U.S. DEPARTMENT OF ENERGY

Office of
ENERGY EFFICIENCY & RENEWABLE ENERGY

2019 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
WIND ENERGY TECHNOLOGIES OFFICE

Summary Report
February, 2020

VOLUME I

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Foreword

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

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Preface

Dear Colleague,

On behalf of the U.S. Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy, Wind Energy Technologies Office (WETO), I am pleased to present the results of the 2019 WETO Peer Review, which was held April 30–May 2, 2019, in Alexandria, Virginia. The purpose of the review was to evaluate projects funded by DOE during fiscal years 2017 and 2018 for their contribution to the mission and goals of the office, assess progress against stated objectives, and appraise WETO's overall management and performance.

As an independent, expert evaluation of the office and its body of research, the peer review is an essential part of developing and evaluating the WETO research portfolio. At the review, principal investigators from DOE's national laboratories, as well as academic and industry representatives, presented the progress of DOE-funded WETO research projects to 12 highly qualified, independent reviewers. The reviewers examined and scored the technical, scientific, and business relevance of 58 projects with a total value of over $500 million, including non-federal cost share. They also evaluated the effectiveness of the office itself in executing on its mission and managing the project portfolio.

The office is grateful to the reviewers for their candid and constructive scoring, comments, and recommendations. WETO is using this feedback to assess and revise current and future portfolio decisions. This report includes the WETO's response to reviewer comments, which describes our consideration of this input and the actions underway to address issues of concern.

Volume I of this report includes the executive summary, synopses of the program- and project-level evaluation results, and WETO's response to the 2019 Peer Review findings. Volume II includes the complete program-level, activity-level and project-level evaluation results—as well as the report appendices.

WETO is committed to developing a portfolio of innovative land-based, offshore, and distributed wind energy technologies for cost-effective domestic power generation. The 2019 Peer Review results will help WETO evaluate and plan its research portfolio, ensuring effective investment of taxpayer dollars to achieve these goals for the benefit of the nation.

Sincerely,

Robert C. Marlay, Ph.D., P.E.

Director
Wind Energy Technologies Office
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy

Acknowledgments

Organizing, planning, and executing a U.S. Department of Energy peer review requires a dedicated and integrated effort from numerous participants. The Wind Energy Technologies Office (WETO) would like to offer special thanks to the peer review chairs and reviewers (see Table 2-2) for contributing their time and expertise to this vital event. WETO would also like to acknowledge the time and work dedicated to this effort by the peer review planning and reporting team (Jian Fu, Raphael Tisch, Gary Norton, Alexsandra Lemke, Shanika Benedicto, Ivette Gonzalez, Maggie Yancey, Terri Krantz, and Liz Hartman); principal investigators; and all WETO staff.

Nomenclature

Acronym	Terminology
A2e	Atmosphere to Electrons
Analysis	Analysis and Modeling
ANL	Argonne National Laboratory
AOP	Annual Operating Plan
AWEA	American Wind Energy Association
AWWI	American Wind Wildlife Institute
BAR	Big Adaptive Rotor
BWEC	Bats and Wind Energy Collaborative
CFD	computational fluid dynamics
DOE	U.S. Department of Energy
EERE	DOE's Office of Energy Efficiency and Renewable Energy
ESIG	Energy Systems Integration Group
FOA	funding opportunity announcement
FY	fiscal year
GW	gigawatt(s)
HFM	high-fidelity modeling
HPC	high-performance computing
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IECRE	IEC Renewable Energy Standards System
INL	DOE's Idaho National Laboratory
kWh	kilowatt-hour
LBNL	DOE's Lawrence Berkeley National Laboratory
LCOE	levelized cost of energy
LEEDCo	Lake Erie Energy Development Corporation
LES	large-eddy simulation
LLNL	DOE's Lawrence Livermore National Laboratory
MA&D	Market Acceleration and Deployment
MMC	Mesoscale-Microscale Coupling
NGO	Non-government organization
NOAA	National Oceanic and Atmospheric Administration
NREL	DOE's National Renewable Energy Laboratory
NWCC	National Wind Coordinating Collaborative
NWTC	NREL's National Wind Technology Center
O&M	operations and maintenance
OC3	Offshore Code Comparison Collaboration
OC5	Offshore Code Comparison Collaboration, Continued, with Correlation
OEM	original equipment manufacturer
ORNL	DOE's Oak Ridge National Laboratory
PI	principal investigator
PNNL	DOE's Pacific Northwest National Laboratory
PRUF	Performance, Risk, Uncertainty, and Finance
R&D	research and development
RFI	request for information
RRC	Regional Resource Center
SCADA	supervisory control and data acquisition
SNL	DOE's Sandia National Laboratories
SOWFA	Simulator for Wind Farm Applications
SWiFT	Scaled Wind Farm Technology Facility
T2M	Technology to Market

TD	Technology Development & Scientific Research
TRL	Technology readiness level
UQ	uncertainty quantification
USWTDB	U.S. Wind Turbine Database
WETO	DOE EERE's Wind Energy Technologies Office
WFIP	Wind Forecast Improvement Project
WREN	Working Together to Resolve Environmental Effects of Wind Energy
WTG	wind turbine generators

Executive Summary

Introduction

The U.S. Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy's (EERE's) Wind Energy Technologies Office (WETO, or "the office") 2019 Peer Review was held on April 30–May 2, 2019, in Alexandria, Virginia. The purpose of the peer review was to evaluate DOE-funded projects for their contribution to the mission and goals of the office, to assess progress made against stated objectives, and to assess the office's overall management and performance.

WETO drives innovation through research, development, and testing of advanced wind energy technologies. The portfolio focuses on land-based, offshore, and distributed wind, as well as integration of wind energy on the grid. The primary goal is cost reduction, while also informing market choices; ensuring the reliability, resilience and security of wind power and the grid; exploring means for mitigating siting and environmental challenges; and nurturing a robust U.S. manufacturing sector and related workforce. The work is underpinned by investments in related science, modeling and analytical tools; complemented by selective, cost-shared demonstrations; and carried out as collaborations with industry, academia, DOE National Laboratories and facilities, and other research enterprises.

Completing the 2019 Peer Review Report marks a successful milestone, as the office strives to continually reflect, respond, and improve to best manage and execute the WETO program and its contributions to DOE's mission. A peer review conducted by an EERE technology office is defined as, "*a rigorous, formal, and documented evaluation process using objective criteria and qualified and independent reviewers to make a judgment of the technical/ scientific/business merit, the actual or anticipated results, and the productivity and management effectiveness of an office's portfolio of projects.*"[1]

The Peer Review presented a broad range of research activities and highlighted the technical expertise being applied to this research from within the wind industry, DOE's national laboratories, and academia. This process resulted in a dialogue on program priorities, plus specific feedback for the office to integrate into its daily operations, both in managing the projects reviewed and in providing lessons-learned to apply to all projects. WETO compiled this final report to provide the results of the 2019 Peer Review evaluation to facilitate practical use of the feedback. The report consists of two volumes: Volume I provides overviews of WETO and the peer review process, as well as summaries of the reviewer scores and qualitative comments, along with the WETO responses at the office and technical program levels; Volume II provides all the scores and comments, including those for each individual project that was reviewed.

WETO values the peer review as a programmatic cornerstone to assess and improve its management and implementation of wind energy R&D and enable continued benefits nationwide. The review panel's feedback has been carefully considered to ensure that the office is aligned with, but not duplicative of or competing with, industry research and development (R&D) priorities, and that projects are being effectively managed and executed. WETO program managers and office leadership have reviewed the scores and qualitative feedback from the panel. Since the peer review, the office has been working to implement a number of the recommendations and address many of the reviewers' comments regarding areas for improvement.

Review Process

The review panel at the 2019 Peer Review evaluated activities for fiscal years (FYs) 2017 and 2018. WETO's activities were organized into three programmatic groupings, referred to as "tracks" for the peer review. These tracks were (1) Technology Development and Scientific Research (TD), (2) Market Acceleration and Deployment (MA&D), and (3) Analysis and Modeling (Analysis). Each track was then further divided into

1 The EERE Peer Review Guide is available on the DOE website: https://www.energy.gov/eere/downloads/eere-peer-review-guide. The Peer Review description is drawn from definitions used by DOE, the National Academy of Sciences, the White House Office of Management and Budget, the U.S. General Accounting Office, and other federal agencies and institutions.

activity areas. See Table ES-1 for a listing of the programs, the activity areas, and the number of projects in each.

Table ES-1. Wind Energy Technologies Office Peer Review Programs and Activity Areas, Including Number of Projects Reviewed in Each

Program	Activity Areas	Number of Projects
TD	Offshore-Specific R&D	4
	Atmosphere to Electrons	10
	Distributed Wind	1
	Testing Infrastructure	2
	Standards Support and International Engagement	1
	Technology to Market and Small Business Vouchers	4
	Advanced Components, Reliability and Manufacturing	5
MA&D	Stakeholder Engagement and Workforce Development	3
	Environmental Research	13
	Regulatory and Siting	3
	Grid Integration	7
Analysis	Analysis and Modeling	5
	Total Projects Reviewed	**58**

The 58 projects reviewed represented 100% of the active WETO-funded R&D project work during FY 2017 and FY 2018. The total DOE funding represented by the projects active during this time period is provided in Figure ES-1, broken down by the three program areas. The total of over $253 million includes funds appropriated in prior fiscal years for projects that continued into the current review period. Non-federal cost-share is not included in the figure. When non-federal cost share is factored in, the total value of all projects is over $500 million. Internal program operations and management funding was excluded from consideration in the Peer Review.

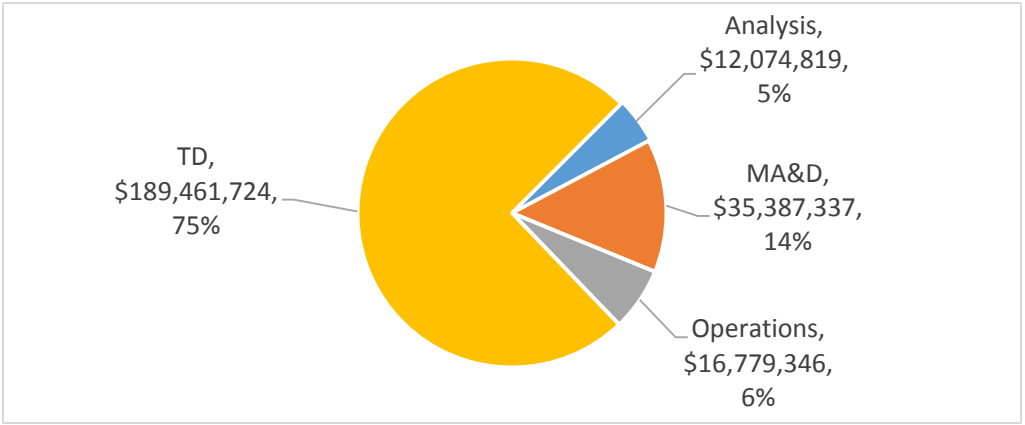

Figure ES-1 Breakdown by program of total WETO funding for projects that were active during FY17–FY18

The review panel consisted of 12 expert reviewers from academia, non-governmental organizations, and the private sector. Each project was assigned at least five reviewers, who provided both numeric evaluations and written comments. Two chairpersons were selected to oversee the peer review tracks and review process: Mr.

Dan Blake of NextEra Energy Resources presided over the TD track and, John Anderson, previously with Nossaman LLP, presided over the MA&D track. All reviewers evaluated the projects in the Analysis track.

Evaluation Metrics

In accordance with EERE peer review guidance, the peer review panelists were asked to submit both quantitative (i.e., numerical scores) and qualitative (i.e., narrative comments) evaluations as part of their review of WETO and its research portfolio.

The panel evaluated WETO and the WETO project portfolio at four organizational levels. They completed evaluation forms assessing the management, performance, and effectiveness of the office as a whole ("office-level" evaluation); the three program areas ("program-level"); each of the activity areas within the programs ("activity-level"); and separately evaluated each individual project ("project-level").

The evaluation process and criteria for each level of evaluation are summarized in section 2.4 of this report and the full evaluation forms can be found in the Appendix of Volume II.

In addition to providing scores on a scale of 1 ("unsatisfactory") to 10 ("outstanding") for certain criteria, the reviewers were asked to comment on the strengths and weaknesses behind their scoring, and to provide recommendations that they felt that the office should consider.

Scoring Overview

Graphs summarizing the reviewer scoring at the project, program, and office levels are provided below.

The average scores for all individual projects are broken down by evaluation metric in Table ES-2. These averages are provided first for all WETO projects as a whole on the top line of the table, followed by the three program tracks at the bottom.

Table ES-2. Average Scores for Peer-Reviewed WETO Projects by Evaluation Metric

Average Scores for all WETO Projects	*8.78*	*8.33*	*8.26*	*8.20*	*8.15*	*7.94*
Average Project Scores by Track	**Technical Merit & Relevance**	**Weighted Average Performance**	*Weighted scores used in determining Performance** — Approach & Methodology	*Weighted scores used in determining Performance** — Accomplishments & Progress	*Weighted scores used in determining Performance** — Communication, Coordination, & Commercialization	**Upcoming Activities** (if applicable)
Technology Development	**8.01**	**7.83**	7.51	7.61	7.48	**7.49**
Market Acceleration	**9.67**	**8.83**	9.08	8.74	8.74	**8.41**
Analysis & Modeling	**8.31**	**8.45**	8.03	8.54	8.69	**7.95**

*See Section 2.4 for the weighted average methodology used to determine the "Performance" metric.

All three tracks performed well, with MA&D scoring the highest of the three. The lowest of the scores in Table ES-2 is 7.48 for the Communication, Coordination, & Commercialization subcomponent in Technology

Development projects; however, this is an increase from the 2017 Peer Review, in which Communications & Outreach for Technology Development projects scored 3.4 out of 5.[2]

The following three graphs (Figure ES-2, Figure ES-3, and Figure ES-4) plot the relative scores of each of the projects evaluated within the three program areas, with weighted average project performance on the [X] Axis and technical merit and relevance on the [Y] Axis. The boxes on the graph represent 1σ and 2σ (standard deviations) from the average of all the scores within that program area. The better a project scored overall, the higher and farther to the right the representative dot for that project is located on the plot. The intersection of the dashed lines on the plots shows the average scoring of the two metrics for each track, with the darker and lighter shaded areas around it indicating one and two standard deviations (1σ and 2σ) from that average, respectively.

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 of 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 responsible WETO technical leads to determine why certain projects scored higher or lower than others, as well as what programmatic adjustments could be made to ensure highest levels of performance for all projects.

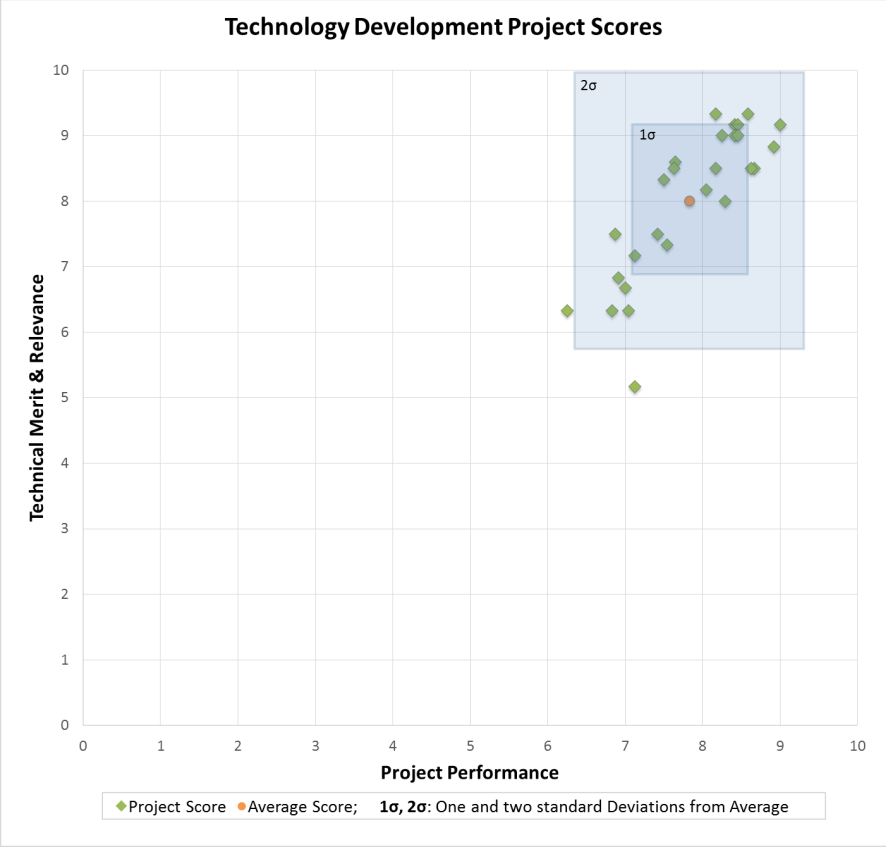

Figure ES-2. Average scores for relevance and weighted average performance for projects within the TD track

[2] The 2017 WETO Peer Review Report is available on the DOE website: https://www.energy.gov/eere/wind/downloads/2017-peer-review-report

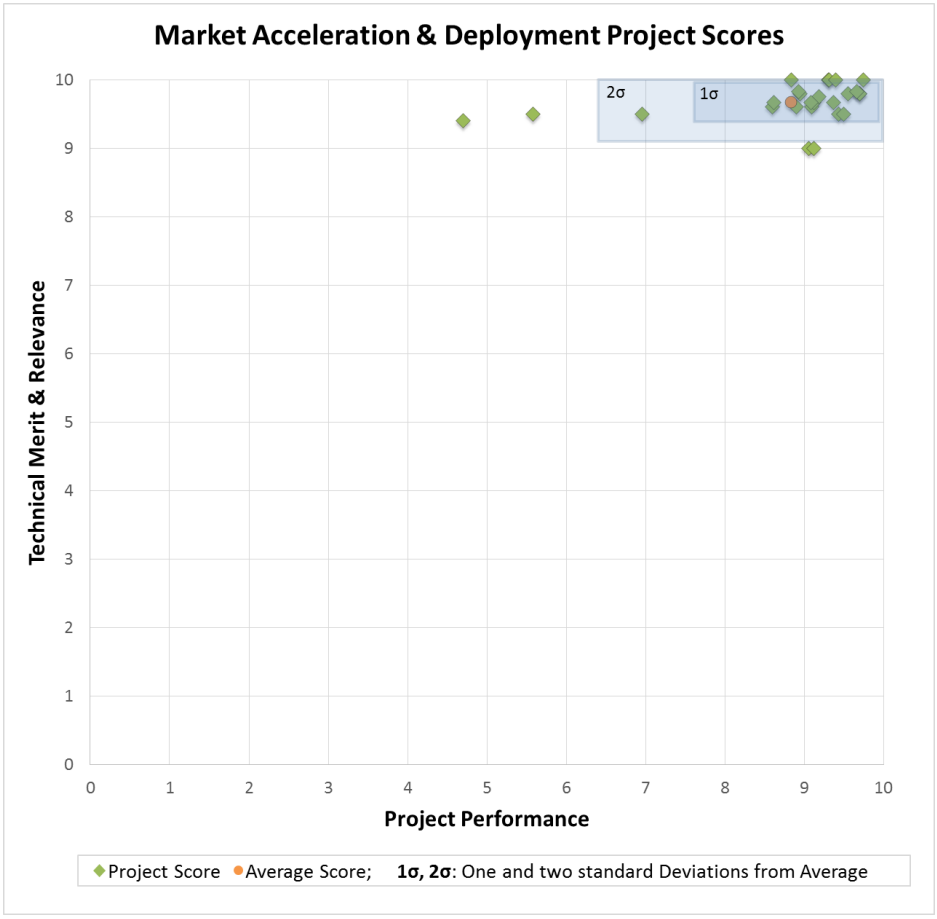

Figure ES-3. Average scores for relevance and weighted average performance for projects within the MA&D track

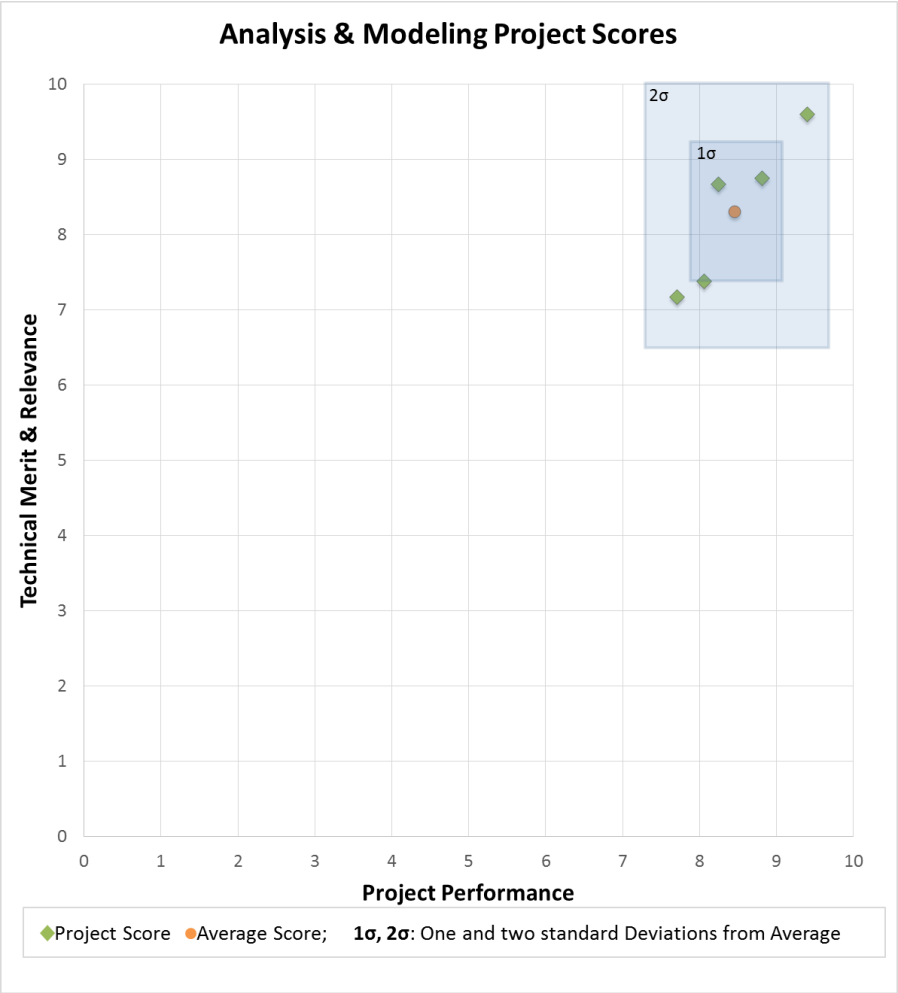

Figure ES-4. Average scores for relevance and weighted average performance for projects within the Analysis track

Figure ES-5 summarizes the reviewer scoring for technical merit and project performance of all the reviewed projects arranged by the three program review tracks within the WETO peer review.

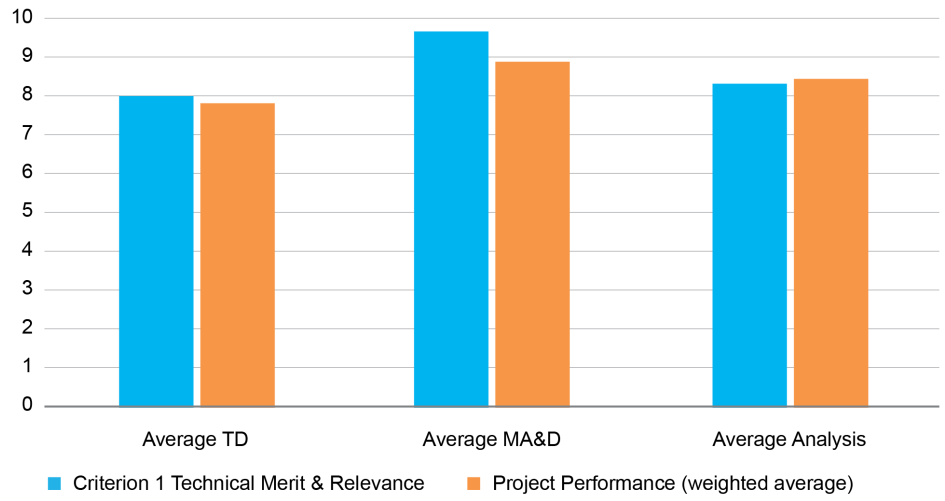

Figure ES-5. Average reviewer scores for all projects by program area

Figure ES-6 summarizes reviewers' quantitative assessments of how WETO is performing overall based on four office-level criteria.

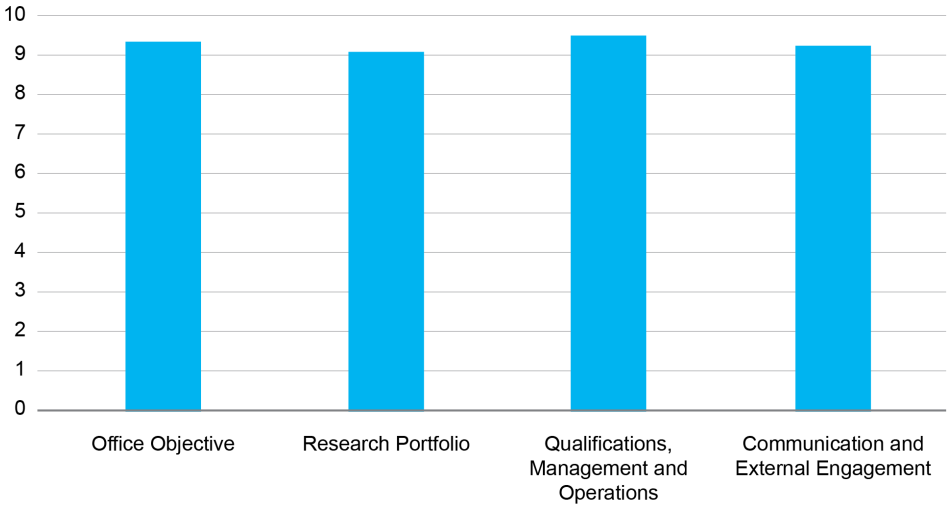

Figure ES-6. Average reviewer scores for the four office-level criteria

Overall, the average scores reflected in Figures ES-5 and ES-6 indicate that reviewers rated the office's approach, execution and individual projects as "Good" (7–8 on the scale) or "Outstanding" (9–10 on the scale).

Overview of Qualitative Comments (Office and Program-Level)

In addition to quantitative scoring, each member of the review panel provided qualitative comments on WETO as a whole; on each of the program and technical activity areas; and on all the individual projects that were reviewed. A representative sampling of the office and program-level comments by reviewers is provided in Table ES-3. They were selected to illustrate key themes and trends from the feedback received. Representative reviewer comments at the office level, as well as at each program and activity area evaluation level, can be found in sections 3 through 6 of Volume I, along with WETO responses. Complete comments can be found in Volume II. All peer review comments have been considered by WETO staff and integrated into program and project management and planning as appropriate.

Table ES-3. Sample Office and Program-Level Comments

Strengths Identified by Peer Review Panelists
• "The current research portfolio aligns well with the office's objectives, effectively meets those objectives, represents an effective use of appropriated funds (particularly considering the private sector cost-sharing and technology investment spurred by the office's efforts), and is generating results in reducing barriers to deployment and levelized cost of energy (LCOE) for wind energy." • The office's oversight and organization of the various programs and labs is "clear with priority alignment communicated at all levels." • The office has a "strong strategy" with which its various activities and programs are aligned. The office ensures that its management and operations are advancing the goals of the office, are driving down the cost of wind energy, and are an adequate, defensible use of taxpayer funds. • The office is staffed by "incredibly competent professionals who understand key needs and priorities for the industry." In particular, the office has "incredible internal capacity for modeling and analytics," which has been critical to driving priorities and tailoring future activities. • Most projects were delivered on time and within budget, with most delays being managed well. • "The level of collaboration across industry, interest groups, and academia is world-class and truly impressive." • The office "does a great job of communicating to key stakeholders while also communicating to the general public." "One of the greatest strengths and roles of this office is its ability to disseminate and explain credible information."
Weaknesses or Potential Issues Identified by Peer Review Panelists
• Not all projects successfully communicated how they are contributing to advancing the state of maturity of technology. • Several projects were unable to complete their field work due to company insolvency or over-scoping of activities. Efforts should be made at the front end to prevent this from occurring in the future. • The focus on safety and safety qualifications needs to be improved. • More research and focus on offshore wind is needed in the Market Acceleration and Deployment Program. • Suggest increased Market Acceleration and Deployment work. "This work is as important as the technology and development work of driving down costs and overcoming barriers to siting." These market and acceleration challenges are only expected to grow as the industry builds out, and as such, focused attention is needed now to overcome these barriers.
Specific Recommendations of Peer Review Panelists
• The office should "focus on ensuring the right mix between small, medium, and large projects, making sure to cover projects from low technology readiness levels (TRLs) to high TRLs." • Continue to engage industry as much as possible. • Improve coordination with other stakeholder groups to leverage knowledge, skills, experience, etc. • Academic collaboration should be increased. Sponsor more graduate students. • Have all team leads and above involved in any physical activity complete OSHA 30-hour training.

Table ES-4. Generalized Overview of Office Responses to Reviewer Comments

Summary of Office Response to Reviewer Feedback (Office and Program-Level)
• The office agrees with the comments highlighting the continued value that outreach and engagement with external stakeholders can bring to the design of future initiatives that continue to reduce the cost of wind energy and remove barriers to continued deployment. • Regarding the comments on the relevance and value of our research portfolio, we have and will continue to work on planning and executing a balanced and results-driven research portfolio that aligns with industry and stakeholder needs. This will continue to be informed by timely input from the office's private and public sector partners, strategic analysis to determine most appropriate technology innovation activities, and measuring and reporting on the results. The office will always strive to maintain its standing as an independent and valued source of information for our stakeholders. • The comments acknowledging our effective management, strategic direction, and operational oversight of our enterprise are appreciated. We recognize that the professional capabilities and expertise of our staff enable effective portfolio planning and execution. We also understand the need to recognize shortcomings and areas for growth and improvement to continue developing the next-generation workforce capable of addressing the challenges of the future. The office also recognizes the need to apply "lessons learned" from past project failures, while continually monitoring ongoing projects to identify potential failure points and mitigate the risk to maximize the benefits of public funding. • The office agrees with the comments recognizing the need to include hands-on industry expertise throughout all levels of activities as appropriate, particularly for later-stage research. We will continue to seek opportunities for early and sustained input from external experts. • Recommendations were made by the reviewers regarding the need for a balanced portfolio, increased and focused market acceleration and deployment activities, and ensuring that cross-cutting DOE and EERE-level grid activities align with wind industry interests. The office will continue to seek input on the most appropriate use of limited program funding and will work with external and internal stakeholders to plan and execute an investment portfolio that maximizes the benefit to the wind industry, its stakeholders, and U.S. taxpayers. • Comments were shared with respect to continuing communications and external engagement. The office takes great care to: promote interaction, coordination, and cooperation with key external stakeholders through direct dialogue and by producing high-level events, summits, and executive roundtables; provide high-quality, impactful, objective communications products and information services to the right people at the right time—informing them of the work WETO does and demonstrating its impact; and coordinate with project awardees to ensure they are communicating project results. • The office plans to continue its efforts to ensure that industry needs inform WETO research, development, and market acceleration activities to sustain a long-term approach to technological innovation and system integration efforts.

