U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

2017 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
WIND ENERGY TECHNOLOGIES OFFICE

Summary Report
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VOLUME II

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Volume II: Complete Evaluation Results and Appendices

This report details the results of the 2017 Peer Review for the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy Wind Energy Technologies Office (WETO). The purpose of the review was to evaluate projects funded by DOE from fiscal year 2014 through fiscal year 2016 for their contribution to the mission and goals of the office, assess progress against stated objectives, and appraise WETO's overall management and performance.

This volume (Volume II) includes Sections 6 and 7—the complete program-level and project-level evaluation results—as well as the report appendices. Volume I includes Sections 1–5 of the report: the executive summary, synopses of the program- and project-level evaluation results, and WETO's response to the 2017 Peer Review findings.

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6 Complete Program Evaluation Results

6.1 Overview

As discussed in Section 3, the 2017 WETO Peer Review included a quantitative and qualitative analysis of the overall office activities. Reviewers scored WETO based on four metrics. These metrics, as they appear in the scoring worksheets (Appendices) are:

1. Program Objectives: How well do program objectives align with industry needs and (Presidential) Administration Goals?

2. Research and Development (R&D) Portfolio: Is the Program's investment portfolio appropriately balanced across research areas and recipient organizations to achieve the program's mission and goals?

3. Management and Operations: What is the quality of the WETO's team, management practices, and operations?

4. Communications and Outreach: How effective is the Program at engaging with industry, universities, other agencies, international actors, and other stakeholders?

Reviewer members were also asked to comment on the strengths and weakness of each program, and to provide written recommendations for maintaining and improving WETO activities.

Each criterion was scored as a stand-alone metric. Numerical scores were based on a five-point scale, with qualitative descriptors given for the numerical scoring index (i.e., a score of 1 corresponds to a "Poor" rating, 2 corresponds to a "Fair" rating, 3 corresponds to an "Average" rating, 4 corresponds to a "Good" rating, and 5 corresponds to an "Outstanding" rating). Figure 4.1 summarizes the panelists' overall quantitative evaluation of the performance of the program.

Table 6-1 highlights the reviewers' quantitative evaluation of the performance of each program. Sections 6.2 and 6.3 provide the full body of qualitative comments from reviewers for each program.

Table 6-1. Program-Level Evaluation Scores, by Reviewer

Wind MA&D	Program Objectives	R&D Portfolio	Management and Operations	Communication and Outreach
Reviewer1	5.0	5.0	5.0	5.0
Reviewer2	5.0	4.0	5.0	5.0
Reviewer3	5.0	4.0	5.0	5.0
Reviewer4	5.0	4.0	5.0	5.0
Reviewer5	4.0	4.5	4.0	3.0
Wind RC and Tech RD&T				
Reviewer6	5.0	5.0	5.0	5.0
Reviewer7	5.0	5.0	5.0	5.0
Reviewer8	5.0	4.0	5.0	4.0
Reviewer9	4.8	4.5	5.0	3.0
Reviewer10	4.0	4.0	5.0	3.0
Reviewer11	4.0	3.0	5.0	2.0
Reviewer12	2.9	2.5	2.8	2.0

6.2 Resource Characterization and Technology Research, Development, and Testing Comments

Table 6-1 provides the full body of verbatim comments as provided by the RC and Tech RD&T reviewers at the 2017 WETO Peer Review. Comments have been edited to clarify spelling, typographical errors, and acronym usage *only*; no content has been altered from the original submissions.

Table 6-1. All Reviewer Comments by Metric for Resource Characterization and Technology Research, Development, and Testing Track

Program Objectives

- There is ample evidence that the government investment in wind energy has led to the reduction in the LCOE (levelized cost of energy). The industry has grown significantly and become quite robust.
- I think the program overall is very well suited to the industry needs. The majority of the projects that have been funded have addressed key technology gaps and uncertainties, or they have extended to SOP (standard operating procedure) in wind farm development.
- The overall design of the programs have considered key issues, data gaps, etc. that have been identified and prioritized very well. This definition of program goals and objectives has led to a very reasonable set of projects to address those goals. This systematic approach to defining projects that should receive funding (i.e., where should we allocate our limited resources) must continue.
- The majority (but not all) of the projects funded have contributed to the industry in ways that could not easily be realized by other means (i.e., private sector investments)
- I think that the work that the program has done on the development and validation of simulation tools is very important. In particular, the use of full scale tests and data collected from real wind farms is excellent.
- The program has included a number of projects that seek to distribute information to a wider body of contributors and stakeholders. I think that this is an excellent goal and will help to address the rather limited distribution of information in this industry that is based on OEM (original equipment manufacturer) IP (intellectual property) concerns.
- Major gap in strategic direction: program objectives do not include a goal specific to ramping up U.S. distributed wind sector, which holds great potential for the southeastern United States, exports, and other high retail rate markets with relatively small investments needed
- Impact of planned actions are limited due to constrained funding for important research areas, with large portions of budget devoted to offshore demonstration projects with questionable need
- Industry's current emphasis on life extension, predictive controls and retrofit market are valuable research areas, but reliability collaboratives should be expanded to include distributed wind stakeholders
- Very appropriately focused vision and plan of action to support and grow an industry and enable otherwise unattainable progress to lowering the cost of energy
- Innovation: advanced manufacturing, testing facilities and reliability collaboratives are all key areas that industry relies on to advance their technology. The consistent support and careful design of this part of the program resulted in some of DOE's most important and lasting contributions to the wind industry. This is evident from accomplishments dating back 40 years. The presentations in this review demonstrate DOE's continued focus on applying their broad resources to the broad industry stakeholder needs very successfully. Perhaps the most important yet underappreciated are the test facilities and the role they play in aiding industry. But the laboratory's strategic collaboration with industry, especially end user stakeholders, has set a new standard. Excellent work.
- A2E (Atmosphere to Electrons): the science part of the DOE program is perhaps where the most leadership has been needed and nowhere in the program is it more evident that DOE leadership has led to access to deep laboratory engagement of the most valuable talents. The mesoscale/microscale modeling could not be done by private industry and yet the broad industry stakeholder benefits are immeasurable. Industry could not have accomplished the coordinated modeling, validation, physical insights resulting from the HFM (high-fidelity modeling), wake physics modeling and control, weather forecasting improvements, design model improvements and so many other byproducts of the science part of the program. This is a truly remarkable and bold step forward for DOE. Their leadership has set the industry on a new course to address wind plant physics that will be the basis for a vibrant, world class industry for decades to come.

- Offshore: the offshore program has two major elements, demonstration and R&D. On the demonstration program, the staged nature of the program enabled them to preserve funds and course correct as the programs evolved in unpredictable ways. Many issues beyond DOE control were handled very efficiently and careful adjustments were made to maximize the value to industry. On the science part of the program, the efforts to develop validated design tools, provide industry leadership, provide leadership across agencies and focus on international collaboration have all capitalized on DOE's unique, objective and trusted position in the industry. No other organization with such broad laboratory technical resources exists. In the science part of this program DOE has strategically applied those resources to long lasting impact the industry. They capitalized on their resources to impact issues where they could have impact regardless of external forces out of their control. Very impactful.
- Standards and IEA (International Energy Agency): international collaboration almost always originates from engagement in these two areas. International standards are where the most talented industry experts reach consensus on deep technical issues resulting in industry accepted design requirements. Impacting the trajectory of technology evolution is most efficiently effected in this framework. DOE's commitment to international collaboration in this structured way has incubated technical advancements and R&D collaborations in a highly leveraged way. DOE's support for these collaborations has enabled the United States to be leaders in the most important developments over the past decades. Extremely important.
- WFIP (Wind Forecast Improvement Project), MMC (Meso/Micro scale coupling) and PRUF (Performance Risk, Uncertainty, and Finance): DOE's leadership in these areas capitalizes on unique laboratory talents that are not available anywhere else in the industry. The science and industry value of these programs could not be duplicated by private industry.
- From my perspective (End Users), the Program Objectives are in-line with Industry needs. I was very encouraged to see the wide-variety of programs that are applicable to issues we face on a daily basis (see below) as well as programs that will improve wind resource estimation and provide initial benchmarks for Offshore Wind costs.

R&D Portfolio

- The program is substantially well balanced to meet mission goals, but as industry builds capacity in some areas (e.g., some areas of turbine design, avian hazards), the DOE should focus on research efforts that are more clearly out of reach for industry such as R&D that requires exascale computing (e.g., flow characterization, plant optimization). This move in this direction is a good move.
- There is a substantial need for more work in this industry to address issues related to risk, uncertainty and the potential cost impacts associated with each. It is too easy to become overly confident based on, in the case of offshore, just a few years of operating experience. It is very important that the DOE, working in combination with other government entities and the private sector, continue to identify, prioritize and address these issues which will continue to evolve as the industry matures.
- I think that the portfolio is reasonably well balanced across topics and organizations to properly leverage the skills and resources available to address the issues
- Program lacks effective broad integration of distributed wind into most RD&D (Research, development and deployment) efforts
- Promising domestic distributed wind market confirmed by NREL Distributed Wind report, analytics to support expanding export markets also needed to retain U.S. leadership and manufacturing jobs
- Wind resource characterization - good to look at complex terrain, need to prioritize improving public online/searchable siting tools for microgrid/distributed wind market; encourage investments abroad to confirm target global markets for U.S. products
- Investments in offshore wind R&D should be structured to ensure benefits for commercial land-based wind market
- Well considered and well formulated
- (See comments above)
- Many programs have direct applicability to operational challenges we face on a daily basis. Programs such as; Additive Manufacturing, On-site tower fabrication, Test Lab capabilities, Drivetrain and Rotor reliability collaboratives, and Wake Dynamics measurement - all topics that are needed to optimize operations and maintenance costs.

Management and Operations

- The experience and expertise of the staff is outstanding. The overview presentation content was well articulated. The focus on industry needs to accelerate technology adoption is of particular importance.
- I'm very impressed by how the DOE program managers have helped to stimulate a more collaborative approach to these projects.
- The "failure" of the first three demonstration projects provides valuable information to the DOE and the industry at large in that, while we were expecting significant technical issues to perhaps limit project success at the beginning of the work, it was actually non-technical issues that got in our way. This is a very important take away for the industry and the DOE should not hesitate in making this information clear to all stakeholders.
- While the demonstration projects have not all concluded the way we would have hoped, the fact that the DOE has had to make the changes it has is a testimony to good program management. While these have been difficult decisions, the ability of the team to recognize the need to make a change is key and helps to assure that there is continued value to this part of the program.
- Distributed wind sector is less able to stand on own feet and maintain quality, so the guidance and support role of government is more clearly needed
- High quality NREL, PNNL, and DOE distributed wind team leadership are poised for success with better integration and leveraging across program
- Program investments are not resulting in timely enough state-of-the-art manufacturing innovation as compared to international counterparts, U.S. is losing edge particularly in distributed wind sector
- The program has done an exemplary job of attracting, retaining and empowering a world-class team of professionals. The global industry looks to the program and this group for its expertise and leadership.
- Many, many competing priorities and requests from industry make managing a coherent program very difficult. DOE has done a masterful job of addressing these broad stakeholder needs. In particular they have expanded the program to include end user stakeholder concerns. This is a difficult part of the industry to help because they often have very local needs but there is nearly a common set of issues that DOE can address with their broad resources. They have done this well. Coordinating different laboratory talents to address broad industry needs has been well managed and orchestrated.
- Without a doubt, the overall project management is excellent, especially in the programs I mentioned above.

Communication and Outreach

- It appears that the communication process is robust and extensive, but it's hard for me to judge the overall scope of these activities since I am not directly involved or monitoring all the disparate efforts
- While there is a good level of collaboration with other entities and, specifically, private sector contributors through each individual project, there may be more value gained with a large involvement from a broader range of stakeholders as the program is defined. Such a process may help to further optimize the value of the research dollar spent by minimizing redundant projects, projects where private sector funds may be available as well are areas where cross-reference with other industry research may help address issues more cost effectively.
- The program has included a number of projects that seek to distribute information to a wider body of contributors and stakeholders. I think that this is an excellent goal and will help to address the rather limited distribution of information in this industry that is based on OEM IP concerns.
- Communications strategy should include defensive monitoring of bad actors making unverifiable claims, and engagement with all branches of government to ensure high quality procurement and siting decisions
- Increased dissemination and outreach are critical to the program's success, program has not always effectively communicated outcomes of research and activities
- Maps with "white" states (such as slide #7 in WPG16001 and Figs 12 & 13 in NREL DW (Distributed Wind) Future report) are misleading in implying zero capacity in those states; lowest category should have lightest shading to avoid sending incorrect message that some states have no distributed wind installations/potential
- There may not be enough money to educate the public nor enough logic to sway lawmakers, but the Wind Program has done an excellent job publishing its findings, working with the industry and reaching out beyond the industry to leverage experience and knowledge elsewhere. While one may have to do a substantial amount of reading to develop the perspective, the Program has been diligent and disciplined in injecting support where the industry can help itself the least and needs it the most. It's difficult to imagine greater expectations from a group working within its resources.

- Transparency and peer review has been the cornerstone of management of the program. DOE managers have set the culture for communication and industry outreach for the laboratories. It is evident in all the programs and all the lab personnel.
- This is an area where improvement is desired. I can speak from experience, that getting relevant, factual information out to a broad user group is very challenging, and I admit I have yet to define a strategy that is completely effective. For the most part, I was unaware of the breadth and depth of programs that have been in progress over the past 3 years, indicating a more targeted approach so those who would benefit from the research should know about its existence and progress.
- Especially with respect to the offshore wind industry, the 'look back" shows a lack of real coordination with the industry. However, knowing that the updated offshore wind strategy was developed in greater collaboration with industry, this is something that looks to be improving.
- Generally observed a lack of usual dissemination of information in usable formats for the target audiences needed to advance DOE's wind program goals

Strengths

- DOE is commended for being on top of the industry trends, needs, and technology gaps. The focus on costs, implementation barriers, and environmental impacts are the right foci. Clearly the growth of industry and lowering of costs is evidence of the success of these efforts.
- The mix of topical areas seems to cover the breadth of need for wind energy
- The validation of tools and use of real world data is excellent
- The use of open source platforms and efforts to provide open data access to the industry at large is excellent
- Positioned for success in serving expanding international markets with numerous communities worldwide requiring electrification, with 70% of current U.S. distributed wind OEM sales exported
- Small wind turbines often serve as test beds for larger scale efforts, and distributed wind projects help pave the way for broad public acceptance
- Knowledgeable insight enables strategically applied support where industry would be constrained if left on its own
- Extremely skilled staff has and continues to mentor the industry
- Broad resources, objective and trusted position in the industry, strategic execution of the program within a difficult and ever changing environment
- The breadth and depth of the programs completed, or still in progress, is impressive. Most (if not all) major disciplines in wind energy are represented by one or more of these programs. The company I work for will benefit in many areas; Wind Resource evaluation, Offshore Cost Models, as well as Operations and Maintenance.
- Leads across programs were all very impressive
- Breadth and depth are apparent
- Working in all the fundamental areas (though offshore wind work can be more targeted)

Weaknesses

- There is a cost of regulation on the wind industry. The cost is actual financial impacts and barriers for RD&D. There were several examples of how regulations impact deployment. I believe it would be beneficial to focus some efforts on estimating the costs of regulation (federal, state, local).
- More value can be gained with a larger involvement from a broader range of stakeholders as the programs are defined (i.e., get more input from all stakeholders before the project objectives are set)
- There are some instances where there has been some redundancy between different projects. It is not clear if this was intentional, but it seems that this was probably due to the separate evolution of project scopes.
- Limited funding not sufficient to address high priority distributed wind RD&D needs, as generation near load provides high value, strengthens local grids, and reduces need for expensive transmission upgrades
- Low levels of engagement with local stakeholders has in some cases reduced impact of taxpayer funds
- Funding uncertainty is a tremendous distraction
- Federal policy is at odds with known technical and commercial advancement opportunities which constrains the program's effectiveness

- Not enough financial resources
- Communications and outreach would be the areas I would focus on for improvement
- Overemphasis on advanced technology demonstration projects in the offshore portfolio
- Lack of cohesion across the technologies (less than optimal attempts to leverage research undertaken to "lift all boats," where appropriate)
- Lack of a plan to meet future testing needs for offshore wind energy technology

Recommendations

- Keep up the excellent work. Continue to focus on lowering costs and focusing on R&D that is generally out of reach of industry or focused on the long-term anticipated needs.
- It may be prudent to focus efforts on assessing the costs of regulation to RD&D. The feedback could be used to review regulations that may overreach and hence impact industry growth.
- The grid modernization effort and need to look at reducing variable generation variability will require more R&D into how to manage the grid over larger geographical regions. Additional modeling of resources and optimizing the distribution of generation to minimize variability should be expanded. The need for a more centralized grid operation over larger regions (load and generation balancing) will grow as the wind portfolio expands.
- The focus on taller towers will also mean that some blade tips will extend up into regions where the low-level jet (LLJ) is active. This extreme wind shear and turbulence zone will put additional stresses on wind turbine blades and drivetrains. This issue may need more focus as specific designs may need to be developed for turbines operating in areas where the LLJ is active.
- The impact of ice accretion and snow deposition on turbine performance and wear and tear seems to need more attention. This will be more important for offshore deployments in the Northeast.
- I think that there is too much pressure on the DOE to champion the R&D efforts needed to address all of the issues and that other entities should step up and take on more responsibility. The contribution of the industry association (AWEA (American Wind Energy Association)) in this respect has been an absolute failure. While it is appropriate for the DOE to continue to hold the lead role in managing and executing projects such as those included in this peer review, there should be more cooperation and funding made available by industry through entities like AWEA to carry some of the load. Such a collaboration from an industry association would also provide greater access for owners and other stakeholders.
- Distributed Wind topics are cross-cutting (both R&D and MA&D), need improved cohesive "portfolio" management
- Development of innovative business models is a useful area to increase deployment and ease purchase decisions across all sectors, including distributed and offshore wind sectors
- Additional investments to support grid integration and increased wind penetration, particularly with microgrids and distributed generation, are timely with rapidly expanding electrification of transportation sector
- Wind as a source of energy has transitioned in 2-1/2 short decades from a fledgling experiment to the least-cost source of utility-scale electric power in many locales. This would not have occurred without federal encouragement, including the support of the DOE. Continuation of these efforts through ongoing technical advancements to bolster robustness and lower costs is an opportunity that should receive federal priority.
- Wind energy is more expensive than it should be due to policy uncertainty and mixed messaging from the federal level. Just as wind is demonstrating its viability and taking the next step to offshore, needed incentives to support growth are being removed. The public deserves an objective discussion, insight and guidance around energy. The DOE should be that objective source.
- Balance program priorities as much as possible but recognize when support drops below critical mass to be effective in any particular area and trim to enable focus on highest priority issues
- Keep up the good work in these challenging times

6.3 Market Acceleration and Deployment Comments

Table 6-2 provides the full body of verbatim comments as provided by the MA&D reviewers at the 2017 WETO Peer Review. Comments have been edited to clarify spelling, typographical errors, and acronym usage *only*; no content has been altered from the original submissions.

Table 6-2. All Reviewer Comments by Metric for Market Acceleration and Deployment Track

Program Objectives
• Across the program, there is not enough focus on uncertainties, emerging issues, and surprises beyond technology developments. The reason this is important is that society and the political context may be changing and the future may be quite different. The way forward on these complex issues was not clear and the full capabilities may not be available yet. • Interagency initiatives are critical - both in radar and wildlife areas--and DOE has a unique role. More interagency activities and bold solutions for historic problems are sorely needed. See wildlife comment below. • Collegiate competition and Wind for Schools are critical areas of investment that should be expanded to build enthusiasm among students and the future workforce capabilities; perhaps more investment from AWEA (American Wind Energy Association) and other industry groups would expand the resources • Oversight & peer review from NREL and DOE on all new biological studies (e.g., 5 bat deterrent studies) are critical skills to ensure quality control. It was not clear how all the studies get oversight from internal scientific experts; also important for sharing information and public access to data that gets posted on WiLD (Wind-Wildlife Impacts Literature Database) (NREL) and Tethys (PNNL). • This is a good set of objectives for the industry and deployment - for MA&D track two of these on the list are relevant, and I think that is capturing well the weight needed in the whole wind R&D picture • In general the program objectives are highly relevant to the current position of the industry • In particular, the objectives of reducing deployment barriers, improved manufacturing, reduced costs and optimized operations are all extremely relevant to the industry • Now that wind power is one of the cheapest sources of electricity on the grid, wind power now needs to be considered as main stream and the program objectives need to evolve accordingly • Focus may need to shift to more central issues such as wind friendly market design and market coupling to improve balancing of wind power • I believe that the DOE Wind Energy Program/Office is incredibly well aligned with the broad wind industry needs and has done a phenomenal job coordinating with industry and other stakeholders on identifying needs and adjusting periodically to address emerging issues. The Wind Energy Office under the leadership of Jose Zayas and the associated National Laboratory program have done yeoman's work in identifying ways of bringing down the LCOE (levelized cost of energy) of wind energy (which I believe has been reduced by something to the effect of 60-70% over the past decade - making it cost competitive with new gas-fired generation) and aided in reducing barriers to deployment through the grid integration, radar mitigation, and wildlife deterrent efforts; and have helped to address the more intangible aspects (i.e. social acceptance, property values, baseline wildlife data, stakeholder engagement, etc.) associated with wind energy deployment. All of these efforts collectively have aided the wind industry as a whole to become an increasingly important part of the U.S. electric generating market and as a result the program should continue to be fully funded. • The program continues to improve since the last Peer Review, with clearer expressions of purpose and intent from the Program Managers and most of the presenting PIs (Principal Investigators). • The DoE seems uniquely capable to broaden the information and data available for issues related to wind energy to include as part of a more logical scope of energy sector wide issues so wind is not looked at in isolation but among all the electron options for the United States. Thus the negative is combined with the positive and compared directly to the positive and negative of other energy sources. This assumes that there are similar efforts conducted for other generation sources. • The applicability and practicality of the grid integration studies suggests to me that the WETO did a remarkably good job of hearing from industry and stakeholders what the emerging issues are (in this case, increasingly higher variable power penetration) and making the investment of tax dollars to study the current circumstances and modeling viable mitigation options.

R&D Portfolio

- The program still overemphasizes technology innovations, although we know without doubt that technology is not the limiting factor for large scale deployments of land-based wind power; we understand quite clearly that community values and responses, details supporting comparative energy impacts, and institutional capabilities/ governance (including regulatory challenges) are some of the central barriers. The DOE program should try to balance the resources to reflect these realities and the interagency initiatives are extremely important activities. However, the committee is also aware that this "re-balancing" of the program resources may not be supported by internal or external decision makers.
- Some critical areas and barriers related to community concerns are not addressed with the current portfolio and may become even more important over time. Many areas that we know from scientific literature are relevant to successful deployments of wind power, such as sound and LFN (long fat network), sense of place, compensation, equity, and risk perception are not addressed with the DOE or ANY government or lab programs; some areas are being addressed in the academic programs (in the United States and EU---refer to IEA (International Energy Agency) Task 28) but the findings are not translated into pragmatic policies that are relevant to government and industry. This also relates to how issues are addressed with the effective (low budget) Wind Exchange and RRCs (Regional Resource Centers).
- After 20 years of investment in biological studies assessing wildlife impacts from wind and 20 years of investment in NWCC (National Wind Coordinating Collaborative) wildlife "outreach" it seems important to sift out what are the significant risks (and benefits) related to wildlife and broader habitat issues; are we working on the right risks? Can we "off-ramp" some of the issues scientifically (if not with regulatory agencies)? How will DOE move this question forward and prepare for the unexpected -both on political and ecological fronts? New experts (outside the current groups/individuals that are wind experts as well) may need to advise DOE on these questions to develop a broader, interdisciplinary strategic environmental plan).
- Since BOEM (Bureau of Ocean Energy Management) is the lead agency on offshore wind (environmental and stakeholder areas), DOE's role has changed since the 2005 rule setting up their office. But DOE and labs still have a critical role in identifying proactive areas that may not be addressed by the BOEM program. Stakeholder engagement is underfunded at BOEM although their focus --- primarily on state/fed agency task forces and significant risks (fisheries)---is central to success. It appears that DOE could have a more impactful role. Perhaps a lessons learned document on the offshore demonstration projects (and Capewind) would highlight some areas appropriate for DOE to partner with DO as well as states that have committed to buying offshore wind power. It is without question that additional DOE resources should be allocated to the upcoming offshore wind market while building additional capabilities. We could also add the small (distributed) wind market to this recommendation to broaden the focus on the portfolio.
- The money spent - and the results from the funding - are generally speaking very efficient
- Generally the R&D topics in MA&D track are well chosen and justifiable. I was hoping to see some work on icing issues, and some more work on distributed wind, closer to buildings, taller turbines and noise issues, but also can see that those topics are not as relevant in United States as in Europe.
- In general, there appears to be a good balance across research areas
- There is a large focus on wildlife protection activities. In relation to ultrasonic deterrents and systems to automate detection of wildlife, there are numerous projects appearing to have similar objectives. This may be intentional and reflective of the need to pursue varying approaches to identify the successful ones. In some areas, perhaps a more focused approach could be adopted with a focus on exploitation and deployment of solutions in the field.
- In some areas, the coverage appears a little sparse. For example, the issue of distribution connected utility scale wind. This is a very large research area.
- An observation is that lab and university led projects seem to deliver broader benefits due to the more open approach adopted, so although industry led projects are fewer, this can still be viewed as the right balance
- I believe this portfolio is incredibly diverse in its goals and objectives and deals with multiple critical aspects of addressing the needs of the wind industry. Further, the investment portfolio is spread across numerous national laboratories, and through funding opportunities provides for additional public (universities) and private (corporate) resources to be brought to bear in addressing these issues.

- WETO efforts lend well to investigate potential, otherwise unconventional mitigation options to vested stakeholders that would not likely have accomplished these studies on their own until pressed by emerging issues fully realized.
- The wildlife impact mitigation technology tract of projects responds to a very necessary and crucial area of inspiring innovation and shifting the national dialog about wildlife impacts away from measurement and speculation to near future use of innovation to keep impacts to some less than baseline levels

Management and Operations

- (Added per J. Ahlgrimm request) Stove-piped programs and tasks should be more integrated to push innovation and creative ideas. But this is a huge lift, given the limited resources and mostly engineering emphasis of the R&D program. A small proposal to begin the process: Perhaps the next peer review and/or department meetings would design breakout groups and new blood (experts and not just engineers) to discuss ways to approach multi-disciplinary, multi-pronged science and engineering program areas. Need to select multiple disciplines to participate -i.e., engineers with biologists; biologists with social scientists; economists with community leaders, etc. Could also be a role for the RRCs to select more technology and wildlife topics along with local concerns. These experiments could inform the national R&D program in a very interesting way. Another suggestion is to link the offshore and water program environmental studies, as they seem to be on different tracks with different priorities; significant risks to wind will link to those for the future water power technologies; now that programs are separate, an ongoing dialogue between the DOE programs along with BOEM environmental studies program is essential for effective coordination.
- It appears that the program is very responsive to industry concerns and challenges (e.g., bat deterrent projects) and the allocation of additional resources so quickly with a competitive process is quite extraordinary! Kudos to the DOE managers!
- Team seems to engage really well with stakeholders, having a good picture of what is needed for both research and deployment, and enabling working groups and outreach in authorities
- DOE has taken the role of objective and transparent, bringing together entities that is not possible for others, getting parties together and providing safe neutral arena for all parties
- I personally have been highly impressed with the level of energy, enthusiasm and professionalism of the leadership team. Also striking is the openness to feedback and improving the program.
- The management team actively participates in dissemination and collaboration - this is of huge benefit to the program
- The milestone achievement performance across all projects is impressive and speaks of a highly proactive management approach that appears to strike a good balance between incentivizing progress and efficiency but also allows for flexibility and changes of direction where appropriate
- From Jose Zayas on down, all the DOE Wind Program and NREL/National Laboratory staff that I've had the pleasure of working with have been consummate professionals. The Program leadership has been outstanding as have the operational practices.
- Procedurally for the peer review, introductory .ppts [Power Point presentations] for the categories of each area of emphasis are unnecessary given the time constraints. Much of it is redundant info from either the Program ppt. or individual project ppts. Understanding the intent is to draw connections among the projects, time is short and I feel encouraged discussions between PIs and reviewers could lend well to realizing additional value of a given project (e.g. stimulating the idea of bat mitigation project that may have applicability in RCS (radar cross-section) reduction efforts) or other unintended opportunities explored.
- Program managers engaged with reviewers, listened but also highlighted for reviewers areas that are in question for the program. This type of engagement helped me and other reviewers to pay additional mind to those questions, stimulated good dialog.
- Virtually all projects reported to have met milestones on time and at or under budget. This is a remarkable feat yet at the same time reviewers were not able to immediately ascertain all budget information and many milestones, while discussed, were not easy to understand from a quality perspective. I would give consideration to presenting budget information in a more robust and relevant way for future reviews.

- Most PIs seemed well versed on the project itself but some did not seem well versed on the importance of the project or spoke of the relevance more by rote than as subject matter experts. If a function of presentation style, understandable. However, if a lack of substantive knowledge of the broader context that might be an area of improvement.
- Competing objectives among the labs' projects is frustrating. For example, PNNL has Tethys yet NREL has Wind Wildlife Impacts Literature Database. In order for WETO to have an effective clearinghouse of information, it needs to have one place for all such literature. I suspect the purpose is offshore vs. onshore but I noted onshore studies in Tethys when investigated and in my mind there should not be a distinction anyway since to do so automatically puts offshore wind behind the curve ball for what seems a lack of relevant information. It may very well be that avoidance behavior observed onshore (United States) as well as offshore (Europe) means that we can assume avoidance behavior in U.S. offshore.

Communication and Outreach

- These are critical activities for the DOE program. The task is ominous given the limited resources. The score is high because there is significant accomplishment with very limited resources and funds. So the challenge is how to more effectively communicate across a larger group of stakeholders (including those that do not support wind). The RRCs appear to be a successful model with quite limited resources; could these be expanded and become more effective?
- Perhaps external experts on science communication could be engaged to understand better how to access more resources or collaborate with other agencies (e.g., NOAA (National Oceanic and Atmospheric Administration) on offshore and water); also NAS (National Academy of Sciences) has lots of resources about science communication that could be explored by existing staff (see Baruch Fishhoff on NAS site– http://www.nasonline.org/programs/sackler-colloquia/completed_colloquia/science-communication.html)
- Program has specific funding for outreach and helping deployment with identifying stakeholders, going directly to them, and providing information in easy format also for wider public
- Across most programs there is a strong focus on dissemination and outreach. Highlights in this regard are WREN (Working Together to Resolve Environmental Effects of Wind Energy) Hub, Tethys, engagement with UVIG (Utility Variable-Generation Integration Group) and IEA Wind Tasks 25, 28 and 34.
- Having attended UVIG sessions, this organization in particular appears to play a very effective role in linking DOE funded research with industry stakeholders, particularly utilities and ISOs (Independent Service Operators)
- The radar challenge is one that may benefit from increased collaboration internationally notwithstanding the sensitivity issues
- My personal belief is that reaching out to the younger generation is key to the long term development of the industry. Therefore, I see huge potential in broadening the Wind for Schools program.
- From my perspective the collaboration and stakeholder engagement of the Wind Energy Program with the various stakeholders has been outstanding. Definitely a model for other offices and agencies.
- Dissemination and outreach efforts this reporting period seem notably more purposeful and likely more effective than in prior review periods. Project findings and accomplishments are more likely to generate additional, unintentional value as a result.
- Projects specifically geared to provide additional communication and outreach support (e.g. 137) is a thoughtful way to lessen the tendency of accomplishments and products going stale after project completion. Reallocating a portion of each project's C&O (Communications and Outreach) budget to similar, cost-shared outreach projects within each session category might lend well to informing the relative importance of each project in a given category but also centralize C&O approaches such that more efficiencies might be realized.
- The RRC project seems somewhat weakly supported. Recognizing that there is only so much budget to go around but perhaps there are opportunities to realign funding (execution of focused, regional public acceptance studies), interconnect objectives between projects that have regional relationships (e.g., education outreach), and provide RRCs access to industry representatives and projects within the region (e.g., students visiting wind farms).

- It may be that the WETO could assemble a group of portfolio advocates in the industry who have responsibilities to interface with subject matter counterparts (UVIG, AWEA, AWWI (American Wind Wildlife Institute), etc), socialize accomplishments and products with these advocates so when they engage their respective arena they can draw attention to applicable DOE efforts and know DOE capabilities when issues/projects are being realized.

Strengths

- Excellent personnel capabilities (engineering and science) at DOE and with the labs and hardworking people who really care!
- Grid integration: good portfolio of projects from large integration studies to ambitious power system demonstration laboratory and turbine capabilities and finally to very good impact/outreach activities. Good leverage of funding combining with solar and electricity office funding.
- Deployment and R&D in same program - something not happening in Europe - has more possibilities to get the wealth of information from R&D towards larger outreach with help of linking information in condensed easier formats. Also enabling DOE to provide objective facts (instead of industry lobby producing materials), helping to distinguish perceived problems from real problems
- Program clearly has world class talent working in projects
- Verification and validation of tools - across all subprograms - is really important, and this would not happen with only industry funding
- Personal investment and engagement of the management team
- Very strong focus on outreach and open access which is benefitting not only the U.S. industry, but the global industry. Some highlights for me include engagement with UVIG and IEA Wind tasks, Wren Hub, Tethys, Wind for Schools, the Collegiate Wind Competition, Generic Model Development project, ERGIS (Eastern Renewable Generation Integration Study) and WWSIS 3 (Western Wind and Solar Integration Study 3).
- Very effective use of national research lab capacity to address relevant industry challenges
- The seriousness of the wildlife protection efforts which lend credibility to the information put out
- Strong leadership role of the DOE in addressing the industry challenges
- The dedication, commitment, intelligence of the program staff and the way they approach issues and address them are all key indicators of a high quality organization
- The RRC concept is worth pursuing, disseminating the work of DOE out to regional stakeholders and effectively getting stakeholder feedback vis-à-vis the RRC efforts, informing the evolution of the WETO portfolio. Clearly, continued funding is a challenge and suggests that some thought to diverse funding structure might be appropriate. More comments under the applicable project.

Weaknesses

- In four days of presentations, there was not a mention of climate change or reduction of emissions. This is astounding. Even with climate challenges with the existing administration, the reality is that wind is not necessary unless a state fulfills RPSs (Renewable Portfolio Standards) or wants to reduce emissions; why the lack of linkages to climate science? There are data in the vision documents (carbon, water) that seem quite relevant but why the absence of this data all week?
- As mentioned above, the stovepiped program may be limiting innovation and emerging issues that would be more likely to be identified with a multidisciplinary approach; involvement of experts from other energy sectors (starting within the DOE agency) would also assist in creative scientific thinking, e.g., how do the oil, gas and shale gas industries handle environmental regulations on public lands? Perhaps wind can learn some lessons about environmental and community experiences?
- How effective are other regional centers? Check this link for an example: https://www.ncdc.noaa.gov/customer-support/partnerships/regional-climate-centers.
- Some topics were not addressed at all (icing issues), or very little (distributed wind; public acceptance of noise from closer to buildings, taller turbines), compared to their importance. Probably this is due to not so many projects close to buildings and in distribution networks as in Europe. However, as pointed out by several project presentations, these are emerging issues, and important to analyze before bringing acceptance problems.
- (Not sure whether the above comment is more of pointing out a weakness than a recommendation, so will put it to both.)

- The targets could be more ambitious. It would be great to see the thinking moving quickly beyond 20% before people get too comfortable.
- The efforts in the wildlife protection space could be a little more focused. This is not really a weakness but perhaps a next step.
- None that I can identify at this time
- Likely nothing to be done about it but the national lab and headquarters dynamic seems to remain an area where silos are naturally formed. Given the limited budget and large potential portfolio of issues deserving of attention, it seems some means of cross pollination among the labs and project managers would be healthy. My sense is that while each lab has experts that logically should manage a given project, some projects seemed out of step, from a relevance standpoint, with the rest of the portfolio. When this seemed to occur the project seemed to coincide with being a given lab's sole project under the WETO portfolio.

Recommendations

- Easy recommendation: talk about climate and other environmental benefits each time wind is discussed with external audiences (carbon and water)
- Initiate an internal cross energy working group to understand better the way environmental and social issues are addressed with sister organizations; also this would help understand the level of resources available. Perhaps there are opportunities for collaboration and shared resources.
- Grid integration - for keeping high ambition to next phase and the Strategy mission: leadership in the transition to a global clean energy economy: 1. what do you say when the discussion starts on wind breaking down markets, answers getting prices back need studies on demand response and sector integration electricity/heat/transport and market design, customer /prosumer dominated future with energy transition. Involving large utilities early on not to result in huge stranded costs from investments to fossil infrastructure. 2. Integration stakeholder impact: towards improved operational practices (stochastic planning tools, probabilistic forecasting result usage, dynamic reserve allocation, sharing of balancing). 3. Integration studies next phase: higher share studies or local very high stability. How to address the fast declining PV (photovoltaic) prices in scenarios.
- Some topics were not addressed at all (icing issues), or very little (distributed wind; public acceptance of noise from closer to buildings, taller turbines), compared to their importance. Probably this is due to not so many projects close to buildings and in distribution networks as in Europe. However, as pointed out by several project presentations, these are emerging issues, and important to analyze before bringing acceptance problems.
- Regarding icing, I think that DOE could help solving the chicken-and-egg problem of getting ice prevention systems tested, improving their reliability and showing that the costs can be moderate taking into account the production losses mitigated - and solving the problem of safety from ice throw risk. Now icing is happening, even in California, nobody has clear picture of how much production is lost, and what an ice prevention system would cost when manufactured in industry scale instead of one-off pilots.
- Perhaps consider higher targets and increased focus on dynamic stability in extreme instantaneous wind penetration scenarios
- Consider focusing efforts in the wildlife protection space
- Consider broadening outreach to younger generations
- As noted above, this program has done great work on behalf of the nation in advancing an important source of clean, reliable and affordable energy and should be fully funded in FY18 and in coming years

7 Complete Project Evaluation Results

7.1 Overview

This section includes project scores and reviewer comments for the full body of projects evaluated at the 2017 WETO Peer Review. As discussed in Section 5, reviewers scored individual projects on six evaluation metrics, using a numeric 5-point scale (1 = Poor, 5= Outstanding). Qualitative descriptors apply to the numerical scores. These descriptors vary for each of the metrics and are included in the project-level scoring sheet used by reviewers (Appendix C). Score tabulations in this report include averages and standard deviations, providing relative as well as absolute assessments of WETO and its projects.

The peer review evaluations focused on the following six evaluation metrics. Where applicable, the shortened name used in the project-level Scoring Tables in this report is shown in parentheses:

1) *Relevance to wind energy industry needs and overall DOE objectives* (Relevance)—the degree to which the project aligns with objectives and goals of WETO and meets the needs of the wind energy industry at large. This is a stand-alone metric reported separately in the scoring tables.

2) *Methods / Approach*—the degree to which the project is well designed, technically feasible, and likely to overcome the technical and non-technical barriers.

3) *Technical Accomplishments and Progress* (Accomplishments/Progress)—the degree to which the project has delivered results and/or progressed technically compared to the stated project schedule and goals.

4) *Project Management*—the effectiveness of the project's management, including project planning, project execution, and allocation of resources to complete the project within scope, on-time, and within budget.

5) *Research Integration, Collaboration, and Technology Transfer* (Collaboration/Tech Transfer)—the degree to which the project successfully interacts, interfaces, or coordinates with other institutions (e.g. industry, universities, other laboratories) and projects, and the degree to which projects are disseminating the results of the R&D.

6) *Proposed Future Research (if applicable)* (Future Research)—the degree to which the future research proposed is relevant, well-planned, and worthwhile of continued funding.

Scoring Tables include a **Weighted Average Performance** score. This weighted score represents the overall performance of each project along evaluation metrics, exclusive of the **relevance** score. It is calculated using the weights listed in Table 7-1.

Table 7-1. Metrics and Scores for Project-Level Evaluations

Relevance	Stand-alone metric	Relevance to wind energy industry needs and overall DOE objectives
Weighted Average Performance	30%	Methods / Approach
	30%	Technical Accomplishments and Progress
	20%	Project Management
	10%	Research Integration, Collaboration, and Technology Transfer
	10%	Proposed Future Research (if applicable)

7.2 Project Scoring Chart Description

Project scores are reported using a detailed chart that provides project information, reviewer scores, and comparative graphs. For the purposes of the 2017 WETO Peer Review, WETO's portfolio was organized into two tracks: (1) Resource Characterization and Technology Research, Development, and Testing (RC and Tech RD&T), and (2) Market Acceleration and Deployment (MA&D). Each track was then divided into four primary subprograms for the peer review. Project results are reported based on these tracks and their respective subprograms. Projects within each subprogram are listed in numerical order based on their PRID (Peer Review ID number). Figure 7-1 provides an overview and explanation of the project scoring charts.

The plots illustrate that, in general, the reviewers evaluated the entire portfolio of projects highly in terms of both relevance and performance. Although several projects fell outside the shaded area that indicates two standard deviations from the average score, those projects remained in the "Average" to "Good" categories of scores. The scores and associated reviewer comments for all projects have been considered by the WETO technical leads to determine why certain projects scored higher or lower than others, and what programmatic adjustments could be made to ensure highest levels of performance for all projects.

Note that "PM" stands for "Project Management" in the project scoring charts.

Project demographics include project name, WETO program, and funding information.

Error bars show the 1st and 3rd quartiles based on the statistics from all projects. The average is also included as the center dash with numeric labels. As an example, the "Methods" metric shown here is scoring is above the 3rd quartile, which indicates this project is performing in the top 25% for that metric.

Reviewer scoring histogram illustrates scoring distributions of the reviewers for each metric. Taller bars indicate more reviewers gave a specific score, e.g. this project's Relevance was scored a "5" by 75% of the reviewers and a "3" by 25% of the reviewers. Wide distributions may indicate disparate reviewer opinions.

Performance vs. Relevance graph illustrates how this project performed on Relevance (y-axis) and Weighted Average Performance (x-axis), compared to the review averages and other projects. The middle of the inner blue shaded area is the review average for each score, and each box is one standard deviation from the average. This example shows this project scored slightly above average for Relevance and greater than >1 standard deviation above the average for the "Performance" (weighted average performance).

This graph also displays how this project performed relative to its Subprogram (orange dots) and the entire program (blue dots).

Figure 7-1. Explanation of project scoring charts for individual project evaluations

7.3 Resource Characterization and Technology Research, Development, and Testing Track: Project Results

For the 2017 WETO Peer Review, RC and Tech RD&T projects were organized into four subprograms: Atmosphere to Electrons (A2e); Distributed Wind Research, Development, and Testing; Innovation, Manufacturing, Reliability, and Testing; and Offshore Wind. Table 7-1 provides a master list of projects in the RC and Tech RD& T track, along with respective average scores. Sections 7.3.1–7.3.4 include the individual project score charts and reviewer comments for every project in each respective track. The project score charts also include subprogram funding information for the DOE portion of funding and the cost share, which is the portion of funding provided by project awardees.

Table 7-1. Resource Characterization and Research, Development, and Testing Track Master Project List

Resource Characterization and Research, Development, and Testing Track	Relevance	Weighted Average Performance	Methods/Approach	Results	Project Management	Technology Transfer	Future Research
Average scores across all WETO peer-reviewed projects	**4.4**	**4.1**	4.1	4.0	4.3	4.0	3.9
Atmosphere to Electrons, High-Performance Computing, Resource Characterization, Flow Field Analysis, and Testing (A2e)							
Average scores for A2e subprogram	**4.6**	**4.4**	4.4	4.3	4.5	4.3	4.4
MMC: Model Development and Validation (PRID 218) Sue Haupt, PNNL	4.7	4.5	4.4	4.4	4.6	4.6	4.6
High-Fidelity Modeling (PRID 206) Mike Sprague, NREL	4.7	4.3	4.2	4.2	4.4	4.1	4.7
PRUF: Performance Risk, Uncertainty, and Finance (PRID 208) Jason Fields, NREL	4.7	4.6	4.7	4.3	4.6	4.7	4.7
Wake Dynamics Measurement, Testing, and Validation (PRID 222) Brian Naughton, SNL	4.6	4.4	4.7	4.3	4.3	4.0	4.6
WFIP II [Wind Forecast Improvement Project II]: Mesoscale Physics and Inflow (PRID 217) Will Shaw, PNNL	4.6	4.4	4.5	4.2	4.3	4.4	4.4
ISDA: Integrated Systems Design and Analysis (PRID 211) Katherine Dykes, NREL	4.5	4.4	4.5	4.3	4.7	4.0	4.1
Wind Plant Flow Control (PRID 207) Alan Wright, NREL	4.5	4.4	4.4	4.4	4.4	4.5	4.5
DAP: Data Archive and Portal (PRID 219) Chitra Sivaraman, PNNL	4.3	4.2	4.2	4.3	4.3	4.0	3.9
Distributed Wind Research, Development, and Testing							
Average scores for Distributed Wind subprogram	**4.4**	**4.4**	4.3	4.2	5.0	4.4	4.2
Distributed Wind Research, Development, and Testing (PRID 209) Ian Baring-Gould, NREL	4.4	4.4	4.3	4.3	5.0	4.5	4.1
Competitive Improvement Project (PRID 231) Ian Baring-Gould, NREL	4.4	4.4	4.3	4.1	5.0	4.4	4.3

Resource Characterization and Research, Development, and Testing Track	Relevance	Weighted Average Performance	Methods/Approach	Results	Project Management	Technology Transfer	Future Research
Innovation, Manufacturing, Reliability, and Testing							
Average scores for Innovation subprogram	**4.3**	**4.0**	4.0	4.0	4.1	4.0	3.8
Testing Facilities and Capabilities at NWTC [National Wind Technology Center] (PRID 210); Dave Simms, NREL	4.9	4.6	4.6	4.6	4.7	4.6	4.4
Wind Standards Development (PRID 130) Jeroen VanDam, NREL	4.7	4.8	4.7	4.7	4.9	4.9	4.7
Drivetrain Reliability (Collaboratives, Monitoring, and O&M [operations and maintenance]) (PRID 182) Jonathan Keller, NREL	4.6	4.5	4.6	4.6	4.3	4.4	4.3
Testing Facilities and Capabilities at SNL (PRID 223) Jon White, SNL	4.4	4.2	3.9	4.1	4.4	4.5	4.2
Innovative Blade Test Methodology (PRID 184) Scott Hughes, NREL	4.4	4.2	4.3	4.2	4.4	3.9	3.9
Rotor Reliability (Collaboratives, Monitoring, and O&M) (PRID 221) Josh Paquette, SNL	4.4	4.1	4.4	3.6	4.1	4.2	4.1
Additive Manufacturing in Wind Turbine Components and Tooling (PRID 187) Brian Post, ORNL	4.4	4.2	4.2	4.2	4.2	4.0	4.4
Development of On-Site Tapered Spiral Welding for Large Turbine Towers (PRID 237); Eric Smith, Keystone Tower Systems	4.3	4.1	4.2	4.3	4.1	3.9	3.9
Online Intelligent Prognostic Health Monitoring (PRID 239) Wei Qiao, University of Nebraska–Lincoln	4.2	3.6	3.8	3.4	3.6	3.6	3.9
Innovative Drivetrain Concepts FOA [Funding Opportunity Announcement] Phase II: Next Generation Drivetrain (PRID 74) Jonathan Keller, NREL	4.1	4.1	4.1	4.1	4.2	4.1	3.4
The Incubation of Next-Generation Radar Technologies to Lower the Cost of Wind Energy (PRID 240); John Schroeder, Texas Tech University	4.0	3.1	3.0	3.3	3.1	3.1	3.1
Advanced High Torque Density Magnetically Geared Generator (PRID 236) Jonathan Bird, University of North Carolina at Charlotte	3.7	3.1	3.2	3.0	3.3	3.3	2.9
Hexcrete Tower for Harvesting Wind Energy at Taller Hub Heights (PRID 238) Sri Sritharan, Iowa State University	3.5	3.6	3.5	3.7	4.0	3.8	2.7
Offshore Wind							
Average scores for Offshore Wind subprogram	**4.4**	**3.7**	3.7	3.6	4.1	3.5	3.3
The University of Maine's New England Aqua Ventus I Program (PRID 248) Habib Dagher, University of Maine	5.0	3.9	3.5	3.5	5.0	4.0	3.9
National Offshore Wind Strategy Supporting Analysis (PRID 213) Walt Musial, NREL	4.8	4.2	4.4	4.3	4.4	3.8	3.9
Modeling and Validation for Offshore Wind (PRID 214) Amy Robertson, NREL	4.8	4.2	4.2	4.1	4.3	4.4	3.7

Resource Characterization and Research, Development, and Testing Track	Relevance	Weighted Average Performance	Methods/Approach	Results	Project Management	Technology Transfer	Future Research
Structural Health and Prognostic Management for Offshore Wind Projects (PRID 225) Todd Griffith, SNL	4.5	3.7	4.0	3.7	3.7	3.0	3.1
Instrumentation Planning for the Offshore Wind Advanced Technology Demonstration Projects (PRID 215) Walt Musial, NREL	4.4	3.9	4.1	3.7	4.2	3.4	3.1
Hywind Maine Project (PRID 245) Andrea Nina Eugster, Statoil	4.4	3.4	3.5	3.3	3.6	3.3	2.7
WindFloat Pacific Project (PRID 244) Kevin Banister, Principle Power, Inc.	4.4	3.5	3.6	3.2	3.9	3.7	3.1
DOE Offshore Wind Lidar Buoy Deployment Program (PRID 220) Will Shaw, PNNL	4.3	3.7	3.9	3.5	3.7	3.8	3.8
Project Icebreaker (PRID 249) Dave Karpinski, Lake Erie Energy Development Corporation	4.2	3.6	3.3	3.2	4.5	3.6	3.5
Fishermen's Atlantic City Wind Farm (PRID 242) Chris Wissemann, Fishermen's Energy	4.2	3.4	3.3	3.1	4.3	3.1	3.4
Turbine Advanced Controls for Offshore Wind Floating Applications (PRID 241) Dhiraj Arora, General Electric	4.2	3.6	3.8	3.5	3.9	3.7	2.6
Wave Impacts on Fixed Offshore Wind Foundations (PRID 227) Ralph Nichols, SRNL	4.1	3.6	3.7	3.9	3.7	3.0	3.0
Sediment Transport Impacts on Offshore Wind Projects (PRID 226) Jesse Roberts, SNL	4.1	3.3	3.3	3.2	3.9	2.9	2.8

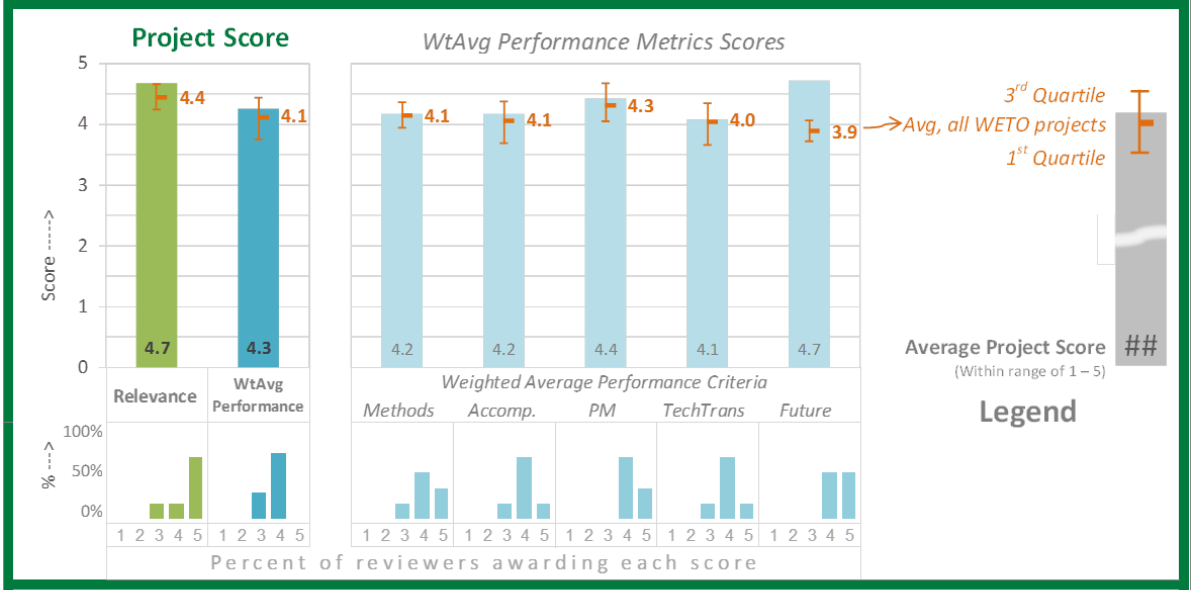
7.3.1 Atmosphere to Electrons

DOE Wind Energy Technologies Office 2017 Peer Review Project:

High-Fidelity Modeling

Principal Investigator	Mike Sprague, National Renewable Energy Laboratory		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Atmosphere to Electrons; Resource Characterization		
FY 2014-2016 Funding	DOE	$ 0.4 M	100%
	Cost Share		
	Total	**$ 0.4 M**	**100%**

Peer Review ID# 206



Comments made by reviewers during the evaluation of this project (PRID 206)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- It has been demonstrated that industry needs and utilizes SOWFA (Simulator fOr Wind Farm Applications) to help with turbine and plant design
- Significant plant performance increases can occur with proper design, which is enabled with modeling tools
- HFM (High-fidelity modeling) is necessary to understand the fluid dynamics and aerodynamics (e.g., physics) of individual turbines and interactions within the plants
- Once there is confidence in the model code performance, the emerging HPC (high performance computing) architectures (e.g., exascale computing should be utilized to further advance and accelerate scientific discovery. Running models on faster computers only provides results faster, so there is a critical prerequisite to invest in research and model verification that will lead to model improvements. The DOE may want to look at the resources across these programs to ensure appropriate balance given the dependencies.
- This is a very important project and integrates well with the other programs related to laboratory and field testing and data acquisition
- The development of improved CFD (computational fluid dynamics) models may have significant impact on wind farm design, specifically addressing wake effects, turbine spacing, wake control, etc.
- Unclear why this work is needed now due to current state of industry; not relevant for distributed wind
- Another example of value-add/cost-lowering/reliability-improving technology development that would not and could not be realized by industry alone
- When successful will reduce uncertainty, lower financing cost and lower the LCOE (levelized cost of energy) of wind
- Goal is customizing CFD models to run on super computers. SOWFA needs to be optimized for Super Computers.
- There is strong evidence that Meso/Micro scale coupling is impacting wind plant performance. This work will help quantify the importance of Meso/Micro scale coupling to capturing the wake interaction and energy loss due to arrays.
- Only DOE labs, collectively, have the resources and expertise to perform this type of analysis. This is required to understand the physics of wind plant performance.
- Is SOWFA "scalable"?
- Industry is already using early versions of SOWFA. How are GE, Vestas, Envision using SOWFA and what class computers?
- Not my area of core expertise, but I can say the developers/end users communities need highly accurate wind resource information in order to make financially prudent decisions on project location and size, as well as cost-effective operation of the plant throughout its lifetime

Question 2: Methods and Approach

- It's important that sufficient resources be spent on validation of the models
- The Open Source design of the project is good and should help to expand the value of improved models and tools as other researchers become involved
- Planning process for validated open source community model should take into consideration needs of all industry sectors, including distributed wind and small companies
- Leverages approaches successfully used elsewhere but heavily theoretical. Validation is critical.
- Flow modeling from Meso/micro/wind turbine scales has never been possible before. The unique resources of the DOE labs are required for this work.
- Results have already produced game changing results in wind plant wake physics understanding
- The methods and approach appear to be very good for a project of this complexity

Question 3: Technical Accomplishments and Progress

- Progress is mostly planning and early code testing
- No major concerns here
- This project is still in its early stages so it’s difficult to assess accomplishments. Most of the work achieved to date relates to selection of appropriate software and transfer of existing models.
- Would like to see more practical outcomes for this level of funding

Comments made by reviewers during the evaluation of this project (PRID 206)

- Early SOWFA results are used by industry already
- Tools used for controls are already being applied and tested
- $10m high performance computing award for exa scale computing
- Not my area of expertise, but accomplishments to date look reasonable for a project of this complexity

Question 4: Project Management

- Strong team. Did a nice job vetting modeling options. Good focus on how to assess performance.
- On time and budget
- Good potential ROI (return on investment) for the funds used so far
- Scope should be adjusted to balance coding needs and address current industry priorities, including needs of the distributed wind sector
- Excellent project management of multiple laboratories has been required and very successful leveraging of DOE resources
- Based on above ratings and comments for methods, approach, and accomplishments, the project management appears to be very good

Question 5: Research Integration, Collaboration, and Technology Transfer

- Good interaction with the modeling community in planning efforts
- Continued collaborations with the modeling and numerical weather prediction is strongly encouraged
- Good that team is working with NVIDIA and Intel
- Reasonable collaboration with other labs
- Good to leverage resources at Office of Science but collaboration focused on large multinational stakeholders
- Lab collaboration is excellent
- Industry collaboration is premature but they are obviously monitoring because they are using the early tools
- The project appears to have good collaboration across the National Labs. End user input is probably not a key requirement at this time, until the physics and code have been sorted out.

Question 6: Proposed Future Research, if applicable

- The move toward exascale computing is exciting, but will require a lot of code optimization to take advantage of new compute environment
- Budget is modest for making progress in this area - more funding is likely required
- Everything hinges on the completed validation, verification and demonstration of applicability of the new tool to support innovations in wind farm design
- Timing is off for further large investments. Transfer to commercial sector or require cash match to confirm usefulness to industry.
- Exa Computing will have multiple byproducts
- The proposed future research looks reasonable to meet program goals

Question 7: Project Strengths

- There is significant merit in advancing modeling at these scales. The impact and benefits will go well beyond wind energy.
- The HFM tool will also provide an opportunity to look at wake steering and other options for optimizing flows within the plant to increase overall performance
- Builds on OpenFAST
- Acknowledgement that high-fidelity wind resource modeling is critical to wind industry success

Question 8: Project Weaknesses

- Budget seems small for refactoring code to exascale
- Need more information on how flow field results are going to be verified at these scales
- IT (Information technology) infrastructure should be covered by labs' high overhead
- None identified

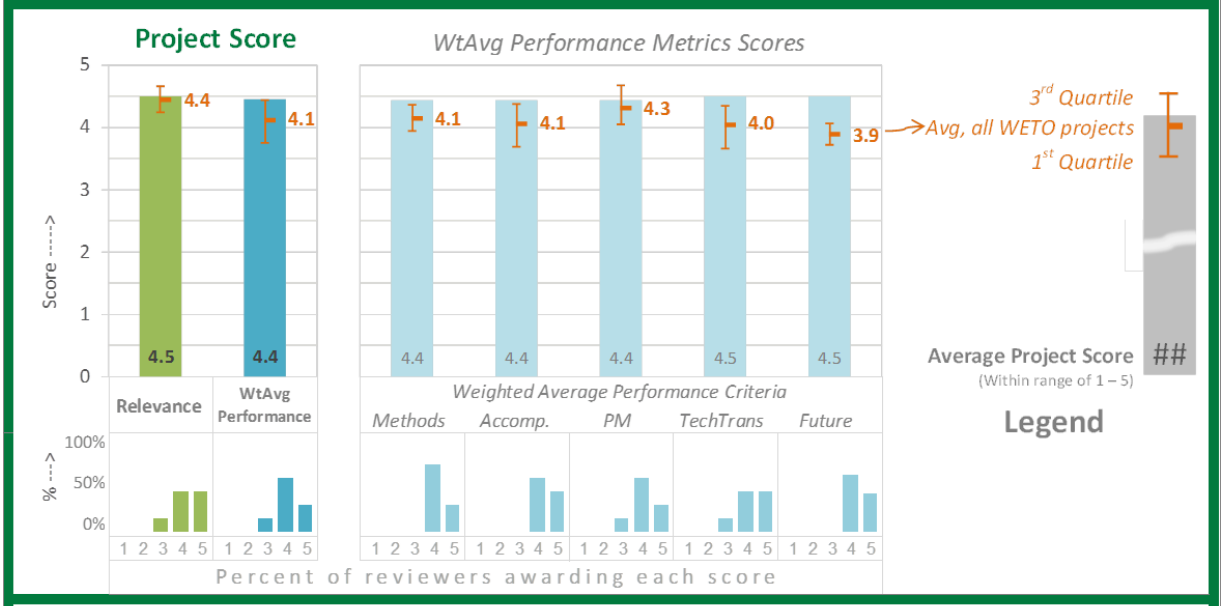
Question 9: Recommendations

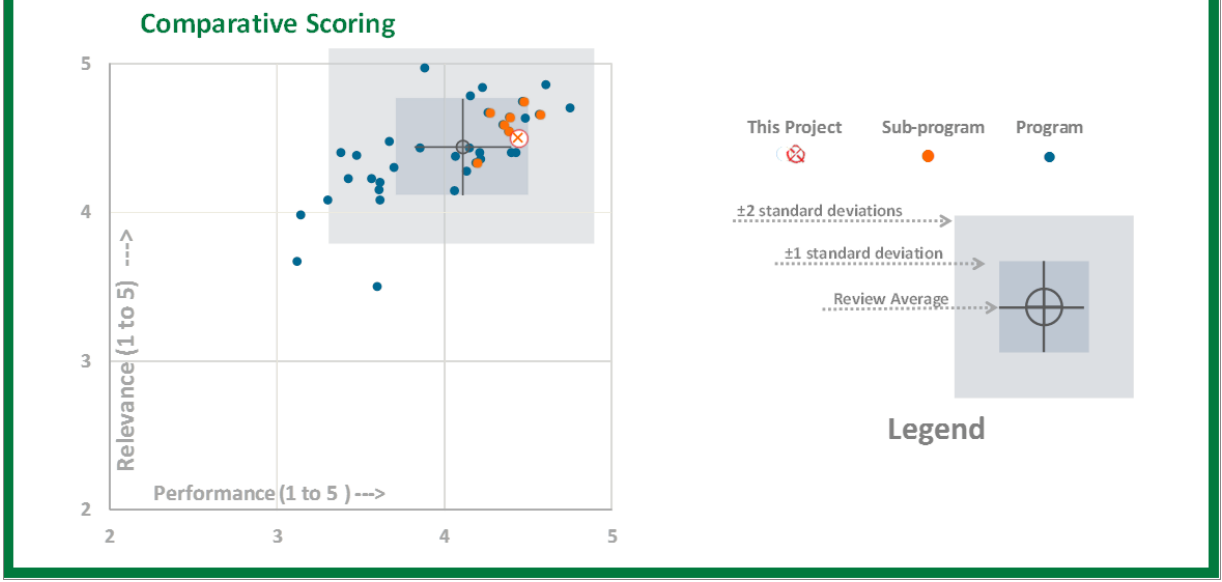
- Slow down or transfer to the commercial sector, while preserving public investments to date
- Start discussions with end users regarding DOE data output format, and the integration of that output into their internal models

DOE Wind Energy Technologies Office 2017 Peer Review Project:

Wind Plant Flow Control

Principal Investigator	Alan Wright, National Renewable Energy Laboratory			
Program	Wind Resource Characterization and Technology RD&T			
Sub-Program	Atmosphere to Electrons; Resource Characterization			
FY 2014-2016 Funding	DOE	$ 2.5 M	85%	
	Cost Share	$ 0.5 M	15%	
	Total	**$ 3.0 M**	**100%**	Peer Review ID# 207





Comments made by reviewers during the evaluation of this project (PRID 207)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- This work is very important to optimize plant output and minimize wear and tear. The public is very focused on squeezing performance out of almost all systems (e.g., furnaces, electrical appliances, light bulbs, etc.) - wind plants shouldn't be any different.
- It doesn't appear that industry is doing a lot of fundamental work in this area
- Excellent project with strong ROI (return on investment) for the funding based on good results at the levels tested
- The project is very relevant to the DOE overall objectives
- Could have future implications for sub MW and distributed wind projects, particularly those in industrial/built environments
- Potentially large returns from a modest investment
- Extremely relevant. This project ties all the other aspects of the A2E (Atmosphere to Electrons) program together and demonstrates how increased understanding of wind plant flow can improve plant performance through coordinated control of multiple turbines. This grounds the research in actionable application of the models to reduce loads and improve performance.
- Demonstrates how rows of turbines can be operated in a coordinated way to improve performance. It may be possible to introduce large scale vorticity into the wind plant to promote mixing and energy entrainment. This would require meso/micro scale models to capture the coupling of these different levels of flow characteristics.
- This effort focuses on and capitalizes on increased knowledge of the flow to improve performance of the wind plant
- Fascinating concept of wake-control and steering. I'm looking forward to additional data supporting the implementation of this technology. Within our portfolio, we have one 150MW windfarm laid out in a 10X10 matrix that could benefit from this technology. Most of our windfarms do not have 3 or more rows in a downwind (of the prevailing wind direction) configuration. Most of our wind farms are in complex terrain, so understanding wake-steering in complex terrain will be necessary.
- Understanding and characterizing wake flow and behavior on downwind turbines is critical to understanding expected performance and optimizing future wind farm layouts
- Applying wake-steering controls on a wind farm level may be challenging to integrate into wind farm plant control. Requires integration into wind turbine manufacturer's wind farm control or end user's proprietary wind farm control.

Question 2: Methods and Approach

- No concerns here. Good use of SWiFT (Scaled Wind Farm Technology facility) and the WTRC (Wind Technology Resource Center).
- The project includes a good progression from design, testing, control system refinement and validation
- Full-scale field verification/validation, collaboration with industry
- This project obviously capitalized on several other A2E program elements but it is the essential implementation element that informs and defines the needs from the high fidelity modeling efforts
- Excellent use of FLORIS (FLOw Redirection and Induction in Steady-state) to explore control options
- The methods and approach appear reasonable for this project

Question 3: Technical Accomplishments and Progress

- Good use of both modeling and field testing
- Large scale test shows 10% improvement in energy capture with wake steering without other losses. This seems to me like an easy way to get 10% on LCOE (levelized cost of energy) across many installations.
- All milestones met on schedule, impressive summary of results
- From prediction to field demonstration of wake steering the coordination of multiple DOE labs is very impressive
- International collaboration is extensive

Comments made by reviewers during the evaluation of this project (PRID 207)

- Education and PhD candidate participation has shown a huge growth of knowledge base deployed into the industry
- Data provided to industry has dramatically increased their ability to conceive of and implement unique control strategies
- Visual representation of effects of wake steering is remarkable
- Actual results from SWiFT testing validate computational model predictions

Question 4: Project Management

- Solid
- Work done on time and budget
- Project provides very good value for the amount invested
- Well documented use of funds
- Impressive list of collaborating international and national experts
- Program coordination of so many contributing experts is difficult yet key for producing results
- Project management appears good at this time

Question 5: Research Integration, Collaboration, and Technology Transfer

- Good collaboration between labs and outside DOE
- Solid publication record
- Good collaboration with other labs and the private sector
- Cost-share leveraging with partners, funds from "work for others" contracts
- Impressive lists of publications and project partners. However, involving distributed wind sector stakeholders would help improve relevancy to applications in remote locations and smaller wind turbines.
- This part of the A2E program elements along with the field validation of wakes are the essential integrating elements. Results from this effort offer industry actionable design tools.
- The long list of participating industry partners, including end users such as NextEra demonstrates the interest level
- International research lab participation is educating engineers for the industry
- Excellent collaboration with IEA (International Energy Agency) Task 32. This approach exploits the benefits of international collaboration.
- Project coordination within National Labs is good, as well as with industry partners, and good to see future collaboration with NextEra on full-scale test program

Question 6: Proposed Future Research, if applicable

- Will test power capture differences of waked turbine in next phase
- Nothing specific identified. It's not clear why there would not be specific work identified to carry this further.
- Further tech transfer efforts on "smart" controls is warranted, particularly for the distributed wind sector
- Simulation results sufficiently encouraging to warrant field testing
- Next level of testing at SWIFT and NREL will build on foundation of results
- Proposed full scale testing with NextEra is an appropriate next step

Question 7: Project Strengths

- This is an excellent example of leveraging of modeling, V&V (verification and validation), use of DOE facilities, and collaboration
- Real results
- Field-verified advanced control strategies that decrease levelized cost of energy through increased energy capture, reduced loads, and increased reliability
- Potentially significant opportunity to optimize loads and plant output for lowest LCOE
- Not something private industry could likely do on its own
- Pulls together world class DOE laboratory resources, broad industry stakeholders and international experts from labs and IEA projects
- Quantifying the effects of wake interaction on downwind turbines is exceptional

Comments made by reviewers during the evaluation of this project (PRID 207)

Question 8: Project Weaknesses

- Limited number of OEMs (original equipment manufacturers) involved, no distributed wind stakeholders
- Persistence of steering dependent upon stability
- It's not clear to me if the complexity of integrating wind farm level plant control has been fully understood and resolved

Question 9: Recommendations

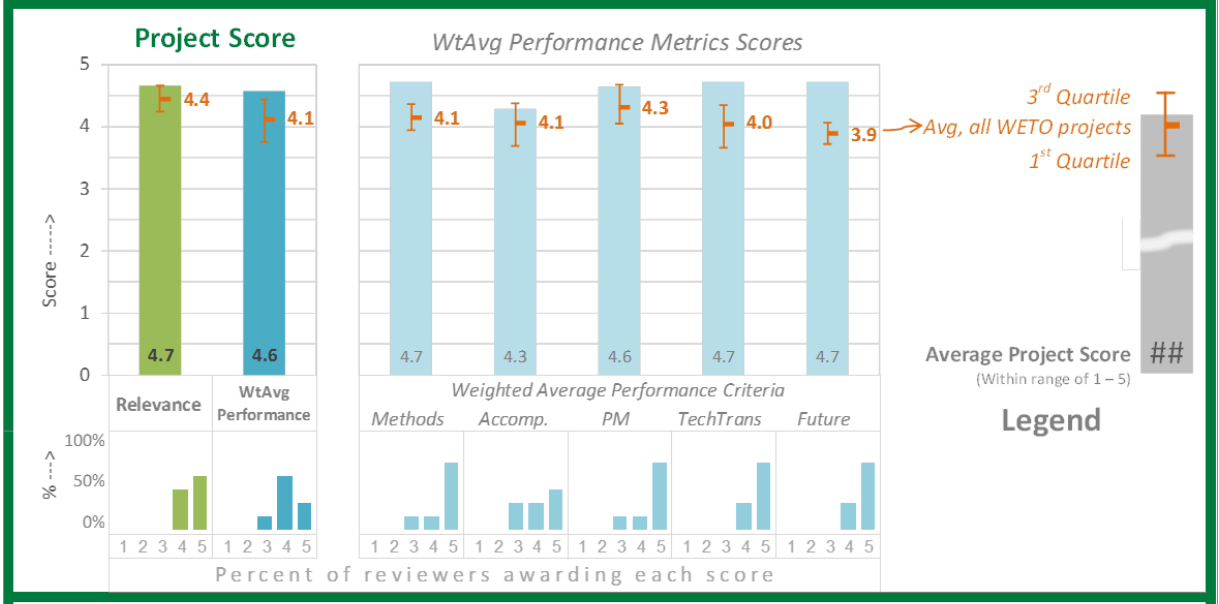
- Work to better integrate this and overall A2E area across all scales of industry, including distributed wind sector

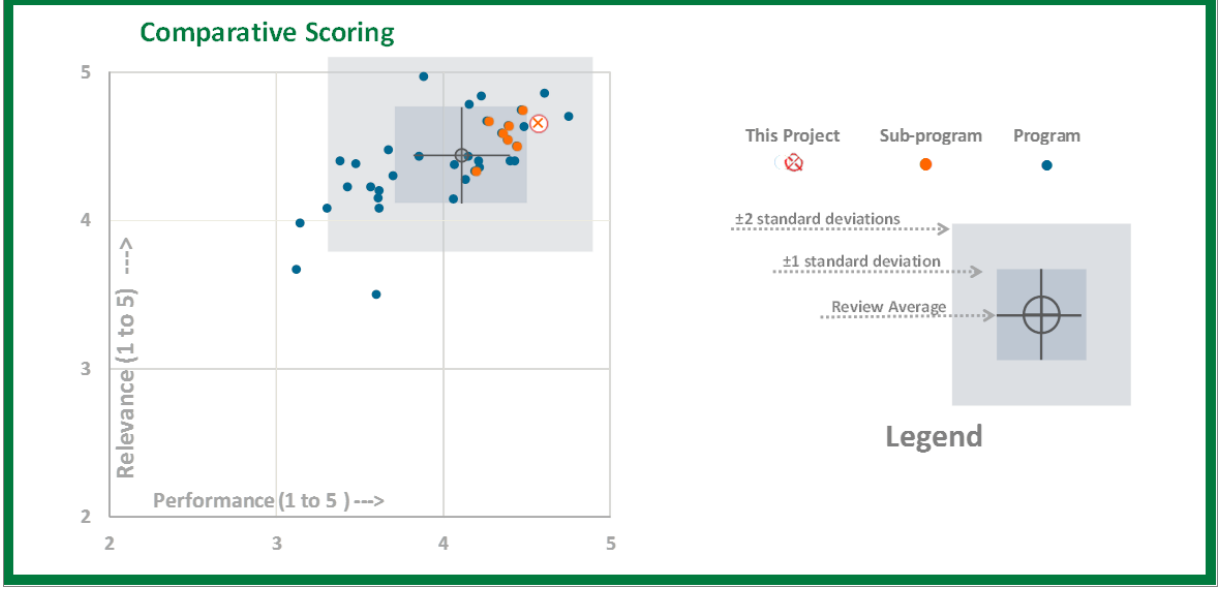
DOE Wind Energy Technologies Office 2017 Peer Review Project:

PRUF: Performance Risk, Uncertainty, and Finance

Principal Investigator	Jason Fields, National Renewable Energy Laboratory		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Atmosphere to Electrons; Resource Characterization		
FY 2014-2016 Funding	DOE	$ 0.7 M	100%
	Cost Share		
	Total	**$ 0.7 M**	**100%**

Peer Review ID# 208





Comments made by reviewers during the evaluation of this project (PRID 208)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- This is an important effort to help understand wind plant performance and uncertainty. Financiers need to understand the factors contributing to uncertainty.
- This is a very well-conceived project and provides a very high ROI (return on investment) for the amount of money budgeted. The concept of using real world data to help improve our ability to estimate power/revenues generated provides excellent leveragability.
- Currently focus limited to utility-scale wind - but method could have high value for smaller scale projects
- Unique and thoughtful approach to a longstanding issue
- This project has very high value for wind plant owner operators. Performance uncertainty is one of the major risks for investors.
- DOE is uniquely positioned as an objective trusted high quality organization to coordinate industry collaboration. Excellent and highly leveraged use of DOE lab talents.
- This work is directly relevant to challenges we have with project development within our company. There is always a debate around what level of uncertainty should be assigned to the wind resource estimation. The level of uncertainty can influence whether a project is approved or disapproved.

Question 2: Methods and Approach

- Working with industry to get SCADA (supervisory control and data acquisition) data to better understand performance is critical to this effort
- The approached developed for this project includes a good progression through design, implementation and dissemination. The concept of performing statistical analysis on data collected from existing facilities and then distributing this back to the industry via the data center is outstanding.
- The methodology developed here is very consistent with similar applications for other industries and is consistent with the SOP (standard operating procedure)
- Utilizing industry consortium, data sharing & collaboration including OEMs (original equipment manufacturers), O&M (operations and maintenance) providers, and investors
- Exceptional work bringing together participants and mitigating their concerns
- Innovative approach to the problem
- Industry has attempted to document performance prediction bias but because it was done by the consulting firms that performed the original performance estimations it was not trusted and lacked the transparency to be totally compelling or transferable to future operators. (DNV/GL, garrad hassan, etc). This project is commercially objective and transparent. It also includes many more stakeholders across more varied projects. Excellent.
- Have international projects been included such as DONG?
- Excellent broad stakeholder inclusion: JP Morgan, CITI, etc.
- It is understood that this project will inform international standards. Describe the standards coordination/impact of this work. How is IEC (International Electrotechnical Commission) WG15 (Working Group 15) informed by this work?
- The methods and approach look reasonable for this project

Question 3: Technical Accomplishments and Progress

- Data sharing was a major accomplishment
- A lot of the important analysis is pending
- The project is now just in planning phase, so the results are pending full deployment
- Alignment with stakeholders has been achieved. This is critical to the success of the project.
- Impressive that data from 12 GW, 80+ projects captured - but smallest project is 25 MW
- The project design is accomplished, stakeholders committed. It appears that the toughest hurtles have been accomplished.
- The technical accomplishments and progress look reasonable for this stage of the project

Comments made by reviewers during the evaluation of this project (PRID 208)

Question 4: Project Management

- Seems to be on track and budget
- Excellent use of funds
- On-schedule, lots of pre-work conducted with NDAs (non-disclosure agreements) etc.
- Efficient use of relatively small budget, high leverage of industry data and participation
- Large collaborative projects are difficult. This one appears to have impressive industry stakeholder buy in, a credit to the management of the project.
- The management of the project looks reasonable at this stage of the program

Question 5: Research Integration, Collaboration, and Technology Transfer

- The involvement of major owners and operators and financiers is key
- The data-sharing aspect of this project is critical to its success
- Excellent integration with stakeholders
- Good leveraging of industry relationships at NREL, however research would have greater impact with involvement of distributed wind stakeholders
- Industry collaboration is at the core of this project. It would not be possible if excellent industry integration was not successful.
- Collaboration with end users, industry, and OEM's is exceptional
- Continue to push for more creative ways to acquire data to make this important work as useful as possible

Question 6: Proposed Future Research, if applicable

- Need to continue to collect data and conduct ongoing analyses
- If this project continues to build support from operators, the value of the data obtained will grow substantially
- Important effort, should be expanded to include distributed wind
- Very enlightening initial results support continued research
- The fruits of this project will only come with consistent trusted leadership from the labs. DOE continued support will be highly leveraged with lasting industry benefits.
- Future research is on target to meet program goals and to address the needs of the end user community

Question 7: Project Strengths

- This is a critical effort to get a sense of performance across the industry. The DoE is uniquely suited to do this as a neutral party
- Excellent leveragability
- Large scale comparison of operational data to predictions can aid continuous improvements on many levels
- Could not be done by industry alone
- Broad industry buy in and engagement
- Collaboration with end user community is key to program success
- Best project of the review

Question 8: Project Weaknesses

- Coordination of numerous data providers is daunting, caution of "biting off more than we can chew" limits speed of ramp up
- None identified

Question 9: Recommendations

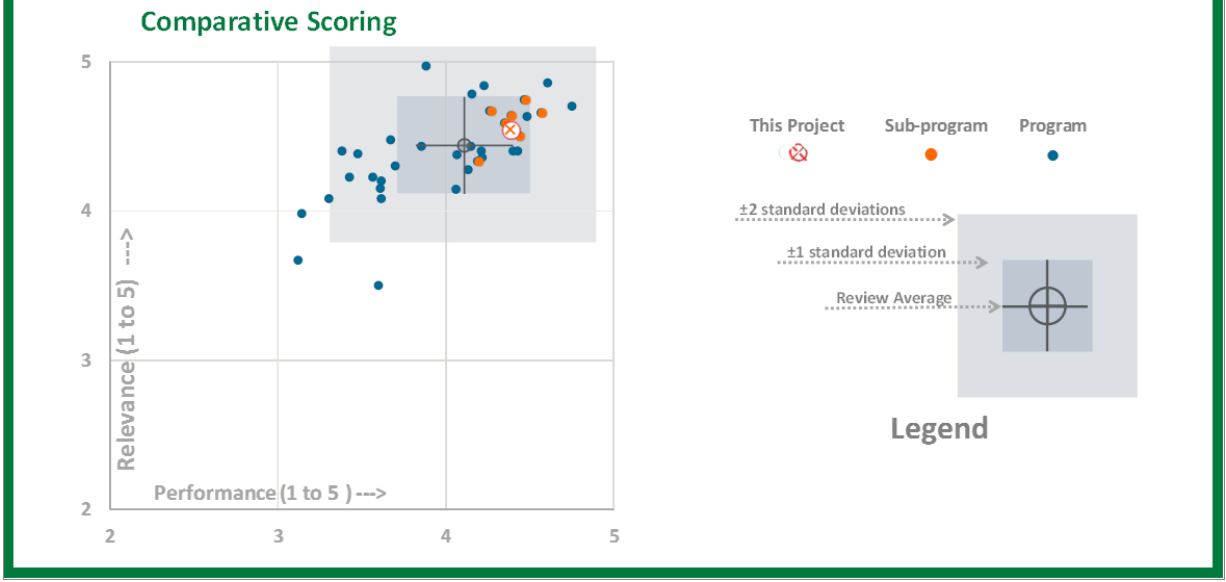
- Ensure ongoing funding is adequate to keep database covering projects of all scales (including micro/distributed wind projects) is up to date and accessible to industry/academia, higher priority than some deep dives

DOE Wind Energy Technologies Office 2017 Peer Review Project:

ISDA: Integrated Systems Design and Analysis

Principal Investigator	Katherine Dykes, National Renewable Energy Laboratory		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Atmosphere to Electrons; Resource Characterization		
FY 2014-2016 Funding	DOE	$ 3.1 M	100%
	Cost Share		
	Total	**$ 3.1 M**	**100%**

Peer Review ID# 211



Comments made by reviewers during the evaluation of this project (PRID 211)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- This is an important effort to tie-in results from other areas within the A2E (Atmosphere to Electrons) effort and the collaborations demonstrate genuine industry interest
- A focused effort on stakeholders and technology transfer is a critical part of A2E
- This project leverages several other DOE projects presented during this review
- FAST is a key tool for the industry and its continued improvement and refinement is important
- The value of WISDEM (Wind-Plant Integrated System Design and Engineering Model) is not clear
- Useful to connect tools for integrated evaluations/innovation and collaborate across sectors, however models currently geared toward utility-scale only
- Output is demonstration of optimization of design
- Key goal: translate increased knowledge from scientific discoveries into design tools capable of benefiting and advancing design process
- Wind turbine design is a very complicated system optimization task. But when turbines are integrated into a wind plant which is coupled with extremely complicated meso/micro scale flow and wake interactions the optimization task becomes nearly an impossible task. This task introduces system optimization tools and strategies that make the task tenable and useable by multiple industry stakeholders.
- The tools introduced by this task provide a bridging analysis tool that can be used by designers of turbines, wind plants and economists. This broad stakeholder appeal offers a common analysis framework which can be scaled to meet the needs of different stakeholders. Tremendously valuable.
- Wind farm optimization is critical to our success as owner/operator of a substantial fleet. Although complex physics-based model development and validation is outside my core competencies, the goal of the project is in line with end user's needs and expectations.

Question 2: Methods and Approach

- Refactoring FAST into a modular, more easily usable tool is commendable
- Creating a tool to help stakeholders understand the value chain is likely to be very helpful
- Transition to Open FAST platform is key and should expand the value of the work
- Progression thought software development, testing and validation is consistent with SOP (standard operating procedure)
- Open source software, community development platforms leveraging outside designers, demonstrating optimization best practices for LCOE (levelized cost of energy) reductions
- Primary focus on wind plants does not consider fleet-wide and utility system level optimization opportunities
- Slide 8: Wind plant performance improvement after optimization demonstrates remarkable performance improvement potential
- NextEra collaboration project to demonstrate wake steering in full scale commercial wind plant is excellent industry collaboration
- What boundary conditions were assumed for Meso/Micro scale coupling (MMC) for the optimization exercise in Slide 8? How representative was it, i.e. what temporal and spatial details were not included. What impact might accurate MMC have on wind plant optimization?
- How is community development of OpenFAST being accomplished? No budget to support a WRF (Weather Research and Forecasting) like organization
- The Open MDAO (Multidisciplinary Design Analysis and Optimization) framework offers the ability to couple very different analytical tools for system optimization. This public domain analysis framework provides a unique solution for wind plant optimization.
- Is there a trimmed down version of FAST that can be used for real time control? Hardware in the loop control? Yes, depending on the modules chosen.
- The methods and approach appear reasonable for the complexity of the project

Comments made by reviewers during the evaluation of this project (PRID 211)

Question 3: Technical Accomplishments and Progress

- FAST8 (modular version is completed) - moving to OpenFAST is next step
- Completed transition to new platform, refinements and rollout of FAST 8
- Completing modular format of FASTv8 important step forward, but would like to see validation conducted on smaller-scale wind turbines as well
- FAST 8 is a significant accomplishment. It introduces a highly flexible design tool that can be adapted to suit different levels of modeling fidelity and industry needs.
- Demonstrated dramatic performance improvements by using the Open MDAO tools to optimize a wind plant layout and wake steering control. Very impressive.
- This optimization approach capitalizes on the full range of design tools needed for industry to transition to full wind plant optimization
- Coupled tools enable LCOE analysis coupling with complicated dynamics and fluid flow models. Truly unique and transformative step in advanced design process improvement.
- As mentioned above, development of complex physics-based models is outside my core competency, but accomplishments appear reasonable to meet program goals

Question 4: Project Management

- Appears solid with good stakeholder engagement
- On time and budget
- Good ROI (return on investment) for the amount invested
- High overhead has impacted amount of practical outcomes for high dollar effort; cause of carryover unclear
- Excellent use of IEA (International Energy Agency) Task 37 international collaboration for leveraging international expertise
- Coordinating multiple organizations was very successful
- Project management appears to be very good

Question 5: Research Integration, Collaboration, and Technology Transfer

- The stakeholder engagement is solid and the use of open source codes is key to industry utilization of tools
- Good in-kind contributions from industry
- Good collaboration with labs and private sector
- Impressive amount of tech transfer but no distributed wind stakeholders involved - could consider strategies to optimize regional dispersed fleets
- 7 countries and 15 organizations--very well done
- All the best wind research experts in the world as well as largest owner/operator in the United States are participating
- Collaboration within National Labs appears appropriate, and my understanding is that a full-scale test with NextEra is scheduled for the near future
- Could be strengthened by integrating with offshore wind industry

Question 6: Proposed Future Research, if applicable

- Focusing on uncertainty quantification is a good step
- Expanding collaborations with IEA
- The specific future developments are somewhat vague and difficult to assess in terms of ROI. Further definition is needed.
- Recommend that turbulence model validation include implications for micro, small and mid-size distributed wind projects
- An important component of addressing remaining uncertainties and lowering the LCOE of wind
- Proposed future research of demonstrating validation of models and quantifying potential reduction in LCOE appears appropriate
- If integrated with offshore wind

Comments made by reviewers during the evaluation of this project (PRID 211)

Question 7: Project Strengths

- Important externally facing project to ensure stakeholder needs are met and tools resulting from A2E and other projects are accessible and usable to a broad stakeholder group
- FAST is a key tool for the industry and needs to be enhanced further
- Open-source software available
- Well focused; well managed. Essential first steps to the long term goal
- The initial steps of one of the more important goals for this program
- Only analysis framework that could optimize a wind plant system and capture the impact of coupled dynamics, atmospheric models and cost models
- Efforts to quantify benefits of wind farm optimization by incorporating improved physics-based models

Question 8: Project Weaknesses

- Needs a community code support base
- Has not involved or considered needs of distributed wind stakeholders
- None noted
- Similar comment made to other wind farm optimization efforts depending on wake-steering; deployment of the technology may be limited. We have one wind farm that may benefit, but the majority of our plants are in complex terrain, with 3 or less downwind rows of turbines in prevailing wind direction.

