarding small business is too general. It would be best to describe the details on what the small business support is to help with distributed wind deployment.
- It is not clear that the project has adequate resources and a clear timeline to achieve goals, which are quite ambitious.
- Significant funds were invested with failed manufacturers (NPS). The applicant fails to explain how the current approach preserves the value of the knowledge gained and justifies further investments in manufacturers who are also likely to struggle due to larger market forces.
- The applicant fails to explain why it thinks a National Wind Resources map will be more accurate. It is not used by the utility-scale market; why is it okay for BTM projects? It is NOT accepted by any financial institution to my knowledge.
- Nothing in the information provided suggests that the applicant is making progress towards improving the market. Further, nothing suggests that they are even tracking whether they are positively affecting the overall BTM market.

Accomplishments and Progress

Comments on Strengths

- Several specific accomplishments described.
- Progress has been made in some important areas. The development of the new Bergey turbine design is an important accomplishment showing substantial reduction of the LCOE. A DW economic viability assessment report has been developed for 3 states. Other reports addressing economics, costs, resource assessment, etc., are also mentioned.
- It was nice to see that an actual product was certified as a result of this effort and demonstrated significant reduction in LCOE.

Comments on Weaknesses

- I am confused about the specific objectives of this project. It is stated that because not enough funding was available to accomplish goals, much of the work has focused on setting the stage for future work. Not much detail is given to understand exactly what was intended to be delivered.
- Deliverables have not been mapped clearly with project goals. For example, it is not clear what efforts have been undertaken to assess wind resource and energy production.
- A detailed list of publications from this project, including properly cited reports and papers, is not provided, making it hard to assess what exactly has been produced.
- Most of the projects have not actually created market value.

Communication

Comments on Strengths

- Several communication methods were described.
- Reports have been disseminated through DWEA, AWEA, websites, and relevant conferences. Workshops with the industry have also been organized.
- Strong plan for future activities.

Comments on Weaknesses

- Seems like the effort is not significant enough.
- It will be useful to provide a bit more detail about various communications strategies.
- Properly cited reports produced by this project could help the reviewer assess what has been produced.
- Commercialization is not properly addressed beyond one example with the Bergey turbine.

- Where are analytics on communication, web traffic, report downloading, etc.? No specifics are provided.

Upcoming Project Activities

Comments on Strengths

- Five specific future projects are defined.
- This project appears to have ended, but future work will continue because of new recently funded projects.
- The Distributed Wind Market Report is valuable to industry participants.

Comments on Weaknesses

- How are adjustments being made to account for recent industry failures? What new measures are being put in place to ensure that future CIP investments don't have same results? No information has been presented to show that TAP improves access to capital. No financial parties have indicated that TAP will help in their underwriting of the project.
- There does not appear to be significant LCOE reduction plans that would bring small wind to parity with solar.

Recommendations (Not Scored)

- How is the group handling that failure of Northern Power Systems and the Small Wind Certification Council? The $3.6 million budget represents a very large percentage of the entire nationwide behind-the-meter market revenue.
- The applicant is properly defining the market as behind-the-meter or off-grid to capture unique distributed market.
- The applicant does not articulate how future results will improve on past lack of results for industry market growth. Millions are being expended on an industry that is struggling to invest millions. This entire program needs to be rethought to ensure that this is not a continuation of a failed program.
- I believe that there is a compelling market/public need to study and try to improve the DG market. I am not sure that the applicant's current approach has done anything to improve the current market’s position, nor has applicant presented any information to show that it is creating positive change in the market.
- I recommend developing an offramp plan unless a unique solution to solar challenge is possible.

Project Results - Testing Infrastructure

Testing Facilities and Capabilities at NWTC

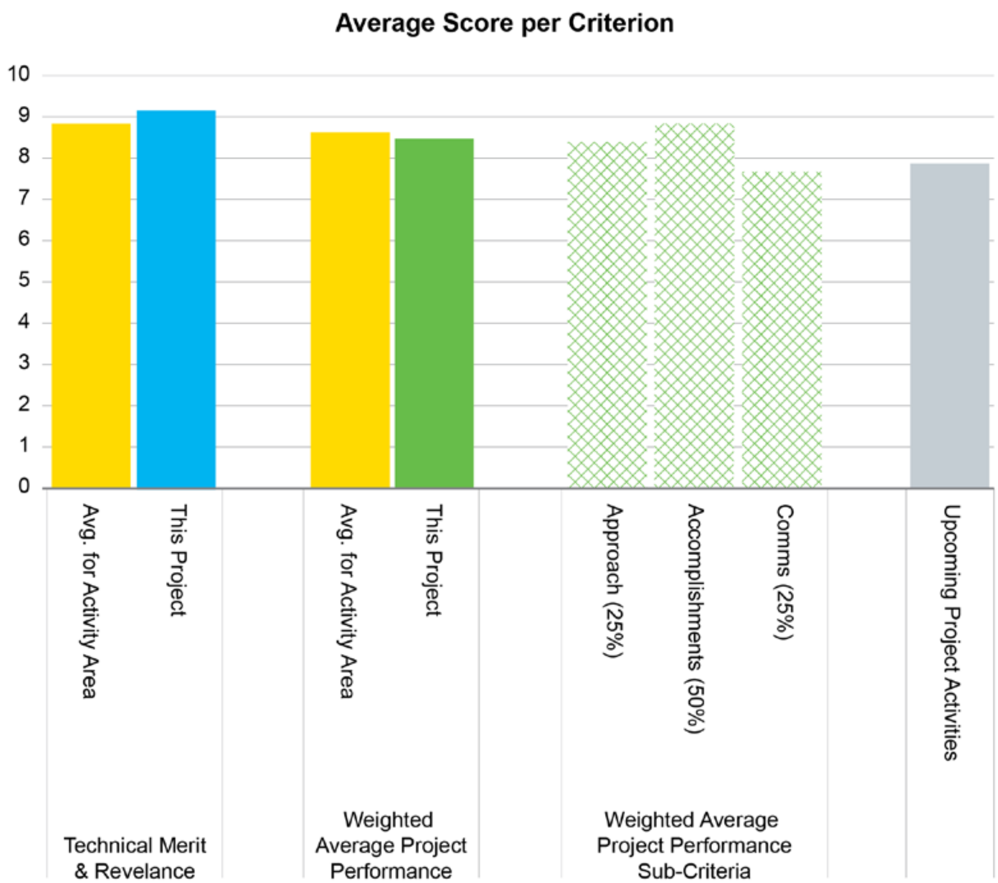
PI: David Simms	Unique Project ID: T01
Organization: NREL	WETO Program: Technology Development and Scientific Research
Project Status: Active	WETO Activity Area: Testing Infrastructure
Total Available Budget (FY17 & FY18):	$11,841,501
Actual Costs (FY17 & FY18):	$8,138,336

Project Description

Safely operate and maintain reliable performance of DOE's world-class research facilities and capabilities at the National Wind Technology Center (NWTC). Support fundamental research, development, experimentation, and validation of components and systems, and understand operation and failure modes. Support evolving DOE and industry research needs.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- The testing facilities are very important to the wind energy industry.
- The goal is to provide facilities to support real world testing in support of the industry.
- NWTC operates impressive testing facilities in support of DOE and industry missions. The project is highly relevant to industry and other stakeholders and is producing unique datasets that are advancing the state of the art.
- NWTC has unique testing capabilities. Maintaining these facilities is very relevant. Good focus on industry partners. Very diverse capabilities.
- Maintaining this capability is very important to the industry and future research.
- The NWTC test facilities have been historically the most important means available to industry for testing a wide range of component and full-scale wind turbine components. It forms the U.S. center of wind energy testing excellence.
- All reference grade test programs for 40 years have started at this wind site. It has evolved to meet the growth of the industry as well as the changing industry needs, including large blade structural testing, drive train testing, grid interaction simulation, and field testing of every configuration of wind turbine since 1977 has taken place at this site. It is truly a national treasure.

Comments on Weaknesses

- Limitations of some onsite components that are not under NWTC control. For example, some of the wind turbines not owned by NWTC.
- If the goal is to support offshore wind, then larger blade test centers located near a deep-water port will be necessary to have available to support the U.S. market.

Approach and Methodology

Comments on Strengths

- Approach supports five parallel focus areas. Each area supports different testing capabilities.
- I give this project very high marks on approach and methodology. The range of facilities is impressive and the degree of engagement with other DOE projects, industry, and universities more than justifies the major investment in this project.
- The NWTC team consists of very competent researchers who ensure high scientific standards and rigor.
- The structural testing facility is very relevant and important to advance R&D in the area of blade testing and structural reliability. The grid integration testing facility is unique and relevant to the industry.
- These facilities are technically valuable to the wind industry.
- The new migration to adapt to other renewable testing technology is admirable. It appears that this transition to assist other technologies has already begun.

Comments on Weaknesses

- The walkthrough of the presentation was somewhat superficial.
- Weak grid, low fault current, and other issues affecting distributed wind should be included in planning for facility improvements.
- I am concerned about the perception of safety vs. actual safety. Safety statistics should be published to reviewers as a part of this program. Multiple OSHA violations are shown on at least one of the pictures in the presentation.

Accomplishments and Progress

Comments on Strengths

- The facilities in all areas are fully capable.
- Significant progress is reported on all aspects of the project. The development of new facilities and maintenance and operation of existing facilities is progressing well. A number of specific projects are also listed, which illustrate how the NWTC facilities are utilized in research projects. I especially note the range of projects and stakeholders benefiting from the facilities, including A2e, SNL, industry, and universities.
- All milestones were completed on time and within budget. Amazing safety record.
- Number of successful test programs led by both industry partners and NREL testing experts.

Comments on Weaknesses

- The walkthrough of the presentation was somewhat superficial.
- While several examples of projects utilizing the facilities are given, no specific accomplishments from these projects are provided. The project report could be strengthened by providing concrete results showing how specific innovations and advancements have been enabled by the NWTC facilities. Such examples could help further make the case for the return of investment of this project.

Communication

Comments on Strengths

- A number of industry partners are listed. Most are through CRADAs or other partnership agreements.
- A broad range of communication and outreach activities are implemented, including tours to visitors, student engagement, conferences, and interactions with the industry.
- There was a strong use of the testing facilities by industry partners.
- Excellent communication and publication history. It also had excellent participation in international standards to share experience in testing standards.

Comments on Weaknesses

- The walkthrough of the presentation was somewhat superficial.
- External communication activities/attempts to inform the industry (non-partner players) is not discussed.
- There is no list of journal and/or conference papers published based on work carried out at NWTC. This aspect of the communications plan needs to be strengthened significantly.
- There are no specific examples of commercialization of technologies tested at NWTC.
- Need to have a good list of discovery stories. Also, focus on the staff talent as an asset and communicate that as much as facilities. Also, you may want to advertise the unusual wind conditions as testing attributes.

Upcoming Project Activities

Comments on Strengths

- It is very important for the industry.
- Transitioning site to support non-wind technologies (i.e., Flatiron Site).
- This is a great program and it has the capability to be maintained going forward.
- It is a great plan to expand the access to other renewable technologies.

Comments on Weaknesses

- It is not clear when the additional capabilities will be available.

Recommendations (Not Scored)

- DOE should budget for and acquire the non-DOE owned equipment at the site (wind turbines).
- The external communication plan should be developed to inform the industry of site capabilities.
- Consider developing up-range visualization instrumentation to "see" inflow to site
- Consider this site for WFIP3.
- This is a very successful project, which could be strengthened by improving the communications plan. More emphasis on research papers and commercialization of technologies tested at the NWTC facilities will help make a much stronger case about the value of this unique testing infrastructure.
- The site is ideal to collect validation data for HFM multi-scale validation of turbines in complex terrain and under extreme conditions
- Invest in instrumentation to better understand the complex flow on this site. NWTC provides a unique opportunity to test extreme wind events.
- The shift from testing to research focus needs to be carefully balanced. The ability of WETO to do non-market testing of critical components is important to future R&D.
- The answer of, "I should have just removed the picture," when asked about a safety concern demonstrates a clear lack of top-down safety culture and is completely unacceptable. This facility's job is to provide a safe and valuable test facility; it is failing in one of two areas.
- Adding the ability to look at weak grid and close proximity to buildings would be valuable.
- Continue funding this valuable research facility. Provide regular tours, especially for local schools. Could this be a WFIP3 site?

Testing Facilities and Capabilities at SNL: Field Test Facilities - DOE Turbine Facilities and Test Sites O&M

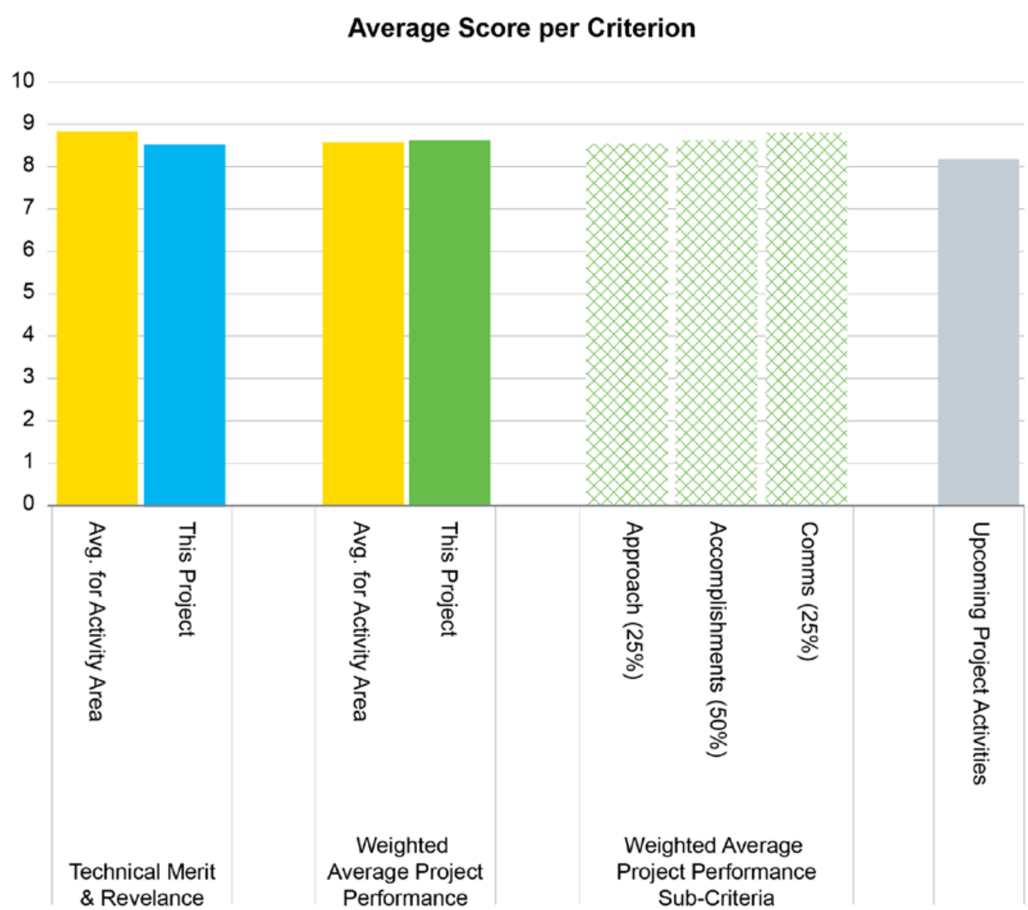
PI: Jon Berg	Unique Project ID: T02
Organization: SNL	WETO Program: Technology Development and Scientific Research
Project Status: Active	WETO Activity Area: Testing Infrastructure
Total Available Budget (FY17 & FY18):	$4,625,145
Actual Costs (FY17 & FY18):	$3,399,427

Project Description

The purpose of the Scaled Wind Farm Technology (SWiFT) Facility, being a DOE wind turbine test facility, is to provide the United States with world-class test capabilities for conducting innovative wind turbine and wind plant research & development. SWiFT's unique testing capabilities are derived from three key features: the turbines, the layout, and the wind resource.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- It is an important facility for the WTG OEM research.
- The goals focus around maintaining SWiFT capabilities.
- SWiFT is a premier field scale experimental facility to support wind turbine rotor and wind farm-scale innovations. It is highly innovative and very relevant to advancing fundamental understanding of wake turbulence in wind farms, producing unique data sets for model validation and uncertainty quantification, developing advanced control strategies, and supporting industry innovation.
- SWiFT research can ultimately lead to wind farm innovations that will help reduce the leveled cost of energy.
- The SWiFT facility is a world class testing facility for wind farm research.
- The wind plant performance research is a key area to lower LCO.
- The facility strongly supported other DOE-funded programs like A2e.
- Facilities like this are a national asset.
- High-quality test facility and testing expertise. Uniquely suited test facility for wake testing and validation of Nalu-Wind model. Flat terrain about this site seems like it offers good testing conditions for wakes.

Comments on Weaknesses

- Very narrow focus.
- Issues related to distributed generation should be included in future operations of the facility (weak grid, ability to create high obstructions, etc.).
- Are there obstacles around the site that might disturb inflow conditions?

Approach and Methodology

Comments on Strengths

- It was a good presentation of the methods.
- It was a straightforward approach to maintain functionality and capability.
- Research approach and methodology are sound and are based on a compelling scientific vision.
- The research conducted at SWiFT is of a very high caliber. This was made evident by many of the papers presented and published at premier wind energy conferences.
- Collaboration with universities and the industry is strong. The proximity of SWiFT to TTU is a major advantage, which is effectively leveraged through the active engagement of TTU students and researchers.
- Using an open source controller is a good idea to make the outcome of this effort available to the industry community.
- Controlled wind site provides a unique opportunity to perform validation and high-quality experimentation.
- Very well thought out approach from turbine, layout, and site data.
- Excellent collaboration with industry, academia, and other national laboratories.

Comments on Weaknesses

- "One of our staff has experienced a mild electrical shock." I am concerned about the safety culture at the site.

- Control system and possible structural blade failures have impeded progress. SNL should be commended for early detection and corrective action. But, could onsite engineering management, reviews, or other steps help avoid potential failures in the future?
- The new hire of a site manager from Siemens Wind and NASA mission safety experience is a commendable step.

Accomplishments and Progress

Comments on Strengths

- Good progress and strong accomplishments were seen.
- Good progress on site commissioning. Some data is already becoming available to support other DOE research (e.g., wake steering).
- Major progress has been made developing the facility and associated instrumentation. The modification in turbine A1 to enable wake steering and the scanning LiDAR instrumentation to monitor wake steering are impressive accomplishments and bode well for the future research at this site.
- The new results on wake steering and its effect on downwind turbines are novel and quite exciting. They serve to clearly illustrate the potential of this facility once fully developed.
- Good results to quantify the impact of yaw angle on power and load.

Comments on Weaknesses

- Delays in commissioning have been noted due to errors, staff transitions, and an accident. While some of these delays can be expected due to the highly innovative nature of this facility, others could have been addressed with better management structure and safety procedures in place. While it appears that steps were taken to mitigate these issues, it is clear that the project can benefit from improving management and stricter safety guidelines and procedures.
- Progress has been slow to get the facility up and running. Blade stud failure seems like it could have been avoided, but it is good that they caught it before an operational failure.

Communication

Comments on Strengths

- There was very good communication, even to the European research communities.
- Information was available through several methods (website, reports, and a virtual tour).
- Communication of research results is very strong. I am impressed by the quality of research that is already coming out from SWiFT.
- Research results are presented at premier wind energy conferences and are published in journals.
- The Sandia Blade workshop is an important component of the communications strategy.
- Strong collaboration with the industry. This is important to advance the research and accelerate commercialization
- 8th Blade Workshop held in 2018 at SWiFT was a success.
- The virtual tours are a model for other programs on how to communicate to a new generation.

Comments on Weaknesses

- No weaknesses noted by reviewers.

Upcoming Project Activities

Comments on Strengths

- It was an important and good outline.
- Several expected future activities were listed.

- A plan appears to be in place to complete remaining commissioning activities started in 2018 and begin new testing.
- Comments on Weaknesses
- No clear schedule was listed. I am unsure of when the capabilities will be available or if timeline goals are being met.
- It is critical that project management and safety are improved to avoid mishaps of the past.

Recommendations (Not Scored)

- Consider WFIP3 at this facility.
- Safety leadership needed.
- SWiFT is an impressive facility that has enormous potential to drive land-based and offshore wind farm innovation. The results that have already been produced are impressive and underscore the promise of this facility, especially the new findings on wake steering and its effect on downwind turbines. I also note multiple high-quality papers coming out of the SWiFT group. However, project management and safety need to be improved so that delays and safety issues that plagued the site in the past are not repeated.
- Can possibly expand the partnership to include other industry partners.
- Keep focusing on improving safety.
- A safety accident at the test facility would have broad negative industry impact. It is important that a clear safety culture be demonstrated, including reporting.
- Continue funding this test facility and use it to perform a Nalu-Wind validation test, with WFIP3 style measurement for atmospheric modeling validation.

Project Results - Standards and International Engagement

Wind Standards Development

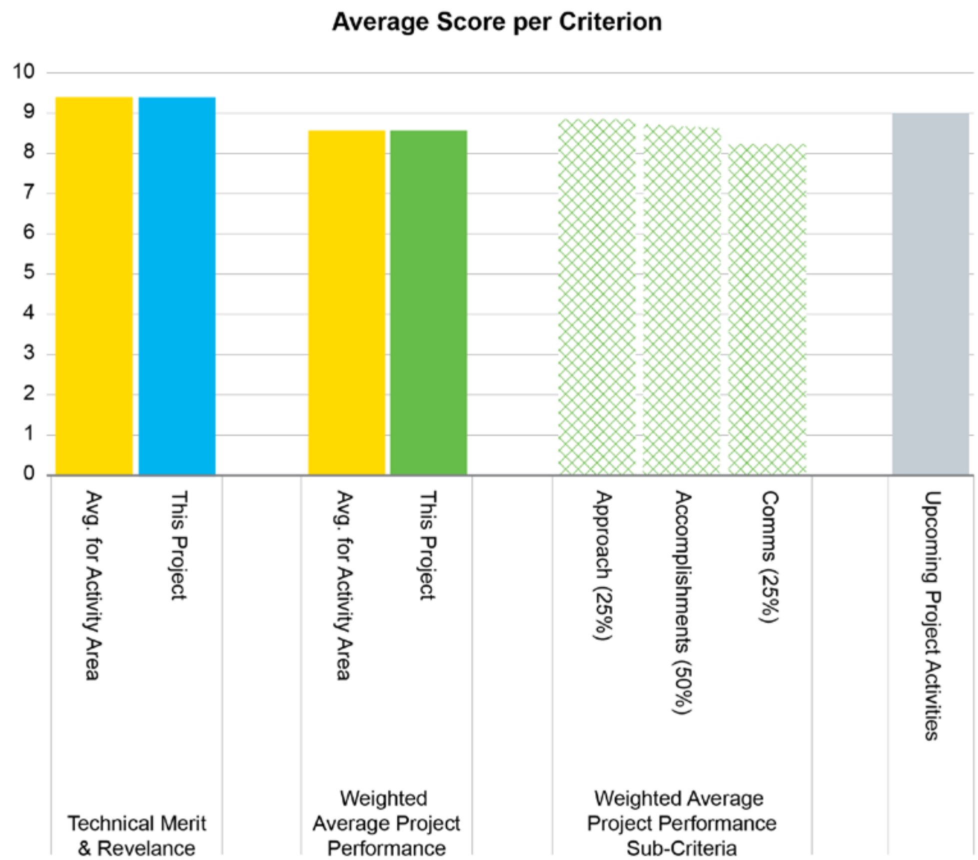
PI: Jeroen van Dam	Unique Project ID: T18
Organization: NREL, PNNL, SNL	WETO Program: Technology Development and Scientific Research
Project Status: Active	WETO Activity Area: Standards Support and International Engagement
Total Available Budget (FY17 & FY18):	$1,842,708
Actual Costs (FY17 & FY18):	$1,088,926

Project Description

This project provides funding to participate in and, where logical, lead the development of domestic and international standards. The project also supports the education and engagement of the U.S. industry in the process.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- I find it very relevant that NREL is leading the U.S. stakeholders' effort in drafting U.S. standards if international standards are not applicable.
- Six clear benefits are defined.
- Development of standards for the U.S. industry fulfills a critical industry need.
- NREL has an excellent team and well-qualified to represent the U.S. in international standards setting. Very important for international harmonization.
- Since offshore wind is new to the U.S., I understand a compelling need to help define the standard.
- Critical international engagement that sets design standards for the world. This is also the key DOE advanced technology transfer path. When DOE develops new technology, it must first be tested against existing standards. And, when improvements or better design methods are needed, DOE experts are in a position to introduce them to international and national standards, which help build international and national regulation, improve quality, and, ultimately, lower LCOE.
- DOE experts regularly have a major influence on the standards content because they are equipped with research data to support their technical arguments.

Comments on Weaknesses

- NREL's participation in onshore standards, IEC 61400, and NEC does not provide unique value to the industry. The role as the arbitrator of truth may be valid, but it is hard to understand how researchers' views directly tie to practical industry views. The distributed generation element of this is lacking and the current approach may be hurting the industry.

Approach and Methodology

Comments on Strengths

- The approach is to support standards that are the most beneficial to the U.S. A clear prioritization approach is defined.
- The standards approach is multi-pronged and comprehensive focusing on design standards and standards that impact DOE programs and other stakeholders.
- Very strong approach to prioritizing involvement. The team played a strong role in the drivetrain reliability collaboration.
- The utility-scale efforts are strong.
- This is highly leveraged and effective funding. The project works through all the key standards organizations (IEC, IECRE, AWEA, ANSI, ASME, AGMA, etc.). DOE experts' influence is unmatched and always trusted.

Comments on Weaknesses

- Nothing presented by the authors demonstrates a compelling need or a unique qualification that is additive to the process. No unique industry value proposition is presented.

Accomplishments and Progress

Comments on Strengths

- Timeline of standards developed shown.
- This is a multi-year continuing effort. Multiple standards activities have been undertaken and accomplished, spanning rotor blades, gearboxes, offshore floating turbine design, etc. Overall, this is an impressive level of activity.
- It successfully engaged end users from the U.S. into the international standards development and certification so that financial and owner/operator's voices are integrated into standards.

Comments on Weaknesses

- No weaknesses noted by reviewers.

Communication

Comments on Strengths

- U.S. Standards Summit is the primary communications method.
- Communication focuses on organizing the U.S. Wind Energy Industry Standards Summit. This the major venue for educating industry and stakeholders about latest standards and assessing industry needs.
- The Wind Energy Standards Summit was a great success.
- Semi-annual Wind Standards Summit is the premiere communications mechanism.

Comments on Weaknesses

- Additional methods need to be explored to communicate to the industry in the United States on the standards and to seek involvement.
- Author acknowledges that main event draws only 30-40 people. No other objective statistics are presented to demonstrate value of communication or use by others.

Upcoming Project Activities

Comments on Strengths

- This is a continuing multi-year project
- Continuous support is what has the biggest impacts.

Comments on Weaknesses

- Not a lot to show as standards are a long-term process.
- Applicant does not define specifics on going forward activities, and simply states that priorities will adjust based on WETO priorities. No active shaping of upcoming activities is shown.

Recommendations (Not Scored)

- Consider sponsoring U.S. delegations to IEC meetings to ensure more (and needed) U.S. participation and influence.
- Only DOE labs can undertake this critical-for-the-industry activity. This is painstaking and hard work, but it has yielded useful results and needs to be continued.
- The work being done under this project is amazing and critical for maintaining U.S. leadership and contribution to international standards.
- The "defensive" role in the NEC code is a good motive, but it is likely that the more appropriate role is to bring in more outside industry experts to take an active, non-defensive role.
- Continue funding this program.

Project Results - Tech to Market and Small Business Vouchers

Small Business Vouchers - Micron/NIRE/SkySpecs

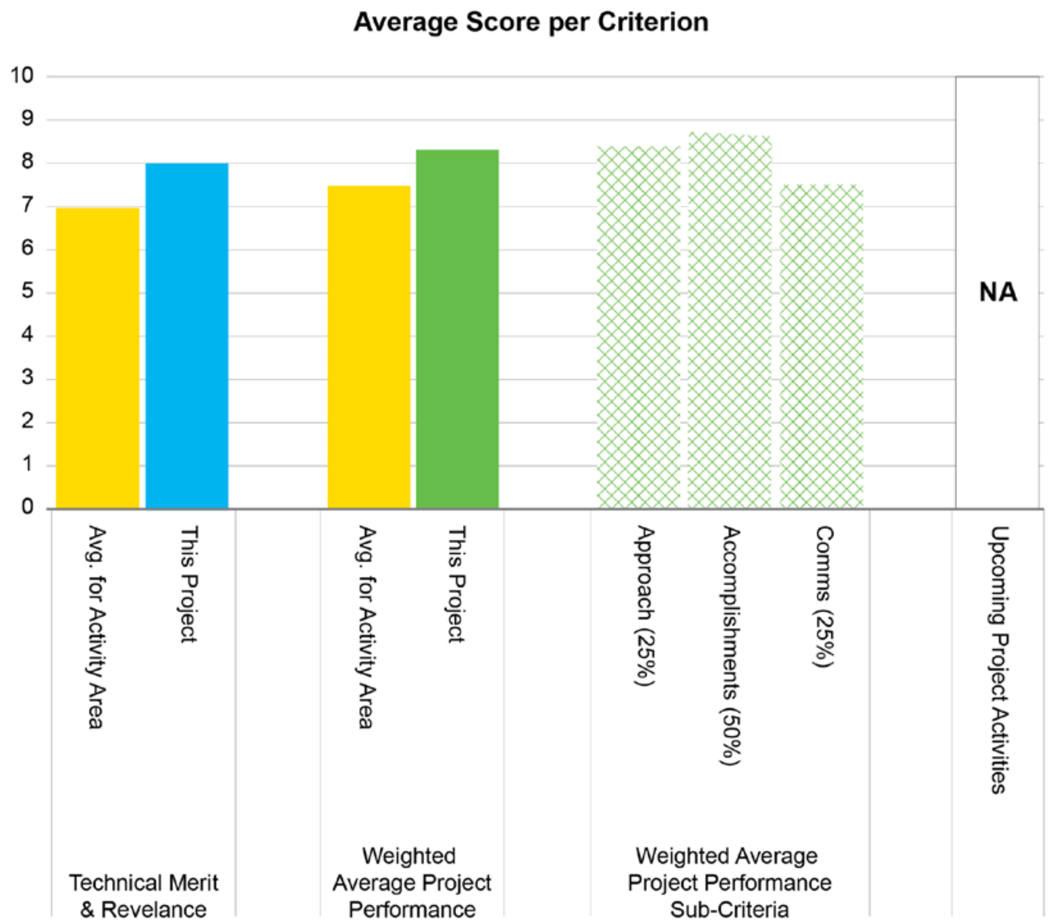
PI: Brandon Ennis; Joshua Paquette; Jon Berg	Unique Project ID: T19
Organization: SNL	WETO Program: Programmatic Support
Project Status: Completed	WETO Activity Area: Technology-to-Market (T2M)
Total Available Budget (FY17 & FY18):	$781,616
Actual Costs (FY17 & FY18):	$781,616

Project Description

- SkySpecs: Evaluate advanced drone-deployed nondestructive inspection methods.
- Micron Optics: Demonstrate wind turbine fiber-optic data acquisition in real-world operating environment.
- GroupNIRE: Develop remote grid services controller utilizing rotor inertia.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- I find it relevant to support the companies bridging from technology development to product development through the demonstration and validation of the technology.
- SMEs were selected to rank 20-30 applications to select the most impactful one.
- Three small projects focused on technology transfer to the industry. All three are highly relevant and clearly meet industry needs.
- Drone inspection is very relevant to the industry and has lot of potential to reduce O&M cost.
- These three projects all are well selected, well executed, and likely to advance the state of the art in the industry.
- The SBV program is an opportunity to support short term projects that capitalize on lab expertise.

Comments on Weaknesses

- Unsure of how the project was selected versus other potential projects of merit.
- The economics and financially viability of some of these technology solutions need to be assessed prior to undertaking the research.
- Consider the cost of adopting these technologies in your analysis.

- Infrared inspection has potential, but it needs lots of follow up to be successful. The industry is already using drone inspection and has used infrared sensing as well.

Approach and Methodology

Comments on Strengths

- Seems as if all three of the projects were well planned for the objectives.
- Evaluation approach of each system seems clear.
- Operations and maintenance using drones and AI technology.
- Micron Optics fiber optic system installed and tested at the SWiFT facility.
- Grid controls for wind plants.
- Methodology for all three projects is state of the art. They all demonstrate the importance of having a facility like SWiFT for testing.
- The research is well distributed among three different topics.
- All projects were well structured and well executed. All showed clear progress toward real world applications and value creation for the industry.

Comments on Weaknesses

- I don't like that the reports appear to lack commentary that goes beyond the selected partner. For example, is there an inherent advantage or disadvantage with SkySpecs that makes it a better or worse platform for this type of inspection compared to industry alternatives? Adding this type of objective step back would complete the study and better enable the industry to advance with the knowledge contained in the study.
- It needs to be able to follow up to be successful.

Accomplishments and Progress

Comments on Strengths

- Looks as if the results were made in the projects within time.
- All three of the projects showed expected beneficial results.
- Good progress was made in all 3 sub-projects of this project. Very promising results that could impact turbine inspections, turbine controls and sensing technologies, and grid controls for wind plants.
- Good focus on the testing.
- All objectives appear to have been accomplished.

Comments on Weaknesses

- It is not clear how much this project helped advanced the TRL of technologies.

Communication

Comments on Strengths

- Fine communication for such small-scale projects.
- Publications related to each project were developed.
- Publications and discussions with the industry to explore commercialization potential.
- Continuous strain measurement has lot of potential for turbine control and possible blade failure prediction.
- Papers and other materials appear to have been prepared and widely distributed to enable future stakeholders.

Comments on Weaknesses

- Awareness of project existence is not widespread.

- Technology transfer and commercialization should be more actively explored to ensure that these projects do impact the industry. For example, the grid integration project does not appear that it will make an impact as current PPA practices do not make it economically viable.
- It is not clear if any of the three technologies have been commercialized.

Recommendations (Not Scored)

- All three of the projects were successful, but not all of them are likely to make an impact.
- The separate and discrete projects all offer unique industry value and were well defined to facilitate specific results. The value created is likely to far exceed the cost if adopted.

Small Business Vouchers - Sentient

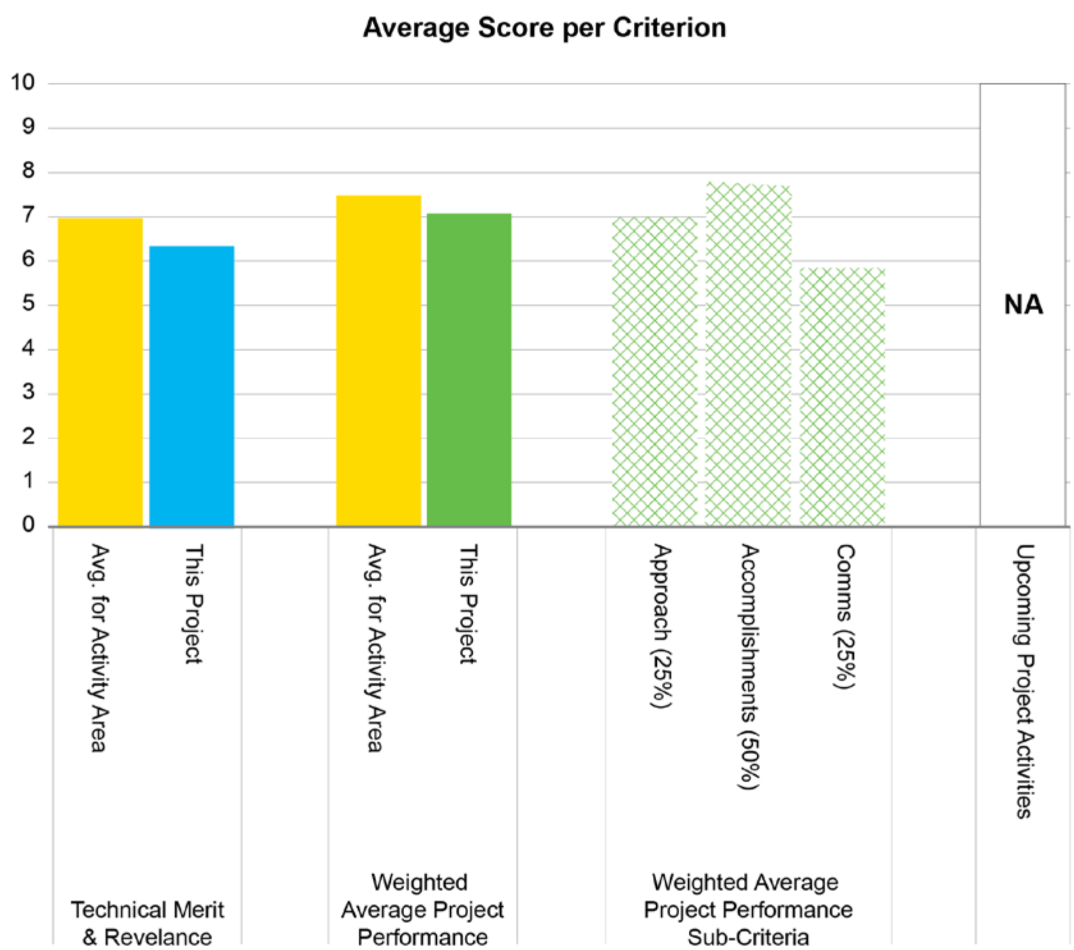
PI: Brandon Ennis	Unique Project ID: T20
Organization: SNL, NREL	WETO Program: Programmatic Support
Project Status: Completed	WETO Activity Area: Technology-to-Market (T2M)
Total Available Budget (FY17 & FY18):	$295,000
Actual Costs (FY17 & FY18):	$181,497

Project Description

This project will provide operational fatigue data of a realistic wind turbine blade for testing and improving damage detection models to Sentient Science. The project will include three main components; (1) test article development, (2) blade fatigue testing, and (3) damage model generation and validation.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Due to significant offshore wind costs, a proactive operation strategy such as this should be beneficial.
- Operational fatigue data for a realistic turbine blade to improve detection models developed by Sentient. The project results could have a direct impact to help advance a small business.
- Project could be relevant to the industry if repair and maintenance costs due to fatigue comprise a significant portion of O&M costs of a wind plant.
- Developing blade life predictive models is very relevant for the industry if it can replace the time consuming onsite visual inspections. It is very relevant to help accelerate commercialization and maturation of this technology.
- The project has the potential to provide valuable information to inform private research in an area that will have material value to the industry.
- Provided blade failure test data for private company to validate crack propagation prognostic analysis.

Comments on Weaknesses

- The premise of the need (i.e., significant O&M cost and fatigue driven maintenance) is not seen by all operators.
- The project was based on the premise that fatigue is a major cause of failure in wind plants. It is not clear, however, that this agrees with what plant operators experience in the field.
- The project does not appear to have shared the information and model publicly, which makes its current effort nearly worthless to the industry overall.
- Artificial flaw was needed to cause failure. DOE's role was only to supply failure data and FEA model. The success of the technique is proprietary. Given that this analytical technique is supposed to predict when and where cracks originate, the requirement that a flaw be artificially introduced would seem to render the test as low value.

Approach and Methodology

Comments on Strengths

- Straightforward, three-step approach is outlined.
- Developed a heavily instrumented 13 m blade model and performed blade fatigue testing. The lumped parameter and finite element models were also developed.
- Good use of lab capabilities.
- The testing support was well executed.

Comments on Weaknesses

- The method still needs validations on a full-scale turbine where fatigue is more of a design driver.
- The approach, overall, missed the objective. The blades were not designed as a fatigue-based failure design, so the testing had to be manipulated. The form of manipulation is inconsistent with natural events. It would have been better to create a fatigue-governed design or to introduce natural damage like simulated bird strikes, gun shots, etc.
- Test conception by the industry partner appears to be poorly conceived to validate their analytical technique.

Accomplishments and Progress

Comments on Strengths

- This has been a successful project. The extensive data collected revealed sensitivity to specific parameters, and it guided the development and validation of a lumped parameter model and a finite element model. The results were transferred to Sentient so that the methods could be further developed, but this was not communicated broadly.
- The study appears to have met most of its objectives.
- The test was completed on time.

Comments on Weaknesses

- Schedule creep caused partially by utilizing a blade characterized was not fatigue-driven.
- The value of the findings of this work is unclear, as the project has assumed that fatigue is the main source of failure. Industry experience, however, may suggest otherwise.
- A project of this type should not be funded by DOE as data is not publicly available.
- The project did not study a blade through natural failure.

Communication

Comments on Strengths

- Report has been produced for Sentient and models have also been transferred to the industry partner.

Comments on Weaknesses

- I see only communication between sentient and SNL. Should this effort be shared with the wind industry?
- Nothing has been communicated outside of the company involved in this effort.
- Nothing presented by the applicant implies that this model is available publicly for other industry participants to use. Nothing about this model is proprietary to the private partner.
- The test data and analysis results are proprietary.

Recommendations (Not Scored)

- While the work appears to have been done carefully, it is unclear that this project will have a real impact. Also, the fact that results cannot be disseminated openly makes it impossible to thoroughly assess what has been done. Such a project may not be suitable for funding by the program.
- I suggest testing on a full-scale turbine. Maybe use NWTC at NREL or the SWiFT facility to do so.
- A national lab is uniquely qualified to help create the model and resulting data set, so involvement makes sense. The model also has the potential to inform and encourage private research and advancement. The project test was not properly constructed. Not publishing the model, FEA, materials, etc. makes no sense and is not in the public interest. Nothing about the model is proprietary to the private partner.

Small Business Vouchers - Tower Technology

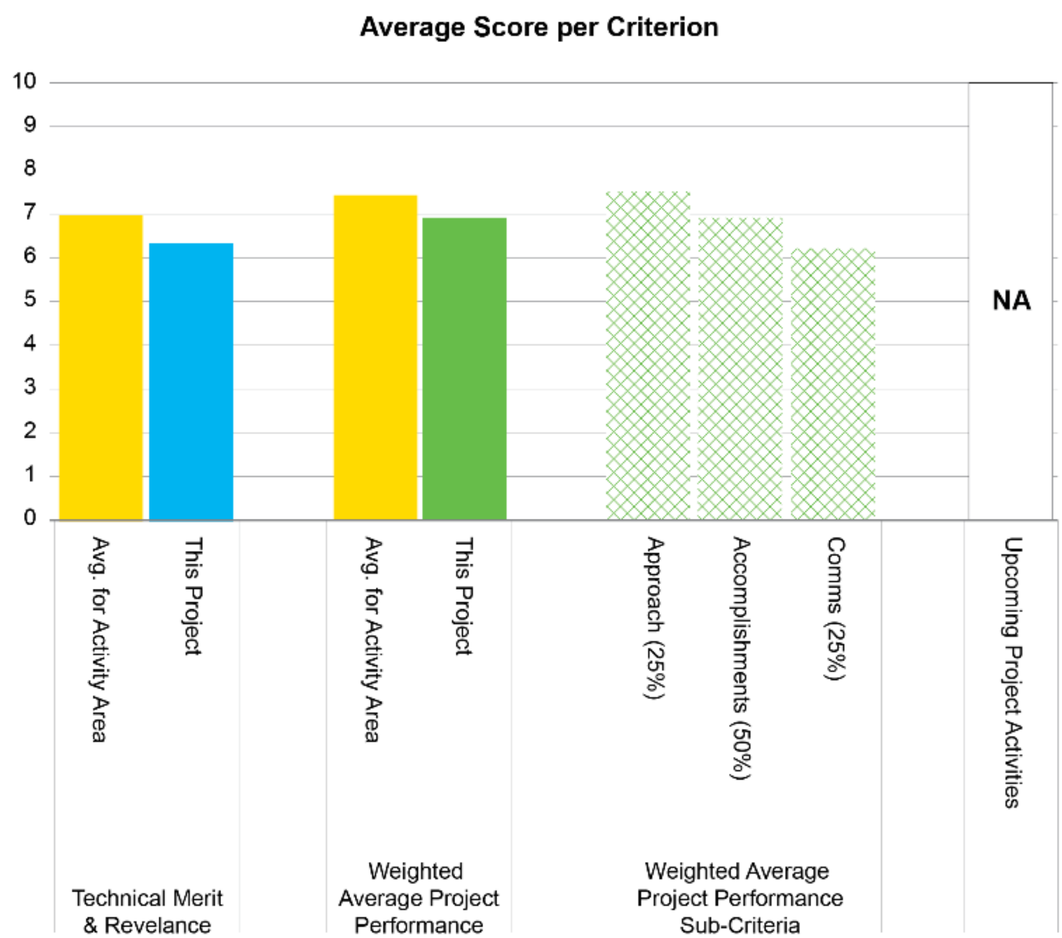
PI: Paul Veers	Unique Project ID: T21
Organization: NREL	WETO Program: Programmatic Support
Project Status: Completed	WETO Activity Area: Technology-to-Market (T2M)
Total Available Budget (FY17 & FY18):	$170,000
Actual Costs (FY17 & FY18):	$166,738

Project Description

As part of the DOE's Small Business Vouchers Pilot, leverage and develop NREL's expertise in the evaluation of system impacts of technology innovations to support a new wind energy technology developed by Wind Tower Technologies (WTT). NREL provided WTT with a techno-economic evaluation of how their innovative self-erecting concrete tower (SECT) system compares to traditional technology. SECT will address challenges for tall wind that are associated with traditional cranes and their limitations in terms of both logistics and costs for installing turbines with hub heights of 140 m and greater.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Nice description of the constraints of the problem and the benefit.
- Onsite manufacturing of concrete towers using a self-erecting system. This technology could be applicable to building tall towers that open up access to low-wind resource areas.
- Tall tower technology is very relevant to the wind industry and has the potential to open new markets and lower LCOE.
- Tall towers are an important and valuable topic for the industry.
- Developed an improved onsite balance of station model applicable to concrete tower fabrication. Good support for the private industry of onsite concrete tower fabrication.

Comments on Weaknesses

- This project is like many other small business acceleration/feasibility studies; it was very narrow for the industry in general.
- While tall towers are important, this specific project was about cost for constructing a tall tower.
- The proposed technology does not compete well with conventional tower manufacturing methods in terms of cost effectiveness. It would have been more helpful if they had focused on steel versus concrete towers.
- This is a construction cost and feasibility project, not a tall tower project.
- Since the critical information obtained through this project was confidential, it had zero chance of adding value to the problem. Nothing in the applicant's information shows that the applicant is uniquely qualified to assist in nor add value to solving this problem. The industry is already investing millions of private R&D funds into solving this problem. It is highly unlikely that a national lab will add value here.
- Narrowly applicable to one company and one concrete tower approach. A tall tower study and/or a steel versus concrete tower tradeoff would be more useful.

Approach and Methodology

Comments on Strengths

- Well described approach.
- Straightforward approach.
- Gap analysis study and tower models for identified scenarios, coupled with LCOE assessment studies for various scenarios.
- Good focus on cost modeling and capturing details. Good use of lab knowledge to present an objective study.
- NREL did a good job supporting the private company with excellent technical support, using system optimization design tools.

Comments on Weaknesses

- Without crane and rigging experts participating in this process, the conclusions are likely ill informed. The conclusions that result are either obvious or superfluous (taller cranes = more weather delays). No scientific rigor is presented or demonstrated by the applicant's materials. The most reliable way to cost a project is to have qualified contractors bid the project and to then use that to validate the models.

Accomplishments and Progress

Comments on Strengths

- Fine progress and due in time.
- Although all results were not favorable, insights were determined and project aspects were met.
- While the work was carefully conducted, the findings were not encouraging.
- Good project management. Very clear plan in place.
- The applicant accomplished its goals.

Comments on Weaknesses

- It is questionable how valuable the cost model that was used is.
- The study outcome was not very promising as it showed growing costs with height for the self-erecting technology.
- The technology as originally defined is not likely to do well.
- The applicant's goals add little value to the U.S. wind industry. They likely added material value to the private company they supported.

Communication

Comments on Strengths

- The project outcome was clearly communicated.
- The project team looked for innovative ways to share the information of the project while maintaining the protected nature of the work scope.
- Results were only internally communicated to DOE.
- Outcomes from this work are very clear and have clear conclusions.

Comments on Weaknesses

- CRADA limitations prevented wide dissemination of results. It is not clear why such a project is funded by the program if the results cannot be openly distributed.
- No communication of any value appears to have been shared with the industry.
- Narrow applicability except for improved balance of station model.

Recommendations (Not Scored)

- The study outcome is not very promising as it showed growing costs with height for the self-erecting technology.
- This was a complete waste of U.S. tax dollars. The applicant did not have a unique ability to add value to this problem, the data was kept confidential by the private company, and the efforts herein are de minimis compared to existing industry efforts. The project that resulted was effectively an equity contribution to a private party who took the knowledge and expanded their business in China.
- Nothing presented by the applicant justifies the $166k in cost.
- Consider integrating the improved tall tower trade off model into the balance of station model for use with different tower strategies.

Technology to Market (T2M)

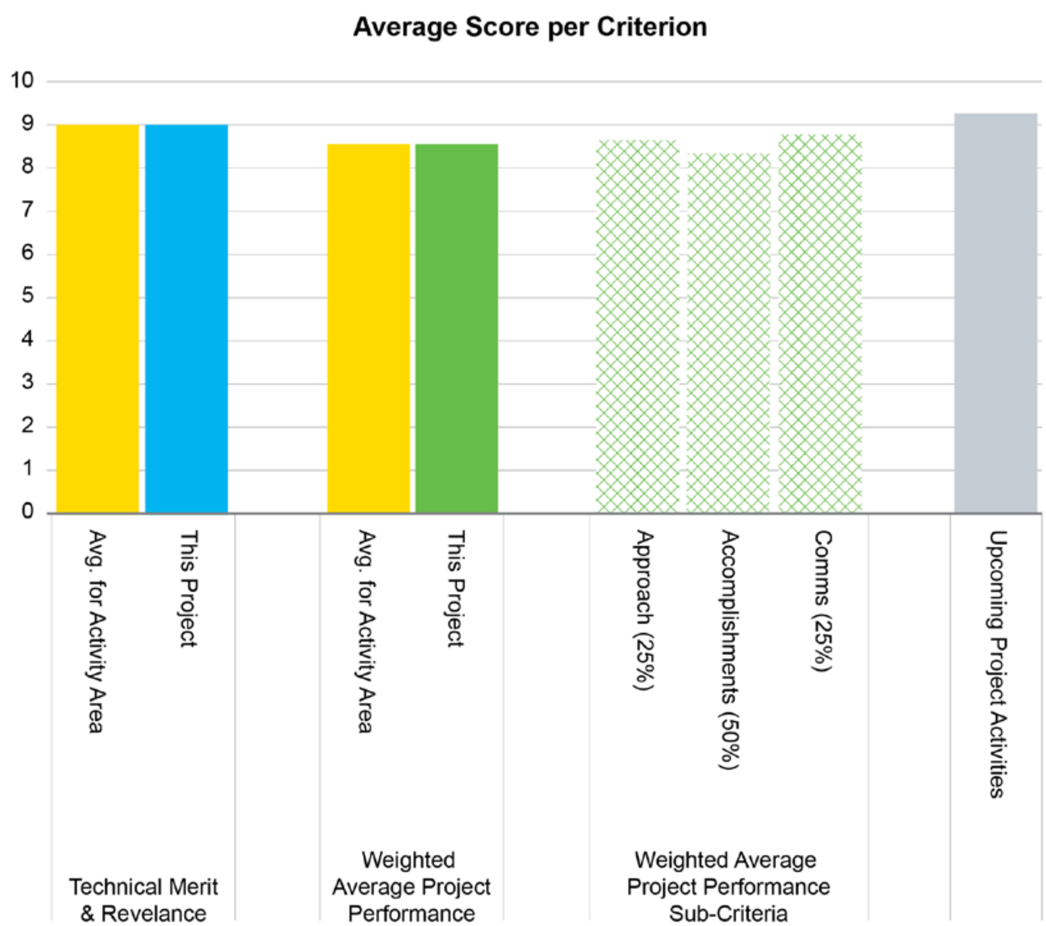
PI: Alex Lemke; Lara Aston	Unique Project ID: T23
Organization: NREL, PNNL, SNL	WETO Program: Programmatic Support
Project Status: Active	WETO Activity Area: Technology-to-Market (T2M)
Total Available Budget (FY17 & FY18):	$525,466
Actual Costs (FY17 & FY18):	$382,043

Project Description

The Technology to Market (T2M) Industry Survey Project solicited feedback from a broad range of wind industry representatives to identify the research areas of highest value that would benefit from DOE investment. The 2018 Wind Industry Partnership Summit focused on where wind power industry R&D and technology development needs intersect with the capabilities of DOE national laboratories and other participants in R&D initiated by the DOE Wind Program.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Overall, new technology to market is important.
- Important to understand where industry needs are.
- Project seeks to identify what technology areas are important for research and development industry. This is important work as it helps inform R&D effort with industry needs.
- Strong survey response rate. Good way to capture inputs from the industry to better understand their R&D needs and challenges. This approach is encouraging for reducing the gap between the private and public sectors, and encourages them to collaborate on reducing LCOE.
- High value project, communicating and acting as the coordinator of industry and surveying the industry. DOE is in a unique position to coordinate industry technology focus workshops. Both industry and DOE benefit from direct feedback.

Comments on Weaknesses

- I really doubt that small- and medium-sized companies should be a special focus.

Approach and Methodology

- Comments on Strengths
- Good approach for the purpose.
- Defined survey and summit as method to gauge industry perspective.
- Survey was conducted across 18 technology areas, engaging over 100 participants. Very broad and inclusive process.
- Good focus on turbine technology innovation and large-scale turbines. Good way to engage industry stakeholders from different parts of the value chain.
- Industry workshops have worked very well and were very well organized and executed.

Comments on Weaknesses

- Applicant does not show where potential financial benefit or total industry value was included in discussions.

Accomplishments and Progress

Comments on Strengths

- Fine accomplishments.
- Survey results were documented and evaluated. Survey completed.
- Findings of survey were conclusive and led to specific proposals for R&D. Barriers to successful technology transfers and areas of improvement were also identified.
- Overall, this is a successful project and has yielded useful information for future R&D in specific technology areas. The areas identified are exciting and very forward looking.
- The survey had a strong response rate, and the summit was successful in capturing R&D inputs.
- Good participation at the Wind Industry Partnership Summit.

Comments on Weaknesses

- No weaknesses noted by reviewers.

Communication

Comments on Strengths

- Fine communication and presentation of the activities. Good presenter.
- Partnership Summit was conducted.
- The Wind Industry Partnership summit was organized as part of this effort. Strong communication and engagement with the industry is leading to clear input for future R&D led by DOE.
- Over 90% of participants responded that they were interested in more similar meetings in the future. This is a sign of success.
- Workshop approach is excellent.

Comments on Weaknesses

- Internal results were required per the agreement with survey respondents.
- It will be hard to capture the real value of such work. A lot of input will be collected, but the challenge will be what is done with it.

Upcoming Project Activities

Comments on Strengths

- Fine plan ahead.

Comments on Weaknesses

- Unsure what is being done with the survey results to steer R&D activities.

Recommendations (Not Scored)

- Survey results should be evaluated to determine potential future R&D activities.
- This is an excellent program and should be continued and expanded.
- It would be nice to see how the results from the survey and summit influenced the DOE roadmap or R&D focus. Keep building on the results of this project and make it a recurrent event.
- Conduct more workshops.

Project Results - Advanced Components, Reliability and Manufacturing

Additive Manufacturing in Wind Turbine Components and Tooling

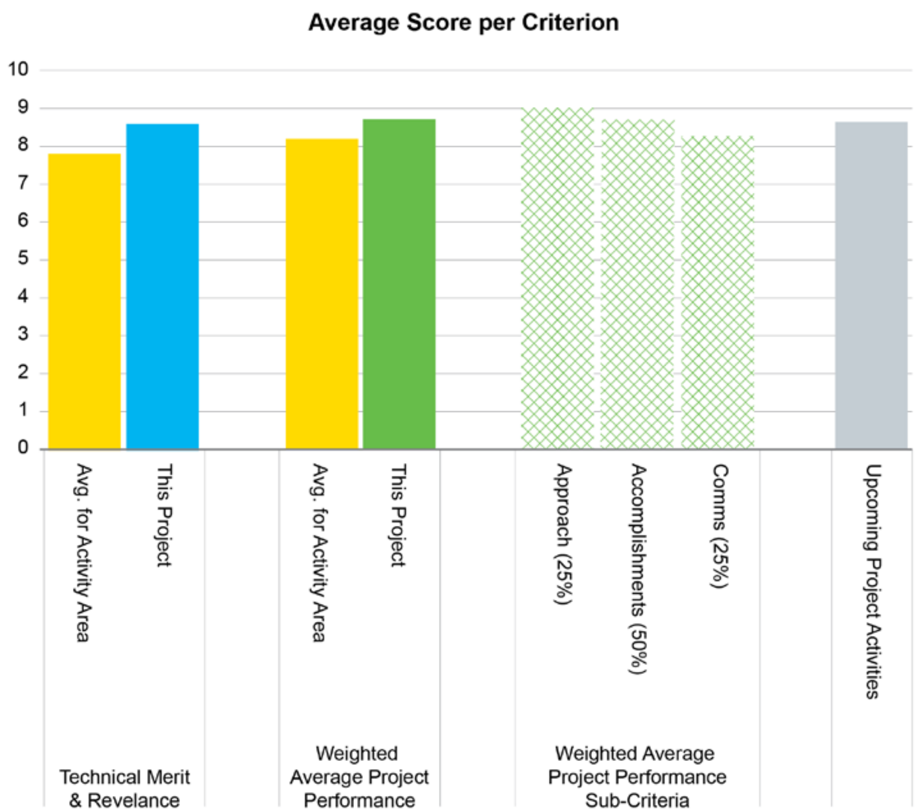
PI: Brian Post	Unique Project ID: T13
Organization: ORNL, NREL	WETO Program: Technology Development and Scientific Research
Project Status: Active	WETO Activity Area: Advanced Components Reliability and Manufacturing
Total Available Budget (FY17 & FY18):	$694,295
Actual Costs (FY17 & FY18):	$341,918

Project Description

Cost must be competitive to enable wind energy nationwide. Additive Manufacturing (AM) is an efficient and rapid (design-to-product cycle) manufacturing technology that can produce complex parts with multiple integrated functionalities. However, applicability, value propositions, risks, etc. of different AM processes for wind are not known. This project will explore the applicability of AM as a manufacturing tool for wind turbine components and tooling.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

<u>Technical Merit and Relevance</u>

Comments on Strengths

- Good description of potential positive impacts. Good to see the tie to LCOE.
- The project seeks to explore the applicability of additive manufacturing for wind turbine components. This work could be transformative for blade and component manufacturing. It will lead to a paradigm shift and can revolutionize the industry.
- Additive manufacturing is very relevant topic for the industry. It has the potential to accelerate time to market.
- AM has the potential to completely change the way we make blades by digitalizing manufacturing.
- This is a high-value and high-risk area of research that is appropriate for a national lab and government funding.
- Additive manufacturing for blade components or blade molds is an excellent way to reduce the cycle time of low-production components. Advancing manufacturing techniques and reducing costs through innovation, especially robotic and additive manufacturing, is a high value approach to reducing LCOE.