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1 The Wind Energy Technologies Office

1.1 Background and Mission

Wind energy provides over 6% of U.S. annual net electricity generation.[i] Today, with the help of a federal production tax credit, prices for land-based wind in regions of the country with good wind resources and access to transmission are low, in many cases under 2 cents per kilowatt-hour (cents/kWh).[ii] Over 100 gigawatts (GW) of land-based wind is deployed across 41 states,[iii] supporting over 110,000 U.S. jobs,[iv] and providing enough electricity to power 30 million U.S. homes.[v] The United States has been a global leader in small wind and has over 83,000 wind turbines deployed in distributed applications across all 50 states.[vi] An offshore wind industry is developing in the United States, and it is driven by falling offshore wind turbine prices, accelerated federal offshore wind lease auctions,[vii] and state policies. Even with this success, continued wind energy science and technology innovation offer the potential for wind energy to add substantially more value nationwide.

DOE's Wind Energy Technologies Office drives innovation through research, development, and testing of advanced wind energy technologies. The portfolio focuses on land-based, offshore, and distributed wind, as well as integration of wind energy on the grid. The primary goal is cost reduction, while also informing market choices; ensuring the reliability, resilience and security of wind power and the grid; exploring means for mitigating siting and environmental challenges; and nurturing a robust U.S. manufacturing sector and related workforce. The work is underpinned by investments in related science, modeling and analytical tools; complemented by selective, cost-shared demonstrations; and carried out as collaborations with industry, academia, DOE National Laboratories and facilities, and other research enterprises.

There is significant untapped wind potential in every region of the nation. There are numerous key opportunities for federal government research and development (R&D) investment to drive U.S. wind technology and siting costs even lower—increasing cost competitiveness on a fully unsubsidized basis. This would expand the wind energy resource extraction potential nationwide and further increase the value of wind energy to the nation. With its continued unique role in federal science-driven research, the office can provide leadership in supporting industry to develop the next generation of wind technology innovations—driving economic benefits for U.S. manufacturers, businesses, and consumers.

DOE wind energy efforts over the past four decades have led to significant innovation and cost reductions. From 1976 to 2008, the office ranked first in wind energy patents and citations linked to commercial power from wind.[viii] As of 2019, WETO-sponsored R&D has resulted in 155 wind energy patents and over 20 patents pending. Driven by DOE-funded R&D and market barrier mitigation, as well as industry innovation, the unsubsidized cost of wind energy in good to excellent U.S. wind sites has dropped 90% since 1980.[ix]

1.2 Research Objectives

The projects presented at the 2019 Wind Energy Peer Review aligned with one or more R&D objectives for projects awarded within the fiscal year (FY) 2017–FY 2018 timeframe, including:

- Reducing costs and improving performance through applied R&D of components or whole technology systems
- Validating technologies and reducing risk by confirming the performance of technologies, both in controlled laboratory and real-world conditions, and providing benchmarks for performance and durability
- Reducing market barriers by addressing specific gaps—such as a lack of reliable publicly available sector data; inadequate skill standards for the clean energy workforce; and lack of environmental impact assessment and mitigation technologies, as well as data gathering, analysis and dissemination

- Optimizing energy production through complex aerodynamics R&D, wind plant reliability improvement, and resource characterization
- Optimizing grid integration through interconnection studies and operational forecasting tool development.

1.3 Budget Overview

The 2019 Wind Energy Peer Review evaluated projects that were active in FY 2017 and FY 2018. EERE guidelines call for peer reviews to cover projects representing, in aggregate, at least 80% of a program's project-related funding during the review period.

The total WETO funding for projects initiated, active, or completed during these two years was $253.7 million. This total includes funding appropriated to the office during those fiscal years, plus carryover funding from prior year appropriations. With funding and in-kind contributions from industry and other project partners included, the total funds applied to WETO-supported projects in FY 2017–FY 2018 exceeded $500 million.

The project funding was distributed through three WETO program areas (as illustrated in Figure 1-1): Technology Development and Scientific Research (TD); Market Acceleration and Deployment (MA&D); and Modeling and Analysis (Analysis). Additionally, WETO had funding of just over $16.5 million across the program for Operations and Communications, supporting the execution of the program budget. Reviewers evaluated 100% of WETO's active FY 2017–FY 2018 R&D projects during the 2019 Peer Review. Internal program operations and management and communications were addressed during peer review as part of the office-level assessment.

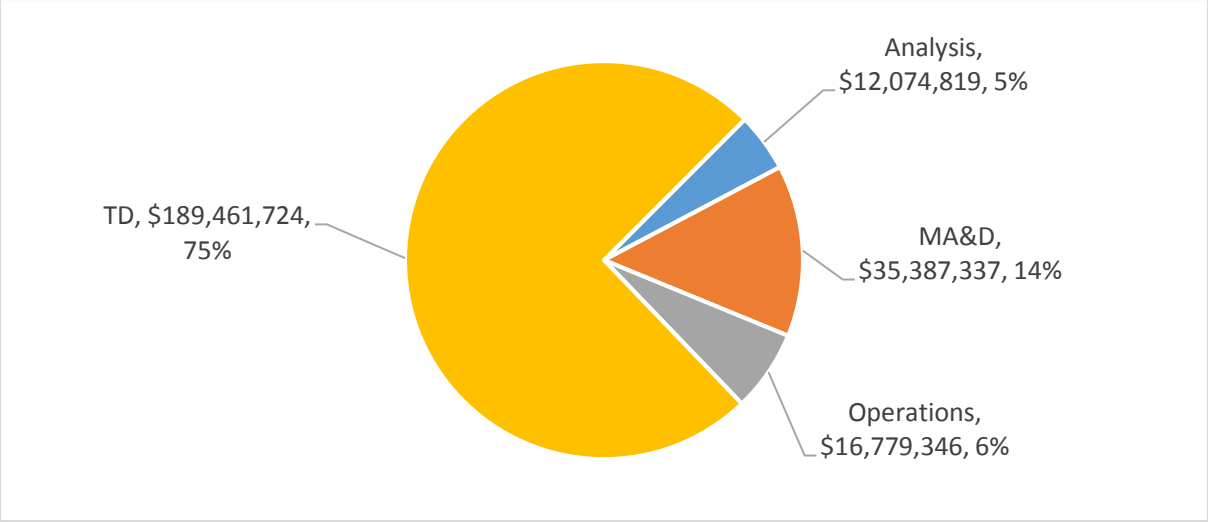

Figure 1-1. Breakdown of WETO funding during FY17–FY18 by program area

1.4 Organization

WETO is housed within EERE, under DOE's Office of the Under Secretary for Science and Energy. EERE is made up of three major sectors—each of which has several technology offices. WETO is housed within the Renewable Power sector, which also comprises Geothermal, Solar Energy, and Water Power Technologies Offices. Formerly part of the integrated Wind and Water Power Technologies Office, WETO became a stand-alone entity in 2016.

WETO's role is codified through public law and informed by the priorities and guidance of the Administration, Congress, DOE, and EERE; Congress makes budget appropriations.

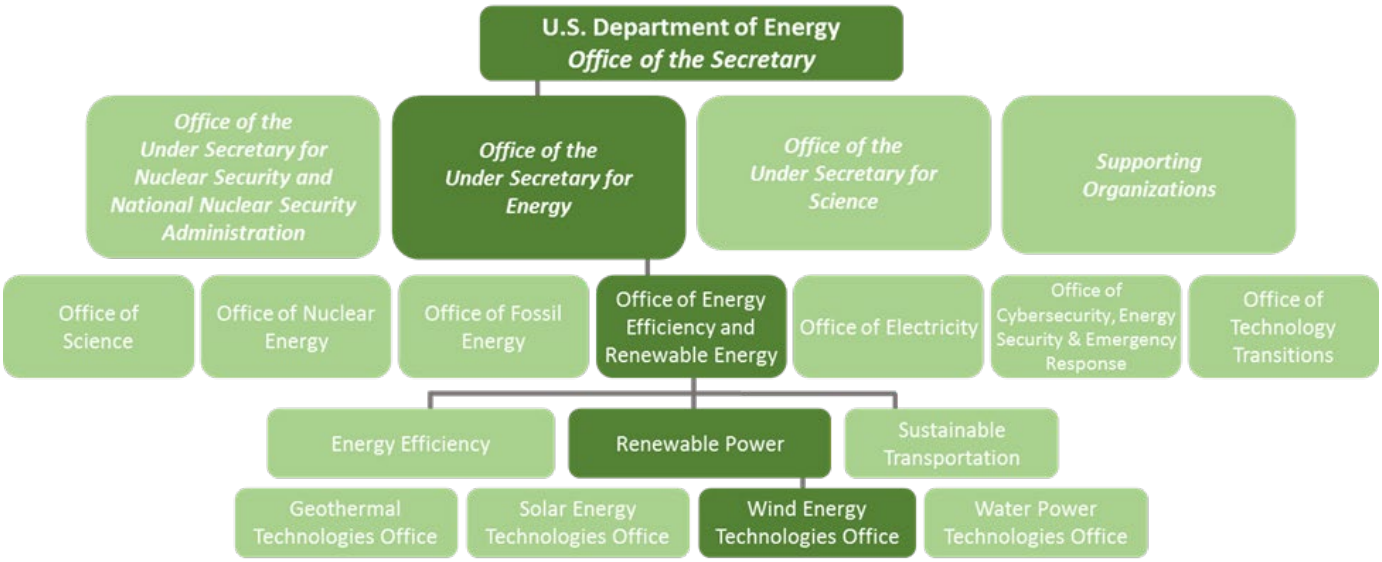

Figure 1-2. DOE organization indicating WETO's position within EERE

Since the 1970s, WETO has evolved to reflect the changing status, needs, and prospects of wind power technology. In the peer review period, the office's roles included:

- Scientific research
- Technology innovation and evaluation
- Leadership in the wind community
- Formation and management of collaborations
- Facilitation of stakeholder interactions and education
- Outreach to the broader energy community.

The overall aim has always been to develop and enable the installation of competitive and reliable wind power in U.S. electrical grid.

The activities and projects of the office support the development of three market segments: (1) offshore wind, (2) land-based wind, and (3) distributed wind, as well as a fourth category, grid integration, which integrates the energy production of the first three to maintain a reliable, cost-effective, and cyber secure grid infrastructure. Activities and goals within these segments include the following:

- **Offshore wind** – technology development and siting and permitting research initiatives needed to support the development of shallow water, fixed-bottom wind energy in the short term and floating offshore wind energy in the longer term
- **Land-based wind** – technology development and siting and permitting research initiatives needed to achieve land-based cost reduction goals and expand access to U.S. land-based wind resources for utility-scale wind energy
- **Distributed wind** – technology development and siting and permitting research initiatives needed for distributed wind energy technology to generated power and connect at the electrical grid distribution system level
- **Grid systems integration** – research needed to integrate increasing levels of wind energy into the grid, while maintaining cost effectiveness, reliability, cyber security, and resiliency.

2 Peer Review Overview

2.1 Background and Strategy

From April 30 to May 2, 2019, WETO conducted its 2019 Peer Review at the Hilton Alexandria Old Town hotel in Alexandria, Virginia. A total of over 130 principal investigators (PIs), researchers, stakeholders, and WETO staff attended.

WETO leadership and project managers use the peer review results to help inform programmatic decision making, modify or discontinue existing projects, guide the future funding and direction of newly funded projects and future opportunities, and support other budget and strategic planning objectives.

This report details the observations and findings of the WETO reviewers, WETO's response to these findings, and the supporting meeting materials, including an agenda and list of participants in Volume II.

EERE recognizes the value of objective review and advice from peers—known as "peer review"—as an important tool for "enhancing the relevance, effectiveness and productivity of EERE's projects." As such, EERE requires its offices to conduct regular peer reviews and to consider the findings of those peer reviews in program planning. Under EERE peer review guidance, "Results of Peer Reviews should inform Office planning, including Multi-Year Program Plan development, Lab and Annual Operating Plans Planning, and Funding Opportunity Announcement Planning."[3]

DOE offices generally hold peer reviews on a recurring basis approximately every two years. EERE guidelines call for peer reviews to cover projects representing, in aggregate, approximately 80% of a program's project-related funding during the review period.

WETO held its previous peer review in 2017, covering activities for FY 2014, 2015, and 2016. The 2017 WETO Peer Review report is available on the DOE website.[4] The 2019 WETO Peer Review evaluated activities for FYs 2017 and 2018.

In accordance with EERE guidelines, the review evaluated a selection of WETO-funded projects for their contribution to the mission and goals of the office, to assess progress made against stated objectives, and to assess overall management and performance of the office. The peer review was structured to facilitate objective evaluation of the strategy and goals of WETO and the progress and accomplishments of projects funded by the office in FYs 2017 and 2018. There was also a strong emphasis on fostering research-focused

[3] The EERE Peer Review Program Guide is available on the DOE website: https://www.energy.gov/eere/downloads/eere-peer-review-guide.
[4] The 2017 WETO Peer Review Report is available on the DOE website: https://www.energy.gov/eere/wind/downloads/2017-peer-review-report

interactions among DOE's National Laboratories, industry, and academic institutions; and facilitating dissemination of information regarding WETO-funded projects.

As part of the 2019 Peer Review, reviewers evaluated 58 WETO projects organized into three tracks by program, with activity areas grouped by topic within each program, as outlined in Table 2-1

Table 2-1. WETO Peer Review Programs and Activity Areas, Including Number of Projects Reviewed in Each

Program	Activity Areas	Number of Projects
TD	Offshore-Specific R&D	4
	Atmosphere to Electrons	10
	Distributed Wind	1
	Testing Infrastructure	2
	Standards Support and International Engagement	1
	Technology to Market and Small Business Vouchers	4
	Advanced Components, Reliability and Manufacturing	5
MA&D	Stakeholder Engagement and Workforce Development	3
	Environmental Research	13
	Regulatory and Siting	3
	Grid Integration	7
Analysis	Analysis and Modeling	5
	Total Projects Reviewed	**58**

Reviewers evaluated a total of 58 WETO projects during the 2019 Peer Review, representing 100% WETO's active project funding during FY 2017 and 2018.

Six peer reviewers were assigned to evaluate each project, except in the event of a conflict of interest. At a minimum, there were five reviewers assigned to each project. Each reviewer provided both numeric evaluations and written comments in response to project presentations by PIs, as well as written project summaries. The reviewers were also asked to provide office-level, program-level, and activity area evaluations based on presentations by the office management and technical program leads.

2.2 Peer Review Panels

For the 2019 Peer Review, WETO commissioned a peer review panel composed of 12 reviewers to conduct the formal peer review. Reviewers were experts from wind energy-related organizations, including industry, academia, trade organizations, and technical and environmental organizations.

WETO screened reviewers to ensure no conflicts of interest existed on reviewed projects. Reviewers submitted recusals from projects on which they worked or for which they had relationships with project team members or a financial interest in the subject matter. Table 2-2 lists the 2019 WETO peer reviewers. There were six reviewers assigned to the TD track and six reviewers to the MA&D track. All reviewers participated in and evaluated the Analysis track.

Table 2-2. WETO 2019 Peer Reviewers[5]

TD Track	
Reviewer	*Affiliation*
Dan Brake, Chair	NextEra Energy Resources
Christina Aabo	Orsted
Sandy Butterfield	Boulder Wind Consulting
Jereme Kent	One Energy
Jacques Nader	Siemens Gamesa Renewable Energy
Fotis Sotiropoulos	Stony Brook University
MA&D Track	
Reviewer	*Affiliation*
John Anderson, Chair	Nossaman LLP
Jody Dillon	Energy Reform Limited
Hannele Holttinen	VTT Technical Research Centre of Finland
Joy Page	Defenders of Wildlife
Sam Enfield	Windline Development, LLC
Catherine Bowes	National Wildlife Federation

The peer review planning team provided reviewers with briefing materials and guidance via web conference sessions and a website prior to the meeting. This information included a peer review plan that included reviewer instructions, the peer review agenda, the PowerPoint presentations[6] and 2-page project summary documents submitted by project PIs, a review of the overall goals of the office, and the online evaluation workbooks. Reviewers were required to submit conflict of interest forms if applicable. Unless they declined compensation, the reviewers received honoraria for their time, as well as travel and per diem reimbursement.

Two chairpersons were selected to oversee the peer review tracks and review process: Mr. Dan Brake presided over the TD track, and Mr. John Anderson presided over the MA&D track. The primary role of the chairs was to provide oversight and guidance to ensure consistency, transparency, and independence in the peer review process. The chairs also submitted project evaluations.

2.3 Project Selection Process

WETO used a multi-step process to identify and select projects for review at the 2019 Peer Review and to plan the agenda. These steps included:

1. The office assessed all funding and expenditures in FY 2017 and FY 2018 across the portfolio of both National Laboratory and competitively awarded funds.

    - WETO included any active project competitively awarded through the funding opportunity announcement (FOA) process, including those funded during prior fiscal years but active or completed during FY 2017–2018.

[5] All reviewers participated in the Analysis track.
[6] The 2019 WETO Peer Review presentations are available on the WETO website: https://www.energy.gov/eere/wind/2019-wind-program-peer-review-presentations

- For projects at DOE's National Laboratories, the WETO peer review team worked with WETO technical program managers to identify which individual funding actions across the labs were closely related in scope. The related groups of funded actions were combined to represent a single "project." For example, in case of the TD project "Atmosphere to Electrons (A2e): Mesoscale Physics and Inflow: Wind Forecast Improvement Project 2," 6 different funding actions were combined to represent a single project. In other cases, stand-alone funding actions at the National Laboratories (with no other lab partners) were also treated as "projects."

2. WETO management and technology managers provided high-level guidance about project selection and agenda planning, including:

    - Logistics, such as total amount of time to allocate at the peer review for project presentations
    - Organization of research portfolio into tracks incorporating the WETO programs and activity areas within each
    - Priority projects considered mandatory for review.

The selected projects and subject-matter areas were organized into a multi-track session agenda reflecting overall WETO activities by programs and activity areas.

Because the scope and length of many projects reviewed in this peer review were not limited to the FY 2017–FY 2018 period, WETO established a framework to define what project work and duration to consider in the review. As part of WETO's normal operational policy, multi-year projects funded through DOE's National Laboratories are merit reviewed by an external panel before the decision to fund them through a lab's Annual Operating Plan (AOP) is made. Project duration is the total length of an AOP project, as negotiated and officially approved during the merit review process. While these projects are funded annually, the total planned duration of a given project may extend for three years or longer. For projects competitively awarded through the FOA process, project duration is considered to be the contractual period of performance (from award date to completion date).

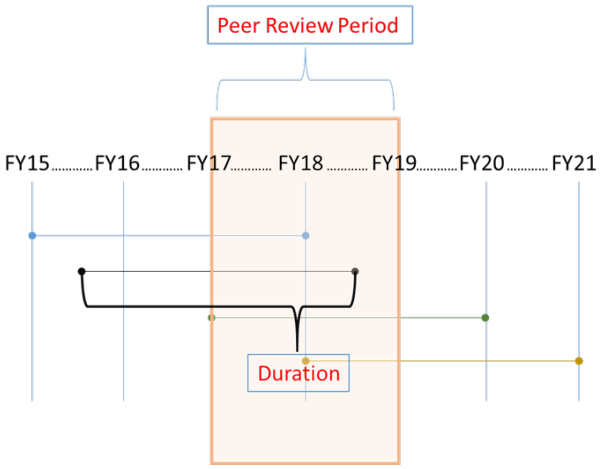

Figure 2-1. Illustration of Project Duration for Peer Review Purposes

As noted in Section 1.3, project budgets include not only the funds allocated to each project in a given fiscal year (referred to as Budget Authority), but also include carryover funds from previous fiscal years. For the 2019 Peer Review, a national laboratory's AOP project budget was defined as: FY 2017 Beginning Uncosteds[7] + FY 2017 Prior Year Unobligated Carryover[8] + FY 2017 Budget Authority[9] + FY 2018 Prior Year Unobligated Carryover + FY 2018 Budget Authority. For competitive awards, WETO defined the budget as the total award amount + the cost share[10] provided by the awardee.

2.4 Evaluation Criteria

In accordance with EERE peer review guidance, the peer review panelists were asked to submit both quantitative (i.e., numerical scores) and qualitative (i.e., narrative comments) evaluations as part of their review of WETO and its research portfolio.

The peer review panel evaluated WETO and the WETO project portfolio at four organizational levels, assessing the management, performance, and effectiveness of: (1) the office as a whole ("office-level" evaluation); (2) the three program areas ("program-level"); (3) each of the activity areas within the programs ("activity-level"); and (4) each individual project ("project-level").

The evaluation process and criteria for each level of evaluation are summarized below. For reference, each of the evaluation forms used by the reviewers is included in the Appendix of Volume II of this report. Numeric scores were based on a 10-point scale, with a 1 corresponding to an "Unsatisfactory" rating and a 10 corresponding to "Outstanding." More information on scoring can be found in the evaluation forms.

Office-Level Evaluation Criteria

Reviewers were asked to provide both comments and numerical scores to evaluate the overall objectives and performance of WETO based both on specific office overview presentations and on general impressions from all the peer review presentations.

Office-level assessments were based on the four criteria listed below, with specific questions provided under each criterion, on which the reviewers based their scoring:

1. Office objectives
2. Research portfolio
3. Qualifications, management, operations
4. Communications and external engagement.

The reviewers were asked to comment on the strengths and weaknesses behind their scoring and to provide recommendations for the office to consider.

Program and Activity Area Evaluation Criteria

Reviewers were asked to separately provide comments on the programs and on the activity areas within them in response to the seven questions listed below. No numerical scores were provided at these two evaluation

[7] *Beginning Uncosted* refers to funds obligated to a project in a previous year that remain uncosted and are being carried over to a subsequent year. For example, in FY 2017, if your budget was $100, and you spent $75, you would have $25 in carryover. In FY 2018, at the beginning of the year, the balance you carried over ($25) from FY 2017 becomes "Beginning Uncosteds."

[8] *Prior Year Unobligated Carryover* refers to unspent funds from prior year appropriations that WETO can obligate to a previously unassociated project. They are not part of the current fiscal year Budget Authority, nor are these funds considered to be Beginning Uncosteds, as they are funds "new" to the project.

[9] *Budget Authority* refers to the maximum amount of congressional appropriations authorized by WETO or by congressional direction for obligation to a project in that specific fiscal year.

[10] *Cost Share* refers to the financial or in-kind resources a project awardee leverages against the federal funding awarded to that project. Cost share percentages range, depending on award requirements.

levels. In answering these questions, the reviewers responded to specific program and activity area presentations; they were also asked to take into account their scores and general impressions of the individual projects within those areas.

Review questions:

1. Are the activities and projects within this portfolio on the leading edge of work within this field?
2. Has the rationale behind the funded activities and projects been effectively conveyed during the peer review?
3. Within this field, are thought leaders aware of the WETO-supported work?
4. Are there important topic areas that are underrepresented or missing within the program (or activity area)?
5. Are there any notable strengths to the program portfolio content or direction that you would like to point out?
6. Are there any notable weaknesses to the program (or activity area) portfolio content or direction that you would like to point out?
7. What recommendations would you like to convey to the manager(s) of this program (or activity area)?

Project-Level Evaluation Criteria

Reviewers were asked to provide both comments and numerical scores in evaluating the individual projects based both on the project presentations by the PIs and on the written project summaries that the PIs provided in advance of the peer review.

Project assessments were based on the five criteria listed below, with specific questions provided under each criterion, on which the reviewers based their scoring:

1. Technical Merit and Relevance
2. Approach and Methodology
3. Accomplishments and Progress
4. Communication, Coordination, and Commercialization
5. Upcoming Project Activities *(only if applicable)*.

For purposes of comparison between projects, scores of criteria 2–4 were combined into a "Weighted Average Performance" metric. The relative weighting of each criterion within that average is provided in Table 2-3 below.

Table 2-3. Criteria and Weighting Applied in "Weighted Average Performance" Metric

Performance Criteria	Weighting of Scores
Criterion 2 – Approach and Methodology	25%
Criterion 3 – Accomplishments and Progress	50%
Criterion 4 – Communication, Collaboration, and Commercialization	25%

The "Technical Merit" and "Performance" results were then plotted in a graph with the results of the other projects in each activity and program area, as well as with all the office projects taken as a whole.

The reviewers were asked to comment on the strengths and weaknesses reflected in their scoring of each criterion and to provide project recommendations for consideration by the office and the individual PI.

3 Summary of Office-Level Results and Responses

3.1 Overview

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

Office-Level Evaluation Criteria

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

1. Office Objectives

   Overall, the office's portfolio of funded projects:

   - Reflect an understanding of the near- and long-term challenges facing industry and other wind energy stakeholders
   - Meet the needs of industry and other stakeholders in addressing those challenges to realize opportunities for economic growth, technical advancement, and/or dissemination of objective information

2. Research Portfolio

   Overall, the office's portfolio of funded projects:

   - Align with the stated office objectives
   - Effectively meet those objectives
   - Represent an effective use of congressionally appropriated funds
   - Meet the office's objectives by generating results of near- or long-term value to industry and other stakeholders

3. Qualifications, Management, Operations

   Overall, based on both the programmatic and project presentations, the office team:

   - Effectively manages and directs the activities needed to meet its objectives
   - Demonstrates the professional capabilities needed to identify, monitor, and guide its portfolio of projects
   - Has operations and oversight procedures in place to ensure efficient direction of office activities, both internally and with project awardees

4. Communications and External Engagement

   Overall, the office:

   - Engages with industry, academia, other agencies, non-governmental organizations, and international research organizations to ensure high levels of cooperation and information exchange
   - Effectively disseminates information regarding its activities and results of its funded projects
   - Ensures that its project awardees engage in effective communication regarding project results

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

3.2 Quantitative Office-Level Results

This section includes graphs that summarize the reviewer scoring at the WETO office level and for all the WETO projects that were reviewed; and how the project scores within each of the three WETO program areas compare to each other.

Figure 3-1 summarizes reviewers' quantitative assessments of how WETO is performing overall based on the four office-level criteria that peer reviewers scored.

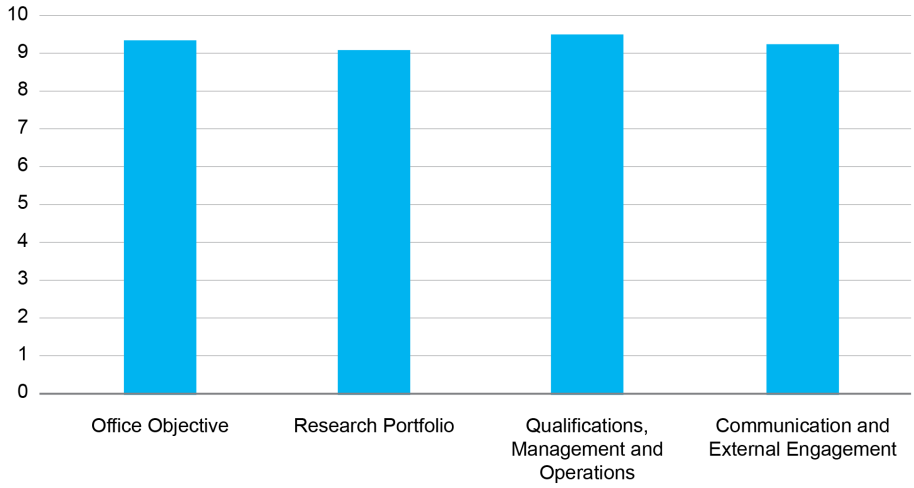

Figure 3-1. Average reviewer scores for the four office-level criteria

Figure 3-2 summarizes the reviewer scoring for technical merit and project performance of all the reviewed projects arranged by the three program review tracks.

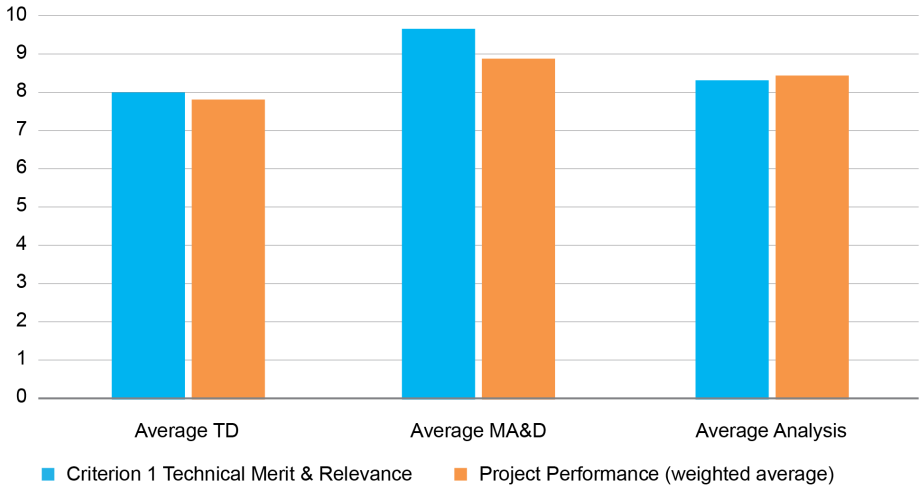

Figure 3-2. Average reviewer scores for all projects, by program area

The average scores for all individual projects are further broken down by evaluation metric in Table 3-1. These averages are provided first for all WETO projects as a whole on the top line of the table, followed by the three program tracks at the bottom.

Table 3-1. Average Scores for Peer-reviewed WETO Projects by Evaluation Metric

Average Scores for all WETO Projects	*8.78*	*8.33*	8.26	8.20	8.15	*7.94*
Average Project Scores by Track	**Technical Merit & Relevance**	**Weighted Average Performance**	*Weighted scores used in determining Performance**			**Upcoming Activities** (if applicable)
			Approach & Methodology	Accomplishments & Progress	Communication, Coordination, & Commercialization	
Technology Development	**8.01**	**7.83**	7.51	7.61	7.48	**7.49**
Market Acceleration	**9.67**	**8.83**	9.08	8.74	8.74	**8.41**
Analysis & Modeling	**8.31**	**8.45**	8.03	8.54	8.69	**7.95**

*See Section 2.4 for the weighted average methodology used to determine the "Performance" metric

3.3 Representative Office-Level Comments and WETO Responses

For each of the four evaluation criteria, a representative sampling of comments on strengths and weaknesses is provided below, chosen to convey a balanced impression of the reviewer's inputs. A complete list of all comments can be found in Volume II of this report.