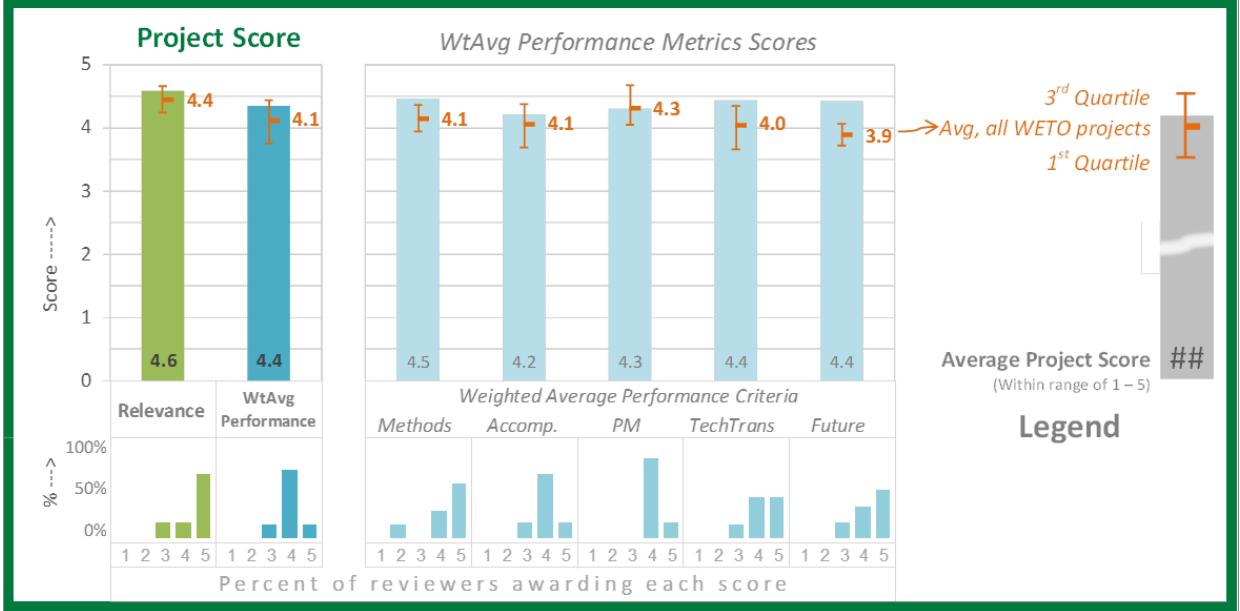
Question 9: Recommendations

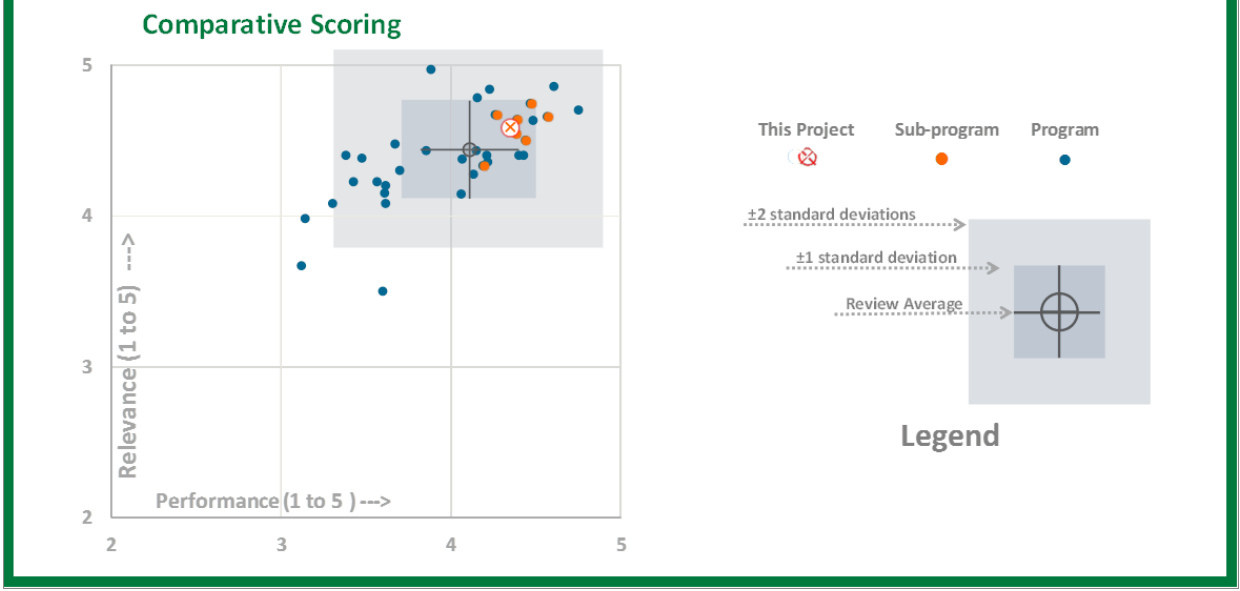
- Make sure FAST8 has the community support framework in place to manage the code base and test external code contributions
- From SMART (Sustainable Manufacturing, Advanced Research & Technology) Wind Roadmap: Provide educational courses on computer-aided engineering tools available for distributed wind system design (e.g., FAST, Crunch) for industry, college students; update aerodynamic models in FAST v8 to include distributed wind turbine towers & tails
- Should have the highest of funding priorities

DOE Wind Energy Technologies Office 2017 Peer Review Project:

WFIP II [Wind Forecast Improvement Project II]: Mesoscale Physics and Inflow

Principal Investigator	Will Shaw, Pacific Northwest National Laboratory			
Program	Wind Resource Characterization and Technology RD&T			
Sub-Program	Atmosphere to Electrons; Resource Characterization			
FY 2014-2016 Funding	DOE	$ 6.8 M	48%	
	Cost Share	$ 7.4 M	52%	
	Total	**$ 14.2 M**	**100%**	Peer Review ID# 217





Comments made by reviewers during the evaluation of this project (PRID 217)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Improving our understanding of the wind resource (wind speed, turbulence, and wind shear) and the site-specific frequency of occurrence of extreme or transient events that will impact production, efficiency, and turbine longevity (wear and tear) is foundational to reducing the LCOE (levelized cost of electricity). Therefore, investments in field programs that advance our knowledge of atmospheric boundary layer flows are very important (e.g., WFIP I and WFIP II). Looking ahead - Post field program resources need to be available to the project team for analysis and publication of results to take full advantage of the funding spent on the field campaigns. The results will be very useful to NOAA (National Oceanic and Atmospheric Administration), the research community, and private sector firms that support the wind energy industry.
- This score applies to 217, 192 and 148 which were 3 separate presentations on the same project
- When viewed within the context of the whole program, this project helps to fill a key gap in that it addresses the integration of mesa and micro data for a real wind farm in complex terrain. This data cannot be captured (easily) within the current infrastructure of test facilities.
- The applicability of the results generated here to other sites is a concern
- High dollar effort with little relevance to distributed wind sector
- A long overdue effort!
- Improving Meso scale models for forecasting in complex terrain is key for grid integration. Understanding the source of and forecasting the timing of power ramps is critical for large scale wind integration.
- How accurate do we need for dispatching? For hourly energy forecasting the accuracy can be lower than forecasting large power ramps which effect stability.
- All experience gained from the improved physics modeling is transferable to other locations and environments
- The scale of the WFIP II project is impressive. Not only the number of high precision instruments but the broad geographical scale needed to capture data needed for both the meso scale model correlation and the local plant conditions. Truly unique research program.
- Wind farm wind resource characterization is the most important variable to quantify for optimized wind farm development and cost-effective wind farm operation. This research is critical to the success of our business and the future viability of the wind industry, in this era of ever-decreasing PPA (power purchase agreement) awards.
- We are directly affected by the mesoscale-microscale interactions on the lee side of Mt. Hood, Oregon. Having a better understanding of this effect may have guided us in a different direction in the development of the complex in Wasco, Oregon, or at a minimum, recalibrated our expectations of expected performance.

Question 2: Methods and Approach

- Taking advantage of WFIP 1 results and successes was the right approach for planning WFIP 2
- Good observational network design and utilization
- After showing how assimilation of local data could improve forecasts in WFIP 1, it made sense to focus on improvements to model physics to extract more skill
- Excellent progression through design, modeling, field data acquisition and analysis
- This is a large project with a significant field campaign and equipment, the costs are therefore high. While the potential value is high it's difficult to assess the ROI (return on investment). High value, high cost, single set of project conditions.
- The model development and validation against collected data seems rigorous and in line with industry best practices
- Cost-effectiveness of such a large-scale effort unclear
- This instrument layout spans nearly two entire states of Oregon and Washington. And then focuses down to a physics site with high density arrangements. This is a huge effort in placement and coordination and synchronizing data. But very necessary for addressing modeling across 2-3 orders of magnitude in weather physics.
- The methods and approach appear outstanding

Question 3: Technical Accomplishments and Progress

- Good results so far but the applicability of the results of this project for other sites is unclear
- The project is ongoing and it's difficult to assess the overall impact of the data that has been generated
- Delays due to leasing issues, would like to see more meaningful progress for this level of funding
- Experiment design and instruments set up and taking data
- Organization complete and functioning
- Data archiving system operational
- Data collection efforts to date are exceptional

Question 4: Project Management

- This project involves a lot of participants, so the use of a steering committee was a good idea as well as the development of an integrated science plan since this is a complex scientific field project
- Work on time and budget
- Large team structure with high overhead seems unwieldy, value of steering committee unclear
- Excellent organizational structure with multiple organizations and a steering committee. Maximizes the benefit of tech transfer.
- Project management appears to be very good, and program goals should be met

Question 5: Research Integration, Collaboration, and Technology Transfer

- The WFIP 2 team included several key players and a broad array of experts to make progress on this topic
- Excellent project with respect to data sharing include power information from plant operators
- The project is well integrated with industry, national labs, etc. and seems to be well integrated with the other DOE efforts
- Impressive list of partners, good to see utilities including BPA (Bonneville Power Administration) involved and high degree of cost-sharing
- Specific publication examples not provided to peer reviewers
- Good example of industry and interagency cooperation and contribution. Good participation from academia, utilities, owners.
- Broad stakeholder participation across the entire value chain for forecasting. From instrument supplier to forecast agencies to wind plant operators the breadth of stakeholder participation is impressive and necessary for success.
- Demonstrated exceptional collaboration across other National Labs, industry, and end users

Question 6: Proposed Future Research, if applicable

- The development of tools that can be used across multiple types of sites would be good
- Decision support tools and alert system could be funded by utilities/commercial sector
- Fill out the database, analyze the data and improve models. Must pursue all the way to the model improvement to reap the benefits.
- Proposed future development of Decision Support Tools are critical to improved operations/performance optimization of our assets

Question 7: Project Strengths

- Excellent suite of participants. There is a lot to be learned scientifically from this well-instrumented field program.
- Given the expansion of wind farms from good sites to those with more complex terrain and weather systems, the information from this study will be very valuable
- Improved forecasts in areas of complex terrain can improve grid integration/balancing with hydro and other renewables, and reduce utility curtailment requirements such as seen in the Pacific Northwest
- Targeted research on complex terrain site is extremely important to wide-scale distribution of model tool set

Question 8: Project Weaknesses

- High cost fundamental science project
- None identified

Question 9: Recommendations

Comments made by reviewers during the evaluation of this project (PRID 217)
• Transfer work to the commercial sector, while preserving public investments to date • Continue program research trajectory

The subsequent two lists of comments refer to **PRID 148, WFIP II: Modeling**, and **PRID 192, WFIP II: Field Testing**. These projects were presented with **PRID 217, WFIP II: Mesoscale Physics and Inflow**, as all three projects are part of WETO's overarching Wind Forecast Improvement Project. The three PRIDs were not evaluated separately quantitatively, but some reviewers provided separate comments specific to each PRID. Comments for PRIDs 148 and 192 follow.

Comments made by reviewers during the evaluation of this project (PRID 148)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- See notes from #192
- See 217 notes
- Ensuring that datasets will be available to future researchers, portal setup
- Research will ultimately aid grid operators (eg BPA (Bonneville Power Administration)) reduce uncertainty and excessive requirements for curtailment
- Tool is targeted at improving forecasted energy delivery. Advancing weather science considerably.
- Please see the evaluation of Project #217, the same comments apply to this project

Question 2: Methods and Approach

- Please see the evaluation of Project #217, the same comments apply to this project

Question 3: Technical Accomplishments and Progress

- Please see the evaluation of Project #217, the same comments apply to this project

Question 4: Project Management

- Please see the evaluation of Project #217, the same comments apply to this project

Question 5: Research Integration, Collaboration, and Technology Transfer

- Please see the evaluation of Project #217, the same comments apply to this project

Question 6: Proposed Future Research, if applicable

- Please see the evaluation of Project #217, the same comments apply to this project

Question 7: Project Strengths

- Please see evaluation of Project #217, the same comments apply to this project

Question 8: Project Weaknesses

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Question 9: Recommendations

- Continue process and involvement
- Continue with the same. Nothing really to scope here.
- This critical work for all sectors of the wind industry, especially small and micro wind turbines, likely would not happen without U.S. DOE funding, and enables financial confidence in products
- Consider increasing future funding to accelerate progress for distributed wind sector, which may not be ranked as top priority by stakeholders involved but is critically important for credibility of entire industry
- Consistent participation is so important for implementing the U.S. strategy. NREL's and DOE's leadership has been consistent and must remain consistent for it to continue to be effective. The U.S. (and international) industry depends on this leadership.
- Continue the exceptional work

Question 7: Project Strengths

- Supporting industry's ability to participate with level playing field and global conformity
- The U.S. Wind Energy Standards Summit appears to be worthy endeavor with DOE leadership
- The standards are very important and, in some areas (e.g., offshore), very weak compared to where we need to be. It is helpful to know that the DOE has a consistent involvement in the process of progressing international standards.
- Creates level playing field for U.S. industry to compete globally
- U.S. leadership in the international role builds confidence and certainty in the process
- Industry leadership
- Broad stakeholder participation
- Appropriate R&D agenda integration
- The ability to gain cross global acceptance of processes and procedures

Comments made by reviewers during the evaluation of this project (PRID 148)

Question 8: Project Weaknesses

- It seems that AWEA (American Wind Energy Association) should take this seriously and create a subcommittee led by industry representatives to lead the effort
- I think that it is asking the DOE to do too much to carry the ball as much as it has on standards efforts. The industry, through AWEA, needs to do more and to provide better funding for this process.
- Undercapitalized small and micro wind OEMs (original equipment manufacturers) have not all been able to effectively participate
- None
- None identified

Question 9: Recommendations

- Ensure near-term scope includes work identified as high priority by distributed wind sector, including a gap analysis for certification requirements for various global markets and consumer education on importance of certified products
- Stay the course
- Continue the exceptional effort

Comments made by reviewers during the evaluation of this project (PRID 192)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Important field program to develop, test, and improve weather prediction models capabilities which are used by information providers for wind energy prediction
- See 217 notes
- Please see the evaluation of Project #217 - same comments apply

Question 2: Methods and Approach

- Taking advantage of WFIP 1 results to plan WFIP 2 is solid approach
- Excellent experimental design
- Please see the evaluation for Project #217, the same comments apply for this project

Question 3: Technical Accomplishments and Progress

- Good progress to date with data collection and archiving
- Please see the evaluation for Project #217, the same comments apply to this project

Question 4: Project Management

- No concern
- Please see the evaluation for Project #217, the same comments apply to this project

Question 5: Research Integration, Collaboration, and Technology Transfer

- Good collaborative team
- Data sharing will be critical - good that DAP (Data Archive and Portal) was used
- Time still needed for analysis and publication writing
- Please see the evaluation for Project #217, the same comments apply to this project

Question 6: Proposed Future Research, if applicable

- Analysis and verification are needed
- Plan to develop some alerts based on the model predictions
- Physics improvements will get to end users via NOAA (National Oceanic and Atmospheric Administration) (HRRR (High Resolution Rapid Refresh)) and NCAR (National Center for Atmospheric Research) (WRF (Weather Research and Forecasting model))
- Please see the evaluation for Project #217, the same comments apply to this project

Question 7: Project Strengths

- Excellent field dataset
- Should lead to significant improvements in model boundary layer physics that will be incorporated into research and operation models used by the NWS (National Weather Service) and weather industry
- Please see the evaluation for Project #217, the same comments apply to this project

Question 8: Project Weaknesses

- It could take years to do the analysis and publish results. Are funds available for these efforts?

Comments made by reviewers during the evaluation of this project (PRID 192)

Question 9: Recommendations

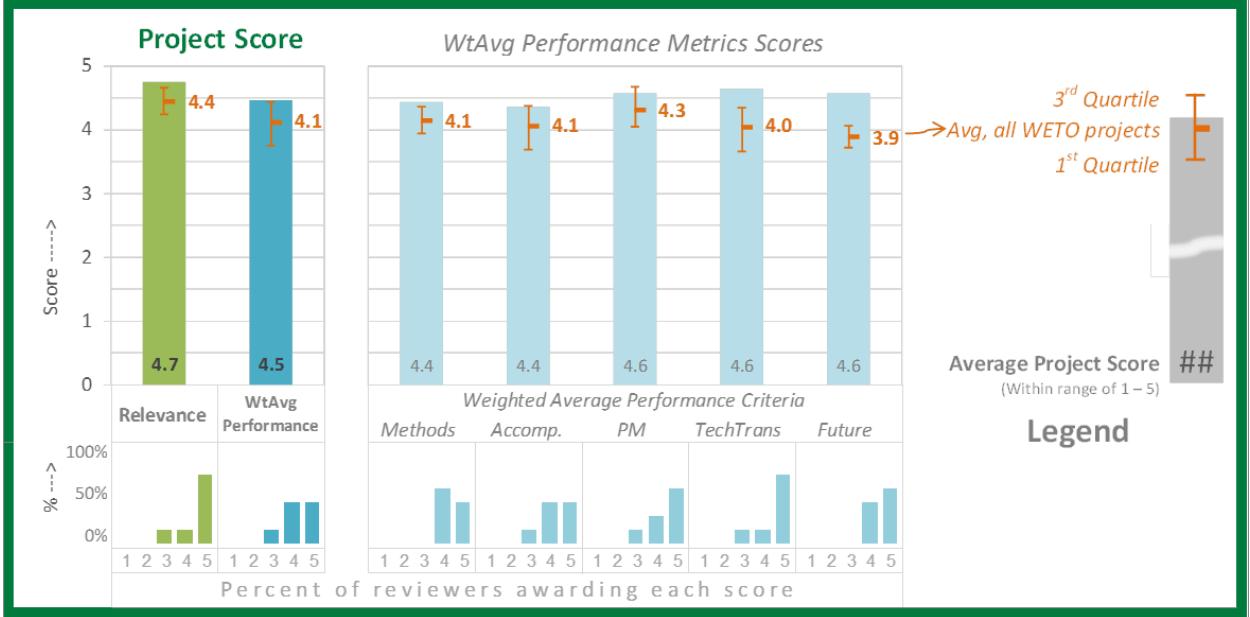
- Continue to fund analysis efforts. This is important given the investment in the field campaign.

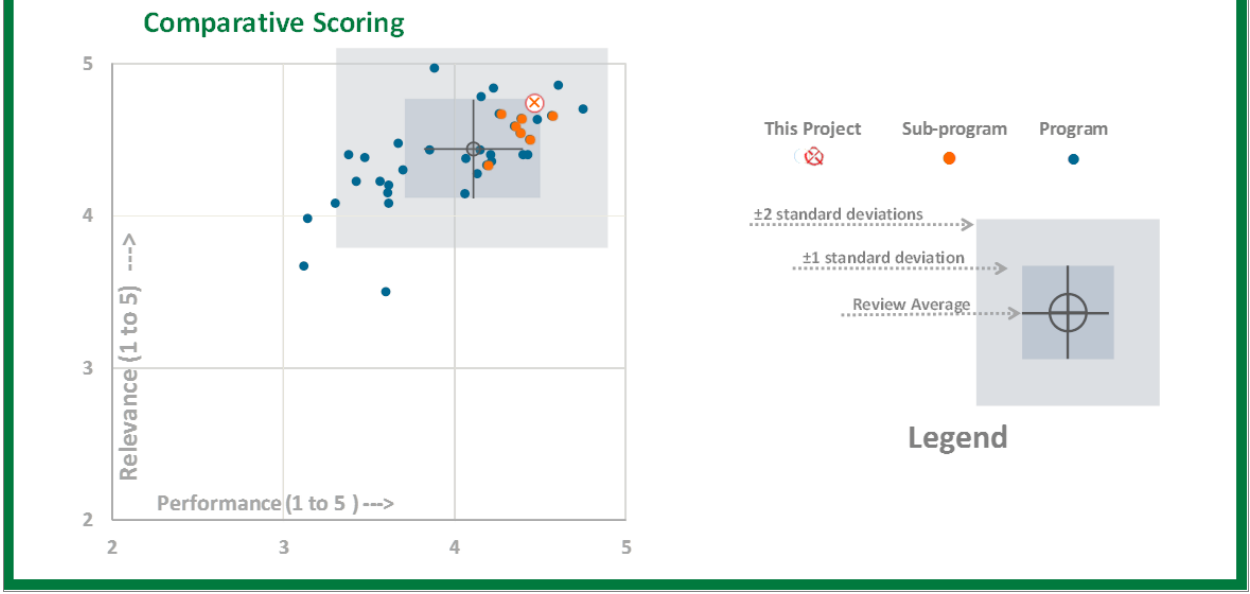
DOE Wind Energy Technologies Office 2017 Peer Review Project:

MMC [Mesoscale to Microscale Coupling]: Model Development and Validation

Principal Investigator	Sue Haupt, PNNL		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Atmosphere to Electrons; Resource Characterization		
FY 2014-2016 Funding	DOE	$ 3.5 M	100%
	Cost Share		
	Total	**$ 3.5 M**	**100%**

Peer Review ID# 218





Comments made by reviewers during the evaluation of this project (PRID 218)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Critical to understand and model the real atmosphere and most of its variations to support resource assessment, plant optimization, turbine design, and control strategies
- Datasets created by this effort will help create more realistic datasets for design (capturing right turbulence scales) and eventually real-time control. There is a deficiency in realistic flow datasets so the complexity is underappreciated.
- The knowledge gained from the scientific field programs is critical to improve the physics schemes implemented in the meso- and micro-scale weather models, which themselves are powerful tools for characterizing the wind resources in a broad array of geographies (e.g., flat and complex terrain, coastlines, offshore, and for exploring methodologies for improving wind resources within large wind plants). The progress made on the Meso-to-Micro program is noteworthy and the results that demonstrated the diurnal evolution of the boundary layer across stability regimes were impressive.
- This project is addressing a key gap in the process of resource assessment and control. While it is difficult to assess with the current results, the potential impact is very high.
- The project is fully relevant with the DOE objectives
- Unclear why so much funding is needed at each lab for this effort
- Research currently has little but could have more future relevance to distributed wind sector, particularly for micro site screening (including southeastern United States)
- Meso/Micro scale modeling has been a challenge for many years but with the advent of wind plant optimization it has become the critical path issue to understanding poor wind plant performance and investigating opportunities to improve performance. This central challenge could only be led by the world's leader in weather modeling, NCAR (National Center for Atmospheric Research).
- Wind turbine design process uses rudimentary turbulence models today. These engineering models match the statistical properties of turbulence but lack the fidelity needed to capture the real physics of the wind. If the wind industry is to understand how to optimize wind plant performance we must have models that characterize the real physics of the wind and its coupling wind plant flow, micro scale and meso scale weather physics. This effort gets to the heart of that challenge.
- The presentation was exceptional. Fascinating video on the influence of the diurnal convection cycle on local wind flow conditions. Some validation done at SWiFT (Scaled Wind Farm Technology) facility. Need to target more complex terrain situations, for example, on the lee side of Mt. Hood. Accurately predicts and characterizes low-level jet stream.
- Accurate understanding of microscale wind flow and wind resource conditions are critical to financial success of a wind farm

Question 2: Methods and Approach

- Solid experimental approaches were applied with model intercomparisons and sensitivity testing
- The technical approach that has been developed for this study is very clear and appropriate for the task
- Coupling across scales with verification and validation, modeling in complex terrain
- Tools, knowledge and best practices for modeling across spatial and temporal scales made available to both industry and broader research community
- Slide 7: Has any quantification of MMC impact on plant performance optimization or loads using improved microscale models been done? Can it be bounded? Can the maximum impact be estimated using assumed extreme Meso Scale conditions? Answer: Meso scale physics are necessary to capture convective behavior and hence turbulence characteristics. Comparison of MMC based turbulence to IEC (International Electrotechnical Commission) turbulence models?
- Slide 8: OK, Low Level Jet modeling needs Meso scale physics to capture realistic behavior
- One way coupling between the meso and micro scale is being used now. Is two way coupling ever likely to be warranted? What is potentially sacrificed by ignoring two way coupling?
- Is WRF (Weather Research and Forecasting) coupling with LES (large eddy simulation) coupling sufficient to capture low level jet?

Comments made by reviewers during the evaluation of this project (PRID 218)

- The so called "Terra Incognito" represents the gap between Meso and Micro scale weather that drives all wind energy. The greatest amount of turbulence energy important to wind energy production lies in this gap. Understanding the coupling is key to understanding how to maximize energy extraction from it. Using the latest versions of the public domain weather models for the meso scale and LES for micro this effort is attempting to develop modeling techniques that bridge this all important gap for wind plant performance optimization.
- Although development of complex physics-based wind resource models is outside my core competency, the methods and approach appear reasonable to meet program objectives and goals

Question 3: Technical Accomplishments and Progress

- Excellent demonstration of evolution of the boundary layer with the mesoscale forcing using SOWFA (Simulator fOr Wind Farm Applications)
- Work appears to be progressing at solid pace
- The work is still in progress and does not address a full range of conditions, but the results that have been generated to date are very promising
- Would like to see more meaningful progress at industry speed for this level of funding
- Impressive and enlightening flow visualization
- A challenging topic that needs continued effort
- LLJ (Low Level Jet) coupling dependency demonstrated! Remarkable.
- Complex terrain modeling and coupling next, major challenge.
- Video representation of diurnal wind flow turbulence was stunning! As an operator I can now visualize the behavior of our 'fuel' for our wind turbine fleet.

Question 4: Project Management

- No concerns as national and international level experts are involved from many labs
- Project completed on budget and schedule
- Project provides reasonable value for the amount invested
- High overhead at labs has impacted amount of practical outcomes for high dollar effort
- Very well managed and very concisely and clearly presented
- Good coordination on integration with other A2E (Atmosphere to Electrons) components
- Very close coordination across multiple labs is key and has been done well
- Low level of funding spread across makes program management more challenging
- Project management appears very good

Question 5: Research Integration, Collaboration, and Technology Transfer

- Excellent collaboration between DOE Labs
- Industry is now regularly involved and international works are occurring
- Excellent collaboration amongst labs
- Industry invited and polled to provide input; data provided on portal. Future engagement should include stakeholders at all scales including distributed wind sector
- 7 national labs plus NCAR
- Part of the strategy for multiple lab collaboration is to achieve tech transfer. It appears to be working.
- Collaboration with other National Labs appears to be very good

Question 6: Proposed Future Research, if applicable

- Leveraging WFIP2 (Wind Forecast Improvement Project 2) results to deal with complex terrain
- Testing for multiple land surface types in future
- The datasets created from this project could form a nice archive for datasets of more realistic flow conditions that could be used by industry for turbine and plant design
- Important to verify results with WFIP2 and SWiFT datasets
- The continuation of this effort is clearly defined and appropriate for the DOE's goals
- Expand objective for modeling to inform distributed wind siting and fleet optimization, expedite corrections on turbulence structures at microscale

Comments made by reviewers during the evaluation of this project (PRID 218)

- Modeling complex terrain is critical for most onshore wind plants. To make this science applicable it must succeed at this challenge.
- Proposed future research targeting complex terrain is directly applicable to most of our wind farm installations

Question 7: Project Strengths

- Excellent presentation with very clearly stated goals, methods and progress to date
- Addressing problem that current microscale models cannot account for many conditions found in real-world wind turbine locations, particularly in sites with high surface roughness
- U.S. weather laboratories are world leaders, second to none. DOE access to these laboratories and universities specializing in weather modeling is unique and makes DOE one of the few organizations in the world that can lead this effort.
- Quantifying and producing a visual representation of diurnal wind flow patterns was exceptional

Question 8: Project Weaknesses

- Limited focus on plant-level control systems reduces relevancy for distributed wind fleet optimization
- Challenging to validate
- None identified

Question 9: Recommendations

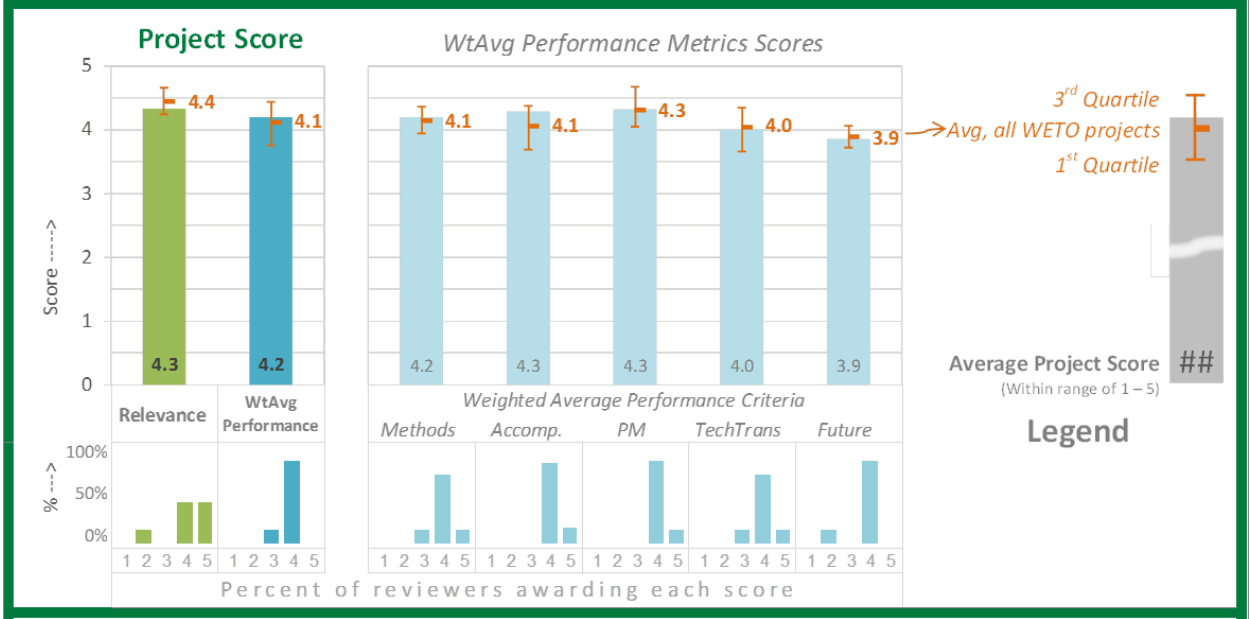
- Data archive should include improved nation-wide layer @30m hub height to assist with distributed wind siting
- Continue research in complex terrain installations

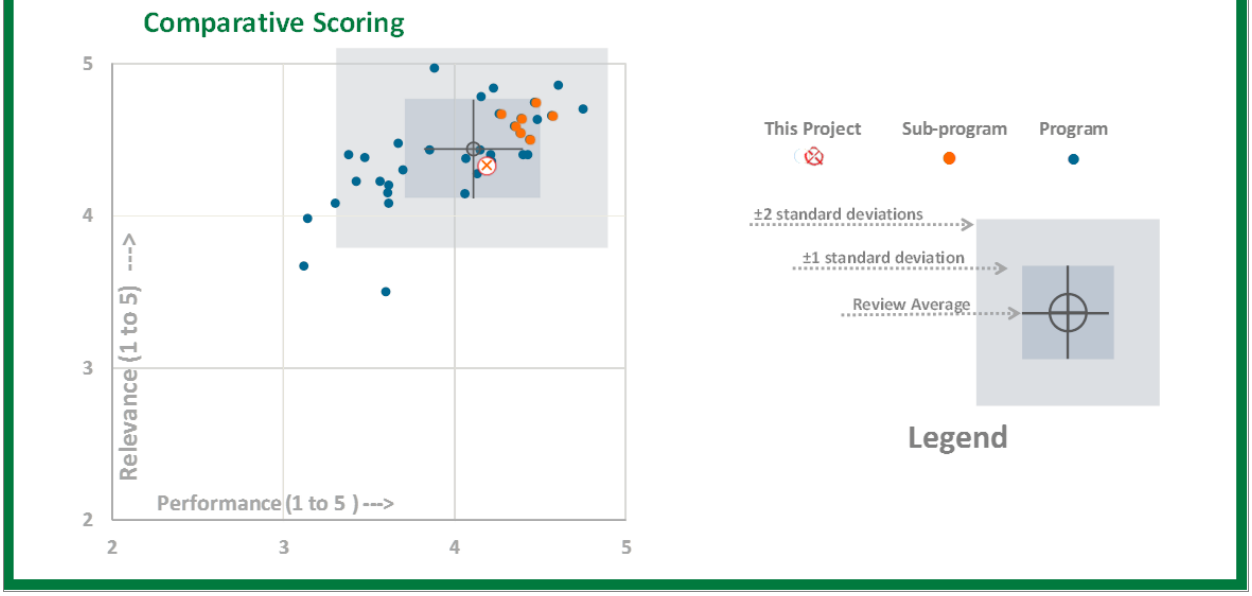
DOE Wind Energy Technologies Office 2017 Peer Review Project:

DAP: Data Archive and Portal

Principal Investigator	Chitra Sivaraman, Pacific Northwest National Laboratory		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Atmosphere to Electrons; Resource Characterization		
FY 2014-2016 Funding	DOE	$ 1.3 M	100%
	Cost Share		
	Total	**$ 1.3 M**	**100%**

Peer Review ID# 219





Comments made by reviewers during the evaluation of this project (PRID 219)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Now being used as main portal for A2E (Atmosphere to Electrons) datasets (11 projects, 100+ users, 81 TB (terabytes), etc.)
- This is an important capability for internal and external stakeholders. The DOE should continue to advertise its availability.
- The dissemination of data to other labs, research institutions, industry, etc. is an element of the overall strategy. Data transfer seems to be achieved by the individual projects but this is limited to the sponsors and partners. This project is needed for a wider distribution.
- This project is unique as, unlike all others, it is not targeted to develop new models, data, etc.
- Effort currently has little relevance for distributed wind sector, but possibly could in the future
- A fundamentally essential part of the program
- Is the general framework used for DAP similar to that used by NOAA (National Oceanic and Atmospheric Administration) and other data intensive programs?
- If so did we need to reinvent DAP specifically for A2E? What were the unique requirements.
- This is a very valuable service that can now serve not only all of A2E but other DOE programs. It looks robust.
- One of the Top 5 DOE programs in importance to the wind industry. Indirectly positively affects the end user as all this research data is permanently accessible for future research and development.
- I wouldn't say it's critical to objectives of the wind industry per se, but to the A2E program

Question 2: Methods and Approach

- Was glad to see other archiving systems and data format best practices were reviewed prior to selecting an approach
- Good that data.gov could be leveraged and DOIs (digital object identifiers) are being used
- The process of developing standards, datasets, access methods, etc. has been thought through carefully and is consistent with BP (best practices).
- Open, easy-to-navigate and low-maintenance user interface to facilitate community data access, interaction, and collaboration
- Data archiving may seem obligatory and mundane but it is frequently underestimated and poorly executed. Here it has capitalized on previous experience to create a lasting benefit for the DOE program.
- Methods and approach are world-class

Question 3: Technical Accomplishments and Progress

- The work required to achieve the goal of easy/direct open access to so much data is significant and it is easy to get started down the wrong path. This project looks like it has been very carefully organized and structured to avoid many of the pitfalls of database and data access.
- Would like to see data from more projects incorporated for this level of funding
- It's up and running and being used!
- Technical accomplishments are world class

Question 4: Project Management

- Appears solid
- Project completed on time and under budget
- High overhead has impacted number of projects archived for high dollar effort; organized coordination of multiple labs and agencies
- Nice execution
- Project management is exceptional

Question 5: Research Integration, Collaboration, and Technology Transfer

- Good team that includes big data experts such at AWS (AWS Truepower)
- Very good integration with industry partners and subs
- Data sharing and preservation important to avoid duplication of efforts, but lack of involvement of distributed wind sector limits impact
- This is a service for all of A2E so it necessarily integrates the other programs
- Collaboration and technical transfer, by definition of the project goals, are exceptional

Comments made by reviewers during the evaluation of this project (PRID 219)

Question 6: Proposed Future Research, if applicable

- Adding access and data management capabilities is the right approach
- Can users perform data manipulation within the data storage framework?
- Work identified is focused on expanding the utility of data that is included in the database. This program will add real value to the industry once it becomes a standard point of access for a wide number of users. The continued outreach to others in the public and private sectors is important.
- Expansion and ongoing maintenance of portal is needed to realize initial investment
- Keep it running!
- Proposed research is in-line with supporting other project goals and objectives

Question 7: Project Strengths

- A data portal was a significant need for A2E and beyond so it's nice to see how much progress has been made in the last 12-16 months
- Collaboration with and review of existing platforms including OpenEI
- Fills a need to be the data repository of all research efforts

Question 8: Project Weaknesses

- IT (Information technology) infrastructure should be covered by lab overhead
- None identified

Question 9: Recommendations

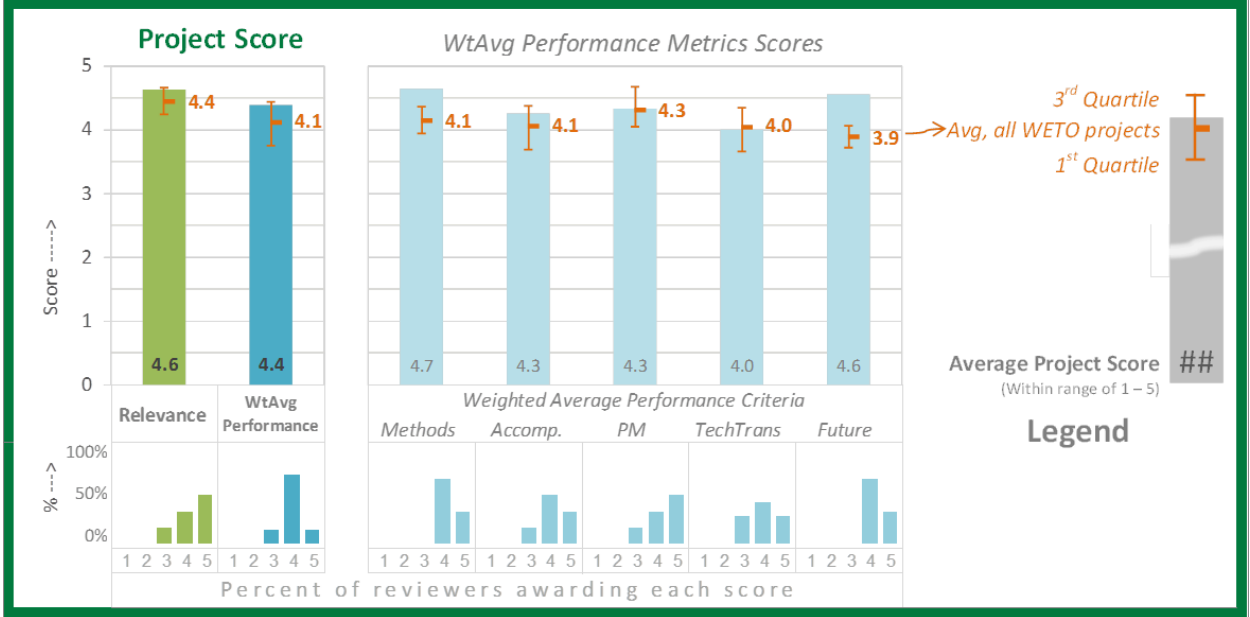
- Work to better integrate this and overall A2E area across all scales of industry, including distributed wind sector

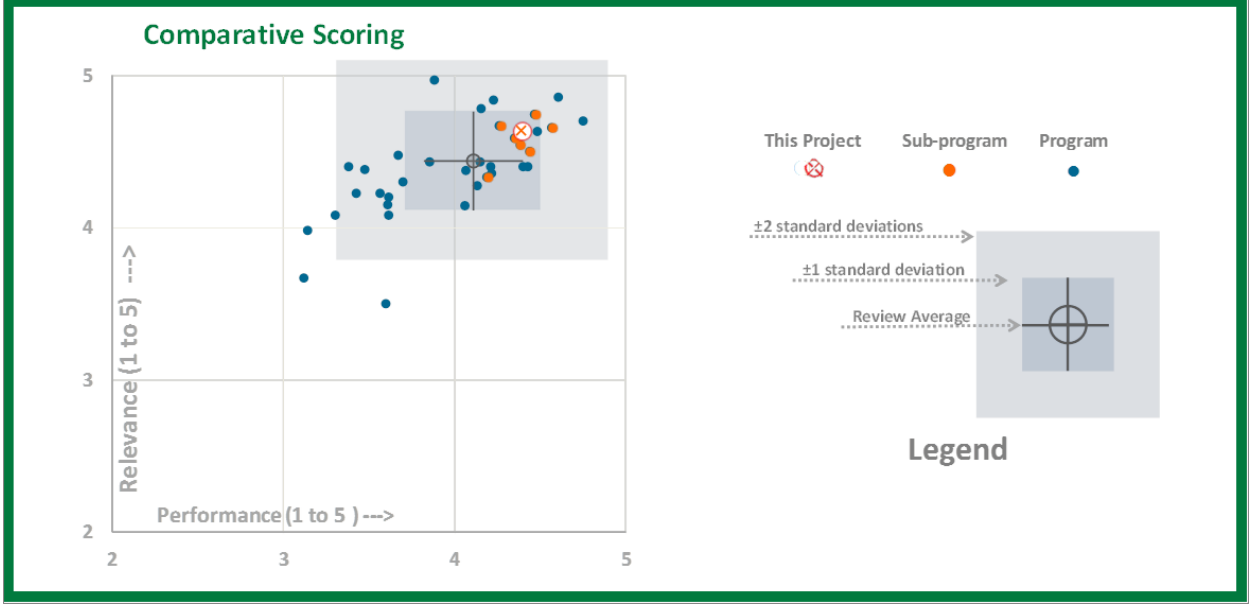
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Wake Dynamics Measurement, Testing, and Validation

Principal Investigator	Brian Naughton, Sandia National Laboratories		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Atmosphere to Electrons; Resource Characterization		
FY 2014-2016 Funding	DOE	$ 11.4 M	100%
	Cost Share		
	Total	**$ 11.4 M**	**100%**

Peer Review ID# 222





Comments made by reviewers during the evaluation of this project (PRID 222)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Better understanding of wake dynamics is critical for plant optimization, reducing wear and tear, and for overall plant optimization
- As plants expand and increase in number, optimization will become more important
- This project is very relevant to industry needs as it helps to fill a major gap in our understanding of optimal wind farm design
- The power area density of large wind farms is an issue that will become as important as LCOE (levelized cost of energy) as regions continue to build wind farms (i.e., eventually it's not the CAPEX (capital expenditures) costs but the available space that is the issue). This project is key in addressing this issue now.
- This program includes a number of separate projects and the costs are consequently higher
- High dollar effort with little relevance to distributed wind sector
- Capability to measure wake maps in detail with high spatial and temporal resolution and accuracy is key to validating high fidelity wake models. Without this capability there is no way to close the loop on the meso/micro scale modeling or the wind plant modeling. Essentially, without this capability the A2E (Atmosphere to Electrons) model validation is severely handicapped.
- Primary value is establishing wake predictive capability with validation
- Wind turbine wakes characterize most of the important details of rotor performance. Wake interaction with other turbines and plant micro scale flow impacts wind plants. Measurement capability is critical to unlocking the mystery and hence improvement of wind plant performance.
- In addition to having access to high-fidelity wind resource information, understanding wake generation and wake interaction behavior is critical to successful wind farm layout planning. Optimizing wind farm layout increases the chances of maximum energy production.

Question 2: Methods and Approach

- Developing and implementing a V&V (verification and validation) effort is important and necessary
- Utilizing SWiFT (Scaled Wind Farm Technology facility) and the Milano wind tunnel are important aspects of the V&V effort
- The progression of modeling, analysis, testing and validation is well structured and consistent with the SOA (state-of-the-art) for these types of projects
- Questionable whether this will result in practical improvements
- Dual Doppler radar offers remarkable precision and resolution. This is a sea change in instrumentation, enabling wake structure detail visualization never before possible. Excellent approach, excellent work.
- For such a complex project, the methods and approach look appropriate using recognized verification and validation processes

Question 3: Technical Accomplishments and Progress

- Good progress to date. No concerns here.
- Important to validate wake behavior in neutral, stable, and unstable boundary layer conditions
- It's still early in the project and difficult to assess the value of the data that will be generated. The results to date look promising.
- Little meaningful progress to date, especially relative to large amount of funds expended
- No reports of results
- Multiple levels of validation accomplished (scaled wind tunnel, field, analytical)
- The accomplishments to date offer high degree of confidence to future measurements. This is the basis needed for future validation.
- Applied creative method for scaling circulation distribution of a commercial turbine to scaled rotor blades for use at SWIFT. Very useful in establishing the connection between SWIFT tests and full scale commercial tests, including the NREL/DOE 1.5 turbine planned for 2017.
- This measurement ability will be crucial in quantifying how the wind plant impacts the Meso/Micro scale coupling
- The project has realized many accomplishments to date which are impressive given the wide range and complexity of the project

Question 4: Project Management

- Seems solid
- Project seems to be progressing on schedule and a lot of work has been completed. No indication of budget or schedule issues.
- Unclear why "uber-PI" (Principal Investigator) project managers needed, leading to high overhead
- No cost share documented
- This project is intimately connected and coordinated with HPC (high performance computing) and other A2E projects. Crucial for success of the integrated A2E program and essential for coordinating interlab analytical efforts.
- Given the level of complexity of this project, the management is exceptional

Question 5: Research Integration, Collaboration, and Technology Transfer

- Thus far, the effort seems to be appropriately collaborative
- Important to tie this work into the HPC
- Integration with labs and private sector is good
- Computational code and experimental data are all made public via a web-based portal
- Specific publication examples not provided to peer reviewers
- Good collaboration
- Lab coordination is excellent and essential
- Collaboration and technology transfer appear exceptional, as verified by the number of participants within the various disciplines of the project
- It would be beneficial to see this work integrated better with offshore wind, including collaboration with offshore wind industry and academics looking at these issues w/r/t to offshore wind (i.e. Archer et al)

Question 6: Proposed Future Research, if applicable

- This work is fundamental to support several other projects, so base support is important
- Everything hinges on the ability to use the data generated from this project to support innovations in wind farm design. The potential is there and time will tell.
- Future funding in this area is not justified
- NREL field tests of 1.5 MW turbine at full scale very important
- SWIFT testing with multiple wakes very important
- Planned future research looks appropriate. Wake steering may have limited use in existing wind farms, but fully understanding turbine-wake interactions will allow for better wind turbine layout within a proposed wind farm.

Question 7: Project Strengths

- The V&V work is critically important for many other projects. This capability needs appropriate levels of support.
- Stakeholder input and planning workshops
- Capitalized on DOE unique lab resources
- Capitalizes on international research collaboration and relationships built through IEA (International Energy Agency) projects and other international collaborations
- Acknowledgement that rotor wakes have a detrimental effect on downwind turbine energy production, and developing methods and processes to measure and quantify the effect of said wakes

Question 8: Project Weaknesses

- High cost science experiment with little practical application
- None identified

Question 9: Recommendations

- Redirect efforts to current industry priorities such as life extension
- As mentioned above, focus on wake-steering methods and control may have limited applications. Within our 5GW (nameplate) fleet, we have one, 150MW plant, laid out in a 10X10 matrix, that may benefit from the concept. However, we have many wind farms where there is downwind turbine interaction with wakes, and understanding the level of impact on energy generation may help us quantify the effect. Also understanding wake behavior will benefit us as we develop and install new projects.

Comments made by reviewers during the evaluation of this project (PRID 222)
• Integrate work with OSW (offshore wind) program

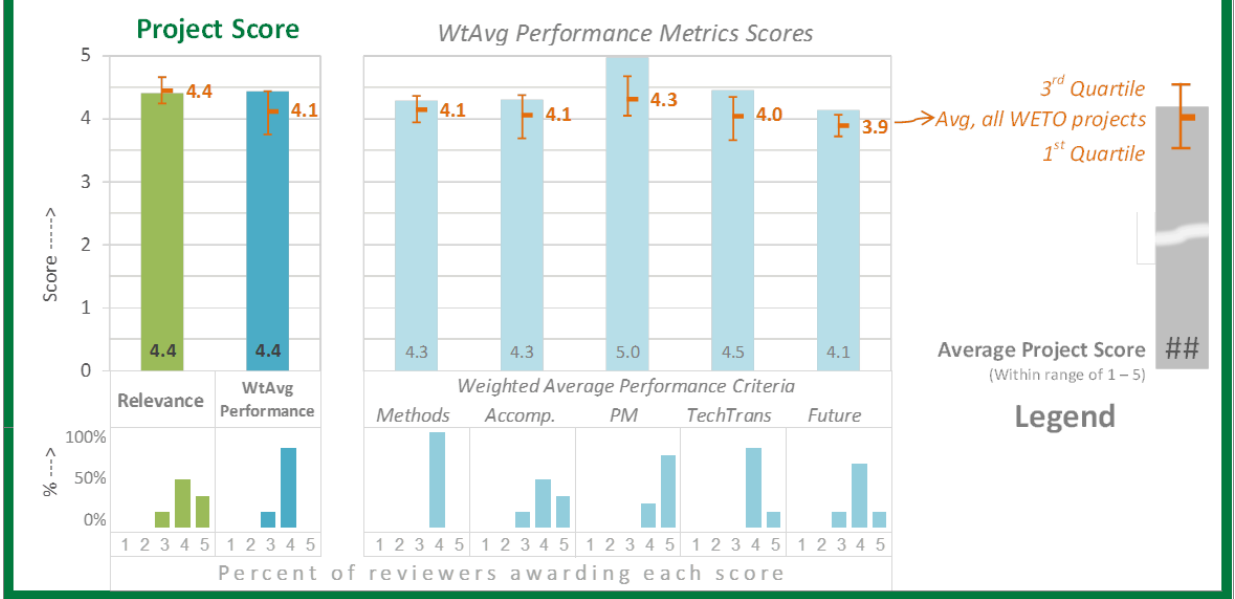
7.3.2 Distributed Wind Research, Development, and Testing

DOE Wind Energy Technologies Office 2017 Peer Review Project:

Distributed Wind Research, Development, and Testing

Principal Investigator	Ian Baring-Gould, National Renewable Energy Laboratory		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Distributed Wind Research, Development, and Testing		
FY 2014-2016 Funding	DOE	$ 3.5 M	100%
	Cost Share		
	Total	**$ 3.5 M**	**100%**

Peer Review ID# 209



Comments made by reviewers during the evaluation of this project (PRID 209)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- There is significant opportunity to grow U.S. business in this area with U.S. and foreign sales making this effort noteworthy
- This could amount to about 2.5% of total in 2050
- Could be up to 3 million DW (distributed wind) units globally by 2050
- This project is aligned with the DOE goals, however, it is difficult to assess the actual value that this program brings to the development of wind energy in general
- Energy supply moving to distributed generation/microgrid model, important area for U.S. jobs and exports for global development
- NREL deployment model confirmed that distributed wind has at least half the potential of off-shore wind (including substantial opportunities in southeastern U.S. states), but even if the distributed wind market sees flat or low growth the negative risks still justify increased levels of DOE investment
- Standards and certification is a very relevant goal for this small turbine industry
- Cost of energy is primary challenge this small industry faces. Competitive pressure from low cost solar for residential applications and built environment is key.
- DW faces similar challenges as does utility-size wind; determination of wind resource and advances in hardware cost reduction. The DW industry is too small to organically develop solutions to these challenges. Include pressure from Chinese-backed PV (photovoltaic) solar, and it is obvious that the DW industry must have DOE support to make incremental progress in further product development/testing/certification as well as rapid wind resource estimation.
- If DOE has Distributed Wind as a part of its Wind Vision for a good reason then this program appears to be an essential and successful part of creating a more robust and credible industry

Question 2: Methods and Approach

- The broad suite of projects (testing, standards, certification, market reports, etc.) seem to cover the right topics
- This project seems focused on market analysis and reports. It is difficult to see what this program can do to really expand the build out of distributed wind.
- Important focus on consumer protection to "keep froth down", siting as a key barrier, and reducing large soft costs
- Continued efforts needed on reducing resource assessment costs and improving power production predictions focused on distributed wind applications in particular
- Assistance with certification testing and technology improvements is very efficient approach
- The methods and approach appear reasonable to meet program goals. The Core Principals of the program and Programmatic Approach to problem identification appear to be optimum criteria to ensure success of the project.

Question 3: Technical Accomplishments and Progress

- Impressive amount of work conducted relative to funds invested, however slower progress on soft cost reduction steps and other key industry priorities is disappointing
- The concept of applying resources such that there is incremental progress across a broad front rather than targeted progress in a narrow field, appears to be a solid philosophy

Question 4: Project Management

- Seems solid
- Efficient use of limited funds; management of sector has avoided major black eyes that could negatively impact overall wind industry and DOE
- The program manager has been very creative in the design and execution of this program. His challenge is working with weak partners in a difficult competitive environment.
- Project management appears to be very good

Question 5: Research Integration, Collaboration, and Technology Transfer

- R&D efforts and agenda are coordinated with the DWEA (Distributed Wind Energy Association) and other industry stakeholders
- Close industry collaboration including formal request for input to identify focus areas

Comments made by reviewers during the evaluation of this project (PRID 209)

- Limited dissemination of useful reports including market assessment and many others noted in accomplishments, but impressive considering scale of budget
- Collaboration and technology transfer appears very good, in reviewing the list of organizations participating in the effort

Question 6: Proposed Future Research, if applicable

- Similar work areas seem to be in the plan
- Increased DOE investments in this area are critical for ensuring quality and positive public image of wind energy, retaining and increasing U.S. manufacturing jobs, and strengthening local grids
- Additional work needed on additive manufacturing specific to small and micro wind turbines including producing parts close to installations and tooling
- Improved integration of distributed wind into many DOE-funded projects is needed, e.g. FAST, O&M (operations and maintenance), NDT (non-destructive testing), soft costs
- I fully support proposed research and collaboration toward optimizing installation costs by proposing a workshop for DW installers. That effort, possibly in conjunction with a CIP (Competitiveness Improvement Project) program for foundation and tower design, could make a significant impact on cost of energy.

Question 7: Project Strengths

- Provides a "homeroom" for this industry to advance its capabilities and become more competitive
- Important to keep “adults in the room” and provide guidance, monitoring to aid distributed wind industry members to mature into successful leaders, avoiding repeated false starts in wrong directions
- Broad-brush strokes in determining greatest challenges and highest impacts to greater adoption of DW

Question 8: Project Weaknesses

- It's not clear if DWEA performs market reports or how it may supports its own industry. Is DOE performing some work that DWEA should be doing?
- Very limited budget has stretched resources and slowed progress, with the United States losing historical global leadership in sector
- Challenged by residential PV
- None identified

Question 9: Recommendations

- Accelerate plans to develop comprehensive distributed wind "vision" incorporating lessons learned from offshore wind vision process and SMART (Sustainable Manufacturing, Advanced Research and Technology) Wind Roadmap (action plan for manufacturing)
- Reconsider expanding work on distributed grid integration, ongoing needs not addressed by other EERE programs
- Annual market study critical but could be better integrated with LBNL annual market report
- Improved site assessment tools, installer safety trainings, QA and QC are important next steps beyond certification to build consumer confidence
- As mentioned above, target efforts toward; rapid wind resource assessment, CIP for foundations and towers

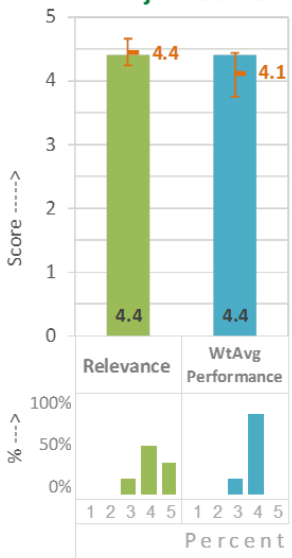
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Competitive Improvement Project

Principal Investigator	Ian Baring-Gould, National Renewable Energy Laboratory		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Distributed Wind Research, Development, and Testing		
FY 2014-2016 Funding	DOE	$ 4.4 M	69%
	Cost Share	$ 2.0 M	31%
	Total	**$ 6.4 M**	**100%**

Peer Review ID# 231

Project Score



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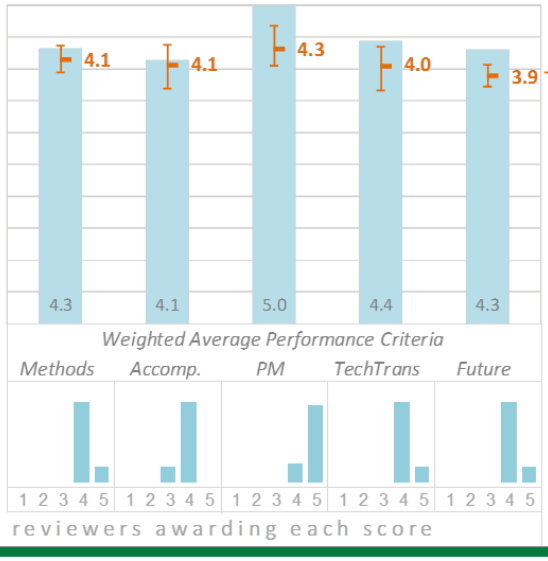
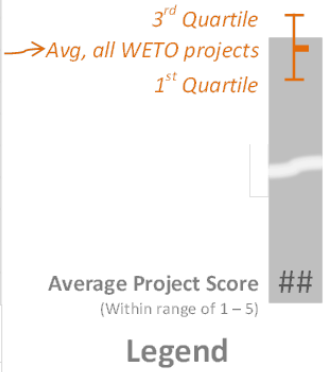
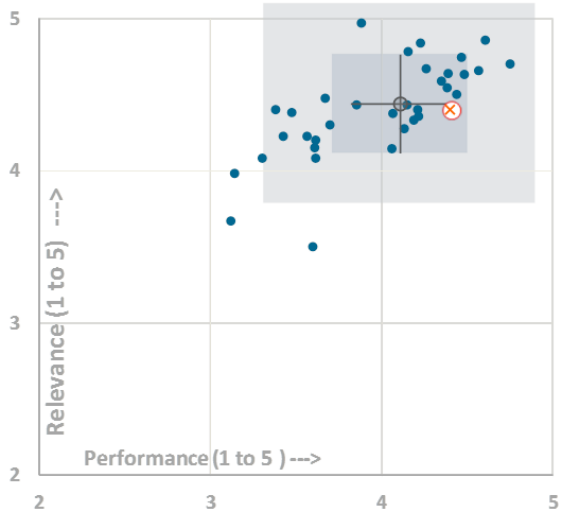
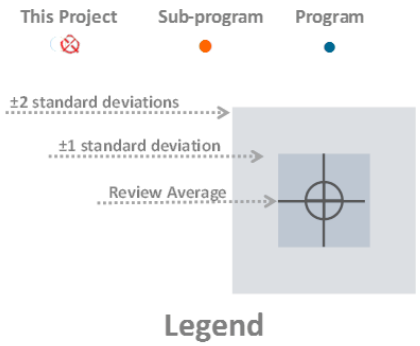




Comparative Scoring





Comments made by reviewers during the evaluation of this project (PRID 231)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Industry greatly appreciates DOE investment in FOAs [Funding Opportunity Announcements] to improve capabilities to help them compete with solar
- Project helps move toward turbine certification
- Project is aligned with overall DOE objectives in terms of improving turbine performance to overcome market penetration issues
- This project has a strong approach in that the cost sharing model demonstrates higher value as the sponsors have to have some skin in the game
- Critical funding for undercapitalized U.S. OEMs (original equipment manufacturers) to improve products, create jobs, and increase exports
- Very thoughtful, well-conceived attention to how to support and encourage an industry with certification and innovation development that would not otherwise occur
- The small and medium scale turbine industry must first improve reliability and second reduce LCOE (levelized cost of energy). This program accelerates the latter. With pressure from PV (photovoltaics) lowering costs the residential market appears to be a greater challenge than ever before.
- Please see the evaluation for Project #209, the same comments apply to this project
- If DOE has Distributed Wind as a part of its Wind Vision for a good reason then the CIP (Competitive Improvement Project) appears to be an essential part of creating a more robust and credible industry

Question 2: Methods and Approach

- CIP "grant" process with cost sharing seems like an appropriate framework
- The CIP logic of supporting high cost share work with a variety of vendors is good, as this takes some of the load off of DOE and keeps the vendors well entrenched in the process
- Competitive cost-shared open solicitations to allow innovative concepts, with early discontinuation when warranted
- Direct financial assistance can be very effective with companies that have the engineering capacity to execute a comprehensive design and product development process. Those that lack these essential competencies may not benefit as much. In the latter cases engineering assistance is recommended to reach the necessary minimum technical design process requirements.
- Recommend meeting IEC (International Electrotechnical Commission) standards for all design development projects
- Please see the evaluation for Project #209, the same comments apply to this project

Question 3: Technical Accomplishments and Progress

- There are some good examples of successes in this program
- 16 awards were made but results were shown for two projects, both with good results. The ROI (return on investment) for the full amount of DOE funding is not clear.
- Impressive results, but limited number of companies have benefited from this program to date
- Impressive success, eg, 90% blade mfg cost reduction at Pika, 15% energy capture increase on NPS (Northern Power Systems) turbines with increased blade length
- New injection molding tooling for small blades, updated blade design and tooling for 100 KW stall control turbines and similar is very effective assistance for financially strapped small companies
- Please see the evaluation for Project #209, the same comments apply to this project. In addition to those comments, the development of an injection molding machine for Pika Energy is exactly what this industry needs to realize product improvement and cost reduction.

Question 4: Project Management

- Seems solid
- Work completed on time and within budget
- Close contract monitoring and technical assistance have aided resource-constrained company participants
- The creativity, enthusiasm and talent that the program manager brings to this project is evident in the presentation and industry support for the program
- Please see the evaluation for Project #209, the same comments apply to this project

Comments made by reviewers during the evaluation of this project (PRID 231)

Question 5: Research Integration, Collaboration, and Technology Transfer

- The collaborator lists seems to be at the right level
- The project is well integrated with industry and, specifically, turbine manufacturers and distributors
- Flexible vehicle responsive to industry priorities, involvement of numerous OEMs
- Publication of certified power curves has been transformative for distributed wind sector
- Direct collaboration with the industry is key
- Please see the evaluation of Project #209, the same comments apply to this project

Question 6: Proposed Future Research, if applicable

- Similar scope of efforts planned for future years
- Future steps are not clear
- Perhaps this program needs to take a step back and, with participation from the OEMs, address specific goals that may help this sector become a more viable option when compared against solar
- Substantially increased funding for this program, including "Phase 0" assistance for qualified applicants, is critical to health and maturation of distributed wind sector
- Perhaps targeted research in foundation and tower cost reductions would provide significant incremental reduction in cost of energy

Question 7: Project Strengths

- The small amount of DOE funds in this program seem to be generating a decent return on investment
- The investments provided so far seem to be lowering costs
- Major improvements achieved with relatively small investment, with considerable low hanging fruit remaining
- High level of industry cost share confirms importance
- Please see the evaluation of Project #209, the same comments apply to this project

Question 8: Project Weaknesses

- Current level of funding not adequate for full damage control, especially considering aging fleet of 90,000 distributed wind turbines installed in the U.S. over the past 15 years, many that have not been properly maintained
- None identified

Question 9: Recommendations

- More frequent application cycles, with ongoing acceptance of applications, and expanded areas of focus needed to better meet evolving industry needs
- Adjust programmatic metric to reflect success in certification progress considering the high number of turbine models tested/discontinued which has prevented widespread sales of products not ready for consumer deployment
- Please see the evaluation of Project #209, the same comments apply to this project

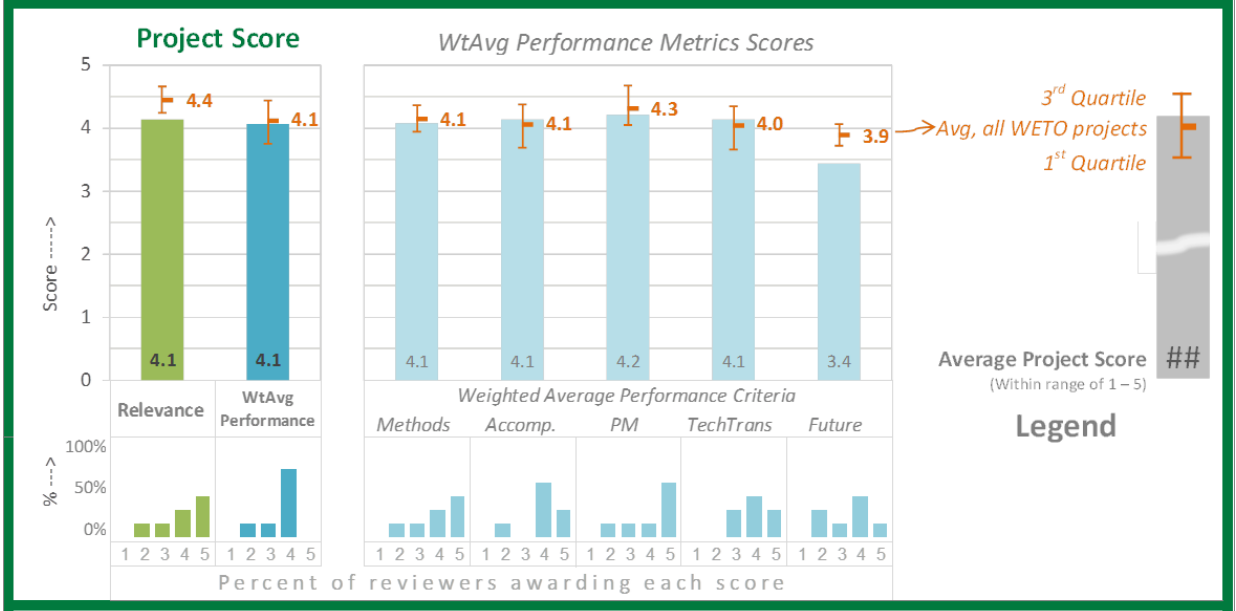
7.3.3 Innovation, Manufacturing, Reliability, and Testing

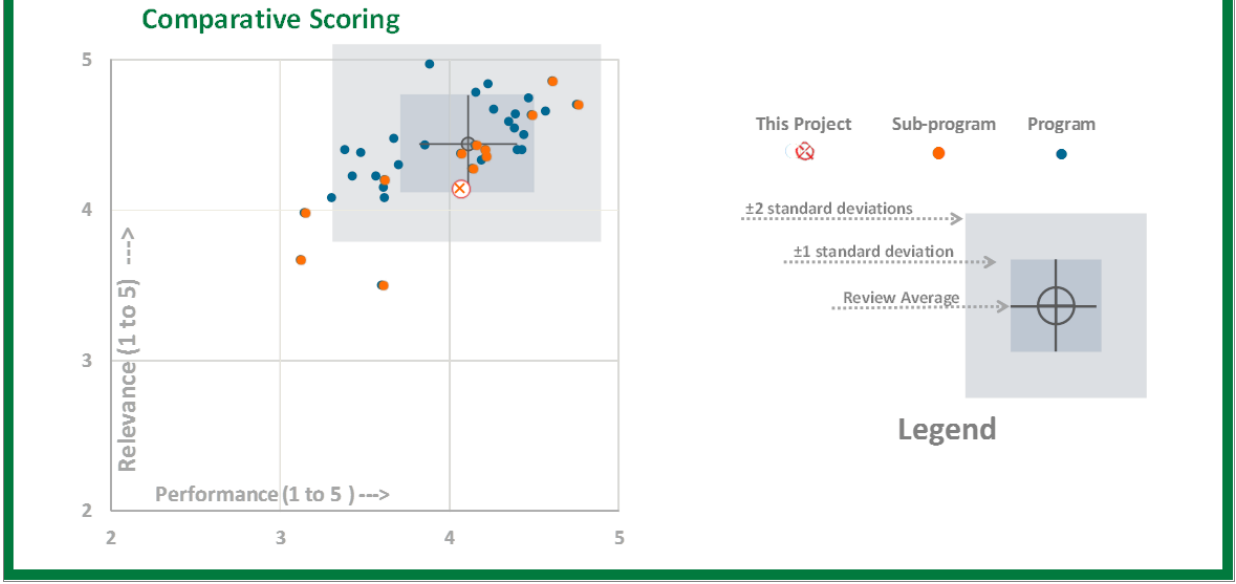
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Innovative Drivetrain Concepts FOA [Funding Opportunity Announcement] Phase II: Next Generation Drivetrain

Principal Investigator	Jonathan Keller, National Renewable Energy Laboratory		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Innovation, Manufacturing, Reliability, and Testing		
FY 2014-2016 Funding	DOE	$ 1.6 M	68%
	Cost Share	$ 0.7 M	32%
	Total	**$ 2.3 M**	**100%**

Peer Review ID# 74





Comments made by reviewers during the evaluation of this project (PRID 74)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- There is an industry need for a next generation drivetrain due to too many gearbox failures, so project well aligned with industry needs
- Goals of lighter, less expensive solution, lowered LCOE (levelized cost of energy) (up to 13%), achieved so far (based on test estimates)
- This is exactly the type of testing the lab should focus on given the high potential ROI (return on investment) of improved drive train reliability. Reduced O&M (operations and maintenance) costs and gear box replacement is an area that can potentially have very positive impact on industry.
- Questionable whether results will be useful given the state of the industry
- The evolution of equipment scale has increased the cost and risks around significant architectural innovation
- The innovations in the new drivetrain are ahead of current industry practice. Journal bearings have not been used but have been recommended by experts as a solution to constant roller element bearing failures. Planet drives with more than three planets do not load share well so torque density improvements are limited by adequate load sharing strategy. Using flex pins to accomplish load sharing as well as journal bearings needs to be demonstrated in transparent laboratory grade test to be compelling. Very relevant test.
- Goal of FOA was to design next generation drive train and demonstrate with power condition system included as total electrical energy system delivery
- Journal bearing durability testing very valuable for start/stop conditions. Testing Off design operating conditions is the real challenge and likely the source of some types of failures.
- Reduced losses and hence reduced heating in Silicon/silicon carbide hybrid switches may address failures in field. SiC devices are much more robust but have not been available in the current/voltage range needed for MW scale turbines. Demonstrating this hybrid technology could turn the industry towards new technology and open up medium voltage architectures.
- Increased efficiency from switches is non-trivial improvement. Will likely translate into lower failure rates in inverters that power cycle as wind turbines typically do.
- Interesting combination of areas of focus; development of a medium-speed drivetrain and research into power electronics. Gearbox and power converter corrective maintenance account for the majority of our O&M budget expenditures. From an end user's perspective, eliminating the gearbox altogether is optimum, converting to direct-drive technology. However, current DD (direct-drive) technology is too expensive, and thus, a medium-speed gearbox solution may be financially viable.

Question 2: Methods and Approach

- Good results to date through phase II
- Good progression through failure modes identification, analysis of mitigations, design, and testing
- Analytical results are very clear and provide a clear result for the program
- Good to see that a variety of Low Voltage Ride-Through (LVRT), High Voltage Ride Through (HVRT), and frequency deviation events were tested, however results and implications are unclear
- Technical approach uses a public domain design to demonstrate innovative design improvements that could be used in many different gearbox/drivetrain architectures
- Laboratory tests of load sharing, efficiency, and robustness during low lubrication start/stop cycling is exactly what is needed to prove robustness in representative operating conditions
- The methods and approach look similar to those of the Drivetrain Reliability project, and thus are likely to result in a successful outcome

Question 3: Technical Accomplishments and Progress

- Progress has been good to date and the need for this R&D continues
- Load sharing and switching results are promising
- Good that multiple innovations were tested, but would like to see more progress for this scale of funding
- Remarkable accomplishments demonstrating long standing speculation about the ability of flex pins to share load. This project quantified this load sharing ability indisputably and established new load sharing factors for standards.

Comments made by reviewers during the evaluation of this project (PRID 74)

- Increased efficiency was demonstrated, which could only have been done in a high precision laboratory test due to the high accuracy requirements of measuring efficiency
- Start/stop load cycling is likely the cause of many failures. Finalizing this test removes the final questions about using journal bearings in wind turbines.
- Interesting combination of gearbox and power electronics improvement work. Interesting work on planet bearing flex pins and journal bearings.

Question 4: Project Management

- No concerns here
- Significant delays
- Project budget shows good value and ROI for the overall program
- Milestones delayed
- Very effective leveraging of reliability collaborative accomplishments and industry network
- Extensive industry cost sharing
- Excellent use of prior program drivetrain hardware (1.5 MW medium speed drive)
- Excellent program management, as was to be expected from this PI (Principal Investigator) and the work done on the drivetrain reliability improvement program

Question 5: Research Integration, Collaboration, and Technology Transfer

- A solid collaborative team was assembled for the FOA project
- Strong mix of public and private entities
- Impressive collaboration, cost-sharing and publications, but involving distributed wind stakeholders would help improve relevancy to smaller wind turbines and projects
- Collaboration minimal but well focused
- Highest integrity was required due to many industry observers and investments
- Industry collaborators were key to success and will quickly transfer the experience to field operation
- Industry and research partner teams look adequate, perhaps more end user feedback and partnerships would have been appropriate

Question 6: Proposed Future Research, if applicable

- Future research plan is not well-developed yet
- Additional field testing and development of advanced controllers is unclear
- Reliability and O&M cost reductions important areas for focus, but research needs to keep pace with evolving industry needs including priorities of distributed wind sector
- This was a great program but final proof of benefits need field testing. It would very useful to have enough funding to place this unit in the field.
- Focus on medium-speed generator is probably appropriate at this time

Question 7: Project Strengths

- Work is well-aligned with industry needs and could results in significant O&M cost savings
- This project seemed to have really progressed our understanding of gearbox failures and methods to improve performance
- Advances technical knowledge that reduces risk essential to industry efforts to lower wind LCOE
- Capitalized on unique test capabilities at NREL and Drivetrain Reliability Collaborative network. No other organization in the world could have done this.
- Acknowledgement that planet load sharing is critical to success and that current bearing technologies are not optimized. Work on journal bearings is interesting and may be a game-changing technological breakthrough. I fully support parallel work in power electronics as this is a big driver in corrective maintenance costs.
- See comments for phase 1 -- # 182

Comments made by reviewers during the evaluation of this project (PRID 74)

Question 8: Project Weaknesses

- Still need more R&D to demonstrate success of tower
- As was stated for the sister project, I would think that this program should receive additional financial support from industry
- Not enough funding to finalize validation in field demonstration
- None identified

Question 9: Recommendations

- Project R&D should continue
- If funding becomes available, continue on current trajectory

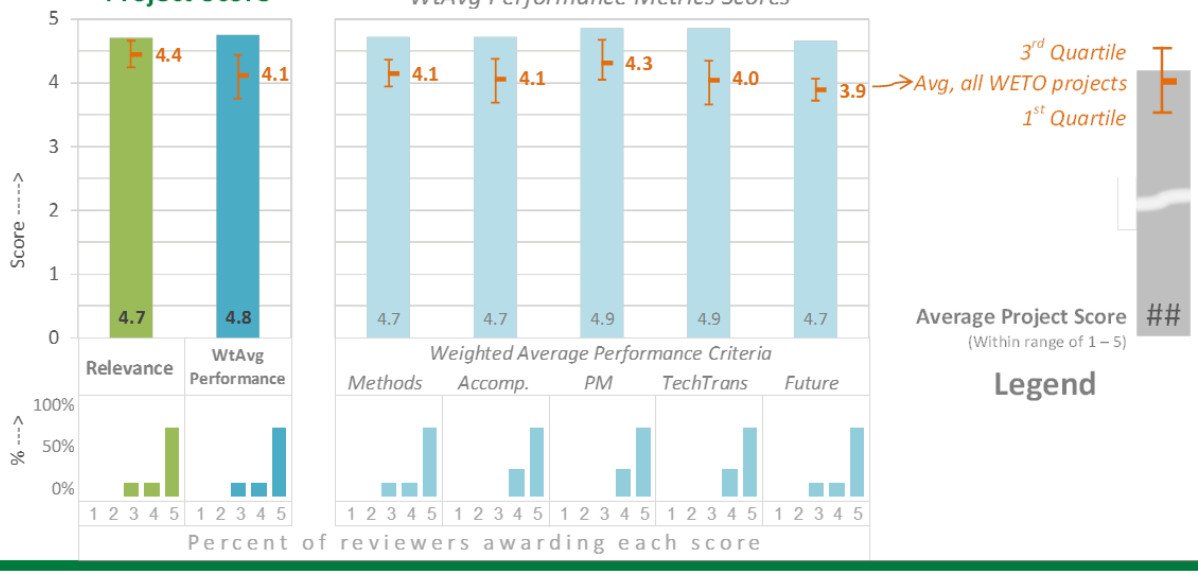
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Wind Standards Development

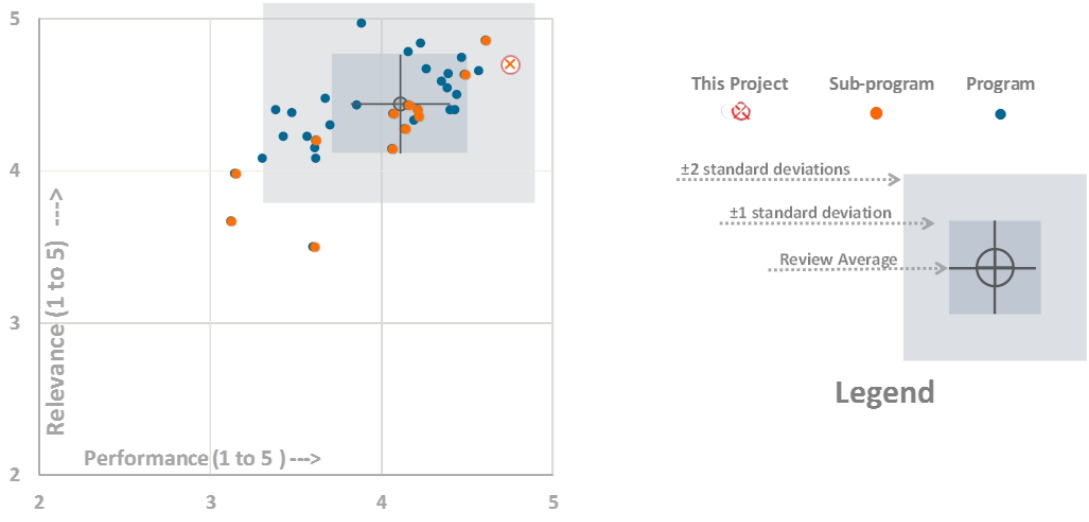
Principal Investigator	Jeroen VanDam, National Renewable Energy Laboratory		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Innovation, Manufacturing, Reliability, and Testing		
FY 2014-2016 Funding	DOE	$ 1.4 M	100%
	Cost Share		
	Total	**$ 1.4 M**	**100%**

Peer Review ID# 130

Project Score



Comparative Scoring



Comments made by reviewers during the evaluation of this project (PRID 130)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- This standard development project is important to ensure safety and reliability of systems and lowering risk
- Standards help level the playing field for industry including globally which is a very important aspect
- Provides confidence to financial firms that invest in wind energy
- The development of effective standards is key to the DOE's overall objectives, so the effort included in this project is well in line with the DOE goals
- However, to the extent that the DOE is advising rather than leading the effort to develop new standards, the value provided by this specific program is somewhat less clear. This is why I've marked the score down from a 5 to 3.5.
- Provides U.S. and global leadership engaging industry, ensuring conformity and predictability. This work is particularly important for consumer protection and access to export markets for the small and micro-wind turbine sector.
- Pushing a young industry with much promise but with significant technical challenges and cost pressure requires this kind of leadership which it is unable to deliver itself
- Very modest cost for value delivered
- Standards are a cross cutting role for the DOE program. They are a mechanism for international experts to reach consensus on important design requirements and the implied design process used by all turbine designers. Further, it demands the best industry experts collaborate on acceptable methods of satisfying the design requirements. The standards supply a common set of rules that enable the industry to conduct business internationally. It also provides a foundational design basis, common technical vocabulary. From an R&D perspective the technical collaboration reveals deficiencies in turbine and wind plant design methods that constrain industry's evolution. These are the most relevant research topics which focus the DOE program. Topics ranging from consistent testing methods for performance, loads and blade structure to onshore and offshore design conditions and methods for establishing design life. International collaborations are incubated by U.S. experts participating in the standards meeting. When U.S. experts apply their DOE-funded research results to standards it is the most effective form of tech transfer and most credible source of R&D requirements.
- The impact is broad, affecting all stakeholders
- DOE research has impacted every international standard and had a very direct impact on advancing the design process that has led to wind system reductions in LCOE (levelized cost of energy)
- Perhaps the most effective technology transfer strategy available. Also stimulated international collaborations that advanced the industry (Aerodynamics testing and R&D, advanced testing techniques, design process and technical requirements)
- DOE's influence is imbedded in every IEC (International Electrotechnical Commission) wind standard and is a lasting testimony to its contributions to the wind industry's success
- IEA (International Energy Agency) research programs are very often the incubator of international collaborative research that ends up in the standards. Once it's in the standards research becomes design foundations for the industry. Any industry adoption of new technical results will inevitably be imbedded in the standards.
- Review of relative importance of design standards and their benefit to the industry. Probably the single most important effort within DOE's scope. If not for design and testing standards, the financial community would be skeptical of financing wind projects. Incubator for research needs. Builds valuable relationships. Only DOE can support this effort.

Question 2: Methods and Approach

- This project is somewhat difficult to score on approach as it involves simply the identification and participation on relevant standards committees. The standards that have been identified and supported represent a good set of applicable standards.
- Industry-wide consensus process ensures high quality products while not stifling innovation
- All data shared, leveraging knowledge from rest of program
- Prioritized strategic approach to funding excellent

Comments made by reviewers during the evaluation of this project (PRID 130)

- Assuming leadership positions has helped DOE leverage influence internationally for the benefit of the U.S. industry and stakeholders
- Leading U.S. industry engagement at the international level has allowed the United States to significantly influence and balance other international agendas
- DOE support for developing international standards and certification is by far the most effective way to solidify R&D results into industry practice. They are the essential building blocks of a successful industry.
- IEA collaborative research is very effective incubator for standards
- Researchers who participate are informed of international norms and able to recognize research opportunities. Conversely researchers are able to inform and influence international colleagues and set new design norms.
- Exceptional work on methods and approach. Working cross-globally is one of the most difficult tasks imaginable.

Question 3: Technical Accomplishments and Progress

- Work appears appropriate for this type of standards development process
- Good progress has been made on summit meetings, etc. to identify gaps and further work required
- Impressive progress for relatively low investment
- The DOE-funded experts have been leaders in international standards as well leading multiple committees
- DOE experts are critical thought leaders in all of the standards, often initiating new standards that benefit the industry
- The U.S. experts have played a leading role in including broad end user stakeholders into the standards process, giving owner/operators, financial members, insurance a direct voice in technical requirements
- End user participation has made the standards more relevant and valuable. Some standards are used as the basis for legal agreements and have been influential in resolving commercial issues.
- The ability to gain cross-global concurrence on standards is close to a miracle, I speak from experience. The amount of published material validates the score.

Question 4: Project Management

- While it's difficult to score this effort consistent with other projects, I think that the work has been managed well and that there is a good ROI (return on investment) provided for the funds that the DOE has allocated
- Nice to see such thorough and clear documentation of completed milestones
- Prioritized management of a small budget has enabled DOE to leverage industry participation into a broad influential, coherent strategy that has benefitted the U.S. industry
- NREL leadership has been critical in U.S. participation internationally
- Project management is exceptional

Question 5: Research Integration, Collaboration, and Technology Transfer

- There is plenty of international and U.S. collaboration - it naturally comes with the process
- The collaboration here comes from the contact that is created via committee participation, so the score of 4.5 is a bit unfair, but it compensates for the lower scores in 2 of the other areas that worked the other way
- Work has served as an important incubator for design innovation
- Although cost sharing not tracked, 1:10 leverage of industry contributions confirms importance of work
- As stated earlier, there is no other mechanism that is so effective at integrating industry needs into R&D goals
- There is no other approach that more effectively forces collaboration on difficult technical issues
- There is no other approach that more efficiently transfers technology to industry
- Collaboration and integration are truly world-class, by the nature of the project itself. Probably the highest level of collaboration in the DOE program portfolio.