Comments on Weaknesses

- To me, it looks as if the project had been looking for applications for AM randomly.
- The business case and economics for using AM for blade tooling or manufacturing might not be able to compete with conventional methods.

- Are there other components that might benefit from additive manufacturing? How about onsite manufacturing?

Approach and Methodology

Comments on Strengths

- Well described project method.
- Very clear methodology. The focus areas and tasks are clearly stated and laid out with participants and general timing (year).
- The project seeks to explore the efficacy of AM for wind turbine blades and evaluate what is feasible with current and upcoming AM processes. The research also focuses on understanding costs and relative advantages of AM for wind turbines
- Good focus on cost and performance.
- Good job including industry partners to have direct industry perspective.
- Good focus on risk.
- The approach is well laid out and is likely to result in either advancing the state of the art or determining that the means/methods are unlikely to advance the state of the art; both of which are valuable conclusions.
- Very innovative technique.

Comments on Weaknesses

- Broadening the specific steps beyond wind turbine blades would be valuable. Areas outside of blade AM are not as well documented or discussed.
- Must consider manufacturing more major components for onsite manufacturing.

Accomplishments and Progress

Comments on Strengths

- Interesting first accomplishments.
- Very detailed description of the accomplishments, along with the focus areas.
- Progress presented is really impressive. Current technology is very precise and has already been demonstrated by printing 13 m turbine blade molds. Hyper-scale AM technology is now coming online and could revolutionize the industry. Ongoing work with Vestas is exploring 3D printing of turbine components, including topology optimization. Overall, this is very impressive progress.
- Good demonstration of AM capabilities and showing the potential for cost reduction.
- All steps appear to have been met to date.
- Very productive.

Comments on Weaknesses

- No weaknesses noted by reviewers.

Communication

Comments on Strengths

- Well-presented and clear.
- Nice to see the recognition of needed communication with AM industry and the plan to correct it.
- Papers and conference presentations are used to communicate the outcomes of this project.
- The communication plan appears to be robust and appropriate.

Comments on Weaknesses

- I am not clear what publications or public forums were engaged for communications to the public and wind/AM industries. My impression is that more is needed.

- I would like to see results shared at non-industry AM conferences to encourage new manufacturers to enter the wind industry. This is potentially a valuable tool for bringing new manufacturers into the industry.

Upcoming Project Activities

Comments on Strengths

- Interesting perspectives for the industry.
- A good clear plan is presented with quarterly goals.
- Future work will focus on expanding the collaboration with Vestas to carry out techno-economic analysis.
- Good focus on testing. Good focus on economics.
- Upcoming activities seem appropriate.

Comments on Weaknesses

- It seems that the material cost is the largest component. It would be good to see how that cost compares to conventional manufacturing and identifies opportunities to reduce cost.

Recommendations (Not Scored)

- Engage broader wind and AM community in project accomplishments and future plans.
- Take AM to the field. Build towers and blades.
- This is impressive work at the frontier of additive manufacturing. It can revolutionize wind turbine manufacturing and cause a paradigm shift by enabling onsite manufacturing. The team should start thinking about how to do this onsite and focus on 3D printing components like blades and towers that are the hardest to transport.
- I would consider a track that investigates how AM can impact blade design, as it opens the door to manufacturing more complex shapes.
- This is a good cost/benefit/risk program that is currently too high risk for the industry to commit sufficient capital to. Advancing this topic, if successful, would advance the industry and provide significant value.
- Investigate onsite manufacturing and/or assembly innovations for blades, generators, and towers.

Wind Turbine Blade Durability and Damage Tolerance

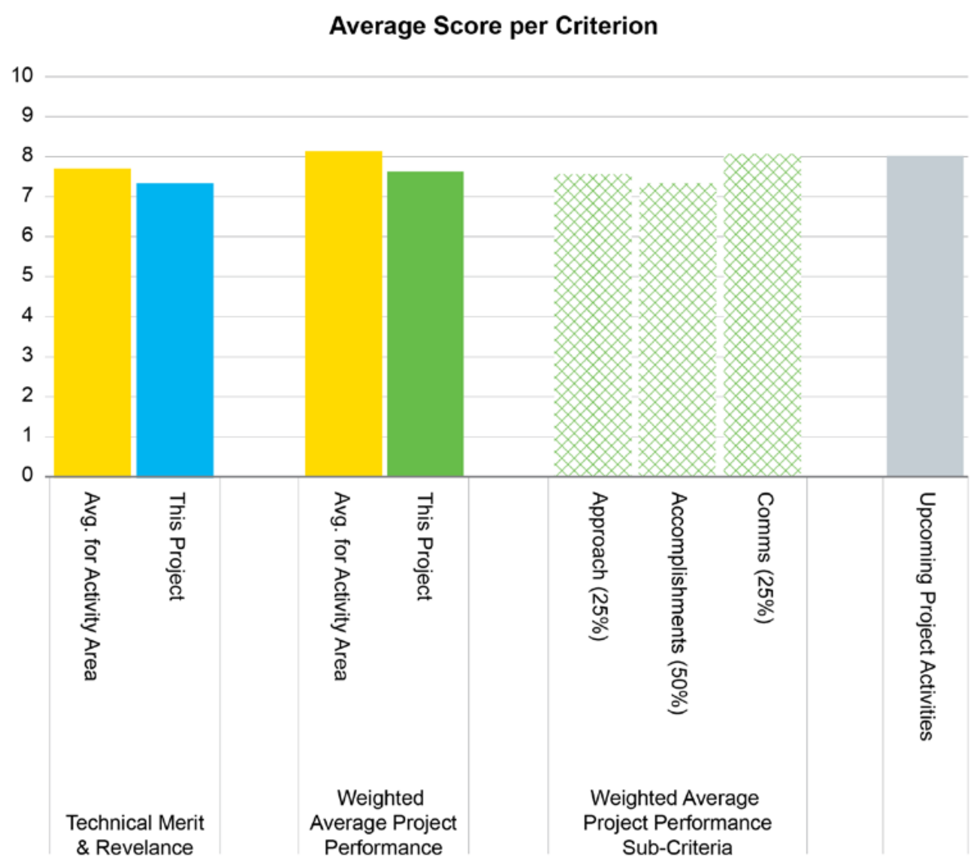
PI: Joshua Paquette	Unique Project ID: T14
Organization: SNL	WETO Program: Technology Development and Scientific Research
Project Status: Active	WETO Activity Area: Advanced Components Reliability and Manufacturing
Total Available Budget (FY17 & FY18):	$1,510,900
Actual Costs (FY17 & FY18):	$1,117,524

Project Description

Development and transfer of knowledge to industry on state-of-the-art inspection and defect/damage modeling methods. Project-led workshops with industry specified formats will enable immediate utility of the project outcomes. Lower the uncertainty in blade lifetimes and reduce the cost of building and maintaining a blade in operation. Enable the larger, higher-energy capture rotors of the future, which will be main driver of LCOE reduction and thus deployment.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- It is important that DOE research is in front, or at least following, the R&D in the blades areas.
- It is good practice to plan to memorialize improvements in standards and best-practice documents.
- The project adds value to the industry by developing and transferring knowledge about state-of-the-art inspection and defect/damage modeling methods.
- Good focus on blade reliability and failure prevention.
- Developing methods to quantify the remaining lifetime of the blade can save the industry millions each year.
- This is a very valuable effort that will advance the state of the art and create significant industry value.
- Valuable development of automated damage detection techniques. Valuable damage prognostics analysis technique.

Comments on Weaknesses

- There is an assumption that durability-and-damage-tolerant design with associated field repair is less costly than safe-life design. That is not intuitive to this reviewer.
- Blade failure is rarely design-related and most often is random.
- The cost of implementing this approach might be too high given the rate and nature of failures in the field.
- Most blade failure is random and hard to predict.
- The financial evaluation component of this does not add material value at this time, and it is best left to industry for a clearly defined problem like the one being studied herein.
- What NDT methods are currently used by private operators? How much do private operators spend on NDT? What is the value proposition for NDT?

Approach and Methodology

Comments on Strengths

- Okay methods.
- Good detail and clarity on the methodology with specific goals for each task outlined.
- Methodology is based on comprehensive coupling of inspection methods, using autonomous inspection technology, defect and progressive damage modeling and repair methods, and blade lifetime value modeling.
- Good focus on the economics of the full-cycle.
- Takes an innovative approach to develop a blade-lifetime value model.
- The overall approach is well reasoned and will likely result in valuable information.
- Blade durability is important. Given the amount of time and expense this project was, the approach was appropriate.

Comments on Weaknesses

- The approach may not be economical to implement in the field.
- The current approach does not address two critical elements: frequency of inspections and rate of propagation of damage/defects. Understanding those two elements will be necessary to create full industry value out of the project.
- This project may need focus and follow through to yield useful results for DOE.

Accomplishments and Progress

Comments on Strengths

- Accomplishments were met as described in milestones.
- The main accomplishment is the development of a report and demonstration of robotic inspection technology.
- This work produced a good number of publications.
- The progressive damage modeling code is useful for the industry.
- The team has accomplished the majority of what it intended to accomplish to date.

Comments on Weaknesses

- The impact of this work for wind developers is unclear as proposed technology might be too costly to implement and may have limited return.

Communication

Comments on Strengths

- Good and clear communication.
- Broad set of publications and presentations. Blade conference creates environment for more collaboration.
- Publications and presentation in conferences.
- Good interaction with the industry and design-standard committees.
- The current communication has been well executed.
- Blade reliability and collaborative meeting excellent.

Comments on Weaknesses

- The work needs to be better communicated to wind farm operators as it is not clear that it will be of value to them.
- Not sure if the result of this work influenced industry standards.
- It is important that sufficient communication continues in the upcoming activity to include raw data, raw images, and results with the industry to better inform private R&D. Nothing in the communication plan detailed how the next phases will be shared with the industry.

Upcoming Project Activities

Comments on Strengths

- Important area.
- One lightning test to be completed; delayed due to facility availability.
- Nothing is reported in the project summary and presentation was not available on the review tool.
- Good plan forward.
- Upcoming activities seem logical and appropriate.

Comments on Weaknesses

- Nothing is reported in the project summary and the presentation was not available on the review tool.

Recommendations (Not Scored)

- I recommend that the U.S. based blade research looks into European based research on blades, especially leading-edge erosion.
- Consider broadening presentations to conferences that are not blade specific to draw in additional wind industry participants.

- While the idea of this project seems interesting, the economics of implementing it at utility scale is questionable. Input from developers and operators should be critical for developing a plan for future work.
- With the exception of the financial modeling, this project makes sense to study at the WETO level. There are market forces that do not want to lead this research privately because it is not in all market participants' best interests to have this information. Thus an objective national lab makes sense. The results are valuable and are a gateway for private R&D dollars to follow. The project needs to be expanded to study inspection frequency and damage/defect propagation. The potential benefits of this high risk/reward research justify the expense.

Wind Turbine Drivetrain Reliability

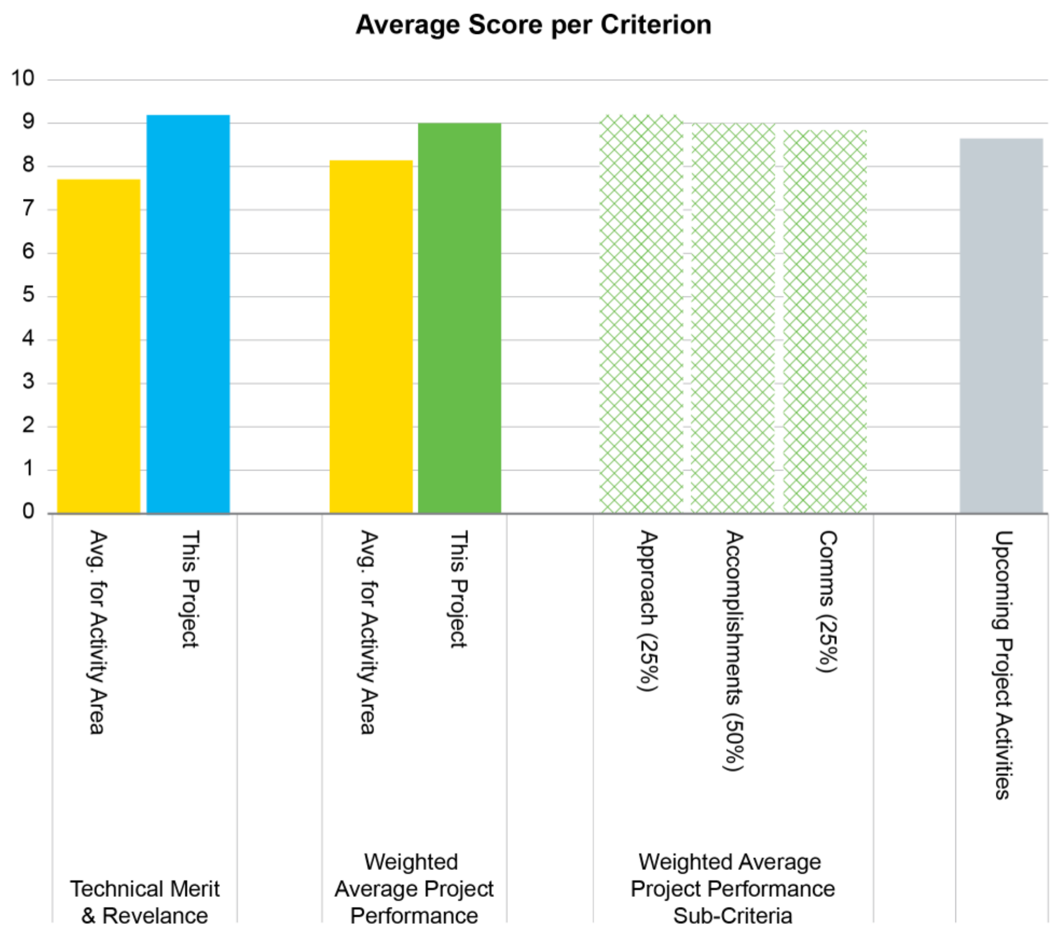
PI: Jon Keller	Unique Project ID: T15
Organization: NREL, ANL	WETO Program: Technology Development and Scientific Research
Project Status: Active	WETO Activity Area: Advanced Components Reliability and Manufacturing
Total Available Budget (FY17 & FY18):	$4,065,568
Actual Costs (FY17 & FY18):	$3,475,387

Project Description

Conduct drivetrain validation testing and analysis to characterize failure modes and predict remaining useful life, thereby improving drivetrain reliability and availability, and reducing wind plant operations and maintenance (O&M) costs. The predominant failure modes are not accounted for in design standards, not attributable to quality control, and not specific to individual component suppliers.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Very relevant project from an industry point of view.
- This group is seen as an independent (non-biased) evaluator of industry issues.
- The project seeks to address drivetrain reliability, which is a major contributor to O&M costs.
- Has strong potential to reduce LCOE by reducing O&M costs.
- This project attempts to solve a problem that the industry is disincentivized to solve itself, but that is of very high importance to the long-term success of the industry.
- This project attacks drivetrain problems that have existed for 30 years. It has a very scientific and systematic approach, which is what is needed.
- Definitively determining the source of white etch cracking and other forms of premature bearing cracking in both gearbox bearings and main shaft bearings is critical. This project is the only one that can resolve long-standing industry debates about the real source of that problem and others that plague drive train failures.

Comments on Weaknesses

- Although these various failure modes have been issues in the industry, to date the industry has incorporated analysis/solutions for many of these into current designs and IEC standards.
- The overall scope of this project will likely need to increase, in order to achieve its full benefit.

Approach and Methodology

Comments on Strengths

- Proper and fine approach.
- The five tasks are logically laid out.
- Argonne testing facilities were used to study axial cracking formation in bearings. NWTC field scale gearbox testing was also employed. This project leveraged an impressive set of capabilities that only DOE labs could accomplish.
- Novel work in the area of charactering failure modes. The team shows a strong approach to providing fundamental understanding, test and validation, and to providing a solution.
- The overall approach is well reasoned and likely to produce valuable results.
- Excellent systematic approach involving broad industry stakeholders such as tribologists, lubrication experts, and gearing and bearing designers. And, it has direct feedback to international standards.

Comments on Weaknesses

- Industry partners would likely be willing to provide out of warranty failed gearboxes to labs to study to obtain more objective information on failures. This will expand the scope and provide information that goes beyond the current information efforts herein.

Accomplishments and Progress

Comments on Strengths

- Fine progress and results.
- All tasks seem to be adequately progressing in a parallel fashion. Task 1 is already complete.
- The test identified specific operational conditions that give rise to bearing loads conducive to axial crack formation. Subsequent analysis and field testing at NWTC identified specific turbine conditions that can produce loads to bearings that can lead to such cracks forming in gearboxes.
- The team appears to have accomplished the majority of what it intended to accomplish to date.

Comments on Weaknesses

- No weaknesses noted by reviewers.

Communication

Comments on Strengths

- Very well. Easy to understand the presentation.
- Drivetrain Reliability Collaborative is a good forum for collaboration and communication. Several very technical papers have been published in focused publications.
- This is an exciting project and its results have been adequately communicated.
- The project led to several peer reviewed journal articles. Strong engagement with industry partners.
- The communication package is robust.
- Annual workshops are well attended and there are interannual meetings of experts all organized by the Drivetrain Reliability Collaborative.

Comments on Weaknesses

- It would be good to see how the knowledge from this work is transferred to the industry and how it can improve design specifications.
- The communication still restricts certain data sets (grd.nrel.gov) to study participants. There are many non-participants in the industry who would gain valuable information from more detail on the results (while still protecting participant privacy). Insurance companies, finance partners, independent engineers, and researchers should all have access to the summary information.

Upcoming Project Activities

Comments on Strengths

- Very relevant for the industry.
- Future project activities are well thought out and will focus on developing specific mitigation solutions.
- Upcoming activities seem logical and appropriate.
- WEC and main shaft bearing lab testing through additional conditions, including electrical currents, will be very important for industry.

Comments on Weaknesses

- No real targets are established other than continuing to progress.
- Encourage broader information gathering from firsthand investigation into failures from a wide range of sources.
- Must consider increased testing for statistical significance.

Recommendations (Not Scored)

- I suggest communicating findings in more general wind industry forums.
- This is a very exciting project that brilliantly leverages unique DOE lab capabilities. The team should continue their excellent work and advance from understanding mechanisms of failure to developing mitigation strategies.
- This study has the potential to add billions in value to the wind industry, and the industry key stakeholders are disincentivized to find the solution on their own. The problem crosses OEMs and regions. It makes sense to continue to investigate this problem, and it likely makes sense to expand the funding and scope of this program.
- Continue with additional conditions, parameter sensitivity, electrical currents, and model validation.

Optimized Carbon Fiber Composites for Wind Turbine Blades

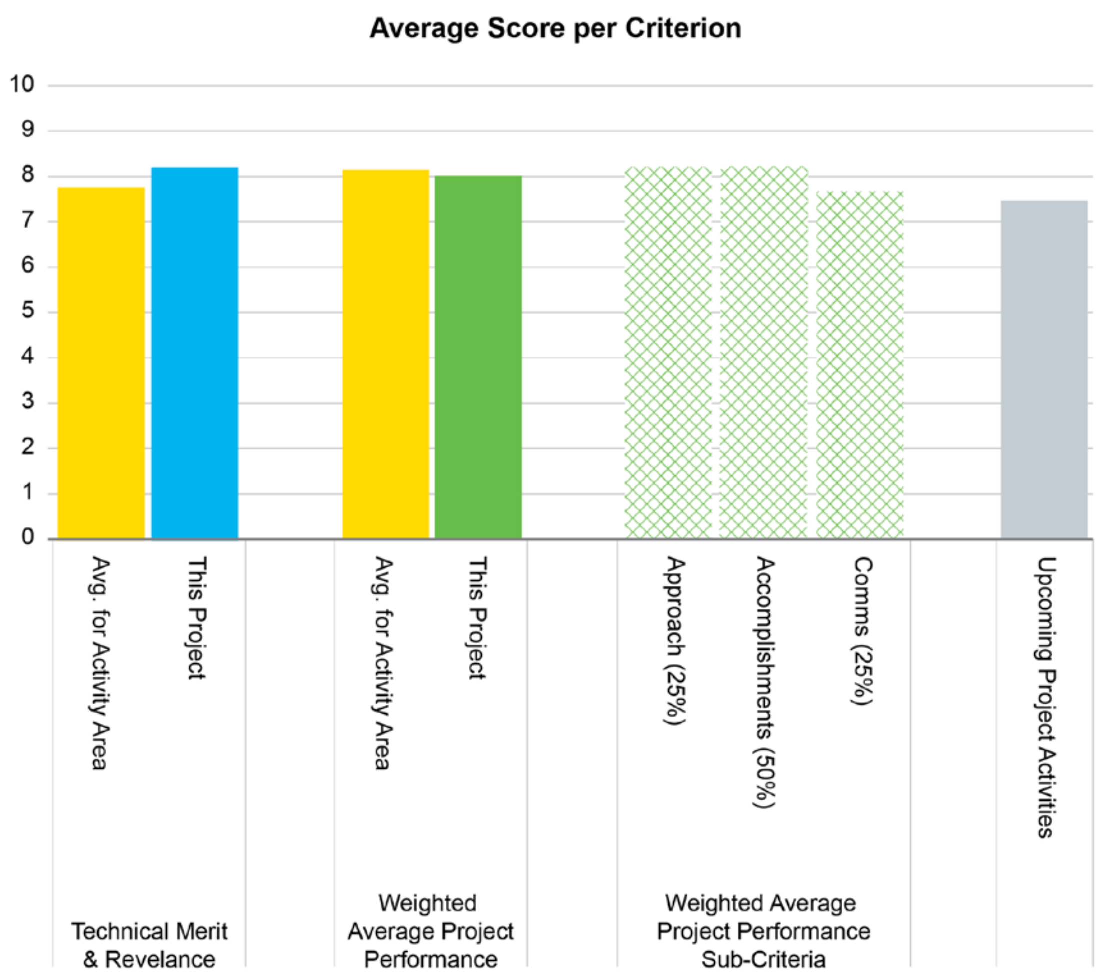
PI: Brandon Ennis	Unique Project ID: T16
Organization: SNL, ORNL	WETO Program: Technology Development and Scientific Research
Project Status: Active	WETO Activity Area: Advanced Components Reliability and Manufacturing
Total Available Budget (FY17 & FY18):	$1,049,960
Actual Costs (FY17 & FY18):	$775,585

Project Description

The objective of this project is to assess the commercial viability of cost-competitive, tailored carbon fiber composites for use in wind turbine blades. The project includes cost modeling and material testing of different low-cost and industry baseline carbon fiber materials. Material viability for wind turbine blade applications is assessed through structural blade design optimizations.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- It brings together non-commercial technologies and drives LCOE down.
- The project has the potential to transform commercial design of turbine blades using cost-optimized novel carbon fiber materials. It will help bridge OEMs with the carbon fiber manufacturing sector.
- Lowering the cost of carbon fiber is very relevant to lowering the LCOE. The industry is currently trending toward more use of carbon fibers as the rotor size become larger.
- Expanding the use of carbon fiber by the industry will have a material positive impact on the industry. The incorporation of expertise gained by ORNL is logical and valuable.
- Carbon fiber is one of many materials that turbine OEM have available to reduce weight and cost and improve performance of blades. Pultruded carbon spar caps could offer a significant reduction in cost, weight, and improvement in material performance.
- Pultrusion is one the lowest cost manufacturing methods producing the high fiber density ratio composites. Integrating pultruded carbon into blade spar caps is a good idea, as long as the secondary bonds are treated well to avoid debonding and stress concentration cracks.

Comments on Weaknesses

- To me, it looks as if this project is behind the industry's R&D.
- There is clearly merit, but the effort needs to engage the industry in more direct ways.
- Pultrusion with heavy tow carbon fiber is difficult and still maturing.
- What are the benefits to the private industry? Focus on compression fatigue testing might be highly valued by the private industry. Why hasn't the private industry developed these novel fibers?

Approach and Methodology

Comments on Strengths

- Fine approach.
- Graphical description of approach is good.
- The approach is scientifically rigorous, integrating cost-optimization of novel composite materials and development of representative reference models. The integration of and breaking the silos between OEMs and carbon fiber composite manufacturers are important strengths of this project.
- Comprehensive approach that includes cost modeling, testing, and blade design.
- Overall the method is logical and strong.
- Good work with the private industry and the industry's advisory teams.

Comments on Weaknesses

- The industry may already be advancing in these areas, so industry input needs to be integrated.
- Heavy tow carbon might lead to lower mechanical properties. It seems like currently only around 51% of fiber volume fraction can be achieved in pultrusion with this low-cost heavy tow fiber. This creates uncertainty with regards to the mechanical properties and cost scenarios that are currently forecast by DOE's carbon project.
- The use of cost models developed in the abstract can result in accuracy errors. Trying to validate the cost model with empirical evidence would validate the model's accuracy.
- The focus on the material, instead of how to use it, would be beneficial. The report would have been more valuable if it stopped at low-cost carbon and provided price and material specs to the wind industry, as opposed to trying to solve the protrusion and market value options.

Accomplishments and Progress

Comments on Strengths

- Sounds like the findings were accomplished.
- Significant cost reductions are shown approaching 50%.
- Major progress has been made in the last 3 years. The cost model has been developed and optimization studies have been completed. Testing has also been completed. Exciting cost reductions have been achieved through this approach.
- Reference models at 3MW and 10MW have been developed to assess varying materials demand at low and high resource sites.
- Identified materials can be commercialized in the very near term.
- The results show good potential for low-cost carbon.
- The project has successfully engaged the industry for feedback through the industry advisory board.
- All stated goals appear to have been accomplished.

Comments on Weaknesses

- Due to the large tow size, fiber alignment—which is critical in the pultrusion process—will be a challenge and may result in poor mechanical properties relative to current standards.
- Mechanical properties for laminates based on the ORNL LCCF as of today are inferior relative to baseline industrial standards, due to the low fiber volume fraction that is currently achievable. The future performance will be dependent on how well the pultrusion process with this heavy tow fiber matures.

Communication

Comments on Strengths

- Fine presentation.
- Project results have been presented at conferences.
- Good communication with the industry through the industry advisory panel.
- Materials appear to have been well distributed to stakeholders.

Comments on Weaknesses

- Although a plan exists to be executed, I suggest broader dissemination to the wind industry beyond blade manufacturers and designers.
- The industry's input should be better integrated in this project.

Upcoming Project Activities

Comments on Strengths

- The initial phase focused on spar caps while the next phase will focus on blade and rotor design.
- Upcoming activities appear to be logical extensions of current research progress.

Comments on Weaknesses

- To me, it doesn't sound very relevant.
- It is not clear that this approach will be cost effective when extending it to the rest of the blade.
- Using the carbon outside of the spar cap might not be the best way to use this material.

Recommendations (Not Scored)

- The strong focus on cost optimization and near-term commercialization bodes well for the success of the effort. A very nice blend between rigorous research in materials and optimization with a strong translational focus driven by industry needs. But the industry input needs to be incorporated as expanding the activity to the entire blade may not be economically viable.

- Current estimates (around 57% cost reduction predicted relative to current costs) are based on assumptions that need to be verified.
- The cost/benefit value of this project is very high and would likely result in significant market-value creation for the industry. This project has the potential to advance the state of the art in the industry.
- Add compressive fatigue testing to the program.

Big Adaptive Rotor

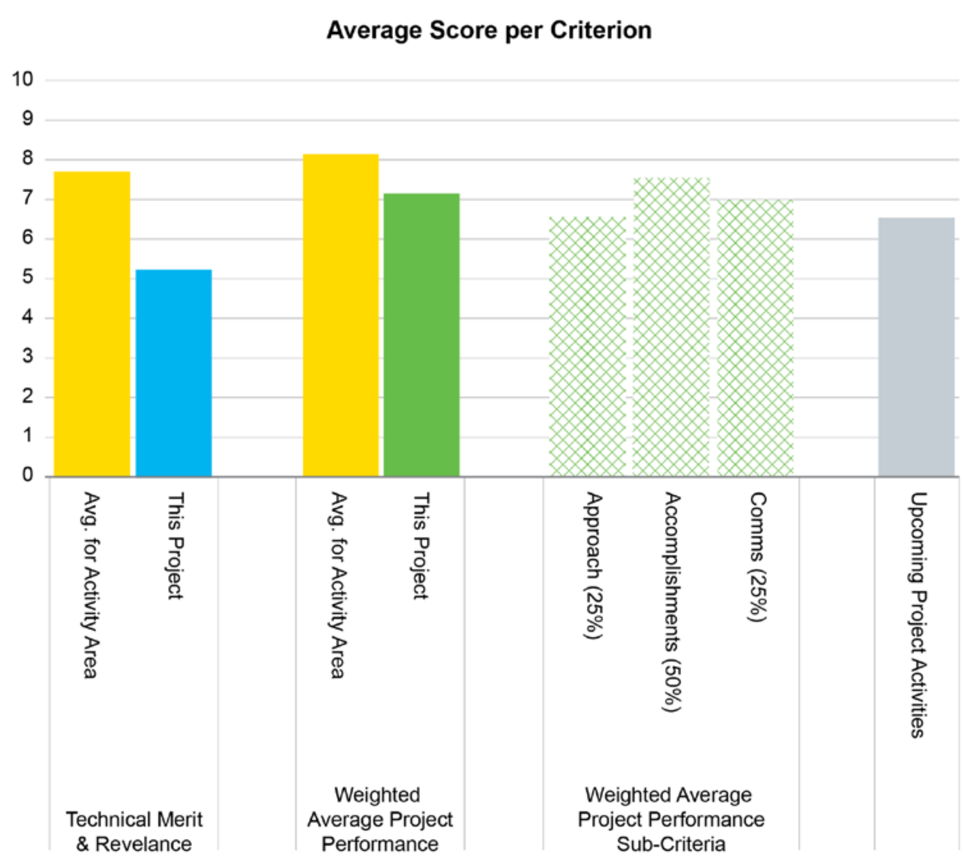
PI: Joshua Paquette	Unique Project ID: T17
Organization: SNL, NREL, LBNL, ORNL	WETO Program: Technology Development and Scientific Research
Project Status: Active	WETO Activity Area: Advanced Components Reliability and Manufacturing
Total Available Budget (FY17 & FY18):	$2,705,610
Actual Costs (FY17 & FY18):	$1,067,768

Project Description

Identify enabling technology for the next generation of high capacity factor wind turbine rotors. Investigate value of low specific power turbines. Evaluate all innovative rotor technologies. Understand logistics challenges for large onshore blades.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- This project has the potential to enable the next generation of super-large rotors for class III resource areas. It is highly relevant to the industry as it will open up large areas of the country for wind development.
- Strong engagement from the industry in this project. It is a good opportunity to have an objective assessment of technologies.
- The goal is valuable to the industry.
- Focused on innovative rotor configuration to get to large swept area and low specific rating. This reinforces the industry trend.

Comments on Weaknesses

- This R&D is behind the WTG OEM blade lengths.
- 100 m blades have already been built. There is an open question (addressed in the approach) as to the need for the specific W/m2 target.
- The industry is already very advanced in this area with blades larger than 100 m currently being built. This is not an activity for DOE to be pursuing, as the industry is already way ahead.
- Turbine with low specific power does not necessary lead to lower LCOE.
- The industry has committed hundreds of millions of dollars to studying this on its own. Nothing presented by applicants demonstrates a unique value that the team brings to the problem that makes it more likely than the industry to achieve success. This appears to be a "me too" study that is unlikely to advance the state of the art.
- Pursuing a specific, risky rotor configuration that the private industry might not pursue would be valuable. But this project seems focused on a broad survey of topics that the industry has already addressed, which appears to have less value and seems like a role for the industry.

Approach and Methodology

Comments on Strengths

- Well described method and approach.
- I appreciate the specific task level detail and the value/impact focus of task 1.
- The approach focuses on initial design stages including data collection, technology market assessment, identification of R&D areas, and cataloguing existing concepts, and large blade logistic issues. The approach is well thought out and comprises the critical first steps for developing a large rotor design.
- Good focus on technology gaps that enable low SP turbines to become competitive
- Good focus on cost modeling. Good focus on innovation.
- The knowledge collection portion of the work may have merit to track industry progress on the topic.

Comments on Weaknesses

- Several items in task 5 appear to be in the ORNL carbon fiber project that has recently been completed.
- Input from the industry has not been incorporated.
- It would be good to show the LCOE gap that this research is trying to close. It would be good if there is a stronger focus on advancing technology readiness levels.
- Tasks 4 and 5 are unlikely to advance the state of the art or result in value creation for the industry.
- The industry has moved beyond this large blade scale.

Accomplishments and Progress

Comments on Strengths

- Several open forums have been held to listen to the industry and challenge the group to think farsighted for enabling technologies.
- Data has been compiled and market targets have been defined. A large catalog of innovative concepts has been compiled to develop a list of possible options.
- A workshop to engage the industry on large blade logistics has been organized. This is a critical step, as logistics for moving such huge blades will be challenging.
- The work in this project has the potential to reduce the LCOE and make a large impact on a national scale.
- "Creating Pathways to Success for Supersized Wind Turbine Blades" was a great report.
- The team has accomplished the milestones it has defined to date.

Comments on Weaknesses

- I don't really see any conclusions yet.
- The industry is already far more advanced than this project.
- Low specific power as a trend is understood and it doesn't necessarily lead to lower LCOE.

Communication

Comments on Strengths

- Okay communication.
- Although the plan has yet to be executed, the range of conferences is good to see.
- Journal papers, conference presentations, and workshops. International advisory board has been set up to enable industry/academia/lab coordination.
- There was a strong emphasis on engaging industry leaders.
- Communication has been planned.

Comments on Weaknesses

- Establishing communication with key industry stakeholders already doing this work is critical and has not been done.
- Communication appears to be small relative to the task. It seems that a formal report and/or "State of the Technology" report is warranted and not just brief papers and presentations.
- If the goal is to aggregate and understand the existing state of the art relative to the task, then the burden of communication seems higher than is currently proposed. Consider integrating into the Wind Technology Market Report on an annual basis.

Upcoming Project Activities

Comments on Strengths

- A series of activities is proposed. They are very appropriate to advance toward a new blade design.
- A good plan is in place for future work.
- Upcoming activities are well laid out and documented.

Comments on Weaknesses

- Would like to see a lead lab identified for each task, as well as a time frame (quarterly?).
- Industry input is critically needed as large rotors have already become reality!
- It seems unlikely that upcoming activities will accomplish the goals of the project.

Recommendations (Not Scored)

- Consider changing the goal of this project from creating a 150 W/m^2 rotor to creating blades >100 m long. Most, if not all, of the work should directly translate.
- As noted above, the team should engage leading OEMs. The industry has already developed it and is building such rotors. This may not be a project suitable for DOE's investment.
- The industry is already spending significant private capital in this area. Why does the government add value here?
- Suggest concentrate on infield manufacturing or assembly of rotors.

Market Acceleration and Deployment Projects:

Project Results - Stakeholder Engagement and Workforce Development

WINDExchange and Regional Resource Centers

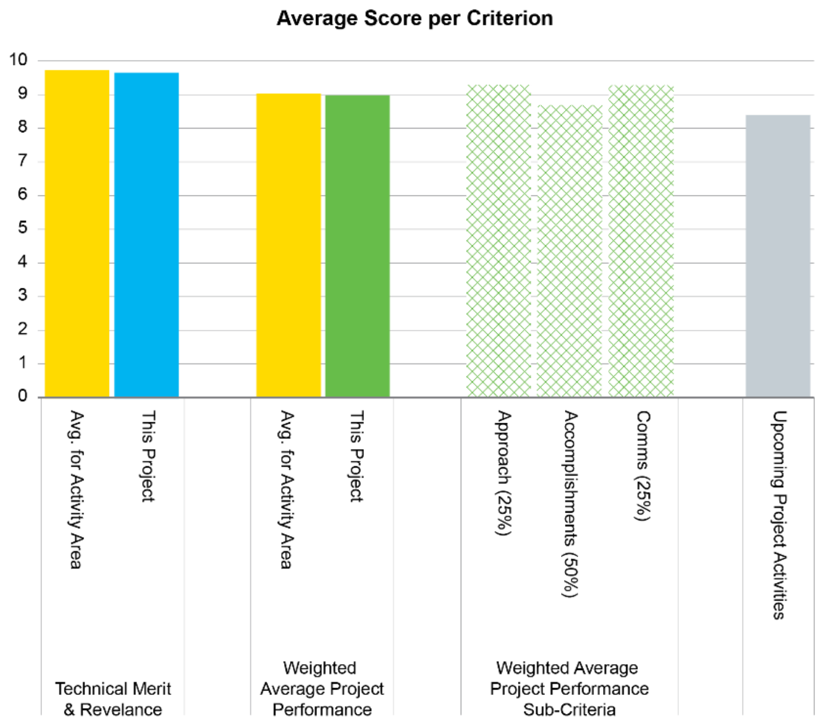
PI: Ian Baring-Gould	Unique Project ID: M13
Organization: NREL	WETO Program: Market Acceleration and Deployment
Project Status: Active	WETO Activity Area: Stakeholder Engagement, Workforce Development, and Human Use Considerations
Total Available Budget (FY17 & FY18):	$3,088,735
Actual Costs (FY17 & FY18):	$2,213,842

Project Description

WINDExchange and Regional Resource Centers (RRCs) are DOE’s stakeholder engagement and outreach efforts. These efforts are focused on creating and disseminating credible and fact-based information about wind energy, which can be used by decision makers considering future wind energy deployments.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- I completely agree that as the easier-to-permit wind project locations are developed, building wind energy onshore is becoming increasingly difficult. Acknowledging that and helping provide objective, credible info to help inform decision-making is critical. Effective efforts to facilitate meaningful, relevant stakeholder engagement is a critical tool for avoiding costly conflicts and advancing cost-effective projects.
- Getting easy access to un-biased information from credible sources is very important to help further wind deployment in sites that affect more people, as well as reduce cost of deployment. There is a magnitude of false information and myths still going around. This project is addressing an important barrier in an efficient way to reach more people through national and regional dissemination.
- Crucial need for information at a publicly digestible level to mitigate false information propagated by opponents of wind power. Getting information to those who need to know about wind, but wind isn't their thing.
- While not a "technology" per se, the WindExchange tool is an important element of the WETO program, providing stakeholders with factual non-biased information about wind energy. This clearly fits within WETO/EERE/DOE's roles and serves the purpose of informing the public on the facts of wind energy development and operations. That could reduce opposition and improve likelihood of project approval at the state and local level, which, in turn, should reduce the LCOE for wind energy.

- This scope of work is of incredible importance in the deployment of wind energy and reducing costs, given that wind energy facility permitting occurs primarily on a local level (across all levels of government). The nature of overall wind energy permitting is incredibly localized—each county has the ability to establish its own permitting program and requirements. Local governments across the country are as diverse as the communities they serve. While they range in diverse opinions, they also cover a broad swath of sophistication and resources. Moreover, much of the top-down decision making is executed by elected officials who serve county government on nights and weekends. Therefore, providing them technical resources through WindExchange is so invaluable in order to ensure that these public officials have the resources and information they need to make thoughtful, defensible decisions.
- Even federal permitting, when applicable, often occurs regionally—whether it be a USFWS endangered species permit or a Notice to Proceed from the BLM. Finding a critical vehicle to effectively communicate to these important decision makers is imperative. DOE through NREL has the opportunity to play a strong role in disseminating important information given its objectivity and credibility, as well as its expertise and ability to be a key thought leader and assemble and disseminate priority information. For these reasons, the industry cannot effectively fill this gap and there is a clear need for an unbiased source for this to happen effectively.
- In addition, given regional disparities in values, resources, conflicts, culture, etc., a one-size-fits-all national approach will not successfully overcome barriers and achieve goals. That is why a local on the ground, relationship-building presence is key through the Regional Resource Centers.

Comments on Weaknesses

- I wonder if the scale of this activity and the supporting funding of a sufficient magnitude to have the desired impact. Is the project ambitious enough?
- No weaknesses. Technical merit is strong.

<u>Approach and Methodology</u>

Comments on Strengths

- While there is an important need for national data and generalized information about wind power, ultimately, it is essential that local decision makers have unbiased local info about local projects. The WindExchange platform is great, but the concept of building more localized awareness and resources for stakeholder and decision maker education through the RRCs was really promising.
- WindExchange web for linking all information.
- Regional efforts to distribute the information more locally. Information will go to local authorities, but also to individual people living close to projected wind power plants, which means outreach towards millions of people.
- Ways of increasing dissemination through collaborative partnerships to engage and leverage existing stakeholder networks, which allows a transition to a portal of content.
- WindExhange is a very good web site with a lot of materials available in an easily accessible way.
- National and regional approach. Provision of unbiased objective information. Website is a useful tool
- JEDI model is an excellent resource and innovative approach to managing community interactions with wind power.
- This is a sound approach to the collection and public dissemination of the facts on wind energy.
- The two-pronged approach from this scope of work was strong. First, on the national level, WindExchange provides a tremendous clearing house of critical and valuable materials to regulating stakeholders. The materials populated in these documents span a strong range of content, and provide technical expertise on economics, local permitting models, etc. It's also smart to develop opportunities to interact with users, such as the newsletters and webinars, to remind its constituency base of the resource.

- However, while objective resources and tutorials are important, they are not successful in a vacuum. This is why the Regional Resource Centers are a critical component of this work. Not only to disseminate the information on WindExchange, but also to serve as an information gathering hub to identify gaps in information and feed the next generation of work product that should be prioritized for inclusion on WindExchange. The RRCs, and local outreach and relationship building, are critical to ensuring that NREL's analytical work is reaching its intended audience and that this work is being used effectively. The use of local radio segments and face-to-face meetings also was a key part of the approach applied.
- WindExchange and the RRCs depend on each other for success, so it was a strong strategy to deploy both in concert. As was referenced during the peer review, the relationships built through the RRCs create the audience, and the technical work product developed through WindExchange becomes the "leave behinds" and helps advance the lasting impact. The 2017 state of the regions report also does a tremendous job of documenting regional trends, helping understand challenges, and building future informed strategies.

Comments on Weaknesses

- The United States is very large and, at least in first phase, this work does not reach to all states. Some regional centers cover such a large area that they probably will have challenges reaching all that would need information.
- Could video be used more extensively to directly tackle some of the more damaging myths propagated by wind power opponents?
- Not really a weakness in the approach and more of a recommendation to do more to provide simplified "sound bites" (e.g., short videos/animations) that can be widely distributed and promoted for public consumption and use by wind energy supporters. It's great to have an enormous volume of information, but if the general public has to wade through all details it will likely not be as understandable and digestible, and therefore useful, as it could be. Also, considering the millennial generation reliance on social media, it might be helpful to have someone regularly post factoids, etc. via Facebook, Twitter, Instagram, etc. to direct interested stakeholders to WindExchange for more information.
- What I am unclear on is how effective the RRCs were at engaging the federal and state level. These are also key players in the deployment of wind energy and often decisions are made at the local level in field offices, which can be decentralized. Moreover, state laws can have real implications for local counties. For example, Virginia is a Dillon Rule State, which means local control is often preempted by state authority. You can easily contrast this with New York, which is a home rule state, meaning that local counties have extraordinary discretion in drafting local ordinances.
- I didn't see any reference to technical workshops bringing in local leaders to share challenges and opportunities.
- Expanding more into offshore issues will also be critical to WindExchange's reach and success moving forward.

Accomplishments and Progress

Comments on Strengths

- The Windexchange website is fabulous and all the publicly accessible info is really valuable.
- WindExhange is a very good website with a lot of materials presented in an easily accessible way.
- Audio interviews on topics relevant to rural communities is a good new approach.
- Economic analysis impact research with actual wind power plant case.
- 300,000 unique users on website.
- Very comprehensive analysis of effective communications and engagements.

- Rush Creek Wind Farm economic analysis and JEDI model.
- All the accomplishments align with the project goals and were very good.
- While stakeholder outreach's impact on advancement toward goals is challenging to measure, WindExchange is doing a tremendous job of building resources and subscribers.
- The RRCs appear to have broad outreach.

Comments on Weaknesses

- While I truly love the concept of region-specific outreach efforts as envisioned by the RRCs, it is disappointing that they were not able to accomplish the objective of effectively providing needed information and delivering stakeholder engagement strategies on an ongoing basis—particularly in regions where offshore wind development is under consideration.
- The outcomes on the work on new marketing metrics were not clear. Analytical way to measure the impact in number of engagements has been used, and ideas using method of engagement had some information. Qualitative would be something like stories behind a successful development of a wind power plant.
- Wind energy states fact sheet looks like not updated after 2017, but actually goes to well updated AWEA site. Perhaps point that out instead of showing a 2017 date which is a bit discouraging.
- Without metrics it is difficult to assess the impact this activity is having.
- Looking at the website, the most recent publications appear to date from 2017.
- Continual understanding of examples of where local governments and other stakeholders have used the materials developed during this program would be helpful to better understand their impact and refine future strategies based on what has been most effective. The 2017 State of Wind Development in the United States by Region does a tremendous job of this. However, I saw no indication that another regional report would be prepared. These reports are incredibly valuable in tracking the evolution of local challenges and opportunities over time, and it is short sighted to discontinue their production. Hopefully, the RRC technical report will pick up on some of the evolution of these themes, but it appears that this report is focused on the RRCs themselves and not greater trends in regional factors more broadly.
- I didn't see any reference to a peer review of WindExchange as is done with Tethys. This would be a valuable exercise.

Communication

Comments on Strengths

- Very impressive multi-modal outreach strategies, with numbers indicating a really broad reach.
- Excellent website and regional collaboration that has reached 100,000 local decision makers.
- Well networked with organizations and other projects like A3.
- Communications-focused activity. Website is a useful communications resource. JEDI model library is a very valuable communications and outreach tool.
- The communication and collaboration/coordination were excellent.
- WindExchange and the RRCs did a great job at communication and coordination, particularly its involvement across labs with key stakeholder groups. It is clear that it is reaching a tremendous number of subscribers.

Comments on Weaknesses

- Reports, fact sheets, and other online resources are key, but only represent one piece of a communication strategy designed to achieve these kinds of stakeholder engagement goals. Ongoing, local, in-person engagement, as envisioned by the RRCs, is critical for building enduring support.

- While a lot was done to reach the local level, this still needs work. Maybe a comment more about future work.
- Consider video as a means of interaction with a wider audience.
- Has the Rush Creek Wind Farm economic analysis and the availability of the JEDI model been widely disseminated? This appears to be a power tool for addressing community concerns, and wider dissemination and outreach centered around this could have a significant impact.
- Given all of the collaboratives at play, improving day-to day integration among them is key. Therefore, additional and enhanced collaboration with Tethys, WREN, BWEC and the NWCC would be valuable. As a stakeholder, I sometimes get confused by which role each platform plays. Moreover, I think there is tremendous overlap with WindExchange and WREN, and I think exploiting that overlap is important. Both of these platforms speak to decision makers—internationally and domestically—and thus both organizations can benefit from each other.

Upcoming Project Activities

Comments on Strengths

- This is really important work to continue in the years ahead.
- Very good to continue updating the WindExchange website and also the JEDI economic analyses on the benefits of wind power projects.
- Future work appears in line with project goals and current funding levels.
- The proposed activities continue on this great body of work and will continue to provide an important function for the industry.
- The focus on continuing investment in this space is critical.

Comments on Weaknesses

- Looking forward, it would be good to see a more balanced approach, including resources focused on offshore wind (both East and West Coast) more prominently. Also, it would be great to see a renewed effort to accomplish the critical goals of the RRCs (building on lessons learned re: partners/resources/etc.) in providing state/regional-specific info. This is particularly important for offshore wind where the learning curve for regulators and stakeholders is so steep.
- I would like to see regional centers continuing for offshore states.
- Future work appears to lack ambition. Perhaps worth exploring new outreach methods and dramatically increasing the reach of the activity.
- The only weakness on future activities is the lack of continued support of the RRCs. While I realize this was a time-limited function of the program, it is essential that the initial work in this space continue. If there is a role for DOE moving forward, I suggest that this be reprioritized.

Recommendations (Not Scored)

- Nothing more to add, except to further encourage to not learn the wrong lesson from the failure of the RRCs. There is huge opportunity and need for DOE to help provide relevant, accurate, and compelling materials and to help stakeholders and energy policy makers more fully embrace wind energy and push back on opposition.
- Reaching local stakeholders/public remains a challenge, maybe the regional centers need to be revisited unless other new ideas emerge. For example, regional centers could perhaps still be funded for the states that were not covered for the past 4 years, like offshore northeast.
- Consider scaling up the operation to have greater impact.
- Consider use of alternative media such as video to increase reach.
- Consider wider dissemination of JEDI model and case studies around it (e.g., Rush Creek).
- This is excellent work. Keep doing what you are doing in this space. Please continue to prioritize WindExchange and funding for the work in this space.

- As this project undergoes negotiation, I strongly recommend a thoughtful approach as opposition from local communities grows. The largest strength of WindExchange is its objectivity and technical support for local stakeholders. Overcoming opposition doesn't always just mean explaining facts and science; it can also mean arming these communities with the knowledge and power they need to make the best decision for their community. This means taking advantage of this development to build local tax payments and, in turn, potentially overcome opposition. However, WindExchange itself cannot play this multi-faceted role as a website. It needs this local, on-the-ground presence to understand local conditions, facts, etc. Basically, it needs something to fill the role the RRCs played to ensure the information developed by WindExchange is deployed.
- Therefore, understanding opportunities to continue to support a regional presence under a specific strategy and prioritization based on regional factors is important.
- Understanding baselines and regional trends is also critical to advancing this work. Supporting annual state of the region wind reports—whether it's a stand-alone document or integrated into other work products from DOE—will be very important.
- State and local governments are policy laboratories. Disseminating the success of these policy experiments helps everyone.
- Continue to support RRCs or a similar entity. For example, AWWI has achieved great success with its work bringing local stakeholders together in New Mexico for listening sessions.
- Continue assessing regional trends and success stories, and document what is working and what is not from a stakeholder outreach perspective.
- Improve coordination with other stakeholder groups to leverage knowledge, skills, experience, etc. (e.g., Tethys, WREN, NWCC, etc.)
- Continue to innovate on communication mediums, including video and local press.
- Improve directed outreach to federal agencies.
- Continue supporting local communities on opportunities for pollinator conservation since this is of growing interest and there are several leaders on this (particularly in the Midwest).
- Consider technical workshops and symposiums to broaden reach and build relationships across sectors.

Collegiate Wind Competition

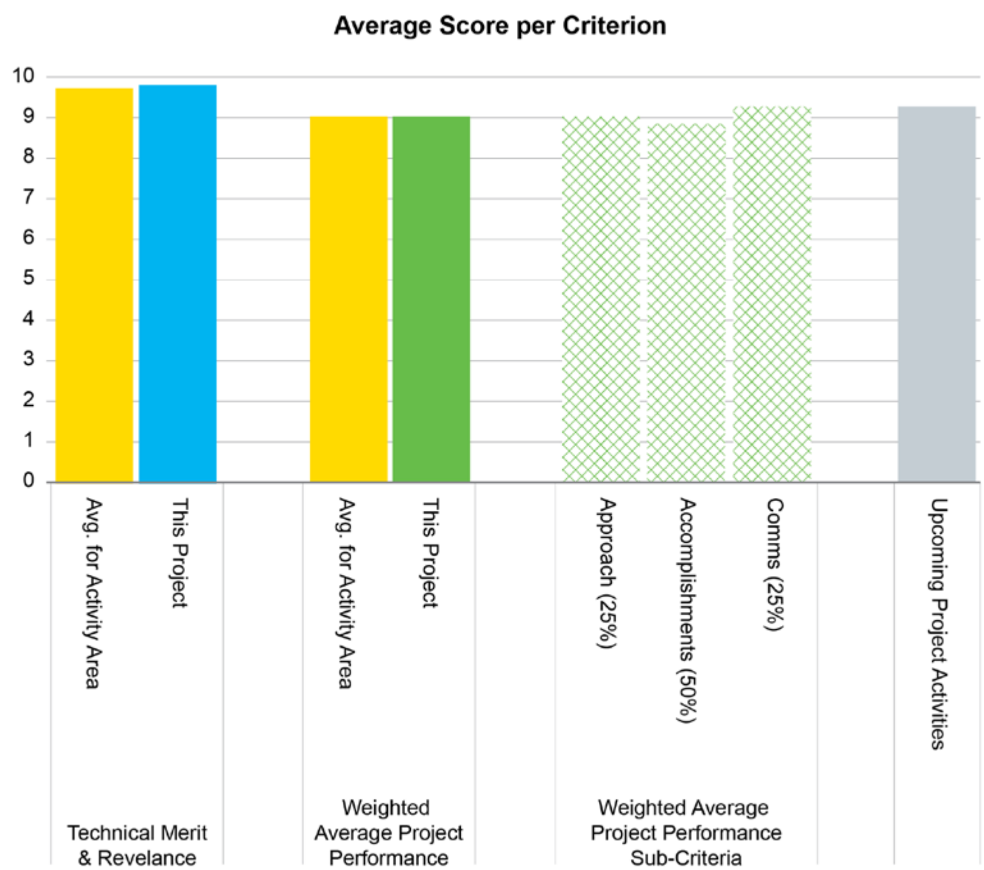
PI: Ian Baring-Gould	Unique Project ID: M14
Organization: NREL	WETO Program: Market Acceleration and Deployment
Project Status: Active	WETO Activity Area: Stakeholder Engagement, Workforce Development, and Human Use Considerations
Total Available Budget (FY17 & FY18):	$3,490,665
Actual Costs (FY17 & FY18):	$1,815,696

Project Description

The U.S. Department of Energy (DOE) Collegiate Wind Competition (CWC) challenges interdisciplinary teams of undergraduate students from a variety of academic programs to offer unique solutions to complex wind-energy challenges.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- This is a fabulous program, especially because it is targeted at filling gaps the industry has identified in the workforce.
- Clear need for education to build a qualified wind energy workforce, especially bachelor grade having knowledge/understanding of base-level wind energy. Project aims to inspire and prepare students from multiple disciplines to enter the wind energy workforce by providing real-world technology and business experience.
- An exemplary activity, which attracts and develops interest in the area from talented engineers and makes a critical connection between industry needs and relevant educational programs.
- This project plays a critical function in workforce development and utilizing bright young minds to think about turbine design and siting issues in ways that companies might not yet have realized or refining current thinking in a way that could lead to reductions in LCOE. I have always thought of this program as R&D for the future workforce of wind energy.
- It is incredibly important that we build up a strong workforce for wind energy for several reasons. First, our country is in a time of great energy transformation. Ensuring that the collective workforce can respond to this transformation will be key to the success of our country's future energy portfolio. Focusing on universities is a great opportunity to build this future workforce. In addition, the future deployment of wind energy and keeping energy costs low depends on a robust, talented, and invested work force. The solutions that will drive efficient and productive wind technology across the country will depend on the next generation of innovators.

Comments on Weaknesses

- How well does the competition meet the industry needs?
- The only weakness I have recognized is the relatively low job placement of students coming out of the program and lack of meaningful engagement by industry with the participants at WINDPOWER or otherwise. I see these students as excellent candidates for jobs in the industry and it seems to be a lost opportunity by WETO, the universities, and industry to not capitalize on that. I think some coordination with AWEA and several key companies leading up to the event could be incredibly meaningful in addressing this gap. And, even if the engagement by companies didn't result in actual job offers, I would think the students would love to just meet with company representatives to hear about how they got into the industry, what they do, and to encourage the students to find work in the field and explain how they might do that.

Approach and Methodology

Comments on Strengths

- Excellent approach to locate the competition at AWEA to facilitate networking for students and visibility for them to see the industry/careers in action. Also, I love the synergy with KidWind and other similar efforts like WRISE.
- Building of CWC has proved to attract a large group (270+ students per year), and some funding also used for supporting materials/educational webinar series that is very useful.
- Good to have interdisciplinary groups that look at siting and other issues beyond just the technical.
- Friendly competition environment has been very inspiring to the participants and created a good amount of publicity.
- The CWC is a powerful tool that provides an opportunity for students to get first-hand experience with various aspects of turbine design and deployment with significant benefits for the employment prospects of those involved.

- The continuous evolution of the activity each year is a key strength in maintaining interest and capturing more interest each year.
- Inclusion of siting element.
- I think the program design is just great and appreciate the addition of the siting challenge in 2018.
- The program has done a good job of querying the industry to understand its workforce needs and their perspective from what the industry needs from a technical perspective.
- The two-year implementation approach is incredibly strategic—with the first year of bringing them to the NWTC, and then the second year hosting the competition at AWEA wind power. This is a thoughtful sequence for building their understanding and confidence in this technical space. The two-year engagement builds a sustained interface between university students and the wind industry. It is also a great opportunity to leverage the resources of the NWTC.
- The program builds momentum within universities themselves. The credibility of NREL's/DOE's engagement provides a platform around which more holistic programs within universities can build—one of the current gaps that needs to be addressed. The program also includes an important opportunity for universities to shadow this experience before jumping in.
- The program does a good job of building a pipeline by integrating younger children into the experience.

Comments on Weaknesses

- How can we get more students engaged? Also, are there ways to focus efforts on schools/initiatives that can help increase diversity in the wind workforce?
- Would a higher impact come from more directly designing university courses with practical demonstrations/excursions to industry?
- Is it worth considering including dramatically different elements to the competition, such as wildlife mitigation measures, offshore challenges (floating platform), or grid integration issues?
- Is there a follow-up piece required to try and increase the capture rate of participant students?
- Sustained engagement with industry throughout the program appears to be lacking. For example, not integrating them with wind power and encouraging interviews, etc. was a missed opportunity.
- Further exploration of opportunities to expand diversity/inclusion and outreach is needed. Additional partnership with the industry on this is warranted regarding how to strategize improving this and building resources.