Following the representative comments, WETO's response to the reviewer feedback is provided under each criterion.

Criterion 1 – Office Objectives

Representative comments:

- The objectives of the office are well balanced and have a significant, noticeable impact on the industry. The focus on cost reductions and mitigation of deployment barriers is appropriate and effective. The core activities of the office are vital to the industry and advance the state of the art.
- The office objectives are broad, primarily long-range (good), but include some short-term objectives (primarily demonstrations). In general, they appear to meet industry needs, but may be based on industry's short-term focus.
- The office's aggressive approach has effectively invigorated industry and non-government organization (NGO) partners and has attracted significant cost share—yielding incredible returns for taxpayers. WETO is playing an important, centralized role in driving the future of the industry and focusing on longer-term issues that the industry doesn't have the energy to focus on—especially now as the Production Tax Credit winds down.

Office Response

Several reviewers noted the strong alignment between the portfolio of the office investments and industry and broader stakeholder needs. We agree that continued value can be realized through outreach and engagement with external stakeholders as we design future initiatives that continue to reduce the cost of wind energy and remove barriers to continued deployment within the U.S. electricity sector.

Criterion 2 – Research Portfolio

Representative comments:

- The office's research portfolio is strong and covers key industry priorities to drive down costs and increase integration and penetration on the grid. It is impressive to see the broad reach of this research portfolio and also the impressive prioritization that DOE has undertaken to address the most pressing needs for industry.
- The current research portfolio aligns well with the office's objectives, effectively meets those objectives, represents an effective use of appropriated funds (particularly considering the private sector cost-sharing and technology investment spurred by the program efforts), and is generating results in reducing barriers to deployment and levelized cost of energy (LCOE) for wind energy. The funds are distributed to different fields of R&D in a sensible way, cover all relevant main areas, and are used effectively.
- The program continues to have a big impact and continues to have a strong leadership role, bringing multiple agencies and interests together to work constructively on a broad range of relevant issues.
- More focus is needed in offshore wind on key issues facing the industry today and in the future (such as backbone grid) to support reaching full potential. Additionally, address grid system impacts of very high instantaneous amounts of variable renewables coming online, along with system behavior. Continuing studies of flexibility adequacy in the system with an explicit representation of uncertainty is important.
- Additional focus and vision are needed on distributed wind activities, impacts of and mitigation options for noise and icing, and enhanced academic collaboration through sponsorship of graduate students.

Office Response

The office agrees with the reviewer's comments regarding the relevance and value of our research portfolio. We have and will continue to work on planning and executing a balanced and results-driven research portfolio that aligns with industry and stakeholder needs. This will continue to be informed by timely input from the office's private and public sector partners, strategic analysis to determine most appropriate technology innovation activities, and measuring and reporting on the results. The office will always strive to maintain its standing as an independent and valued source of information for our stakeholders.

Criterion 3 - Qualifications, Management and Operations

Representative comments:

- The office has a strong strategy through which they align various activities across and within subprogram elements. By articulating this strategy, the office is ensuring that its management and operations are advancing goals across the office and driving down the cost of wind energy and are an adequate, defensible use of taxpayers' money. In addition, it is clear that the office is staffed by incredibly competent professionals who understand key needs and priorities for the industry.
- The office is being effectively run and managed; and, through stakeholder engagement and the peer review process, is ensuring that oversight of the program is effectively maintained.
- "The office's oversight and organization of the various programs and labs is clear, with priority alignment communicated at all levels. These qualities are seen in well-run private organizations and I appreciate them being so clear in WETO."
- Some projects failed to deliver at the critical stage. This isn't necessarily a weakness, but it is evidence of an appropriate amount of risk-taking on the part of the office, which is

important. However, perhaps there are lessons to apply to future projects (e.g., functional testing of devices before field testing is important).

- Figure out how to incorporate industry workforce participants into later-stage research. Practical, hands-on field experience from industry workforce participants would provide value in the practical applicability of the later-stage programs.

Office Response

Reviewer comments acknowledged the effective management, strategic direction, and operational oversight of our enterprise. We recognize that the professional capabilities and expertise of our staff enable effective portfolio planning and execution. We also understand the need to recognize shortcomings and areas for growth and improvement to continue developing the next-generation workforce capable of addressing the challenges of the future. The office also recognizes the need to apply "lessons learned" from past program failure, while continually monitoring ongoing projects to identify potential failure points and mitigate the risk of failure to maximize the benefits of investing taxpayer dollars.

The office also agrees with the need to include hands-on industry expertise throughout all levels of activities as appropriate, particularly later-stage research. We will continue to seek opportunities for early and sustained input from external experts.

Criterion 4 – Communications and External Engagement

Representative comments:

- The office does a strong job engaging and communicating with its stakeholders and has dedicated appropriate resources for this engagement. The office proactively seeks input through working groups with governmental agencies and other stakeholders, and it holds frequent meetings with industry and relevant organizations.
- Communication and external engagement are a very strong part of the office's activities and performance. In general, there is a huge amount of engagement, collaboration, and communication. Some highlights in this regard are Energy Systems Integration Group (ESIG), engagement with International Energy Agency (IEA) Task 25, Working Together to Resolve Environmental Impacts of Wind Energy (WREN), Tethys, and the Radar mitigation work.
- The communications team does a spectacular job of communicating sophisticated information to the public across various mediums. The office also does a great job of communicating to key stakeholders, while also communicating to the general public. One of the greatest strengths and roles of this office is its ability to disseminate and explain credible information.
- More focus should be given to communicating (through both traditional means and social media) the efforts and successes of the program.
- The communications team is active in helping the projects disseminate results.

Office Response

The office agrees with and has demonstrated our commitment to the comments with respect to communications and external engagement. Great care is taken to:

- Promote interaction, coordination, and cooperation with key external stakeholders through direct dialogue and by producing high-level events, summits, and executive roundtables

- Provide high-quality, impactful, objective communications products and information services to the right people at the right time—informing them of the work WETO does and demonstrating its impact
- Coordinate with project awardees to ensure they are communicating project results.

The 2017 WETO Peer Review did not evaluate Communications and External Engagement at the office level, but did evaluate Communications & Outreach at the program level for the Resource Characterization and Technology Research, Development, and Testing program (analogous to Technology Development in the 2019 review) and for the MA&D program. In the 2017 Peer Review, the office received feedback, and the scoring results indicated that MA&D projects were doing a better job communicating the portfolio and project results than TD projects. Upon receiving this feedback, office staff held several internal meetings to brainstorm and facilitate the transfer of best practices and process improvements from MA&D staff and projects to their TD counterparts. Since then, the WETO communications team has also reviewed and provided comments on the communications and information dissemination plans outlined in the Annual Operating Plans of tasks at DOE's national laboratories, as well for large competitively selected projects, such as the National Offshore Wind R&D Consortium. The reviewer comments in the 2019 Peer Review, combined with the increase in scores for similar metrics,[11] indicate there has been improvement in this area since the previous peer review.

The office plans to continue its efforts to ensure that industry needs inform WETO research, development, and market acceleration activities to sustain a long-term approach to technological innovation and system integration efforts.

The office recommends the following comprehensive and coordinated set of engagement activities that build on past successes and lessons learned, while accelerating the state of the technology and contribution to the nation's security, economic, and environmental goals.

- Foster industry engagement and communicate WETO's relevant R&D portfolio with clear input from, and handoffs to, wind industry stakeholders by holding partnership summits and working groups with governmental agencies and other stakeholders focused on technology development and environmental and human use considerations
- Leverage and encourage consistent and open communication between WETO, DOE national laboratories, and wind industry stakeholders by disseminating communication materials and encouraging face-to-face engagement with office leadership
- Work directly with the private sector, across EERE offices, and other public sector partners to address wind energy system needs and develop specific connections and investments focused on the feedback obtained.

In response to the comment that the office should focus more on communicating through traditional and social media and the recommendation that the office use indirect communication such as broadcasting newsletters and project summaries, the office does and will continue to frequently use these channels, in addition to encouraging National Laboratories and FOA awardees to promote their WETO-funded work. Throughout the course of an average year, WETO broadcasts 50–65 news items (e.g., press release, blog, newsletter, or

[11] Projects in the Technology Development program received an average score of 7.48 for Communication, Coordination, &Commercialization in 2019, indicating there is still some room for improvement. However, in the 2017 Peer Review, the Technology Development program received a score of 3.4 out of 5, which would be equivalent to 6.8 on a 10-point scale.

article), which are emailed to over 40,000 subscribers and can be viewed on WETO's website at https://www.energy.gov/eere/wind/listings/wind-news.

In addition to the previously existing DOE Twitter, DOE and EERE Facebook, DOE Instagram, and EERE LinkedIn accounts, in 2019, EERE launched the @EEREGOV Twitter account, which WETO submits content for on a weekly basis.

3.4 Representative Office-Level Recommendations and WETO Responses

Reviewers were asked to provide recommendations for the office to consider. A representative sampling of recommendations is provided below, chosen to convey a balanced impression of the reviewer's suggestions. A complete list of all recommendations can be found in Volume II of this report.

WETO's response to the reviewer recommendations is also provided.

Reviewer recommendations:

- DOE should continue to support the efforts of WETO, labs, and individual projects.
- The office should continue its commitment to an open approach to data, modeling, and tool development.
- The office should ensure a mix of different project sizes and different technology readiness levels.
- The office should take a longer-term view, such as the A2e effort, as well as support projects across technology readiness levels. The office should ensure that all projects succeed in communicating how they are contributing to advancing the state of maturity of technology.
- The office should continue to prioritize and increase support for the market acceleration and deployment MA&D efforts, as these challenges are only expected to grow as the industry builds out, and as such, requires focused attention to overcome these barriers. Cost-efficient deployment will be more and more important as wind power is built in new areas, is distributed, and is closer to people. For example, European experience shows that work with industry and stakeholders on issues like noise and ice throw are important.
- The office should greatly increase funding (e.g., "moon shot" approach) to do more on wildlife detection and deterrent system R&D to reduce the time it will take for field verification, and therefore increase availability of trusted impact minimization measures.
- The office should continue wind-specific related integration work and increase its focus on offshore wind integration and the dedicated offshore infrastructure required.

Office Response

The office agrees with and has demonstrated a commitment to incorporate recommendations made by the reviewers regarding the need for a balanced portfolio, increased and focused market acceleration and deployment activities, and ensuring that cross-cutting DOE and specific EERE-level grid activities align with wind industry interests. The office will continue to seek input on the most appropriate use of limited program funding and will work with external and internal stakeholders to plan and execute an investment portfolio that maximizes the benefit to the wind industry, its stakeholders, and U.S. taxpayers.

4 Summary Results: Technology Development Program

4.1 Overview

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

The results are organized by the activity areas into which individual projects were grouped for the 2019 Peer Review. The outline below lists those activity areas, along with the number of the report subsection in which their respective summaries can be found.

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

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

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

Complete listings of all reviewer comments regarding programs and activity areas, as well as the full scoring and comments for each of the projects reviewed can be found in Volume II.

4.2 Program-Level Evaluation: Technology Development and Scientific Research

This section provides an overview of the scoring for all projects within the TD program; a balanced sampling of reviewer comments in response to the evaluation criteria; and the WETO response to the evaluation results. Full evaluation results can be found in Volume II.

Figure 4-1 plots the relative scores of each project in the TD program area—as well as the average for all projects in the program area—with weighted average *Project Performance* on the X-Axis, and *Technical Merit & Relevance* on the Y-Axis. The shaded boxes on the graph represent 1σ, and 2σ standard deviations from the mean average of all the program project scores.

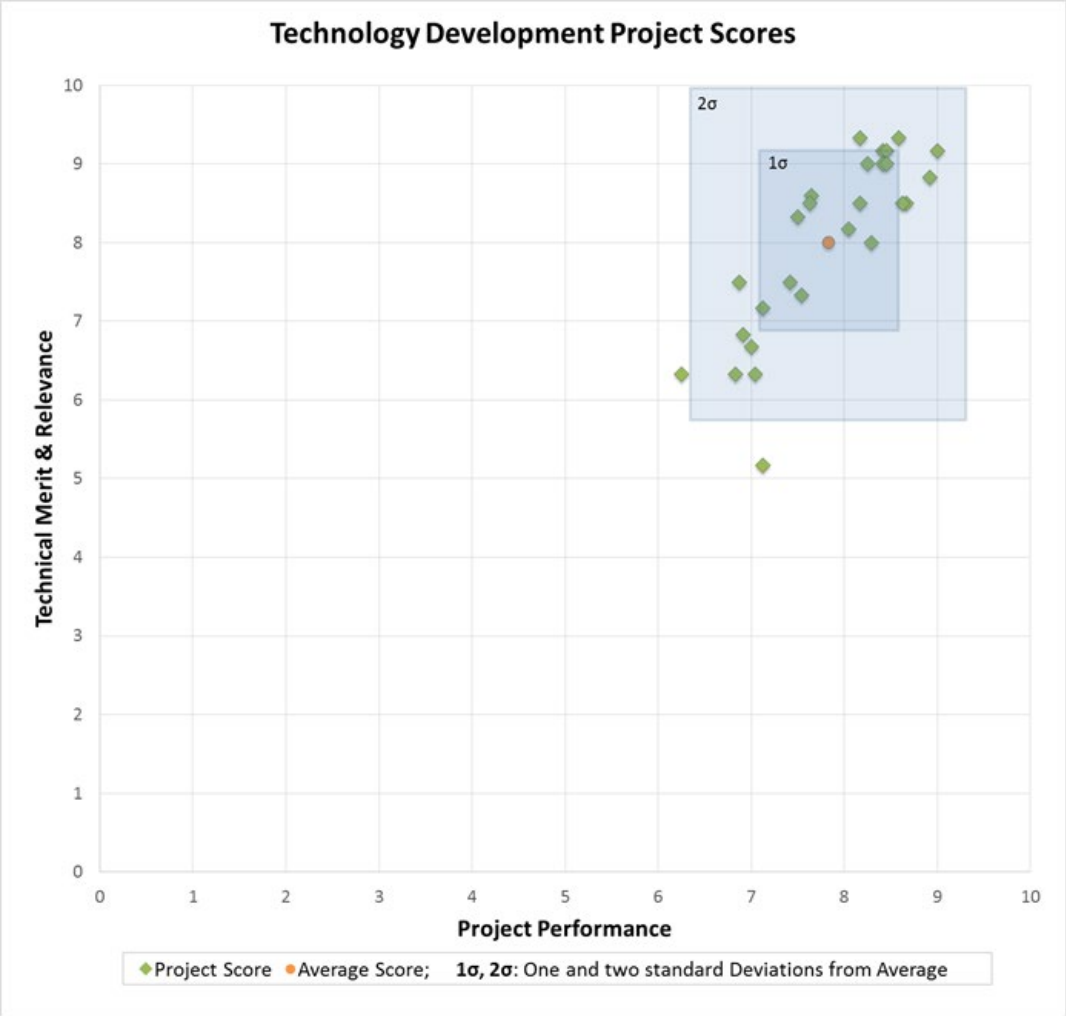

Figure 4-1. Overview of project scoring within the TD program[12]

Representative Comments and Recommendations

1. Are the projects within this program on the leading edge of work within this field?
    - Many of the program activities are at the cutting edge of research and are industry leading.
    - Overall, the program is diverse and valuable to the state of the art.
    - Several of the demonstration or small-business projects would not qualify as leading edge, but in general appeared helpful in establishing industry capability.
    - The A2e program specifically could not be accomplished in any other way.
    - Since several projects had lifetimes that were longer than planned, it appeared as if they might have been advancing the state of the art when they were conceived but would no longer have the same impact.

[12] The outlier project in Figure 4-1 is T17: Big Adaptive Rotor. Additional information on this project is available in Section 4.9, with all project-specific comments available Volume II.

2. Has the rationale behind the funded activities and projects been effectively conveyed during the peer review?
    - The rationale for projects and activities was clearly conveyed during the review, including the ties to office-level objectives.
    - The motivation to continue to lower the cost of energy was very clear and specific.
    - While the research rationale is generally apparent, it may not be expressly stated in most cases. Therefore, defining, in each case, more explicitly what the problem is that they are solving and, at the conclusion of the research, evaluating how the individual project advanced the state of the art would be valuable and could help long-duration projects stay current.
    - One opposing view: I think that this group needs to distinguish why each of these projects builds on answers to specific questions and results. Some of this research is amazing, some seems to be curiosity, and some is not relevant to the industry. On the whole, the program is valuable, but focus would be helpful.

3. Within this field, are thought leaders aware of the WETO-supported work?
    - Much of the work is known to thought leaders, but not all. Improved regular summary-level information flow to industry is recommended.
    - Industry leaders are well aware of activities.
    - Some of the smaller activities are overshadowed by the flagship projects, despite the fact that the smaller projects may be more practically advancing the immediate future of the industry.

4. Are there important topic areas that are underrepresented or missing within this Program?
    - Industry input is urgently needed to guide certain projects.
    - Support for non-core technical issues (e.g., technical aspects of logistics and construction) is needed to help the American workforce participate in the construction of offshore projects.
    - Industry concern has been stated to be equipment safety (catastrophic failure). This can be addressed by creating a closed equipment safety layer separate from the open-source control layer. This is already done by some original equipment manufacturers (OEMs) in the combustion turbine industry.
    - Understanding how distributed wind applications exist inside current research areas would increase the value of existing work.

5. Are there any notable strengths to the activity portfolio content or direction that you would like to point out?
    - The research activities are well diversified with common focus on lowering the cost of energy.
    - The coordination between labs and other government departments is impressive. This is especially exemplified in the A2e program.
    - The work currently done on floating offshore is amazing and can put the United States in a leadership position in this industry.
    - Tech to market is a high-value project communicating and acting as the coordinator of industry and surveying the industry. DOE is in a unique position to coordinate industry

technology focus through workshops. They are impactful and were very well organized and executed, resulting in both DOE and industry benefiting from direct feedback.

6. Are there any notable weaknesses to the activity portfolio content or direction that you would like to point out?
    - No there is not.
    - The interaction and integration between projects can be improved.
    - There does not appear to be significant LCOE reduction plans that would bring small wind to parity with solar
    - Low end-user participation in the standards has resulted in underrepresentation of siting, project development, installation, commissioning, operations and maintenance (O&M) standards, and best practices. These have become more important for risk reduction for the financial community.
    - Some of the Small Business Voucher topics selected seemed to be of marginal value. Consider modifying the process of selection.

7. What recommendations would you like to convey to the manager(s) of this Program?
    - Overall, the program is very well done. Understanding specific questions that specific projects are trying to answer and then measuring progress and results against those questions will help focus value. Incorporation of distributed wind problems into existing research would add value.
    - Figure out what the next big problems are ahead of time. Focus on the near-term problems, as well as the 10, 15, 20, and 30 out-year problems and how to get ahead of them. For example, one reviewer felt that power electronics, cable system fatigue, aging control systems, and tower/foundation life extension are the next big problems for the industry, and these do not seem to be represented in any of the research.
    - The portfolio of activities should be driven by industry needs, and some of the projects may not be appropriate for DOE investment.
    - Technology transfer and commercialization should be more actively explored to ensure that projects impact industry.
    - Show how the results from the Technology to Market Industry Survey and 2018 Wind Industry Partnership Summit influenced the DOE roadmap or R&D focus.
    - Evaluate ways to cost effectively utilize more privately-operated facilities at test facilities.
    - Although publications and presentation forums are top rated, the communication could be better if a wider swath of industry publications and forums were engaged; efforts are too focused on finance/resource-specific venues.
    - Program needs more focus on conference papers, as opposed on peer-reviewed academic journals.
    - Ensuring a safe operating culture at both the National Renewable Energy Laboratory (NREL) and Sandia National Laboratories (SNL) sites was stressed.

<u>Themes among Comments on Projects in Program Area</u>

Comments on Strengths (under any criterion)

- WETO is providing valuable leadership in wind energy technology research and development.

    - WETO and DOE laboratory leadership are a key element of the success for the U.S. offshore industry and that the projects reflect that.
    - This work capitalizes on the unique position DOE has to pull together the best talent from all the labs and collaborate with industry for the benefit of the wind industry.
    - The National Wind Technology Center (NWTC) and Scaled Wind Farm Technology Facility (SWiFT) are world-class facilities with important capabilities.

- DOE is filling a proper government role
    - DOE is in a unique, trusted position for many of its projects.
    - Only DOE labs can supply the level of quality on the scope of data needed for industry confidence.
    - Consistent support for standards and certification work has enabled the United States to influence international standards in major ways.
- Wind energy technology development projects supported by WETO are highly relevant and impactful.
    - The research done under this area is at the leading edge of technology. Projects clearly advance the state of the art. The rationale behind projects has been well thought out.
    - The projects are important and relevant to help accelerate commercialization and maturation of the technology.
    - The project has the potential to transform the market.
    - Projects are valuable to the industry and to directing future research.
- WETO collaborates with others when appropriate
    - Strong coordination of various labs and DOE resources that are required to accomplish several of the program goals.
    - Very productive and successful collaboration with industry.
    - Conducting this project with a private company that plans to commercialize it was a good strategy for accelerated technology to market (T2M) transfer.
    - Excellent collaboration with industry to get them what they want and the tools they need.
    - DOE did a great job engaging academia, standards agencies, and industry.
    - Excellent systematic approach involving broad industry stakeholders.

Comments on Weaknesses (under any criterion)

- A couple of projects were identified as potentially overlapping with work being conducted by industry, which may indicate DOE does not need to continue investing in the project.
    - The industry is well-incentivized to get this right on their own. Market forces are driving them to an answer.
    - This is a concept that the industry is already investing in heavily. This seems to be better suited for industry.
    - The industry should be driving this project and future activities. This does not appear to present a compelling government interest or unique qualification to advance this beyond what the industry could do itself.
    - BAR is already well-studied by industry; Industry is already building super large rotors.

- Reviewers identified a couple of projects that could do a better job communicating their results to relevant stakeholder audiences.
    - One reviewer was not sure that thought leaders were aware of the WETO-supported work. “I work in this field, and I learned about the projects funded by this activity during the review process.”
    - Unclear what communication actually occurred other than to DOE internally.
    - Sharing results publicly would allow for broader, non-participant feedback on the results. All communication appears to be internal, which materially decreases value.
    - “I would expect peer reviewed journal papers from a (offshore resource characterization) project of this caliber.”

Recommendations

- Many recommendations were to continue or expand on existing work.
- Several reviewers noted that projects could be expanded to benefit other market segments, most notably distributed wind.
    - WETO needs to leverage work happening across its entire portfolio to advance distributed wind.
    - Projects like Mesoscale-Microscale Coupling (MMC) could make the distributed wind industry transform fundamentally if properly applied.
    - Explore the possibility of easy wins if large wind technology lessons can be brought down to small wind technology.
    - Offshore testing capability is under-represented and should be developed further in the future.
    - Further investment at the NREL Flatirons Campus is commendable, especially in the areas of distributed wind grid integration and grid support and potentially offshore wind.

Office Response

As in past peer reviews, the panel’s comments remain invaluable, as the perspective of external evaluators has provided identification of weaknesses that those close to the projects may not always recognize.

WETO appreciates the acknowledgement of the general value of the TD subprogram activities and our focus on coordination internally and externally with key stakeholders, including other agencies. We have demonstrated and fully embrace coordination across the labs and internal DOE leadership.

The office strives to continue to be open to support new innovations by analyzing what the next big problems are likely to be (10, 15, 20, 30 years from now) and best paths forward to address those challenges.

WETO recognizes the importance of national-level test facilities in the United States for carrying out innovative R&D related to offshore wind energy.

The WETO team shares the peer reviewer’s concern that safety should always be of paramount importance in any operations.

The office understands that supporting wind standards development in itself is not cutting-edge R&D; however, standards are a mechanism by which important R&D results can be institutionalized for the benefit of

the entire industry. Robust standards have had a huge impact on improving wind turbine design and operation. Better standards will be produced if the technical diversity of the group can be enhanced. WETO will make the effort to recruit new experts to the standards development process that reflect all components of the industry.

WETO understands the importance of addressing specific project weaknesses, such as a lack of clear understanding of the distributed wind activities and how those activities derive from or benefit from utility-scale wind activities. WETO will ensure that utility-scale wind technology development activities, both in the land-based and offshore wind sectors, are planned, executed, and communicated in a manner that supports and benefits the distributed wind research, development, and demonstration. Further investigation as to the impact of standards on distributed wind is warranted. WETO will engage with the distributed wind industry to better understand the problems and solutions.

The office appreciates the positive feedback regarding the T2M activity and the purpose of creating and evaluating innovative programs that eliminate the common barriers that promising technologies face along the pathway to market. Furthermore, we believe more private sector companies are in need of having access to emerging technologies to remain competitive in the global marketplace, and it is imperative to fund projects that enable and bring the business mindset into the laboratory and increase collaboration with industry so that wind innovations can be evaluated by the market.

We acknowledge the Peer Review results suggesting the need to develop strategies for reaching a broader audience with the goal to communicate the value of investments to a greater range of stakeholders. The office recognizes that its TD projects require a variety of outreach strategies to communicate effectively with both technical experts and the public. Conveying the value of more complex R&D to the public is important to ensure that the return on investment to the industry—and, ultimately, the taxpayer—is clear. DOE researchers whose work was evaluated in the TD track will continue to consult with colleagues across the program and with our external performers to create strategies to amplify and communicate program work successfully.

The peer review team acknowledged the broad range of communication and outreach activities at both sites, including visitor tours, student engagement, conferences, and interactions with industry. WETO will continue to promote the development of solid external communication plans that present expertise and facilities, detailed accomplishments, patents, journal articles, and technology commercialization achievements.

4.3 Activity Area: Offshore-Specific Wind R&D

This section provides an overview of the scoring for all projects within the Offshore-Specific Wind R&D activity area; a summary of reviewer comments in response to the evaluation criteria; representative and noteworthy comments regarding individual projects; and the WETO response to the evaluation results. Full evaluation results can be found in Volume II.

Overview of Project Scoring

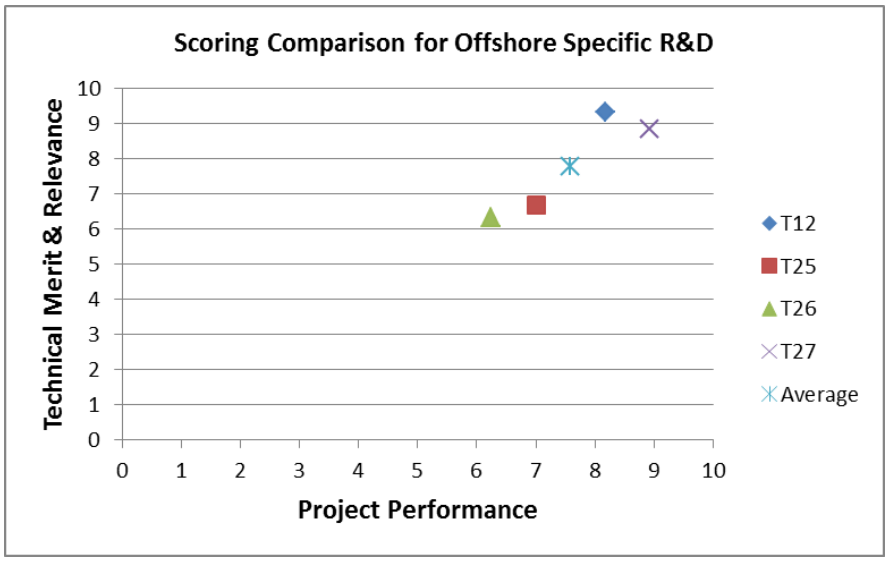

Figure 4-2. Relative scores for the Offshore Wind-Specific R&D activity area projects

Project List

Table 4-1. List of the Projects Reviewed in the Offshore Wind Specific R&D Activity Area

Unique ID	Project Name	Organization	Budget	Actual Costs	Project Status
T12	Offshore Resource Characterization	Pacific Northwest National Laboratory (PNNL)	$3,899,785	$592,066[13]	Active
T25	Cost of Energy reduction for offshore Tension Leg Platform wind turbine systems through advanced control strategies for energy yield improvement, load mitigation and stabilization	General Electric	$4,417,226	$4,402,983	Active
T26	Project Icebreaker	Lake Erie Energy Development Corp. (LEEDCo)	$204,054,465	$17,301,859	Active
T27	Aqua Ventus	University of Maine	$179,386,280	$16,084,010	Active

[13] For "active" projects, differences between "Budget" and "Actual Costs" represent funding still available to complete the scope of work. In examples where this difference is large, projects are likely in early stages of the project scope, with the expectation that Actual Costs will increase in FY19 and beyond, as scope is completed. More detail is available for any individual project in Vol. II.

Summary of Reviewer Comments on the Activity Area

1. Are the projects within this activity on the leading edge of work within this field?
    - The reviewers indicated that, in general, the offshore wind projects presented were leading edge and critical for advancing offshore wind in the United States. They highlighted the need for work focusing on advanced controls, resource characterization, and field facilities development for full-scale testing.
    - Since several projects had lifetimes that were longer than planned, it appeared as if they might have been advancing the state of the art at the time they were conceived but would no longer have the same impact.
    - Several reviewers commented that the offshore projects might not be far reaching enough technically given the pace at which industry growth and technical innovation is occurring.

2. Has the rationale behind the funded activities and projects been effectively conveyed during the peer review?
    - Reviewers commented that WETO and DOE laboratory leadership are a key element of the success for the U.S. offshore industry and that the project selection reflects that.
    - It was stated that while the research rationale is generally apparent, it may not be expressly stated in most cases. Therefore, defining, in each case, more explicitly what the problem is that they are solving and, at the conclusion of the research, evaluating how the individual project advanced the state of the art would be valuable and could help long-duration projects stay current.

3. Within this field, are thought leaders aware of the WETO-supported work?
    - Opinions varied in response to this question depending on the perspective and experience of the reviewer. Most felt that the thought leaders do “appear to engage and are well aware of WETO's work, and that the industry is depending WETO and the national lab's leadership.”
    - One reviewer indicated “I am not really sure about this. I work in this field, and I learned about the projects funded by this activity during the review process.”
    - Another reviewer suggested that that “some of the smaller activities are overshadowed by the flagship projects, despite the fact that the smaller projects may be more practically advancing the immediate future of the industry.”