Comments made by reviewers during the evaluation of this project (PRID 130)

Question 6: Proposed Future Research, if applicable

- Continue process and involvement
- Continue with the same. Nothing really to scope here.
- This critical work for all sectors of the wind industry, especially small and micro wind turbines, likely would not happen without U.S. DOE funding, and enables financial confidence in products
- Consider increasing future funding to accelerate progress for distributed wind sector, which may not be ranked as top priority by stakeholders involved but is critically important for credibility of entire industry
- Consistent participation is so important for implementing the U.S. strategy. NREL's and DOE's leadership has been consistent and must remain consistent for it to continue to be effective. The U.S. (and international) industry depends on this leadership.
- Continue the exceptional work

Question 7: Project Strengths

- Supporting industry's ability to participate with level playing field and global conformity
- The U.S. Wind Energy Standards Summit appears to be worthy endeavor with DOE leadership
- The standards are very important and, in some areas (e.g., offshore), very weak compared to where we need to be. It is helpful to know that the DOE has a consistent involvement in the process of progressing international standards.
- Creates level playing field for U.S. industry to compete globally
- U.S. leadership in the international role builds confidence and certainty in the process
- Industry leadership
- Broad stakeholder participation
- Appropriate R&D agenda integration
- The ability to gain cross global acceptance of processes and procedures

Question 8: Project Weaknesses

- It seems that AWEA (American Wind Energy Association) should take this seriously and create a subcommittee led by industry representatives to lead the effort
- I think that it is asking the DOE to do too much to carry the ball as much as it has on standards efforts. The industry, through AWEA, needs to do more and to provide better funding for this process.
- Undercapitalized small and micro wind OEMs (original equipment manufacturers) have not all been able to effectively participate
- None
- None identified

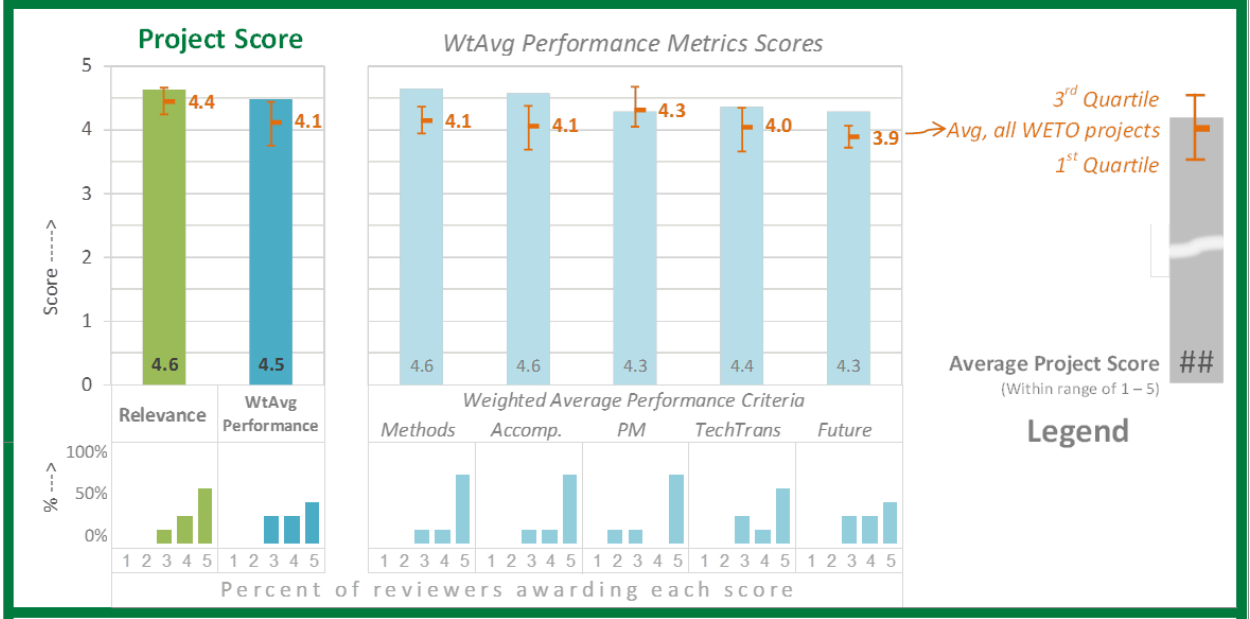
Question 9: Recommendations

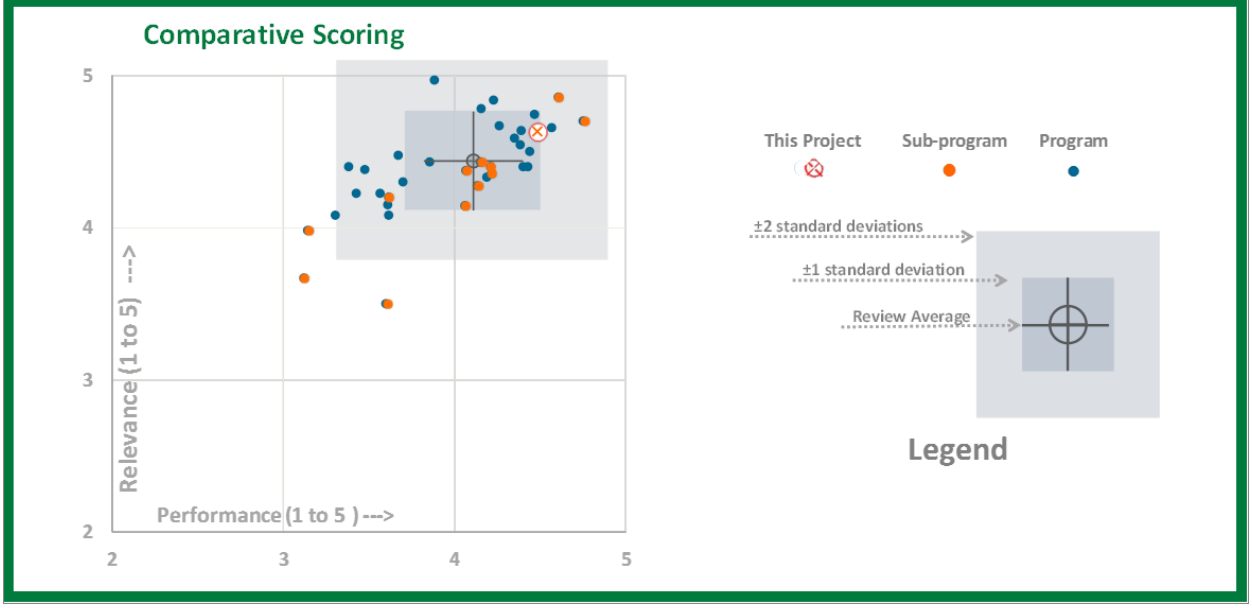
- Ensure near-term scope includes work identified as high priority by distributed wind sector, including a gap analysis for certification requirements for various global markets and consumer education on importance of certified products
- Stay the course
- Continue the exceptional effort

DOE Wind Energy Technologies Office 2017 Peer Review Project:

Drivetrain Reliability (Collaboratives, Monitoring, and O&M [operations and maintenance])

Principal Investigator	Jonathan Keller, National Renewable Energy Laboratory			
Program	Wind Resource Characterization and Technology RD&T			
Sub-Program	Innovation, Manufacturing, Reliability, and Testing			
FY 2014-2016 Funding	DOE	$ 5.6 M	82%	
	Cost Share	$ 1.2 M	18%	
	Total	**$ 6.8 M**	**100%**	Peer Review ID# 182





Comments made by reviewers during the evaluation of this project (PRID 182)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Focuses on failures that are not well understood by industry, which is appropriate
- Keeping 2.5MW dynamometer busy at NREL, which is a good sign
- Also focused on next generation component innovations which is important
- Working to improve estimates of useful lifetime before repairs or replacement needed, which is what industry needs
- This is exactly the type of testing the lab should focus on given the high potential ROI (return on investment) of improved drivetrain reliability. Reduced O&M costs and gear box replacement is an area that can potentially have very positive impact on industry.
- Little current relevance to distributed wind sector, but scope could be adjusted so efforts could be more applicable for smaller-scale wind projects
- Drivetrain components are the leading indicators of insufficient design standards. The cost of wind is higher than it could be due to industry-wide drivetrain reliability issues. This program supports improvement on both fronts.
- White etch cracking plagues all wind turbine gearbox designs and appears to be unique to wind application. Understanding the root cause has benefited reliability dramatically. Why are white etching failures generally unique to wind energy application?
- Demonstrating and validating models of bearing load sharing improvement with laboratory grade experiments could only be done by DOE laboratories. It has impacted gearbox design process forever. Is this a new design practice under development?
- New testing techniques have been developed that industry would have been challenged to develop
- Has the WEC (white-etch cracking) design practice been included into design standards?
- This project capitalized on DOE lab unique capabilities
- This research is directly applicable to immediate needs we have with our operational fleet. Gearbox maintenance costs are by far the largest percentage of preventative and corrective maintenance costs. As we extend the operating life of these machines past their 20 year design life, it is even more critical we implement design improvements into the next generation of gearboxes that will replace the existing fleet. We fully support the inclusion of the mainshaft bearing(s) in the research.
- Good project with clear relevance, but unclear the extent to which DOE's wind tech program balances the need for drivetrain reliability research with the important need to advance direct drive technology

Question 2: Methods and Approach

- Excellent capabilities and testing environment
- Able to recreate white-etch cracking on the bench
- Able to test new gearbox design
- Strong progression through analysis of various failure modes, analysis and testing
- Research plan to predict bearing remaining useful life through fusion of physics and data-based methods complete, but could have broader scope
- Annual reliability workshops and seminar to define R&D needs and exchange results with industry collaborative
- Slide 6: Database is tremendously valuable to industry but only a neutral party would be trusted by industry. Please elaborate on data base web portal.
- Has WEC damage model been validated in non-laboratory failures, i.e. field failures?
- Slide 5: Have models, design data and dyno test data been made public so they can be used for baseline modeling and design process improvements?
- Slide 6: Is it still a mystery about what is unique in wind application that challenges HSS (high-speed shaft) bearings. It would appear that the HSS bearing configuration is very well established and well isolated from the non-torque wind loading. Acceleration / deceleration?
- Engaging independent experts and academic researchers as well as industry experts and end user stakeholders is excellent approach to elevating the knowledge base and focusing academic research
- Very impressive list of partners and industry engagement across the entire value chain! Understand the list of partners and attendees to the workshops is long but could you offer a pie chart distribution of stakeholder types who have been consistently engaged?
- We are a 'Charter Member' of the GRC (Gearbox Reliability Collaborative) and fully support the methods, approach, and direction of the research

Comments made by reviewers during the evaluation of this project (PRID 182)

Question 3: Technical Accomplishments and Progress

- Excellent progress made over last couple years
- Results are of great interest to industry
- Strong results on failure mode identification
- Impressive attendance at events, but unclear if/how findings have led to substantial O&M cost reductions to date
- It is clear that this project has dramatically impacted wind turbine design process and hence the standards. Describe the impact the GRC & DRC (Drivetrain Reliability Collaborative) have had on IEC (International Electrotechnical Commission) 61400-4. How has it changed the design process?
- Gearbox reliability has improved dramatically as a result of industry engagement in this project. Explaining how it has changed the industry's design process would be useful.
- Why has it been important for the DOE/NREL to do this work? E.g. would industry have done this basic work and influenced the design process if DOE/NREL had not stepped up? I believe industry would not have been able to develop transparent remedies without DOE leading this work.
- Is ISO (International Organization for Standardization) TC (Technical Committee) 60 still resisting IEC TC88 WG4 (Working Group 4) drafting of wind turbine bearing requirement standards?
- What are the operating conditions that are likely to be causing WEC? Don't know yet.
- Like many others, we suffer the financial effects of WEC in our gearbox bearings. We fully support the direction of research and fully support the conclusions that come from these efforts.

Question 4: Project Management

- Seems solid, no concerns
- Some delays in program
- Schedule delays, carryover funds and rebalancing
- Difficult management of so many different industry partners, all with their own proprietary notions of the root cause. This project has accomplished the impossible by conducting transparent analysis, lab testing and field experiments. This is a legacy program that DOE can take credit for. No other organization could have done this with credibility, transparency, objectivity.
- Exceptional program management. We work regularly with Jon through the GRC efforts and fully support the direction of the program.

Question 5: Research Integration, Collaboration, and Technology Transfer

- This is work of interest to industry. 100+ attendees.
- Stakeholders are engaged via the collaborative; some CRADA's (cooperative research and development agreements)
- Publications popular
- Strong mix of public and private entities
- Excellent distribution of information
- Impressive collaboration and publications including book chapter on wind turbine prognostics and health management, but involving distributed wind stakeholders would help improve relevancy to smaller wind turbines and projects
- I have personally attended most of the annual meetings of the GRC/DRC. It has delivered leadership, guidance and results that have provided tremendous value to the industry. The growth in attendance of the meetings speaks for itself. The DRC is making technical advancements critical to the improvement of reliability and lowering of costs that the industry could not have achieved on its own. The global industry as well has come to rely on the leading edge research being pursued by the collaborative.
- The very nature of this collaborative with annual plenary meetings and frequent topical experts meetings with world class researchers and tribologists created immeasurable value for the industry and instant tech transfer. Perhaps the most efficient and timely tech transfer possible. It also allowed industry to impact the direction of the program in real time.
- Exceptional coordination with end users, industry, and other Labs
- Unclear if the needs of the offshore wind industry have been incorporated into this research program

Comments made by reviewers during the evaluation of this project (PRID 182)

Question 6: Proposed Future Research, if applicable

- All topics are well aligned with stakeholder needs
- Work on mitigation strategies is key. Understanding the cause of early gearbox failure is not valued until this information improves design or life extension via O&M. This leads to the next project review (74).
- Reliability collaborative, monitoring and O&M efforts are valuable to maintain and expand, but would like to see higher speed progress for this scale of funding
- The field tests and validation efforts are excellent and absolutely required
- MUST follow the white etch cracking issue all the way to end and produce robust validated design guidelines to benefit the industry for future generations
- The 750kW gearbox was good for the start of the program, but we need to graduate to the multi-megawatt sized gearboxes for continued research
- It was unclear from the presentation why DOE's leadership is necessary and why this is something better suited for private industry, given the OEM's (original equipment manufacturer's) maturity

Question 7: Project Strengths

- Dealing with complex problems that need to be addressed
- Excellent presentation. Objectives are very clear.
- No other failure data-gathering effort combines root cause information across broad stakeholders and time scales, reducing uncertainty and knowledge gaps
- Very good cross lab and industry participation
- Drives research that lowers LCOE (levelized cost of energy) that industry could not do alone. An ideal example of the good use of public funds.
- Totally unique project. Unmatched in relevance and impact.
- Key strength is listening to the voice of the end user, and adjusting research appropriately. From the conclusions reached thus far, we have been able to adjust our repair strategy to minimize any premature failures.
- Important research findings with relevance to current wind industry needs

Question 8: Project Weaknesses

- None noted
- It does not seem as if there is substantial support from the OEMs for this program. Given the high potential value of reduced gearbox replacements, I would think that this program would be almost fully funded from industry.
- Work primarily benefits imported wind turbines, stakeholders involved should emphasize U.S. OEMs (original equipment manufacturers) and operators
- Funding uncertainty
- Not enough funding to answer all the questions that this project is uniquely qualified to resolve
- Need to upgrade to multi-megawatt sized gearbox(es) for future work
- Unclear how this represents a transformative research program focused on the next generation. Instead, appears to be work that is more suited to existing onshore fleet, and would expect owners/operators and OEMs to be investing more heavily in this area if this is related to the longevity of their wind farms.

Question 9: Recommendations

- Continue this R&D with strong industry involvement
- Condition monitoring data could enable field performance feedback loops from wind turbines of all scales so OEMs can more effectively refine designs
- Maintain focus and momentum as funding permits
- Stay the course
- Focus research work toward product improvements that can be implemented into fit, form, and functionally interchangeable gearboxes that will be installed into existing wind turbines as we run them beyond their baseline 20-year design life

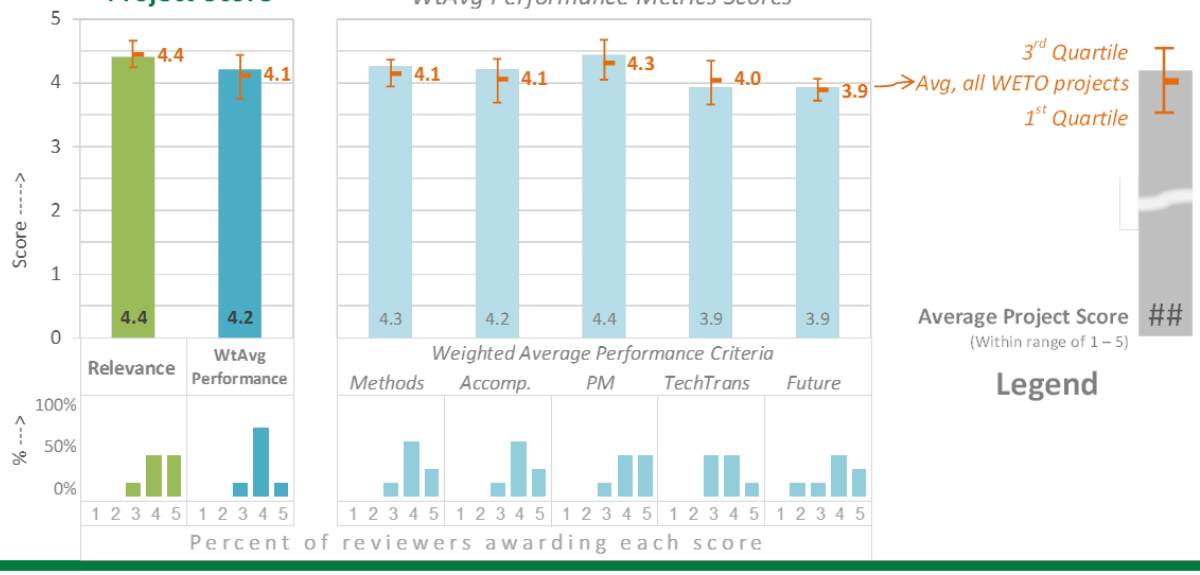
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Innovative Blade Test Methodology

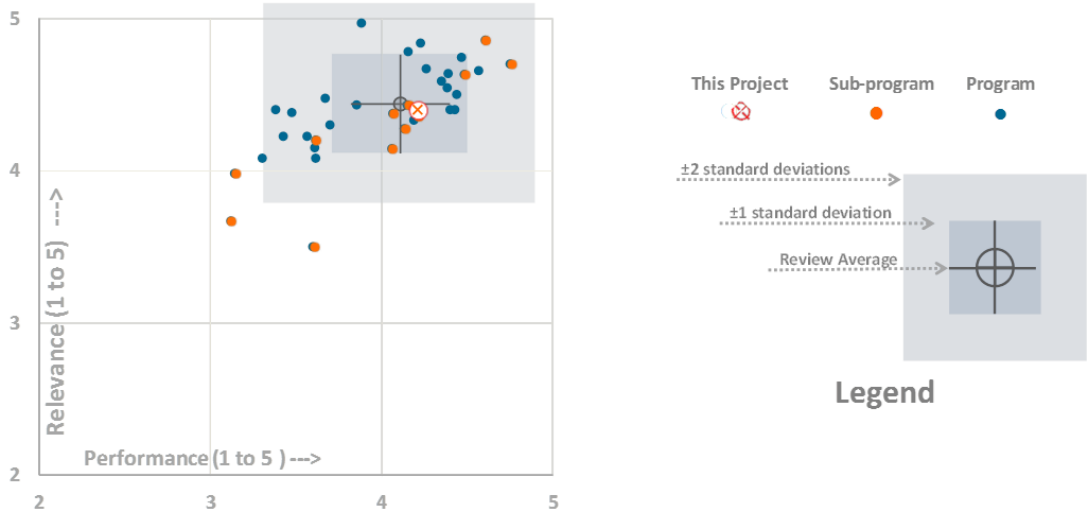
Principal Investigator	Scott Hughes, National Renewable Energy Laboratory		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Innovation, Manufacturing, Reliability, and Testing		
FY 2014-2016 Funding	DOE	$ 1.3 M	100%
	Cost Share		
	Total	**$ 1.3 M**	**100%**

Peer Review ID# 184

Project Score



Comparative Scoring



Comments made by reviewers during the evaluation of this project (PRID 184)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- This is an important aspect of the research portfolio
- Improvements in blades enabled through better testing methods will lead to a lower LCOE (levelized cost of energy)
- As blades get larger the testing aspects become more expensive
- Need this capability to develop industry testing standards
- Need this capability to develop methods to test new materials
- Blade reliability is a key technical issue for the industry. The improved testing methodologies developed from the project may help to address this issue.
- The information that may be generated from this new testing method would provide value to all OEMs (original equipment manufacturers)
- 13-m and 9-m blade tests - unclear whether method can be used to reduce testing time and costs for micro and small wind turbine blades, how results can be transferred to distributed wind OEMs
- Valuable industry resource. Supports industry with blade testing advancements critical to reliability. Cooperating with other labs to harmonize test methods for uniform, comparable results, transfer results to others.
- Over the past 20 years the NWTC (National Wind Technology Center) blade testing facilities have changed the way many blade tests are done throughout the world, making ever larger blade tests more efficient, faster and more representative of in-field service loads. This new and unique test procedure development capability is likely to make similar advancements.
- The wind industry needs more efficient test methods for representative testing of in-service conditions. The biaxial testing appears to be a very efficient method that adds no more time to a fatigue test yet simultaneously exercises both flap and edgewise structural regions in a realistic way.
- Blades are the only component that is truly unique to wind turbines. The industry cannot rely on any other industry for experience base. Blade reliability is crucial to wind industry success.
- Need aircraft design and validation process at the expense of farm equipment. This biaxial testing is a significant step in achieving cost effective blade structural validation and certification. This technique will inform the next steps in standards. FEA (finite element analysis), material testing, substructure, full scale laboratory testing, field testing
- Critical for risk reduction
- Design process relies on analysis with model validation based on laboratory testing plus field testing
- The wind industry needs the most accurate test methods available to optimize wind turbine blade design. Blade parameters (weight, size, aerodynamics, etc.) influence the design of the entire wind turbine system. The proposed biaxial blade fatigue test methodology appears to be the best opportunity toward this goal.

Question 2: Methods and Approach

- Current test practices do not reflect actual loads in the field. This facility gets closer to the real world.
- Facilities appear to be state-of-the-art
- The progression through various models of response to test program develop is well thought through
- Benefits shown for developing, demonstrating, and validating new methods at smaller (less expensive) scales
- Concerned that methods were patented using DOE funds, especially when no cost-sharing was documented
- Simultaneous flap and edgewise fatigue testing will significantly reduce testing time with more realistic loading
- The project approach as defined and presented will likely be successful

Comments made by reviewers during the evaluation of this project (PRID 184)

Question 3: Technical Accomplishments and Progress

- New test methods are better than older separate axis testing
- Not yet able to replicate real world loads and stresses
- The program has developed the methods for biaxial test. The full-scale deployment is pending further industry funding. The ultimate value of this program will be determined once those full scale tests are completed.
- Best practice guidelines improving advances in blade technology
- Demonstrated multiple methods to achieve biaxial edgewise / flapwise fatigue testing
- Capitalized on extensive blade testing experience and test facilities to demonstrate a novel biaxial fatigue testing procedure
- The demonstration of a scalable phased-locked biaxial blade fatigue test is extraordinary

Question 4: Project Management

- No concerns here. Strong experience levels present.
- The program's budget seems appropriate for the work and offers high ROI (return on investment)
- No PM (project management) issues indicated. All milestones met. No budget problems.
- Project plan appears to be on schedule, but would like to see more practical deliverables for this scale of budget
- Excellent partners and appropriate for developing and demonstrating methods
- Industry OEM partners were MHI Vestas Offshore Wind which also benefited operators of MHI turbines
- Plans to introduce new blade testing standards using advanced fatigue testing methods?
- Given that these full scale tests are relatively expensive it is remarkable that the program was conducted at such low cost. I assume that was done by industry tests with research elements to benefit both.
- Capitalizing on the flow of industry blade tests to accomplish mutually beneficial results
- The project management is exceptional, as the test results indicate

Question 5: Research Integration, Collaboration, and Technology Transfer

- Collaborations seem to be well developed, but there seems to be room for expansion
- There are good testing facilities in Europe which draws some of the OEMs there
- Good industry involvement and integration with other testing facilities
- Involvement with IEA (International Energy Agency) defining test methods shows important global leadership. However, a larger degree of collaboration would help improve relevancy to distributed applications in remote locations and smaller wind turbines.
- Good cross-lab cooperation. Minimal OEM participation.
- Excellent collaboration with IEA Task 37. This is the perfect example of international collaboration that impacts how all test laboratories fatigue test large blades. The technology transfer is very well targeted with direct interaction with those experts who perform the blade tests.
- Collaboration with SNL very efficient
- The coordination on this project looks appropriate

Question 6: Proposed Future Research, if applicable

- Publications on capabilities planned
- Future research list is solid and worthwhile
- Potential full scale tests are defined but require additional funding
- Future RD&D (research, development and deployment) in this area should ensure 20-50% industry cash cost-share
- Consider developing sensor and condition monitoring protocol
- Decoupled resonant biaxial fatigue testing would be the ultimate in blade testing efficiency. Both speed and required testing energy would be minimized.
- The project is complete. If additional funding becomes available, I would recommend continued testing toward full-scale deployment of the technology.

Comments made by reviewers during the evaluation of this project (PRID 184)

Question 7: Project Strengths

- This briefing was excellent. It included a very clear definition of the program and its objectives.
- Valuable project goals to develop faster and more cost effective approaches for wind turbine blade certification testing, domestic capabilities enabling rapid validation of novel blade materials and manufacturing methods
- Industry collaboration can be very effective, as well demonstrated by the DRC (Drivetrain Reliability Collaborative). Blades are more OEM specific and carry a greater sense of competitiveness that can make cooperation more challenging. Still, common areas such as testing are good ways to engage and build collaboration.
- Capitalized on existing facilities and industry blade tests to accomplish the research
- Successful coupling of flap-wise and edge-wise fatigue loading to better simulate real-world stresses on blades

Question 8: Project Weaknesses

- Would like to see more progress/outcomes for this scale of budget
- Light OEM participation
- None identified

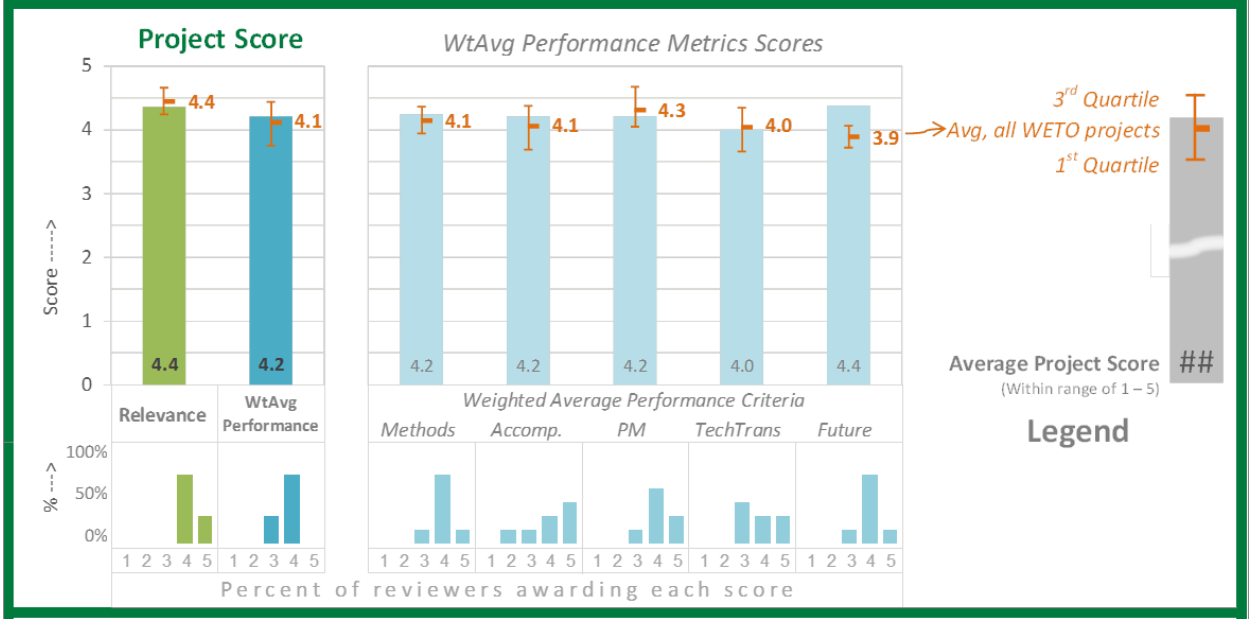
Question 9: Recommendations

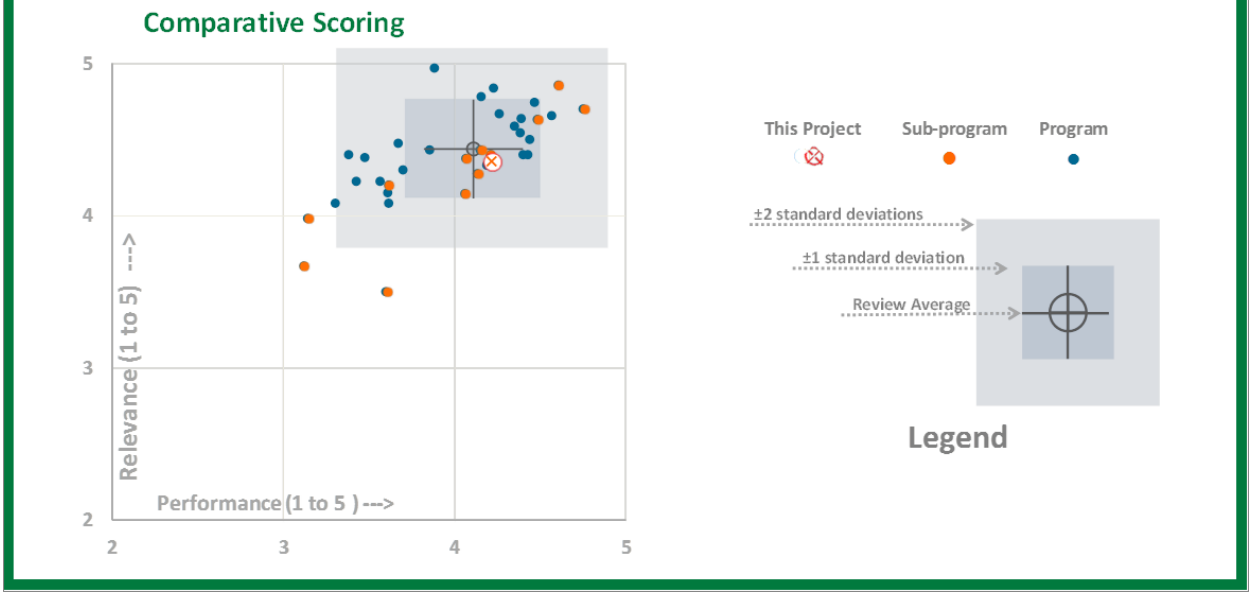
- While ongoing involvement with IEA is important, if substantial program cuts are needed further R&D in this area could be transferred to the commercial sector, while preserving public investments to date
- Increase industry collaboration. Pursue cost-effective CBM (condition-based monitoring) recommendation for detecting structural performance/degradation for industry.
- Continue program to demonstrate resonant biaxial fatigue test
- Other opportunities for blade performance testing are; quantify blade expected life in the context of operating this equipment beyond its current 20-year design life. Partner with Rotor Reliability group for continued research in this area.

DOE Wind Energy Technologies Office 2017 Peer Review Project:

Additive Manufacturing in Wind Turbine Components and Tooling

Principal Investigator	Brian Post, Oakridge National Laboratory			
Program	Wind Resource Characterization and Technology RD&T			
Sub-Program	Innovation, Manufacturing, Reliability, and Testing			
FY 2014-2016 Funding	DOE	$ 0.8 M	78%	
	Cost Share	$ 0.2 M	22%	
	Total	**$ 1.1 M**	**100%**	Peer Review ID# 187





Comments made by reviewers during the evaluation of this project (PRID 187)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- It's clear that improvements in blade manufacturing will lead to lower costs, so this is a relevant investment area
- The potential ROI (return on investment) for the application of [additive manufacturing] is clearly large and could have a major impact on project CAPEX (capital expenditures) and O&M (operations and maintenance) costs
- The application of this process for blade repair and replacement is potentially unique and may have a major impact to the life extension of existing, older, wind farms. The potential value of this has not been quantified in any way.
- Research currently doesn't but could also have relevance to distributed wind sector, particularly in producing tooling and parts at distant/remote sites (including the [southeastern] United States).
- Helps increase domestic content/create local jobs, reduce transportation & installation costs
- Represents advance in manufacturing technique - helps enable feedback loop from field performance so OEMs (original equipment manufacturers) can more quickly refine designs
- Impressive innovation and advancement of developing technology
- Aging fleet and retrofits? Life extension? Standards related to retrofits?
- Can BAAM (Big Area Additive Manufacturing) be applied to onsite manufacturing?
- Can it be applied to retrofitting blades in the field?
- The BAAM has been applied to blade mold fabrication which is of course an important part of the blade manufacturing process. Rapid production of high quality accurate molds will enable greater accuracy and greater flexibility in introducing new blades to product lines. But the ultimate goal seems like it should be to automate in-factory blade fabrication process. Another goal could be to automate in-field blade fabrication. The latter could enable larger turbines by avoiding transportation constraints. Even though this was not discussed in the presentation it is assumed that this goal is possible. An additional goal could be to automate infield blade repair of existing blades. Extending the life of existing blades may become an important goal for the huge fleet of aging turbines.
- Overall, this is a remarkable first step in BAAM and deserves DOE attention
- This technology is useful for developing blade tip molds to repair blades heavily damaged by lightning
- This technology can be used to produce blade tip molds for fabricating new blade tips for better performance
- Unknown lifespan of AM (additive manufacturing) mold makes economic comparison to traditional blade molds difficult. More research needed.

Question 2: Methods and Approach

- The approaches presented seen to be taking advantage of new technologies that could significantly reduce manufacturing costs
- The project includes a strong integration of a new technology (large-scale 3d printing) which helps to broaden the value of the DOD (Department of Defense) program beyond the other more mainstream issues
- The project goes from design to prototype testing of one blade design, so the end results should provide a strong confirmation of the concept
- Impressive results for small investment, but various scales also useful
- Solid approach to understanding industry needs/opportunities
- Process is multi-step, mold part initially manufactured and they require subsequent fiberglassing and machining to be usable
- Much potential, can be used for site, near-site mfg. Material 30% and machine time 30% and are related. Glass vs. carbon fiber material.
- Originally cost effectiveness not a priority but part of next steps. What about just printing blades directly vs. indirection through mold mfg. Big design challenge with material orientation. Can control metal rate of cooling to effect grain orientation.
- Demonstration of Big Area Additive Manufacturing (BAAM) is excellent and unique goal
- Segmented nature of molds lends themselves to transportation to field for onsite manufacturing? And perhaps modification to suit field retrofits?

Comments made by reviewers during the evaluation of this project (PRID 187)
• Automation can help increase quality of manufacturing

Comments made by reviewers during the evaluation of this project (PRID 187)

- Automated post manufacturing inspection of quality?
- This technology can replace manual hand layups over existing blades to make a blade tip mold
- This technology has demonstrated comparable manufacturing capabilities to traditional molds

Question 3: Technical Accomplishments and Progress

- There are still risk areas here (scaling, longevity of finished product), but that is typical for this type of R&D
- The project has not really established any cost savings relative to current manufacturing techniques, so this aspect of the work is not complete. The time savings that were presented were significant, but less than what might have been expected given the automation afforded by the process (27 to 20 weeks).
- The work is not yet finished
- Good to leverage ORNL expertise however their relatively low familiarity with wind industry needs monitoring/interactions, particularly for relevance to DW (distributed wind)
- Continuous development/improvement/scaling. Blades currently being made by TPI Composites.
- Given that this project has had a relatively short life it has shown remarkable accomplishments. The PIs (Principal Investigators) have set a high bar for future expectations. Perhaps application to full blade fabrication, infield application and other components.
- Future plans? Onsite manufacturing is a possible focus but not in current scope
- Blade fabrication automation can add precision to material distribution such as carbon and fiber orientation
- Current program focused on building molds only. Need to accelerate to building full blades
- We did not discuss AM applied to magnets but this is a worthy application since automated material deposition and grain orientation would enable low cost high quality customization of pole flux shaping which can improve PM generator efficiency
- Progress with fabrication of mold for SWiFT (Scaled Wind Farm Technology facility) program confirms delivered results

Question 4: Project Management

- This complex project seems to be well managed
- Some minor delays in schedule but within reason given the type of work
- The project budget seems very appropriate and the project provides good value to the DOE program for the amount invested
- Some project delays, no expansion of budget
- The project's success to date, as clearly indicated by actual industry deployment, speaks to being well managed
- Excellent industry partners
- Cost effective budget
- Industry interaction excellent with TPI
- Meeting ambitious schedule
- Progress with fabrication of mold for SWiFT program confirms effective project management

Question 5: Research Integration, Collaboration, and Technology Transfer

- Good collaboration to date
- A qualified team has been assembled for the project but there is less indication of collaboration across other DOE projects. There is no indication of input from industry other than team members.
- Good to see involvement of AMO (Advanced Manufacturing Office) and multiple labs, and substantial cost-sharing by industry partner. However, a larger degree of collaboration would help ensure relevancy to more sectors of wind industry, particularly for distributed applications in remote locations and smaller wind turbines.
- Appears to be a very fluid and interactive working relationship with TPI and SNL
- Can wind plant operators be included in an investigation into the needs of on-site manufacturing and/or on-site blade repair or blade modification to meet life extension of aging fleet?
- There appears to be good collaboration/communication across the National Laboratories (Sandia, Oak Ridge, NREL) as well as with Industry Partner TPI
- There does not seem to be interaction with the offshore wind industry, which has a different set of constraints, opportunities for on-site manufacturing and needs

Comments made by reviewers during the evaluation of this project (PRID 187)

Question 6: Proposed Future Research, if applicable

- The testing of the blades at SWIFT will provide critical feedback on the process. This project should continue.
- The continued development of 3d printing for wind applications shows promise and the team has presented some good options for future work
- The progression to full length printing of forms on site could provide substantial value if it leads to further cost reduction
- Additive manufacturing is a critical area for future research for distributed wind sector to retain and grow U.S. jobs
- Would like to see application to blade manufacturing and on-site manufacturing considered
- Would like to see other major wind turbine components considered
- This technology is immediately applicable to end user needs for quick, cost effective blade tip repair from lightning damage

Question 7: Project Strengths

- Clearly this is cutting edge research that could transform blade manufacturing. Continued coordination with industry is very important.
- The project has demonstrated a unique application of new technology to help reduce costs for wind projects
- Collaboration between DOE Wind and AMO; wide dissemination of promising results
- Clear industry value-add opportunity
- Further opportunities for incremental value-add improvements exist
- Interagency collaboration and cost sharing was a significant benefit and key to this project's success
- Industry and laboratory collaborations were significant element of the success. ORNL appeared to be a great leader and innovator in this area.
- As mentioned above, this technology is immediately applicable to end users' needs

Question 8: Project Weaknesses

- None could be identified
- The findings to date have not realized the amount of cost reductions that would normally be expected with this type of process
- Limited scope/budget
- No weaknesses detected beyond normal uncertainties
- No weaknesses
- Tempting to want to extend the application beyond the scope and budget allowed
- Useful life of material used for AM is not fully understood. Current comparable costs do not provide incentive to change over from traditional mold making to AM methods.
- Hard to see how this might scale to the needs of offshore wind blades (eighty meters or greater)

Question 9: Recommendations

- Continue this effort
- Molds for small-scale wind turbines are also a major cost constraint and should be addressed in future research
- Future research should also address challenges of producing a variety of wind turbine parts on site or close to distributed wind installations
- Pursue accuracy improvements in fabrication and assembly processes to reduce incremental machining, etc. steps
- Could ask the team to consider an assessment of the applicability to full scale in-factory blade fabrication, onsite blade fabrication and onsite blade repair and/or blade modification for life extension of the aging fleet
- Continue research and look for opportunities to provide value through performance improvement or life extension
- Collaborate with offshore wind industry as well to maximize the opportunity to contribute to lower-cost manufacturing for all types of wind energy

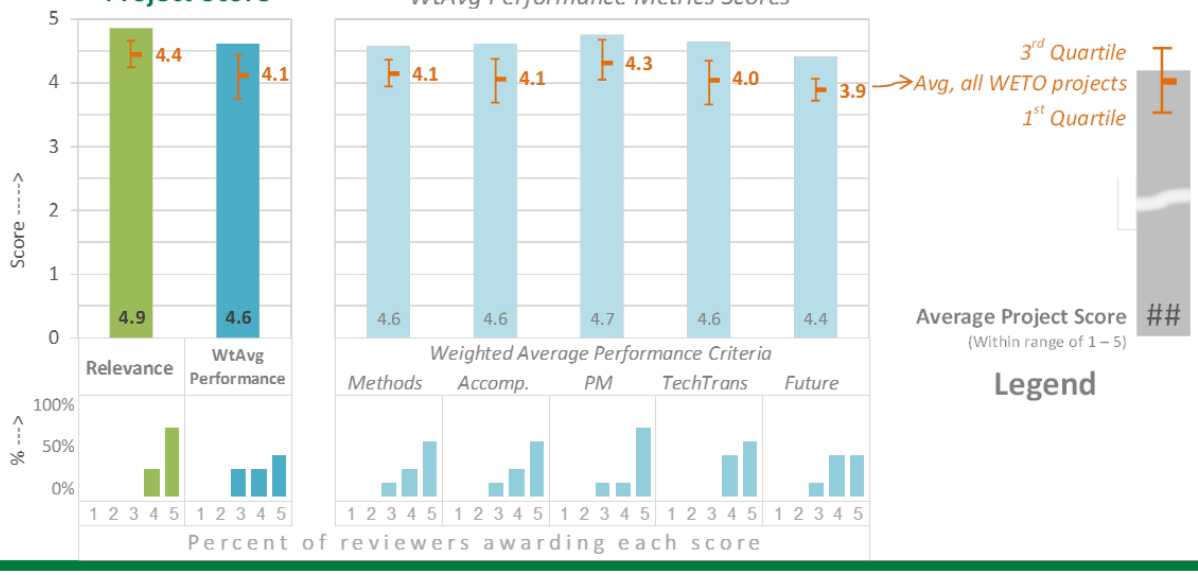
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Testing Facilities and Capabilities at NWTC [National Wind Technology Center]

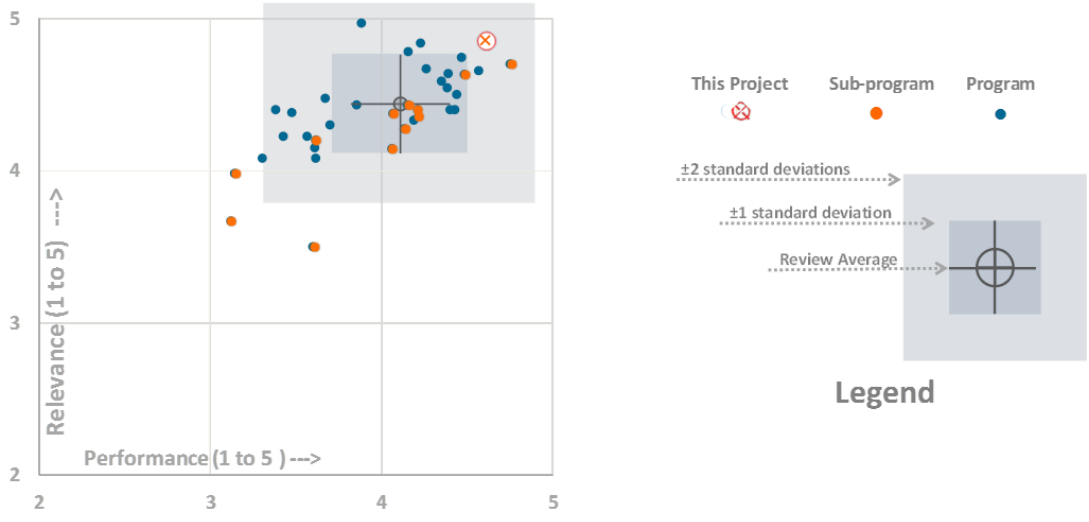
Principal Investigator	Dave Simms, National Renewable Energy Laboratory		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Innovation, Manufacturing, Reliability, and Testing		
FY 2014-2016 Funding	DOE	$ 12.1 M	25%
	Cost Share	$ 37.0 M	75%
	Total	**$ 49.1 M**	**100%**

Peer Review ID# 210

Project Score



Comparative Scoring



Comments made by reviewers during the evaluation of this project (PRID 210)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- This is a unique world class facility for proof of concept and safety testing
- The ability of small companies to test their systems provides support for emerging technologies
- The extreme wind conditions at this site provide a good test environment
- It would help to clarify the technical "sweet spots" between the WTRC (Wind Technology Resource Center) and SWiFT (Scaled Wind Farm Technology facility)
- Significant use of the facility from OEMs (original equipment manufacturers) and other private sector customers demonstrated the high value of this facility
- Contribution to distributed wind R&D, including management of regional test sites, has been substantial
- Not originally a wind test site but has transitioned well from its former existence
- Enables drivetrain, blade and grid interface testing that is otherwise very unlikely to have occurred, or occurred to any significant degree
- The NWTC has a nearly 40-year history of development starting with small turbines in late '70s to the most ambitious scientific tests ever attempted. These facilities have supported a wide variety of technical challenges from unsteady aerodynamic behavior to drivetrain reliability. Leading edge instrumentation and testing techniques have resulted from these efforts. Every international testing standard has been informed by testing techniques developed at these test facilities. Advanced control strategies have been validated on a wide variety of turbines on this test site. The extreme wind characteristics common at this site have proven to be a tough proving ground, eliminating weak designs and validating robust designs. Over the years the breadth and depth of capabilities resident at the NWTC have proven to be DOE's most valuable resource. No test facility can serve every industry need but the NWTC supplies more than any other in the world and is likely to remain the wind industry's most valued testing resource.
- A very few industry members could supply some of the same resources some of the time but most of the industry cannot duplicate the resources the NWTC offers
- Accredited laboratory certification to international standards has proven to be valuable in providing high quality testing and informing IEC (International Electrotechnical Commission) testing standard protocols. All of the international testing standards have benefited from the practical experience gained at the NWTC.
- Full scale blade structural testing, drivetrain loads testing, advanced aerodynamic testing were all pioneered at the NWTC. These testing techniques informed international testing standards in some cases and led to transformative reliability improvements in others. In the case of aerodynamics testing the deeper understanding of unsteady aerodynamic loading resulted in dramatically improved ability to predict dynamic loads caused by turbulence, all a result of innovative testing on the NWTC.
- Development of new testing standards
- From our perspective, the NWTC is the most important test facility of all the National Lab's facilities. We have directly benefited from several research projects conducted by the NWTC. For example, we had a blade structure issue that the manufacturer researched in conjunction with full-scale testing at the NWTC. We have also benefited from research conducted by the Gearbox Reliability Collaborative, working in conjunction with the NWTC dynamometer facility. All wind turbine owners and operators benefit from research on blade tip vortices.

Question 2: Methods and Approach

- All aspects of the WTRC seem to be well managed and use state of the science/practice approaches
- The project covers the O&M (operations and maintenance) of the facility. The new work included in the project includes new 5MW dyno NTL (non-torque loading) system.
- Good focus on O&M and grid integration research
- Clear culture of focus on facility user/customer needs
- Impressive grid testing facility
- (See comments above)
- Plans for a future NWTC substation will expand the capacity to perform grid integration tests safely

- Grid integration testing at high penetrations and fault conditions will be valuable for validating turbine compliance with new grid rules and control systems which stabilize the grid with high penetrations of mixed renewable energy sources
- The methods and approaches used for test development and analysis are exceptional, and the results validate this comment

Question 3: Technical Accomplishments and Progress

- Good diversity of turbine and blade types
- Good atmospheric sensing capabilities
- Excellent suite of testing systems
- Doing any testing of remote stress monitoring systems?
- Much of the work performed under the last funding cycle is dedicate to O&M and there is a significant amount of that. Based on the accomplishments shown in the briefing, it seems that the project accomplished the majority of the O&M.
- Additions of new dynamometer capability
- Technical accomplishments of what is essentially an O&M effort is difficult to score
- Impressive amount of research completed with all milestones on time and within budget. Testing of several small wind turbine designs has helped avoid larger-scale equipment failures and industry setbacks
- Active budget control, planning and staff utilization/efficiency sensitivity
- Hundreds of blades have been tested at the NWTC. A list of blades tested would be interesting and useful.
- List of drive trains tested?
- Turbines tested?
- Specialized grid tests completed?
- The NWTC has delivered world class, innovative accomplishments throughout its history. We have directly benefited from many of the R&D efforts conducted at the facility. Several examples are defined in this review.

Question 4: Project Management

- There is substantial PM (project management) experience at this site
- Excellent management of programs included in O&M. There is clearly a high value added from this facility due to the experience the team has gained over so many years of operation.
- High overhead is challenging for small projects
- The NWTC has many simultaneous tests in process. Most of them require large scale and unique test setups. Management and support for them requires careful prioritization. This appears to be done well.
- Project Management of many of the projects is world class, the accomplishments validate this comment

Question 5: Research Integration, Collaboration, and Technology Transfer

- This facility has strong partnerships (~75 collaborating organizations)
- Financial leveraging aspects of the site are key
- The facility is a keystone within the industry and is used by most major O&Ms within the industry
- Very impressive collaborations and cost sharing, however would like to see greater portion of research more clearly relevant to distributed wind within this level of budget
- Examples of good cooperation/collaboration with other labs and facilities. Have helped build up WTTC-MA (Wind Technology Testing Center – Massachusetts) and not take business away.
- The NWTC seems to work very collaboratively with the broad research community, other laboratories and industry. Industry members commonly work collaboratively in all the on-site test facilities. Industry friendly flexible arrangements have been established. In some cases industry runs their own equipment and test program with minimal support from NWTC staff. The NWTC seems to be filling the role of an industry "User Facility" very effectively.
- The level of integration, collaboration, and technology transfer are among the best in the world. The NWTC accomplishments over the course of its history validate this comment.
- No evidence of identifying priorities of offshore wind industry and determining how to meet them

Comments made by reviewers during the evaluation of this project (PRID 210)

Question 6: Proposed Future Research, if applicable

- New "grid simulator" is a good addition
- Active flow control is very worthwhile future research
- Was a mention of offshore testing support, but not clear on the role the WTRC would play
- Proposed future research of what is essentially an O&M effort is difficult to score
- Would like to see increased education and support of distributed wind industry partners, especially smaller companies
- Grid integration research, including battery storage interactions, should be designed to benefit distributed/remote applications
- Prudent plans for enabling transmission interface and battery testing
- Wake testing, controls testing, aerodynamics testing, drive train testing, instrument development and validation testing, advanced blade structural testing are all valuable to the industry. The NWTC is uniquely positioned to perform these tests in support of DOE's agenda.
- Research in the area of Grid Integration is critical to our company as we expand into areas that have marginal grids as well as grids that have a high percentage of intermittent renewable generation
- Integrate offshore wind into future plans/research to the extent practicable
- It is an open question, coming out of the peer review, how much external expertise is drawn upon to understand approaches and to build upon external work done in academic institutions. There was some appearance of insularity.

Question 7: Project Strengths

- High value leveraged from experience
- Long-term DOE investment has built effective team of highly skilled experts, high value testing/data acquisition infrastructure
- Unique capabilities as well as breadth and depth of different tests
- The NWTC works on projects that have a direct effect on the operation of our wind turbine fleet. For example, we are having challenges in the ERCOT (Electric Reliability Council of Texas) area with regards to grid integration. The Grid Integration Test Facility could be beneficial in helping us understand and adjust our operating procedures to better integrate with the grid.
- Interdisciplinary approach to cutting edge problems for wind energy industry

Question 8: Project Weaknesses

- The ratio of fees collected versus DOE overhead is high. Can this facility become self-sufficient based on fees?
- Heavier focus on VAWTs (vertical axis wind turbines) than warranted
- Not located in a particularly good wind resource area relative to typical commercial, utility-scale wind plants. However, local conditions have proven adequate.
- None

Question 9: Recommendations

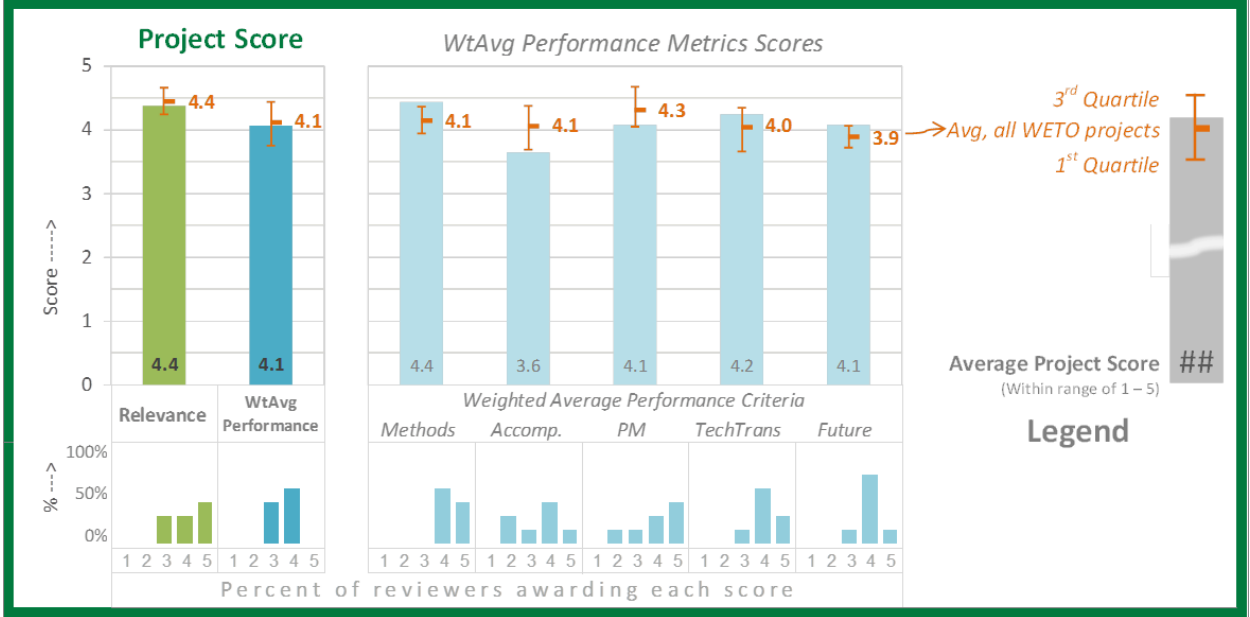
- Assess potential to increase revenue through expansion of services provided to private ventures
- Address impact of low voltage ride-through and high voltage ride-through requirements on induction machines in the micro/residential/mid-size sectors, identified by SMART (Sustainable Manufacturing, Advanced Research and Technology) Wind Roadmapping process as distributed wind industry priority
- Carefully consider any future VAWT testing; schedule rotation of equipment so make room for more promising designs
- Document the history of accomplishments and tests
- Continue the world-class efforts you have demonstrated up to this point. Grid integration and blade aerodynamic efficiency are key areas for research.

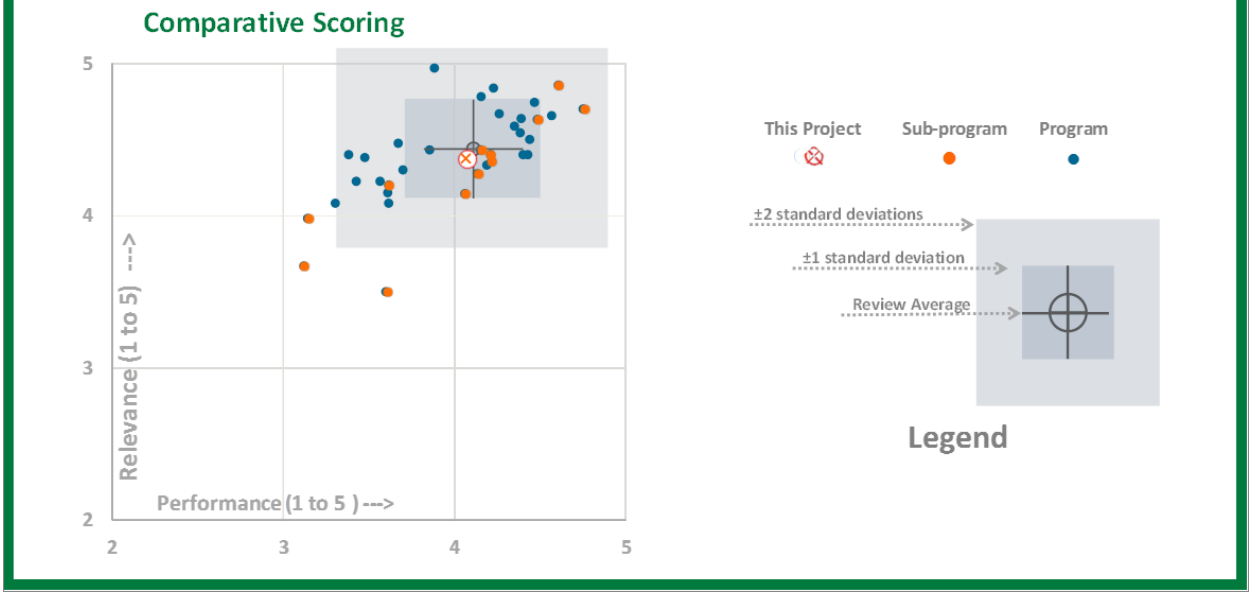
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Rotor Reliability (Collaboratives, Monitoring, and O&M [operations and maintenance])

Principal Investigator	Josh Paquette, Sandia National Laboratories		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Innovation, Manufacturing, Reliability, and Testing		
FY 2014-2016 Funding	DOE	$ 3.9 M	100%
	Cost Share		
	Total	**$ 3.9 M**	**100%**

Peer Review ID# 221





Comments made by reviewers during the evaluation of this project (PRID 221)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- How does this capability compare to the WTRC (Wind Technology Resource Center) blade testing facility? Is there significant overlap?
- This R&D seems to be aligned with what industry is worried about with older blade failures
- The owner-operators need the results of this research
- Developing methods for more reliable blade testing is very important and adds significant value to the industry
- The program includes 3 separate projects, CREW (Continuous Reliability Enhancement for Wind), Composites and Inspection Methods. While these efforts all relate to improvements in overall blade reliability, it is unclear how well the individual programs integrate with one another. It may have been better to focus on each topic separately.
- The work on improved inspection methods and establishing thresholds for blade damage may have a substantial ROI (return on investment) for the industry
- Minimal current relevance to distributed wind sector, but scope could be adjusted so life extension efforts could be more applicable for smaller-scale wind projects
- Focused on an industry support need. Project concept seems well focused.
- Reliability database excellent goal and well suited for DOE's unique objective position in the industry (slide 10)
- Reliability database gives DOE objective quantitative metrics for assessing impact on industry and impact of DOE research (slide 10)
- Excellent broadly applicable tools for assessing and improving reliability and performance of blades (material knock down factors, fatigue life of flawed material, NDT (non-destructive testing) methods for detecting flaws, performance impact of leading edge erosion) (slide 4)
- Improved design for reliability methods can help standards and certification. Excellent goal. (slide 7)
- Are members of the research team engaged and attending IEC (International Electrotechnical Commission) WG6 (Working Group 6) (Blade Design Requirements) standards meetings? This is needed to 1) understand the state of the art design process and 2) introduce advanced design methods into the design process (slide 7).
- Blades are the most important and unique component in the wind industry. The industry can rely on no other industry for lessons learned or core technology.
- This program is directly applicable to immediate needs we have with our operational fleet. Damage detection and progression are areas that affect us on a daily basis. We need accurate assessment and the ability to quantify energy loss from leading edge erosion. We need guidance on the feasibility of carbon-spar damage from lightning. Currently, private industry is not able (or willing) to repair significant damage to carbon spars. We also need guidance on extending the run time of these structures past the 20 year design life.

Question 2: Methods and Approach

- It seems as though the work done on leading edge flow separation is similar to what had been done in the aerospace industry for many decades. Is anything new really being learned when applied to turbine blades?
- Lightning testing, NDI (non-destructive inspection) testing and analysis of blade repair methods is well suited for the DOE
- The assessment of real world inspection results is a key part of this study as, typically, standards are based on vendor theoretical optimum. The actual results are typically not nearly as good and owners/operators need to know the delta to assure higher reliability levels.
- The NDI program includes a strong progression of methodology development, validation and testing
- Field NDI is helpful focus for all scales of wind technology, especially for distributed/remote locations
- Useful to track reliability and performance trends over time including component failure issues
- Program needs greater industry participation
- Continue attention to better correlation of sample testing to full blade structural performance
- (Slide 10) Flaws can be very blade, material, manufacturing method specific. What is the strategy for selecting flaw characteristics that have broad applicability?

- Slide 10: Industry collaborative for blade failure database is excellent approach

Comments made by reviewers during the evaluation of this project (PRID 221)

- The challenge is to get the data reported and in a consistent way. What is the strategy for data retrieval?
- Reliability project has tremendous value if long term consistent data collection is accomplished. Must have long term support to have value for the industry.
- NDAs (Non-disclosure agreements) are nearly impossible. Must have a plan B for getting the data or direct contact with experts who have analyzed the failures to make sure the focus is on target. Consultants?
- Leading edge erosion is a performance issue, perhaps less important for reliability. If focus is to serve the end users (non-OEM (original equipment manufacturers)) stakeholders this will benefit wind plant performance in the United States.
- Program methods and approach are meeting end user's needs

Question 3: Technical Accomplishments and Progress

- It wasn't clear how many results are in practice now, but the ongoing and proposed work will have a positive impact on industry
- Very good progress on the NDI program
- Progress on composites and crew are more difficult to assess. It is unclear how much real value has been added through those parts of the program.
- Important goal for higher-quality blades to leave factories, but unclear how this project ensures improvements will be implemented
- Blade NDT and material testing for manufacturing flaws is good role for DOE. Neutral party can provide blind objective data on effectiveness of flaw detection QA practices.
- Composite NDT methods are needed for QA before blade shipping and in-service remaining useful life estimation.
- Is LE (leading edge) erosion a major performance issue that needs research? The value of estimation of performance loss from progressive erosion?
- Technical accomplishments are meeting end user's needs and expectations such as quantifying efficiency loss due to leading edge erosion and damage tolerance from manufacturing defects in fiberglass laminate layup

Question 4: Project Management

- Appears solid
- Potentially some mismanagement of the CREW program
- Milestones delayed, budget carryovers/shifts
- Managing industry collaborations is very difficult to get constructive interactions. Progress has been meaningful in spite of these challenges. Most valuable industry contributions can be failure details which are generally highly protected. Project management creativity to resolve this will be key. NDA, if required may be the biggest hurdle for managing the project to constructive conclusion.
- Project management appears excellent, as program is on track and in sync with end user's needs and expectations

Question 5: Research Integration, Collaboration, and Technology Transfer

- There seems to be a lot of good outreach with this project
- Strong collaboration with academia, other labs and private sector partners
- Unclear how results shared beyond partners
- Impressive collaboration and publications, but involving distributed wind stakeholders would help improve relevancy to smaller wind turbines and projects
- Good partners. MSU (Montana State University) has been major contributor to composite database. Other end user partners appear to be very constructive.
- Have blade consultants been active in the collaborative? They hold the deep knowledge of root causes for blade failures as do the end users.
- Program collaboration and technology transfer are exceptional, and in line with end user's needs and expectations
- Great collaboration but illuminated greater need for data sharing

Comments made by reviewers during the evaluation of this project (PRID 221)

Question 6: Proposed Future Research, if applicable

- Project transitioning to focus on blade reliability; lightning damage, carbon fiber study, repair methods, etc.
- The application of probabilistic models to assess rate of damage growth is a great idea and can potentially add significant value to the program. A similar method was used to assess joint damage in offshore platforms resulting mainly from fatigue. This work led to some significant improvements in inspection schedules, methods and better overall effectiveness of O&M budget allocations.
- Further field deployment of advanced NDI is warranted at distributed wind project sites
- Leading edge erosion testing and mitigation development would be valuable
- Is leading edge erosion modeling valuable to the industry and unique to lab skills?
- Continued research into blade leading erosion is critical to help end users make cost-effective decisions on when to remediate, to optimize repair ROI. Continued research into damage tolerance will help end users make informed decisions in the aftermath of lightning-induced damage.

Question 7: Project Strengths

- Well aligned with needs of owner/operators
- NDI work is outstanding
- Improving operations and maintenance (O&M) practices by quantifying reliability provides high value
- Blade reliability is critically important for the wind industry. DOE is in a unique position to objectively lead the industry to indisputable conclusions for root causes of poor reliability.
- This research is exactly what end users are needing to better utilize their assets
- Relevance to industry needs

Question 8: Project Weaknesses

- May need more resources to make more progress as need for system testing grows as fleets age
- The integration of the three projects is unclear and perhaps erodes the overall ROI of the program
- Restrictions on data sharing has slowed progress
- No OEM (original equipment manufacturer) participation–challenging due to the competitive perception of information
- Unfortunate loss of industry support on reliability improvement effort. Perhaps Jason Fields could provide guidance in easing industry concern and bolstering support.
- Biggest challenge is getting failure data and/or root cause analysis results. NDAs are nearly impossible.
- None identified
- Need better methods of data sharing

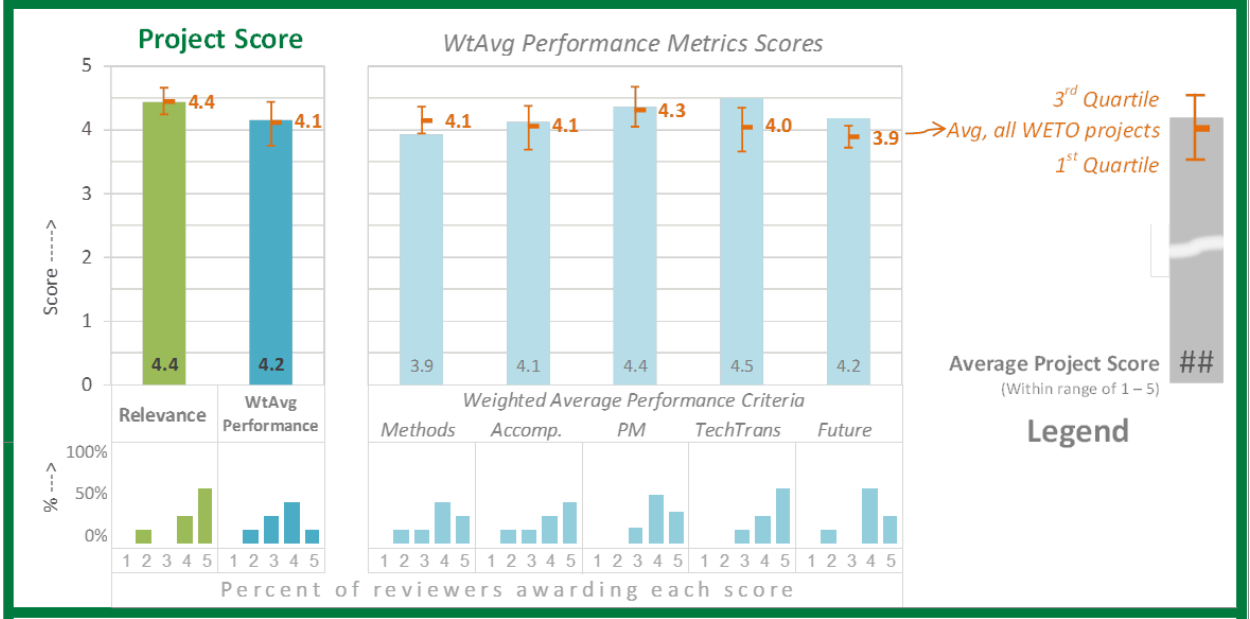
Question 9: Recommendations

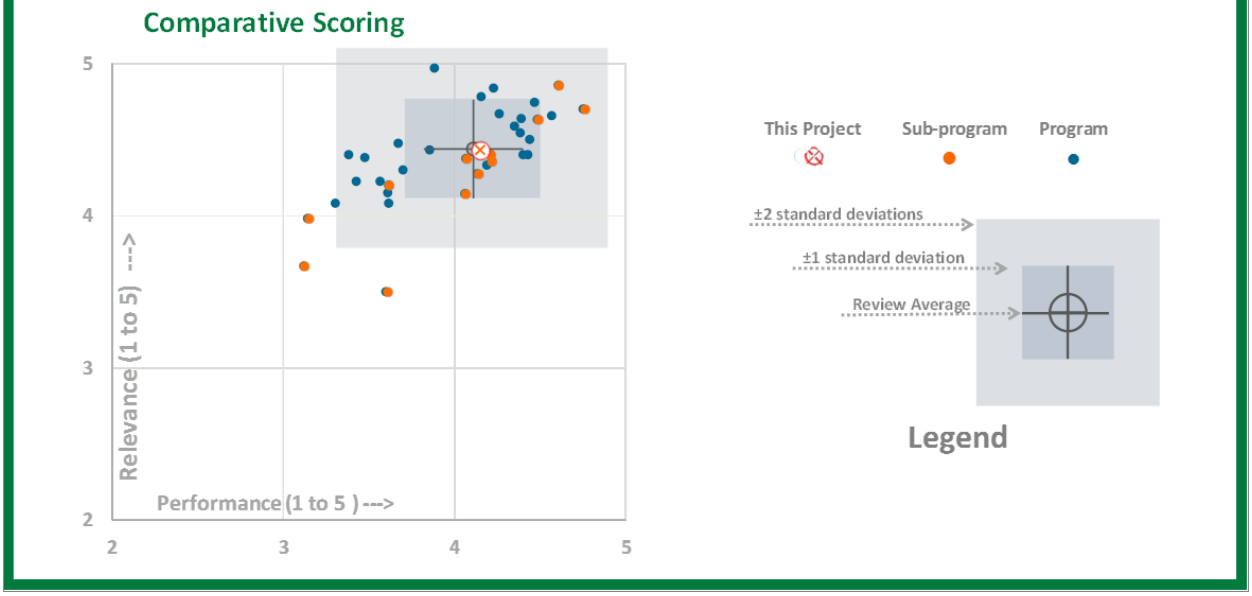
- Focus on the NDI work as that will provide bigger bang for the buck
- Agree that blade reliability needs continual improvement commitment, but would like to see effort address distributed wind sector for this scale of funding
- Industry needs a blade instrumentation protocol for sensors and data collection to detect defects and damage
- If funding is limited, focus on structural reliability
- Continue with research on leading edge erosion

DOE Wind Energy Technologies Office 2017 Peer Review Project:

Testing Facilities and Capabilities at SNL [Sandia National Laboratories]

Principal Investigator	Jon White, Sandia National Laboratories			
Program	Wind Resource Characterization and Technology RD&T			
Sub-Program	Innovation, Manufacturing, Reliability, and Testing			
FY 2014-2016 Funding	DOE	$ 4.7 M	68%	
	Cost Share	$ 2.2 M	32%	
	Total	**$ 6.9 M**	**100%**	Peer Review ID# 223





Comments made by reviewers during the evaluation of this project (PRID 223)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- There is a critical need for field data to support modeling and overall testing. SWiFT (Scaled Wind Farm Technology facility) is a unique and necessary facility, especially for wind characterization. Model Verification – It goes without saying that the skill of models to characterize the lower atmosphere (verification/validation) needs to be assessed and measuring the atmospheric flows and the turbulence (4D) down to sub-meter scales is very challenging. The SWiFT facility is uniquely suited to serve the purpose of measuring the atmosphere at scales important to wind power, particularly over flat terrain. Resources should continue to be focused on improving current and implementing new sensing technologies, where appropriate, that will provide quality datasets for characterizing the flows which will lead to increased understanding and useful data for model performance assessment.
- The sharing of data with industry and research institutions is also very important
- It would be helpful to differentiate the technical sweet spots (unique capabilities) between SWiFT and the WTRC (Wind Technology Resource Center)
- Better data is critical to optimize the design and O&M (operations and maintenance), particularly for larger and new turbine designs. However, it is difficult to assess the net benefit of the program as there is little information on the data that has been generated (e.g., Wake effects)
- Improved wake models could generate significant ROI (return on investment). The potential value of data that may be generated at this facility is substantial.
- Open-source concept is useful but not clear whether facility and research have much if any relevancy to distributed wind sector
- Well located for wind testing
- Facilities staff are the unsung backbone of the lab
- Is the primary goal and value to the program reference validation data sets for wake testing in wind plant simulation? This seems like the most valuable and unique attribute for this facility. It should deliver reference grade data for the HPC (high performance computing) analyses as well as validation for wake steering control models.
- Uniquely suitable for wake tracking and validation and quantification testing
- Deficiencies, if any, of subscale testing need to be addressed. I believe this test facility is well suited for validation of wind plant models but it might be worth documenting potential impact of testing at subscale.
- This test site is also valuable and uniquely suited for wind flow sensor validation
- Laboratory test facilities are perhaps the most important and unique DOE resource. Historically they have enabled many other research investigations that have fundamentally changed the wind industry. There are multiple examples of technical issues limiting industry success that have been resolved by unique DOE test facilities. Maintaining and upgrading these facilities will enable the next generation of wind technology. Each laboratory has its own unique strengths. This facility has the unique role of validating wind plant models, which are likely to be a transformative step in wind plant LCOE (levelized cost of energy) reduction. It might be valuable to differentiate the capabilities of SWiFT with NREL.
- Project research is directly applicable to end user's questions on how individual wind turbines interact across a wind farm complex, and how to optimize that operation

Question 2: Methods and Approach

- Is the sensor suite adequate to measure the inflow and wakes with sufficient fidelity to validate LES (large eddy simulation) and CFD (computational fluid dynamics) codes? What is the smallest atmospheric feature that can be resolved with the current sensors?
- Is a wide variety of inflow conditions (gust fronts, low-level jets, icing) being captured for use in future testing? Is there a way to assess the frequency of occurrence of "extreme" inflow conditions that can be used for turbine design and for O&M purposes?
- How limiting is the reduced scale aspects of the site?
- Open source is very important. A key issue today is the limited distribution of data primarily due to OEM (original equipment manufacturer) IP (intellectual property) concerns. I applaud the Open source approach and hope this can expand into other areas of the industry.

Comments made by reviewers during the evaluation of this project (PRID 223)
• The project plan is complete and includes a reasonable progression of activities to establish the systems required to run the facility. The details of the failure of the WTGa2 (Wind Turbine Generator a2) were not discussed, and it is difficult to assess if this could have been avoided.

- Facility and research seem duplicative with other test sites and commercial sector, limited in capabilities
- Excellent results within geographic and budget constraints
- Scaled identical turbines placed optimally for wake and wind plant flow measurement and model validation is the unique attribute of this test facility
- What was the root cause of fail on the one turbine that failed? Was it a deficiency unique to this turbine or was the lesson applicable across the industry?
- Group NIRE? Low cost for-profit testing company is a shared resource with Texas Tech. This is an efficient management strategy. They do certification testing?
- Location in Texas Panhandle is excellent. Consistent wind, flat terrain.
- Open source turbine. Controller is public. Dynamics model publicly available.
- Project methods and approach are outstanding, ensuring a researchable database for future works

Question 3: Technical Accomplishments and Progress

- Build-out and operation of the site is a major accomplishment, but the site needs to be continuously modernized to be relevant to industry. Can DOE keep up with the evolving nature of the industry?
- Major findings are still pending
- There is apparently existing commercialization of the facility as data related to improved control systems has already been sold to Vestas. It is not clear how these funds have been used to further expand the facility or offset DOE support. Given financial pressures, it is important that a potential commercialization of the facility be accelerated.
- Usefulness of testing Multi-Rotor Wind Turbine questionable; other progress disappointing
- Developed, documented and commissioned 300 kw turbines
- Setting up operations and testing for research ready wind plant test site is a significant accomplishment
- Hardware in the Loop is a very exciting concept. Directly applicable to end user's needs.
- In some ways difficult to discern, however, if same accomplishments could be met at other existing test facilities

Question 4: Project Management

- The site seems to be well managed
- The project seems to have met the established objectives on time and within budget, however, the information provided in this regard was limited
- See earlier comment on WTGa2 failure
- Milestones cancelled and turbine failure raise concerns
- Prioritize on highest value unique capabilities for the program. I assume that would be reference quality wind plant model validation data.
- Ramping up new test facilities to meet a specific set of requirements with all the requisite on-site support and operations is not easy. This was done well.
- Project management appears excellent, based on accomplishments to date
- Regardless of any overlaps, SNL's wind test site is a world-class operation and recognized internationally as such

Question 5: Research Integration, Collaboration, and Technology Transfer

- The open source and data sharing aspects of the facility are real assets to the wind energy enterprise
- The core partner list only included Vestas as an OEM representative. Should additional OEMs and turbine types be added?
- Ties to TTU (Texas Tech University) for educational purposes is an important feature
- A significant number of public and private entities have been involved in this program. The collaboration between other researchers is very strong. This is critical given the overlap and integration with other associated R&D efforts.
- Impressive lists of collaborators and cost sharing, however would like to see some research more clearly relevant to distributed wind within this level of budget
- Good that all data from DOE funded activities at SWiFT all engineering specifications and models are publicly available and downloadable

Comments made by reviewers during the evaluation of this project (PRID 223)

- Good collaboration with other labs and facilities
- Good industry partners
- Is the primary customer for the research quality data the other DOE laboratories running HPC wind plant models? I believe other DOE laboratories (other than NREL) collaborating in requirements but were not mentioned as much as industry partners in report.
- Collaboration across industry, academia, and other labs is exemplary

Question 6: Proposed Future Research, if applicable

- Not a lot of detail was provided w.r.t. future research, but the facility has a lot of potential to provide verification datasets for research and industry
- The collection of real data to support all aspects of technical issues in this industry is critical (e.g., resources, loads, wakes). It is very clear that there is a substantial amount of potential for further optimization within the industry at large. The future tests that are proposed for Swift should help to realize these goals.
- Applicability to distributed wind unclear
- Continued research on wind farm optimization is critical for end users and continued success in deploying wind power in low and medium wind speed sites

Question 7: Project Strengths

- This type of facility is unique and very much needed
- The value of high quality data from multi turbine tests is substantial and could have a "game changer" impact on the industry
- Wake-steering wind plant controller could potentially be applicable to distributed wind installations in industrial settings
- Supporting OEMs assessing technical advancements and risks
- Unique wind plant test facility
- Optimum location for research on wind turbine wake analysis
- Unique, open-source wind plant that allows the study of interaction effects is important and a critical need for wind industry

Question 8: Project Weaknesses

- Facility needs to ensure it can keep up with industry developments to remain relevant for the long term
- While there are no direct conflicts with other existing facilities, given the limited funds available for these types of facilities, it is extremely important that SWiFT focus on expanding our ability to acquire data to address technical gaps rather than refining data acquisition that may be available from other facilities, but with less fidelity or accuracy.
- Would like to see more progress/outcomes for this scale of budget
- None

Question 9: Recommendations

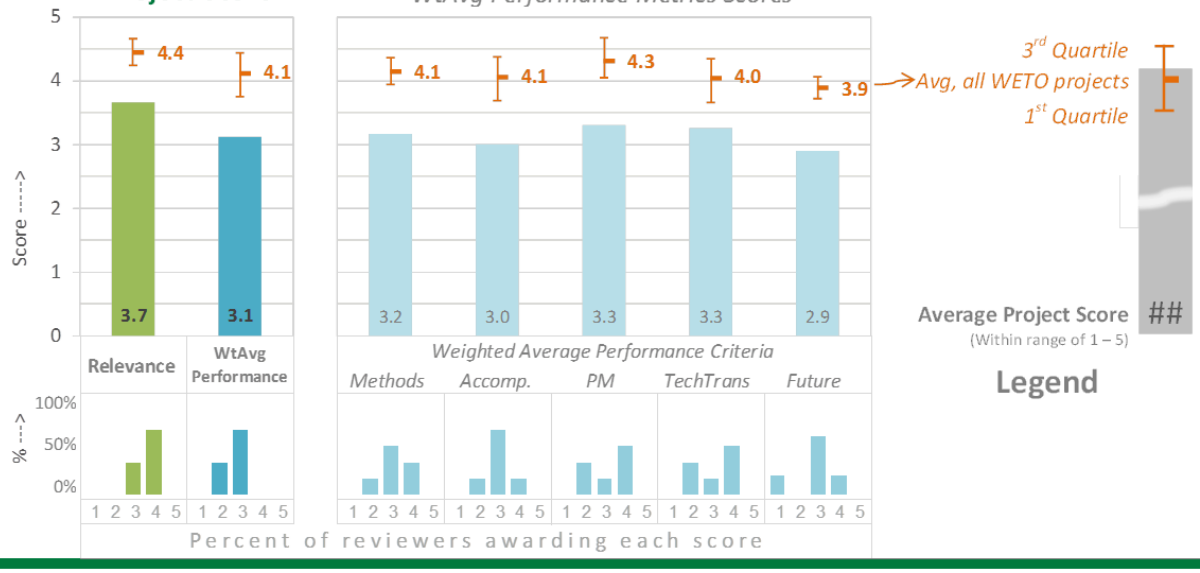
- If substantial program cuts are needed this seems to be a site that could be transferred to the commercial sector, while preserving public investments to date
- Focus on the highest priority tests that capitalize on unique capabilities
- If possible, research on ice throw distance would be valuable for end user's determination of setback requirements. We receive constant push-back from town councils on setback distances due to concerns on ice throw. There is a large body of research on the topic, but no wind tunnel or full-scale testing that we have been able to find.
- There appears to be some overlap between the facilities

DOE Wind Energy Technologies Office 2017 Peer Review Project:

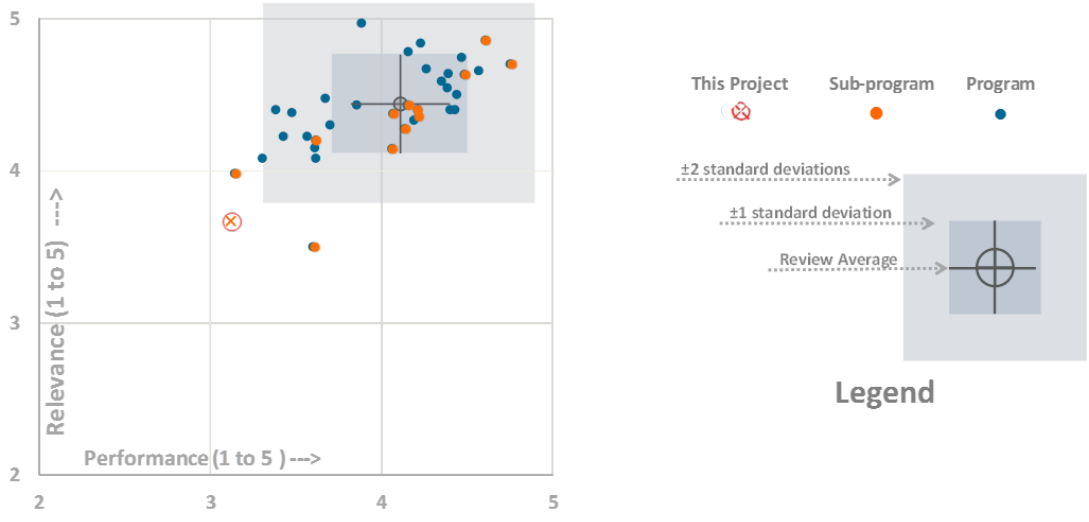
Advanced High Torque Density Magnetically Geared Generator

Principal Investigator	Jonathan Bird, University of North Carolina at Charlotte			
Program	Wind Resource Characterization and Technology RD&T			
Sub-Program	Innovation, Manufacturing, Reliability, and Testing			
FY 2014-2016 Funding	DOE	$ 0.5 M	84%	
	Cost Share	$ 0.1 M	16%	
	Total	**$ 0.6 M**	**100%**	Peer Review ID# 236

Project Score



Comparative Scoring



Comments made by reviewers during the evaluation of this project (PRID 236)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- This appears to be the type of fundamental research and development with high potential payoff that is appropriate for DOE investment
- Budget is rather small
- This project is relevant, however, it is unclear if the product of this work will scale to have any tangible effect on the industry before other competing alternatives come online
- Pioneering work on novel design, potential new pathway for WT (wind turbine) design, possible applications for both distributed (100 kW+) and off-shore wind
- Thermal efficiency not sufficiently addressed--a preliminary assessment of such and potential for improvement should have been considered prior to funding, or at the very least, should been a project deliverable
- How is this different than ManoMatics design (https://www.youtube.com/watch?v=4XfB29wTrRM): mainly this approach uses a higher ratio than others but in fact they had to go to multiple stages to get the ratios they wanted. If I understand this correctly that essentially says they have the same ratio available in other systems.
- Is model validation one of the goals?
- Is demonstrating efficiency one of the goals?
- Reliable low cost drivetrains are very relevant for the industry
- High efficiency is part of achieving low LCOE (levelized cost of energy) so measured efficiency must be a high priority to validate COE (cost of energy) model
- Very unique method of speed increasing technology. Major challenges remain with managing thermal issues which affect efficiency. Upcoming demonstration project is very small, indicating we are years from a suitable multi-megawatt prototype. Not clear in the presentation how many others are doing similar work, and the differentiation of this work to other's work. Claims much existing work has been done by EEs (electrical engineers), but many challenges are mechanical in nature. From an end users perspective, more effort should be put into direct-drive technology, and bypass the gearbox altogether.