Accomplishments and Progress

Comments on Strengths

- Excellent, high-quality program that undoubtedly has a powerful impact on the students.
- Very well organized and disseminated activity, attracting 270+ students, creating positive publicity.
- Wind tunnel to test the prototypes accomplished.
- Activity appears to engender significant interest and enthusiasm and is a very valuable educational tool.
- Third wind-testing tunnel completed and is an excellent resource.
- Great continued progress on refining, improving, and growing the program. The addition of the new wind tunnel and siting challenge was outstanding.
- It is clear that these are successful, well-run events that students and universities alike are benefiting from.

Comments on Weaknesses

- Would love to see more metrics on where the students go in their careers. Also, it would be great to have some more structured opportunities for student engagement with wind industry professionals at AWEA or other venues. Perhaps add a mentor program for CWC alumni or some other aspect to the follow up that could help create more pathways to success in the industry.

- This is supposed to be an industry event, but seemed to be too busy for the industry to come meet the teams.
- It has been mentioned that the capture rate of students involved in the competition is relatively low and the reasons for this should be understood.
- Low industry employment of participants.
- This program is still in its infancy and it is still unknown what impact it is having on future workforce resources. Building industry partners and leveraging other revenue sources will be key to its success in broadening outreach. Soliciting input on where "graduates" of the program are now would also be valuable in understanding the program's success.

Communication

Comments on Strengths

- Excellent outreach strategy, including strategic utilization of social media to get the word out and create a buzz, etc.
- This project creates a lot of inspiration and positive publicity. Partnering with AWEA, hosted in their event, and KidWind activity.
- The project itself is a highly valuable communication tool, which attracts increasing numbers of students to the area each year and engenders excitement about wind power.
- With changing locations, the geographical reach is very impressive with teams from Alaska to Puerto Rico involved.
- The communication plan is good and there is a nice balance between social media and web-based information.
- Focusing on social media is an important strategy for communicating given the audience.

Comments on Weaknesses

- Consider outreach directed at past participants to increase capture rate.
- I would suggest doing more to promote the program through industry trade publications, media coverage, etc. This is a great program that should be more widely publicized.
- There is room for improvement regarding increasing communication with the industry and specific companies in particular. All of these companies run intern programs and have strong communication departments. Leveraging these would be valuable.

Upcoming Project Activities

Comments on Strengths

- Glad to see it continue! Such a great program.
- The project has been developing from year-to-year and has, again, a good list for improvements, especially improving industry communication, developing a CWC alumni program, and expanding industry ties.
- Upcoming activities are well aligned with project plan and goals.
- The proposed continuation of activities leading up to and at WINDPOWER 2020 are solid.
- Future plans for continuing this program appear strong. The goals referenced are important, including increasing expanding student diversity, as well as an integrated alumni network. This network of alumni members can serve so many purposes, including integration with industry players, student mentor opportunities, and an ability to track "graduates" throughout their career.

Comments on Weaknesses

- It would be great to see an offshore-wind-specific project track, or some focus on offshore wind development aspects, in future competitions. Also, I'd like to see more attention to recruiting students from a diversity of backgrounds, including underserved and minority communities.
- The challenge remains on the impact of the funding as outreach and success to take the involved students to industry.
- Future plans appear to lack ambition around how to develop the competition further in more interesting ways and increase the capture rate of students entering the workforce.
- While it made sense for NREL/DOE to organize and craft this program, it is now time for a deepened partnership with industry. This is critical moment for refining the program activities to meet industry needs and to expand outreach. Moreover, industries' inclusion could provide the resources and additional support necessary to bring a diverse set of universities into the mix. These universities may suffer from cost and other resource barriers that have kept them from joining the competition. Encouraging the development of scholarship programs within companies also provides valuable opportunities for companies and meets specific company goals. Further training and outreach to specific companies on these topics would be valuable.
- The program is not fully taking advantage of its co-location with AWEA wind power. More thought to networking and other career-related skills should be considered, including, for example, practice interviews.
- Universities should be encouraged to be more thoughtful of their internal wind energy programs and how they can be building the workforce of tomorrow with more thoughtful curriculum programs that meet industry's needs.

Recommendations (Not Scored)

- This “industry event” seemed to be too busy for the industry to come meet the teams. Would a separate event with industry invited work better?
- Would better impact come from more teams? This year only 12 teams of 20 willing to join were selected. Would it be possible to organize a second event for the interested ones?
- Is there use for the wind tunnel outside of the events, such as a university/college?
- Given the success of the project, is there scope for more ambition in the areas covered. For example, covering grid integration issues and/or looking towards 100 percent renewable systems? Offshore wind? Wildlife mitigation issues?
- Examine why the student capture rate is low.
- I view this program as an essential element of the cultivation of the next generation of wind energy minds and think the work needs to continue to be prioritized by WETO. I believe more could be done to promote the work and engage with industry (developers and OEMs) to connect the students with potential employers.
- Brainstorm opportunities to expand industry engagement—both within the collegiate itself and beyond. Additional webinars and expanded outreach with human resources departments should be integrated with the programs. Interviews at AWEA wind power, mentor programs with industry representatives, etc. are currently missed opportunities.
- Through improved industry engagement, seek opportunities to expand the reach of the program and leverage resources to reach more communities and more schools.
- General trainings on how universities can improve their programs and better prepare their students would be valuable.
- Building a strong alumni network is a great idea.

Wind for Schools

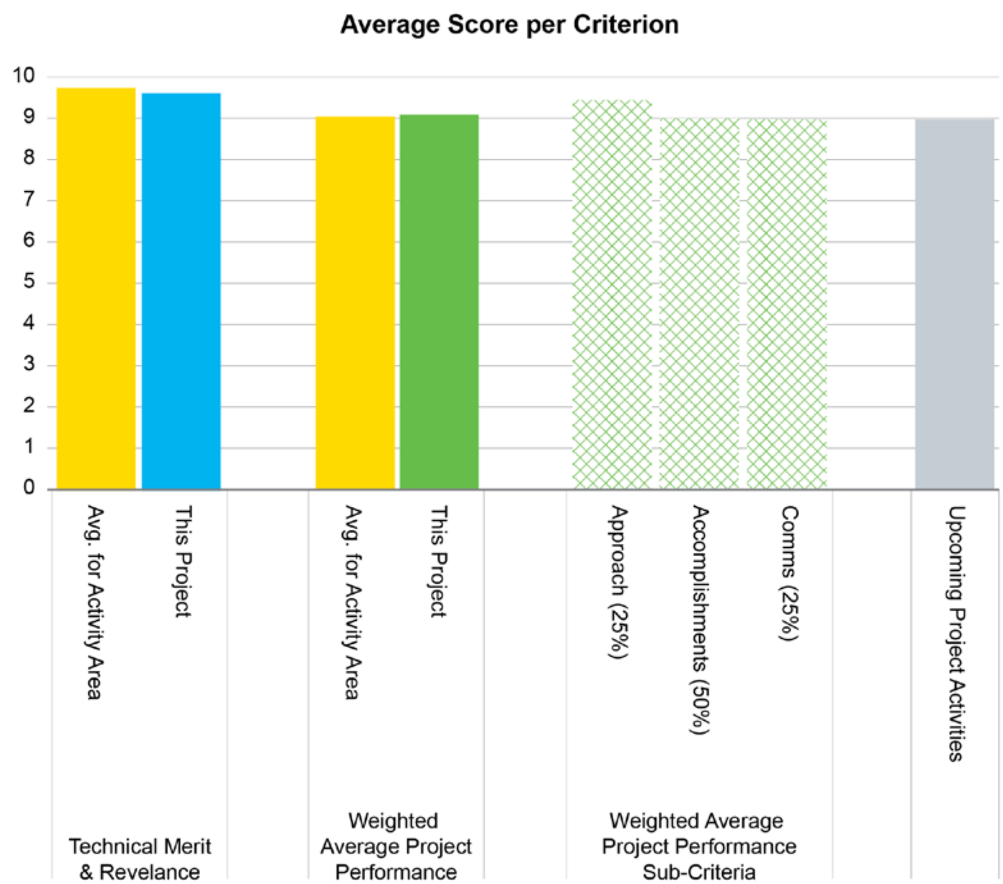
PI: Ian Baring-Gould	Unique Project ID: M15
Organization: NREL	WETO Program: Market Acceleration and Deployment
Project Status: Active	WETO Activity Area: Stakeholder Engagement, Workforce Development, and Human Use Considerations
Total Available Budget (FY17 & FY18):	$2,708,542
Actual Costs (FY17 & FY18):	$1,823,708

Project Description

Understand current and future wind industry workforce needs and the educational infrastructure to support them. Support the development, expansion, and collaboration of university-based wind education programs. Provide hands-on, wind-focused educational programming across the educational spectrum (from ages 4–20) to expand interest in and knowledge of wind energy.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- This is really essential work targeted at specific identified "breaks in the ladder" of career development for wind industry professionals. There is a very real gap in programs and in awareness that renewable energy—and wind energy, on- or offshore specifically—is a lucrative and fun career track to be pursued. Building up a U.S. wind industry workforce is an essential strategy for bringing costs down and increasing the overall economic benefits of wind energy.
- Tackles the U.S. wind workforce challenge with hands-on, wind-focused educational programming across the educational spectrum to expand interest in and knowledge of wind energy in collaboration with educators, industry, government entities, and other workforce stakeholders.
- Directly addresses workforce development goal. Directly addresses workforce diversity issue.
- Reaching students early in their educational experience plays a huge role in developing positive attitudes towards wind power and in engendering interest in the area as a possible career pathway.
- Like the Collegiate Wind Competition, I view the WfS program as being an important element of the WETO program to help engage schools to develop a future industry workforce. While not a technology-based activity or one designed to reduce LCOE, I do firmly believe this is a relevant activity for DOE/WETO and one that would not be taken on by another organization if DOE did not fund it. Helping engage and shape the future industry workforce is essential to growing a stable industry.
- This incredibly important that we build up a strong workforce for wind energy development for several reasons. First, we are in a time of great energy transformation in this country. Ensuring that the workforce responds to this transformation will be key to the success of our country's future energy portfolio. Focusing on universities is a great opportunity to build this future workforce. In addition, the future deployment of wind energy and keeping energy costs down depends on a robust, talented, and invested work force. The solutions that will drive efficient and productive wind technology across the country will depend on the next generation of innovators. Engaging and leveraging the curriculum from K–12 and beyond is the best way to build this future workforce. We shouldn't have to import this talent from overseas given the tremendous academic resources we have in the United States.
- One of the key gaps that seems apparent in the United States is the lack of more integrated wind energy curriculums in universities. While coordination among universities is strong, there appears to be a real need for building university centers or strategic programs, and this program helps foster the development of these centers and programs.

Comments on Weaknesses

- Is the scale of effort and duration of guaranteed funding sufficient for such long-term activities?

Approach and Methodology

Comments on Strengths

- Love seeing DOE funds dedicated to important initiatives like this, not only because it greatly increases our ability to cost-effectively grow a domestic wind industry, but also because it can have such a profound impact on the people it reaches.
- Collaboration with existing activities and organizations (NAWEA).
- Seed funding to established university programs.
- Support for the development of curricula and access to a curricula portal on Open EI.
- Providing wind-energy industry information to potential workers through tools and resources such as the Wind Career Map.

- Survey of industry to assess the gaps.
- All age ranges from K through to university are covered by this program.
- Effort to develop a sustainable funding mechanism.
- Efforts around increasing understanding of the workforce.
- The outlined approach is solid, and I have been pleased to see it evolve over time.
- The strategy is sound, and the program has put together the right pieces to advance goals. This diverse portfolio of reach is an important part of its success (i.e., university seed programs, K–12 curriculum, focus on sustainability, and baseline workforce statistic generation).
- One clear strength is the framework under which this program was developed. It is based on a gap assessment to understand the training needs from industry as well as current university programs. Developing this baseline study is critical to the program's success.
- The program is strategic to maximize its impact by diversifying its engagement geographically and across age ranges with a keen eye on sustainability over time. This problem appreciates that growing the industry leaders and innovators of tomorrow has to start young, build in complexity as students age, and occur across the country in many schools to have the necessary economies of scales. It is important that this curriculum begin early.
- This program implements this strategy in many important ways. By training teachers, you increase your reach and also broaden momentum. Also, the web-based access to the curriculum is incredibly valuable for teachers to leverage and use.
- The program provides a critical opportunity for hands-on experience with turbines. It is hard to think of a successful overall program without this broad opportunity.

Comments on Weaknesses

- Approximately 190 schools have been contacted, mainly through in-person visits. Has the impact of these visits been assessed? 190 seems like a small percentage of all schools across the United States. Is there a more effective way to increase the reach of the program?
- Program is aimed at workforce development, but it is worth considering broader activities aimed more at fostering a more positive attitude towards wind power, perhaps by working directly with the U.S. Department of Education to influence regular curricula items that are relevant?
- The approach and methodology appear focused on funding and support aspects, while the progress and accomplishments of the project suggest that the biggest impact is from personal contacts. Should human element of this effort be more to the fore and more deliberate and involve other disciplines from the humanities? For example, social scientists, psychologists, educators, etc.
- Additional thought should be put into reach of the program to improve diversity and inclusion in the wind industry. Also, more integration and alignment with the collegiate wind program appears to be needed.

Accomplishments and Progress

Comments on Strengths

- This program has a really impressive list of tangible accomplishments, including the potentially lifelong impact on the students and other individuals served.
- Support for the education of thousands of engineers entering the workforce, WACs at 12 universities that—in collaboration with KidWind and the NEED Project—have impacted tens of thousands of elementary and secondary school students.
- Improving the course materials for all levels of education. Excellent to have an OpenEI portal for easy access and sharing of all work both for the courses and small wind turbine data from WfS. OpenWind tool for siting is suitable for different levels of education.
- Analysis on the workforce needed and gaps.
- Significant numbers of teachers and students reached through outreach programs.

- Educational materials reached 2100 students.
- The continued advancement of and refinement of the program has been great.
- The program has made tremendous progress, particularly given the fact that the program was temporarily shuttered in 2013 and 2014.
- It is impressive how far a reach this program has had over the last two years. The number of teachers and students already directly touched by this program is impressive. Also, having 141 turbines registered in the Wind for Schools Network is fantastic, along with all of the teacher trainings.

Comments on Weaknesses

- NAWEA collaboration has been difficult to start, and university collaboration to get a snowball effect on the courses and study programs offered has not generally succeeded.
- Relatively small portion of children reached directly through this project.

<u>Communication</u>

Comments on Strengths

- There is such great stuff here, but the scale of the impact of this work is closely linked to the effectiveness and reach of the communications and outreach efforts to recruit participants. The online portal and regular conference calls seem like a good balance of active/passive engagement.
- National wind workforce report.
- Links with WindExchange and CWC.
- OpenEI.
- WACs.
- NAWEA and AWEA for dissemination.
- Communications are a key aspect of this activity.
- NREL engaging directly in several outreach activities.
- The communications and coordination to date have been good.
- The program's outreach strategy is impressive and comprehensive. The coordination with the WACs and monthly calls is a vital way to keep ongoing communication moving, as well as accountability for tasks. The planned future engagement with states is also an important next step, as states should be large partners in this program as they invest in their flagship universities.
- Continuing to support the NAWEA Research Symposium should be prioritized as well since this provides an opportunity for networking and enthusiasm.

Comments on Weaknesses

- Informing industry recruiters is only beginning.
- What level of interaction is there with other WETO programs? For example, could a number of WETO projects be "encouraged" to have presentation materials aimed at education as a deliberate output?
- Interaction with the U.S. Department of Education would seem like a worthwhile exercise.
- Consider a broader-based effort targeting the regular curriculum less focused on workforce development and more on fostering positive attitudes towards wind power.
- While the level of communication and engagement has been good, I think more can be done to promote the program and thought should be given to how to do that using traditional and social media.
- Additional media, such as video, would be valuable for this program and should be considered when developing promotional brochures and stickers. Integrating with school age entities, such as

Girl Scouts or Boy Scouts, might also be a valuable opportunity to expand the reach of this program given that they often have large regional centers.

Upcoming Project Activities

Comments on Strengths

- This initiative is essential, so it is great to see DOE providing seed funding for these efforts that will require much additional/diverse funding streams over the longer term.
- Focused plan forward freeing WETO funding where possible.
- Strategic plan to engage a broader audience. In general, future planned activities appear to target the identified weaknesses.
- Given the growth of the industry and limited resources I understand the need to transition the program, but I do think DOE should continue to play a role to ensure that all the work to date is not lost when DOE steps back. Hopefully, the sustainability plan will help address this concern. I was encouraged to see that that WfS activities are being integrated with the Collegiate Wind Competition, which may also address my concerns with the transition away from the WfS program and my concern with CWC that there is no clear engagement between students participating in the program and potential industry employers.
- The outlined approach is sound. Building the resources and training within states and other entities is the best strategy for advancing this program. It is also important that this work evolves into a broader workforce strategy. Right now, that cohesiveness is needed.
- More thought and attention should be put in diversity and inclusion in this strategy, and there should be more effort to understand why students do not appear to be staying in the wind industry after graduation.

Comments on Weaknesses

- Looking forward, I would love to see more focus on offshore wind development needs (some of which are very different or non-existent in the onshore space).
- Open-source tools to universities and colleges could be encouraged.
- Engaging with industry needs more focus, both getting information from gaps to workforce needs, but also informing about the good wind programs and future workforce.
- Essential to take a long-term view of this activity.

Recommendations (Not Scored)

- Open-source tools to universities and colleges could be encouraged.
- Engaging with industry needs more focus, both in getting information from gaps to workforce needs but also in informing about the good wind programs and future workforce.
- Excursions to industry as part of courses, or visits to fairs/events to see exhibits and meet professionals.
- Consider more interaction with U.S. Department of Education.
- Consider a broader effort aimed also at fostering positive attitudes towards wind power.
- Take a long-term view when evaluating impact.
- Ensure funding mechanism can support the long-term view.
- Nothing significant beyond what is stated above. I see the value of this program and appreciate the WETO efforts to ensure that the good work to date in this area is supported into the future.
- A broader workforce strategy that integrates a variety of state and educational stakeholders is clearly needed. This program is building the capacity and experience needed to craft a workforce strategy that is effective and meets the future needs of tomorrow.
- There needs to be a more concentrated effort and strategy to encourage the development of centralized curriculums. The industry is at a maturity level such that university programs should

not be as ad hoc as they currently are. Coordinating with Europe and their curriculums through the IEA or other forums should be a high priority. NREL should continue to engage with NAWEA and NSF to ensure that we can address these barriers now.

- More coordination with tribes is needed and further integration with current job training programs for tribes at both the state and federal level.

Project Results - Environmental Research

Wind Operational Issue Mitigation

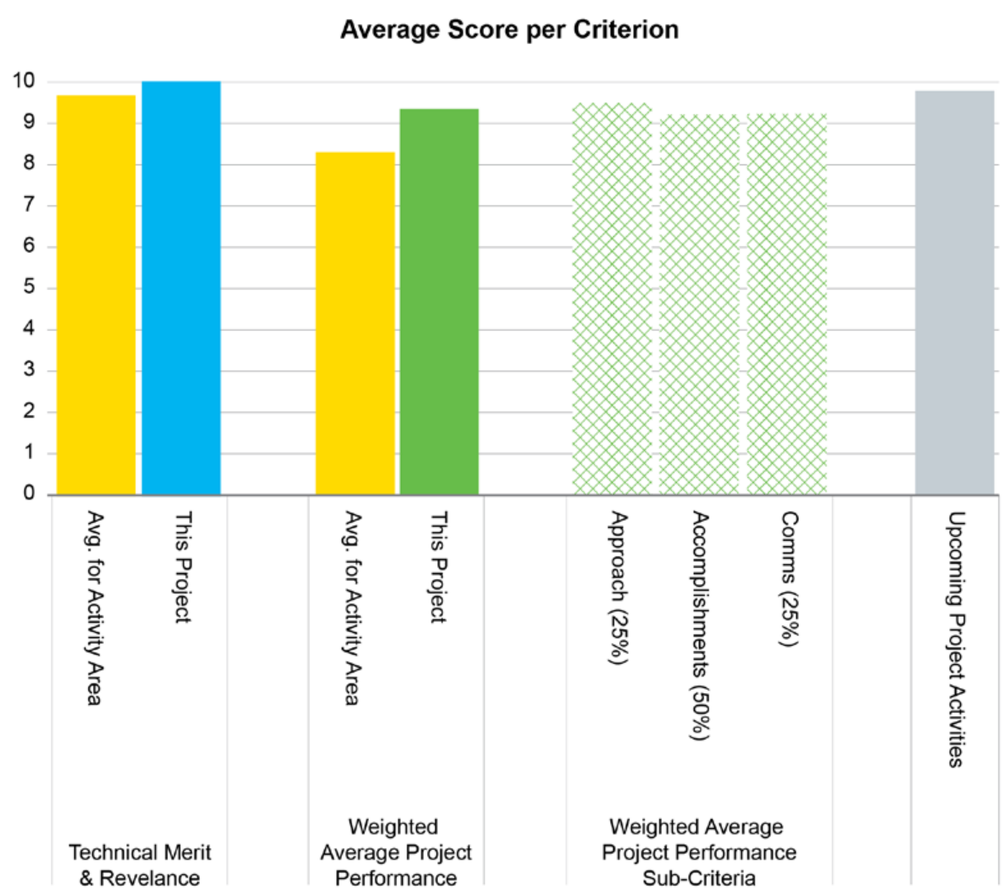
PI: Cris Hine	Unique Project ID: M01
Organization: NREL	WETO Program: Market Acceleration and Deployment
Project Status: Active	WETO Activity Area: Environmental Research
Total Available Budget (FY17 & FY18):	$3,510,820
Actual Costs (FY17 & FY18):	$1,534,460

Project Description

Facilitate the reduction in environmental constraints to wind energy deployment. Support advancement of early-stage technological solutions that reduce impacts to wildlife. Oversee research-based collaboratives focusing on outreach and stakeholder engagement.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Helps the industry and wind developers to develop turbines that can coexist with wildlife and sites that minimize the risks to wildlife. Engages with research that has the potential to advance the state of the art of knowledge on environmental impacts and mitigation measures.
- This is a highly relevant issue, which currently results in wind power curtailments. The point was raised that if the issue is not tackled and currently unprotected species become listed, the issue could be greatly exacerbated.
- The efforts undertaken by NREL during the reporting period are critical to identifying and finding solutions to the various wind-wildlife interactions, which can act as barriers to deployment or reduce technology effectiveness and efficiencies through forced operational adjustments and in turn avoided production. The meetings and work product that have come out of the TD&I, LBC, and WREN over the years have been extremely high quality, and have helped answer some of the key questions regarding wind-wildlife interactions and/or resulted in new R&D focal areas and the identification of issues needing additional research.
- This program has incredible merit given the increasing interaction with wind and wildlife and the importance of addressing this potential conflict in order to build public support, reduce permitting costs, and expand areas of potential deployment. The project provides a unique opportunity for sophisticated stakeholders to collaborate and leverage capacity as well. It is also unique in that it takes a holistic approach to wind wildlife interactions across geographies and species.

Comments on Weaknesses

- The only weakness is a technical one in that these efforts are, more often times than not, process-oriented rather than the technology-advancing R&D (exceptions being the deterrent work) that one would typically expect. However, as these processes have resulted in a better understanding of the issues, and, in turn, direct the focus of future technology R&D by DOE and private sector organizations/companies, it is an essential component of the WETO program.

Approach and Methodology

Comments on Strengths

- Good collaboration with PNNL for WREN activities.
- TDI choosing of UV light deterrent is good as new approach not overlapping with any DOE Bat FOA.
- Work to support networks: AWWI/NWCC and BCI/BWEC
- Competitive solicitation to further develop potential technology solutions is a sensible approach.
- Communication and collaboration between industry and interest groups is a key part of the wildlife impact mitigation strategy and the benefits of this collaboration are evident across the program.
- The NREL work encompass all the elements identified.
- The multi-faceted approach for this work is well executed.
- The TD&I program allows researchers to leverage resources that are unique to the state-of-the-art National Wind Testing Center. It is often challenging and expensive to test technologies out in the field on operating wind facilities. The TD&I program provides an invaluable opportunity to pioneer new technologies and solutions in a setting that would not be available to researchers without this program. It also provides an opportunity for smaller start-ups and innovators to advance technology—an opportunity that they would not otherwise have without this program.
- The land-based collaborative (LBC) is one of the most important projects that DOE funds in the wind-wildlife research space. The work supported under the LBC umbrella strategically advances

the technical solutions, expertise, and cost sharing necessary to solve the most pressing challenges. The work plan is developed in a stakeholder-driven, peer-review environment to ensure that the needs of the stakeholder community are addressed. The LBC also provides a forum to address new challenges when they arise in a measured, thoughtful, cost-effective manner and has the power to bring together a range of key stakeholders from federal agencies, states, NGOs, academia, industry, etc. And, it has done this quite effectively. Also, when new research is published, this is the entity that makes sense of the completed (often nuanced) results, and how these results can be strategically leveraged to drive down costs in the future. Furthermore, the webinars, vis a vis, the NWCC ensure that the entire community is aware of what research is ongoing, reducing duplication and increasing synergy and collaboration.
- WREN provides a rare opportunity for international collaboration on the technical level needed to share experiences and address on-the-ground challenges.

Comments on Weaknesses
- It could more clearly identified how all the pieces of work in the TD&I, LBC, and WREN portfolios are being integrated into one overall strategy. Timelines for answering the questions each are focusing on would also be good, rather than an open-ended approach.

Accomplishments and Progress

Comments on Strengths
- Unbiased mortality estimator.
- Coordination of WREN network and attracting more international partners.
- Generalized mortality estimator appears to be a significant development with a big impact.
- Impact of Barotrauma research is a good example of the value of the project, particularly in correcting misinformation.
- A large number of dissemination and collaboration events have been held.
- WREN and Thethys really appear to have high value and high impact across the industry and internationally.
- For TD&I, projects have been selected and installed onsite, and are on schedule at the NWTC.
- Through each of the focal areas, significant progress has been made in understanding the true risks posed to wildlife by wind energy development and operations; what issues are not as significant as once thought and therefore can be de-prioritized; and what types of technology-based solutions could help ameliorate those risks.
- The accomplishments of this work are impressive. The activities of these groups are incredibly strong.
- The TD&I program's open houses were a valuable way to expose stakeholders to the capabilities of the National Wind Training Center.
- The LBC's training workshops hosted with the states are incredibly valuable. So often these state regulators lack the on-the-ground experience associated with wind facility monitoring. This exposure provides states the resources to permit more effectively and efficiently.
- The new mortality estimator has been rolled out very thoughtfully and has great potential to standardize fatality estimates across facilities in a statistically defensible manner.
- BWEC's research strategy will set the stage for addressing one of the highest wildlife priorities for the industry: interactions with bats.
- The NWCC science meeting is an incredibly well-run meeting and brings together the most important researchers in this space. The proceedings supported from the LBC provide an important documentation of the material presented at this meeting. It also provides a forum where DOE-funded research can be presented and shared with stakeholders.

Comments on Weaknesses

- BWEC is undergoing a time of transition when its presence is more important than ever given increasing concerns for bat fatalities at wind facilities. Ensuring that this group is staffed appropriately and strategically focused is a key need.

Communication

Comments on Strengths

- Communication to stakeholders nationally through AWWI/NWCC and BCI/BWEC.
- Very good outreach with WREN webinars being available to watch later.
- Many of the results will be published and disseminated in 2019. Looking forward to hearing from barotrauma to dispel myths around it, as well as the results of the TD&I projects
- For the wildlife impacts mitigation work, communication and collaboration is at the very core of the activity and is very effectively carried out.
- For the TD&I projects, a webinar has been hosted and general information about the projects is available on the NREL website.
- Through both the TD&I and LBC efforts in particular, the groundwork has been laid for technology development and testing of emerging technologies that have promising potential for future commercialization. Providing both funding and a "safe" space for new technology to be tested has been essential to the advancement of a number of detection and deterrent systems that have the potential to be more cost-effective than lost production associated with wildlife-related operational adjustments (e.g., raising cut-in speeds, curtailment, etc.). Participation in conferences like the annual AWEA Siting Conference and WINDPOWER and hosting meetings like the NWCC Biennial Science meeting have helped inform the industry and public of advancements and emerging issues, brought together thought leaders on the subject, and provided stakeholders with an opportunity to engage and have productive dialogues about prioritization of issues and what to focus on in the future.
- The coordination and outreach of this group has been tremendous. The collaboration built across this project is also unparalleled.
- NREL has been incredibly focused at engaging a variety of technical stakeholders and did a fantastic job connecting technology providers and other stakeholders to the capabilities of the NWTC at its open house.
- The annual peer review of the LBC serves a dual purpose of not only peer reviewing its plans for the future, but also bringing in the leadership staff of BWEC, NWCC, and the peer review community. This fosters a dialogue among partners across a range of issues and challenges faced in the environmental siting world.

Comments on Weaknesses

- It appears that there is not a huge amount of dissemination relating to the TD&I projects, but perhaps that is a function of the stage at which these projects are currently at.
- Given the importance of communication, I see some room for improvement in both the international space (WREN) and the bats-and-wind space. While I know the topics of WREN reports and that they are published on Tethys, I have never seen any communication regarding the lessons learned or the outcomes. As the WREN program matures, increasing this level of outreach will be critical to ensuring that the lessons learned through WREN are adequately disseminated to the stakeholders.
- There is need to increase communication and engagement in the bats-and-wind space. The strategies developed through BWEC should be more widely communicated, as well as the numerous state and NGO working groups that have been developed to address the problem.

- Opportunities for better integration across stakeholder engagement platforms should also be considered (e.g., Tethys, WindExchange, and the NWCC).

Upcoming Project Activities

Comments on Strengths

- Very interesting results coming up in 2019 from the work in FYs 2017–18.
- Planned upcoming activities in line with project plans.
- The stated future work seems to continue the good efforts to date.
- Supporting the third year of the LBC is more important than ever to ensure that the community can continue to address wind wildlife challenges most effectively. Supporting additional TD&I projects is also important given the range of technology opportunities at various TRL levels. The WREN future work identified is very compelling since the topics are more sophisticated in substance and are focusing in areas where the United States and Europe work together to improve permitting programs, advance social acceptance, and move the needle. The issues identified are the ripest in this space, particularly offshore wind given the European experience, and the European investment we are seeing in U.S. waters. There is also strategic focus on migratory species with international ranges where a collaborative international effort is needed such as California condors.

Comments on Weaknesses

- No significant issues identified.

Recommendations (Not Scored)

- Consider bats for international coordination through WREN—particularly since they were listed in Appendix II of the Convention on Migratory Species.
- Focus WREN to be more outcome rather than output oriented. Explore how this group can effect change and advance goals on the ground rather than merely sharing information (though information sharing is still of critical import for WREN).
- Expand the LBC's work on prairie grouse and wind. In order to inform this work, a meaningful assessment should be completed to understand needs, gaps, and opportunities. There is also growing opposition in LPC country, so understanding impacts will be important.
- More BWEC support is needed through the current transition to ensure this group has the capacity and focus needed to address the most critical wildlife deployment issues on the horizon for the industry.
- Consider developing an entity similar to the NWCC for offshore wind with the hope that this effort will incubate the future "AWWI" for the offshore wind stakeholder community. Currently, formalized collaboration is desperately needed, but there isn't an obvious vehicle to kick start this work. A state-of-the-science workshop and assessment with stakeholder interviews should be completed prior to launching this effort to ensure this group is thoughtful and understands factors unique to offshore wind—both the stakeholders (e.g., new companies and affected communities such as fishers) and the technology itself.
- Continue outreach with the R&D community to share priorities and contemplate opportunities to prime future research projects that will contribute to the TD&I program's success.
- Future TD&I workshops at NWTC should be considered.

Wind Operational Issue Mitigation

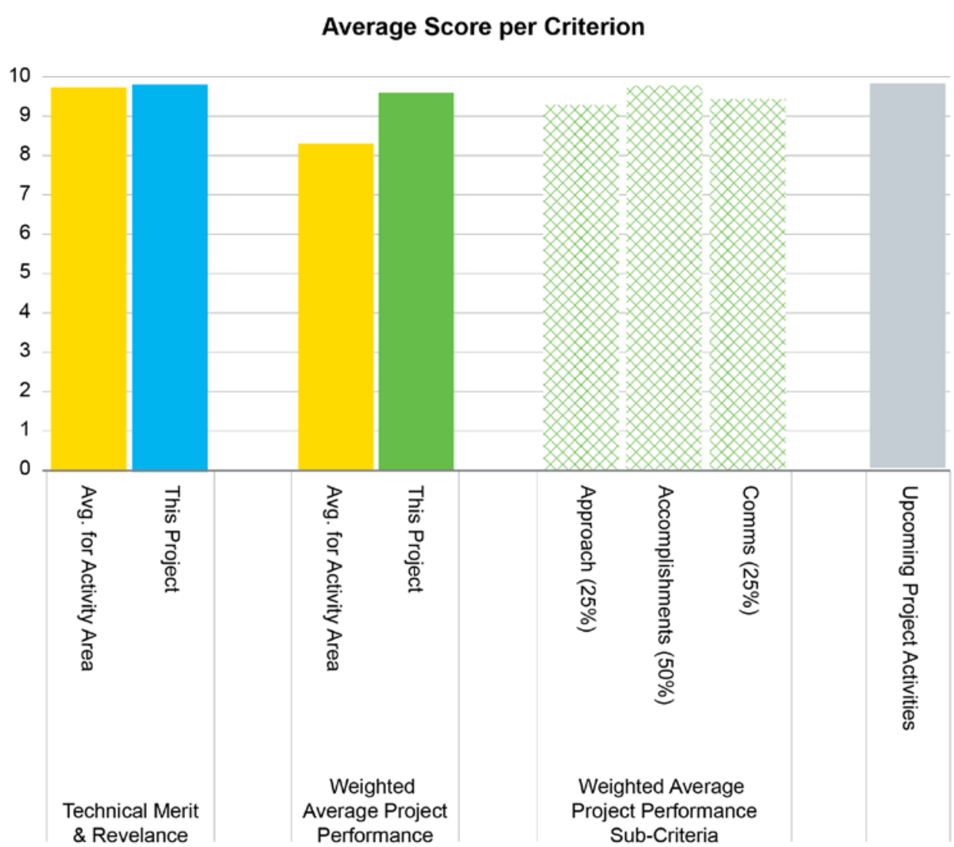
PI: Andrea Copping	Unique Project ID: M02
Organization: PNNL	WETO Program: Market Acceleration and Deployment
Project Status: Active	WETO Activity Area: Environmental Research
Total Available Budget (FY17 & FY18):	$1,884,022
Actual Costs (FY17 & FY18):	$992,108

Project Description

This project works with an international collaborative to share and develop new information on wind energy and wildlife issues (WREN) The project also collects, collates, analyzes, and disseminates scientific information to inform and accelerate siting and permitting processes (Tethys). This project develops and tests technologies to observe birds and bats around wind farms, to decrease uncertainty of wind energy effects on these animals (Avian Remote Sensing).

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- All three of the initiatives in this project provide unique and incredibly valuable forums for helping advance cost-effective, environmentally sound wind development. Increasing understanding of real vs. perceived impacts to wildlife from wind energy is critical, as is lowering the costs of resolving those conflicts, and this project brings great value to each of those efforts.
- Helps the industry and wind developers to develop turbines that can coexist with wildlife, and sites that minimize the risks to wildlife. Engages with research that has the potential to advance the state of the art of knowledge on environmental impacts and mitigation measures. Helps in permitting and tackling opposition to wind projects.
- Remote sensing: The current state of the art in identification of avian activity around turbines is to have people in boats and radar, which are both expensive and puts people at risk.
- WREN/Tethys: Both activities address a highly relevant area that is currently impacting wind power deployment and operation.
- Similar to the NREL work, generally the work of PNNL as the lead on the WREN and Tethys initiatives and the technology advancement of the Avian Remote Sensing technology has been outstanding. It is helping advance the knowledge of wind-wildlife interactions and finding practical, technology-based solutions to avoiding/minimizing risk to development and operation of wind farms throughout the United States.
- The merit of these projects is strong. The three tasks supported in this project play valuable roles in addressing wind wildlife siting barriers, increasing deployment, and reducing costs. The ability to monitor bird activity at night is a key need given how little we know, and this technology has significant power to support our understanding offshore. As of now, we have no capacity to monitor how birds move offshore and know little about what species there are and in what abundance offshore. This camera technology holds great promise in understanding this more.

Comments on Weaknesses

- More attention to offshore wind across all these platforms is needed.

Approach and Methodology

Comments on Strengths

- This project brings both in person (WREN) and online (Tethys) value to the many conversations currently underway by regulators, stakeholders, and other decision makers attempting to work through real or perceived wind-wildlife conflicts. Among the many unique values of the Tethys database is how comprehensive it is (published as well as gray literature) and its ability to house research that is not or is no longer available online so that it may be accessed.
- Good collaboration with NREL for international collaboration Task 34 WREN activities.
- Tethys web portal for WREN enables information with easy access for regulators and stakeholders about potential effects of wind energy development on wildlife and habitats. Peer review of web site annually is a good approach, to ensure that working well and contents up to date.
- More focused work on an important topic for offshore wind development: avian remote sensing offshore.
- Remote sensing: Use of off-the-shelf technology is a significant strength. Open-source approach to software development a major strength. Combination of off-the-shelf technology and open software really creates a lot of opportunities and flexibility in deployment and combination with other systems.

- WREN/Tethys: Communication, collaboration, and dissemination-based activities with high impact.
- The evolution of issue identification from concept to prototype to refinement of the avian remote sensing technology is a good model for future detection and deterrent technology R&D. I appreciate that they took the feedback from the last Peer Review and incorporated it into the study design. While the WREN and Tethys efforts are process initiatives vs. technology R&D, they are again, as noted in the NREL review, an essential element to issue identification that can lead to technology development and testing.
- The strategy and approach on all of these are strong.
- Tethys is such a well-known, well-populated resource. If I am ever looking for wind-wildlife resources, I go straight to Tethys. There has been a lot of work done to cultivate this database and broadcast this resource to stakeholders.
- WREN is a valuable international collaboration and will become increasingly important as the U.S. offshore industry grows.
- The thermal avian remote sensing work has the potential to move forward technology for offshore wind monitoring. The fact that this software integrates off-the-shelf cameras and will be open source will support future commercialization from private vendors.

Comments on Weaknesses

- More resources could significantly increase the impact of these programs, which is needed, especially in the early days of U.S. offshore wind advancement because the learning curve is steep and the potential wildlife conflicts are significant. Also, need to ensure sufficient context in the "curation" of wildlife studies so as not to inadvertently further misconceptions of potential wildlife impacts (positive or negative).
- Is there an opportunity for somehow synthesizing the literature (or highlighting such synthesis) in Tethys in order to give some perspective on current thinking? For example, in the case of Barotrauma, it could be difficult to distill quickly from the available literature that this is, in fact, not a real issue. This synthesis is tackled in other work, but the question here is if somehow it should be incorporated into Tethys. It's also important to maintain the objective nature of the material.
- The only critique on the avian-sensing technology field test is on the use of drones. It would seem prudent at this point to use trained raptors at the NWTC during the field test as they would be more representative of what the system will ultimately be looking at if deployed at an operating wind farm. Obviously, the turbines would need to be locked if the birds were flying within the rotor swept area, but in order to get a true representation of flight patterns, bird size, etc., actual birds should be employed, not just a mechanical drone (although for riskier engagement drones would be a fine supplement).

Accomplishments and Progress

Comments on Strengths

- All three initiatives in this project have really impressive accomplishments and progress to date.
- Good number of WREN updates to Tethys database, as well as short summaries that are useful first step for many of the stakeholders.
- Avian remote sensing offshore is proceeding well towards free, open source software, and is enabling several hardware options.
- 25% of grey literature that has been captured by Tethys has subsequently disappeared online. That points to the high value of the resource and its reach is constantly growing.
- This work sets out the United States as a thought leader in this space.

- Avian remote sensing prototype field tested with encouraging results and the need for two cameras identified.
- Project performance seems to match the approach and methodology.
- The project had many strong achievements, particularly with the advancement of the avian remote sensing technology and the number of users engaged with Tethys.

Comments on Weaknesses

- There could be a more robust outreach plan for Tethys among state and federal resource agencies and environmental stakeholders.

Communication

Comments on Strengths

- The Tethys site is fabulous.
- WREN and Tethys are excellent forms of dissemination of information. The webinars have been able to attract a considerable amount of people. Newsletter is attracting increasing audience.
- Avian remote sensing offshore is moving towards commercialization.
- Communications and collaboration-based activities of WREN and Tethys are very strong.
- Through the collection and dissemination of information associated with WREN and Tethys and the presentation of project results at the NWCC Biennial Science meeting, it appears the project team coordinated and communicated efficiently with stakeholders. Additionally, patenting of the technology and selection of the project for the Energy I-Corps program, it appears PNNL is also meeting the goals of commercialization.
- Overall, there has been great communication and collaboration on this project. One of the largest strengths to this end was the selection of the project to be part of Energy I-Corps. This is a great opportunity to engage industry early in the development.

Comments on Weaknesses

- Need to ensure sufficient resources to effectively communicate the results and findings of these efforts so as to not have unintended consequences (i.e., data about wildlife impacts needs to be carefully conveyed in a manner that reduces the likelihood that it could be taken out of context and used to perpetuate myths about adverse impacts).
- International collaboration has some challenges regarding the topics chosen. For example, it looks like green versus green is not an easy publication for the U.S. point of view. Fortunately, the collaboration brings about so many publications and so much expertise that these drawbacks seem small.
- Appears little communications activity has been carried out in relation to the Avian Remote Sensing project. A strength of this project, as mentioned already, is that it is flexible, using open software and off-the-shelf technology. There must be many opportunities for combining the solution with other technology-mitigation solutions, so broad communication of the work could have a significant impact.
- Better outward facing communication on WREN's work products would be valuable. While they are uploaded to Tethys, there doesn't seem to be much integration of the outputs with the stakeholder community.

Upcoming Project Activities

Comments on Strengths

- It is essential that this critical work continue and expand in the years ahead—with a specific focus on offshore wind given its early stage of development here in the United States and the great potential for providing cost-effective energy in the (relatively speaking) near term.

- WREN and Tethys continue the good work. The avian remote sensing tool work is continuing towards commercialization. It seems to have promising applications for collecting baseline data for understanding different birds (probably also bats) at site, and also migratory patterns important to know for siting. Also, applicable for wind power plants online, monitoring behavior of birds and bats, and perhaps collisions. Software is based in thermal imaging, but may be applicable to optical/underwater. Cost-effective technology solution, especially offshore.
- Field testing of Avian Remote Sensing at NWTC will be of high value.
- Continued WREN activity.
- Moving to new platform for Tethys.
- The future activities are well defined and appear to be an appropriate next step for the technology R&D. Similarly, the continued efforts of WREN and Tethys appear to be appropriate in the collection and dissemination of information in the wind-wildlife space.
- Upcoming project activities are strong. Supporting the maintenance of Tethys is important as it's a tremendous resource. It is great that PNLL will be able to partner with the NWTC to advance the development of the avian remote testing work through testing and validation.

Comments on Weaknesses

- The remote sensing work would be super helpful for avian species, as well as marine mammals, offshore.
- WREN challenge is to draw useful summaries to disseminate. The international partners have different strengths to draw from.
- Communication on environmental impacts in a way that helps solve the issues and doesn't create unnecessary new ones is sometimes challenging and important to get right.

Recommendations (Not Scored)

- Continuing and expanding work in this area is a huge value-add that DOE can bring on an ongoing basis to both help identify data gaps in the science, and provide a place where stakeholders and regulators alike can review and assess the full suite of research and data collection efforts (both past and ongoing) funded by a variety of entities.
- Make sure that the topics from WREN are as useful as possible, and the communication and dissemination is done in a way that will help solve the issues, not create new problems (unless new important issues are really seen). Regulators may react in ways that will create more barriers to wind deployment, and it is important to make sure this does not happen unnecessarily.
- Consider developing synthesis aspect of Tethys that provides users with some perspective and overview of the issues at a high level.
- My recommendation is for the funding for this effort to continue.
- Expand collaboration with technology providers in this area. One key opportunity is to invite experts to NREL during the testing phase. This can accomplish two goals: (1) to expand their exposure to this technology in the hope they will take it to commercialization in the future; and (2) to also provide an opportunity for collaboration in a highly proprietary space.
- For the avian remote sensing, be more thoughtful and strategic in the ultimate use of this technology. This will help advance its eventual use in the environment and also ensure that communications and troubleshooting are tailored to the intent and objective of the technology.
- For WREN, think about the appropriate work share between PNLL and NREL. It may not make sense for both labs to take ownership of this project. Instead one of the labs should be led and bring in other laboratory expertise as needed. Moreover, WREN should be better integrated with DOE's strategy and priorities. Now that the program is up and running, a more explicit link to broader efforts and priorities is warranted.

- For Tethys, explore ways for improved integration for the various websites (WindExchange, NWCC, etc.). Currently, they seem to operate in silos.

A Biomimetic Ultrasonic Whistle for Use as a Bat Deterrent on Wind Turbines

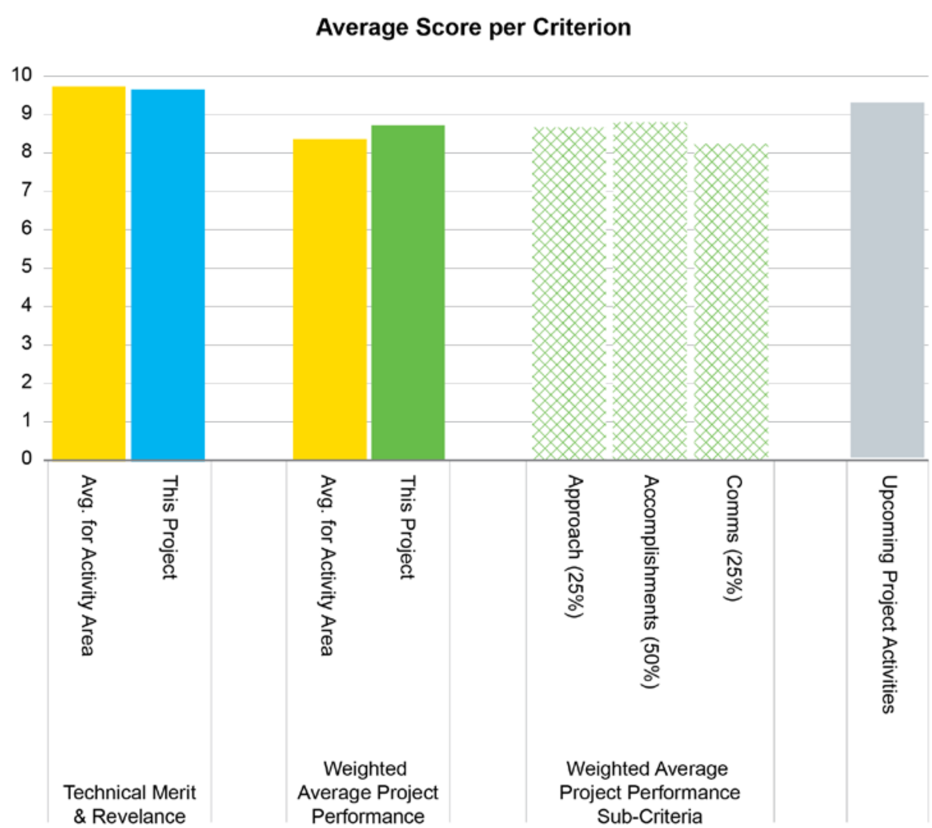
PI: Paul Sievert	Unique Project ID: M16
Organization: University of Massachusetts - Amherst	WETO Program: Market Acceleration and Deployment
Project Status: Active	WETO Activity Area: Environmental Research
Award Amount	$249,684
Cost Share	$62,500
Total Project Budget	$312,184
Actual Costs	$282,363

Project Description

UMass is working to design a series of ultrasonic pulse generators, or whistles, to be affixed to a wind turbine blade, which produce ultrasound through mechanical means, and thus deter bats from approaching.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Bat deterrent is important for many sites. Developing systems that could effectively deter bats flying close to wind turbines is relevant. New idea tested in this project: passive/wind-induced ultrasound reaching the whole range of rotor.
- Addresses the highly relevant issue of bat mortality at turbine sites and specifically aims to produce a robust, low-cost solution that addresses the gap of incomplete coverage of the turbine swept rotor area. Noting especially the field deployment problems experienced by electrical-based solutions, this project is particularly interesting and worth investing in.
- Given the importance to the industry of finding solutions to reducing bat fatalities at wind farms, the development and testing of this whistle fits within the industry's priorities and is therefore a good use of DOE funding in the MA&D space. The study design appears sound and the iterative approach allows for adjustments during the study period.
- The merit and relevance of this project represents one of the top priorities for the wind industry with respect to wildlife interactions and reducing costs. Bats pose significant challenges for industry for two primary reasons. One guild of bats hibernates in caves and is being decimated by white nose syndrome. Because of this, they are facing increasing regulatory protection and scrutiny. These bats do not seem to be at high risk for collision at turbines due to their scarcity and behavior. However, they do occasionally collide, meaning that wind developers need to seek ESA permits for regulatory coverage. These permits can be incredibly challenging to get, even if wind energy facilities are having a much smaller impact on these bats in comparison to white nose syndrome.
- On the flip side, there is a guild of bats that migrates. They are spared white nose syndrome, but they are at much higher risk of wind turbine fatality due to an unknown behavioral attraction. Wind is believed to have a population-level impact on at least one migratory bat species, and there are concerns that wind energy facilities are also having population-level impacts on other species with similar behaviors and migratory patterns.
- Developing effective bat deterrents now is critical to future wind energy deployment in reducing permitting costs and precluding future ESA listings of migratory bats. Because these bats are migratory, they have incredibly wide ranges and a listing could affect nearly all wind energy facilities across the country.
- This project is additional to the innovation ongoing in this space as it tests a passive whistle—an important opportunity given the challenges in integrating with the electrical system at a wind turbine, as well as the potential use of this device on wind blades to amplify sound emitted from complementary technologies from the nacelle.
- Highly relevant, given industry's continued need for effective and affordable bat impact mitigation (including deterrence) options. Addresses the greatest single shortcoming of prior acoustic deterrents: the inability to affect the full rotor-swept area. Also, passive in operation, which allows it to avoid some of the operational issues other deterrents have experienced.
- Utilizes a different type of sound emission—pulsing—which has been less tested in other deterrent devices.

Comments on Weaknesses

- Lacks a discussion of the behavioral basis for the use of biomimetry. One has to presume that by creating ultrasound, the devices will confound foraging bats and thus deter them (as is the premise with other acoustic deterrents).

- Suggestion by DOE to use thermal imaging to document behavioral response by bats to the devices (Task 7) does pose a question as to the validity of the results of Task 1, in which thermal imaging was presumably not used.

Approach and Methodology

Comments on Strengths

- The plans to test the device are good, taking steps towards a full prototype at field.
- The approach has the strength that it is passive, since mounting on blade is challenging with power supply.
- Biometric modeling approach to appears to have worked well.
- Incorporated findings from other researchers and included thermal imaging in field tests.
- Prototype can be tuned to different frequencies enabling the flexibility to target different species.
- Well-structured plan that allowed findings influence and change design at each stage.
- The study's stepwise methodology appears well thought out and allows for adjustments to be made in order to fully evaluate the proposed design.
- The methodology is strong. It started with the basics—understanding avoidance behavior in bats to ultrasound regimes and studied nature to identify biological models for creating sound at the right frequency to elicit the avoidance behavior identified in the original study. Also, it was important that they developed whistles operating at a range of kHz so the technology will be adaptive as we learn more about avoidance/deterrent behavior and target certain sound ranges to certain species of concern based on a variety of factors. The methodology also expanded beyond the laboratory and integrated real work factors such as background noise, as well as the operating variables of a wind turbine.
- It is particularly impressive that the researchers identified an explicit step to consult and coordinate with other researchers in this space. This explicit step has been missing from many of the other methodologies incorporated in this peer review.
- Good grasp of wind turbine-related issues (location on blade, range of edgewise wind speeds, boundary effects on both blade sides). University of Massachusetts has good resources in that regard.
- Deliberate, step-by-step approach throughout.

Comments on Weaknesses

- Technology approach has potential weaknesses like mounting many devices on the blade or the initial idea of combining with vortex generators not working out as expected. The operation with dirt accumulating may also be challenging. These points would have been nice to include in the approach/studied items of the project.
- Other projects of this nature have failed at the field-test stage when faced with deploying the device on actual turbines. Have enough time, resources, and partners been dedicated to this aspect of the project and have lessons from other projects been considered? Particularly, separate functional tests and field tests help mitigate deployment issues in the field.
- No mention of experts in the field, particularly of bat biology and behavior, consulted. Dr. Sievert does not appear to have a strong background with bats.

Accomplishments and Progress

Comments on Strengths

- The project has proceeded with all the tests planned.
- Developed the physical device, which produces the desired frequencies at the requisite power levels.
- Hypothesis appears to be have validated well in the lab with increased turns away.

- Device has been tested on a small turbine.
- Comprehensive reporting at all stages.
- The project team appears to be meeting all the goals they set out in the study design within budget and on time. Their adjustments in the field trials in order to fully evaluate the potential of the device should assist with the evaluation of the effectiveness of the whistle.
- Strong accomplishments to date that align with the proposed methodology.
- Stepwise process successfully executed thus far.
- Modest extensions of time with no budget increase.

Comments on Weaknesses

- Unfortunately, the CFD test by NREL concluded that the devices should not be mounted where vortex generators are, which leaves out one potential benefit. Some challenges of the operation on a real blade that may be potential dealbreakers (e.g., challenge to keep them alive in turbine blades, not getting dirty with insects) still have not been studied.
- Lessons from field tests of similar projects should be taken on-board and a risk assessment could be carried out for the field tests to mitigate risk of failure at this point.
- Modest extensions of time required.

Communication

Comments on Strengths

- Several publications and presentations to diverse audiences, including some stakeholders.
- Findings from other researchers have influenced the project. Thermal imaging cameras have been included in the field test design.
- It appears the project team has been actively communicating through participation in various working groups and community media.
- The communications with external stakeholders seem generally good.
- This project team really excelled in this space. First, they were able to collaborate extensively with researchers and energy experts across universities and subject matter expertise. Second, they noted the importance of collaborating with external experts in their actual methodology. This is particularly important in this space since the collective expertise and knowledge on bat avoidance and deterrent technologies is growing rapidly. Finally, the project has a solid communication strategy: addressing various subject matter groups such as the acoustical society, as well as collaborative groups interested in this particular issue, such as the New England bat working group. There was also even international engagement. Finally, it was great to see this project get press coverage.
- Reasonably extensive communication with a range of relevant groups.

Comments on Weaknesses

- Communication with wind industry/developer stakeholder groups would have been nice to see.
- There is no mention of any conference or journal articles, but perhaps these will follow in due course.
- Prior to discussing the potential for the device with external stakeholders outside of the industry, the study team should have spent more time socializing their concept and study design with industry representatives and others who work in the wind-wildlife space.
- Communication has been principally on a regional level. Little evidenced with national organizations or at national scientific meetings involving industry or leading bat scientists.

Upcoming Project Activities

Comments on Strengths

- Project close to end, and one more bat-related assessment is still ongoing this year.
- Upcoming work appears well aligned with project plan.
- The proposed future activities should answer the question one way or another as to whether the technology has merit and should continue to be evaluated or not; they are a logical next step in the project evaluation.
- Strong set of upcoming activities. Great addition to incorporate the use of thermal imaging photography in their study design to better understand how bats in the wild are reacting to this technology.
- Task 7 appears to be an appropriate final step in the theoretical demonstration of the relative effectiveness of the devices.

Comments on Weaknesses

- Would have been nice to see some of the challenges of concepts addressed, at least on a high level.
- No evidence of plans to test devices on commercially operating wind turbines, or of a follow-on proposal to do so.

Recommendations (Not Scored)

- Not sure what are the plans to forward this technology. The approach has potential weaknesses like how to keep them alive in turbine blades, and not getting them dirty with insects. These points still need to be addressed, perhaps before a full-turbine field test.
- Could consider risk assessment and mitigation strategies for avoiding field deployment issues.
- It is recommended that this project continue to be funded in order to evaluate the effectiveness of this device with other deterrent systems. It would be good for the project team to evaluate and estimate what the cost of initial deployment, along with the repair and replacement rates/costs would be to outfit a typical wind farm so that DOE and the industry can fully understand what the cost benefits are. Additionally, the project team should work with a number of turbine manufacturers to understand what challenges might exist in attaching the whistles to turbine blades, if such work has any warranty implications for the owner/operator, and how those issues might be addressed. Further, it should be evaluated how the use of the whistles might affect the operation of the turbines. If multiple small devices per turbine could increase friction and decrease generation, even if slight this should be answered one way or another.
- Further collaboration with industry might be warranted to ensure that the blade-mounted whistle will not affect energy production or warranties. Also, further collaboration with NRG and GE should be considered. It would be incredible to see how the integration of these blade-mounted whistles can supplement and augment the nacelle devices.
- Should be encouraged, assuming Task 7 demonstrates the effectiveness of the device's sounds, to field test devices on operating turbines.