4. Are there important topic areas that are underrepresented or missing within this Activity area?
    - Areas that the reviewers called out for greater emphasis included:
        - Mooring systems and/or mooring system deployment
        - High-fidelity modeling, taking into account ocean waves, atmospheric turbulence, and floating structure dynamics
        - More data collection efforts
        - Support for non-core technical issues (e.g., technical aspects of logistics and construction) to help the American workforce participate in the construction of these projects

5. Are there any notable strengths to the activity portfolio content or direction that you would like to point out?
    - The reviewers indicated that "the standards work and floating platform parts of the program are standout strengths."
    - The floating Aqua Ventus project was called out as being especially notable, as it will "provide invaluable data for developing high fidelity models"

6. Are there any notable weaknesses to the activity portfolio content or direction that you would like to point out?
    - Reviewers offered these specific comments regarding weaknesses that could be addressed or improved:
        - "The challenges of large dynamic systems that are typhoon tolerant could be more emphasized"
        - "Sponsoring university research where more graduate students can benefit from it"
        - "By the time that non-recourse debt is willing to come into a project, the program should ask if it is still a high-risk project that needs taxpayer funds."

7. What recommendations would you like to convey to the manager(s) of this activity area?
    - Reviewers offered these specific recommendations:
        - Support for "projects that collaborate with states on deployment programs"
        - "Develop a clear and specific plan for developing multi-scale, high-fidelity, and engineering modeling tools for floating turbines"
        - "Make sure that the basics are included, or the advanced will be worthless. In order for offshore to succeed in the U.S., an entire industry of fabricators, contractors, ships, crews, and engineers has to be created in the U.S. And, unlike onshore or distributed wind, most of these skills are not present in the U.S. currently. If the U.S. is going to create this industry domestically, it should acknowledge and address its shortfalls."

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

Comments on Strengths (under any criterion)

- "The project seeks to evaluate control strategies for reducing LCOE for floating platforms and turbines. Highly relevant to industry and at the leading edge of the state of the art."
- "This is an exciting project that has the potential to make a major impact in advancing offshore wind energy in the United States. I just hope that the team continues with the same level of enthusiasm and attention to detail."
- "This research has tremendous merit to the offshore industry. Wind resource characterization is essential for future model validation and demonstration activities." The project is "highly cost effective."
- "Economical floating offshore demonstration is key to reducing LCOE. This approach to floating platforms capitalizes on known concrete construction techniques. The systematic, modeling, certification, scale modeling and 1:8 scale, onsite DeepCLiDAR tests all form a solid basis for the design." (UMaine Demonstration Project)

Comments on Weaknesses (under any criterion)

- It should be considered whether "product improvement of a specific wind turbine generators (WTG) type and TPL concept is research that has industry-wide relevance and impact."
- "Wave effects and non-linear fluid-structure interaction due to coupled ocean/atmosphere/structural effects will be critical for developing and assessing (floating turbine/platform) control algorithms. It is not clear how these were accounted for in this effort"
- "The overall (floating platform) project seems to be a random shotgun blast of activity and not an organized effort to answer a question"
- "The lack of full analysis (of metocean buoy data) is less than ideal. The program seems to have struggled to get industry support."
- In reference to the LEEDCo offshore wind project: "This project does not appear to be advancing the state of the art anymore. The foundation technology has been used and other than the ice interface, much of the technology is understood globally."
- "I would expect peer reviewed journal papers from a (offshore resource characterization) project of this caliber."

Recommendations

- "I think that the metocean data program needs to have a better self-directed vision and rely less on industry cooperation for the time being. Developing a plan to gather data in the 10–15 highest value areas and publishing and sharing that plan seems like a far better direction than trying to operate a loan program."
- "I think it would be relevant if more communication (on the floating platform project) would have been done outside the U.S. as both related academia and industry (on WTG and floating structures) is based in Europe"
- In reference to the University of Maine demonstration project: "Consider making this a WETO test site, giving the WETO the right to some equity like upside, even if delayed."

Office Response

By and large, the reviewers' scores and comments on the four offshore wind-specific research projects indicate that they are very supportive of the work and feel it is being executed well. They were particularly enthusiastic about the two projects (PNNL-led resource characterization; and University of Maine's innovative floating platform demonstration) that they felt had the greatest applicability to the industry in general and are advancing the current state of the art. They felt that the two projects that did not score as highly as the others (GE's floating platform controls research and LEEDCo's Lake Erie demonstration project) were well executed, but did not necessarily have as much broad relevance as they did when initiated six or more years ago.

The office appreciates the reviewers' feedback and suggestions on areas for greater emphasis. Fortunately, the office is already incorporating many of the suggested areas for additional research or greater programmatic focus into its offshore project portfolio or strategic planning; these projects either were not yet advanced enough to be among the projects presented in this peer review or were covered as part of other activity areas. These include further emphasis on (1) mooring systems, (2) hurricane impacts, (3) coupled wind/wave design models, (4) supply chain and workforce development, and (5) resource characterization field observations and model refinement. The reviewer's feedback helps support the office's planning and use of available appropriations for these topics.

The practical suggestions that the office will strive to address in its management of current and future projects include:

- Broaden the conceptual approach of the resource characterization work, including the lidar buoys, into a more comprehensive effort engaging industry and other research partners
- Ensure that the core questions being asked under a project scope are clearly stated and that progress toward answering them is periodically evaluated, and evaluate whether they remain optimal solutions
- Better articulate the strategy and key components of developing the required suite of high fidelity, coupled analysis, and modeling tools for floating systems.

With respect to the LEEDCo Icebreaker project, the office feels that while it may offer limited technical innovation at this point in its development, it remains an extremely important first-of-its-kind project, paving the way for offshore wind in the Great Lakes through demonstration of technology, operational viability, and stakeholder engagement. Reviewers believe that the project could provide important public data to the offshore wind industry. WETO has also received Congressional direction to continue its support for this project (as well as Aqua Ventus).

The GE project, completed in 2018 led to research and technical innovations that are now being considered for floating versions of the new Haliade X turbine, which is currently the world's largest wind turbine.

4.4 Activity Area: Atmosphere to Electrons

This section provides an overview of the scoring for all projects within the A2e activity area; a summary of reviewer comments in response to the evaluation criteria; representative and noteworthy comments regarding individual projects; and the WETO response to the evaluation results. Full evaluation results can be found in Volume II.

Overview of Project Scoring

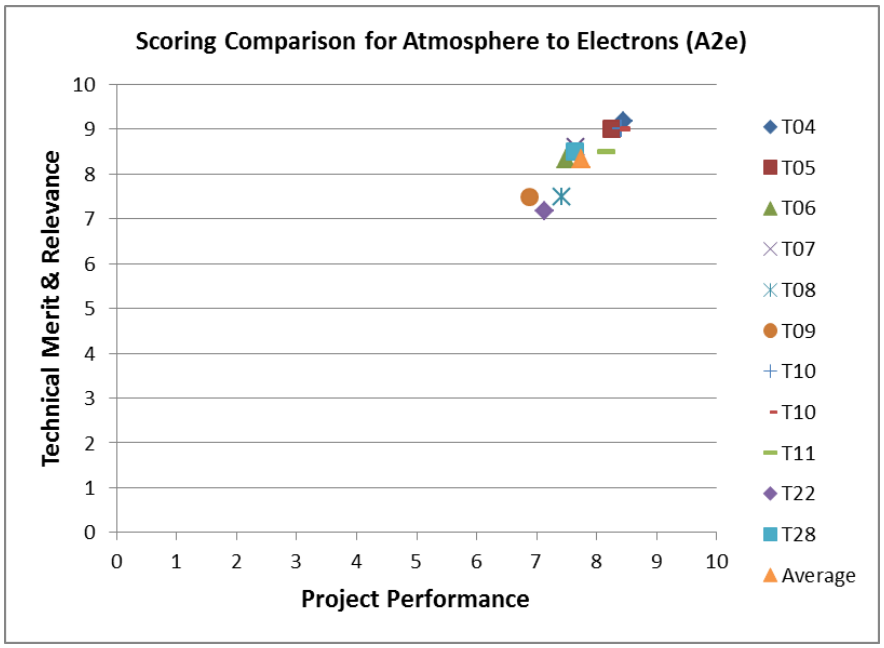

Figure 4-3. Relative scores for the A2e activity area projects

Project List

Table 4-2. List of the Projects Reviewed in the A2e Activity Area

Unique ID	Project Name	Organization	Budget	Actual Costs	Project Status
T04	A2e: Mesoscale Physics and Inflow: Wind Forecast Improvement Project (WFIP) 2	Argonne National Laboratory (ANL), Lawrence Livermore National Laboratory (LLNL), NREL, PNNL	$8,773,529	$7,910,582	Active
T05	A2e: Mesoscale Physics and Inflow: WFIP 2	ANL, LLNL, NREL, PNNL, SNL, Los Alamos National Laboratory	$3,674,279	$2,923,357	Active
T06	High-Fidelity Modeling	NREL, SNL	$4,304,928	$3,654,798	Active
T07	Rotor Wake Measurements & Predictions for Validation	NREL, SNL	$10,730,881	$8,108,373	Active
T08	Advanced Flow Control Science for Wind Plants	NREL	$2,816,078	$2,218,862	Active
T09	Integrated Systems Design and Analysis	NREL	$2,337,058	$1,451,808	Active
T10	Integrated Systems Design and Analysis Offshore Wind	NREL	$1,888,656	$1,135,128	Active
T11	A2e Performance, Risk, Uncertainty, and Finance (PRUF)	NREL	$2,242,837	$1,552,943	Active
T22	Small Business Vouchers - WindESCo	NREL	$200,000	$131,367	Complete [14]

[14] For "complete" projects, unspent funds (difference between "Budget" and "Actual Costs") were returned to the program and repurposed to other activities, as required.

T28	Multi Physics Model Validation & Uncertainty Quantification (UQ)	NREL	$663,017	$485,079	Active

Summary of Reviewer Comments on the Activity Area

1. Are the projects within this Activity on the leading edge of work within this field?
    - A2e is pushing the industry and DOE laboratories to develop technology for full wind plant system optimization through a greater understanding of the coupled physics.
    - No single lab has the collective expertise to exploit the range of tools needed to fully understand these wide range of physics.
    - Validation of these tools is extremely important. Only DOE labs can supply this level of quality on the scope of data that is needed for industry confidence.
    - This is a truly unique and world-class program that is the envy of all international research programs.
    - This is an impressive and ambitious program both in scope and breadth.
    - It weaves together multiple projects that address critical building blocks toward A2e's vision to develop predictive understanding of complex flows in wind plants and provide the industry with the next generation of computational tools for reducing the LCOE.
    - The research done under this area is at the leading edge of technology.
    - They clearly advance the state of the art.

2. Has the rationale behind the funded activities and projects been effectively conveyed during the peer review?
    - WETO did a masterful job of explaining the reasons for each program and how they fit together as well as the funding
    - Clear line-of-sight to office objectives and rationale.
    - The rationale behind individual projects has been well thought out and presented very effectively.
    - The team did a great job explaining the rationale behind their work.
    - One opposing view: I think that this group needs to distinguish why each of these projects builds on answers to specific questions and results. Some of this research is amazing, some seems to be curiosity, and some is not relevant to the industry. On the whole, the program is valuable, but focus would be helpful.

3. Within this field, are thought leaders aware of the WETO-supported work?
    - A2e program has done an outstanding job in communicating and coordinating the project and results. All of the thought leaders are not only aware but deeply engaged.
    - For the most part, thought leaders in the field should be aware of A2e. Various A2e project teams are present and visible in relevant scientific meetings showcasing the work; they also publish quite extensively.
    - DOE did a great job engaging the research and industry communities.

4. Are there important topic areas that are underrepresented or missing within this Activity area?
    - Offshore wind plant design needs might need more attention in the future. Air/sea interactions and modeling could improve load predictions and perhaps offer greater insights into control methods for mitigating large motions of floating platforms and/or loads.

- High-fidelity modeling for offshore wind turbines and plants—especially floating turbines, coupling waves, atmospheric turbulence, and structural dynamics—does not seem to be part of A2e at this point. It will be important to develop such focus soon, as the offshore wind industry is advancing in the United States.
- I feel the controls direction should be slightly shifted. As with modeling tools for industry to use to determine loads, a controls framework should be developed to allow industry to experiment with various controls algorithms—an open-source controller.
- While the tools are advancing the state of the art, creating applications where they can be practically applied (even at a lower accuracy) would multiply the value.
- Additionally, many of these projects have distributed wind applications that are not being properly considered or accounted for in the research or methodology. This work has the potential to make the distributed wind market a reality, and it is not being considered.

5. Are there any notable strengths to the activity portfolio content or direction that you would like to point out?
    - Modeling of the "Tera Incognito" (meso/micro scale atmospheric coupling) is impressive. This is an important part of understanding the coupling that impacts wind plants. Modeling of these part of the atmosphere will help forecasting transient wind conditions, which drive power ramp rates.
    - One strength includes the coordination of various labs and DOE resources that are required to accomplish several of the program goals. Excellent work!
    - The various measurement efforts are especially impressive and critical for catalyzing progress. The SNL SWiFT project and the multi-scale atmospheric boundary layer measurements campaign were really impressive and will yield essential data for driving the development of computational codes
    - Keep focusing on open-source code development. DOE can play an excellent role in this area. A2e brings analysis to validation.

6. Are there any notable weaknesses to the activity portfolio content or direction that you would like to point out?
    - High-fidelity modeling (HFM) for offshore wind turbines and plants—especially floating turbines, coupling waves, atmospheric turbulence, and structural dynamics—does not seem to be part of A2e at this point. It will be important to develop such focus soon as the offshore wind industry is advancing in the United States.
    - The interaction and integration between projects can be improved. While the HFM framework of A2e is the Nalu code, most of the projects are employing the Simulator fOr Wind Farm Applications (SOWFA). While I assume that this is the results of Nalu being under development and at rather early stages, it will be important to begin integrating the development of the code with effort to generate inflow conditions and enable coupling with meso-scale models
    - The development of Nalu code needs to accelerate to catch up with and hopefully surpass where the HFM state of the art is today for land-based and offshore wind farms. The code should also leverage recent major advances in the field of HFM. This is critical for the success of the entire A2e program, as HFM is at the center for the entire effort.
    - Projects like the MMC could make the distributed wind industry transform fundamentally if properly applied.

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

- Inter-laboratory coordination is hard, but A2e has succeeded remarkably. Keeping a focus on this is important. A recommendation to continue the positive trend with good leadership.
- Given the importance of HFM for A2e the program, it could be strengthened by diversifying its focus to consider other computational methodologies as well that incorporate most of the relevant physics for modeling wind farms. This is especially critical for offshore floating turbines for which successful HFM requires advanced computational models to simulate waves, air/sea interactions, and structural dynamics.
- Experiments need to be designed and carried out for validating meso-micro scale coupling models and demonstrate the ability of Nalu to predict turbulence from the blade boundary layer scale to wake meandering scales for a range of operating conditions and atmospheric states.
- Cost/benefit needs to be better considered in this program.
- When research is directly translatable into immediate industry value (day ahead forecasting), the industry should support the research more. If the industry is not willing to support the research more, then the value of the research should be questioned.

Representative and Noteworthy Comments on Projects in Activity Area

Comments on Strengths (under any criterion)

PRUF:

- Very productive and successful collaboration with industry.
- This project requires very careful communication plus protection of confidential information. This project has accomplished that.
- The first objective is transparent research analysis and quantification. DOE is in a unique, trusted position to perform the task. It is critical for investor confidence. The industry needs this trusted benchmark.
- Can reduce LCOE, increase annual energy production, and accelerate technology transfer. It is of critical importance for the wind industry and can bring much needed quantitative insights to decisions guiding investment and wind development.
- This project could lead to exciting results benefiting the entire industry. And equally importantly, it could contribute to advancing an industry culture for sharing data as a means to advance the state of the art.

Mesoscale Physics and Inflow: WFIP

- This project, perhaps more than any other, capitalized on the unique position DOE has to pull together the best talent from all the labs and collaborate with industry to improve the weather forecasting tools and science for the benefit of the wind industry.
- This project is of critical importance for A2e and ultimately highly relevant for industry, as it can produce the fundamental understanding of atmospheric processes required to improve wind forecast models and reduce uncertainty in short-term energy production predictions.
- The dual focus on improving model initialization and model physics is scientifically rigorous and very much what is needed to dramatically improve the accuracy and reliability of short-term forecasts.
- Approach is scientifically rigorous. The field experiments are impressive in scale and resolution and are conducted with the most advanced field measurement techniques available. The approach integrates sophisticated field measurements with numerical simulations and numerical model assessment and improvement.

MMC – Model Development & Validation

- Computational techniques for coupling meso-scale with micro-scale models to derive proper inflow conditions for wind-plant scale large-eddy simulation (LES) are of critical importance for developing accurate and reliable computational tools for wind plant simulations. This project seeks to address this important issue by integrating numerical simulations and meso-micro-coupling techniques with field experiments. As such, the project has the potential to make a significant contribution to the modeling state-of-the-art and lead to computational tools that will be invaluable for the wind industry.
- This project clearly advances the cutting edge and it is high risk/high reward. It has the potential to transform the distributed generation wind forecasting market.

High-Fidelity Modeling:

- HFH/HFM is key to tech transfer of complex physical understanding of MMC and all other atmospheric coupling between wind plants, wind turbines, wakes, and local and large-scale weather impacts. With improved knowledge of the atmospheric physics, but no means to transfer actionable engineering tools to industry, the DOE investment is lost.
- HFM models for wind plant simulations are critical for achieving the A2e mission and enabling the industry to reduce LCOE and quantify uncertainties in energy production. To that end, this project has the potential to make an important contribution to the industry and advance the state of the art.

Rotor Wake Measurements & Predictions for Validation:

- Wakes are the source of significant poor performance of wind plants. Improving the understanding of wakes will only happen through accurate modeling of wakes and their interactions, but validated models are key to achieving that challenge, and validation can only happen with high-fidelity, high-quality measurements. This program is the source of such measurements
- The success of the HFM aspects of A2e hinges on the availability of high-quality measurements to validate the computational models. To that end, this project is highly relevant and can make a major impact to the state-of-the-art and have major benefits for industry.
- Distributed generation typically has much tighter rotor spacing (2D), and thus wake modeling is particularly important.
- SWiFT wake data from LIDAR is very impressive. Validation of wake control and quantification of the wake displacement control is a major accomplishment. Final wind plant validation of long-term performance improvement is key.

Advanced Flow Control Science for Wind Plants:

- Advanced flow control for wind plants will help quantify uncertainty, reduce intermittency in power generation, and help reduce the LCOE. As such, this project is highly relevant to industry and is of critical importance for the success of the A2e program.
- The overall approach to couple an efficient controls-level model, like FLORIS, with an LES model like SOWFA is scientifically sound and has great promise. The integration of the models with field experiments is also essential to ensure that the approach yields physically meaningful results.
- Good success with wake steering controls has been demonstrated. The design tools for offshore controls shows good progress in this important area

- The project has made good progress in delivering some of its goals. The field scale validation results are impressive and promising and bode well for future applications of this approach
- The project is developing open-source software that will be valuable to industry. Project results have been published in journals and presented in conferences.

Small Business Vouchers – WindESCo:

- This is a very simple wind plant control technique that capitalizes on supervisory control and data acquisition (SCADA) data to correctly orient errant wind turbines based on their neighbors within the plant. The surprising result of 2% improvement represents a no-cost control strategy. Even if it isn't implemented as a control strategy, it seems it should be implemented as a SCADA-based operations quality control test of wind turbine performance, along with other such turbine-to-turbine performance tests.
- Consensus control is a promising idea that has the potential to increase energy production by aligning wind turbines in wind farms. The project is relevant to industry.
- The overall idea to develop some kind of "collective intelligence" in a wind farm by enabling turbine-to-turbine communications to achieve alignment with wind direction is quite interesting.
- Overall, a promising approach, but such an idea that requires turbine-turbine communications in wind farms can be tricky to implement and demonstrate. Given the relatively small size of this project, however, I consider this to be a successful project as the work has yielded promising results.

Multi Physics Model Validation & UQ:

- This project demonstrates how A2e has already improved the engineering models. Excellent work!
- This project is critical for next generation turbine design and the project has the potential to dramatically advance the state of the art. Highly relevant to industry.
- Specific efforts to validate long-term DOE efforts are very important. Projects like this are cost effective and valuable.
- The design load case/parameter sensitivity study was an excellent way to identify the most important physics that A2e must focus on. This project demonstrates the powerful value of having a continuum of code/modeling fidelity.
- I very much like the effort to systematically assess the sensitivity of aeroelastic models to various parameters.
- Impressive demonstration of isolating the important physics for HFM to focus on. This sensitivity analysis is a perfect demonstration of the power of engineering models informing HFM.
- I very much like the future focus on assessing the effects of inflow conditions on wind plant predictions and turbine loads.

Integrated Systems Design and Analysis:

- Very powerful system optimization tools that can be used for wind plant optimization, as well as integrate all A2e physics and engineering models into the optimization process. This cannot be done by any other individual models.
- This platform provides a common interface protocol that enables customized optimization tools made of any DOE codes and industry proprietary codes. It is uniquely suited for wind plant modeling and is future proofed by the basic linkable code architectures.

- This project takes an integrated systems approach, focusing on wind plant level modeling, optimization, and controls. It seeks to advance an integrated systems design approach for the entire wind plant. As such, the project is timely, highly relevant to industry, and has the potential to advance the state of the art and reduce the LCOE for future wind plants.
- The project can be viewed as the ultimate deliverable of the entire A2e effort, as it has the potential to integrate all computational modeling and experimental validation efforts of A2e to develop reliable engineering resolution tools for wind plant scale optimization and controls.

Integrated Systems Design and Analysis – Offshore Wind

- The continuous careful dissection of offshore codes from IEA OC3 (Offshore Code Comparison Collaboration) through OC5 (Offshore Code Comparison, Collaboration, Continued, with Correlation) has delivered major improvements to all international predictive capabilities. It has been through constant support and leadership of NREL, with huge credit to the principal engineers for intelligent and persistent work in collaborating with international researchers.
- There has been dramatic improvement in code accuracy and also isolation of the physics that cause errors in loads analysis. This informs researchers on the important areas to focus for improvements.
- The goals of the project will help to gain confidence in offshore wind designs and costs.
- While some promising results have been reported, significant discrepancies between model predictions and measurements were identified. The project has made an excellent contribution by clearly illustrating the importance of non-linear effects in such systems and exposing limitations of engineering models.
- The project has led to improvements for industry design tools and guidelines on how to approach offshore wind modeling. Conference and journal papers have been published.

Comments on Weaknesses (under any criterion)

PRUF:

- The geographic diversity of projects should be carefully considered, as it will be important to account for various region-specific conditions in cost estimate predictions.
- The industry does not have a broad agreement on normalizing operating data, so the methods used to compare operational assessments to predictions still introduces debated uncertainty. This analysis needs to be on a per turbine basis to truly understand precision vs. accuracy of the assessments.
- Although publications and presentation forums are top rated, the communication could be better if a wider swath of industry publications and forums were engaged. Too focused on finance/Resource specific venues.

Mesoscale Physics and Inflow – WFIP:

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

MMC – Model Development & Validation:

- The strategy for this project needs to be clarified.
  Many of the accomplishments appear tentative.
- Critical for the ultimate success of this project will be the comprehensive validation of the proposed MMC strategies using appropriate laboratory and field measurements. But

at this point, the team does not seem to even have a clear path as to which micro-scale code they will use.

- It is also stated that the team is ready to tackle offshore wind applications. But it is not clear that they have solved the MMC problem for land-based applications—in the sense of demonstrating the predictive ability of their approach and quantifying the uncertainty of predictions.
- Much more work is needed before such conclusions can be drawn; This work should explore MMC coupling with micro-scale tools that can account for complex terrain and turbine wake interactions and validation with laboratory and field measurements.

High-Fidelity Modeling:

- Offshore wind plant design needs might need more attention in the future. Air/sea interactions and modeling could improve load predictions and perhaps offer greater insights into control methods for mitigating large motions of floating platforms and/or loads.
- The HFM modeling state of the art is very advanced today. Moreover, such codes have already demonstrated validation at the utility scale and are rapidly driving forward our understanding of real-life physics. And achieving this level of predictive ability did not require understanding the details of the boundary layers on the turbine blades.
- Developing a code that can run on exascale machines is important, but it is not clear what the vision for this code is. Also, there does not seem to be a clear plan for coupling this code with the MMC efforts.
- A strength of Nalu is that the code scales well and can be applied on exascale systems. Yet, scalability of the code (especially with all the new features added to it) is not addressed.
- Given the current state of the project as reported in this report, the upcoming activities do not appear to be realistic.

Rotor Wake Measurements & Predictions for Validation:

- For such a complex validation undertaking, numerical simulations need to be tightly integrated with measurement campaigns to identify resolution requirements for measurements and areas of complex physics where measurements can focus. The project could be strengthened by adopting such an approach.
- Applicant should continually assess progress relative to the problem statement; in this case, reducing uncertainty. It is not clear that the project is solving the problem.
- The spatial and temporal resolution of the measurements is not explained. State of the art LES models available today can resolve wake dynamics at much finer scale than what is suggested by the measurement results reported.
- I was a bit disappointed by the project's vague conclusion. Also, the fact that the wind direction variability can influence the accuracy of simulations is well known.
  Such experiments should strive to reduce such uncertainties if the goal is to provide validation for HFM tools.

Advanced Flow Control Science for Wind Plants:

- The project as described is too narrowly focused on wake steering. This is an important control benefit, but the described range of benefits— power production, decreasing operation and maintenance costs, and providing grid services—need to be addressed with a range of potential control methods.

- There are other control strategies for wind plants. It is not clear why the project focuses exclusively on wake steering. Study could be strengthened by considering other control strategies as well.
- The team does not seem to have a good grasp of the physics of wind plants.
- I see little effort in developing control strategies based on available actuators and sensors, and more focus on development of the physics-based models.
- The results appear to overstate the value of the research, given that modern projects are laid out to minimize project wake interactions, as opposed to 7 turbines in a straight line. This project does not focus on all of the stated objectives.

Small Business Vouchers – WindESCo:

- Yaw misalignment does not appear to be considered, nor does turbine self-orientation knowledge. Most turbines do not have a dynamic source of North, so the process of determining how the specific turbine Norths were set may materially alter the conclusions of the report. (Most are set by a technician trying to use a compass, which is unreliable; the turbines may all have been pointing the same direction but not known it.)
- The paper and algorithm are academic in approach and will suffer signifying practical shortcomings (technology, yaw misalignment, north misalignment, and lack of a local vs. consensus self-check step).
- Unsure how real the accomplishments are, as this is a desktop exercise.
- It is not clear that consensus control has been objectively achieved using the data and overall approach used in this work.
- I do not see how this report/information was communicated to non-project stakeholders.
- The conclusions are beyond the capability of the dataset.

Multi Physics Model Validation & UQ:

- It is not clear how wakes are modeled in FAST.Farm, as well as how new physics is incorporated in the model.
- The entire project is based on the premises that SOWFA is the "truth." Yet, SOWFA has its own uncertainties, and it is not applicable to complex terrain and offshore environments. The project could benefit by broadening the focus to consider interfacing with other models that incorporate a wider range of wind farm physics.
- The terms high-fidelity, mid-fidelity, and low-fidelity need to be precisely quantified for the benefit of this and ALL projects.
- I do not see how the accomplishments relate to the goals of this project.
- I do not understand how turbulence models were evaluated and how such effort fits within the current project. This project has several pieces, and it is not clear how they all connect together.
- Unclear what communication actually occurred other than to DOE internally.

Integrated Systems Design and Analysis:

- This is a concept that the industry is already investing in heavily. I am not sure this program fully understands where the current state of the art is, nor do I think that this program is directly advancing the state of the art.
- This program seems to be attempting to include areas beyond the expertise of the national laboratories. The industry is already factoring in most of these factors and several other factors that are not being considered in this program. I do not see where the national

laboratories have demonstrated any unique expertise in construction and functional cost engineering for a project. This seems to be better suited for industry.

- Validation of the models has not been addressed.
- I do not see how this project integrates well with other components of A2e. For example, HFM and field validation studies should be critical components of this project. Yet, this is not discussed.
- It is not clear how industry has been engaged.
- This program would do better if it focused on single variable manipulation and then communicated those results with industry to better inform industry models on whole plant design. The program has not demonstrated a unique ability to lead in the unified plant design relative to industry capabilities.
- The success of this project will hinge on the accuracy and reliability of the tools used for the various components and on the ability to integrate these components together into a unified framework. Validation of the various components is critical for this approach to provide reliable results. It is not clear how this is addressed in this project. It is not clear if the team has attempted to validate their approach with real-life operational data.
- The goal to extend this work to floating offshore is not realistic at this point, as there is no HFM tool available in A2e right now to guide the development of offshore engineering models. Development of HFM tools for floating turbines in realistic ocean environments along with experimental data that can be collected in currently designed projects (e.g., the Aqua Ventus project) will be critical for such a project to succeed in the future.

Integrated Systems Design and Analysis – Offshore Wind:

- Intellectual property issues and data sharing conflicts have created difficulties in this project. This is understandable given the industry challenges, but without data sets for systems that can be accurately prescribed as input to models, it is difficult to have meaningful validation studies.
- Engineering models are inherently incapable of accounting for the non-linearities arising in real-life ocean conditions and the coupling of atmospheric turbulence with waves and structural dynamics. Without a high-fidelity model to provide guidance, I am skeptical how much progress can be made.
- The set up with NREL and the Institute for Wind Energy Studies and many, many participants seems rather bureaucratic; did it really work well?
- It is unlikely to make major progress without incorporating in the validation effort a high-fidelity model that can couple wind, waves, and fluid-structure interaction of turbine structures.
- Unclear what improvements have been found or performed.

Recommendations

PRUF:

- Strongly encourage introducing the Open Operational Assessment (Open OA) to IEC 61400-15 standard as an annex or IECRE certification system as an assessment tool.
- The project must communicate data the financial market needs, which includes individual turbine analysis as well. The more transparent this is, the more it will move the industry.
- This needs long-term support by DOE. DOE is the only objective trusted group with no conflicts of interest. Publish public reference energy assessment tool.

- Suggest PRUF explore and at least catalogue all levers that affect LCOE, even if the main focus is Wind Plant Performance Prediction Benchmark
- This is the foundation for a game-changing project, but the value will only exist if the analysis and reporting is done well. This project needs to look at per turbine and not just per project basis to be fully valuable.

Mesoscale Physics and Inflow – WFIP:

- Duplicate projects with additional unique field sites would help accelerate the understanding of other site-specific weather anomalies.
- This project is of critical importance for A2e and ultimately highly relevant for industry, as it can produce the fundamental understanding of atmospheric processes required to improve wind forecast models and reduce uncertainty in short-term energy production predictions.
- The industry should be driving this project and future activities. This does not appear to present a compelling government interest or unique qualification to advance this beyond what the industry could do itself. Improving the overall accuracy of NOAA models is valuable, but it may not be an appropriate use of WETO funds.