Question 2: Methods and Approach

- Appears sound for this type of somewhat risky R&D
- The project plan of design, analysis and scale testing was appropriate for this effort and consistent with SIP (standard industry practices)
- Differentiated from other research - focused on higher torque density, involving mechanical engineers as well as electrical engineers
- Appealing if goals can be met but program doesn't demonstrate such
- Demonstrated heating and electromagnetic efficiency?
- Is torque density the best metric? It's easily quantifiable and objective but misses the cost and efficiency. I believe a cost model is needed that reflects the cost of materials, fabrication costs, performance/efficiency impacts.
- How is this different than two Magnomatics machines connected in series?
- The methods and approach looked reasonable for this project

Question 3: Technical Accomplishments and Progress

- The research is resulting in learning as it goes forward. Not sure about final outcomes at this stage.
- The test results that were presented are positive, but there is not enough yet done to show clearly that this design will work as intended
- Behind schedule due to unforeseen experimental testing issues, change in design approach
- They have built a scaled model but it doesn't represent a 59:1 ratio in one stage
- Low cost effort. This project needed funds to do a magnetic model and adequate thermal analysis. Good idea, just a bigger challenge than funds allowed.
- This needs a more serious design effort to demonstrate the real challenges
- Wasn’t integration of the generator part of the goal? Worthy goal but it appears that design challenge was not possible within the constraints of this project.
- The technical accomplishments for such a complex project looked reasonable for a 2 year timeline

Comments made by reviewers during the evaluation of this project (PRID 236)

Question 4: Project Management

- Appears sound
- Some delays and cost overage
- The budget for this effort is very low. Therefore, while the comments above are generally more negative, the project has still delivered a reasonable ROI (return on investment) for the amounts invested.
- Slipped milestone and PI's (Principal Investigator's) relocation raise concerns
- Great effort to get into even a scaled test stand
- Needed more analytical support to work out design difficulties
- Project management looked good for the complexity of the project and timeline

Question 5: Research Integration, Collaboration, and Technology Transfer

- There is a solid industry partner team
- Good technical advisory board, however, it became clear during the presentation that the board has not been involved in a long while, if ever
- Involvement of multiple OEMs (original equipment manufacturers) and other industry stakeholders on advisory panel helps ensure broad relevancy
- Good to see local cost sharing and publications
- Industry collaboration would have helped focus on relevant variables
- The industry partners appear to be good but were they engaged enough to help with the technical challenges
- It does not appear reasonable effort was expended in soliciting feedback from end users prior to project start, or during the project

Question 6: Proposed Future Research, if applicable

- Not clear at this stage what the appropriate next steps will be, but probably should continue work
- Prior to any further development, there needs to be a clearer identification of how full scale performance can be achieved. The work now seems to be too exploratory.
- Ensure design challenges are resolved before investing in larger scale prototype
- A high ratio box with integrated generator is a worthy goal but the level of funding and expertise to complete appears more than available
- Upcoming testing results should provide guidance on future research

Question 7: Project Strengths

- This work has a lot of potential well beyond wind energy
- The concept of magnetic generators is a good one and deserves attention
- More efficient use of materials (steel, magnets, copper)
- Unique perspective of alternative technology to gear-driven speed increasing gearboxes

Question 8: Project Weaknesses

- This is risky R&D and not clear how much success is possible with this level of effort and how it compares to other related R&D
- If this concept is viable, it deserves more support from the private sector. The DOE should not have to carry the ball fully on this one.
- Some claims are questionable
- Much of past work has been by EEs but the real challenges are mechanical. Getting air gaps down is a mechanical challenge.
- Back iron requirements probably too great and efficiency too low to be competitive with existing technology--program doesn't address these critical variables

Question 9: Recommendations

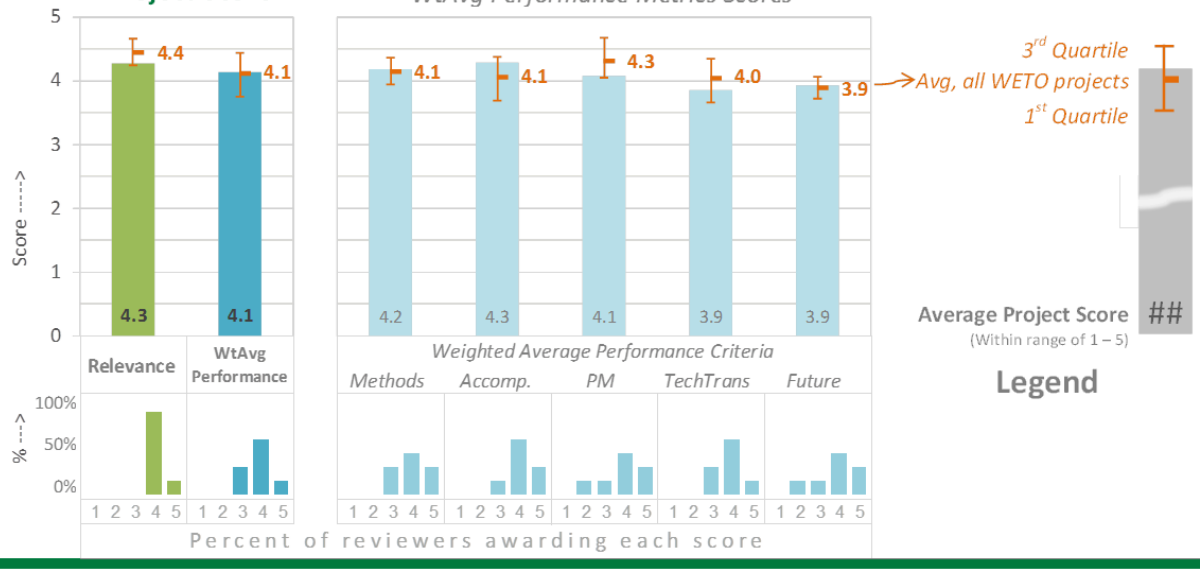
- Continue investing in this area
- Consider reducing scope to focus on smaller-scale wind turbine design
- Consider just developing a preliminary LCOE model

DOE Wind Energy Technologies Office 2017 Peer Review Project:

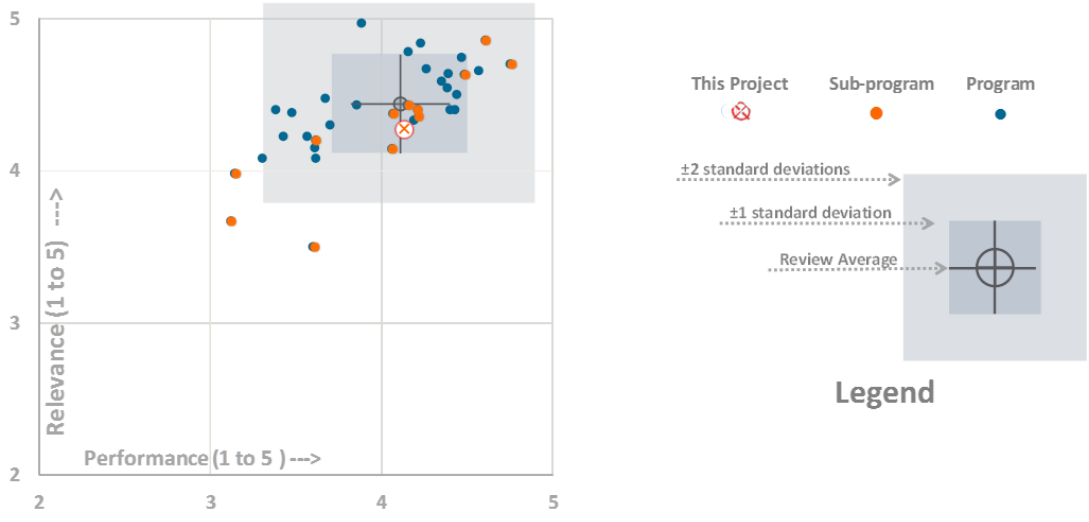
Development of On-Site Tapered Spiral Welding for Large Turbine Towers

Principal Investigator	Eric Smith, Keystone Tower Systems			
Program	Wind Resource Characterization and Technology RD&T			
Sub-Program	Innovation, Manufacturing, Reliability, and Testing			
FY 2014-2016 Funding	DOE	$ 1.0 M	77%	
	Cost Share	$ 0.3 M	23%	
	Total	**$ 1.3 M**	**100%**	Peer Review ID# 237

Project Score



Comparative Scoring



Comments made by reviewers during the evaluation of this project (PRID 237)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- This is an excellent example of how an SBIR (Small Business Innovation Research) project can stimulate new technologies or applications
- Project does well in establishing both feasibility and cost savings, very well aligned with program goals
- It would be helpful to know how much cost reduction comes from weight reduction (seems like 1/3) and how much comes from savings realized by on site fabrication
- The project has created multiple avenues to add value
- Research could have relevance to distributed wind sector, which has high priority need to produce monopole towers less expensively
- Approach could help increase domestic content/create local jobs, reduce transportation and installation costs
- Represents advance in manufacturing technique
- Reducing amount of steel has important environmental benefits
- Extremely relevant to industry and market needs and DOE objectives
- Goal of expanding cost effective wind resources to larger areas of the U.S. using taller towers is very worthy goal
- Onsite manufacturing is key strategic limitation requiring research
- Increasing rotor height above ground increases energy capture
- Currently, a 100m tall tower is the tallest tower that is cost effective to transport within the United States for our projects. Alternative tower manufacturing methods are necessary to realize cost-effective taller tower installations.
- If LCOE (levelized cost of energy) reduction projections are accurate, this can be key to reducing costs

Question 2: Methods and Approach

- The technical approach and collaborators required to be successful were well considered
- The project plan is appropriate for its goals and objectives. Taking the process from concept, through engineering and prototype is good.
- Good to consider crane sizes, smallest projects needed to be cost effective
- Greater clarification on cost effectiveness of approach to supply tall towers for kW-scale distributed wind applications would be useful
- Spiral welding comes from pipeline industry. Leveraged bridge industry and oil & gas recovery industries.
- Focused on meeting tolerances and specifications. Initially working with Vestas but also working with other OEMs (original equipment manufacturers). Attention to certification needs of towers.
- Can take 200T out of tower weight. Cost increase less than energy increase of turbine.
- Spiral welding is an established technology. Applying it to on-site tower manufacturing has multiple advantages of enabling large diameters. Tapered spiral welding for onsite high quality manufacturing could also enable larger onshore turbines.
- Transportation constraints are avoided…
- Post fabrication QA automation?
- Hybrid onsite manufacturing? Large segments onsite joined with offsite smaller segments?
- Variable diameter and wall thickness are possible
- Reduced tower weight enabled through larger diameter tower bases
- Eric has researched all of the relevant variables to enable on-site or near-site tower manufacturing

Question 3: Technical Accomplishments and Progress

- Results to date seem to be very encouraging with materials and time savings
- One tower produced every two days is workable and matches erection periods
- The 40% cost reduction comparison is still somewhat unclear, but a 40% reduction in LCOE, which includes both resource and cost benefits (what is the ratio?) is a substantial accomplishment
- If the 40% cost reduction is proven through an actual field application, this process could represent a significant game changer for the industry

Comments made by reviewers during the evaluation of this project (PRID 237)

- Certification useful but need more assurance on QA, confirming economic analysis
- Mfg aligned with field deployment
- 3MW turbine project. Construction time and quantity reduction, can cut turbine requirement in half for same energy delivery. 40% reduction in LCOE. 8%-10% added cost for 20-yr to 40-yr life. Working with tooling mfg's.
- Can do inline inspection along with the welding process. Spiral welding is 3x faster and 20% cheaper.
- Scaled in-factory demo has been accomplished
- Need a field demonstration which was obviously beyond the scope and funding possible in this project
- Can produce a tower every two days, consistent with erection schedules
- Tall towers require tall cranes which require new roads. Still challenges.
- Maintenance access requires elevators which require federal, state and local inspections
- LCOE reductions appear optimistic
- Spiral welding is an established technology, this work applies spiral welding technology to tapered tower manufacturing

Question 4: Project Management

- It appears that the project was well managed and generated very promising results
- There were some delays that seem to be on the DOE
- The project budget is appropriate for the effort and brings a significant ROI (return on investment) to the DOE program
- Explanation for project delay was unclear
- There appears to be excellent management of this project

Question 5: Research Integration, Collaboration, and Technology Transfer

- The team is working well with industry and the follow-up plans seem to be poised to take it to the next level
- The project seems to have been well integrated with industry stakeholders. This is a particularly important quality for a development like this with immediate practical applications.
- Good to see involvement of multiple industry partners and 30% cost share. However, a larger degree of collaboration would help relevancy to more sectors of wind industry, particularly for distributed applications in remote locations and smaller wind turbines.
- Good industry partners and collaboration
- Good focus on relevant in-field manufacturing issues
- Great collaboration across major industry partners. It's not apparent to me how much collaboration was between the National Laboratories or other DOE facilities with Keystone.
- Encourage better collaboration with offshore wind industry

Question 6: Proposed Future Research, if applicable

- This project seems well poised for a demonstration project
- It seems as if this project is now progressing into commercial applications and may not require any further support from the DOE. Therefore, while there is clearly additional value to be gained through further demonstration of the concept, this may no longer require DOE funding.
- Unclear that a 160m+ hub height demonstration project is the best next step, would prefer seeing additional testing of smaller-scale applications
- Would like to see in-field demonstration, either scaled or better yet, at scale
- The project is complete. If any future research is funded, I would recommend a focused effort on ensuring high quality, reproducible welding. Weld quality control is extremely critical to the longevity of this technology, especially when applied away from a traditional manufacturing facility.

Comments made by reviewers during the evaluation of this project (PRID 237)

Question 7: Project Strengths

- Great collaboration; project achieved its goals; tech transfer is occurring
- This process uses existing technologies that have been developed in other industries so there is very little technical risk that comes from uncertainty in the process itself. If the suggested cost savings are confirmed, this process can potentially be deployed very quickly.
- Pioneering application of in-field manufacturing process used in the pipeline and piling industries to fabricate wind towers at project site
- Leverages existing technology
- More of a logistical than a technical challenge
- Highly promising opportunity to provide substantial LCOE reductions
- Highly enables lower wind resource regions to deliver wind energy competitively
- More aesthetically pleasing finished product than other tall tower options
- This technology appears to be ready for an infield demonstration at scale with an industry partner
- Can the LCOE estimates be independently confirmed
- Eric and his colleagues at Keystone Tower Systems have presented this concept to the Construction and Development teams at Avangrid Renewables (the company I work for). These people provided me a summary of the meeting so I have been aware of this technology for about 1 year. Keystone has evaluated all the variables I could think of, including but not limited to; increased cost of technician access to taller nacelles, near-site transportation of large diameter base section, foundation design variations, painting, natural frequency, weld quality and inspections, etc.
- Strong potential for cost reduction

Question 8: Project Weaknesses

- More work is still required to understand long-term viability and endurance, but industry seems to be supporting this phase
- The presenter suggested that the concept would deliver both a 40% reduction in LCOE and 40% reduction in CAPEX (capital expenditures), which seems inconsistent. Further work is required to make this more clear.
- The work clearly has significant commercial applications and will provide value to the industry if the suggested savings are confirmed. The R&D aspects of this work are not as significant as other projects and it is not clear why this project could not have been fully funded by the private sector.
- Some claims, such as 40% LCOE reduction and 3x increase in developable land, are questionable
- Portable factories require substantial, temporary space
- Portable factory setup/storage/relocation is a substantial effort and cost
- Product quality assurance has added challenges for in-field/portable manufacturing facilities
- Must demonstrate infield at scale
- None identified at this time
- Manufacturing close to deployment site is already needed for offshore wind. What additional contributions does this work potentially have for offshore wind? Should be explored.

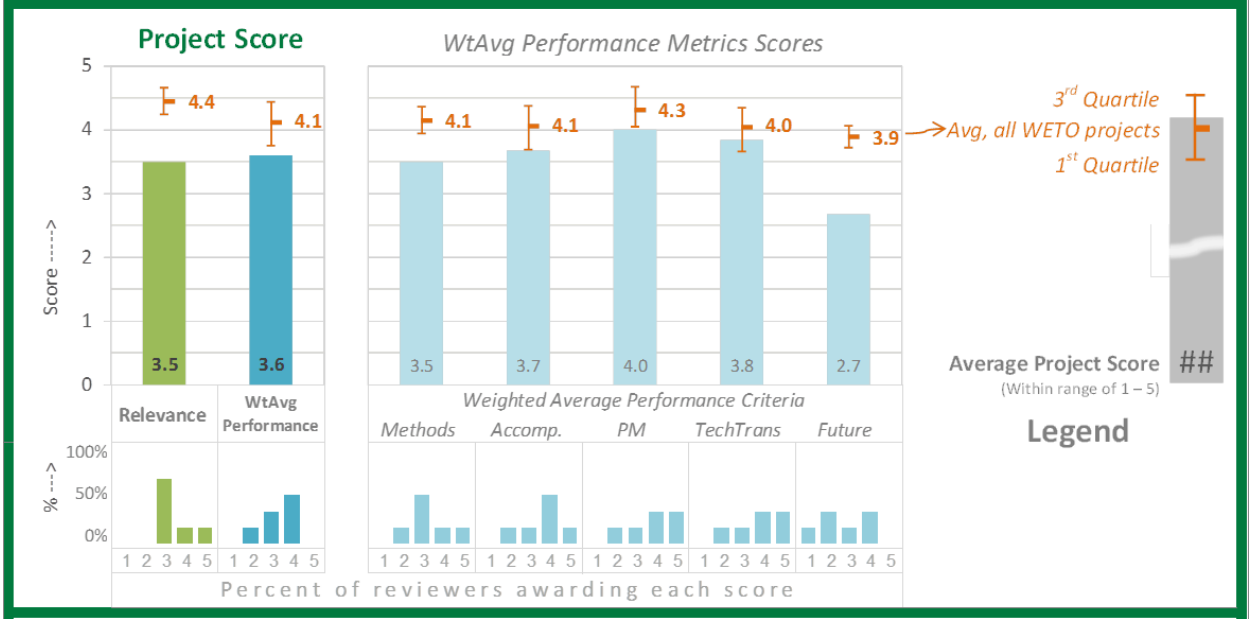
Question 9: Recommendations

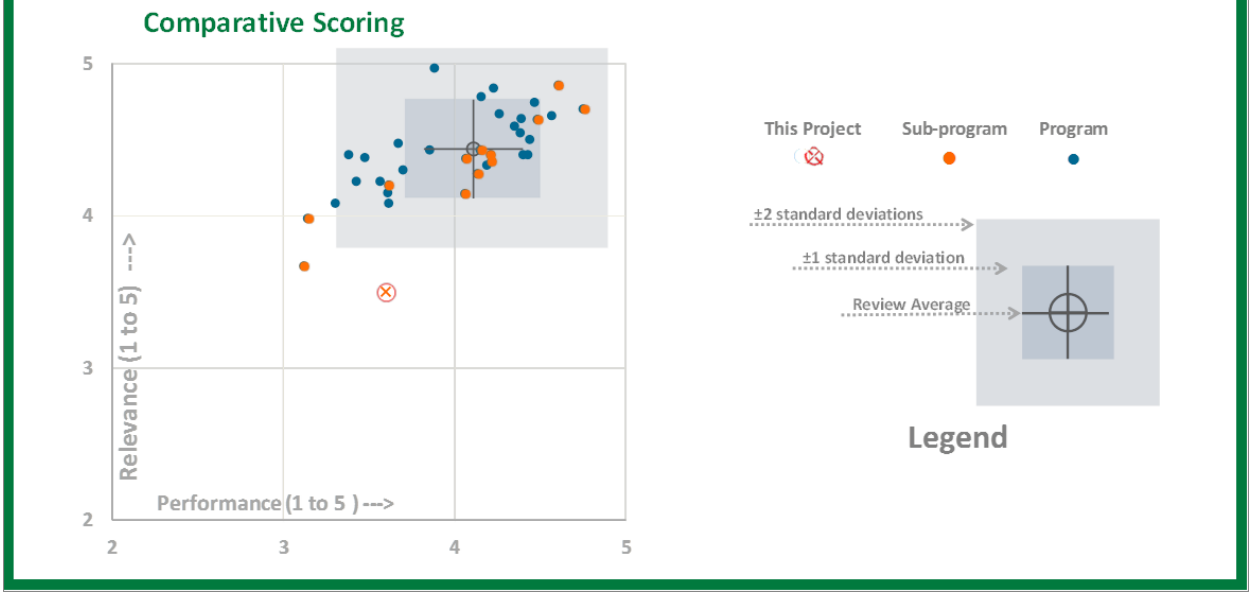
- Follow-on RD&D (research, development and deployment) of this approach, particularly in reducing soft costs due to permitting and mobile manufacturing related to remote/distributed locations, is warranted
- Invest in dialogues with wind project developers and constructors from multiple organizations for exchanges of information on temporary land use, logistics and costs
- Continue research. The end users need taller tower options, and a step-change in manufacturing techniques is needed.

DOE Wind Energy Technologies Office 2017 Peer Review Project:

Hexcrete Tower for Harvesting Wind Energy at Taller Hub Heights

Principal Investigator	Sri Sritharan, Iowa State University			
Program	Wind Resource Characterization and Technology RD&T			
Sub-Program	Innovation, Manufacturing, Reliability, and Testing			
FY 2014-2016 Funding	DOE	$ 1.0 M	80%	
	Cost Share	$ 0.2 M	20%	
	Total	**$ 1.2 M**	**100%**	Peer Review ID# 238





Comments made by reviewers during the evaluation of this project (PRID 238)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- This is another excellent example of how an SBIR (Small Business Innovation Research) project can stimulate new technologies or applications. Success will lead to a lower LCOE (levelized cost of energy) and could support local manufacturing.
- Project is relevant, but the findings of the study do not demonstrate a strong added value. LCOE 10%.
- The brief and presentation do not clearly describe the process and findings of the study
- Good goals to increase local manufacturing & reduce dependence on foreign steel, but practicality of design unclear
- Research currently doesn't but possibly could in the future have relevance to distributed wind sector, particularly in producing monopole towers at distant/remote sites (including southeastern United States)
- Theoretically could help increase domestic content/create local jobs, reduce transportation & installation costs
- Leveraging of bridge/bldg design and technology and existing precast industry reduces risk
- While tower height has DOE goal relevance, objectionable aesthetics is a substantial distractor
- Self erection potential? It was investigated but minimizing the crane onsite time was the governing factor
- Must have a much longer design life than 20 years due to life extension of aging fleet
- Fatigue life of concrete? Governed by post tensioning system?
- Suitable for small turbines?
- Can LCOE (levelized cost of energy) benefits be verified?
- The post tensioning system was not discussed in any detail but obviously it is critical to the success of this type of tower. Long term maintenance of the post tensioning system must be considered as part of the LCOE analysis.
- Increasing rotor height above ground increases energy capture
- Currently, a 100m tall tower is the tallest that can be cost effectively shipped within the United States for our projects. Alternative manufacturing methods are necessary to achieve cost effective taller tower installations.
- See comments in Project Weakness section for concern on the visual impact of this technology

Question 2: Methods and Approach

- It appears that the right combination of local manufacturers were involved and fatigue testing of a variety of designs was appropriate
- Integration with industry partners is good and needed for a project such as this
- The project has not fully addressed, or presented on, all of the technical issues related to Hexcrete tower construction. It is not clear if this is a limit to the project or presentation.
- Good to prioritize crane costs and testing, but would like to see more progress for this scale of budget
- Solid engineering approach. Targets comprehensive needs.
- Technically feasible design, however, continued investment not recommended
- Earthquake tolerance? Probably pretty good since the resonant frequencies are likely to be relatively low resulting in a compliant structure.
- Standards and certification requirements?
- There are many joints inherent in this system. Each joint is completed in the field with a secondary bond. Most of the critical joints are held in compression with post tensioning but not all it appears. Secondary bond efficiency and bond quality control?
- Concrete towers have typically been challenged to deliver the stiffness and dynamic characteristics needed. Was a system dynamics analysis done? Frequency compliance?
- Concrete performance in cyclic compression, shear and tension?
- Adding internal features needed for mounting ladders, conduits, elevators, access ports?
- The project demonstrated good methods and a reasonable approach to meeting its goals

Comments made by reviewers during the evaluation of this project (PRID 238)

Question 3: Technical Accomplishments and Progress

- Good progress was made and a business plan to take it forward was prepared
- The project partially establishes the feasibility of the concept but has not delivered on lower, reliable cost reductions
- Slipped milestones
- Claims that approach will lead to 67% increase in U.S. land area for wind energy production and 20% LCOE reductions are questionable
- Good concrete manufacturer partners
- Siemens is good turbine OEM (original equipment manufacturer) partner
- Full scale laboratory test very impressive
- The project appeared to show encouraging results toward achieving the goal of designing a suitable tall tower

Question 4: Project Management

- No deficiencies could be identified
- Academic approach seems to present challenges with working at industry speed
- Numerous typos in materials lead to questions on quality control of research, overall work products
- Appears technically well managed but public acceptance overlooked
- Good industry partners
- The project appeared to be well organized and well managed

Question 5: Research Integration, Collaboration, and Technology Transfer

- Outreach seems appropriate for this effort
- The project had impressive lists of collaborators and publications, however focus seems misplaced before field results are available
- Good to see state cost sharing
- Good industry partners
- There appears to be good coordination between industry, end users, and national labs
- No evidence of collaboration with offshore wind industry

Question 6: Proposed Future Research, if applicable

- This project seems well poised for a demonstration project
- A small-scale field demonstration of the tower design on a distributed wind installation could be useful
- Defunding of current approach recommended due to objectionable aesthetics
- The project is complete, but if future research is conducted, the maintainability of the post tensioning cables and hardware is critical to understanding how maintainable this system is
- The visual appeal of the structure must be improved. See comments in Project Weakness section, below.

Question 7: Project Strengths

- Excellent concepts to re-apply this technology for tall towers
- Reducing amount of steel has important benefits to the economy
- Leverages bridge/bldg design and technology and existing precast industry. Enables local manufacturing. Addresses transportation challenges.
- Leverages existing precast concrete industry
- Concrete is a very low cost indigenous material that should be explored
- Recognition that cost-effective taller towers are necessary for increased energy capture
- Major strength is avoiding foreign steel markets

Comments made by reviewers during the evaluation of this project (PRID 238)

Question 8: Project Weaknesses

- Still need to do some exploration as to the overall feasibility of using this technique more broadly across the country
- The summary that was provided for this project is poorly written and contains a number of errors
- Manufacturing and aesthetic challenges
- The wind industry has been and remains challenged with public acceptance most significantly due to visual impact and what is sometimes characterized as "industrialization"
- Albeit subjective, and precisely the point, individual turbine and tower and overall plant design must include a high degree of sensitivity to aesthetics to maintain and improve public acceptance. Clean, smooth, less industrial shapes, transitions and symmetry are necessary for visual acceptance, even attractiveness. This project's efforts are not sufficiently sensitive to this point.
- The aesthetics of this approach could be challenging
- As owners/operators, we are subject to public opinion on the aesthetic appeal of wind turbines. The visual signature of the proposed tower will further challenge our tenuous relationships with town councils and nearby landowners. The structure is too industrial looking and will further challenge wind installations in more populous areas of our country.
- While post tensioned concrete structures are a mature industry, I see O&M (operations and maintenance) challenges with this concept. If further research is conducted, I would like to know how we will be able to cost-effectively inspect and remediate any issues with the post tension cables and hardware.
- Unclear whether or not this has an application to offshore wind. Concrete I believe is applicable only for gravity-based subsea structures. Where those are headed compared to other subsea structures is unclear.

Question 9: Recommendations

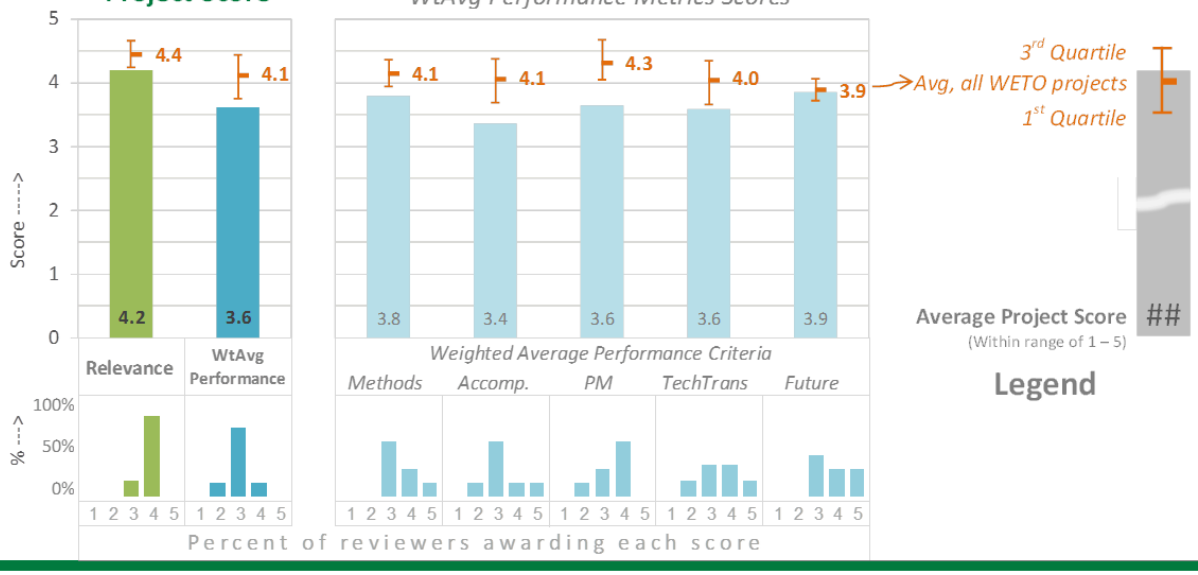
- Continue with demonstration project to demonstrate feasibility
- Continue to learn more about concrete longevity and testing processes to reduce risk
- Future RD&D (research, development and deployment) in this area should include reducing soft costs due to permitting and mobile manufacturing related to remote/distributed locations
- Consider a design approach that provides smooth, clean visual lines
- Consider larger footprint to reduce costs
- It is reasonable to encourage continued research, however, general public comment of the visual appeal of such structures should be solicited to provide feedback on possible design changes

DOE Wind Energy Technologies Office 2017 Peer Review Project:

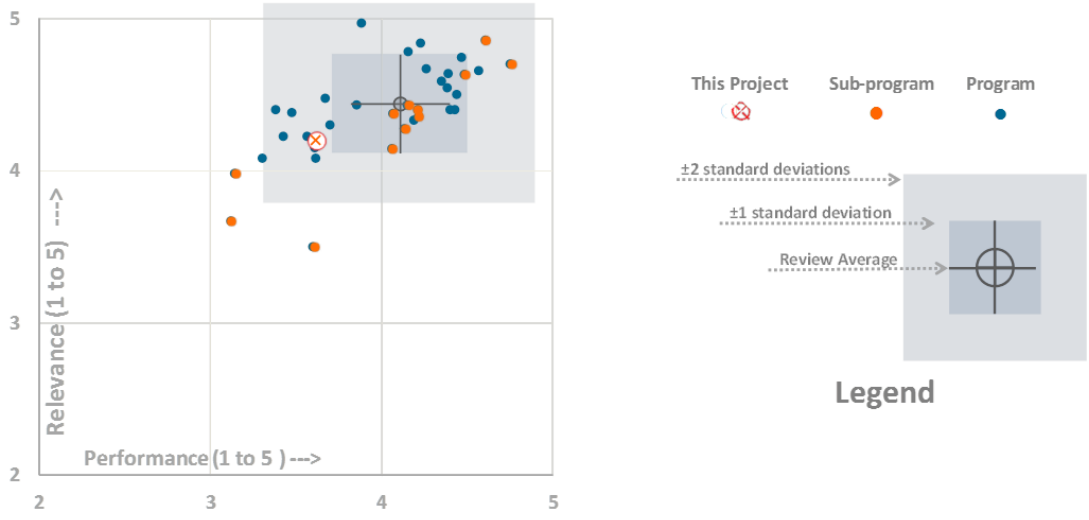
Online Intelligent Prognostic Health Monitoring

Principal Investigator	Wei Qiao, University of Nebraska–Lincoln			
Program	Wind Resource Characterization and Technology RD&T			
Sub-Program	Innovation, Manufacturing, Reliability, and Testing			
FY 2014-2016 Funding	DOE	$ 1.5 M	90%	
	Cost Share	$ 0.2 M	10%	
	Total	**$ 1.7 M**	**100%**	Peer Review ID# 239

Project Score



Comparative Scoring



Comments made by reviewers during the evaluation of this project (PRID 239)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- There is a strong industry need for advanced remote monitoring capabilities. This need will increase with offshore wind.
- This project has a strong objective and could offer high value across the industry, but it is unclear if the result of the work meets the goals of the project
- Real time health monitoring is a mature concept that has been applied to several other industries. Leveraging this process with prognosis is interesting, but the means to achieve this were not described very well.
- Low-cost prognostic health monitoring is a high priority area of focus for the distributed wind sector, as identified in the SMART (Sustainable Manufacturing, Advanced Research and Technology) Wind Roadmap
- Technology development has enabled data and analytics to become an important component of the future design and reliability improvements that will lower the LCOE (levelized cost of energy) of wind
- Good innovation on combining and analyzing data
- While robust condition monitoring systems are very important to wind turbines both on and offshore areas have matured significantly. This approach appears to compete with multiple commercial condition monitoring systems which claim to have prognostication capabilities.
- The novelty appears to reside in the diagnostic algorithms that enable disaggregation of transient speeds and loads to extract feature details with enough detail information to isolate fault characteristics and track trends. This strategy is implemented by other CM (condition monitoring) systems. The unique addition is the current signal which is a proxy for torque.
- From our perspective, condition monitoring has been tough to justify in our business model. We have evaluated several technologies, all of which have strengths and weaknesses. Sensors appear to be a mature industry, but signal processing is not yet mature. Systems evaluated to date need highly detailed gearbox design information (bearing details, gear details, etc.). Trying to get that information from gearbox suppliers has been difficult. Next challenge is data interpretation, usually needed to be done by an expert. Last challenge is cost, and ROI (return on investment). Many claims of reduced maintenance costs are not true, as if the damage is in the planet section, cost to remediate is still very high.
- We would most likely not implement this technology as a retrofit. Capital costs to retrofit the fleet are significant. Signal processing and simple 'red light, green light' annunciation is not yet fully developed. Questionable ROI claims based on repair cost assumptions.
- Implementation on new projects is possible, but simplified failure annunciation is critical to acceptance of the technology

Question 2: Methods and Approach

- Combines machine learning and spectrum analysis to extract generally weak fault signals
- Field testing was performed on several drivetrains for diversity
- Includes a prognosis component for predicting remaining useful life
- Still need some clarity on how the "training" dataset was generated
- The overall program was well conceived and consistent with SOP (standard operating procedure) methods for health monitoring systems
- Approach is innovative and good to see lab and field testing conducted on commercial small-scale wind turbines, however involvement of only one industry partner has limited scope and applicability of results
- Usually frequency based diagnostics are difficult with significant non-linearities in the system
- Is plant model integrated into the PHMS (prognostic health monitoring system)?
- Can you assess operational loads compared to design loads and hence whether the turbine is operating within its design limits?
- How are wind turbine physics integrated into the PHMS?
- Using a tiny wind turbine in a wind tunnel presents scaling questions
- Testing on the GE 1.6 is a meaningful scale. More description of fault detected, how features were extracted, how the faults were tracked and results from those tests would be appreciated.

Comments made by reviewers during the evaluation of this project (PRID 239)

- The methods and approach look reasonable for this project. Interesting concept of obtaining potential or impending damage from generator electrical signals in conjunction with traditional vibration signals.
- As mentioned earlier, signal acquisition and processing is only part of the challenge. Distilling the data down to a 'red light or green light' output, and that output sent to a central control facility, is an equivalent-sized challenge.

Question 3: Technical Accomplishments and Progress

- This is the first major attempt to include a prognostic failure capability
- Testing to date appears to have resulted in solid results
- More testing is probably necessary to prove performance
- The systems developed were able to properly identify the faults during field tests, however, it is not clear if this system would be able to account for the range of faults that might occur during actual operations
- Great to see that faults in numerous components were successfully diagnosed solely using current and/or vibration signals, and that RUL (remaining useful life) was predicted well before alarm system was triggered so maintenance could be scheduled before actual failures occurred
- Laboratory and Field validation of technology is encouraging to warrant further investigation of the accuracy of the technology

Question 4: Project Management

- This project management seems solid
- Project was delayed
- Schedule delays due to contract negotiations with industry partner raise concerns about cost of system for other OEMs (original equipment manufacturers)/operators and relevance for distributed wind sector
- Project management looks acceptable to me

Question 5: Research Integration, Collaboration, and Technology Transfer

- The partnership with GE and other collaborators was solid
- Was the multitude of 3rd party condition monitoring companies heavily engaged?
- While collaboration with GE was mentioned, the integration with other researchers and private entities seemed limited. Given that this is a mature topic in other industries, there may have been more value added to this project with greater outreach.
- Impressive list of publications, however patent applications for work 90% funded by DOE raises concerns
- Involving additional industry stakeholders would help improve relevancy for additional wind turbine models
- Collaboration limited to one OEM
- This publicly funded effort resulted in patents owned by GE?
- GE as industry partner exemplary
- The sole partner appears to be GE Global Research. Collaboration with end user is mandatory to get the true financial benefit picture.

Question 6: Proposed Future Research, if applicable

- There is a strong desire for improved condition monitoring and prognostic guidance, so the project should continue
- It's difficult to assess the viability of the future research opportunities for this program given that there is still some work to do on the existing scope
- Extending wind turbine prognostic health monitoring via remote sensing and data acquisition, improving reliability including diagnostic accuracy of power electronics using big data collected from many wind turbines, is a critical next step
- Extending to other non-drivetrain subsystems may be useful
- Project is complete

Comments made by reviewers during the evaluation of this project (PRID 239)

Question 7: Project Strengths

- High value if successful in producing a low-cost, reliable solution for the wind industry to reduce failure rates, O&M (operations and maintenance) costs, and downtime, improve reliability, and extend product life
- Focused in a high value-add area for reliability improvement
- Robust Condition monitoring is relevant

Question 8: Project Weaknesses

- This was a weak presentation in general and my comments are clearly impacted by the lack of information that could have been given during the briefing. I think that this general area still holds promise, but it is not clear to me if the current team can get there.
- Involvement of only one OEM indicates pricing will limit applicability for other wind turbine models
- Competes with multiple CM approaches also claiming robust prognostics

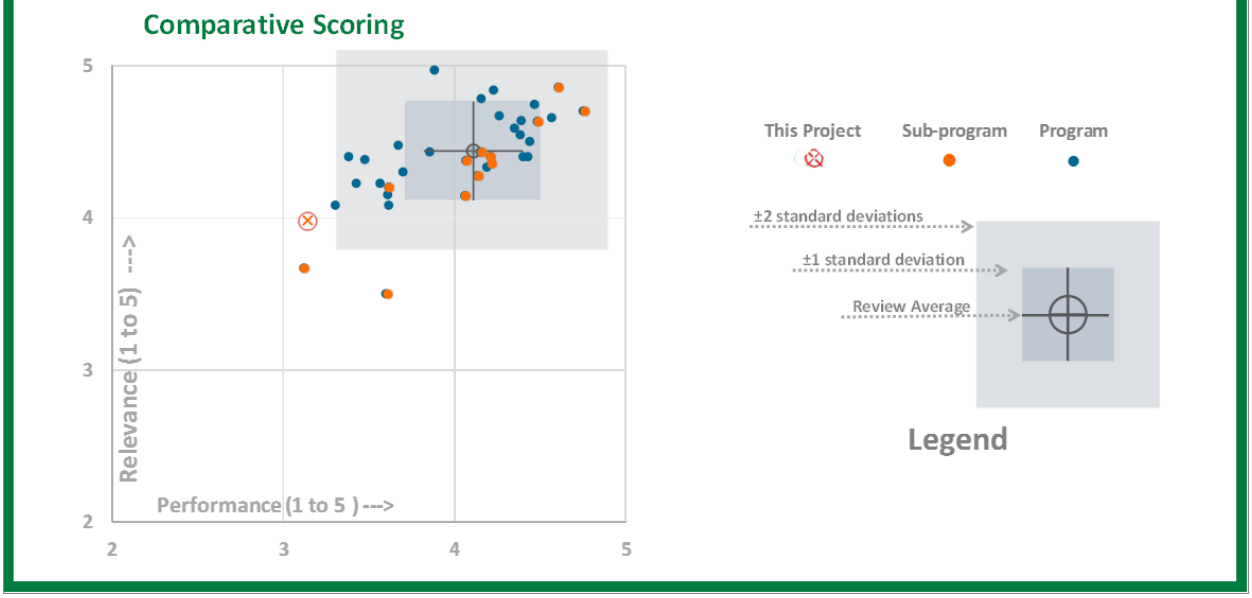
Question 9: Recommendations

- Additional RD&D (research, development and deployment) efforts in this area, including commercialization efforts involving additional OEMs, is warranted to reduce O&M costs, improve reliability and extend turbine life
- Discuss project with end users to get information on probability of industry acceptance

DOE Wind Energy Technologies Office 2017 Peer Review Project:

The Incubation of Next-Generation Radar Technologies to Lower the Cost of Wind Energy

Principal Investigator	John Schroeder, Texas Tech University			
Program	Wind Resource Characterization and Technology RD&T			
Sub-Program	Innovation, Manufacturing, Reliability, and Testing			
FY 2014-2016 Funding	DOE	$ 1.4 M	89%	
	Cost Share	$ 0.2 M	11%	
	Total	**$ 1.6 M**	**100%**	Peer Review ID# 240



Comments made by reviewers during the evaluation of this project (PRID 240)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- There is a need for improved clear and cloudy air sensing of the boundary layer flows and wakes for research and also for use in real-time plant optimization. These datasets are also useful for anticipating ramp events the radars can see gust fronts and other wind discontinuities.
- Lidar is good for clear air and radar (with a narrow beam width) is better for precipitation and cloudy air - there is a need for a system with lidar characteristics, but radar penetration, so there is merit to this topic.
- This project is relevant to the DOE's objectives, however, the work presented does not indicate a significant improvement beyond what could otherwise be deployed with existing systems
- Unclear why research needed as commercial solutions are available, did not incorporate Lidar; not relevant for distributed wind sector
- The industry is in indisputable need of effective array flow measurement technology
- Technology has added benefit of detecting avian neighbors
- Are there other products available on the market that duplicate this radar system?
- This new radar can use BRAGG and thermal gradients in the atmosphere to increase spatial and temporal resolution. Normally RADAR needs particulates in the air to get data returned.
- Game changer? "other X Band RADAR systems are not tuned for wind farm use. This system uses pulse compression which is needed because wind turbines cause pulse feedback. Fusion with LADAR (laser RADAR) would be a good approach" custom filtering added is unique to this system and required to prevent backscatter from turbine blades to differentiate from real data.
- Not my core area of expertise. It was not clear to me why developing a radar system was better than purchasing an 'off-the-shelf' system. I understand the over-arching priority is to measure complex wind flows throughout the windfarm, but it was not clear why the program top priority was to enhance data availability.
- Comments: Who is the typical end-user? X&Y plot, but Z plot? Many commercial X-band radars commercially available. Custom receiver, to mitigate certain windfarm-unique issues. Getting rid of ground clutter. Lidar/Radar research?

Question 2: Methods and Approach

- Why not buy an off the shelf x-band radar with some processing customization? It would seem like a lower cost and lower risk approach or use a lidar + radar combination?
- The project included a reasonable progression of system design, procurement and field testing
- Cost-effectiveness unclear to inform future turbine siting, operational strategies, proactive controls during complex flows, track birds
- Open questions about lower cost of leveraging existing available technology
- Customizing the software of a commercial system might have been faster and perhaps lower cost
- The methods and approach looked reasonable for this project
- Discussion during presentation suggested that perhaps the approach was overkill for the desired objectives

Question 3: Technical Accomplishments and Progress

- Upgrading the existing k-band to x-band seemed to be a more complex strategy then buying a new COTS (commercial off-the-shelf) x-band
- The data presented is impressive and it's clear that higher powered, low wavelength, systems will yield better results, but it seems that this project was performed to confirm what was already known
- Would like to see more progress and more timely completion of deliverables for this level of funding
- The resulting system works successfully and is a much needed asset for measuring wind plant flow
- The technical accomplishments appeared to meet program goals
- It is encouraging that industry players like DONG Energy are utilizing the technology but it would be interesting for DOE to get end-user evaluation. Also would be important to understand value of the technology development of THIS project v. the ancillary support systems developed by the company that commercialized. All in all, that signals a successful collaboration, but hard to tease out what could have been done by private industry v. what was needed to be done with federal funding.

Comments made by reviewers during the evaluation of this project (PRID 240)

Question 4: Project Management

- It seemed as though a lower risk approach could have been taken that would have resulted in a solution faster
- Some delays occurred
- Project delays not explained - final report 6+ months late
- Was a request for quotation issued to see if commercial suppliers could meet the required specification?
- Project management appears good as the program met its goals

Question 5: Research Integration, Collaboration, and Technology Transfer

- It seems that additional weather radar experts could have contributed to a less costly solution faster. Concerns that the industry partner was seeking funding to develop their own new radar system.
- There was limited industry involvement and collaboration with other labs in this project
- A higher level of cost sharing and collaboration might make the work more relevant. Tech transfer to date is disappointing.
- It appears a startup company resulted from this work
- The program appeared structured toward one or two stakeholders, no end users or other national labs collaborated on this project

Question 6: Proposed Future Research, if applicable

- The radar building aspect is complete. Can now use the radar for wind characterization.
- The use of weather radar to characterize the lower atmosphere is a critical observational capability to understand the flow and validate meso-scale and LES (large eddy simulation) models
- Since it's now owned by the DOE, the existing facility should be used to the fullest extent possible, possibly as part of other wind research facilities
- Future funding in this area is not justified
- Software refinements could help improve the radar performance
- N/A (Not applicable), the project is complete

Question 7: Project Strengths

- There is a need to sense the atmosphere at meter to 10s of meter resolution in a variety of weather conditions, so advancing technologies in this area is a worthy cause
- Represents increase in data quality - wind resource/wind plant flows, wide area (35 km), more atmospheric conditions
- Not my area of expertise
- Important objective for a variety of reasons

Question 8: Project Weaknesses

- It seems that purchasing a COTS system with some customization would have been a more time and cost effective approach
- The main partner on this project, SmartWind, is a privately owned spin-off of the project intended to commercialize this product. The funding for additional support to develop a product line for SmartWind is not in line with the DOE objectives.
- Duplication with commercial sector
- Not my area of expertise
- See comments above re: value of this research v. what commercialization did and the need for federal funds for the project

Question 9: Recommendations

- Further RD&D (research, development and deployment) in this area could be transferred to the commercial sector, while preserving public investments to date
- Not my area of expertise

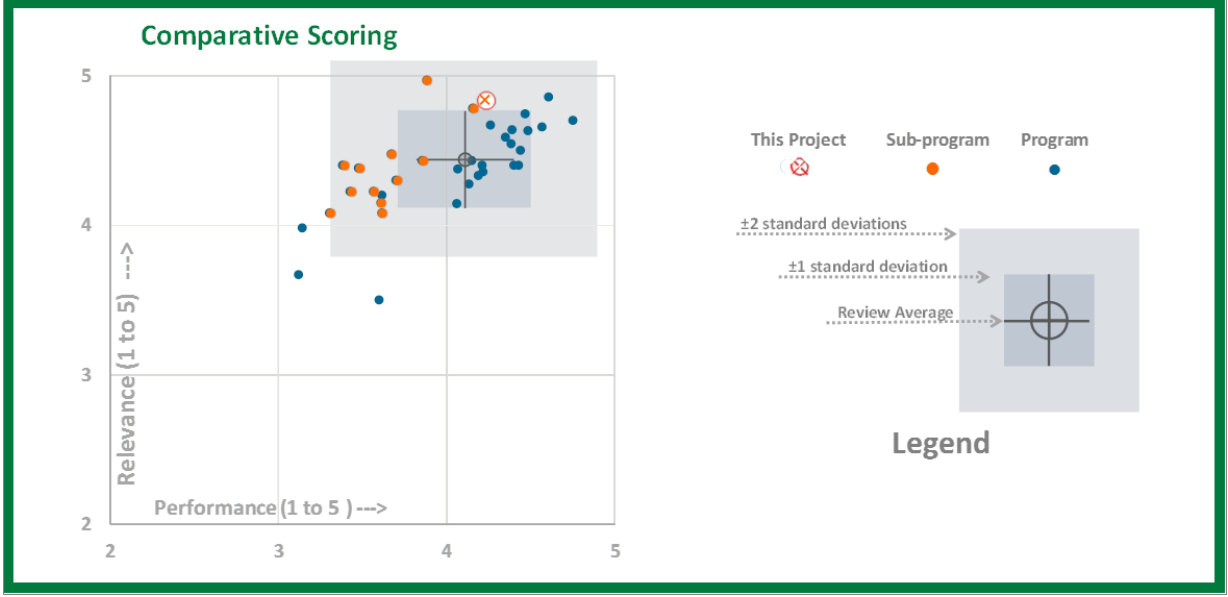
7.3.4 Offshore Wind

DOE Wind Energy Technologies Office 2017 Peer Review Project:

National Offshore Wind Strategy Supporting Analysis

Principal Investigator	Walt Musial, National Renewable Energy Laboratory		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Offshore Wind (OSW)		
FY 2014-2016 Funding	DOE	$ 0.2 M	100%
	Cost Share		
	Total	**$ 0.2 M**	**100%**

Peer Review ID# 213



Comments made by reviewers during the evaluation of this project (PRID 213)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- This is an important project to support the National Strategy Analysis and estimate the value proposition
- This project is key to the DOE objectives and includes data analysis and distribution of information needed within the industry that could not be generated without DOE's support
- At this stage of development within the industry, the information assembled within the DOE's analysis is very needed by other entities, private investors, states, utilities, etc. to develop their plans for the continued development of wind power in the United States
- Would prefer to see more analysis and tools that benefit all sectors of wind industry, how directed DOE dollars can be leveraged for current industry needs
- Offshore wind strategy document gives visibility to a national strategy and defines R&D, regulatory, standards and incentive strategies
- Critical research necessary to quantify the viability, cost, and cost-efficiency targets for deployment and operation of offshore wind energy
- Development of cost models is key to accurate assessment of the potential viability of a project. Challenges are in predicting future cost efficiencies in; wind turbine development, foundation development, O&M (operations and maintenance) costs - including prediction of unscheduled large corrective maintenance costs.
- Whereas the National Strategy on Offshore Wind set U.S. offshore wind on a practical, collaborative pathway for advancement, and whereas the supporting analysis was crucial in underscoring both the case for offshore wind as well as the case for various strategies, this work was critical to achieve the wind industry's objectives.

Question 2: Methods and Approach

- This work includes the collection of data, analysis and presentation of information to describe markets, technical issues, etc. associated with offshore wind
- The key aspect of this work is to present an honest assessment of the costs and challenges associated with further development. The data contained within these reports cannot be significantly biased.
- Opportunity space analysis could be useful for land-based and distributed wind sectors also
- Completing the strategy and publishing is significant
- Most important recommendation?
- Most important technical barrier?
- The execution of the strategy and coordination has already proven to help deployment of offshore systems
- Industry collaborative effort represents consensus
- The methods and approach follow a time-tested methodology used on other programs

Question 3: Technical Accomplishments and Progress

- Five publications and outreach is excellent progress
- The work from this effort provides a key contribution to the overall DOE planning effort
- Many parallels with distributed wind sector: cost reductions depend on supply chain growth and maturity
- The program met its goals for technical accomplishments

Question 4: Project Management

- Work done on time and under budget
- The funds allocated to this effort are well worth the product. The project generated a very good ROI (return on investment).
- Unclear why scope/budget needed to be increased for analysis that is largely premature and doesn't benefit current commercial industry
- Large coordination effort required independent leadership
- The project management appeared to be good

Comments made by reviewers during the evaluation of this project (PRID 213)

Question 5: Research Integration, Collaboration, and Technology Transfer

- Five published reports were created and released in 2016
- Very good collaboration amongst the various DOE and DOI (Department of Interior) agencies
- Good dissemination of reports within the industry. They are seen by many.
- More work could be done to include contributions from other stakeholders and the private sector
- Several reports published, however high price tag of offshore wind not widely communicated
- The program appeared to have limited collaboration with industry, but good use of DOE personnel. Although not in the presentation, apparently there was a partnership with a Dutch company for data relating to O&M expenses.

Question 6: Proposed Future Research, if applicable

- Continue to update estimates as new data become available
- These analyses will need to be updated regularly as the industry continues to grow and the economics, markets and technologies all mature
- While a small amount of analysis on offshore wind risks is warranted, further work on benefits and facilitating development at the expense of RD&D (research, development and deployment) for land-based wind is not justified
- N/A (Not applicable), the project is complete
- It is important that this work continue, given its relevance to case-making at the state (and federal) level

Question 7: Project Strengths

- Excellent resource for policy and industry stakeholders
- Development of a cost model for standardized evaluation of individual project merits
- Well-targeted in terms of need
- Widely accessible and disseminated

Question 8: Project Weaknesses

- None identified
- More "end user"-friendly reporting of findings is needed to truly maximize the value of this important work

Question 9: Recommendations

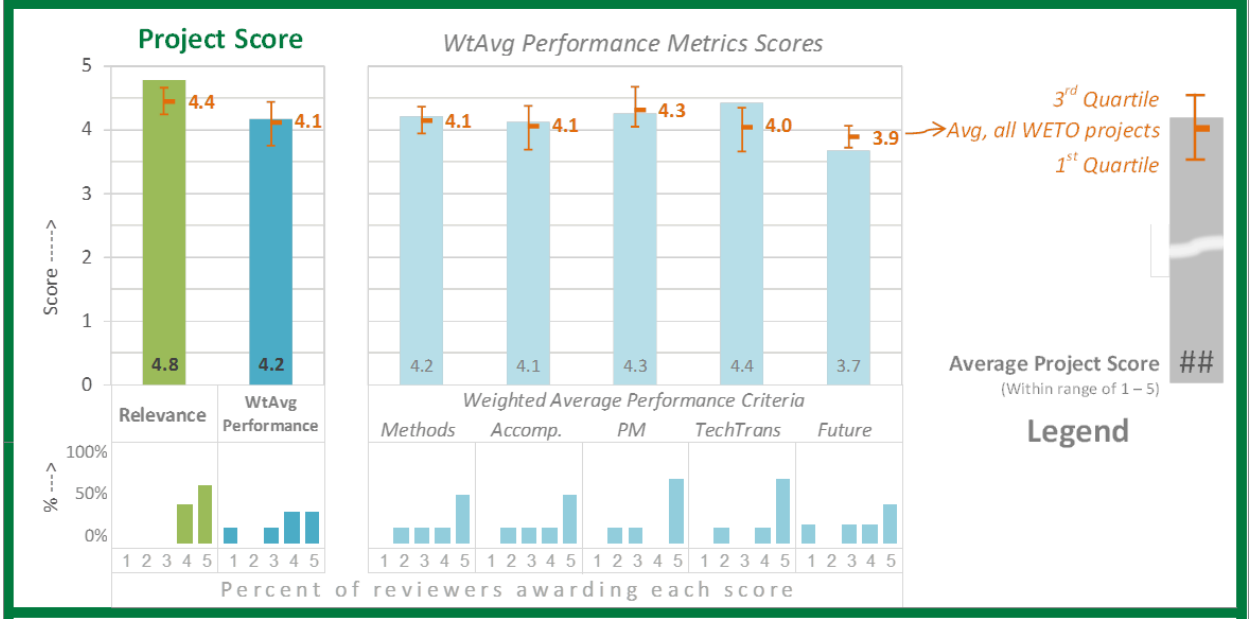
- Redirect efforts to expose relative costs/benefits of land-based wind compared to offshore wind to help policymakers understand best use of limited funds

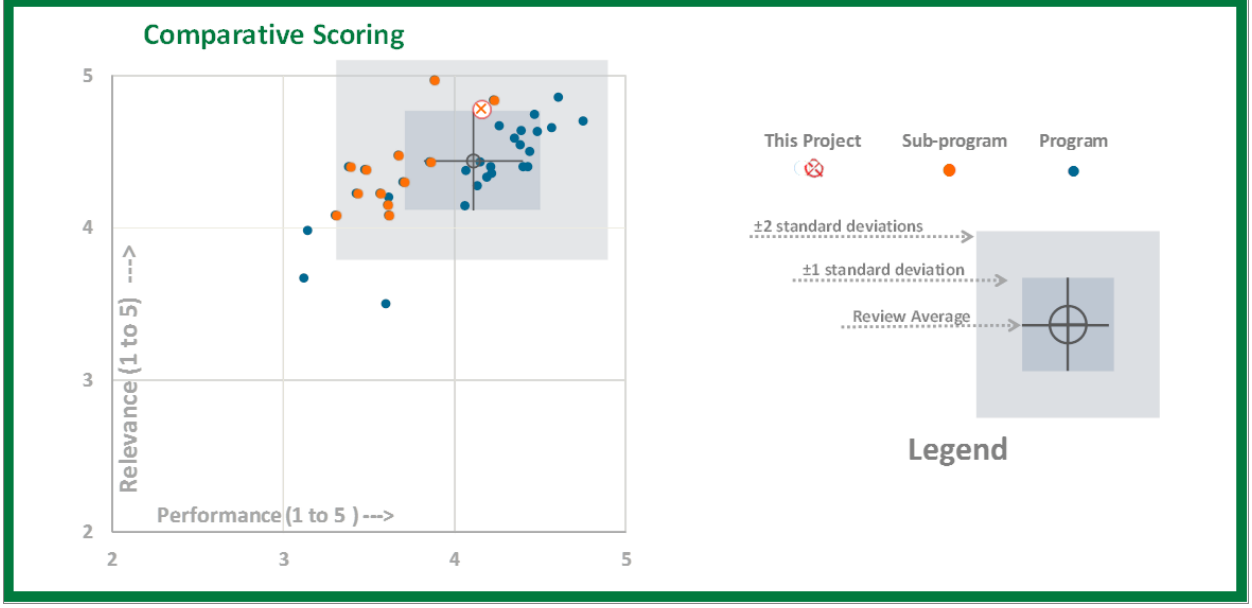
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Modeling and Validation for Offshore Wind

Principal Investigator	Amy Robertson, National Renewable Energy Laboratory		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Offshore Wind (OSW)		
FY 2014-2016 Funding	DOE	$ 3.1 M	100%
	Cost Share		
	Total	**$ 3.1 M**	**100%**

Peer Review ID# 214





Comments made by reviewers during the evaluation of this project (PRID 214)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- It's good that the innovations being explored are building off of the current state of practice in Europe
- New high resolution models such as hurricane WRF (weather research and forecasting) and even higher resolution models that can be used to characterize the hurricane eye-wall should be used to assess the “extreme” aspects of the met-ocean environment for load studies. All of these factors need further investigation as they will influence the LCOE (levelized cost of energy). Perhaps some of these tools should be folded into the overall modeling and validation effort to cover some of the more extreme, but not rare events.
- Outstanding project fully aligned with the DOE objectives
- Working to reduce the technology gaps and uncertainties that are inherent in our simulation tools is extremely important. There is a tendency to assume that our simulations tools are inherently accurate and this false sense of security had led to serious problems.
- Timing seems off for relatively large investment in model validation work since offshore wind industry is in infancy
- Offshore wind turbine hydro-elastic/aero-elastic engineering models are the fundamental tools used to estimate very complex dynamic loads and stability. The results from this study clearly show that seemingly minor engineering simplifications can result in drastically under predicting dynamic loads, fatigue loads and misjudging stability. This project essentially qualifies each code and the analyst's use of it. Without participating in this project it is doubtful that any analyst could make accurate predictions. Thus it has become a necessary precondition of any analyst predicting loads or verifying loads predicted by others for offshore certification of any turbine.
- Implementation of this comparison through the IEA (International Energy Agency) is the most effective use of international collaboration that DOE has. It is the most leveraged effort DOE could expect and the most valuable for the offshore wind industry.
- OC5 (Offshore Code Comparison Collaboration, Continued, with Correlation) has lasting impact and relevance to the industry. This project exploits the unique capability of DOE labs and places them in an international leadership position. There is no better position from which to influence the offshore wind technology design process. That durable value of project will be imbedded in every offshore design code and hence every offshore turbine designed in the future.
- This project trains and informs all analysts as well as tests and harmonizes the codes
- Results from this study have become reference material and mandatory for any analyst contemplating offshore turbine design. It will be referenced in all text books on the topic.
- Highly leveraged project. Perhaps the most valuable offshore contribution DOE has made to the industry.
- Offshore Wind is outside my core competency, however here are comments I had from the presentation; as I understand it, the project is modeling aerodynamic and hydrodynamic forces on a floating platform. There are an amazing number of people involved in the project. Could this be a seed effort for certification process? There are concerns on model under-estimation of fatigue loads as compared to instrumented results. Current floating designs have excessive margins to make up for high-level of uncertainty. These tools are starting to be used on fixed-bottom foundations too.

Question 2: Methods and Approach

- Have the load studies adequately considered structural ice loading impacts? This would be particularly important for floating wind.
- The use of multiple programs and users is excellent. The project will provide very helpful information to owners who can see the COV (coefficient of variance) amongst different simulation tools.
- The approach used here is very consistent with SOA (state-of-the-art) methods for this kind of study
- Integration of simulation results with test results is outstanding
- Not clear why commercial sector cannot conduct comparison of various tool results
- Still need more comprehensive offshore data set with reference quality inflow and seastate measurements. Need offshore vertical profilers. Has BOEM (Bureau of Ocean Energy Management) or NOAA (National Oceanic and Atmospheric Administration) been approached for collaboration? Other agencies.

Comments made by reviewers during the evaluation of this project (PRID 214)
• IEA framework for highly leveraged work is an excellent strategic decision. This approach should be used whenever possible and suitable (see comments above).

Comments made by reviewers during the evaluation of this project (PRID 214)

- Provides reference data sets and models for future harmonization and education of industry
- Very happy that the certifiers involved. If they don't participate they have no credibility in judging the accuracy of others.
- Huge list of tools tested. Effectively a code certification process.
- Analysis methods advanced as well as design process which has impacted offshore design process importantly. FAST has become the public dissemination vehicle for lesson learned in OC5.
- The concept of coupling aerodynamic and hydrodynamic forces on a wind turbine is relevant to determining the optimum design of an offshore wind turbine

Question 3: Technical Accomplishments and Progress

- Good progress to date for a complex suite of projects
- Very good work on code comparisons and using the data available from these tests to identify specific areas that need more attention
- Little meaningful progress
- Slide 8: Most results show dramatic under prediction of fatigue loads. Remarkable results.
- Under prediction of fundamental amplitude response by all codes is concerning. Should be important focus to resolve.
- Slide 12: 146 participants and 68 organizations in 18 different countries! That is impact!
- This is feedstock for offshore standards and certification
- Highly leveraged
- As I understand it, there is wide disparity across different model platforms. Highlights the need for empirical experimental data comparison to model output.

Question 4: Project Management

- Some delays, but no slip in overall program. Work done within budget.
- The funds allocated to this effort are delivering a very high ROI (return on investment)
- Major milestone delayed; overall completion slower than planned due to unexpected data analysis challenges
- Very clearly and competently presented
- Managing 146 different participants from 18 different countries is difficult to do well and yet, the results speak for themselves. There is no more compelling approach to settling technical debates then to see comparisons of predictions with test data lined next to peer analysts.
- Outstanding leadership!
- Offshore wind is outside my core competency, but it appears the project is well managed

Question 5: Research Integration, Collaboration, and Technology Transfer

- Excellent collaborations with U.S. and international industry, academia, and government players
- Broad range of collaboration across firms in the public and private sector
- Large number of collaborators, unclear why cash match was not provided
- (See comments above)
- An incredible amount of integration and collaboration across industry partners

Question 6: Proposed Future Research, if applicable

- Not clear that additional work is needed in the area at present due to current state of industry
- Leadership through the next phase is critical. The greatest value for the invested time is reaped at this advanced stage of project maturity.
- Moving toward OC5 would accelerate the validation of model output

Question 7: Project Strengths

- Strong collaborations within and outside the United States
- Quickly building off of the lessons learned from European offshore wind
- Comparison of codes is outstanding and tells us a lot about how much more work we have to do
- Highest level of broad technical collaboration
- Incredible collaboration across industry
- Best project in the offshore wind portfolio, bringing together an important need with extensive collaboration to deliver actual results used to make a difference

Comments made by reviewers during the evaluation of this project (PRID 214)

Question 8: Project Weaknesses

- More validation is required in the real offshore environment
- There is an emphasis on floating systems. While there is more work to do on floating systems and the end ROI may be high, there are still technical gaps for conventional foundation types that require more work.
- None identified

Question 9: Recommendations

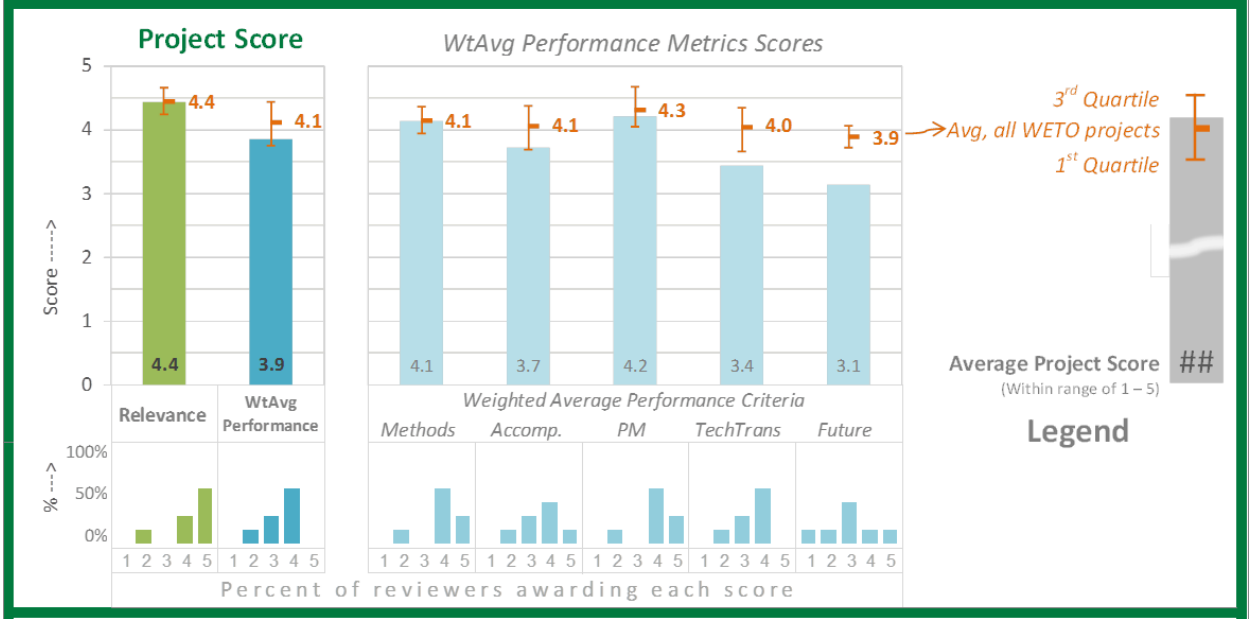
- Continue

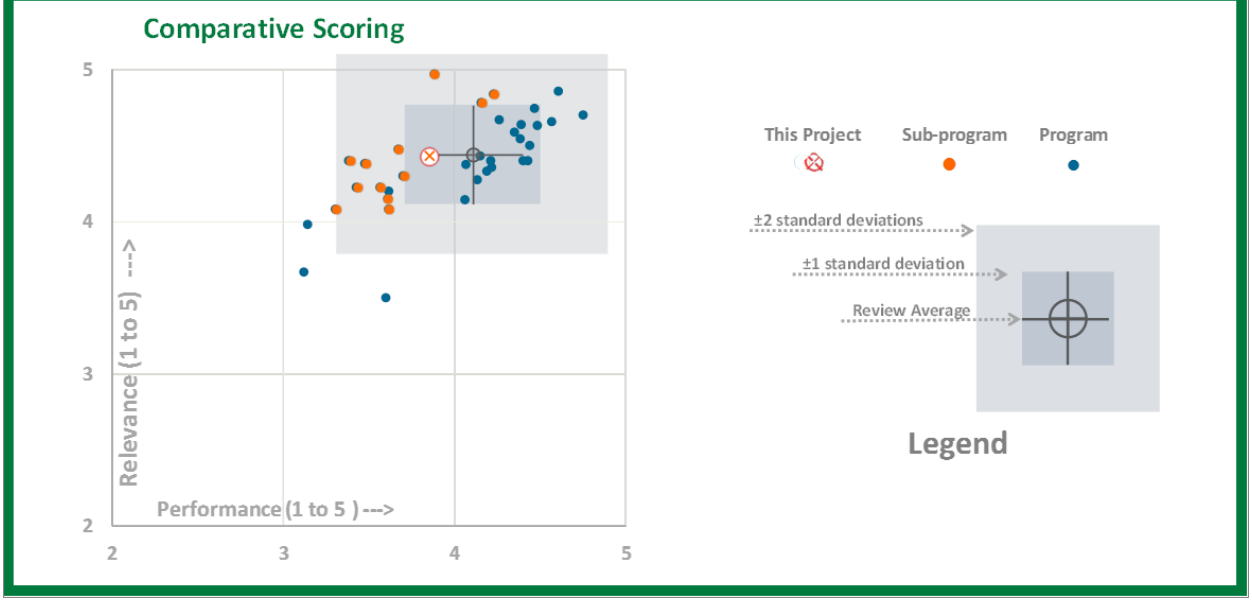
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Instrumentation Planning for the Offshore Wind Advanced Technology Demonstration Projects

Principal Investigator	Walt Musial, National Renewable Energy Laboratory		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Offshore Wind (OSW)		
FY 2014-2016 Funding	DOE	$ 0.2 M	100%
	Cost Share		
	Total	**$ 0.2 M**	**100%**

Peer Review ID# 215





Comments made by reviewers during the evaluation of this project (PRID 215)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- This was a critical risk reduction project to support the ATDs (Advanced Technology Demonstrations)
- The lack of usage of the outcomes in commercial projects takes away from the project
- The collection of data from actual wind farm installations is essential and will help to progress the SOP (standard operating procedure) for many aspects of design as new information is distributed throughout the industry. This project is therefore very relevant to the overall DOE goals.
- The project has yielded useful information in the form of the instrumentation plans, however, there has not been any data collected from these wind farms as they have not yet been built
- If/when any of the DOE-funded offshore wind demonstration projects are built, it will be helpful to collect and evaluate performance data. However the timing of this project was several years premature and sensor/DAQ (data acquisition) technology will have evolved substantially by the time it is relevant.
- Critical fundamental steps to enable cost-effective offshore deployment
- Facilitating needed interagency guidance
- Minimum $5M to implement instrumentation. Discussion with BOEM (Bureau of Ocean Energy Management) on requiring data as part of ocean lease-not palatable. Have considered data opportunity for Block Island but no funding carve-out available.
- Documenting unique U.S. offshore conditions is important, key?
- Documenting the experience gained from the DOE funded demonstration projects
- This project gives transparency to offshore experience while private commercial projects will not provide public knowledge or guidance for government or regulators or standards for future projects
- Standardized testing and instrumentation programs are critical to the success of any program, be it onshore or offshore wind. This program leverages past successes and applies them to offshore wind testing and evaluation.
- Efforts were critical to the overall demo project initiative

Question 2: Methods and Approach

- The project has addressed instrumentation needs and data dissemination in a logical and systematic manner, consistent with SOP for these types of projects
- Planning for data sharing based on prior experience - however not collecting data at only existing OSW (offshore wind) project in the United States
- Maximize public transparency
- Very good foresight on data including collection, quality, dissemination, security, etc.
- Data archiving and dissemination plan?
- Pre-installation instrumentation and data collection?
- Excellent instrumentation plan. Is it possible to include Doppler radar for vertical profiling?
- The methods and approach are based on successful prior work, now applied to offshore wind

Question 3: Technical Accomplishments and Progress

- What was envisioned is worthwhile, but the outcomes are not yet being utilized
- The instrumentation planning document is useful and will hopefully be used across other projects, both within the DOE's demonstration program and elsewhere
- Guidelines developed in 2014 are likely now outdated
- Great plan
- Disappointing that it has not been implemented due to demonstration project failures
- Published reports and technical guidelines met project goals

Question 4: Project Management

- The work was completed on time and budget
- The funds allocated to this project were not significant, resulting in a high ROI (return on investment) for the work completed
- Completed on-time and within budget, however no-cost time extensions would have been a more efficient use of DOE funding
- Project management appeared to be very good

Comments made by reviewers during the evaluation of this project (PRID 215)

Question 5: Research Integration, Collaboration, and Technology Transfer

- Reasonable tech transfer via the webinar and the reports generated
- More work could have been done to integrate with other entities involved with instrumentation programs such as this
- 80-page report with 13 contributors and webinar seem premature, overkill
- Enabled needed guidance to BOEM
- This project appears to be an internal NREL program, and had significant participation across a large number of NREL employees. It does not appear there was any cross-functional collaboration with other National Labs or industry partners.
- Efforts should be made to better use the work done in the demo program to help advance the broader offshore wind sector

Question 6: Proposed Future Research, if applicable

- Not Applicable
- The future work is limited to some extent due to the change in demonstration projects
- It would be helpful to leverage this work beyond the DOE demonstration projects
- Disappointing that instrumentation planning staff not involved with demonstration project negotiations, as projects with such high levels of public funding should be required to collect and release consistent data
- Uncertainty here
- No specific plans at this time
- Completion of at least one advanced technology demonstration project is important to advancing technology and the industry more generally

Question 7: Project Strengths

- This effort was an important support project to improve the outcomes of the ATDs - The funding was very small
- Leverages previous, successful work, and does not 'reinvent the wheel'
- This was important/proper work to do within the advanced technology demonstration projects

Question 8: Project Weaknesses

- Not certain the outcomes of the activity are being utilized yet
- Efforts should be made to determine how this work can be useful in the event that the projects do not get power off-takes. Unclear what that will look like -- making the work done useful to the broader effort of facilitating a U.S. offshore wind industry.

Question 9: Recommendations

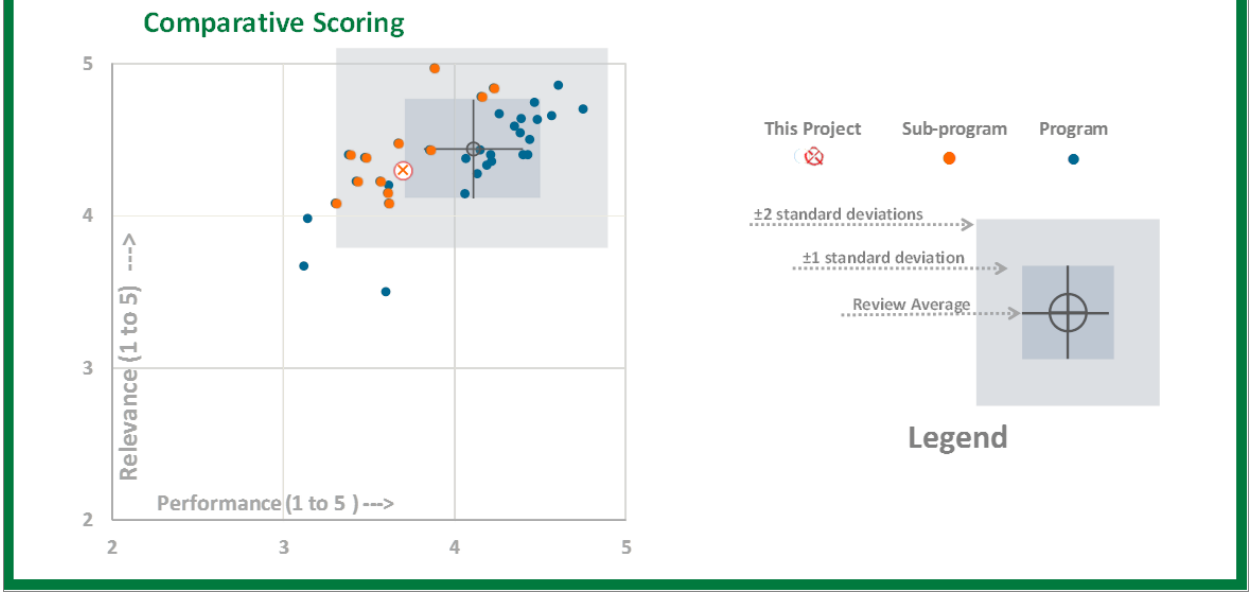
- It would be helpful to leverage this work beyond the DOE demonstration projects
- Rethink ATD (Advanced Technology Demonstration) funding to advance near-term deployment by collecting data from only existing U.S. OSW project (Rhode Island)
- None identified

DOE Wind Energy Technologies Office 2017 Peer Review Project:

DOE Offshore Wind Lidar Buoy Deployment Program

Principal Investigator	Will Shaw, Pacific Northwest National Laboratory		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Offshore Wind (OSW)		
FY 2014-2016 Funding	DOE	$ 1.4 M	100%
	Cost Share		
	Total	**$ 1.4 M**	**100%**

Peer Review ID# 220



Comments made by reviewers during the evaluation of this project (PRID 220)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Measuring offshore wind profiles to support resource assessment is a critical need
- There are differences in the boundary layer over water that need to be understood (nocturnal fluxes, LLJ (low level jet), wave impacts on low-level winds, wind shear, sea breeze impacts, etc.)
- The met-ocean environment is very different than onshore, especially w.r.t. how the boundary layer responds to the diurnal cycle, rime and clear ice accretion, sea-spray and marine aerosols, all of which reduce production and impact the infrastructure. The lidar buoy is an important component of the research effort.
- I think that this is a good project and generally in line with the DOE goals
- The benefit of confirming that floating LIDAR can be used in place of conventional fixed base met towers is substantial
- My main concern about this project (and the lower score here) is that this project could easily have been completed with the support of the private sector. There is no new technology being developed here really and it seems like more of a proof of concept.
- High dollar effort, premature based on state of industry
- Project enabled information highly valuable to plant output and viability assessments
- Buoy demonstration of LIDAR is key. Need easy low cost method of wind speed and shear offshore. But moving platform for floating buoys is the challenge.
- Interesting concept to develop portable floating LIDAR buoy. Challenges with pitch-and-roll motion correction claimed to be overcome. Not clear from presentation on how accurate measurements are as compared to a fixed met tower system. Project was for development of the buoys, not for wind resource analysis.
- Could benefit from loaning out the buoys in exchange for data sharing
- Offshore wind is outside my core competency, but I do understand the importance of accurate wind resource measurements. What is not clear to me is the benefit (cost or accuracy) of this technology as compared to traditional met tower installations.
- With respect to planning, risk reduction and cost reduction site characterization is a critical element of advancing offshore wind in the United States.

Question 2: Methods and Approach

- Good idea to test the device slightly offshore at the PNNL Marine Sciences Lab to start
- Excellent selection of the device to measure the complete met-ocean conditions (above and below surface)
- Design, acceptance testing and deployment of system at demonstration project sites was well thought through and consistent with SOP (standard operating procedure) for this kind of work
- Issues associated with the limitations of Lidar were not fully addressed
- Unclear why DOE funding needed for long-term measurements
- Excellent design, development and deployment of the initial prototype buoys in Sequim
- Data archiving in the A2E (Atmosphere to Electrons) DAP (Data Archive and Portal) excellent
- Deployment off east coast major accomplishment
- Why recover the buoys? Buoys required maintenance. There is a cost to maintain them onsite. The successful demonstration was complete. Ready for commercial deployment.
- The methods and approach appeared to be good
- Whereas these started as buoys for the ATDs (Advanced Technology Demonstrations) there is an opportunity to use them strategically. Greater collaboration with BOEM (Bureau of Ocean Energy Management) and industry could yield a more effective program.

Question 3: Technical Accomplishments and Progress

- Two deployments - 17 months of data (through June 2016 and November 2016 for the second). Both east coast.
- No funding for analysis as part of this project
- If this project supports greater acceptance of floating Lidar in place of fixed met towers then I would score this as a 5, but I don't see that happening
- Unable to complete planned West Coast deployment

Comments made by reviewers during the evaluation of this project (PRID 220)

- Successful validation of buoy's ability to accurately measure vertical profiles and seastate was demonstrated. Non-trivial accomplishment.
- The program is complete and achieved its technical objectives

Question 4: Project Management

- This was a challenging project to manage. Schedule delays and budget issues were a problem.
- There was a significant budget allocated here and the ROI (return on investment) is not as strong as it could have been
- Slipped milestone, redirection of funds for recovery of unit; no contingency funds planned
- Cost overruns but buoys remain available for use
- Excellent exploitation of PNNL marine lab skills to execute validation deployment
- Successful execution of east coast data collection
- The project management was good as the program achieved its technical goals

Question 5: Research Integration, Collaboration, and Technology Transfer

- Good outreach to date, but more critical information will come during the analysis phase
- Reasonable collaboration and tech transfer
- Data publicly available, loan program with data sharing requirement
- Commercial requests to borrow buoy for commercial studies is evidence that industry values the accomplishment
- The program had a limited number of partners in the development of the hardware
- More coordination with BOEM, state governments and industry

Question 6: Proposed Future Research, if applicable

- Need analysis funding!
- Future funding should be spent on analysis before funding is spent on new deployments
- There is some potential that the hardware will be used by others and that, over time, the data that is generated will provide much greater value to the industry
- Further DOE investment in this area not warranted at this time, recommend transfer to commercial sector
- Loan program is excellent plan to leverage accomplishments of project
- N/A (Not applicable), the project is complete. However, further validation of the accuracy of measured data would be of value.
- This is a very important activity to continue funding

Question 7: Project Strengths

- Interesting technology of portable, floating wind resource measurement
- Well-supported within offshore wind sector. Opportunities to leverage project for greater outcomes.

Question 8: Project Weaknesses

- Limited information on accuracy of measured data, as compared to a known standard technology
- Less than ideal collaborations/partners

Question 9: Recommendations

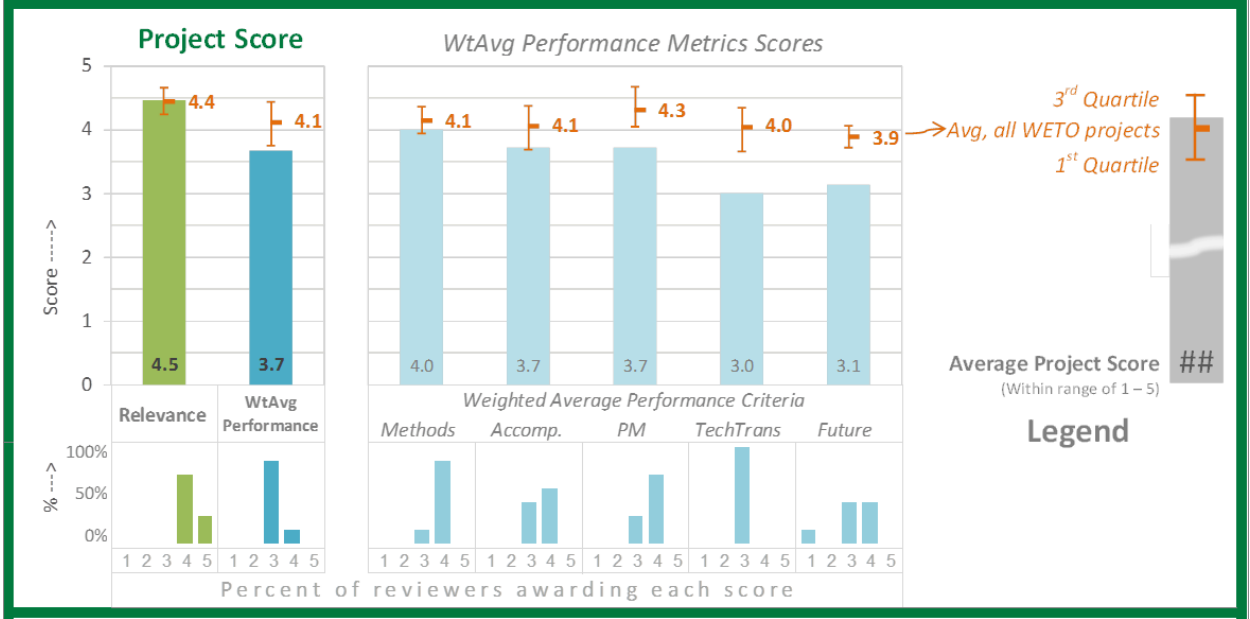
None at this time

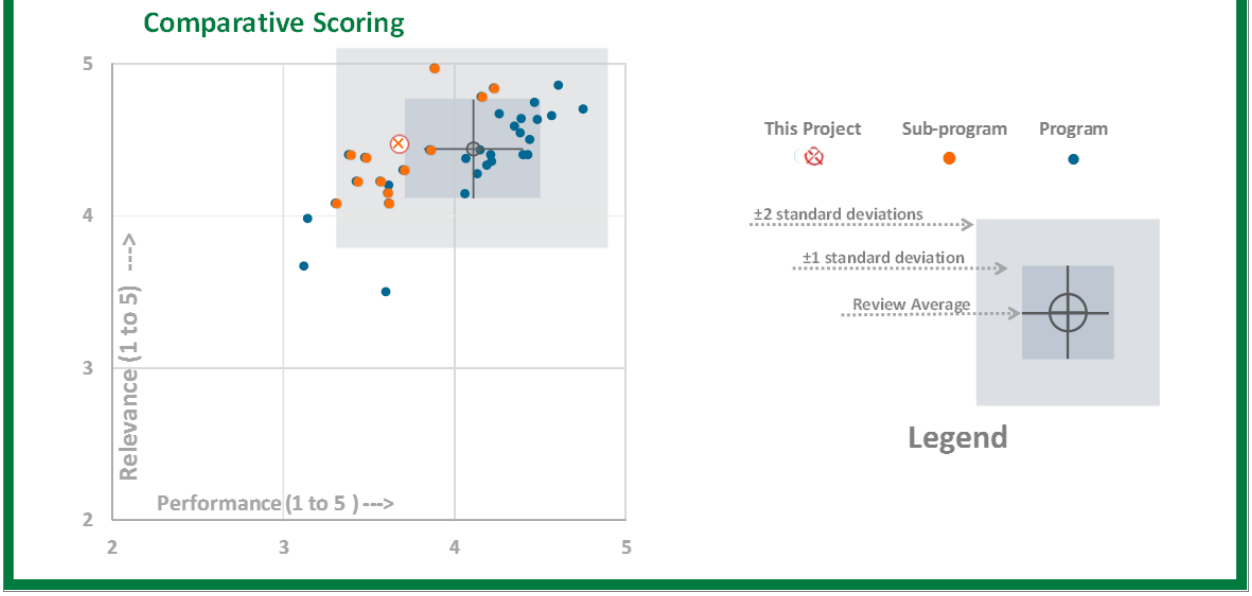
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Structural Health and Prognostic Management for Offshore Wind Projects

Principal Investigator	Todd Griffith, Sandia National Laboratories		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Offshore Wind (OSW)		
FY 2014-2016 Funding	DOE	$ 0.3 M	100%
	Cost Share		
	Total	**$ 0.3 M**	**100%**

Peer Review ID# 225





Comments made by reviewers during the evaluation of this project (PRID 225)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- How are the offshore environment needs different from onshore, except for the increased cost of offshore O&M (operations and maintenance)?
- How much of this work should be covered or is being performed by industry?
- The ability to assess blade damage and refined operating envelopes is an industry need
- This is a very good project and well aligned with the DOE goals
- The concept of structural health monitoring, damage detection, thresholds and adaptive management to extend life and/or manage O&M is strong
- Research has some relevance to land-based/distributed wind in reducing O&M costs of remote installations
- SHPM (Structural Health and Prognostic Management) different for offshore? No
- Blade focused project but could be used for other parts of the structure
- Robust early onset of blade damage detection seems like the greatest technical challenge. What were the results of this early part of the program?
- It seems like most of the effort was partial damage operational strategies to maximize revenue. Does the decision to continue operating depend on the probability that the damage will not grow rapidly and hence the risk of much greater damage is low?
- Seems like the greatest contribution to the industry would be cost effective early blade damage sensing methods
- Structural Health Management and Condition Monitoring are critical to optimizing offshore wind operations and maintenance. I was especially interested in the blade structural monitoring as this technology is directly applicable to onshore wind O&M. Currently, there is no commercially available blade health monitoring system that can be installed or retrofitted. This technology is now needed in the existing fleet, and will be critical to extending the operational life of these assets beyond their 20 year design life.
- Smart Loads Management is directly applicable to existing onshore wind fleet and is needed now

Question 2: Methods and Approach

- Somewhat limited by budget
- The approach consists of a good progression of analysis and development of damage detection strategies
- More work is needed on testing and validation, however, the work that was done is in line with the budget allocated
- Technology agnostic
- Needs validation
- Would an operator really consider running a turbine with a partially damaged blade? (Yes, depending on the kind of damage. But most importantly need a remote method of detecting the extent of damage. Also life extension is key.)
- Were there other life extension operational strategies?
- The methods and approach appear to be very good

Question 3: Technical Accomplishments and Progress

- Major report published
- This work has established a methodology for SHM (structural health monitoring) and adaptive control to avoid failure. While this methodology is good, more work is needed to fully demonstrate its applicability on real systems; either at the labs or on actual sites.
- The larger deployment of this approach is unlikely without further work
- Exploring life extension strategies, determine how long damaged equipment can be safely operated
- Comprehensive roadmap for prognostics management, framework for decision-making
- Damage detection and Smart Loads Management are fantastic technical accomplishments

Comments made by reviewers during the evaluation of this project (PRID 225)

Question 4: Project Management

- Some schedule slippage
- The budget for this effort was very reasonable given the value of the study. The ROI (return on investment) on this project is very good.
- A few slipped milestones, but overall impressive amount of work conducted
- Cost overruns
- The project management appears to be good, as program goals were met

Question 5: Research Integration, Collaboration, and Technology Transfer

- Seems a bit limited to date. May want to reach out to those in industry worried about service life extension.
- Moderate collaboration with other parties. Could be expanded. There is some overlap here with other research efforts.
- Good publication and dissemination of data
- Unclear why DOE-funded work without cost-share led to patent (early detection with minimal sensing)
- Impressive list of publications and presentations
- More industry input may have been helpful
- Were there other end user stakeholders as partners?
- Collaboration appears to be targeted to a small group, perhaps more onshore, end user input could have been of value.
- Hard to tell from presentation how involved industry has been with findings, usability, etc.