Texturizing Wind Turbine Towers to Reduce Bat Mortality

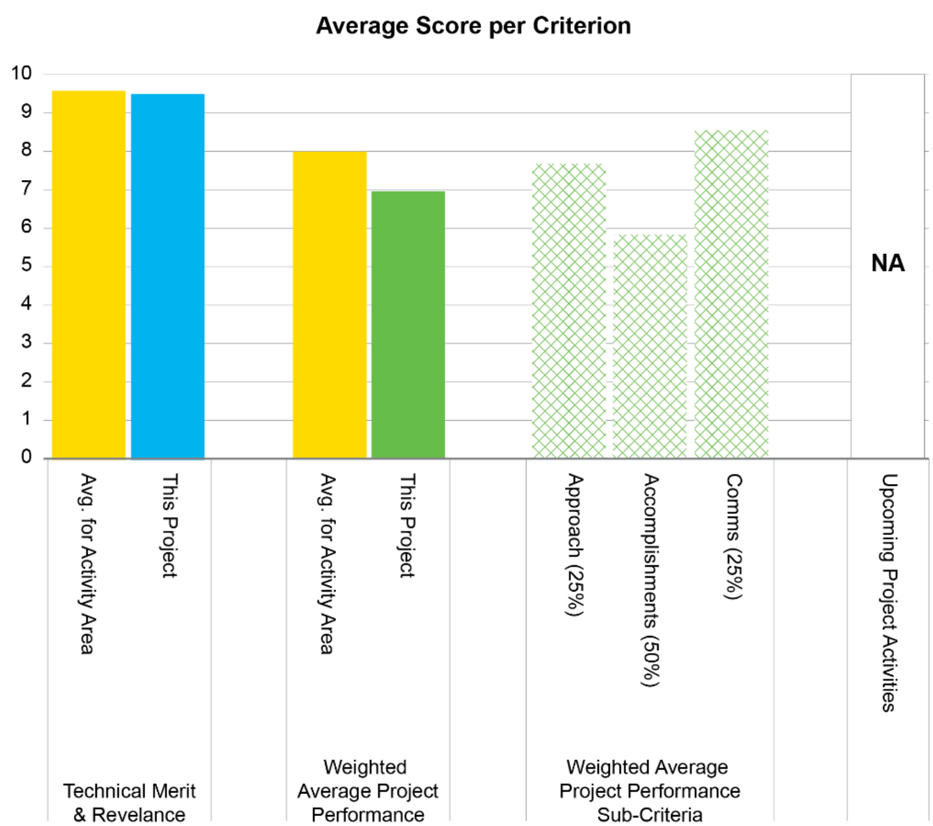
PI: Amanda Hale & Tori Bennett	Unique Project ID: M17
Organization: Texas Christian University	WETO Program: Market Acceleration and Deployment
Project Status: Completed	WETO Activity Area: Environmental Research
Award Amount	$249,076
Cost Share	$237,882
Total Project Budget	$486,958
Actual Costs	$486,958

Project Description

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.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Advancing effective and affordable solutions to reduce impacts to bats is urgently needed. This project was so promising in offering a potentially cheap option that would not require any power to run.
- Research on environmental impact mitigation of wind power. Testing and developing a very promising bat deterrent.
- Addresses the highly relevant issue of bat mortality at turbine sites and specifically aims to develop turbine tower texture coating based on the hypothesis that bats are attracted to the smooth surface of turbine towers because they misperceive them to be water sources. Potentially, a robust passive solution that can be deployed at low cost during turbine construction and well worth investigating.
- Finding alternate solutions to both operational adjustments and deterrent systems has long been a priority of the industry and the conceptual approach at making the turbines less attractive through texturizing definitely falls within this category.
- The merit and relevance of this project represents one of the top priorities for the wind industry with respect to wildlife interactions and reducing costs. Bats pose significant challenges for industry for two primary reasons. One guild of bats hibernates in caves and is being decimated by white nose syndrome. Because of this they are facing increasing regulatory protection and scrutiny. These bats do not seem to be at high risk for collision at turbines due to their scarcity and behavior. However, they do occasionally collide, meaning that wind developers need to seek ESA permits for regulatory coverage. These permits can be incredibly challenging to get even if wind energy facilities are having a much smaller impact on these bats in comparison to white nose syndrome.
- On the flip side, there is a guild of bats that migrates. They are spared white nose syndrome, but they are at much higher risk to wind turbine fatality due to an unknown behavioral attraction. Wind is believed to have a population-level impact on at least one migratory bat species, and there are concerns that wind energy facilities are also having population-level impacts to other species with similar risk.
- This project has strong merit in that it potentially reduces one of the potential attractants of bats to wind turbines: their perception of the smooth turbine pole as water. We need to explore a variety of tools to keep bats away from turbines and reduce the time they are spending near turbines. This technology provides one opportunity.
- The project also considered the turbine marketplace and focused on opportunities that would be cost effective and could be integrated with existing turbines.
- Provides a needed additional approach, based on a reasonable hypothesis with respect to bat behavior, toward an effective risk minimization strategy.

Comments on Weaknesses

- Unclear if toxicity of material used was considered, which could potentially be a downside of this approach.
- Hypothesis of smooth surface attraction of or use in foraging by bats is reasonable, but not conclusive. Still, worth pursuing.

Approach and Methodology

Comments on Strengths

- The technology and research hypothesis it is based on are very promising: a coating, being passive, and not emitting any sounds.

- A sound plan to test bat behavior in smooth and textured towers.
- A robust scientific approach was used, which involved validation of the fundamental hypothesis. Experiments to validate hypothesis using wild-caught bats in a test facility was robust and provided much insight.
- The project design from concept through execution was well laid out with seemingly achievable goals and time frames. The methodology seems sound and the iterative approach from laboratory to field testing, and making corrective adjustments along the way, was logical and appropriate.
- The methodology had several strengths, including the stepwise approach and laboratory testing prior to application in the field. The preparatory work provides a strong framework for testing in the future.
- Initial laboratory tests are the appropriate first step in the development of bat deterrent devices, so appropriate here as well.

Comments on Weaknesses

- Bulk of testing was done in a lab, then only one option tested in real conditions and only at five turbines. Not a very significant sample size, especially given questions about how/if bats in captivity mimic wild behavior.
- Easy to say afterwards, but the time and effort allocated to Task 5, applying the texture to blades in a wind power plant, had too few resources to be finished in case problems occurred.
- Difficult to determine if the problems around deployment of the texture coating in the field could have been foreseen and if something could/should have been done differently. Given that 3M were involved in the texture development and application, it is my conclusion that there is little more that could have been done to reduce the risks in this area. Perhaps the tasks of developing the coating and applying it in the field were greatly underestimated and greater resources should have been set aside for this. This should be a major lesson from the project.
- The sample size of the number of towers to be treated and evaluated seems low—particularly when you consider the application failure. This was made challenging by limiting the budget and, therefore, the amount of time to get the coating applied, which further reduced the number of turbines to be included in the study. As so much of the outcome was dependent upon proper execution of the treatments, more time and budget should have been dedicated to getting this right.
- Sadly the weaknesses in this methodology were concentrated almost exclusively in field testing, resulting in a serious cliff hanger in results. While unexpected challenges are frequent in any real-world testing—particularly a commercial wind facility in Texas in summer—what was lacking was any flexibility or cushion for the unexpected. There was also no contingency plan and the sample size was too small in scope regarding the number of turbines.
- Proponent's acknowledgement that additional observations are needed to identify the most appropriate turbine towers for field tests indicates that the turbines selected for this effort, even if the treatment had been successfully applied, might not have offered sufficiently powerful results.
- Insufficient planning for field test.

Accomplishments and Progress

Comments on Strengths

- Promising initial results given very little attraction to the rough surface. Lots of good lessons learned re: how to do this more efficiently in the future.
- Good first results achieved. There is reduced activity of bats within 1m of the tower.
- Hypothesis was validated. Understanding of bat behavior around turbines has greatly increased. Merit of texture coating has been shown to an extent just short of effectiveness in the field.
- While the concept was intriguing and study design thorough, the execution was a bit lack luster, both in terms of the number of towers that would be evaluated, and amount of time and money set

aside for the treatment application. However, what was accomplished in terms of the behavioral studies in the laboratory and advancement of the concept was valuable.
- The project was successful in advancing this potential technology and testing it.
- Laboratory results demonstrated the potential effectiveness of tested approach.

Comments on Weaknesses
- Didn't have enough budget to generate any usable data or findings.
- Field tests did not succeed. Probably too ambitious plan from low-to-high TRL in one moderately funded project. Application of coating on large surfaces in the heat/lighting storms of Texas would be challenging even if experts were involved. Testing a totally new coating would require more time and effort to get a prototype that works in the field.
- Project has failed to demonstrate the effectiveness of the coating in the field, but there are many mitigating factors, including weather and failures of the contractor.
- Because so much of the proving of the theory depended on proper execution of the treatment application so that the reaction of the bats could be evaluated in the field, the failures in the field make it challenging to rank this project higher overall.
- This project obviously failed in its ability to meet expectations, but more importantly in its inability to adapt to technical or programmatic challenges. What has become evident in our testing of deterrents is there will always be challenges in the field. The ability to build in some flexibility to respond to those challenges is of critical importance.
- Field demonstration of effectiveness of the tested treatment were not accomplished.

Communication

Comments on Strengths
- Lots of presentations in relevant forums.
- Good research publications and research event presentations, and results from the flight facility experiments and the field test coming in 2019. Wind developer communication directly in the project for Nextera.
- Numerous Master's theses and conference presentations resulting from the project.
- The communications plan was fairly well executed with the project design and testing discussed at a number of key wind-wildlife forums during the study period. The future publication in a peer-reviewed journal will help amplify this effort.
- The PI for this project is one of the best communicators in the field. She has done an incredible job articulating and communicating the underlying theory for this technology and progress every step of the way. She has also been very transparent and candid with the challenges, which is a unique strength of a researcher.
- Multiple presentations at major scientific fora.

Comments on Weaknesses
- Even if the research is not on a commercialization pathway, some communication with the industry stakeholders would have been nice to see—especially as touching the towers may have implications to the turbine design.
- No journal articles, which would validate the technical merit of the project.
- Commercial applicability not demonstrated.

Recommendations (Not Scored)
- Good to see that research partners are sought to continue, and that Nextera collaboration has possibilities to continue. It would be good to get the five towers tested long enough to make sure that the findings are okay before closing.

- This technology may prove to be very valuable to the industry, even if may need to be combined with other deterrents.
- Glean lessons from the field application phase that can be applied to other projects to risk failures in this area. Specifically, conduct additional functional testing before field deployment is attempted.
- Consider funding a project with adequate support from manufacturers/operators to conduct field trials of a number of projects that demonstrated technical merit but failed at this stage.
- The concept remains intriguing and likely warrants further evaluation to test the hypothesis. If additional funding becomes available to continue this study, it would likely be worth pursuing.
- Consider opportunities to improve contingency plans for these projects, including flexibility in DOE budgets when available. Develop a workshop where these researchers can share experiences (and woes) and identify best management practices for the future. More meaningful peer review may be helpful up front, including realistic cost estimates and adequate methodology.
- Recommend offering as a more robust, broad-based effort. Concept deserves further exploration.

Rotor-Mounted Bat Impact Mitigation System

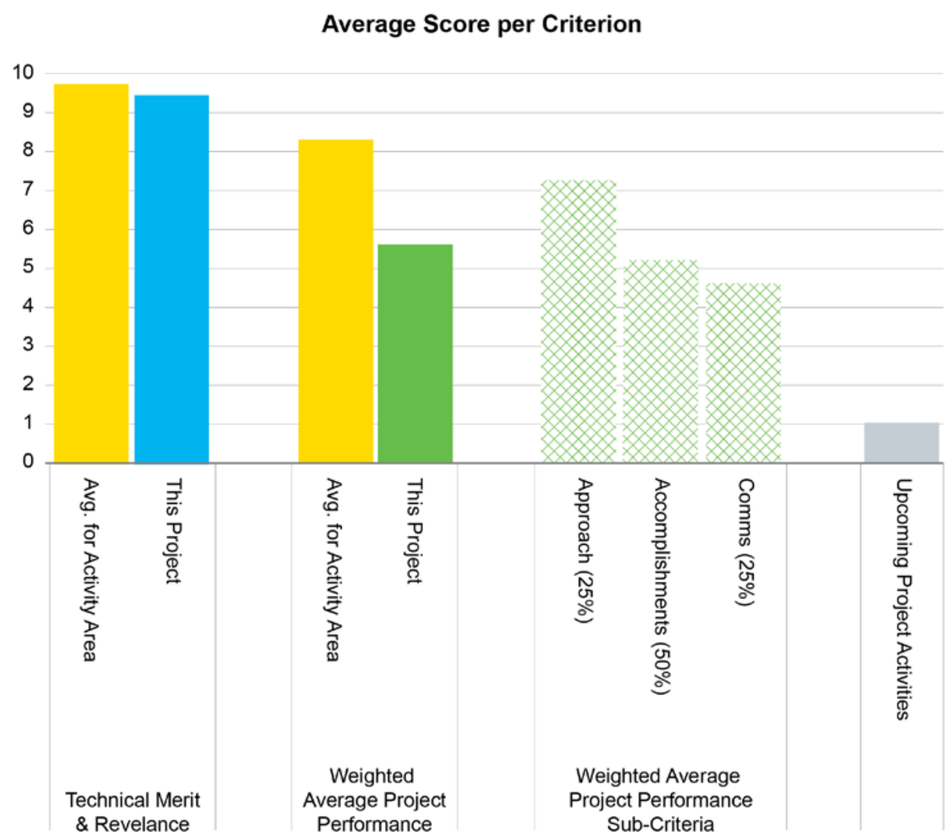
PI: Robert Kelly	Unique Project ID: M18
Organization: Frontier Wind	WETO Program: Market Acceleration and Deployment
Project Status: Active	WETO Activity Area: Environmental Research
Award Amount	$249,045
Cost Share	$78,655
Total Project Budget	$327,700
Actual Costs	$327,700

Project Description

To develop and test a piezo-electric, blade-mounted ultrasonic acoustic bat deterrent suitable to provide ultrasonic coverage across the entire rotor-swept zone of a wind turbine, regardless of blade length.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Advancing effective solutions to reduce risks of wind energy to bats is urgently needed.
- Addresses the highly relevant issue of bat mortality at turbine sites. Specifically aims to develop an electronic-based, turbine-mounted solution with full rotor swept area coverage.
- Functional deterrent systems that are both cost-effective and achieve significant levels of wildlife impact reductions have long been desired by the industry and continue to remain a top priority. The Frontier Wind system seemed to represent a potentially promising technology. It is unfortunate that technical, funding, and situational issues made completion impossible.
- The merit and relevance of this project represents one of the top priorities for the wind industry with respect to wildlife interactions and reducing costs. Bats pose significant challenges for industry for two primary reasons. One guild of bats hibernates in caves and is being decimated by white nose syndrome. Because of this, they are facing increasing regulatory protection and scrutiny. These bats do not seem to be at high risk for collision at turbines due to their scarcity and behavior. However, they do occasionally collide, meaning that wind developers need to seek ESA permits for regulatory coverage. These permits can be incredibly challenging to get even if wind energy facilities are having a much smaller impact on these bats in comparison to white nose syndrome.
- On the flip side, there is a guild of bats that migrates. They are spared white nose syndrome, but they are at much higher risk of wind turbine fatality due to an unknown behavioral attraction. Wind is believed to have a population-level impact on at least one migratory bat species, and there are concerns that wind energy facilities are also having population-level impacts on other species with similar behavior and migratory patterns. Given that these species are migratory, their ranges are expansive and listings could affect nearly the entire industry. Moreover, the migratory bat of greatest concern at the moment is the hoary bat. This species is a strong flier so curtailment strategies (without any deterrents) will be costly, and, as wind expands, deployment creates potential energy shortages during the fall migration season.
- The niche of this particular technology is its ability to be mounted on blades while allowing for related components to be housed in the nacelle. This is important given the challenges in nacelle mounted devices to cover the entire rotor sweep—and this will certainly get more challenging as turbines get bigger. This one also is an active system, which may provide for greater efficacy than a passive whistle alone system.
- Addresses important industry need for more effective acoustic deterrent devices.
- Device type has proven significantly—if not completely—effective in other systems.

Comments on Weaknesses

- Solution with electronics exposed to weather and invasive installation on turbine blades.
- The project design and initial concept and goals seemed sound, but they failed on implementation.
- As with other electrically activated deterrent devices, robustness has been a significant issue through the development process. Perhaps that should have been more readily anticipated in the design of these units, as might the power supply requirements they require.

Approach and Methodology

Comments on Strengths

- Focusing the deterrent devices right at the blades seems smart.

- Robust approach to design of solution with required acoustic characteristics. Approach included significant field testing, which ultimately highlighted a number of shortcomings—signifying effectiveness of testing procedure.
- The research concept, design, and project team response to challenges in the first phase all seemed well thought out and achievable for the purposes of answering the questions on the technology's effectiveness.
- There were several strengths in the methodology and approach. Perhaps the most valuable was the iterative approach and the ability to react to unforeseen circumstances for the first part of the project.
- Field testing plan appears sound. Capable team assembled.

Comments on Weaknesses

- Didn’t take sufficient actions to ensure power supply or prevent water damage to sensor units.
- It appears that device failure was only detected at the data collection phase. An additional functional testing phase and/or more proactive device monitoring could have identified issues earlier. For example, in M20 separate functional tests and comparative tests allowed device issues to be identified and corrected prior to the comparative test.
- Water ingress could possibly have been foreseen as a potential problem during functional testing.
- One potential weakness was the project's challenges integrating with the power supply of the turbine. Additional collaboration and partnering with turbine OEMs might have helped resolve that problem.
- Insufficient planning for delivering power to the devices in the field deployment.

Accomplishments and Progress

Comments on Strengths

- Developed the physical device, which produces the desired frequencies at the requisite power levels. Devices were installed and tested on a significant number (12) of operating turbines. Significant issues detected and corrected during testing. A power supply capable of handling the power characteristics in the turbine nacelle was developed with potential further application elsewhere. Acoustic performance of field-deployed devices was validated.
- The initial execution and response to power issues in the first phase was all handled well. The failure came in the execution of the second phase as a result of inadequate funding and the force majeure of wildfire in the project area, so it is not possible at this time to evaluate their full ability to achieve the project goals in a timely manner.
- The project made significant advancement, particularly in light of the unforeseen circumstances.
- Units performed at or above expectations.

Comments on Weaknesses

- Power supply failed and they didn’t have enough data to look at. Water issues further impacted ability to get any meaningful results.
- Ultimately, the efficacy of the solution was not demonstrated in the field. Additional functional testing on a turbine and/or proactive monitoring of deployed devices could have identified issues earlier.
- The obvious weakness here is the developer's inability to finish the project.
- Aside from uncontrollable circumstances (Carr fire), design shortcomings prevented demonstration of the unit's effectiveness, given schedule and budget.

Communication

Comments on Strengths

- Webinar and poster presentation.

- The communications on the project design and achievements in the first phase seemed adequate. Due to the project cancellation, it is not possible to fully evaluate the additional communications associated with the second phase.
- The project presented at the NWCC twice, an important platform for communicating information.
- Modest communications effort.

Comments on Weaknesses

- Project appears light on the communications side with no conference or journal articles. Some report documenting field deployment experiences could be useful to other projects of this nature.
- The only communications referenced were presentations. It's unfortunate that no reports or other documentation was shared. Also, the project may have benefited from more broad coordination with other researchers and turbine OEMs.
- Unclear if any research organizations were consulted. Premature for commercialization strategies.

Upcoming Project Activities

Comments on Strengths

- Given the project cancellation by the awardee, it is not possible to evaluate future activities.

Comments on Weaknesses

- The project was unable to finish and it's unclear whether the environment is such that it would be easy to transfer the progress to date to another entity.

Recommendations (Not Scored)

- For future projects, highlight challenges associated with field deployment and testing, particularly ensuring that enough resources are dedicated to this aspect of the project with sufficient contingency allowed for. In particular, separate functional testing of turbine mounted devices should be carried out in order to identify and correct issues before full deployment.
- Consider funding a project with adequate support from manufacturers/operators to conduct field trials of a number of projects that demonstrated technical merit but failed at this stage.
- Given the investment in the technology by DOE and need for additional technologies to evaluate—coupled with initial product and study design—if there is an opportunity for another company to acquire the IP from Frontier Wind and pick up where they left off, it is recommended that additional funding be provided.
- DOE should work hard to disseminate this work and look for additional collaborators and partners.
- This project highlights the value of the TD&I program and the importance of DOE continuing to support that program.
- Probably worth another try in the field.

Ultrasonic Bat Deterrent Technology

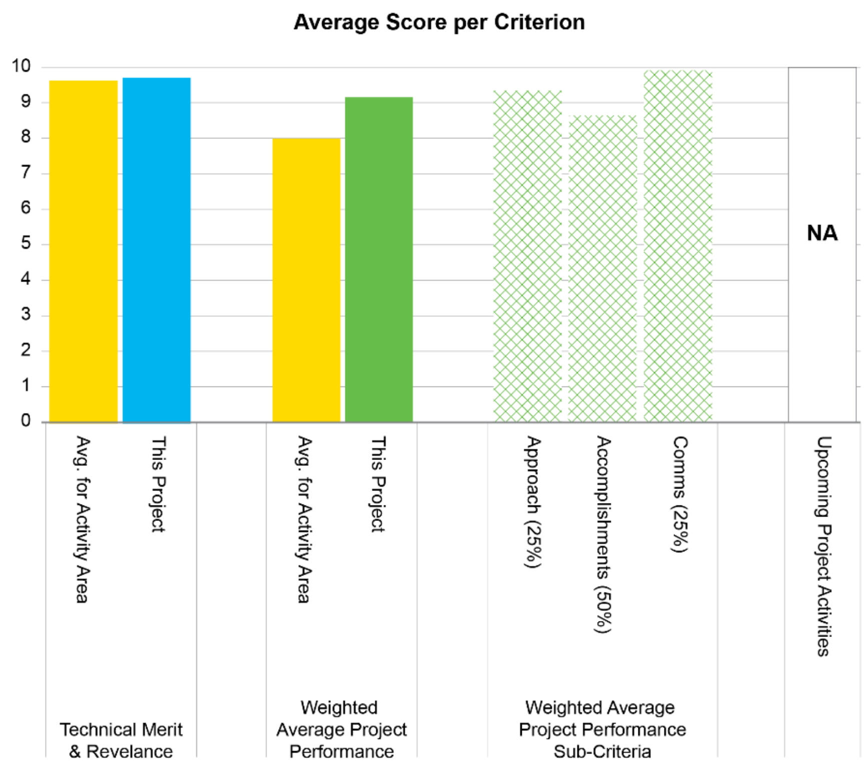
PI: Kevin Kinzie	Unique Project ID: M19
Organization: General Electric Company – GE Power & Water	WETO Program: Market Acceleration and Deployment
Project Status: Completed	WETO Activity Area: Environmental Research
Award Amount	$625,000
Cost Share	$839,087
Total Project Budget	$1,464,087
Actual Costs	$1,464,087

Project Description

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 with a 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. Conducted behavioral studies in controlled (i.e., flight room) and in small-scale (e.g., foraging areas) environments to enhance the information gathered during field testing, which will be important to eventual commercial viability of the deterrent device

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Advancing effective solutions to reduce risks of wind energy to bats is urgently needed. Good to have a specific goal (50% reduction in bat mortality).
- Important work to find mitigation to bat mortality at wind power plants. Ultrasound emitting deterrent method tested by turbine manufacturer GE. DOE funding enabled to test on multiple turbines and improve the device.
- Addresses the highly relevant issue of bat mortality at turbine sites. Specifically aimed to develop acoustic noise deterrent using compressed air source. Potentially, a robust solution requiring minimum wiring and non-invasive with regard to the turbine blades. No electronics exposed to weather.
- Functional deterrent systems that are both cost-effective and achieve significant levels of wildlife impact reductions have long been desired by the industry and continue to remain a top priority. The GE system has apparently made significant advancements since the initial prototype and looks to be able to make additional improvements in what will be hopefully the final stage before being commercially available.
- The merit and relevance of this project represents one of the top priorities for the wind industry with respect to wildlife interactions and reducing costs. Bats pose significant challenges for industry for two primary reasons. One guild of bats hibernates in caves and is being decimated by white nose syndrome. Because of this, they are facing increasing regulatory protection and scrutiny. These bats do not seem to be at high risk for collision at turbines due to their scarcity and behavior. However, they do occasionally collide, meaning that wind developers need to seek ESA permits for regulatory coverage. These permits can be incredibly challenging to get even if wind energy facilities are having a much smaller impact on these bats in comparison to white nose syndrome.
- On the flip side, there is a guild of bats that migrates. They are spared white nose syndrome, but they are at much higher risk of wind turbine fatality due to an unknown behavioral attraction. Wind is believed to have a population-level impact on at least one migratory bat species, and there are concerns that wind energy facilities are also having population-level impacts to other species with similar risk. Given that these species are migratory, their ranges are expansive and listings could affect nearly the entire industry. Moreover, the migratory bat of greatest concern at the moment is the hoary bat. This species is a strong flier so curtailment strategies (without any deterrents) will be costly and, as wind expands, deployment creates potential energy shortages during the fall migration season.
- The niche of this project is its advancement and higher TRL toward a commercialized bat deterrent.
- Meets an important need of the industry for effective acoustic bat deterrent. System appears to be robust.

Comments on Weaknesses

- Might a system that doesn’t require power be less risky?
- The study design and technology itself does not seem to suffer from any particular weaknesses. The only question I have for this system or any others being considered is: What level of "avoided" impacts would be deemed worthwhile by the industry, regulators, and environmental community, such that companies would want to purchase and install the system? This is complicated by the fact that minimization of impacts to non-regulated species for the purposes of demonstrating "responsible" development is very different than the nearly full avoidance of impacts to regulated

species that would allow a facility to operate at full capacity (i.e., without environmental operational adjustments or curtailment) without having to obtain an expensive and time consuming permit. Therefore, it needs to be clear what is technically achievable and communicated with all stakeholders—whether the device is intended to be a minimization tool or one for avoidance purposes—as that will likely dictate how much a company would be willing to pay and the utilization rate by the industry as a whole.

- One of the key aspects of this project and others like it will be to attempt to bookend the costs for installation, O&M, likely repair rates and costs, and replacement rates and costs over a 20–30 year period, as understanding these costs will be a critical component to project financing and/or decision-making by a project proponent on whether or not to employ the technology vs. the lost revenue associated with operational adjustments.
- As an active system, it relies on mechanical processes. With units located on the nacelle and tower, potentially retains the challenge to reach the full area in the rotor-swept area used by bats.

<u>Approach and Methodology</u>

Comments on Strengths

- Robust test at 20 turbines. Advanced technology so more sophisticated results. No electronics exposed to water. Applicable to any turbine size.
- Pneumatic-powered ultrasonic jet for high-power, wide-ranging ultrasonic frequency noise. This evaluation is for the second phase of testing on how it works at actual wind turbines, and determining the best mounting spot to cover the appropriate directions with sound that is emitted. Field testing at wind power plant will also bring more information on the bat behavior near turbines and at ultrasounds.
- Hypothesis verification carried out using flight test facility to understand bat response to acoustic stimuli. Bat behavior around wind turbines researched in order to understand how deterrent can be adapted for greater efficacy.
- The study design and iterative approach appear to be well designed and executed.
- The main strengths in this particular deterrent is that the system is a pneumatic air drive system (rather than a transducer system) and that GE had the expertise to protect a majority of the system within the nacelle. Engineering-wise, GE also developed a relatively simple system with strong components and given their expertise they didn't run into the magnitude of technical issues that Frontier did with tapping into the turbine's energy system. GE also experimented to find the best placement of this technology based on thermal visuals of where bats typically fly in the rotor swept area.
- Strong team of collaborating organizations.
- This phase benefits from prior research by the same sponsor.
- Units tested in multiple contexts and configurations, with multiple indices of success.
- 3D imaging is useful in observing bat behavior, with and without the deterrent in operation.

Comments on Weaknesses

- Relatively few configurations tested. Given the challenges for devices surviving in the field, this solution seems to have a lot of potential. I have the impression that the efficacy of the solution can be further improved with testing of more varied configurations and wonder if this could have been designed into the methodology a little better.
- The weakness of the methodology is the fact that they ran into a problem with the pulsed system and water vapor. That is an understandable development, but it appears that they read too much into the limited collected data from that year by surmising that a pulsing system is no longer worth exploring. Their written materials for this peer review were also not very transparent on the implications the water vapor issue had for their study design, how it may have affected the results

(e.g., due to shorter review period), and how it may not be appropriate to compare this data with other years without further explanation.
- The deterrent has one year of success with eastern red bat deterrence (success unparalleled by any other deterrent) and does no further exploration or consideration of that result to understand if the success was luck or a result of the technology. It is odd that they discarded this success given the challenges other facilities have had deterring eastern red bats.
- There is no reference to the statisticians they collaborated with in generating their methodology or results.

Accomplishments and Progress

Comments on Strengths

- Technology functioned as planned, showing a significant reduction in impacts for all four targeted species.
- The method was improved from last phase tests and has evolved to a first industry product available.
- The technical improvements led to a pulsed-deterrent system of similar effectiveness as the continuous-emission system tested in prior years. The water condensing due to pulsing operation was resolved. Mounting the devices involves drilling through the tower in a couple of places where the deterrent is installed. This was determined to be okay as the holes were only about 1 mm diameter.
- The results of the carcass monitoring/field test further indicated there was no advantage to the added cost and complexity of a 6-nozzle pulsed system over the simpler, 4-nozzle constant system that was tested in previous studies.
- Understanding of bat behavior around turbines increased. Understanding of bat response to acoustic stimuli increased for the different species evaluated.
- I am encouraged by the increase in mortality reduction related to project's refinements since the last reporting period. The proposed refinements for the next several years appear to be a logical outgrowth of the successes to date and changes in response to noted deficiencies and observed issues during testing.
- GE had strong success in the field implementing their technology and didn't run in to the same level of obstacles that other technology developers did. If this is due to their thoughtful approach to the engineering side of things, this stresses the importance of these technology developers to collaborate more with turbine OEMs. If it's because of the maturity of their work in this space, that is also valuable since GE has been invested in advancing bat deterrents for quite some time—and it's been great to see their investment in this space.
- Program executed fully and according to schedule.
- Multiple modes of the device studied.

Comments on Weaknesses

- The reduced bat mortality did not improve with the technical improvements. It is still not above 50% for some bats, much less over 70%, though this may still be enough for mitigation impact.
- Would need much more funding to find out the impact of pulsing sounds to bats.
- Given that this phase of the project was dedicated to studying bat behavior with a view to increasing system effectiveness, data provided on slide 11 appears to indicate that was not achieved on average. Performance is increased for some species but degraded for others.
- When evaluating the effectiveness of operational adjustment vs. deterrents life cycle, costs of both need to be calculated to truly understand the cost-benefit ratio is of each. Even if operational adjustments may result in a greater reduction in mortality, the effect on avoided/lost wind energy generation, and the resulting increase of GHGs produced by gas and coal-fired generation that

would need to replace that generation, need to be calculated. Additionally, the cost associated with the curtailment-related loss in generation that would be borne by the wind farm owner needs to be weighed against differences in effectiveness between the two approaches. On the current testing period results, I am still not entirely clear on what the most recent refinements resulted in. In plain terms, what was the improvement in fatality reduction? Was it 38–54% or something else? If the increase was 16%, why is that not significant? What would be considered significant and at this point, and with further testing and refinement does that seem achievable?

- The weakness has to do with the challenges in 2016 with the pulsed device and the uncertainties that created in the effectiveness of their technology, given the limited amount of data available.
- Effectiveness of the system demonstrated, although not with results significantly better than other strategies being deployed or studied.

Communication

Comments on Strengths

- Really robust communications plan, talking to the right people. Especially helpful that FWS is supportive.
- Both a peer review publication and wide outreach conducted. The product is available for turbines made by companies other than GE.
- Available as a commercial solution from GE.
- Journal article in revision.
- Collaboration with TCU.
- Numerous industry and interest group presentations.
- Good consultation with industry.
- System can be installed on non-GE turbines.
- The project team seems to have engaged in stakeholder communications that have helped identify issues for them to consider in project testing and design refinement and are working towards commercialization.
- GE has been a strong coordinator and collaborator, both with industry through their partnership with Invenergy, as well as their work and outreach with federal agencies. They have also been at several workshops and done quite a few effective presentations.
- Consultation accomplished with federal and state wildlife agencies and wind industry participants.
- Multiple presentations to national research organizations and gatherings.
- System is commercially available and adaptable to any wind turbine.

Comments on Weaknesses

- More coordination on standardizing the statistics would have been helpful, particularly as we compare technologies and there is work underway to develop targets for minimization based on population modeling.
- There should be more transparency around the issues with the pulsed system and the implications for that year of monitoring. The vagueness in the peer-review materials presents more questions than answers regarding what this means for the future of pulsing deterrents.

Recommendations (Not Scored)

- As the mortality reduction was less than 50% for many species, it is worth it to continue the efforts, maybe combining with other deterrents.
- Highly recommend the continuation of this project. It is showing promising results that need further refinement and testing in alternate environmental settings, which the study team prepares to do. Some recommendations include examining the frequency and other qualities of ultrasonic

sounds emitted by hawk moths and other species that may utilize sound to deter predation by bats and see how those acoustic signals compare to those emitted by the GE deterrent.

- Develop standards for statistical evaluation of these deterrents—especially for DOE-funded projects. Explore potential reasons why the deterrent was so effective with eastern red, given the NRG systems' challenges deterring them. Consider testing the device in new landscapes and where the use of this deterrent can be coupled with smart curtailment. Test the curtailment on non-GE turbines.
- System developer intending to test the system in northeastern United States, a region with significant bat presence and impacts attributable to wind. Unclear whether federal support for this effort is being sought. Worth supporting, if it is.

Evaluating the Effectiveness of Ultrasonic Acoustic Deterrents in Reducing Bat Fatalities at Wind Energy Facilities

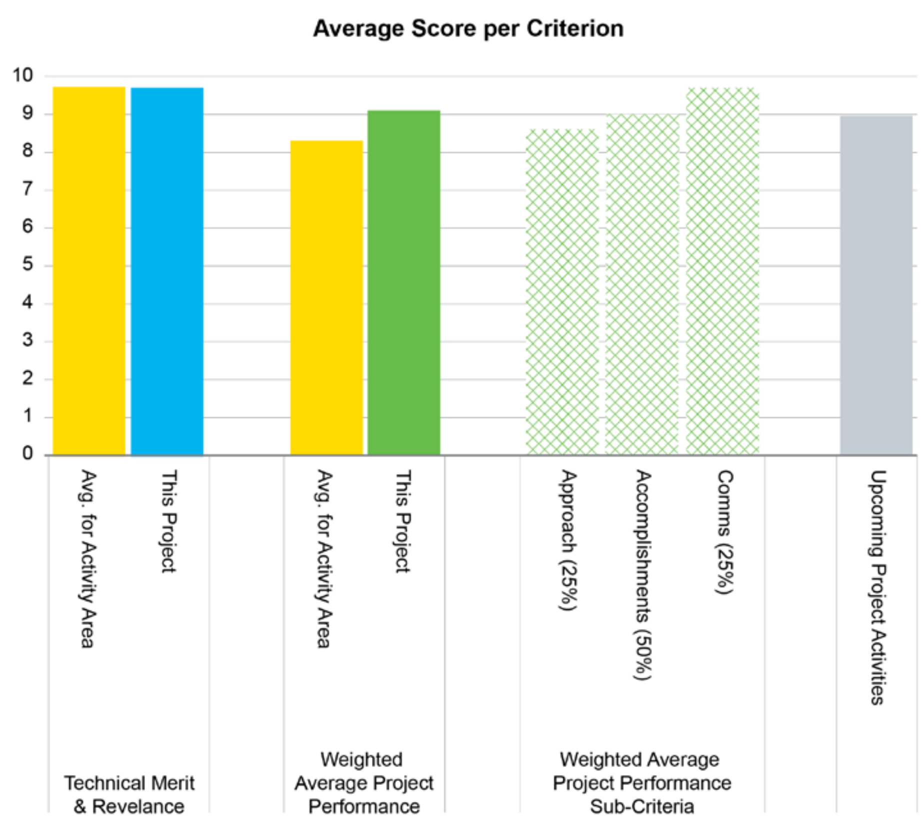
PI: Cris Hine	Unique Project ID: M20
Organization: Bat Conservation International	WETO Program: Market Acceleration and Deployment
Project Status: Active	WETO Activity Area: Environmental Research
Award Amount	$624,040
Cost Share	$2,462,283
Total Project Budget	$3,086,323
Actual Costs	$3,066,231

Project Description

UADs produce ultrasound overlapping with bat echolocation frequencies. Preliminary lab and ground-based field-testing show bats avoiding areas exposed to ultrasound. Distance ultrasound travels varies by frequency and is influenced by weather (e.g., humidity). Reduce fatalities by creating an uncomfortable or disorienting airspace near wind turbines

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Addresses the highly relevant issue of bat mortality at turbine sites. Specifically aimed to develop and test the effectiveness of an ultrasonic acoustic deterrent. Potentially a robust solution requiring only half a day's installation per turbine on average and no invasive installation on the turbine blades.
- Project aimed to increase understanding of bat behavior around turbines and interaction between UADs and operational curtailment.
- Functional deterrent systems that are both cost-effective and achieve significant levels of wildlife impact reductions have long been desired by the industry and continue to remain a top priority. The NRG system evaluated by BCI has shown promise since the initial prototype and looks to be having some success in deterring some species of bats at wind turbines. It is encouraging to hear that it is already commercially available for deterring at least one species, but additional refinement appears necessary to make it viable for broader commercial application. Question remains whether some additional targeted refinement is needed to improve effectiveness of this particular technology universally and/or on specific species or if this is as good as the device will ever be.
- The merit and relevance of this project represents one of the top priorities for the wind industry with respect to wildlife interactions and reducing costs. Bats pose significant challenges for industry for two primary reasons. One guild of bats hibernates in caves and is being decimated by white nose syndrome. Because of this they are facing increasing regulatory protection and scrutiny. These bats do not seem to be at high risk for collision at turbines due to their scarcity and behavior. However, they do occasionally collide, meaning that wind developers need to seek ESA permits for regulatory coverage. These permits can be incredibly challenging to get, even if wind energy facilities are having a much smaller impact on these bats in comparison to white nose syndrome.
- On the flip side, there is a guild of bats that migrates. They are spared white nose syndrome but they are at much higher risk of wind turbine fatality due to an unknown behavioral attraction. Wind is believed to have a population-level impact on at least one migratory bat species, and there are concerns that wind energy facilities are also having population-level impacts on other species with similar risk. Given that these species are migratory, their ranges are expansive and listings could affect nearly the entire industry. Moreover, the migratory bat of greatest concern at the moment is the hoary bat. This species is a strong flier so curtailment strategies (without any deterrents) will be costly and, as wind expands, deployment creates potential energy shortages during the fall migration season.
- The niche of this technology is its high TRL and the fact that it uses a slightly different technology for producing sound than the GE deterrent. Also, this project resulted in the benefit of a more automated advanced thermal video monitoring method. This will be valuable going forward for testing these technologies and understanding when and how bats interact with turbines.

Comments on Weaknesses

- While the technology clearly has some limitations with respect to being able to deter a wide range of species, the field evaluation study design seems to also suffer from some challenges. It is unclear if the identified issues could have been overcome through the use of more deterrent devices being at additional turbines or larger sample sets generally. Equally, it is unclear if different results could be achieved in different landscapes, as testing the deterrent at only one site in one type of geographic setting seems limiting. Suggest that any future studies consider those

points as the scope to date may have been too small to truly evaluate the effectiveness and derive value of the technology.
- When evaluating the effectiveness of operational adjustment vs. deterrents, life cycle costs of both need to be calculated to truly understand what the cost-benefit ratio is of beach. Even if operational adjustments may result in a greater reduction in mortality, the effect on avoided/lost wind energy generation, and the resulting increase of GHGs produced by gas- and coal-fired generation that would need to replace that generation needs to be calculated. Additionally, the cost associated with the curtailment-related loss in generation that would be borne by the wind farm owner needs to be weighed against differences in effectiveness between the two approaches. On the current testing period results, I am still not entirely clear on what the most recent refinements resulted in. In plain terms what was the improvement in fatality reduction? What would be considered significant and at this point? And, with further testing and refinement, does that seem achievable?

Approach and Methodology

Comments on Strengths

- Separate functional tests and comparative tests. This allowed issues with the devices to be identified and corrected prior to commencement of the comparative tests. If this been done in other projects, it may have mitigated some issues.
- Comparative study combined different observation approaches, including thermal video monitoring, which allowed for additional insights such as duration in and crossings of the rotor swept area.
- Public release of 3D software will greatly increase impact and is commended.
- It was encouraging to see the evolution of the study design and resulting refinements between project phases. Some improvements in methodology were clearly made in the second phase in response to the identified issues in the first phase.
- One of the greatest strengths in the methodology was the development of 3D thermal video processing, which will benefit all bat studies going forward. This will be incredible since prior to this level of automated processing, it took significant personnel time to evaluate hours of nighttime thermal video footage.
- The methodology compared the effectiveness of the deterrents to curtailment, which is an important baseline and comparison. In addition, the results showcased that there is much to learn about the effectiveness of curtailment.

Comments on Weaknesses

- Full rotor swept area not covered by the deterrent, difficult to know to what extent this impacts on the conclusions.
- Only a single configuration of devices was tested. However, it is acknowledged that more may not have been possible it the time frame available.
- The scope of the project may be too limited to draw any significant conclusions. In order to truly evaluate the effectiveness of the technology it will likely need to be field tested with additional refinements at multiple sites within different settings (e.g., agricultural fields vs. forested ridge tops) with different species composition. Additionally, it is unclear if any thought had been given to changing the frequency to focus on the three species that make up nearly 80% of the fatalities? For non-regulated bats, if the goal is to reduce those impacts in a meaningful way, then targeting the efforts on those species would seem to have the greatest potential for success.

Accomplishments and Progress

Comments on Strengths

- Device developed and tested successfully.

- Well-designed project plan allowed device issues to be detected and corrected prior to comparative test, resulting in 99% availability rate in the comparative tests. This should be considered a lesson for future similar projects.
- Devices installed on all 16 turbines, which is a significant achievement, especially when viewed in the context of challenges experienced in other projects.
- Comparative study successively executed with some findings consistent with other studies (e.g., increased fatalities of Eastern Reds at treatment turbines).
- 3D thermal monitoring tools enabled increased understanding of bat behavior around turbines.
- In general, a well-designed, well-executed project that has increased understanding of bat behavior and effectiveness of acoustic deterrents.
- Given that the NRG design has been around in concept for such a long time since the initial inception by Deton Engineering, it is encouraging to see the progress that has been made to refine the technology and scale/commercialize it. The project team clearly took steps to respond to issues identified in earlier stages in order to achieve the target results.
- Project is on track with meeting its accomplishments. Also, the accomplishments of this study truly were the "but for" causation of a commercialized product that has been refined since these tests, shown impressive efficacy for certain species, and has garnered industry support. This was evidenced by a developer implicitly "endorsing" this technology during a presentation at AWEA siting. In addition, developers are in negotiations with NRG to actually deploy this technology at their project.
- DOE should honor this accomplishment and what this means for bats and the industry—even if this is just the beginning.

Comments on Weaknesses

- While the design seems sound and modifications/refinements were made between phases in response to data from the preceding phase, the results were less than encouraging. As noted elsewhere, some of this may be addressable through different site selection and broader study area. It is unclear what would be considered "significant" in terms of reduction in mortality and should be better defined in the future. It is also unclear at this point if the identified challenges in the second phase can be overcome and the technology further refined to be more effective with the targeted species.
- Additionally, the increase in bat activity at an operational turbine with the deterrent vs. a non-operation turbine with the deterrent is somewhat explained as being related to weather conditions. However, the project team does not seem to consider that the difference may be an attraction of bats to some quality of a moving turbine vs. a stationary one. Understanding that relationship may help with refining the deterrent system and should be considered in the future.

<u>Communication</u>

Comments on Strengths

- Public release of 3D software will greatly increase impact of project and is a great outreach tool.
- Two journal articles expected.
- Results communicated at conferences and webinars.
- Commercialized version of product is available.
- Work has led to further DOE funded studies.
- Based on the project team's description, it appears that they socialized the results of the study well and sought input from stakeholders to help refine future study.
- There has been great communication and coordination throughout. One of the unique features of this study is that it was a partnership with BCI and NRG and as such there was significant

coordination and collaboration throughout across sectors and various experts. The project-related communication has also been very transparent.

Comments on Weaknesses

- It is unclear how much of this effort could be viewed as advancing the technology for market readiness vs. simply testing the effectiveness of the existing technology in comparison to operational adjustments. While it sounds like the technology is being utilized commercially for at least one species, it would have been preferable at this point in time for the study to have considered how to broaden the use.

Upcoming Project Activities

Comments on Strengths

- Future planned activities align well with project objectives and plan.
- I appreciate the efforts to evaluate the technology and it sounds as though there are some questions remaining to be answered, technology refinement that can occur to improve effectiveness, and testing that can be done to evaluate field performance in other settings. All of which could improve the viability of the technology and bring it closer to full commercialization.
- Finishing off the 3D video work is a critical next step.

Comments on Weaknesses

- It is not entirely clear to me what, if any, next steps the project team has identified to further evaluate this technology or make refinements in order to advance it to market readiness. It is suggested that if they do seek additional funding, that many of the points outlined here be taken into consideration during the study design.

Recommendations (Not Scored)

- The separate functional and comparative tests employed in this study successfully allowed device issues to be identified and corrected prior to commencement of the comparative study, resulting in a 99% availability rate. This should be held up as exemplary of best practice for other projects of this type.
- The technology itself does not seem to suffer from any particular weaknesses, but it is unclear if the effectiveness can be improved to increase the number of species deterred at wind turbines and that the "avoidance" rate can be increased through additional refinement. The question I have for this system, as with others being considered, is what level of "avoided" impacts would be deemed worthwhile by the industry, regulators, and environmental community such that companies would want to purchase and install the system? This is complicated by the fact that minimization of impacts to non-regulated species for the purposes of demonstrating "responsible" development is very different than the nearly full avoidance of impacts to regulated species that would allow a facility to operate at full capacity (i.e., without environmental operational adjustments or curtailment) without having to obtain an expensive and time consuming permit. Therefore, it needs to be clear what is technically achievable and communicated with all stakeholders, and whether the device is intended to be a minimization tool or one for avoidance purposes—as that will likely dictate how much a company would be willing to pay and the utilization rate by the industry as a whole.
- One of the key aspects of this project and others like it will be to attempt to bookend what the costs for installation, O&M, repair rates, and replacement rates are over a 20–30 year period will be. Understanding these costs will be a critical component to project financing and/or decision-making by a project proponent on whether or not to employ the technology vs. the lost revenue associated with operational adjustments.

- It is recommended that this project be continued if some of the questions above can be addressed. It is showing some promising results that need further refinement and testing in alternate environmental settings. Some recommendations include examining the frequency (i.e., pulsed vs. constant) and other qualities of ultrasonic sounds emitted by hawk moths and other species that may utilize sound to deter predation by bats and see how those acoustic signals compare to those emitted by the NRG deterrent.
- It would be valuable for NRG to partner and collaborate on some of the work that is being done for blade-mounted technologies to see if there is an opportunity to expand the efficacy of this device. Further data on the efficacy across species and landscapes is necessary as we look to preclude any further population-level impact on migratory tree roosting bats. If we are to brainstorm industry-wide solutions, we need a better understanding of this technology. Also, further inquiry on pairing this technology with curtailment is important.

Evaluating the Effectiveness of a Camera-Based Detection System to Support Informed Curtailment and Minimize Eagle Fatalities at Wind Energy Facilities

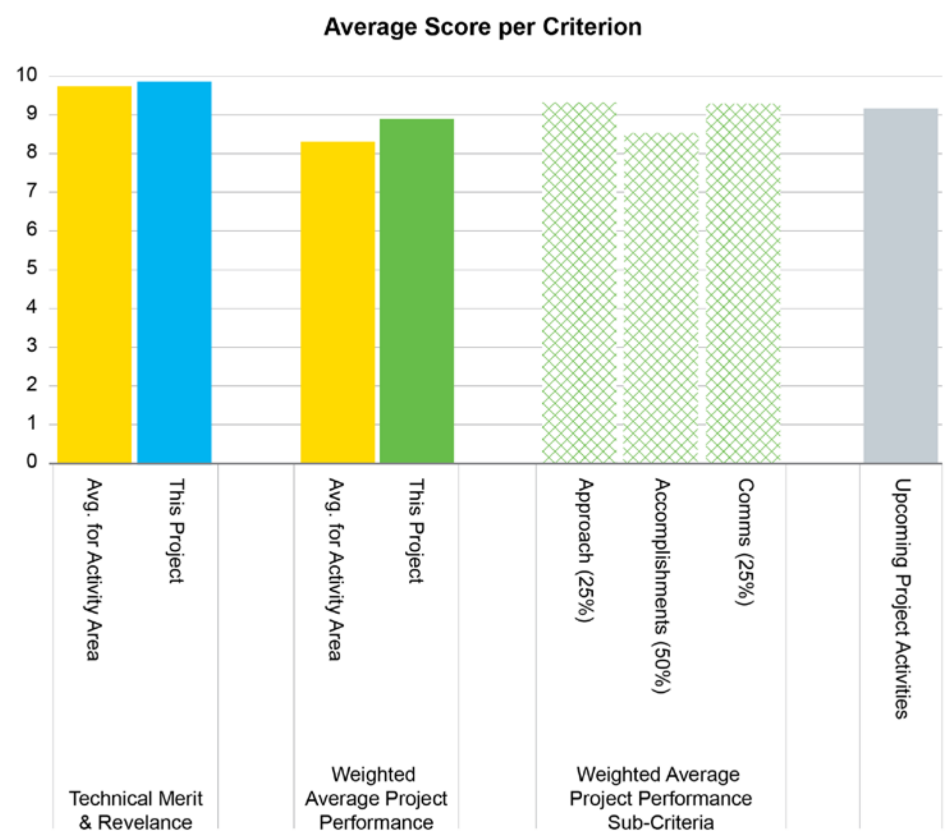
PI: Taber Allison	Unique Project ID: M21
Organization: American Wind Wildlife Institute	WETO Program: Market Acceleration and Deployment
Project Status: Active	WETO Activity Area: Environmental Research
Award Amount	$821,697
Cost Share	$1,011,500
Total Project Budget	$1,833,197
Actual Costs	$105,556

Project Description

IdentiFlight is a camera-based, autonomous eagle detection, classification, and tracking system intended to facilitate turbine shutdown (a.k.a. 'informed curtailment') to reduce collision risk of golden eagles and other protected species. IdentiFlight uses two camera types (fixed wide-field-of view cameras and stereoscopic HD cameras) and a classification algorithm based on machine vision learning.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Advancing technology options that can reliably detect an avian target, trigger a curtailment, then resume production once the bird is tracked out of the area is extremely valuable. This is a critical piece of the puzzle for evaluating takes so that we can properly quantify any compensatory needs. Establishing third-party verification of these systems is critical for securing regulator and stakeholder support for the approach and advancing its usefulness in the regulatory context. This system could greatly increase our ability to detect target species because it can function when human monitors have to go inside due to lightning. It will also be interesting to see how the functionality could expand given that it is already making nighttime identifications.
- IdentiFlight for eagle detection and triggering of turbine curtailment signifies relevant work for mitigating eagle mortality in wind power plants.
- This project directly addresses the highly relevant issue of eagle mortality at wind turbine sites. Third-party evaluation of system effectiveness is of high value for informing improvement of systems, determining when and where it is best employed, and feeding into the development of the next generation of systems.
- IdentiFlight is showing very high promise for automating the detection and curtailment-based deterrent of eagles (thereby avoiding potential fatalities) at operating wind facilities. The practical effect of this is a reduced cost of annual contracting of human biomonitors and the reduction of false-positive curtailments and total curtailment hours—all of which will decrease project/facility LCOE. The field verification of this technology at several sites by independent third-party evaluators is critically important for the commercialization and acceptance of the technology as an effective impact minimization tool.
- This project is incredibly important to understanding and commercializing deterrent technologies for eagles. The commercialization of effective eagle deterrents will expand deployment opportunities and reduce permitting costs pursuant to the Bald and Golden Eagle Protection Act. This project has particular merit since these new technologies must be verified by a trusted source before USFWS will provide regulatory incentives for their use and thus drive demand from developers. DOE is one of the only organizations with the capacity and credibility to serve this role of working with AWWI.
- Eagles garner significant social and cultural interest. They are a charismatic species driven in part to their role as our national symbol. They also have spiritual and cultural value for native tribes across the United States. Accordingly, these deterrents can play a key role in both reducing costs and gaining support and approval for wind development in communities.
- This effort explores a machine-based alternative to the use of human bio-monitors in smart curtailment programs for the avoidance of impact to eagles. As such, it is of significant importance to the wind industry, given the statutory and regulatory protection of these species.
- The potential for the IdentiFlight system to reduce risk to eagles, as estimated by the U.S. Fish and Wildlife's Bayesian model, to be explored in future work. If successful, this would result in lower mitigation requirements through the use of the system.

Comments on Weaknesses

- Curious if there are times or light conditions that will be important for eagle detection that this wouldn't work in (i.e., fog, glare).
- Individual systems have limited coverage within the wind plant, making this a relatively expensive option.

Approach and Methodology

Comments on Strengths

- It's really important to test this out at actual wind farms (rather than lab/demo turbine setting).
- Independent merit review of the experimental study design to ensure the quality and usefulness of data and research results.
- Third party making the survey. Tested at several sites.
- In addition to validating the tracking accuracy, surveys focused on evaluating the curtailment decisions (number and duration).
- Incorporation of GPS-tracked eagles adds significant value.
- Comprehensive evaluation, including comparison with human observers and absolute assessment with GPS-tracked birds.
- Study involves quarterly review of machine learning improvements.
- Significant cost share.
- Study design is merit reviewed.
- Study covers entire operational sites that will enable a comprehensive plant level analysis to be carried out.
- The proposed approach to evaluating the technology at several operating wind farms and the questions they are seeking to answer seems sound.
- This dynamic, long-term project has a very well thought out methodology. Particular strengths include:
  - Testing the technology in two different landscapes since we know that landscape features have the potential to affect the effectiveness of the camera technology.
  - Testing the curtailment efficacy on two different wind facilities that have their own respective operational policies and parameters (and ideally, turbine type).
  - Incorporating a pathway to credibly estimate the reduction in collision risk (i.e., an efficacy rate). This will be critical in the eventual deployment of the technology since USFWS will need this data when making permitting decisions. Developers will also need this information when costing out the value of this technology in comparison to compensatory mitigation investments.
  - Using GPS data in an incredible way to validate this technology, producing indisputable, real-world eagle flight information.
- Robust research plan, exploring multiple aspects of the relative efficacy of the IdentiFlight system.
- Benefits from prior 2016 pilot study at one of the two study sites.
- Geographic diversity of two study sites.
- Strong project team, independent of IdentiFlight manufacturer.

Comments on Weaknesses

- Given the challenges this project faced in being dependent on a not-yet-permitted project, an alternative approach could be to target existing wind farms for this kind of study to remove that variable.
- The system cannot detect birds at night, and it has been established that eagles do fly at night. The impact of this should at least be quantified and understood.
- Only weakness was the self-identified challenge of the need for additional environmental evaluation/permitting at the host site causing a delay in being able to construct and evaluate the system at two facilities in the same year. In the future, proposed host sites should be pre-cleared to avoid such a delay.
- Will multiplicity of research issues depress statistical power of any or all of them?
- Permitting challenges resulted in loss of one (excellent) candidate site.

Accomplishments and Progress

Comments on Strengths

- Impressive persistence and creativity by project team to push forward through delays.
- Larger wind farm has 47 IdentiFlight systems and a library of previous videos for identification.
- Project on budget at this stage.
- Inclusion of GPS-tracked birds at WY site.
- First quarter data under review.
- Given that the evaluation is in the early stages of data collection, there is not much to comment on, but the pre-study work progress seems both necessary and appropriate.
- The project appears to be on track with its intended objectives and progress.
- Overall progress generally according to plan, if not schedule, and on track to provide desired findings.

Comments on Weaknesses

- Delay at the start, which reduced the data collected.
- Installation at Oregon site appears to be behind schedule.
- Again, the only potentially identifiable issue that the project team should have anticipated and caught was the need for additional site clearance work at the second facility in Oregon. However, this does not seem to have seriously delayed the overall project schedule to the extent it would jeopardize the study.
- Asynchrony between sites.

Communication

Comments on Strengths

- Good to see that the goal is to have final report peer reviewed.
- Publications planned, and dissemination by AWWI to stakeholders.
- Large number of collaborators. Study design merit reviewed. Significant outreach carried out. Results will inform improvement and development of commercial product and will serve as an effective demonstration of the product.
- This section is hard to score given the preliminary nature of the study. However, the proposed outreach strategy seems sound.
- Overall sound communication plan.
- Manuscripts to be prepared and submitted for peer review.
- AWWI plans outreach to promulgate results.
- System manufacturer prepared for commercialization.

Comments on Weaknesses

- More intensive engagement and outreach with states and federal agencies is necessary. To the extent possible, this communication and collaboration should include in-depth workshops, forcing the USFWS—including MBTA chiefs across regional offices—to directly engage. Getting ownership and buy-in from federal regulators (not just approximate knowledge) into the methodology and testing will be critical to the future success of this project. Also, it is critical to ensure that experts from USGS are engaged (both statisticians and eagle biologists). It appears from the write-up that this engagement will come at the end of the project, but that is too late.
- System cost may limit commercial opportunities.

Upcoming Project Activities

Comments on Strengths

- Really looking forward to seeing the final outcomes of this important project!
- A good plan for realizing the project objectives.
- Planned future activities appear well aligned with project objectives and plan.
- The meat of the project is the future work and I will be curious to see how the technology fares against human monitors and answers the questions on false negatives that could lead to either eagles being at greater risk or excessive curtailment that would drive up LCOE.
- Upcoming activities align with sound project methodology.
- Potential of IdentiFlight system to produce lower estimates of collision risk via the U.S. Fish and Wildlife Service's Bayesian model to be explored, with lower associated mitigation requirements and costs.

Comments on Weaknesses

- Collaboration with some of the other tracking systems would be great to see.
- Could consider quantifying the impact of non-operation during night hours.
- A more robust outreach program with regulators is needed now.

Recommendations (Not Scored)

- Collaboration with some of the other tracking systems would be great to see.
- Consider quantifying the impact of non-operation during night hours.
- This is a critical stage in the evaluation of this promising technology and funding should be continued. I do think that the PI and project team should attempt to evaluate the cost differential associated with biomonitoring and Identiflight deployment, both in terms of lifecycle technology costs (e.g., initial deployment, repair rates/cost, replacement rates/costs) vs. life-of-project human contractor employment, and projected curtailment loss of energy associated with each approach. Other than that, I cannot identify any issues for the project team. For the WETO office, I'd encourage the Department engagement with DOI to ensure that when and if the data shows that the technology is effective at avoiding/reducing eagle fatalities, that it be accepted by USFWS as a reliable and effective tool that can be deployed readily. Also, the project developer/operator should be allowed to forgo biomonitoring and/or be given credit for using the technology (e.g., reduced permitting burden, reduced mortality monitoring requirements, and/or reduced mitigation costs). At present, the Service is apparently not allowing for any credit at the time of permit issue and is saying they will credit back mitigation costs at a later date, which is difficult for a company to manage through financing, etc. Regardless of technology, once confirmed by a DOE-funded effort to be effective the Service and other agencies need to accept and incentivize their use if we are to see them broadly adopted.
- Plan an engaging workshop with USFWS, USGS, and state regulators to embed them further into this work. This workshop could be broader than just IdentiFlight, but it is clear that such a workshop is necessary if these deterrents are going to have the impact we anticipate in the short term.
- This project should be very helpful in assessing the viability of this system.