MMC – Model Development & Validation:

- Looking forward to applying new MMC knowledge to the offshore challenges, including air/sea interface coupling.
- It is not clear if a comprehensive validation case of the MMC approach has been carried out so far. The work can benefit by designing a wind tunnel experiment with scale separation along with appropriately designed field experiments to carefully validate the MMC approach. Without such experiments, this project will not be able to realize its full impact.
- It is not clear if the research team has sought to engage researchers beyond DOE labs from universities where similar research is being conducted to increase knowledge base and leverage what is being done elsewhere to maximize the impact of this project.
- While Weather Research and Forecasting can account for complex terrain effects, neither SOWFA nor Nalu can, so I am confused as to why these models were selected for micro-scale tools. There are highly developed open-source codes that can account for complex terrain, so a better explanation regarding the rationale for making these specific micro-modeling choices will be useful.
- The project needs to figure out how to provide real-world validations of its work so far to demonstrate the value to the market and industry. I understand the complexities in doing this, but without it, the work will not create market value. Consider looking at distributed generation forecasting as a means to validate based on actual data.

High-Fidelity Modeling:

- It is very important for this part of the program to embrace not only the HFH/HFM but to seamlessly dovetail this modeling capability with engineering models like OPEN Fast. One informs the other and vice versa. Together, they form a complete package of tools that designers and researchers can use to simulate real-world wind plant performance and load issues, as well as ability to design optimize turbines, plants, and controls.
- Need to coordinate with Integrated Systems Design and Analysis to begin seeking a deeper understanding of the physics of critical gaps in the engineering models.
- The team would benefit by tapping into a large body of literature on modeling complex turbulent flows as developing tools that can resolve the blade boundary layers; predicting

transition and separation under complex atmospheric conditions and at utility scale, is extremely challenging.

- The project has the potential to make a major contribution to the state of the art if a tool capable of running on exascale computers AND producing physically realistic results across a range of operating conditions and atmospheric states. However, the team has many challenges to overcome, and it was not clear to me from the report and presentation that they fully grasp the challenges ahead.
- I suggest that a gap analysis is conducted to show the difference or gap between SOWFA, FAST, and Nalu.

Rotor Wake Measurements & Predictions for Validation:

- High-fidelity spatial and temporal accuracy is required for computational fluid dynamics (CFD) validation. This is extremely difficult to perform at utility scale open atmospheric conditions. Yet, that is what this project must do to succeed. The results so far are excellent but event greater spatial resolution is needed for CFD validation.
- The resolution issues noted should be carefully considered in future experiments. I would also suggest a carefully designed single turbine experiment to produce data from blade boundary layer to wake meandering scales.
- Continue with field measurements, but consider complementary test techniques to enhance spatial resolution of test data.
- This study is essential for the success of A2e. The project has produced promising results and very useful data sets, but more emphasis should be placed on obtaining the multi-resolution data required for validating the HFM tool of A2e. Also, validation studies need to focus on quantifying the accuracy of the simulations across the entire wake and avoid qualitative statements like "reasonable" accuracy.
- If the stated problem is improving the uncertainty, it seems like more effort should be made to quantify progress toward removing uncertainty. This modeling should also be used to look at how turbines interact with large buildings in distributed generation applications.

Advanced Flow Control Science for Wind Plants:

- When industry implements wake steering and sees measurable improvements in wind plant annual performance that will be the final validation. Are there industry members who are planning to implement these controls?
- The team needs to strive to understand what coherent vortices are present in a wind plant and explain how 3D physics will be incorporated in FLORIS.
- Aggressively explore coordinated wake steering with deeper understand of turbine/turbine coupling to enhance upper layer mixing to increase kinetic energy entrainment to the interior of the wind plant.
- More emphasis should be placed on validation with field data for wake steering and other control strategies. The team should engage researchers who understand turbine wake fluid mechanics.

Small Business Vouchers – WindESCo:

- Challenges may arise from implementation of consensus control algorithms in the field due to data resolution and noise.
- The project sought to demonstrate the effectiveness of consensus control on wind farms using SCADA data. The reported results are certainly promising, and given the overall

size of the project, I consider progress to be satisfactory. Certainly, the results demonstrate that the idea has merit and should be further investigated.
- Continue with validation plus explore other big data control applications, which capitalize not only on synchronized wind plant measurements, but also historical performance, fault, and maintenance data.
- Team up with a wind farm operator to validate AEP gain.

Multi Physics Model Validation & UQ:
- FAST.Farm could be an important contribution of A2e, as such a tool could serve as the work horse for industry simulations and wind plant optimization. The success of the project, however, hinges on its integration with HFM and validation efforts. The goals of this project need to be better defined and articulated. Presently, pieces seem to be a bit disconnected. A2e will benefit a great deal by clearly defining what various fidelity levels mean to this and all other teams of A2e. Also considering SOWFA as the LES-truth should be carefully reconsidered. Uncertainty quantification is an important aspect of this project, but validating FAST.Farm using a so-called LES truth introduces all the uncertainties of the LES in this model making UQ even more difficult and "uncertain."

Integrated Systems Design and Analysis:
- The methodology integrates optimization strategies with turbine controls and modeling tools with the aim to produce wind plant. There are 3 main thrusts that need to be integrated into a single systems design framework: (1) Optimization strategies for wind plant layouts; (2) Controls using wake steering; and (3) Development of engineering-fidelity modeling tools for wind plants.
- The idea to use turbines of variable size for non-heterogeneous wind plants, while not new, is promising.
- Integrated Systems Design and Analysis team collaboration with HFM and MMC teams to identify high priority model gaps is very important. It seems that the state of each of these projects is now ready for more fruitful summit meetings.
- Validation of the various components is critical for this approach to provide reliable results. It is not clear how this is addressed in this project. It is not clear if the team has attempted to validate their approach with real-life operational data.
- Seek collaboration with both WTG manufacturers and some of the owners as there are tests of wake steering to optimize output ongoing in industry.

Integrated Systems Design and Analysis – Offshore Wind:
- Data collected in systems that can be fully shared with modelers will be important for future progress to minimize uncertainties in validation studies. The limitations of engineering models are well known when applied to such non-linear systems, and major progress can only come by validating HFM models with such experiments and using the results to improve engineering models.
- Develop a transparent modeling proficiency process with public reference turbines, support structures, wave inputs, etc. for certification assessment and industry academic use.
- Clearly show what benefits have been provided to tools from the project.
- Consider the opportunity to leverage the future data that will be generated by the work done under the two-demonstration projects funded by DOE (AquaVentus and Project Icebreaker).

Office Response

The Atmosphere to Electrons research portfolio is a diverse collection of activities targeting the science and research needs necessary to advance wind plant performance. The review team has done an excellent job in recognizing the key program elements of the A2e approach and have provided insightful feedback on both the strengths and weaknesses of ongoing research from the perspective of industry, academia, and engineering consultant practitioners. The comments provided will be used to strengthen ongoing activities and help guide the development of future initiatives.

The A2e program is a mix of science and engineering projects with a goal of advancing wind plant performance by gleaning a better understanding of the underlying physics that drives performance. As noted by the panel, a significant investment is being made in developing high-fidelity modeling tools that provide predictive capability from first principles. Selection of the Nalu code and weather research and forecasting have provided a new baseline for the development of plant-level tools to assess the complexities of inter and intra wind plant flow dynamics and impacts. While the program has historically focused on engineering design tools for industry use, the HFM investment will be used to help facilitate future deployment and provide a new capability to extend the fidelity of our existing portfolio. Based on the feedback, additional clarity is needed to more clearly define the applicability of the existing portfolio and indicate both the gaps in our current capability that will be addressed, as well as the development and delivery timeline for new high-performance computing (HPC) tools.

Also, the strong linkages that exist between verification, validation, and UQ and the experimental program need to be more clearly articulated. Formal HFM code verification and validation is a program cornerstone driven by industry guidance and the collection of high-quality experimental validation data that serves both the program needs and community is a program priority. The recent formation of a verification &validation/UQ research team within the wind science and engineering program, the recent announcement of the AWAKEN experimental program to collect high-resolution field data to validate HFM codes, and our controls research methodologies should help address some of these concerns.

The A2e initiative will be transitioning into a new program structure. In the new construct, research initiatives in science and engineering will support four key program platforms: land-based wind, offshore wind, distributed wind, and grid integration. As noted by the reviewers, an increased emphasis in offshore-related work needs to occur immediately to help the newly emerging domestic market. We are already transitioning our atmospheric science programs and developing HPC HFM code to support deep water floating platform development and it anticipated to be a research priority by FY 2021.

4.5 Activity Area: Distributed Wind

This section provides an overview of the scoring for the Technology Development project within the Distributed Wind activity area; a summary of reviewer comments in response to the evaluation criteria; representative and noteworthy comments regarding the project; and the WETO response to the evaluation results. Full evaluation results can be found in Volume II.

Project Scoring

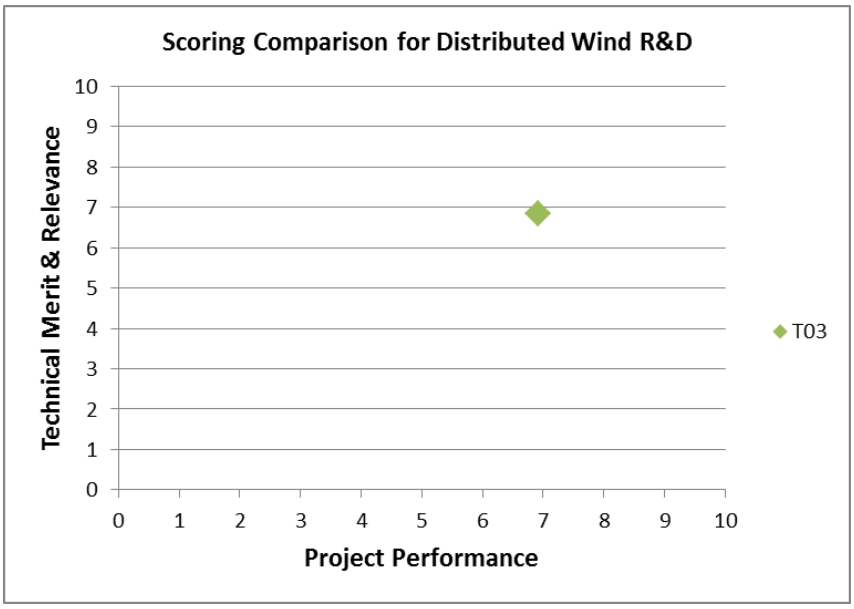

Figure 4-4. Score for the Distributed Wind activity area project

Project List

Table 4-3. List of Projects Reviewed in the Distributed Wind Activity Area

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

Summary of Reviewer Comments on the Activity Area

1. Are the projects within this activity on the leading edge of work within this field?
    - There were mixed responses to this question, both positive and negative. Generally speaking, reviewers suggested that foundational work needs to be completed to support a more robust effort toward advancing the state of the art.
    - WETO needs more clearly defined research challenges and goals to advance the state of the art.
    - WETO needs to leverage work happening across its entire portfolio to advance distributed wind.

2. Has the rationale behind the funded activities and projects been effectively conveyed during the peer review?
    - Most reviewers felt funded activities and projects had been effectively conveyed.
    - WETO should consider a modified funding focus to target issues that benefit the broader distributed wind industry, not individual OEMs.

- WETO needs to better define what questions are being answered or how answers to those questions advance the industry.

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

4. Are there important topic areas that are underrepresented or missing within this activity area?
    - This activity area could benefit from more distinguished, clearer areas of focus.
    - A shotgun approach may be diluting important areas for the program that should be more focused to have a greater impact.

5. Are there any notable strengths to the activity portfolio content or direction that you would like to point out?
    - The data collection and analysis conducted by PNNL is a strength because it is helpful in focusing the research on the highest impact areas.

6. Are there any notable weaknesses to the activity portfolio content or direction that you would like to point out?
    - In some cases, it appears that some of the work was directly advantageous to a specific vendor. Look for generic work that all interested vendors could access and utilize.
    - One reviewer disagrees with WETO's definition of distributed wind and identified it as a weakness.

7. What recommendations would you like to convey to the manager(s) of this activity area?
    - WETO either needs to eliminate funding for the Distributed Wind portfolio or put in place a long-term strategic plan with more robust funding to make an impact in this area.
    - Leverage applicable investments in land-based and offshore wind.
    - Revisit definition of Distributed Wind.

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

Comments on Strengths (under any criterion)

- Excellent collaboration with industry to get them what they want and the tools they need.
- Great effort to help the small and distributed wind industry with targeted market studies, resource assessment tools, and technical assistance.

Comments on Weaknesses (under any criterion)

- Not clear that adjustments are being made to account for recent industry failures and to ensure that Competitiveness Improvement Project investments aren't going to companies that are likely to go out of business.
- There does not appear to be significant LCOE reduction plans that would bring small wind to parity with solar.

Recommendations

- Explore the possibility of easy wins if large wind technology lessons can be brought down to small wind technology.
- Benchmarking and detailed project cost breakdowns provide material value to inform market and new business plans.

- Recommend developing an off-ramp plan, unless a unique solution to complement or beat solar cost is possible.
- A focus on accessibility could be a good metric to use in addition to LCOE.

Office Response

WETO acknowledges that distributed wind systems, specifically those using small wind technology, are going to have a hard time competing with solar photovoltaic systems on an LCOE basis. However, WETO feels strongly that we still need to focus on cost reductions in order for small wind to play a complementary role in hybrid Distributed Energy Resource systems, which can be used to provide backup power and energy cost savings.

FY 2018–FY 2020 congressional direction required the distributed wind budget to be increased to $10 million annually; as a result, WETO developed a new multiyear program plan and portfolio of projects for the program. The WETO team is confident that the new plan and portfolio will address reviewer concerns around the lack of focused efforts and the need for a strategic plan.

4.6 Activity Area: Testing Infrastructure

This section provides an overview of the scoring for all projects within this activity area; a summary of reviewer comments in response to the evaluation criteria; representative and noteworthy comments regarding individual projects; and the WETO response to the evaluation results. Full evaluation results can be found in Volume II.

Overview of Project Scoring

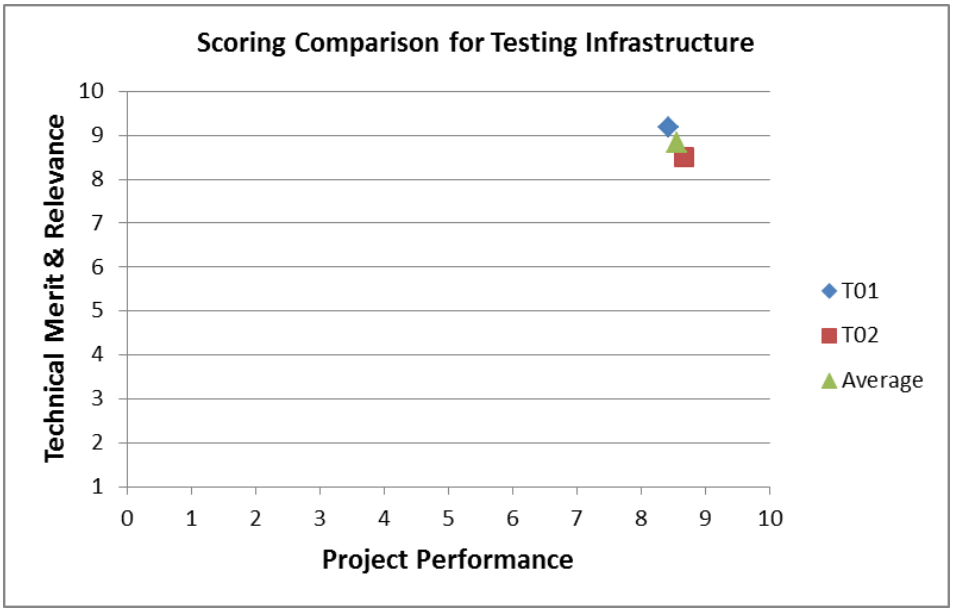

Figure 4-5. Relative scores for the Testing Infrastructure activity area projects

Project List

Table 4-4. List of Projects Reviewed in the Testing Infrastructure Activity Area

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

Summary of Reviewer Comments on the Activity Area

1. Are the projects within this activity on the leading edge of work within this field?
    - All projects in this activity are in the leading edge of the field.
    - The team is doing a great job with leading edge research at both the NWTC and SWiFT facility.

2. Has the rationale behind the funded activities and projects been effectively conveyed during the peer review?
    - The team did a good job explaining the rationale behind their work.
    - The rationale for funding is clear and warranted.

3. Within this field, are thought leaders aware of the WETO-supported work?
    - These facilities and capabilities have been clearly conveyed in the industry. All thought leaders are engaged and appreciate WETO support and leadership.

4. Are there important topic areas that are underrepresented or missing within this activity area?
    - Offshore testing capability is under-represented and should be developed further in the future.
    - Understanding how this research can impact distributed wind would yield a benefit.

5. Are there any notable strengths to the activity portfolio content or direction that you would like to point out?
    - The SWiFT facility provides exciting opportunities for collecting critical data and doing field testing for advancing wind plan modeling and controls.

6. Are there any notable weaknesses to the activity portfolio content or direction that you would like to point out?
    - There are concerns with safety and the safety culture at both testing sites.

7. What recommendations would you like to convey to the manager(s) of this activity area?
    - Ensure budget for maintaining and upgrading facilities and testing innovation.
    - Ensure that the data collection strategy is tightly integrated with high-fidelity modeling needs.

- Take steps to manage the safety culture, including use of consultants, training, and appropriate reporting.
- Evaluate ways to cost effectively utilize more privately-operated facilities as test facilities.

Representative and Noteworthy Comments on Projects in Activity Area

Comments on Strengths

- NWTC operates impressive testing facilities in support of DOE and wind industry missions. It has evolved to meet the growth of the industry, as well as changing industry needs, ranging from blade and drivetrain testing, to component reliability and grid integration testing. Maintaining these facilities is important, and the industry partnerships are excellent.
- Transitioning the NWTC to the Flatirons Campus to support other renewable energy technologies is a positive thing, as is maintaining state-of-the-art existing facilities.
- The SWiFT facility is a world-class testing facility for wind farm research. The site is highly innovative and relevant to advancing a fundamental understanding of wake turbulence in wind farms, producing unique datasets for model validation, and developing advanced control strategies.
- The SWiFT results on wake steering and its effect on downwind turbines are novel and quite exciting. They serve to illustrate the potential of this facility once fully developed.

Comments on Weaknesses

- Progress has been slow to get the SWiFT site up and running. Delays in commissioning have been noted due to errors, staff transitions, and an accident. While some of the delays could have been expected due to the highly innovative nature of the facility, others could have been addressed or avoided with a better management structure and safety procedures. The project could benefit from improved management of the site and stricter safety guidelines and procedures. The site currently has a narrow focus, and R&D issues related to distributed generation should be included in future operations of the facility.
- There is a need to communicate "discovery story" successes at the NWTC. The staff talent at the site is as important as the testing facilities, and this should be widely communicated. Conference papers published based on NWTC testing should also be more widely communicated. More specific examples of how utilization of NWTC facilities have enabled specific innovations and advancements, including technology commercialization, would be useful.
- Ensuring a safe operating culture at both the NREL and SNL sites was stressed.

Recommendations

- Further investment at the NREL Flatirons Campus is commendable, especially in the areas of distributed wind grid integration and grid support and potentially offshore wind. Utilization of the site to collect data for HFM validation of turbines in complex terrain and under extreme conditions was recommended. An external communications plan should be developed for the site to inform industry of the site capabilities.
- It is important to continue funding the SNL SWiFT site. The facility has enormous potential to drive land-based and offshore wind development and wind farm innovation. However, project management and safety culture need to be improved so that delays and

safety issues that plagued the site in the past are not repeated. It is important that the SWiFT team continue to expand industry partnerships and collaborative R&D.

Office Response

WETO thanks the peer review team for recognizing the important role that the NREL Flatirons Campus/ NWTC and the SNL SWiFT site facilities and staff play in carrying out WETO's R&D mission, while supporting the U.S. wind industry. The WETO team will continue to manage this activity area to enable state-of-the-art wind R&D, both from a programmatic perspective and as an asset to the U.S. wind industry. Based on the transition of the NWTC to the Flatirons Campus, some of these future planning efforts will be coordinated with other EERE technology offices, such as the Water Power Technologies Office, the Advanced Manufacturing Office, and the Solar Energy Technologies Office. Besides added grid integration R&D investments, including a second controllable grid interface, programmatic planning is underway to evaluate distributed wind testing, grid integration capabilities, and advanced wind turbine control development utilizing the GE 1.5-megawatt turbine.

WETO recognizes the importance of national-level test facilities in the United States for carrying out innovative R&D related to offshore wind energy. Multi-year program planning discussions identified this need, and WETO issued a request for information (RFI) specific to test facilities for offshore wind in July 2018. RFI input was critical to informing the development of the 2019 WETO crosscutting FOA, which included a topic area addressing the utilization and upgrading of national-level test facility applicable to offshore wind R&D. WETO made project selections under this solicitation in October 2019, with the project R&D timelines ranging between FY 2020 and FY 2022.[x]

The peer review team acknowledged the broad range of communication and outreach activities at both sites, including visitor tours, student engagement, conferences, and interactions with industry. WETO will continue to promote the development of solid external communication plans that present expertise and facilities, detailed accomplishments, patents, journal articles, and technology commercialization achievements.

The WETO team shares the peer reviewers' concern that safety should always be of paramount importance in any operations. DOE's Environment, Safety, Health, & Quality team closely monitors safety at the NWTC, and the entire NREL team meticulously plans and carries out operations at the site, following well-defined processes and procedures. The NWTC has an outstanding safety record, with only five recordable cases since November 2014 and four Days Away, Restricted or Transferred. The SNL SWiFT team has worked tirelessly in FY 2019 to improve the safety culture at the site by developing safety processes, procedures, and protocols; increasing involvement of the SNL Environment, Safety, and Health team; and expanding training for the entire staff.

4.7 Activity Area: Standards Support and International Engagement

This section provides an overview of the scoring for the project within the Standards Support and International Engagement activity area; a summary of reviewer comments in response to the evaluation criteria; representative and noteworthy comments regarding the project; and the WETO response to the evaluation results. Full evaluation results can be found in Volume II.

Overview of Project Scoring

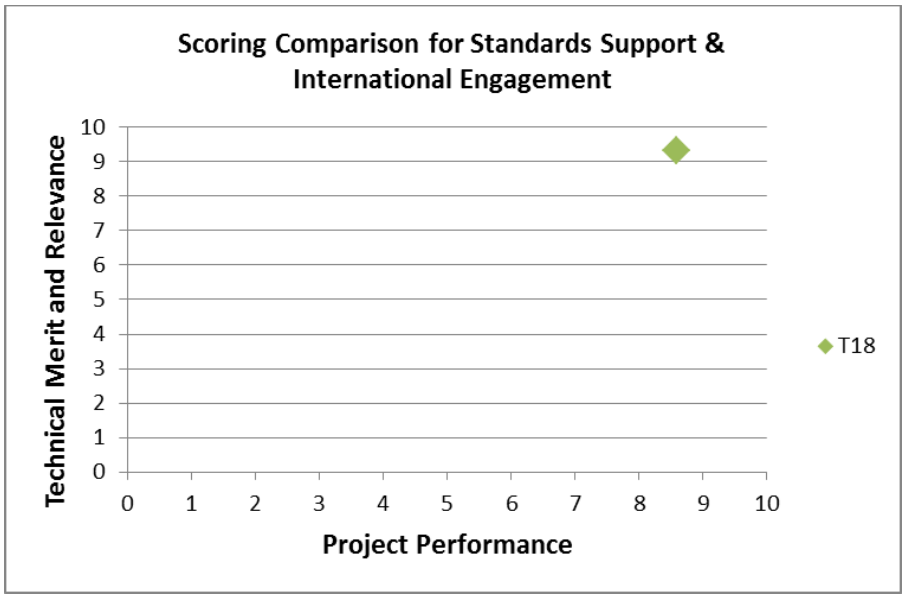

Figure 4-6. Scores of the Standards Support & International Engagement activity area project

Project List

Table 4-5. List of the Reviewed Projects in the Standards Support & International Engagement Activity Area

Unique ID	Project Name	Organization	Budget	Actual Costs	Project Status
T18	Wind Standards Development	NREL, PNNL, SNL	$1,842,708	$1,088,926	Active

Summary of Reviewer Comments on the Activity Area

1. Are the projects within this activity on the leading edge of work within this field?
    - Standards are not leading-edge R&D; they are developed based on technology experience, such as prototyping and validation testing.
    - Standards document consensus.

2. Has the rationale behind the funded activities and projects been effectively conveyed during the peer review?
    - Yes.

3. Within this field, are thought leaders aware of the WETO-supported work?
    - DOE did a great job engaging academia, standards agencies, and industry in this work.

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

- Low end-user participation in the standards has resulted in underrepresentation of siting, project development, installation, commissioning, O&M standards, and best practices. These have become more important for risk reduction for the financial community.

5. Are there any notable strengths to the activity portfolio content or direction that you would like to point out?
    - WETO support for U.S. participation in IEC standards and certification has been exemplary over many years. This consistent support has enabled the United States to influence international standards in major ways.

6. Are there any notable weaknesses to the activity portfolio content or direction that you would like to point out?
    - WETO might be able to facilitate cross-government-agency adoption or acceptance of international standards as the United States develops the offshore wind industry.
    - DOE should take a more active role in gaining focused standards development activities to move industry metrics toward increased deployment.

7. What recommendations would you like to convey to the manager(s) of this activity area?
    - This activity would benefit from publishing its stated positions on the standards publicly and in advance, so that the industry can understand and provide commentary on the opinion since the group does carry weight beyond the normal participants.

Representative and Noteworthy Comments on Projects in Activity Area

Comments on Strengths (under any criterion)

- WETO support for U.S. participation in IEC standards and certification has been exemplary over many years. This consistent support has enabled the United States to influence international standards in major ways.

Comments on Weaknesses (under any criterion)

- WETO might be able to facilitate cross-government agency adoption or acceptance of international standards as the United States develops the offshore wind industry. DOE should take a more active role in gaining focused standards development activities to move industry metrics toward increased deployment. The work in support of small wind certification has harmed the large distributed wind market.

Recommendations

- Continue to support this program area with the same forward-looking vision.

Office Response

WETO understands that supporting wind standards development in itself is not cutting-edge R&D. However, standards are a mechanism by which important R&D results can be institutionalized for the benefit of the entire industry. Robust standards have had a huge impact on improving wind turbine design and operation. Better standards will be produced if the technical diversity of the group can be enhanced. WETO will make the effort to recruit new experts to the standards development process that reflect all components of the industry.

Further investigation as to the impact of standards on distributed wind is warranted. WETO will engage with the distributed wind industry to better understand the problems and solutions.

4.8 Activity Area: Technology to Market and Small Business Vouchers

This section provides an overview of the scoring for all projects within the T2M and SBV activity area; a summary of reviewer comments in response to the evaluation criteria; representative and noteworthy comments regarding individual projects; and the WETO response to the evaluation results. Full evaluation results can be found in Volume II.

Due to the differences in scope between the two initiatives, the summary and response portions of this section are divided into two sub-activities: Technology to Market and Small Business Vouchers.

Overview of Project Scoring

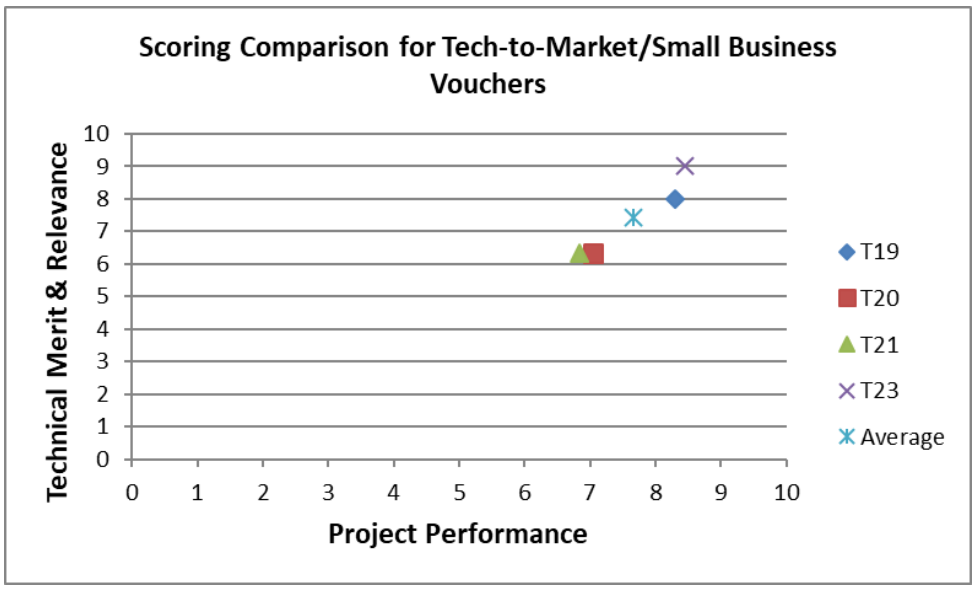

Figure 4-7. Relative scores for the T2M activity area projects

Project List

Table 4-6. List of Projects Reviewed in the T2M and SBV Activity Area

Unique ID	Project Name	Organization	Budget	Actual Costs	Project Status
T19	Small Business Vouchers - Micron/NIRE/SkySpecs	SNL	$781,616	$781,616	Complete
T20	Small Business Vouchers - Sentient	SNL, NREL	$212,000	$181,497	Complete
T21	Small Business Vouchers - Tower Technology	NREL	$170,000	$166,738	Complete
T23	Technology to Market (T2M)	Idaho National Laboratory (INL), NREL, PNNL, SNL	$525,466	$382,043	Active

Technology to Market (Sub-activity 1)

Summary of Reviewer Comments on the Sub-Activity Area

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

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

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

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

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

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

recurrent event.

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

Representative and Noteworthy Comments on Projects in Sub-Activity Area

Comments on Strengths (under any criterion)

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

Comments on Weaknesses (under any criterion)

- Sharing results publicly would allow for broader, non-participant feedback on the results. All communication appears to be internal, which materially decreases value.

- It would be nice to see how the results from the survey and summit influenced the DOE roadmap or R&D focus. Recommend continuing to build on the results of this project and to make it a recurrent event.

Recommendations

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

intersection of wind power industry R&D and technology development needs with DOE capabilities in wind energy technology.

- To address the short- and long-term challenges of wind energy development and operations, WETO should continue to provide wind power professionals the opportunity to share their insights on the technological, science, and deployment gaps that limit the growth of wind power capacity and generation and impede the enhancement of wind power technology and operations nationwide.