Question 6: Proposed Future Research, if applicable

- Not Applicable
- There are no plans to carry this forward. It would be unfortunate if this idea just died due to lack of attention.
- Prognostics management using state of wind turbine health for revenue optimized decision making
- Unfortunate that lab experiments were de-scoped, consider shifting focus to land-based and distributed wind fleets for field verification
- Future blade damage detection approaches?
- N/A (Not applicable), the project is complete

Question 7: Project Strengths

- Provides some useful information that could be used by industry planning and operating offshore projects
- The development of Damage Detection and Smart Loads Management are key findings that can be implemented in the current onshore fleet

Question 8: Project Weaknesses

- Not clear how unique the project findings are to the offshore environment. Is there overlap with similar efforts for on-shore?
- Is this type of work something that industry should do itself to stay cost competitive?
- None identified

Question 9: Recommendations

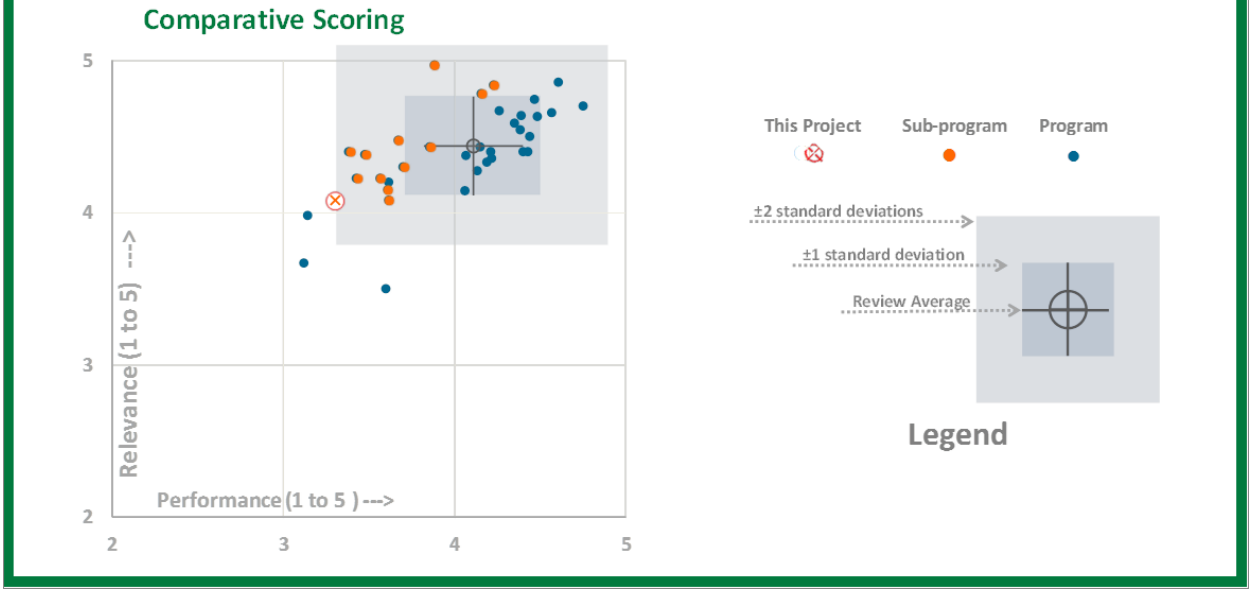
- Continuing effort to understand blade operating loads and reliable sensing is worthwhile and only increasing with value with increasing rotor diameters and the move offshore
- Beg, borrow, steal, or recycle aluminum cans to obtain funding for research on blade damage detection and smart loads management!

DOE Wind Energy Technologies Office 2017 Peer Review Project:

Sediment Transport Impacts on Offshore Wind Projects

Principal Investigator	Jesse Roberts, Sandia National Laboratories		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Offshore Wind (OSW)		
FY 2014-2016 Funding	DOE	$ 0.2 M	100%
	Cost Share		
	Total	**$ 0.2 M**	**100%**

Peer Review ID# 226



Comments made by reviewers during the evaluation of this project (PRID 226)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- This is critical research to assess environmental impacts and risk
- This project addresses a key technical issue related to the design of monopile support structures and is very relevant to the DOE objectives
- While the goals of this study are good, the work plan was not put together to yield useful results. The limitations of the budget were an issue.
- Unclear why DOE Wind program funding was required for this work
- High importance. Addresses potential coastal impact and BOP (balance of plant) reliability issues.
- OS (Offshore) WTGs (wind turbine generators) can affect sediment movement that impacts locale, flora but also perhaps foundation design
- Great foresight on impact to foundations but also wave energy absorption and impact on coastal circulation and sedimentation and habitat. Good leveraging of outside support.
- Some validation would be prudent, assess potential impact before construction and gauge actual impact in the process
- Very important issue for both fixed and floating! Slides in the GOM (Gulf of Mexico) have proven how important. Pipelines displaced by 100s of meters during storms.
- Is it unique to the U.S. seabeds? Does the API (application programming interface) have models and proven analytical tools?
- Goal is to reduce the regulatory challenges and make compliance for seabed impact easier and more comprehensive. Sediment movement and sea life impact?
- Offshore wind is outside my core competency, but as I understand it, this program is a study of the effects of infrastructure on seabed. Developing this data could support permitting process. This project leverages studies from offshore oil and telecom experiences. Ocean bed scour occurs around any structure, being piles or anchors. High resolution modeling. Installations could affect near-shore habitat. Project is complete.

Question 2: Methods and Approach

- Approaches appear to be sound
- The approach that was developed did not address the impacts of local and global scour in a systematic way. The study may have generated some useful results, but the findings will not progress the SOP (standard operating procedure) in any substantial way.
- Selection of Oregon coast seems inappropriate
- Tools developed and customized and made available for industry and regulators
- Underwater landslides considered
- Simplified tools based on comprehensive analyses have been developed. Based on successful methods used in the oil and gas industry
- Comparison to API experience?
- The methods and approach appear reasonable

Question 3: Technical Accomplishments and Progress

- The study may have generated some useful results, but the findings will not progress the SOP in any substantial way
- Too much emphasis on environmental effects
- Unclear whether Guidance Document has had any impact on industry
- Did a guideline result from this work?
- Input to the AWEA (American Wind Energy Association) 2013 guideline for offshore design requirements?
- The technical accomplishments appear to satisfy program goals

Question 4: Project Management

- Project completed on time and budget
- Funds allocated for this study were not substantial
- Little effort conducted to ensure work relevant to industry needs
- $200k in 2014. $0 since.
- The project management appears to be good

Comments made by reviewers during the evaluation of this project (PRID 226)

Question 5: Research Integration, Collaboration, and Technology Transfer

- More effort could have been made to assess the industry need with respect to scour to help with the definition of the methods used for the study
- Appears to be an expensive literature review
- Collaboration and integration appears targeted at a small, specialized group
- Discouraging to hear that this research has not been collaborative or shared with BOEM (Bureau of Ocean Energy Management), when indeed they should be a target audience of the work

Question 6: Proposed Future Research, if applicable

- Not Applicable
- No real clear vision of where this goes from here
- Further DOE Wind program investment in this topic not warranted
- N/A (Not applicable), project is complete
- Depending on dissemination and collaboration

Question 7: Project Strengths

- These tools are very useful for risk reduction and should be more broadly utilized across industry and academia
- Offshore wind is not my core competency, but this research appears to be very important to understanding, and preemptively solving, the effects of scour on the ocean bed from offshore wind infrastructure
- Important issue

Question 8: Project Weaknesses

- Lack of clear goals and work plan have resulted in limited value for this project
- None identified
- Poor dissemination. Presentation materials suggest presentations made at BOEM seminar, however the offshore wind group did not seem to be aware. Moreover, hard to see any substantive interaction with the offshore wind industry in design or dissemination.

Question 9: Recommendations

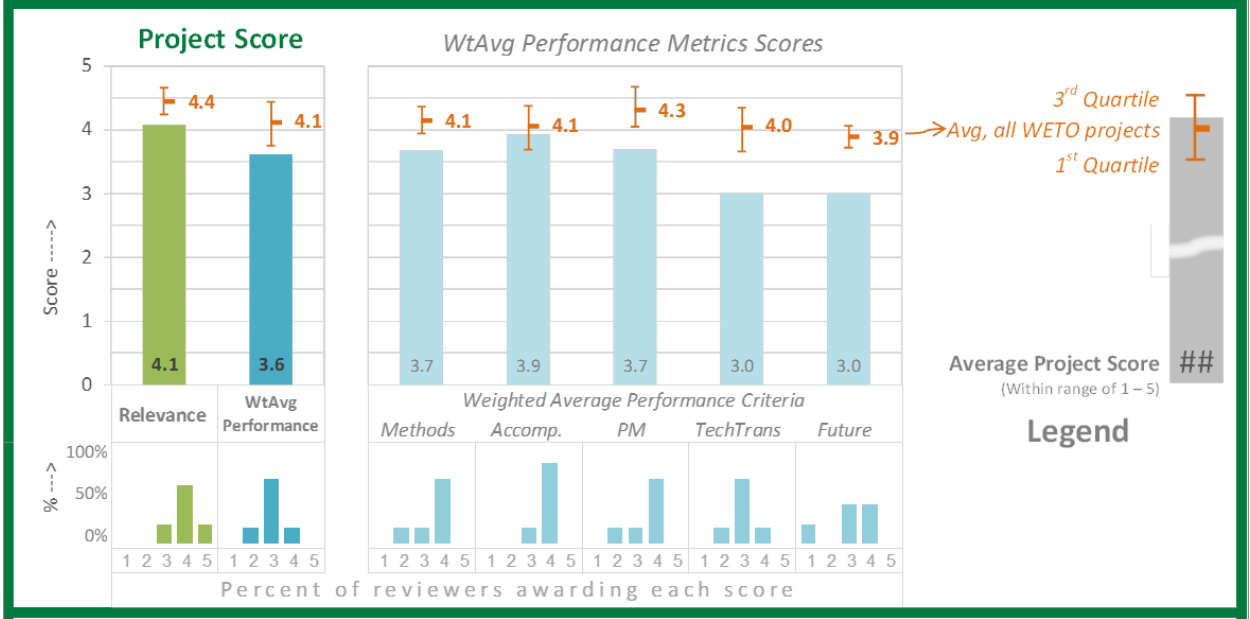
- None

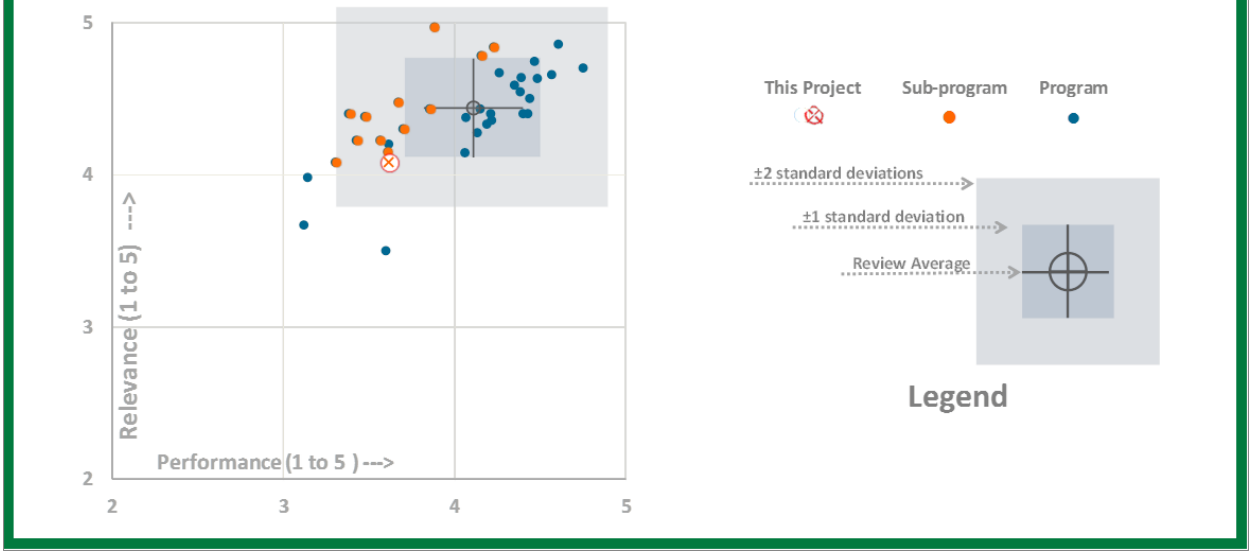
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Wave Impacts on Fixed Offshore Wind Foundations

Principal Investigator	Ralph Nichols, Savannah River National Laboratory		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Offshore Wind (OSW)		
FY 2014-2016 Funding	DOE	$ 0.1 M	100%
	Cost Share		
	Total	**$ 0.1 M**	**100%**

Peer Review ID# 227





Comments made by reviewers during the evaluation of this project (PRID 227)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- This work is very relevant and should be repeated with higher fidelity modeling that can better represent the extreme metocean environment
- I participated as a subcontractor on this study and will not score it due to COI (conflict of interest). The "Conflict?" cell above is locked.
- Unclear why DOE Wind program funding was required for this work
- Mapping extreme wave conditions along the coast can provide valuable design conditions
- Predicting breaking wave loads is very important. But much work has been done on this topic already. Did the modeling part introduce new modeling techniques or unique results?
- Offshore wind is outside my core competency, however, I appreciate that offshore wind can service a large amount of close-by load, and as such, accurate assessment of the environmental effects (wind & waves) on a wind turbine structure is critical to the success of implementation of offshore wind.
- While this is an important topic, I was left feeling that this was a misplaced priority. Wave state data is critical for a variety of reasons, but hurricane/southeast conditions are not as important as other wave-state issues, in the nearer term. Acknowledging that the program is future-oriented and that this was not a tremendous amount of funding, it still isn't clear to me that this was critical to wind industry needs.

Question 2: Methods and Approach

- Glad to see that extreme weather (metoocean) environments are being considered in the design process
- Nested modeling approach appears appropriate and grid spacing a little low at 720 m as it won't pick up sharp wave crests
- Were old waves (swells) advecting into the domain factored into the spectrum analysis - could add the constructive interference
- Valid concerns about increased hurricane activity
- Have typhoon conditions as simulated by Julie Lungstrum been considered? Very high peak wind and veer in cyclonic wall. Answer: The typhoon work was done after this project.
- Much European breaking wave research has been done. How does the breaking wave modeling compare to that work?
- Can the wave mapping work include new results from detailed typhoon modeling such as Lungstrum?
- Interesting concept of coupling open-source models for atmosphere and ocean to simulate the effects of extreme weather on an offshore wind farm

Question 3: Technical Accomplishments and Progress

- Higher resolution modeling should be done as a follow-on
- Reports completed on projected initiated in FY12
- Wave mapping process
- Project is complete, and technical accomplishments appear to be reasonable and met program goals
- Scoring for accomplishments within the project (modeling)

Question 4: Project Management

- Questions about quality of data
- $305 budget in 2014 and $0 after that. Good results from a modest budget.
- Project management appears to have been good

Question 5: Research Integration, Collaboration, and Technology Transfer

- Good collaborations as part of the team with appropriate expertise
- Useful publications of findings
- Were experts from IEC (International Electrotechnical Commission) 61400-2-1 included or consulted to reveal the body of prior work on breaking wave loads? Opti OWECS (Opti-Offshore Wind Energy Conversion System) project?
- Collaboration was within a small group, but appears to have met program goals
- Hard to see how these findings are being utilized for practical effect

Comments made by reviewers during the evaluation of this project (PRID 227)

Question 6: Proposed Future Research, if applicable

- Not Applicable
- Further investment in this topic not needed at present
- N/A (Not applicable), program is complete

Question 7: Project Strengths

- This was a good initial effort to assess the met ocean environment
- Development of new combined model from 2 open source models

Question 8: Project Weaknesses

- Higher fidelity modeling should be done as a follow-up that takes into account "old wave swells" moving into the domain, hurricanes, and eye wall dynamics. There are modeling capabilities that can be used now.
- None identified

Question 9: Recommendations

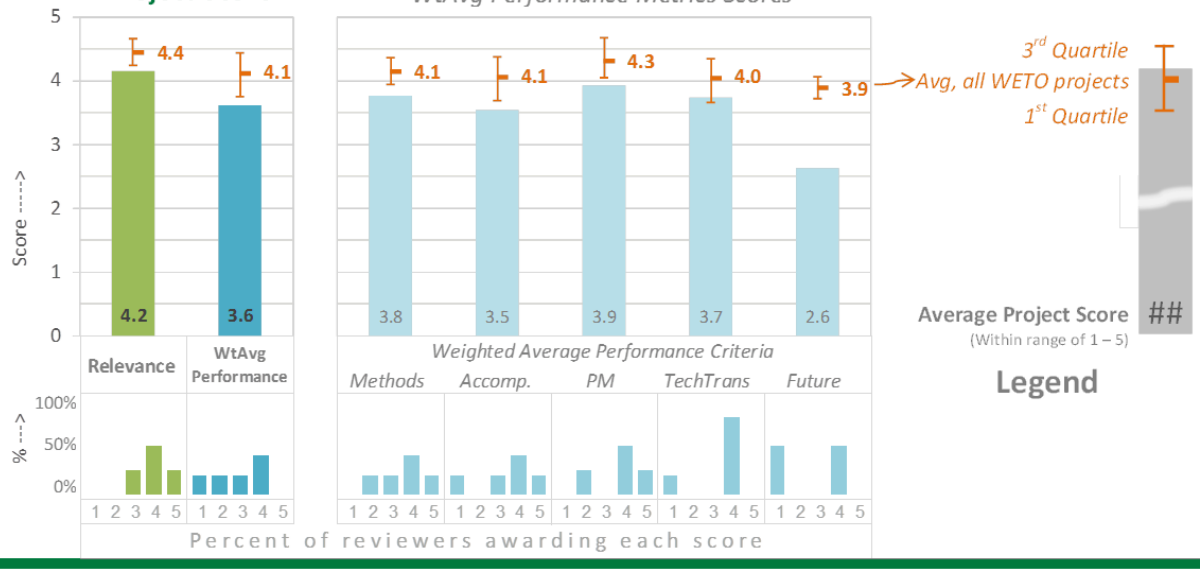
- None

DOE Wind Energy Technologies Office 2017 Peer Review Project:

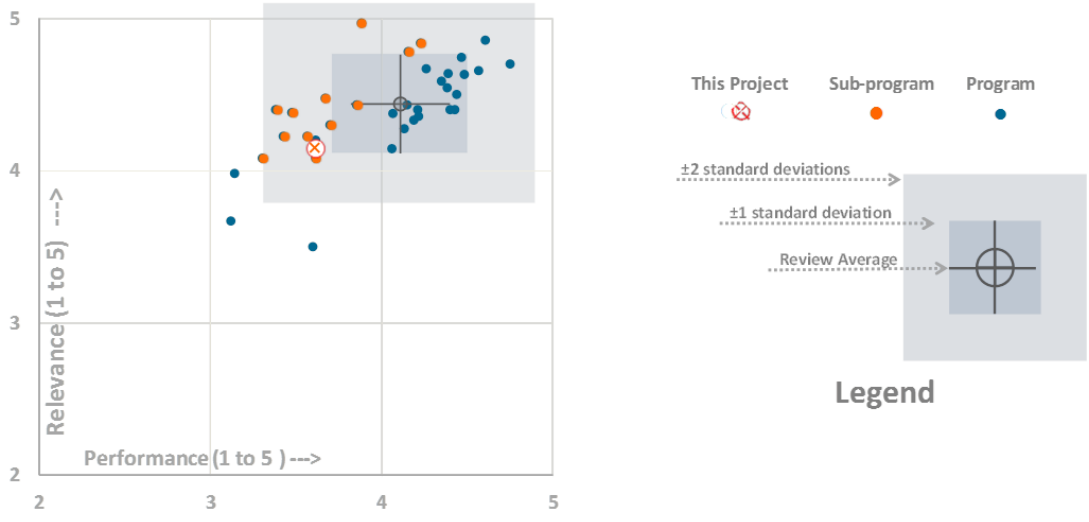
Turbine Advanced Controls for Offshore Wind Floating Applications

Principal Investigator	Dhiraj Arora, General Electric			
Program	Wind Resource Characterization and Technology RD&T			
Sub-Program	Offshore Wind (OSW)			
FY 2014-2016 Funding	DOE	$ 2.1 M	81%	
	Cost Share	$ 0.5 M	19%	
	Total	**$ 2.6 M**	**100%**	Peer Review ID# 241

Project Score



Comparative Scoring



Comments made by reviewers during the evaluation of this project (PRID 241)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- This is a topic rich for research and development appropriate for DOE to support the lowering of the LCOE (levelized cost of energy)
- This project is very relevant to the DOE objectives in that it could help to make both fixed and floating systems much more viable through active controls and load reductions
- While some very positive results were presented, it is unclear which of the simulation estimates have been fully validated with tests. This was not explained fully during the briefing leading to the conclusion that some of the results may be optimistic.
- Unclear why DOE funding was required for this, scope duplicative of NREL's work on wind plant controls (#207)
- Controls are very relevant and effective tools for reducing loads and increasing stability
- The primary goal and benefit of this project was to demonstrate operational hardware in the water. Unfortunately that was unsuccessful.
- Controls for turbine operation, and structural dampers for non-operating conditions. Project ends in April, but asking for 1-year no cost extension.
- Active controls - minimize mainshaft bending moments, smoother torque through the system

Question 2: Methods and Approach

- The methods explored seemed to be comprehensive w.r.t. the current state of technology
- The work here seems to focus on the best case results that can be achieved via simulation and have not adequately addressed the variabilities and uncertainties associated with actual deployments
- The approach that has been developed using dampers, lidar and controls is well thought through and may result in substantial value to the industry. It is unclear if the work has fully achieved these objectives.
- Useful to conduct field verification on small and medium wind turbines
- GE used FAST. Does GE have other internal codes they use for offshore wind design?
- Has GE participated in the IEA (International Energy Agency) OC5 (Offshore Code Comparison Collaboration, Continued, with Correlation) code comparison collaborative? How have they validated their codes and models?
- LIDAR shows low level jets off Virginia. Is this an anomaly of the LIDAR power level?
- Passive dampers seem effective in load reduction. What type of dampers is envisioned? What maintenance requirements are needed.
- Controls are more broadly effective for different frequencies as opposed to a tune mass damper which is only good for narrow frequencies and directions of vibration
- Very impressive reductions in loads estimated

Question 3: Technical Accomplishments and Progress

- Results to date are encouraging and cover a nice array of options
- The work has progressed well and has at least established the validity of advanced control systems
- Improvements haven't met targets, project delays
- Project was not completed

Question 4: Project Management

- Appears solid
- The work has been delayed and this has not been managed well
- Significant funds were allocated to the project bringing into question the ROI (return on investment) for this investment
- Schedule overruns, recommend re-scoping to focus on research relevant to land-based wind
- Project appears to be managed very competently and explored all avenues to complete it but ultimately was not successful
- Staged management approach preserved funds

Comments made by reviewers during the evaluation of this project (PRID 241)

Question 5: Research Integration, Collaboration, and Technology Transfer

- Strong technical team. Results still need to be disseminated.
- Outstanding collaboration with various stakeholders and contributors
- Very good distribution of information
- Would like to see more meaningful integration and tech transfer for this level of funding

Question 6: Proposed Future Research, if applicable

- Ideas proposed to continue this work are appropriate
- No real follow on after current work is completed. This leads to the question of the project's real value.
- Recommend against approving no-cost extension and de-scoping as ongoing research appears unlikely to provide meaningful benefits

Question 7: Project Strengths

- There is a lack of global R&D in this area so this is an area of applied R&D that is appropriate for the DOE

Question 8: Project Weaknesses

- Only that the results are still pending, but the preliminary results are promising

Question 9: Recommendations

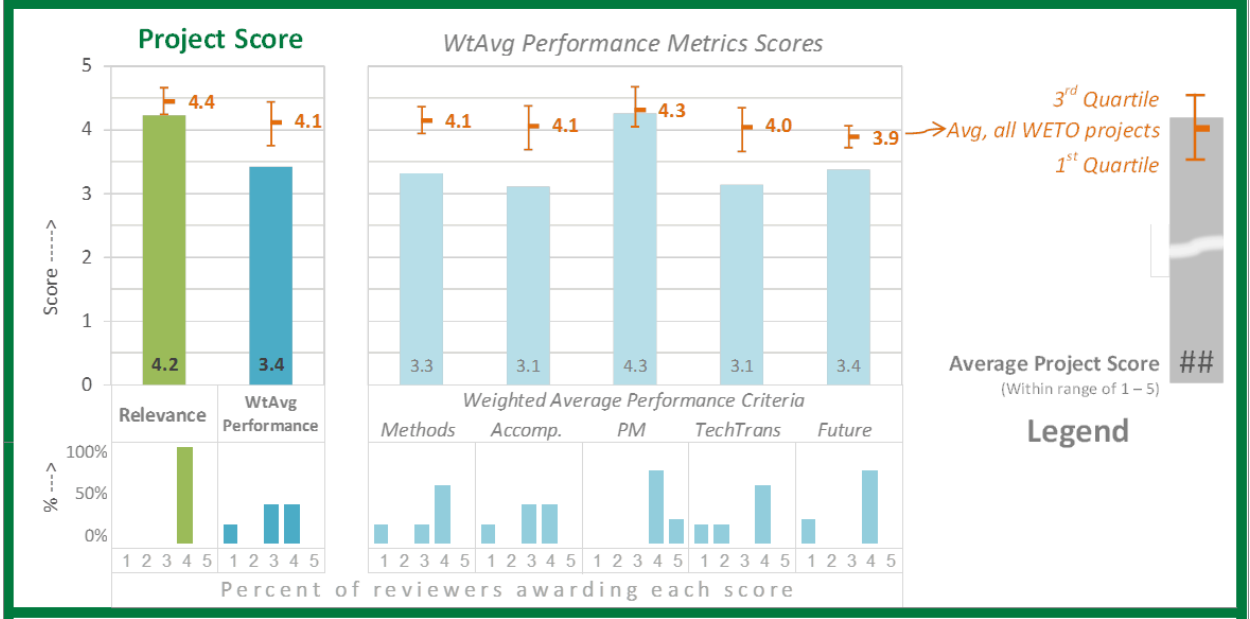
- None

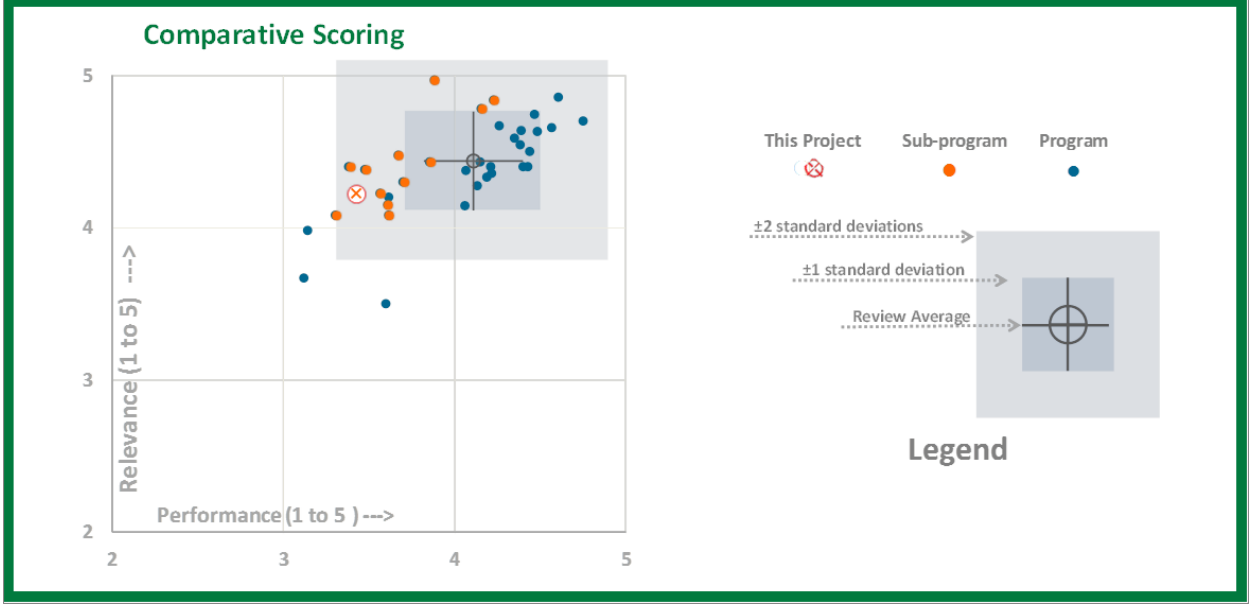
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Fishermen's Atlantic City Wind Farm

Principal Investigator	Chris Wissemann, Fishermen's Energy		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Offshore Wind (OSW)		
FY 2014-2016 Funding	DOE	$ 33.3 M	94%
	Cost Share	$ 2.1 M	6%
	Total	**$ 35.4 M**	**100%**

Peer Review ID# 242





Comments made by reviewers during the evaluation of this project (PRID 242)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Planned to be 2nd offshore wind plant in the United States
- Major challenge was politics of selling power, not engineering
- The impact and cost of regulations for wind energy implementation should be captured and reflected to the public and policy makers!
- I am currently under contract to provide independent review of the demonstration projects and, as such, I am restricted by COI (conflict of interest) to review this project
- Unwise to spend so much federal $ without having a PPA (power purchase agreement) in place, shouldn't have been a surprise
- Fishermen's is still in
- Lower CapEx (capital expenditures) by using a support structure that can be made of smaller components with smaller vessels
- Needed to prove lower fabrication and installation costs
- Came in as a developer, then partner with technology groups. Prime challenge in politics of selling power. Untested lattice-type multi-pile foundation. Smart curtailment during construction. NJ Gov not interested in OS (offshore) wind. NY said no, also. Not clear if any scale prototype foundation had been tested.
- Two objects of demonstration are of value to the offshore wind industry

Question 2: Methods and Approach

- Strategy around foundation design was sound
- Goal to complete offshore implementation within 60 days laudable
- Strategies to minimize impacts on wildlife was also laudable
- Lesson learned that permitting in commercially developed area was not a problem, however permit required curtailment when low cloud ceiling or low visibility
- Innovative, practical approaches to wildlife
- Permitting was relatively easy. Engineering also manageable.
- PPA was the big challenge. Politics. Failed to get a PPA. Financing, engineering, permitting all successful.
- Lower risk for financers
- Keystone Inward Battered Guide Structure (IGBS)
- The approaches and methods used were the right ones, however in bad circumstances. It is unclear that the project has a path forward to overcome its non-technical barriers (power off-take).

Question 3: Technical Accomplishments and Progress

- Foundations certified by ABS Group
- Jones Act compliant installation procedures
- Plan was to have steel in the water in 2016, but politics in state changed
- Critical slipped milestone
- Support structure relatively proven by oil and gas industry
- Low technical risk project
- It would be useful for the project to illuminate its findings and disseminate them. Even though the project hasn't been built, what has been learned? What is the Jones Act compliant installation method they planned to use? How can these accomplishments be used, even if not in the construction of the project?

Question 4: Project Management

- General plan and processes were well-developed before the political landscape changed
- Disappointing that spending not slowed to match technical progress

Comments made by reviewers during the evaluation of this project (PRID 242)

Question 5: Research Integration, Collaboration, and Technology Transfer

- Excellent team and many lessons learned
- Work on wildlife mitigation and worker safety (access ladder) helpful
- Identified that technical challenges were manageable and that energy offtake and politics are the greater barriers
- Good partners
- Beyond what was stated above regarding dissemination of information regarding what HAS been learned in this project, it was unclear what if any integration there has been with permitting agencies. If indeed the project was demonstrating approaches to overcome regulatory barriers, what has the collaboration been with those agencies?

Question 6: Proposed Future Research, if applicable

- It makes sense for the team to continue where feasible to move this technology forward
- Poor use of such a large level of public funding, especially considering that technology is in commercial use in Europe

Question 7: Project Strengths

- The project has the potential to demonstrate a cost-effective foundation design as bankable and to demonstrate approaches to reduce regulatory barriers, also reducing cost. Both are important to reducing the cost of offshore wind power.

Question 8: Project Weaknesses

- Project led by stakeholders who felt offshore wind is encroachment on their resource, wanted to shape from inside out (ie delay)
- Dependent on political will

Question 9: Recommendations

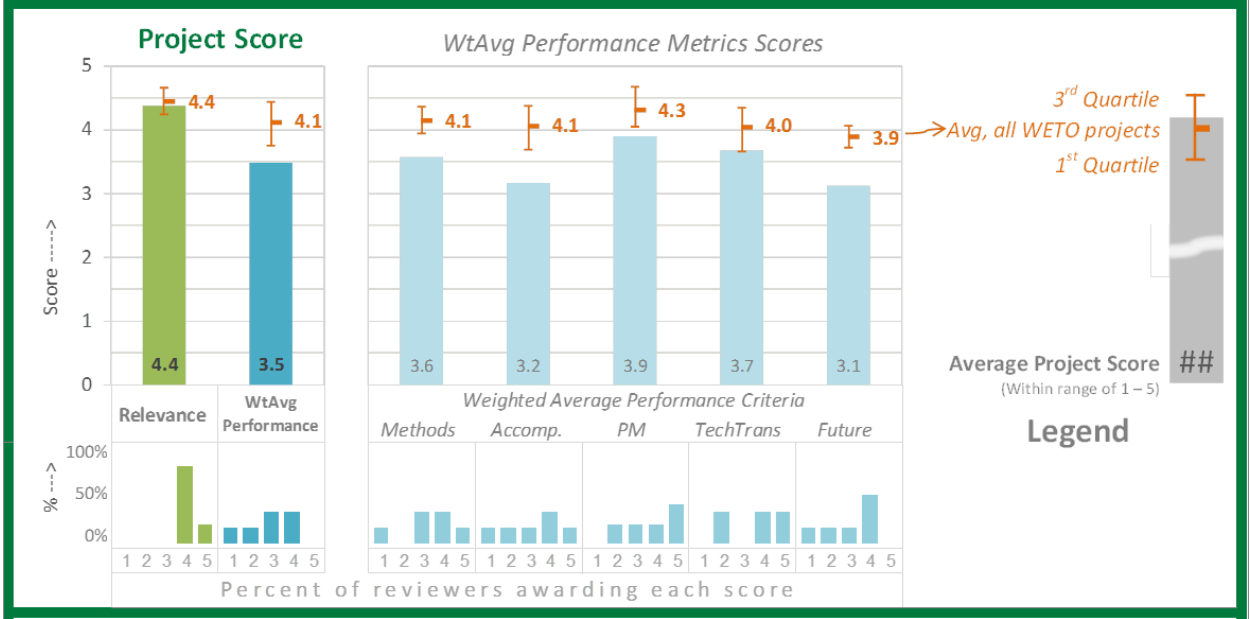
- Even such a large portion of DOE Wind program funding spent on early stages of such demonstration projects doesn't move the needle much, better to utilize other approaches to spur technical innovation and ultimately lead to successful offshore wind market

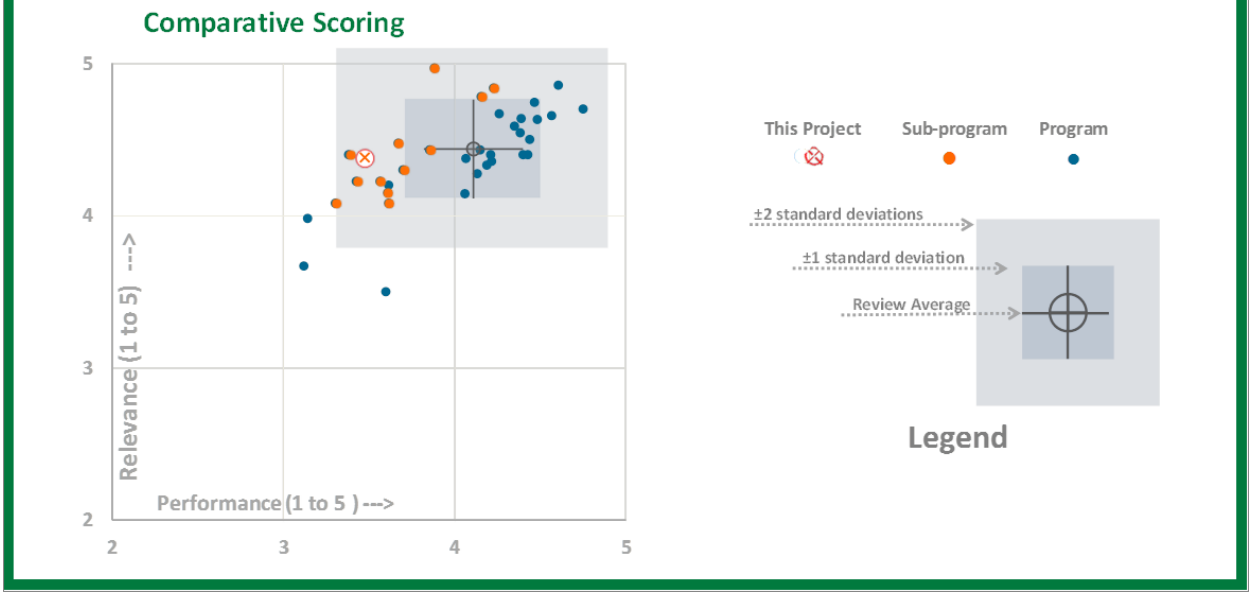
DOE Wind Energy Technologies Office 2017 Peer Review Project:

WindFloat Pacific Project

Principal Investigator	Kevin Banister, Principle Power, Inc.		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Offshore Wind (OSW)		
FY 2014-2016 Funding	DOE	$ 33.3 M	80%
	Cost Share	$ 8.5 M	20%
	Total	**$ 41.9 M**	**100%**

Peer Review ID# 244





Comments made by reviewers during the evaluation of this project (PRID 244)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- The project challenge was broad and risky
- Working through all the permitting processes for the first time on the West Coast was a major pathfinder process
- The impact and cost of regulations for wind energy implementation should be captured and reflected to the public and policy makers!
- I am currently under contract to provide independent review of the demonstration projects and, as such, I am restricted by COI (conflict of interest) to review this project
- Poor use of $10.7 million of taxpayer funds
- Principle Power had to pull out of the DOE program because they were not able to get a PPA (power purchase agreement) for their project
- Very ambitious goals: 300 m water depth, 20 miles offshore, extreme wind metocean environment
- Novel support semisubmersible structure. But the economic advantages over other floating systems?
- Offshore wind is outside my core competencies, but I do recognize that floating offshore wind will be a necessary part of the mix in foundation technologies, especially for installations off the West Coast
- Interesting concept of assemble in port, then tow completed machine and foundation out to site. Would tow back into port for major corrective maintenance, which is highly desirable.
- With 60% of the U.S. wind resource in waters deep enough to require floating foundation technology, demonstrating this in the United States and having it as a laboratory of sorts is a critical objective for offshore wind industry in the United States

Question 2: Methods and Approach

- ABS Group approved design was an accomplishment
- Plan for fabrication to be performed quayside, then tow to site was practical
- Unclear why this configuration of publicly-funded demonstration project needed when floating technology has been deployed for 5 yrs in Portugal
- Lowered O&M (operations and maintenance) cost very attractive
- Well suited for deep water
- What is the minimum depth constraint? 30m?
- Time and level of effort to retrieve to quayside for maintenance? (Decouple, tow in). Float in/out seems like an attractive strategy but decoupling and towing in/out is also not trivial. What is the threshold maintenance event?
- The methods and approach appeared to be good
- The approaches and methods used were the right ones, however in bad circumstances. It is unclear that the project has a path forward to overcome its non-technical barriers (power off-take).

Question 3: Technical Accomplishments and Progress

- Significant progress was made on several of the hurdles
- PPA could not be obtained
- NEPA (National Environmental Policy Act) process not completed
- Useful lesson learned: permitting negotiations drove project farther away from shore than economical (18 mi), with conventional project finance scheme
- Completed front end design
- ABS approval in principle
- Many of the project's goals were met, however, no operating wind turbine was installed. The inability to secure a power purchase agreement should be considered outside the objectives (if not outside the influence) for this program.
- It would be useful for the project to illuminate its findings and disseminate them. Even though the project hasn't been built, what has been learned? How can those lessons, funded with federal funds, be applied to additional offshore wind development in deeper water?

Comments made by reviewers during the evaluation of this project (PRID 244)

Question 4: Project Management

- This was a complex project and it seemed to be managed well given the technical and political challenges
- Project scaled back from 30 MW to 16 MW, just two wind turbines which doesn't make sense for application
- Critical path milestones not completed
- Failed to secure PPA
- The project management appeared to be good

Question 5: Research Integration, Collaboration, and Technology Transfer

- Excellent team breadth and expertise
- Project highlighted major barrier for offshore wind, very large project size needed for economics to work
- The program appeared to have good collaboration across industry and good communications outreach
- Communications regarding lessons should go well beyond a website and conference presentations

Question 6: Proposed Future Research, if applicable

- No U.S. project planned, but Portugal and France projects are moving forward
- Still must get over initial project hurdles
- Very disappointing that all DOE funds expended even though major milestones not met and project is ultimately a failure
- Portugal project
- N/A (Not applicable) the project is complete

Question 7: Project Strengths

- Great project, not the right time

Question 8: Project Weaknesses

- Cost effectiveness and need for floating wind turbines off Northwest coast unproven, considering low retail electricity rates and developable land still available throughout region

Question 9: Recommendations

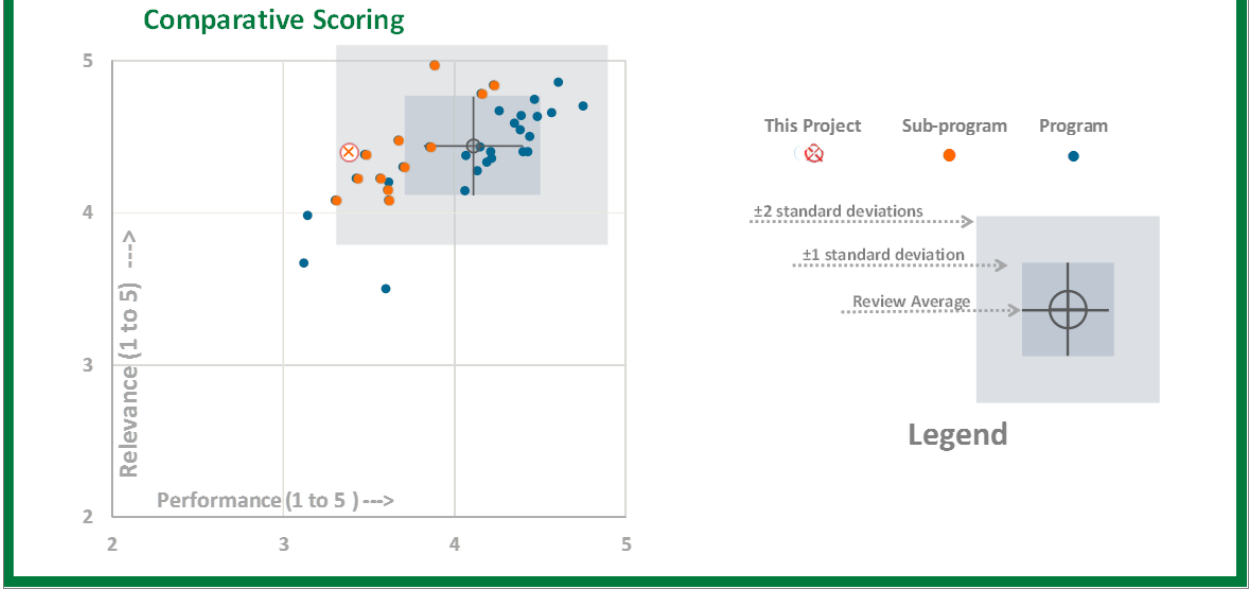
- For future projects DOE should tie payments to completion of important milestones for such large projects to ensure public dollars well spent
- Consider lessons from 6 MW Coastal Community wind project on Washington State coast - benefit to local service organization (providing funds for low-income weatherization, meals-on-wheels programs, etc.) enabled public acceptance, reducing aesthetic concerns and permitting challenges

DOE Wind Energy Technologies Office 2017 Peer Review Project:

Hywind Maine Project

Principal Investigator	Andrea Nina Eugster, Statoil		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Offshore Wind (OSW)		
FY 2014-2016 Funding	DOE	$ 1.5 M	82%
	Cost Share	$ 0.3 M	18%
	Total	**$ 1.9 M**	**100%**

Peer Review ID# 245



Comments made by reviewers during the evaluation of this project (PRID 245)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Interesting and somewhat unique project to combine floating design in an array looking at wakes and wake control, waves, loads, etc.
- Research appropriate to inform other offshore concepts
- This scope of work for this project was modified after Statoil's plans for the site changed
- The modified scope of work is generally consistent with the DOE objectives, but it does not seem as if this project added significantly to the SOP (standard operating procedure) or provided any new information that was already available from other sources
- Need for DOE Wind funding is unclear, as technology has already been deployed in Norway
- Statoil initially pulled out but are back in committed to the project
- Updated to 6 MW turbine from 3 MW
- Only commercial floating system so it has the best chance of demonstrating floating systems in the United States and has commercial plan
- Offshore Wind is outside my core competencies, but I recognize that floating offshore wind will be a necessary part of the mix in foundation technologies, especially for installations off the West Coast
- I give the project a 5 for relevance related to its purpose/goals, however as will be noted below, there are concerns about how this unfolded and whether or not its value was maximized

Question 2: Methods and Approach

- Good use of a wide variety of modeling tools to explore offshore loads and controls
- All work packages have value for supporting the emerging industry
- This project addressed advanced issues related to floating wind farm design, however, it is not clear if this information can be adapted to help with other generic applications of floating wind farm development
- Confidential data, proprietary tool not available for others to use, good that DOE working to release layers
- Extensive use of NREL modeling tools and experience to investigate hydro-elastic stability and control strategies
- Most proven floating platform of any concepts
- Will future data be available for model validation?
- Favored anchor configuration? It depends…
- The methods and approach appeared good
- Research conducted seemed well designed

Question 3: Technical Accomplishments and Progress

- All work packages have resulted in very usable information to reduce risk for future projects
- Some positive results provided to assess wake steering and fatigue
- Results have been used for company-specific business development, unclear what benefit work has had for overall industry
- Relatively low cost-sharing provided for work to benefit a specific multinational oil & gas corporation headquartered outside the United States
- Lower fatigue loads than a bottom fixed system? Excellent.
- Have not demonstrated operating turbines in U.S. waters yet
- The technical accomplishments appeared to meet program objectives
- The presentation suggests that the research accomplished yielded important benefits/findings

Question 4: Project Management

- Some challenges, but mostly overcome
- It's difficult to assess the PM (project management) on this effort given the rescoping, but the work slipped significantly
- The funds allocated to this effort were significant and led to a low ROI (return on investment)
- Slipped milestones, poor allocation of resources
- Funding clarification? (See budget summary. About $2m. Mostly to NREL for all the modeling).

Comments made by reviewers during the evaluation of this project (PRID 245)

- Statoil could have abandoned the project completely but they continued to participate with NREL analysis team. This low level of engagement led to a possible more fruitful continuation.
- The project management appeared to be good

Question 5: Research Integration, Collaboration, and Technology Transfer

- Solid team and publications have been generated and some pending
- The outreach seems a bit limited by the project team. Perhaps the DOE is disseminating the information.
- Generally good collaboration with NREL. Not much more beyond that.
- Limited sharing of meaningful outcomes
- Data presented as proprietary and won't be shared
- Mostly NREL effort but there was much Statoil engagement
- The project appeared to make good use of NREL personnel, but appeared to have limited interactions with industry outside of NREL
- This was my main concern about this project. Upon questioning, the PI (Principal Investigator) indicated that all data was a) proprietary to Statoil and b) being used for their business development as a company. If this is the case, it would be unacceptable I would think to have DOE ATD (Advanced Technology Demonstration) funds go to Statoil to provide them proprietary information for their own business development. So, I am assuming that there is more to this. Indeed, the written presentation and summary indicate that findings are being used by NREL for further research. This should have been made much more clear.

Question 6: Proposed Future Research, if applicable

- It makes sense to continue to advance this capability toward deployment
- No real follow on proposed
- Further analysis in this area is not warranted given state of industry
- Depends
- N/A (Not applicable), the project is complete
- As described there is no future research planned

Question 7: Project Strengths

- R&D filled a niche for floating systems. Results seem very encouraging.
- Original purpose of demonstrating Hywind technology was an important goal; the objectives were correct

Question 8: Project Weaknesses

- More real world testing is needed to validate modeling
- Seemingly limited requirements on project finding dissemination

Question 9: Recommendations

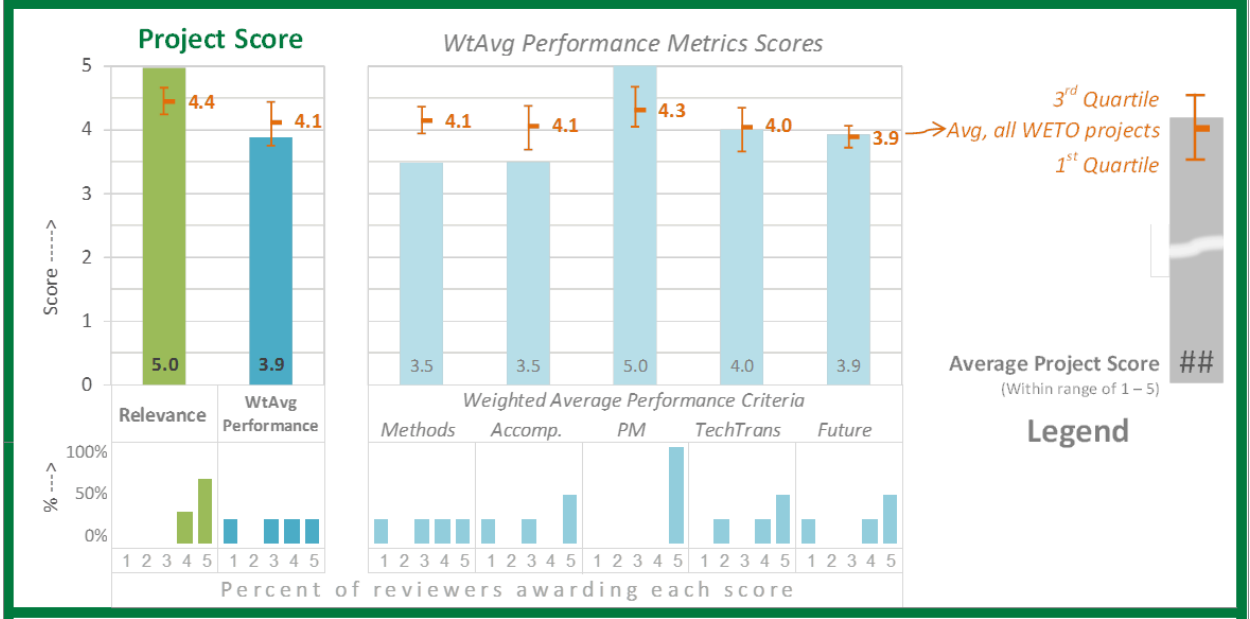
- Consider applying spatio-economic analysis to inform strategic decisions on commercializing distributed wind

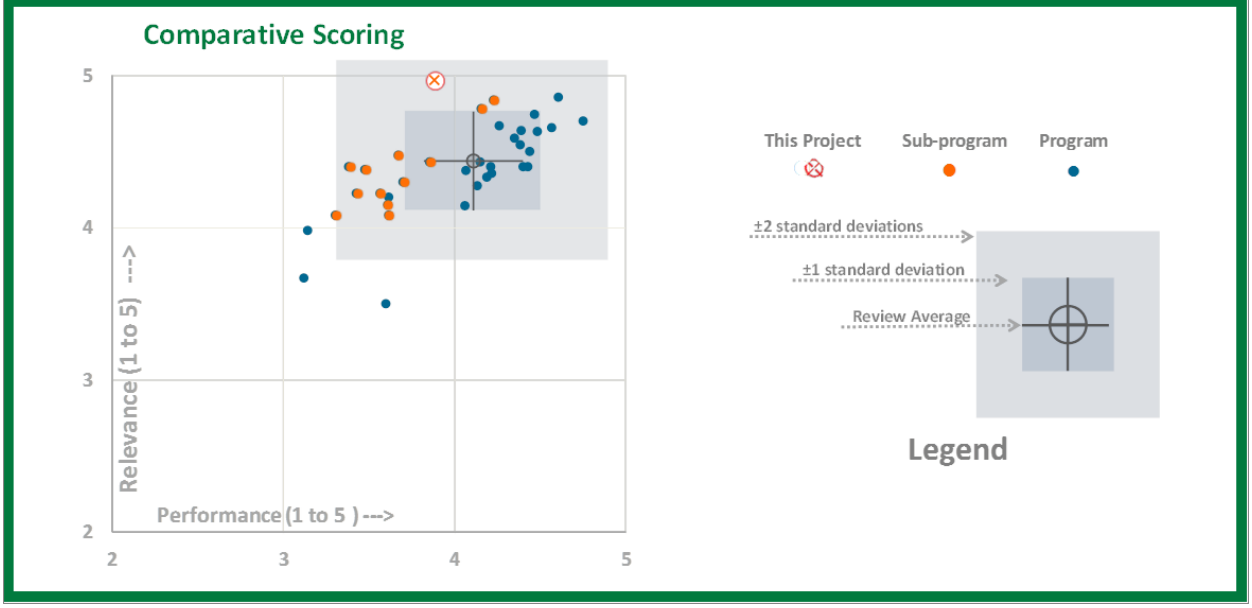
DOE Wind Energy Technologies Office 2017 Peer Review Project:

The University of Maine's New England Aqua Ventus I Program

Principal Investigator	Habib Dagher, University of Maine		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Offshore Wind (OSW)		
FY 2014-2016 Funding	DOE	$ 6.7 M	78%
	Cost Share	$ 1.9 M	22%
	Total	**$ 8.6 M**	**100%**

Peer Review ID# 248





Comments made by reviewers during the evaluation of this project (PRID 248)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Given prior R&D (before DOE ODP), this was a good project since some risk had already been addressed
- I am currently under contract to provide independent review of the demonstration projects and, as such, I am restricted by COI (conflict of interest) to review this project
- Unclear how financing will be secured within target timeframe, high risk for such large budget
- Strategic gain by deploying just two 6 MW far from load is not justified, why build "skyscraper" in remote location?
- Well presented, well managed project
- Four different initial awards of $4m each. After a go/no-go a down-select was done in May of 2016. Dominion and Principle Power were dropped. Maine and LeadCo were brought back. $6.7 m have been received for each. Next go/no-go is 2018. Fisherman's is still included.
- This project actually did demonstrate a floating system, at subscale but still relevant demonstration of the basic technology that will be applied to full scale
- Introduced innovative floating platform technology
- Demonstrating the cost reduction pathway/potential for floating offshore wind in the United States is a critical objective towards a robust U.S. offshore wind industry. Importantly, it is an area of innovation of which the United States can be at the forefront.

Question 2: Methods and Approach

- Solid project plan and experienced team members
- Use of concrete option was well studied w.r.t. cost and technology
- External design reviews were important
- Wind-wave tank testing was creative
- 6 MW investor driven, but major scaling of unproven technology
- Unclear why site is so far (14 m) from coast
- Cianbro bridge construction technique leads to low cost, low risk approach to semi-submersible platform
- Excellent deployment approach, capitalizing on commercial experience
- Excellent partnership with commercial industry partner
- I have concerns about ability of the project to overcome non-technical barrier of power offtake, regardless of whether or not UMaine has a PPA (power purchase agreement) term sheet

Question 3: Technical Accomplishments and Progress

- Hull review and approval by ABS Group is noteworthy
- The testing process seemed appropriately comprehensive
- Even though PPA Term Sheet approved by PUC (Public Utility Commission), negotiations likely to drag out
- ABS approval is significant
- Will ABS approve according to IEC (International Electrotechnical Commission) 61400-3 standard?
- Did ABS consider ice accumulation on the structure?
- Is there sufficient funding for a significant instrumentation and data collection effort? Also data analysis?
- Full scale not demonstrated yet but promising subscale testing demonstrated viability
- For reasons stated above in Q2 comment

Question 4: Project Management

- Unclear why FY16 funds only 25% expended, 2019 commercial operations date unlikely
- Demonstrated staying power with innovative subscale testing, creative partner, leveraged state funding for experimental work

Question 5: Research Integration, Collaboration, and Technology Transfer

- No concerns here
- Good to see refereed journal papers and conference presentations, however focus seems misplaced before field results are available
- Good commercial platform partner
- Need strong turbine partner

Comments made by reviewers during the evaluation of this project (PRID 248)

Question 6: Proposed Future Research, if applicable

- Project plan for 2019 full demo seems reasonable
- Future expenditures at FY15 rate are not warranted

Question 7: Project Strengths

- Significant testing and validation of design performed along the way
- Seems to be a practical design with significant potential
- Good innovation. A good investment of public funds from which strong returns can be expected
- Floating is the future of large-scale offshore wind. Demonstrating it and making it a part of the mix is important to the advancement of the industry.

Question 8: Project Weaknesses

- Need to evaluate icing potential
- Unclear path to off take

Question 9: Recommendations

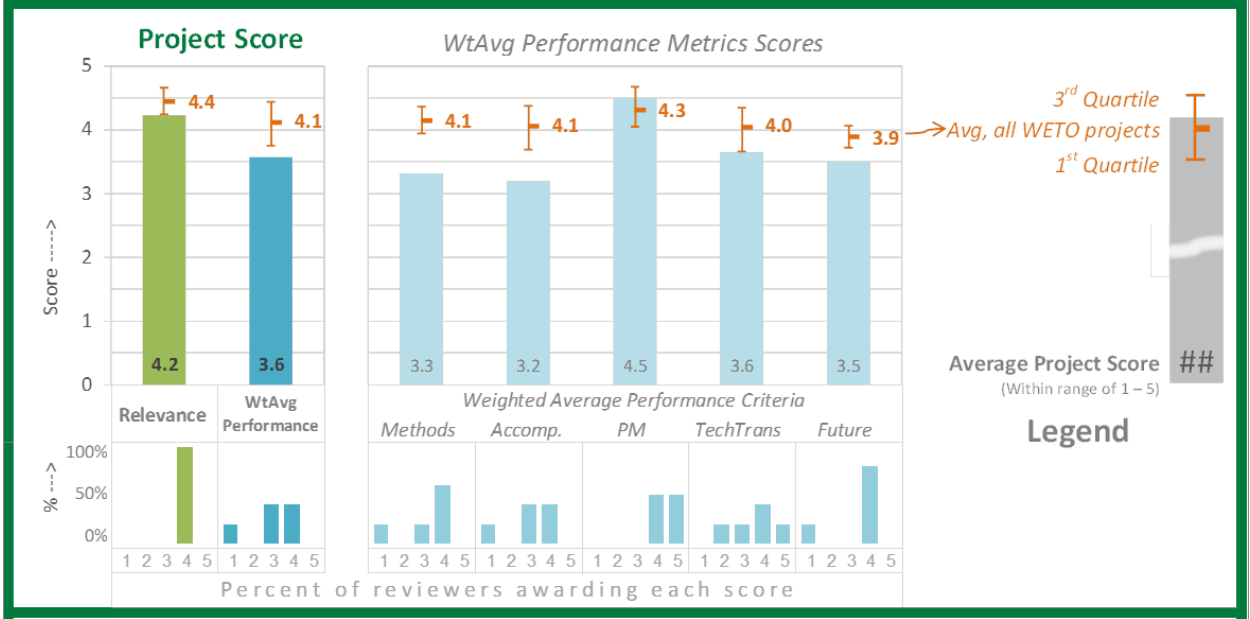
- None

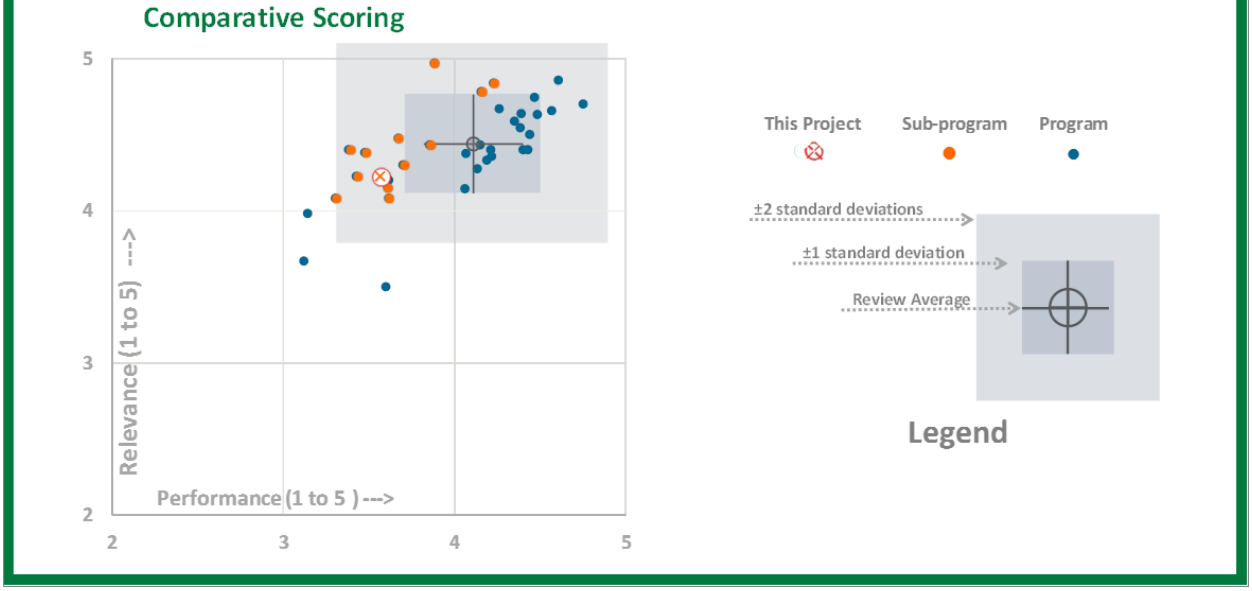
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Project Icebreaker

Principal Investigator	Dave Karpinski, Lake Erie Energy Development Corporation		
Program	Wind Resource Characterization and Technology RD&T		
Sub-Program	Offshore Wind (OSW)		
FY 2014-2016 Funding	DOE	$ 6.8 M	77%
	Cost Share	$ 2.1 M	23%
	Total	**$ 8.8 M**	**100%**

Peer Review ID# 249





Comments made by reviewers during the evaluation of this project (PRID 249)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Goal to create a pathway for offshore wind in the Great Lakes is laudable
- Good decision to use the Mono Bucket given lake bed characteristics
- Muni Power provided a more streamlined PPA (power purchase agreement) process
- I am currently under contract to provide independent review of the demonstration projects and, as such, I am restricted by COI (conflict of interest) to review this project
- Need for DOE funding for this work is not warranted
- All these demo projects are more support structure demo projects than system demos because the main difference and risk is in the support structure. But the final barriers were not permitting, or engineering, or financing. It was PPA and the politics of getting a PPA. State politics are easier than federal politics.
- Unique bottom conditions (20 meters of mud on top of granite rock) demanded special support structure design
- Ice flow design impact? The standard solution is an inverted cone on the tower. It appears that solution has been chosen.
- Suction bucket solution was successfully executed in Denmark many years ago. This significantly de-risks project.
- Blend European technology with local experience. Foundation concept is used in oil and gas, unique to wind is critical verticality during installation. No prototype testing.
- Good presentation - focused on new technology - foundation
- Evaluation of foundation type for the United States (with broader application than in the Great Lakes) is important to identifying multiple, least-cost subsea foundation types for U.S. offshore wind industry

Question 2: Methods and Approach

- Solid process to evaluate foundation structures
- Design was vetted by external experts
- Unclear why project site so far (8 miles) offshore
- It is unclear if the project will be able to overcome the non-technical barriers (power offtake)

Question 3: Technical Accomplishments and Progress

- Was able to achieve a solid evaluation and selection process for the foundation
- The PPA process was mostly completed (2/3) with munis
- The real proof of success is pending…lot of potential
- Developed 10 prospects for U.S. fabrication supply chain
- It is important that these projects be given the same amount of time as previous ATDs (Advanced Technology Demonstrations) to reach their goals/milestones. Offshore wind's development lead time is longer than anyone has expected (in the United States) and perhaps those timelines should be extended to reflect that. However, only in the event that progress occurs that can be transferred to other subprograms and to the industry at large.

Question 4: Project Management

- No concerns about competency
- Budget increases and delays related to design verification issues, geotech tests

Question 5: Research Integration, Collaboration, and Technology Transfer

- Good team put in place for this effort
- Innovative PPA structure (64% of power utilized "behind the meter" good strategy for other projects
- The extent to which lessons already learned through the project are being made known to the industry was clear

Question 6: Proposed Future Research, if applicable

- The team should continue to move ahead with these risk reduction activities toward a model deployment
- Continuation of funding not justified until financial closing
- Complete the installation and commissioning

Comments made by reviewers during the evaluation of this project (PRID 249)

Question 7: Project Strengths

- Design and approval of the foundation design
- Dealing with initial PPAs
- Overall strength of the program design, which ensured good stewardship of funds for the advanced technology demonstration projects
- LEEDCo (Lake Erie Energy Development Corporation) project has been well-managed

Question 8: Project Weaknesses

- Still concerns about how the design will deal with sheets of ice that move with the wind on Lake Erie and ice breaking complexities
- The overall program did not seem as if it was developed in true partnership with industry, to demonstrate and advance the true needs of the nascent offshore wind industry in the United States

Question 9: Recommendations

- Cut losses sooner, public funding should not be provided until all critical factors are in place to ensure such projects will indeed be built within expected timeframe

7.4 Market Acceleration and Deployment Track: Project Scores and Comments

For the 2017 WETO Peer Review, MA&D projects were organized into four subprograms: Analysis and Modeling; Grid Systems Planning and Operation; Siting, Radar, and Environmental; and Stakeholder Engagement. Table 7-2 provides a master list of projects in the MA&D track, along with respective average scores. Sections 7.4.1–7.4.4 include the individual project score charts and reviewer comments for every project in each respective track. The project score tables also include subprogram funding information for the DOE portion of funding and the cost share, which is the portion of funding provided by project awardees.

Table 7-2. Market Accelerations and Deployment Track Master Project List

Market Acceleration and Deployment Track	Relevance	Weighted Average Performance	Methods/Approach	Results	Project Management	Technology Transfer	Future Research
Average scores across all WETO peer-reviewed projects	**4.4**	**4.1**	4.1	4.0	4.3	4.0	3.9
Wind MA&D: Analysis and Modeling							
Average scores for Analysis and Modeling subprogram	**5.0**	**4.6**	4.6	4.6	4.4	5.0	4.6
Cost of Energy, Policy Impact Analysis, and Market Report (PRID 126) Ryan Wiser, LBNL	5.0	4.6	4.6	4.6	4.4	5.0	4.6
Wind MA&D: Grid Systems Planning and Operation							
Average scores for Grid Systems subprogram	**4.5**	**4.4**	4.4	4.3	4.6	4.3	4.2
Wind Integration Studies (ERGIS and WWSIS 3)[1] (PRID 131) Aaron Bloom, NREL	4.8	4.6	4.5	4.8	4.8	4.6	4.0
Active Power Controls (PRID 136) Yingchen Zhang, NREL	4.8	4.4	4.5	4.5	4.8	4.3	3.7
Wind Generator Modeling (PRID 144) Ben Karlson, SNL	4.6	4.6	4.8	4.6	4.8	4.6	4.0
Connecting the National Wind Test Center to the Energy Systems Integration Facility (PRID 134) Dave Corbus, NREL	4.5	4.6	4.8	4.6	4.8	4.3	4.3
Grid Integration Support, UVIG, IEEE, NERC, IEA[2] Task 25 (PRID 132) Dave Corbus, NREL	4.5	4.6	4.5	4.3	5.0	4.8	5.0
Analysis Using PMU [phasor measurement unit] Data and Dynamic Analysis (PRID 135) Edward Muljadi, NREL	4.3	4.4	4.3	4.3	4.4	4.5	5.0
Distributed Wind Integration (PRID 133) Bri-Mathias Hodge, NREL	4.3	4.1	3.9	4.3	4.4	3.9	4.0
Stochastic Tool Evaluation (PRID 124) Audun Botterud, ANL	4.2	4.0	4.0	3.8	4.4	4.0	4.0

[1] ERGIS = [Eastern Renewable Generation Integration Study], WWSIS = Western Wind and Solar Integration Study

[2] UVIG = [Utility Variable-Generation Integration Group]; NERC = North American Electric Reliability Corporation; IEA = International Energy Agency

Market Acceleration and Deployment Track	Relevance	Weighted Average Performance	Methods/Approach	Results	Project Management	Technology Transfer	Future Research
Concurrent Cooling (PRID 125) Jake Gentle, INL	4.2	4.0	4.0	4.0	4.1	4.2	3.7
Wind MA&D: Siting, Radar, and Environmental							
Average scores for Siting subprogram	**4.5**	**4.1**	4.3	4.1	4.3	3.8	3.8
MIT Lincoln Labs Radar Mitigation R&D (PRID 128) Jason Biddle, Massachusetts Institute of Technology, Lincoln Laboratory	5.0	4.4	4.5	4.5	4.5	4.4	4.0
SNL Wind-Turbine RCS [radar cross section] Mitigation (PRID 145) Ben Karlson, SNL	5.0	4.4	4.5	4.5	4.3	4.4	4.1
Texturizing Wind Turbine Towers to Reduce Bat Mortality (PRID 150) Victoria Bennett, Texas Christian University	4.8	4.5	4.7	4.6	4.5	3.4	4.9
Wind Environmental Collaborative Research and Support (PRID 137) Karin Sinclair, NREL	4.8	4.4	4.5	4.4	4.4	4.5	4.5
A Biomimetic Ultrasonic Whistle for Use as a Bat Deterrent on Wind Turbines (PRID 149) Paul Sievert, University of Massachusetts Amherst	4.8	4.0	4.3	3.8	4.5	3.2	4.0
Evaluating the Effectiveness of Ultrasonic Acoustic Deterrents in Reducing Bat Fatalities at Wind Energy Facilities (PRID 153) Cris Hein, Bat Conservation International	4.6	4.3	4.5	4.3	4.4	3.9	4.5
Rotor-Mounted Bat Impact Mitigation System (PRID 151) Myron Miller, Frontier Wind LLC	4.6	4.2	4.3	4.1	4.3	4.0	4.2
OSW [Offshore Wind] Environmental Data Aggregation, Analysis and Dissemination (PRID 143) Andrea Copping, PNNL	4.5	4.3	4.3	4.4	4.3	4.5	4.4
Ultrasonic Bat Deterrent Technology (PRID 152) Michael Booth, General Electric	4.5	3.7	4.0	3.7	4.2	3.0	3.0
Stereo-Optic High Definition Imaging: A New Technology to Understand Bird and Bat Avoidance of Wind Turbines (PRID 147) Evan Adams, Biodiversity Research Institute	3.7	3.5	3.6	3.6	4.1	3.1	1.5
Avian Remote Sensing (PRID 269) Shari Matzner, PNNL	3.5	3.8	3.8	3.8	4.3	3.8	2.9
Wind MA&D: Stakeholder Engagement							
Average scores for Stakeholder Engagement subprogram	**4.4**	**4.4**	4.3	4.4	4.5	4.6	4.1
WindExchange and Regional Resource Centers (PRID 138) Ian Baring-Gould, NREL	4.6	4.2	4.0	4.2	4.4	4.6	4.4
Wind for Schools (PRID 140) Mark Jacobson, NREL	4.5	4.6	4.7	4.6	4.6	4.6	4.4
Public Acceptance Baseline Analysis (PRID 127) Ben Hoen, Lawrence Berkeley National Laboratory (LBNL)	4.4	4.2	3.9	4.4	4.4	4.8	3.9
Collegiate Wind Competition (CWC) (PRID 139) Suzanne Tegen, NREL	4.2	4.4	4.4	4.4	4.4	4.6	3.8

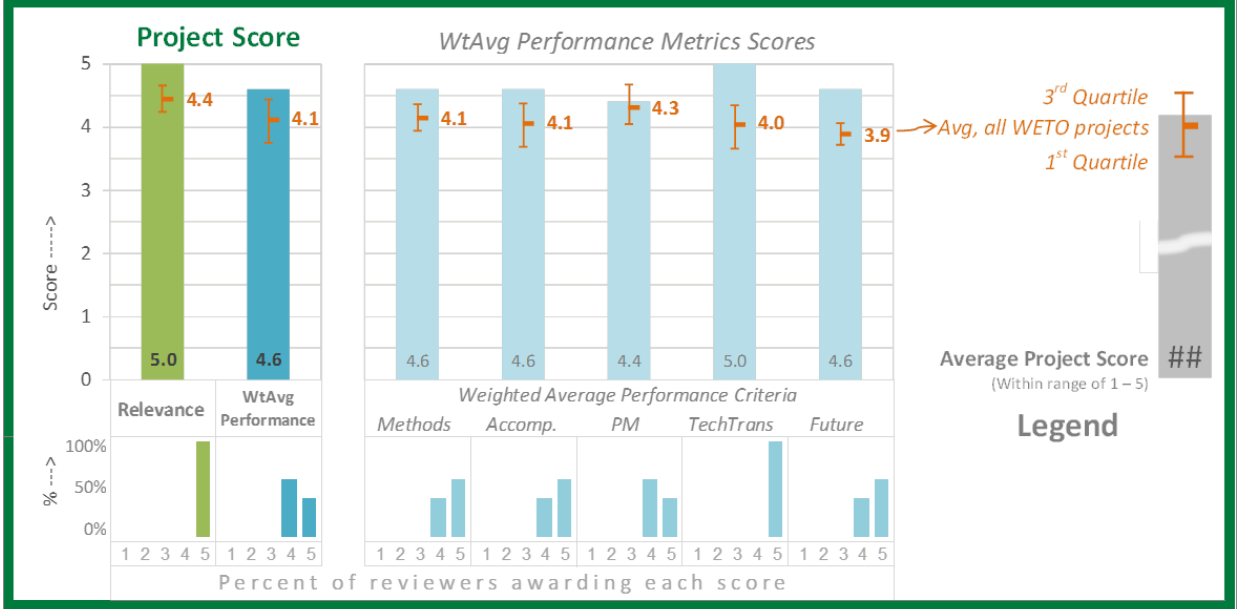
7.4.1 Analysis and Modeling

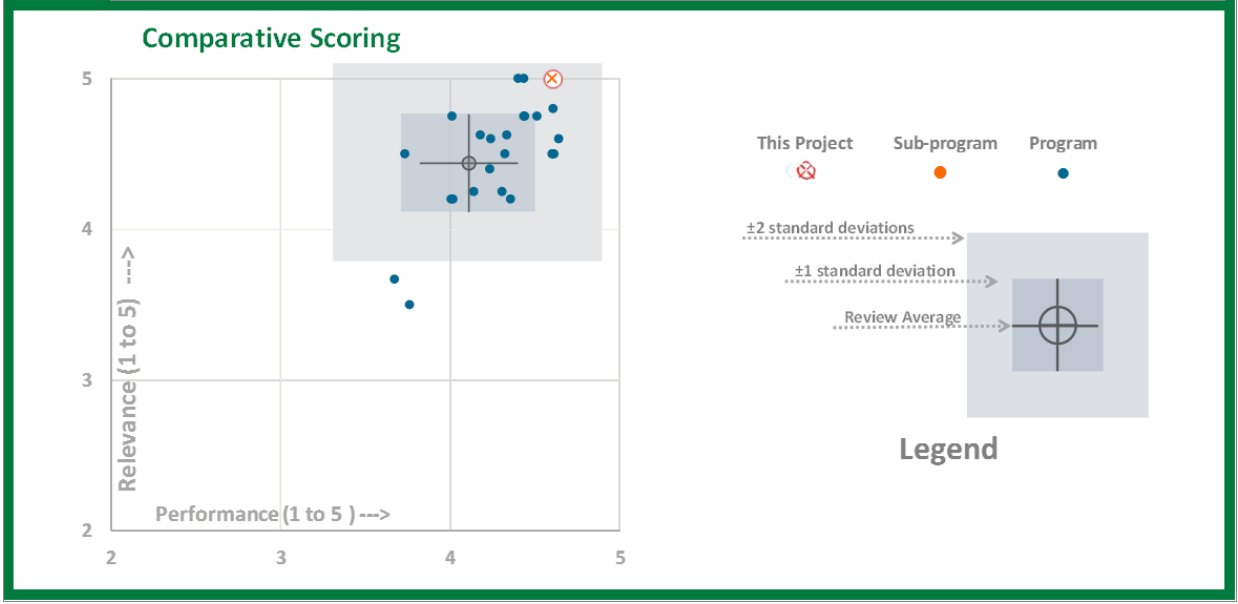
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Cost of Energy, Policy Impact Analysis, and Market Report

Principal Investigator	Ryan Wiser, Lawrence Berkley National Laboratory		
Program	Wind Market Acceleration and Deployment		
Sub-Program	Analysis and Modeling		
FY 2014-2016 Funding	DOE	$ 2.0 M	100%
	Cost Share		
	Total	**$ 2.0 M**	**100%**

Peer Review ID# 126





Comments made by reviewers during the evaluation of this project (PRID 126)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Very productive with reports and publications; seven (7) peer reviewed; 64 presentations over three years
- Expert elicitation method is innovative for the DOE program and other underutilized social science methods should be used more often
- Need more social and environmental integration into the story - PAW is an important beginning
- Essential tool for both DOE and industry in general, getting data analyzed and published on deployment and topical issues
- This appears to be an extremely valuable and capable analytical resource that has been utilized to good effect
- In my mind this is a core element/foundation of the wind program and provides great basis for everything else that comes after. Without community acceptance, societal appreciation for the benefits and understanding of the cost of wind, what the challenges are that need to be overcome in order to have higher deployment levels, etc. none of the rest really matters as the demand for the product will be low.
- Operations are trying to determine what the implications are for rising interest rates with respect to long term contracts (this is an issue for financing as well but DOE seems to have looked at that aspect already)
- With PTC (production tax credit) winding down, uncertainties around climate change policies, and analyses that look at market opportunities could be beneficial. It might be prudent to reach out to industry leadership to further define such a scope of work.

Question 2: Methods and Approach

- Expert elicitation method is innovative for the DOE program and other underutilized social science methods should be used more often
- The national focus of the market reports is very ambitious and wondering whether there is a way to focus on a regional scale as well (possible useful information for RRCs (Regional Resource Centers))?
- Cost reduction work - surveys is one way of analyses that can give valuable insight on future trends. As recent findings show, from unexpectedly low prices from recent Denmark and NL tenders that were not anticipated by any of the experts in the survey, this is not easy and surveys generally are only as good as the people answering them. Important that also other expert work on possible trends is ongoing.
- Important work on quantifying value of wind energy. This information is needed in deployment activities.
- Good tool to have a project able to respond to emerging needs during the project, leaving some analyses to be defined as needed
- This project has been described as less of a project and more of a "basket" of studies/tasks. The question arises whether the activity could benefit from more coherency.
- All these studies/reports serve a vital role in communicating the value of wind to the public and are great resources
- Methods seem to trend consistently since inception of project tasks, thus providing consistent and comparative long term trend data
- While the concept of such an analysis resonates, I am not completely sure the health benefits analysis can accurately capture the myriad of variables that affect regional air and other environmental benefits of wind energy

Question 3: Technical Accomplishments and Progress

- Excellent work on yearly market report, also great that it is building on many years of data. I have not seen similar reporting/real data analyses on costs from any other country.
- Very important work on quantifying value. Very little analyses internationally so will make a big impact.
- Property evaluation, now made for one state allowing better capturing data. These studies are made every now and then, perhaps evolving turbine size makes updates important, and also information from different states needed. (One day, these are not needed anymore?)

Comments made by reviewers during the evaluation of this project (PRID 126)
• Cost reduction work - surveys are one way of analyses, good to hear that also other work on possible trends is ongoing

- The analytical capability appears to be used to good effect. Some examples which stand out are the results showing the minimal impact of wind turbines on house prices compared to other technologies and the upcoming article on the historical health benefits of wind power. These types of studies from a credible source are key in "winning hearts and minds" and dismissing "alternative facts".
- In my estimation each of the studies/reports issued by Ryan and his team have accomplished the goals they were established to meet
- Consider a reduction in scope (i.e., fewer tasks) that focuses on some key, near-term added value investigations. It may be helpful to canvas industry and public policy stakeholders to determine what gaps in knowledge are best attended to in future work.

Question 4: Project Management

- Similar to comment in "Methods/Approach" - perhaps a more coherent structure could permit more to be done through pooling of resources etc.
- It appears Ryan's team has developed all the anticipated reports, articles, etc. on time and within their budget. The work products have been outstanding and given the volume of the work think this was a well-managed project.
- The presentation did not breakdown the budget expenditure by task and given the broad diversity and volume of tasks performed it may be that some level of funding was spent out of alignment with stakeholder needs. More financial information provided to reviewers might reveal more substantive feedback on value of a given task.
- For example, while the public acceptance work adds value to stakeholders in industry and government, if budget constraints dictate change in focus for this project's scope, it might be that public acceptance tasks, while continually beneficial, would not be as valuable as market or technology performance reports

Question 5: Research Integration, Collaboration, and Technology Transfer

- Excellent both scientific and other dissemination
- Working with collaborators, and IEA (International Energy Agency) WIND Task 26
- Extremely strong focus on outreach and dissemination
- Very high level of collaboration
- I know first-hand from my experiences with the Wind Vision report that this team actively sought out input from a variety of sources and worked hard on integrating the views of these parties into the final work product. First rate example of public - private partnering where the government is seeking to involve and take feedback from outside sources and not merely develop something internally.
- It seems that the broad subject matter that LBNL conducts would be suitable for regional centers to be briefed on in order to increase their knowledge base and use them to further disseminate information and reports

Question 6: Proposed Future Research, if applicable

- LBNL is very effective at selecting relevant and timely issues for the wind community
- Proposed future research appears to be highly relevant
- I think the outlined future research goals are all good. The only recommendation I have on addressing a major issue the wind industry has faced for decades is to develop a comparative analysis of the life cycle impacts on wildlife, water, land, and other natural resources from all major energy sources (gas, oil, coal, wind, solar, nuclear, hydro, and geothermal). Without that analysis the wind industry is left to try and counter claims about the impacts on wildlife in an uneven playing field as it is the one industry actively studying and collecting this data. I recognize it would be difficult for the wind program to undertake this alone but perhaps with its sister programs, big DOE, USGS (U.S. Geological Survey), and/or National Academies of Science it could be done in an impartial/non-partisan way so that the public can once and for all understand what the environmental and social costs of our energy generating sector are.
- Rhode Island offshore project being looked at to begin long-term analysis of offshore energy? Not sure about immediate value but beginning data collection and assessment early on in the project's life might lend well to robust, long-term assessments for future offshore project development
- Domestic content of turbine technology would continue to be a valuable data source for manufacturers and supply chain portion of industry

Comments made by reviewers during the evaluation of this project (PRID 126)

Question 7: Project Strengths

- Top notch methods and analysis
- Very productive on number of publications and webcasts
- Extremely strong technical capability
- Extremely strong outreach, dissemination and collaboration
- Very valuable results produced and communicated - particularly impact of wind power on house prices compared to other developments
- The overall value of providing detailed information to the public on the value and cost of wind energy deployment
- Consistent and comprehensive report generation adds value by providing reliable long term trend information

Question 8: Project Weaknesses

- Would be even more impressive program if LBNL continues to incorporate more social science methods and issues (beyond economics) into their well-respected program. So recent methods used such as expert elicitation and national mail/telephone surveys on social acceptability of folks living near turbines, are good steps that should continue.
- I do not see any that would apply
- Difficult to assess value proposition on all tasks for lack of breakdown of task costs. Given overall budget allotment, it might be prudent to pare down budget and focus on future tasks that maximize value.

Question 9: Recommendations

- As noted above, the only recommendation I have is for the wind program to work with others (DOE as a whole, USGS, NAS (National Academy of Sciences), etc.) to develop a comparative analysis of the life cycle impacts on wildlife, water, land, and other natural resources from all major energy sources (gas, oil, coal, wind, solar, nuclear, hydro, and geothermal). Without that analysis the wind industry is left to try and counter claims about the impacts on wildlife in an uneven playing field as it is the one industry actively studying and collecting this data.

