U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

2017 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
WIND ENERGY TECHNOLOGIES OFFICE

Summary Report
February 2018

VOLUME I

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

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Volume I: Overview and Summary of Evaluation Results

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

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

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, or "the office"), I am pleased to announce the release of the 2017 WETO Peer Review Report. This report details the results of the WETO Peer Review, held February 2017 in Arlington, Virginia. The purpose of the review was to evaluate projects funded by DOE from fiscal year 2014 through fiscal year 2016 for their contribution to the mission and goals of the office, assess progress against stated objectives, and appraise WETO's overall management and performance.

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 the national labs and 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 the projects, as well as the management of the office itself.

The office is grateful to the reviewers for their constructive and candid scoring, comments, and expert recommendations. WETO is using this valuable 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.

WETO is committed to developing a portfolio of innovative land-based, offshore, and distributed wind energy technologies for cost-effective domestic power generation. The 2017 Peer Review results will help WETO evaluate and plan the office's research portfolio, ensuring effective investment of taxpayer dollars to achieve these goals for the benefit of the nation.

Sincerely,

James M. Ahlgrimm
Deputy Director
Wind Energy Technologies Office
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy

Acknowledgments

Organizing, planning, and executing a DOE 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 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 team, principal investigators, and WETO staff.

List of Acronyms

A2e	Atmosphere to Electrons
AM	adaptive management
ANL	Argonne National Laboratory
AWEA	American Wind Energy Association
AWWI	American Wind Wildlife Institute
BCI	Bat Conservation International
BWEC	Bats and Wind Energy Collaborative
CFD	computational fluid dynamics
DLR	dynamic line rating
DOE	U.S. Department of Energy
DWT	distributed wind technology
EERE	Office of Energy Efficiency and Renewable Energy
EIA	Energy Information Administration
ERGIS	Eastern Renewable Generation Integration Study
ESIF	Energy Systems Integration Facility
FERC	Federal Energy Regulatory Commission
FWS	U.S. Fish and Wildlife Service
FY	fiscal year
GW	gigawatt(s)
HPC	high-performance computing
IEA	International Energy Agency
INL	Idaho National Laboratory
kW	Kilowatt(s)
LBNL	Lawrence Berkeley National Laboratory
LCOE	levelized cost of energy
MA&D	Market Acceleration and Deployment
MW	megawatt(s)
NAS	National Academy of Sciences
NERC	North American Electric Reliability Corporation
NRC	Nuclear Regulatory Commission
NREL	National Renewable Energy Laboratory
NWCC	National Wind Coordinating Collaborative
NWTC	National Wind Technology Center
O&M	operation and maintenance
OEM	original equipment manufacturer
ORNL	Oak Ridge National Laboratory
OSW	offshore wind
PI	principal investigators
PNNL	Pacific Northwest National Laboratory
R&D	research and development
RC and Tech RD&T	Resource Characterization and Technology Research, Development, and Testing
RCS	radar cross-section
ROI	return on investment
SMART (Wind Roadmap)	Sustainable Manufacturing, Advanced Research and Technology [Wind Roadmap]
SNL	Sandia National Laboratories
SWiFT	Scaled Wind Farm Technology Facility
UVIG	Utility Variable-Generation Integration Group
WETO	Wind Energy Technologies Office
WiLD	Wildlife Impacts Database

WREN	Working Together to Resolve Environmental Effects of Wind Energy
WWSIS 3	Western Wind and Solar Integration Study 3

Table of Contents

List of Figures

List of Tables

Executive Summary

Introduction

The U.S. Department of Energy's (DOE's) Wind Energy Technologies Office (WETO) 2017 Peer Review was held between February 14 and 17, 2017, in Arlington, 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.

Completion of the 2017 Peer Review Report marks a successful milestone as the office strives to continually reflect, respond, and improve to best serve the American public. A peer review conducted by a technology office within DOE's Office of Energy Efficiency and Renewable Energy (EERE) 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, national laboratories, and academia. This process resulted in a beneficial 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 has compiled this final report to provide the results of the peer review evaluation in an analytical manner facilitating practical utilization of the feedback. WETO values the peer review as a programmatic cornerstone in continuing its legacy of successful program management and implementation to enable wind energy nationwide.

WETO has carefully considered the peer review panel's programmatic and project feedback to ensure the office is aligned with industry research and development (R&D) priorities, and that projects are being effectively managed and executed. The program managers and office leadership within WETO have thoroughly reviewed the scores and qualitative feedback of the panel. Since the peer review, the office has been working diligently, for instance in the 2018 Annual Operating Plan planning process, to implement several recommendations and address the reviewers' comments regarding areas for improvement.

Review Process

The review panel at the 2017 Peer Review evaluated activities for fiscal year (FY) 2014, FY 2015, and FY 2016. WETO's activities were organized into two programmatic groupings, referred to as "tracks" for the peer review. These tracks were (1) Resource Characterization and Technology Research, Development, and Testing (RC and Tech RD&T), and (2) Market Acceleration and Deployment (MA&D). Each track was then further divided into four subprograms (see Table ES-1). The peer review panel consisted of 12 expert reviewers from academia, government agencies, and the private sector. Each project was reviewed by a minimum of three reviewers who provided both numeric evaluations and written comments.

Reviewers evaluated 61 projects, representing approximately 80% of the work funded by WETO during FY 2014–2016, in accordance with EERE guidelines for peer reviews. This included 36 projects in the RC and Tech RD&T track and 25 projects in the MA&D track. See Section 2.3 of this report for a budget overview.

Two chairpersons were selected to oversee the peer review tracks and review process: Mr. Sandy Butterfield, of Boulder Wind Consulting, presided over the RC and Tech RD&T track, and Mr. Stu Webster, an independent consultant, presided over the MA&D track. The other reviewers are listed in Table 1-2 in this

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 the DOE, National Academy of Sciences, White House Office of Management and Budget, U.S. General Accounting Office, and other federal agencies and institutions.

volume. Biographies of the chairs and reviewers are available in the 2017 Peer Review Program Guide on the WETO website.

Table ES-1. Wind Energy Technologies Office Peer Review Tracks and Subprograms

Resource Characterization and Technology Research, Development, and Testing	Market Acceleration and Deployment
Resource Characterization and Technology Research, Development, and Testing	Market Acceleration and Deployment
Atmosphere to Electrons, High-Performance Computing, Resource Characterization, Flow Field Analysis, and Testing	Modeling and Analysis
Distributed Wind Research, Development, and Testing	Grid Systems Planning and Operation
Innovation, Manufacturing, Reliability, and Testing	Siting, Radar, and Environmental
Offshore Wind	Stakeholder Engagement

Evaluation Metrics

The peer review panel evaluated two aspects of the WETO portfolio. The reviewers completed evaluation forms assessing the management, performance, and effectiveness of the office ("program-level" evaluation); and separately evaluated each of the individual projects ("project-level" evaluation).

Reviewers were asked to perform quantitative and qualitative analyses of each of the two tracks based on the program- and project-level metrics summarized in Table ES-2, scoring them on a scale of 1 to 5 for each metric. A score of 1 corresponds to a "Poor" rating, 2 to "Fair," 3 to "Average," 4 to "Good," and 5 to "Outstanding." Reviewers were also invited (but not required) to provide qualitative comments for each metric.

Table ES-2. Summary of Evaluation Metrics for 2017 Wind Energy Technologies Office Peer Review

Program Evaluation Metrics (Completed for WETO as a whole)		Project Evaluation Metrics (Completed for each project)	
• Program Objectives • R&D Portfolio • Management and Operations • Communication and Outreach	Scored individually on a scale of 1- 5	Relevance	Scored 1- 5
		• Performance	Calculated based on weighted average of the 5 metrics below
		○ Methods / Approach ○ Accomplishments / Progress ○ Project Management ○ Collaboration / Tech Transfer ○ Future Research	Scored individually on a scale of 1–5
• Overall Strengths • Overall Weaknesses • Recommendations	Written Comments Only		
		• Strengths • Weaknesses • Recommendations	Written Comments Only

Within the project evaluation metrics, "Relevance" refers to the overall perceived value of a project in addressing WETO objectives and the needs of the wind industry. "Performance" is an indicator of how well

the project is being executed based on a weighted average of scores in five separate but related metrics. Project-level metrics and scoring are defined further in Section 5 (see Table 22) of this report, including the weighting used to determine the performance score. Details of program evaluation metrics and scoring methodology are provided in Section 3.

Program-Level Scoring Summary

Figure ES-1 summarizes the reviewers' quantitative assessment of how the RC and Tech RD&T and the MA&D tracks are performing programmatically, based on their scoring of the four evaluation criteria.

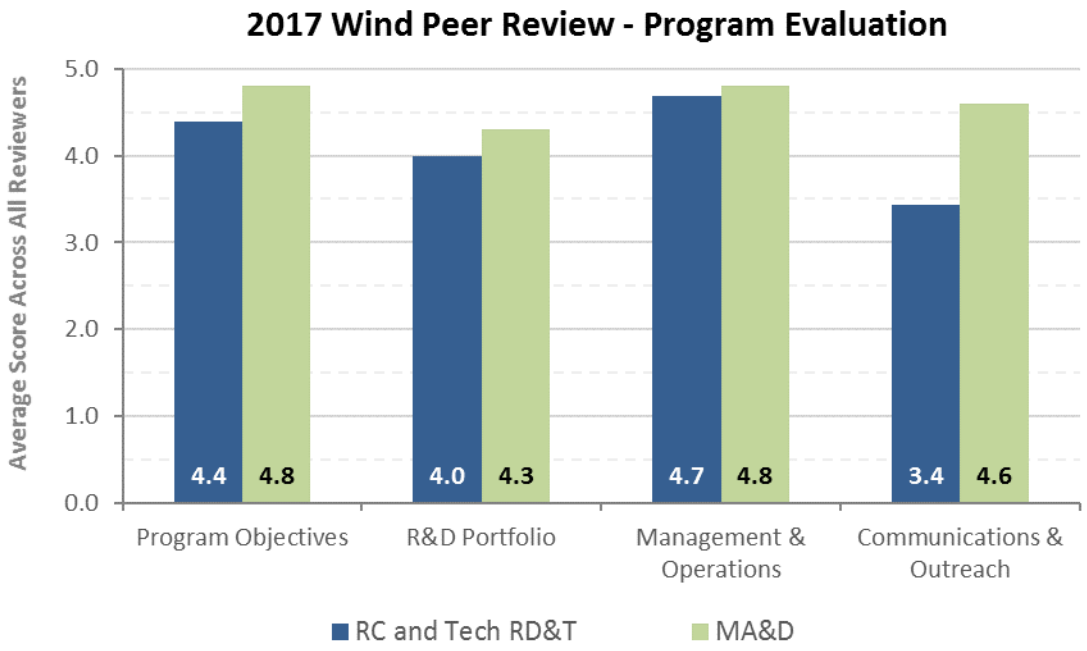

Figure ES-1. Average program-level scores by metric

Overall, the average scores in Figure ES-1 indicate that reviewers highly rated WETO, particularly on Program Objectives and Management and Operations. Under the R&D Portfolio category, the RC and Tech RD&T and the MA&D tracks were rated as "Good" and above. In the Communications and Outreach category, the MA&D track was evaluated as "Excellent," while the RC and Tech RD&T portfolio scored between "Average" and "Good."

Project-Level Scoring Summary

The average scores for individual projects are provided in Table ES-3 by evaluation metric. In the top row of Table ES-1, these averages are provided first for all WETO projects, followed by the two review tracks at the bottom.

Table ES-3. Average Scores for Peer-Reviewed WETO Projects by Evaluation Metric

	Relevance	Performance	Scores Used in Determining Performance*				
			Methods/ Approach	Accomplishments/ Progress	Project Managment	Collaboration/ Tech Transfer	Future Research
RC and Tech RD&T	4.4	4.0	4.1	3.9	4.2	3.9	3.8
MA&D	4.5	4.3	4.3	4.3	4.4	4.2	4.1
Average Score Across All Peer-Reviewed WETO Projects	4.4	4.1	4.1	4.0	4.3	4.0	3.9

*See Section 5 for the weighted-average methodology used to determine the performance metric.

The dot plots in Table ES-2 and Table ES-3 provide insight into the scoring for all 61 of the individual WETO projects reviewed. Table ES-2 provides data on the 36 projects in the RC and Tech RD&T track, while Table ES-3 includes the 25 projects in the MA&D track. Each dot indicates how a single project scored in terms of both the "Relevance" metric and the "Performance" metric scores are indicated up the Y axis, while performance scores are along the X axis. 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 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, and what programmatic adjustments could be made to ensure highest levels of performance for all projects.

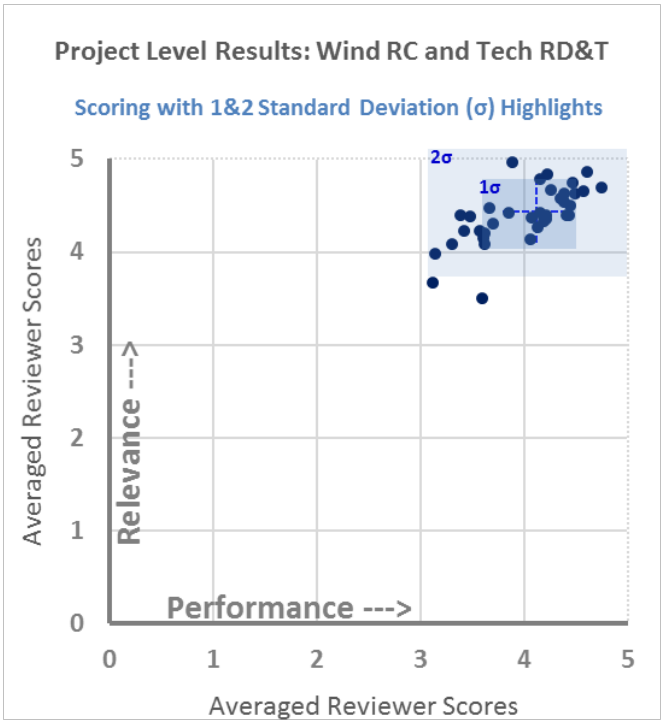

Figure ES-2. Average scores for relevance and weighted-average performance for the 36 projects within the Resource Characterization and Technology Research, Development, and Testing Track

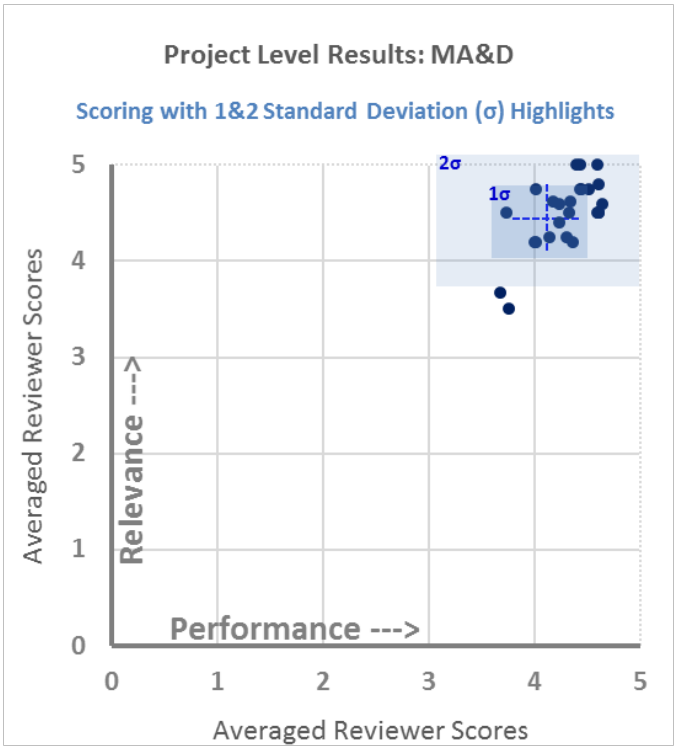

Figure ES-3. Average scores for relevance and weighted-average performance for the 25 projects within the Market Acceleration and Development Track

Overview of Qualitative Comments (Program-Level)

In addition to quantitative scoring, the members of the peer review panel each provided qualitative comments on the WETO as a whole and as each of the projects reviewed. A representative sampling of the 166 track-level comments are provided in Table ES-4. They were selected to illustrate key themes and trends within the feedback received from reviewers. The comments in the table are the direct, verbatim reflections of reviewers' written evaluations. They are taken from both the RC and Tech RD&T track, and the MA&D track. The full set of the reviewer comments on the program can be found in Volume II, Section 6 of this report. The total 3,000 comments received about individual projects are in Volume II, Section 7, separated by respective project. All peer review comments have been considered by WETO staff and integrated into program and project management and planning.