Office Response

The office appreciates the positive feedback regarding the T2M activity and the purpose of creating and evaluating innovative programs that eliminate the common barriers that promising technologies face along the pathway to market. Furthermore, we believe more private sector companies are in need of having access to emerging technologies so they can remain competitive in the global marketplace, and it is imperative to fund projects that enable and bring the business mindset into the laboratory and increase collaboration with industry so that the market can evaluate wind innovations.

The T2M activity provided an opportunity to convene a diverse group of stakeholders from the wind industry (manufacturers, developers, owner/operators, consultants, and financiers), as well as office management and national laboratory wind energy researchers. These activities emphasized listening to industry perspectives through a survey, a targeted workshop, and facilitated discussions. The findings emphasized a significant transition underway in the electricity and broader energy sector. Wind energy still needs to compete on LCOE to achieve continued large-scale deployment, but at the same time, there is increasing pressure for wind energy to contribute more to the electric grid system—in terms of reliability, stability, and resiliency—than ever before. In a future with more variable renewable generation resources on the electrical system and therefore less physical inertia in the system, wind energy and other inverter-based resources will have to contribute more in terms of essential grid system services than they currently provide.

This shifting paradigm will drive significant research into understanding the physics and modeling of wind turbines and plants and larger inverter-dominated electricity systems. In addition, there are technology development needs associated with future wind energy systems with extremely large turbines. These systems need to be highly optimized wind plants with low uncertainty in terms of expected performance and energy production that serve the diverse set of needs for stable, reliable, and resilient grid operation.

Small Business Vouchers (Sub-activity 2)

Summary of Reviewer Comments on the Sub-Activity Area

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

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

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

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

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

6. Are there any notable weaknesses to the activity portfolio content or direction that you would like to point out?
    - The economics and financial viability of some of these technology solutions need to be assessed prior to undertaking the research.
    - Infrared inspection has potential but needs lots of follow up to be successful. The industry is already using drone inspection and has used infrared inspection sensing as well.
    - I don't like that reports appear to lack commentary that goes beyond the selected partner. Example: Is there an inherent advantage or disadvantage with SkySpecs that makes it a better/worse platform for this type of inspection compared to industry alternatives?

Adding that objective step back would complete the study and better enable the industry to advance with knowledge from the study.

- Since the critical information obtained through this project was confidential, it had zero chance of adding value to the problem. Nothing in the applicant's information shows that the applicant is uniquely qualified to assist in or add value to solving this problem. The industry is already investing millions of private R&D funds into solving this problem. It is highly unlikely that a national lab will add value here.
- While the work appears to have been done carefully, it is unclear that this project will have a real impact. Also, the fact that results cannot be disseminated openly makes it impossible to thoroughly assess what has been done. Such a project may not be suitable for funding by the program.
- The applicant did not have a unique ability to add value to this problem, the data was kept confidential by the private company, and the efforts herein are de minimis compared to existing industry efforts. The project that resulted was effectively an equity contribution to a private party who took the knowledge and expanded their business in China. Nothing presented by the applicant justifies the cost.
- Test conception by industry partner appears to be poorly conceived to validate their analytical technique.

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

Representative and Noteworthy Comments on Projects in Activity Area

Comments on Strengths (under any criterion)

- The SBV Program provided clean energy small businesses access to select national labs – making the contracting process simple, lab practices transparent, and access to the labs' unique facilities practical.
- Through SBV, selected small businesses received access to the state-of-the-art facilities and experts at participating DOE national labs, while the labs expanded their knowledge of and involvement with the private sector, helping small businesses with advanced technologies contribute to American competitiveness and economic growth.

Comments on Weaknesses (under any criterion)

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

Office Response

The office would like to express its gratitude for review of the SBV projects. The office believes in the importance of opening the National Laboratories to qualified clean energy small businesses by making the contracting process simple, laboratory practices transparent, and access to the labs' unique facilities affordable. Most importantly, SBV is intended to offer U.S. clean energy small businesses a competitive advantage in the global marketplace, and it increases national lab awareness of the challenges small businesses face in the energy sector.

WETO appreciates the progress reports on all three projects within the SBV portfolio, and we believe the results could impact turbine inspections, turbine controls and sensing technologies, and grid controls for wind plants, and the results could have a direct impact to help advance a small business.

In addition, it is our responsibility to communicate our projects and disseminate the results of these projects; however, due to non-disclosure agreements with private partners, there are limitations on what specific results can be shared. In the future, the office will suggest the partner provide an economic and financial viability assessment prior to undertaking the research. With these suggestions in mind, the office agrees technology transfer and commercialization should be more actively explored to ensure that these SBV projects do impact industry.

4.9 Activity Area: Advanced Components, Reliability, and Manufacturing

This section provides an overview of the scoring for all projects within the Advanced Components, Reliability, and Manufacturing activity area; a summary of reviewer comments in response to the evaluation criteria; representative and noteworthy comments regarding individual projects; and the WETO response to the evaluation results. Full evaluation results can be found in Volume II.

Overview of Project Scoring

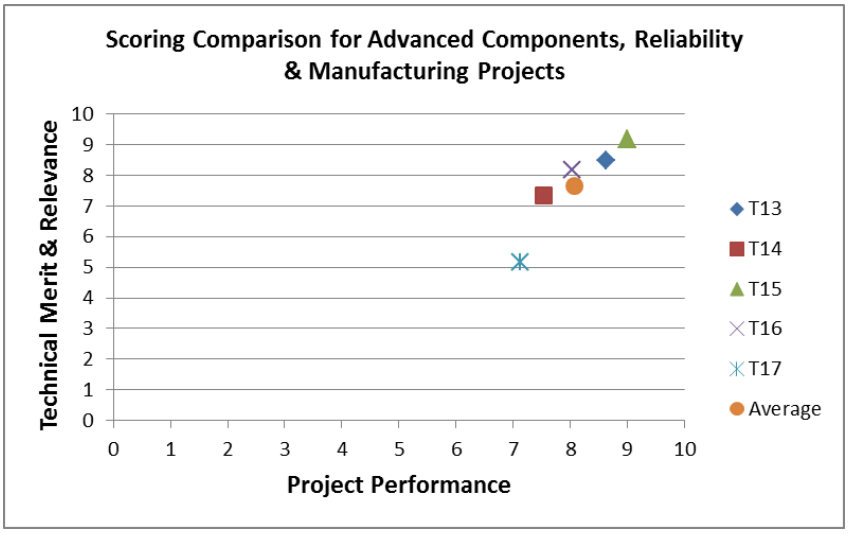

Figure 4-8. Relative scores for the Advanced Components, Reliability, and Manufacturing activity area projects

Project List

Table 4-7. List of Projects Reviewed in the Advanced Components, Reliability, and Manufacturing Activity Area

Unique ID	Project Name	Organization	Budget	Actual Costs	Project Status
T13	Additive Manufacturing in Wind Turbine Components and Tooling	NREL, Oak Ridge National Laboratory (ORNL)	$694,295	$341,918	Active
T14	Wind Turbine Blade Durability and Damage Tolerance	SNL	$1,510,900	$1,117,524	Active
T15	Wind Turbine Drivetrain Reliability	ANL, NREL	$4,065,568	$3,475,387	Active
T16	Optimized Carbon Fiber Composites for Wind Turbine Blades	ORNL, SNL	$1,049,960	$775,585	Active
T17	Big Adaptive Rotor	SNL, NREL, Lawrence Berkeley National Laboratory (LBNL), ORNL	$2,705,610	$1,067,768	Active

Summary of Reviewer Comments on the Activity Area

1. Are the projects within this activity on the leading edge of work within this field?
    - Very high overall activity area, with multiple supported projects ranging from manufacturing innovation to improved reliability. This is one of the most productive areas of the WETO program.
    - The Drivetrain Reliability Collaborative is one excellent example of continuous improvement that has improved industry's reliability.
    - All projects in this activity are at the leading edge addressing major challenges in components, reliability, and manufacturing—all in areas in which DOE must play a major role.
    - All projects at the leading-edge work especially in low-cost carbon fiber and 3D-printed mold technology.
    - Big Adaptive Rotor work appears to be behind current industry direction.

2. Has the rationale behind the funded activities and projects been effectively conveyed during the peer review?
    - No weaknesses. The tie to the office objectives has been clear.
    - Very well presented and articulated.
    - For the most part, yes, but not cohesively. It seems like the questions are: "what are the big industry problems?" and "what is next big change?" But not all of the programs fit well into those categories. Several presenters struggled to articulate the question they were trying to answer and were unclear whether or not they actually answered that question.

3. Within this field, are thought leaders aware of the WETO-supported work?
    - Excellent communication through reports and regular workshops.
    - In the reliability side, the communication has been clear. The manufacturing activities could use broader communication.
    - DOE did a great job engaging the research and industry communities around funded research.
    - It seems like this group is communicating well with the specific stakeholders it is targeting, but could communicate better with other stakeholders who may not be the anticipated counterparts, but may benefit from the value created by this activity.

4. Are there important topic areas that are underrepresented or missing within this activity area?
    - Perhaps more emphasis on accelerating the final resolution of the white etching problem in main bearings and exploration of plain bearings for high-load drive applications.
    - The focus on tower and blade manufacturing is helping push the industry in the right areas. However, it may be worthwhile to focus efforts on technology that creates lower cost repair solutions versus focusing on improving reliability.
    - More detailed evaluation of all the BAR options, including advanced components.
    - Maybe stronger focus on structural testing programs of wind blades. This is an area were DOE can play a larger role to develop new test methods that can reduce testing time and cost.
    - It is felt that power electronics (insulated-gate bipolar transistors), cable system fatigue, aging control systems, and tower/foundation life extension are the next big problems for the industry, and these do not seem to be represented in any of the research.

5. Are there any notable strengths to the activity portfolio content or direction that you would like to point out?
    - The drivetrain reliability collaborative is an excellent project that should continue bear fruit for the industry.
    - The additive manufacturing and gearbox projects are excellent. They highlight how DOE national laboratory facilities can be brilliantly leveraged to solve problems that the industry cannot tackle and to break new ground that paves the way to onsite manufacturing.
    - Bringing in the skills of other national laboratories is an excellent and high-value use of the activity. The ability to pull from other centers of excellence is way beyond the capability of the industry and has huge rewards (additive manufacturing, carbon fiber, material science for drivetrain).

6. Are there any notable weaknesses to the activity portfolio content or direction that you would like to point out?
    - The robotic blade inspection project appeared to lack a high-value result for the industry.
    - Blade reliability is far more important in distributive wind situations where turbines are located closer to populations. It seems like this group is responding well to known problems and is not working on identifying the next systemic problem. While the surveys that the group conducted are valuable, they are a reflection of the present and not the future.

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

7. What recommendations would you like to convey to the manager(s) of this activity area?
    - Industry input is urgently needed to guide certain projects.
    - Improve communication to the entire wind industry.
    - Continue to be open to new innovations to support and be prepared to adjust the balance of projects if needed to fund high-value projects.
    - Most of the work reported is impressive and should be expanded. Portfolio of activities should be driven by industry needs, and some of the projects may not be appropriate for DOE investment.
    - Keep focusing on effect of defects studies and ways to improve turbine reliability.
    - Figure out what the next big problems are ahead of time. Focus on the near-term problems, as well as 10, 15, 20, 30-year problems and how to get ahead of them.

Representative and Noteworthy Comments on Projects in Activity Area

Comments on Strengths (under any criterion)

T13 Additive Manufacturing in Wind Turbine Components and Tooling:

- Advancing manufacturing techniques and reducing costs through innovation, especially robotic and additive manufacturing, is a high-value approach to reducing LCOE. Additive manufacturing is a very relevant topic for the industry, is an excellent way to reduce the cycle time of low-production components, and has the potential to accelerate time to market. This work could be transformative for blade and component manufacturing. This is a high-value, high-risk area of research that is appropriate for national lab and government funding. Advancing this topic, if successful, would advance the industry and provide significant value.

T14 Wind Turbine Blade Durability and Damage Tolerance:

- Wind Turbine Blade Durability and Damage Tolerance work to improve blade reliability and failure prevention is a valuable effort that will advance the state of the art and create significant industry value. Developing methods to quantify remaining lifetime of blade has the potential to save the industry millions each year.
- With the exception of the financial modeling, this project makes sense to study at the WETO level. There are market forces that do not want to lead this research privately because it is not in all market participants' best interests to have this information, thus an objective DOE national laboratory makes sense.

T15 Wind Turbine Drivetrain Reliability:

- This project leveraged an impressive set of capabilities that only DOE national laboratories could accomplish. Excellent systematic approach involving broad industry stakeholders such as tribologists, lubrication experts, and gearing and bearing designers. The overall approach is well reasoned and likely to produce mitigation solutions and other valuable results. Future activities seem logical and appropriate to address these wind drivetrain concerns.
- Very relevant project from an industry point of view. This group is seen as an Independent (non-biased) evaluator of industry issues. The project seeks to address drivetrain reliability, which is a major contributor to O&M costs. The project has a strong potential to reduce LCOE by reducing O&M costs. This project attempts to solve a

problem that the industry is disincentivized to solve itself, but that is of very high importance to the long-term success of the industry.

- Annual workshops are well attended, and there are inter-annual meetings of experts all organized by the Drivetrain Reliability Collaborative. The Collaborative is good forum for collaboration and communication. Several technical papers have been published in focused publications, and the project has direct feedback to international standards. This is an exciting project, and its results are adequately communicated. There is strong engagement with the industry partners. The communication package is robust.

T16 Optimized Carbon Finger Composites for Wind Turbine Blades:

- Lowering the cost of carbon fiber is very relevant to lowering the LCOE. The project has the potential to transform the commercial design of turbine blades using cost-optimized novel carbon fiber materials. It will help bridge OEMs with the carbon fiber manufacturing sector.
- The approach is scientifically rigorous, integrating cost-optimization of novel composite materials and development of representative reference models. The integration of and breaking the silos between OEMs and carbon fiber composite manufacturers are important strengths of this project; this is a comprehensive approach that includes cost modeling, testing, and blade design.
- Good work with private industry and industry advisory teams; good communication with the industry through the industry advisory panel. Materials appear to have been well distributed to stakeholders.

T17 Big Adaptive Rotor:

- Technical Merit: This project has the potential to enable the next generation of super-large rotors for class III resource areas. It is highly relevant to industry, as it will open up large areas of the country for wind development. Good opportunity to have an objective assessment of technologies. Goal is valuable to industry.
- "Creating Pathways to Success for Supersized Wind Turbine Blades" was a great report.
- Note: most reviewers had little to “no comment” on strengths.

Comments on Weaknesses (under any criterion)

T13 Additive Manufacturing in Wind Turbine Components and Tooling:

- The business case and economics for using additive manufacturing for blade tooling or manufacturing might not be able to compete with conventional methods. Broadening the specific steps beyond wind turbine blades and the Skeleton Node component would be valuable; areas outside of blade additive manufacturing are not as well documented or discussed. The information dissemination plan needed more specificity with regards to which publications and conferences would be utilized to engage with wind and the additive manufacturing industries (i.e., stronger communication plan).

T14 Wind Turbine Blade Durability and Damage Tolerance:

- The current Wind Turbine Blade Durability and Damage Tolerance approach does not address two critical elements: (1) frequency of inspections and (2) rate of propagation of damage/defects. Understanding those two elements will be necessary to create full industry value out of the project. Additionally, it is important to identify the non-destructive testing methods currently used by private operators, to identify their associated costs to the wind industry, and to develop the value proposition for the Wind Turbine Blade Durability and Damage Tolerance work.

- In the next phase of this work, it is important that the communication plan include raw data, raw images, and results with the industry to better inform private R&D and ensure wind plant operators are aware of the opportunities to reduce costs associated with wind turbine blades.

T15 Wind Turbine Drivetrain Reliability:

- The communication of some important testing results and certain data sets are restricted to study participants. There are many non-participants in the industry who would gain valuable information from more detail on the results (while still protecting participant privacy). Mechanisms need to be identified so that insurance companies, finance partners, independent engineers, and researchers all have access to the summary information.
- The project must consider increased testing for statistical significance. No real targets are established other than continuing to progress. Encourage broader information gathering from firsthand investigation into failures from a wide range of sources.

T16 Optimized Carbon Finger Composites for Wind Turbine Blades:

- The report would have been more valuable if it stopped at low-cost carbon and provided price and material specs to the wind industry, as opposed to trying to solve the protrusion and market value options. It is not clear that this approach will be cost effective when extending it to the rest of the blade. Using the carbon outside the spar cap might not be the best way to use this material.
- Due to the large tow size, fiber alignment, which is critical in pultrusion process, will be a challenge and may result in poor mechanical properties relative to current standards. Due to the low fiber volume fraction currently achievable, mechanical properties for laminates based on the ORNL low-cost carbon fiber are inferior relative to baseline industrial standards. The future performance will be dependent on how well the pultrusion process with this heavy tow fiber matures. This creates uncertainty with regards to the mechanical properties and cost scenarios that are currently forecast by the DOE carbon project.
- Suggest broader dissemination to the wind industry beyond blade manufacturers and designers. Industry input should be better integrated in this project, and there should be more direct engagement. Industry may already be advancing in these areas, so industry input needs to be integrated.

T17 Big Adaptive Rotor:

- The industry has committed hundreds of millions of dollars to studying this on its own. Nothing presented by applicants demonstrates a unique value that the team brings to the problem that makes it more likely than the industry to achieve success.
- This is not an activity for DOE to be pursuing, as industry is already way ahead.
- Pursuing a specific risky rotor configuration that private industry might not pursue would be valuable, but this project seems focused on a broad survey of topics that industry has already addressed, which appears to have less value and seems like a role for industry.
- 100-M blades have already been built. There is an open question (addressed in the approach) as to the need for the specific W/m^2 target.
- Input from industry has not been incorporated; industry input is critically needed.
- It would be good to show the LCOE gap that this research is trying to close; it would be good if there is a stronger focus on advancing technology readiness levels.
- Tasks 4 and 5 are unlikely to advance the state of the art or result in value creation for the industry.

Recommendations

T13 Additive Manufacturing in Wind Turbine Components and Tooling:

- Continue and consider R&D for other major components, such as blades, generators, and towers that would benefit from additive manufacturing. Based on current (and future planned) research, begin to look at how to perform advanced manufacturing and additive manufacturing onsite. Reach out and engage the Wind and AM industries more, and keep them abreast of accomplishments and future work. Use progress and findings to attract non-industry additive manufacturing manufacturers into the wind space.

T14 Wind Turbine Blade Durability and Damage Tolerance:

- It is recommended that this U.S. blade research look into European-based research on blades, especially leading-edge erosion.
- Consider broadening presentations to conferences that are not blade specific to draw in additional wind industry participants.
- While the idea of this project seems interesting, the economics of implementing it at utility scale is questionable. Input from developers and operators should be critical for developing a plan for future work.
- The results are valuable and are a gateway for private R&D dollars to follow. The project needs to expand to study inspection frequency and damage/defect propagation. The potential benefits of this high risk/reward research justify the expense.

T15 Wind Turbine Drivetrain Reliability:

- This is a very exciting project that brilliantly leverages unique DOE national laboratory capabilities. The team should continue their excellent work and advance from understanding mechanisms of failure to developing mitigation strategies.
- The overall scope of this project will likely need to increase to achieve its full benefit. It would be beneficial if industry partners would be willing to provide out of warranty failed gearboxes to these national laboratories to study and provide additional information on failures. This would expand the scope and provide information that goes beyond the current efforts.
- This study has the potential to add billions in value to the wind industry, and the industry key stakeholders are disincentivized to find the solution on their own. The problem crosses OEMs and regions. It makes sense to continue to investigate this problem, as well as expand the funding and scope of this program.
- This study has the potential to add billions in value to the wind industry, and the industry key stakeholders are dis-incentivized to find the solution on their own. The problem crosses OEMs and regions. It makes sense to continue to investigate this problem, as well as expand the funding and scope of this program.
- Communicating project results needs to be expanded to ensure all wind stakeholders are aware of the results and mitigation strategies. It is suggested that the communication of findings should be expanded and included in more general wind industry forums.

T16 Optimized Carbon Finger Composites for Wind Turbine Blades:

- The strong focus on cost optimization and near-term commercialization bodes well for the success of the effort. It is a very nice blend between rigorous research in materials and optimization, with a strong translational focus driven by industry needs. But industry

input needs to be incorporated, as expanding the activity to the entire blade may not be economically viable.

- Current estimates (around 57% cost reduction predicted relative to current costs) are based on assumptions that need to be verified. General comments: The cost/benefit value of this project is very high and would likely result in significant market value creation for the industry. This project has the potential to advance the state of the art in the industry.
- Suggest broader dissemination to the wind industry beyond blade manufacturers and designers. Industry input should be better integrated in this project.
- Add compressive fatigue testing to the program.

T17 Big Adaptive Rotor:

- Suggest concentrating on infield manufacturing or assembly of rotors.
- The team should engage leading OEMs. Industry has already developed and is building such rotors. This may not be a project suitable for DOE investment.
- Consider changing the goal of this project from creating a 150W/M^2 rotor to creating blades >100M long. Most, if not all, work should directly translate.

Office Response

Key takeaways and lessons learned:

- Overall, work in this activity area is strong and well-focused, all projects are contributing to state of the art, are areas in which DOE must play a major role, and are providing high value to industry, except BAR. Work is helping push the industry in the right areas, and most of the work should be expanded.
- There are weaknesses for each project that will be evaluated and addressed to improve the work as current projects continue and before new work in these areas begins.
- There are several recommendations to expand work that will be considered—such as carbon fiber, manufacturing (additive manufacturing for other major components, on-site manufacturing, and assembly), and in reliability areas (including inspection/repair),—as well as areas where work needs to be more focused and targeted, such as BAR.
- All work areas could have stronger industry feedback loops and stakeholder engagement to communicate importance and progress; engagement should be more direct and conference participation expanded to reach more stakeholders and crosscuts. Use industry feedback to evaluate future work plans; the group is communicating well with the specific stakeholders it is targeting, but could communicate better with other stakeholders who may not be the anticipated counterparts, but may benefit from the value created by this activity.
- The BAR project appears to be behind industry and not well-advised as per peer review comments; the team will re-engage industry where more clarity and feedback is needed and will re-evaluate the scope of work for Task 5 and broader goals to provide the highest impact to industry.
- The office will continue to be open to new innovations to support; the office will also work to figure out what the next big problems are ahead of time, focusing on near-term problems, as well as 10, 15, 20, 30-year problems and how to get ahead of them.
- Bringing in the skills of other national laboratories is an excellent and high-value use of the activity. The ability to pull from other centers of excellence is way beyond the capability of the industry and has huge rewards (i.e., additive manufacturing, carbon fiber, and materials science for drive train).

5 Summary Results: Market Acceleration and Deployment Program

5.1 Overview

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

The results are organized by the activity areas into which individual projects were grouped for the 2019 Peer Review. The outline below lists those activity areas, along with the number of the report subsection in which their respective summaries can be found.

Program:	5.2	Market Acceleration and Deployment
Activity Areas	5.3	Stakeholder Engagement and Workforce Development
	5.4	Environmental Research
	5.5	Siting and Wind Radar Mitigation
	5.6	Advanced Grid Integration

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

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

Complete listings of all reviewer comments regarding programs and activity areas, as well as the full scoring and comments for each of the projects reviewed can be found in Volume II.

5.2 Program-Level Evaluation: Market Acceleration and Deployment

This section provides an overview of the scoring for all projects within this program; a balanced sampling of reviewer comments in response to the evaluation criteria; and the WETO response to the evaluation results. Full evaluation results, as well as a summary description of the program, can be found in Volume II.

plots the relative scores of each project in the MA&D program area—as well as the average for all projects in the program area—with weighted average *Project Performance* on the X-Axis, and *Technical Merit & Relevance* on the Y-Axis. The shaded boxes on the graph represent 1σ, and 2σ standard deviations from the mean average of all the program project scores.

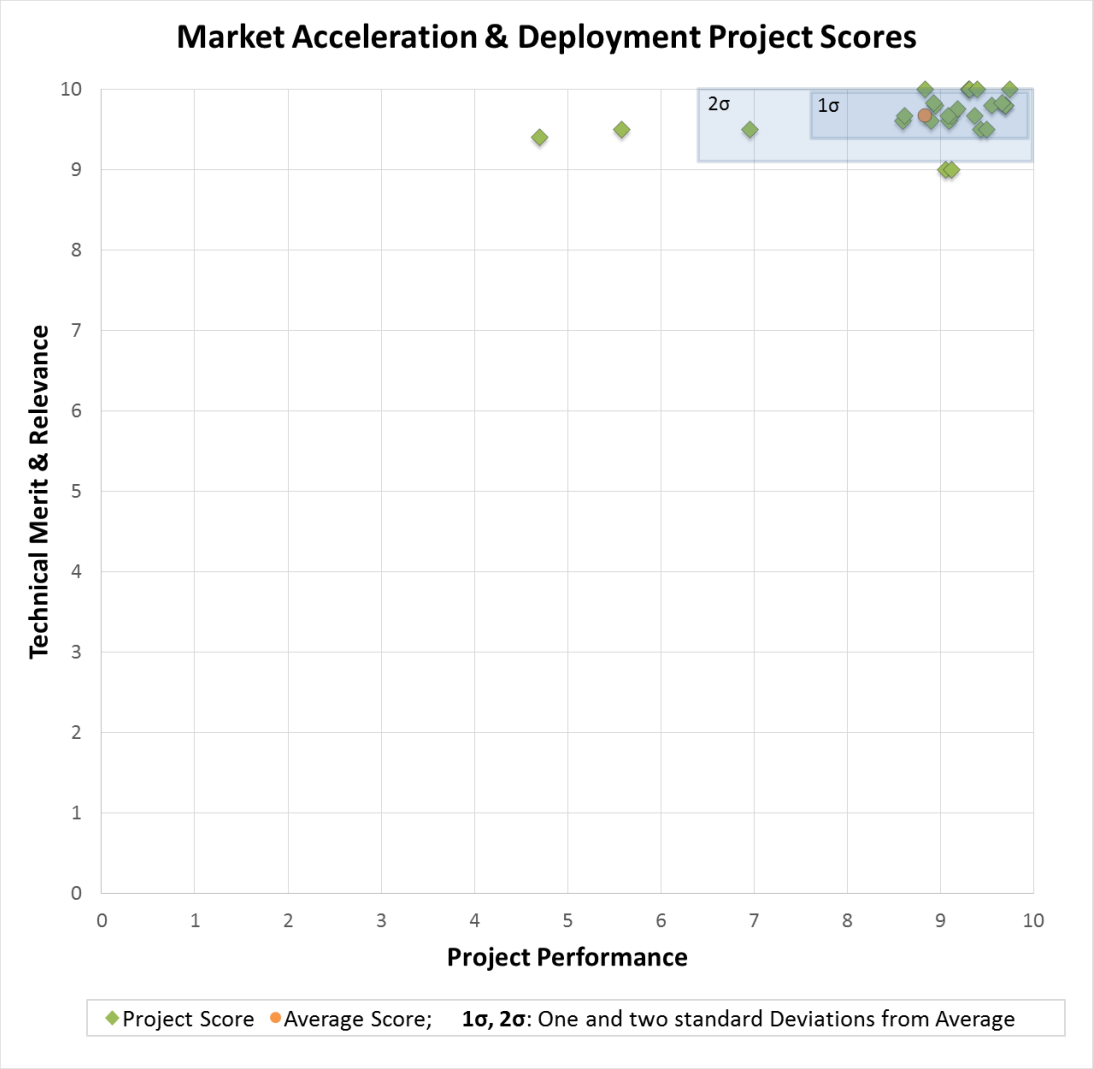

Figure 5-1. Overview of project scoring within the MA&D program[15]

Representative Comments and Recommendations

1. Are the projects within this program on the leading edge of work within this field?
    - "The efforts of the program in this field has helped spur private sector investment and led to rapid increase in knowledge on technology."
    - Yes—reviewers felt that the projects within the activity comprise an "incredibly innovative range of interesting and valuable" work and that DOE shows great leadership in these areas.

2. Has the rationale behind the funded activities and projects been effectively conveyed during the peer review?

    Yes—reviewers felt that the presentations were strong and informative and that WETO provided strong justification for the funding of the work.

[15] The projects with performance scores more than two standard deviations below average in Figure 5-1 are M25 Eagle Take Minimization System and M18 Rotor-Mounted Bat Impact Mitigation System. Additional information on these project scores is available in section 5.4 below, with all project-specific comments available in Volume II.

3. Within this field, are thought leaders aware of the WETO-supported work?
    - DOE has wisely included meaningful investments in stakeholder collaboration and communication to complement their research FOAs.
    - Industry and thought leaders are well aware and actively involved in the WETO-funded work.

4. Are there important topic areas that are underrepresented or missing within this program area?
    - Across all program areas, the reviewers encourage more focus on offshore wind research needs.
    - There should be increased support for work across the program area, with specific emphasis on filling stakeholder outreach gaps and ensuring workforce development projects large enough to fill needs.

5. Are there any notable strengths to the activity portfolio content or direction that you would like to point out?
    - The level of collaboration across industry, interest groups, and academia is world-class and truly impressive.
    - DOE's foresight and strategy has been invaluable to this space.
    - The use of the assets at the NTWC is extremely important in addressing the existing knowledge gaps around the full range of grid services that wind energy can provide, as well as the leading development and validation work occurring at the facility.
    - Other notable strengths are stakeholder engagement activities through ESIG, open platform visualization tool WindView, and also the work going on with dynamic line rating forecasting.
    - On the U.S. Wind Turbine Database and social science work, reviewers felt that project deliverables have been exceptional and that no other entity could have credibly funded or conducted the work.
    - Excellent work in building web-based information systems.

6. Are there any notable weaknesses to the activity portfolio content or direction that you would like to point out?
    - Need for greater offshore wind focus.
    - The scale of some efforts, which perhaps need to be ramped up for the desired impact.
    - There were three environmental projects that were unable to complete their field work due to company insolvency or over-scoping of activities. Efforts should be made at the front end to prevent this from occurring in the future.
    - Modeling capabilities of variable renewable energy with regards to capacity expansion models and operations have limitations, such as curtailment handling and the representation of uncertainty.

7. What recommendations would you like to convey to the manager(s) of this program area?
    - All: Increase offshore wind focus
    - Environmental: In the environmental work, keep continuously engaging industry, OEMs, mitigation technology developers, regulators, and third-party validators to inform strategic prioritization, information dissemination, and collaboration between these stakeholders.

- Encourage broader self-promoting to ensure the industry and other stakeholders are acutely aware of everything WETO is doing in this space.
- Grid: Continue the work targeting market design recommendations for wind/solar heavy systems; increase focus on transmission planning/future modeling; and consider looking at projects in 100% renewable/inverter space.
- Regulatory & Siting: Continue to focus on broadly applicable social science and siting issues affecting wind development, increasing industry involvement in the radar work, and extending current pilot mitigation projects to other DOD facilities where wind development is an issue.
- Engagement and Workforce Development: Ensure strategies are developed and in place and that projects' scales are sufficient to meet end goals.