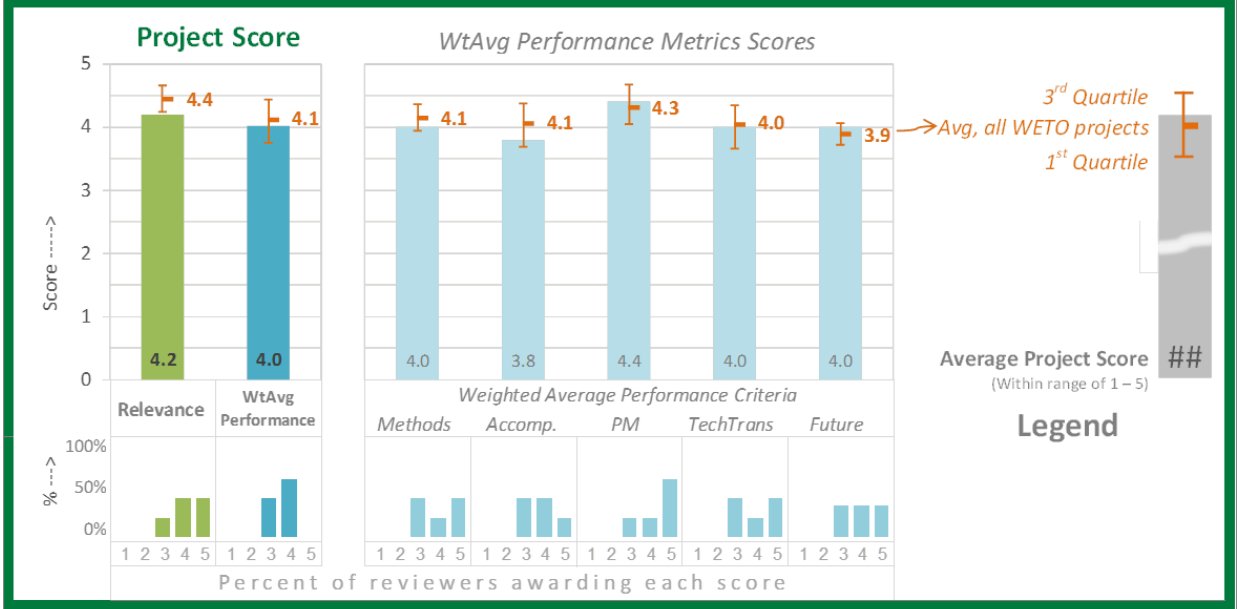
7.4.2 Grid Systems Planning and Operation

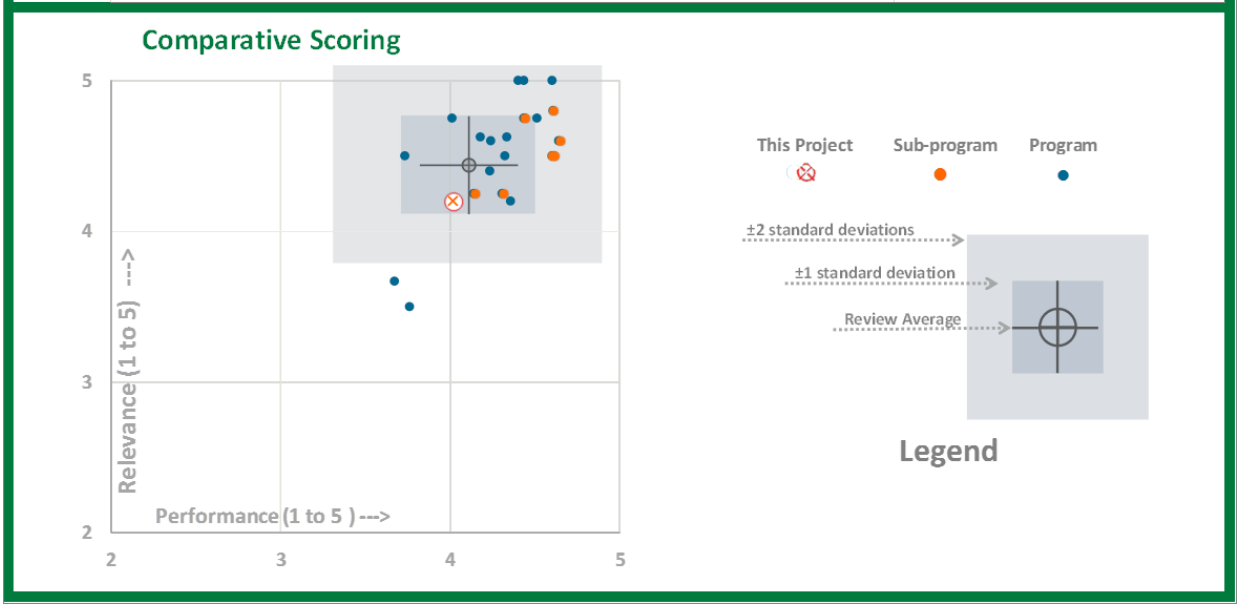
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Stochastic Tool Evaluation

Principal Investigator	Audun Botterud, Argonne National Laboratory		
Program	Wind Market Acceleration and Deployment		
Sub-Program	Grid Systems Planning and Operation		
FY 2014-2016 Funding	DOE	$ 0.5 M	100%
	Cost Share		
	Total	**$ 0.5 M**	**100%**

Peer Review ID# 124





Comments made by reviewers during the evaluation of this project (PRID 124)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- I do not have the expertise to evaluate the utility of this task so these scores are only gut feelings and utility of the work
- Operational practices are one important route to improve wind integration, and stochastic planning tools are one part of this
- This project targets a very relevant question for system operators as more information becomes available regarding wind forecast uncertainties. Traditional production cost simulation does not capture uncertainty information well but there is a relatively high cost in adopting new approaches and more information is required on the available techniques and the benefits of using them.
- This project is outside my area of expertise so it is difficult for me to assess the value of the project and how it aligns with the Wind Program goals, however, it seems to be a well-designed and executed project that met its goals and stayed within budget
- Unclear from presentation and summary what the relevance of the project is. The approach seemed academic in nature and scope and therefore real world applicability was unclear.

Question 2: Methods and Approach

- Improvement of tools, and benchmarking benefits against existing practice good work
- It was stated that it is hard to make realistic comparison between different operational strategies. Also the share of wind /uncertainty in generation impacts the results as stochastic methods have more benefits at larger shares of wind, so comparing existing literature is not really possible.
- The project is well thought out. The various modelling approaches are each applied to the IEEE 118 bus system and result costs and run times are compared.
- In stochastic unit commitment models, there is a tradeoff to be made between the number of scenarios to run and the solution run time. It has been shown that 6 are enough to achieve a stable result while retaining the benefits. The study could have benefitted from exploring the impact of fewer stochastic scenarios on cost and run time. Moment matching techniques also provide an efficient way to generate an arbitrary number of scenarios: See e.g. Lowery, Colm, O'Malley, Mark : Impact of Wind Forecast Error Statistics Upon Unit Commitment. IEEE Transactions on Sustainable Energy, 3 (4) 2012-10, pp.760-768.
- While it is convenient to use the IEEE 118 bus system for such studies, the results could look quite different when applied to an actual system - it would be interesting to see this result
- The project seems to have been well designed and executed
- For lack of subject matter expertise, limited in what can be said about methods

Question 3: Technical Accomplishments and Progress

- New knowledge has been provided, and advances in tools at ANL
- Testing of operational strategies on IEEE 118 bus system with 21% wind power over four months simulation period - some benefits were shown with using stochastic methods but probably should be tested with higher shares of wind, and solar to make more benefits
- Valuable insight gained into the relative merits of different production cost modelling approaches
- The project appears to have achieved its stated goals and is meeting its milestones

Question 4: Project Management

- On budget
- Milestones met successfully
- Project seems to have been well managed and is within its budget

Question 5: Research Integration, Collaboration, and Technology Transfer

- This work is still quite theoretical, as there is not much interest in utilities and system operators to take new tools into use. A collaborator from the Electric Reliability Council of Texas is mentioned, and Texas is the place where the benefits of stochastic methods will be seen first.
- Good amount of scientific articles, and conference dissemination. Good impact scientifically, as can be seen from the citations to this work.
- Project results disseminated in relevant for a including IEEE, UVIG (Utility Variable-Generation Integration Group)

Comments made by reviewers during the evaluation of this project (PRID 124)

- UVIG presentation of results particularly valuable as industry adoption of stochastic methods is still limited
- Project development appears to have been well coordinated and the results shared with external stakeholders
- I may have missed a key piece of information from the presentation but collaboration seems to be mostly academic institutions which further begs the value of the project (for lack of industry or system operator participation)

Question 6: Proposed Future Research, if applicable

- Need to incorporate human elements in these approaches
- Future work is made in market related project ongoing where stochastic planning can be applied, computational aspects developed also. This may be adequate at the moment. Also linking with using probabilistic forecasting is important.
- Partly this work can continue as university/PhD/academic work, but the application in real life remains to be a challenge that maybe DoE could have an impact on - starting with utilities/markets that have a >20% share of variable generation where they would see the benefit
- Future collaboration with NREL on “Market and Reliability Opportunities for Wind on the Bulk Power System" appears to lead naturally from this work and is a very relevant topic under consideration internationally
- Would be interesting to see the same comparisons on a real system
- Unknown what additional work is needed in this area
- It might be prudent to explore with potential stakeholders what the perceived value proposition is before further work is performed in this area

Question 7: Project Strengths

- Advancing tools for stochastic methods, providing new knowledge on the different ways of using them, and potential benefits
- Sound methodology
- Valuable insight provided on the benefits of stochastic optimization
- Project results well disseminated

Question 8: Project Weaknesses

- Impact of the number of stochastic scenarios could have been explored
- IEEE test bus system results informative but not necessarily an indication of results for a real system

Question 9: Recommendations

- The impact of the number of stochastic scenarios could be considered as an area for further research in this context as it is important to fully understand the cost/run time trade off associated with stochastic methods
- Perhaps testing on a real system could be considered in future work

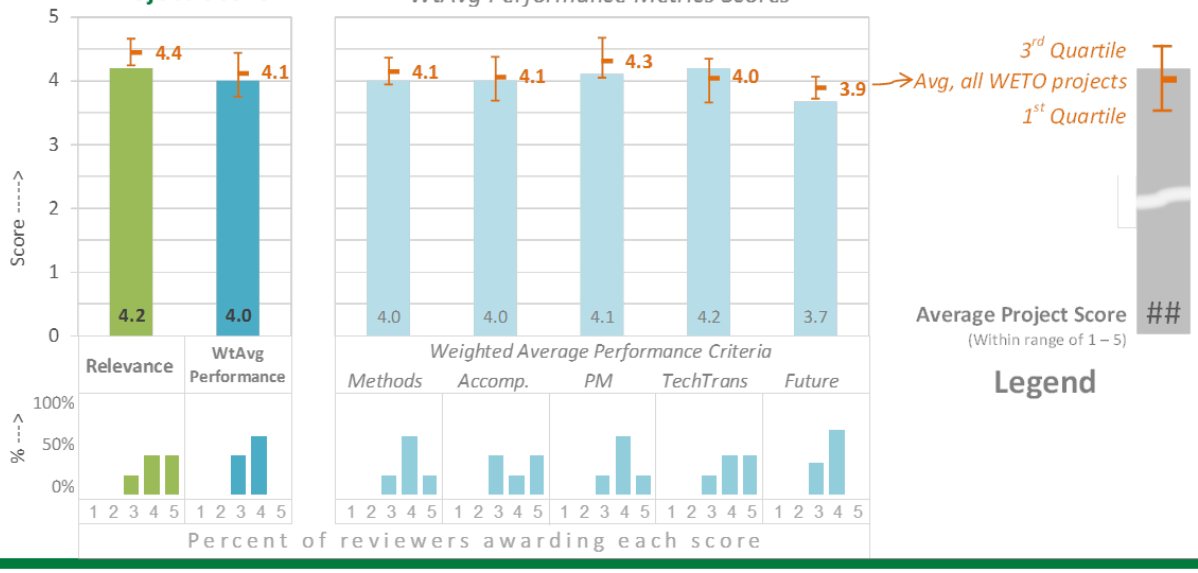
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Concurrent Cooling

Principal Investigator	Jake Gentle, Idaho National Laboratory		
Program	Wind Market Acceleration and Deployment		
Sub-Program	Grid Systems Planning and Operation		
FY 2014-2016 Funding	DOE	$ 1.6 M	70%
	Cost Share	$ 0.7 M	30%
	Total	**$ 2.3 M**	**100%**

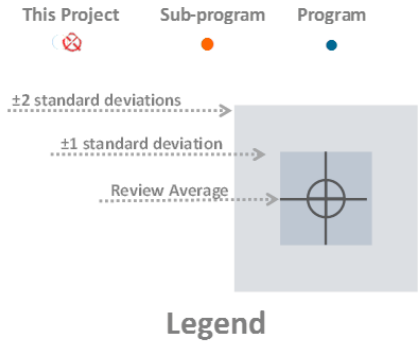
Peer Review ID# 125

Project Score



WtAvg Performance Metrics Scores

Comparative Scoring



Comments made by reviewers during the evaluation of this project (PRID 125)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- I do not have the expertise to understand the value of this project but I have provided some assessment
- Taking temperatures and wind cooling impact into account in real time grid management as well as planning important generally for better use of existing grid infrastructure, helping reduce bottlenecks. It is related to wind integration in places where lack of grid may impose curtailments, or need to reinforce grid infrastructure.
- This is a highly relevant topic. The potential to realize increases in transmission line capacity relatively inexpensively is a goal worth pursuing.
- While outside my area of expertise this project seems well aligned with the DOE Wind Program goals and objectives and would benefit the broader industry
- What is the implied increase in operator management of active information in terms of dynamic properties that change over time and at times deviate from assumed average values?
- Does this project provide empirical data that system operators can use to reduce the margin of errors assumed in line capacities by taking actual conditions in place of model assumptions (i.e., SLR (static line ratings))?

Question 2: Methods and Approach

- CFD (Computational fluid dynamics) layer is run beforehand so avoids that complication; but not a lot of people using this - so trying to focus on users in control facility is a central component. But I do not have the expertise to evaluate this method.
- Simulations of real-time wind field and temperature along the lines – CFD used to improve estimating the wind speeds. Reliability in catching the hot spots is crucial - you can only count on cooling impact as much as it reduces the temperature on the hottest point on line. Question is how well WindSim CFD is doing the job, as the estimate needs to be 100% reliable (so usually safety margins used to make a conservative estimate).
- Work includes also taking different devices/sensors available in the market and making them part of system monitoring line sag or temperature
- CFD needs to be run before, as real time would take too long. This seems to be a good approach.
- Taking also the control room monitoring and human impact into account is excellent
- There is no doubt that this project utilizes state of the art modelling and analytics applied to what is a very large problem involving many complex modelling challenges including complex fluid dynamics
- However, one wonders if the complexity of the approach becomes a barrier to adoption. For example, is there the potential to deliver 80% of the benefit of dynamic line rating at 20% of the cost in a package that is more readily adoptable by asset owners/operators. Perhaps the focus of this work should be to identify the key aspects to model rather than to model everything.
- Work has been ongoing on dynamic line rating for many years now and it appears the barriers to adoption are not technical in nature but more in how the solution is packaged up
- The project appears well designed and executed
- While the project seems to validate a source of additional capacity on lines due to narrowing otherwise precautionary assumptions about line heat, it is unclear from the presentation how practical the implementation of this methodology is to system operators, both equipment to monitor actual cooling effect as well as changes to processes to accommodate empirical/modeled data

Question 3: Technical Accomplishments and Progress

- Copyright seems significant
- The project has advanced the knowledge. Several journal articles implying good international scientific level of work.
- Validation still needed to gain enough confidence, and may be still point measurement needed once the hot spot has been identified
- It appears that significant progress has been made over the years 2014-2016
- The project appears to have met its intended goals and achieved the desired results
- What has the acceptance of this effort been to date with system operators?

Comments made by reviewers during the evaluation of this project (PRID 125)

Question 4: Project Management

- Appears to be on budget. Budget seems large for a DLR (dynamic line rating) project. Benefit of complex modelling is not clear.
- Milestones met mostly on time so far
- Project management appears to have been highly effective with delivering results within its budget and specified milestones
- Considering the funding levels for this project in light of questions of actual relevance or likelihood of practical application it is difficult to assess performance of management

Question 5: Research Integration, Collaboration, and Technology Transfer

- IEEE and international work are important groups to involve
- Idaho and Alberta have been involved in collaboration and technology transfer. As noted in previous peer review, it is important to advance this further, and it seems that a large group of utilities have been involved in some way (not directly specified but even if only dissemination it is good and important).
- Some utilities like Hydro Quebec already use temperatures in dynamic line rating, which has probably the most impact in increases of available transfer capacity of lines - this is of course site specific (in forested/sheltered areas less cooling of wind). Even if the wind impact can be challenging to estimate reliably enough, using temperatures already a good improvement.
- From an academic perspective, this project appears to be very successful with a high level of academic output and achievement
- Very high level of industry collaboration
- Project appears to have been well coordinated with a variety of stakeholders and numerous results reported in a variety of publications
- However, a broad and diverse number of participating stakeholders, some with cost sharing implies a value proposition to the project

Question 6: Proposed Future Research, if applicable

- Important need to understand if this concept is even open to being used in the future; this was not clear until PI (Principal Investigator) mentioned the NERC (North American Electric Reliability Corporation) contact; more human element needed. In other words, who needs this analysis and how will this work be relevant to industry and other stakeholders.
- Future research “DOE (EERE-OE) Grid Modernization Lab Consortium. Very good to take also forecasting into account to better impact the grid operation in day-ahead time scales.
- Perhaps add to UVIG (Utility Variable-Generation Integration Group) /grid integration support work once good results come - and try to get dynamic line rating more of an industry standard. Even getting the first steps - using temperatures - is a big advance. Actually getting the wind cooling impact may not prove to have much additional benefit in many terrains, this also would need to be assessed, how much extra benefit and in what type of terrains?
- Future research is focused on increasing the modelling capability of the system
- Inclusion of direct measurement sensor data is a good idea
- Unclear what, if any, additional research is needed

Question 7: Project Strengths

- Advancing DLR with hardware, simulation tools, field tests and control room human impact
- Very high level of modelling capability and sophistication - state of the art
- Great level of industry cooperation
- The high utilization of cost-sharing for this project was apparent and good example of leveraging private funding through public "seed" money

Comments made by reviewers during the evaluation of this project (PRID 125)

Question 8: Project Weaknesses

- Perhaps the wind cooling part of this project is a bit overestimated. Getting simulation tools for wind speeds to work with high enough confidence levels, with validation and proof enough for system operation to rely on still needs work.
- The solution seems very expensive in terms of the up-front set-up requirements
- While the high level of modelling complexity is probably justified on paper by the capacity gains it delivers, it may also act as a barrier to adoption
- None that I can identify

Question 9: Recommendations

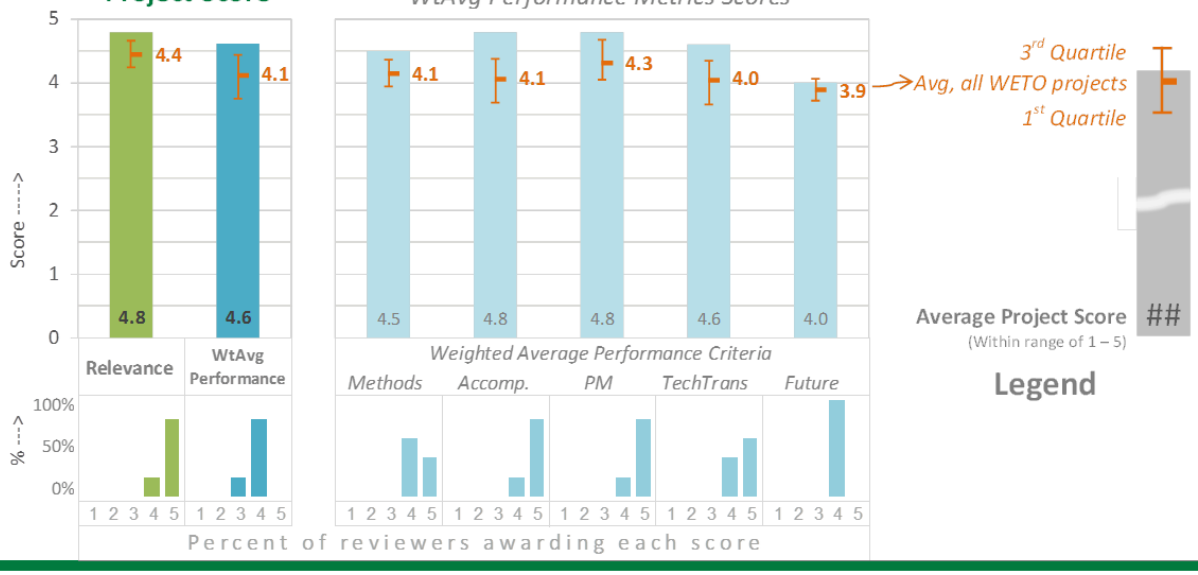
- I am not convinced that a highly complex system is the way to go for DLR. My fear is the very high up front set up and modelling costs will deter utilities from adopting such a solution.
- Perhaps the focus should be on a "quick to deploy" solution that delivers many of the benefits but in a more adoptable package?

DOE Wind Energy Technologies Office 2017 Peer Review Project:
Wind Integration Studies (ERGIS and WWSIS 3) [Eastern Renewable Generation Integration Study, Western Wind and Solar Integration Study 3]

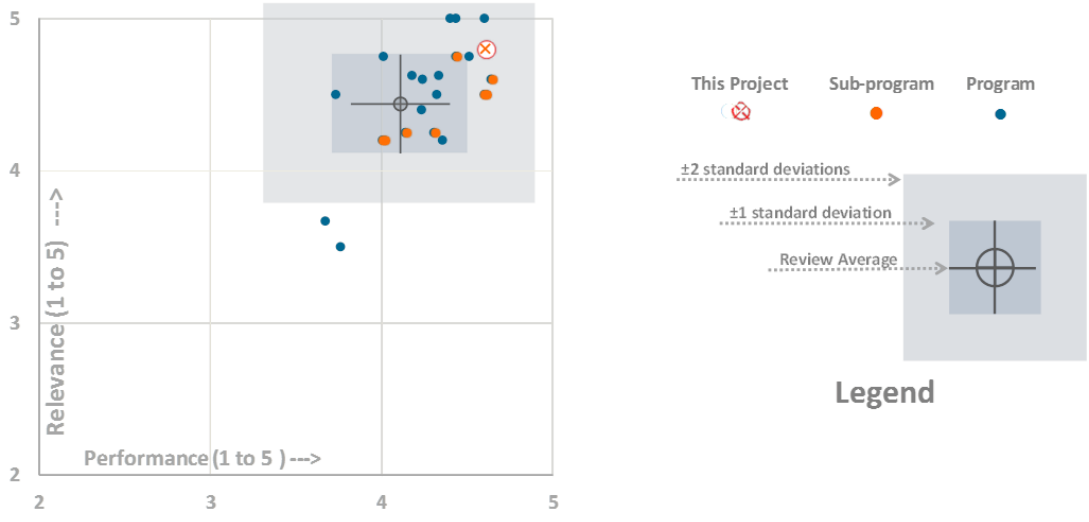
Principal Investigator	Aaron Bloom, National Renewable Energy Laboratory		
Program	Wind Market Acceleration and Deployment		
Sub-Program	Grid Systems Planning and Operation		
FY 2014-2016 Funding	DOE	$ 1.6 M	100%
	Cost Share		
	Total	**$ 1.6 M**	**100%**

Peer Review ID# 131

Project Score



Comparative Scoring



Comments made by reviewers during the evaluation of this project (PRID 131)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Critical studies and impressive quality of reports given the level of resources
- Large interconnector wide studies needed to show that larger shares of wind (and solar) are feasible - higher policy targets will work without system breaking down or bringing extra costs
- Hugely relevant and highly impactful study advancing the state of the art in many areas and producing useful tools. Also, carried out at relatively modest cost for projects of this scope.
- While outside my area of expertise, the grid integration work and in particular identifying issues and offering solutions is key to large-scale deployment of wind nationally. This project aligns well with multiple objectives and goals of the Wind Energy Office and needs of the industry as a whole.
- Short term energy predictions are becoming a challenge as transitional periods, ramp up/ramp down and backup generation capability issues are being grappled with by the industry
- The number of instances of renewable energy generation and demand intersections are being saturated, disrupting the traditional mechanism for the renewable energy markets. Shifting this intersection to preserve market appetite for variable generation, through storage or spreading power over greater loads would be helpful to explore.
- The applicability and practicality of the grid integration studies suggest to me that the WETO did a remarkably good job of hearing from industry and stakeholders what the emerging issues are (in this case, increasingly higher variable power penetration)

Question 2: Methods and Approach

- Great technical work based on the studies beforehand (including ReEDS (Regional Energy Deployment System) and others)
- An additional area that is sorely needed with these studies is to link to human capabilities and impact upon the system operators, e.g., the response of system operators to more renewables as well as expected uncertainties of increasing levels of distributed resources (both wind and solar)
- New methods developed, to explore stability issues of a larger interconnect (WWSIS3) and a very detailed 5 min dispatch feasibility of balancing (ERGIS)
- Eastern Interconnect balancing study, huge system size simulated with detail not seen before anywhere internationally
- Leverages and builds upon previous studies increasing "bang for buck"
- Developed innovative methodology for decomposing large problems across time and that has now been incorporated in commercial tools (Plexos)
- Development of innovative approaches and tools to analyze and visualize large amounts of time sequential geographic power flow data
- Studies have shown that in some systems, transient and frequency stability are the limiting factors in high instantaneous penetration scenarios. Achieving ambitious average RES-E penetration targets can mean accommodating far higher shares of renewables on an instantaneous basis and these often define the limitations of the system to accommodate target levels of renewables. These transient stability and frequency stability studies will need to be carried out to identify the limits of stability and understand the potential to accommodate higher shares of renewables.
    - Sharma, S., Huang, S. H. and Sarma, N., ""System Inertial Frequency Response estimation and impact of renewable resources in ERCOT interconnection,"" 2011 IEEE Power and Energy Society General Meeting, San Diego, CA, 2011, pp. 1-6.
    - O'Sullivan, J., Rogers, A., Flynn, D., Smith, P., Mullane, A., and O'Malley, M.J., "Studying the Maximum Instantaneous Non-Synchronous Generation in an Island System – Frequency Stability Challenges in Ireland", in IEEE Transactions on Power Systems, vol. 29, no. 6, pp. 2943-2951, Nov. 2014.
- The project appears to be well designed and has been successful to date
- Difficult to comment on for lack of subject matter

Question 3: Technical Accomplishments and Progress

- These studies use rigorous methods and well respected engineers/scientists in the field
- Results of ambitious plan delivered and reported in due time
- Two progressive wind integration studies carried out

- Extensive exploitation and dissemination of results using traditional channels and social media
- Development of visualization tools to aid interpretation of large volumes of power flow data
- New insights gained into implications of higher renewable shares on the system
- Both the execution of the research as well as the publication of the results have been outstanding and all goals/deadlines have been met to a large degree (with one exception)

Question 4: Project Management

- Good coordination across difficult data sources
- Leveraging on solar and electricity office funding on top of wind program funding, so amount of results seem ample with the funding used here
- Reasonable budget for project of this size
- Studies completed successfully
- Management of this project appears to have been very high with a number of deliverables that could only be achieved through proper project management
- Difficult to ascertain effectiveness of management from the presentation but execution seems appropriately executed
- Good leveraging of other department dollars
- Enthusiastic presenter who did well taking highly technical, esoteric subject matter and making it digestible and interesting

Question 5: Research Integration, Collaboration, and Technology Transfer

- Project has a number of workshops, but the PM (Project Manager) did not get into these outreach efforts. These exchanges are critical to dissemination of results and ongoing studies; perhaps there is a link to UVIG (Utility Variable-Generation Integration Group) but it was not clear in presentation.
- A wide TRC (Technical Review Committee) supporting results and direct dissemination to relevant system operator/utility forum
- Communication, YouTube videos with really great visualization tool helping dissemination to broader audience
- From the publication list, the scientific part (journal articles) seems to be at a lower level than anticipated from this new research
- Excellent tool development and sharing: already reporting that in use in Philippines and South America
- New test system proposed for IEEE for market design studies, very good impact on scientific forum
- High level of engagement and dissemination through conventional means and through social media
- Sets a new standard for producing generally digestible material from studies such as this
- While it is difficult for me to know how much coordination with external parties was necessary during the design and execution phases of the project and therefore whether or not that was achieved it is clear that the findings were provided both verbally and in print in multiple outlets/conferences
- Publication of the work is an important step to take in order to socialize the findings. Seems that future outreach needs to be with the system operators for their buy-in.
- Does the cost-share participation from other agencies include their dissemination of the findings to their stakeholders?

Question 6: Proposed Future Research, if applicable

- More studies were identified on the North American level - very challenging and interesting - but again perhaps regional level studies are more effective; there should be some information about how next generation studies are identified; is it through interviewing the users and industry, other stakeholders? How will emerging issues be identified?
- Research is continuing in an even larger integration study for North America (NARIS (North American Renewable Integration Study)), in interconnection seems study focusing on links between the three synchronous systems in United States, and market design project. All these are very relevant and good continuation of the balancing part of this study. Studying more scenarios for ERGIS system, getting from can we do it towards how we can do it in best cost effective way. Geographical decomposition, in addition to parallel computing to reach simultaneous optimization of the large system, is also very interesting as closer to realistic ways of operating the system.

Comments made by reviewers during the evaluation of this project (PRID 131)

- For the stability part, the WWSIS3 results will clearly bring enough answers for the short term stability issue questions, however, for longer term, studying larger share extreme cases (>60% variable generation in one instant) will be relevant probably sooner than later. Also as there is no model in Eastern Interconnect to study stability this will need to be made at some stage. For the much smaller size ERCOT (Electric Reliability Council of Texas) synchronous system the stability work is ongoing and will also give good indications for the larger systems.
- Without detailed information on scope, difficult to evaluate the merits of the upcoming "North American Renewable Integration Study"
- Important to keep up the momentum and to keep moving forwards in terms of thinking to improve understanding of the system and the impacts of ever increasing RES-E targets
- It isn't clear to me whether any additional work is needed on this subject but given its relative importance to large-scale deployment of wind energy I would say additional project funding would be recommended
- The planned future research "coordinated power system planning and operations across NA" seems ambitious and vague, unclear from the presentation what is contemplated other than dissemination of the project results
- Would it make sense to scope some future work towards maintenance of the model, keeping it up to date and thereby increasing its currency with stakeholders over time?

Question 7: Project Strengths

- Large studies showing that impact of wind on stability and balancing are doable
- Large TRC and good dissemination to stakeholders. Excellent new visualizations.
- Modelling tools developed will provide a good basis for also continuation, simulating more cases for Eastern and Western Interconnects, and use elsewhere
- Employed and advanced the state of the art in such studies
- Carried out successfully a very large integration study and applied innovative thinking to gain new insights into the future power system with higher shares of RES-E
- Produced tools which will benefit the community going forwards
- Successfully leveraged previous work
- Set new standards on dissemination
- None that I can identify at this time

Question 8: Project Weaknesses

- In comparison to current thinking in Europe and elsewhere, the RES-E targets in ERGIS and WWSIS-3 are not that ambitious
- Studies have shown (see comment in Methods/Approach) that the ultimate limiting factor regarding RES-E integration can be frequency stability and/or dynamic stability in high instantaneous penetration scenarios, which hasn't been addressed in these studies. As in the experience of Ireland, these limitations can eventually limit the average penetration. It is important to study these phenomena to fully understand the impacts of further increased integration.
- None that I can identify at this time

Question 9: Recommendations

- Consider studying further increased RES-E penetration scenarios beyond 25% to keep the thinking moving forwards
- Investigate the frequency stability and dynamic stability performance of the system in extreme instantaneous penetration scenarios and/or include this to a greater extent in proposed future work

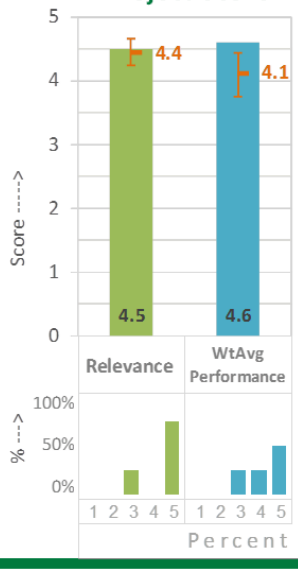
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Grid Integration Support, UVIG, IEEE, NERC, IEA (Task 25)*

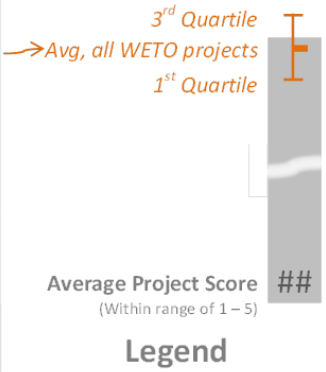
Principal Investigator	Dave Corbus, National Renewable Energy Laboratory		
Program	Wind Market Acceleration and Deployment		
Sub-Program	Grid Systems Planning and Operation		
FY 2014-2016 Funding	DOE	$ 1.3 M	100%
	Cost Share		
	Total	**$ 1.3 M**	**100%**

Peer Review ID# 132

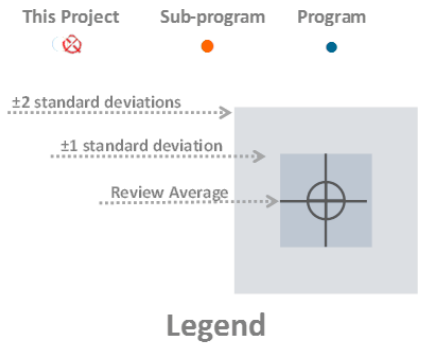
Project Score



WtAvg Performance Metrics Scores



Comparative Scoring



Comments made by reviewers during the evaluation of this project (PRID 132)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Essential task for disseminating technical information as well as follow up issues with important group of stakeholders
- Also supporting UVIG which is a central actor in this field & provides trusted forum for stakeholders
- Getting all available integration work results to utilities, ISOs (Independent System Operators) and regulators, and moving the system operation towards new practices enabling wind integration and larger shares of wind and PV (photovoltaics), is very important work
- This work enables the translation and connection of DOE funded research being conducted by National Labs with ISOs and other interested parties from industry. In particular UVIG and IEA Task participation enables national and international dialogues with those directly facing the issues
- While outside my area of expertise this project seems to address an important issue for the broader wind industry and is well aligned with the goals and objectives of the Wind Energy Office
- The project seems to serve as a funding response to the interest created by technical projects, further disseminating out beyond the budget ability of individual projects

Question 2: Methods and Approach

- There wasn't an obvious technical approach to how and what is communicated ("engaging and educating" (on his slide) is very simplistic--this would make efforts more effective--perhaps add to the integration support review committee? (later in questioning, a more targeted answer was provided)
- Different audiences and different messaging was mentioned and obviously a key component of success
- Partnership with UVIG is effective as leader in wind integration with large membership - but the fact that they are a convener was lost until the end
- Getting the integration messages to utilities, really high number of them in the United States
- Communicating/synthesis of work done, some analyses also
- Efforts convening people together, and also taking part in working groups influencing regulation. Outreach through UVIG and NERC working groups, international collaboration IEA Wind Task 25.
- Well thought out strategy for linking DOE research with national industry stakeholders (UVIG), national regulatory stakeholders (NERC, FERC (Federal Energy Regulatory Commission), WECC (Western Electricity Coordinating Council)) academic community (IEEE), international stakeholders (IEA Task 25)
- Very effective model for linking government funded research with key stakeholders
- Project appears to have been well designed to achieve the stated goals
- Difficult to assess value the project adds to the program for lack of clear decision making around use of funds

Question 3: Technical Accomplishments and Progress

- Strong organizational activities and many stakeholders engaged in the discussions
- UVIG work has gathered an outstanding amount of utilities and keeps giving them up-to-date information, as well as engaging them in integration related activities and discussions and moving operational practices towards better practices
- IEA WIND Task 25 benefits from active U.S. participation through NREL, UVIG and DOE representatives, and enables the United States to get valuable insights from European experience
- Working towards NERC and IEEE and CIGRE (International Council on Large Electric Systems) to ensure wind integration applied
- Effective communication of relevant work and results in a wide range of national and international forums
- The project appears to have achieved the stated goals and is complete

Question 4: Project Management

- Effective, consistent manager for a diverse level of activities
- Within budget - modest for the high impact it achieves
- Milestones met successfully
- The project appears to have been appropriately managed and has been completed within its budget and specified timeframe

Comments made by reviewers during the evaluation of this project (PRID 132)

- Is there a reliable, hindsight view of how this project's budget was spent with respect to what the level of interest is distributed across the technical projects? In other words, can the expenditure streams of this project provide insight to end user interest in the various technical projects?
- It is unclear what the decision process is for supporting an outreach effort under this project's scope. What are the metrics for deciding whether a proposed outreach has added value?

Question 5: Research Integration, Collaboration, and Technology Transfer

- Important resource to serve on panels for other organizations
- Three targeted groups are key stakeholders that need technical information
- IEA participation is usually effective investment for building international partnerships and sharing technical info
- Excellent impact, very important work both in United States and internationally
- EIM (Energy Imbalance Market) in West – influence from this work has been notable. NREL helping to reduce Pacificorp balancing costs from 9 to 1 c/kWh. Working group work (NERC/FERC) also important to make sure that no recommendations are made that would be barriers to wind integration and improved operational practices.
- Being a key objective of the work, this project is very strong is this area
- The project development and execution appears to have been well coordinated with a variety of key stakeholders
- Scored 'good' due to volume of outreach and publications, the purpose of which is hard to discern from the presentation

Question 6: Proposed Future Research, if applicable

- These are important issues that need consistent exchange of information among the stakeholders
- This important work has transitioned to a new Grid Modernization Lab Consortium project. Keep up the excellent work in finding the networks where discussions help to enable wind integration!
- Work has transitioned to a new Grid Modernization Lab Consortium project
- The stated grid integration work, while no longer a DOE project looks appropriate

Question 7: Project Strengths

- UVIG work getting the stakeholders together
- Resources to contribute to important regulative work and task forces
- Work to create simple dissemination of large studies, as well as experience from national and international best practice
- Very effective at connecting stakeholders and end users with DOE funded research
- World class DOE funded work is effectively disseminated internationally
- Tools made available by national labs such as PVWATTs, SAM (System Advisor Model), ERGIS (Eastern Renewable Generation Integration Study) visualization tool etc. showcase U.S. capabilities in this sphere
- None that I can identify

Question 8: Project Weaknesses

- Perhaps not the mandate of the project but converting research findings into institutional change appears difficult - e.g. market reform for renewables - larger balancing areas etc.
- None that I can identify

Question 9: Recommendations

- None

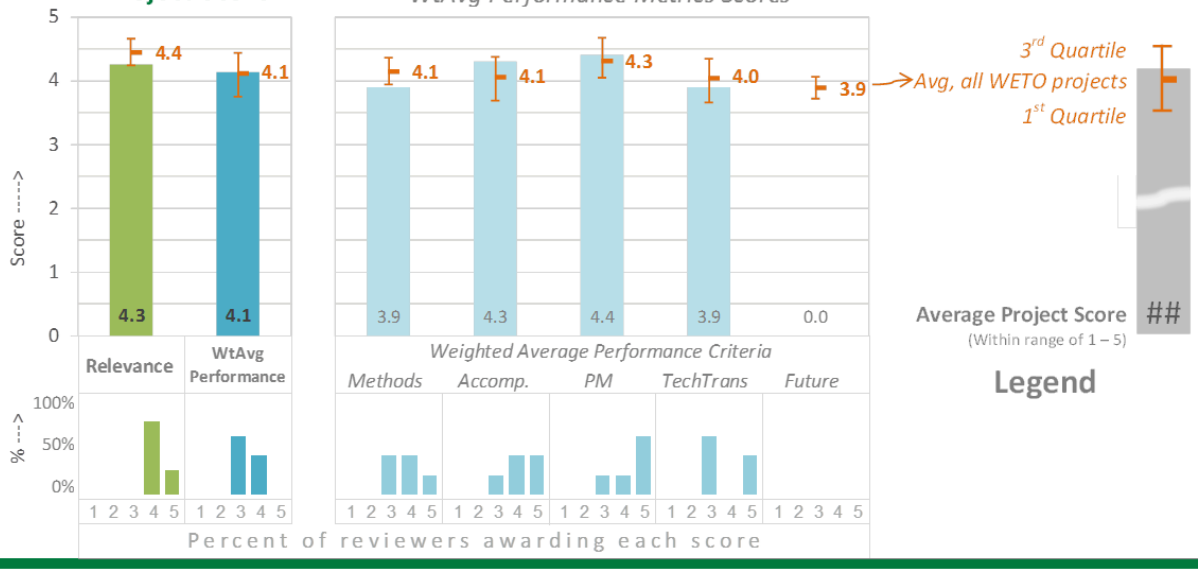
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Distributed Wind Integration

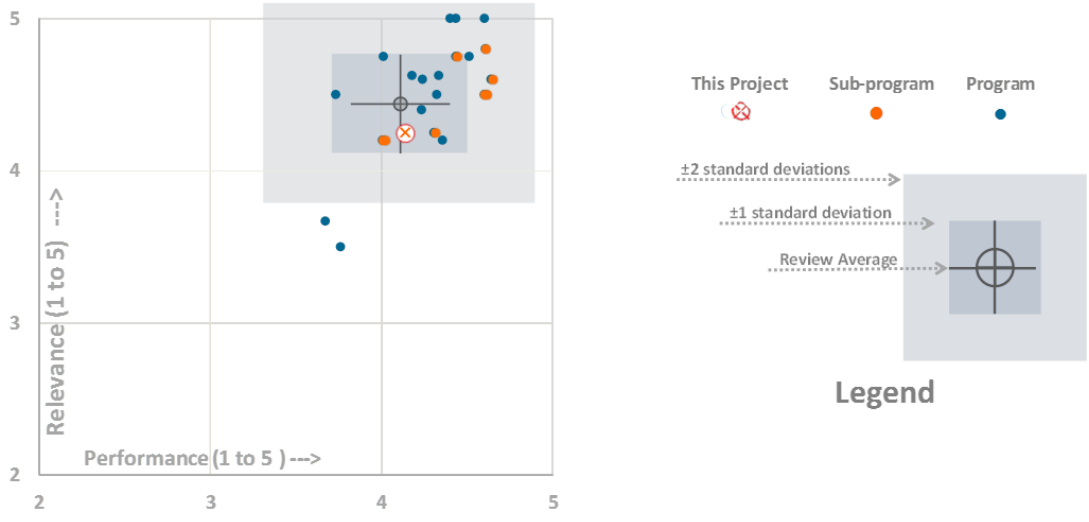
Principal Investigator	Bri-Mathias Hodge, National Renewable Energy Laboratory		
Program	Wind Market Acceleration and Deployment		
Sub-Program	Grid Systems Planning and Operation		
FY 2014-2016 Funding	DOE	$ 0.1 M	100%
	Cost Share		
	Total	**$ 0.1 M**	**100%**

Peer Review ID# 133

Project Score



Comparative Scoring



Comments made by reviewers during the evaluation of this project (PRID 133)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- A link to the social sciences and how distributed wind relates to the needs and values of specific regions would be an important and useful aspect to include
- Important link to rural America where loads/feeders are small ---more nuanced analysis is needed to understand the variations across the country, including market, financing, and community needs
- Distribution network connected wind power has clearly less impact in United States than in Europe at the moment. In some states could be important, where (or when) sites for larger wind power plants are not (or no longer) available.
- Connection of utility scale wind generation at distribution voltages is relatively common in other areas of the world and presents challenges. This is thus a highly relevant issue to address. However, the issues associated with domestic level installations such as those installed "behind the meter" are different in nature and not necessarily impacting the grid in the same way.
- This project seems to align well with the overall objectives and goals of the Wind Program, although I'm not entirely sure to what degree it benefits the broader wind energy industry as much of my experience has been with utility scale generation. However, this does seem to address an important aspect of the grid integration issue.
- What is the market potential for utility scale turbines on distribution lines? Capital, construction and operation costs may make such utility scale turbine injection at distribution level fundamentally cost prohibitive. Is there retail customer, behind the fence type customers for such configurations that drive the need of the project?

Question 2: Methods and Approach

- Estimation of 22% = 2000 turbines but there needs to be a link to market and siting needs rather than only technical potential
- New England used as case, looking at rural feeders and their hosting capacity, with wind turbines providing voltage control. Voltage rise issue and stability impact studied. Also how DS (distribution system) connected wind power starts to impact system level generation is studied.
- Trying to cover quite large range of impacts in short project. Probably this approach fits with the generally lower role of distribution connected wind in the United States.
- The study took 4 representative sample feeders to estimate the maximum amount of capacity that could be installed at various locations along the feeder. It appears that this was used to estimate the total amount of wind power capacity that could be feasible nationally.
- It has been shown that due to the increased voltage control challenges at the distribution level, wind power capacity connected at one distribution voltage can impact on the capacity possible at another. See for example: Mario Džamarija, Andrew Keane, "Autonomous Curtailment Control in Distributed Generation Planning", Smart Grid IEEE Transactions on, vol. 7, pp. 1337-1345, 2016, ISSN 1949-3053. It is not clear if these interactions have been properly considered.
- Typically it is required to use AC (alternating current) optimal power flow to adequately model the challenges of managing generation at the distribution level - the extent to which this has been used in this study is not clear
- This project appears to be well designed to achieve the intended goals
- It is suggested in the presentation that the project identified, within the study area, where distribution line injection could be done where limited incidence of negative impact (tripping off line) might occur. Does this mean that the project mapped out viable areas of turbine location as it related to the distribution line network within the study area?
- How many individual simulated "developments" make up the various percent injection scenarios evaluated (e.g., how many turbines made up the ~22% maximum injection scenario)?

Question 3: Technical Accomplishments and Progress

- Software tool developed and is commendable
- Results reported in reports and articles. Practical results with general rules relating feeder resistance to the expected maximum voltage change levels analysis examining line and transformer overvoltage conditions. Studying impacts of disturbances to stability, and impacts of distribution connected wind to market prices and transmission level.

Comments made by reviewers during the evaluation of this project (PRID 133)

- The project has resulted in a number of reports, conference papers and a journal article
- The project appears to have achieved the stated goals and did so within its budget and on-time
- Limited knowledge of the study's approach but conclusions seem to suggest that technical opportunities were realized where before they were not considered

Question 4: Project Management

- Good work for the minimal amount of funding for this effort
- Lot of results for one year project of not very extensive cost
- Project completed within budget
- Milestones met successfully
- This project appears to have been well managed

Question 5: Research Integration, Collaboration, and Technology Transfer

- Important link to EU studies and scenarios with distributed wind, but the public sector funding for infrastructure makes a huge difference in a reliable system
- Use of ERGIS (Eastern Renewable Generation Integration Study) modeling data is significant and good use of that data
- Practical guides, like how voltage control has impacts
- Automatic conversion software developed to convert from GridLab-D to OpenDSS format – has been very useful, data from one model to another, and overall models developed have been used in other projects
- 6 Conference presentations
- Software conversion tool developed
- While there doesn't appear to have been any collaboration during the project development phase, the findings of the study were well reported in 6 different publications indicating good socialization of the results
- To further add value to the project, does it have applicability to PV (photovoltaic) technology or smaller scale turbine injection on distribution line networks?
- There was no indication from the presentation materials what the reception of the findings was. It is difficult to ascertain whether the right audiences were reached out to and, regardless of applicability, whether or not those exposed to the project found value.

Question 6: Proposed Future Research, if applicable

- This research is not on-going. Distribution network issues mainly on-going on the solar side.
- Not Applicable
- N/A (Not applicable)

Question 7: Project Strengths

- A set of different aspects of distribution connected wind - local impacts and system wide impacts
- Solid analysis of voltage impacts of wind generation capacity at various locations on 4 different distribution feeder types
- None that I can identify

Question 8: Project Weaknesses

- The validity of scaling up results from 4 different feeder types is not clear
- Interactions between capacities at different locations on distribution networks, the so called "network sterilization" effect, does not appear to have been considered
- None that I can identify

Question 9: Recommendations

- None

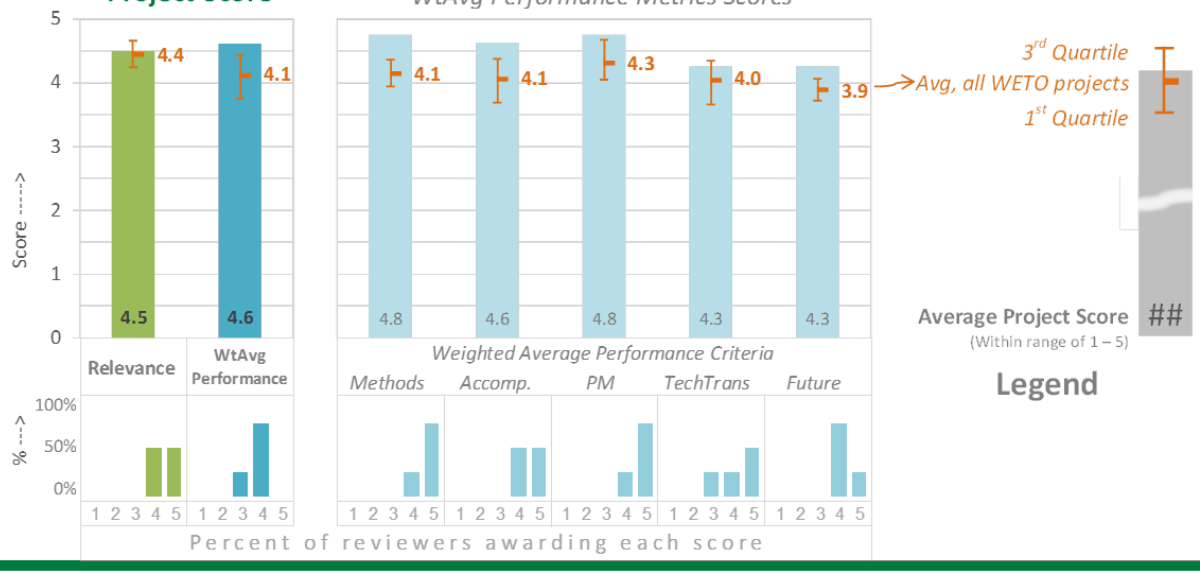
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Connecting the National Wind Test Center to the Energy Systems Integration Facility

Principal Investigator	Dave Corbus, National Renewable Energy Laboratory		
Program	Wind Market Acceleration and Deployment		
Sub-Program	Grid Systems Planning and Operation		
FY 2014-2016 Funding	DOE	$ 0.5 M	78%
	Cost Share	$ 0.2 M	22%
	Total	**$ 0.7 M**	**100%**

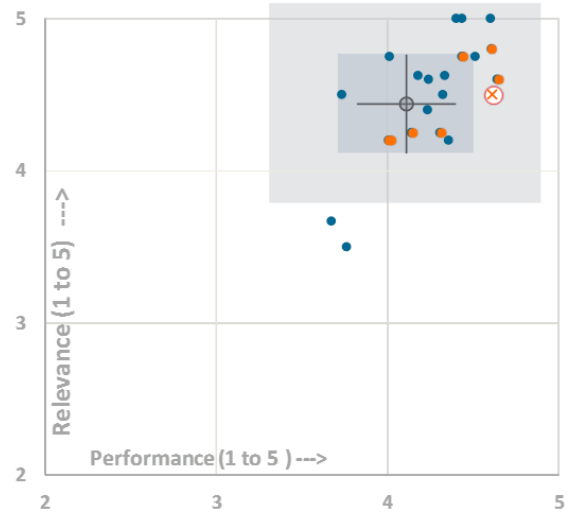
Peer Review ID# 134

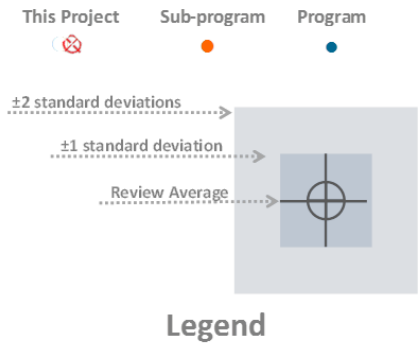
Project Score



WtAvg Performance Metrics Scores

Comparative Scoring





Comments made by reviewers during the evaluation of this project (PRID 134)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Focus on how wind could provide ancillary services to the grid is an important scope of work for the wind community and utilities
- Also testing of both solar PV (photovoltaic) and wind systems on the grid and integrating sources for a microgrid seem to be overdue
- Testing environment that allows power system impacts and mitigation methods to be tested and simulated - enables very interesting and relevant future work
- Inaccessibility to the grid for developing technologies can greatly increase time to market. Test facilities such as this allow technologies to be tested that allow product developers to test their product while system operators can have access to test data. Increasing the capability and capacity of test facilities is a highly relevant activity.
- The approach adopted allows the permutation of connected devices and simulated test environments to be vastly increased
- Both test facilities gain access to additional RTDS (real-time digital simulators) capacity at collaborating external organizations while the collaborators gain access to national lab test facilities
- This was a relatively low-cost, unique and high quality project that aligns well with the technology solutions aspect of DOE's mission and the Wind Program as a whole, and I believe will benefit the broader industry by being able to test real-world issues
- Does the integration of the PV energy source allow for NREL to test viability or address realized/perceived complications of co-locating PV and wind? This would have value as co-locating PV within a windfarm is being explored at the least on a cursory level.

Question 2: Methods and Approach

- Taking existing facilities and linking them is a very cost effective approach and enables a broad range of future issues to be studied, on top of validating new capabilities and models
- In connecting two test facilities together and connecting each to a high performance real time digital simulation capacity, it is magnifying the total value creating a system vastly greater in value than the sum of its parts
- The approach adopted allows the permutation of connected devices and simulated test environments to be vastly increased
- Both test facilities gain access to additional RTDS capacity at collaborating external organizations while the collaborators gain access to national lab test facilities
- This project appears to have been well designed and executed
- What is micro grid level?

Question 3: Technical Accomplishments and Progress

- Was not clear how this would have a national impact or how other users might be able to use this unique configuration
- The link was accomplished and demonstrated, with good publications
- The various linkages have been tested for functionality
- Wind farm of one capability appears to be of significant value in evaluating ancillary service provision and synthetic inertial response
- The project appears to have delivered the stated goals on time and within budget
- Are the "grid friendly" controls installed at the NREL wind turbine necessary to have beneficial services discussed in the project summary or are they only necessary to convert said turbine to be a unique "wind farm of one"? In other words, are these controls unique to the NREL project or are they commercially available?

Question 4: Project Management

- Project builds on previous work, but still seems to get a lot done with moderate budget
- Completed within budget
- Milestones met successfully
- The project appears to have been well managed

Comments made by reviewers during the evaluation of this project (PRID 134)

Question 5: Research Integration, Collaboration, and Technology Transfer

- Grid simulation workshop with Clemson and also international
- Last review comments highlighted that industry should be included at tests – clearly working towards it as now GE and the project have brought about more work with GE and Siemens and First Solar (allowing also wind/PV integration)
- High level of academic and Industry collaboration
- Collaboration and significant cost share from GE
- Coordination with several stakeholders and publication of results were identified and appear to be appropriate (although engagement with more than one turbine manufacturer would have been advisable)
- Limited number of collaborators but presentation notes that future work could include additional industry partners, which seems an important element to assure return on investment

Question 6: Proposed Future Research, if applicable

- Future work as part of GMLC (Grid Modernization Lab Consortium), and involving more manufacturers
- Integrating with ESIF (Energy Systems Integration Facility) allows future interesting work on consumer/prosumer interaction and flexibilities from demand side (also building thermal loads)
- Proposed active power control for wind is a highly topical project - this is currently a very active area of research internationally and practical experience of such controls is needed
- Not sure on the degree future research is warranted but it certainly seems that through the grid integration consortium and potential "pay-to-play" users this project will continue to provide value and should be supported to the extent necessary
- As this is being rolled under the Grid Modernization Lab call, the overall question is with WETO's investment to materialize the testing facilities, what opportunities are there for services for hire to the OEMs (original equipment manufacturers) and other supply chain manufacturers that would benefit from the testing facilities?

Question 7: Project Strengths

- Successful building on previous work and building a world class new testing environment
- Has already shown that the test environment brings interesting new projects and also direct industry assignments
- Magnifies the capability and value of the individual facilities
- Expands the testing possibilities
- Allows access to remote RTDS capacity
- None that I can identify

Question 8: Project Weaknesses

- Potential lack of simulation results to illustrate the capability of the testing facility. However, it is understood that this was not the focus of the project.
- Only criticism is that to the extent practical more than one turbine manufacturer should have been consulted on this project

Question 9: Recommendations

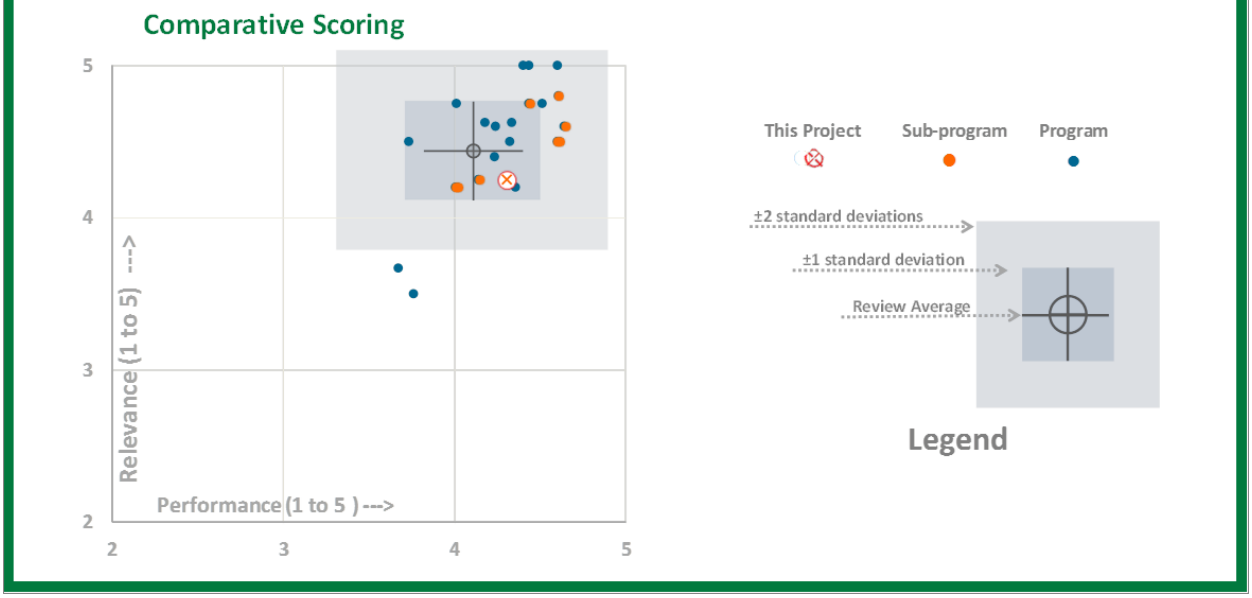
- None

DOE Wind Energy Technologies Office 2017 Peer Review Project:

Analysis Using PMU [phasor measurement unit] Data and Dynamic Analysis

Principal Investigator	Edward Muljadi, National Renewable Energy Laboratory		
Program	Wind Market Acceleration and Deployment		
Sub-Program	Grid Systems Planning and Operation		
FY 2014-2016 Funding	DOE	$ 0.2 M	100%
	Cost Share		
	Total	**$ 0.2 M**	**100%**

Peer Review ID# 135



Comments made by reviewers during the evaluation of this project (PRID 135)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- I do not have the expertise to evaluate this project
- PMUs can provide high resolution measurements of power system quantities in real time. The potential for PMUs to aid in our understanding of the system, enhance its security and aid operation and control is huge and is a highly active area of research.
- This project is outside my area of expertise but appears to align with the objectives and goals of the Wind Energy program

Question 2: Methods and Approach

- New technology installed in grids (already 1700 PMUs in the United States), synchronous phasors communicate and compute very fast giving situational awareness of grid state
- Development of various methods to utilize PMU data: to detect and characterize disturbance events, to analyze power system conditions, to estimate on-line power system inertia and short circuit impedance, and to track the stability margin. There is possibility also to implement active power damping, and to validate dynamic models of wind turbines and wind plant.
- The development of tools to automatically analyze, filter and categorize data greatly aids with gaining the full value from PMUs
- The potential use of PMU data in active control of power systems is an innovative, proactive application of the technology
- Project appears to have been well designed to address the questions it sought to answer
- Latency of data acquisition and time delay presents how much of a problem for real time mgmt of systems using information from PMUs?

Question 3: Technical Accomplishments and Progress

- Many publications for the relatively short project, with good scientific articles. In addition algorithms, applications, user guide
- Identification of sub-synchronous oscillations on the ERCOT (Electric Reliability Council of Texas) system is an excellent illustration of how the development and use of tools can realize the potential of PMUs
- Dynamic model validation and estimation of actual system inertial response are more good examples of PMU use in combination with tool development
- Excellent academic output with 4 PhDs, papers and numerous reports
- Project appears to have been well designed and achieved the stated goals
- If PMUs are being incorporated as a new generation of system operator tools, is it fair to presume that at some point in the future system operators will have the capability to use PMUs in the manner proposed and tested by this project?

Question 4: Project Management

- Very good results and collaboration in a short project
- Within budget
- Milestones mostly met successfully
- Project appears to have been well managed

Question 5: Research Integration, Collaboration, and Technology Transfer

- Good scientific collaboration and articles – also good collaboration with 3 utilities and WECC (Western Electricity Coordinating Council), manages to combine both
- Tools developed and made available for download along with reports and user guides
- Six journal articles published - this is an impressive outcome
- Appears there was good academic collaboration across 4 institutions including one international university
- Appears there was significant industry collaboration
- Project team appears to have coordinated with a variety of stakeholders and reported their findings in multiple publications

Comments made by reviewers during the evaluation of this project (PRID 135)

Question 6: Proposed Future Research, if applicable

- No future work has been funded in wind program (but some general PMU work in Electricity Office)..Good topic for future research is to move more towards wind integration, using PMU information in determining how to use wind power plant capabilities. This may emerge as a potential good research topic but probably more effective as part of a larger project, like Grid Modernization future work.
- Proposed work on using PMU data for wind farm control is a very interesting proposition
- Utilization of NWTC (National Wind Technology Center) also sounds like an excellent idea to test control development
- None identified

Question 7: Project Strengths

- Research on improving the use of new technology in power grids (PMU) also towards wind integration
- Successful demonstration of how PMUs can be used on systems to good effect
- Development of tools to filter, visualize and categorize data was a key strength of this project
- Good industry collaboration
- None identified

Question 8: Project Weaknesses

- None identified

Question 9: Recommendations

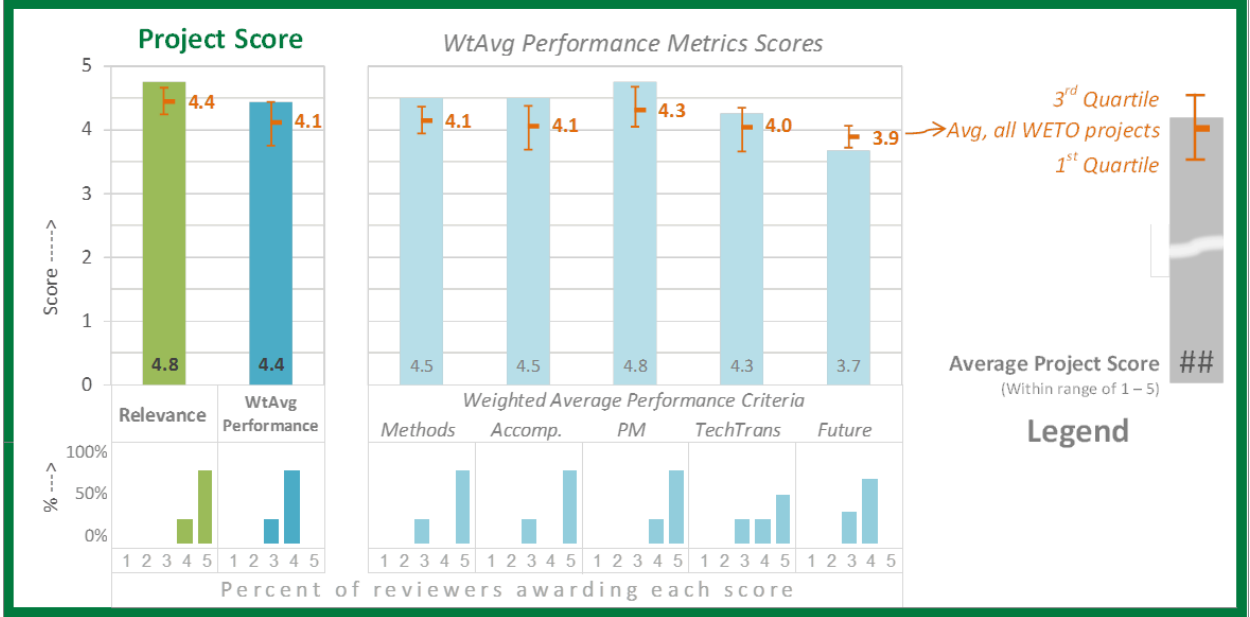
- None

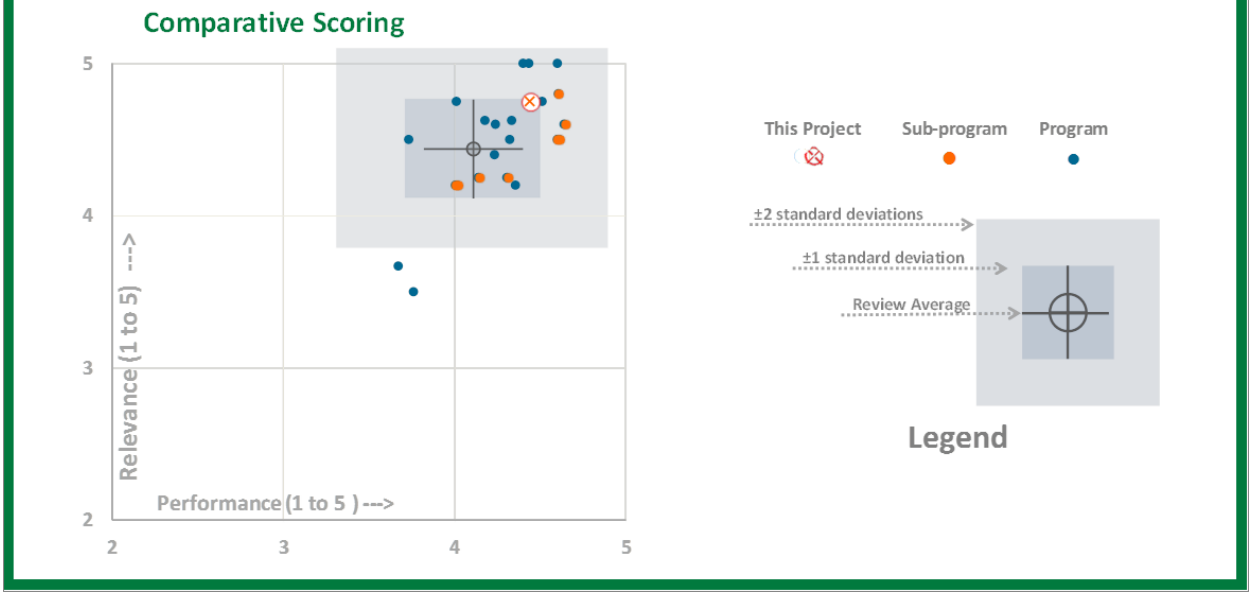
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Active Power Controls

Principal Investigator	Yingchen Zhang, National Renewable Energy Laboratory		
Program	Wind Market Acceleration and Deployment		
Sub-Program	Grid Systems Planning and Operation		
FY 2014-2016 Funding	DOE	$ 0.8 M	100%
	Cost Share		
	Total	**$ 0.8 M**	**100%**

Peer Review ID# 136





Comments made by reviewers during the evaluation of this project (PRID 136)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- I do not have the expertise to evaluate this project
- Grid supporting wind turbines are key to achieving higher shares of wind power
- Provision of ancillary services from wind plants is a very active area of research internationally. In future power systems with large shares of renewable generation, it is clear that services must be provided by a wider range of technologies. Projects such as these are necessary to explore this further and provide the necessary reassurance that wind turbines can reliably provide these services.
- This project was developed in alignment with DOE's Wind Energy Office's objective and goals and will serve to benefit the broader industry
- Overall relevance of project is it seems to validate the notion that wind energy can provide APC (active power control) to the grid

Question 2: Methods and Approach

- Wide range of simulations, both markets, power systems (inertia/stability) and controls of turbines. Interesting research questions: new ways of providing services with minimized loss of energy: only higher wind sites providing; only first row in wind farms (reducing the wake effect); new insight to how primary/secondary reserve can be optimized (now based on rules of thumb)
- State of the art has been advanced with the MAFRIT (Multi-Area Frequency Response Integration Tool) tool and Festiv (Flexible Energy Scheduling Tool for Integrating Variable Generation) to simulate multi-area frequency response. This is a very valuable capability.
- Analysis includes modelling of the wake effect
- Modelling includes analysis of impact of structural load on turbines
- The project was extremely well designed and set out to answer some innovative and interesting questions and appears to have met the goals on time and within the allotted budget

Question 3: Technical Accomplishments and Progress

- Good results for the interesting research questions, like showing that better utilizing wind turbines operating under good wind condition will overcome the synthetic inertia “payback” issue, and showing very fast responses to APC command even under waked conditions without imposing additional loading on structure, and a tool that can reveal the interaction between the primary and secondary reserves, thus providing understanding of system response that so far has mainly been based on rules of thumb
- Study complete with results and analysis that will inform future AS (ancillary services) market design and AS portfolio requirements
- Project was executed well and delivered very strong results
- What are the pathways to move the findings of this and related projects into the regulatory arena where changes in compensation to wind plants would effectively lead to implementation of APC support from wind?

Question 4: Project Management

- Within budget
- Milestones met successfully
- Project appears to have been well managed and was successful

Question 5: Research Integration, Collaboration, and Technology Transfer

- Dissemination - good publications, several journal articles with high ranked scientific journals (IEEE). Excellent examples of impacts on NERC (North American Electric Reliability Corporation) and system operators.
- Collaboration, mainly research collaboration, but also collaboration from a large international industry stakeholder group was mentioned
- Work appears to have been widely cited
- Two technical reports and five journal articles produced
- Coordination with stakeholders like EPRI (Electric Power Research Institute) during the research period was apparent and the level of reporting on the results was outstanding
- Transferring the knowledge gained from the project into the regulatory arena in which compensation is lacking for APC support from wind energy would further add significant value

Question 6: Proposed Future Research, if applicable

Comments made by reviewers during the evaluation of this project (PRID 136)

- Part of grid modernization, active power controls, little linked with A2E (Atmosphere to Electrons) (more controls but not grid impact). I wonder if at some stage linking these two aspects could prove useful. Clear link with Grid lab at NREL.
- Not clear to what extent future research will also be involving operators of plants/manufacturers/other stakeholders
- Interesting research is also at what point is active power control needed/cost effective from system point of view (optimizing all assets in the system)- is it needed before 20% shares of wind? APC will lose some wind generation (except in case of contingencies/curtailed operation, and when using kinetic rotational energy from rotor)
- Integrated platform concept is a good next step to further develop AS product offerings from wind plants
- None identified
- See prior comments about deploying practices among grid stakeholders. Operators are capable of providing the support but disincentivized for lack of compensation. If technically capable, if operationally capable, and a need exists then any future work should focus on how to change compensation (or inform those perceptions that prevent a change in compensation).

Question 7: Project Strengths

- Research covered many aspects of active power control from turbine controls and field tests, to system simulations and markets
- Internationally high quality research, well published
- Successful demonstration of concept through advanced modelling
- Development of a new capability to model multi area frequency response
- Inclusion of the wake effect
- Strategy to mitigate "payback effect"
- None identified

Question 8: Project Weaknesses

- Possibly missing the multi-service provision aspect - can wind turbines simultaneously provide services such as fault ride through, reactive power control, frequency response and synthetic inertia?
- None identified

Question 9: Recommendations

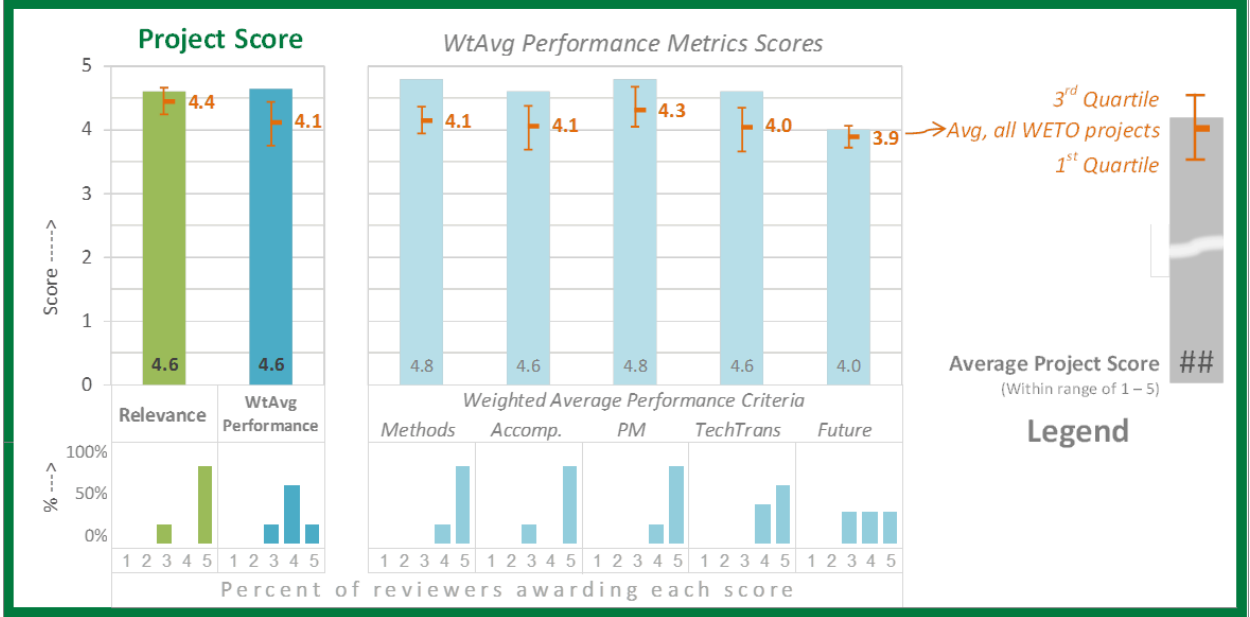
- In addition to providing frequency response and inertial response, conventional generators also provide synchronizing torque. How does this impact on the overall needs of the system. Is there a need to investigate these impacts?
- Possible need to address the multi-service provision issue - can wind turbines simultaneously provide services such as fault ride through, reactive power control, frequency response and synthetic inertia?

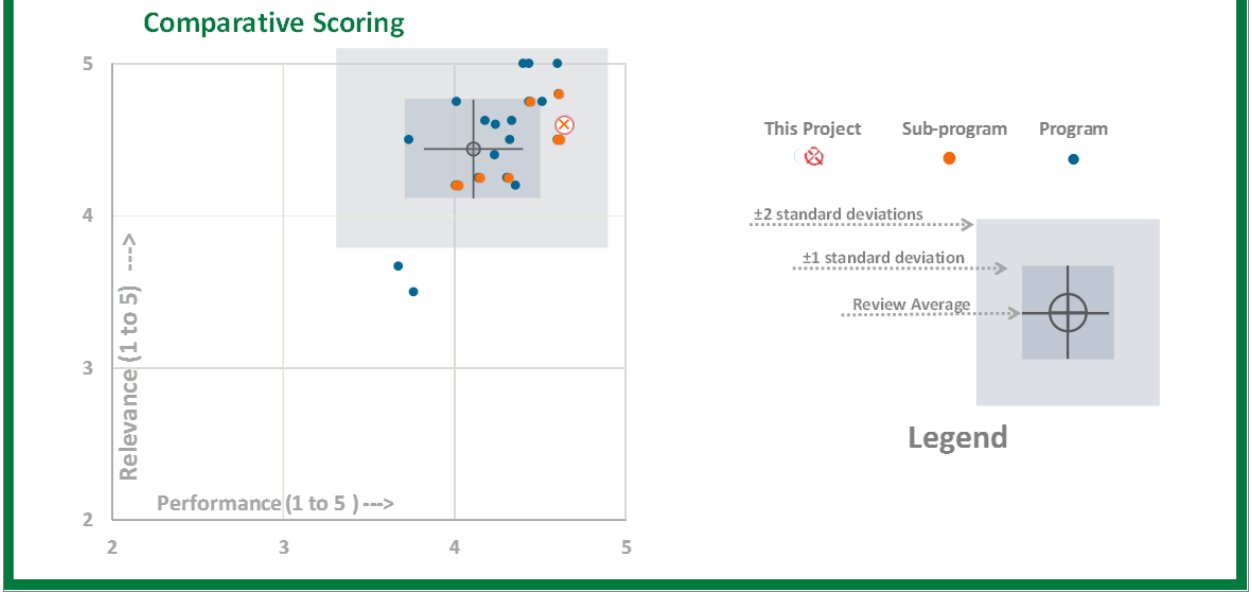
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Wind Generator Modeling

Principal Investigator	Ben Karlson, Sandia National Laboratories		
Program	Wind Market Acceleration and Deployment		
Sub-Program	Grid Systems Planning and Operation		
FY 2014-2016 Funding	DOE	$ 0.6 M	100%
	Cost Share		
	Total	**$ 0.6 M**	**100%**

Peer Review ID# 144





Comments made by reviewers during the evaluation of this project (PRID 144)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Very important research area especially the relationship to NERC (North American Electric Reliability Corporation), IEC (International Electrotechnical Commission TC88 (Technical Committee 88) WG27(Working Group 27), and WECC (Western Electricity Coordinating Council) REMTF (Renewable Energy Modeling Task Force)
- Studies are even more critical as wind energy integration grows
- Enables easier/faster handling of wind power in system operator transmission planning studies
- A hugely necessary initiative that is enabling system operators internationally to better understand the system impacts of increased shares of wind turbine technologies
- This project is outside my area of expertise so it is difficult for me to assess the value of the project and how it aligns with the Wind Program goals, however, it seems to be a well-designed and executed project that met its goals and stayed within budget
- How are the WTG (wind turbine generator) models able to be updated and kept current? Is the work to date robust enough to be expanded upon and thereby retain its value proposition over time?
- How well does the model output inform developers in terms of evaluating possible system impact caused by their proposed project? Can this model be used to narrow the unknown impacts to the system, in effect to eliminate pie-in-the-sky projects with those that may not have substantial hurdles for interconnection that would otherwise be unknown until final determinations by system operator assessments?

Question 2: Methods and Approach

- Conservative approach may be outdated given the high levels of integration ongoing? Be bolder!
- Developing generator models, provision of generic turbine models, for grid planning studies. Parameter tuning for different turbine types.
- Development of generic models attempts to strike a balance between capturing the behavior of wind turbine technologies on power systems and their response under various conditions whilst also respecting the IP (intellectual property) concerns of OEMs (original equipment manufacturers). The approach has been very successful with the models developed being used by many operators worldwide and incorporated into most major software packages in common use.
- It would be nice to see a greater emphasis on validation and comparison with measured results for various turbines
- Modular approach for second generation models is a huge step forwards
- Again this is outside my expertise but does seem well-designed and executed
- Difficult to comment on for lack of subject matter

Question 3: Technical Accomplishments and Progress

- Many journal articles showing work at international front
- White paper on the limitations of models has been published - this is important as this is an evolving field
- Second generation generic wind turbine models made available - indispensable resource for system operators internationally
- Models available in most commonly used simulation tools
- Model seems to fill in a key component of missing information for project developers that otherwise could wait for years for system impact studies to be completed
- A question remains as to the true value of the model. Is the proposed value for system operators or generation developers? If the latter what the model says likely cannot be definitive in comparison of system operator assessments. Therefore, what is the value proposition for developers? If the former, what about this model should compel a system operator to deviate to or rely upon this tool as opposed to theirs?

Question 4: Project Management

- High level of results and publications for a moderate budget
- Very reasonable budget for such an impactful task
- Milestones met successfully so far

- Project seems to have been well run, achieved its stated goals and stayed within budget
- A means of testing the robustness and viability of the model would be to "shop" the model with potential end-users to determine whether future funding can be leveraged for expansion and maintenance of the model
- Information presented seems to suggest a well-managed project

Question 5: Research Integration, Collaboration, and Technology Transfer

- Very important research area especially the relationship to NERC, IEC TC88 WG27, and WECC REMTF
- Impressive list of papers and web materials
- Great impact on standards - generic model of IEC
- Many journal articles showing work at international front
- WECC task force used for stakeholder outreach
- Collaboration with all relevant technical bodies including IEEE Power & Energy Society, UVIG (Utility Variable-Generation Integration Group) and WECC
- Website with downloadable material made available
- Effective collaboration with OEMs greatly enhances credibility of models
- The project seems to have been well coordinated with other entities and results reported
- Good use of publications to disseminate the model and outputs to date
- It is unclear what the model has accomplished in the way of system operators responding differently than previous to the model. What hole has the model filled that streamlines or otherwise makes development of wind energy more efficient?
- Though not explicitly stated, the lack of good data for model expansion begs the question of system operator or wind turbine manufacturer response

Question 6: Proposed Future Research, if applicable

- How will emerging issues be addressed?
- Was not clear how this model will help a broader group of stakeholders such as developers and grid operators
- Relevant future work has been proposed. Model validation against a range of system events remains a high priority. Future revisions of the models are inevitable as new features are added and grid codes are adopted. A risk that use of conservative models (as they already now are) in future studies will underestimate the capabilities of wind.
- More data, and compliance tests: possibility to integrate with NREL test site, and Grid modernization lab project?
- Nicely targeted future research. Models will need to keep pace with developments in grid codes, increasing focus on ancillary services and technology capabilities.
- Validation is an extremely important component of this work and is critical to provide confidence in the models
- Not sure what additional effort is needed beyond the current project
- Maintenance of the model is important to keep it current and outputs reliable. However, the presentation noted that difficulty of good data makes additional expansion of the model's validation challenging. This impediment should be the focus of future efforts rather than relying on less than good data since poor or untrustworthy results will substantially weaken the use of the model, thus potentially negating value generated to date.

Question 7: Project Strengths

- Real world needs for grid stakeholders
- Detailed work with developing the models for studying different stability impacts, getting stakeholder inputs on what is needed
- OEM collaboration
- Industry, ISO (International Organization for Standardization) and research collaboration
- Concept of the generic model has been a key industry development
- Technical approach appears sound
- Second generation models a great improvement
- None that I can identify

Comments made by reviewers during the evaluation of this project (PRID 144)

Question 8: Project Weaknesses

- More could be done on the validation side - but this is included in future work
- Modelling of unbalanced faults for type 3 and 4 turbines remains a challenge - is this within the remit of the task?
- None that I can identify

Question 9: Recommendations

- The project could benefit from greater focus on validation
- Is there scope for investigating modelling of type 3 and 4 turbines in unbalanced conditions?

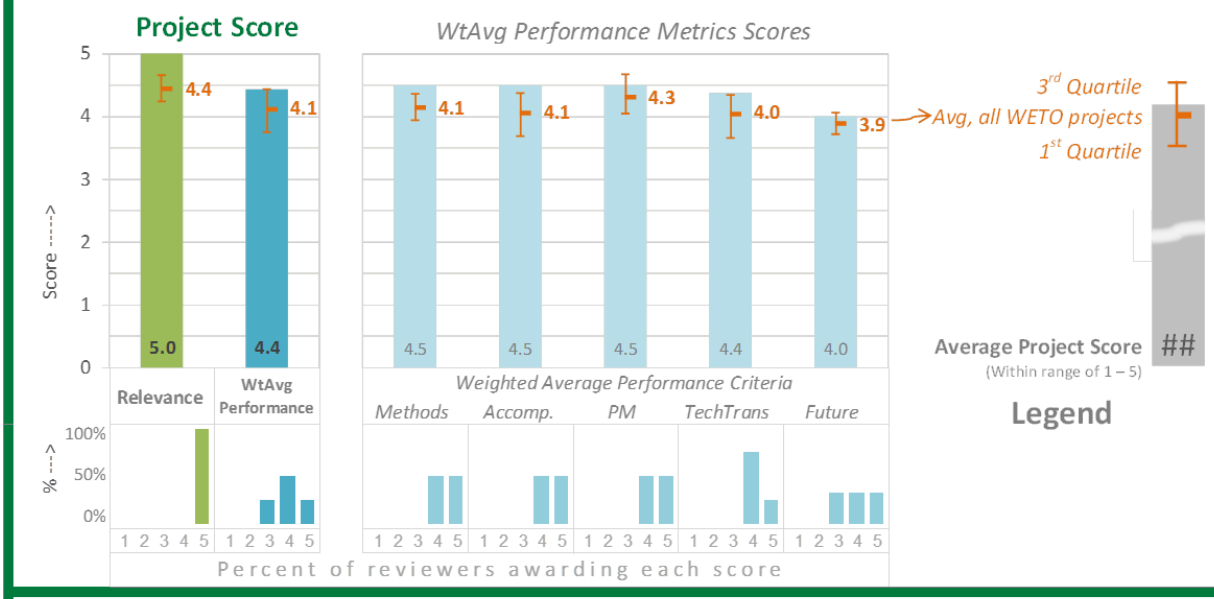
7.4.3 Siting, Radar, and Environmental

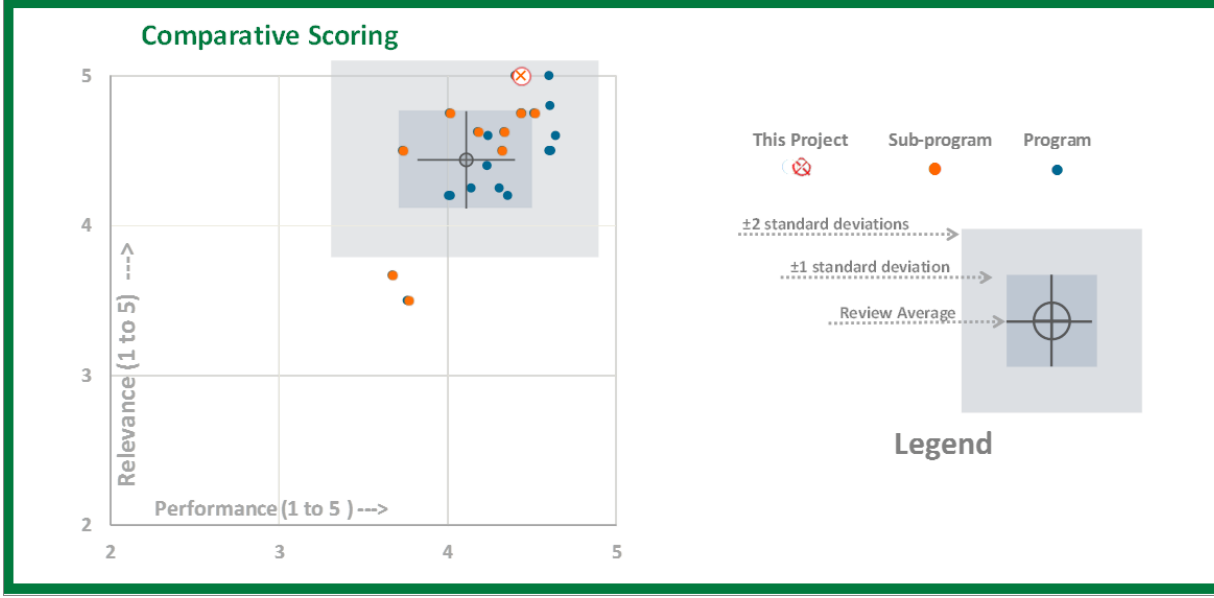
DOE Wind Energy Technologies Office 2017 Peer Review Project:

MIT [Massachusetts Institute of Technology] Lincoln Labs Radar Mitigation R&D

Principal Investigator	Jason Biddle, MIT LL		
Program	Wind Market Acceleration and Deployment		
Sub-Program	Siting, Radar, and Environmental		
FY 2014-2016 Funding	DOE	$ 1.0 M	20%
	Cost Share	$ 3.7 M	80%
	Total	**$ 4.7 M**	**100%**

Peer Review ID# 128





Comments made by reviewers during the evaluation of this project (PRID 128)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Leveraging the data to mitigate impacts is useful to the industry
- Evaluations of 2 models are needed
- Radar interference is a real issue with the potential to significantly impede wind power development and potentially public safety. This project aims to directly tackle this issue through a number of distinct efforts and is thus highly relevant.
- This project has high value to the wind industry broadly and aligns well with the goals and objectives of the DOE Wind Program
- What happened to the coating mitigation idea for turbine RCS (radar cross-section)?
- The WETO should, to the extent feasible, broadcast the continued value provided by the data collected during the IFT&E (Interagency Field Test and Evaluation)

Question 2: Methods and Approach

- MIT lab is a leading technology leader in this area so their approach seems robust
- Moving into offshore is needed
- Need more national than site specific scale; but this seems like a large lift with existing resources
- Testing new mitigation options for radar impacts, field tests, data collection, evaluation of models
- Improvement of modelling capabilities using real field-collected data appears to be a sound approach lending increased credibility to available modelling tools in predicting radar impact
- The technical mitigation methods examining possible hardware and software solutions to some of the issues appear to have been well thought out and executed
- The project was extremely well designed to address a current risk to the wind energy development community and has delivered tangible outcomes in addressing that risk

Question 3: Technical Accomplishments and Progress

- Interesting results from multi beam tests, improves resolution, in all situations except when low-flying planes. Can help weather radars and airports. With defense can be part of a solution.
- Identification and assessment of specific technical mitigations (TANC (Turbine Adaptive Nulling Concept) and IRR (Increased Range Resolution)) represent significant progress
- Validation of TSPEAR (Tool for Siting, Planning, and Encroachment Analysis of Renewables) models is a good development
- The project results appear to have been achieved as expected
- Progress to date is promising but sense from the presentation that there is a stall out happening without a sense of what the next logical step is or how to go about it. Recommend if this is the case that WETO and other WTRIM (Wind Turbine Radar Interference Mitigation) entities determine which technique seems most worth pursuing, relative to perceived or real impacts on landscape, and focusing on development of it to the point of commercial readiness. Let other techniques follow suit in succeeding budget years.