Table ES- 4. Sample Program-Level Comments for the 2017 Wind Energy Technologies Office Peer Review

Strengths Identified by Peer Review Panelists
• WETO projects have aided the wind industry in becoming an increasingly important part of U.S. electricity generation. There is ample evidence that DOE investment in wind energy has led to reductions in LCOE and industry growth. • WETO projects distribute information to many contributors and stakeholders. This is an excellent goal and helps address existing barriers to information sharing due to intellectual property concerns. • Milestone achievement across all projects is impressive and speaks of a highly proactive management approach that strikes a good balance between incentivizing progress and efficiency while allowing for flexibility and changes of direction where appropriate. • WETO has done an exemplary job attracting, retaining, and empowering a world-class team of professionals. The global industry looks to them for expertise and leadership. • Transparency and peer review has been a cornerstone of program management. DOE managers have created a culture of communication and industry outreach. • DOE is commended for being on top of industry trends, needs, and technology gaps. The focus on costs, implementation barriers, and environmental impacts is correct. • The dedication, commitment, intelligence of the program staff, and the way they approach issues and address them are all key indicators of a high-quality organization. • Broad resources, objective and trusted position in the industry, and strategic execution of the program are all strengths. • R&D topics in the MA&D program area are well chosen and justifiable. The money spent—and the results from the funding—are generally efficient. Many WETO projects have direct applicability to operational challenges industry faces on a daily basis.
Potential Issues Identified by Peer Review Panelists
• Most PIs seemed well-versed on their projects, but some did not seem well versed on the overall importance of their project. • Despite challenges, WETO has done an excellent job publishing its findings, working with the industry, and reaching out beyond the industry to leverage experience and knowledge elsewhere. Given limited resources, WETO has been successful in this area. The challenge is how to more effectively communicate across a larger group of stakeholders (including those that do not support wind). • Some topics were not addressed at all (e.g., icing issues) or in a limited way (distributed wind; public acceptance of noise from proximity of turbines to buildings; taller turbines). • Funding uncertainty is a tremendous distraction, and federal policy is at odds with known technical and commercial advancement opportunities. This constrains WETO's potential efficacy.

Specific Recommendations of Peer Review Panelists
• WETO is substantially well balanced to meet mission goals, but as industry builds capacity in certain areas, DOE should focus on research efforts that are more clearly out of reach for industry such as R&D requiring exascale computing (e.g., flow characterization, plant optimization). • While there is a good level of collaboration with other entities and, specifically, private sector contributors through each individual project, there may be further value to be gained with involvement from a broader range of stakeholders. • Program objectives for distributed wind should be better defined and expanded in scope. WETO should expand distributed wind R&D.

Summary of Office Response to Reviewer Feedback

WETO acknowledges the compliments received regarding overall project management, execution, impact, and alignment with industry needs, as well as the positive feedback regarding scientific leadership and the relevance of the projects to address the challenges facing the nation today. In addition to the overall programmatic responses summarized here, the main body of the report includes detailed responses addressing key programmatic comments made by reviewers as they considered individual evaluation metrics.

WETO received praise for its focus on technology gaps, costs, implementation barriers, and environmental impacts. WETO also recognizes that there are several areas reviewers identified that require attention and overall improvement in project selection, execution, and relevancy to the office's overall strategy; and addressing instances of project redundancy and lack of clarity in goals and dissemination of results.

The office recognizes ongoing requests for more R&D in the offshore and distributed wind sectors, and the value of enhanced verification and validation of computational models.

Based on constructive feedback from this peer review, WETO is improving its communication strategy for complex research and development in RC and Tech RD&T to reach not only interested and invested stakeholders, but also a broader nontechnical audience. The office recognizes that clear and concise communication of results is vital to maximizing the impact of its research investments.

1 Peer Review Overview

Background

The U.S. Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy (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."[2] For example, 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]

Between February 14 and 17, 2017, DOE EERE's Wind Energy Technologies Office (WETO; "office") conducted its 2017 Peer Review at the Sheraton Pentagon City hotel in Arlington, Virginia. The purpose of the WETO review was to evaluate a selection of DOE-funded projects for their contribution to the mission and goals of the office, assess progress made against stated objectives, and assess overall management and performance of the office.

The objectives of the 2017 WETO Peer Review were to:

Review and evaluate the strategy and goals of the Wind Energy Technologies Office

Review and evaluate the progress and accomplishments of projects funded by the office in Fiscal Year (FY) 2014, FY 2015, and FY 2016

Foster interactions among the national laboratories, industry, and academic institutions conducting research and development on behalf of the office.

DOE offices generally hold peer reviews so activities are reviewed on a recurring basis approximately every 2 years. WETO held its previous peer review in 2014, covering activities for FY 2012 and FY 2013. The 2014 WETO Peer Review report and presentations are available on the DOE website.[4] The 2017 WETO Peer Review evaluated activities for FY 2014, FY 2015, and FY 2016. The event was co-located with the 2017 Peer Review for DOE's Water Power Technologies Office, which is now a separate office from WETO (prior to 2016, the two offices combined as the Wind and Water Power Technologies Office). A total of 275 principal investigators (PIs), researchers, and stakeholders attended the combined reviews.

As part of the 2017 Peer Review, reviewers evaluated WETO projects organized into two tracks for the peer review in eight peer review agenda sessions—Resource Characterization and Technology Research, Development, and Testing (RC and Tech RD&T) and Market Acceleration and Deployment (MA&D)—as well as eight related technology subprograms,.[5] Table 1 details these tracks and subprograms.

[2] The EERE Peer Review Guide is available on the DOE website: https://www.energy.gov/eere/downloads/eere-peer-review-guide.
[3] See footnote 2.
[4] The 2014 WETO Peer Review Report is available on the DOE website: https://energy.gov/eere/wind/downloads/2014-wind-program-peer-review-report; and the WETO 2014 Peer Review Presentations are available on the DOE website: https://energy.gov/eere/wind/downloads/2014-wind-program-peer-review-compiled-presentations.
[5] WETO's portfolio is formally divided into four subprograms: Resource Characterization and Technology Research Development and Testing (Land-Based, Offshore, Distributed); Technology Validation and Market Transformation; Mitigate Market Barriers; and Modeling and Analysis. For the purposes of the peer review, projects from these subprograms were divided into two tracks described in this report.

Table 1. Wind Energy Technologies Office Peer Review Tracks and Subprograms

Track: Resource Characterization and Technology Research, Development, and Testing	Track: Market Acceleration and Deployment
Atmosphere to Electrons, High-Performance Computing, Resource Characterization, Flow Field Analysis, and Testing (8 projects)	Analysis and Modeling (1 project)
Distributed Wind Research, Development, and Testing (2 projects)	Grid Systems Planning and Operation (9 projects)
Innovation, Manufacturing, Reliability, and Testing (13 projects)	Siting, Radar, and Environmental (11 projects)
Offshore Wind (13 projects)	Stakeholder Engagement (4 projects)

In the 2017 Peer Review, 61 WETO projects were evaluated. Each project was reviewed by a minimum of three experts, each of whom provided numeric evaluations and written comments. The peer review panel evaluated two aspects of WETO: (1) an evaluation of the management, performance, and effectiveness of the office and its research as a whole ("program-level" evaluation, Sections 3 and 6 of this report); and (2) each of the individual projects supported by the office and selected for review ("project-level" evaluation, Sections 4 and 7 of this report).

Results of the peer review will be used 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 and response to these findings, and the supporting meeting materials, including an agenda and list of participants. In accordance with the EERE Peer Review Guide, peer reviewers provided quantitative and narrative evaluations of the materials and projects presented at the peer review. The comments herein are the direct, verbatim reflections of reviewers' written evaluations.

WETO Peer Review Panels

For the 2017 Peer Review, WETO commissioned peer review panels consisting of 12 reviewers to conduct the formal peer review. Reviewers were experts from wind energy organizations, including industry, academia, trade organizations, nongovernmental organizations, and other federal agencies. Reviewers evaluated the progress and relevance of WETO-funded projects, based on presentations by the project PIs. Projects were evaluated according to a defined set of criteria, as described in Sections 5 and 7 of this report. Reviewers also provided a quantitative and qualitative evaluation of the overall management and direction of WETO, as discussed in the program-level evaluations.

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 lists the WETO peer reviewers for 2017. Note that there were seven reviewers in the RC and Tech RD&T track and five reviewers in the MA&D track.

Table 2. Wind Energy Technologies Office 2017 Peer Reviewers

Resource Characterization and Technology Research, Development, and Testing Reviewers		Market Acceleration and Deployment Reviewers	
Reviewer	*Affiliation*	*Reviewer*	*Affiliation*
Sandy Butterfield, Chair	Boulder Wind Consulting	Stu Webster, Chair	Independent Consultant
Dan Dolan	Moffat & Nichol	John Anderson	American Wind Energy Association
Mike Kelly	Mistral Renewable Energy	Jody Dillon	University College Dublin
Bill Mahoney	National Center for Atmospheric Research	Hannele Holttinen	VTT Technical Research Centre of Finland
Stephanie McClellan	University of Delaware	Bonnie Ram	University of Delaware
Heather Rhoads-Weaver	eFormative Options		
Scott Winneguth	Iberdrola		

The peer review planning team provided reviewers with briefing materials and guidance via web conference sessions and a Microsoft SharePoint site prior to the meeting. This information included a Peer Review Plan that included reviewer instructions, peer review agenda, PowerPoint presentations[6] and two-page project summary documents submitted by project PIs, review of the overall goals of the office, and evaluation workbooks (in Microsoft Excel). Reviewers were also required to submit conflict of interest forms as well as honorarium and travel reimbursement forms.

Two chairpersons were selected to oversee the peer review tracks and review process: Mr. Sandy Butterfield presided over the Wind RC and Tech RD&T track, and Mr. Stu Webster presided over the Wind 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. Biographies for the chairs and reviewers are available in the 2017 Peer Review Program Guide on the WETO website.

Project Selection Process

WETO used a multistep process to identify and select projects to be reviewed at the 2017 Peer Review and plan for the agenda. This process is described in more detail in Section 2.

[6] The 2017 WETO Peer Review presentations are available on the WETO website: https://energy.gov/eere/wind/wind-program-peer-reviews.

Evaluation Criteria and Process Overview

In accordance with DOE 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. Quantitative assessments were submitted using detailed Microsoft Excel workbooks, which were provided to reviewers prior to the event. The peer review planning team hosted web information sessions to guide reviewers on how to use the workbooks and how to access review materials. Not every reviewer provided narrative evaluations for every program-level review category or for every project.

The peer review panel evaluated two aspects of the WETO portfolio. The reviewers completed evaluation forms assessing the management, performance, and effectiveness of the office as a whole ("program-level" evaluation); and separately evaluated each of the individual projects ("project-level" evaluation).

Reviewers were asked to perform quantitative and qualitative analyses of each of the two subject matter tracks based on the program- and project-level metrics summarized in Table 3, scoring them on a scale of 1 to 5 for each metric. A score of 1 corresponds to a "Poor" rating, 2 to "Fair," 3 to "Average," 4 to "Good," and 5 to "Outstanding." Reviewers were also invited (but not required) to provide qualitative comments for each metric.

Table 3. Summary of Evaluation Metrics for 2017 Wind Energy Technologies Office Peer Review

Program Evaluation Metrics (Completed for WETO as a whole)	
• Program Objectives • R&D Portfolio • Management and Operations • Communication and Outreach	Scored individually on a scale of 1- 5
• Overall Strengths • Overall Weaknesses • Recommendations	Written Comments Only

Project Evaluation Metrics (Completed for each project)	
Relevance	Scored 1- 5
• Performance	Calculated based on weighted average of the 5 metrics below
○ Methods/Approach ○ Accomplishments/Progress ○ Project Management ○ Collaboration/Tech Transfer ○ Future Research	Scored individually on a scale of 1- 5
• Strengths • Weaknesses • Recommendations	Written Comments Only

Note: Research and development (R&D).

Within the project evaluation metrics, "Relevance" refers to the overall perceived value of a project in addressing WETO objectives and the needs of the wind industry. "Performance" is an indicator of how well the project is being executed based on a weighted average of scores in five separate but related metrics. Project level metrics and scoring are defined further in Section 5 of this report, including the weighting used in determining the performance score. Details of program evaluation metrics and scoring methodology are provided in Section 3.

The Wind Energy Technologies Office and Peer Review Project Selection

Background and Mission

The United States has abundant land-based and offshore wind resources across the nation. Wind has rapidly become a mainstream power source in the U.S. electricity portfolio, with 86 gigawatts of installed capacity across 41 states as of June 2017,[7] supplying 6.1% of the nation's electricity end-use demand in 2016,[8] and representing 30% of all newly installed U.S. generation capacity between 2012 and 2016.[9] Strong market demand, coupled with the increasing size of wind turbine components, has spurred the growth of a robust domestic manufacturing sector. The U.S. wind industry supports over 100,000 U.S. direct jobs in installation, manufacturing, operations, and other sectors, [10] with more than 500 U.S. wind-manufacturing facilities in 41 states.[11]

The Office of Energy Efficiency and Renewable Energy's (EERE) WETO funds early-stage applied energy science research, development, validation, and market barrier mitigation activities for U.S. land-based, offshore and distributed wind power generation to build the knowledge base upon which industry can develop and deploy technologies. This enables the continued growth of the U.S. wind industry, enhances U.S. competitiveness, increases U.S. energy security and independence, strengthens domestic manufacturing, and provides local economic opportunity across the entire United States.

The efforts of the DOE's wind office over the past 4 decades have led to significant innovation and cost reduction. From 1976 to 2008, the office ranked first in wind energy patents and citations linked to commercial power from wind.[12] As of 2017, WETO-sponsored research and development (R&D) resulted in 154 wind energy patents and over 20 patents pending. DOE-funded research and development and market barrier mitigation, as well as industry innovation, led to a 90% drop in the unsubsidized cost of wind energy from 1980 to 2016.[13]

An analysis of U.S. wind energy potential, entitled *Wind Vision: A New Era for Wind Power in the United States,* was conducted by a collaboration between DOE and over 250 experts from the industry, electric power system operators, environmental stewardship organizations, state and federal governmental agencies, research institutions and laboratories, and siting and permitting stakeholder groups that were published by DOE in 2015.[14] This report concluded that increasing the penetration of wind power is technically feasible; generates long-term economic savings; creates good-paying, long-standing jobs; and provides substantial local community and environmental benefits. The *Wind Vision Study Scenario* (where wind provides 35% of U.S.

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[7] U.S. Federal Energy Regulatory Commission. Energy Infrastructure Update. Available on the FERC website at https://www.ferc.gov/legal/staff-reports.asp.
[8] U.S. Department of Energy, Energy Information Administration. Electricity Data, Form EIA-861M. Available on the EIA website at https://www.eia.gov/electricity/data/eia861m/.
[9] U.S. Federal Energy Regulatory Commission. Energy Infrastructure Update. Available on the FERC website at https://www.ferc.gov/legal/staff-reports.asp.
[10] U.S. Department of Energy, 2017 U.S. Energy and Employment Report. Available on the DOE website at https://www.energy.gov/downloads/us-energy-and-employment-report.
[11] American Wind Energy Association. Wind Brings Jobs and Economic Development to All 50 States. March 9, 2017. Page 12. http://awea.files.cms-plus.com/AWEA%20Economic%20Development%20Impacts%20of%20Wind%20Energy%20FINAL.pdf.
[12] Ruegg, R, and P. Thomas. Linkages from DOE's Wind Energy Program to Commercial Renewable Power Generation. U.S. Department of Energy. September, 2009. https://energy.gov/eere/analysis/downloads/linkages-does-wind-energy-program-commercial-renewable-power-generation.
[13] Bolinger, Mark; Wiser, Ryan. Documentation of an Historical LCOE Curve for Wind in Good to Excellent Wind Resource Sites. Lawrence Berkeley National Laboratory, June 11, 2012. (Internal memorandum to DOE, and additional direct conversation with the authors).
[14] *Wind Vision*: A New Era for Wind Power in the United States. U.S. Department of Energy, March 2015. DOE/GO-102015-4557. Available on the DOE website at http://energy.gov/eere/wind/wind-vision.

electricity demand) results in significant cumulative benefits by 2050, compared to a 2013 baseline that includes:

600,000 gross jobs created

$149 billion in consumer cost savings

$3.2 billion in annual local tax revenues

260 billion fewer gallons of water (23%) consumed

$108 billion in reduced air pollution impacts (22,000 premature deaths avoided).