Themes among Comments on Projects in Program Area

Comments on Strengths (under any criterion)

- Outreach, collaboration, and communication is strong.
    - Work provides a sophisticated and unique opportunity to collaborate across key stakeholders to address issues in a multi-disciplinary way.
    - Many projects include multiple industry meeting appearances, peer reviewed journal publications, and participation in stakeholder webinars, and many have had media coverage.
    - Project teams, generally, have very good representation across stakeholders and include members that are well versed in the technology, science, and study design execution needed to run a successful project.
    - The ability for DOE to bring very different agencies together, assess challenges, and advance solutions is vital to overcoming these challenges.
    - Project set-up allows project performers to address topical issues as they emerge and react to any potential barriers seen.
- Projects have strong technical merit, demonstrate innovation, and use appropriate methods.
    - Federal funding in this area provides an invaluable opportunity for any company, large or small, to pioneer new technologies and solutions in a setting that would not be available to researchers without the resources offered by WETO.
    - Strong approach that addresses the full aspect of advancing solutions from developing methods, to designing products, to validating results and integrating products.
    - Given regional disparities, a one-size-fits-all national approach will not be successful, and this project's approach is key.
- Projects are relevant, appropriate for DOE, and address important issues.
    - The data provide a significant value to the industry and permitting authorities.
    - Finding solutions to address these issues has been and continues to be a top industry priority. The project's focus and results hold promise for resolving conflicts. These efforts represent a critical tool for avoiding costly conflicts and advancing cost-effective projects.
    - Getting easy access to un-biased information from credible sources is invaluable. This project is addressing an important barrier in an efficient way to reach more people.
    - DOE has the opportunity to play a strong role given its objectivity/credibility, as well as its expertise and ability to be a key thought leader and assemble and disseminate priority information. For these reasons, the industry cannot

effectively fill this gap; there is a clear need for an unbiased source for this to happen effectively.
    - Projects are well designed and serve an important role/critical function. This is a unique and important role for the DOE/WETO and one unlikely to be fully replaced by others if future funding is not provided.

Comments on Weaknesses (under any criterion)

- More attention to offshore wind is needed.
- Work could have benefited from collaboration with more international or interagency partners.
- Work could be scaled up to increase the magnitude of impact.
- While the level of communication and engagement has been good, more can be done.

Recommendations

- Work remains a high priority for the industry and should continue to be funded by DOE.
    - Continue supporting this work, whether it's a stand-alone document or integrated into other work products from DOE.
- Expand collaboration and communication.
    - R&D projects could benefit from engagement with industry partners to help inform project design and methods, as well as to help inform potential end-users and regulators about the status of the technology.
    - Increase collaboration with international partners.
    - Improve coordination with other stakeholder groups to leverage knowledge, skills, experience, etc.
    - Continue to innovate on communication media.
    - Consider technical workshops and symposiums to broaden reach and build relationships across sectors.

Office Response

Overall, the reviewers recognized the value, impact, and leadership of the MA&D funded portfolio, and we thank them for their supportive words in this regard. We also appreciate the reviewers' comments that more resources should be devoted to work in this area of the program.

WETO recognizes and agrees with reviewer feedback that additional focus on offshore wind is needed. Over the coming year, we will be evaluating the potential for expanding offshore wind focus in each of our program areas, as well as exploring opportunities for inclusion into existing projects.

A number of reviewers noted that several environmental projects were not able to complete their field trials. While the office believes in adopting a portfolio that includes high-risk projects, the MA&D team will work diligently in the future to manage risks and maximize the likelihood of project success. We will also work to ensure that collaborative projects are focused on outcomes, rather than outputs or process, and that outreach activities are well-aligned across the environmental program.

Additionally, the office recognizes and is working to address the need for more holistic stakeholder engagement and workforce development strategies, as well as the need for a critical examination of the level of impact that can be expected given the relatively small size of these existing projects. The team will look for continued ways to integrate the wind industry into workforce development efforts throughout our work, as well as ways to better integrate OEMs into our environmental research portfolio.

5.3 Activity Area: Stakeholder Engagement and Workforce Development

This section provides an overview of the scoring for all projects within the Stakeholder Engagement and Workforce Development activity area; a summary of reviewer comments in response to the evaluation criteria; representative and noteworthy comments regarding individual projects; and the WETO response to the evaluation results. Full evaluation results can be found in Volume II.

Overview of Project Scoring

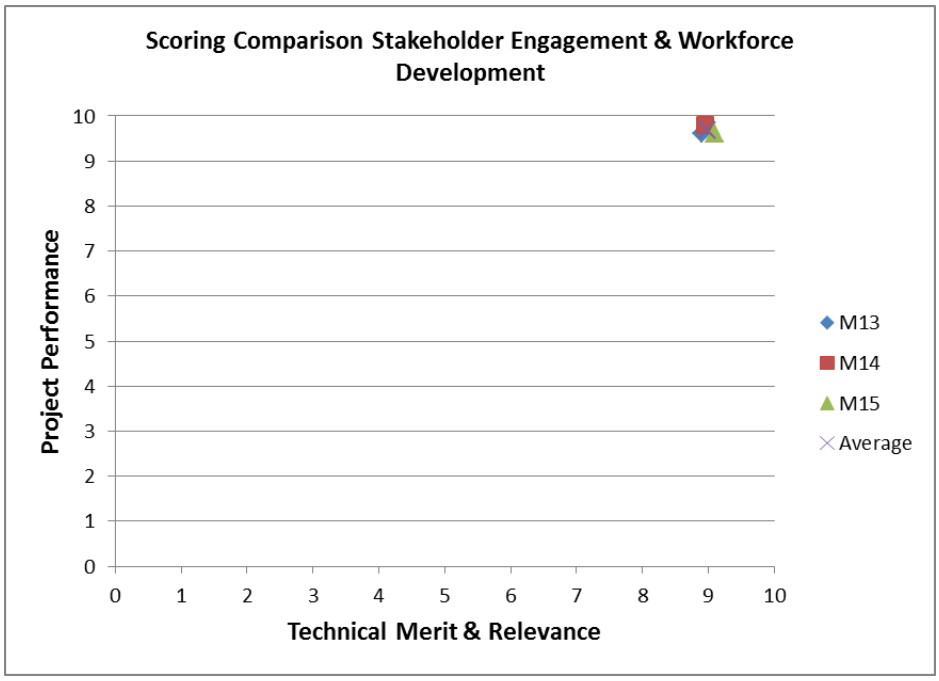

Figure 5-2. Relative scores for the Stakeholder Engagement & Workforce Development activity area projects

Project List

Table 5-1. List of Reviewed Projects in the Stakeholder Engagement & Workforce Development Activity Area

Unique ID	Project Name	Organization	Budget	Actual Costs	Project Status
M13	WINDExchange and Regional Resource Center	NREL	$3,088,735	$2,213,842	Active
M14	Collegiate Wind Competition	NREL	$3,490,665	$1,815,696	Active
M15	Wind for Schools	NREL	$ 2,708,542	$1,823,708	Active

Summary of Reviewer Comments on the Activity Area

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

Stakeholder Engagement and Outreach:

- The DOE WINDExchange has built tools and economic models that do not exist anywhere else, nor does any other entity have the credibility or knowledge to assemble this data. Similarly, the Regional Resource Centers (RRCs) are a unique entity that can provide the relationship building and tools necessary to address barriers.
- Yes, this program really takes advantage of the primary strengths of DOE and its reputation as an unbiased provider of information.

Workforce Development:

- Yes, this program really takes advantage of the primary strengths of DOE, its strength as a convener, and its ability to take a longer-term vision that is typically a large challenge for industry.

Shared Feedback:

- Perhaps it is worth considering if the scale and focus of these efforts is sufficient to achieve their goals.
- The work by WETO in this space is important to the continued stable growth and future of the industry. Further, I believe DOE/WETO has a unique role to play in the stakeholder engagement, workforce development, and human use considerations arena, and those efforts are not duplicative, nor would they be undertaken by any other organization.

2. Has the rationale behind the funded activities and projects been effectively conveyed during the peer review?
    - The rationale for all projects is very clear. There are no projects here where one is wondering where the value is. More often, it is the reverse case, where the activity is well perceived as being very valuable but of a scale where it is struggling to have the desired magnitude of impact.
    - The team did a great job conveying not only the rationale but the various and diverse strategies and tactics employed to achieve goals.

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

    Stakeholder Engagement and Outreach:

    - RRCs have made good outreach, and workforce development has contacts with industry.

    Workforce Development:

    - Increase interaction with the Department of Education for a wider reach.

    Shared:

    - The outreach, communication, and engagement of this work has been incredibly effective.
    - I am not sure they are, and it would likely be worthwhile pulling together a meeting/summit to discuss who is doing what in the space, gather more input on what role DOE/WETO can/should be playing, and assess whether or not any of these efforts started by WETO would survive without continued DOE support.

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

    Stakeholder Engagement and Outreach:

    - Regional centers do not reach all U.S. states and are no longer funded. This may present problems for local stakeholder outreach.

    Workforce:

    - For Collegiate Wind Competition, I do believe there is a missing component of connecting the participating students with potential employers, and more needs to be done to coordinate between the American Wind Energy Association (AWEA) and

companies (OEMs and developers/owner-operators) to create opportunities for engagement at WINDPOWER or between competition years.
- Perhaps a general, broader focused effort at fostering a more positive attitude toward wind power in younger children.

Shared:
- Offshore wind is an underrepresented area.

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

Stakeholder Engagement and Outreach:
- Excellent work in building web-based information systems both for WINDExchange and resources.
- Good strategy for WINDExchange to improve outreach by networks.

Workforce:
- This program is well designed and serves an important role in the development of young minds potentially entering the wind energy field. This is a unique and important role for the DOE/WETO and one unlikely to be fully replaced by others if future funding is not provided. I encourage leadership to find ways of continuing to support this work.
- The level of collaboration and personal energy that is directed into these efforts by passionate people, particularly notable in this regard is the Collegiate Wind Competition.

Shared:
- The collaboration and commitment to these programs is clearly one of their biggest strengths. They also fill key needs—enhancing the resources and tools of regulators, policy makers, and educators—and play a huge role in the acceleration of wind energy.

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

Workforce:
- Advancing a larger strategy for workforce development is necessary, including increasing industry's engagement in these programs. Also, the future gap in regional on-the-ground engagement is of concern.

Shared:
- Lack of offshore wind-specific projects.
- The scale of some efforts, which perhaps need to be ramped up for the desired impact. In particular the wind for school program, WINDExchange, and the RRCs.
- Reaching local stakeholders/public remains a challenge, as well as the students reaching industry; new strategies are needed.

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

Stakeholder Engagement and Outreach:
- Expansion to include offshore wind would be greatly valuable.
- Identify a strategy for regional engagement.
- Further, local information about wind energy opportunities, as well as potential conflicts and stakeholder engagement needs, is essential for adding value to the very complex dynamics surrounding wind energy development and the many issues holding back its development. Continued efforts are needed to help bring credible, helpful information about wind power to stakeholders and state energy decision makers.

Workforce:

- There still seems to be a lack of undergraduate level students reaching industry; collaboration between universities to share courses may be needed, as well as the impact of current activities geared toward students, and industry engagement to make sure they know about the efforts to increase wind related education.

Shared:

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

Representative and Noteworthy Comments on Projects in Activity Area

Comments on Strengths (under any criterion)

Stakeholder Engagement and Outreach:

- Effective efforts to facilitate meaningful, relevant stakeholder engagement is a critical tool for avoiding costly conflicts and advancing cost-effective projects.
- Providing them technical resources through WINDExchange is so invaluable to ensure public officials have the resources and information they need to make thoughtful, defensible decisions. DOE, through NREL, has the opportunity to play a strong role in disseminating important information given its objectivity/credibility, as well as its expertise and ability to be a key thought leader and assemble and disseminate priority information. For these reasons, the industry cannot effectively fill this gap; there is a clear need for an unbiased source for this to happen effectively.
- Given regional disparities in values, resources, conflicts, culture, etc., a one-size-fits-all national approach will not successfully overcome barriers and achieve goals. That is why a local, on-the-ground, relationship-building presence is key through the RRCs.
- WINDExchange is a very good website; it contains a lot of materials in an easily accessible way. Audio interviews on topics relevant to rural communities is a good new approach. Also, economic analysis impact research with wind power plant actual case.

Workforce Development and Outreach:

- The workforce development projects are well designed and serve an important role in the development of young minds potentially entering the wind energy field. While not a cost-lowering or technology-based activity, this is a unique and important role for the DOE/WETO and one unlikely to be fully replaced by others if future funding is not provided.
- The Collegiate Wind Competition plays a critical function in workforce development and utilizing bright young minds to think about turbine design and siting issues in ways that companies might not yet have realized or to refine current thinking in a way that could lead to reductions in LCOE.
- The workforce program also builds momentum within universities themselves. The credibility of NREL/DOE's engagement provides a platform around which more holistic programs within universities can build.
- Reaching students early in their educational experience through Wind for Schools plays a huge role in developing positive attitudes toward wind power and in engendering interest in the area as a possible career pathway. Engaging and leveraging the curriculum in k–12 and beyond is the best way to build this future workforce.
- DOE provides important wind-energy industry information to potential workers through tools and resources such as the Wind Career Map.

Comments on Weaknesses (under any criterion)

Stakeholder Engagement and Outreach:

- Is the scale of this activity and the supporting funding of a sufficient magnitude to have the desired impact? Is the project too ambitious?
- The United States is very large; and, at least in first phase, this work does not reach all states, and some RRCs cover large areas that probably will have challenges reaching all that would need information.
- The only weakness on future activities is the lack of continued support for the RRCs. While I realize this was a time-limited function of the program, it is essential that the initial work in this space continue, and if there is a role for DOE moving forward, I suggest that this be reprioritized.

Workforce:

- Although, the value of the workforce projects is clear, more often it is the reverse case, where the activity is well perceived as being very valuable but of a scale where it is struggling to have the desired magnitude of impact.
- Offshore wind is underrepresented in the workforce space.
- There is a missing component of connecting the participating students of the Collegiate Wind Competition because there seems to be a relatively low job placement of students coming out of the program and a lack of meaningful engagement by industry with the participants at WINDPOWER or otherwise.
- Sustained engagement with industry throughout the program appears to be lacking. For example, not integrating them with wind power and encouraging interviews etc. was a missed opportunity
- While the level of communication and engagement has been good, I think more can be done to promote the workforce program, and thought should be given to how to do that using traditional and social media.

Recommendations

Stakeholder Engagement and Outreach:

- Objective resources and tutorials are important; they are not successful in a vacuum. This is why the RRCs are a critical component of this work.
- Expanding more into offshore issues will also be critical to WINDExchange's reach and success moving forward.
- A peer review of WINDExchange, as is done with Tethys, would be a valuable exercise.
- Understanding opportunities to continue to support a regional presence under a specific strategy and prioritization based on regional factors is important.
- In addition, understanding baselines and regional trends is also critical to advancing this work. Supporting annual state of the region wind reports, whether it’s a stand-alone document or integrated into other work products from DOE will be very important.
- Furthermore, state and local governments are policy laboratories. Disseminating the success of these policy experiments helps everyone.
- Continue assessing regional trends and success stories, and document what is working and what is not from a stakeholder outreach perspective.
- Improve coordination with other stakeholder groups to leverage knowledge, skills, experience, etc. (e.g., Tethys, WREN, National Wind Coordinating Collaborative (NWCC), etc.)

- Continue to innovate on communication mediums, including social media, video, and local press.
- Consider technical workshops and symposiums to broaden reach and build relationships across sectors.

Workforce:

- A more targeted coordination effort between AWEA and companies (OEMs and developers/owner-operators) to create opportunities for engagement at WINDPOWER or between competition years. Advancing a larger strategy for workforce development is necessary, including increasing industry's engagement in these programs. I think some coordination with AWEA and several key companies leading up to the event could be incredibly meaningful in addressing this gap, and even if the engagement by companies didn't result in actual job offers, I would think the students would love to just meet with company reps to hear about how they got into the industry, what they do, and encourage the students to find work in the field and explain how they might do that.
- Develop a more holistic strategy for workforce development, with strong partnership with industry, states, utilities, universities, etc.
- It might be worth considering including dramatically different elements to the competition, such as wildlife mitigation measures or offshore challenges (floating platform) or grid integration issues.
- Consider outreach directed at past participants of the Collegiate Wind Competition to increase capture rate.
- I would suggest doing more to promote the program through industry trade publications, media coverage, etc. This is a great program that should be more widely publicized.
- Circa 190 schools have been contacted through Wind for Schools, mainly through in-person visits, and it might be helpful to evaluate the impact of these visits and specific outreach.

Office Response

The Stakeholder Engagement and Workforce suite of work aims to continue to improve its strategic focus and responsiveness to wind stakeholder needs in the areas of community impacts and creating the workforce opportunities needed for our energy demands. Across the portfolio, the office concurs with the reviewers' emphasis on the importance of dissemination in ensuring that the work is received, accepted, and effective. The office was pleased to hear that the reviewers identify our portfolio as a significant priority that is responsive to the needs reflected in the goals and structure of the current portfolio, as well as in the impact of the work.

In addressing stakeholder engagement and outreach, the office is continuing to seek examples where local governments and other stakeholders have effectively utilized the WINDExchange materials to better understand their impact and refine future strategies. As the reviewers identified, the project is pursuing the development of a four-year strategy that will explore the question of engagement approaches, impacts, and the needs of stakeholders. Similarly, the office has been conducting a retrospective report on the work conducted by the RRCs. The report examines program implementation challenges, successes, and lessons learned, and it documents the quantitative and qualitative efforts of the initiative to promote transparency and foster future methodological thinking about wind energy stakeholder engagement and impacts. This includes developing key recommendations for future WETO programming. WETO will continue to look for opportunities to strengthen and broaden these partnerships and outreach efforts with the reviewers' informative feedback and recommendations on engagement strategies in mind. Such recommendations, like innovating the communication mediums, is paramount for programmatic success.

Through the reviewers' responses, the workforce program impacts were highlighted as meaningful, and the office will work to continue to assess long-term impacts. Metrics and data showing the number of students entering the wind workforce would be helpful in evaluating the strategy of future project activities. To address the reviewers' concerns, a more focused approach and further understanding of the importance of industry engagement is needed. Additionally, WETO will further examine ways to incorporate meaningful engagement with industry, AWEA, universities, and other key organizations throughout the workforce initiatives.

The office values the reviewers' feedback and thanks them for sharing their expertise and insight to shape and improve the future of these initiatives. The reviewers' remarks on the significance of this work and the critical nature of DOE supporting these efforts underlines the importance for the program to go forth strategically and with focus.

5.4 Activity Area: Environmental Research

This section provides an overview of the scoring for all projects within the Environmental Research activity area; a summary of reviewer comments in response to the evaluation criteria; representative and noteworthy comments regarding individual projects; and the WETO response to the evaluation results. Full evaluation results can be found in Volume II.

Overview of Project Scoring

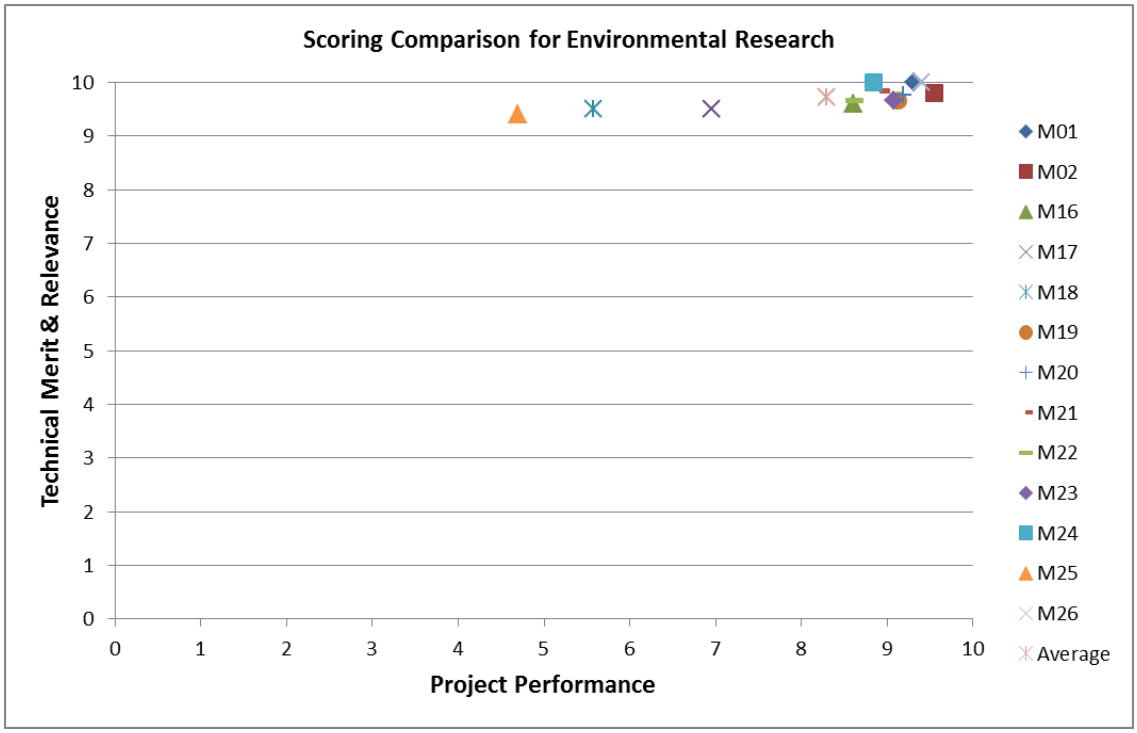

Figure 5-3. Relative scores for the Environmental Research activity area projects

Project List

Table 5-2. List of Projects Reviewed in the Environmental Research Activity Area

Unique ID	Project Name	Organization	Budget	Actual Costs	Project Status
M01	Wind Operational Issue Mitigation	NREL	$ 3,510,820	$1,534,460	Active
M02	Wind Operational Issue Mitigation	PNNL	$1,884,022	$992,108	Active
M16	A Biomimetic Ultrasonic Whistle for Use as a Bat Deterrent on Wind Turbines	University of Massachusetts - Amherst	$312,184	$282,363	Active
M17	Texturizing Wind Turbine Towers to Reduce Bat Mortality	Texas Christian University	$486,958	$486,958	Complete
M18	Rotor-Mounted Bat Impact Mitigation System	Frontier Wind	$327,700	$327,700	Active
M19	Ultrasonic Bat Deterrent Technology	General Electric Company - GE Power & Water	$1,464,087	$1,464,087	Complete
M20	Evaluating the Effectiveness of Ultrasonic Acoustic Deterrents in Reducing Bat Fatalities at Wind Energy Facilities	Bat Conservation International	$3,086,323	$3,066,231	Active
M21	Evaluating the Effectiveness of a Camera-Based Detection System to Support Informed Curtailment and Minimize Eagle Fatalities at Wind Energy Facilities	American Wind Wildlife Institute	$1,833,197	$105,556	Active
M22	Detection and Perception of Sound by Eagles and Surrogate Raptors	University of Minnesota	$333,660	$333,660	Active
M23	Understanding the Golden Eagle Sensory World to Enhance Detection and Response to Wind Turbines	Purdue University	$375,000	$242,849	Active
M24	Evaluating the Effectiveness of a Detection and Deterrent System in Reducing Golden Eagle Fatalities at Operational Wind Facilities	American Wind Wildlife Institute	$1,626,931	$177,547	Active
M25	Eagle Take Minimization System	Laufer Wind Group, LLC	$578,598	$274,825	Active
M26	A Heterogeneous System for Eagle Detection, Deterrent, and Wildlife Collision Detection for Wind Turbines	Oregon State University	$600,399	$305,993	Active

Summary of Reviewer Comments on the Activity Area

1. Are the projects within this Activity on the leading edge of work within this field?
    - Yes. "USDOE shows great leadership in the environmental impact research for wind power."

- "The efforts of the program in this field has helped spur private sector investment and led to rapid increase in knowledge on technology."
- "DOE has undoubtedly done more for advancing wind-wildlife co-existence than any other agency – federal or nongovernmental."
- "In general, the projects are complementary, and the focus consistent with the program objectives."
- With respect to international collaborations such as WREN, it is abundantly clear that the U.S. experts are thought leaders in this space. Most of the U.S. experts appear to be engaged with WETO-supported work at some level, as well, across interest groups, industry, and academia.

2. Has the rationale behind the funded activities and projects been effectively conveyed during the peer review?
    - Yes. "There are no projects in the activity where one is wondering if they should have been supported or not."

3. Within this field, are thought leaders aware of the WETO-supported work?
    - Yes, it would seem so, but broader self-promotion is encouraged to ensure the industry and other stakeholders are acutely aware of everything you are doing in this space.
    - DOE has wisely included meaningful investments in stakeholder collaboration and communication to complement their research FOAs. This is a brilliant and well thought out strategy since the constraints surrounding wind and wildlife are much more nuanced and complicated than solely technology-related operational issues.
    - The solutions in this space require so much more than simply advancing a technology; they require stakeholder buy-in, fact-based communication, and a better understanding of biological processes, populations, and landscape threats.
    - DOE cannot do this alone, but they have done a great job of centralizing these questions among a variety of diverse, sophisticated stakeholders and bringing a much-needed objectivity to the questions and solutions

4. Are there important topic areas that are underrepresented or missing within this activity area?
    - Offshore wind; protected bird/wildlife species beyond eagles.
    - The focus is moving a bit toward offshore in FY 2019, which is a good trend to continue.
    - Prairie grouse and offshore wind energy have not received enough focused investments over the last 2–3 years. Supporting an NWCC for offshore should be a priority for the near-term future. Similar to the land-based experience, by kick-starting a collaborative, DOE can set the stage and be the catalyst for the future American Wind Wildlife Institute (AWWI) and Bats and Wind Energy Collaborative (BWEC) in the offshore space. Population impacts research for bats, offshore bird species, and other offshore wildlife.

5. Are there any notable strengths to the activity portfolio content or direction that you would like to point out?
    - The Land-based collaborative is one of the most important projects that DOE funds in the wind wildlife research space. The work supported under the land-based collaborative umbrella strategically advances the technical solutions, expertise, and cost sharing necessary to solve the most pressing challenges.
    - Excellent networks like NWCC, as well as the bats and birds collaboratives, enable stakeholder interaction.

- Bats: helped renew interest in work on deterrents and testing systems, as well as improving their systems (GE and NRG).
- The level of collaboration across industry, interest groups, and academia is world-class and truly impressive.
- See comments regarding thought leaders. DOE's foresight and strategy has been invaluable to this space.
- The fact that some projects failed actually suggests that a portfolio of risk was accepted and that overall, it was balanced.

6. Are there any notable weaknesses to the activity portfolio content or direction that you would like to point out?
    - Lack of offshore wind-specific projects.
    - Projects that were unable to complete their field work
        - Some projects of smaller enterprises did not manage to conclude their projects as planned.
        - Some projects involving field deployment failed at this stage. Project M20 mitigated this issue by way of functional tests where the performance of turbine mounted devices was tested prior to full scale deployment for field tests.

7. What recommendations would you like to convey to the manager(s) of this activity area?
    - Expand offshore.
    - Cost analysis of mitigation would be great to see when more project results cumulating; summary of costs for all phases.
    - At the end of eagle FOA, it would be great to see a summary of different approaches to tracking and comparison between deterrent and curtailment approaches to mitigation.
    - Keep continuously engaging industry, OEMs, mitigation technology developers, regulators, and third party validators to inform strategic prioritization, information dissemination, and collaboration between these stakeholders. “This context can help its PIs better brainstorm the final application of their technology or information gathering so they can best tailor methodologies to what is needed long term.”
    - These issues are complex and multi-faceted. The more collaboration and scrutiny on the front end will surely improve outcomes. In addition, the challenges of moving these technologies from the lab to the field was an apparent theme throughout this peer review. DOE should host a session where researchers can share their experiences and lessons learned.

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

Comments on Strengths (under any criterion)

Wind Operational Issue Mitigation (WREN, Collaboratives, Tech Development, etc.):

- Work to minimize impacts to bats remains highest priority for land-based wind energy stakeholders, followed closely by golden and bald eagles. The projects funded by WETO focus heavily on those species.
- This work advances the state of the art, is high quality, addresses key questions, and pushes the envelope of new research questions by funding unique R&D projects.
- Proactively seeking to address non-listed species’ issues prior to being driven by regulatory requirements.
- Work in this area provides a sophisticated and unique opportunity to collaborate across key stakeholders to address wind/wildlife issues in a multi-disciplinary way.

- Overall, the work is very well communicated to stakeholders through various pathways, including the NWCC/AWWI/WREN webinars and meetings.
- [Future work Offshore]: The issues identified are the ripest in this space, particularly offshore wind given the European experience and the European investment we are seeing in U.S. waters.
- "Open source approach to software development a major strength. Combination of off the shelf technology and open software really creates a lot of opportunities and flexibility in deployment and combination with other systems."

Eagle FOA:

- Third party validation (field research study team independent of manufacturer) of technology is very important for communicating unbiased results.
- Multiple sites, over multiple seasons is also very valuable.
- Studies that utilize in-situ targets that are equipped with tracking (GPS or otherwise) provide a significant value to validation of tracking tools.

Bat FOA:

- Investing in impact minimization options that do not require turbine curtailment or costly deterrent systems is ideal for wind industry stakeholders (e.g., textured towers).
- Several projects have adopted recommendations from previous tests and reviews to accommodate significant concerns with respect to operation, placement, and target species.

Comments on Weaknesses (under any criterion)

Wind Operational Issue Mitigation (WREN, Collaboratives, Tech Development, etc.):

- Work efforts under Wind Operational Issue Mitigation can be seen as overly process oriented, rather than outcome (technology R&D oriented); however, these processes have resulted in a better understanding of the issues and, in turn, direct the focus of future technology R&D by DOE and private sector organizations/companies.
- Need to more clearly show the strategic linkages between funded programs (e.g., TD&I, land-based collaborative, WREN) and timelines for achieving the goals.
- Communication around WREN/Tethys engagement outcomes and status updates for ongoing R&D projects would be useful.
- The strategies developed through BWEC should be more widely communicated, as well as the numerous state and NGO working groups that have been developed to address the problem.
- Tethys needs to improve outreach to state and federal regulatory/resources agencies and environmental stakeholders.
- "More attention to offshore wind across all these platforms is needed."
- Lack of literature synthesis within Tethys hinders one's ability to quickly distill the essence of a given topic, such as barotrauma, for instance.

FOA projects:

- Lack of outreach and communication of failed projects. Better stakeholder engagement throughout the life of the project may have provided more avenues for project completion, in spite of organizational issues.
- For ultrasonic bat deterrents, "The technology itself does not seem to suffer from any particular weaknesses, but it is unclear if the effectiveness can be improved to increase

the number of species deterred at wind turbines and that the "avoidance" rate can be increased through additional refinement."