Question 4: Project Management

- Under budget so far
- Milestones met successfully so far
- The project appears to have been well managed and executed - staying within budget and on schedule
- Good cost sharing opportunities with other agencies

Question 5: Research Integration, Collaboration, and Technology Transfer

- Seems that DoD cost-share is important and should be encouraged into future as a key partner in the solution
- More industry interaction is needed for awareness
- For this project technology transfer directly to stakeholders using radars important. Project was working with previous project, directly with DoD (Department of Defense) and model assessment of radar interference impact models was briefed to Government stakeholders and model developers.
- Results disseminated for wider audience in conferences

Comments made by reviewers during the evaluation of this project (PRID 128)

- Appears to be effective collaboration between government agencies, national agencies and academic institutions
- Could project benefit from greater international collaboration?
- The collaboration between federal agencies and the industry throughout the process was stellar. While the results were reported sufficiently I would have liked to see them published more broadly as I don't believe the broader development community and other interested parties are aware of the suite of mitigation options generated by this project.
- Concerns about use of TSPEAR modeling. Would like to see WETO play a required or at least common role of reviewing TSPEAR modeling efforts, especially those that conclude a non-compatible scenario.
- Has there been a thought to petitioning radar community to gauge what missions and radar technologies are in use in order to ascertain whether a focused effort on one technique over another (e.g,. TANC vs. IRR) would provide the best bang for the buck?

Question 6: Proposed Future Research, if applicable

- It is not clear if the future work will involve determining a strategy for implementing a wider rollout of the identified mitigations and thus exploit the successes of the project
- I'm not sure what additional research needs there are at this point or if there are plans to fund any additional analysis and/or mitigation options, but if so this would be a good priority for the Program
- It is unclear from the presentation what the future research is. Would infer and promote that additional testing and deployment of techniques and technologies take place in areas with real or perceived impacts.

Question 7: Project Strengths

- Concrete ideas for mitigation of radar impacts, with flight tests and demonstration of real-time operation at air traffic control radars. Working with software changes seems more promising and effective mitigation in practice compared to investing in new radars and this kind of work supports that.
- Good interagency collaboration
- Two specific technical mitigation measures identified, implemented and tested
- None that I can identify

Question 8: Project Weaknesses

- If the ultimate source of the problem/impact is related to outdated hardware and radar infrastructure (and conservative approaches of bureaucracies) and not ACTUAL conflicts between turbines and safety, then why should DOE invest in sophisticated modeling? Why not ramp up interagency collaborations and work with others to fund replacement of hardware and software programs (as in the UK)?
- Still further work needed as the proposed mitigation options do not work in all cases
- Could the project benefit from increased international collaboration?
- Is there a strategy for wider rollout and exploitation of identified mitigations
- Only weakness is that the results of the project were not more broadly socialized

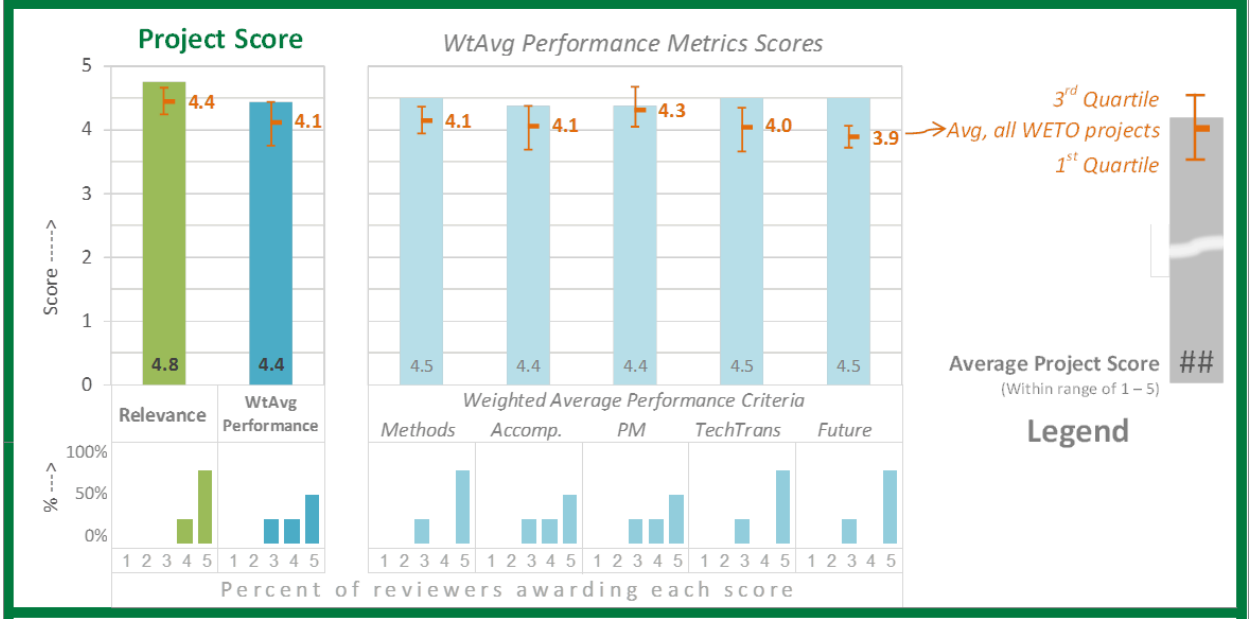
Question 9: Recommendations

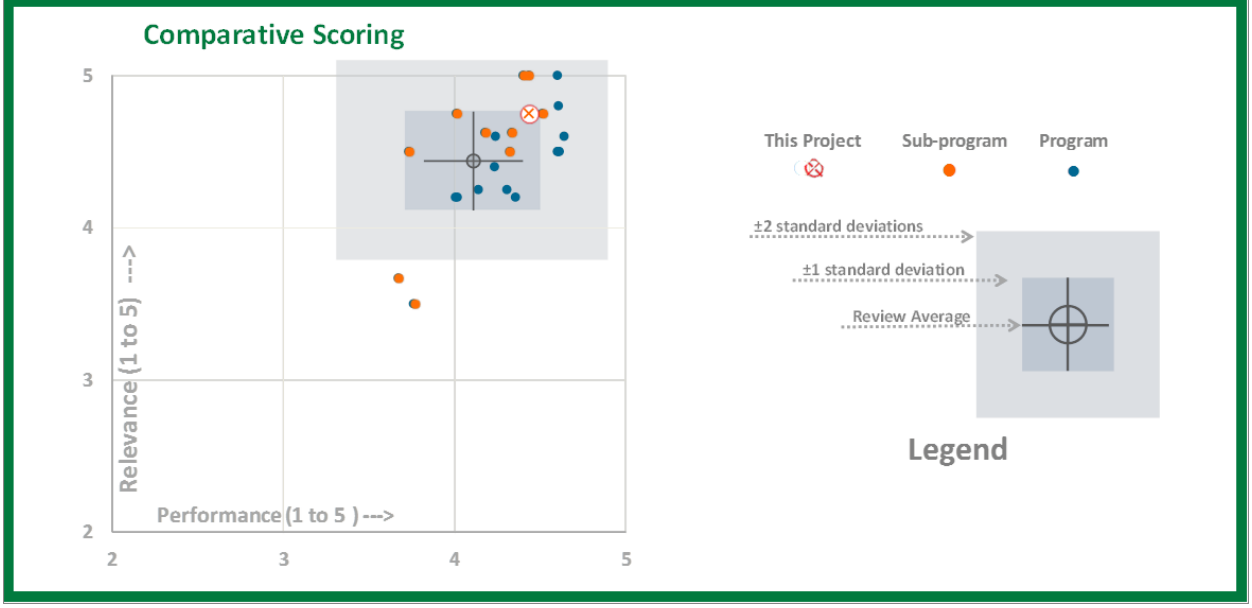
- Consider great international collaboration
- It seems like this good work should be followed up with a strategy for exploitation and wider rollout

DOE Wind Energy Technologies Office 2017 Peer Review Project:

Wind Environmental Collaborative Research and Support

Principal Investigator	Karin Sinclair, National Renewable Energy Laboratory			
Program	Wind Market Acceleration and Deployment			
Sub-Program	Siting, Radar, and Environmental			
FY 2014-2016 Funding	DOE	$ 1.3 M	63%	
	Cost Share	$ 0.8 M	37%	
	Total	**$ 2.1 M**	**100%**	Peer Review ID# 137





Comments made by reviewers during the evaluation of this project (PRID 137)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- This is a 20 year old initiative that is important for industry and agency stakeholders with a trusted partner at NREL and DOE (but comparative approaches are overdue)
- Collaboration with NGOs (non-governmental organizations), such as BCI (Bat Conservation International), BWEC (Bats and Wind Energy Cooperative), and NWCC (National Wind Coordinating Collaborative) is important role for NREL
- Addressing environmental impacts with a national project, with international collaboration is an excellent approach. These questions need answers to get building permits, and getting them through centralized database is a valuable support to deployment.
- Proactive approach to addressing the challenge of wildlife impacts of wind power, thus highly relevant to the program objective of "Facilitating coexistence between wind energy and wildlife"
- This work has been outstanding and is one of the best examples of the Wind Program taking a holistic long-term approach at addressing the industry needs with respect to its impacts and being fluid enough to change course to address the highest priority issues. As such I believe it fits squarely within the goals and objectives of the Wind Energy Office and is meeting the needs of the wind industry broadly.
- Are the WREN (Working Together to Resolve Environmental Effects of Wind Energy) members discussing or working towards sharing fatality data within the group? Have there been discussions around the extent that each member country views the robustness of fatality data collected from their respective wind farms? Is the United States ahead, behind or in step with the efforts of other countries?
- Support for focus groups is an important means to leverage the funding from other sources, maximizing the groups' value potential

Question 2: Methods and Approach

- Training workshops are essential to communicate new science, equipment, and methods
- R&D collaborative approach is very effective and strengthens trust in the results
- More proactive scientific approaches on emerging issues and uncertainties are needed. Right now very focused on short term, industry concerns with permitting (important, but often not necessarily strategic).
- Wildlife studies need a comparative approach to other energy sources to frame the real impacts; this is an old problem that continues not to be resolved at DOE (or FWS (Fish and Wildlife Service)); is this a job for NAS (National Academy of Sciences)/NRC (National Research Council)? DOE should explore more aggressively!
- Very good approach: facilitating cooperatives/collaboratives for bats, eagles, sage grouses. Collecting an impressive database for information, linked with international collaboration.
- Dissemination of relevant scientific studies and results is a key aspect of this work
- Making a link between concerned parties and the scientific literature appears to be very effective
- WREN Hub appears to be a highly valuable resource
- The approach of bringing together key stakeholders periodically to retest assumptions about wind energy's impacts and invest in research (and then disseminate the findings) is essential to the advancement of the wind industry and therefore representative of a well-designed project
- It may be the nature of the presentation but it seems so much territory is covered by this project that it is hard to get down to a substantive level that problems, perceived or real, are actually addressed
- Support for focused groups is a good means of assuring that maximum value is attained with that investment. "One way" dialogs such as webinars and conference calls might not attain the valuable outreach hoped for (i.e., just because folks listen to a presentation does not mean their viewpoints are swayed. Those pro-wind versus those pro-wildlife will persist in the realm of inevitable uncertainty of scientific inquiry. Support, directly or indirectly, for those entities developing risk minimization technologies means that both parties gain value in their respective positions.

Comments made by reviewers during the evaluation of this project (PRID 137)

Question 3: Technical Accomplishments and Progress

- Peer reviewed reports and article are critical; impressive list
- NREL is key to building robust knowledge base for the industry here and in EU
- Tethys is an excellent platform and the amount of information collected is excellent. The work is rolling well, no doubt that this work will get even more inputs and usage as time passes.
- Significant accomplishments in terms of dissemination and collaboration
- Impact appears to be mostly preventative - thus difficult to measure
- Appears to have generated very wide collaborative base for raising and addressing wildlife impacts
- The ability of this project to identify priority risks for the industry and support efforts to answer questions around those risks has been a key value of this project. The significant amount of reports generated by this project at a relatively low cost is impressive.

Question 4: Project Management

- Effective and cost and schedule conscious manager
- Appears within budget
- Milestones mostly met on time successfully
- This project has been well managed and stayed within budget and delivered tangible outcomes at each milestone
- What is the percentage breakdown of how this project's budget is expended?
- Both for work to date and future work, there is much territory covered yet is difficult to understand how such broad reach actually makes a substantive impression with any one topic. Support of focus groups such as BCI, AWWI (American Wind Wildlife Institute) and possibly WREN (I'm still unfamiliar with this group's scope but it seems less focused than others mentioned but for its international scope) determines a level of substantive engagement on focused topics. However, the same is hard to be said for webinars and conferences "targeting regulatory community".

Question 5: Research Integration, Collaboration, and Technology Transfer

- IEA (International Energy Agency) work is essential to keep in touch with scientific advances in other countries and to share results from the United States
- WREN database is an important tool (as is WiLD (Wind-Wildlife Impacts Literature Database), land based) and should continue to be priority; no other organization bringing resources under one roof
- The international work is led by the United States and very helpful for others, as well as for the United States, especially as covering also offshore
- The foundation of this project is its highly collaborative nature - the project is extremely strong on this front - with particularly strong international collaboration
- Stakeholder engagement and reporting on results of this project has been excellent
- The overall scope of the project to collect and disseminate information is a good objective (though a question remains as to whether or not this same objective is being duplicated in other projects as a standard component of a project's objective)
- There should be some form of assessment done for webinars and conference calls. Convening stakeholders to hear from each other is a worthwhile endeavor but not if it leads to little progress towards risk mitigation. Stakeholders might be better served if WETO focuses instead on energizing mitigation technology development so means of risk reduction can be deployed with a robust market of technologies and techniques, minimizing the response to perceived or real impacts with BMPs rather than studies that beget more studies.

Comments made by reviewers during the evaluation of this project (PRID 137)

Question 6: Proposed Future Research, if applicable

- After 20 years of investment in wildlife impacts from wind it seems important to sift out what are the significant risks (and benefits) related to wildlife; are we working on the right risks? How will DOE move this question forward? Need to work outside of old school groups - same old biologists, engineers, and consultants advise DOE; establish new science group with new blood!
- Hope to see as enthusiastic continuation of the efforts, bringing together a large group of experts, and knowledge for sharing
- The Land Based Collaborative and IEA Wind Task 34 projects appear to carry on this work in an appropriate manner
- This effort should continue to be funded until it is no longer needed as wildlife impacts are consistently viewed as the single greatest impact of the wind industry and critical to resolving
- Is there a potential for the DoE to use the information collected to date, reports generated, and syntheses published to generate a macro-level report that pinpoints what questions seem most useful to ask because answering them addresses actual, unsustainable impacts?
- Caution to consider the value of forming an eagle collaborative. Given the iconic nature of the species there are ample collaboratives with varying levels of effectiveness. None of which actually do anything other than convene their select group of experts. Rather, WETO might be better serving the community of wind/wildlife by funding research on deterrents so tools are available, negating the need to further explore the nuances of whether or not impacts rise to population level concerns.

Question 7: Project Strengths

- Pulling together existing knowledge from wide set of research nationally, and with important international collaboration
- National and international collaboration
- WREN Hub is a very valuable resource
- Dissemination and linking concerned parties with relevant science
- None that I can share beyond the above

Question 8: Project Weaknesses

- The only weakness I see with this work is that while the effort has evolved and priorities have shifted I am not sure I can point to an example of a risk being "retired" and the industry is still being questioned on aspects of its impacts that have largely been resolved. For instance, at this point I think we have successfully concluded that impacts to common migratory birds are low, relative to sources of energy generation and other human impacts in general but are still talking about this issue. I would like to see DOE say that through this work we have done enough on the subject and should move on to focusing on eagles, bats, and species of habitat fragmentation concern and strive to develop answers to the questions around those species and finding mitigation solutions so that we can retire those issues as well in the next 5-10 years.

Question 9: Recommendations

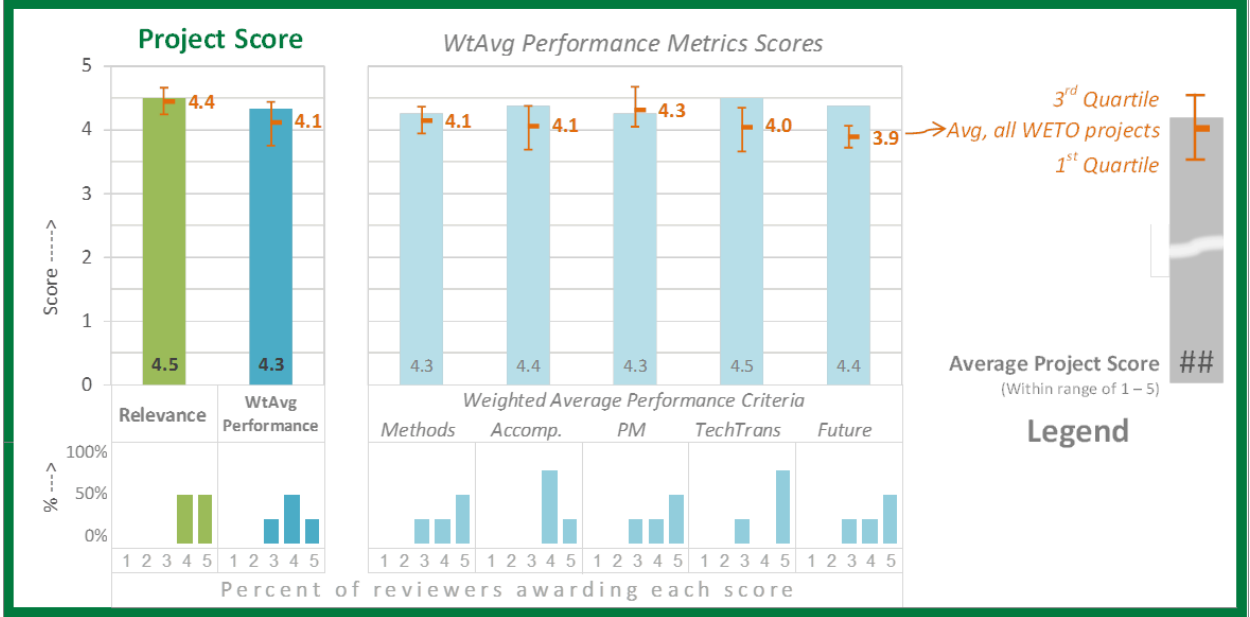
- None

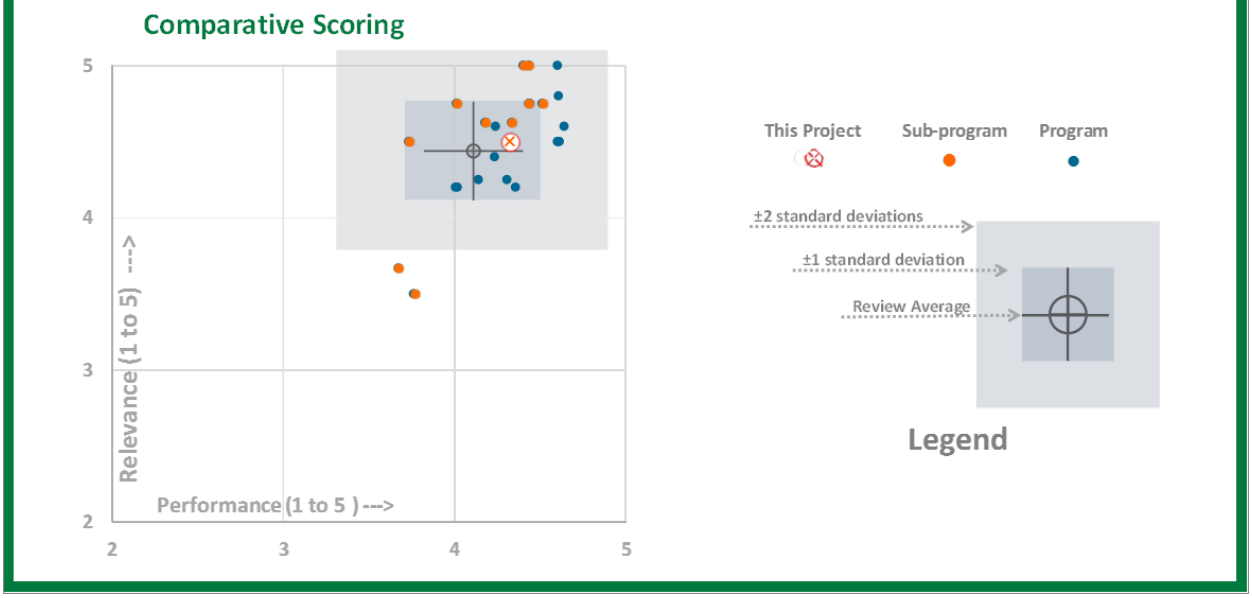
DOE Wind Energy Technologies Office 2017 Peer Review Project:

OSW [Offshore Wind] Environmental Data Aggregation, Analysis and Dissemination

Principal Investigator	Andrea Copping, Pacific Northwest National Laboratory		
Program	Wind Market Acceleration and Deployment		
Sub-Program	Siting, Radar, and Environmental		
FY 2014-2016 Funding	DOE	$ 1.3 M	100%
	Cost Share		
	Total	**$ 1.3 M**	**100%**

Peer Review ID# 143





Comments made by reviewers during the evaluation of this project (PRID 143)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Very important initiative particularly comparing what other countries are doing and tracking studies across environmental impacts - with WREN (Working Together to Resolve Environmental Effects of Wind Energy) and TETHYS
- Reaching out with emails to stakeholders is also effective to remind folks about the resource (I am on that list and appreciate the notifications/ not annoying either)!
- This project directly addresses a number of program objectives including "Facilitating coexistence between wind energy and wildlife", "Offshore wind environments" and "Information synthesis and dissemination"
- This project is well aligned with the goals and objectives of the DOE Wind Program and serves to meet the broader industry needs by disseminating data on the industry's environmental impacts
- It is unclear from the presentation what the level of usage is for the Tethys database, which will ultimately decide the value of the project
- There is a general impression, perhaps incorrect, that the tasks within this project are fundamentally treated separately (i.e., development/maintenance of Tethys, participation in WREN, and technical papers), thus it is hard to know if funding is being leveraged to maximize value

Question 2: Methods and Approach

- A lot of useful content on TETHYS -with practical search criteria for how it is organized
- Collection and posting of land-based data seems duplicative with WiLD (Wind-Wildlife Impacts Literature Database) database at NREL (later checked with PI (Principal Investigator) and found out that NREL provides that data to PNNL---so non-issue)
- Pulling data together for the offshore pilots in US
- Building Tethys database
- Writing white papers together with NREL, first one on adaptive management in permitting in this project
- Use Tethys or WREN Hub to gather relevant science in the area, particularly relating to offshore wind experience is setting best practice for information gathering, outreach and dissemination
- Thorough project design with good results
- It is unclear how the stated objective of "reducing monitoring and mitigation requirements, and decrease time and cost to deployment" was achieved or being achieved by the work of this project over last three years
- Adaptive management is fraught with challenges for lack of any concise and clear methodology for employing it. I commend the WETO in attempting to address these fundamental issues with their AM (adaptive management) white paper and appreciate the inclusion of the broad diversity of issues and expectations that complicate the concept, especially when it is attempted to be applied to regulatory structures. I will be reading the paper with great interest.
- Is WREN working to synthesize what is already known (e.g., what the composite of information in Tethys tells us) so researchers are informed where the uncertainties are and therefore WREN drives where research is conducted? Or does WREN only receive new research (e.g., guest speakers on a qtrly webinar) without any context to it? One challenge of the research community is a lack of cohesion around what the non-research community actually needs to make decisions. WREN seems well postured to fill such a role.

Question 3: Technical Accomplishments and Progress

- Adaptive management white paper is complex but useful; grappling with these challenges is relevant here and in the EU; not clear how the DOE program will utilize this perspective
- Very useful progress: Tethys database adding offshore content and 2 page summaries, per species what is known, detailed papers as links
- Journal articles listed look like from marine side (perhaps directly applicable for offshore)
- Seems like the offshore data collected in demo projects not very well aligned for use /comparisons (report on analyzing data usefulness)

- Pre and post construction data gathering is an extremely valuable exercise
- Adding content to Tethys and standing up WREN hub are high value achievements
- Tethys statistics show good reach and healthy growth
- Accomplishments and work product to date have been very high quality and answered the mail in many regards to understanding and socializing the impacts of wind energy on the environment
- The Tethys database of information fills a necessary void so far as a one-stop-shop location for various papers accomplished internationally. However, the usage data provided in the presentation does not suggest a heavy rotation of use by regulators, industry biology contractors and other practitioners.
- A random sample taken (a paper located under the North Sea catalog: Percival S. "Avian Collision Risk at an Offshore Wind Farm", 2005) notes avian collisions are rare (~1%) and avoidance is the primary response of birds to turbines. The point is what efforts are being undertaken by WREN or other components of this project to canvas what the international literature has concluded thus far? Are we focusing on the right unknowns?

Question 4: Project Management

- Working through IEA (International Energy Agency) on this task is a very important activity for sharing information and keeping up to date with European studies ---since they are way ahead of the US on deployments and number of years that turbines are operating in their seas
- NREL is OA of the WREN but the role of another lab in this area was not made clear in her presentation (although I know that PNNL has offshore environmental capabilities that NREL does not)--NOTE: -later I checked with the PI and it was clarified that NREL and PNNL are collaborating and there is no duplication of efforts
- Coordination: WREN collaboration with NREL, and regarding offshore wind building on marine energy work also
- Within budget so far
- Milestones met successfully
- Project management appears to have been very strong - staying within budget and meeting project deliverable timeframes
- Suggest that the individual tasks be structured so that each supports the other. Tethys should evolve into a library of information that researchers strive to have their work added to, effectively Tethys becomes a source of well researched efforts, rejecting grey literature and poorly conducted peer review work.

Question 5: Research Integration, Collaboration, and Technology Transfer

- List of countries involved is impressive and countries that have useful experiences and studies and references; would be interesting to assess how this knowledge base has or is changing the perception of significant risks of offshore wind
- Appears to have significant number of webinars and reaching a significant number of folks and organizations
- High impact through Tethys also the webinars are being watched later
- Also regulators and developers have joined webinars
- Outreach and dissemination are a key focus for this project and are very strong
- Very strong international collaboration
- High level of collaboration between PNNL and other partnering entities. Report publication and socialization of study results through webinars and other forums has been of a very high quality.
- As previously stated, it is unclear what the usage rate is for information contained in Tethys nor is it clear what the added value is of the WREN community. Coordination with the international community should determine what offshore questions the US should care about. If the preponderance of European literature suggests avian collision risk does not rise to population level concerns then the US should diminish the importance of determining whether or not such is the case here. Conversely, if the European community is unsure about marine mammal interaction with windfarms, then the US should partner under WREN to focus on such questions. The presentation seemed to suggest the focus of WREN is less structured with any such objective; rather it is simply a forum for international stakeholders to convene and hear the latest research results. Such arenas already exist (e.g., NWCC (National Wind Coordinating Collaborative)).

Comments made by reviewers during the evaluation of this project (PRID 143)

Question 6: Proposed Future Research, if applicable

- White papers on risk-based management and cumulative effects are important topics that need to be addressed
- Short science summaries seem worthwhile for reaching a larger audience (but I have not seen these products)
- Good to continue
- Future planned research appears to carry on the successful work of the project out to 2020
- Not explicitly mentioned, but it would seem to make sense to further the pre and post construction data gathering and analysis
- It appears this project has run its course. While I would put it at a lower priority level than say the wildlife deterrent and radar work, the quality of the work is such that if there is additional need and funding exists I would support continued investment.
- Continued improvements and additions to Tethys encouraged; WREN less sure about but believe with some refocused objectives of the group that it could add value. Alternatively, depend on other groups that already offer an academic arena for research results.

Question 7: Project Strengths

- Tethys database (WREN work together with NREL), dissemination and webinars, international collaboration
- Outreach and dissemination are very strong
- It appears a growing international community has been established
- Tethys and WREN Hub appear to be excellent resources
- None that I can identify

Question 8: Project Weaknesses

- Did not seem to have a link to BOEM (Bureau of Ocean Energy Management) Env. Science Studies ---the lead on OSW studies; this would seem critical for success
- Opinion is divided on the merits of Adaptive management - focus on this is perhaps questionable
- None that I can identify

Question 9: Recommendations

- It would be interesting to see some sort of report on the pre and post construction data gathering and analysis

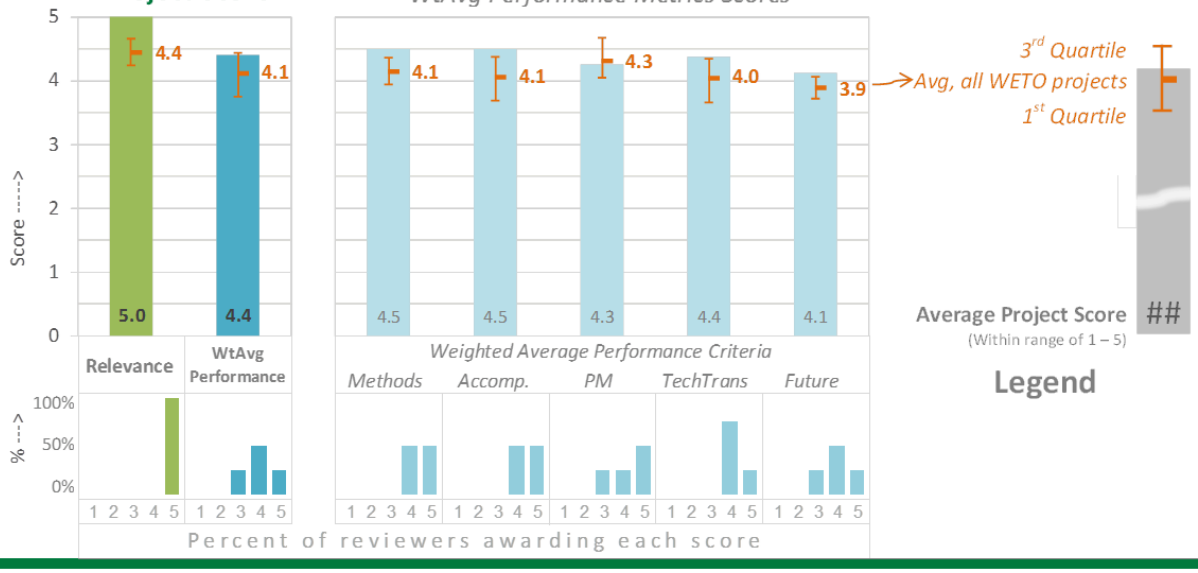
DOE Wind Energy Technologies Office 2017 Peer Review Project:

SNL [Sandia National Laboratories] Wind-Turbine RCS [radar cross section] Mitigation

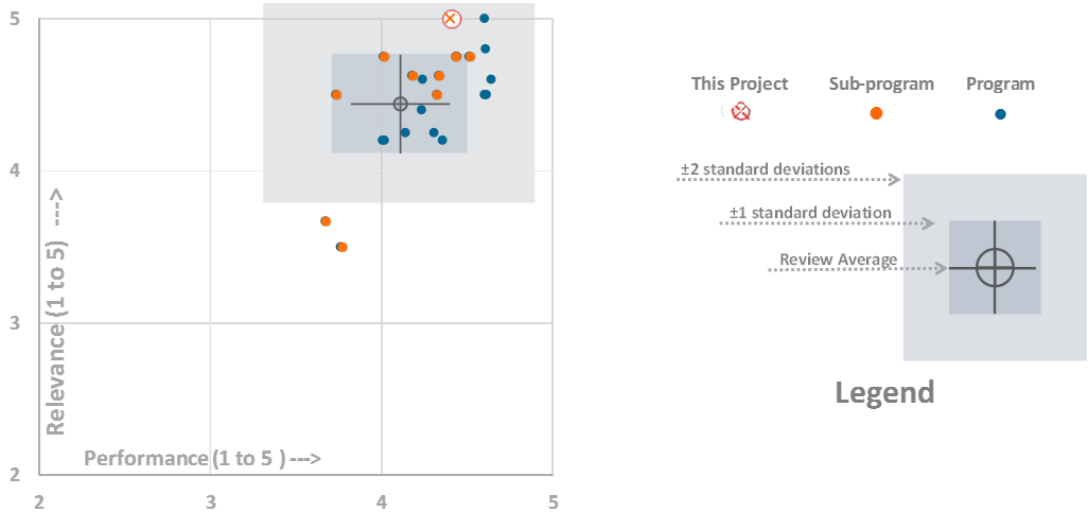
Principal Investigator	Ben Karlson, Sandia National Laboratories		
Program	Wind Market Acceleration and Deployment		
Sub-Program	Siting, Radar, and Environmental		
FY 2014-2016 Funding	DOE	$ 1.9 M	95%
	Cost Share	$ 0.1 M	5%
	Total	**$ 2.0 M**	**100%**

Peer Review ID# 145

Project Score



Comparative Scoring



Comments made by reviewers during the evaluation of this project (PRID 145)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Important to drive an interagency solution ---policy and legislative along with replacement and upgrade of radars that could handle the intervention
- Radar interference is a real issue with the potential to significantly impede wind power development and potentially public safety. This project aims directly to tackle this issue through a number of distinct efforts and is thus highly relevant.
- This project is absolutely critical to the advanced deployment of wind energy nationally and aligns well with the needs of the wind industry and program goals of the Wind Energy office
- What are the near-term mitigation options mentioned in the presentation (PMP (Pilot Mitigation Project))? There is no elaboration on this in the Summary.
- There remains the issue that mitigating this issue on the turbine side of the equation effectively ignores the radar side of the equation, which has other benefits of being improved upon beyond mitigating turbine interference

Question 2: Methods and Approach

- Collaboration across agencies so SNL acting as convener is an important role that only DOE or labs can play in this area
- Lightning cable relationship is interesting add on - but link was not clear
- The project needed both technical work (field tests, model for public/authority use, mitigation measures) and discussions with stakeholders to find ways to co-existence of radars and wind power plants. Clearly good that project was covering both parts
- The project aims to address this issue through a number of distinct efforts which attempt to:
  - improve inter agency coordination and planning
  - improve modelling capabilities
  - make information regarding potential impacts on radar installations available to developers
  - specific technical mitigation advancement
- Project was well designed and addressed the stated goals
- For the radar mitigation work, DoE should evaluate the findings of the 2007 JASON report that concluded there is no fundamental technical impediment to rectifying this problem with modern radar technology
- The current generation of radars is fully capable of addressing wind energy impacts. The scope of concern for wind/radar compatibilities is virtually exclusive to older radar technology. This should result in symbiosis between ameliorating wind energy impacts and replacing aging infrastructure.

Question 3: Technical Accomplishments and Progress

- TSPEAR (Tool for Siting, Planning, and Encroachment Analysis of Renewables) model validation is needed although it is available for developers - this is a good milestone; are developers aware
- Some interesting findings from field tests. TSPEAR siting tool. Facilitation of working group (with challenging number of agencies).
- A major challenge in dealing with this issue is the number of diverse stakeholders involved. The establishment of the multi-agency working group and associated memorandum of understanding is a significant achievement.
- The TSPEAR tool appears to be a very valuable resource to the wind development community in self mitigating the issue
- Progress to date on this issue has been outstanding and DOE has shown itself to be a great leader in not just evaluating the issue and seeking solutions but using it's convening authority to bring together other agencies (DOD (Department of Defense)) and interested stakeholders within the wind industry to work through the issue
- The presentation suggests that lightning protection is a large percentage of a wind turbine's RCS profile. What is the percentage? Are there discussions with OEMs (original equipment manufacturers) on opportunities to change the configuration of their lightning protection approaches?

Question 4: Project Management

- Appears to be operating within budget
- Appears to have met milestones successfully
- The project managers effectively and efficiently ran this project and delivered tangible outcomes

Question 5: Research Integration, Collaboration, and Technology Transfer

- Given that this is an infrastructure and software related issue, it appears to be a risk communication issue rather than a substantive issue. Good to build this expertise, but if this is more a modeling issue but the former, perhaps more emphasis needs to be put on the interagency coordination and awareness within relevant agencies.
- This is the most challenging and important part of this project. How to make best use of TSPEAR remains, and validation/quality check that it will be used properly in authorities. For the publicly available version NOAA (National Oceanic and Atmospheric Administration) radars can be on it but probably DoD radars not, and FAA (Federal Aviation Administration)/DoD/Homeland Security etc., would use a different version.
- Industry collaboration was highly successful with 6 different wind farm owners providing wind turbine telemetry
- Appears to be good collaboration between government agencies, the wind industry and academia
- Given that this issue is quite widespread internationally, perhaps the program would benefit from increased international collaboration, although the sensitive security aspects of this project make this challenging
- Coordination with a variety of stakeholders was key to the success of the design and execution of this program. However, the only criticism I would share is that I am not sure the broader wind energy development community is aware of the availability of the TSPEAR model and there should be greater effort employed in socializing its availability and encouraging its use.
- Recognizing the sensitivity of the outputs to TSPEAR modeling, is there nonetheless an intention to publish the model assumptions used and how a conclusion reached by a given agency is verified by a broader set of stakeholders (e.g., WTRIM (Wind Turbine Radar Interference Mitigation working group))?
- Has there been an effort by WETO to substantively engage NOAA to create an equal footing partnership between the office and an end user of radar technology (NOAA)? This agency in particular is low hanging fruit for resolving one area of radar/wind conflict, both robustness of the radar technology as well as the singular use of the radar technology throughout the US.

Question 6: Proposed Future Research, if applicable

- NEXRAD (Next Generation Weather Radar) needs to be addressed
- The level of the problem should be defined so we understand better the level of attention this deserves
- Interagency collaborations need to be continued but perhaps add a more robust training component so more agency folks are aware of the potential challenges
- Future work not clear but at least the interagency "Wind Turbine Radar Interference Mitigation" Working Group (WTRIM WG) which includes DOE, DOD, DHS (Department of Homeland Security), FAA, and NOAA seems to continue which is very important and a major outcome of DoE and the project
- In most cases the mitigation will be updating radars, either software update, infill radars or totally new ones. If larger amount of wind power plants in the impact area, consortium could pay for a new radar, but getting that kind of collaboration ongoing and working seems to be a challenge. Work is clearly still needed to find ways that work with different stakeholders, weather, air traffic and defense.
- Proposed future research appears to continue to address the issues in a coherent way, particularly continued support of pilot projects and validation of TSPEAR models
- I am not sure what additional research effort is needed at this point but if additional work is required this is one area in particular that should receive high attention as the negative impacts on military and civilian radar systems can/do result in project delays and cancellations at present (vs. theoretical long-term impacts that may need to be addressed at a future date) and therefore should be viewed as a priority issue to be addressed
- NEXRAD technology mitigation is understandable and achievable given a single, unclassified user, use and technology. Dialog to that end would be good to have as the implication is we could solve a real, national scale impact for a relatively modest investment.

Comments made by reviewers during the evaluation of this project (PRID 145)
• The presentation suggests that lightning protection is oftentimes replaced in wind turbines once lightning strikes. Have there been any attempts to partner with an operator to test alternative approaches to lightning technology that also reduce RCS?
Question 7: Project Strengths • Facilitation of stakeholder group. Testing mitigation methods. • Interagency cooperation and memorandum of understanding appears to be a crucial aspect of this effort • TSPEAR appears to be a very valuable tool to the community • None that I can identify **Question 8: Project Weaknesses** • Not enough emphasis on the hardware limitations • Perhaps project would benefit from increased international collaboration • Only weakness as stated above is potential insufficient socialization of the work and available tools within the development community **Question 9: Recommendations** • Perhaps increased international cooperation could be considered where appropriate • The NOAA weather radar issue seems to be a low hanging fruit where there is no security sensitivity; it is a single agency with a single radar technology. Perhaps this could be more directly addressed. • A commonly adopted mitigation approach appears to be for wind developers to collectively subsidize (partially or completely) replacement radar systems. Perhaps this could be explored.

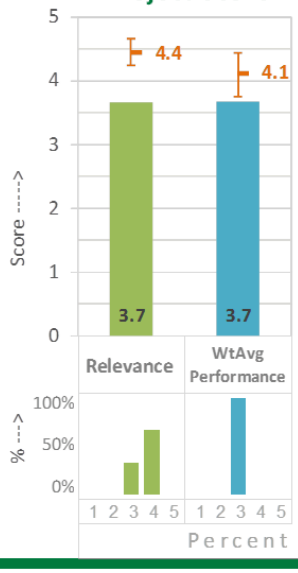
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Stereo-Optic High Definition Imaging: A New Technology to Understand Bird and Bat Avoidance of Wind Turbines

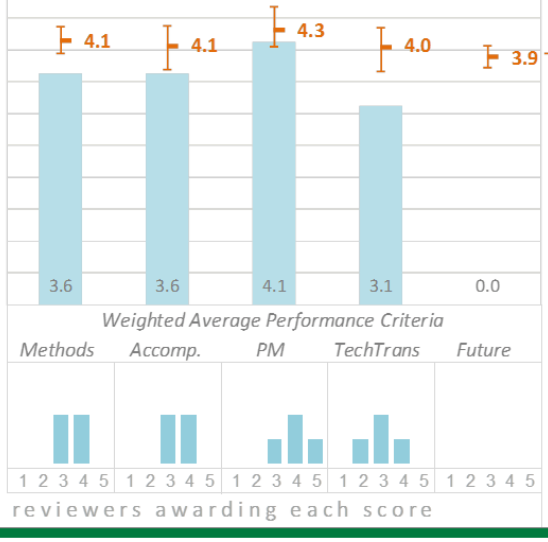
Principal Investigator	Evan Adams, Biodiversity Research Institute		
Program	Wind Market Acceleration and Deployment		
Sub-Program	Siting, Radar, and Environmental		
FY 2014-2016 Funding	DOE	$ 1.1 M	55%
	Cost Share	$ 0.9 M	45%
	Total	**$ 2.0 M**	**100%**

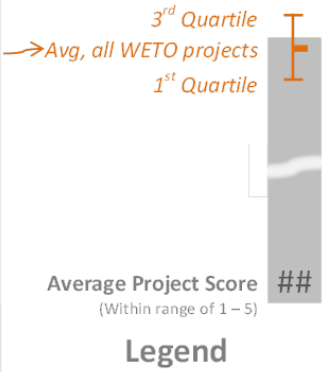
Peer Review ID# 147

Project Score

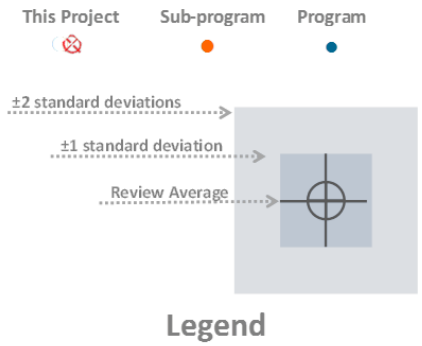


WtAvg Performance Metrics Scores





Comparative Scoring



Comments made by reviewers during the evaluation of this project (PRID 147)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- These technologies are interesting but seem expensive and potentially controversial for the needs of the industry or the coastal agencies
- Research tool for permitting and to bridge the science gap with avoidance seems reasonable; it just was not clear how this matches with BOEM (Bureau of Ocean Energy Management) guidance
- Relevant to the program objective of "Facilitating coexistence between wind energy and wildlife"
- While I understand the intent of this project and do believe there is some alignment between this research and the goals and objectives of the Wind Energy Office and addressing the needs of the industry I think the cost outweighs the value and don't see how this would have practical application at an offshore wind farm in either informing decisions about operations or future siting considerations
- The project seems to provide a variation of a theme that monitors a single or limited set of turbines to record 24/7 observations of avian and bat interactions around wind turbines. As the birds, there is little added value to such observations as the bulk of bird species display avoidance behavior around wind farms. Those that do not, principally birds of prey are better served to determine effective means of deterrence rather than study of their behavior. Similarly for bats, their behavior can be ascertained with a variety of proven technologies and thus prototype development of new technology begs questions of value unless said development leads to effective deterrence.
- As to the offshore wind impact question, looking at one or a limited number of turbines may not provide sufficient scale for asking the appropriate question of risk, which is do birds display avoidance behavior around offshore wind "farms"? To observe a bird collision at a single turbine substantiates what is already known (collisions occur) but does nothing to address the question of population level impacts (i.e., cumulative impacts).

Question 2: Methods and Approach

- Identifying species collision is an important contribution to the technology capabilities we currently have--- but the distance is limited (100m or 300m) so overall I am not sure whether this method has a future
- 2 fish eye lenses, automated finding of moving objects. Building the system, testing various methods of data transfer/tracking.
- Value of approach is not clear. How will this be used to reduce collision mortality rates?
- Collision detection appears to have been an objective but this does not appear to have been addressed
- The fundamental idea and approach to bird identification appears to have worked well, less so for bats
- I think conceptually the project was well designed and appears to have operated as intended. I fail to see the real world application/value the technology would provide
- Optical devices have been developed and are commercially available that observe avian and bat behavior around wind turbines so it is unclear what this technology adds in that regard. Lack of any additional, proposed research further suggests a lukewarm reception of findings to date.

Question 3: Technical Accomplishments and Progress

- Getting to some clarity on species identification for these cameras seems like an important contribution
- There was no mention of the other activities related to this work, particularly private consulting firms working in this area; EU related technology for the same challenges and as mentioned, the link to BOEM guidelines
- Basically a working concept has been proved, distance in day time 200-300 m but in night time for smaller objects like bats 30-60 m only. Also problematic is fog when works only as well as human eye, thermal camera then better.
- Bald Eagle detection functionality appears to work well
- Good progress has been made on algorithms for image processing, distance estimation and pattern recognition
- Collision detection appears not to have been addressed

Comments made by reviewers during the evaluation of this project (PRID 147)

- Exploitation of the work and how it will be used to mitigate mortality rates appears to be lacking
- Progress to date appears well aligned with the study design
- Developing an optical device that can withstand the elements of offshore environment and have processing power to assess species identification may be useful verification technology when used with deterrence device development

Question 4: Project Management

- Within budget
- Milestones met mostly successfully
- 6-month no cost extension
- The project appears to have been effectively managed, meeting project milestones and staying within budget
- Significant funds expended by the WETO for a technology that has no stated "next step", albeit cost-share approaching 50% does suggest a value proposition worth the investment

Question 5: Research Integration, Collaboration, and Technology Transfer

- This approach seems to be quite costly, especially for larger wind farms. There are concerns that perhaps will be easy to require this even if it will be challenging to implement.
- Good collaboration
- Modest level of dissemination
- No academic output
- Collaboration during study design and execution, as well as the reporting of results, appears adequate
- It does not seem that much work was done to disseminate the results of the field tests nor much outreach done to explore improvements in detection/species identification capabilities

Question 6: Proposed Future Research, if applicable

- This is another example of the same question: are we working on the right risks?
- Future work will be merged to two other projects. This seems to be a costly approach, and not sure how far the quite costly project reached. Probably good idea to keep this as an option when developing other approaches.
- Appears not to be applicable, but it would have been nice to see something on exploitation and how this system can be used in practice
- I do not think additional funding should be provided to this project given the relatively high capital cost and low benefit/value to the broader industry

Question 7: Project Strengths

- New techniques tested and validated for remote sensing of birds and bats
- All detection techniques still not 100% reliable so this approach may be useful in some cases
- Methods have been developed to utilize stereoscopic cameras to automatically identify certain bird types
- None identified beyond what is stated above

Question 8: Project Weaknesses

- Challenging to detect especially bats this way - detection rates are not very good more than 100 m away
- Costly work and system - not sure how much cost reduction potential exists
- Value of developed system is not clear
- No plan for exploitation or deployment
- Collision detection appears not to have been addressed
- High cost with little perceived value in real-world application

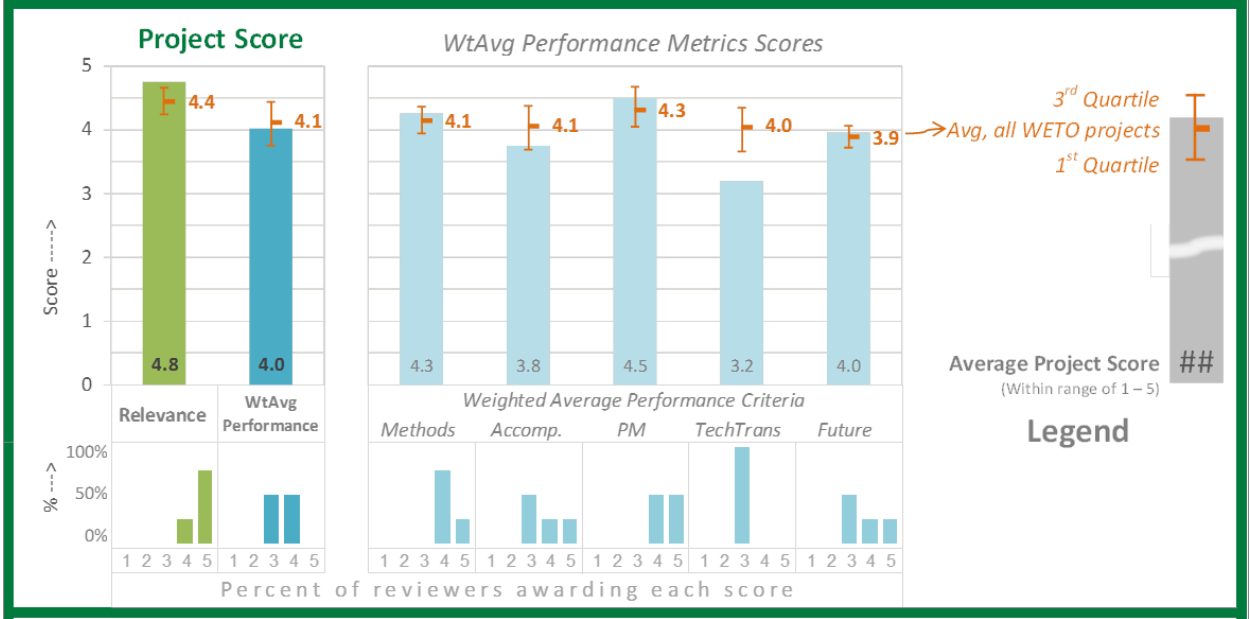
Question 9: Recommendations

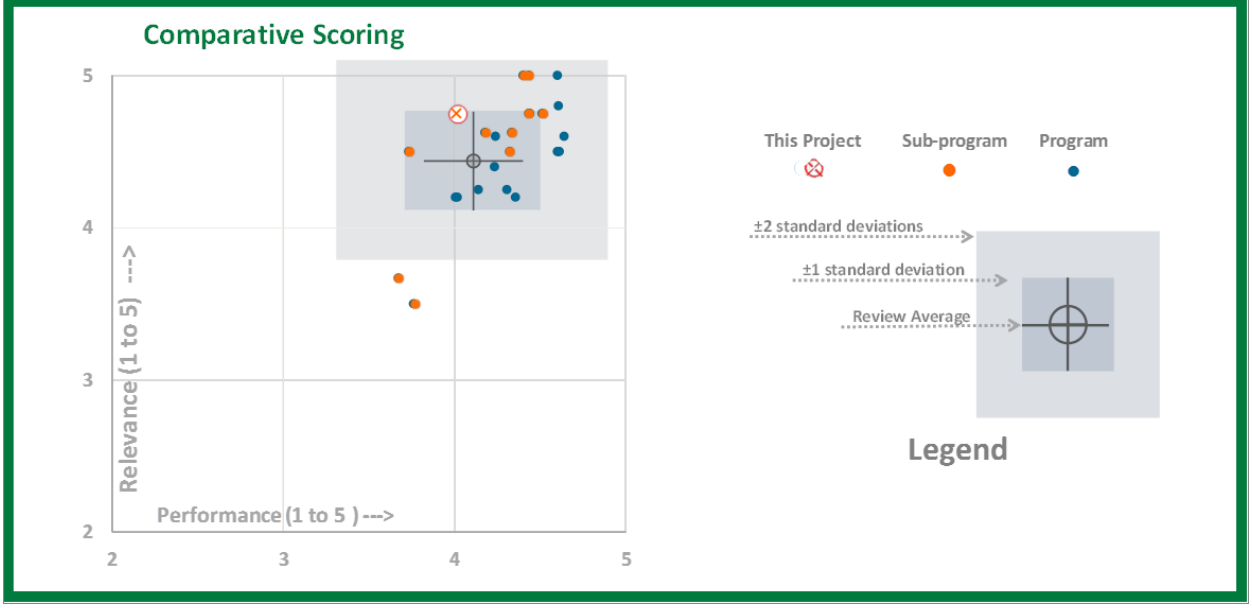
- It would be good to see a plan for exploitation and deployment of the system
- Consider communicating better how such a system would be used in practice

DOE Wind Energy Technologies Office 2017 Peer Review Project:

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

Principal Investigator	Paul Sievert, University of Massachusetts Amherst			
Program	Wind Market Acceleration and Deployment			
Sub-Program	Siting, Radar, and Environmental			
FY 2014-2016 Funding	DOE	$ 0.2 M	80%	
	Cost Share	$ 0.1 M	20%	
	Total	**$ 0.3 M**	**100%**	Peer Review ID# 149





Comments made by reviewers during the evaluation of this project (PRID 149)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Mitigating bat fatalities is important research particularly because there is no curtailment and low costs
- Haven't we dealt with deterrents on birds that were unsuccessful - not sure why we are trying this again?
- Highly relevant to the program objective of "Facilitating coexistence between wind energy and wildlife"
- As with the other wildlife work this project is critical to finding solutions to reduce wind energy impacts on bats and therefore is well aligned with the objectives and goals of the Wind Energy Office (i.e. coexistence of wind energy and wildlife) and meets the broader wind industry need in finding a practical solution to addressing this critical real-time issue
- Good project. Objectives and low-cost, high-value proposition balances well the mission of the WETO and budgetary constraints.
- No mention of impact to technology due to harsh operating conditions, a necessary component of technology development of this kind

Question 2: Methods and Approach

- Ultrasonic signals at base and tip of the blade
- Have other research on deterrents been brought to bear on this research?
- Interesting concept of passive whistles on blades - a new concept and the project aims to get this through the lab tests and wind tunnel tests and simulations
- Potentially elegant, passive solution to bat deterrence
- Potential need to estimate drag impact on power generation
- Possible need for actual field testing earlier in the project to identify practical issues not present in lab conditions such as insect collection and the ability to withstand storm conditions
- The study design and hypothesis seem sound and approach technically feasible
- Ultrasonic frequencies used were not annoying bats and therefore they did not avoid them. Were there experiments to suggest that other frequencies would be viewed as uncomfortable or otherwise not have bats adapt and ignore the sound but actively avoid?
- Seems that low wind speeds, at which bats are most at risk, would leave attenuation of sound from whistle at what effective distance (i.e., attenuation distance is a function of wind speed such that period of greatest risk to bats is period of weakest attenuation of device).

Question 3: Technical Accomplishments and Progress

- Challenging work to design this kind of passive whistle operating at certain wind speed and pressure - turned out to be more difficult than anticipated
- Project is ongoing, looks like in the lab test phase. Not much results yet on whether it actually works.
- Prototype developed and tested
- Results appear to show successful bat deterrence under lab conditions
- Progress to date appears to be on track with the project milestones and shows advancement from concept to testing phase
- Seems the project is on the verge of exploring effectiveness in the field and over time, a critical juncture. Still curious about effectiveness during low wind speeds

Question 4: Project Management

- Potentially important technology for industry to address bat mortality
- Appears to be under budget so far
- Milestones met successfully so far
- Project management appears to be effective in meeting the project goals and staying within budget
- Low cost opportunity to develop risk mitigation technology and good indication of cost sharing with non-WETO entities

Question 5: Research Integration, Collaboration, and Technology Transfer

- Cost share is important from MA CEC (Massachusetts Clean Energy Center)
- Good partnerships with UMass and Texas A&M
- Urgent need to interact with manufacturers about whether mounting this whistle is even possible
- Good academic collaboration
- Perhaps project would benefit from direct collaboration with a wind farm operator
- Work still in progress and limited dissemination carried out so far
- Good local community outreach

- While some collaboration across departments within UMass Amherst is good I would have preferred to see greater collaboration with other bat biologists and with turbine (blade) engineers to determine if the thinking is that these devices will not cause additional drag/friction resulting in lost generation. In my opinion this work is a bit too insular to project team/UMass faculty. I also think it is a bit premature to be discussing this project with media outlets and others before demonstrating the effectiveness of the device - so while laudable that the design/project team is sharing details with the public and making their work known I would have preferred they waited and published the results in a peer-reviewed journal and then socialize the findings further after that.
- Limited dissemination of results to date but seemingly justifiable given infancy of testing. Broadcasting efforts such as this, even in their infancy, tells broad community of potential and actual stakeholders that something is being done to address impacts - a good message for all involved.

Question 6: Proposed Future Research, if applicable

- This concept still needs a lot of work to prove it works
- Planned future research to test devices on blades of an operational turbine is critical to assess the potential of the approach
- Future research, perhaps, could also consider estimate of drag impact on turbines
- Impact on devices under storm conditions installed on a feathered blade should be considered
- Ongoing maintenance impact should be assessed - how often will devices need to be cleaned
- Given the importance of this work I think it definitely should continue to be funded and advanced to the field testing phase but I would suggest that the issues of collaboration and communication outlined above be addressed moving forward
- Advance effort to field testing, determine effectiveness. Be sure tests include durability tests given the harsh operating environments.

Question 7: Project Strengths

- Aiming to increase the impact of ultra sounds by blade mounted devices
- Devices will require no external power source, should require little maintenance, and will be small and cost-effective
- Elegant, passive solution to problem not requiring any wiring or power source
- Biomimetic modelling approach appears to have worked successfully so far
- None identified at this time

Question 8: Project Weaknesses

- Appears to be a weakness in the analysis across projects: There needs to be an overall peer reviewer/collaborator to bring all bat deterrent research together; For example, thermal imaging is expensive and valuable data---how will this be archived and shared with others?
- The concept still has quite a lot of challenges ahead like keeping them alive in turbine blades, and not getting dirty with insects. They will be producing sounds also at day time when not needed - even if the sounds are not audible to humans the concept of more sound emissions from turbines does not feel a good approach.
- Project may benefit from direct collaboration with a wind farm operator
- There are many potential practical issues with the device that would need installation on an operating turbine to be fully assessed. These include durability under extreme weather conditions, maintenance and cleaning requirements.
- Potential need to evaluate impact of drag on power generation
- Other than the previously noted issues about greater collaboration and timing of result publication the only other weakness I can flag is that they should do some controlled testing of the device to determine effectiveness in reducing bat activity and range of disturbance before attempting a field test where they are mounting the device on turbines. Ideally they would use a step-wise approach of a controlled environment test, followed by a field test where high bat activity is known to occur (e.g. over a pond), and then the full field test at a wind turbine.

Question 9: Recommendations

- Consider collaborating directly with wind farm operator to get input at the design stage
- Consider estimating impact on power generation
- Consider developing strategy to test maintenance requirements and durability under extreme weather conditions
- Consider developing strategy to estimate expected life of devices

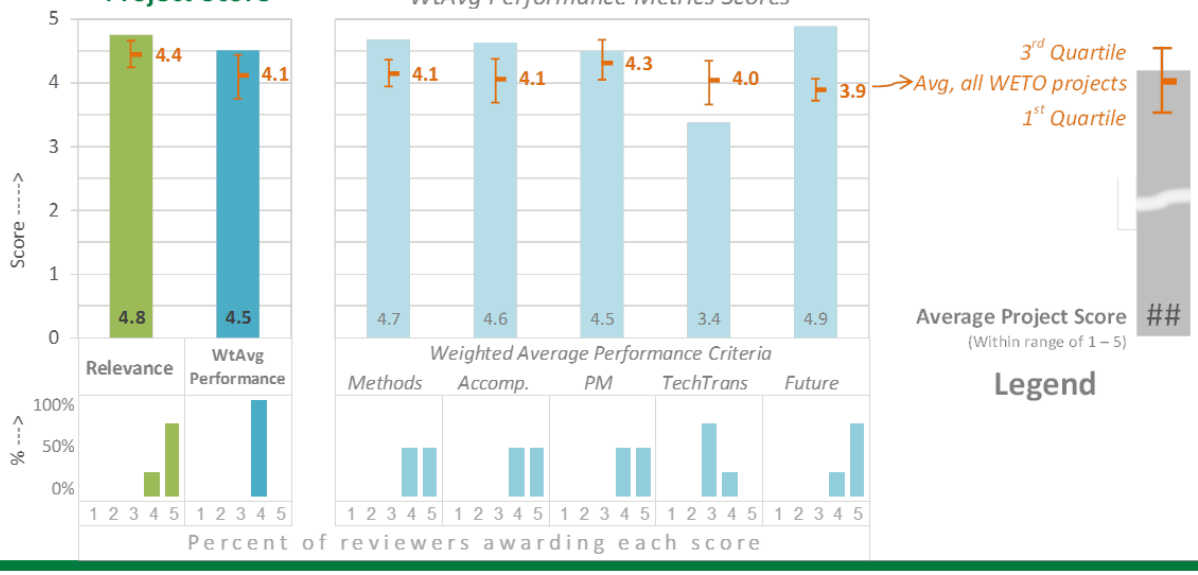
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Texturizing Wind Turbine Towers to Reduce Bat Mortality

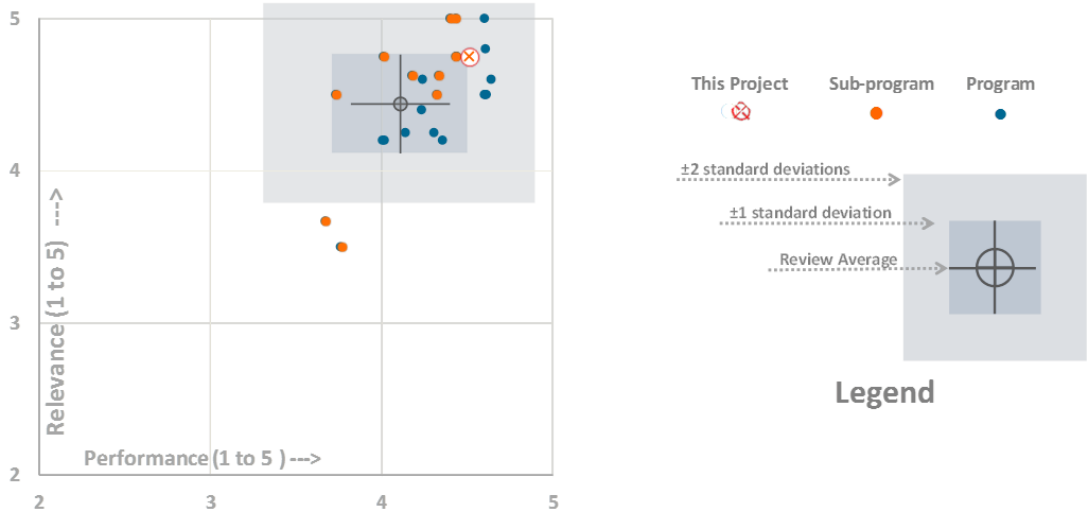
Principal Investigator	Victoria Bennett, Texas Christian University		
Program	Wind Market Acceleration and Deployment		
Sub-Program	Siting, Radar, and Environmental		
FY 2014-2016 Funding	DOE	$ 0.2 M	51%
	Cost Share	$ 0.2 M	49%
	Total	**$ 0.5 M**	**100%**

Peer Review ID# 150

Project Score



Comparative Scoring



Comments made by reviewers during the evaluation of this project (PRID 150)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- NextEra involvement demonstrates that this is an important industry research area; plus NextERA was founder of BWEC (Bats and Wind Energy Cooperative)
- Mitigating bat fatalities is important research particularly because their curtailment seems to be the only strategy proposed for some years; not fair to wind industry when other energy suppliers do not turn off production for environmental impacts; perhaps this should be highlighted too!
- Highly relevant to the program objective of "Facilitating coexistence between wind energy and wildlife"
- This project meets the objectives and goals of the DOE Wind Energy Office by seeking to find a solution to reducing impacts to bats (i.e. coexistence of wind energy and wildlife) and will advance the needs of the wind industry by reducing risks and a potential barrier to deployment
- Good project. Objectives and low-cost, high-value proposition balances well the mission of the WETO and budgetary constraints.
- Has there been any cross-pollination with the wind/radar community that texturized paint on towers (and nacelles) could potentially reduce RCS (radar cross-section)?

Question 2: Methods and Approach

- Interesting water attraction hypothesis but it is based on one peer reviewed paper ----that seems weak
- Builds the knowledge base for BWEC although the presenter did not make any links with this research
- Eastern red bats is an important species with wind impacts
- This new idea that bats are attracted by towers due to misperception of water is very promising - as the mitigation of coating turbine towers is way easier to handle than ultrasounds
- Excellent scientific approach to testing a hypothesis, developing a mitigation strategy and developing a solution
- Tests should be designed to assess the impact of textured coatings on air flow around turbine and potential impacts on other turbines down-wind
- The project is well designed to answer the question as to whether bats are somehow drawn to turbine towers and if the hypothesis is proven correct could provide a cost-effective solution to reducing wind energy impacts to wildlife, thereby reducing a barrier to deployment

Question 3: Technical Accomplishments and Progress

- Impressive research given the limited timeframe
- Feasibility phase ongoing that looks promising. Next going to field, now tests in chamber.
- Experiments well thought out and implemented well
- Commercial-ready texture coating developed
- Flight test facility established economically
- Progress to date has been promising and the study design sound in attempting to address the question
- Promising results with profoundly inexpensive mitigation technology approach

Question 4: Project Management

- Additional funding required for texture coating
- Milestones mostly met on time
- The project to date appears to have been well managed and is within budget
- Seems well managed and impressive to secure ~50% cost sharing from industry participant

Question 5: Research Integration, Collaboration, and Technology Transfer

- Cost-share is impressive from Next Era
- Too early to tell if this will lead to solution since this is a work in progress
- Four masters students from this work is impressive
- Working with BWEC (Hein) is critical
- Good collaboration with wind farm operator
- Limited dissemination so far, but project is a work in progress

Comments made by reviewers during the evaluation of this project (PRID 150)

- The collaboration between TCU (Texas Christian University), industry, and Aeolus is admirable but additional stakeholder engagement on the theory and study design would have been recommended. It is also not clear how the results of this study will be reported and socialized. The findings should be reported for the benefit of the broader industry at the end of the study period.
- Limited outreach but understandable given state of research effort. Expect to see a full disclosure of work to date and findings from the effort as the low cost implications are worthy of stakeholder community looking for cost-effective means of reducing risk.

Question 6: Proposed Future Research, if applicable

- There needs to be an overall peer reviewer/collaborator to bring all bat deterrent research together; For example, thermal imaging is expensive and valuable data---how will this be archived and shared with others?
- Promising concept, well worth continued efforts
- Future work is well thought out to assess effectiveness of texture coating
- Should include work to assess power generation impacts, particularly on down wind turbines
- It is unclear what additional research beyond the initial study period is needed or expected but this is a high priority topic that should be funded further
- Looking forward to reading about results of field tests conducted in 2017

Question 7: Project Strengths

- A new concept where no ultra sounds are needed, thus not adding to the sound emissions of turbines
- Tower coatings easy to make also as retrofits
- Great scientific approach to validating hypothesis
- Well-designed experiments
- Development of commercial ready coating and field trial of coating
- None that I can identify beyond the above

Question 8: Project Weaknesses

- Appears to be a weakness in the analysis across projects. There needs to be an overall peer reviewer/collaborator to bring all bat deterrent research together. For example, thermal imaging is expensive and valuable data---how will this be archived and shared with others?
- New concept not yet sure if there is enough impact /reduction of bat deaths
- Limited dissemination so far
- Need to consider power generation impacts
- The only weaknesses I can identify are that there should have been broader collaboration over the project design and no clear communication plan for the study results

Question 9: Recommendations

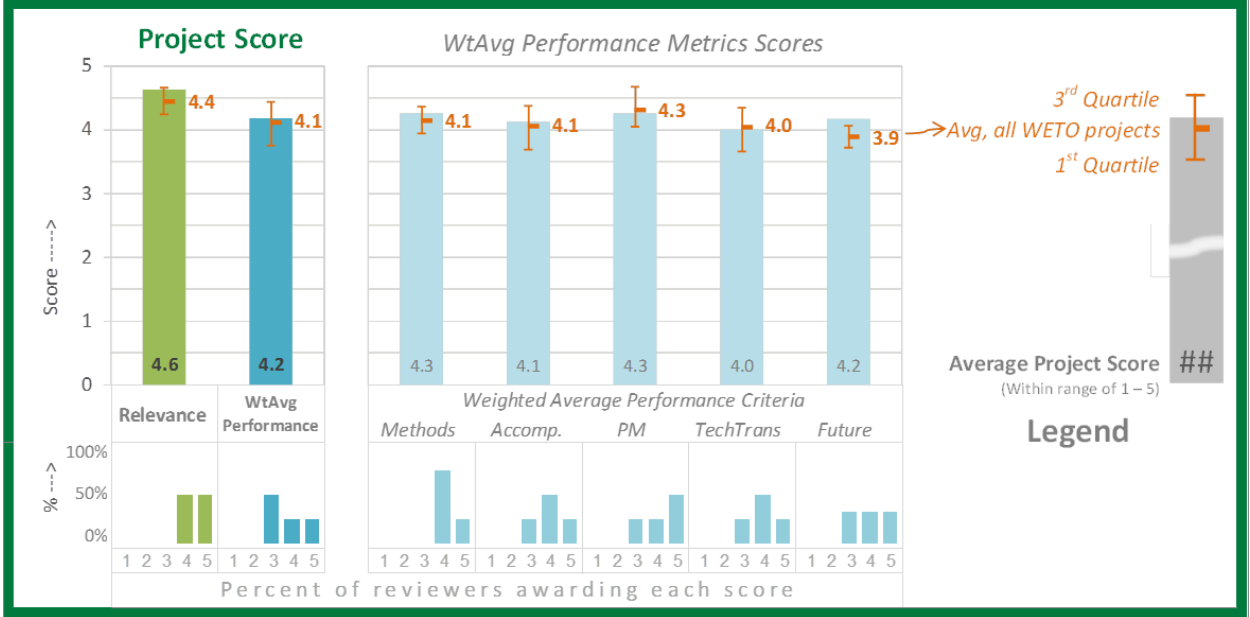
- Considering identifying opportunities for dissemination
- Consider approach to assess impact on power generation, particularly on down wind turbines

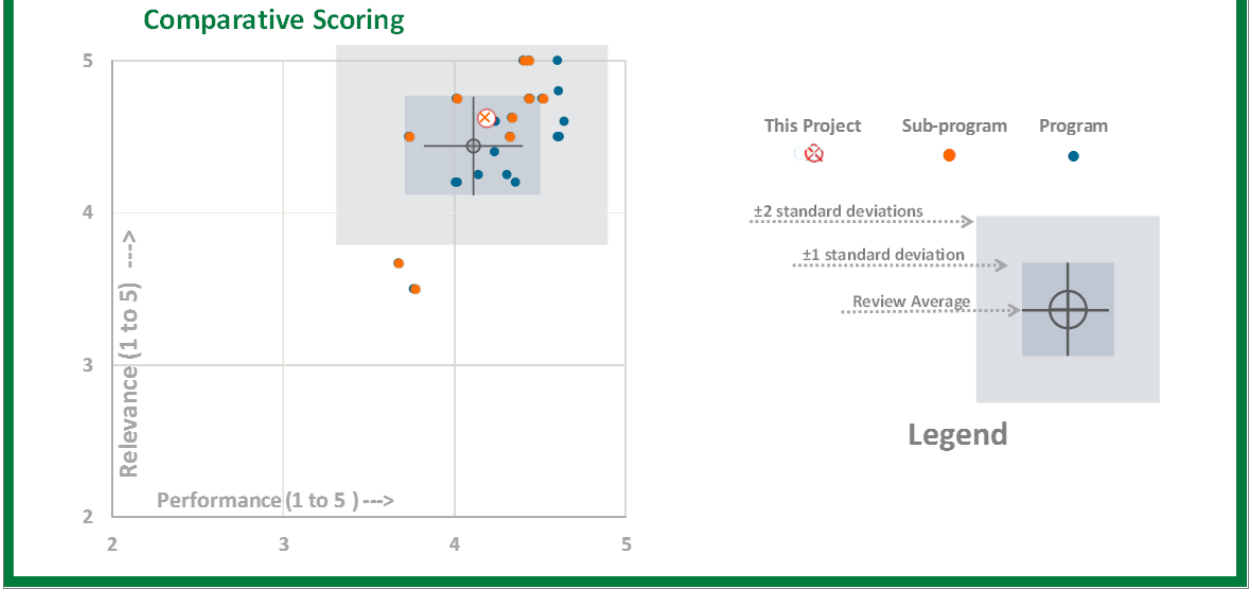
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Rotor-Mounted Bat Impact Mitigation System

Principal Investigator	Myron Miller, Frontier Wind LLC		
Program	Wind Market Acceleration and Deployment		
Sub-Program	Siting, Radar, and Environmental		
FY 2014-2016 Funding	DOE	$ 0.2 M	74%
	Cost Share	$ 0.1 M	26%
	Total	**$ 0.3 M**	**100%**

Peer Review ID# 151





Comments made by reviewers during the evaluation of this project (PRID 151)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Low cost solutions that reduce curtailment are needed, but these are now $15,000 each which is prohibitive until it is implemented on a wider scale
- Highly relevant to the program objective of "Facilitating coexistence between wind energy and wildlife"
- This project is well aligned with the coexistence of wind energy and wildlife goals of the DOE Wind program (the other two goals stated by the project team are a bit of a stretch in my opinion but not a negative with respect to the concept design and testing). Further this work meets the broader industry needs of finding a practical solution to reducing wind energy impacts to migrating bats.
- This hypothesis seems to be driven by commercialization interest, not to suggest an inappropriate drive but it seems the study methodology lacks design rigor (e.g., absence of factoring in wind, blade movement in modeling sound attenuation; insufficient durability of electronic development)
- No mention of impact to harsh operating conditions

Question 2: Methods and Approach

- 20–60 kLh achieved in the field -- may be important result
- Seeing minor impacts from the transmitter might be a non-starter for the blade manufacturer so more work is needed here--working with Siemens is a good strategy where no-go zones were identified
- Power supply went down so the data was limited in 2016; hard to know whether this is worthwhile yet
- Very strong advisory committee
- Better coverage of sounds is sought by mounting the deterrents to blades. However wiring and power supply to rotating blades is challenging, as well as keeping the devices working in quite extreme conditions along the blade. The company has good experience in blade mounting which helps.
- Innovative approach to covering the entire rotor swept area with ultrasonic signals
- Effective product design, development and testing approach
- Perhaps there is a need to consider the impact of wind and rotor rotation on the signal envelope - it may impact on optimal location of devices
- The project concept, design and testing all seem well thought out and the project team has already shown the ability to overcoming a technical challenge of the device in initial testing phase

Question 3: Technical Accomplishments and Progress

- On site Pattern Energy site is a very good case study approach (hatchet ridge)
- No control site --all in the field --- could be potential major weakness
- Problems have been encountered during the project. Basically blade mounting, with wiring inside the blade and one inch hole to get wiring through has been worked with the OEM (original equipment manufacturer). However, slip rings are problematic for signals from blades, data lost in 2016 migration season. Reliability of blade mounted devices is an issue, still needs demonstration that it can survive.
- Not yet results to prove the concept works
- Product designed, tested and installed on an operational turbine
- Signal envelope successfully tested
- Accomplishments to date appear to be well aligned with the project goals and timeframe
- Seems promising and kudos for being able to install on a manufacturer's blades, a remarkable milestone reached if no other. This type of install could be a hindrance for broad deployment if proven effective as a risk minimization tool.

Question 4: Project Management

- Project has encountered problems and project plan has been revised accordingly
- Project appears within budget so far
- Milestones met successfully so far
- Project management appears to have been effective in ensuring deliverables at each milestone and within the estimated budget
- Would hope to see additional funding by vested parties to the project in subsequent project work

Question 5: Research Integration, Collaboration, and Technology Transfer

Comments made by reviewers during the evaluation of this project (PRID 151)

- Important cost share from Frontier and California Energy Commission
- Outreach to Berlin bat meeting is important to share across the pond
- Some collaboration and dissemination has already happened, some months left of the project
- Excellent collaboration including national agencies, academics and industry
- Limited dissemination so far
- It does appear that this project was well coordinated between state and federal regulatory agencies, other researchers and industry and initial findings reported appropriately

Question 6: Proposed Future Research, if applicable

- Risky approach keeping the system alive in rotating blades with controls through slip rings
- I am not an expert but the concept of setting more sound emitting devices to wind turbines is not the best possible - if other ways to get bats out of turbines exist. At least using the sound as little time as possible would be important. This concept not as promising as mitigation through towers.
- 2017 migration season bat fatality study will provide valuable information on effectiveness of solution
- Commercial development a natural follow on from the work
- Perhaps in future work, feedback from migration seasons fatality study could be included in further product development
- Given the importance of the issue I strongly support additional evaluation of this device and recommend additional funding be provided for a period appropriate to determine the effectiveness of the device

Question 7: Project Strengths

- Approach trying to help reach higher coverage of ultrasound keeping the bats out of turbine area
- Discrete solution designed, developed and deployed on operational turbines
- Signal envelope verified through testing
- None in addition to the above

Question 8: Project Weaknesses

- Appears to be a weakness in the analysis across projects. There needs to be an overall peer reviewer/collaborator to bring all bat deterrent research together. For example, thermal imaging is expensive and valuable data---how will this be archived and shared with others?
- Approach of mounting to blades may turn out to be too challenging - both keeping the power source working and keeping the devices alive
- I am not an expert but the concept of setting more sound emitting devices to wind turbines is not the best possible - if other ways to get bats out of turbines exist. At least using the sound as little time as possible would be important
- Limited dissemination so far
- Solution is invasive and requires holes to be drilled in turbine blades. Could this be a barrier to deployment?
- The project summary comes across a bit too sales pitchy and lacks specificity at times (e.g. when discussing the impact of the mounted devices on energy generation I would prefer the project team consult with a turbine engineer and provide a range of potential energy loss anticipated rather than saying "little to no" impact is anticipated without providing data supporting that position). Further the reference to bat mortality should be referenced and qualified and not stated as an absolute without citation. Finally the reference to "baurotrauma" is inappropriate as there has only been one study on this potential source of impact, which was based on a limited data set, and NREL engineers have largely debunked the potential for the phenomenon - showing that physics limits the distance from a turbine blade where conditions exist that could lead to this type of impact. Recommend the research team and PI (Principal Investigator) stick to facts and less on gray literature/rhetoric.

Question 9: Recommendations

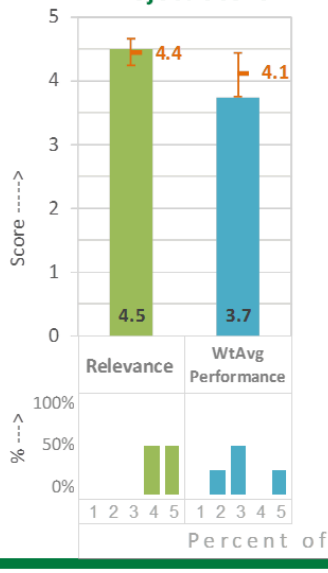
- Consider investigating non-invasive/less invasive install methods
- Migration season fatality study should drive future product improvement

DOE Wind Energy Technologies Office 2017 Peer Review Project:

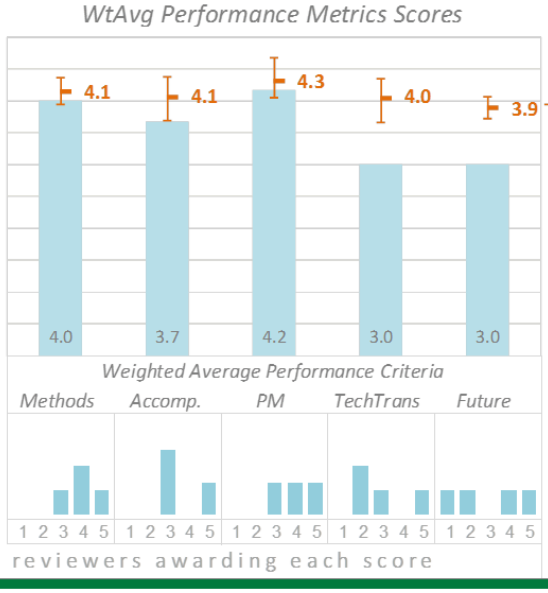
Ultrasonic Bat Deterrent Technology

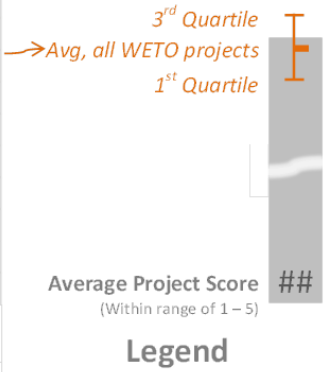
Principal Investigator	Michael Booth, General Electric			
Program	Wind Market Acceleration and Deployment			
Sub-Program	Siting, Radar, and Environmental			
FY 2014-2016 Funding	DOE	$ 0.6 M	51%	
	Cost Share	$ 0.6 M	49%	
	Total	**$ 1.2 M**	**100%**	Peer Review ID# 152

Project Score



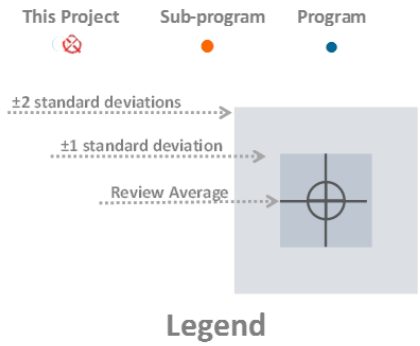
WtAvg Performance Metrics Scores





Percent of reviewers awarding each score

Comparative Scoring



Comments made by reviewers during the evaluation of this project (PRID 152)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Low cost deterrent device would be a valuable tool to address bat fatalities
- Needed to better explain how this technology works ---not clear from the presentation
- Highly relevant to the program objective of "Facilitating coexistence between wind energy and wildlife"
- As with the other bat deterrent studies, this project is serving to meet the needs of the industry in identifying cost-effective measures to reduce impacts to bats, thereby further minimizing the effects of development/operations on wildlife and eliminating a barrier to deployment. As a result this project is also well-aligned with the objectives and goals of the DOE Wind Energy Office (e.g. coexistence of wind energy and wildlife).
- Are future endeavors of the project driven by proof of concept or achieving the additional 20% effectiveness objective (total of 50% achievement goal)?
- No mention of impact to harsh operating conditions

Question 2: Methods and Approach

- 33% reduction in bat mortality with experiments is significant; 50% if remove eastern reds
- Pulsing created a burst--and then adjusted - but how this will be avoided was not clear
- California ridge was field site but was there a control site?
- Field tests from several years, trying out different sensor/emission direction
- Based on deterrence results, it does not appear that the fundamental hypothesis of the project is verified
- Based on deterrence results well below target, one might expect a greater level of innovation and experimentation in the fundamental product design. It appears that placement and pulsing were the only variations of the solution that were tested. Perhaps an ultrasonic transducer based device could have been used to establish a baseline on some turbines?
- It does appear through experimentation that the signal is better focused down towards the tower and lower half of the rotor swept area. This appears to be consistent with the hypothesis from Amanda Hale's research that bats are attracted to the tower.
- This project was incredibly well designed from the initial conceptual phase, to the ground testing, and on to applied testing at an operating wind farm. Results of each phase were documented along the way to inform the go - no go decision point for the next phase.
- What are the retrofit challenges to this system as opposed to development for inclusion for new turbine products?

Question 3: Technical Accomplishments and Progress

- The results are interesting, and seem to indicate that mounting on blades not needed as mounting on nacelle seems to be as effective - but overall the ultrasound concept is not as effective as one would hope. Clear reduction of mortality, even though less than 50 %. The concept is easy to retrofit to existing turbines.
- No publications so far, but the project is still ongoing
- The best deterrent result of 33% is well below the project target of 50%. That said, this is the only deterrent project to have produced quantitative results on actual deterrence.
- Information has been gained through experimentation that the signal is best directed to the tower and lower half of the swept rotor area. This information could potentially be useful in other projects.
- Accomplishments to date have been notable and largely aligned with the goals established at the project conceptual phase. While there were some schedule slips they appeared unavoidable and the project team adjusted in real-time to reflect the noted conditions.
- The presentation seemed to suggest that target objectives have yet to be met but presenter indicated no intention of pursuing further development of technology?

Question 4: Project Management

- GE [General Electric] covered the increased costs -kudos
- Very high budget compared to other projects in the same area
- Project over budget with GE picking up the overrun

Comments made by reviewers during the evaluation of this project (PRID 152)

- Milestones met successfully so far
- Project management has been excellent; evolving the project as challenges arose, staying within budget and largely according to schedule
- Difficult to ascertain from the presentation what issues were present that created delays and overruns. Commend the principal commercial interest for covering the overages.
- Presenter seemed to lack technical knowledge of project

Question 5: Research Integration, Collaboration, and Technology Transfer

- No OEM (original equipment manufacturer) major challenge and this could be major obstacle to deployment? Not sure.
- Prototype is about $15,000 but realize that it needs to be $5000 to be commercialized; could be a major problem
- This is an industry project (OEM) and there is clear interest to make this commercial as soon as possible. Are the results convincing enough for a larger roll-out?
- Research collaboration with university and consultants
- No publications nor dissemination yet, but project still ongoing
- Some collaboration with Texas Christian University
- Communications and Technology Transfer: "None to date"
- The collaboration between the project team, wind farm operator, and academia to help inform the design and implementation of the study is extremely valuable. It isn't clear how and when results will be reported but when appropriate the project team should be encouraged to publish in a peer reviewed journal and then socialize the results more broadly. The only concern I have is regarding the transfer of technology. It is not clear to me if this device, once proven and market ready, will be available to only GE customers or if the design will be shared more broadly so that it can be deployed at non-GE wind turbines. I believe this is critical as the goal is to reduce the industry's impacts to bats, therefore the technology should be made available as broadly as possible to maximize the value of the device in bringing down bat mortality rates across the U.S. (and hopefully global) fleet.
- Did not get the sense that any sharing of results to date was broadly accomplished. It is important for stakeholders to know that such efforts are underway, encourages a different course in the dialog around wind/wildlife impacts for the better.