Detection and Perception of Sound by Eagles and Surrogate Raptors

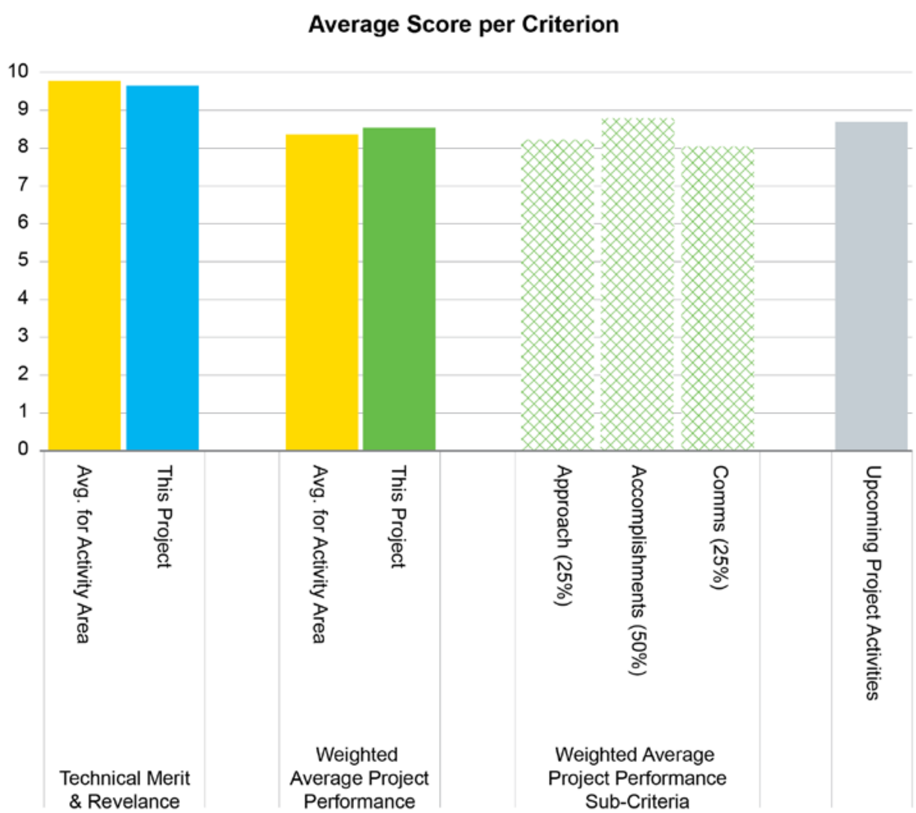
PI: Jeffrey Marr	Unique Project ID: M22
Organization: University of Minnesota	WETO Program: Market Acceleration and Deployment
Project Status: Active	WETO Activity Area: Environmental Research
Award Amount	$299,996
Cost Share	$33,664
Total Project Budget	$333,660
Actual Costs	$333,660

Project Description

This project seeks to support the development of eagle deterrent technologies by studying eagle hearing capabilities and providing recommendations to technology developers to improve the effectiveness of their devices. UMinn will develop robust audiograms for bald eagles, golden eagles, and red-tailed hawks, record and analyze bald eagle vocalizations, and quantify behavioral response of bald eagles to several auditory stimuli in controlled lab setting.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Understanding what these birds hear is one essential piece of informing acoustic deterrence strategies, so advancements in this area seems critical.
- Directly addresses the highly relevant issue of wildlife mortality at wind turbine sites that is currently impacting on operation and deployment of wind power. Excellently conceived fundamental research that can potentially accelerate and inform deterrent eagle deterrent projects. Greater understanding of eagle vocalization, hearing capabilities, and response to acoustic stimuli has the potential to focus the development of more effective deterrents.
- This project addresses a key element to future designs of auditory deterrent systems and the study appeared to be well designed and thorough in its approach.
- Strong technical merit. Understanding how eagles hear is an important step to understanding if we can deter them from wind turbines, particularly as wind energy expands. Eagles are habitat generalists, meaning they are abundant in many parts of the country, particularly bald eagles. The commercialization of effective eagle deterrents will expand deployment opportunities and reduce permitting costs pursuant to the Bald and Golden Eagle Protection Act. Eagles also garner significant social and cultural interest. They are a charismatic species, driven in part by their role as our national symbol. They also have spiritual and cultural value for native tribes across the United States. Accordingly, these deterrents can play a key role in both reducing costs and gaining support and approval from communities.
- Meets industry need for eagle impact mitigation options.
- Contributes to basic science needed for the identification of strategies for mitigation options. Strong team, particularly for bald eagles.

Comments on Weaknesses

- This kind of data for other protected birds, especially those in the offshore space, would be really helpful. Also, further research into how they respond to certain sounds, not just whether they can hear them, feels like a missing piece of this.

Approach and Methodology

Comments on Strengths

- I wonder if birds in captivity really behave/respond to sound the same way they do in a wild setting. So, while this is a piece of the puzzle, it seems like it would really need to be validated in a wild setting for a broader range of protected birds.
- Well-conceived and designed series of experiments to test the auditory and visual perception of eagles.
- Use of independent judges to evaluate responses.
- Approach informed by other similar studies.
- Eagle vocalization recordings being made available to the public.
- Proven brain stem response methodology used.
- The study methodology and approach seem focused, detailed, and thorough in answering the question of what eagles hear in order to better inform future efforts in acoustic deterrent systems.
- Overall, the approach was sound with the three important components of examining eagle hearing and behavior. Understanding the frequency of different eagle calls and differentiating these calls will be valuable in the future, as well as beginning to address eagle habituation—a major concern when it comes to exploring potential deterrents. Another key strength was including red tail hawks since these raptors often serve as surrogates in research and this knowledge will be valuable in the future.

- Assessed existing information, which is poor, so started with the basic scientific approach.
- Recorded eagle vocalizations as potentially effective deterrence sounds. Bald eagles' behavioral responses to sound studied.

Comments on Weaknesses

- Sample sizes seem really low—only three species studied and less than 10 birds each.
- The study failed to consider the effect of background noise or the complexities of sound, which became more evident when contrasted to the other project. Rather than just doing pure sounds, this project failed to evaluate frequency sweeps and harmonic stacks or chords. The project also failed to incorporate background sound—an obvious gap given the noise emitted by wind facilities. While the Purdue study did move the science forward in our understanding, in this respect it was a missed opportunity.
- This study failed to study behavior in golden eagles due to challenges procuring study subjects. This may have been rectified with greater collaboration with the Purdue scientists.
- Inability to use procedures for behavioral observations of goldens and was possible for balds.
- Small sample size, particularly for the bald eagle behavioral response assessment.

<u>Accomplishments and Progress</u>

Comments on Strengths

- The strategy of testing out similarities of red tails to eagles hearing seems quite valuable as it could set up opportunities for more studies in the wild of more common birds.
- Auditory response map of eagles established and compared to other birds.
- Validated the more common red-tailed hawk as a validation species.
- Multi-disciplinary team worked well together.
- Birds were tested within 3 months of contract award.
- Discrete call types identified and characterized to a high level of detail. Response to various call types established. Several acoustic stimuli that evoked a strong response have been identified.
- The project seemed to accomplish what it set out in addressing goals/expected outcomes.
- The project accomplished what it was intended to do and advanced our understanding of eagle hearing, vocalization, and behavioral responses.
- Characterized bald and golden eagle and red-tailed hawk hearing abilities, using sounds characteristic of wind farms.
- Methodology for assessing responses to sound was developed. Assessed responses of bald eagles to a range of 10 different sounds, drawing on recorded sounds and hearing thresholds from prior activities.
- Completed the project.

Comments on Weaknesses

- Not sure how applicable or helpful this data will actually be. Even if we know what level of noise they can technically hear, we don't know what they'll do in response to that sound in the wild with a broad range of additional factors at play. While that may have been outside the scope of the study, it seems like a limitation worth mentioning.
- The only weaknesses were related to the gaps left open related to golden eagle behavior, background noise, and the implications of more dynamic sound patterns.
- Behavioral study of golden eagles not possible. Small sample size of bald eagles permitted only a weak finding of no habituation (by wild eagles).

Communication

Comments on Strengths

- Seems too early to judge since the results have not yet been published (or accepted?) by any peer-reviewed journals. A handful of presentations at relevant venues is good.
- Significant number of journal articles pointing to academic rigor of research. Significant outreach in the form of conference presentations.
- The dissemination of information was fairly broad in nature and thorough.
- The clear strength of this project was the incredible collaboration and integration of experts across the university from a variety of programs. Also, the combination of three journal articles and a final report are significant and impressive outputs.
- Three peer-reviewed articles generated. Multiple presentations.
- "Knowledge transfer package" designed for use by developers of systems.

Comments on Weaknesses

- Need to be clear what this research is and isn't able to inform. “Acoustic deterrence” means different things to different people. Unclear if this research will be able to help inform strategies to just alert birds or actually deter them from flying toward the turbine.
- This is a really nice piece of work highlighting the proactive approach towards wildlife impacts mitigation. Some sort of outreach more directed at the general public could have a positive impact.
- It does not appear that the researchers from Purdue and Minnesota collaborated, and that was a potential missed opportunity. Replication is an important part of science, but in this case, it appears that the two projects could have benefited from each other's input, even amidst the competitive world of academia. There are enough differences in these two studies that they both add scientific value, but some crosspollination between the two studies may have generated value, including modifying the sound eagles were exposed to and integrating a way to account for background noise.

Upcoming Project Activities

Comments on Strengths

- While there are no future planned activities in this space, given the limited sample set of tested eagles and fact that one of the three reacted differently than the other two when subjected to the sound stimuli, I would suggest additional application to a larger sample set to validate the findings.
- The project is completed, so no relevant comments on upcoming activities. It is a great accomplishment that this project will result in three peer-reviewed papers.
- Seeking follow-on funding via Wind Wildlife Research Fund for more extensive testing using behavioral assessment methodology developed though this work.

Comments on Weaknesses

- Limited match capability.
- Challenge of studying golden eagle behavior remains.

Recommendations (Not Scored)

- This is a really nice piece of work highlighting the proactive approach towards wildlife impacts mitigation. Some sort of outreach more directed at the general public could have a positive impact.
- Given the limited sample set of tested eagles and fact that one of the three reacted differently than the other two when subjected to the sound stimuli—I would suggest additional application to a larger sample set to validate the findings.
- Consider testing the hearing distance range of the birds (e.g., at what distance would the birds notice the acoustic stimuli) as this would help inform whether or not an acoustic deterrent at the

turbine tower could be heard by the birds soon enough for them to take corrective action to avoid collision.

- Test in the field to further evaluate the responses and distance from the sound source the eagles can hear and take notice of the sound
- Study the potential for habituation to the sounds longer
- Evaluate how background noises (e.g., wind turbine operations, wind, etc.) can mask or otherwise limit the stimuli response.
- Overall, this was a very good study that should answer some important questions and hopefully lead to the development of acoustic-based alert/deterrent systems. I would encourage and support future work in this area.
- A major recommendation is to crosswalk these results with DTBird and the frequencies used in their deterrent to understand overlap. In addition, more work should also be done to explore what eagle vocalizations might be most unnerving to a nearby bird and employ biology to exploit natural eagle aversions in the wild when developing or refining future deterrent sound profiles.
- In the future, if two similar research projects are awarded at the same time, explore opportunities to support collaboration (acknowledging that science depends on replication and that collaboration is tricky in these circumstances).
- This work has provided an excellent basis for identifying the types of sounds which could be exploited by a vendor such as DTBird for its warning sounds. Recommend pursuing that path.

Understanding the Golden Eagle Sensory World to Enhance Detection and Response to Wind Turbines

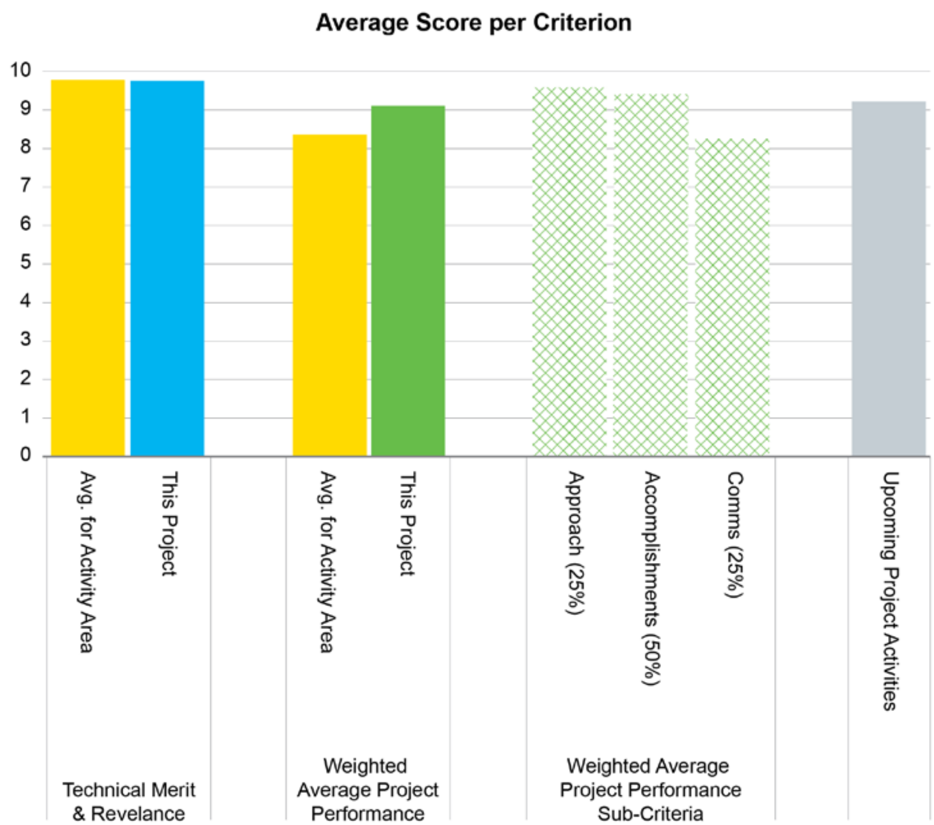
PI: Jeffrey Lucas & Esteban Fernandez-Juricic	Unique Project ID: M23
Organization: Purdue University	WETO Program: Market Acceleration and Deployment
Project Status: Active	WETO Activity Area: Environmental Research
Award Amount	$300,000
Cost Share	$75,000
Total Project Budget	$375,000
Actual Costs	$242,849

Project Description

Researchers at Purdue University designed, built, and tested portable devices at 3 rehab facilities needed to measure visual and auditory properties of bald and golden eagles.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Understanding how eagles hear and see and respond to various sounds/sights is essential for informing acoustic deterrence strategies, so advancements in this area seem critical.
- Important knowledge for industry and wind developers of eagle visual and auditory systems and behavior for mitigating environmental impacts.
- Directly addresses the highly relevant issue of wildlife mortality at wind turbine sites that is currently impacting on operation and deployment of wind power.
- Excellently conceived fundamental research that can potentially accelerate and inform eagle deterrent projects.
- Specifically aimed at understanding eagle behavior and vision capabilities, this project has the potential to aid the development of more-focused, effective deterrents.
- The study design was extremely thorough and well thought out. I particularly appreciated the focus on both audio and visual stimuli and am hopeful that result of the study will help better inform future R&D in eagle deterrent systems.
- Strong technical merit. Understanding how eagles hear is an important part to understanding if we can deter them from wind turbines—particularly as wind energy expands. Eagles are habitat generalists, meaning they are abundant in many parts of the country, particularly bald eagles. The commercialization of effective eagle deterrents will expand deployment opportunities and reduce permitting costs pursuant to the Bald and Golden Eagle Protection Act. Eagles also garner significant social and cultural interest. They are a charismatic species driven in part by their role as our national symbol. They also have spiritual and cultural value for native tribes across the United States. Accordingly, these deterrents can play a key role in both reducing costs and gaining support and approval from communities.
- Addresses industry need for eagle impact avoidance strategies.
- Dual approach exploring auditory and visual characteristics of eagles which, in combination, potentially offer a means to alert eagles to the presence of turbines and trigger their natural avoidance mechanism.
- Provides an analytical basis for the long-assumed vulnerability of foraging eagles to collision with turbines, based on the difference in their fields of vision when looking down as opposed to looking forward. This validates the potential for systems (e.g., DTBird, etc.) to be able to reduce impacts.
- Identifies sound types with potential for respective eagle species, depending on which is the species of regulatory interest.

Comments on Weaknesses

- Modest financial match.

Approach and Methodology

Comments on Strengths

- Project utilized a known, proven methodology to assess vision and hearing. They seem to have taken a very opportunistic approach by seeking animals in rehab, etc. I like the three-step process of not just assessing hearing/vision, but also then attempting to track actual responses to those stimuli and develop recommendations for deterrent strategies. It is very comprehensive. I also like the concept of testing out the possibility of using red tails as a proxy for eagles so that perhaps more testing in the wild could be possible.
- Detailed research on the sound impacts on brains, also with background noise, and visibility of colors.

- Well-conceived and designed series of experiments, testing the auditory and visual perception of eagles.
- Auditory testing approach complimentary to other studies (M22) by use of different testing approach and with an assessment of the impact of noise.
- Very high-quality study plan and execution.
- The approach and methodology of this study was incredibly well thought out. It was fascinating to see the variation in bald and golden eagle hearing when exposed to complex sounds, particularly considering that differences in bald and golden eagle hearing were not evident in pure tones or tonal down sweeps. The study design also incorporated background noise, a key factor when integrating deterrents at any wind facility.
- The idea to incorporate both sound and hearing in a behavior study is a brilliant way to maximize the effectiveness of future deterrents and decrease opportunities for habituation. It was also impressive that they had the opportunity to run these behavior tests on both species.
- Strong team. Extremely sophisticated capabilities in eagle physiology and study.
- Work focused on both visual and auditory factors.
- Effective networking among raptor rehab centers for access to retina samples and eagles for study.

Comments on Weaknesses

- Sample sizes seem small, and I continue to wonder how/if the birds will react differently in this intense lab setting vs. flying in the wild. While I realize the challenges in doing this another way, I still have doubts about how birds in captivity/rehab might react differently compared to wild birds.
- Relevance of response to chords is unclear, but this is more likely due to my lack of expertise in this area!
- The only small weakness identified is they didn't run these tests on a surrogate species such as red-tailed hawks.
- Challenges in obtaining retina material and golden eagle subjects for auditory study.

Accomplishments and Progress

Comments on Strengths

- Upcoming project activities are all important steps for completing this study and achieving its objectives.
- Results on what sounds are highly audible even in background noise showed that complex auditory stimuli, such as chords and fairly rapidly changing tones are excellent candidates for sending an alerting signal to eagles.
- Preliminary results on colors, and showing how hunting/looking down impacts the visibility.
- Established auditory response under a variety of noise conditions.
- Validated results from other work (M22).
- Eagle field-of-view as function of head position has provided invaluable insights into deterrent development.
- The accomplishments to date have been impressive and continued forward progress has been seemingly on schedule and meaningful.
- Strong accomplishments to date.
- Substantial progress on both auditory and visual paths of inquiry.
- Have established that bald eagles have excellent hearing.
- Established that eagles hear differently, but that certain sounds may be effective for both.
- Established that background sound (noise, in their words) reduces both species' processing of tones.
- Charted fields of view for both species in alternative head positions.

Comments on Weaknesses

- Delay associated with difficulty in obtaining retina samples and eagle subjects.

Communication

Comments on Strengths

- Communications efforts seem appropriate given the stage of the project (i.e., no final results to communicate yet).
- Presentations made and publications expected in 2019.
- Significant number of conference presentations.
- The collaboration with other thought leaders in the field (e.g., Todd Katzner) has been good and communications of the study and results decent.
- Communication overall is strong and was a necessary and integral part of success to date. As results come in, strengthening outreach activities and reach will be important.
- Three presentations at scientific meetings. Publications planned or in process.

Comments on Weaknesses

- No journal articles yet, but perhaps these are to come. This is a really nice piece of work highlighting the proactive approach towards wildlife impacts mitigation. Some sort of outreach more directed at the general publish could have a positive impact.
- While I realize the results are preliminary and the study is ongoing, the project team should think about how to broaden the communication of their efforts and the results once completed, as the communications to date are somewhat limited.
- Some collaboration between Purdue and the Minnesota laboratories would have likely added value to both projects.
- Delays have affected the ability to publish thus far.

Upcoming Project Activities

Comments on Strengths

- Upcoming project activities are all important steps for completing this study and achieving its objectives. I really like the added element of looking into lead toxicity and how that impacts behavior.
- The work to finish the main work in 2018 and testing with live eagles.
- Future planned activities align well with project objectives and plan.
- Collection of surrogate data from red-tailed hawks makes sense as this has been verified as a valid proxy species.
- The future activities look very good and should result in some good and interesting information that can inform future thinking on deterrent technology. On the sound side, if there is future activity associated with this project on this particular aspect of the study the PI should consider:
    - 1) Testing the hearing distance range of the birds (e.g., at what distance would the birds notice the acoustic stimuli), as this would help inform whether or not an acoustic deterrent at the turbine tower could be heard by the birds soon enough for them to take corrective action to avoid collision.
    - 2) Testing in the field to further evaluate the responses and distance from the sound source the eagles can hear and take notice of the sound.
    - 3) Evaluating further how background noises (e.g., wind turbine operations, wind, etc.) might mask or otherwise limit the stimuli response.

- The blood lead study is a great idea. Wind farm owner/operators have long argued that a large portion of eagle collisions might be related to lead levels that are affecting their ability to reason and navigate.
- A robust set of future activities is planned. The lead-related study they wish to do will be incredibly valuable, as many have speculated regarding the neurological effects of eagles from lead exposure and how this impacts their behaviors. Understanding hearing and visual aberrations where there is high lead toxicity will contribute greatly to answering this question. Also, the future work to carry out the study is also impressive and very cost-effective given the overall budget.
- Plan to assess impact of blood lead levels on eagle hearing.
- Late additions to auditory samples form golden eagles.
- Behavioral trials planned.
- Red-tailed hawks to be studied as surrogates in visual work.

Comments on Weaknesses

- In addition to lead, mercury levels of tested birds should also be considered in future analyses if possible.
- Not sure how high on the priority list the blood-lead-level impact research is for the deterrents.
- Behavioral trials still “preliminary.”
- Not assured of desired amount of golden eagle auditory data.
- Additional eye tissue samples from bald and goldens appear not to be available.

Recommendations (Not Scored)

- Important work that has an impact on the deterrent research. Keeping in mind the final deterrent/alerting objective is important.
- Seems like similar work for bat impact mitigation could steer the deterrent development work.
- I think this is critically important work that needs to remain a high-funding priority for WETO. Please see suggestions above for thoughts on potential additional areas of refinement/focus.
- Crosswalk final results with DTBird's sound patterns. Explore opportunities for further collaboration with the technology.
- Depending on results of behavioral work, auditory results may be appropriate for promulgation to developers of alerting systems (e.g., DTBird) for use in versions of their systems going forward.
- I would question whether further visual work is necessary.

Evaluating the Effectiveness of a Detection and Deterrent System in Reducing Golden Eagle Fatalities at Operational Wind Facilities

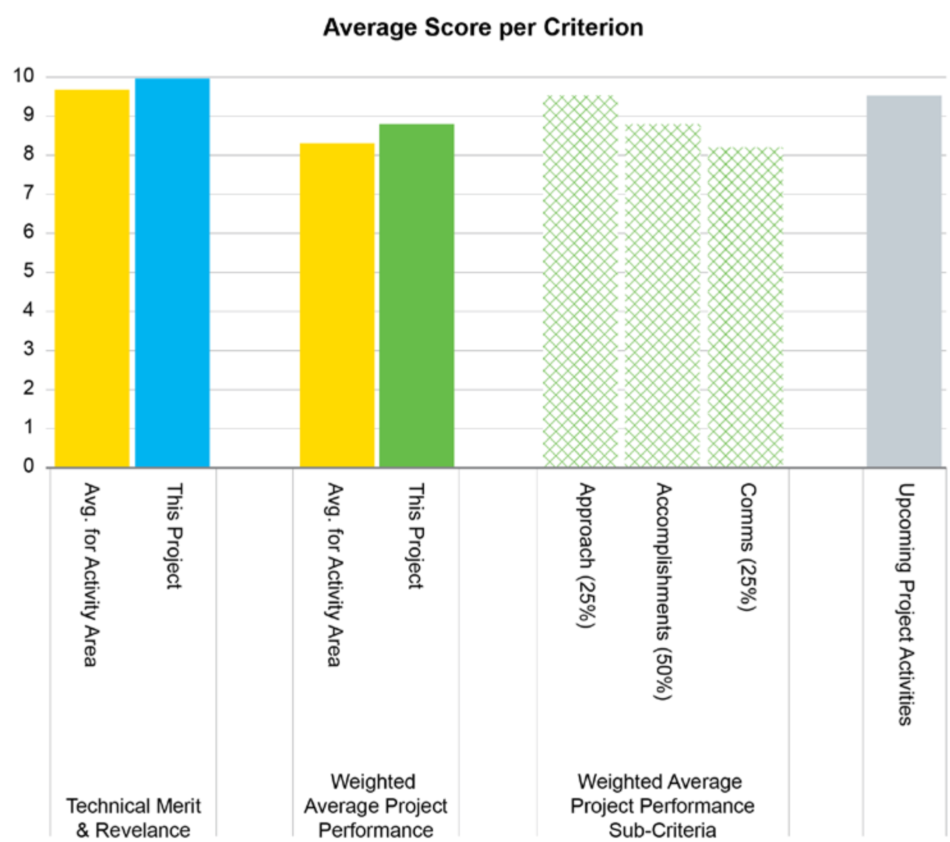
PI: Taber Allison	Unique Project ID: M24
Organization: American Wind Wildlife Institute	WETO Program: Market Acceleration and Deployment
Project Status: Active	WETO Activity Area: Environmental Research
Award Amount	$700,688
Cost Share	$926,243
Total Project Budget	$1,626,931
Actual Costs	$177,547

Project Description

DTBird is a turbine-mounted system for automated bird (optical) detection and (acoustic) deterrence. Multiple cameras and speakers mounted on each turbine work in concert with on-site software to determine when an eagle crosses pre-determined distance thresholds, triggering sounds to either alert or dissuade the eagle from collision risk zone of a wind turbine.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- It is extremely valuable to advance commercial availability of a system that can accurately detect specific birds of concern and assess if a visual deterrent (especially one so cheap and easy to deploy) will reduce collisions, especially given that, in some locations, there may be public acceptance issues with application of acoustic deterrents. Further, third-party verification of this system is key so as to build public support and buy-in for the take reduction estimates it will make possible.
- Eagle mortality mitigation. Testing to validate tracking and deterring eagles in different environments.
- This project directly addresses the highly relevant issue of eagle mortality at wind turbine sites, which currently impacts operation and deployment of wind turbines.
- Third-party evaluation of system effectiveness is of high value for informing improvement of systems, deciding when and where it is best employed, and feeding into the development of the next generation of systems.
- Critical to understand effectiveness of available systems to establish the state of the art and direct research to advance the same.
- The use of detection systems to identify at-risk eagles and inform operational adjustments has long been a priority of the industry. IdentiFlight has been a leader in this area and the initial testing, as noted in the project summary, has proven to be promising. Validation of this technology so that it can be quickly commercialized and deployable at scale is essential to addressing one of the industry’s biggest regulatory/legal challenges. The design and preliminary execution of the study is well thought out and iterative, and appears focused on answering some critical questions that, if affirmed, could lead to widespread employment of the system.
- This project is incredibly important to understanding and commercializing deterrent technologies for eagles. The commercialization of effective eagle deterrents will expand deployment opportunities and reduce permitting costs pursuant to the Bald and Golden Eagle Protection Act. This project has particular merit since these new technologies must be verified by a trusted source before USFWS will provide regulatory incentives for their use and thus drive demand from developers. DOE is one of the only organizations with the capacity and credibility to serve the role of working with AWWI.
- Eagles garner significant social and cultural interest. They are a charismatic species driven in part by their role as our national symbol. They also have spiritual and cultural value for native tribes across the United States. Accordingly, these deterrents can play a key role in both reducing costs and gaining support and approval for wind development in communities.
- Addresses industry needs for eagle impact avoidance strategies and is intended to be used in regulatory decisions on mitigation requirements.
- Multi-pronged approach, testing the DTBird system's capabilities and eagles' response to DTBird signals.
- Study was conducted at two geographically distinct sites.
- Strong financial match.
- Study team independent of system manufacturer.

Comments on Weaknesses

- Comparing effectiveness of visual vs. acoustic deterrent would be a helpful additional output.
- Perhaps underestimated the regulatory situation with respect to one site.

Approach and Methodology

Comments on Strengths

- Approach appears solid. Key is getting 360-degree coverage and comparing live birds to drones to further study effectiveness.
- Tracking and deterring eagles with an existing prototype product by third party. Testing to validate and prove the concept for multiple years and in multiple sites.
- First of its kind.
- Differences in cloud cover and landscape (e.g., hilly versus flat) could affect performance. Getting similar performances while testing at different, diverse sites could prove the system is not sensitive to site environment.
- The concept has been deployed in Europe and has potential to be used for birds other than eagles. An offshore version is also being developed.
- Merit-reviewed study design. Third-party, peer-reviewed findings.
- Use of two geographically diverse sites.
- Multi-year study.
- Includes comparative cost analysis.
- Study design informed by pilot study.
- Pilot study informed updates to DTBird system.
- The project design is well thought out and if executed properly should provide tangible results.
- This dynamic, long-term project has a very well thought out methodology. Particular strengths include:
    - 1) Testing the technology in two different landscapes since we know that landscape features have the potential to affect both the effectiveness of the camera technology as well as the response of the eagles.
    - 2) Incorporating a pathway to credibly estimate the reduction in collision risk (i.e., an efficacy rate). This will be critical in the eventual deployment of the technology since USFWS will need this data when making permitting decisions. Developers will also need this information when costing out the value of this technology in comparison to compensatory mitigation investments.
    - 3) The randomly generated transects of the UAV are really important and interesting. To the maximum extent possible, the technology should serve as a surrogate for bird flight to efficiently improve the technology over the research period.
    - 4) The long-term nature of the project is critical to its value and will provide an insight into long-term habituation, particularly for resident eagles.
- Multiple issues being explored: DTBird system recognition accuracy with respect to wild birds, other visual cues, and unmanned aerial vehicles in programmed flight patterns; and wild bird response to DTBird system.
- Two years of data at two distinct sites.
- Study team independent of system manufacturer.

Comments on Weaknesses

- Sound used as a deterrent can also be heard by people close to turbines. In the California pilot, with high eagle activity and thus frequent sound emissions, there was a neighbor complaining. There may still be work to do in the deterrent strategy.
- Were GPS-tracked birds available for inclusion in the study and/or could this have been included? How relevant is the UAV testing given the different characteristics of the target (more predictable, fewer sudden movements, etc.)? Has this error been quantified?
- Evaluate the cost associated with automated "curtailment" and operational adjustments made by biomonitors and determine if there is a meaningful difference in lost energy production. Similarly,

with automated curtailment is there a perceived need to further refine the parameters in order to reduce the lost operational hours? Or is the risk of potential collision from having too many filters in place outweighed by having gross parameters that result in slightly more curtailed hours? How much of a difference should be bookended? Finally, if there is a way to quantify the installation and lifecycle O&M costs of the system vs. annual employment of biomonitors that should be done so that stakeholders are well aware of the financial costs of the technology's use at a typical wind farm.

- 5-year overall schedule.

Accomplishments and Progress

Comments on Strengths

- No results to submit yet, but project is on track.
- Some delays in starting due to host site changes, so no results yet. Only planning the tests.
- Merit-reviewed study design approved.
- Pilot study has informed updates to DTBird system, which are currently being implemented by vendor.
- Established quantitative performance target.
- As the vast majority of this project will occur in the coming years, other than study design, there is not much to evaluate on the project implementation side. What has been accomplished to date is in line with what the project team set out to accomplish and they seem to be responding well to challenges in the field and making adjustments accordingly.
- While there has been some delay, the project appears on track. These projects are complicated to get up and running.
- Accuracy of DTBird assessed, using prior recordings by the system reviewed by biologists to assess system accuracy.
- 18 DTBird units installed at Washington site in preparation for UAV-based trials.
- Continued behavioral data collection at California site, documenting large raptor response to DTBird system.

Comments on Weaknesses

- No weaknesses noted by reviewers.

Communication

Comments on Strengths

- The communication plan is adequate, use of AWWI to disseminate the results to stakeholders is good.
- Comprehensive communication plan that includes submission of journal articles and outreach to relevant industry and interest groups.
- Third-party peer review approach. Merit-reviewed study design.
- The proposed stakeholder engagement and communication plan seems to be well developed.
- Great to see they plan to publish as well as host webinars, etc.
- Manuscripts planned (none to date).
- AWWI to promote.
- Results to manufacturer for product improvement.

Comments on Weaknesses

- Collaboration with European project would add value to the work.
- Relatively early in project, but not much outreach at this stage.

- More intensive engagement and outreach with states and federal agencies is necessary. To the extent possible, this communication and collaboration should include in-depth workshops, forcing the USFWS—including MBTA chiefs across regional offices—to directly engage. Getting ownership and buy-in from federal regulators (not just approximate knowledge) into the methodology and testing will be critical to the future success of this project. Also, it is critical to ensure that experts from USGS are engaged (both statisticians and eagle biologists).
- Work not far enough along to allow for manuscripts or presentation of results.

Upcoming Project Activities

Comments on Strengths

- Really looking forward to seeing the full outcomes of this important project!
- Possibility to test for potential habituation to the DTBird signals is good.
- Future planned activities align well with project objectives and plan.
- The proposed future activities seem appropriate and well designed.
- Future activities are overall strong and adhere to the methodology.
- Significant amount of data collection ongoing and in the future.
- Habituation to be studied by not rotating treatment (DTBird operating or muted) for full year of data collection.
- System cost analysis to be prepared.

Comments on Weaknesses

- Adding collaboration to similar projects, for example in Europe, would be great to see.
- Additional robust collaboration with Purdue and Minnesota should be integrated into the plan, as well as an engaging workshop with federal decision makers. Now that the science is available on eagle hearing, it would be a missed opportunity if these results were not incorporated into the design and testing of this project. There should also be cross-collaboration on eagle behavior (methodology and observations) to better evaluate how eagles respond to noise and how to test that.
- Significant portion of work still to be performed.

Recommendations (Not Scored)

- Important to also get the public acceptance results. Have there been complaints by neighbors for the deterrent noise?
- Comparisons to experience in Europe would be great to add if possible.
- Consider inclusion of GPS-tracked birds if this is possible.
- Strongly recommend that this work continue to be funded and proceed as outlined in the study plan.
- Plan an engaging workshop with USFWS, USGS, and state regulators to embed them further into this work. This workshop could be broader than just DT bird, but it is clear that such a workshop is necessary if these deterrents are going to have the impact we anticipate in the short term.
- Collaborate with scientists working on eagle hearing and behavior to better integrate their results in study design.
- Consider future plans to test this project in the Midwest and Northeast.
- Would it make sense to integrate the sounds identified (or at least studies) via the Purdue and Minnesota groups in the later phases of this work?

Eagle Take Minimization System

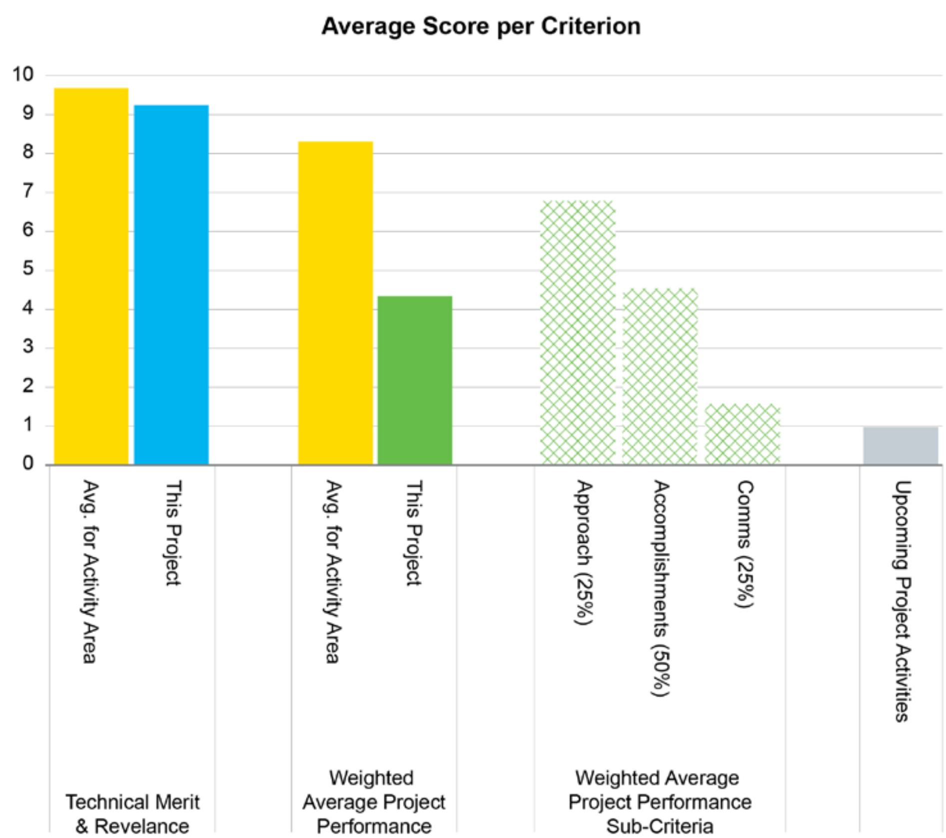
PI: Eric Laufer	Unique Project ID: M25
Organization: Laufer Wind Group, LLC	WETO Program: Market Acceleration and Deployment
Project Status: Active	WETO Activity Area: Environmental Research
Award Amount	$452,688
Cost Share	$125,910
Total Project Budget	$578,598
Actual Costs	$274,825

Project Description

Laufer Wind (LW) has developed a prototype Eagle Take Minimization System that shows capabilities for autonomously detecting, tracking, and visually identifying eagles and other protected birds out to approximately 1 km range with no human verification required. The SCADA-connected system would then trigger curtailment or activate a deterrent system.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Advancements in our ability to accurately detect specific protected birds are critical to informing cost-effective strategies for minimizing collisions.
- This project directly addresses the highly relevant issue of eagle mortality at wind turbine sites, which currently impacts operation and deployment of wind turbines.
- Technically innovative solution using radar and cameras and incorporating direct SCADA interface with turbine.
- The use of detection systems to identify at risk eagles and inform operational adjustments has long been a priority of the industry. Validation of this technology so that it can be quickly commercialized and deployable at scale is essential to addressing one of the industry's biggest regulatory/legal challenges. The design and preliminary execution of the study is well thought out and iterative, and appears focused on answering some critical questions that, if affirmed, could lead to widespread employment of the system.
- I appreciated this project team estimating what the installation costs would be for a typical wind farm. This type of information is helpful to the broader industry to understand whether or not a given technology is worth investing in as opposed to paying consultants to serve as biomonitors.
- This project is important to understanding and commercializing deterrent technologies for eagles. The commercialization of effective eagle deterrents will expand deployment opportunities and reduce permitting costs pursuant to the Bald and Golden Eagle Protection Act. This project is interesting since it incorporates a new component in its detection system: the use of radar. This expands the detection ability beyond cameras alone.

Comments on Weaknesses

- In view of other projects in this space, this technical solution looks "heavy" and complex compared to others (e.g., four radars per turbine).
- The cancellation of the project by the awardee. It would be good to understand what the cause of the cancellation was from a “lessons learned” perspective and to potentially help inform future technology evaluations.

Approach and Methodology

Comments on Strengths

- I love the idea of using drones to increase our ability to target specific species and create larger data sets looking at a broader range of scenarios (weather/lighting/forest cover/flight behavior) than would be possible using either trained birds or opportunistic wild birds. Seemed really promising!
- Use of open-source software.
- Innovative testing using UAVs disguised as eagles.
- The proposed approach and methodology appeared sound and—other than the optics of the company that developed the system to self-evaluate vs. having a third party undertake it—that work appeared to be heading in the right direction.
- The methodology was sound and it allowed for modification as the Laufer group learned more, such as the addition of a second camera.
- It is the first system that I have seen tested in the tree-abundant Northeast, a landscape very different than that of the studies that have been performed in the west.

Comments on Weaknesses

- Given that the project failed due to company solvency issues, there must have been a flaw somewhere on the project management side.
- System is rather complex with many high-cost components including radar and advanced controls incorporating machine learning.
- Appears to be turbine-level system rather than plant-level system.
- The cancellation of the project makes it impossible to truly evaluate the performance. It did appear that the project awardee was working to adjust technical issues and deficiencies. It would be good to know if the technology would have been effective.

Accomplishments and Progress

Comments on Strengths

- Eagle recognition system developed based on open-source software and trained to recognize birds with confidence reporting.
- Developed working system with cameras slewing to radar track.
- As stated above it is impossible to judge the project performance based on its cancellation.
- Laufer was able to make appropriate progress for the time that it was running.

Comments on Weaknesses

- Project was terminated by awardee prior to completion.
- It is unfortunate that Laufer could not complete the activities as intended.

Communication

Comments on Strengths

- There were no results to communicate.
- Tested system at NWTC.
- It does not seem that the awardee communicated with stakeholders to socialize the technology and project scope nor communicated with DOE, so it is not possible to judge this element of the project.

Comments on Weaknesses

- There were no results to communicate.
- No reported communications activity during project.
- While the project was terminated early, it did operate for almost a year and there was no asserted coordination or collaboration during that time. The success of all of these projects requires active collaboration given the dynamic, multi-faceted characteristics of these technologies.

Upcoming Project Activities

Comments on Strengths

- With the project cancellation this section is not relevant.

Comments on Weaknesses

- No future activities due to insolvency.

Recommendations (Not Scored)

- It would be worth investigating if DOE can recover any assets purchased for this project.
- Training data for bird species recognition using open-source Caffe software could be quite valuable and used in other projects in this space.

- The technology seemed to hold promise. Assuming the cancellation was not related to the awardee determining that the technology was ineffective, and if another company could pick up where Laufer left off, it is recommended that the evaluation continue (.
- DOE should work hard to disseminate this work and look for additional collaborators and partners, particularly other camera vendors. While it is great to see the innovation by multiple vendors around the various camera speciation algorithms, at some point, further collaboration should be pursued, particularly for those projects where DOE supported the development of the algorithm.
- While these situations (i.e., PIs going out of business) cannot be prevented, and DOE does have due diligence procedures to minimize this risk, more thought should be put into policies and procedures to prevent this, as well as to identify new partners to carry on the work. These types of situations and partnerships should be contemplated upfront. I also wonder, if Laufer had been more collaborative early on, could they have had a better chance of attracting some VC funds or at least entering into a deal with a prospective buyer of this technology?
- This project highlights the value of the TD&I program and the importance of DOE continuing to support that program. While those capabilities were not used here, it is a reminder how challenging it is for small companies to sustain the valleys of the R&D process.

A Heterogeneous System for Eagle Detection, Deterrent, and Wildlife Collision Detection for Wind Turbines

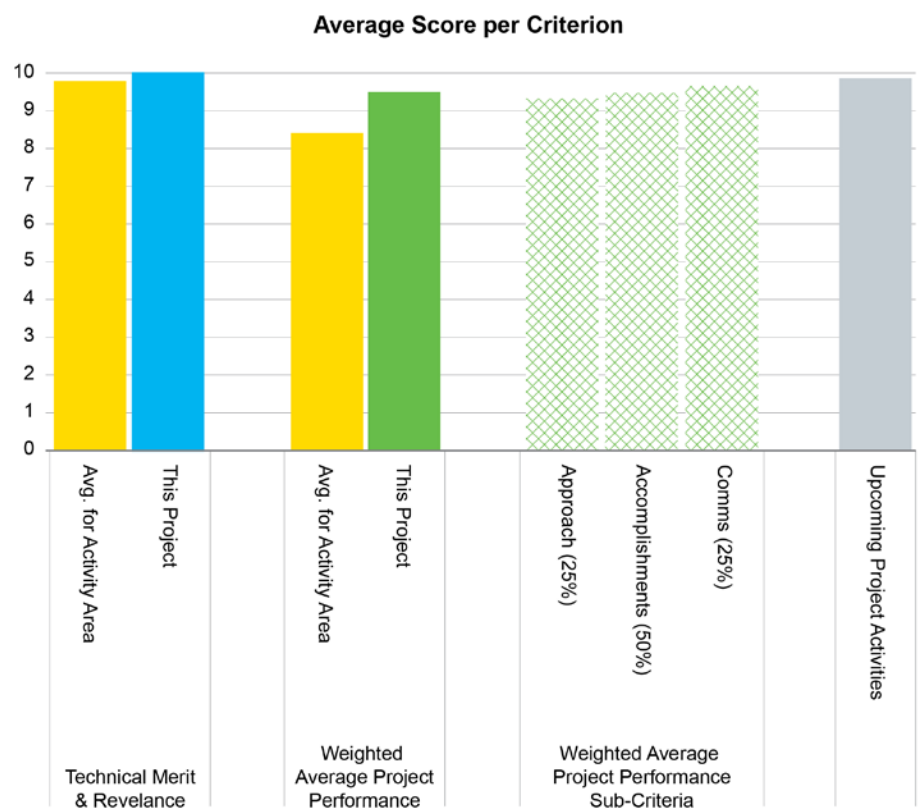
PI: Matthew Johnston	Unique Project ID: M26
Organization: Oregon State University	WETO Program: Market Acceleration and Deployment
Project Status: Active	WETO Activity Area: Environmental Research
Award Amount	$537,785
Cost Share	$62,614
Total Project Budget	$600,399
Actual Costs	$305,993

Project Description

Automated system for visual detection of eagles, kinetic eagle deterrent, and wind turbine blade collision detection using a wireless network of intelligent sensors.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- It is extremely valuable to advance commercial availability of a system that can accurately detect specific birds of concern and assess if a visual deterrent (especially one so cheap and easy to deploy) will reduce collisions, especially given that, in some locations, there may be public acceptance issues with application of acoustic deterrents. Additionally, validating ability of blade sensors to confirm collisions will be a really helpful advancement to apply offshore where it is far more difficult to track collisions.
- A full eagle mortality mitigation system using automated visual detection, kinetic deterrents, and wind turbine blade collision detection connected to a wireless network of intelligent sensors.
- This project directly addresses the highly relevant issue of eagle mortality at wind turbine sites which currently impacts operation and deployment of wind turbines.
- Coherent solution involving detection, deterrence, and collision monitoring.
- Relatively simple system compared to some other solutions.
- The use of detection (and deterrent) systems to identify at-risk eagles and inform operational adjustments has long been a priority of the industry. Validation of this technology so that it can be quickly commercialized and deployable at scale (if determined to be effective) is essential to addressing one of the industry's biggest regulatory/legal challenges. The design and preliminary execution of the study is well thought out and iterative, and appears focused on answering some critical questions that, if affirmed, could lead to widespread employment of the system.
- This project is incredibly important to understanding and commercializing deterrent technologies for eagles and potentially other birds offshore. The commercialization of effective eagle deterrents will expand deployment opportunities and reduce permitting costs pursuant to the Bald and Golden Eagle Protection Act. This project had particular merit since it took an interesting approach to testing new frontiers for deterrents and monitoring.

Comments on Weaknesses

- Without more data, I do not agree with the claim that a system designed to detect and deter eagles would be "broadly" applicable to other birds or bats given the differences in size/behavior/etc.

Approach and Methodology

Comments on Strengths

- Love the three-step approach: detect, deploy deterrent, and validate. The camera-based system to validate collisions at the blade is particularly valuable.
- Combining 3 different phases: detection, deterrent activation, and monitoring of potential collision.
- Software development with possibility to use several types of hardware to detect and deter or curtail the turbines.
- Highly integrated system where sensors and detection equipment reside on and within the turbine itself.
- Innovative, low-cost kinetic deterrent.
- Triggered usage of deterrent to mitigate habituation.
- The study design is thorough and the stepwise approach should allow for adjustments to be made throughout the study period. While much data points to eagles being easily adaptable so they quickly habituate to deterrents, it will be interesting to see if the deterrent system coupled with the detection system increases effectiveness in collision avoidance. One recommendation along those lines would be to have a paired system evaluated alongside just a detection system and just a deterrent system to see if any statistically significant difference exists. Additionally, given the

potential for habituation, the effectiveness of the deterrent systems needs to be evaluated over several years at the same location.

- The most innovative, interesting, and impactful part about the approach taken is the researchers' ability to craft an integrated system that is incredibly modular. This means that the researchers are not only advancing a particular system that could prove useful in deterring avian collisions, but it also has the potential to move forward three distinct components that could eventually be integrated in different systems or technology. These three components each have their own merit. Perhaps the most innovative of the three is the automatic blade-collision detection for continuous monitoring. Advancing such a technology could have wide application across the industry, especially offshore. In addition, the integrated deterrent tests an idea that has been discussed frequently, but I have yet to see explored in a scientific setting: the use of a humanoid "air dancer."
- If another researcher advances a better version of one of the three components being tested, that superior method or equipment could easily be swapped into the integrated system. Again, the flexibility and modularity are really impressive.

Comments on Weaknesses

- It would be great if there was some way to track these results over a longer time scale to determine if eagles in the area who are initially deterred then become accustomed to the humanoid and do not see it as a danger to be avoided.
- The deterrent part is quite weak as not sure if the kinetic scarecrows actually work with eagles or how they should be positioned.
- Building a modular system so deterrent part could be different, or curtailment.
- Seems like inclusion of an automatic curtailment module would increase the value of this system.
- Seems like it would be relatively simple to include an acoustic deterrent in addition.
- Has the deterrent effectiveness of the "scarecrow" been tested?

<u>Accomplishments and Progress</u>

Comments on Strengths

- Results seem really strong and project is well positioned for final tasks.
- Complete and integrated system demonstrated: validated eagle detection from real-time 360º camera stream, remote wired and wireless triggering of kinetic deterrents, and continuous, on-blade monitoring for impact detection and image capture of colliding objects.
- 3D camera-based eagle detection system has been developed and trained, and has achieved a 91% accuracy level for eagle vs. non-eagle target identification so far.
- Recorded 10 flight videos over three days.
- Color of humanoid air dancer optimized based on M23.
- On-blade collision detection system developed and deployed.
- Integrated system testing underway.
- Given that this is an early-stage project, there is not much to be evaluated at this time, but what has been undertaken to date seems to be achieving good outcomes and the project team is sticking to its schedule.
- The project is on track with accomplishments.

Comments on Weaknesses

- It would have been good to get information on validation of the kinetic deterrent.
- Has testing of kinetic deterrent effectiveness taken place?

Communication

Comments on Strengths

- Project team has done an impressive number of presentations and generated a lot of media coverage, which is great for helping increase public awareness of the research going into these kinds of strategies to protect wildlife and help the industry resolve potential conflicts.
- Plans to disseminate include reporting, presentation at conferences, and publishing—the list at this phase of project is very good.
- Coordination with M23 to inform color of kinetic deterrent.
- Local media coverage.
- Patent application.
- Local community outreach.
- Through presentations and publications, this project seems to have been socialized well with stakeholders.
- Strong communication and collaboration to date. It is great that they are taking advantage of the NWTC. This is a perfect project for this use. Also, it is great that they were able to get media coverage in Oregon. It is also valuable that they had engaged Todd Katzner and Manuela Huso at USGS.

Comments on Weaknesses

- For this project, mere scientific publication and presentation is not quite enough; engagement with industry and commercialization activities are also needed.
- From a commercialization perspective, could consider detection component market separately for inclusion of third-party deterrent systems.

Upcoming Project Activities

Comments on Strengths

- This is a really important project. The final tasks described in the presentation and accomplishments section are exciting, essential steps toward taking the promising results from testing each module and combining them into a package that can advance toward commercialization.
- The testing plans are good.
- Future planned activities align well with project objectives and plan.
- The proposed future activities seem well designed and, if executed properly in the field, should result in answering questions on the viability and effectiveness of the technology.
- The upcoming project activities align with the methodology.

Comments on Weaknesses

- The project description did not contain a separate section on upcoming activities, which would be helpful.
- Not much information on this part. Activities towards commercialization/further dissemination could have been mentioned.

Recommendations (Not Scored)

- Unless the deterrent part proves successful in field tests, the collaboration of this project with others in the FOA could be a good idea.
- A key strength of this project is the simple, single-camera-based detection system that shows good potential accuracy. If the solution is developed in a modular way, this system could be combined with other deterrent systems. It seems like this would be a good idea to consider.

- Highly recommend continued funding of this project. The only recommendation to the project team is to attempt to estimate the cost of the initial installation of the technology along with the projected repair rates/costs, replacement rates/cost, and general O&M costs during the lifecycle of the devices and typical operational life of a wind farm (e.g., 20–30 years).
- Collaborate with other video algorithm developers prior to testing the technology, particularly with the researchers at PNNL. This will be valuable for fine tuning the AI, as well as considering the integration of thermal trackers offshore. Track results from Purdue regarding the effect of visual and noise deterrents on eagle behavior and incorporate any lessons learned with the deterrent system.

Project Results - Siting and Wind Radar Mitigation

Siting - Radar Wind-Turbine Radar Cross-Section Mitigation

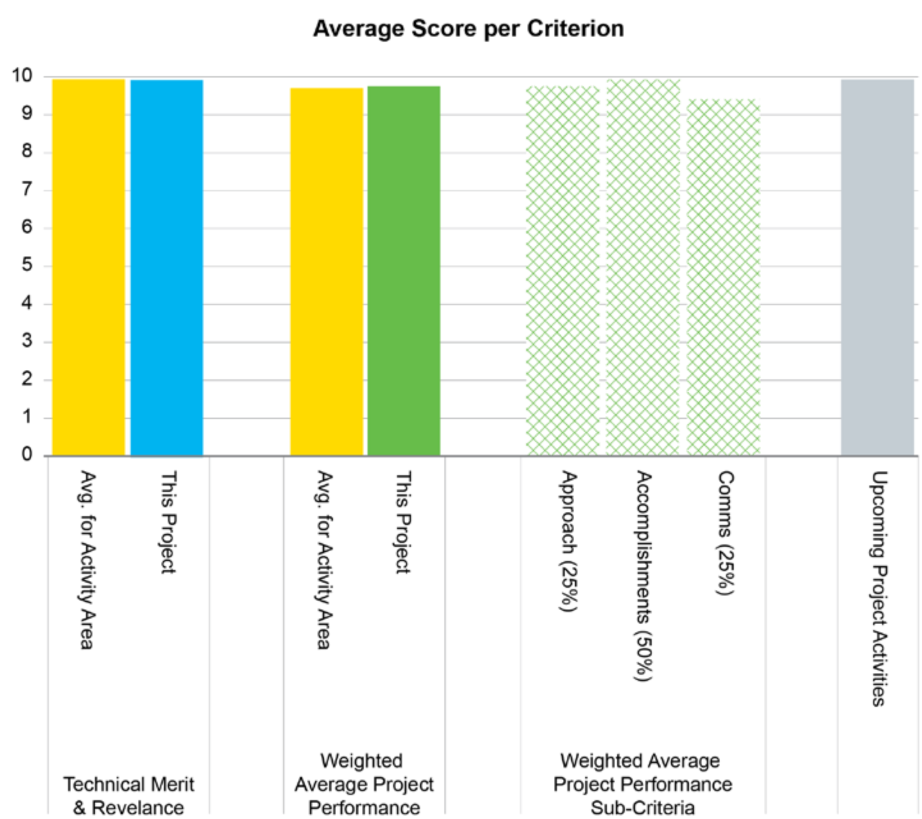
PI: Benjamin Karlson	Unique Project ID: M10
Organization: SNL	WETO Program: Market Acceleration and Deployment
Project Status: Active	WETO Activity Area: Regulatory and Siting
Total Available Budget (FY17 & FY18):	$1,501,084
Actual Costs (FY17 & FY18):	$1,125,521

Project Description

This effort is aimed at solving deployment barriers for wind energy systems by developing mitigation methods that reduce or eliminate the adverse effect of wind turbines on radar systems. Sandia will continue to support and lead Wind Turbine Radar Interference Mitigation (WTRIM) activities including strategic planning and field-testing, as well as mitigation technology development, demonstration, and deployment. The work plan for FY17 and FY18 is aligned with the Federal Interagency Wind Turbine Radar Interference Strategy published by the DOE.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Addressing real or perceived impacts of wind turbines on radar is essential for continued deployment of wind energy in the United States, both onshore and offshore. This is a very big deal for national security, so it is great to see this effort pulling together all of the major players in the federal family to ensure a forum and process for all these key players to engage in identifying issues and potential solutions.
- Radar impacts of wind is more and more important to assess with increased deployment and land use need also close to radars. The project directly addresses this barrier to wind deployment, with all authorities present.
- Highly relevant issue which has the potential to deny much land area to wind power developers.
- In addition to finding solutions to avoid and minimize environmental impacts, finding solutions to reducing wind energy's impacts on radar systems has been and continues to be a top industry priority.
- The project's focus and results hold much promise for resolving much of the conflict between radar systems and wind energy development and operations.
- Siting wind turbines requires a significant number of considerations. We need diverse solutions to overcome these diverse barriers if we are to have sufficient siting opportunities to meet industry goals. New solutions to overcome radar challenges provide a significant opportunity for expanding deployment opportunities.
- DOE plays a critical role in overcoming these challenges due to its credibility and ability to bring various agencies together and serve as an objective centralized role. DOE has done this effectively through its development of a working group that brought six Federal agencies together to work collaboratively. Also, the Travis Air Force Pilot project is an important effort to advance solutions while building trust and understanding.
- Addresses a critical industry need for procedures and technology solutions to minimize conflicts between air traffic control and weather and defense-related radars, which can result in hazard determinations on the part of the FAA, which, in turn, can preclude turbine placement or entire project construction.
- The solutions explored include both those associated with radars and wind turbines.

Comments on Weaknesses

- Turbine-associated solution explored (alternative lightning protection systems) are not promising with respect to all radar types.

Approach and Methodology

Comments on Strengths

- The WTRIM is a really important forum and the range of tools created all seem useful and relevant.
- Working group of the authorities is a direct way of working to mitigate the radar issue with wind.
- The main way forward is through using infill radars and developing the signal processing of radars, but there is some work also for wind turbine technology development. Focus on lightning protection and cables in the blades. And, developing a public tool for siting will help developers.
- A coordinated approach that involves collaboration, tool collection, development, and specific mitigation projects.
- The sequential approach of this study and methodology employed to answer the critical questions related to the effort seem thorough and well-developed.