Recommendations

Wind Operational Issue Mitigation (WREN, Collaboratives, Tech Development, etc.):

- BWEC is undergoing a time of transition when its presence is more important than ever given increasing concerns for bat fatalities at wind facilities. Ensuring that this group is staffed appropriately and is strategically focused is a key need.
- Focus WREN to be more outcome rather than output oriented. Work more closely with WREN members on bat issues.
- Strongly suggest following up basic biology/physiology research around deterrents, etc. with field validation/in situ validation of initial results to determine effectiveness and response in a more natural environment.
- Physiology work with bats could also be very helpful in developing deterrent measures that are more targeted/specific.
- Early stage and near commercial R&D projects could benefit early on by engaging an industry partner (OEM, Owner/Operator) to help inform design, operation, and testing concepts throughout the design/build of early stage prototypes, as well as help inform potential end users and regulators about the status of the technology.

FOAs

- For any technology under development, it is critical to demonstrate the potential for cost reductions, in comparison to whatever the current industry standard is. Also, all tested treatments (of potential impact minimization solutions) should undergo comparative cost assessment.
- It would be valuable to combine research efforts between hub-mounted and blade-mounted deterrents to compare fatality reduction results to other treatments, such as hub/tower mounted only, or various curtailment regimes.

Office Response

WETO greatly appreciates the feedback on the environmental impacts minimization research portfolio. The office agrees with reviewers and is pleased to hear that the areas of focus are, by and large, addressing the highest priority questions for most stakeholders. We are encouraged to hear that our efforts provide critical leverage that enables the stakeholder community to keep advancing cutting-edge research in this space. We intend to keep focusing on the thee key pillars of our program, which include (1) understanding drivers of risk for wind wildlife interactions, (2) using that to inform the development of efficient impact minimization measures, and (3) regularly engaging with stakeholders to synthesize the state of knowledge on wind wildlife issues and ensure that information is made publicly available.

The office acknowledges the recommendations and constructive feedback provided by the review panel, in particular with respect to our focus on offshore wind environmental issues, species of concern other than protected bats and eagles, and the recommendation for better engagement with wind turbine manufacturers during the development of impact minimization technologies. The program is committed to continuing to expand our portfolio to include more offshore wind related environmental research. We have seen tremendous value in the collaborative models we have used in the past, and we are exploring strategies for addressing offshore issues with a similar approach, beyond the WREN initiative.

Over the last two years, the program has invested most heavily in eagle, bat, and offshore instrumentation areas. We have also been exploring opportunities to help expand our grouse research portfolio, as well as keeping our fingers on the pulse of potential new issues of concern, especially those that might emerge as wind energy development expands into new regions of the country.

With respect to impact minimization technology development, the office is in full agreement with the reviewers that more can be done to help ensure these tools are designed with greater input from the turbine manufacturing community. The office appreciates the need for better partnering between technology solution developers and technology component designers and manufacturers. The office has consistently encouraged all program performers to seek appropriate partnerships with industry, national laboratory and academic experts to ensure solutions meet the needs of the end-users and their stakeholders. The office will review how we can better encourage and require where needed such partnering and cooperation in future R&D investment opportunities. We are also committed to ensuring that such entities are more regularly engaged and participate in workshops and events focused on impact minimization technology development, as well as conducting more active outreach in these areas to help inform our understanding of design limitations.

5.5 Activity Area: Siting and Wind Radar Mitigation

This section provides an overview of the scoring for all projects within the Siting and Wind Radar Mitigation activity area; a summary of reviewer comments in response to the evaluation criteria; representative and noteworthy comments regarding individual projects; and the WETO response to the evaluation results. Full evaluation results can be found in Volume II.

Overview of Project Scoring

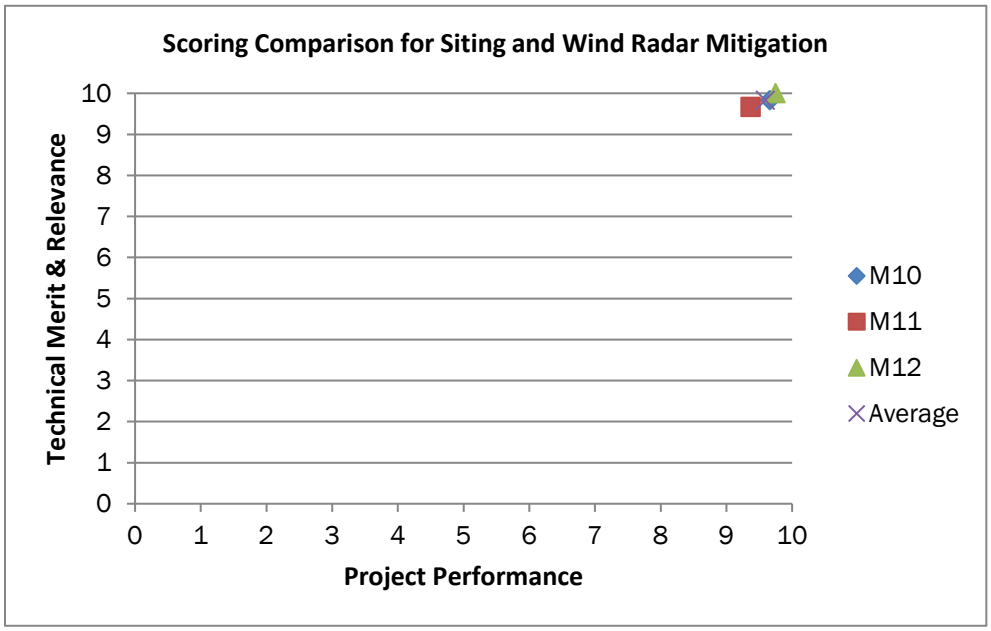

Figure 5-4. Relative scores for the Siting & Wind Radar Mitigation activity area projects

Project List

Table 5-3. List of Projects Reviewed in the Siting & Wind Radar Mitigation Activity Area

Unique ID	Project Name	Organization	Budget	Actual Costs	Project Status
M10	Siting - Radar Wind-Turbine Radar Cross-Section Mitigation	SNL	$ 1,501,084	$1,125,521	Active
M11	Siting - Radar Wind-Turbine Radar Cross-Section Mitigation	MIT Lincoln Labs	$1,768,294	$792,794	Active
M12	National Wind Turbine Database and Location Impacts R&D	LBNL	$ 1,214,449	$586,837	Active

Summary of Reviewer Comments on the Activity Area

1. Are the projects within this activity on the leading edge of work within this field?
    - Yes—reviewers felt that the projects within the activity comprise an "incredibly innovative range of interesting and valuable" work.

2. Has the rationale behind the funded activities and projects been effectively conveyed during the peer review?
    - Yes—reviewers felt that the presentations were strong and informative.

3. Within this field, are thought leaders aware of the WETO-supported work?
    - Yes, especially for the U.S. Wind Turbine Database (USWTDB) and social science work.

4. Are there important topic areas that are underrepresented or missing within this activity area?
    - Reviewers felt an increased focus on offshore wind would be beneficial.

5. Are there any notable strengths to the activity portfolio content or direction that you would like to point out?
    - On the USWTDB and social science work, reviewers felt that project deliverables have been exceptional and that no other entity could have credibly funded or conducted the work.

6. Are there any notable weaknesses to the activity portfolio content or direction that you would like to point out?
    - Offshore wind is currently underrepresented.

7. What recommendations would you like to convey to the manager(s) of this activity area?
    - Reviewers recommended continuing to focus on broadly applicable social science and siting issues affecting wind development—increasing industry involvement in the radar work and extending current pilot mitigation projects to other DOD facilities where wind development is an issue.

Representative and Noteworthy Comments on Projects in Activity Area

Comments on Strengths (under any criterion)

- [On USWTDB and Location Impacts] "This work was absolutely outstanding and critically important to answering the questions related to wind turbine annoyance and creating a web-based tool to evaluate turbine deployment impacts on civilian and military

radar systems. With respect to the latter, being able to evaluate existing system impacts and allowing for improved siting to avoid and minimize impacts related to future development provides a significant value to the industry. On the former, having a robust, unbiased data set regarding annoyance that can be used by developers in siting and defending applications before state and local permitting authorities on issues regarding sound-health and annoyance (as well as inform future research) is simply priceless."

- [On radar] "In addition to finding solutions to avoid and minimize environmental impacts, finding solutions to reducing wind energy's impacts on radar systems has been and continues to be a top industry priority. The project's focus and results hold much promise for resolving much of conflict between radar systems and wind energy development and operations."
- "The ability for DOE to bring very different agencies together through this working group and the execution of an MOU, assess challenges, and advance solutions is vital to overcoming these challenges."

Comments on Weaknesses (under any criterion)

- [On USWTDB and Location Impacts] "The noise audibility/annoyance work could have benefited from international collaboration."
- [On Radar] "Turbine-associated solution explored (alternative lightning protection systems) not promising with respect to all radar types."
- "More focused attention to help BOEM and NOAA address this issue in the offshore space would be most helpful… clearly there are strategies that may be deployed to address interference issues in a project specific context when the time comes."
- "Not all materials from this [radar] work can be published and disseminated more widely."

Recommendations

- [On USWTDB and Location Impacts] "Public acceptance is a very important topic to keep in USDOE projects – make sure that the noise modelling/annoyance work is well aware of work internationally. Recommendation to join Task 39 of IEA Wind."
- [On Radar] "This work remains a high priority for the industry and should continue to be funded by DOE."
- "Radar impacts of wind is more and more important to assess with increased deployment and land use need also close to radars. Good to see that this work is continuing. Further development of NEXRAD to include more radars and potential mitigation measures would be useful. It is important to have radar manufacturers involved in future phases, as well as turbine/blade manufacturers to the extent that the turbine technology developments are seen useful. Main mitigation impact will come from developing the radars."

Office Response

WETO greatly appreciates the feedback on the USWTDB and associated social science work around wind energy, as well as the radar work. The office agrees that this activity addresses key challenges associated with wind development and plans to continue to support it. With respect to the reviewers' suggested alterations to the radar work, the office has chosen not to continue the lightning protection system research based on the limited success SNL was able to achieve, the narrow range of radars/lightning protection service improvements would mitigate, and the technical difficulties associated with addressing multiple frequencies with lightning protection system improvements in the class of radars where improvements would be most beneficial. The office will continue to assess potential turbine-side radar mitigations as promising ideas are identified, but

agrees with the reviewers that radar-side mitigations (such as infill systems and signal processing improvements) are more promising. On the USWTDB and associated social science research, the office concurs that the work would benefit from sustained and deepened international collaboration and will encourage LBNL to continue to seek partnerships with researchers in Europe and elsewhere who are conducting similar work.

5.6 Activity Area: Advanced Grid Integration

This section provides an overview of the scoring for all projects within the Advanced Grid Integration activity area; a summary of reviewer comments in response to the evaluation criteria; representative and noteworthy comments regarding individual projects; and the WETO response to the evaluation results. Full evaluation results can be found in Volume II.

Overview of Project Scoring

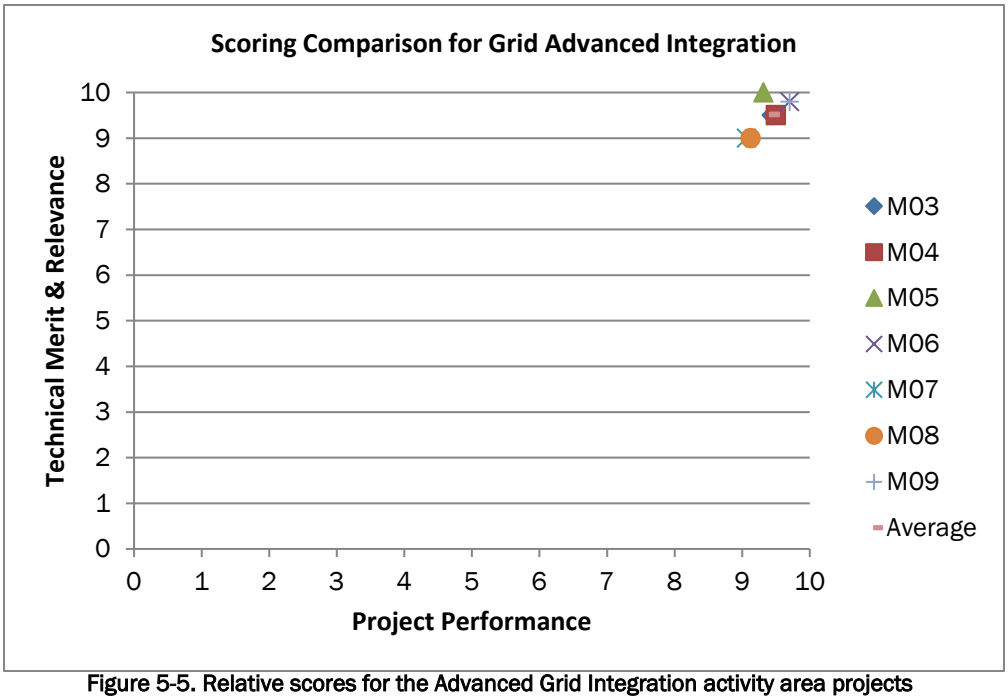

Figure 5-5. Relative scores for the Advanced Grid Integration activity area projects

Project List

Table 5-4. List of Projects Reviewed in the Advanced Grid Integration Activity Area

Unique ID	Project Name	Organization	Budget	Actual Costs	Project Status
M03	Operational and Strategic Implementation of Dynamic Line Rating for Optimized Wind Energy Generation Integration	INL	$1,606,371	$1,365,416	Completed
M04	Market and Reliability Opportunities for Wind on the Bulk Power System	ANL, NREL	$1,349,127	$1,211,827	Completed

M05	North American Renewable Integration Study	NREL	$1,392,086	$796,483	Active
M06	Power System Reliable Integration Support to Achieve Large Amounts of Wind Power (PRISALA)	NREL	$1,065,537	$934,696	Completed
M07	Providing Ramping Service with Wind to Enhance Power System Operational Flexibility	NREL	$1,205,649	$1,018,257	Completed
M08	WindView: An Open Platform for Wind Energy Forecast Visualization	ANL, NREL	$1,168,518	$1,036,439	Completed
M09	Understanding the Role of Short-term Energy Storage and Large Motor Loads for Active Power Controls by Wind Power	INL	$1,609,910	$1,205,824	Completed

Summary of Reviewer Comments on the Activity Area

1. Are the projects within this activity on the leading edge of work within this field?
    - Yes, the current projects are providing valuable and credible information to stakeholders and industry.
    - The projects are also producing leading research results in both domestic and international scopes with respect to increasing levels of wind penetration and the grid challenges that exist. They are following and establishing the state of the art in the area.

2. Has the rationale behind the funded activities and projects been effectively conveyed during the peer review?
    - All of the reviewers agreed that the rationale behind the projects was clearly laid out and addresses highly relevant issues concerning grid integration of wind energy.

3. Within this field, are thought leaders aware of the WETO-supported work?
    - Yes, industry and thought leaders are well aware and actively involved in the WETO funded work.
    - This can be seen through domestic and international organizations/conferences like International Energy Agency and ESIG.

4. Are there important topic areas that are underrepresented or missing within this activity area?
    - There was a general consensus among the reviewers that projects relating to offshore integration of wind energy is needed.
    - With movement toward 100% inverter-based systems, WETO has an opportunity to continue to leverage its existing assets, like the NWTC, to address challenges that emerge from this transition.

5. Are there any notable strengths to the activity portfolio content or direction that you would like to point out?
    - The use of the assets at the NTWC is extremely important in addressing the existing knowledge gaps around the full range of grid services that wind energy can provide, as well as the leading development and validation work occurring at the facility.

- Other notable strengths are stakeholder engagement activities through ESIG, the open platform visualization tool WindView, and also the work going on with dynamic line rating forecasting.

6. Are there any notable weaknesses to the activity portfolio content or direction that you would like to point out?
    - There is a lack of offshore wind specific projects.
    - Modeling capabilities of variable renewable energy with regards to capacity expansion models and operations have limitations such as curtailment handling and the representation of uncertainty.

7. What recommendations would you like to convey to the manager(s) of this activity area?
    - Increased focus on offshore-specific grid issues. Potential offshore integration study for eastern interconnect.
    - Continue the work targeting market design recommendations for wind/solar heavy systems.
    - Increased focus on transmission planning/future modeling.
    - Consider looking at projects in 100% renewable/inverter space.

Representative and Noteworthy Comments on Projects in Activity Area

Comments on Strengths (under any criterion)

- Good model development to enable detail in large footprint—building on previous large wind and solar integration work. Geographic decomposition approach is pushing the state of the art and is exemplary of how large-scale studies such as this should be carried out.
- Strong communication and collaboration—impressive hosting of first international dynamic line rating workshop.
- Project setup allows participants to address topical issues as they emerge and react to any potential barriers seen. Wide coverage of collaboration in the United States and internationally (IEA WIND Task 25), with ESIG as the flagship international collaboration, gives inputs from the high-share wind countries experience from Europe, as well as the European research.
- The approach successfully captures the interactions and interdependencies between modeling at different timescales, particularly between investments/capacity/reliability and operations.
- Strong merit to advancing a very innovative first of its kind demonstration of wind power's capacity to serve as active power controls.
- Strong approach that addresses the full aspect of advancing solutions from developing probabilistic forecasting methods, to designing products, to validating benefits and integrating ramping products.
- Development of open-source tools is a high-impact activity. Helping system operators extract forecast information to use in decision making is critical.

Comments on Weaknesses (under any criterion)

- The project combines aspects of tool and methodology development, and it is not clear if there is, from this, a complete, easily deployable solution.
- The one thing missing from the approach is the assessment uncertainty of forecasts with confidence levels.

- Some consideration of flexibility requirements of the system would enhance this work, although this is not straight-forward.
- It is not clear to what extent operational issues/constraints are captured in the capacity expansion model.
- Offshore seems not to be taken into account as one major scenario with considerable amounts of offshore grids.
- Visualization is a significant first step in extracting useful information from probabilistic wind power forecasts, but industry needs to adopt the state of the art in terms of using this information in a scientifically robust way (i.e., stochastic optimization).

Recommendations

- Uncertainty information needs to be added to tools and models that are being developed. Open source will be better received.
- In future integration studies, it could be worthwhile to consider advancing the complexity of the modeling to explicitly consider uncertainty and greater focus on flexibility issues.

Office Response

WETO appreciates the positive feedback from the peer reviewers for the Grid Integration activity. We are pleased to hear that the suite of work is strategically focused and well communicated. We are very proud of the recognition of the world-class research facility at NWTC and how it has and will continue to benefit the development and validation of the research. Over the next several years, we will continue addressing challenges for future wind integration and continue the effective communication and engagement with industry and stakeholders. We will also give careful focus to examining ways in which we can put additional emphasis on grid integration needs for offshore wind.

The Grid Integration team is currently developing strategic planning for integrating an increasing amount of wind into the grid. The feedback from the reviewers will be helpful to inform the priorities of future research activities. We have and will continue to collaborate with other federal partners to address common challenges. We will continue to encourage open source of tools to benefit broader industry ad research community.

6 Summary Results: Analysis and Modeling Program

6.1 Overview

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

This program track of the 2019 Peer Review included five individual projects and was not divided into multiple activity areas.

Reviewers were asked to provide comments on the programs in response to seven questions. No numeric scores were provided at this evaluation level. In answering the questions, the reviewers were responding to the program presentation but were also asked to take into account the scores and general impressions of the individual projects they reviewed within the program.

Complete listings of all reviewer comments regarding the program, as well as the full scoring and comments for each of the projects reviewed can be found in Volume II.

6.2 Program-Level Evaluation: Analysis and Modeling

This section provides a listing of all the projects within this program, a comparative figure of the technical merit and performance scoring for the projects, a balanced sampling of reviewer comments in response to the program-level evaluation criteria, and the WETO response to the evaluation results.

Figure 6-1 plots the relative scores of each project in the Analysis program area—as well as the average for all projects in the program area—with weighted average *Project Performance* on the X-Axis, and *Technical Merit & Relevance* on the Y-Axis. The shaded boxes on the graph represent 1σ, and 2σ standard deviations from the mean average of all the program project scores.

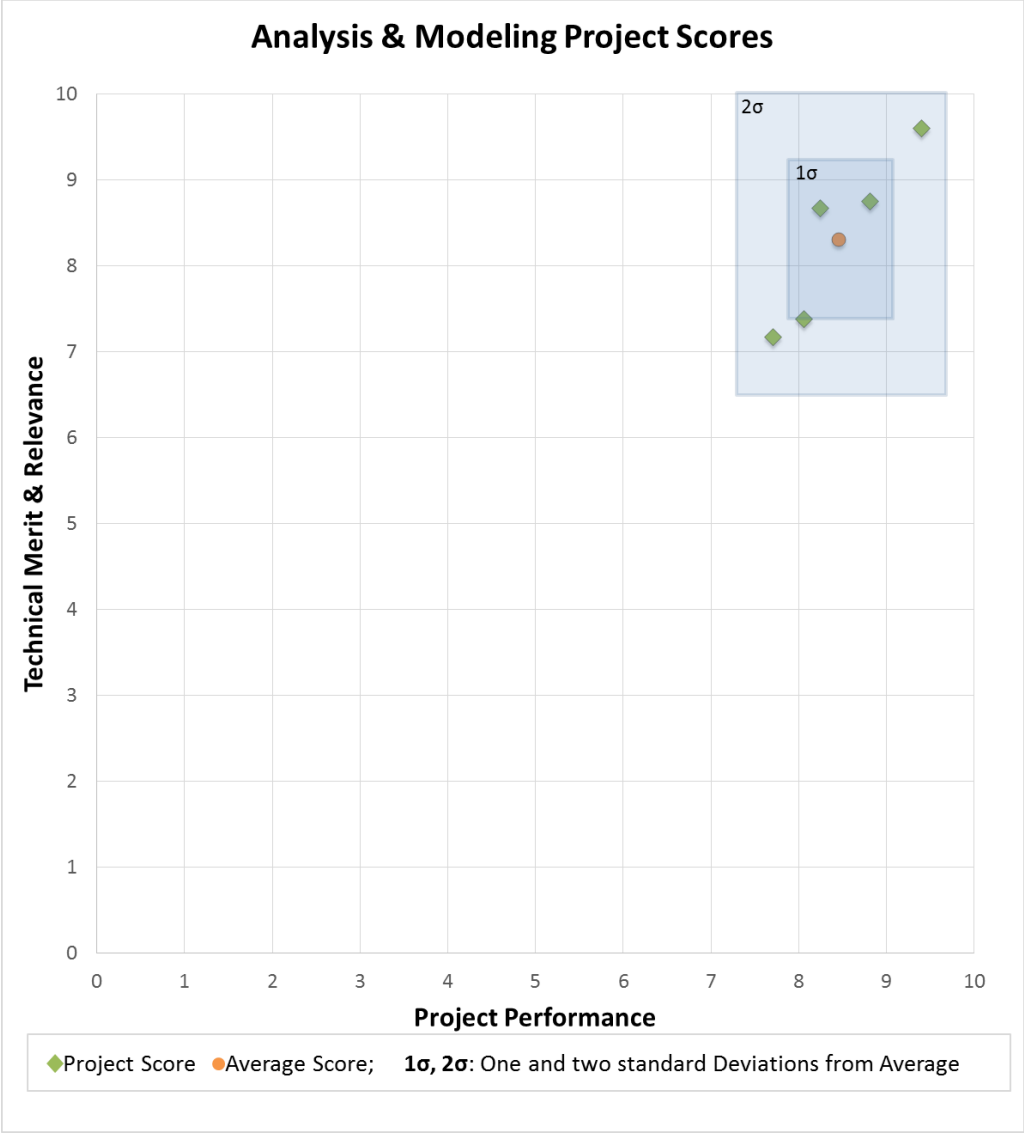

Figure 6-1. Overview of project scoring within the Analysis program

Table 6-1. Analysis and Modeling Project List

Unique ID	Project Name	Organization	Budget	Actual Costs	Project Status
A1	Distributed Wind Research, Development, and Testing (PNNL)	PNNL	$881,394	$700,098	Active
A2	Land Based and Offshore Wind Plant Technology Characterization and System Cost of Energy Analysis Involving Data Collection, Model Development and Analysis Activities	NREL	$4,358,295	$2,935,436	Active
A3	Modeling & Analysis to Inform WETO R&D	LBNL	$2,949,895	$1,813,820	Active
A4	Techno-Economic Modeling, Analysis and Support for HQ Taskers/Urgent Needs	NREL	$957,513	$588,384	Active
A5	Offshore Wind Strategy Follow on Analysis	NREL	$2,244,242	$1,674,019	Active

Representative Comments and Recommendations

1. Are the projects within this Program on the leading edge of work within this field?
    - 9 of 10 reviewers said yes, including "The work is important and time critical" and "industry…and academia depend on the products of this program," and projects "provide valuable data collections and analysis that only this program can do."
    - 1 of 10 reviewers said no, stating "The work is important and time-critical, but appears to be standard activities that could be accomplished or already known (albeit not in the public sphere) by others."

2. Has the rationale behind the funded Activities and Projects been effectively conveyed during the peer review?
    - 9 of 10 reviewers said yes, without a caveat, including "in all cases, the relevance and rationale for projects is very clear," and "strong presentations summarizing the value of this work."
    - 1 of 10 reviewers said yes, but with a caveat, including "In general yes. Several of the projects though did not have a good tie."

3. Within this field, are thought leaders aware of the WETO-supported work?
    - 9 of 10 reviewers said yes, including "DOE has done a tremendous job of circulating its well written reports and summary reports broadly" and "Through IEA Task 25, IEEE and ESIG in particular, the supported work is well disseminated nationally and internationally," and "the reports are well received and used by the industry."
    - 1 of 10 reviewers said, "not necessarily," stating that "Much of this work is internal DOE driven and requested. Not intended fully for public consumption."

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

- Multiple reviewers had specific areas identified as underrepresented or missing, primarily in Offshore. There were three comments on Offshore:
    - "Offshore wind is an underrepresented area."
    - "Offshore grid infrastructure to support offshore wind power deployment [is underrepresented]."
    - "More analysis and synthesis on the state of offshore wind energy is needed."
- There were two comments on offshore wind & grid:
    - "Offshore grid infrastructure to support offshore wind power deployment [is underrepresented]."
    - "Achieving wind deployment targets will require a better understanding of the offshore market and grid integration."
- There was one comment on safety
    - "I think that workforce and turbine safety issues should be included in the collection and reporting."

5. Are there any notable strengths to the Activity portfolio content or direction that you would like to point out?
    - 7 of 10 reviewers noted specific significant strengths, including
        - "The Market Reports are incredibly well done and such an important resource and culmination of impressive analyses."
        - "The capability of and cooperation between the national laboratories to deliver on complex studies and modeling needs is very impressive."
        - "The computational analysis capabilities of the DOE and labs are impressive."
        - "A2e is a notable strength and well recognized part of the program."
    - The remaining 3 reviewers had no specific comments.

6. Are there any notable weaknesses to the Activity portfolio content or direction that you would like to point out?
    - 5 of 10 reviewers noted minor weaknesses, including
        - "More analysis with respect to offshore wind energy is needed,"
        - "Lack of offshore wind-specific projects,"
        - "Not sure if this is a weakness, but the reliance on Plexos," and "the weakness is mainly in how to communicate each project topics."
    - 5 of 10 reviewers noted no weaknesses.

7. What recommendations would you like to convey to the manager(s) of this Program?
    - Multiple comments to "keep up the good work"
    - Additional specific recommendation comments including
        - "Support efforts to develop fundamental modeling capabilities, particularly to address challenges associated with very high penetrations of wind power,"
        - "Consistent funding, especially for engineering model advancement and collaboration with high fidelity modeling to inform the latter."
        - "Include safety in all the reports."
        - "[More] projects like the National Offshore Wind Strategy."

Themes among Comments on Projects in Program Area

Comments on Strengths

- Projects are relevant and appropriate for DOE.
    - The Wind Energy Market report has been established as the benchmark for the wind industry annually. It provides a valuable assimilation of market data that are not commercially available. The sophistication of the underlying analysis in the annual report is impressive. Project has been successful in producing unbiased data on an objective analysis.
    - Scientifically sound work covering a large area of topics. Very good reports on topical issues like health impacts.
    - Tasks provide WETO with objective, quantitative information to guide the program and answer critical questions for other government agencies and the public; it is extremely valuable to have trustworthy models to make these comparisons. This work is very important for supporting other DOE wind research projects.
    - Strong focus on floating offshore structures, which is very relevant to the U.S. market. Approach appears solid, utilizing the best available sources of data.
    - This program needs to exist to be responsive to technical questions by DOE and U.S. leadership. Fundamentally necessary capability to support decision making and policy development.
- Strong communication and dissemination of information.
    - Good publications, presentations, journal articles, and technical assistance with nice press coverage.
    - Dissemination is wide, with excellent outreach also internationally. The annual market report from the United States has gained an international brand—excellent work.

Comments on Weaknesses

- Models used may not be the most relevant for industry.
    - Models that are very complicated are generally disregarded by industry stakeholders because they have a low probability of accuracy and do not inform decisions.
    - Complicated and inter-related models are not likely to accurately predict a complicated and emerging market.
    - Is there a need for modeling that is more nimble?
- Work could be more relevant with clearer goals.
    - Offshore wind is an underrepresented area.
    - There are a lot of analysis projects that seem to overlap to different extents. Could these be more focused and coordinated with clear and differentiating goals?
    - There is a lag in information obtainable by the group. This is probably unavoidable, but does limit the usefulness of the information in the active market context.

Recommendations

- Recommend expanding future work to include specific emerging topics related to flexibility, uncertainty, curtailment, and U.S. versus European offshore wind costs.
- It is important that offshore wind analysis will continue, potentially with offshore grid integration, as these are critically important future issues for wind development in United States.
- Need to extend analysis to be more agile and suitable for adaptation to future challenges and include full life-cycle impacts and challenges as related to siting and operations.

Office Response

The office concurs with the general themes raised by the peer reviewers. In particular, WETO plans to expand its focus on offshore wind and offshore wind grid integration analysis, as well as continue to extend its capabilities to conduct high renewable energy futures analysis to understand how wind technology can be optimized to provide the greatest value to the grid in potential future energy scenarios.

The office agrees that improving its underlying data collection and modeling process to be more agile and time responsive would be of great benefit—though, as the reviewers point out, there are lags in data availability that in some cases are outside WETO's ability to control. As DOE moves the Regional Energy Deployment System and other tools into open-source software, there may be opportunities to work with NREL, as well as external users to make improvements to these tools in a more timely and efficient manner. WETO will work with stakeholders to explore ways to increase the timeliness of its market data collection and model improvements in FY 2020 and beyond.

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