Budget Overview

The 2017 Peer Review has evaluated projects funded over 3 fiscal years: FY 2014, FY 2015, and FY 2016. The EERE guidelines recommend peer reviews to cover projects representing, in aggregate, approximately 80% of a program's project-related funding during the review period. The cumulative appropriations over these 3 years totaled $290.6 million (Figure 1). Of this total, direct project funding through the four wind energy subprograms[15] (Resource Characterization and Technology Research Development and Testing (Land-Based, Offshore, Distributed); Technology Validation and Market Transformation; Mitigate Market Barriers; and Modeling and Analysis) accounted for $243.6 million. Of this total project funding, projects reviewed in the 2017 Peer Review accounted for $190.8 million, or approximately 80% of FY 2014 to FY 2016 direct project appropriations. Figure 1 shows the relationship between total office funding and funding for reviewed projects.

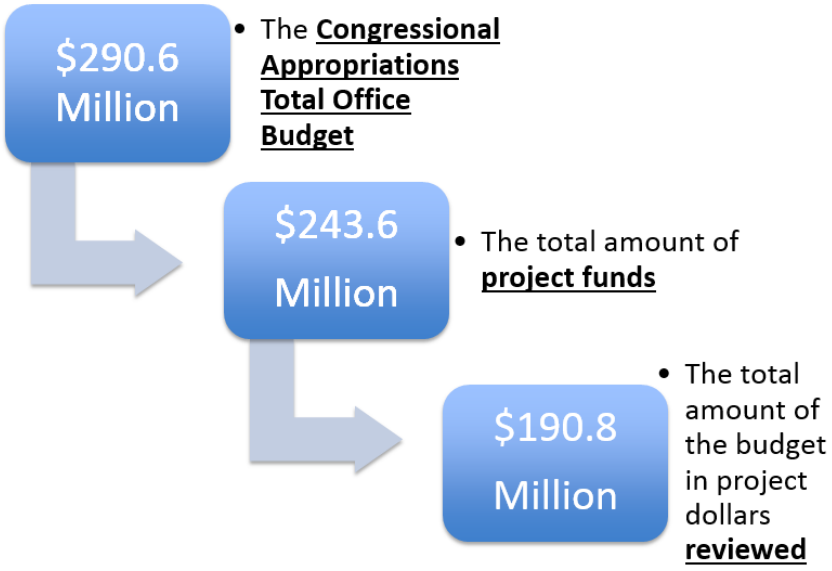


Figure 1. WETO FY 2014–2016 appropriations flowchart (in nominal dollars)

Three categories of WETO appropriations were excluded from consideration in the peer review: National Renewable Energy Laboratory (NREL) Site-Wide Facility Support, an amount all EERE offices contribute to DOE facility support; Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) projects, which are funded by EERE offices but not under their direct control given that they are

[15] These are the formal WETO subprograms as denoted by Congress. These subprograms were condensed into two programs or tracks for the peer review: Market Acceleration and Deployment; and Resource Characterization and Technology Research, Development, and Testing.

Administered by DOE's Office of Science; and Technology Management, which accounts for internal program support functions. Budgets for these sectors are included in Table 4 to provide total WETO funding.

Table 4. Budget Appropriations of the Wind Energy Technologies Office for FY 2014–FY 2016 (in nominal dollars)

($ thousand)	FY 2014	FY 2015	FY 2016	Total FY 2014—2016
Wind Energy, Total Appropriations	88,126	107,000	95,450	290,576
Resource Characterization & Technology RD&T	35,163	30,301	21,869	87,332
Technology Validation and Market Transformation	20,054	46,250	47,650	113,954
Mitigate Market Barriers	10,324	11,116	12,132	33,573
Modeling and Analysis	3,261	2,853	2,618	8,731
NREL Site-Wide Facility Support	9,000	4,700	2,450	16,150
SBIR/STTR	1,091	1,064	750	2,905
Technology Management*	9,233	10,716	7,981	27,931

Categories of WETO FY14—FY16 Appropriations Addressed in the Peer Review

*Technology Management includes laboratory and DOE HQ technology management support

Review Strategy

For the purposes of the peer review, the projects being reviewed were divided into two "tracks" and organized into "subprograms" by topic area within each track. This peer review structure and related funding by track and subprogram is reflected in Table 5. Track and subprogram titles were based on the internal project administration and oversight structure of WETO, and therefore do not directly align with the categories in Table 4. For instance, the RC and Tech RD&T and the MA&D tracks both include projects that were appropriated within the Technology Validation and Market Transformation category of Table 4.

Table 5. Funding for Peer-Reviewed Projects by Track and Subprogram

Peer Review Track and Subprogram	FY 2014—16 Total Funding
Resource Characterization and Technology RD&T	
A2e, HPC, RC, Flow Field Analysis and Testing	$29,603,375
Distributed Wind Research, Development, and Testing	$7,888,710
Innovation, Manufacturing, Reliability, Adv Components, & Testing	$36,898,609
Offshore Wind Unique RD&T	$89,265,208
RC and Tech RD&T Total	$163,655,902
Market Acceleration and Deployment	
Analysis, Modeling, COE, and Policy Impact	$1,950,000
Grid Systems Planning and Operation	$7,240,488
Siting, Radar and Environmental	$8,987,724
Stakeholder Engagement, Outreach, and Workforce Development	$8,979,866
MA&D Total	**$27,158,078**
WETO Total	**$190,813,980**

Note: Atmosphere to electrons (A2e), high-performance computing (HPC), (RC), and (COE).

The RC and Tech RD&T track accounted for $163.7 million (86%) of reviewed direct project funding, with MA&D accounting for the remaining $27.2 million (14%). The diagram in Figure 2 indicates how this funding was distributed among recipient types, illustrating the connections WETO has with a wide range of stakeholders, including industry partners, national laboratories, and academic institutions.

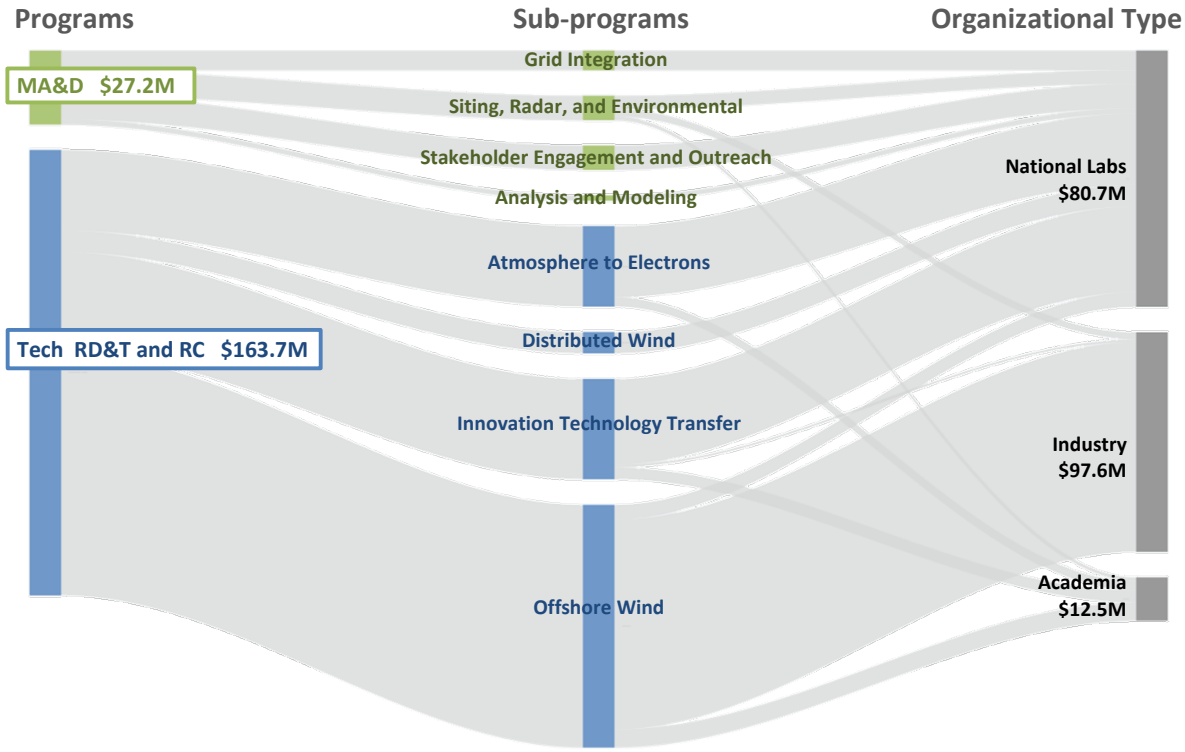


Figure 2. Portions of the WETO budget represented by peer review track and subprogram

Project Selection Process

WETO used a multistep process to identify and select projects to be reviewed at the 2017 Peer Review and to plan the agenda. These steps include:

The office evaluated all projects funded in FY 2014, FY 2015, and FY 2016.

To identify projects meeting this criterion, the office used budget data, contracts with laboratories and industry recipients, and a project inventory database.

The WETO director provided high-level guidance about project selection and agenda planning, including:

A. Logistics such as total amount of time to allocate at the peer review for project presentations

Organization of research portfolio into tracks

Priority projects considered mandatory for review.

Along with the director's guidance, WETO technology managers selected projects based on criteria, including magnitude of funding, relevance/importance of research, project stage, desire for peer review feedback on project, and overall diversity of each program portfolio represented at the review.

A. WETO further narrowed project selection to comply with EERE peer review guidelines that projects representing approximately 80% of total office funding be scheduled for review. This included a mix of program-level and project-level presentations.

Every national laboratory that received funding within the review period (FY 2014–FY 2016) was required to present at least one project at the review.

The allocated projects and subject matter areas were assigned to accommodate a two-track session agenda that reflected overall WETO priorities and funding areas.

Summary of Program-Level Evaluations

Reviewers were asked to provide comments and numeric scores as part of an overall evaluation of both WETO tracks: Resource Characterization and Technology Research, Development, and Testing (RC and Tech RD&T) and Market Acceleration and Deployment (MA&D). The program-level assessment provides an overall view of WETO programmatic management and research portfolios. The office's response to the program-level evaluation metrics is in Section 4.

Process Overview

Program-level assessments were based on four metrics:

1. **Program Objectives**—How well do program objectives align with industry needs and administration goals?

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

3. **Management and Operations**—What is the quality of the WETO team, management practices, and operations?

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

Each criterion for the program-level evaluations was scored as a stand-alone metric. Numerical scores are based on a five-point scale, with a 1 corresponding to a "Poor" rating; 2 corresponding to "Fair"; 3 corresponding to "Average"; 4 corresponding to "Good"; and 5 corresponding to "Outstanding." Reviewers were also asked to provide comments with qualitative feedback on overall program strengths and weaknesses as well as additional recommendations (overall strengths, weaknesses, and recommendations did not receive quantitative scores). The program-level scoring sheet used by reviewers is included in Volume II.

Results for the program-level evaluations have been tabulated from each of the two WETO tracks and are reported separately herein.

Quantitative Program-Level Results

Figure 3 summarizes the reviewers' quantitative assessments of how WETO is performing on the four-evaluated metrics.

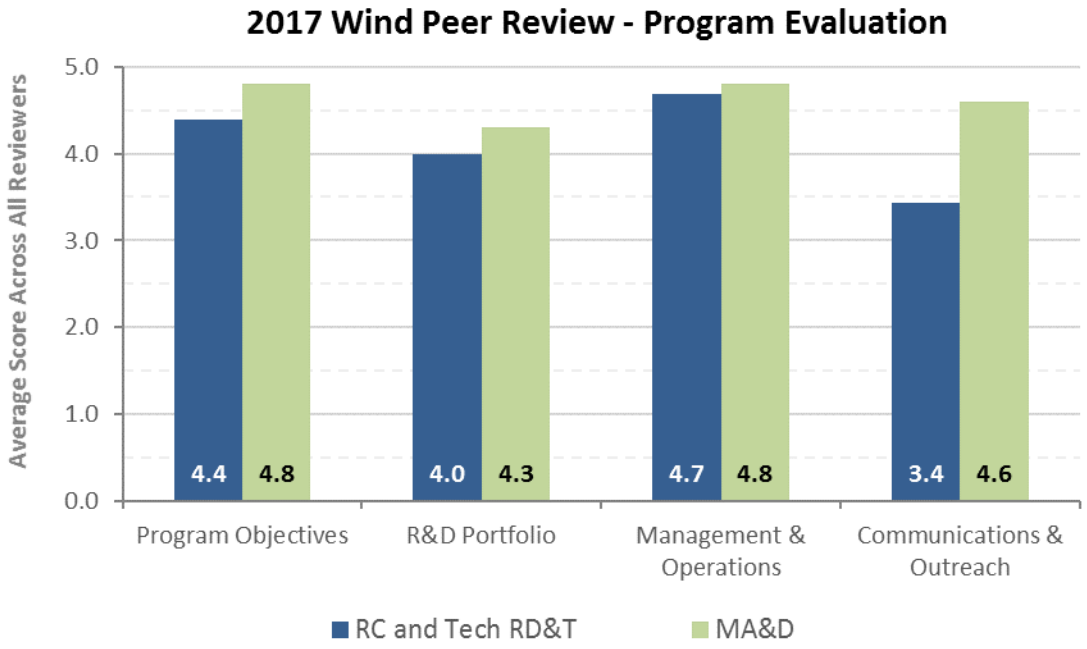


Figure 3. Reviewer average scores for the four program-level metrics

Resource Characterization and Technology Research, Development, and Testing

Comments by Evaluation Metric

Table 6 features selected comments from the reviewers' qualitative assessments of how WETO's RC and Tech RD&T portfolio is performing on the four-evaluated metrics. The table also features key comments related to program overall strengths, weaknesses, and recommendations that were not scored quantitatively. This information was compiled through a comprehensive review of the Wind RC and Tech RD&T reviewer comments captured in the evaluation workbooks and the peer review wrap-up session. The comments in these tables are not comprehensive but intended to provide a representative selection of both positive and negative input from reviewers. This representative selected is also intended to provide a snapshot of the feedback about WETO portfolio and program management.

Table 6. Select Program-Level Comments: Resource Characterization and Technology Research, Development, and Testing Track

Program Objectives

- There is ample evidence that DOE investment in wind energy has led reductions in LCOE and industry growth.
- From the end-user perspective, WETO objectives are in line with industry needs. It is encouraging to see a wide variety of projects that are applicable to issues facing industry as well as programs that will improve wind resource estimation and provide initial benchmarks for offshore wind costs.
- WETO funds several projects that distribute information to many contributors and stakeholders. This is an excellent goal and will help address existing barriers to information sharing due to intellectual property concerns.
- Program objectives for distributed wind should be better defined and expanded in scope.

R&D Portfolio

- WETO is substantially well balanced to meet mission goals, but as industry builds capacity in some areas (e.g., some areas of turbine design, avian hazards), DOE should focus on research efforts that are more clearly out of reach for industry such as R&D requiring exa-scale computing (e.g., flow characterization, plant optimization).
- There is a substantial need for more research addressing issues related to risk, uncertainty, and the potential cost impacts associated with each.
- It is very important that DOE, working in combination with other government entities and the private sector, continues to identify, prioritize, and address these issues which will continue to evolve as the industry matures.
- Many WETO projects have direct applicability to operational challenges industry faces on a daily basis.
- WETO should expand distributed wind R&D.