- The ability for DOE to bring very different agencies together through this working group and the execution of an MOU, assess challenges, and advance solutions is vital to overcoming these challenges. It also allows DOE to assess and vet a variety of radar challenges in a centralized manner.
- This project fosters the development of relationships, as interpersonal dynamics are one of the most important factors in overcoming these challenges. Moreover, it allows cross-pollination across radar technologies and uses. Some of the lessons learned in one context may be applicable to another. By doing this, DOE is fostering collaboration and is bringing fact-based information to both federal agencies and developers. It is also advancing on-the ground solutions and ensuring federal agency ownership and engagement from the beginning.
- The working group also does a great job keeping work on task from the various agencies. The pilot mitigation project at Travis Air Force is a great way to evaluate technologies while building support within DOD for solutions.
- By including BOEM in the working group, the project is looking at offshore and the challenges that will exist there in a timely manner. BOEM can also quickly learn from the onshore experience.
- Wind Turbine Radar Interference Mitigation (WTRIM) Working Group involves full cross-section of agencies with stakes in radar operations, bringing together a strong team that includes Sandia, MIT Lincoln Lab, and Air Force Research Lab. Full range of approaches has been undertaken from modeling to field demonstrations of mitigation options.

Comments on Weaknesses

- It would be great to have NOAA & BOEM as actual participants, not just observers. Given how big of an issue this is already becoming in the offshore space, it would also be good to include the Coast Guard.
- NOAA not being very cooperative.

<u>Accomplishments and Progress</u>

Comments on Strengths

- This project has a really impressive list of accomplishments, from convening key players to testing out technologies. Very diverse, relevant outcomes.
- Working group facilitation and activity was at a good level.
- Tools development. NEXRAD is helping developers. Also, it would be helpful to provide a list of tools with the report.
- Turbine blade modification regarding lightning-protection cables is promising, even if it was mainly working for some frequencies.
- The project appears to have had a major impact in bringing stakeholders together. The capability to assess the impact of potential developments appears to have increased dramatically.
- The Pilot Mitigation Project at Travis AFB is an excellent example of multi-stakeholder cooperation that is having a real positive impact on the issue. Lightning cable-radar cross-section reduction mitigation working at certain frequencies, but more research is needed.
- The project has achieved most of what it set out to address and what remains should be completed in the near future.
- There have been numerous accomplishments. First, publishing a strategy as well as progress brings cohesion and transparency to the work. Moreover, success is evidenced by the agencies' agreement to continue participation in this working group. There also have been several important outcomes in solutions. The ability to successfully manage a dynamic working group while developing outputs can be challenging. Sandia has done a great job doing both.
- NEXRAD screening tool developed and made available for wind industry use in siting decisions.
- Fully executed a Pilot Mitigation Plan for Travis Air Force Base.

- Developed candidate mitigation approaches for Cannon Air Force Base and Fort Drum.
- Identified alternative turbine lightning-protection systems with applicability to some radar systems.

Comments on Weaknesses

- Limited progress with NOAA.

Communication

Comments on Strengths

- Very robust external communication efforts and deliverables.
- Working group allows for direct communication with all of the authorities.
- Publications provided to help the developers/wind deployment activities.
- There is some contact with wind turbine manufacturers and more with radar manufacturers to inform them of mitigation measures that are available for any new radars that are purchased.
- Significant number of publications.
- Project involves a high degree of collaboration which appears very effective.
- While this specific project does not lend itself well to broad stakeholder engagement, the continued communication with AWEA and the development community throughout the study period seems sufficient and appropriate.
- The working group ensures significant coordination and collaboration. The pilot project and open house at Travis Air Force Base is such an important opportunity for DOD and the wind industry to build relationships, trust, and an understanding of priorities. It also provided opportunities for face-to-face engagement such as the wind industry listening session.
- Extensive activity on Sandia's part via the WTRIM.
- Hosted wind industry at Travis Air Force Base in briefing on the mitigation project at that site.
- Participated in industry-sponsored listening sessions and conferences.
- Website on radar mitigation.

Comments on Weaknesses

- More focused attention to help BOEM and NOAA address this issue in the offshore space would be most helpful. Currently, DOD appears to be taking massive ocean areas off of the table for offshore wind energy leasing when there are strategies that may be deployed to address interference issues in a project specific context when the time comes.
- It is obvious that not all materials from this work can be published and disseminated more widely.

Upcoming Project Activities

Comments on Strengths

- This effort is really important, so I am glad to see it continuing to address the key issues in this area as they evolve.
- The upcoming activities are outlined in a very general way, other than FY2019 finishing the tools and reports from FY2018. Radar impacts on wind are more and more important to assess with increased deployment, as is land use close to radars. Good to see that this work is continuing.
- Future work appears to be well-aligned with the project objectives and plan.
- The remaining activities seem appropriate for answering the residual questions and supporting the study design and goals.
- These are strong upcoming project activities, which will be important for meeting industry and agency needs.
- Continuation of full scope of activities planned.

Comments on Weaknesses

- Offshore wind needs very focused and resourced attention in this area, which seems like a major missed opportunity in both the current and future iterations of this project.
- It looks like the NEXRAD tool still needs work for the NOAA radars, including mitigation measures. (This may already be in the upcoming activities.)
- It could be useful to assess whether NEXRAD or a related tool could be made in a way to show if a potential wind site would be okay or if mitigation measures might be needed without giving out the sites/coordinates of radars. Perhaps mixing all three types of radars and giving a green/yellow/red code would allow all radars to be included in the tool, which would help the developers a lot.

Recommendations (Not Scored)

- Further development of NEXRAD needs to be done to include more radars and potential mitigation measures.
- It is important to have radar manufacturers involved in future phases, as well as turbine/blade manufacturers to the extent that the turbine technology developments are seen useful. Main mitigation impact will come from developing the radars.
- This work remains a high priority for the industry and should continue to be funded by DOE.
- Continue investing in this working group. Also, identify alternative opportunities for pilots and integrate more non-governmental stakeholder engagement.
- I very strongly recommend continuing this overall effort. I suggest a stronger interagency approach to engaging NOAA meaningfully.

Siting - Wind Turbine Radar Interference Mitigation R&D

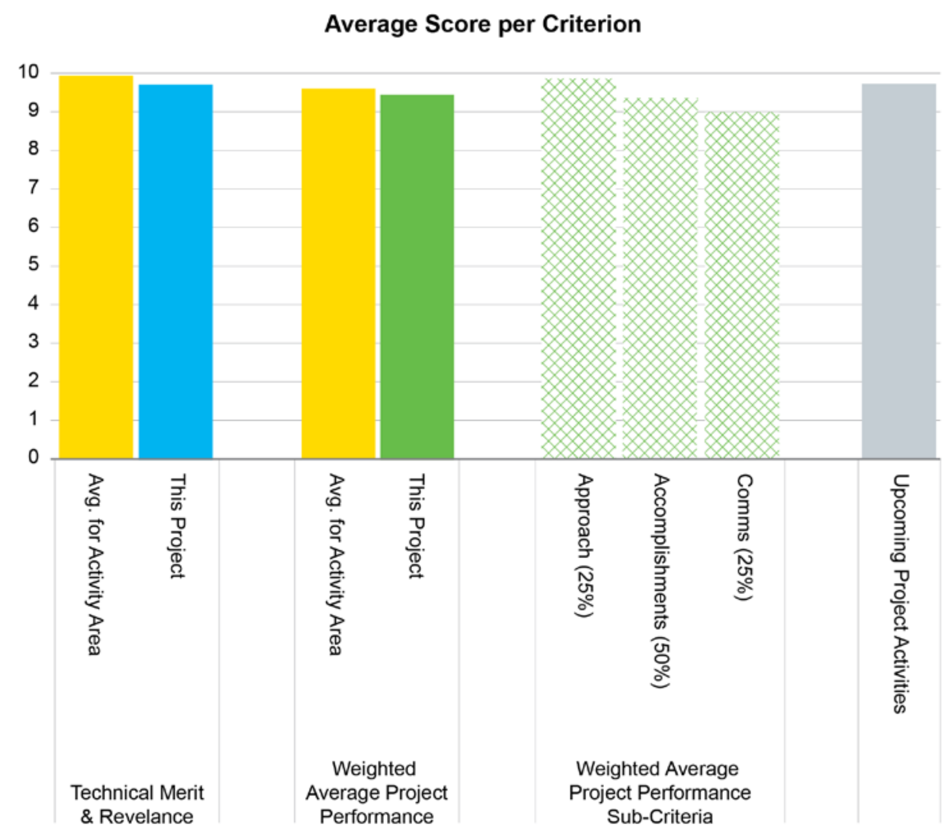
PI: Jason Biddle	Unique Project ID: M11
Organization: MIT Lincoln Labs	WETO Program: Market Acceleration and Deployment
Project Status: Active	WETO Activity Area: Regulatory and Siting
Total Available Budget (FY17 & FY18):	$1,768,294
Actual Costs (FY17 & FY18):	$792,794

Project Description

This effort is aimed at solving deployment barriers for wind energy systems by developing and evaluating mitigation methods that reduce or eliminate the adverse effect of wind turbines on radar systems. MIT Lincoln Laboratory draws on deep radar expertise to support Wind Turbine Radar Interference Mitigation (WTRIM) tasks such as interference modeling and mitigation development and demonstration. The work plan for FY17 and FY18 is aligned with the Federal Interagency Wind Turbine Radar Interference Strategy published by DOE.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Addressing real or perceived impacts of wind turbines on radar is essential for continued deployment of wind energy in the U.S., both onshore and offshore. This is a very big deal and it is great to see this project focus on the technological solutions. Exploring options that can work with existing radar systems as well as the exploration of next generation systems, since both applications will likely be needed to solve for this issue.
- Radars will be a considerable barrier to wind deployment. Improving the resilience of radar operations in the presence of wind turbines and removing radar interference is a challenge that must be addressed for the future wind energy development.
- Project directly addresses highly relevant issues, which have the potential to deny much land area to wind power developers.
- Combines a broad range of strategies to address the issue.
- Proactively addresses the emerging issue of offshore wind turbines.
- In addition to finding solutions to avoid and minimize environmental impacts, finding solutions to reducing wind energy's impacts on radar systems has been and continues to be a top industry priority. The project's focus and results hold much promise for resolving much of the conflict between radar systems and wind energy development and operations.
- The merit of this project is strong given the variety of ways the research and efforts are used to overcome radar-related barriers.
- Addresses industry need for mitigation of impacts to air traffic control, weather, and defense-related radar systems.
- Glad to see the Block Island Wind Farm and other coastal sites analyzed given how much of an obstacle radar conflicts has already become for wind development offshore.

Comments on Weaknesses

- No weaknesses noted by reviewers.

Approach and Methodology

Comments on Strengths

- The task list is a great mix of key venues and needs for solving this issue.
- This project is collaborating well with project M10 on stakeholders/authorities and is addressing several topics on interference modeling and mitigation development and demonstration in this two-year phase.
- Visual classification tool that automates data collection from several authority sources provides a good link to the turbine database in another project that can be checked before using in M10 NEXRAD.
- Combines a broad range of strategies for a theme-based approach to issue mitigation.
- Combines technology and data processing-based approaches to issue mitigation.
- Aims to increase the quality of tools and data available to decision makers to assess the severity of the issue on a case-by-case basis.
- The study design and approach were well thought out and were very thorough in evaluating multiple aspects of the issue.
- This was a strong multi-faceted portfolio that evaluated several different pathways for mitigating radar risk. The portfolio addresses a myriad of threats, from pre-planning in the offshore wind space, to integrating existing radar systems, all the way to evaluating infill systems and software

updates. This project took a unique multi-faceted approach to drive solutions and alternatives depending on the landscape and technology.

- Strong foresight to map offshore environment and future radar challenges. Now is the time we can get in front of these challenges offshore; particularly because the offshore environment is actually pretty crowded. So, it is important to reduce limitations based on radar. In addition, change is hard, so it is important to educate and accept work on the front end.
- The methodology is strong in that it leverages existing capacity to solve problems in an analytical, fact driven way, with the ability to add data feeds from other radar sources to mitigate some of the deterioration caused by wind turbines.
- The Travis Air Force Pilot project is also one of the most important things DOE is doing in this space related to DOD. The military faces enough risk and uncertainty in advancing their mission. In addition to their mission-critical work, DOD faces significant burden regarding their land management status. To the extent DOE and the wind industry can validate the effectiveness of these technologies on the ground, partnering with DOD to reduce risk and burden is better.
- Even though it wasn't successful, it was also important to evaluate whether existing radar systems can be upgraded. At this time, it doesn't look cost-effective, but it is a good baseline study and helps developers understand the best approach for mitigating radar barriers.
- The GIS automation work to identify decommissioned turbines is an interesting aid on to this work to improve the turbine location database. I was pleased that they published an article since the science is evolving quickly in this work and its applicability.
- Multi-pronged approach to various aspects of the problem, including improvement to inventorying of wind turbine fleet potentially interfering with radar; analysis of additional radars' (new or existing) ability to enhance coverage; improvements to radar signal processing to mitigate wind turbine interference; and initial assessment of offshore wind's impacts to coastal radar systems.
- Technically proficient investigator(s).

Comments on Weaknesses

- No weaknesses noted by reviewers.

<u>Accomplishments and Progress</u>

Comments on Strengths

- For offshore wind, it is very valuable to know as early in the process as possible if there are areas that potentially present conflicts due to radar.
- Signal processing to add data feeds from existing radars not in the current operational automation network, as well as future radar capabilities. Coastal study to screen for potential radar impacts. Travis pilot recommendations to use infill radars put into practice.
- Automated visual identification of decommissioned turbines appears to have been very successful.
- Successfully demonstrated how multiple overlapping radars can eliminate/reduce interference from WTGs.
- Offshore areas where wind power development would interfere with radar systems proactively identified.
- Successfully demonstrated how advanced signal processing can mitigate clutter in capable systems.
- Has produced signal processing recommendations for clutter avoidance in future radar systems.
- Ongoing test of mitigation measure effectiveness at Travis AFB a significant achievement and appears very valuable.
- The project performance and goals achieved by the project team were exceptional—essentially answering all of the questions they set out to evaluate. Progress appears to fall within the project schedule and budget.

- Very important project to identifying real deployable solutions to address radar barriers.
- 4 of 5 tasks completed.
- Determined that advanced signal processing is probably not an option for existing systems, but probably feasible for future systems.
- Demonstrated that including additional existing radars into network can resolve conflicts in certain circumstances.

Comments on Weaknesses

- It seems like the project was less successful in finding solutions to existing radar systems. I remain unclear which is a higher priority, but given what I assume is a wind range of economic contexts where this issue comes up, it seems important to have solutions for both.
- Task 4 ongoing and is to be completed in 2019, so the demonstration of in-fill radar's ability to resolve conflicts is not fully validated.

Communication

Comments on Strengths

- Communication with the government seems strong and it is very important to follow all protocols necessary to avoid any security risks.
- Good list of publications and collaborations. Dissemination to the working group of authorities is an impactful way to go.
- Impressive degree of cooperation between research, government agencies, and interest groups.
- Two publications in the public domain and three for restricted distribution.
- The socialization of the project design and results appears to be appropriate and well executed.
- Strong set of written reports and communication materials, even if they were limited in circulation.
- Modest open-source and limited-distribution manuscripts.

Comments on Weaknesses

- Information is not very accessible beyond those with a clearance, which seems like an aspect of this that will need to change moving forward in order to get the information and technologies to those who will need them.
- It is understandable that not all of the information is public.
- Potentially more outreach could have been done with industry stakeholders since they are not part of the federal agency working group.
- The sensitive nature of the topic, radar system characteristics, limits the opportunity to widely publicize results. Not the fault of the investigator(s).

Upcoming Project Activities

Comments on Strengths

- This is really important work to continue, especially in the offshore space.
- Important topics covered for future and ongoing work include pilot mitigation projects, offshore, and turbine layout impacts.
- Upcoming activities appear well aligned with the project objectives and plan.
- The remaining efforts related to the effectiveness of infill radar systems to reduce the impact of wind farms on military radar is essential to being able to demonstrate that the impacts are mitigatable, and that wind energy development and military installations can coexist.
- Strong set of future work, particularly the focus on pilot projects. Wind farm layout optimization is also something worth exploring, especially offshore, where the resource is less variable.
- Completion of Task 4 is important for validation of infill radar as mitigation.
- Analysis of wind project layout design as potential mitigating factor worth exploring.

Comments on Weaknesses

- Please make sure that the role/need for radar and wind turbine/blade manufacturers are appropriately addressed.
- The schedule was probably not under the control of this team.

Recommendations (Not Scored)

- There is still a lot of technical work to improve the radars, as well as stakeholder work regarding mitigation measure uptake. Glad to see that this work is continuing.
- Can infill radar systems also play a role in bird collision identification/avoidance. Is a combined solution worth investigating?
- As noted above, this work is critical to solving one of the industry's biggest siting/operational challenges, and it should remain a high priority for DOE. It should continue to receive funding until the questions are fully answered. Any software or hardware solutions should be rapidly commercialized once available.
- More outreach to industry and other related stakeholders invested in siting. Understanding these limitations and opportunities is important. This is also true for state agency officials and other agencies as sometimes radar siting issues are exploited to achieve other aims.
- Activities outlined in Upcoming Project Activities in the write-up deserve support.

National Wind Turbine Database and Location Impacts R&D

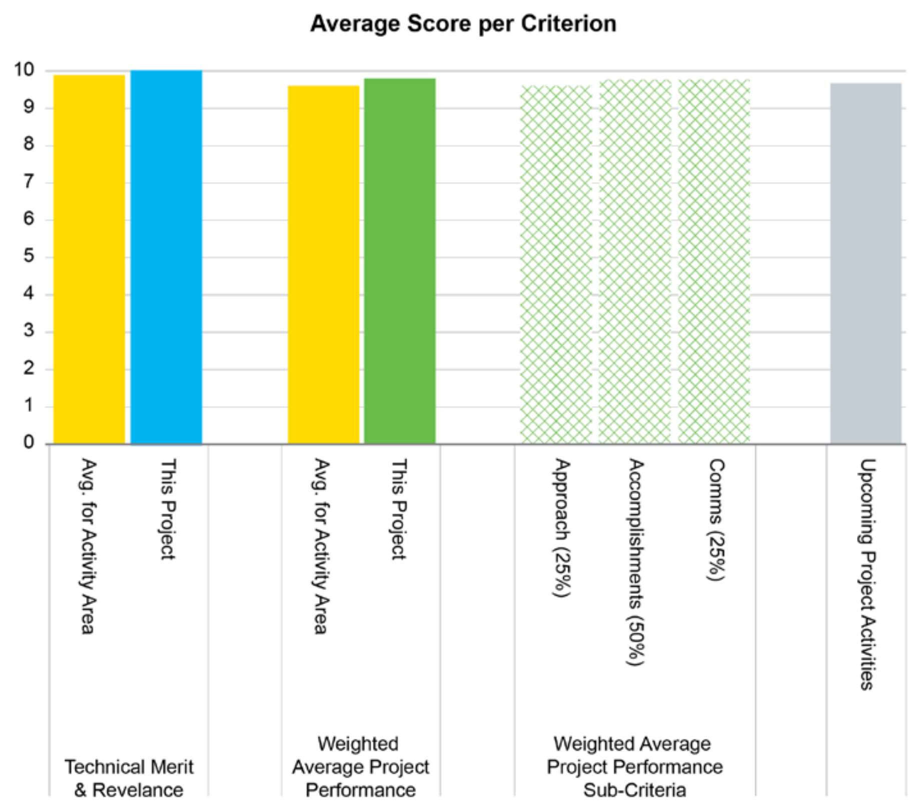
PI: Ben Hoen	Unique Project ID: M12
Organization: LBNL	WETO Program: Market Acceleration and Deployment
Project Status: Active	WETO Activity Area: Regulatory and Siting
Total Available Budget (FY17 & FY18):	$1,214,449
Actual Costs (FY17 & FY18):	$586,837

Project Description

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 modeling results on turbine sound.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- This is such an important project that makes it possible to produce many helpful reports and analyses, as wind energy ramps up in the United States. It is essential for helping produce compelling, credible, and current information needed to help push back on grounded myths about wind turbine development. The fact that the FAA database was out of date, (i.e., showing turbines that aren't there and not showing those that are) was an important issue to address given that out-of-date info could be inaccurate.
- In addition to supporting the radar impact mitigation with location database, it provides important public acceptance-related work. Work on noise annoyance is very important and will grow even more so as larger turbines get deployed and as the sites get closer to houses.
- The project directly addresses highly relevant issues which have the potential to deny much land area to wind power developers.
- It puts quality information directly in the hands of all parties impacted by the issue.
- This work was absolutely outstanding and critically important to answering the questions related to wind turbine annoyance and creating a web-based tool to evaluate turbine deployment impacts on civilian and military radar systems.
- With respect to the latter, being able to evaluate existing system impacts and allowing for improved siting to avoid and minimize impacts related to future development provides a significant value to the industry.
- On the former, having a robust, unbiased data set regarding annoyance that can be used by developers in siting and defending applications before state and local permitting authorities on issues regarding sound-health and annoyance (as well to inform future research) is simply priceless.
- This project includes a strong methodology that addresses significant social science-related barriers to wind energy development. These are nuanced barriers, and we need to better address and overcome them. In addition, the U.S. turbine database can be effectively applied in a variety of circumstances from understanding interactions with radar, social acceptance, and natural resources. It is also valuable in understanding industry trends.

Comments on Weaknesses

- The three sub activities in this project are very different, yet each plays an important role in addressing constraints to siting. Each activity expands our understanding of key challenges and trends in those challenges, while providing policy makers important insight into meaningful and effective approaches to overcome them.
- From these activities, we can better understand how wind is affecting communities and the environment (based on a critical, objective analysis), where it may be appropriate to site wind in the future, and what areas may not be viable.

Approach and Methodology

Comments on Strengths

- I love the idea of combining sound modeling with survey data on actual impacts to neighbors to help dig deeper into what is actually fueling the opposition. It is great to see focus on making sure data is getting used by a variety of stakeholders. Love the PAW study, especially the focus on the "highly annoyed" since they pack a bigger punch in the permitting and political processes needed to move wind energy forward.

- Good work on the turbine database, linking it to use by authorities and the public. Excellent analysis of the public survey, processing the data to a national data set of wind neighbor survey responses, and combining the results with noise audibility and annoyance modeling results.
- Good collaboration internationally through IEA Wind Task 28 and EU project.
- It continues the development of a tool that has proven itself useful by understanding data needs of those using the tool and combining various big data sources to produce a high quality, authoritative, and reliable data set, which earns a high degree of confidence across the industry. It addresses public acceptance issues with objective and directed research, and its specific focus on audibility issues is timely.
- I cannot say enough positive things about the design of this study and the methodology utilized to develop it. Kudos to the LBNL team (as well as MIT Lincoln for their assistance).
- The U.S. Wind Turbine Database provides value across all stakeholder groups more than any other resource that DOE produces. It provides mission critical value to several federal agencies, and this value will only increase as the wind industry fleet expands. It's also incredibly valuable for managing wildlife resources and understanding industry trends. It allows practitioners to assess the cumulative development of wind across the landscape (nature and extent) and understand what that means for conservation and strategies to mitigate future risk. It is also valuable for transmission planning.
- The metadata in this database is impressive since it incorporates extensive data related to the wind facility (including specific information about the individual turbines). It is also a highly reliable source given that every turbine in the database is geo-referenced.
- The public acceptance research is critically important. As the industry builds out and moves into new geographies, particularly the southeast, understanding the social science behind siting will be critical for gaining acceptance and advancing deployment. Siting for people and wildlife are often at odds. Areas near communities are often more degraded and are lower habitat quality.
- However, these areas often face opposition from community members, which drive developers to more remote places—areas that tend to be higher quality for wildlife. This creates a real tension in siting. Accordingly, just as we strive to understand wildlife and opportunities to address impacts, we need to understand people so the industry, communities, policy makers, and land managers can make fact-based decisions.
- The noise study is important since this is a real concern for neighbors and landowners, and the real effects of it should be understood. It is also incredibly timely given recent concerns raised by the current Administration. It was also strategic to study both annoyance and audibility.

Comments on Weaknesses

- The public survey was designed to get good national coverage. While 1,700 answers sounds like ample material, the distribution of sites made it less useful than it could be. It would be helpful to give more detailed information to assess the impacts of turbine size to acceptance/noise levels.
- The noise audibility/annoyance model used did not seem to account for the low frequency noise being more disturbing, while some studies use a correction curve to take that into account.

Accomplishments and Progress

Comments on Strengths

- Having 1 million users for the database is just phenomenal. Very strategic to create a secure section so it can also have information that’s not public, but that is needed for government/security purposes. Really interesting findings about what is underpinning wind energy opposition (i.e., not proximity as much as perception of the planning process). The project demonstrated that there's a silent majority of support alongside the vocal minority. This kind of information on an ongoing basis is extremely valuable for informing strategies to neutralize opposition.

- Database work has had a good impact.
- In the public acceptance survey, important results have been drawn and published to disseminate, similar to results in other countries. Opening the materials for further use is good.
- The materials could show the same results about noise that has been found in some European studies (i.e., in Finland) that annoyance is more correlated with attitude than with audibility.
- The project has produced a very useful tool, based on a high quality, authoritative, and reliable data set, which earns a high degree of confidence across the industry. The large number of users of the database demonstrates the tool's usefulness.
- The project team appears to have stuck to their schedule and achieved all significant milestones on time and within budget.
- Strong accomplishments on all front.

Comments on Weaknesses

- I think that the original design of the survey had enough material to draw upon to answer questions about exploring turbine technology that could be changed to reduce noise impacts, yet I didn't see any such statements.

<u>Communication</u>

Comments on Strengths

- The outreach with this information is almost as important as generating the information itself! The communications plan appears solid and comprehensive.
- The database has excellent usage. It is clearly useful and has a good impact.
- Good publishing and dissemination on the public acceptance survey, which can also be used as a database in the future.
- Significant number of publications results from the work.
- High degree of collaboration across all work streams.
- The level of communication and collaboration on this project was outstanding and very thorough.
- The communication and coordination have been incredible. They have done a great job at publicizing the results and ensuring the right stakeholders have an adequate understanding of the results.
- European collaboration on the public acceptance side comparing and contrasting results itself can yield information.
- Leveraging the WTRIM and the collaboration that exists there.
- So many great papers and excellent summaries online.
- The half day workshop at AWEA siting really allowed key stakeholders to delve into the substance and understand how this may affect their work.

Comments on Weaknesses

- The noise audibility/annoyance work could have benefited from international collaboration.

<u>Upcoming Project Activities</u>

Comments on Strengths

- It is great to see this work continuing.
- It is good to keep updating the database, as it clearly gets a lot of use.
- Interesting way to assess the wind power plant benefits on local districts through taxes using school district data.
- Very good to include future turbines/noise studies.
- Upcoming activities appear to be well-aligned with the project plan and goals.

- The proposed future activities continue to build on the great work of the LBNL team and seem to be the logical next steps in demonstrating the value of wind to communities, now that the impact to the human environment are better defined and understood.
- Better understanding the differences between what has been noted in the EU and here in North America will be enlightening. On the radar work, continued and increased access to the data and expansion of capabilities will be key to getting other stakeholders comfortable with the deployment of wind in the years to come.
- It was incredibly impressive to hear the ideas for the future. Continuing to study the effects of noise should be a priority to fully understand the issue and share fact-based information publicly.
- The planned economic study on the influence of wind energy development and school funding is so important, and even more valuable if that funding could be tied to the quality of education. Education is one of the biggest investments we collectively make in our communities. It is also one of the most important social programs funded at the local level.
- These communities are often remote, and the energy produced is exported to unconnected urban areas that will increasingly be in other states (e.g., the California market will likely import energy from all over the west). This energy export market creates perceived environmental justice concerns and related disparities. Some of these concerns are real, and this study can help overcome some of these concerns, both real and perceived, and show the value wind energy development can bring to local communities. If there are successful gains, jurisdictions can model the tax revenue and spending policies of states like Illinois.

Comments on Weaknesses

- I'd love to see this effort plan ahead for integration of offshore wind (i.e., before/after public support studies in communities near offshore wind projects, including cable landing sites and onshore port infrastructure development).
- A potential weakness is the noise modeling; this should be checked preferably through international collaboration (Task 39 of IEA Wind).

Recommendations (Not Scored)

- Public acceptance is a very important topic to keep in DOE projects. Make sure that the noise modeling/annoyance work is well aware of work internationally. My recommendation is to join Task 39 of IEA Wind.
- This work is critically important to the wind industry development and should continue to be a priority of the WETO and funded accordingly. My only recommendation is to make sure the information collected and the resulting conclusions in the sound/annoyance work is digested down to "sound bites" (e.g., simplified talking points, short videos/animations, graphics, etc.) that developers and the general public can use in public hearings and regulatory processes where this issue is being raised in opposition to the facility.
- I would encourage LBNL and WETO to broadly, as much as possible, disseminate this information to the public through traditional and social media to increase potential exposure to the public.
- Consider other alternative ways to study economic benefits to communities through tangible results.

Project Results - Advanced Grid Integration

Operational and Strategic Implementation of Dynamic Line Rating for Optimized Wind Energy Generation Integration

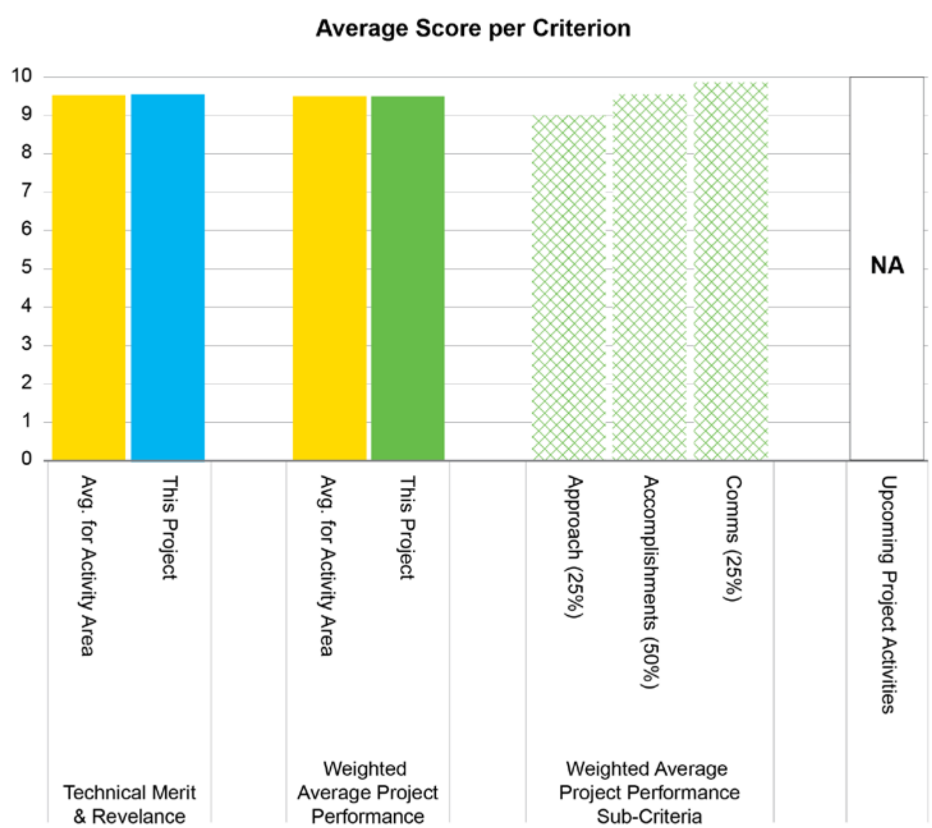
PI: Jake Gentle	Unique Project ID: M03
Organization: INL	WETO Program: Market Acceleration and Deployment
Project Status: Completed	WETO Activity Area: Grid Integration
Total Available Budget (FY17 & FY18):	$1,606,371
Actual Costs (FY17 & FY18):	$1,365,416

Project Description

A Cool" Way to (1) increase the utilization of existing transmission and distribution infrastructure with dynamic line rating, and (2) improve the optimization of new infrastructure developments using the Transmission Route Engineering Analysis and Design (TREAD) Toolkit

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- DLR is clearly a topic that needs to be addressed to better utilize the transmission infrastructure.
- Science and engineering has been successfully to achieve the project goals: releasing free transmission capacity
- Software projects have been developed to utilize real time and forecast data to calculate real-time ampacity of transmission lines which is significantly higher than the conservative static ratings most of the time, which effectively releases free transmission capacity.
- The cost-benefit is huge: According to published transmission project data in Ireland, the budget of this project would uprate just 5.8 miles of 275kV overhead line.
- Human factors have been recognized as being important
- Integration of new technologies into the ultra-conservative environment of the control center can be challenging.
- This project is outside my area of expertise, but it seems to be a valuable project with potential to generate important data that would support the continued growth and expansion of wind energy and its integration on the grid.
- Transmission capacity is a growing barrier for siting wind energy facilities. It can be incredibly challenging; especially in remote areas where wind facilities are typically sited to identify transmission lines with sufficient capacity.
- Also, many wind energy developers are sending their electrons on congested lines leading to unwanted curtailment at certain times of high energy production. Developing new transmission is incredibly challenging, costly, and can take decades to get permitted and complete. T
- These are long linear projects that transcend various jurisdictions and natural resources (including river crossings). Thus, these transmission projects are often highly uncertain. Accordingly, it is a high priority to make better use of the potential capacity in existing infrastructure; this project explores an innovative and important cost-effective way to do that. It is even more interesting that the energy resource itself can help solve the problem (i.e., concurrent cooling areas).

Comments on Weaknesses

- The project combines aspects of tool and methodology development. It is not clear if there is a complete, easily deployable solution; i.e., to what extent is ease of deployment considered as this can be a barrier for utilities.

Approach and Methodology

Comments on Strengths

- The project addresses all relevant issues: measurements, forecasting tools, and usage of tools in control room.
- There appears to be a high level of collaboration right across the industry, as evidenced by the large numbers of partners and collaborators.
- A multidisciplinary team has been established involving engineering, research, software, and psychology.
- Inclusion of psychologists is a major strength of the project.
- The approach utilizes existing tools in combination with forecasts, which provides future indications of available transmission capacity, and it is shown how the increases over ambient temperature based methods is significant.
- Movement of critical span over time validates approach and importance of the consideration of a line's entire length.

- While outside my area of expertise, the project methodology seems sound.
- This project applied a strong methodology to address the problem and better manage real world conditions at transmission lines to maximize loads. The approach seems to focus on a variety of models and real world measurements to utilize capacity when it exists.

Comments on Weaknesses

- The one thing missing from the approach is the assessment uncertainty of forecasts with confidence levels.
- Probabilistic forecasts are used to produce a single point forecast of future transmission line availability. It could potentially be more robust to provide a distribution or confidence level associated with the forecast(s).
- Additional focus of deployability of a complete solution could potentially increase the adoption rate of DLR.

Accomplishments and Progress

Comments on Strengths

- Work and results on control room adoption with alerts and human factor is good and may have also other applications for wind integration.
- A study case for evaluating the use of dynamic line rating for planning the transmission line for wind developer is a good example case of potential use of tools with impact; cut in wind speed is higher than the design wind speed in normal cases.
- Toolbox where every span of line data simulated with wind models and use of weather stations in critical spans. Results showing how lines through complex terrain can have complicated time varying hot spots.
- The tool GLASS can include other vendors' weather measurements which is good.
- The project has been delivered, so far, under budget, on time, and all planned deliverables were met.
- 4 software products have been developed with 3 copyright assertions.
- The system has been deployed in an existing control centers.
- The approach has been validated in a real-world case study.
- It appears the project goals and milestones were met in the stated time frames.
- Accomplishments are strong— including excellent results from field studies realizing cost savings and opportunities for expanded wind energy development that are exploiting existing infrastructure.

Comments on Weaknesses

- Results on the uncertainty levels of the wind speed/direction and ampacity measurements compared with real time and forecasted simulations would be a good addition to the work. There is obviously a lot of data to perform this.
- Development of a complete, easy to deploy solution would help with adoption. At the moment, it looks like a collection of tools and methodologies that might be difficult to deploy.

Communication

Comments on Strengths

- Excellent publication list, with journal and conference articles.
- Wide dissemination, with impact reaching Congress. DLR Video complementing a good dissemination activity.
- Excellent to work with standardization: IEEE and CIGRE.

  - Involvement on a large number of relevant task forces, working groups, and sub-committees.
  - A well-attended workshop in November 2017.
  - Over 10 journal articles.
  - Large number of partners and collaborators.
  - Multidisciplinary team.
  - Active licenses for utility users.
  - The communication plan development and execution appears appropriate.
  - Strong communication and collaboration —impressive hosting of first international dynamic line rating workshop, formal partnerships, and peer reviewed literature. Integration with NOAA forecasts is also impressive and valuable.

Comments on Weaknesses

- It could be very helpful to see a plan and/or the process for deployment of the solution at new sites.
- A commercial exploitation plan would be useful to see.

Recommendations (Not Scored)

- Technology transfer to system operators is the goal, but to reach that, the tool needs to add uncertainty information for them to choose a confidence level they are ready to operate with.
- The next step for TSO applications needed is US wide experience, to show how the tools work to create confidence in operators. The project has gathered a lot of data to do this. Wind speed and direction forecasting is developing to help extrapolation from the measurement spots, and will create more opportunities and impact with reduced confidence levels. Combining with probabilistic forecasting would be great to see.
- GLASS, TREAD, and SAND availability open source would be good.
- It would be helpful if a clearer picture could be presented regarding the effort for a utility to deploy this solution as this would be key to the potential of the tools at a system level.
- This work seems valuable and worthy of continued pursuit.
- Continue expanding this research and building support. Identifying additional capacity on existing lines is great for the industry as well as communities and wildlife where conflicts with new line construction often arise.
- Also, continue thinking of innovative ways to advance the application given the conflict of interest with transmission vendors.

Market and Reliability Opportunities for Wind on the Bulk Power System

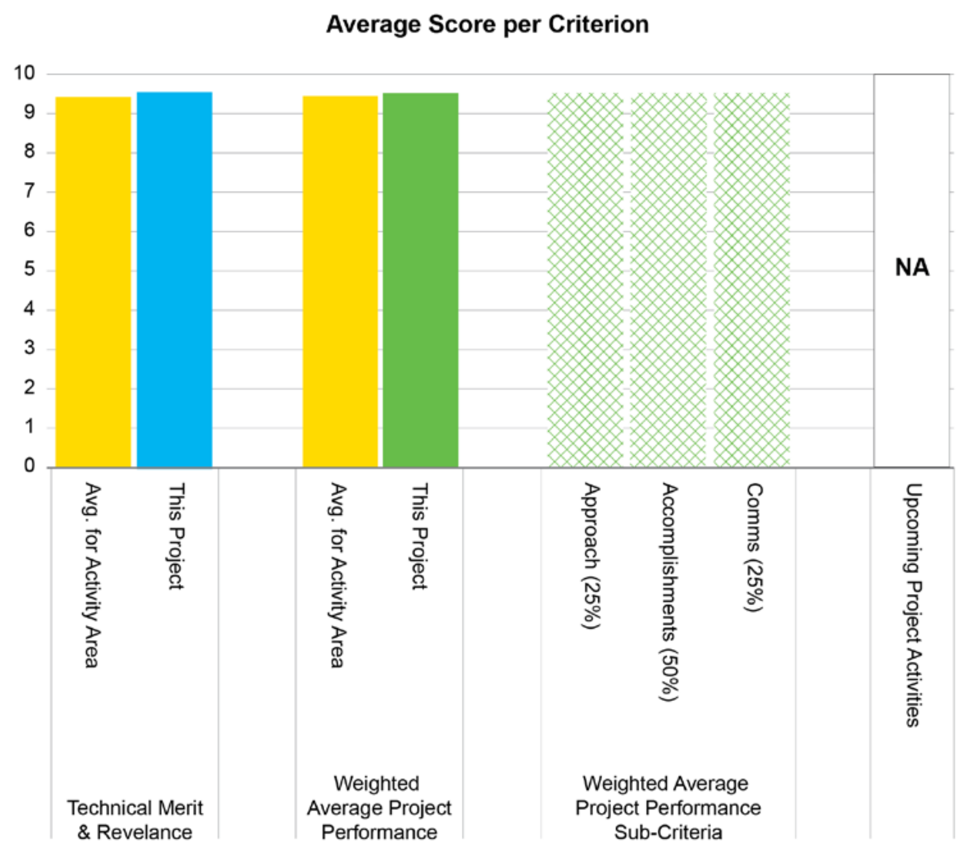
PI: Jessica Lau	Unique Project ID: M04
Organization: NREL, ANL	WETO Program: Market Acceleration and Deployment
Project Status: Completed	WETO Activity Area: Grid Integration
Total Available Budget (FY17 & FY18):	$1,349,127
Actual Costs (FY17 & FY18):	$1,211,827

Project Description

This project aims to understand the impact of wind and other zero-marginal cost resources on reliability and revenue sufficiency under a wide range of market design options and revenue sources. Understanding the broader impacts to wind and other technologies is key to supporting reliability.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Market design is a topical research topic, crucial for both integrating large amounts of wind power, as well as cost efficient and reliable power system operation.
- The project setup had challenging goals reaching new information that was relevant to all stakeholders internationally; both system operation (reliability) and market players. This includes potential shortcomings caused by current market structures and key drivers to operating a cost-effective and reliable electricity market with high shares of wind power.
- This is a highly relevant issue in the context of increasing variable renewable penetration.
- Combined with the various market mechanisms for energy, capacity structures, ancillary services and in some cases, flexibility, this is a particularly difficult challenge to unpack.
- The appropriateness of the traditional distinction between capacity and operations in the context of increasing VRE has been examined to some extent (i.e., results appear to show a breakdown of pricing mechanisms in high VRE cases, and the divergence in design and impact of administrative parameters of capacity markets has been addressed).
- This project is outside of my area of expertise, but it seems to be a valuable project with potential to generate important data. That would support the continued growth and expansion of wind energy and its integration on the grid.
- This project has strong merit since the uncertainty regarding how existing transmission systems will integrate wind has created perceptions that are often based on assumptions rather than fact.
- Robust analysis and modeling is important to understanding how transmission networks will react to high penetrations for wind and what can be done now to address any challenges as wind deployment expands. T
- This project also provides opportunities to consider opportunities to address potential future challenges through markets and other related policies in order to keep energy costs and prices down.

Comments on Weaknesses

- Some consideration of flexibility requirements of the system would enhance this work, although this is not straightforward. Some acknowledgement of flexibility issues would perhaps be relevant.
- Perhaps the project could have been more ambitious in the examination of alternative pricing

Approach and Methodology

Comments on Strengths

- New simulation model to assess behavior in more realistic, non-ideal, markets.
- New algorithms and approaches for market design had an impact on resource adequacy.
- Analyzing historical market data and material that already exists to draw conclusions on how well the current markets work, in addition to energy/ancillary services/capacity. Testing other options for ways to improve it.
- New market design principles focus on reliability and revenue sufficiency. Reliability, as of capacity adequacy, through revenue sufficiency in markets is looked at mainly as a capacity expansion problem. –But, revenues from ancillary services are also analyzed. Multi-agent models to enable studying non-perfect markets are a good expansion of current simulation tools.
- The approach successfully captures the interactions and interdependencies between modeling at different timescales, particularly between investments/capacity/reliability and operations.
- A non-least cost model for capacity expansion and consideration of investor behaviors is a key strength.

- The project approach and methodology seems to have been well developed and executed.
- The report appears to have been completed under sound methodology.

Comments on Weaknesses

- Load flexibility was not taken into account.
- It is not clear to what extent operational issues/constraints are captured in the capacity expansion model(s). The model does not appear to allow for operational issues as modeled in the production cost model to impact on capacity expansion. This is particularly important in systems with high levels of variable renewable generation. Issues like flexibility and renewable curtailment are often not captured in capacity expansion models

Accomplishments and Progress

Comments on Strengths

- Good tools were developed:
  - New and very interesting approach on market modeling (bi-level optimization), giving a tool to assess market behavior of individual actors.
  - Creation of open source test systems (IEEE update and ERCOT).
- Case study results and the analyses of data gave many interesting results. It had insights on:
  - Impact of excess capacity and level of LOLE on energy market prices; which showed how the historical capacity market rules are scattered.
  - Energy only markets: pricing mechanisms, scarcity pricing schemes, and revenue sufficiency.
  - Ancillary services markets: modeling and income for generators.
- Project team has met milestones and deliverables while remaining on-budget.
- Development of the Reliability Test System has had a significant impact.
- The significant impact of regulated capacity market parameter levers has been highlighted.
- The relationship between reliability target, variable RES penetration, and market prices has been established and illustrated quite clearly.
- The high VRE case appears to suggest a breakdown of the pricing paradigm and is perhaps a related and important issue to consider further.
- The project stated goals appear to have been completed in the stated time frames.
- The project resulted in important modeling capabilities to further study the grid as markets change. The analysis also identified some important predictions for further evaluation and consideration. Also, the results of the study were detailed for example one finding was that capacity markets can add capacity, but it depends on the demand curve (an important consideration).

Comments on Weaknesses

- I was expecting more direct results on "how does reliability of future power systems vary depending on wholesale electric market designs?" and "how realistic, non-ideal market behavior could impact the reliability and economic efficiency of the grid under high wind penetrations."
- Hopefully, even leading to market design recommendations.
- The project did show that the capacity markets may result in overcapacity and energy only markets in higher energy and ancillary service prices. This is a somewhat higher level answer to these questions.

Communication

- Comments on Strengths

- Excellent scientific dissemination through journal, conference articles, and presentations. Good engagement to main stakeholders through the partnership with EPRI and their ISO/RTO Markets Working Group.
- Published more than 10 technical and peer-reviewed papers.
- Presented and led panels in more than 16 industry events, including conferences to share the project's findings and engage with stakeholders.
- There appears to have been significant collaboration with a wide range of industry and research partners.
- The project communication plan and coordination/outreach seems to have been well developed and executed.
- The project had a strong communication strategy; which was particularly related to the one-on-one conversations with ISOs. It is also valuable that at least one of the models is public. Research collaboration seemed very effective for this project.

Comments on Weaknesses

- No detail provided regarding publications (i.e., distinction between journal articles and conference papers etc.).
- It would have been helpful to see at least a list of selected publications.

Recommendations (Not Scored)

- Future market design is very important to get right, for both cost efficiency and reliability with higher amounts of variable generation. Any results from simulations that can contribute to market design are valuable.

North American Renewable Integration Study

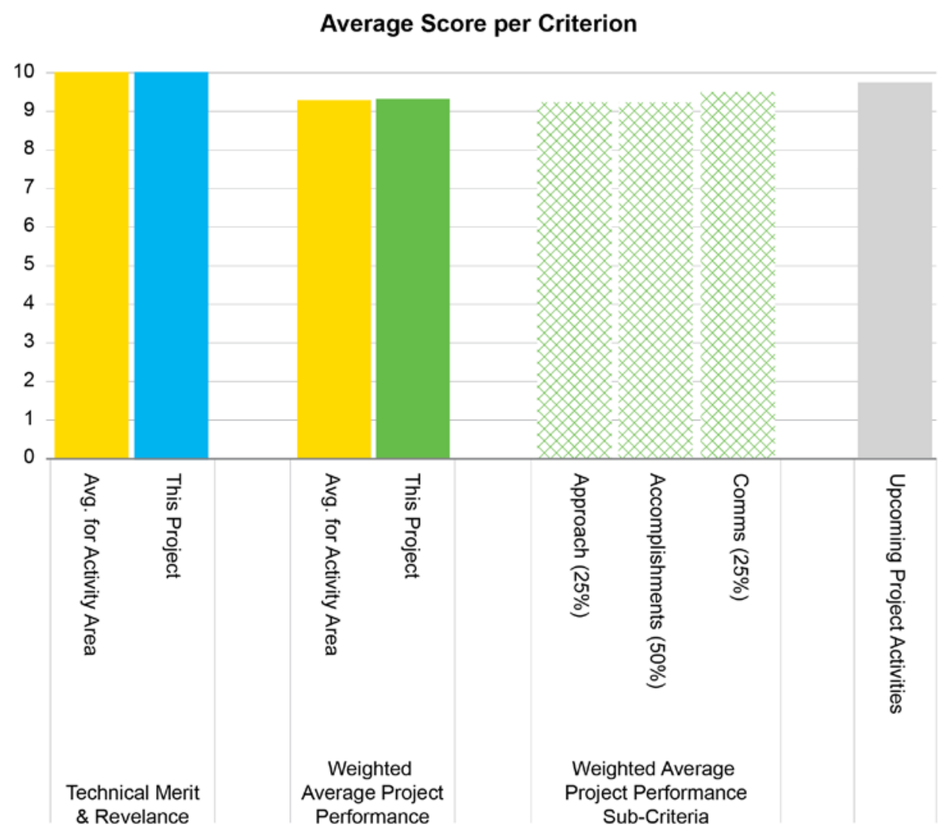
PI: Greg Brinkman	Unique Project ID: M05
Organization: NREL	WETO Program: Market Acceleration and Deployment
Project Status: Active	WETO Activity Area: Grid Integration
Total Available Budget (FY17 & FY18):	$1,392,086
Actual Costs (FY17 & FY18):	$796,483

Project Description

The North American Renewable Integration Study (NARIS) will analyze the challenges and opportunities of transitioning to a modern electric power system in North America through the year 2050. It is a partnership between the U.S. Department of Energy, the Ministry of Energy in Mexico, and Natural Resources Canada. NARIS studies timescales from multiple decades down to minutes and will produce novel data sets, methods, and tools for stakeholders and future use.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- The grid is becoming more and more meteorology dependent, and there is need for new tools when aiming toward a reliable modern grid. Interesting new study scope covering all of North America.
- Highly relevant topic and natural extension of previous integration studies to continental scale.
- Continental scale introduces new challenges and opportunities.
- Comprehensive scope including reliability, balancing, and capacity expansion, along with scenario development.
- High temporal resolution.
- Continuous development of models and data.
- This project is outside my area of expertise, but it seems to be a valuable project with potential to generate important data that would support the continued growth and expansion of wind energy and its integration on the grid.
- This has strong merit due to the uncertainty of how existing transmission systems will integrate wind into the system.
- Robust analysis and modeling is important to understand how transmission networks will react to high penetrations for wind and what can be done now to address any new challenges as wind deployment expands.
- This project is very timely as well, due to concerns the Administration has raised related to electricity reliability with high integrations of wind energy.

Comments on Weaknesses

- No weaknesses noted by reviewers.

Approach and Methodology

Comments on Strengths

- Good model development to enable detail in large footprint; building on previous large wind and solar integration work.
- Consistent input data, for several meteorological years.
- Including hydropower flexibility.
- PLEXOS wind/solar/load forecast errors included.
- Capacity expansion: ReEDS updated to include MX and CAN. ReEDS to PLEXOS automatically, comparing the curtailments from both to see if discrepancies.
- Capacity value assessment: new tool PRAS for renewables capacity value, has transmission included, and is also used to check different transmission scenarios.
- New Gen model to capture rooftop PV; driven by prices.
- Power flow modeling, power flow cases 100+ to build Plexos area restrictions. It is also possible to use for checking the dispatch after.
- Year 2050 scope. The strength of the simulations will be higher with many scenarios. This includes interesting scenarios for transmission; sharing balancing and future electrification loads are included.
- Interesting point also to collaborate between U.S., Canada, and Mexico and study the impact of collaboration possibilities in transmission planning and operations.
- Significant focus on data and generation of new quality datasets.
- High temporal resolution dispatch.
- Robust approach to reliability.

- Open approach to modeling.
- Geographic decomposition approach is pushing the state of the art and exemplary of how large scale studies such as this should be carried out.
- Novel robust approach to distributed generation modeling (e.g., use of agent based models and LIDAR).
- The project approach and methodology appears well developed.
- This project employed a strong approach. Particular strengths include its development of new tools and data to allow for enhanced modeling. The new methods and tools developed are quite sophisticated, and incorporate changing parameters, including distributed generation, more refined meteorological data, and the electrification of our transportation sector.
- The continental/broad geographic scale of the project is also incredibly valuable as more and more regional markets arise to mitigate variability. In addition, this is a time of great energy transformation. Not only are sources changing, but loads are as well.
- Electricity demand has been flat, but this may change in response to the electrification of the transportation system. Because of these various changes happening in tandem, better predicting how the grid will react to these changes will be critical to getting in front of problems, driving costs down, and building strong support for wind energy.

Comments on Weaknesses

- Offshore seems to not be taken into account as one major scenario with considerable amounts of offshore grids.
- The potential for operational considerations to impact on capacity expansion is limited.
- Uncertainty is not modeled explicitly, but this would not necessarily be appropriate for a project of this scale and scope. Perhaps the impact of uncertainty could have been studied in a smaller subset of systems and cases.
- Limited assessment of flexibility.

Accomplishments and Progress

Comments on Strengths

- Model tool development has had very good progress and the scenarios seem to be well built.
- Comprehensive merit reviewed study plan developed which pushes the state of the art in any aspects.
- Continental scale model has been developed.
- Geographic decomposition methodology developed and implemented.
- 5 technical review meetings so far.
- The project appears to have stayed on schedule and met the stated goals.
- Strong accomplishments in model development as well as related analysis.

Comments on Weaknesses

- It is not possible to evaluate in detail as there are no results. I am very much looking forward to seeing the results, especially the transmission and electrification load scenario results.
- As stated, there have been limited presentations of the results, so it is difficult to comment here.

Communication

Comments on Strengths

- Throughout the project review with a wide Technical Review Committee. Covers for no publications during the project.
- Includes regional partners (Mexico and Canada).
- Internal technical review committee has been established.

- The project communication plan appears to have been well developed and executed.
- This project had a strong communication strategy. The development and engagement of a technical review committee is a critical part of the communication strategy.

Comments on Weaknesses

- I was expecting to see some preliminary results.
- Intentionally no presentations before completion of the study.

Upcoming Project Activities

Comments on Strengths

- Looking forward to all of the results!
- Upcoming project activities seem reasonable in order to finalize the project.
- Communication of results is key and has been a past success of NREL integration studies.
- Development of tools to visualize results has been a key success of NREL in the past.
- The upcoming activities seem appropriate to conclude the work of the project.
- The cost modeling will be an important output from this project.

Comments on Weaknesses

- No weaknesses noted by reviewers.

Recommendations (Not Scored)

- I hope to see results on the collaboration benefits of U.S., Canada, and Mexico in the future challenging higher wind/solar share world. Implications for transmission planning and operation, as well as implications that future electrification load may have, are interesting to see.
- In future integration studies, it could be worthwhile to consider advancing the complexity of the modeling to:
- Explicitly consider uncertainty.
- Inclusion of greater operational detail in the capacity expansion aspect of the modeling and/or co-optimization of capacity expansion and operations.
- Greater focus on flexibility issues.
- While not within my typical area of knowledge, this work seems incredibly important to wind energy's integration in the grid, and the work undertaken was well structured and valuable.
- Consider more intensive modeling for offshore wind. We need a better understanding of how these electrons will be effectively integrated in the grid and what impact this will have on ISOs and regional markets.

Power System Reliable Integration Support to Achieve Large Amounts of Wind Power (PRISALA)

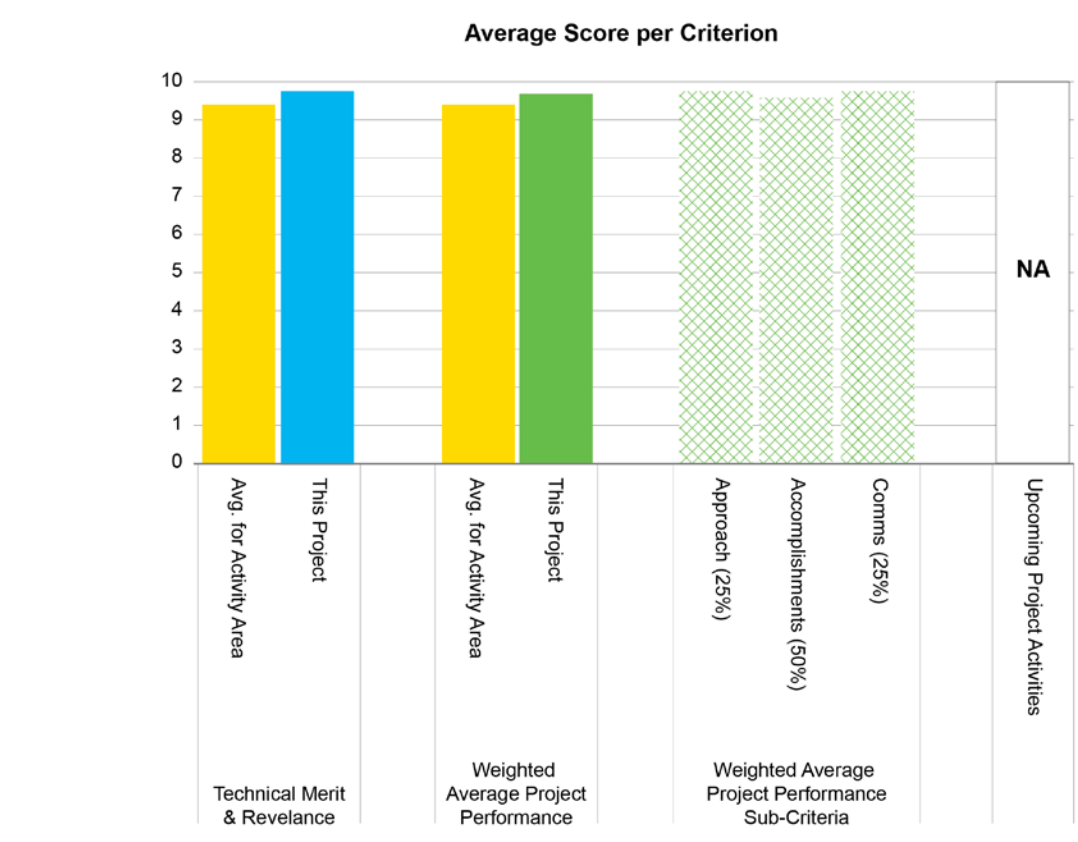
PI: Dave Corbus	Unique Project ID: M06
Organization: NREL	WETO Program: Market Acceleration and Deployment
Project Status: Completed	WETO Activity Area: Grid Integration
Total Available Budget (FY17 & FY18):	$1,065,537
Actual Costs (FY17 & FY18):	$934,696

Project Description

NREL's stakeholder activities focus on disseminating key research results from NREL analysis to regulators, policymakers, utilities, and power system industry stakeholders. Successes in these activities have resulted in decreased barriers to the integration of wind power and increased power system resiliency, reliability, and security.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- It is important work to get the wind integration state of the art and new developments to utilities, system operators, and regulators. This will decrease the barriers to wind, which will also contribute to the reliability, resilience, and cost efficiency of power systems.
- Key high-impact activity in translating and applying research activities and results to "the front" line. Establishing a forum for feedback and information exchange
- This project is outside my area of expertise, but seems to be a valuable project that will support the continued growth and expansion of wind energy and its integration on the grid.
- This project has strong merit given the importance of improving grid operation to maximize resiliency, reliability, and security while keeping energy costs low.
- Technical solutions are needed to accomplish this complex, multi-faceted goal (that cut across a lot of areas). Success will require incredible collaboration among technical expertise, and the energy sector working together to advance and implement the solutions.
- Also, once the solutions are in hand, it will take an effective, robust communication strategy to ensure varying stakeholders have the knowledge and tools needed.
- ESIG is a unique and irreplaceable resource with respect to conveying information on renewable generation capabilities the context of the evolving electrical grid.