Question 6: Proposed Future Research, if applicable

- High ambition to get the product to markets which is good - or bad if the product not ready yet
- Planned Future Research: "None"
- It is unclear to me what, if any, additional research is needed beyond the current study period but I strongly support continued funding in order to fully prove out this technology and advance it to market
- Seems the development of the product is at a prototype phase with no clearly defined set of further development objectives yet 50% goal is not yet reached

Question 7: Project Strengths

- Most extensive field tests of the ultra sound deterrent developed. Results of best orientation and pulsating sound of deterrents and results of how much casualties reduced.
- Project produced bat mortality rate reduction figures
- Solution developed and installed on operational turbines
- Experimentation results could be useful for other projects - i.e. signal directed to lower half of rotor swept area and the difficulty in deterring Eastern Reds
- The cost-sharing for this project is exemplary, with each year's private match exceeding the public funding

Question 8: Project Weaknesses

- Appears to be a weakness in the analysis across projects: There needs to be an overall peer reviewer/collaborator to bring all bat deterrent research together; For example, thermal imaging is expensive and valuable data---how will this be archived and shared with others?
- The targeted 50 % reduction of casualties was not achieved for all species

Comments made by reviewers during the evaluation of this project (PRID 152)

- I am not an expert but the concept of setting more sound emitting devices to wind turbines is not the best possible - if other ways to get bats out of turbines exist. At least using the sound as little time as possible would be important.
- Best result of 33% in bat mortality rate reduction substantially below 50% target
- Project could have involved more ambitious experimentation around the fundamental product design
- No future research planned
- No communications or dissemination
- None beyond what is identified above

Question 9: Recommendations

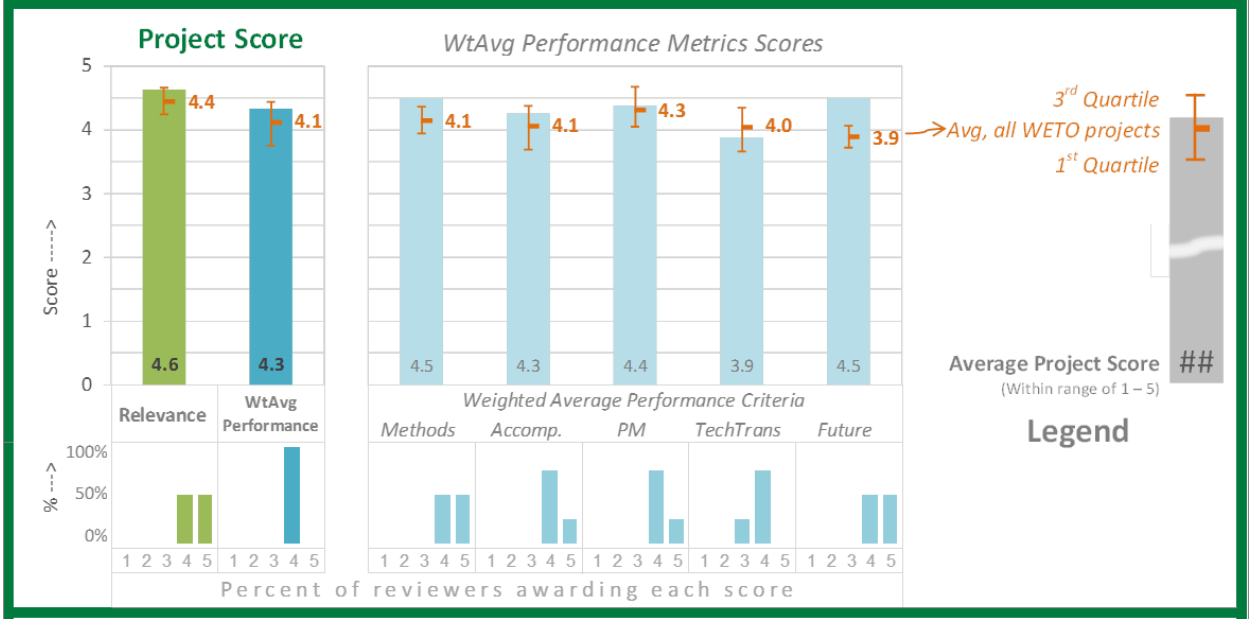
- Perhaps an OEM led effort with a focus on commercial product development rather than solving the core issue is not a good model for this type of project?
- Test results should be communicated with other projects and may be of benefit, i.e. signal directed to lower half of rotor swept area and the difficulty in deterring Eastern Reds. Perhaps there are also other results of interest.

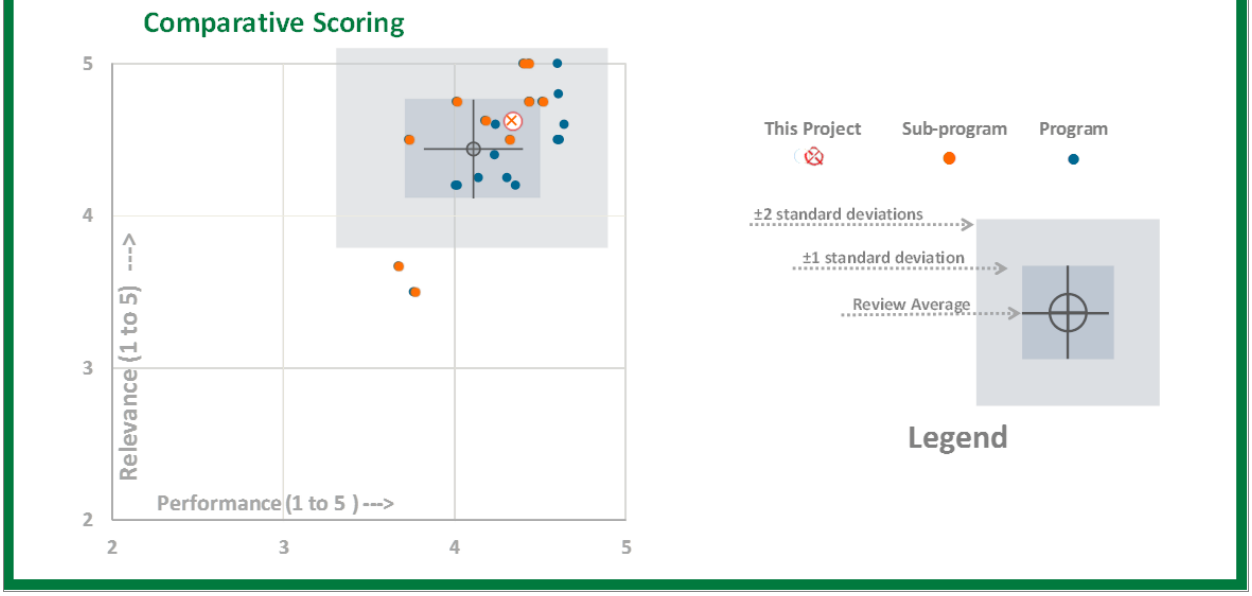
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Evaluating the Effectiveness of Ultrasonic Acoustic Deterrents in Reducing Bat Fatalities at Wind Energy Facilities

Principal Investigator	Cris Hein, Bat Conservation International		
Program	Wind Market Acceleration and Deployment		
Sub-Program	Siting, Radar, and Environmental		
FY 2014-2016 Funding	DOE	$ 0.6 M	56%
	Cost Share	$ 0.5 M	44%
	Total	**$ 1.1 M**	**100%**

Peer Review ID# 153





Comments made by reviewers during the evaluation of this project (PRID 153)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Finding low cost deterrent aligns with the wind community goals to reduce bat fatalities
- Follow on from 2009-10 and improved methods so good to see investments carried forward
- Highly relevant to the program objective of "Facilitating coexistence between wind energy and wildlife"
- This project is well aligned with the goals and objectives of the wind energy office (e.g. coexistence of wind energy and wildlife) and is serving to address an immediate need of the wind industry
- What are the technology goals for fatality reductions - 50%

Question 2: Methods and Approach

- Thermal video is effective method to determine activity (from 20 to 100 bat presence) and have more air space to assess the numbers
- Comparative aspects are critical with deterrent vs operational strategy (5m/s); this will allow test of synergistic effects which seems important
- Randomized treatment each night and large plot search (90 m radius plots) is a good design feature
- Field tests with 6 deterrents. Important work to see how they work in real life.
- The project objective appears to be to determine the optimal placement of deterrents by observing bat interactions with the devices using thermal imaging, however there seems to be a change in focus in the accomplishments section where the discussion is more around improving other performance aspects such as signal power, weatherization etc.
- Other than the above comment, the approach seems comprehensive and addresses all major aspects of device deployment, an aspect of this area that isn't as well covered in some of the other, earlier stage product development projects
- This particular concept has been in development for some time and has apparently improved significantly since RNRG (Renewable NRG) Systems has taken over as the technology lead from Deaton engineering who were able to advance the technology only so far. The current study phases should demonstrate once and for all if this particular approach is effective and the device can be brought to market.
- Good research design, seems to be well thought out by project proponent with a careful approach to verifying effectiveness. This is probably a good approach in light of skepticism that any deterrent technology will have in first set of years of deployment by non-industry stakeholders.

Question 3: Technical Accomplishments and Progress

- Collaboration with USGS (U.S. Geological Survey) is important
- $10,000 cost for the system seems high so cost could be a negative factor for deployment success
- First phase of the project, so far looking good
- Devices have been improved, installed and initial tests carried out according to schedule
- The accomplishments appear to be progressive and data collected in the current phase will help inform and refine the next phase
- Good to see a concentrated effort to address real, operational concerns with a mitigation technology concept. A concept proven to be effective at deterring or otherwise reducing fatalities but that cannot practically be integrated into a wind farm's operation is a lost opportunity. Good to see the evolution of this effort going in this direction.

Question 4: Project Management

- This project has little funding from DoE compared to total funding
- Within very modest budget
- Milestones mostly met successfully so far
- Project management appears strong with work to date staying on schedule and within the allotted budget
- Good use of third party funding to maximize value of WETO funding

Comments made by reviewers during the evaluation of this project (PRID 153)

Question 5: Research Integration, Collaboration, and Technology Transfer

- Working with Avangrid and Renewable NRG Systems provides good technical abilities and potential sites for testing
- Some industry taking part
- Moderate level of collaboration
- Some dissemination has taken place, but the project is at a relatively early stage
- There certainly has been good coordination between the project team, RNRG Systems and USGS which bodes well for the project design. It would have been good for there to be additional collaboration with the wind development community and other researchers at universities and elsewhere but it shouldn't negatively impact the outcome of the project that that did not occur. When appropriate the results of the study should be published in a peer reviewed journal and socialized more broadly, however, this project team in particular should be cautioned on overstating claims about effectiveness and the need for the device to be employed universally rather than at sites with high risk/documented impacts.
- BCI (Bat Conservation International) has done a commendable job over the years discussing deterrent technology as a risk reduction measure. With the development of the technology beyond prototype phase and into the field for testing, look forward to hearing the results.

Question 6: Proposed Future Research, if applicable

- Research plan to Phase II looks very good. After seeing other projects in the same track, may be good idea to collaborate in second phase (if not already doing so).
- Future research appears well thought out, in particular comparing results against operational minimization
- It is unclear what additional research, beyond the current Phase 2 2017 study year, is needed to prove the device fully and get it market ready but if any is needed DOE should be encouraged to provide the funding to achieve that final objective.
- Ideally the pursuit of academic understanding of various treatments (e.g., deterrents independent of and in conjunction with cut-in speed methods) but the focus should be on proving the deterrent technology if funding is limited. A commercially viable technology is of preeminent importance.

Question 7: Project Strengths

- Good work on determining the placement and orientation of the deterrents on the nacelle, comparing several deterrents
- Project is comprehensive in addressing the practical deployment challenges such as positional deployment, weatherization and water resistance
- Thermal imaging will help understand the performance of the devices rather than relying solely on fatality metrics
- Future work is well thought out
- The budget appears to be very modest
- As with the GE project and several others the cost-sharing is exemplary, with the private funds both years exceeding the public funding

Question 8: Project Weaknesses

- Appears to be a weakness in the analysis across projects. There needs to be an overall peer reviewer/collaborator to bring all bat deterrent research together. For example, thermal imaging is expensive and valuable data---how will this be archived and shared with others?
- Are the technologies compared capturing the best state of the art?
- There does not appear to be any academic collaboration
- None beyond what is identified above

Question 9: Recommendations

- More deterrents included, if possible, for example the ones developed in the same program
- Perhaps consider academic collaboration
- Results from GE project no. 152 appear to provide some information on effective placement - perhaps this can be leveraged in the project

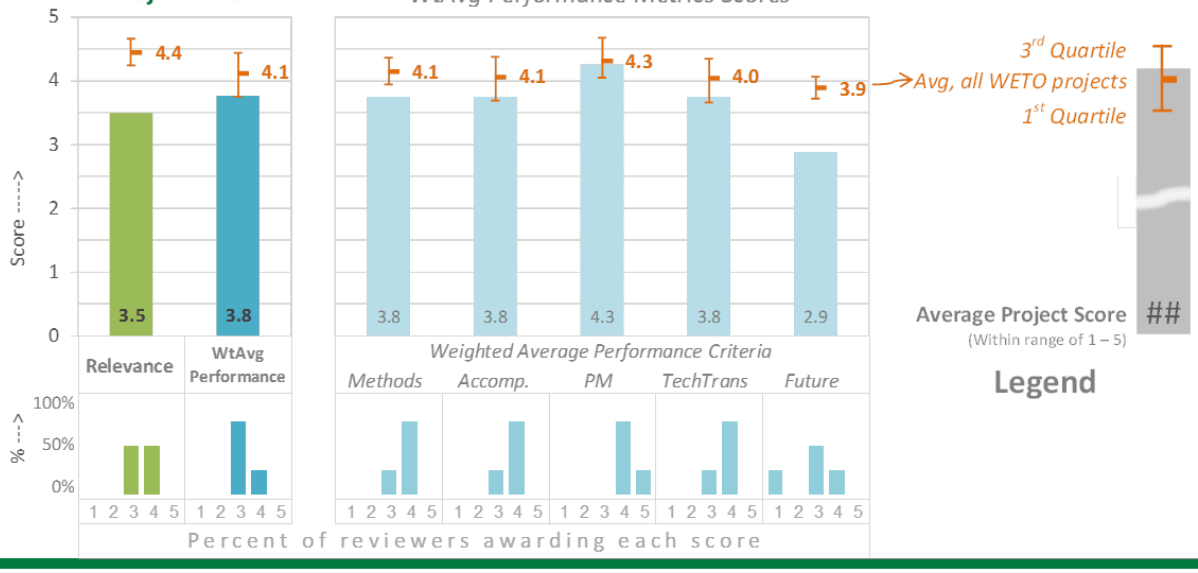
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Avian Remote Sensing

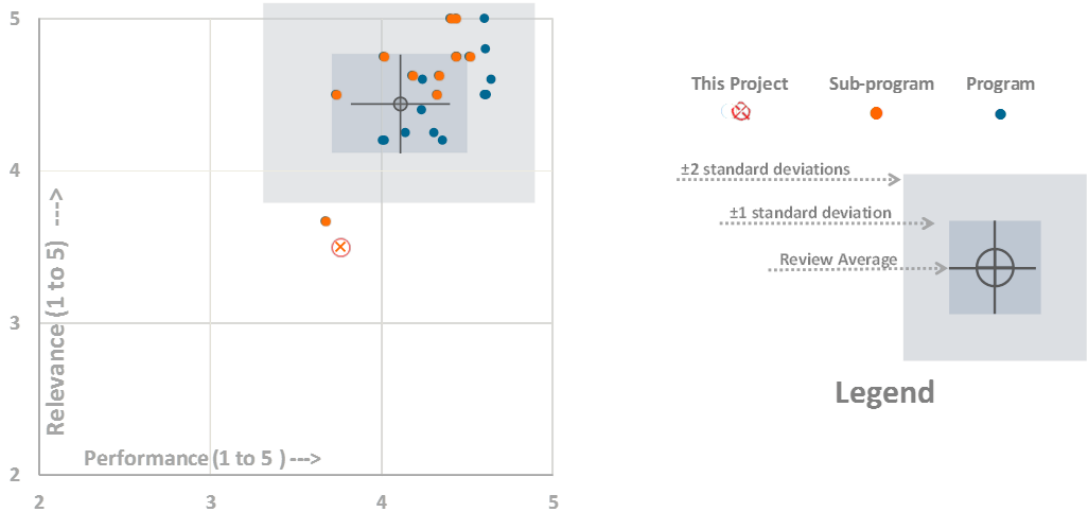
Principal Investigator	Shari Matzner, Pacific Northwest National Laboratory		
Program	Wind Market Acceleration and Deployment		
Sub-Program	Siting, Radar, and Environmental		
FY 2014-2016 Funding	DOE	$ 0.4 M	100%
	Cost Share		
	Total	**$ 0.4 M**	**100%**

Peer Review ID# 269

Project Score



Comparative Scoring



Comments made by reviewers during the evaluation of this project (PRID 269)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Quantifying the risk from avoidance and collisions seems pragmatic particularly the automated processing of camera images
- Relevant to the program objective of "Facilitating coexistence between wind energy and wildlife"
- As with the stereoscopic camera project this project, while aligned with the goals and objectives of the Wind Program to demonstrate the coexistence of wind energy and wildlife, it is hard to discern the value and application of this technology in a real-world setting and therefore what actual value it has to the broader wind industry

Question 2: Methods and Approach

- Thermal camera and algorithms had a high detection rate and low false positive rate which seems like a breakthrough for this technology; would have been useful to discuss other technologies available on the market now and how this compares
- Windbeat frequency is interesting and could be useful for others in the field
- Processing data from thermal video, saving flying objects as flight track image
- Innovative approach to automatically identifying bird and bat flight tracks with identification of species using thermal video and automated processing
- Approach efficiently combines images and reduces data storage requirements
- Project does not appear to include strategy for exploitation and deployment to reduce wildlife mortality
- The project does seem to be well designed to answer the questions the study is intending to evaluate

Question 3: Technical Accomplishments and Progress

- Objectives need to be better defined. Would be good to know how this work links or advances the existing private sector technologies that are working on the same methods.
- Demonstration that the approach works in most cases. Open source tool published.
- Project shows 82% detection rate which is quite impressive, along with relatively low false positive rate
- Progress to date appears to be solid and the project is moving forward as intended
- Good to validate and improve upon already available technology. Overall value is questionable as the effort seems to be addressing a question that may not have that much relevance, given studies in Europe around offshore wind facilities and avian behavior.

Question 4: Project Management

- Cost-effective budget
- Project was completed within budget although development of classification algorithm was postponed
- Milestones met successfully (apart from development of classification algorithm)
- The project seems to have been well managed - meeting project milestones and staying within budget
- Project accomplishes a detection technology for a fraction of cost of other technologies or used existing technology with slight modifications for this specific application. Either way, good value for the dollars expended.

Question 5: Research Integration, Collaboration, and Technology Transfer

- Commercialization possibilities with HiDef are encouraging
- Collaboration with European entities that have been working in this field would be instructive
- Collaboration of researchers, dissemination through collaboratives and WREN (Working Together to Resolve Environmental Effects of Wind Energy). Open source code available ThermalTracker. More collaboration in next phase of project.
- Open source code made available online
- Sharing of code with other universities - good collaboration
- Modest amount of dissemination
- No academic output

Comments made by reviewers during the evaluation of this project (PRID 269)

- There does appear to have been decent collaboration with other parties during the study design and execution and some data sharing - both of which are likely appropriate for this particular project
- Deploying the software for general research consumption (i.e., open sourced) is commendable and adds considerable value to the project. The use of readily available technology to accomplish the project's objective also adds value to the project. Despite questions of actual need, the exploration and use of commercially available technology is good use and a stark contrast with similar efforts that cost considerably more due to development of technology.

Question 6: Proposed Future Research, if applicable

- Research will continue as collaboration with the two approaches studied in this program. Collaboration with other industry and research tools, where applicable, from land based monitoring (also internationally) will be useful.
- Proposed future research aims to characterize and improve performance of the system and to develop 3d stereoscopic processing. This will increase the utility of the system.
- Would be nice to see proposals for actual use of the system to improve understanding and aid with reducing animal mortality rates
- I don't see the value of this project in terms of real-world application. The funding would likely be better spent pre-clearing areas or defining baseline conditions in particular offshore development zones (e.g. possibly by BOEM (Bureau of Ocean Energy Management) lease areas). Hard to imagine what knowing the passage rate and concentrations of birds in a particular offshore are without understanding the species, and whether or not they would avoid the turbines, etc. In short this information, while academically interesting has little real application in either determining where to site a wind farm and/or how to change its operations. All indications from extensive development in Europe is there is not a significant issue regarding impacts to birds and bats in an offshore environment that warrants this level of monitoring and again without the data informing some decision about future siting or operations it seems we are simply collecting data for the sake of collecting data.
- Future research proposed in the presentation may be well served to combine efforts with other projects (e.g., #147). Overall suggestion is to combine results to date related to observational technology and method development, ascertain where maximum value is found (e.g., commercially available technology), develop methods that fit within limits of existing technology and, when combined with what existing literature findings tell us, determine whether more expensive efforts are truly warranted.

Question 7: Project Strengths

- Building on existing thermal video camera devices and producing an open source post processor of automatic data handling towards flight tracks. Demonstration that this works in most cases.
- Open source tool published that seems to be applicable to many
- Very cost effective budget for the work
- The approach has been successful at identifying bird flight tracks in 82% of cases, suggesting strong technical approach and results
- Good collaboration and sharing of code
- None identified beyond the above. However, this project at least has a lower cost than the stereoscopic camera project.

Question 8: Project Weaknesses

- Approach using thermal cameras still not working in 100% of cases, even if now getting quite close
- Project does not appear to address deployment or exploitation
- Little perceived value to the development community

Question 9: Recommendations

- Consider development of strategy to illustrate use of system to improve understanding of wildlife behaviors and /or reducing wildlife mortality

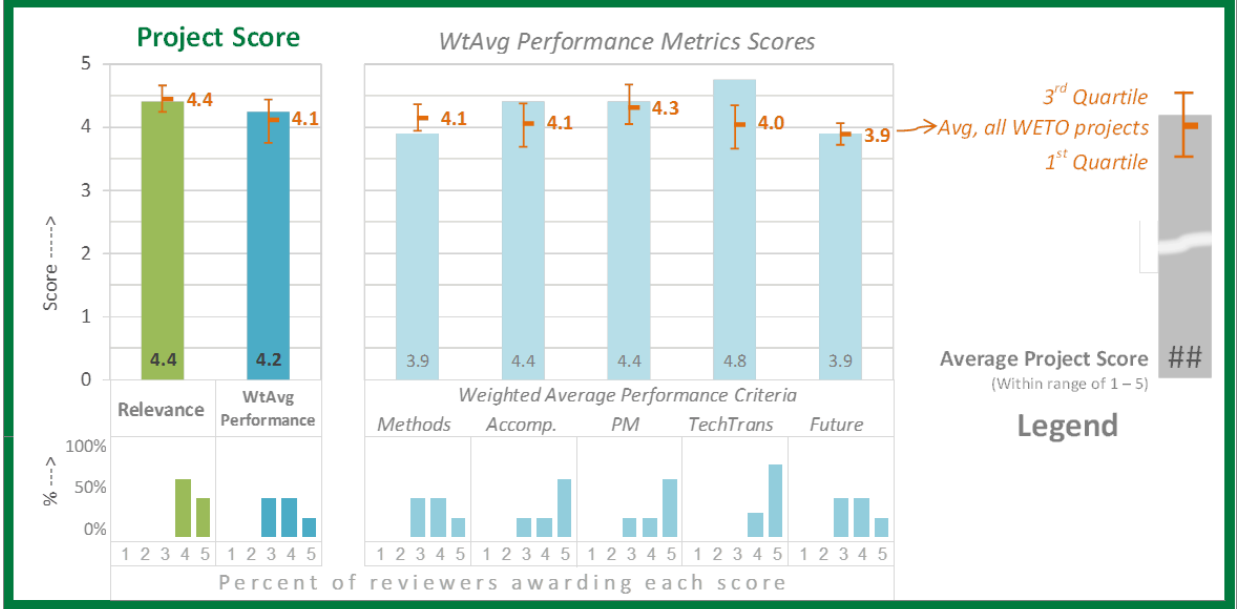
7.4.4 Stakeholder Engagement

DOE Wind Energy Technologies Office 2017 Peer Review Project:

Public Acceptance Baseline Analysis

Principal Investigator	Ben Hoen, Lawrence Berkley National Laboratory		
Program	Wind Market Acceleration and Deployment		
Sub-Program	Stakeholder Engagement		
FY 2014-2016 Funding	DOE	$ 0.7 M	100%
	Cost Share		
	Total	**$ 0.7 M**	**100%**

Peer Review ID# 127



Comments made by reviewers during the evaluation of this project (PRID 127)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Excellent initiative and sorely overdue to build the social science knowledge base; better late than never!
- Need to involve more social scientists in this initiative (beyond just economists & statisticians that are not necessarily wind experts); also European participation on advisory com is commended
- More investment in this area is sorely needed with experts in the social sciences that are NOT wind experts:
- BUT study is only one aspect of what is needed; need interaction and exchange of info to understand risks and uncertainties related to infrastructure and internal knowledge of wind
- CRADA (Cooperative Research and Development Agreement) agreement is very important so critical platform
- Providing facts to support public acceptance is important
- Extremely valuable effort that has enabled gathering of critical data on noise. Questions regarding segmentation of data based on turbine types and exploitation of results and feedback into technology development.
- As with Ryan Wiser's work I believe Ben's study is important in addressing the public acceptance of wind energy deployment and critical in understanding where there are legitimate issues and where opposition groups may be using rhetoric to stall or block development. This baseline data is critical to the wind industry understanding the impact of higher development rates on public acceptance and particularly those in close proximity to denser population areas.
- What is the role of DOE with respect to the mapping tool?
- Regionally focused studies, looking at the NE and SE regions might be good value proposition. I'm sure there are developers and operators that would be open to teaming with DOE as a third party evaluator for public acceptance surveys for operational or development projects. Might be a source of funding leverage.
- The work in the public acceptance arena (e.g., property value analysis) is the types of empirical-based studies that lend well to addressing the unknown that often drives wind energy opposition. Has WETO looked at the timeline/experiences of EMF (electromagnetic field)-based controversies of the transmission industry from the 80s and 90s as a source of lessons learned?

Question 2: Methods and Approach

- Statistical approach is robust
- Need more qualitative measures, e.g., need more nuanced understanding of what is "acceptance" and "annoyance;" although literature review was very broad, it did not include complex definitions of acceptance and annoyance (but not a lot of information in any wind agency around the world); need to involve psychologists and other social scientists in this analysis (e.g., risk perception experts)
- National survey on public acceptance - very good first work on this
- Survey does not have enough data to make proper analyses on where/why more and less acceptance. Especially information on new larger turbines >3 MW would be important.
- In general, approach is sound and definitely enables increased understanding of drivers behind support and annoyance. In particular, a large portion of the total population living within close proximity has been captured and this lends great credibility to the results.
- In addition to total facility size, it has been found that the type of turbine and the tower height in particular impact on annoyance levels and noise. This aspect may be missing from the analysis. Since wind speed increases with hub height, the resultant noise does also and it is important to capture this impact, e.g. ISBN 91-620-5308-6 p10
- Having participated in the project scoping with other stakeholders the PI (Principal Investigator) reached out to while developing the survey scope I believe this project is well designed and developed to address the question it was set up to answer regarding community acceptance
- Will mapping tool released to the public contain the same data and database functions as the version used by agencies?

Question 3: Technical Accomplishments and Progress

- Statistically robust for a national survey; well documented
- First results of national acceptance survey are good information, on general level
- Database of turbines a first step to help see impacts on radars, but still a bit far to go to get real impact
- Appears as though very valuable conclusions have already been reached and that a collaborative framework has been set up and that the necessary framework for ongoing exploitation is working well
- Based on the presentation materials and post-project webinar it appears that the survey participation was high and collected data valuable in answering the questions posed
- Transparency with respect to end use of turbine database is important. DOE likely to play critical role as intermediary agency with respect to sensitive assessments conducted by some gov't agencies.

Question 4: Project Management

- LBNL is a very productive organization for wind office and they continue this strong reputation with high level results on this challenging study
- Under budget so far
- Milestones met successfully so far
- It appears that the project was well managed and within the anticipated budget
- How will the turbine database be maintained, updated and kept relevant? It was unclear from the presentation what those plans are.

Question 5: Research Integration, Collaboration, and Technology Transfer

- Since there will be a lot of data to analyze, involvement of other institutions may be appropriate. Also could invite outside experts to create a robust peer review as well as help interpret and disseminate results.
- Typically LBNL is very effective at dissemination of results and I expect this project manager to follow in that path
- Still in progress - reports and dissemination expected, with wide outreach. Quite wide network of involved institutions.
- Linking to best practices for developers / what can be learned would improve future work
- IEA (International Energy Agency) Wind Task 28 seems to be from this project (in presentations looked like it was in WindExchange - but this is better)
- A collaboration framework appears to have been successfully established
- The project is not yet complete and no dissemination has been conducted - as such, this is considered not applicable
- The project is collaborating with IEA Task 28 - this is very valuable
- Again, based on my knowledge of this project and the presentation materials it is apparent that the PI and his team went out of their way to engage with a variety of stakeholders to help inform the survey focus and kept the same informed during the survey period and provided an overview of the results at the end of the project. This type of engagement by Ben should serve as a model for future PI's.
- Presentation suggests collaboration and transfer of information is forthcoming

Question 6: Proposed Future Research, if applicable

- Given limited time frame for a large survey, it was not clear what the proposed future research path would be. More involvement of social scientists with depth in community related responses and perceptions to energy siting (not necessarily wind) would be a good start.
- More analysis of existing survey on where/why the acceptance is good and where more negative feedback. Especially showing large/smaller turbines, and distance to them. Link to best practices for developers would be valuable.
- Outreach expected in 2017
- In general, planned future research appears sound and a logical extension of work carried out so far
- Perhaps future research could be considered to capture impact of turbine types, in particular hub height

Comments made by reviewers during the evaluation of this project (PRID 127)

- It is a very good idea to look at the positive impacts on communities of wind project development - perhaps this could be extended to identify recommendations and best practices to ensure these positive impacts are maximized for communities
- If there are additional questions remaining to be answered or ones generated by the current research they should be pursued and it would be worthy of dedicating additional DOE funding towards these efforts
- Given the breadth of issues surrounding public acceptance and the oftentimes subjective nature of those issues, it may be useful for project team to meet with AWEA (American Wind Energy Association) Siting and Environmental Compliance Committee members to discuss priority work for the future
- It would be important for the DOE to maintain a role in reviewing assessments by other agencies using the mapping tool. While some assessments will rightfully claim security issues with public disclosure of their findings, such circumstances should not prevent open and transparent communication between agencies and industry stakeholders. Results of evaluations should have an intermediary source that can validate findings.
- Public acceptance studies would be more valuable if broadened to include all energy generation sources. The scope of such an endeavor is likely beyond budgetary means but should be considered for future work, perhaps regional in scope.

Question 7: Project Strengths

- A U.S.-wide survey of public acceptance, and a mapping tool, to help developers
- Very comprehensive data gathering framework which captured a very large proportion of the total impacted population
- Excellent collaboration including international collaboration on IEA Task 28
- Future work on identifying positive impacts on communities is a great idea
- Valuable intelligence has been gained on the impacts of noise, in particular the correlation between measured noise and annoyance
- The foundational, practical application of the information generated by this project is extremely valuable

Question 8: Project Weaknesses

- More data probably needed to get all important results from the survey (what type of projects have better/worse acceptance; noise versus distance and turbine type and terrain)
- Appears not to consider the impact of turbine types and hub height in particular
- Future work could be more ambitious and attempt to identify best practices and recommendations to ensure positive impacts for communities
- None that I can identify. The only criticism I have is that I don't see how this work addresses the "successful coexistence with radar systems".

Question 9: Recommendations

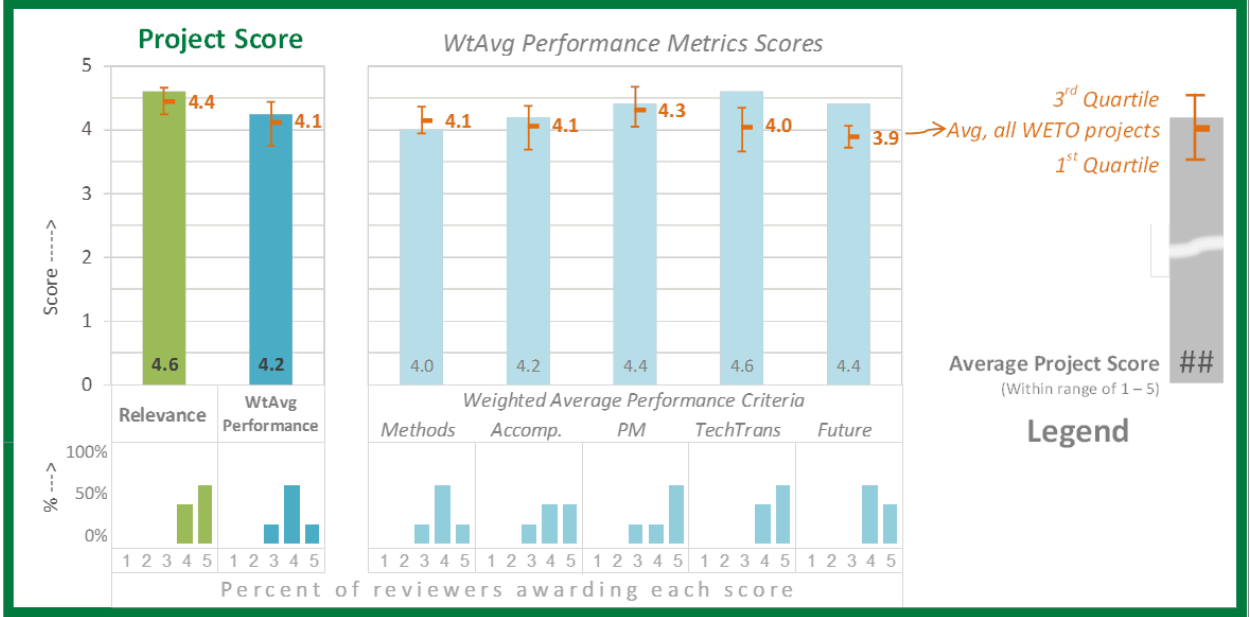
- Consider including the impact of hub height
- Attempt to identify best practices and recommendations to ensure positive impacts for communities
- Consider making a link with OEMs (original equipment manufacturers) and technology development to highlight issue and mitigate noise generation

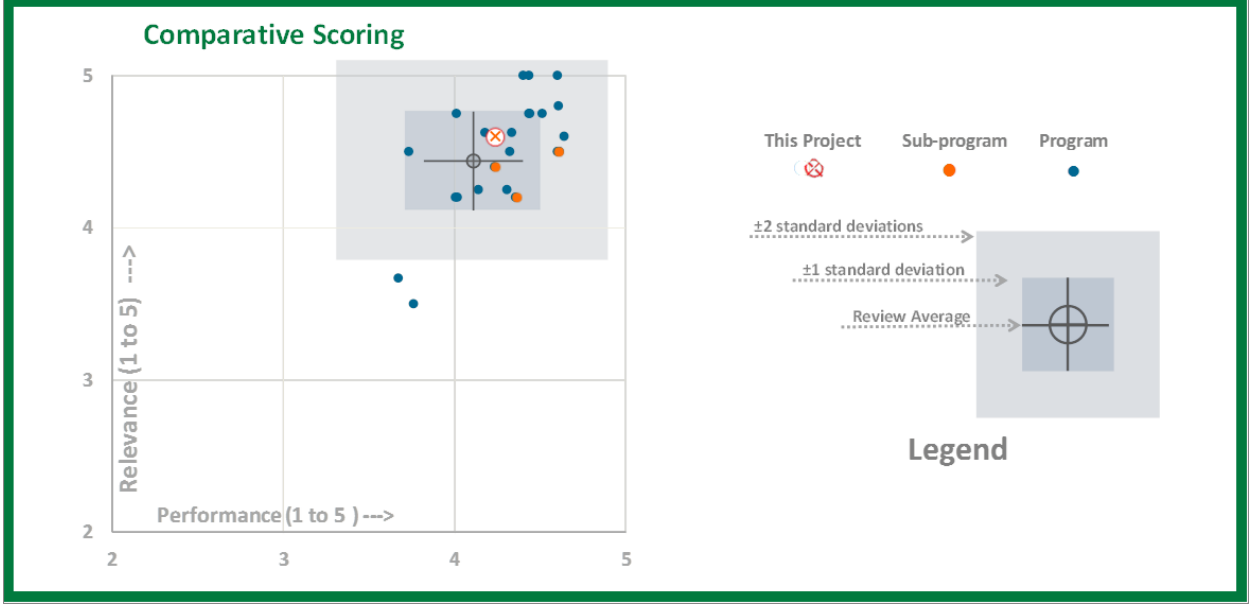
DOE Wind Energy Technologies Office 2017 Peer Review Project:

WindExchange and Regional Resource Centers

Principal Investigator	Ian Baring-Gould, National Renewable Energy Laboratory		
Program	Wind Market Acceleration and Deployment		
Sub-Program	Stakeholder Engagement		
FY 2014-2016 Funding	DOE	$ 4.4 M	78%
	Cost Share	$ 1.2 M	22%
	Total	**$ 5.6 M**	**100%**

Peer Review ID# 138





Comments made by reviewers during the evaluation of this project (PRID 138)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- This is a critical area for stakeholder interaction
- Web portals are important but mostly useless without organizational partnerships and outreach and inreach as these programs focus on; need more investments here
- Documentation of effective engagement is tricky but need to build social science capabilities within NREL and DOE; not just economists & engineers leading the programs
- Mention of offshore but real investments and exchange on this future topic are very weak at the moment; need additional resources to expand into offshore areas
- Collaboration with IEA (International Energy Agency) Task 28 is critical activity
- Supporting DOE to provide information to increase credibility. This is needed to all information that will finally go to individual people living close to projected wind power plants - outreach towards millions of people.
- Highly relevant activity enabling a local resource to address local informational challenges
- Appears necessary to address permitting issues
- The dissemination of positive and factual information provided by the WindExchange and RCCs (Regional Resource Centers) is critical and essential to aid in the advancement of wind energy development. Several of the RCC's are also regional partners of the American Wind Energy Association and key allies in addressing state and regional policies and legislative measures and therefore great examples of how DOE's funds can be matched and leveraged by private funding to maximize the value of the public investment in these types of programs.
- Are RRCs given latitude to shape their individual programs and how?
- Regional Resource Centers seem to be tenuously funded by the WETO yet are critical to providing the office both an insight to localized issues emerging in a given region but also more effectively and efficiently broadcast analyses, studies and reports that inform those regional issues

Question 2: Methods and Approach

- More technical expertise in social science is sorely needed for community engagement; no new staff due to budgets-hire experts or share resources with other programs (solar)?
- Terms and languages are not sophisticated or based on scientific literature; what the heck does "meaningful engagements" mean?
- Dissemination is a very general word and more creative methods are needed; perhaps already in use but social media; YouTube and more on site meetings (WPA (Wind Powering America Partnership) style)
- Metric tracking is important and nuances are critical for evaluation purposes; needs more social scientific input
- Building up regional centers to help support deployment. Providing materials needed for stakeholders - facts with credibility.
- This is excellent plan for supporting deployment. Identifying the stakeholders and targeting them, in addition to general audience/general information provision.
- Something similar has been realized in some European countries (Sweden; NL) but US can leverage on the larger size and resources. On the other hand, US is very large and at least in first phase this work does not reach to all states - and some regional centers cover so large an area that they will probably have challenges reaching to all that would need information.
- In general, the concept of a locally based resource to address specific local challenges appears necessary
- This project is absolutely well designed and will/have led to desirable outcomes for advancing wind energy across the country and seeking means for reducing conflict
- It is unclear whether sufficient funding is available to the RCCs. It might be that while the concept has value, and I believe it does, that limited budget necessitates a reduction in the overall scope. Alternatively, perhaps some time should be spent exploring other funding options for each RCC.

Comments made by reviewers during the evaluation of this project (PRID 138)

Question 3: Technical Accomplishments and Progress

- Wind for Schools is very effective program, but resources are very minimal given the scope needed
- Regional centers set up, stakeholders identified, a lot of information provided and shared
- Program has enabled high level visibility of local issues that have the potential to impede wind power development - for example the 3100 ft setback requirement in Nebraska
- 54,300 stakeholders have been engaged
- Implementation of metric based impact tracking should be valuable in evaluating the effectiveness of the program
- As noted in Q2 above the project has resulted in desirable outcomes and is well aligned with the stated project schedule and goals
- The accomplishments of the project are unclear from the presentation. RRCs seems to be established but not clear how well supported they are.
- I like the concept of RRCs and it seems they are a great source of disseminating information out to a broad set of stakeholders. Would there be value or opportunity to have labs working various projects to include RRC personnel on the team (or vice versa) such that there is an immediate connection between various WETO team members and RRCs?

Question 4: Project Management

- All milestones are met
- Such limited resources for a very large effort needed; but kudos to the project manager for making this such an effective program
- Under budget so far
- Milestones met successfully so far
- All indications are that Ian and his team have done a fantastic job managing the project schedule, budget and resources
- It is not entirely clear this is applicable but the WindExchange concept seems an appropriate means of disseminating work by the WETO and ideally the RRC structure would be a good regional way to focus such dissemination. However, if funding RRCs is challenging and redirecting funding to increase support of RRCs is not feasible then perhaps the RRC structure is not realistic. I like the RRC concept and would encourage an evaluation to determine how best to restructure it such that it gains additional support.
- One idea for additional support may be that RRCs receive partial funding from other projects with the purpose of said funding to be used by RRC to own the dissemination of a project's work product. This would necessitate a partnership with project teams and likely the information would be limited to that which is not highly technical in nature (e.g., grid integration studies would likely be excluded).

Question 5: Research Integration, Collaboration, and Technology Transfer

- The history of WPA and now Exchange is one of the most important program elements; after all we know that technology is not limiting factor for wind now, it's local site conflicts and community responses
- More involvement of social scientists in the development of regional champions, selection of measures to evaluate the program effectiveness, and ways to strengthen a national program with limited resources
- Dissemination is critical to this project
- Web pages with very high outreach >10 000. These look like excellent work: information portal with a growing number of wiki-based community-supported deployment best-practice documents. Referenced myth-busters series of side shows, building on the Wind Vision. Looking more in detail, some information should be updated - a yearly check good to make. The wiki site does not look very attractive, may benefit also from updating.
- Linking the work with educational projects (Wind for Schools) could be useful, probably similar information - this seems to be happening as mentioned in WfS (Wind for Schools) project
- This project has stakeholder engagement as a primary focus
- Project appears to have successfully engaged a wide audience through the WindExchange program
- Project has supported engagement with IEA Task 28 on Social Acceptance of Wind Power
- The project team appears to have regularly worked with a variety of stakeholders throughout the project period, which has improved the quality of the outcome

Comments made by reviewers during the evaluation of this project (PRID 138)

Question 6: Proposed Future Research, if applicable

- Need more comparative studies with natural gas (e.g, CO_2 study) to build knowledge base about all-of-the-above energy and disseminate this info to a broad audience
- Where is the climate link? Is it forgotten given the new political climate? Then continue finding ways to discuss benefits, as was done in the last vision document (air, water, health, jobs, etc).
- Raising a very important issue how to reach 200 GW with larger turbines /public acceptance. European experience (through IEA Tasks), building close to buildings, noise and ice throw risk - to take to those states where relevant.
- Leverage opportunities for future work with wind in schools and communication officers of industry/developers.
- Important opportunity used here to disseminate work from all R&D projects, like wind integration in a very general level. I appreciate all the work that tries to get the integration engineering language to a simpler one!
- Future research appears focused on tackling relevant challenges to the industry
- Proposed initiative to follow up on challenges identified by LBNL is a great idea and a good example of the linkages that the program enables
- Have deducted 1 point from the score in this category as the future work does not appear to increase the scope of coverage of the activity
- This project is worthy of continued future investment by DOE
- RRCs seem to have immense, kinetic value but challenging to support from a funding standpoint. One area where efficiencies might be found is to leverage RRCs as brokers of WETO accomplishments and products, a portion of a given project's funding allocated to the RRC project for outreach purposes.
- Combining RRCs with education outreach efforts (e.g., Wind for Schools) might be a good consolidation and leverage of funding

Question 7: Project Strengths

- Coordinating dissemination to stakeholders of siting/permitting process and general public/social acceptance. Regional centers that can take the general information and focus on regional specificities.
- Excellent opportunity to provide materials for easy access and readability for general public from research results that are usually too detailed/academic/heavy read
- Excellent to provide information that has the USDoE label, being neutral, objective facts (not produced by industry lobby etc.)
- Project appears to have successfully engaged a wide audience through the WindExchange program
- Project has supported engagement with IEA Task 28 on Social Acceptance of Wind Power
- Program has enabled high level visibility of local issues that have the potential to impede wind power development - for example the 3100 ft setback requirement in Nebraska
- Nothing specific to share. Overall this is a high quality and useful project that has been well managed and has delivered favorable outcomes.

Question 8: Project Weaknesses

- Future work does not seek to expand the scope of coverage of the program
- None that I can identify

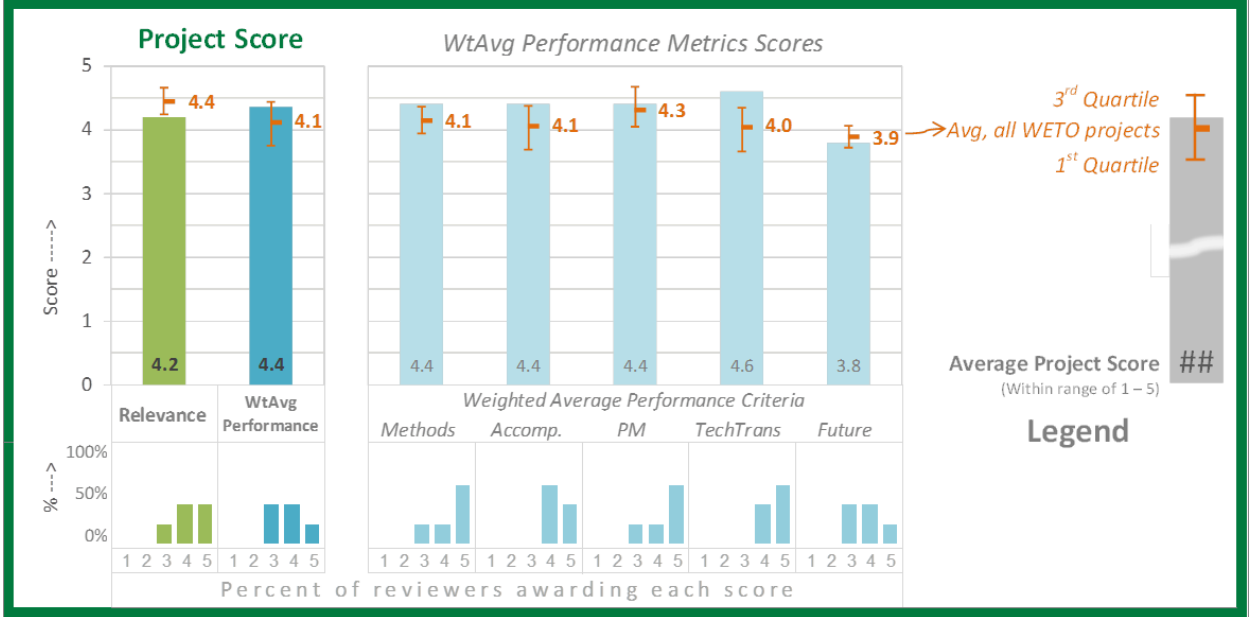
Question 9: Recommendations

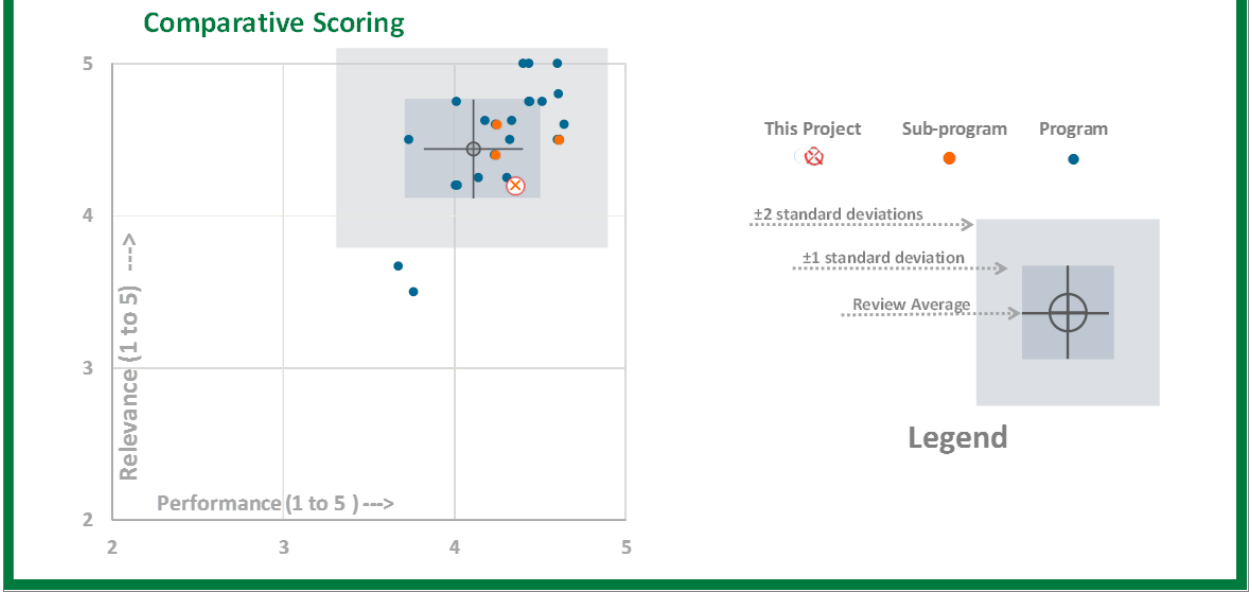
- Some information should be updated - a yearly check good to make. The wiki site does not look very attractive, may benefit also from updating.
- Ice throw is an emerging issue that could be taken into account through this project - for the states where relevant
- Perhaps already planned but perhaps something could be included in the work program to analyze the stakeholder engagement metrics to review the scope of coverage and resource allocation of the various RRCs
- The RRC project seems somewhat weakly supported. Recognizing that there is only so much budget to go around but perhaps there are opportunities to realign funding (public acceptance studies), interconnect objectives of other projects that have related elements or objectives (e.g., education outreach), and provide RRCs accessible purposes to engage industry representatives within the region (e.g., students visiting wind farms or manufacturing facilities).

DOE Wind Energy Technologies Office 2017 Peer Review Project:

Collegiate Wind Competition (CWC)

Principal Investigator	Suzanne Tegen, National Renewable Energy Laboratory			
Program	Wind Market Acceleration and Deployment			
Sub-Program	Stakeholder Engagement			
FY 2014-2016 Funding	DOE	$ 2.4 M	80%	
	Cost Share	$ 0.6 M	20%	
	Total	**$ 3.0 M**	**100%**	Peer Review ID# 139





Comments made by reviewers during the evaluation of this project (PRID 139)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- An impressive hands-on method for involving students to get interested in wind
- Involvement of alumni is a very effective way to build a network of intergenerational wind students and future workforce
- Important in contributing to skillful work force for future
- Evidently hugely beneficial program for all involved, fostering interdisciplinary cooperation and a high level of enthusiasm and passion for all involved
- Workforce development in this area is a major challenge internationally. This project has this as a core objective.
- This project aligns well with the energy independence/workforce development goals of the Wind Program. I've witnessed each of the CWC (Collegiate Wind Competition) events at the AWEA (American Wind Energy Association) WINDPOWER conference and have been impressed both with the quality of the event and enthusiasm and skills of the teams. The concept of encouraging students to think creatively about turbine design and real-time problem solving during the event will hopefully lead to many of these students going on to join the workforce as engineers, wind techs, etc. This incubator type approach has high value in terms of educating college-aged students and advancing the goals of the DOE Wind Program.
- It would be fruitful to further develop educational outreach by applying wind energy development and plant operations skillsets as well as technology design (engineering) into the "curriculum". Many education rudiments (business, economics, communication, sociology, biology, earth sciences such as meteorology) have application in the cradle to grave spectrum of deploying wind energy. Student interest in such non-engineering and other hard science disciplines applicable to technology development could be increased by applying the discipline using wind development as a practical application.

Question 2: Methods and Approach

- Need additional resources for more innovative education initiatives, particularly with a multidisciplinary focus & linking to other educational initiatives (e.g., WFS (Wind for Schools), curriculum developments)
- Very nice follow on that contestants are invited to NREL the following year (without competition) for more exposure
- Video and social media are critical communications for the young engineers and scientists
- Organizing a big event or competition for building a small wind turbine, every 1-2 years
- Providing for a wind tunnel to test the equipment
- This approach does not reach out to many students to actually learn from this, but on the other hand will get much more publicity than other educational materials
- The program has married successfully a number of key elements resulting in a program that attracts and inspires students in the various disciplines involved in wind power development
- The development of a wind tunnel to support this project appears to have added tremendous value
- The step-wise approach of this project allowed for seed funding to be employed, matched, and built upon year over year. This is a well-designed and executed project that resulted in valuable outcomes.
- In terms of generating a source of academic inspiration, the CWC excels in doing so

Question 3: Technical Accomplishments and Progress

- Portable wind tunnels are impressive
- Interdisciplinary emphasis is needed although this is challenging on an institutional level: the fact that siting challenges were included is impressive
- Good trend to broaden the scope from reaching the “engineering” minded students interested in making devices towards other aspects of wind energy. There is a broad line of disciplines from biology, meteorology, social sciences, marketing, … on top of engineering
- Program has produced a growing community of alumni which continue to engage with the project
- Numerous events have been held
- The success of the CWCs in and of themselves point to the value of the project and that they accomplished the stated goals

Question 4: Project Management

Comments made by reviewers during the evaluation of this project (PRID 139)

- Good communication across a variety of organizations with dozens of students and professors; massive coordination with a small staff
- Large budget, probably explained mainly by 2 portable wind tunnels that are taken to AWEA events for testing the competitors' devices
- Under budget so far
- Milestones met successfully so far
- Management of this program along with its budget and schedule has been exceptional. Making sure everything was in place and running smoothly at WINDPOWER was critical to the success of the project and from a coordination standpoint alone it is no small feat to ensure all the teams were prepared and the competition well executed.
- Would like to see much more cost sharing from industry and other sources, given the exposure opportunities for sponsorships.

Question 5: Research Integration, Collaboration, and Technology Transfer

- Broad collaborative efforts across universities, industry, government (labs)
- Need to link across educational programs to build future experts and workers: include NAWEA (North American Wind Energy Academy) as strategic effort (either fund it or cut it loose)!!!
- Competitions a good way of getting publicity and networking opportunities for students towards industry
- Establishment of an alumni community is fostering knowledge sharing
- Social media campaign appears to have reached a large audience
- This project could only have been successful with significant coordination between the 20 universities during the planning and execution phases and AWEA as the competition host
- Are the wind tunnels (both current and planned) able to be used for other purposes? If not it seems there may be a value proposition to consider retaining the use of the existing tunnel and look to fund other academic opportunities instead of a new tunnel.
- The level and breadth of outreach seems impressive

Question 6: Proposed Future Research, if applicable

- Hopefully getting next phase with less funding from DoE as costly wind tunnels have now been made and upgraded, and perhaps publicity gets possibilities to leverage with industry funding
- European Academy of Wind Energy (EAWE) example of working network of universities in organizing courses together (using the special expertise of professors in a complementary way), summer courses and workshops etc. Check if possible to improve this kind of university networking work in US.
- The huge potential for this program leads me to think the future work could be more ambitious
- Could expand the program across more institutions
- The technical scope of the program could be widened to include, for example, grid and environmental issues
- I believe this program is worthy of continued investment and has high value. The only question I have, particularly given the magnitude of the impact to industry as a whole provided by most of the other programs, is whether or not this investment reaches enough students and results in the creation of workforce expansion to a great enough extent. What I mean is that, while a well-structured and executed project with laudable goals, is a dollar invested here going to have the same value for advancing the wind industry as a dollar invested in something like the industry reports, WindExchange, regional wind centers, etc.? For the cost (while much of that is sunk at this point in the wind tunnel) I'm not sure generating a few dozen jobs that might come from the students pursuing careers in wind energy has a high enough value for continuation, unless the annual cost can be kept around $200 K or less for DOE and a more significant share of the funding can be provided by sponsor organizations.

Comments made by reviewers during the evaluation of this project (PRID 139)

- It might be good to look at other technology promotions beyond a wind turbine, however symbolically obvious a wind turbine is. For example, battery technology might be a worthwhile technology competition to undertake with significant relevance to the wind industry should a group of students come up with some new way of looking at that technology (i.e., wind turbine technology is not likely to be advanced and supporting it may be more costly).
- I would question the value of broadening the scope internationally. While a noble endeavor, it would seem more appropriate to contain the scope nationally.

Question 7: Project Strengths

- Engaging a good amount of universities, and getting good publicity, as well as networking for students
- Great to see real enthusiasm in the project spreading
- Program has been hugely successful in inspiring students and attracting them to this area
- Project has fostered collaboration across a large number of institutions
- Program impacted positively on everyone involved with many "soft" benefits way beyond the specific objectives of the project
- Value in generating interest in the industry by young academics before they enter the work force

Question 8: Project Weaknesses

- The amount of outreach and education with the funding spent is limited
- Future work could be more ambitious
- Could expand the program across more institutions
- The technical scope of the program could be widened to include, for example, grid and environmental issues
- As noted above, while a valuable project, the dollar to dollar value of this project and some others that have a more universal/direct impact on the industry as a whole is a bit low and if the project continues to move forward (which I think it should) the DOE portion of the funding should be $200 K or less and a greater portion come from corporate/private (possibly foundations) sponsors

Question 9: Recommendations

- The efficiency of the program should grow with continued investment as experience with logistics improves and to get the best value from investment to date (wind tunnel for example)
- Future work could be more ambitious
- Could expand the program across more institutions
- The technical scope of the program could be widened to include, for example, grid and environmental issues

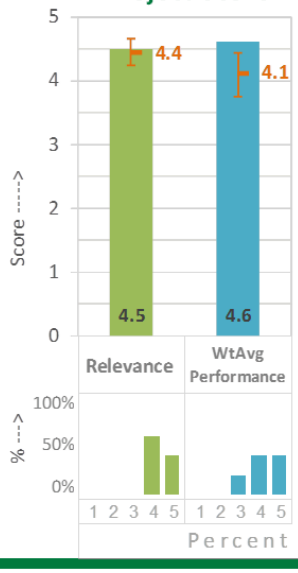
DOE Wind Energy Technologies Office 2017 Peer Review Project:

Wind for Schools

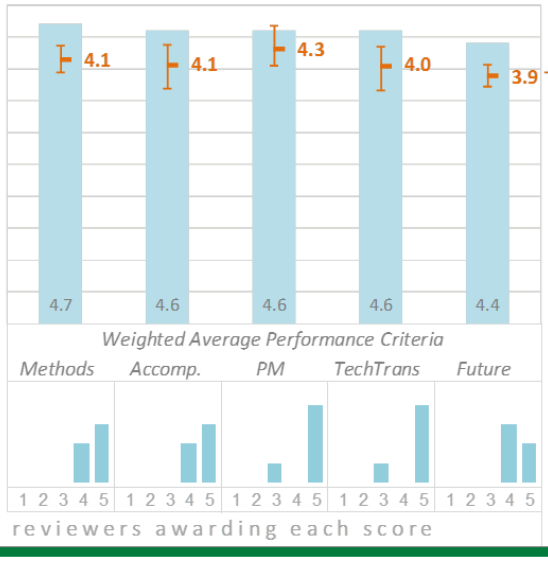
Principal Investigator	Mark Jacobson, National Renewable Energy Laboratory		
Program	Wind Market Acceleration and Deployment		
Sub-Program	Stakeholder Engagement		
FY 2014-2016 Funding	DOE	$ 1.5 M	100%
	Cost Share		
	Total	**$ 1.5 M**	**100%**

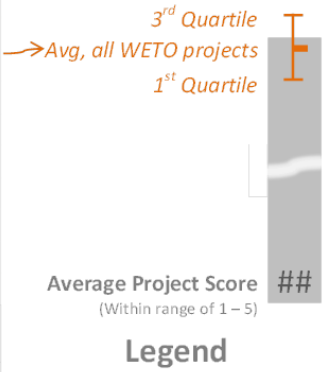
Peer Review ID# 140

Project Score

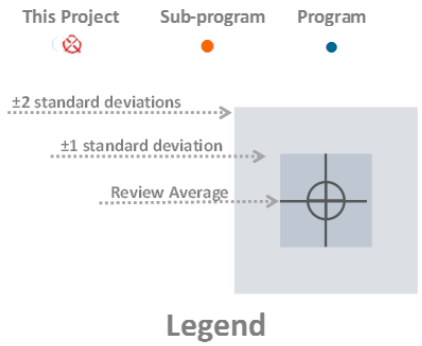


WtAvg Performance Metrics Scores





Comparative Scoring



Comments made by reviewers during the evaluation of this project (PRID 140)

Question 1: Relevance to Wind Energy Industry Needs and Overall DOE Objectives

- Important program for K-12 students and future workers
- 12 in 12 states but should be expanding rather than limited to 12; important for community level exposure too
- Important in contributing to skillful workforce for future
- Workforce development in this area is a major challenge internationally. This project has this as a core objective.
- I score this project very high given the number of different aspects of the Wind Program it aligns with and helps address. The work force development and information dissemination aspects alone are extremely valuable.
- It would seem that opportunities exist to leverage the efforts of NGOs (non-governmental organizations) and foundations that focus on vocational training enhancements in US education curriculum. Mike Rowe Foundation (Dirty Jobs host) focuses on bringing back vocation training in US education. Efforts such as this, supported by DoE education program development, could be an outreach approach akin to the Regional Resource Center concept.
- Wind energy assessments would be a low cost, easy to deploy educational activity. Perhaps (emphasis added if the formatting would allow it) a commercial intersection could occur with wind developers purchasing wind data or partnering with schools to elaborate on students' development efforts.
- This would be especially interesting to execute in areas where greenfield development (e.g., SE region of US) is likely to increase with time. Socializing wind energy in these communities through students' educational interests could reduce the community resistance of wind energy development.

Question 2: Methods and Approach

- Comparative turbine data across schools is a very effective method for bringing different institutions together
- More interdisciplinary themes are needed once the program is on better footing with more resources
- Providing a wide set of materials for education is very good (tools, databases, course materials, small turbines,... for universities, colleges and schools)
- Reaching out and helping the WACs (Wind Application Centers) - this is important to make sure all is used
- The approach appears successful at stimulating interest in the area at secondary (K-12) level
- Is the dependency of the program on a locally installed turbine a limiting factor
- To successfully engage at K-12 level, perhaps the program needs to be less deep and more broad - to make greater use of the funding available. Perhaps more efficient alternatives can be explored than using a local turbine - for example, by visiting utility scale installations.
- The project appears to be very well structured and achieving tangible results. As it is reaching a large volume of students nationally through the WACs the overall value of the investment is extremely high and cost per capita low. In terms of overall success it is well documented that educating young children on a topic at an early age increases the likelihood of them embracing those values throughout their lives and bringing those lessons back to their households and communities - thereby further increasing the value of the investment.

Question 3: Technical Accomplishments and Progress

- 147 turbines since 2005 and 300 teachers trained--impressive numbers given the level of resources involved
- AWS TruePower tool for siting is another interesting real world application
- Entire age group, from schools to universities. Educating teachers. Competitions. Working on siting tool, simplified from AWS Truewind
- Contributing for WindVision - and good to see that this project seems to take full advantage of all other work in the field
- The development of teaching skills at 300 teachers per year is very impressive
- Tool to access turbine data is a valuable resource
- The project has numerous goals and appears to be meeting all of them and staying under budget

Question 4: Project Management

Comments made by reviewers during the evaluation of this project (PRID 140)

- 2013-2014 OMB (Office of Management and Budget) directed funding ended and then reinstated which does not help in building networks or reliability of DOE educational initiatives; this is unacceptable for effective program planning: NREL gets a MAJOR kudo for re-starting the program and having near term successes again; shows trust and commitment
- Monthly calls with universities even without funding is another effective management approach
- Good to see that coordinating with other outreach projects Collegiate Wind Competition and WindExchange
- Under budget so far
- Milestones met successfully so far
- All indications are that this project is being well managed and is successful
- The summary presentation notes that NREL is actively integrating WfS (Wind for Schools) activities with that of the other educational outreach projects. It is not clear what this entails but the notion of integration makes sense. Perhaps opportunities for additional integration vis-a-vis RRCs (Regional Resource Centers) as well?

Question 5: Research Integration, Collaboration, and Technology Transfer

- Diversified funding plan seems like a good approach but this program is very important and should continue to have seed funding
- Reaching 20 + schools per state which is a good state-of-the art. With existing materials, this could probably be broadened in future.
- NAWEA (North American Wind Energy Academy) and AWEA (American Wind Energy Association) collaboration good
- This project is naturally reaching out to a lot of people/citizens, and through students has impact also to their families and communities
- The nature and objectives of the program means a high degree of focus on collaboration and knowledge transfer
- Coordination with industry leaders like AWEA and the schools themselves is essential to the success of the project and appears to have been taking place to a large degree
- The dissemination of the project's efforts seems restricted to communities where activities are taking place. It seems there is some value in creating a "marketing plan" for WfS in communities that have yet to engage. Again, perhaps a role for RRCs.

Question 6: Proposed Future Research, if applicable

- With challenges with funding --not sure how future research or expansion to other schools would work although this is urgently needed since it is only on 12 schools; seems like a drop in the bucket
- KidWind and NEED (National Energy Education Development) curriculum are getting resources from NREL to update their information which is another urgent need
- Working towards securing other than DoE funding
- Expansion into more states is a great idea and necessary to broaden the scope of the program
- Development of curricula adhering to standards also makes huge sense
- Question exists in my mind if this program would be more effective targeting a much wider swathe of schools but perhaps with a less ambitious/deep program. For example, could turbine installs be replaced by a program of site visits and access to data to enable a broader roll out across school curricula nationwide?
- This program is worthy of continued investment
- Encourage the pursuit of "Affiliate WfS Project" (i.e., alternative funders of specific programs). WETO should leverage the experience and knowledge gained from WfS by convening other parties interested in supporting expansion into a new community.

Comments made by reviewers during the evaluation of this project (PRID 140)

Question 7: Project Strengths

- Coordination of ongoing projects like WindExchange, building on growing amount of educational materials, reaching out to increasing amount of students
- Complements the Collegiate Wind Competition - not all are interested in competition but still want to learn about wind
- Very relevant effective program attracting and exposing students to the technology and developing interest in relevant areas such as science and mathematics
- Successful framework established to provide teachers with the resources and training to implement curriculum
- Cooperation across industry bodies and research institutions in this area is very beneficial
- Nothing more to share on this aspect at this point

Question 8: Project Weaknesses

- Currently appears to be a relatively small fraction of students/schools covered by the program
- Although I can see the huge benefit of installing turbines at schools, is this limiting the scope of the program (financial, siting / demographics / lead time)?
- The only criticism I have about the program is that it should be leveraging private funding. Moving forward, if the project continues, I would encourage DOE, to the extent it can, to work with foundations (e.g. Gates, Rockefeller, Duke, etc.) to provide significant matching funds to advance this program.

Question 9: Recommendations

- NAWEA collaboration important to secure that the good materials are used and applied in future. European Academy of Wind Energy (EAWE) can be checked out for their activities, if can be applied in US - and for collaboration possibilities as well. They use a network of professors, all experts at some parts of wind energy technology, and organize summer courses and joint courses open for all member state students.
- Is it possible to greatly broaden the scope of this program to reach more students with the same resources and generate a similar level of interest. Perhaps a combination of site visits and access to communal turbines (State/county level?)
- Rather than a niche curriculum activity available only in certain areas, could a version of it be made more mainstream, more nimble and more easily adopted by a greater number of schools?

Appendix A Peer Review Process

This section contains representative comments and actionable recommendations from the peer reviewers, staff of DOE's Wind Energy Technologies Office and Water Power Technologies Office,[3] and peer review organizers regarding the peer review planning and execution process. These lessons learned will help support improvement and optimization of future peer reviews.

General Feedback on the Peer Review Process

- The order of the presentations in each program was fantastic.
- Incorporating aspects of a "conference atmosphere" to the peer review was a very good idea. It created a rigorous atmosphere in which to conduct a conference of broad stakeholders. Having a keynote speaker worked very well.
- Next time, add time for side meetings and networking. Perhaps the next peer review and/or department meetings would design breakout groups and new experts (not just engineers) to discuss ways to approach multi-disciplinary, multi-pronged science and engineering program areas.
- Very well-managed event. The agenda was controlled well throughout the program. Good job done by all. Overall execution was on-time and high quality. Feedback was great.
- Most of the time the instructions were clear. There were certainly a few communication issues (during the planning stage), but the frequent team update calls really helped alleviate this.
- List the Principal Investigator on the agenda and have the moderator handle changes of presenter at the peer review. Principal Investigators may want to have colleagues and partners gain recognition.
- Would be helpful to have a more clearly delineated "roadmap" for all internal staff that summarizes process, goals, deliverables, quality metrics, and lessons learned from previous peer reviews.
- By-product of peer review process was that colleagues were able to get broad perspective on the larger program, which is invaluable.
- It would be helpful for orienting if we had a funding stream graphic, where each project clusters with others.

Opportunities for Improving the Peer Review Process

Project Templates and Guidance for Principal Investigators

- Project presentations were well documented using a standard format.
- Suggest summarizing for the reviewers the rationale behind how the presentations and project summary templates were developed, and completed by Principal Investigators.
- Include a "definition of terms" page in the Principal Investigator Instructions, and include instructions for incorporating video into presentations as part of Principal Investigator Template Package.

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[3] The Wind Energy and Water Power Technologies Offices held their respective peer reviews concurrently. Content and lessons learned in this appendix represent feedback about both peer reviews, since many aspects of the reviews (e.g. planning efforts, agenda, presentation templates) were identical or similar.

- Provide mechanism to allow Principal Investigators to incorporate project developments into their presentations that occurred subsequent to their initial submission. Perhaps a "Latest Project Developments" or "Stay Tuned" slide in the presentation template to make reviewers and audience members aware of recent accomplishments and/or planned work.

- Ensure uniformity of project-related data such as budgets, annual spending, cost share and start/end dates in both content and format, perhaps utilizing a “key data” form, including instructions, that the office technical leads and the Principal Investigators concur on and update as needed, prior to and separate from the slide presentation.

- Provide stringent guidance about use of acronyms to help ensure reader understanding.

- Reviewers received presentations prior to the review in order to prepare, but those files alone did not provide sufficient understanding of projects. The live presentations with PIs did, however, fill in the gaps.

- Instead of only "Project Title" on the Presentation and Project Summary templates, indicate the original AOP/FOA project title (lead project, if part of a group of projects), current working project title, and peer review presentation title, if different.

- Consider a simplified way to capture and report budget figures among projects so that comparisons are easier for reviewers, e.g. capture total project budget, total project duration, and yearly annual spend in a uniform way. Having a single page with scope and funding and goals would be good, as some projects didn't cover those things as well as others.

- During the planning phase for multi-lab presentations, the "Labs Project List" should be shared with the Principal Investigators of sub-labs/partners in addition to the Principal Investigators of the Lead Lab/partner.

- Project summary sheets were helpful but varied in quality. Presentations were more of a repackaging of the two pagers; provide PIs with more detailed instructions about the type of content to include so that the presentations can stand alone more readily.

Reviewer Guidance

- The evaluation sheet worked very well due to the way it was laid out and the fact that logistics information was incorporated directly in the Excel workbook. Reviewers reported that it was easy to navigate between the project summary, presentations, the agenda, and the evaluation sheet, even with multiple projects.

- Program managers engaged with reviewers and listened but also highlighted in advance for reviewers those areas about which the program itself has questions. This type of open engagement helped reviewers to pay additional attention to those topics, which stimulated good dialog and feedback to the program.

- The process and communications channels within the office related to disseminating project-specific information, including version tracking, could be improved.

- Suggest a pre-review meeting to better understand the areas that each reviewer on a panel considers themselves to be expert in, and address any concerns they have regarding comments on other topics. Define what "expert" means and develop succinct guidance for reviewers. For instance, the NIH process has the peer reviewer state their expertise and comfort for each answer.

- Conduct a pre-review group session with reviewers to identify information, such as budget details, that they consider important to be able to answer evaluation form questions.

- Need more clarity on scoring and commenting on new versus existing projects.

At Review

- More informal time, such as breakfast meetings, for reviewers to interact with one another would be useful.

- DOE might consider a manned poster session in order to manage the volume of project-specific content. This has occurred in other peer reviews and allows individual Principal Investigators of multiple similar projects to avoid making multiple presentations, and still prepare adequate material for review purposes.

- Would be good to have more discussion time. The reviewers really didn't get much time to interact with PIs; it would have been great to hear more of their feedback.

- Audience input was fantastic and helped generate great dialogue.

Appendix B Program Evaluation Form Template

The subsequent two pages feature the blank WETO **program-level** scoring sheet used by reviewers.

Appendix C Project Evaluation Form Template

The subsequent three pages feature the blank WETO project-level scoring sheet used by reviewers.

Appendix D Meeting Attendee List

Note that some attendees in this list were registered to attend both the 2017 WETO Peer Review and the concurrent 2017 Water Power Technologies Office Peer Review, as noted. Attendees are listed in alphabetical order, first by organization name and then by last name.

First Name	Last Name	Organization	Registered to attend
Steven	Englebretson	ABB Inc.	Both Wind and Water
V R	Ramanan	ABB Inc.	Both Wind and Water
Audun	Botterud	Argonne National Laboratory	Wind Peer Review
Guenter	Conzelmann	Argonne National Laboratory	Wind Peer Review
Aaron	Greco	Argonne National Laboratory	Wind Peer Review
Scott	Winneguth	Avangrid Renewables	Wind Peer Review
Cris	Hein	Bat Conservation International	Both Wind and Water
Evan	Adams	Biodiversity Research Institute	Wind Peer Review
Andrew	Gilbert	Biodiversity Research Institute	Wind Peer Review
Charles	Butterfield	Boulder Wind Consulting	Wind Peer Review
Maurice	Falk	Bureau of Ocean Energy Management	Both Wind and Water
Darryl	Francois	Bureau of Ocean Energy Management	Both Wind and Water
Angel	McCoy	Bureau of Ocean Energy Management	Both Wind and Water
Ian	Slayton	Bureau of Ocean Energy Management	Both Wind and Water
John	Cushing Jr.	Bureau of Safety and Environmental Enforcement	Both Wind and Water
Steven	Barras	Bureau Veritas Offshore	Both Wind and Water
Roger	Bagbey	Cardinal Engineer	Both Wind and Water
Peter	Drown	Cleantech Analytics LLC	Both Wind and Water
Johan	Enslin	Clemson University	Wind Peer Review
Patrick	Hipp	Composite Technology Development, Inc.	Both Wind and Water
Joy	Page	Defenders of Wildlife	Wind Peer Review
Neil	Kern	Duke Energy	Both Wind and Water
Heather	Rhoads-Weaver	eFormative Options	Wind Peer Review
Joseph	Dillon	Electricity Research Centre, University College Dublin	Wind Peer Review
Michael	Kelly	Ensemble Energy Services, LLC	Wind Peer Review
Chris	Wissemann	Fishermens Energy	Wind Peer Review
Fraser	Dalgleish, PhD	Florida Atlantic University	Both Wind and Water
William	French	French Development Enterprises, LLC	Both Wind and Water
Myron	Miller	Frontier Wind	Wind Peer Review
Debbie	Mursch	GE Renewable Energy	Both Wind and Water
Kathryn	Rominger	General Electric Company	Wind Peer Review
Johnathon	Marmillo	Genscape	Both Wind and Water
Richard	Rocheleau	HNEI/Univ of Hawaii	Both Wind and Water
Gabriel	Ilevbare	Idaho National Laboratory	Both Wind and Water
Jake	Gentle	Idaho National Laboratory	Wind Peer Review
Richard	Hess	Idaho National Laboratory	Both Wind and Water
Yusheng	Luo	Idaho National Laboratory	Both Wind and Water
Timothy	McJunkin	Idaho National Laboratory	Wind Peer Review

First Name	Last Name	Organization	Registered to attend
Manish	Mohanpurkar	Idaho National Laboratory	Both Wind and Water
John	Bonds	Independent Consultant	Both Wind and Water
Stu	Webster	Independent Consultant	Wind Peer Review
John	Meissner	U.S. Department of Energy/Independent Consultant	Both Wind and Water
Craig	Jones	Integral Consulting	Both Wind and Water
Eric	Smith	Keystone Tower Systems	Wind Peer Review
Ben	Hoen	Lawrence Berkeley National Laboratory	Wind Peer Review
Ryan	Wiser	Lawrence Berkeley National Laboratory	Wind Peer Review
Dave	Karpinski	LEEDCo	Wind Peer Review
Rick	Williams	Leidos Maritime Solutions	Both Wind and Water
David	Duquette	Littoral Power Systems	Both Wind and Water
Dan	Dolan	Moffatt and Nichol	Wind Peer Review
David	Muchow	MuchowLaw	Both Wind and Water
Sue Ellen	Haupt	National Center for Atmospheric Research	Wind Peer Review
William	Mahoney	National Center for Atmospheric Research	Wind Peer Review
Jim	Wilczak	National Oceanic and Atmospheric Administration	Wind Peer Review
Ian	Baring-Gould	National Renewable Energy Laboratory	Both Wind and Water
Aaron	Bloom	National Renewable Energy Laboratory	Wind Peer Review
Dave	Corbus	National Renewable Energy Laboratory	Wind Peer Review
Frederick	Driscoll	National Renewable Energy Laboratory	Both Wind and Water
Katherine	Dykes	National Renewable Energy Laboratory	Wind Peer Review
Johney	Green	National Renewable Energy Laboratory	Both Wind and Water
Scott	Hughes	National Renewable Energy Laboratory	Wind Peer Review
Mark	Jacobson	National Renewable Energy Laboratory	Wind Peer Review
Jonathan	Keller	National Renewable Energy Laboratory	Wind Peer Review
Daniel	Laird	National Renewable Energy Laboratory	Both Wind and Water
Eric	Lantz	National Renewable Energy Laboratory	Wind Peer Review
Alexsandra	Lemke	National Renewable Energy Laboratory	Both Wind and Water
Eduard	Muljadi	National Renewable Energy Laboratory	Both Wind and Water
Walter	Musial	National Renewable Energy Laboratory	Both Wind and Water
Amy	Robertson	National Renewable Energy Laboratory	Wind Peer Review
Robi	Robichaud	National Renewable Energy Laboratory	Both Wind and Water
Dave	Simms	National Renewable Energy Laboratory	Wind Peer Review
Karin	Sinclair	National Renewable Energy Laboratory	Wind Peer Review
Brian	Smith	National Renewable Energy Laboratory	Both Wind and Water
Michael	Sprague	National Renewable Energy Laboratory	Wind Peer Review
Suzanne	Tegen	National Renewable Energy Laboratory	Both Wind and Water
Robert	Thresher	National Renewable Energy Laboratory	Both Wind and Water
Jeroen	van Dam	National Renewable Energy Laboratory	Wind Peer Review
Alan	Wright	National Renewable Energy Laboratory	Wind Peer Review
Yingchen	Zhang	National Renewable Energy Laboratory	Wind Peer Review
Jason	Fields	National Renewable Energy Laboratory National Wind Technology Center	Wind Peer Review
Miguel	Quintero	Naval Surface Warfare Center Carderock	Both Wind and Water
John	Anderson	Nossaman, LLP	Wind Peer Review

First Name	Last Name	Organization	Registered to attend
Dominic	Lee	Oak Ridge National Laboratory	Wind Peer Review
Tony	Lewis	Ocean Energy USA LLC	Both Wind and Water
Nathan	Johnson	Ocean Renewable Power Company	Both Wind and Water
Daniel	O'Connell	Office of Renewable Energy Programs	Both Wind and Water
Belinda	Batten	Oregon State University	Both Wind and Water
William	Toman	Pacific Marine Renewables	Both Wind and Water
Andrea	Copping	Pacific Northwest National Laboratory	Both Wind and Water
Samuel	Harding	Pacific Northwest National Laboratory	Both Wind and Water
Genevra	Harker-Klimes	Pacific Northwest National Laboratory	Both Wind and Water
Shari	Matzner	Pacific Northwest National Laboratory	Both Wind and Water
Will	Shaw	Pacific Northwest National Laboratory	Wind Peer Review
Chitra	Sivaraman	Pacific Northwest National Laboratory	Wind Peer Review
Jason	Busch	Pacific Ocean Energy Trust	Both Wind and Water
Kevin	Koudela	Pennsylvania State University	Both Wind and Water
Kevin	Banister	Principle Power	Wind Peer Review
Mirko	Previsic	Re Vision Consulting, Inc.	Both Wind and Water
D. Todd	Griffith	Sandia National Laboratories	Wind Peer Review
Amy	Halloran	Sandia National Laboratories	Both Wind and Water
Bernadette	Hernandez-Sanchez	Sandia National Laboratories	Both Wind and Water
David	Minster	Sandia National Laboratories	Wind Peer Review
Brian	Naughton	Sandia National Laboratories	Wind Peer Review
Joshua	Paquette	Sandia National Laboratories	Wind Peer Review
Jesse	Roberts	Sandia National Laboratories	Both Wind and Water
David	Womble	Sandia National Laboratories	Wind Peer Review
Ralph	Nichols	Savannah River National Laboratory	Wind Peer Review
Brad	Romano	Shoener Environmental, Inc.	Wind Peer Review
P.J.	Doughterty	SMI	Both Wind and Water
Paul	Gay	SMI	Both Wind and Water
David	Moore	Smith, Gambrell & Russell, LLP	Both Wind and Water
Herbie	Johnson	Southern Company	Both Wind and Water
Stephanie	McClellan	Special Initiative on Offshore Wind	Wind Peer Review
Andrea	Eugster	Statoil	Wind Peer Review
Henrik	Stiesdal	Stiesdal A/S	Wind Peer Review
Amanda	Hale	Texas Christian University	Wind Peer Review
John	Schroeder	Texas Tech University	Wind Peer Review
Craig	Christenson	Turbine Technology Partners, LLC	Wind Peer Review
Jim	Ahlgrimm	U.S. Department of Energy	Both Wind and Water
Bret	Barker	U.S. Department of Energy/Independent Consultant	Both Wind and Water
Jocelyn	Brown-Saracino	U.S. Department of Energy	Both Wind and Water
Charlton	Clark	U.S. Department of Energy	Both Wind and Water
Michael	Derby	U.S. Department of Energy	Wind Peer Review
Rajesh	Dham	U.S. Department of Energy	Both Wind and Water
Alana	Duerr	U.S. Department of Energy	Wind Peer Review
Arlene	Fetizanan	U.S. Department of Energy	Both Wind and Water
Jian	Fu	U.S. Department of Energy	Wind Peer Review

First Name	Last Name	Organization	Registered to attend
Liz	Hartman	U.S. Department of Energy	Wind Peer Review
Megan	McCluer	U.S. Department of Energy	Wind Peer Review
Sara	Paredes	U.S. Department of Energy	Both Wind and Water
Michael	Robinson	National Renewable Energy Laboratory	Wind Peer Review
Roderick	Sampson	U.S. Department of Energy	Wind Peer Review
Jose	Zayas	U.S. Department of Energy	Wind Peer Review
Maggie	Yancey	U.S. Department of Energy	Both Wind and Water
Lillie	Ghobrial	U.S. Department of Energy/Allegheny Science and Technology	Both Wind and Water
Richard	Tusing	U.S. Department of Energy/Allegheny Science and Technology	Both Wind and Water
Fredric	Beck	U.S. Department of Energy/CSRA LLC	Both Wind and Water
Gary	Norton	U.S. Department of Energy/CSRA LLC	Both Wind and Water
Sandyn	Skudneski	U.S. Department of Energy/CSRA LLC	Both Wind and Water
Devan	Willemsen	U.S. Department of Energy/The Hannon Group LLC	Wind Peer Review
Hoyt	Battey	U.S. Department of Energy	Both Wind and Water
Matthew	Grosso	U.S. Department of Energy	Both Wind and Water
Joel	Cline	U.S. Department of Energy	Both Wind and Water
Daniel	Beals	U.S. Department of Energy/ Allegheny Science and Technology	Both Wind and Water
Shane	Beichner	U.S. Department of Energy	Wind Peer Review
Gary	Nowakowski	U.S. Department of Energy	Both Wind and Water
Raphael	Tisch	U.S. Department of Energy/Allegheny Science and Technology	Wind Peer Review
Richard	Bowers	U.S. Energy Information Administration	Wind Peer Review
Christy	Johnson-Hughes	U.S. Fish and Wildlife Service	Wind Peer Review
Bonnie	Ram	University of Delaware	Both Wind and Water
Habib	Dagher	University of Maine	Wind Peer Review
Michael	Bernitsas	University of Michigan and Vortex Hydro Energy	Both Wind and Water
Wei	Qiao	University of Nebraska-Lincoln	Wind Peer Review
Jonathan	Bird	University of North Carolina at Charlotte	Wind Peer Review
Jim	McCaa	Vaisala, Inc.	Wind Peer Review
John	Banigan	Verdant Power	Both Wind and Water
Jephathai	Boontanom	Virginia Tech	Both Wind and Water
Xiaofun	Li	Virginia Tech	Both Wind and Water
Changwei	Liang	Virginia Tech	Both Wind and Water
Susan	Ma	Virginia Tech	Both Wind and Water
Adam	Wise	Virginia Tech	Both Wind and Water
Lei	Zuo	Virginia Tech	Both Wind and Water
Hannele	Holttinen	VTT Technical Research Center of Finland	Wind Peer Review
Michael	Booth		Wind Peer Review
Motunrayo	Kemiki		Wind Peer Review
Justin	Klure		Both Wind and Water
Michael	Martin		Both Wind and Water
Robert	Parker		Both Wind and Water
Paul	Veers	NREL	Wind Peer Review

Appendix E Meeting Agenda

This section includes the meeting agenda only. The full 2017 WETO Peer Review program, including DOE and reviewer bios, is available on the DOE website at: https://energy.gov/eere/wind/downloads/program-guide-wind-energy-technologies-office-and-water-power-technologies. Note that the office allowed principal investigator substitutions and adjusted presentation times as needed to accommodate schedule availability and travel requirements. As appropriate, the agenda was modified to provide more complex projects with sufficient presentation time.

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For more information, visit:
energy.gov/eere/wind/wind-energy-technologies-office

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