Management and Operations

- The experience and expertise of the staff is outstanding, the overview presentation content was well articulated, and the focus on industry needs is critical.
- WETO program managers have helped stimulate a more collaborative approach to program development.
- The way WETO managed the demonstration projects is a testament to good program management. They made difficult decisions and recognized the need for change.
- WETO has done an exemplary job attracting, retaining, and empowering a world-class team of professionals. The global industry looks to them for expertise and leadership.
- Competing priorities and requests from industry make managing a coherent program very difficult. DOE has done a masterful job addressing broad stakeholder needs and including end user stakeholder concerns.
- Coordinating laboratory talent to address broad industry needs has been well orchestrated.

Communication and Outreach

- Transparency and peer review has been a cornerstone of program management. DOE managers have created a culture of communication and industry outreach.
- While there is a good level of collaboration with other entities and, specifically, private sector contributors through each individual project, there may be more value gained with a large involvement from a broader range of stakeholders.
- Despite challenges, WETO has done an excellent job publishing its findings, working with the industry, and reaching out beyond the industry-to-leverage experience and knowledge elsewhere.
- Especially with respect to the offshore wind industry, the “look back" shows a lack of real coordination with industry. However, knowing that the updated offshore wind strategy was developed in greater collaboration with industry and is promising and shows improvement.
- Impressed by some of the information dissemination of the program. Shows way of getting at detailed information. But in other cases, people aren’t always aware of all the things that WETO does. Don’t know what the answer is and think WETO is doing as good a job as can be done—it is awareness and marketing.

- The communications strategy (for wind technology R&D) should include defensive monitoring of bad actors (in industry) making unverifiable claims and engagement with all branches of government to ensure high quality procurement and siting decisions.

Overall Strengths

- The breadth and depth of the completed and ongoing projects is impressive. Most (if not all) major wind energy disciplines represented.
- DOE is commended for being on top of industry trends, needs, and technology gaps. The focus on costs, implementation barriers, and environmental impacts is correct.
- The validation of tools and the use of real world data are excellent.
- WETO R&D is positioned for success in improving distributed wind energy markets.
- WETO staff is extremely skilled and continues to mentor the industry.
- Broad resources, objective and trusted position in the industry, and strategic execution of the program are all strengths.

Overall Weaknesses

- There are some instances of redundancy between different projects. It is not clear if this was intentional, but it seems that this was probably due to the separate evolution of project scopes.
- More value can be gained broadening the range of stakeholders included in program planning (i.e., get more input from all stakeholders before project objectives are set).
- Funding uncertainty is a tremendous distraction, and federal policy is at odds with known technical and commercial advancement opportunities. This constrains the WETO's potential efficacy.
- Overemphasis on advanced technology demonstration projects in the offshore portfolio and the lack of a plan to meet future testing needs for offshore wind energy technology are weaknesses in the current program.
- Limited funding is not sufficient to address high-priority distributed wind RD&D needs.

Key Program Management Feedback

Table 7 summarizes qualitative program-level recommendations and suggested areas of improvement for the RC and Tech RD&T track, as noted by reviewers. These inputs are organized into four categories: DOE programmatic management, issues constraining RC, and Tech RD&T projects/topics, gaps, and potential future focus areas. This table was compiled through a comprehensive review of the RC and Tech RD&T reviewer comments captured in the evaluation workbooks and the peer review wrap-up session. The comments in these tables are not comprehensive but are intended to provide a representative selection of both positive and negative input from reviewers. This representative selected is intended to provide a balanced snapshot of the feedback about WETO status and opportunities.

Table 7. Select Program Management Comments—Resource Characterization and Technology Research, Development, and Testing Track

Programmatic Management

- Project go/no-go requirements tied to specific milestones are critical, especially for larger, more expensive projects.
- Budget limitations can hamper project success, which should be considered during DOE programmatic planning.
- Planning process for validated open-source community models should take into consideration needs of all industry sectors, including distributed wind and small companies.
- Reasonable effort should be made to solicit feedback from end users prior to project start.
- Efforts like the *Wind Vision* and *National Offshore Wind Strategy* are critical for future research planning.
- We count on DOE to be an objective, transparent, third party in the industry. DOE can do things the industry can't or wouldn't do for itself, bringing together different elements, stakeholders. DOE's consistent support has shown lasting value. Be mindful of this position; the industry depends on DOE.

Address the Issues that are Holding Back RC and Tech RD&T Projects and Topics

- Drivetrains evaluated to date need detailed gearbox design information (bearing details, gear details, etc.). Trying to get that information from gearbox suppliers has been difficult.
- For condition monitoring research programs, data interpretation that includes cost and ROI (return on investment) is key, and often missing.
- Owners/operators are subject to public opinion on the aesthetic appeal of wind turbines. Visual signature should be considered in design projects.
- Ensure projects could not be easily completed by the private sector.
- It's not clear that private industry has the deep pockets necessary to validate drivetrain reliability.

Address the Following Gaps in the RC and Tech RD&T Portfolio

- Primary focus on wind plants does not consider fleet-wide and utility system-level optimization opportunities.
- Future tower research should include a focus on ensuring high quality, reproducible welds, which are critical to tower longevity.
- Research into geared drivetrains may be relevant in the short term, but more research into direct-drive drivetrains is warranted and necessary.
- Data sharing is critical, and DOE can expand its efforts to work with industry awardees to accelerate the release of useful results.
- To the degree efforts are made, A2e is exceptional and the need can't be understated. Setting the stage for valuable validation opportunities going forward. Needs to be partnered with high-fidelity data capture.

Future Focus Areas for RC and Tech RD&T Topics

- Fully understanding turbine-wake interactions and the implications of complex terrain will allow for optimized wind farm design and operation.
- There is a critical need to invest in validation and verification as part of model improvement efforts.
- Consider increasing future funding to accelerate progress for distributed wind sector that may not be ranked as top priority by stakeholders involved, but critically important for the credibility of the entire industry.
- Ice-throw distance R&D would be helpful.
- Research into blade damage detection and smart loads management could have large and immediate impacts on reducing operational costs.
- Drivetrain research would benefit from a move to larger-sized test articles.
- There will be needs for testing offshore systems in the future, which will require the necessary infrastructure.
- Activities funding could be directed to in future include additive manufacturing, which could have benefits in producing parts closer to installation sites as well as nondestructive inspection methods, ways to do better with operation and maintenance training and looking at soft costs.

Market Acceleration and Deployment

Comments by Evaluation Metric

Table 8 features key comments from reviewers' qualitative assessments of how WETO's MA&D portfolio is performing on the four-evaluated metrics (Section 3.1). The table also features key comments related to overall program strengths, weaknesses, and recommendations, which were not scored quantitatively. This information was compiled through a comprehensive review of the MA&D reviewer comments captured in the evaluation workbooks and the peer review wrap-up session. The comments in these tables are not comprehensive, but intended to provide a representative selection of both positive and negative input from reviewers. This representative selection is also intended to provide a snapshot of the feedback about WETO's overall portfolio and management.

Table 8. Select Program-Level Comments—Market Acceleration and Deployment Track

Program Objectives

- WETO projects have aided the wind industry in becoming an increasingly important part of U.S. electricity generation.
- WETO continues to improve since the last peer review, with clearer purpose and intent from program managers and presenting principal investigators.
- Interagency initiatives are critical, both in radar and wildlife areas, and DOE has a unique role. More interagency activities and bold solutions for historic problems are needed.
- The applicability and practicality of grid integration studies suggests that WETO did a good job listening to industry and stakeholders.

R&D Portfolio

- WETO investigates unconventional impact mitigation options in coordination with vested stakeholders who would not likely have accomplished these studies on their own.
- R&D topics in the MA&D track are well chosen and justifiable. The money spent—and the results from the funding—are generally efficient.
- R&D gaps include icing issues, distributed wind, building standoff distance, taller turbines, and noise issues.
- There are numerous projects appearing to have similar objectives. This may be intentional and reflect the need to pursue varying approaches to identify the most successful. In some areas, perhaps a more focused approach would be a better path forward.

Management and Operations

- Stove-piped programs and tasks should be opened to push innovation and creative ideas.
- WETO appears responsive to industry concerns and challenges (e.g., bat deterrent projects), and the fast allocation of resources is impressive.
- Stakeholder engagement is strong, leading to a good picture of what is needed for research and deployment, and working groups.
- The management team actively participates in dissemination and collaboration.
- Milestone achievement across all projects is impressive and speaks of a highly proactive management approach that strikes a good balance between incentivizing progress and efficiency while allowing for flexibility and changes of direction where appropriate.
- Most PIs [principal investigators] seemed well versed on their projects, but some did not seem well versed on the overall importance of their project.

Communication and Outreach

- Across most programs there is a strong focus on dissemination and outreach. Highlights in this regard are WREN Hub [Working Together to Resolve Environmental Effects of Wind Energy], Tethys, engagement with UVIG [Utility Variable-Generation Integration Group]) and IEA [International Energy Agency]) Wind Tasks 25, 28, and 34.
- Given limited resources, WETO has been successful in this area. The challenge is how to more effectively communicate across a larger group of stakeholders (including those that do not support wind).
- WETO has specific funding for outreach, which helps deployment by identifying stakeholders and providing relevant information.
- Collaboration and stakeholder engagement at WETO has been outstanding.
- WETO could assemble a group of advocates from industry that interfaces with subject matter counterparts (UVIG, American Wind Energy Association, American Wind Wildlife Institute, etc.) to socialize accomplishments and products. They can then draw attention to specific DOE efforts and capabilities.

Overall Strengths

- The dedication, commitment, intelligence of the program staff and the way they approach issues and address them are key indicators of a high-quality organization.
- Excellent personnel capabilities at DOE and the national laboratories.
- Grid integration has a strong portfolio of projects that leverage funding across DOE.
- Deployment and R&D in the same program—something not happening in Europe—expands the possibility of successful outreach and enables DOE to provide objective facts about real versus perceived problems.
- Very strong focus on outreach and open access benefits both U.S. and global industry. Highlights include engagement with UVIG and IEA Wind tasks, WREN Hub, Tethys, Wind for Schools, the Collegiate Wind Competition, Generic Model Development project, Eastern Renewable Generation Integration Study, and Western Wind and Solar Integration Study 3.

Overall Weaknesses

- Involvement of experts from other energy sectors (starting within the DOE agency) could assist in creative/scientific thinking. For example: how do the oil, gas, and shale gas industries handle environmental regulations on public lands?
- The national lab and headquarters dynamic seems to remain an area where silos are naturally formed. Given the limited budget and large potential portfolio of issues deserving of attention, it seems some means of cross-pollination among the labs and project managers would be healthy.
- Don't think you're getting recognition you deserve. WETO should have different marketing plan. Amazing disconnect.

Key Program Management Feedback

Table 9 summarizes qualitative program-level recommendations and suggested areas of improvement for the MA&D track, as noted by reviewers. These inputs are organized into four categories: DOE programmatic management, constraining MA&D projects/topics, gaps, and potential future focus areas. This table was compiled through a comprehensive review of the MA&D reviewer comments captured in the evaluation workbooks and the peer review wrap-up session. The comments in these tables are not comprehensive, but intended to provide a representative selection of both positive and negative input from reviewers. This representative selected is intended to provide a snapshot of the feedback about WETO status and opportunities.

Table 9. Select Program Management Comments—Market Acceleration and Deployment Track

Programmatic Management
• Continue to leverage and build upon previous studies and reports, such as the well-received Wind Integration and Wildlife studies. • Continue interagency collaboration on future radar impact mitigation research. • Not always under the control of DOE, but try to avoid gaps in funding, which lead to momentum-killing starts and stops for projects. • Implementation of metric-based impact tracking would be valuable in evaluating the effectiveness of the MA&D program. • DOE is taking prior efforts and products and using them effectively down the road (i.e., not getting stale).
Address the Issues That are Holding Back Wind MA&D Projects and Topics
• Wildlife studies need a comparative approach to other energy sources to frame the real impacts; this is an old problem that remains an issue at DOE. • Collaboration with NGOs (non-governmental organizations), such as Bat Conservation International, the Bats and Wind Energy Collaborative, and National Wind Coordinating Collaborative, is an important role for NREL. • More involvement of social scientists with depth in community-related responses and perceptions to energy siting (not necessarily wind) would be beneficial to public acceptance efforts.
Address the Following Gaps in the Wind MA&D Portfolio
• Wind integration studies are missing a link to human capabilities and impacts on system operators; e.g., the response of system operators to more renewables as well as expected uncertainties of increasing levels of distributed resources (both wind and solar). • It has been shown that due to the increased voltage control challenges at the distribution level, wind power capacity connected at one distribution voltage can impact the capacity possible at another. It is not clear if these interactions have been properly considered. • Turbine type and tower height have an impact on annoyance levels and noise. These issues may be missing from the analysis.
Future Focus Areas for MA&D Topics
• Include studies on the impact of rising interest rates on long-term operational contracts. • Transient stability and frequency stability studies are needed to identify the limits of stability and understand the potential to accommodate higher shares of renewables. • Focus may need to shift to more central issues, such as wind-friendly market design. • Explore the significant risks and benefits related to wildlife to ensure the program is working on the most impactful issues. This should include bringing in a fresh group of collaborators, outside the typical DOE partners. • WindExchange and the Regional Resource Centers should expand to better incorporate offshore wind. • The impact and cost of regulations for wind energy implementation should be captured and reflected to the public and policymakers. • Think about how things might interrelate, even things that seem disparate topic-wise.

Office Response to Peer Review Findings

Summary of Wind Energy Technologies Office Response to Reviewer Feedback

This section provides WETO's response to the comments presented in Section 3 to confirm and summarize the learning process that the office has gone through as a result of the feedback received from the peer reviewers. Subsection 4.1 includes several general responses. Subsections 4.2 and 4.3 include point-by-point responses to the comments listed in the tables of Section 3. As in Section 3, the comments and responses in this section are organized by the evaluation metrics, program objectives, R&D portfolio, management and operations, communications and outreach, and overall strengths and weaknesses.

WETO sincerely values the peer review panel's thoughtful and significant effort in conducting a detailed review of the office. WETO acknowledges the compliments received regarding overall project management, execution, impact, and alignment with industry needs, as well as the positive feedback regarding scientific leadership and the relevance of the projects to address the challenges facing the nation today.

While the peer review results were positive, WETO recognizes that there are several areas reviewers identified that require attention and overall improvement in project selection, execution, and relevancy to the office's strategy. Since the peer review, the office has been working diligently—for instance, in the 2018 Annual Operating Plan planning process—to implement several of the recommendations and address many of the reviewers' comments regarding areas for improvement.

WETO acknowledges and will address the noted instances of project redundancy as well as lack of clarity in goals and timeliness in delivering relevant results to stakeholders. The office recognizes ongoing requests for more R&D in the offshore and distributed wind sectors, with success in those markets vital for credibility of the broader wind industry. As suggested in the peer review results, WETO will enhance the computational efforts under the RC and Tech RD&T portfolio by engaging a broad base of partners to inform project objectives and will continue to emphasize verification and validation of computational models.

WETO's responsibility is to provide impartial expertise and leadership in wind energy research and development. The office has evolved significantly since the last peer review in 2014, including the creation of two separate offices; the former Wind and Water Power Technologies Office is now separated into WETO and the Water Power Technologies Office. WETO is well-positioned to assist the U.S. wind industry and its stakeholders as a trusted R&D partner. In the 2017 Peer Review, WETO received praise for its focus on technology gaps, costs, implementation barriers, and environmental impacts.

Based on constructive feedback from this peer review, WETO is improving its communication strategy for complex research and development in RC and Tech RD&T to reach not only interested and invested stakeholders, but also a broader nontechnical audience. The office recognizes that clear and concise communication of results is vital to maximizing the impact of its research investments. The MA&D program scored well in this area and is actively sharing techniques and approaches.

Reviewer and Office Response: Wind Resource Characterization and Technology Research, Development, and Testing

Under each programmatic evaluation metric below, comments from the tables in Section 3.3 are copied in bulleted lists. Office responses to each group of comments are then provided. Complete program-level comments are in Volume II, Section 6 of this report. The office has also reviewed all reviewer comments and incorporated lessons learned from them into their responses.

Evaluation Metric—Program Objectives

Table 10. Select Program Management Comments—Program Objectives

Program Objectives
• There is ample evidence that DOE investment in wind energy has led to reductions in LCOE and industry growth. • From the end-user perspective, WETO objectives are in line with industry needs. It is encouraging to see a wide variety of projects that are applicable to issues facing industry, as well as programs that will improve wind resource estimation and provide initial benchmarks for offshore wind costs. • WETO funds several projects that distribute information to many contributors and stakeholders. This is an excellent goal and will help address existing barriers to information sharing due to intellectual property concerns. • Program objectives for distributed wind should be better defined and expanded in scope.