Comments on Weaknesses

- No weaknesses noted by reviewers.

Approach and Methodology

Comments on Strengths

- Project setup allows topical issues to be address as they emerge and react to any potential barriers.
- Wide coverage of collaboration in the U.S. (NERC, FERC) and internationally (IEAWIND Task 25), with ESIG as the flagship.
- International collaboration gives inputs from the high share wind countries experience from Europe, as well as the European research. ESIG working groups and workshops, NERC and FERC working groups, give concrete dissemination and remove barriers, which brings the stakeholders to the forefront of variable generation integration.
- ESIG events play a key role in the industry both domestically within the U.S. and internationally.
- ESIG facilitates a vibrant community and platform for accessing NREL research and for understanding research needs in the industry.
- U.S. support for IEA Wind Task 25 has been key to its success.
- Having had first-hand experience of ESIG events over the course of my own career, I can testify to the fact that ESIG plays a crucial role in the industry, and it provides a unique platform to access research activities and outputs at the correct technical level, to have the necessary impact
- The project approach and methodology appears sound and well executed.
- The approach and methodology is robust. It includes technical experts who have a range of expertise, including facility operators, transmission experts, and energy modelers. The effort is also formulated into working groups that are driven to produce outputs that address key priorities to achieving goals.
- The project also includes a strong approach for disseminating this work more broadly. Our electricity system is vast and diverse so this coordination and outreach is key. It can be difficult to ensure technical reports get in the right hands, and that they are read and understood. ESIG ensures that the information is disseminated appropriately.

- Also, the longer term relationships developed through face to face meetings and working group memberships build trust and more effective communication.
- Outreach is needed by virtually every grid operator.

Comments on Weaknesses

- Perhaps not the principal focus, but the presentation material would indicate that most of the communication is outwards. To what extent are these communication activities informing the research agenda at NREL and across the U.S. generally?

Accomplishments and Progress

Comments on Strengths

- The work has delivered concrete presentations, planning events, and reports in the ESIG workshops and NERC/FERC working groups. The U.S. has been giving leadership contributions in international IEA Wind Task 25 collaboration.
- Excellent impact. When UWIG started, it had many utilities reporting of overestimated impacts and barriers. Since that time, they have learned from one another's experience about how the system operation goes with wind and solar. And, no major barriers have occurred to slow deployment.
- I think this shows how the stakeholder work has had a real impact. The challenges are communicated to ESIG as well as the progress in tackling them.
- The forum has given the stakeholders confidence.
- Under budget.
- Consistent representation on IEA Wind Task 25 where U.S. involvement is key and influences work in the area internationally.
- U.S. involvement in IEA Task 25 has resulted in a number of conference and journal articles.
- This activity has clearly led to respect for and credibility of NREL research results domestically and internationally.
- Participation in numerous NERC and FERC taskforces and working groups is evidence of the impact of this activity.
- The project seemed to stay on the developed schedule and met the project goals in a timely fashion.
- There was broad engagement in important working groups and with FERC directly. Also strong oversight and support for ESIG.
- Extensive record of interactions.

Comments on Weaknesses

- It is clear that this activity has a strong impact on a policy development and though leadership level internationally. It would be useful to have some appreciation for the impact these activities have at the utility level. How is the research impacting what is happening in utility control centers and planning offices?
- So many audiences; only so many opportunities.

Communication

Comments on Strengths

- Excellent reach out with the stakeholders; the list is exhaustive. Dissemination of experience, study results, tools, data, and also two-way communication to get to know about the challenges that utilities and system operators face in an early phase and letting the research help solve them.
- Good publications: ESIG workshops (also planning the sessions), NERC report, FERC briefings, and IEA Wind Task 25 collaboration articles.

- Communication is the cornerstone and principal focus of this activity.
- This activity facilitates communication and collaboration across a large range of activities and organizations; from providing expert input to inform and influence domestic policy development, to providing thought leadership internationally.
- The project communications appeared appropriate given the project scope.
- Impressive list of conference papers and outreach. The collaborative nature of this group is impressive given the diversity, both regionally and subject matter expertise.
- This is what ESIG is all about.

Comments on Weaknesses

- It would be useful to understand the impact of this activity at ISO level.

Recommendations (Not Scored)

- This work has proved to have an excellent impact on how increasing amounts of wind and solar energy is integrated in the U.S. power system. The challenges are getting bigger with ever faster deployment rates of wind and solar, which makes this work also beneficial in future.
- Could be useful to have some feeling for the impact of this activity at the utility and ISO level.
- While not within my typical area of knowledge, this work seems incredibly important to wind energy's integration in the grid and the work undertaken was well-structured and valuable.
- No specific recommendations, other than continue to support ESIG.
- If anything, raise the level of effort and maximize range of technologies and applications covered.

Providing Ramping Service with Wind to Enhance Power System Operational Flexibility

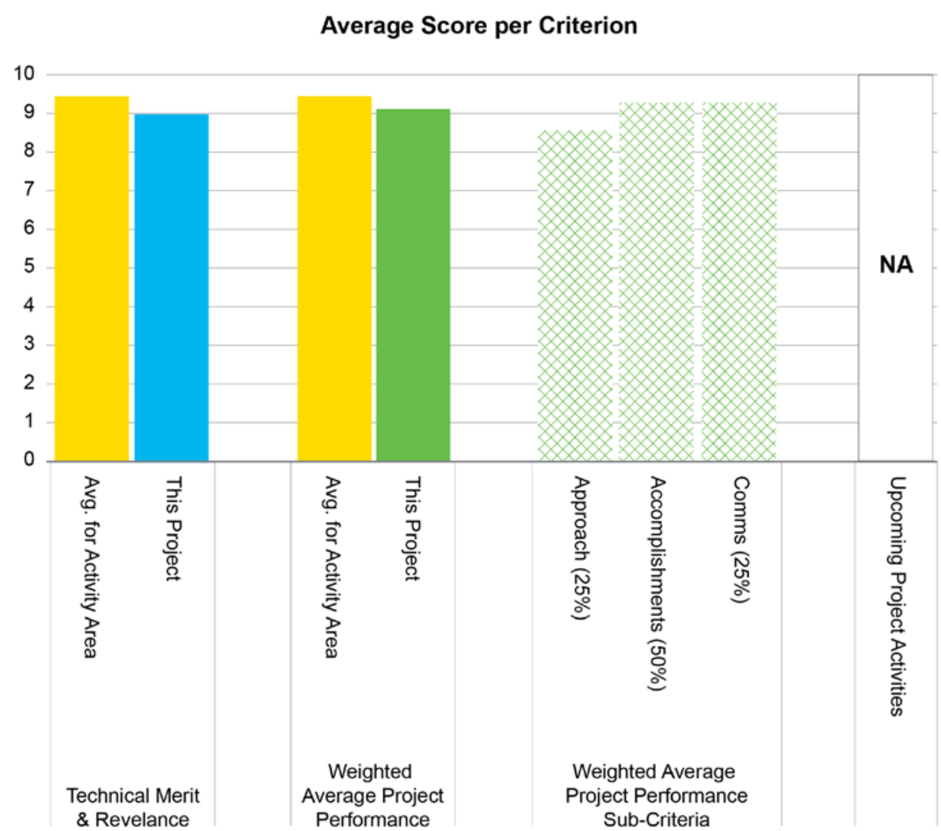
PI: Bri Mathias Hodge	Unique Project ID: M07
Organization: NREL	WETO Program: Market Acceleration and Deployment
Project Status: Completed	WETO Activity Area: Grid Integration
Total Available Budget (FY17 & FY18):	$1,205,649
Actual Costs (FY17 & FY18):	$1,018,257

Project Description

The aim of the wind-friendly flexible ramping product is to transform a natural characteristic of wind power, specifically ramping, into an advantageous one. Through efficient management of wind ramps with probabilistic wind ramps forecasting, the dispatchability of wind power can be improved with wind providing the flexible ramping product in the multi-timescale markets.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Modeling activity that significantly advances the state of the art and addresses a highly relevant issue associated with the integration of VRE.
- Utilizing the forecasted information to increase the economy and reliability of the power system has the potential to have huge impacts.
- This project is outside my area of expertise, but it seems to be a valuable project with the potential to provide a valuable service that would support the continued growth and expansion of wind energy and its integration on the grid.
- Strong merit in this study, since given the transformation in the energy market, there will be a steep increase in variable generation sources necessitating more ramping. The opportunity for wind to be integrated more effectively into transmission systems while providing ramping services is such a win-win for the wind industry. It will drive down costs while increasing penetration.
- Developing an additional product for wind generators is important given the high levels of renewable penetration being pursued in many areas.

Comments on Weaknesses

- Is this simply a way of integrating wind power forecasts at different time scales into markets, to provide greater visibility of future wind power production and net load ramps? In other words, is wind power doing anything differently here?

Approach and Methodology

Comments on Strengths

- Novel use of forecasts at different timescales to improve system economics and operation with large amounts of wind power.
- Development of the open market model is a significant, high-impact achievement that increases confidence in the credibility of results.
- Methodology to forecast wind power ramps at different time scales and the use of this information to benefit the system operation is a very significant achievement.
- The project approach and methodology appear sound and well developed.
- Strong approach that addresses the full aspect of advancing solutions, from developing probabilistic forecasting methods, to designing products, to validating benefits, and integrating ramping products. It also incorporates increasing awareness of this opportunity. It is a very holistic approach to overcoming the barrier.
- Modeling approach.

Comments on Weaknesses

- Improved forecasting of wind power ramps has significant benefits even in systems without specifically structured ancillary services. Perhaps the benefits could be more generally applied if the work was structured as a separate identification of these benefits—with a complimentary analysis of how this could be used to define ramping products—where such a market exists.
- Probabilistic; not empirical.

Accomplishments and Progress

Comments on Strengths

- Six journal articles is a significant achievement, but it would be nice to see the references.

- Partnering with ERCOT lends credibility to results and points to both impact and relevance of the work.
- Best conference paper award points to a well-communicated piece of work!
- The project accomplishments seem very encouraging and will hopefully lead to ISO's and utilities, allowing wind to be considered more and more for ramping services.
- Strong accomplishments towards goals, including an impressive award at the IEE PES general meeting in 2018.
- Modeling complete. Pursuing deployment in a major ISO which has significant wind deployment (ERCOT).

Comments on Weaknesses

- There is significant value in the methodologies to forecast wind power ramps. Presenting this in the context of a wind ramp "product" may have the impact of obfuscating this work for some audiences.

Communication

Comments on Strengths

- Perhaps it is worthwhile to present the methodologies to forecast wind power ramps and their benefit separately to its use in defining a wind ramp product.
- While there did not seem to be a lot of traditional "communication" with external stakeholders, through the conference presentations, publications, and communication with project partners, it appears the project team communicated well throughout the project duration.
- Strong communication strategy; including the partnership with ERCOT and the release of OpenSMEMS to the public so that other researchers could study the problem.
- Multiple articles; presentation at the scientific meeting was well received.

Comments on Weaknesses

- It would be nice to see the list of resulting publications to get additional details of the modeling performed.

Recommendations (Not Scored)

- Perhaps it is worth considering extracting the fundamental benefits to wind power ramp forecasting separately to the ramp product definition.
- While not within my typical area of knowledge, this work seems incredibly important to wind energy's integration in the grid and ancillary use that is more aligned with traditional generation, with the work undertaken by the project team being well-structured and valuable.
- No specific recommendations.
- Definitely worth pursuing with ERCOT and elsewhere.

WindView: An Open Platform for Wind Energy Forecast Visualization

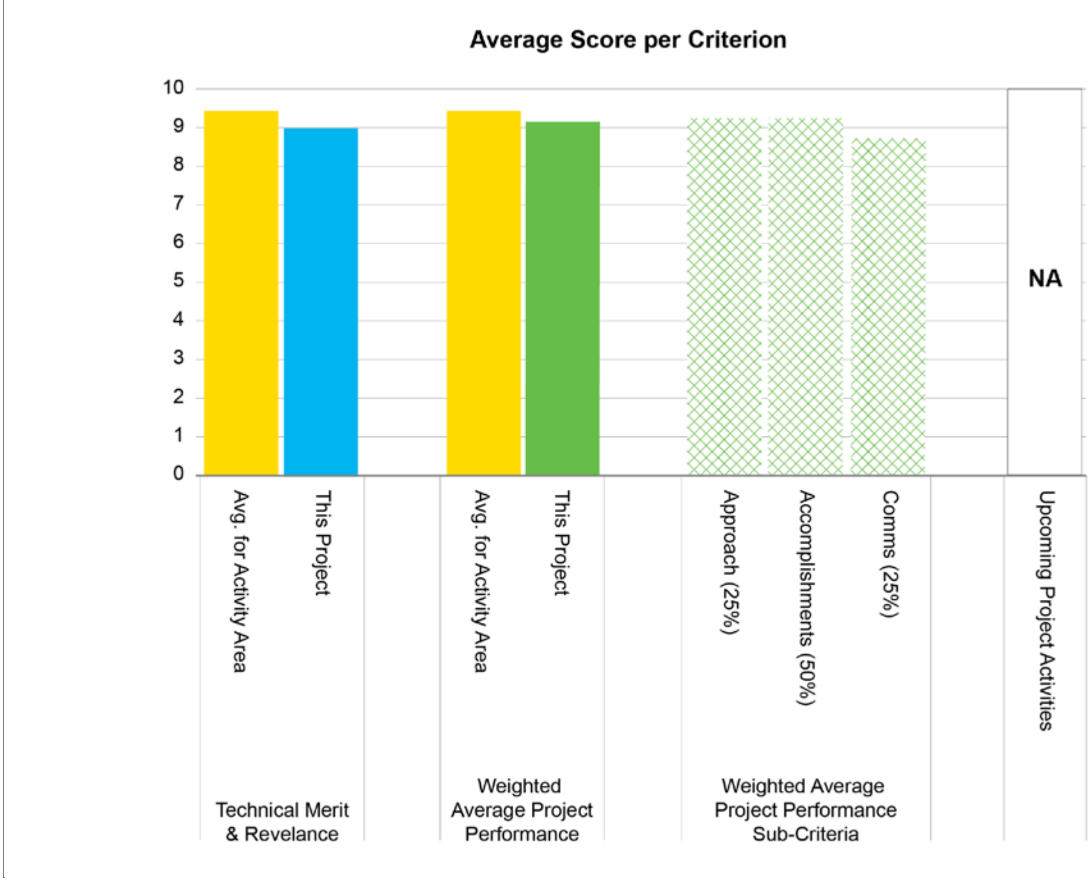
PI: Bri Mathias Hodge	Unique Project ID: M08
Organization: NREL, ANL	WETO Program: Market Acceleration and Deployment
Project Status: Completed	WETO Activity Area: Grid Integration
Total Available Budget (FY17 & FY18):	$1,168,518
Actual Costs (FY17 & FY18):	$1,036,439

Project Description

Create an open-source, free, situational awareness and decision support platform called WindView which will provide grid operators with knowledge on the state and performance of their power system, with an emphasis on wind energy. Focus on utilizing advanced visualization to display pertinent information of wind farms and wind power.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Development of open source tools is a high-impact activity.
- Helping system operators extract forecast information to use in decision making is critical.
- Relatively simple idea with large potential and impact.
- This project is outside of my area of expertise, but seems to be a valuable project with potential to create useful tools that grid operators can utilize to project wind energy generation in their service area. The value of such products support the continued growth and expansion of wind energy and its integration into the grid.
- This project has strong merit. Change is hard for most, but it is particularly difficult for grid operators given the risk adverse nature of energy delivery. The visual platform of this technology allows grid operators to feel more familiar with wind energy on the system increasing comfort in higher penetrations and advancing new approaches.
- Very relevant, given its usefulness to system operators in becoming more effective in managing the wind resources on their systems.

Comments on Weaknesses

- Could the scope be more ambitious to include decision support tools, e.g. integrated with stochastic production cost/scheduling models?
- Visualization is a significant first step in extracting useful information from probabilistic wind power forecasts, but the industry needs to adopt the state of the art in terms of using this information in a scientifically robust way, i.e. stochastic optimization.
- System operators have to want to use their wind resources more effectively but they can't control that.

Approach and Methodology

Comments on Strengths

- Development of M3; probabilistic forecaster is a significant benefit.
- Significant engagement with the industry and ESIG to identify the need for tools to exploit and interpret wind power forecasts.
- The open source development approach greatly increases impact and future potential.
- The cloud solution a significant advantage as it liberates the user having to install a lot of data processing and management functionality locally.
- Compatibility with all wind forecast providers is a significant strength.
- The project methodology and approach was outstanding.
- Strong approach to create an open source platform that provides decision support for operators. It was developed with significant stakeholder input. The product is valuable for its technical capabilities, as well as the training capacity that was developed to transfer knowledge and expand confidence.
- Strong team.
- Developed a user-friendly product.

Comments on Weaknesses

- Is there future potential to integrate with scheduling software, particularly stochastic unit commitment tools, in order to further exploit the information in wind power forecasts?

Accomplishments and Progress

Comments on Strengths

- Development of the M3 forecaster is a significant achievement that greatly increases the value of the tool.
- The open source approach should be greatly commended! It increases the credibility of the tool and the confidence in the tool.
- Four journal articles plus one in development is a significant achievement.
- The project accomplishments and progress were impressive and I believe will lead to the project tools being utilized by system operators across the country over time.
- Strong accomplishments from the project; most notably the fact that wind view is now publicly available and 450 operators have already been trained.
- Tool is complete.
- One major system (WAPA) promulgating to operating personnel.

Comments on Weaknesses

- Only WAPA, so far.

Communication

Comments on Strengths

- Significant number of research and industry partners.
- Discussions on integration in the UK National Grid Control Center.
- Availability of code on GitHub is great for exposure, discussion, and for building a community.
- The communication plan by the project team was incredibly thorough and well-developed.
- Partnering with the Western Area Power Administration Electric Power Training Center was an important collaboration step as well as working with NREL, ANL, and the University of Texas. The technical review process was also robust. There is also a strong plan for longer term communication and outreach to expand usage.
- Open source tool, freely available.
- ESIG presenting to audiences.

Comments on Weaknesses

- It seems like most of the broad industry communication and outreach remains to be done.
- No weaknesses identified.
- Is the promotion of the tool exploiting the natural utility industry networks (EPRI, EEI, and APPA)?

Recommendations (Not Scored)

- This tool has the potential to have significant impact and fills an important gap in the market.
- The team could be more ambitious regarding the tool's potential, particularly regarding integration with stochastic unit commitment tools.
- This tool could play a significant "gateway" role in making stochastic scheduling mainstream within the industry.
- While not within my typical area of knowledge, this work seems incredibly important to wind energy's integration in the grid and the work undertaken by the project team well-structured and highly valuable.
- No specific recommendations at this time.
- Publicize it to the utility industry groups.

Understanding the Role of Short-term Energy Storage and Large Motor Loads for Active Power Controls by Wind Power

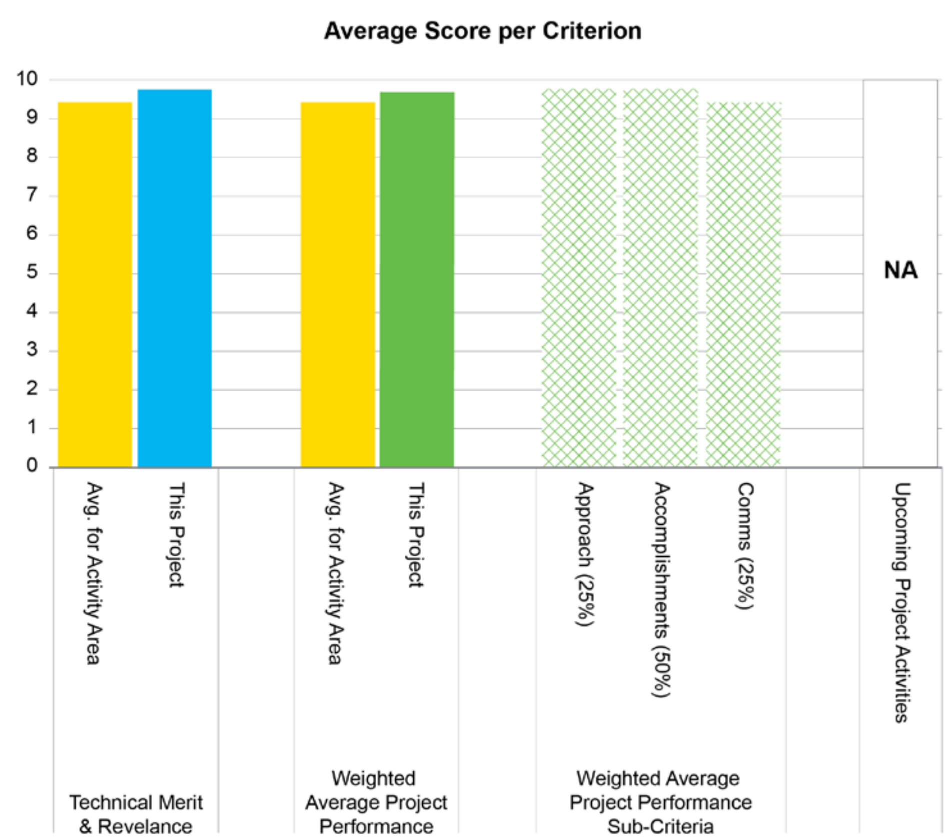
PI: Vahan Gevorgian	Unique Project ID: M09
Organization: NREL, INL	WETO Program: Market Acceleration and Deployment
Project Status: Completed	WETO Activity Area: Grid Integration
Total Available Budget (FY17 & FY18):	$1,609,910
Actual Costs (FY17 & FY18):	$1,205,824

Project Description

This project is aimed to develop and validate coordinated active power controls (APC) by wind generation, short-term energy storage, and large industrial motor drives for providing various types of ancillary services to the grid.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Increases reliability of the grid. Focus on the state of the art of active power controls from non-conventional generators, loads, and storages; with simulations and field tests. The main advancement is comparing the separate and combined performances of these resources.
- Relevant for the industry, including technology manufacturers and operators, and utilities and system operators.
- It is clear that there is significant and advanced capability, particularly the PHIL capability.
- Limited knowledge of the impact of AS provision on turbine lifetime is impeding the use of wind power to provide these services. It also has the potential to impact deployment and operation. For example, use current 65% limit in Ireland due to stability concerns
- This project is outside of my area of expertise, but seems to be a valuable project with potential to generate important information that would support the continued growth and expansion of wind energy and its integration on the grid.
- Strong merit to advancing a very innovative first of its kind demonstration of wind power's capacity to serve as Active Power Controls. Through this demonstration project, NREL and INL provided strong evidence to support future investment in this area.
- The only aspect I can sufficiently understand is the integrated operation of multiple inverter-based resources on a system, which is a model of the grid of the future.

Comments on Weaknesses

- Regarding the coordinated response from wind, storage, and motor loads, it is not entirely clear what the key research questions is and if it has the possibility to undermine service provision from wind turbines by themselves. Perhaps a communications issue.

Approach and Methodology

Comments on Strengths

- Very good/exhaustive list of frequent support options studied give a good overview and summary of results, including which combinations provide the response, with which combination of technologies are the best.
- Addressing one of the challenges of providing a fast response from distributed resource, frequency measurement.
- Very good use of the test facility at NREL.
- Use of RTDS and the NWTS to study impacts of controls is a hugely valuable capability.
- The project approach and methodology seems sound and well developed.
- It appears to be a strong methodology, but beyond my expertise.
- Very strong team.
- Utilization of NWTC grid integration site and INL Global Real-Time Super Lab.

Comments on Weaknesses

- The research question seems to be around the coordination of AS response across different technologies in a balancing area, but the study looks more like getting a local group of resources to behave like a single power plant (i.e., one would rather want to look at turbine level controls that result in an overall stable response).
- What is the benefit of using bulk energy storage to control plant level output at local level—is this a scalable solution? In other words, what is the benefit compared to optimization of storage resources at system level?

Accomplishments and Progress

Comments on Strengths

- Interesting new and concrete results showing the system point of view of sourcing frequency response from different response times/ways of responding, separately and combined.
- Also showing that wind can provide the ancillary services without extra loading, also multiple services.
- Also showing that reactive power capability was considerable. Results show how small amounts of storage can go a long way.
- Testing new innovation for frequency measurement that is currently somewhat a challenge for providing fast responses from distributed resources.
- Very interesting tests on the virtual laboratory approach, combining test facility runs inside the United States and Europe.
- Development of the PHIL is a huge accomplishment; it resulted in a highly valuable capability.
- The integration of the distributed RTDS simulations within the NWTC is a highly valuable capability.
- The ability to test the aggregate impact of multiple individual controls is a significant accomplishment. Also, the ability to test the impact of coordinated controls of different technologies to produce a coordinated response.
- This could be viewed as a showcase of the capabilities of the testing platform and the types of research questions that can be addressed.
- It is a big and hugely relevant result that these advanced turbine controls do not result in mechanical torques in excess of that normally experienced by wind turbines.
- The accomplishments of the project seemed to be in line with the stated goals. The project team appeared to stay on schedule and met their goals in a timely fashion.
- The project demonstrated several opportunities for further exploration as well as new testing concepts and testing capabilities.
- Demonstration that response to ROCOF did not place stress on wind generator in excess of normal wind loading.

Comments on Weaknesses

- The accomplishments of this project are hugely valuable. My only concern is the relevance of the coordination at local level of various technologies to produce a single coordinated response. Will this lead to the message that this is what is required for wind turbine technologies to produce a response that is useful to the system, and without this advanced approach, it is not?

Communication

Comments on Strengths

- Very good list of publications and presentations in the conferences that disseminated the results. It is good to attract industry interest in ESIG, WIW, and IEEE events.
- Collaboration between turbine manufacturers and research.
- 5 strategic collaborations.
- 12 publications and conference presentations.
- The communication with external stakeholders was incredibly thorough and appropriate for the nature of the project.
- Impressive list of conference reports and presentations.
- Multiple manuscripts on the findings and demonstrations of the project generated.

Comments on Weaknesses

- Direct dissemination to technology providers and system operators designing the frequency response schemes could add impact to the dissemination.
- The message around the coordinated response needs to be carefully communicated in order not to undermine the usefulness of services from WTG by themselves.
- Work has been presented at ESIG and more targeted communications are needed to increase the uptake of services from WTGs.
- I do wonder if there were missed opportunities to share the results more broadly through traditional and social media outlets as the focus seemed to be heavily weighted towards publications and presentations. I'm not certain this was either necessary or would have increased visibility of the project accomplishments.

Recommendations (Not Scored)

- Excellent piece of work; very concrete outcomes. Direct dissemination to technology providers and system operators designing the frequency response schemes could add impact to the dissemination in FY 2019 or future work.
- Continuation of this work is highly valuable, particularly in the area of research around 100% inverter based systems.
- While not within my typical area of knowledge, this work seems incredibly important to wind energy's integration in the grid and the work undertaken by the project team was well-structured and valuable.
- No recommendations at this time.
- Continue and expand upon. The most significant work presented.

Modeling and Analysis Project Results

Distributed Wind Research, Development, and Testing (PNNL)

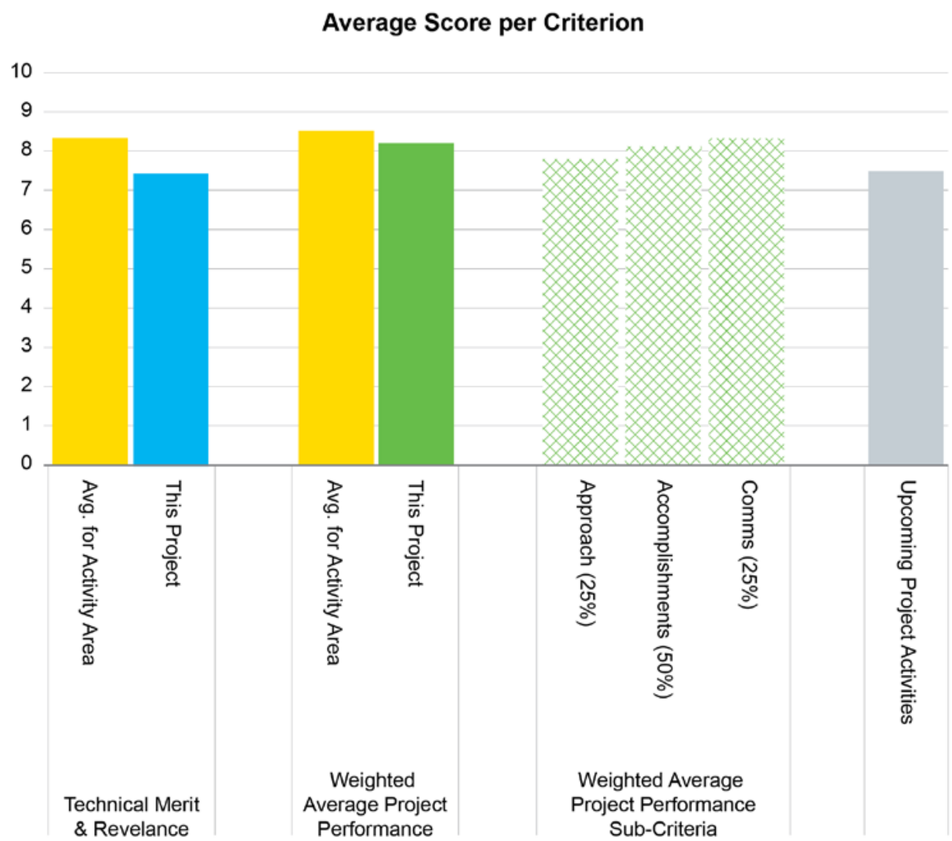
PI: Alice Orrell	Unique Project ID: A01
Organization: PNNL	WETO Program: Analysis and Modeling
Project Status: Active	WETO Activity Area: Distributed Wind
Total Available Budget (FY17 & FY18):	$881,394
Actual Costs (FY17 & FY18):	$700,098

Project Description

Provide distributed wind research, data, and analysis to support and prioritize WETO's research and development activities to achieve program goals. Deliverables are primarily reports (annual Distributed Wind Market Report) and related products, educational materials, and input to other WETO initiatives.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- There is no other database of distributed wind (distribution connected to behind-the-meter and micro-grid).
- The project seeks to collect data and generate reports that will help guide development and investment in distributed wind. Such information should be useful to industry and stakeholders and thus the project meets industry needs.
- Comprehensive approach to understand market opportunities. Strong engagement from stakeholders.
- The report itself is well researched and assembled.
- Important to keep track of developments at this level, given that development of distributed wind is a program objective.
- As noted in the presentation, this work is complementary to the work on land-based, utility-scale, and offshore wind by WETO. This work has high value for the continued growth and expansion of this market segment.
- Objectively, documenting the status of the distributed wind is very valuable to the industry and to DOE WETO. It enables them to make informed decisions about priorities.

Comments on Weaknesses

- The program seems to be focused on data collection and dissemination. I suggest focusing on taking lessons from large wind to drive LCOE of distributed wind (longer blades?).
- Not clear how or if this project advances the state of the art.
- This report, in its current form, has no potential to affect the market and is misleading with respect to the size of the industry. The definition of "smaller than 100kw" or "connected at a distribution voltage" is unsophisticated and is not useful to define the distinct market with its own unique market forces. The current definitions make the report misleading and hard to use.
- I believe there is a compelling market and government interest to understand the unique class of direct-to-load wind projects that are not located on the traditional transmission/distribution systems and are non-utility-interconnected. If this report was narrowed and refocused, I believe that it would provide material market value for monitoring an emerging industry that operates under forces that materially differ from "onshore" and "offshore."
- Why is there a compelling government interest to get certified wind turbines and why isn't this a market issue? The single biggest issue with this report is defining the market that it is studying. Why does DOE have a compelling role to support leasing programs?
- Overall, it appears that levels of distributed wind are very small, and perhaps there are questions regarding the relevance of this work in the greater energy picture.
- No benchmarked costs were presented. Please compare the viability of distributed wind with solar for different applications and locations, including international markets. Does small wind make sense compared to solar now that the COE of solar is so low? What are the situations where distributed wind (small wind) compares favorably with solar?

Approach and Methodology

Comments on Strengths

- As stated in the summary, the data collection process is exhaustive.
- The approach involves market research, data collection, cross-referencing, and classification. While this project does not involve rigorous science, the data gathered and presented in reports seems meticulous and well documented, and it should be useful.

- Publishing an annual report is a great way to document and share the outcome of the work.
- Based on the current definition, it does a good job of completing its goals. The data collection efforts are exceptional.
- Data collection and validation methods appear robust.
- Although installed capacities of distributed wind power are relatively small, it is useful that the mechanisms for gathering the types of data collected in this project are established before the market becomes more significant at utility scale.
- The methodology utilized for this project seems appropriate to develop and disseminate data on the distributed wind market.
- This is a very well-managed project. Excellent approach of collecting data directly from manufacturers and installers.
- The "Ask Me" project was excellent!

Comments on Weaknesses

- Seems very labor-intensive. I wonder if there is an opportunity to acquire the data more programmatically. Is there an opportunity to acquire data through NERC (i.e., NERC GADS) for some of the population?
- It is not clear how this project integrates with other projects in distributed wind. The data collection component could be strengthened by a modeling component to help generalize results and develop tools for evaluating various distributed wind scenarios.
- The report struggles to deal with the duality of its content (utility-connected distributed wind and non-utility wind). The report's focus is rightfully on the subset of non-utility projects, but that means that the focus is on the 5% of the stated generation. This duality makes the conclusions misleading to stakeholders.
- A major activity appears to be data collection. Is this made available in an online database, or is it just accessed via the annual report? An open approach to data would be beneficial.
- Are the end users contributing to the cost data base?

Accomplishments and Progress

Comments on Strengths

- Published reports for 2017 and 2018 along with cost reports. Very impressive deliverable considering the focus and work needed.
- Significant progress has been made collecting data and publishing the market analysis report. Collecting data in such depth is very challenging and the team should be commended for their meticulous work.
- The project met all deliverables on time and on budget.
- The team has done an excellent job at gathering and disseminating the relevant data.
- Major project deliverables appear to have been achieved in time.
- It appears all goals and target milestones were met in both 2017 and 2018.

Comments on Weaknesses

- It is not clear what new information has been derived from this project.
- Increases in distributed wind capacity appear to be quite modest and declining in many states. However, this is obviously not the fault of this activity alone.

Communication

Comments on Strengths

- Some conference presentations, published reports, and online dissemination.
- Outcomes of the study are well documented in annual report.

- Communicators-based activity with publication of market report and cost benchmarking reports.
- Reddit Ask Me Anything participation is an exemplary example of the kinds of ways that new audiences can be reached.
- Healthy total reach figures.
- The workshops and market reports appear to be good ways of disseminating the data gathered by the project. However, I wonder if more could be done to get the summaries of the project data out to a broader audience through trade publications and other traditional and social media means?
- The "Ask Me" outreach project is excellent!

Comments on Weaknesses

- Communication appears limited and very few specifics are provided to assess project impact.
- Where are analytics on report views/downloads following an eventful exposure like Reddit? How many people read this report?
- If the distributed wind market really covers utility-connected projects, then this report does not do a good job communicating to them.
- Other than seeking ways of getting the project data out to a broader audience, I was not able to identify any weaknesses.

Upcoming Project Activities

Comments on Strengths

- Group is trying to find new activities to support development (utilization?) of distributed wind.
- The same path forward is proposed to continue the market report development.
- Strong focus on publishing an annual report with update data.
- Good focus on training programs.
- This report needs to be modified to more narrowly define “distributed wind” to be effective and valuable in the market.
- The future work appears well-aligned with the project goals and plan.
- The future activities of the project team appear to build off the work in 2017 and 2018 and are worthwhile efforts.

Comments on Weaknesses

- Although distributed wind training as part of FEMP seems valuable, it is unclear how relative this is to the program goals.
- The impact and contribution of this project need to be better explained.
- It would have been good to see further exploration of alternative vectors, such as Reddit.

Recommendations (Not Scored)

- While this project collects valuable data and the work is challenging and carefully done, it is not clear that the results so far have shed any light as to whether distributed wind will become a viable economic approach competing with solar. It will be useful if this project can help provide some quantitative insights into this issue.
- The report budget is a material percentage of the entire market revenue for the market that it is studying. This report, as a result of its mandate, creates the illusion that the DW market is thriving. The illusion creates problems. If this report is refocused it could be an exceptional tool to document the growth and needs of the actual DW industry.
- If the benchmarked costs of distributed wind or small wind are unfavorable compared to PV solar and look like they will be for the foreseeable future, I would recommend DOE WETO begin to redirect this project.

Land Based and Offshore Wind Plant Technology Characterization and System Cost of Energy Analysis Involving Data Collection, Model Development and Analysis Activities

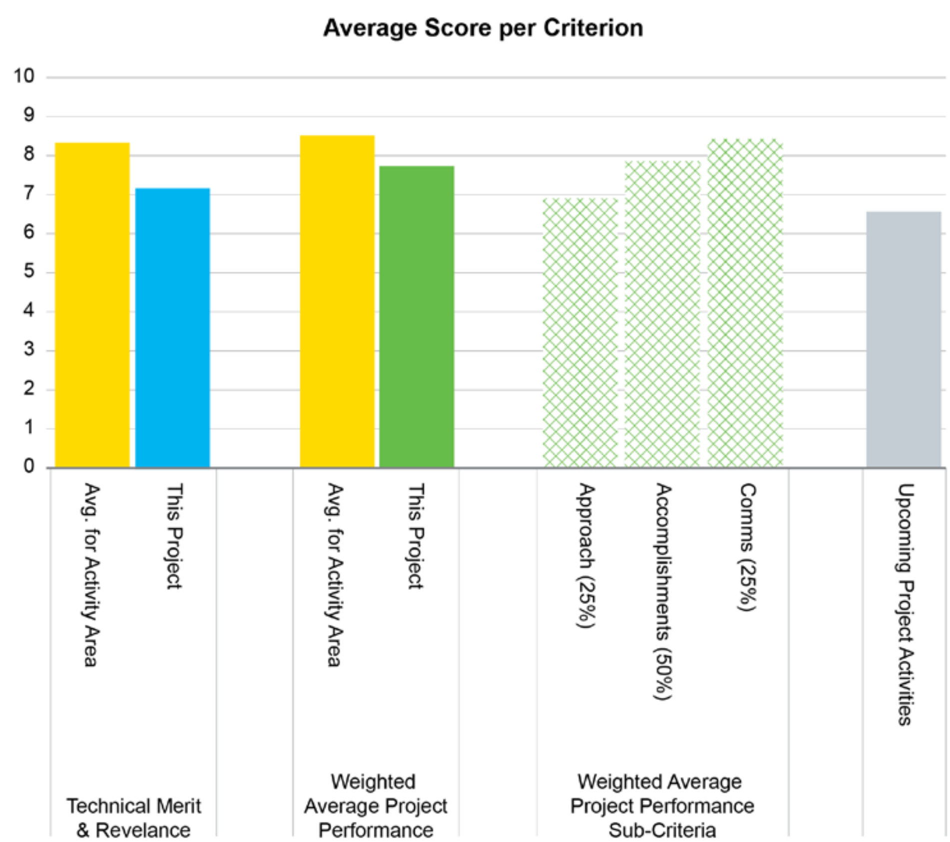
PI: Eric Lantz	Unique Project ID: A02
Organization: NREL	WETO Program: Analysis and Modeling
Project Status: Active	WETO Activity Area: Analysis and Modeling
Total Available Budget (FY17 & FY18):	$4,358,295
Actual Costs (FY17 & FY18):	$2,935,436

Project Description

Analyze trends in wind technology that affect the cost of energy in the U.S. and internationally. Analyze future wind technology research and development (R&D) and cost reduction opportunities. Execute capacity expansion and (power system) operational modeling to understand key technology, market, and policy drivers

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- In general, I see great value in DOE having robust expertise and analytics/modeling capacity in-house to support the ongoing critical work of WETO.
- This work is seen as very important for supporting all of the other DOE wind research projects.
- Goals seem clear and direct. Informing the public, the private sector, and DOE on policy drivers, R&D drivers, priorities, and work of DOE.
- Broader-scale modeling (e.g., energy system) is an appropriate government role.
- Array design modeling useful for industry.
- In general, this task provides WETO with objective, quantitative information to guide the program and answer critical questions for other government agencies and the public. It is extremely valuable to have trustworthy models to make these comparisons. The energy storage comparison impact on curtailment is very interesting and valuable in terms of informing DOE where to invest in storage.
- Will the scaling study help identify barriers to onshore reductions of LCOE?
- Electric-sector modeling helps inform what kind of ancillary service has greatest value and thus what DOE should support and what industry should focus on.
- Making a 15 MW reference offshore wind turbine model has tremendous value to the industry and researchers.
- The national impact of different tower height is very illuminating and helpful in terms of quantifying the value of tall towers in weak wind areas.

Comments on Weaknesses

- Looking forward, I think it will continue to be important to focus on those places where public, rather than private investment, is most needed. As an example, I think the electric sector modeling aspects of this are much more valuable than the plant-level optimization (which I'd think industry would be more incentivized to advance).
- The goals are poorly-stated, but the results are good.
- This project does not appear to provide a unique market informing value, nor does it advance the state of the art. No unique capability is demonstrated. Models this complicated are generally disregarded by industry stakeholders because they have a low probability of accuracy and thus do not inform decisions. It seems like the market has committed material resources to this already.
- Divergence of actual wind deployment pattern from modeled reveals limitations on modeling.
- Modeling of system costs is a challenge for government.
- This is a very broad program addressing many different aspects of the industry. Is focus needed? Or perhaps a well-defined deliverable, such as a documented model and summary report?

Approach and Methodology

Comments on Strengths

- Approach appears solid.
- Okay method description.
- Detailed methodologies are shown.
- Broad-based and robust modeling capabilities.
- Very productive with multiple reports on relevant technical topics.

Comments on Weaknesses

- Not clear how the public is addressed with the methodology. Seems more tailored to DOE and somewhat towards private sector. Not clear how some of the reports are related directly to the goals. Need to tie questions to goals better.
- How is this model validated against real-world events? Has this model been shown to predict the future with any level of accuracy? Innovation in all "objects" is ongoing and makes the overall model usefulness questionable.
- Modeling is not always predictive of actual events.

Accomplishments and Progress

Comments on Strengths

- This team has produced a truly impressive number of important deliverables for both internal and external forums.
- Results of analysis are key to document the performance of other projects.
- Some interesting results. Not certain of the value. Many reports in the works or completed.
- The applicant accomplished what they intended to do.
- Multiple deliverables (33) completed.

Comments on Weaknesses

- Not clear how the questions that are addressed came about. Not a good tie to goals. Not clear if any accomplishments are needed or utilized.
- I struggle to recognize the market value of the accomplishments.

Communication

Comments on Strengths

- This team has produced a truly impressive number of important deliverables for both internal and external forums.
- Good communication.
- Eighteen reports provided in year. Additionally, journal articles and presentations provided.
- The topic appears to be reasonably well communicated.
- Numerous presentations at national and international fora.

Comments on Weaknesses

- As with other comments here, it is not clear the value or usefulness of the reports.
- Report analytics are not included.

Upcoming Project Activities

Comments on Strengths

- It is the electric sector modeling work more so than the plant-specific information that I think is most valuable, so I am glad to see that will continue (just under a separate project). Also, it is great to see more focus on offshore turbines moving forward.
- New activities are well-described and really relevant.
- Several project goals are clearly articulated.

Comments on Weaknesses

- Again, unclear how any of the proposed activities support the project goals.
- I don't see how continuing this activity will advance the state or the art in the industry or how there is a compelling government interest in committing more funds to models like this.
- Focusing on wind system costs (a weakness) and not broad policy-oriented issues.

Recommendations (Not Scored)

- I will recommend building modeling of offshore wind power LCOE on European project track record and focusing on predicting the differences to the U.S. market for future projects.
- The costs of this are better spent in other places. By applicant's own admission, there is no specific question they are trying to answer—so why does it make sense to spend tax dollars on this? It seems like a better use would be to just conduct an annual poll of executives to get actual industry participants' forecasts, and then to aggregate those forecasts.
- Accelerate the development of the 15 MW offshore reference turbine.

Modeling & Analysis to Inform WETO R&D

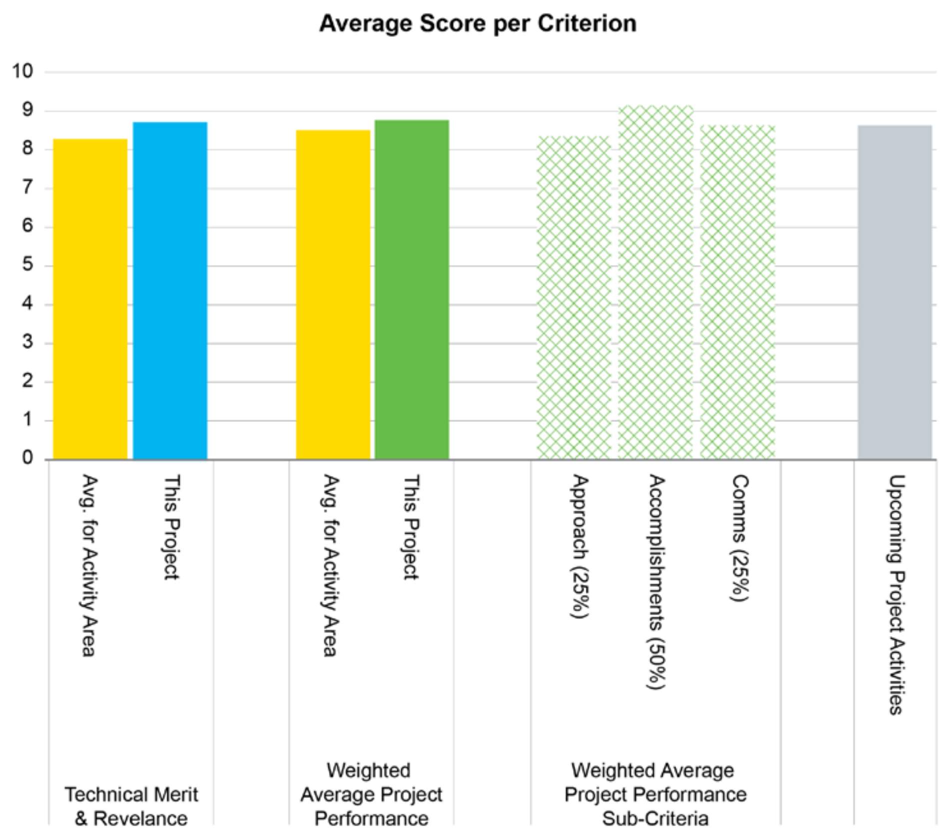
PI: Ryan Wiser	Unique Project ID: A03
Organization: LBNL	WETO Program: Analysis and Modeling
Project Status: Active	WETO Activity Area: Analysis and Modeling
Total Available Budget (FY17 & FY18):	$2,949,895
Actual Costs (FY17 & FY18):	$1,813,820

Project Description

Synthesize foundational data, conduct innovative and targeted analysis, and provide analytical support to WETO and its partners. Fill critical knowledge gaps in support of WETO and the wind sector by conducting analysis on the potential cost, performance, value, and barriers to wind power in the United States.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Quite relevant for industry.
- The modeling and analysis capabilities are described in four complimentary areas.
- The focus on supporting the overall WETO mission is highly relevant to industry.
- Providing data and analyses on cost performance value and barriers in United States. Very relevant work for DOE and also for industry and researchers. Flexible project to include timely new analyses while updating existing ones.
- Provide an independent and objective opinion on the status of the market.
- Comprehensive approach taking into account both engineering and financial analysis.
- The Wind Energy Market Report has been established as the benchmark for the wind industry annually. It provides a valuable assimilation of market data that is not commercially available.
- This project has strong merit. As a stakeholder, I rely heavily on the data and key trend information in DOE's Wind Technologies Market Report and the underlying analysis that supports the information therein. As a stakeholder working to advance pragmatic, defensible policies, it is critical that I understand the state of the wind industry. And, the wind industry is incredibly dynamic—from regional development trends, to cost trends, transmission variables, etc.—and all of this important information is constantly in flux. The report is a tremendous resource that quickly assimilates this data and shares it publicly. This information helps advance a strong industry into the future cost effectively by understanding current status, opportunities, and challenges. There is no other resource that compares to this. This project also supports other analyses as we prepare for the industry's future, particularly as the PTC winds down and offshore wind industry project advancement looks strong.
- Broad-based work on multiple areas of importance to wind development, including wind's role in and effects on power markets. Includes a needed focus on societal impacts of wind, an increasingly important and problematic area.

Comments on Weaknesses

- Several of the other reports, publications, and analyses are hard to see the value in. The financing report, for example, does not routinely inform the market and its conclusions are superfluous. Societal impact reviews are not comprehensive and offer little market value.
- There is a lag in wind cost information obtainable by the group. This is probably unavoidable, but limits the usefulness of the information in the active market context.

Approach and Methodology

Comments on Strengths

- Fine approach.
- The organization is flexible to respond to new inquiries and needs as they develop. The team strives to ensure they both address the technical answer and ground it in economic realities.
- Highly integrated collaborative approach among various labs based on statistical, economic, and engineering analysis grounded on available literature.
- Major progress in four main areas:
    - Wind Tech Market Report: Collects and synthesizes project-level data across the entire wind fleet in the United States and updates with new data annually.
    - Wind Energy Cost and Performance Analysis: Reflects on value of past and future projects. Four projects have been completed, asking questions like "What caused the

    increase and subsequent decline of wind turbine prices?" and "What is the impact of reducing uncertainty in energy forecast?"
  - Advanced the understanding of wind grid integration needs and system values. What are the societal and grid impacts of wind?
  - R&D Opportunity and Impact Evaluation: Seeks to understand the need for and benefits of R&D.
- Project largely on track.
- Analysis tools from previous phases are complemented by interesting new analyses captured every year, such as project degradation analyses. Good decision of focus on cost increase/decrease analysis (including impacts on financing and operational cost decreases), health impacts, etc. Very good collaboration, bringing information and analyses together in the DOE and National Labs (especially NREL) and using international collaboration.
- Strong use of operating wind farm data.
- The Market Report is a well-respected benchmark.
- The sophistication of the underlying analysis in the annual report is impressive. It is rare that I have a question that the wind technologies report does not address. It is a one-stop shop to quickly assess overall industry data, such as cumulative installed capacity vis-a-vis other major energy source generators, or the United States' ranking in wind industry generation, as well as deployed capacity across the country. In addition to this important summary data, the report dives into several very technical areas, such as turbine nameplate capacities, manufacturing capacity, state policy targets, the ownership breakdown of assets, etc. All of these details matter when prioritizing policies and directing R&D spending. The project also performed an important assessment of the industry's benefits and the economic returns on R&D investments. The project's assessment of grid and societal impact assessments also provides some very critical data. Often when considering the environmental impacts of wind energy, the only societal benefit that is considered is mitigating climate change. However, wind energy also provides tremendous benefits in air quality improvement—particularly with respect to criteria pollutants regulated under the Clean Air Act.
- Work is informed through active involvement with various sectors of the wind industry, including industry.

Comments on Weaknesses

- The range of modeling capabilities is not clearly described. Leaves the reader to not appreciate the current capabilities.
- Regarding market value, the trends from historical data do not capture the load transition impact, from load flexibility to new loads from heating/transport etc. It would be good to mention when publishing the decreasing value trends with increasing penetration that load flexibility in future will change this picture.
- The balance of other reports lacks sufficient value. Where is the tracking of how the communication is used by the industry? Why aren't downloads tracked? How does the market use the results of the other reports and can it be shown whether they have influenced anything?
- There is only so much that industry can divulge, particularly with respect to competitive issues, such as cost.

<u>Accomplishments and Progress</u>

Comments on Strengths

- Good outcome.
- great metrics are shown of lower LCOE, higher CF, etc.
- Progress has been made in wind energy cost and performance, grid integration, societal impacts, and R&D opportunities. This is the kind of project that DOE labs can do the best.

- Project has been successful in producing unbiased data on and objective analysis of the potential cost, performance, and value to wind power in the United States. Covers a wide variety of topics, including very good reports also on topical issues like health impacts.
- Excellent report showing key KPI and market trends.
- I agree that the program has accomplished what it intended to.
- Strong accomplishments to date—including, most notably, the completion of two very strong wind technologies market reports.
- FY17 and FY18 milestones complete.

Comments on Weaknesses

- Unclear how the modeling and analysis effort is related to these metrics.
- I would like to see more specificity in accomplishments/goals for R&D area other than "remain nimble."

Communication

Comments on Strengths

- Well communicated.
- More focus on internal deliverables than external presentations and papers. (Good!)
- The project has produced so far numerous lab reports, as well as some journal articles and conference posters. The project also disseminates results online making reports available for downloads. It is impressive that 10,000+ downloads per year have been reported.
- Good publications, presentations, and technical assistance with nice press coverage. Scientifically sound work with journal articles published.
- Dissemination is wide, with excellent outreach internationally. The annual market report from the United States has gained an international brand. Excellent work.
- This report is widely used and read by industry. High visibility.
- The reports are distributed. The supporting material is readily available.
- The communication is strong. It is truly impressive the number of times this research has been presented (44 times), the press uptake, as well as the journal articles, lab reports and conference posters. I am also confident that the analyses performed under this project provide a valuable resource to journalists and reduce the spread of misinformation.
- Extensive and effective efforts to disseminate the products of the work via reports, journal articles, and meeting presentations.
- Extensive email list for notifications of reports, etc.

Comments on Weaknesses

- The project could be strengthened by better assessing the actual impact the work is making to industry and stakeholders. Report downloads is a good metric but some specific examples of how this work has impacted industry would be very useful.
- I do not see any website analytics or other analytics that show what reports are being used and to what extent. No details about how many people on the 10,000+ distribution list click on any links. No details about how follow on reports are used or how many quotes in press/market publications rely on facts from reports. Overall the understanding of defendable analytics in not present and is thus not at an acceptable level.

Upcoming Project Activities

Comments on Strengths

- Relevant for the market ahead.
- Detailed project timeline for future activities and deliverables is shown.

- A clear plan for finalizing this project has been presented.
- Good list provided.
- Strong focus on publishing updated and improved report.
- I am already really looking forward to the release of the 2018 Wind Technologies Market Report, and I am so grateful that DOE continues to support this report. I agree that it’s imperative that this project remain nimble as this industry and U.S. energy policy overall is incredibly dynamic and in constant flux. It’s important that DOE have the ability to redirect resources to critical analyses to inform sound decision-making.
- The project identifies a list of important future projects.
- While FY17 and FY18 milestones were met, team plans on more granular focus on wind's market impacts, which is relevant given the variety of physical and market contexts within which wind is deployed.
- OpEx analysis will be interesting.

Comments on Weaknesses

- I would like to see future market value work, including impacts of load flexibility, as well as getting the uncertainties of both wind and solar in future cost projections.
- I would like to see specific objectives and the representative cost of those objectives. It is hard to tell how much is the Market Report versus the other reports, for example.

Recommendations (Not Scored)

- Project adds value to industry, and it is very much what DOE labs do best.
- The market report, with evolving additions and focus areas, is internationally highly regarded and is also excellent work to refer to outside of the United States. I hope this continues!
- The analyses on costs and cost projections, including analyses on (market) value, are also very relevant for wind industry globally.
- I did not see much on barriers. Would that need to be addressed in future?
- Reports add no value to the market when they conclude that the PTC phase out costs money and that the financing would be cheaper if the debt-service coverage ratio was lowered. The strength of this team appears to be collecting hard-to-collect data and analyzing it so that others can use it. I would recommend focusing efforts in areas of strength. Download statistics appear to support this conclusion.
- There is a need for more sophisticated analyses on curtailment costs across the country, as we anticipate several more bat listings under the Endangered Species Act and seasonal curtailment obligations will likely expand. This impact of ESA-induced curtailment regimes will have quite variable impacts depending on resource quality and turbine efficiency.
- Continue support for this LBL group.

Techno-Economic Modeling, Analysis and Support for HQ Taskers/Urgent Needs

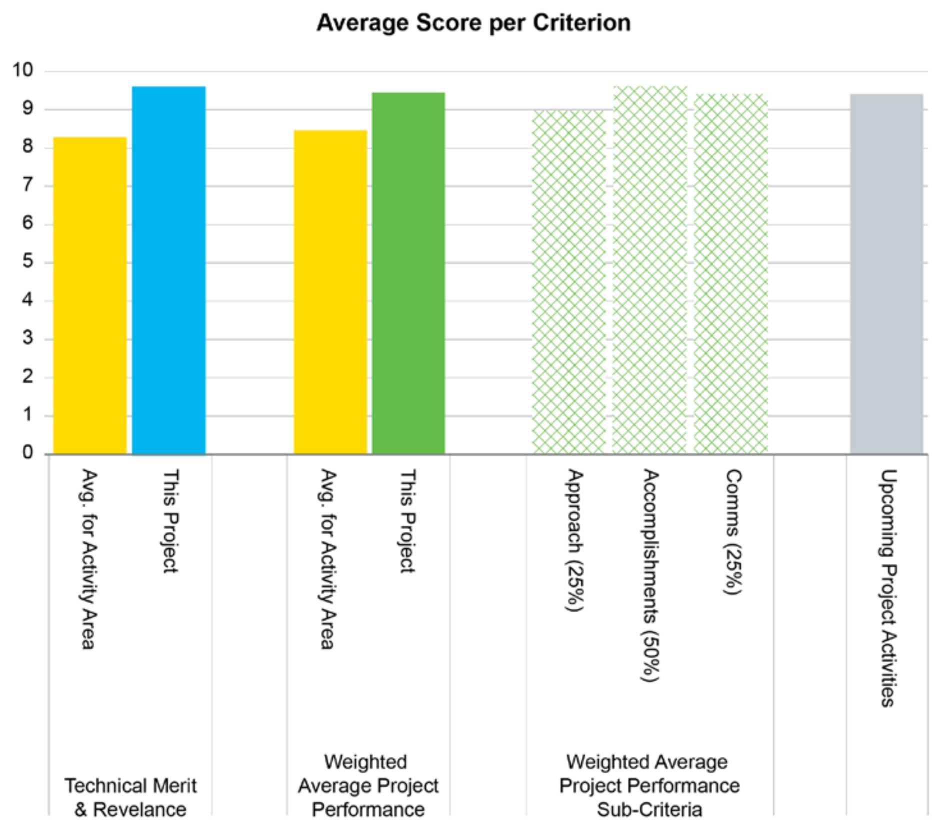
PI: Eric Lantz	Unique Project ID: A04
Organization: NREL	WETO Program: Analysis and Modeling
Project Status: Active	WETO Activity Area: Analysis and Modeling
Total Available Budget (FY17 & FY18):	$957,513
Actual Costs (FY17 & FY18):	$588,384

Project Description

This project provides analytic support at the request of the Wind Energy Technologies Office to meet needs that arise from executive leadership, Congress, senior EERE management, and the WETO director.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

<u>Technical Merit and Relevance</u>

Comments on Strengths

- Very relevant to have this "calculation machine" working well.