The RC and Tech RD&T program (identified as "the program" in this section) has focused on LCOE as a metric for fulfilling DOE's EERE research mission for the last several years. Projects in the program's research portfolio have a common goal of reducing energy costs for U.S. consumers. Peer review results are positive for the program's recent focus on improving wind resource characterization and confirm the importance of independent offshore wind cost analysis for that emerging U.S. market.

Communicating the goals, progress, and products of the RC and Tech RD&T program to the larger stakeholder group is critical for results to positively impact technology and industry growth. The distributed wind portfolio appropriations have varied between fiscal years, but the office recognizes that clarity in scope and variety of R&D approaches can help mitigate that challenge.

Evaluation Metric—R&D Portfolio

Table 11. Select Program Management Comments—R&D Portfolio

R&D Portfolio
• WETO is substantially well-balanced to meet mission goals, but as industry builds capacity in some areas (e.g., some areas of turbine design, avian hazards), DOE should focus on research efforts that are more clearly out of reach for industry such as R&D requiring exascale computing (e.g., flow characterization, plant optimization). • There is a substantial need for more research addressing issues related to risk and uncertainty and the potential cost impacts associated with each. • There is a substantial need for more work in this industry to address issues related to risk, uncertainty and the potential cost impacts associated with each. It is too easy to become overly confident based on, in the case of offshore, just a few years of operating experience. It is very important that DOE, working in combination with other government entities and the private sector, continues to identify, prioritize, and address these issues, which will continue to evolve as the industry matures. • Many WETO projects have direct applicability to operational challenges that industry faces on a daily basis. • WETO should expand distributed wind R&D.

The peer review panel identified several R&D portfolio strengths, including the Atmosphere to Electrons (A2e) portfolio, test facilities, and reliability collaborative groups. The panel also notes several R&D areas where additional emphasis is needed, such as risk and uncertainty analysis, systemic operations and maintenance issues, and distributed wind. Missing elements include attention to the aging U.S. wind fleet and the need for more R&D in opportunities to extend turbine component life. The program also needs to focus more on areas in which the industry is limited, such as large-scale computing. WETO will fulfill its unique government role by facilitating technology breakthroughs and independent assessments, and by conducting high-risk R&D.

Evaluation Metric—Management and Operations

Table 12. Select Program Management Comments—Management and Operations

Management and Operations
• The experience and expertise of the staff is outstanding; the overview presentation content was well articulated and the focus on industry needs is critical. • WETO program managers have helped stimulate a more collaborative approach to program development. • The way WETO managed the demonstration projects is a testament to good program management. They made difficult decisions and recognized the need for change. • WETO has done an exemplary job attracting, retaining, and empowering a world-class team of professionals. The global industry looks to them for expertise and leadership. • Competing priorities and requests from industry make managing a coherent program very difficult. DOE has done a masterful job addressing broad stakeholder needs and including end-user stakeholder concerns. • Coordinating laboratory talent to address broad industry needs has been well-orchestrated. • Program investments are not resulting in timely enough state-of-the-art manufacturing innovation, as compared to international counterparts; the United States is losing its edge, particularly in the distributed wind sector.

WETO acknowledges the exceptional team of professionals at the national laboratories for their acclaimed expertise and leadership and appreciates this important and unique attribute of the government laboratories. Maintaining that talent in uncertain budget conditions is challenging and developing creative ways to attract and retain expertise will be crucial to continued success. The office recognizes the tendency for project managers and researchers to become disjointed from the rest of the portfolio, absorbed in their own work and without connection to other projects. This tendency drives WETO's focus on better collaboration across the labs and internal DOE leadership. WETO will center management and operations efforts on continued excellence in office staff and leadership, as well as stronger research partnerships from the national laboratories.

Evaluation Metric—Communication and Outreach

Table 13. Select Program Management Comments—Communication and Outreach

Communication and Outreach
• Transparency and peer review have been cornerstones of program management. DOE managers have created a culture of communication and industry outreach. • While there is a good level of collaboration with other entities and, specifically, private sector contributors through each individual project, there may be more value gained with a large involvement from a broader range of stakeholders. • Despite challenges, WETO has done an excellent job publishing its findings, working with the industry, and reaching out beyond the industry to leverage experience and knowledge elsewhere. • Especially with respect to the offshore wind industry, the "look back" shows a lack of real coordination with industry. However, knowing that the updated offshore wind strategy was developed in greater collaboration with industry is promising and shows improvement. • Some of the information dissemination of the program is impressive and shows ways of getting at detailed information. But in other cases, people aren't always aware of all the things that the program does. Awareness and marketing can bolster communication.

The principal investigators on RC and Tech RD&T projects have succeeded in communicating with niche subject matter experts, but peer review results suggest 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 program recognizes that its 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 RC and Tech RD&T track have started consulting with the MA&D program, which scored highly on this metric, to create strategies to amplify and communicate program work successfully.

Evaluation Metric—Overall Strengths

Table 14. Select Program Management Comments—Overall Strengths

Overall Strengths
• The breadth and depth of the completed and ongoing projects is impressive. Most (if not all) major wind energy disciplines are represented. • DOE is commended for being on top of industry trends, needs, and technology gaps. The focus on costs, implementation barriers, and environmental impacts is correct. • The validation of tools and the use of real-world data are excellent. • WETO R&D is positioned for success in improving distributed wind energy markets. • WETO staff is extremely skilled and continues to mentor the industry. • Broad resources, objective and trusted position in the industry, and strategic execution of the program are all strengths.

WETO appreciates the positive reviewer comments regarding the relevancy of the office's initiatives and expertise of its staff. It will continue to foster the strengths, such as expert staff at the labs as well as breadth and depth of relevant projects, testing capabilities, data collection, standards development, and validation of tools. The RC and Tech RD&T portfolio will ensure continued analysis and understanding of industry trends, needs, and technology gaps, and will use that information to build a portfolio appropriate for its unique federal role. Maintaining a respected, independent, and unbiased voice within the wind industry community will remain a critical objective for the office.

Evaluation Metric—Overall Weaknesses

Table 15. Select Program Management Comments—Overall Weaknesses

Overall Weaknesses
• There are some instances of redundancy between different projects. It is not clear if this was intentional, but it seems that this was probably due to the separate evolution of project scopes. • More value can be gained by broadening the range of stakeholders included in program planning (i.e., get more input from all stakeholders before project objectives are set). • There is an overemphasis on advanced technology demonstration projects in the offshore portfolio and the lack of a plan to meet future testing needs for offshore wind energy technology are weaknesses in the current program. • Limited funding is not sufficient to address high-priority distributed wind RD&D needs.

WETO understands the importance of addressing specific project weaknesses, such as redundancy, poor out-year planning, and lack of clarity in connection to the larger RC and Tech RD&T portfolio, WETO, and EERE strategy. In some cases, the office has made intentional choices to fund related projects working toward similar end goals, with the goal of diversifying the number of solutions available, lowering cost, and maximizing breadth of applicability. WETO recognizes that the high-risk offshore wind demonstration program has overshadowed specific offshore R&D projects, and that limited funding for distributed wind has affected growth of that important market sector. WETO will investigate all detailed project feedback and, where possible, take immediate action to rectify identified deficiencies. WETO will ensure that RC and Tech RD&T program managers monitor the portfolio to maximize integration, coordination, and communication. The peer

review panel's comments are invaluable, as the perspective of external evaluators has provided identification of weaknesses that those close to the projects may not always recognize.

Reviewer Comments and Office Response: Market Acceleration and Deployment

Explanation: Under each programmatic evaluation metric below, comments from the tables in Section 3.3 are copied in bulleted lists. Office responses to each group of comments are then provided. Complete program-level comments are in Volume II, Section 6 of this report. The office has also reviewed all reviewer comments and incorporated lessons learned from them into their responses.

Evaluation Metric—Program Objectives

Table 16. Select Program Management Comments—Program Objectives

Program Objectives
• WETO projects have aided the wind industry in becoming an increasingly important part of U.S. electricity generation. • WETO continues to improve since the last peer review, with clearer purpose and intent from program managers and presenting PIs. • Interagency initiatives are critical, both in radar and wildlife areas, and DOE has a unique role. More interagency activities and bold solutions for historic problems are needed.

WETO's MA&D program (identified as the "program" in this section) has made a concerted effort over the last several years to ensure that the suite of work is strategically focused and responsive to wind stakeholder needs. The program was pleased to hear that the reviewers identify our portfolio as focused and responsive to the needs reflected in the goals and structure of the current portfolio, as well as in the impact of the work. The program concurs with the reviewers' emphasis on the importance of interagency collaboration in ensuring that the work is accepted and effective. In addressing wind-radar interference, the program leads an interagency working group to identify and address the highest priority challenges and co-fund research to address these challenges. Similarly, the program works closely with a suite of federal partners to address wind energy environmental challenges. This includes formal partnerships on international environmental information sharing, efforts to address wind energy impacts on bats, and the alignment of strategic research priorities for both land-based and offshore wind. WETO will continue to look for opportunities to strengthen and broaden these partnerships and outreach.

Evaluation Metric—R&D Portfolio

Table 17. Select Program Management Comments—R&D Portfolio

• WETO investigates unconventional impact mitigation options in coordination with vested stakeholders who would not likely have accomplished these studies on their own. • R&D topics in the MA&D track are well chosen and justifiable. The money spent and the results from the funding are generally efficient. • R&D gaps include icing issues, distributed wind, building standoff distance, taller turbines, and noise issues. • There are numerous projects appearing to have similar objectives. This may be intentional and reflect the need to pursue varying approaches to identify the most successful. In some areas, perhaps a more focused approach would be a better path forward. • The applicability and practicality of grid integration studies suggests that WETO did a good job listening to industry and stakeholders.

WETO aligned its MA&D program to provide strategic support for a novel suite of solutions to deployment issues, recognizing the potential for federal support to catalyze both research efforts and fiscal support from

external parties. In some cases, the program made intentional choices to fund related projects working toward similar end goals, with the goal of diversifying the number of solutions available, lowering cost, and maximizing breadth of applicability. The program will work to continuously improve R&D project performance and be diligent about sharing information and building a collective knowledge base to expedite wind technology progress. WETO will further advance the evaluation of the program's strategic approach to identifying potential high-priority research gaps.

Evaluation Metric—Management and Operations

Table 18. Select Program Management Comments—Management and Operations

Management and Operations
• WETO appears responsive to industry concerns and challenges (e.g., bat deterrent projects), and the fast allocation of resources is impressive. • Stakeholder engagement is strong, leading to a good picture of what is needed for research and deployment, and working groups. • The management team actively participates in dissemination and collaboration. • Milestone achievement across all projects is impressive and speaks of a highly proactive management approach that strikes a good balance between incentivizing progress and efficiency while allowing for flexibility and changes of direction where appropriate. • Most PIs seemed well versed on their projects, but some did not seem well versed on the overall importance of their project. • Stove-piped programs and tasks should be opened to push innovation and creative ideas.

WETO extends gratitude to the peer reviewers for their recognition of the office's efforts to construct a portfolio that meets high-priority needs, as well as the efforts to engage with key stakeholders, collaborate on work efforts, and manage effective and efficient projects. The program will continue to work with its PIs to ensure articulation of the importance of each project's work to specific programmatic strategic objectives. WETO will also work to minimize silos between topic areas in the future.

Evaluation Metric—Communication and Outreach

Table 19. Select Program Management Comments—Communications and Outreach

• Across most programs there is a strong focus on dissemination and outreach. Highlights in this regard are WREN Hub (Working Together to Resolve Environmental Effects of Wind Energy), Tethys, engagement with UVIG and IEA Wind Tasks 25, 28, and 34. • Given limited resources, WETO has been successful in this area. The challenge is how to effectively communicate across a larger group of stakeholders (including those that do not support wind). • WETO has specific funding for outreach, which helps deployment by identifying stakeholders and providing relevant information. • Collaboration and stakeholder engagement at WETO has been outstanding. • WETO could assemble a group of advocates from industry that interfaces with subject matter counterparts (UVIG, AWEA, American Wind Wildlife Institute, etc.) to socialize accomplishments and products. They can then draw attention to specific DOE efforts and capabilities.

The program has progressed over time and made considerable effort to identify successful means for receiving feedback from the wind community. This includes soliciting input on the complete portfolio, from strategic approaches to specific initiatives, and applying a high level of technical expertise to the execution and evaluation of ongoing projects. WETO has also focused on efforts disseminating information about both ongoing and completed activities to interested stakeholders. Finally, a cornerstone of WETO's MA&D work has been leading and supporting initiatives aimed at aggregating, synthesizing, and disseminating relevant research findings from around the world. WETO is grateful to the reviewers for their acknowledgement of the

office's accomplishments in this area. The office will continue to identify opportunities to reach broad groups of stakeholders and work with partners to help disseminate information about WETO research and activities, recognizing that these areas are important to meeting strategic objectives.

Evaluation Metric—Overall Strengths

Table 20. Select Program Management Comments—Overall Strengths

Overall Strengths
• The dedication, commitment, and intelligence of the program staff and their approach to addressing issues are key indicators of a high-quality organization. • Excellent personnel capabilities at DOE and the national laboratories. • Grid integration has a strong portfolio of projects that leverage funding across DOE. • Deployment and R&D in the same program— something not happening in Europe—expands the possibility of successful outreach and enables DOE to provide objective facts about real versus perceived problems. • Very strong focus on outreach and open access benefits both U.S. and global industry. Highlights include engagement with UVIG and IEA Wind tasks, WREN Hub, Tethys, Wind for Schools, the Collegiate Wind Competition, Generic Model Development project, Eastern Renewable Generation Integration Study, and Western Wind and Solar Integration Study 3].

WETO thanks the peer reviewers for their recognition of MA&D program strengths. Over the next several years, the program will continue to prioritize fostering the teams at DOE headquarters and the national labs. WETO will also continue to establish and maintain key partnerships, both domestically and internationally to catalyze solution development. The program will continue to support wind energy research and development, including an emphasis on developing technical solutions to core challenges.

Evaluation Metric—Overall Weaknesses

Table 21. Select Program Management Comments—Overall Strengths

Overall Strengths
• Involvement of experts from other energy sectors (starting within the DOE agency) could assist in creative/scientific thinking. For example: how do the oil, gas, and shale gas industries handle environmental regulations on public lands? • Some topics were not addressed at all (e.g., icing issues) or in a limited way (distributed wind; public acceptance of noise from proximity to buildings, taller turbines). These are important areas of research. • The national lab and headquarters dynamic seems to remain an area where silos are naturally formed. Given the limited budget and large potential portfolio of issues deserving of attention, it seems some means of cross-pollination among the labs and project managers would be healthy. • Don't think you're getting recognition you deserve. WETO should have a different marketing plan.

As mentioned previously, the program will continue to evaluate the strategic approaches to addressing barriers with an eye toward ongoing evaluation of potential high-priority research gaps. WETO will also pursue better integration between program topic areas and the work of the national laboratories.

Summary of Project-Level Evaluations

Process Overview

Reviewers scored individual projects on six evaluation metrics, using a numeric five-point scale. Score tabulations in this report include averages and standard deviations, providing relative as well as absolute assessments of WETO and its projects. The project-level scoring sheet used by reviewers is included in Appendix C.

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

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

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

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

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

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

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

Scoring tables include a weighted-average performance score. This weighted score represents the overall performance of each project for five evaluation metrics, exclusive of the relevance score. It is calculated using the weights listed in Table 22.

Table 22. Metrics and Scores for Project-Level Evaluations

Relevance	Stand-Alone Metric	Relevance to Wind Energy Industry Needs and Overall DOE Objectives
Weighted-Average Performance	30%	Methods/Approach
	30%	Technical Accomplishments and Progress
	20%	Project Management
	10%	Research Integration, Collaboration, and Technology Transfer
	10%	Proposed Future Research (if applicable)

Numerical project scores are based on a five-point scale: 5–Outstanding, 4–Good, 3–Average, 2–Fair, 1–Poor. Qualitative descriptors apply to these numerical scores. These descriptors vary for each of the metrics and are included in the example scoring sheet in Volume II.

In addition to scoring the evaluation criteria, peer reviewers were asked to provide qualitative assessment of the project in a written narrative. Reviewers were asked to comment on overall strengths and weaknesses, and to include recommendations for ways to improve the projects.

The formula in Figure 4 was used to calculate the overall weighted-average performance scores of WETO projects from the five individual performance metrics. If no further activities were planned for a project, the proposed future research metric was not included in calculating the average.

$$\text{Weighted Overall Average Score} = \left[\left(\frac{\sum_1^n \text{Score 1}}{n}\right) \times (0.3)\right] + \left[\left(\frac{\sum_1^n \text{Score 2}}{n}\right) \times (0.3)\right] + \left[\left(\frac{\sum_1^n \text{Score 3}}{n}\right) \times (0.2)\right] + \left[\left(\frac{\sum_1^n \text{Score 4}}{n}\right) \times (0.1)\right] + \left[\left(\frac{\sum_1^n \text{Score 5}}{n}\right) \times (0.1)\right]$$

Figure 4. n equals the number of reviewers per scoring metric

The scores for all projects were graphed as a means of visually comparing groupings of scores by project, topic area, and reviewer. These charts, the individual project scores, and all comments related to each project were reviewed as a body of data to note any potential scoring anomalies that could significantly impact the reported results. Potential anomalies were defined as individual scores or patterns of scores that vary considerably, higher or lower, from the other scores for a project, particularly in the absence of substantiating rationale for such variance in the reviewer's comments. Several such anomalies or "outliers" were noted.

Following applicable best practices in statistical analysis with which to assess and address deviations that could give an inaccurate impression of overall reviewer results and intent, the interquartile range rule was applied to all tabulated data, resulting in several outliers being excluded from the reported project scoring data. Of the total 2,390 scores submitted for WETO projects, a total of 86 outliers were removed (3.6%). The removal of outliers did not affect written comments.

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

Overall Track Results

As a means of assessing the variability in scores between reviewers, Table 23 presents the average scores by reviewer for each evaluation metric, across all projects in the RC and Tech RD&T track. Note that reviewers did not review projects for which they had an identified conflict of interest. Reviewer results are anonymized before results are calculated. The table lists reviewers in order of their respective relevance and performance scores, not in order by their identifying reviewer number.

Table 23. Variability in Reviewer Scores for Resource Characterization and Technology Research, Development, and Testing Track

RC and Tech RD&T	Relevance	Weighted-Average Performance	Metric Scores Used for Weighted-Average Performance				
			Methods/ Approach	Accomplishments/ Progress	Project Managment	Collaboration/ Tech Transfer	Future Research
Reviewer 1	4.7	4.5	4.6	4.6	4.5	4.2	4.4
2	4.7	4.4	4.4	4.2	4.6	4.5	4.2
3	4.6	4.4	4.4	4.3	4.5	4.4	4.4
4	4.5	4.2	4.1	4.1	4.6	3.8	4.1
5	4.2	4.1	4.2	4.1	4.1	3.8	3.6
6	3.9	3.5	3.7	3.3	3.7	3.8	3.2
7	3.7	2.8	2.8	2.7	3.0	3.0	2.5
Average Score Across All Peer-Reviewed WETO Projects	4.3	4.0	4.0	3.9	4.1	3.9	3.8

Figure 5 reflects the actual project scores (averaged across reviewers) for relevance and weighted-average performance for all projects reviewed within the RC and Tech RD&T track. It plots the averaged reviewer scores for relevance and weighted-average performance. The cross at the center of the shaded area denotes the mean score of all reviewed WETO projects across both peer review tracks. The shaded areas reflect standard deviations of the individual RC and Tech RD&T projects from the average for all WETO peer-reviewed projects. The darker blue block in the middle reflects one standard deviation from the average, and the lighter exterior block reflects two standard deviations from the average.

Across the entire review, projects scored close similarly, and above the scalar average of 2.5 (on a scale of 1–5). The overall review average was 4.3, and the lowest overall score was 3.4. Of the total 61 projects, 54 (89%) were within 0.5 points of the review average and 60 (98%) were within 0.75 points of the review average. The dot plot in Figure 5 illustrates that, of the total of 36 RC and Tech RD&T projects, 32 (89%) were within 0.5 points of the review average and 35 (98%) were within 0.75 points of the review average.

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

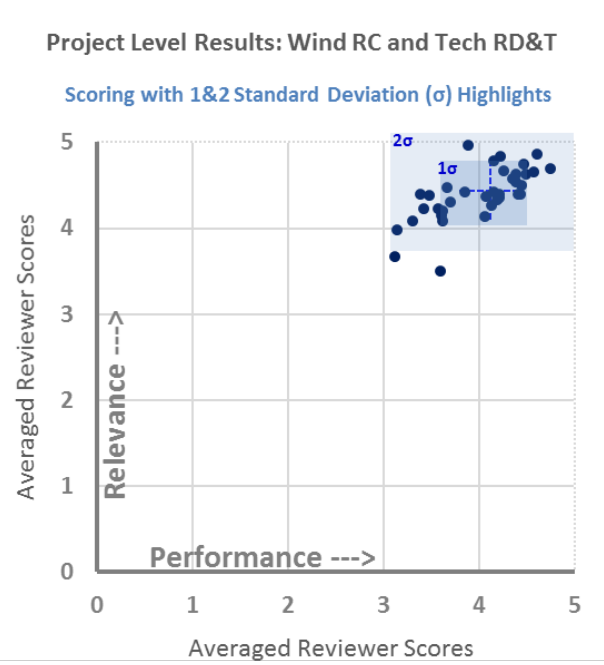


Figure 5. Average project-level reviewer scores for relevance and weighted-average performance, resource characterization and technology research, development, and testing track

Results by Subprogram

This section provides scoring for the RC and Tech RD&T and each of its subprograms as shown in Table 24. For each subprogram, peer review results are shown in two tables:

1. **Project Scores**—These results summarize the scores assigned by reviewers to the projects in each subprogram. This table includes the average scores across all WETO peer-reviewed projects (i.e., across both the MA&D and RC and Tech RD&T tracks). Each table also includes the average for each specific subprogram. The project score tables include graphs illustrating scores on the relevance/performance continuum. The smaller shaded box in the chart represents one standard deviation from the mean; the larger shaded box is two standard deviations from the mean. Note that the graphs use an abbreviated scale (origin = 3) to provide a zoomed-in view. The project score tables also include subprogram funding information for the DOE portion of funding and the cost share ("Share"), which is the portion of funding provided by project awardees.

Key Comments—These comments summarize a selection of comments from reviewers for each subprogram. The comments in these tables are not comprehensive but are intended to provide a representative selection of both positive and negative input from reviewers. The intent is to provide a balanced snapshot of the feedback provided about WETO projects.

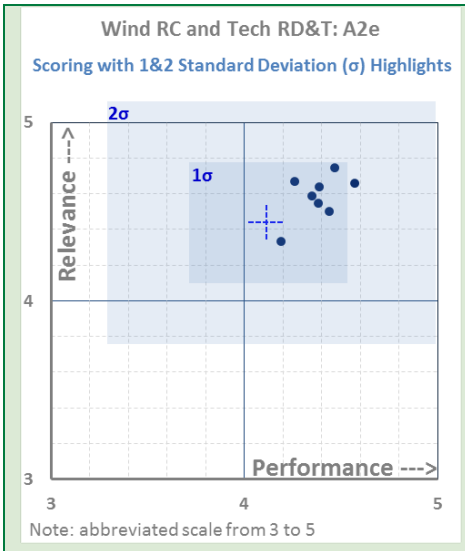
Table 24. Wind Resource Characterization and Technology Research, Development, and Testing Track Subprograms

Atmosphere to Electrons, High-Performance Computing, Resource Characterization, Flow FieldAnalysis, and Testing (A2e) (8 projects)
Distributed Wind Research, Development, and Testing (2 projects)
Innovation, Manufacturing, Reliability, and Testing [13 projects]
Offshore Wind (13 projects)

Note that the following acronyms are used in the project lists to represent the DOE national laboratories:

- ANL: Argonne National Laboratory
- INL: Idaho National Laboratory
- LBNL: Lawrence Berkeley National Laboratory
- NREL: National Renewable Energy Laboratory
- ORNL: Oak Ridge National Laboratory
- PNNL: Pacific Northwest National Laboratory
- SNL: Sandia National Laboratories.

RC and Tech RD&T: Atmosphere to Electrons, High-Performance Computing, Resource Characterization, Flow Field Analysis, and Testing (A2e)



Subprogram funding:
$29.60M DOE
$ 7.80M Share
$37.40M Total

The graph indicates the average relevance and performance scores of these projects compared to the mean of all reviewed WETO projects, denoted by the cross in the shaded area.

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

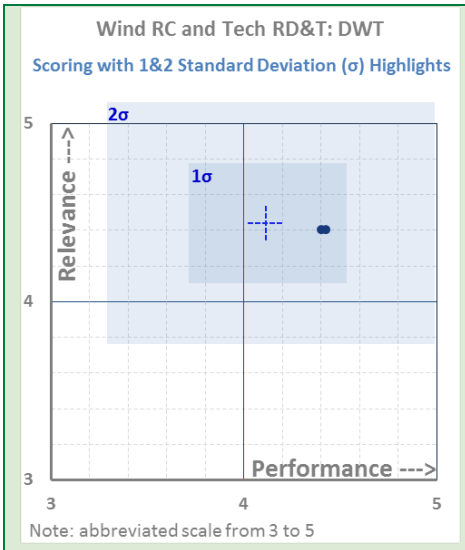
RC and Tech RD&T: A2e

Key Comments

- High-fidelity modeling is critical to improving wind plant performance.
- Methods and approach for Data Archive and Portal are world class.
- The use of real-world data to improve power/revenue estimates may have a huge impact.
- Controls research is important to optimize plant output and minimize wear and tear.
- Investments in field programs that advance our knowledge of atmospheric boundary layer flows are very important (e.g., WFIP II).

Successes Representative Comments	Critiques Representative Comments
• The development of improved computational fluid dynamics models may have significant impact on wind farm design, specifically addressing wake effects, turbine spacing, wake control, etc. • Improving understanding of the wind resource (wind speed, turbulence, and wind shear) and of the site-specific frequency of occurrence of extreme or transient events that will impact production, efficiency, and turbine longevity (wear and tear) is foundational to reducing LCOE. • The Performance Risk, Uncertainty, and Finance (PRUF) project is very well-conceived and provides a very high ROI for the funds budgeted. • Data Archive and Portal is one of the top 5 DOE programs in importance to the wind industry. It positively affects industry via permanently accessible data from R&D activities. • The public is very focused on squeezing out performance in almost all systems (e.g., furnaces, electrical appliances, light bulbs, etc.) - wind plants (via advanced controls) shouldn't be any different.	• Wind Forecast Improvement Project II (WFIP II) is a large, high-cost project with a significant field campaign and equipment. While potential value is high, it is difficult to assess ROI due to the single set of project conditions. • Open-source community models should take into consideration needs of all industry sectors, including distributed wind and small companies. • Emerging high-performance computing architectures (e.g., exascale) should be utilized to further advance and accelerate scientific discovery. Running models on faster computers provides results faster, but there is a critical prerequisite to invest in research, validation, and model verification to truly improve models. • Wake-steering controls applied at the wind farm level may be challenging to integrate into operational wind farms because it will require integration into turbine manufacturer controls or proprietary end user wind farm controls. • Primary focus on wind plants does not consider fleet-wide and utility-system-level optimization.

RC and Tech RD&T: Distributed Wind Research, Development, and Testing



Subprogram funding:
$7.89M DOE
$1.97M Share
$9.86M Total

The graph indicates the average relevance and performance scores of these projects compared to the mean of all reviewed WETO projects, denoted by the cross in the shaded area.

	Relevance	Weighted-Average Performance	Methods/Approach	Results	Project Management	Technology Transfer	Future Research
Average scores across all WETO peer-reviewed projects	4.4	4.1	4.1	4.0	4.3	4.0	3.9
Average scores for Distributed Wind subprogram	4.4	4.4	4.3	4.2	5.0	4.4	4.2
Distributed Wind Research, Development, and Testing (PRID 209) Ian Baring-Gould, NREL	4.4	4.4	4.3	4.3	5.0	4.5	4.1
Competitiveness Improvement Project (PRID 231) Ian Baring-Gould, NREL	4.4	4.4	4.3	4.1	5.0	4.4	4.3

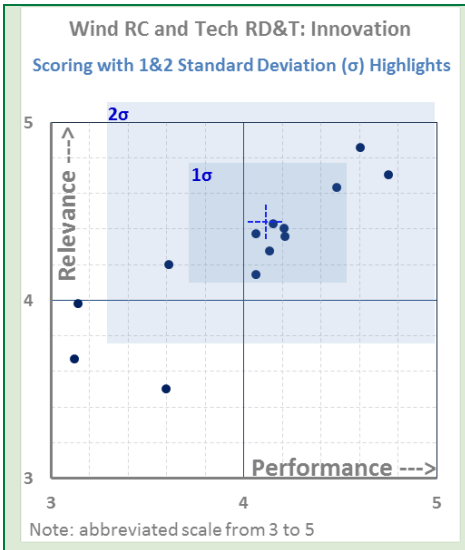
RC and Tech RD&T: Distributed Wind Research, Development, and Testing

Key Comments

- Continued use of competitive, cost-shared open solicitations to explore innovative concepts, with early discontinuation when warranted, is a positive path forward.
- Increased investments in this area are critical for ensuring product quality, which is linked to a positive public image for wind energy.
- Project management appears to be very good.
- Publication of certified power curves has been transformative for distributed wind sector.

Successes **Representative Comments**	Critiques **Representative Comments**
• The methods and approach for distributed wind technology (DWT) projects appear reasonable to meet program goals. • Continued investment in DWT research is vital for retaining and increasing U.S. manufacturing jobs and strengthening local grids. • The core [principles] of the program and programmatic approach to problem identification appear to be optimum criteria to ensure successful projects. • Distributed wind faces similar technology and resource challenges as utility-size wind; however, the DWT industry is too small to organically develop R&D solutions to these challenges. To compete with low-cost solar, DOE support has been critical to making incremental progress in further product development/testing/certification as well as rapid wind resource estimation. • Improvements in determining and modeling the wind resource and advances in hardware cost reduction are critical areas of research for the DWT industry.	• Planning should be accelerated for developing a comprehensive distributed wind "vision" that incorporates lessons learned from the offshore wind vision process and the Distributed Wind Energy Association's Sustainable Manufacturing, Advanced Research and Technology Wind Roadmap (action plan for manufacturing). • Perhaps targeted research in foundation and tower cost reductions would provide significant incremental reduction in cost of energy. • The NREL deployment model confirmed that distributed wind has at least half the potential of offshore wind (including substantial opportunities in the southeastern United States), but even the distributed wind market sees flat or low growth due to market risks. Increased levels of DOE investment are warranted to overcome these risks. • A large amount of the DWT research portfolio seems focused on market analysis and reports. It is difficult to see what these programs can do to really expand the build out of distributed wind.

RC and Tech RD&T: Innovation, Manufacturing, Reliability, and Testing



Subprogram funding:
$36.90M DOE
$42.37M Share
$79.27M Total

The graph indicates the average relevance and performance scores of these projects compared to the mean of all reviewed WETO projects, denoted by the cross in the shaded area.