- This program needs to exist to be responsive to technical questions from DOE and U.S. leadership.
- Fundamentally necessary capability to support decision-making and policy development. Agile capability involving suite of tools that can be applied across a wide range of problems.
- While on its face this project may not seem as critical as some of the real-time technology evaluations being funded by DOE WETO, this is an important project that could result in aiding the industry in reducing its costs further and, therefore, increasing competitiveness with natural gas generation.
- This project entails important excess capacity to address pressing unanticipated analytical needs when they arise. Given the dynamic, transformative nature of our current energy sector, it is vital that DOE have the resources available to respond to pressing high-priority questions through sound, robust analysis. These analyses allow legislators, regulators, and other DOE staff to answer complex questions that need urgent attention and to disseminate fact-based, objective information to stakeholders.

Comments on Weaknesses

- No weaknesses noted by reviewers.

Approach and Methodology

Comments on Strengths

- Methods seem relevant.
- This program needs to exist to be responsive to technical questions from DOE and U.S. leadership.
- Extremely valuable and nimble modeling capability to support policy and decision makers. National Lab modeling has high impact and international visibility.
- Directly supports program goals with high-quality studies, using state-of-the-art modeling capabilities. Extremely capable suite of tools spread across various labs that can be deployed effectively. Continuous model development and improvement of data and models incorporating state of the art.
- Open philosophy towards models and data where this is possible.
- The project seems well designed and outcome oriented.
- This is a strong approach to dealing with these high-priority, unanticipated requests. The core capabilities are vast and impressive and cover the range of expertise needed to thoroughly answer relevant questions. Moreover, this combined, centralized capacity and expertise exists nowhere else in the federal government or private sector.
- The availability of these resources is critical for DOE to nimbly address high-priority questions as they arise without causing frustrating delays in the remainder of DOE's research portfolio. It is important for DOE to have the resources to sustain progress on long-term projects while addressing more immediate needs.

Comments on Weaknesses

- Plexos and ReEDS are used extensively to address these studies. Is there a need to focus on a modeling capability that is more nimble—the development of which is more under the control of the labs--so that state-of-the-art developments can be applied to meet emerging research needs?
- There are limitations to studying capacity expansion (e.g., ReEDS) and operations (e.g., Plexos) separately. For example, curtailment is not generally well-captured in capacity expansion models, which generally have reduced operational detail and limited chronology. Therefore, the value of variable renewable generation is often overestimated and the value of flexible resources is often underestimated. This is particularly an issue in high-VRE scenarios.
- The representation of uncertainty in much of the modeling is quite limited. From what I understand, it is usually captured by use of reserves. Particularly in high VRE, explicit modeling of

uncertainty using stochastic optimization can reveal increased needs for flexibility for shorter-term system balancing. Explicit representation of uncertainty is particularly important when issues of flexibility and curtailment are being addressed. It should be noted that these comments are mostly forward-looking and mostly relevant when looking towards high-VRE scenarios

Accomplishments and Progress

Comments on Strengths

- Good outcome.
- All work was accomplished.
- State-of-the-art models developed and employed to answer specific real-world, relevant research questions. Well-structured suite of integrated tools. Appears to be good coordination across the National Labs. Constant improvement of models and capability.
- The stated accomplishments seem to track well against the proposed goals.
- This program has been utilized in a variety of ways. The offshore wind assessment example identifies the use of this fund to understand factors related to a rapidly advancing new technology. Understanding cost targets necessary for rapid expansion is key to directing near-term policy strategies and other related efforts. This program was also used to better understand a high-priority issue for wind developers: potential future curtailment regimes to reduce impacts to bats. The regional differences produced from this analysis evaluating capacity factor effects provide necessary context for understanding the magnitude of the problem and the pressing need for alternatives to curtailment.

Comments on Weaknesses

- No weaknesses noted by reviewers.

Communication

Comments on Strengths

- Well communicated at the session.
- It appears that the majority of information was shared to the extent possible.
- Excellent coordination between labs.
- Open development of tools and models is high impact (e.g. ReEDS 2.0).
- Work on visualization is high impact and a very valuable tool.
- Extensive National Lab dissemination through ESIG, Task 25, IEEE and many other fora.
- Despite being apparently limited in the project team's ability to coordinate with outside stakeholders or communicate details of the project goals or accomplishments, it is noted that they have attempted to use social media for the purposes of communicating with the project, and, based on the provided data, it is seemingly effective. Through the evaluation of the Rush Creek project's economic development impact, it is also clear that the project team is attempting to collaborate with external parties.
- This project has produced numerous communication materials and reports summarizing the analyses.

Comments on Weaknesses

- No weaknesses noted by reviewers.

Upcoming Project Activities

Comments on Strengths

- Relevant to do ahead too.
- This resource needs to continue to exist.

- Future planned studies address very relevant research questions and industry needs.
- The outlined proposed future activities seem appropriate in the context of this project.
- Strong list of important projects has been identified to address more urgent needs.

Comments on Weaknesses

- Is there a need for DOE to directly support capability development activities?

Recommendations (Not Scored)

- Projects like this are why National Labs exist. This is highly cost effective and a great resource to key U.S. policy makers.
- Explore the use of other modeling assets that can potentially be more agile and suitable for adaptation to future challenges.
- Consider explicit modeling of uncertainty to assess flexibility and curtailment impacts.
- Consider increased operational detail in capacity expansion models where relevant.
- Continue and expand open approach to modeling and data.
- This work seems worthy of continued funding. One area to look at that could serve to help accelerate the deployment of wind energy and avoid some of the challenges related to siting and operations is what the cradle-to-grave life cycle impacts of wind energy are on the environment (e.g., air and water quality, wildlife, land use, etc.) in comparison to other forms of generation (i.e., coal, natural gas, nuclear, solar, and hydro). Without that contextual information, many of the arguments made for why wind energy shouldn't be widely deployed or should be avoided in some locations are without merit. This particular project seems well-suited for taking on such an evaluation and socializing the results through social media and other outlets.
- Continue to support this effort since the availability of these funds allows DOE to be nimble and to react to high-priority challenges as they arise in a fast-paced, dynamic energy market.

Offshore Wind Strategy Follow on Analysis

PI: Garrett Barter	Unique Project ID: A05
Organization: NREL	WETO Program: Analysis and Modeling
Project Status: Active	WETO Activity Area: Analysis and Modeling
Total Available Budget (FY17 & FY18):	$2,244,242
Actual Costs (FY17 & FY18):	$1,674,019

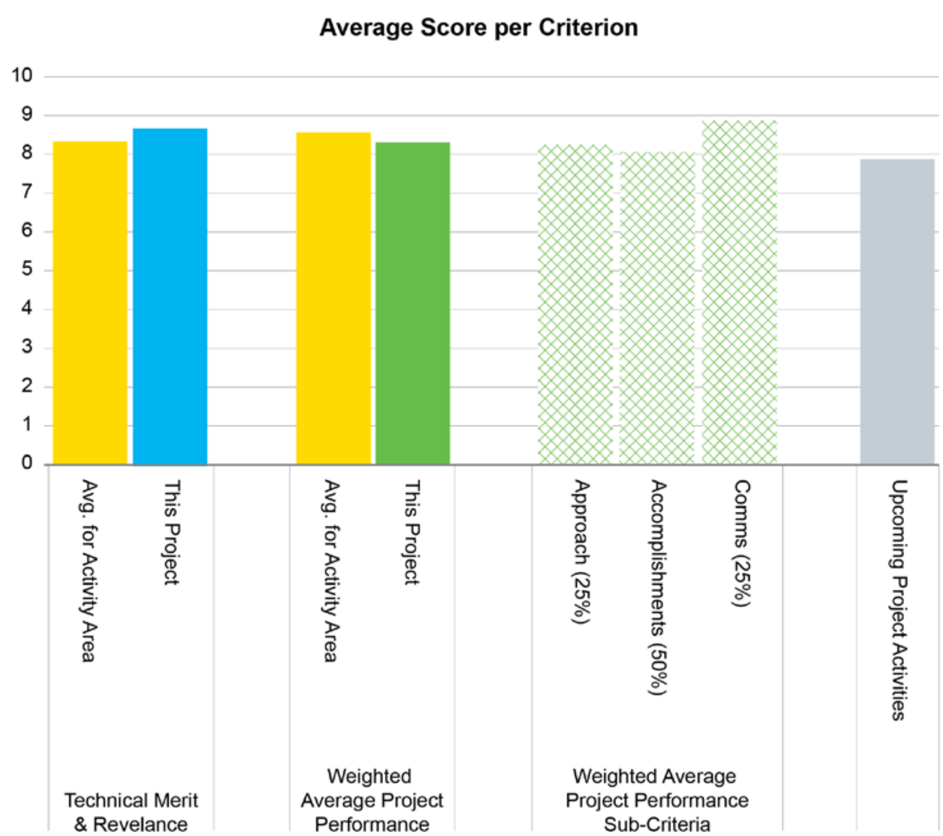
Project Description

This project answered specific questions emerging from the 2016 Offshore Wind Strategy regarding value and innovation opportunities. Project tasks are organized into three specific categories:

1. Offshore Wind (OSW) System Benefits Analysis
2. OSW Technology Pathways and Innovation Analysis
3. Market, Risk, and Resource Analysis.

Project Scoring

Note: The individual project scoring table includes comparisons to the average scores (yellow bars) of all projects in the same Activity Area.



Reviewer Comments

Technical Merit and Relevance

Comments on Strengths

- Given the huge learning curve for U.S. regulators, energy planners, and stakeholders with regard to all aspects of offshore wind power, this effort and the original strategy before it is essential for moving America forward in pursuit of this massive new domestic energy source.
- Content of this work is very relevant for tapping in on experience from Europe regarding offshore wind power.
- Addresses timely and critical issues for all stakeholders that benefit from the analyses proposed with potential to advance the state of the art, such as offshore wind development markets/trends/international experience; floating offshore wind technology options and how to compare them; and offshore wind-related aspects of power system integration.
- Strong focus on floating offshore structures, which is very relevant to the U.S. market.
- The offshore wind market report is a valuable market-informing resource.
- This project identifies technical, as well as institutional, barriers and attempts to project LCOE.
- The analysis of technology pathways is informing DOE on fruitful technology investments.

Comments on Weaknesses

- I would like to see more attention paid to advancing options for fixed-bottom foundation installation (either by avoiding pile driving or significantly reducing the noise it creates). Floating platforms are important to advance as well, but given the scale of the near-term procurement commitments for New England, New York and New Jersey, and the substantial amount of shallow water area leased by developers to serve those markets, there are significant cost-reduction opportunities to be found in helping ease the regulatory pathway for fixed-bottom foundations.
- Nothing contained in the presentation demonstrated that this work (outside of the Market Report) is advancing the state of the art, has industry pull, or that there is a compelling need for government work in the area.
- There are a lot of analysis projects that seem to overlap to different extents. Could these be more focused and coordinated with clear and differentiating goals?

Approach and Methodology

Comments on Strengths

- Approach appears solid, utilizing the best available sources of data.
- Methods are suited for purpose.
- Excellent market and trend survey filtering global experience. Very interesting set up for floating offshore wind. Good idea to use existing scenarios to get a more detailed grid integration analysis.
- Addresses key questions related to offshore market trends. Builds on current knowledge acquired from European market.
- The market report is well assembled.
- Approach uses systematic approach with well-developed tools.

Comments on Weaknesses

- The objectives are very ambitious for an analysis project. Two of the topics would probably need projects of their own to be properly addressed:
- Comparison of very early phase/different technical concepts for floating offshore wind may prove difficult in practice.
- Power system analysis is challenging to set up in a way that gets the offshore wind impacts. Showing locational impacts would demand scenarios that differ considerably from a land-based

scenario. The set up used works for the transmission congestion part, but other impacts are not as clear.

- The complicated and interrelated models contained in this project are not likely to accurately predict a complicated and emerging market. I do not see how this model is validated by real-world observances.
- Focus on highest priority analysis, models, and/or data.

Accomplishments and Progress

Comments on Strengths

- Producing this kind of region/grid-specific information is so critical for helping decision makers up the offshore wind learning curve and for increasing comfort with the idea of bringing large amounts of offshore wind power onto their systems.
- Very good assessment of the global offshore trends in the market report.
- An interesting and useful tool to compare spar, semisubmersible, and combinations of floating concepts and their technology optimization options.
- Integration study confirming that offshore wind has potential to help relieve congestion over some lines, and flexibility for adding 5 percent share of demand from offshore wind on top of 10 percent share of demand from land based will be feasible from flexibility point of view.
- The annual offshore market report is very relevant to the industry stakeholders and presents an independent and objective view of the U.S. offshore market. Strong focus on building modeling capabilities of floating foundations. Currently, this is maybe the best available report on forecasting the value of the different foundation technologies for the U.S. market.
- This project completed what it intended to do.
- Many of the accomplishments come in the form of high-value support to government agencies that are engaged in offshore regulation.

Comments on Weaknesses

- With the dynamics of the offshore sector in Europe and around the globe quickly moving, the results quickly become obsolete.
- The floating technology tool still needs some work to get the needed dynamic loads.
- The grid integration study base case scenario for comparisons could be better chosen with more relevant results comparing a case where either land-based or offshore wind was serving the load. The flexibility results would be more interesting to see for the larger interconnected area.

Communication

Comments on Strengths

- Ensuring the United States has a robust offshore wind strategy supported by the best available industry and market data is essential for gaining momentum in this booming global industry, and maximizing the many benefits that this massive clean energy opportunity can deliver.
- Lots of good communication.
- Excellent market report featuring experiences from global developments and reaching out to IEA/European collaboration. Economic potential as easy-to-visualize maps. Technical assistance used several times. Good timing of the project.
- Highly visible report. Outcomes are widely shared in the industry community.
- The market report is well communicated.

Comments on Weaknesses

- Understanding analytics for an industry this new is key. Capturing this data and using it to inform future communication is key, since the participants are distinct from the onshore participants.

Upcoming Project Activities

Comments on Strengths

- Glad to see this work continuing, and more fully being folded into DOE's core analysis projects. It is critical that offshore wind energy not get siloed or otherwise overlooked when assessing America's renewable energy assets and opportunities on an ongoing basis as costs/trends evolve.
- New activities finely described.
- Good list of future activities (project as such will not continue).
- Strong focus on scaling.
- Continuing with the 15 MW reference turbine would be valuable.

Comments on Weaknesses

- Would like to see attention and resources put toward advancements in noise reduction strategies/technologies for fixed-bottom foundations, not just floating. While they are commercially advanced globally, we have different characteristics here in the United States (i.e., different soil conditions, federally-protected large whales) that need to be addressed and the strategies/technologies for minimizing underwater noise during installation need to be proven to the investment market out here. Advancing these strategies could bring a massive near-term cost reduction benefit for the first phase of U.S. development. Approximately 15 GW and counting will be built over next 15 years almost entirely on fixed-bottom foundations.
- I would like to see a separate project for offshore grid integration.
- Other efforts should be ended since they are also not likely to inform the market.

Recommendations (Not Scored)

- It is important that this work will continue, as offshore is one critically important future issue of wind development in United States—both getting the fixed-bottom projects to start and the floating technology developed and demonstrated.
- Screening the global development trends, on top of technology projects.
- Simulation tools to assess different floating technology economic feasibility is valuable—this can be in either analysis or technology track.
- The offshore grid integration part would merit a study of its own, at least for the Eastern interconnect.
- The majority of this project scope does not modify market behavior; does not advance the state of the art in the market; does not lead to a lower LCOE; and does not provide any other compelling reason for future investment. Complicated, future-predicting models do not historically have value, nor do they modify market behavior. It is hard to define specific value of this work.

Appendix A: Peer Review Process Comments and Recommendations

Peer Review Planning

- Materials Ready for Peer Reviewers 6-8 weeks ahead of peer review. To aid peer reviewers, WETO should ensure all of the peer review materials are completed with more time for review. In 2019, most project files were not completed until 1 month before peer review. Recommend at least 6-8 weeks before peer review. This should not be an issue as all project files and such are "backward" looking, so no work in the 6-8 weeks before peer review would impact the content of the presentations/write-ups.
- Develop and update a running "Lessons Learned" document throughout the Peer Review planning and execution process to ensure all lessons learned are captured.

Project Selection/Project List

- Begin the process by carefully reviewing the methodology and parameters used in the prior review to determine which projects were reviewed, and follow them as closely as possible, making changes in approach only where necessary to accommodate changed circumstances. Determining the project list, including how budget numbers for the review period are calculated, has historically been the most painful and delay-inducing part of the overall peer review process.

Agenda

- Unique Identifiers for projects should be included on Agenda. At the very least, there should be a version of the agenda with the Unique Identifiers for the Peer Reviewers to easier check which presentation is coming up and how that relates to the reviews they have been working on.

- Agenda should include more time for Peer Reviewer Questions. In the 2019 Peer Review, Questions were about 1/3 of the time allocated to the review. Since peer reviewers have the material ahead of time, some have suggested that they would like to spend more time asking questions.

- Better align the agenda and the "order" in which peer reviewers look at the files. To help reviewers better follow what's going on, it might be better to assign unique ID based on the order of presentations in the Agenda, rather than assigning unique ID before the agenda is finalized.

Development of Scoring Metrics (Office, Program, Activity, Project)

- The evaluation criteria and scoring scale to be used by the reviewers was carefully assessed and modified by the full WETO team before the 2019 Peer Review. Any proposed changes to the evaluation framework and details should be carefully considered within the full context of potential related impacts within the overall process.

Peer Review Tool

- Provide an "offline" tool (excel spreadsheet) for Reviewers to log their input. Many reviewers felt the online comment entry portal was clunky and inconvenient for inputting information when they needed to (e.g. working on a flight). An offline tool for initial comment entry was requested as a quality of life improvement. The TD team developed this on their own, but would have preferred DOE provide for continuity.

Presentations and Project Summary Materials

- Presentation “Front Matter” summary information is not necessary to present during peer review. This material is good for the final presentation, as standalone, but only takes up time during peer review. Consider 2 different presentations, or emphasize to presenters that this material should be skipped.
- Presentations should focus more on “story of the project” rather than technical details. Technical details are provided in the Summary Materials, and is reviewed ahead of time. Be more diligent in differentiating between the two documents. The presentation should NOT just be a summary of the project summary, but should support it.

Peer Reviewer Engagement & Support

- Provide Peer Review materials to Peer Reviewers in Binders. Given the amount of material we are asking reviewers to look through, most requested that WETO provide them with binders of the files they should be reviewing and considering. These binders should include a copy of the agenda with unique project Identifier numbers. A list of all materials included in the binder, listed by Unique identifier, and one copy of each presentation and project summary (as well as the office, program, and activity level write-ups) that reviewers should be scoring.

- Prior to Peer Review, Emphasize FACA restrictions. In communications with Peer Review leads, and before peer review, during peer review, emphasize that the peer review panel is not trying to reach any consensus on scores.

Peer Review (Day Of) – Logistics and Execution

- (duplicate) Agenda should include more time for Peer Reviewer Questions. In the 2019 Peer Review, Questions were about 1/3 of the time allocated to the review. Since peer reviewers have the material ahead of time, some have suggested that they would like to spend more time asking questions.

- Facilitators should be much more aggressive keeping people on time. When speakers go over time, it limits time for questions, which peer reviewers found very important, and frustrating if missed. An assigned moderator and program lead should help execute flow of presentations in a given section.

Peer Review Report

- Through succeeding peer reviews the final report format has evolved to the 2019 format. Early in the process, the format and sections of the report should be carefully reviewed to ensure that the details of the desired end product are established well in advance of the review, and responsibilities for and timing of delivering each element are reflected in the scopes of work of both the supporting contractor and the WETO team.
- Of particular importance is generating the individual project reports in draft form as rapidly after the Peer Review as possible for review by the WETO team, circulation to the individual project PIs, and follow-on conversations between the two parties to discuss the results. Historically this process has taken far too long.

Appendix B: Office Evaluation Form

WETO 2019 Peer Review Form #1
Office Evaluation Form

Core Information

Office Name	Wind Energy Technologies Office (WETO)
Reviewer	
Presenter	(WETO Management)
Presenter Organization	(WETO)

Criterion 1
Office Objectives

Overall, the office's portfolio of funded projects:
Reflect an understanding of the near- and long-term challenges facing industry and other wind energy stakeholders
Meet the needs of industry and other stakeholders in addressing those challenges in order to realize opportunities for economic growth, technical advancement, and/or dissemination of objective information

Unsatisfactory							Outstanding		
1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Criterion Scoring

Comments on strengths and weaknesses of the office's objectives:

S☐ or W☐ ______________________________

S☐ or W☐

S☐ or W☐

Criterion 2
Research Portfolio
Overall, the office's portfolio of funded projects:
Align with the stated office objectives
Effectively meet those objectives
Represent an effective use of congressionally appropriated funds
Meet the office's objectives by generating results of near- or long-term value to industry and other stakeholders

Unsatisfactory							Outstanding		
1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Criterion Scoring

Comments on strengths and weaknesses of the research portfolio

S☐ or W☐

S☐ or W☐

S☐ or W☐

Criterion 3
Qualifications, Management and Operations
Overall, based on both the programmatic and project presentations, the office team:
Effectively manages and directs the activities needed to meet its objectives
Demonstrates the professional capabilities needed to identify, monitor and guide its portfolio of projects
Has operations and oversight procedures in place to ensure efficient direction of office activities, both internally and with project awardees

Unsatisfactory								Outstanding	
1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Criterion Scoring

Comments on qualifications, management and operations:

S☐ or W☐

S☐ or W☐

S☐ or W☐

Criterion 4
Communications and External Engagement
The office:
Engages with industry, academia, other agencies, non-governmental organizations, and international research organizations to ensure high levels of cooperation and information exchange
Effectively disseminates information regarding its activities and results of its funded projects
Ensures that its project awardees engage in effective communication regarding project results

Unsatisfactory								Outstanding	
1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Criterion Scoring

Comments on strengths and weaknesses of communications and external engagement:

S☐ or W☐

S☐ or W☐

S☐ or W☐

Recommendations
Please provide any recommendations you would like to make related to WETO.

Appendix C: Program and Activity Area Evaluation Form

This form enables the reviewer to provide comments on WETO's programs. Under each of the three programs listed below, there are summary presentations and multiple activity area and project presentations included in the Peer Review agenda. In your evaluation, please consider the sum of all activities and projects under a given program.

PROGRAM AND ACTIVITY AREA EVALUATION FORM

This form enables the reviewer to provide comments on WETO's programs. Under each of the three programs listed below, there are summary presentations and multiple activity area and project presentations included in the Peer Review agenda. In your evaluation, please consider the sum of all activities and projects under a given program.

Program:

Technology Development and Scientific Research

Activity Areas:

- Atmosphere to Electrons;
- Offshore Wind;
- Distributed Wind;
- Testing Infrastructure;
- Standards Support and International Engagement;
- Advanced Components Reliability and Manufacturing; and
- Technology to Market and Small Business Vouchers

Program:

Market Acceleration and Deployment

Activity Areas:

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

Program:

Analysis and Modeling

- n/a

Program Evaluation

Program ______________________________

Reviewer ______________________________

Comments on the program:

1. Are the Activities and Projects within this portfolio on the leading edge of work within this field?

   ____

2. Has the rationale behind the funded Activities and Projects been effectively conveyed during the peer review?

   ____

3. Within this field, are thought leaders aware of the WETO-supported work?

4. Are there important topic areas that are underrepresented or missing within the Program?

5. Are there any notable strengths to the Program portfolio content or direction that you would like to point out?

6. Are there any notable weaknesses to the Program portfolio content or direction that you would like to point out?

7. What recommendations would you like to convey to the manager(s) of this program?

Appendix D: Project Evaluation Form

Criterion 1
Technical Merit and Relevance
The project:
Meets the needs of industry and/or other stakeholder groups
Has clear potential to advance the state-of–the-art and/or enable other important technical advances, innovations, and/or research results

Unsatisfactory								Outstanding	
1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Criterion Scoring

Comments on strengths and weaknesses of technical merit and relevance:

S☐ or W☐

S☐ or W☐

S☐ or W☐

Project Performance
Note: Criteria 2 – 4 relate to project performance and will be aggregated into a weighted average "Performance" score. The relative weighting is summarized at the end of the form

Criterion 2 (Project Performance #1 - 25% Weighting)
Approach and Methodology
The project:
Is based on a cohesive and realistic strategy including research plan, critical path items, risk mitigation, and timeline to achieving desired outcomes
Is based on sound technical principles, with a credible pathway to technical success and/or meeting the other stated goals of the project
Demonstrates a high degree of scientific rigor in research, testing and other key tasks
Where feasible, includes collaboration with other commercial or research organizations to increase the available resources and/or knowledge base applied to meeting the project goals

Unsatisfactory								Outstanding	
1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Criterion Scoring

Comments on strengths and weaknesses of approach and methodology

S☐ or W☐

S☐ or W☐

S☐ or W☐

Criterion 3 (Project Performance #2 - 50% Weighting)
Accomplishments and Progress
The project has:
Shown progress toward its technical objectives as reflected in milestones reached, deliverables presented, and other achievements
Produced results meeting or exceeding prior expectations and/or obligations relative to the project plan and schedule
Successfully adapted to any technical or programmatic challenges

Unsatisfactory								Outstanding	
1	2	3	4	5	6	7	8	9	10
□	□	□	□	□	□	□	□	□	□

Criterion Scoring

Comments on strengths and weaknesses related to accomplishments and progress:

S☐ or W☐

S☐ or W☐

S☐ or W☐

Criterion 4 (Project Performance #3 - 25% Weighting)
Communication, Coordination, and Commercialization
The project team has, or has presented plans to, disseminate the results of project research to relevant audiences, and to move technical results toward commercialization (IF APPROPRIATE) or other intended application(s) through outreach activities SUCH AS:
Coordination on topic area activities with other research organizations
Conference presentations and/or professional publications
Organizing or attending specialized subject matter meetings and forums
Partnering with industry and other potential end-users to help ensure a viable pathway to commercialization
Engaging in formal "technology-to-market" programs

Unsatisfactory								Outstanding	
1	2	3	4	5	6	7	8	9	10
□	□	□	□	□	□	□	□	□	□

Criterion Scoring

Comments on strengths and weaknesses related to communication, collaboration, and technology transfer:

S☐ or W☐

S☐ or W☐

S☐ or W☐

Criterion 5
Upcoming Project Activities
Note: Relates to completion of WETO-funded projects and previously merit reviewed activities, not to potential future funding opportunities for the research topic; does not apply to projects that have been pre-designated by WETO as being complete or nearly complete for the purposes of the peer review.

The plans for upcoming tasks and completion of the project:
Convey that the remaining activities and resources are sufficient to meet the objectives of the project
Will realistically be able to take into account and compensate for any shortcomings in meeting milestones and deliverables
Have been adjusted to accommodate any known budgetary challenges
Have been adjusted to accommodate any unforeseen technical successes or setbacks
Remain viable and relevant given any related changes in the marketplace, or to other previously assumed future application(s) for the research results

Unsatisfactory							Outstanding		
1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Criterion Scoring

Comments on strengths and weaknesses of upcoming project activities:

S☐ or W☐

S☐ or W☐

S☐ or W☐

Recommendations
Please provide any recommendations you would like to make regarding the project.

Performance Weighting Overview (Criteria 2-5 only)

Performance Criteria	Weighting of Scores
Criterion 2 - **Approach and Methodology**	25%
Criterion 3 - **Accomplishments and Progress**	50%
Criterion 4 - **Communication**, Collaboration, and Commercialization	25%

Example of how overall performance score is derived:
(Score 2 X .25) + (Score 3 X .50) + (Score 4 X .25) = weighted score

When calculated to incorporate the scores of multiple reviewers, it becomes the average weighted performance score for that project.

Appendix E: Meeting Attendee list

Registration Contact List: U.S. Department of Energy | Wind Energy Technologies Office 2019 Project Peer Review			
First Name	Last Name	Title	Company
Christina	Aabo	Head of R&D	Orsted
Jim	Ahlgrimm	Deputy Director	U.S. Department of Energy
Taber	Allison	Director of Research	American Wind Wildlife Institute
John	Anderson	Executive Director	Edison Electric Institute
Lara	Aston	Scientist/Project Manager	Pacific Northwest National Laboratory
Ian	Baring-Gould	Research & Deployment Program Manager	National Renewable Energy Laboratory
Bret	Barker	Advisor	General Dynamics
Garrett	Barter	Senior Engineer	National Renewable Energy Laboratory
Daniel	Beals	Program Analyst	U.S. Department of Energy
Fredric	Beck	Senior Associate	U.S. Department of Energy
Shanika	Benedicto	Project Analyst	U.S. Department of Energy
Jonathan	Berg	SWiFT Program	Sandia National Laboratories
Larry	Berg	Senior Research Scientist	Pacific Northwest National Laboratory
Jason	Biddle	Radar Interference Mitigation Portfolio Manager	Massachusetts Institute of Technology (MIT)
Cynthia	Bothwell	Senior Fellow	Solar Energy Technologies Office
Catherine	Bowes	Program Manager	National Wildlife Federation
Dan	Brake	Sr. Director, Engineering	NextEra Energy
Greg	Brinkman	Engineer	National Renewable Energy Laboratory
Jocelyn	Brown-Saracino	Program Manager for Market Acceleration and Deployment	U.S. Department of Energy
Sandy	Butterfield	CEO	Boulder Wind Consulting
Stan	Calvert		Green Powered Technology, LLC
Scott	Carron	Senior Researcher	National Renewable Energy Laboratory
Chih-Chieh	Chang	Energy& Environment Intern	International Technology and Trade Associates, Inc.
Charlton	Clark	Program Manager	U.S. Department of Energy
Leland	Cogliani	Senior Associate	Lewis Burke Associates
Andrea	Copping	Senior Research Scientist	Pacific Northwest National Laboratory
Dave	Corbus	Wind Grid Integration lead	National Renewable Energy Laboratory
Habib	Dagher	Executive Director	University of Maine

Sujit	Das	Sr. Research & Development Staff	Oak Ridge National Laboratory
Michael	Derby	Head of R&D	U.S. Department of Energy
Jody	Dillon	Independent Consultant	Energy Reform Ltd.
Paul	Donley	Manager, Engineering	Duke Energy
Phillip	Dougherty	Principal	DEC LLC
Caroline	Draxl	Senior Scientist	National Renewable Energy Laboratory
Melissa	Elkinton	Director, Energy Resources & Meteorology	Avangrid Renewables
Sam	Enfield		Windline Development, LLC
Brandon	Ennis	Research Staff	Sandia National Laboratories
Jason	Fields	Senior Engineer	National Renewable Energy Laboratory
Brandon	Fitchett	Sr. Project Manager - R&D	Electric Power Research Institute
Paul	Fleming	Principal Investigator	National Renewable Energy Laboratory
Darryl	Francois	Chief, Eng and Tech Review	Bureau of Ocean Energy Management
Jian	Fu	Technology Manager	U.S. Department of Energy
Jake	Gentle	Power Systems Engineers	Idaho National Laboratory
Jason	Gershowitz	Principal	Kearns & West
Vahan	Gevorgian	Chief engineer	National Renewable Energy Laboratory
Lillie	Ghobrial	Project Engineer	U.S. Department of Energy
Patrick	Gilman	Program Manager	U.S. Department of Energy
Ivette	Gonzalez	Operations Support Specialist	U.S. Department of Energy
Isabel	Gottlieb	Research Program Manager	American Wind Wildlife Institute
Johney	Green	Associate Laboratory Director	National Renewable Energy Laboratory
Amy	Halloran		Sandia National Laboratories
Liz	Hartman	Wind Energy Communications Lead	U.S. Department of Energy
Sue Ellen	Haupt	Senior Scientist, Deputy Lab Director	National Center for Atmospheric Research
Cris	Hein	Senior Project Leader-Wind Energy and Wildlife	National Renewable Energy Laboratory
Alison	Hewett	Senior Analyst	BCS, LLC
Mark	Higgins	Assistant Director	U.S. Department of Energy | Loan Programs Office
Peter	Hill	Director Government Relation	Woods Hole Oceanographic Institution
Eric	Hines	Professor of the Practice	Tufts University

Adam	Hinojos		NREL
Bri-Mathias	Hodge	Chief Scientist	National Renewable Energy Laboratory
Ben	Hoen	Research Scientist	Lawrence Berkeley National Laboratory
Richard	Hogoboom	Student	SAIS
Hannele	Holttinen	Senior Adviser, Partner	Recognis
Allison	Johnson		U.S. Department of Energy Water Power Tech Office
Matthew	Johnston	Assistant Professor	Oregon State University
Jason	Jonkman	Senior Engineer	National Renewable Energy Laboratory
Benjamin	Karlson	Engineer	Sandia National Laboratories
David	Karpinski	VP of Operations	Lake Erie Energy Development Corporation
Jonathan	Keller	Senior Engineer	National Renewable Energy Laboratory
Jereme	Kent	CEO	One Energy Enterprises LLC
Kevin	Kinzie		GE Renewable Energy
Geoffrey	Klise	Manager - Wind Energy Technologies	Sandia National Laboratories
Veerabhadra	Kotamarthi	Atmospheric Scientist	Argonne National Laboratory
Terri	Krantz	Project Analyst	U.S. Department of Energy
Daniel	Laird	Center Director	National Renewable Energy Laboratory
Eric	Lantz	Research Manager	National Renewable Energy Laboratory
Jessica	Lau	Sr. Technical Project Manager	National Renewable Energy Laboratory
Dominic	Lee	Program Manager	Oak Ridge National Laboratory
Alexsandra	Lemke	Sr. Advisor, External Affairs	U.S. Department of Energy
Anna	Luke		American Wind Energy Association
William	Mahoney	Director, Research Applications Laboratory	National Center for Atmospheric Research
Cara	Marcy	electricity analyst	EPA
Jeffrey	Marr	Associate Director of Applied Engineering	University of Minnesota
Nicholas	Massey	Project Analyst	U.S. Department of Energy
Angel	McCoy	Meteorologist	Bureau of Ocean Energy Management
Seth	Menter	Manager	BCS LLC

Patrick	Moriarty	Team Lead	National Renewable Energy Laboratory
Ben	Murray	Project Manager	U.S. Department of Energy
Jacques	Nader	Head of R&D	Siemens Gamesa Renewable Energy
Robert	Norris	Senior R&D Associate	Oak Ridge National Laboratory
Robert	Norris	Senior R&D Associate	Oak Ridge National Laboratory
Gary	Norton	Sr Renewable Energy Advisor	U.S. Department of Energy
Gary	Nowakowski	Project Management Supervisor	U.S. Department of Energy
Akinwumi	Oluwole	Budget Analyst	Department of energy
Alice	Orrell	Energy Analyst	Pacific Northwest National Laboratory
Joy	Page	Director, Renewable Energy & Wildlife	Defenders of Wildlife
Joshua	Paquette	Principal Member of the Technical Staff	Sandia National Laboratories
Amber	Passmore	Workforce Management	U.S. Department of Energy
Eliana	Permutter		Lewis Burke Associates
Brian	Post	R&D Staff Member	Oak Ridge National Laboratory
Valerie	Reed	Acting Director	U.S. Department of Energy
Bradley	Ring	Technical Project Officer	U.S. Department of Energy
Amy	Robertson	Senior Engineer	National Renewable Energy Laboratory
Michael	Robinson	Mr.	U.S. Department of Energy
Mike	Robinson	Senior Technical Advisor	U.S. Department of Energy
Carrie	Schmaus	Fellow	U.S. Department of Energy
Carrie	Schmaus	ORISE Fellow	U.S. Department of Energy
Shahil	Shah	Research Engineer	National Renewable Energy Laboratory
William	Shaw	Earth Scientist/Wind Energy Program Lead	Pacific Northwest National Laboratory
Dave	Simms	NWTC Research Operations Director	National Renewable Energy Laboratory
Brian	Smith	Wind Lab Program Manager	National Renewable Energy Laboratory
James	Smith	Exec Dir	Energy Systems Integration Group
Fotis	Sotiropoulos	Dean	SUNY Stony Brook
Michael	Sprague	Principal Scientist	National Renewable Energy Laboratory
Joseph	Steki		EPRI
Henrik	Stiesdal	CEO	Stiesdal A/S
Ryan	Storke	CEO	Storke, LLC

Raphael	Tisch	Senior Project Manager	U.S. Department of Energy
Richard	Tusing	Senior Advisor	U.S. Department of Energy
Ross	Tyler	Exec VP	Business Network for Offshore Wind
Alessia	Vacca	Doctor PhD	University of Sassari
Jeroen	van Dam	Principal Engineer	National Renewable Energy Laboratory
Paul	Veers	Chief Engineer	National Renewable Energy Laboratory
Tom	Vinson	VP, Policy and Regulatory Affairs	American Wind Energy Association
Anthony	Viselli	Manager, Offshore Model Testing & Structural Design	University of Maine
Lorry	Wagner	President	Lake Erie Energy Development Corporation
Venus	Welch-White		Department of Agriculture
Ryan	Wiser	Senior Scientist	Lawrence Berkeley National Laboratory
Maggie	Yancey	Wind Energy Analyst	U.S. Department of Energy
Elvin	Yuzugullu		General Dynamics Information Technology
Zhi	Zhou	Principal Computational Scientist	Argonne National Laboratory

Appendix F: Meeting Agenda

2019 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
WIND ENERGY TECHNOLOGIES OFFICE

U.S. DEPARTMENT OF ENERGY
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

HOSTED AT THE HILTON ALEXANDRIA OLD TOWN
1767 KING ST | ALEXANDRIA, VA 22314

April 30, 2019 Technology Development						
Start	End	Project Name	Track	Session	Room	Presenter
8:00 AM	8:30 AM	Breakfast			Grand Ballroom A&B	
8:30 AM	9:00 AM	DOE - Program Director, WETO - Valerie Reed	Plenary	Plenary	Grand Ballroom A&B	Reed
9:00 AM	9:30 AM	Keynote Speaker - Henrik Stiesdal	Plenary	Plenary	Grand Ballroom A&B	Stiesdal
9:30 AM	9:50 AM	DOE - Assistant Secretary, EERE - Daniel Simmons	Plenary	Plenary	Grand Ballroom A&B	Simmons
9:50 AM	10:20 AM	Overview of MA&D Program	Plenary	Plenary	Grand Ballroom A&B	Brown-Saracino
10:20 AM	10:50 AM	Overview of TD Program	Plenary	Plenary	Grand Ballroom A&B	Derby
10:50 AM	11:05 AM	Break				
11:05 AM	11:20 AM	Overview of Analysis & Modeling	Plenary	Analysis and Modeling	Grand Ballroom A&B	Gilman
11:20 AM	11:50 AM	Modeling & Analysis to Inform WETO R&D	Plenary	Analysis and Modeling	Grand Ballroom A&B	Wiser
11:50 AM	12:20 PM	Distributed Wind Research, Development, and Testing (PNNL)	Plenary	Analysis and Modeling	Grand Ballroom A&B	Orrell
12:20 PM	1:20 PM	Lunch			Grand Ballroom A&B	
1:20 PM	1:45 PM	Land Based and Offshore Wind Plant Technology-Characterization and System Cost of Energy Analysis Involving Data Collection, Model Development, and Analysis Activities	Plenary	Analysis and Modeling	Grand Ballroom A&B	Lantz
1:45 PM	2:10 PM	Offshore Wind Strategy Follow on Analysis	Plenary	Analysis and Modeling	Grand Ballroom A&B	Barter
2:10 PM	2:35 PM	Techno-Economic Modeling, Analysis and Support for HQ Taskers/Urgent Needs	Plenary	Analysis and Modeling	Grand Ballroom A&B	Lantz
2:35 PM	2:50 PM	Future Work for NREL Wind Analysis	Plenary	Analysis and Modeling	Grand Ballroom A&B	Lantz
2:50 PM	3:05 PM	Transition				
3:05 PM	3:20 PM	Overview of Offshore Specific R&D	Technology Development	Offshore Specific R&D	Grand Ballroom C	Norton
3:20 PM	3:50 PM	Cost Of Energy reduction for offshore Tension Leg Platform (TLP) wind turbine systems through advanced control strategies for energy yield improvement, load mitigation and stabilization	Technology Development	Offshore Specific R&D	Grand Ballroom C	Norton
3:50 PM	4:20 PM	Project Icebreaker	Technology Development	Offshore Specific R&D	Grand Ballroom C	Wagner
4:20 PM	4:35 PM	Break				
4:35 PM	5:05 PM	Aqua Ventus	Technology Development	Offshore Specific R&D	Grand Ballroom C	Dagher
5:05 PM	5:35 PM	Offshore Resource Characterization	Technology Development	Offshore Specific R&D	Grand Ballroom C	Shaw
5:35 PM	6:05 PM	Optional: Peer Reviewer Debrief			Madison	

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U.S. DEPARTMENT OF ENERGY
WIND ENERGY TECHNOLOGIES OFFICE

U.S. DEPARTMENT OF ENERGY
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

May 1, 2019 Technology Development						
Start	End	Project Name	Track	Session	Room	Presenter
8:00 AM	8:30 AM	Breakfast			Grand Ballroom A&B	
8:30 AM	8:50 AM	Keynote Speaker - Bill Mahoney	Plenary	Plenary	Grand Ballroom A&B	Mahoney
8:50 AM	9:20 AM	Overview of WETO Communications & Operations	Plenary	Plenary	Grand Ballroom A&B	Hartman
9:20 AM	9:30 AM	Transition				
9:30 AM	10:00 AM	Overview of Atmosphere to Electrons (A2e)	Technology Development	A2e	Grand Ballroom C	Robinson
10:00 AM	10:30 AM	Atmospheric Science - A2e PRUF	Technology Development	A2e	Grand Ballroom C	Fields
10:30 AM	10:45 AM	Break				
10:45 AM	11:35 AM	Atmospheric Science - A2e: Mesoscale Physics and Inflow: WFIP 2 (+FOA awardee)	Technology Development	A2e	Grand Ballroom C	Shaw, Turner
11:35 AM	12:15 PM	Atmospheric Science - MMC - Model Development & Validation	Technology Development	A2e	Grand Ballroom C	Haupt
12:15 PM	1:15 PM	Lunch			Grand Ballroom A&B	
1:15 PM	1:55 PM	Wind Plant Science - High-Fidelity Modeling	Technology Development	A2e	Grand Ballroom C	Sprague
1:55 PM	2:25 PM	Wind Plant Science - Rotor Wake Measurements & Predictions for Validation	Technology Development	A2e	Grand Ballroom C	Moriarty
2:25 PM	2:55 PM	Wind Plant Science - Advanced Flow Control Science for Wind Plants	Technology Development	A2e	Grand Ballroom C	Fleming
2:55 PM	3:15 PM	Wind Plant Science - Small Business Vouchers - WindESCo	Technology Development	A2e	Grand Ballroom C	Fleming, King
3:15 PM	3:30 PM	Break				
3:30 PM	4:00 PM	Integrated Systems Design - Multi Physics Model Validation & UQ	Technology Development	A2e	Grand Ballroom C	Jonkman
4:00 PM	4:30 PM	Integrated Systems Design and Analysis	Technology Development	A2e	Grand Ballroom C	Barter
4:30 PM	5:00 PM	Integrated Systems Design and Analysis (OSW)	Technology Development	A2e	Grand Ballroom C	Robertson
5:00 PM	5:05 PM	Break				
5:05 PM	5:20 PM	Overview of Distributed Wind R&D	Technology Development	Distributed Wind R&D	Grand Ballroom C	Gilman
5:20 PM	5:50 PM	Distributed Wind Research, Development, and Testing	Technology Development	Distributed Wind R&D	Grand Ballroom C	Baring-Gould
5:50 PM	6:20 PM	Optional: Peer Reviewer Debrief			Madison	

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U.S. DEPARTMENT OF ENERGY
WIND ENERGY TECHNOLOGIES OFFICE

U.S. DEPARTMENT OF ENERGY
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

May 2, 2019 Technology Development

Start	End	Project Name	Track	Session	Room	Presenter
8:00 AM	8:30 AM	Breakfast			Grand Ballroom A&B	
8:30 AM	8:50 AM	Keynote Speaker - Paul Donley	Plenary	Plenary	Grand Ballroom A&B	Donley
8:50 AM	9:10 AM	Multi-Year Program Plan	Plenary	Plenary	Grand Ballroom A&B	Ahlgrimm
9:10 AM	9:20 AM	Transition				
9:20 AM	9:35 AM	Overview of Testing Infrastructure Program	Technology Development	Testing Infrastructure	Grand Ballroom C	Ahlgrimm
9:35 AM	10:05 AM	Testing Facilities and Capabilities at NWTC	Technology Development	Testing Infrastructure	Grand Ballroom C	Simms
10:05 AM	10:35 AM	Testing Facilities and Capabilities at Sandia: Field Test Facilities - DOE Turbine Facilities and Test Sites O&M	Technology Development	Testing Infrastructure	Grand Ballroom C	Berg
10:35 AM	10:45 AM	Break				
10:45 AM	11:00 AM	Overview of Standards Support & International Engagement	Technology Development	Standards Support & International Engagement	Grand Ballroom C	Ahlgrimm
11:00 AM	11:30 AM	Wind Standards Development	Technology Development	Standards Support & International Engagement	Grand Ballroom C	van Dam
11:30 AM	11:40 AM	Break				
11:40 AM	11:50 AM	Overview of Technology to Market Activities & Small Business Voucher Program	Technology Development	Technology-to-Market / Small Business Vouchers	Grand Ballroom C	Lemke
11:50 AM	12:10 PM	Technology to Market (T2M)	Technology Development	Technology-to-Market / Small Business Vouchers	Grand Ballroom C	Lemke, Aston
12:10 PM	12:45 PM	Small Business Vouchers - Micron/NIRE/ SkySpecs	Technology Development	Technology-to-Market / Small Business Vouchers	Grand Ballroom C	Paquette, Ennis, Berg
12:45 PM	1:45 PM	Lunch			Grand Ballroom A&B	
1:45 PM	2:00 PM	Overview of Advanced Components, Reliability, and Manufacturing	Technology Development	Advanced Components, Reliability, & Manufacturing	Grand Ballroom C	Ring
2:00 PM	2:30 PM	Optimized Carbon Fiber Composites for Wind Turbine Blades	Technology Development	Advanced Components, Reliability, & Manufacturing	Grand Ballroom C	Ennis
2:30 PM	3:00 PM	Big Adaptive Rotor	Technology Development	Advanced Components, Reliability, & Manufacturing	Grand Ballroom C	Paquette
3:00 PM	3:15 PM	Break				
3:15 PM	3:45 PM	Additive Manufacturing in Wind Turbine Components and Tooling	Technology Development	Advanced Components, Reliability, & Manufacturing	Grand Ballroom C	Post
3:45 PM	4:05 PM	Small Business Vouchers - Tower Technology	Technology Development	Technology-to-Market / Small Business Vouchers	Grand Ballroom C	Veers
4:05 PM	4:35 PM	Wind Turbine Blade Durability and Damage Tolerance	Technology Development	Advanced Components, Reliability, & Manufacturing	Grand Ballroom C	Paquette
4:35 PM	4:50 PM	Break				
4:50 PM	5:10 PM	Small Business Vouchers - Sentient	Technology Development	Technology-to-Market / Small Business Vouchers	Grand Ballroom C	Ennis
5:10 PM	5:50 PM	Wind Turbine Drivetrain Reliability	Technology Development	Advanced Components, Reliability, & Manufacturing	Grand Ballroom C	Keller
5:50 PM	6:20 PM	Optional: Peer Reviewer Debrief			Madison	

2019 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
WIND ENERGY TECHNOLOGIES OFFICE

U.S. DEPARTMENT OF ENERGY
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

HOSTED AT THE HILTON ALEXANDRIA OLD TOWN
1767 KING ST | ALEXANDRIA, VA 22314

April 30, 2019 - Market Acceleration & Deployment

Start	End	Project Name	Track	Session	Room	Presenter
8:00 AM	8:30 AM	Breakfast			Grand Ballroom A&B	
8:30 AM	9:00 AM	DOE - Program Director, WETO - Valerie Reed	Plenary	Plenary	Grand Ballroom A&B	Reed
9:00 AM	9:30 AM	Keynote Speaker - Henrik Stiesdal	Plenary	Plenary	Grand Ballroom A&B	Stiesdal
9:30 AM	9:50 AM	DOE - Assistant Secretary, EERE - Daniel Simmons	Plenary	Plenary	Grand Ballroom A&B	Simmons
9:50 AM	10:20 AM	Overview of MA&D Program	Plenary	Plenary	Grand Ballroom A&B	Brown-Saracino
10:20 AM	10:50 AM	Overview of TD Program	Plenary	Plenary	Grand Ballroom A&B	Derby
10:50 AM	11:05 AM	Break				
11:05 AM	11:20 AM	Overview of Analysis & Modeling	Plenary	Analysis and Modeling	Grand Ballroom A&B	Gilman
11:20 AM	11:50 AM	Modeling & Analysis to Inform WETO R&D	Plenary	Analysis and Modeling	Grand Ballroom A&B	Wiser
11:50 AM	12:20 PM	Distributed Wind Research, Development, and Testing (PNNL)	Plenary	Analysis and Modeling	Grand Ballroom A&B	Orrell
12:20 PM	1:20 PM	Lunch			Grand Ballroom A&B	
1:20 PM	1:45 PM	Land Based and Offshore Wind Plant Technology-Characterization and System Cost of Energy Analysis Involving Data Collection, Model Development and Analysis Activities	Plenary	Analysis and Modeling	Grand Ballroom A&B	Lantz
1:45 PM	2:10 PM	Offshore Wind Strategy Follow on Analysis	Plenary	Analysis and Modeling	Grand Ballroom A&B	Barter
2:10 PM	2:35 PM	Techno-Economic Modeling, Analysis and Support for HQ Taskers/Urgent Needs	Plenary	Analysis and Modeling	Grand Ballroom A&B	Lantz
2:35 PM	2:50 PM	Future Work for NREL Wind Analysis	Plenary	Analysis and Modeling	Grand Ballroom A&B	Lantz
2:50 PM	3:05 PM	Transition				
3:05 PM	3:20 PM	Overview of Stakeholder Engagement & Workforce Development	Market Acceleration & Deployment	Stakeholder Engagement & Workforce Development	Potomac	Yancey, Brown-Saracino
3:20 PM	3:50 PM	WindExchange and Regional Resource Centers	Market Acceleration & Deployment	Stakeholder Engagement & Workforce Development	Potomac	Baring-Gould
3:50 PM	4:20 PM	Collegiate Wind Competition	Market Acceleration & Deployment	Stakeholder Engagement & Workforce Development	Potomac	Baring-Gould
4:20 PM	4:50 PM	Wind for Schools	Market Acceleration & Deployment	Stakeholder Engagement & Workforce Development	Potomac	Baring-Gould
4:50 PM	5:20 PM	Optional: Peer Reviewer Debrief			Madison	

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U.S. DEPARTMENT OF ENERGY
WIND ENERGY TECHNOLOGIES OFFICE

U.S. DEPARTMENT OF ENERGY
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

May 1, 2019 - Market Acceleration & Deployment						
Start	End	Project Name	Track	Session	Room	Presenter
8:00 AM	8:30 AM	Breakfast			Grand Ballroom A&B	
8:30 AM	8:50 AM	Keynote Speaker - Bill Mahoney	Plenary	Plenary	Grand Ballroom A&B	Mahoney
8:50 AM	9:20 AM	Overview of WETO Communications & Operations	Plenary	Plenary	Grand Ballroom A&B	Hartman
9:20 AM	9:30 AM	Transition				
9:30 AM	9:50 AM	Environmental Research: Program Overview & National Lab Research	Market Acceleration & Deployment	Environmental Research	Potomac	Brown-Saracino
9:50 AM	10:35 AM	Wind Operational Issue Mitigation (NREL)	Market Acceleration & Deployment	Environmental Research	Potomac	Hein
10:35 AM	11:05 AM	Wind Operational Issue Mitigation (PNNL)	Market Acceleration & Deployment	Environmental Research	Potomac	Copping
11:05 AM	11:10 AM	Break				
11:10 AM	11:25 AM	Environmental Research: Overview of Eagle FOA	Market Acceleration & Deployment	Environmental Research	Potomac	Brown-Saracino
11:25 AM	11:55 AM	Detection and Perception of Sound by Eagles and Surrogate Raptors	Market Acceleration & Deployment	Environmental Research	Potomac	Marr
11:55 AM	12:25 PM	Understanding the Golden Eagle Sensory World to Enhance Detection and Response to Wind Turbines	Market Acceleration & Deployment	Environmental Research	Potomac	Tisch
12:25 PM	1:25 PM	Lunch			Grand Ballroom A&B	
1:25 PM	1:55 PM	A Heterogeneous System for Eagle Detection, Deterrent, and Wildlife Collision Detection for Wind Turbines	Market Acceleration & Deployment	Environmental Research	Potomac	Johnston
1:55 PM	2:15 PM	Eagle Take Minimization System (Laufer)	Market Acceleration & Deployment	Environmental Research	Potomac	Tisch
2:15 PM	2:45 PM	Evaluating the Effectiveness of a Detection and Deterrent System in Reducing Golden Eagle Fatalities at Operational Wind Facilities	Market Acceleration & Deployment	Environmental Research	Potomac	Allison
2:45 PM	3:15 PM	Evaluating the Effectiveness of a Camera-Based Detection System to Support Informed Curtailment and Minimize Eagle Fatalities at Wind Energy Facilities	Market Acceleration & Deployment	Environmental Research	Potomac	Allison
3:15 PM	3:30 PM	Break				
3:30 PM	3:45 PM	Environmental Research: Overview of Bat FOA	Market Acceleration & Deployment	Environmental Research	Potomac	Brown-Saracino
3:45 PM	4:05 PM	A Biomimetic Ultrasonic Whistle for Use as a Bat Deterrent on Wind Turbines	Market Acceleration & Deployment	Environmental Research	Potomac	Brown-Saracino
4:05 PM	4:25 PM	Texturizing Wind Turbine Towers to Reduce Bat Mortality	Market Acceleration & Deployment	Environmental Research	Potomac	Brown-Saracino
4:25 PM	4:45 PM	Rotor-Mounted Bat Impact Mitigation System	Market Acceleration & Deployment	Environmental Research	Potomac	Brown-Saracino
4:45 PM	5:05 PM	Ultrasonic Bat Deterrent Technology	Market Acceleration & Deployment	Environmental Research	Potomac	Kinzie
5:05 PM	5:25 PM	Evaluating the Effectiveness of Ultrasonic Acoustic Deterrents in Reducing Bat Fatalities at Wind Energy Facilities	Market Acceleration & Deployment	Environmental Research	Potomac	Hein
5:25 PM	5:55 PM	Optional: Peer Reviewer Debrief			Madison	

2019 PROJECT PEER REVIEW
U.S. DEPARTMENT OF ENERGY
WIND ENERGY TECHNOLOGIES OFFICE

U.S. DEPARTMENT OF ENERGY
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

May 2, 2019 - Market Acceleration & Deployment

Start	End	Project Name	Track	Session	Room	Presenter
8:00 AM	8:30 AM	Breakfast			Grand Ballroom A&B	
8:30 AM	8:50 AM	Keynote Speaker - Paul Donley	Plenary	Plenary	Grand Ballroom A&B	Donley
8:50 AM	9:10 AM	Multi-Year Program Plan	Plenary	Plenary	Grand Ballroom A&B	Ahlgrimm
9:10 AM	9:20 AM	Transition				
9:20 AM	9:35 AM	Overview of Siting & Wind Radar Mitigation	Market Acceleration & Deployment	Regulatory & Siting	Potomac	Gilman
9:35 AM	10:05 AM	Siting - Radar Wind-Turbine RCS Mitigation	Market Acceleration & Deployment	Regulatory & Siting	Potomac	Karlson
10:05 AM	10:35 AM	Siting - Radar Wind-Turbine RCS Mitigation MIT Lincoln Labs	Market Acceleration & Deployment	Regulatory & Siting	Potomac	Biddle
10:35 AM	11:05 AM	National Wind Turbine Database and Location Impacts R&D	Market Acceleration & Deployment	Regulatory & Siting	Potomac	Hoen
11:05 AM	11:20 AM	Break				
11:20 AM	11:35 AM	Overview of Advanced Grid Integration	Market Acceleration & Deployment	Grid Integration	Potomac	Fu
11:35 AM	12:05 PM	Operational and Strategic Implementation of Dynamic Line Rating for Optimized Wind Energy Generation Integration	Market Acceleration & Deployment	Grid Integration	Potomac	Gentle
12:05 PM	12:35 PM	Market and Reliability Opportunities for Wind on the Bulk Power System	Market Acceleration & Deployment	Grid Integration	Potomac	Lau
12:35 PM	1:35 PM	Lunch			Grand Ballroom A&B	
1:35 PM	2:05 PM	North American Renewable Integration Study	Market Acceleration & Deployment	Grid Integration	Potomac	Brinkman
2:05 PM	2:35 PM	Power System Reliable Integration Support to Achieve Large Amounts of Wind Power (PRISALA)	Market Acceleration & Deployment	Grid Integration	Potomac	Corbus
2:35 PM	2:50 PM	Break				
2:50 PM	3:20 PM	Providing Ramping Service with Wind to Enhance Power System Operational Flexibility	Market Acceleration & Deployment	Grid Integration	Potomac	Hodge
3:20 PM	3:50 PM	WindView: An Open Platform for Wind Energy Forecast Visualization	Market Acceleration & Deployment	Grid Integration	Potomac	Hodge
3:50 PM	4:20 PM	Understanding the Role of Short-term Energy Storage and Large Motor Loads for Active Power Controls by Wind Power	Market Acceleration & Deployment	Grid Integration	Potomac	Gevorgian
4:20 PM	4:50 PM	Optional: Peer Reviewer Debrief			Madison	

U.S. DEPARTMENT OF ENERGY

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For more information, visit:
energy.gov/eere/wind

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