	Relevance	Weighted-Average Performance	Methods/Approach	Results	Project Management	Technology Transfer	Future Research
Average scores across all WETO peer-reviewed projects	4.4	4.1	4.1	4.0	4.3	4.0	3.9
Average scores for Innovation subprogram	4.3	4.0	4.0	4.0	4.1	4.0	3.8
Testing Facilities and Capabilities at National Wind Technology Center (PRID 210) Dave Simms, NREL	4.9	4.6	4.6	4.6	4.7	4.6	4.4
Wind Standards Development (PRID 130) Jeroen van Dam, NREL	4.7	4.8	4.7	4.7	4.9	4.9	4.7
Drivetrain Reliability (Collaboratives, Monitoring, and O&M (operation and maintenance) (PRID 182) Jonathan Keller, NREL	4.6	4.5	4.6	4.6	4.3	4.4	4.3
Testing Facilities and Capabilities at Sandia (PRID 223) Jon White, SNL	4.4	4.2	3.9	4.1	4.4	4.5	4.2
Innovative Blade Test Methodology (PRID 184) Scott Hughes, NREL	4.4	4.2	4.3	4.2	4.4	3.9	3.9
Rotor Reliability (Collaboratives, Monitoring, and O&M) (PRID 221) Josh Paquette, SNL	4.4	4.1	4.4	3.6	4.1	4.2	4.1
Additive Manufacturing in Wind Turbine Components and Tooling (PRID 187) Brian Post, ORNL	4.4	4.2	4.2	4.2	4.2	4.0	4.4
Development of On-Site Tapered Spiral Welding for Large Turbine Towers (PRID 237) Eric Smith, Keystone Tower Systems	4.3	4.1	4.2	4.3	4.1	3.9	3.9
Online Intelligent Prognostic Health Monitoring (PRID 239) Wei Qiao, University of Nebraska–Lincoln	4.2	3.6	3.8	3.4	3.6	3.6	3.9
Innovative Drivetrain Concepts FOA (Funding Opportunity Announcement) Phase II: Next Generation Drivetrain (PRID	4.1	4.1	4.1	4.1	4.2	4.1	3.4

74) Jonathan Keller, NREL							
The Incubation of Next-Generation Radar Technologies to Lower the Cost of Wind Energy (PRID 240) John Schroeder, Texas Tech University	4.0	3.1	3.0	3.3	3.1	3.1	3.1
Advanced High Torque Density Magnetically Geared Generator (PRID 236) Jonathan Bird, University of North Carolina at Charlotte	3.7	3.1	3.2	3.0	3.3	3.3	2.9
Hexcrete Tower for Harvesting Wind Energy at Taller Hub Heights (PRID 238) Sri Sritharan, Iowa State University	3.5	3.6	3.5	3.7	4.0	3.8	2.7

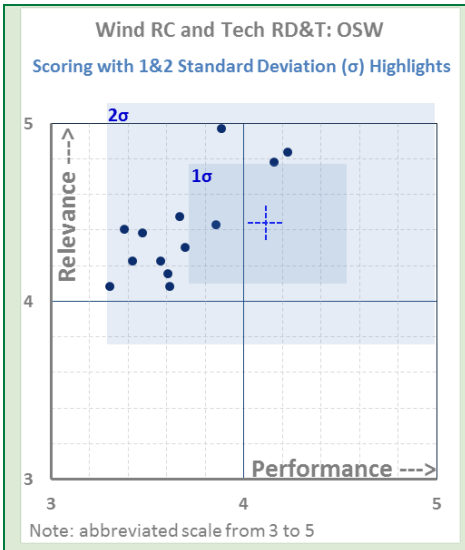
RC and Tech RD&T: Innovation, Manufacturing, Reliability, and Testing

Key Comments

- DOE research and testing facilities are world-class and encourage industry collaboration.
- Innovative component research, research into new manufacturing techniques, and industry working groups to investigate topics like blade inspection and repair can have a real impact on reducing the cost of energy, but they must be done in close collaboration with industry.
- DOE standards efforts have been and remain critical to a successful wind industry.
- Research into improved testing methods is key.

Successes **Representative Comments**	Critiques **Representative Comments**
• Globally collaborative standards efforts are truly world class and vital to DOE's mission. • Scaled Wind Farm Technology facility research is directly applicable to wind turbine interaction and optimization. • National Wind Technology Center facilities, collaboration, and technology transfer are among the best in the world. • Blade inspection/damage R&D is key for industry. • Innovative drivetrain R&D to reduce O&M costs and gearbox replacement is an area that can have a very positive impact on industry. • The demonstration of a scalable, phased-locked biaxial blade fatigue test is extraordinary. • Research into on-site tower manufacturing should be continued; industry needs a step change. • Magnetic gearing could have benefits for distributed and offshore wind applications. • Additive manufacturing of blade tips could be immediately applicable to end-user needs for quick, cost-effective blade tip repair. • The assessment of real-world inspection results is a key part of rotor reliability research, since standards are typically based on vendor theoretical optimums.	• Condition monitoring can be difficult to justify from an ROI perspective, given the strengths and weaknesses of all solutions. Sensors appear to be a mature industry, while signal processing is not. • It is reasonable to encourage continued research into Hexcrete towers; however, public surveys should be conducted on their visual appeal. • The 750-kilowatt gearbox was a good start for the drivetrain reliability collaborative, but the gearbox needs to graduate to multimegawatt - sized gearboxes. • While magnet gearing could be beneficial, it is unclear if the product of this current work will scale to have a tangible benefit for industry. • Other opportunities for blade performance testing include: quantifying blade expected life in the context of operating beyond a 20-year design life and expanding partnership with the Rotor Reliability group. • Address impact of low-voltage ride-through and high-voltage ride-through requirements on induction machines in the micro/residential/midsize sectors, as identified by (the Distributed Wind Energy Association's) Sustainable Manufacturing, Advanced Research and Technology Wind Roadmap.

RC and Tech RD&T: Offshore Wind



Subprogram funding:
$ 89.27M DOE
$ 15.42M Share
$104.68M Total

The graph indicates the average relevance and performance scores of these projects compared to the mean of all reviewed WETO projects, denoted by the cross in the shaded area.

	Relevance	Weighted-Average Performance	Methods/Approach	Results	Project Management	Technology Transfer	Future Research
Average scores across all WETO peer-reviewed projects	4.4	4.1	4.1	4.0	4.3	4.0	3.9
Average scores for Offshore Wind subprogram	4.4	3.7	3.7	3.6	4.1	3.5	3.3
The University of Maine's New England Aqua Ventus I Program (PRID 248) Habib Dagher, University of Maine	5.0	3.9	3.5	3.5	5.0	4.0	3.9
National Offshore Wind Strategy Supporting Analysis (PRID 213) Walt Musial, NREL	4.8	4.2	4.4	4.3	4.4	3.8	3.9
Modeling and Validation for Offshore Wind (PRID 214) Amy Robertson, NREL	4.8	4.2	4.2	4.1	4.3	4.4	3.7
Structural Health and Prognostic Management for Offshore Wind Projects (PRID 225) Todd Griffith, SNL	4.5	3.7	4.0	3.7	3.7	3.0	3.1
Instrumentation Planning for the Offshore Wind Advanced Technology Demonstration Projects (PRID 215) Walt Musial, NREL	4.4	3.9	4.1	3.7	4.2	3.4	3.1
Hywind Maine Project (PRID 245) Andrea Nina Eugster, Statoil	4.4	3.4	3.5	3.3	3.6	3.3	2.7
WindFloat Pacific Project (PRID 244) Kevin Banister, Principle Power, Inc.	4.4	3.5	3.6	3.2	3.9	3.7	3.1
DOE Offshore Wind Lidar Buoy Deployment Program (PRID 220) Will Shaw, PNNL	4.3	3.7	3.9	3.5	3.7	3.8	3.8
Project Icebreaker (PRID 249) Dave Karpinski, Lake Erie Energy Development Corporation	4.2	3.6	3.3	3.2	4.5	3.6	3.5
Fishermen's Atlantic City Wind Farm (PRID 242) Chris Wissemann, Fishermen's Energy	4.2	3.4	3.3	3.1	4.3	3.1	3.4
Turbine Advanced Controls for Offshore Wind Floating Applications (PRID 241) Dhiraj Arora, General Electric	4.2	3.6	3.8	3.5	3.9	3.7	2.6

Wave Impacts on Fixed Offshore Wind Foundations (PRID 227) Ralph Nichols, Savannah River National Lab	4.1	3.6	3.7	3.9	3.7	3.0	3.0
Sediment Transport Impacts on Offshore Wind Projects (PRID 226) Jesse Roberts, SNL	4.1	3.3	3.3	3.2	3.9	2.9	2.8

RC and Tech RD&T: Offshore Wind

Key Comments

- Strategic reports, cost modeling, and distribution of information and results are key to both DOE and industry objectives.
- Industry collaboration and involvement is critical for offshore wind research programs.
- Structural Health Management and Condition Monitoring are critical to optimizing offshore wind operation and maintenance.
- Regulatory and project finance issues are of greater importance than technical issues for developing offshore wind projects.

Successes Representative Comments	Critiques Representative Comments
• The metocean environment is very different than onshore; making lidar buoy research important. • Offshore demo projects successfully identified that technical challenges are manageable and that the energy off-take and politics are greater barriers. • Floating platform R&D made good use of a variety of modeling tools for offshore loads and controls. • The collection of data from actual wind farm installations is essential and will help to progress the standard operating procedure for many aspects of design as new information is distributed throughout the industry. • International Energy Agency framework for highly leveraged work is an excellent strategic decision for offshore modeling. • The *National Offshore Wind Strategy* is critical to quantify the viability, cost, and cost-efficiency targets for deployment and operation of offshore wind energy. • Project Icebreaker utilized an innovative power purchase agreement structure (64% "behind the meter"). • Blade structural monitoring will be critical to extending operational life beyond 20 years. • The WindFloat project provided a useful lesson learned: permitting negotiations drove project farther away from shore than economical (18 miles), with conventional project financing scheme.	• Cost and impacts of regulations for offshore wind should be captured and reflected to public and policymakers. • Lidar buoy project could have been completed with financial support from the private sector. • Hywind Maine has seemingly limited requirements on dissemination of project findings. • Project Icebreaker did not seem as if it was developed in true partnership with industry. • Moving toward Offshore Code Comparison Collaboration, Continued with Correlation (OC5) would accelerate the validation of model output, which should be a critical component of future research. • While the goals of the sediment transport study are good, the budge limited the work plan. • Current research has established a methodology for structural health monitoring and adaptive control to avoid failure. While this methodology is good, more work is needed to fully demonstrate its applicability on real systems.

Market Acceleration and Deployment Track: Summary Project Results

Overall Track Results

As a means of assessing the variability in scores between reviewers, Table 25 presents the average scores for each evaluation metric, across all projects in the MA&D track. Note that reviewers did not review projects for which they had an identified conflict of interest. Reviewer results are anonymized before results are calculated. The table lists reviewers in order of their respective relevance and performance scores, not in order by their identifying reviewer number.

Table 25. Variability in Reviewer Scores for Market Acceleration and Deployment Track

MA&D	Relevance	Weighted-Average Performance	Metric Scores Used for Weighted-Average Performance				
			Methods/ Approach	Accomplishments/ Progress	Project Managment	Collaboration/ Tech Transfer	Future Research
Reviewer 1	4.8	4.9	4.9	4.9	5.0	4.7	4.4
2	4.8	4.4	4.4	4.4	4.7	4.5	4.2
3	4.7	4.7	4.5	4.8	4.9	4.7	4.4
4	4.3	4.1	4.1	4.0	4.3	3.9	3.9
5	3.9	3.5	3.7	3.6	3.4	3.4	3.4
Average Score Across All Peer-Reviewed WETO Projects	4.5	4.3	4.3	4.3	4.5	4.2	4.1

Table 25 reflects the actual project scores (averaged across reviewers) for relevance and weighted-average performance for all projects reviewed within the MA&D track. It plots the averaged reviewer scores for relevance and weighted-average performance. The cross at the center of the shaded area denotes the mean score of all reviewed WETO projects. The shaded areas reflect standard deviations of the individual MA&D projects from the average for all WETO peer-reviewed projects. The darker blue block in the middle reflects one standard deviation from the average, and the lighter exterior block reflects two standard deviations from the average.

Across the entire review, projects scored close to each other and well above the scalar average of 2.5 (on a scale of 1-5). The overall review average was 4.3 and the lowest overall score was 3.4. Of the total of 61 projects, 54 (89%) were within 1/2 a point of the review average and 60 (98%) were within 3/4 of a point of the review average. As shown on the dot plot in Figure 6, MA&D projects also scored well. Of the total 25 MA&D projects, 22 (88%) were within 1/2 a point of the review average and 25 (100%) were within 3/4 of a point of the review average.

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

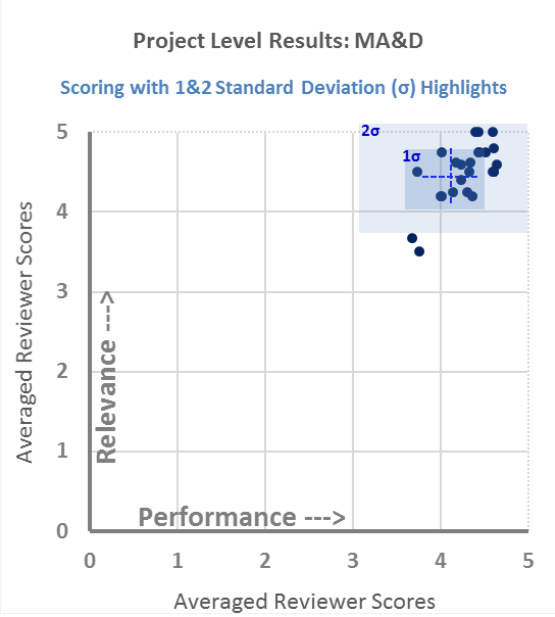


Figure 6. Average project-level reviewer scores for relevance and weighted-average performance, market acceleration, and deployment

Results by Subprogram

This section provides scoring for the MA&D and each of its subprograms as shown in Table 26. For each subprogram, peer review results are shown in two tables:

1) **Project Scores**—This category summarizes the scores assigned by reviewers to all projects in each subprogram. This table includes the review average, which represents the average scores for all WETO projects (i.e., across MA&D and RC and Tech RD&T). Each table also includes the average for a particular subprogram. The project score tables include graphs illustrating scores on the relevance/performance continuum. The smaller shaded box in the chart represents one standard deviation from the mean; the larger shaded box is two standard deviations from the mean. Note that the graphs use an abbreviated scale (origin = 3) to provide a zoomed-in view.

1) **Key Comments**—This category summarizes a selection of comments from reviewers for each subprogram. The comments in these tables are not comprehensive but are intended to provide a representative selection of both positive and negative input from reviewers. The intent is to provide a balanced snapshot of the feedback provided about WETO projects.

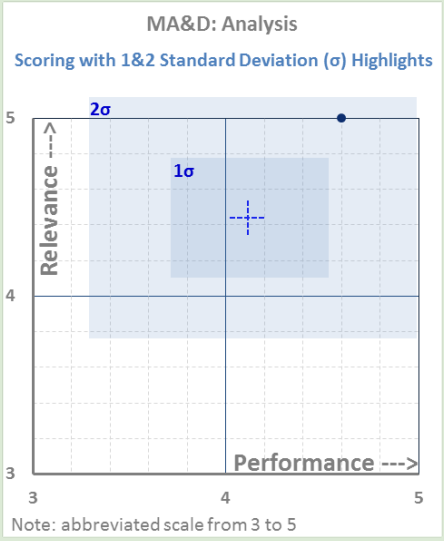
Table 26. Market Acceleration and Deployment Track Subprograms

Analysis and Modeling (1 project)
Grid Systems Planning and Operation (9 projects)
Siting, Radar, and Environmental (11 projects)
Stakeholder Engagement (4 projects)

Note that the following acronyms are used in the project lists to represent DOE national laboratories:

- ANL: Argonne National Laboratory
- INL: Idaho National Laboratory
- LBNL: Lawrence Berkeley National Laboratory
- NREL: National Renewable Energy Laboratory
- ORNL: Oak Ridge National Laboratory
- PNNL: Pacific Northwest National Laboratory
- SNL: Sandia National Laboratories.

Wind MA&D: Analysis and Modeling



Subprogram funding:
$1.95M DOE
$0.00M Share
$1.95M Total

The graph indicates the average relevance and performance scores of these projects compared to the mean of all reviewed WETO projects, denoted by the cross in the shaded area.

	Relevance	Weighted-Average Performance	Methods/Approach	Results	Project Management	Technology Transfer	Future Research
Average scores across all WETO peer-reviewed projects	4.4	4.1	4.1	4.0	4.3	4.0	3.9
Average scores for Analysis and Modeling subprogram	5.0	4.6	4.6	4.6	4.4	5.0	4.6
Cost of Energy, Policy Impact Analysis, and Market Report (PRID 126) Ryan Wiser, LBNL	5.0	4.6	4.6	4.6	4.4	5.0	4.6

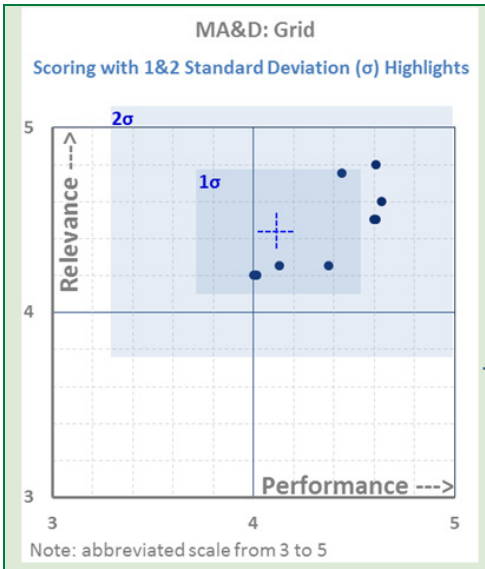
Wind MA&D: Analysis and Modeling

Key Comments

- Extremely strong technical capability.
- Expert elicitation method is innovative for the DOE program, and underutilized social science methods should be used more often.
- With the production tax credit winding down, uncertainties around climate change policies and analyses that look at market opportunities could be beneficial.
- Reach out to industry leadership to further define scope of future work.
- Regional-scale focus could be beneficial.

Successes Representative Comments	Critiques Representative Comments
• The market report and analysis activities are a core element/foundation of the wind program and provide great basis for everything else that comes after. It provides important context and facilitates community acceptance, societal appreciation for the benefits of wind, an understanding of the cost of wind energy, and insights into the challenges that must be overcome. • DOE is currently looking at the financial implications of rising interest rates, and a further extension of this into the implications for long-term contracts would be equally beneficial. • Excellent work on the annual market report. Similar reports are rare across the globe. • It is very positive that the market report builds on several years of data. • Each of the studies/reports issued by the analysis research staff have accomplished the goals they were established to meet.	• Surveys are only one way to approximate future trends. As recent findings show, surveys generally are only as good as the people answering them. For example, recent tenders in Denmark and the Netherlands were not aligned with surveys taken before the tenders occurred. It is therefore important that other paths are explored for getting at trends beyond expert elicitation. • Not completely sure the health benefits analysis can accurately capture the myriad of variables that affect regional air and other environmental benefits of wind energy. • A more detailed breakdown of the budget by task would have been helpful. More financial information provided to reviewers might reveal more substantive feedback on the total value of a given task. • Consider a reduction in scope (i.e., fewer tasks) that focus on some key, near-term added value investigations. It may be helpful to canvas industry and public policy stakeholders to determine what gaps in knowledge are best attended to in future work.

Wind MA&D: Grid Systems Planning and Operation



Subprogram funding:
$7.24M DOE
$0.85M Share
$8.09M Total

The graph indicates the average relevance and performance scores of these projects compared to the mean of all reviewed WETO projects, denoted by the cross in the shaded area.

	Relevance	Weighted-Average Performance	Methods/Approach	Results	Project Management	Technology Transfer	Future Research
Average scores across all WETO peer-reviewed projects	4.4	4.1	4.1	4.0	4.3	4.0	3.9
Average scores for Grid Systems subprogram	4.5	4.4	4.4	4.3	4.6	4.3	4.2
Wind Integration Studies (ERGIS and WWSIS 3)[16] (PRID 131) Aaron Bloom, NREL	4.8	4.6	4.5	4.8	4.8	4.6	4.0
Active Power Controls (PRID 136) Yingchen Zhang, NREL	4.8	4.4	4.5	4.5	4.8	4.3	3.7
Wind Generator Modeling (PRID 144) Ben Karlson, SNL	4.6	4.6	4.8	4.6	4.8	4.6	4.0
Connecting the National Wind Test Center to the Energy Systems Integration Facility (PRID 134) Dave Corbus, NREL	4.5	4.6	4.8	4.6	4.8	4.3	4.3
Grid Integration Support, UVIG, IEEE, NERC, IEA[17] Task 25 (PRID 132) Dave Corbus, NREL	4.5	4.6	4.5	4.3	5.0	4.8	5.0
Analysis Using PMU [phasor measurement unit] Data and Dynamic Analysis (PRID 135) Edward Muljadi, NREL	4.3	4.4	4.3	4.3	4.4	4.5	5.0
Distributed Wind Integration (PRID 133) Bri-Mathias Hodge, NREL	4.3	4.1	3.9	4.3	4.4	3.9	4.0
Stochastic Tool Evaluation (PRID 124) Audun Botterud, ANL	4.2	4.0	4.0	3.8	4.4	4.0	4.0
Concurrent Cooling (PRID 125) Jake Gentle, INL	4.2	4.0	4.0	4.0	4.1	4.2	3.7

[16] Eastern Renewable Generation Integration Study (ERGIS) and Western Wind and Solar Integration Study (WWSIS 3)
[17] Utility Variable-Generation Integration Group (UVIG), Institute of Electrical and Electronics Engineers (IEEE), North American Electric Reliability Corporation (NERC), and International Energy Agency (IEA)

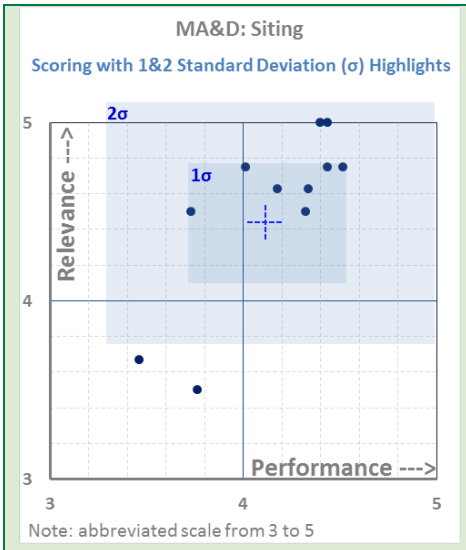
Wind MA&D: Grid Systems Planning and Operation

Key Comments

- Hugely relevant and highly impactful study advanced the state of the art in many areas and producing useful tools.
- Valuable insight gained into the relative merits of different production cost modeling approaches.
- Sharing and dissemination of reports and tools has been excellent. UVIG work gets the stakeholders together.
- Future works should include transient stability, frequency stability, future energy market design and analysis, and highly local impacts of distributed wind.

Successes Representative Comments	Critiques Representative Comments
• The Eastern Interconnect balancing study simulates a huge system with detail not seen elsewhere, leverages and builds upon previous studies, and is of extremely high value for the level of investment. • Active Power Control project was extremely well designed and executed. With wide range of simulations in markets, power system, and control of turbines, an internationally high-quality research was delivered. • Wind generator models strike a balance between capturing the behavior and response of wind turbines on power systems while also respecting the intellectual property concerns of original equipment manufacturers. It has great impact on standards. • UVIG work includes several high-quality, influential utilities, provides them with relevant up-to-date information, engages them in integration-related activities/discussions, and improves operational best practices. • Integrating with Energy Systems Integration Facility allows future interesting work on consumer/prosumer interaction and flexibilities from demand side. • The potential use of phasor measurement unit data in active control of power system is an innovative, proactive application of the technology. • Stochastic tool evaluation project provided valuable insights on the benefit of stochastic optimization. • Dynamic line rating is a highly relevant topic that intends to increase transmission line capacity cost effectively. Concurrent cooling project advanced dynamic line rating with hardware, simulation tools, field tests, and control room human impact.	• Studies have shown that in some systems, transient and frequency stability are the limiting factors in high instantaneous penetration scenarios and often define the limitations for accommodating target levels of renewables. Transient stability and frequency stability studies should be carried out to identify the limits of stability and to understand accommodating higher shares of renewables. • It has been shown that due to the increased voltage control challenges at the distribution level, wind power capacity connected at one distribution voltage can impact on the capacity possible at another. It is not clear if these interactions have been properly considered. • Active power control project may miss the multiservice provision aspect. • Modeling of unbalanced faults for type 3 and type 4 turbines remains a challenge. • Potentially lack of simulation results to illustrate the capability of the testing facility. However, it is understood that this was not the focus of the project. • While it is convenient to use IEEE 118 system for stochastic tool evaluation, the results could look quite different when applied to an actual system. • While the high level of modeling complexity for concurrent cooling is probably justified on paper by the transmission capacity gains, it may also act as a barrier to adoption.

Wind MA&D: Siting, Radar, and Environmental



Subprogram funding:
$ 8.99M DOE
$ 6.96M Share
$15.94M Total

The graph indicates the average relevance and performance scores of these projects compared to the mean of all reviewed WETO projects, denoted by the cross in the shaded area.

	Relevance	Weighted-Average Performance	Methods/Approach	Results	Project Management	Technology Transfer	Future Research
Average scores across all WETO peer-reviewed projects	4.4	4.1	4.1	4.0	4.3	4.0	3.9
Average scores for Siting subprogram	4.5	4.1	4.3	4.1	4.3	3.8	3.8
MIT Lincoln Labs Radar Mitigation R&D (PRID 128) Jason Biddle, Massachusetts Institute of Technology, Lincoln Laboratory	5.0	4.4	4.5	4.5	4.5	4.4	4.0
SNL Wind-Turbine Radar Cross Section Mitigation (PRID 145) Ben Karlson, SNL	5.0	4.4	4.5	4.5	4.3	4.4	4.1
Texturizing Wind Turbine Towers to Reduce Bat Mortality (PRID 150) Victoria Bennett, Texas Christian University	4.8	4.5	4.7	4.6	4.5	3.4	4.9
Wind Environmental Collaborative Research and Support (PRID 137) Karin Sinclair, NREL	4.8	4.4	4.5	4.4	4.4	4.5	4.5
A Biomimetic Ultrasonic Whistle for Use as a Bat Deterrent on Wind Turbines (PRID 149) Paul Sievert, University of Massachusetts Amherst	4.8	4.0	4.3	3.8	4.5	3.2	4.0
Evaluating the Effectiveness of Ultrasonic Acoustic Deterrents in Reducing Bat Fatalities at Wind Energy Facilities (PRID 153) Cris Hein, Bat Conservation International	4.6	4.3	4.5	4.3	4.4	3.9	4.5
Rotor-Mounted Bat Impact Mitigation System (PRID 151) Myron Miller, Frontier Wind LLC	4.6	4.2	4.3	4.1	4.3	4.0	4.2
Offshore Wind Environmental Data Aggregation, Analysis and Dissemination (PRID 143) Andrea Copping, PNNL	4.5	4.3	4.3	4.4	4.3	4.5	4.4
Ultrasonic Bat Deterrent Technology (PRID 152) Michael Booth, General Electric	4.5	3.7	4.0	3.7	4.2	3.0	3.0
Stereo-Optic High Definition Imaging: A New Technology to Understand Bird and Bat Avoidance of Wind Turbines (PRID	3.7	3.5	3.6	3.6	4.1	3.1	1.5

147) Evan Adams, Biodiversity Research Institute							
Avian Remote Sensing (PRID 269) Shari Matzner, PNNL	3.5	3.8	3.8	3.8	4.3	3.8	2.9

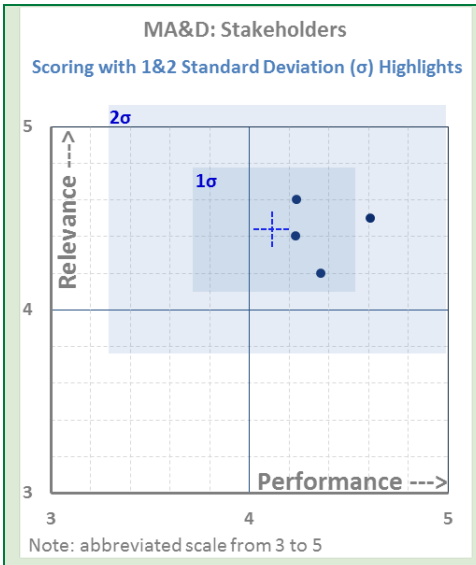
Wind MA&D: Siting, Radar, and Environmental

Key Comments

- Peer-reviewed reports and articles are critical, and the current list is impressive.
- IEA work is essential for sharing results from U.S. research efforts, as well as for keeping U.S. research teams in touch with scientific advances in other countries.
- Cross-agency coordinator is an important role, uniquely suited for DOE or DOE national labs.
- DOE has demonstrated an excellent ability to leverage federal funding to greatly expand research investments in areas that may not otherwise see investments.

Successes **Representative Comments**	Critiques **Representative Comments**
• The Working Together to Resolve Envrionmental Effects of Wind Energy (WREN) Hub database and Wildlife Impacts Database are important wind tools that should continue to be a priority since no other organization brings these resources under one roof. • Use of Tethys to gather relevant science, particularly relating to offshore wind, is setting best practices for information gathering, outreach, and dissemination. • Utilization of U.S. Department of Defense cost share for radar interference mitigation research is important and should continue to be encouraged in the future as a key partnership. • To evaluate the effectiveness of ultrasonic acoustic deterrents in reducing bat fatalities, it is critical to compare deterrents versus operational strategies (5 meters per second). This will allow testing of synergistic effects, which seems to be important. • Adaptive management is fraught with challenges and lacks a clear, concise methodology for employing it. WETO should be commended for attempting to address these fundamental issues with their *Adaptive Management* white paper and for including the broad diversity of issues and expectations that complicate the concept, especially when attempting to apply them to regulatory structures.	➢ Wildlife studies need a comparative approach to other energy sources to frame the real impacts; this is an old problem that continues not to be resolved at DOE (or U.S. Fish and Wildlife Service); is this a job for National Academy of Sciences/Nuclear Regulatory Commission? DOE should explore more aggressively! ➢ Good to build expertise in radar cross section mitigation software and technology, but given that a large part of the problem is outdated hardware, radar infrastructure, and conservative government approaches, perhaps more emphasis should be put on interagency coordination and awareness of the problem within relevant agencies. DOE has not done enough to "retire" wind-wildlife impact issues that have been proven to be low risk, leading to ongoing questions and concerns from regulators and the public regarding those issues.

Wind MA&D: Stakeholder Engagement



Subprogram funding:
$ 8.98M DOE
$ 1.82M Share
$10.80M Total

The graph indicates the average relevance and performance scores of these projects compared to the mean of all reviewed WETO projects, denoted by the cross in the shaded area.

	Relevance	Weighted-Average Performance	Methods/Approach	Results	Project Management	Technology Transfer	Future Research
Average scores across all WETO peer-reviewed projects	4.4	4.1	4.1	4.0	4.3	4.0	3.9
Average scores for Stakeholder Engagement subprogram	4.4	4.4	4.3	4.4	4.5	4.6	4.1
WindExchange and Regional Resource Centers (PRID 138) Ian Baring-Gould, NREL	4.6	4.2	4.0	4.2	4.4	4.6	4.4
Wind for Schools (PRID 140) Mark Jacobson, NREL	4.5	4.6	4.7	4.6	4.6	4.6	4.4
Public Acceptance Baseline Analysis (PRID 127) Ben Hoen, LBNL	4.4	4.2	3.9	4.4	4.4	4.8	3.9
Collegiate Wind Competition (CWC) (PRID 139) Suzanne Tegen, NREL	4.2	4.4	4.4	4.4	4.4	4.6	3.8

Wind MA&D: Stakeholder Engagement

Key Comments

- Collegiate Wind Competition is hugely beneficial for all involved, fostering interdisciplinary cooperation and a high level of enthusiasm and passion.
- The program has successfully developed an outreach program that attracts and inspires students in the various disciplines involved in wind power development.
- In general, the approach to public acceptance baseline analysis is sound and enables increased understanding of drivers behind support and annoyance.

Successes Representative Comments	Critiques Representative Comments
• The public acceptance baseline analysis is an overdue, excellent initiative that examined a large portion of a population living within proximity to wind turbines and captured their sentiment; this lends great credibility to the results and is a critical addition to the social science knowledge base. • For Wind for Schools, NREL gets MAJOR kudos for restarting the program and having near-term successes again; this shows trust and commitment. The project appears to be very well-structured and achieving tangible results. • WindExchange is an excellent project for supporting deployment, identifying/targeting stakeholders, and providing general information. • The development of a wind tunnel to support the Collegiate Wind Competition appears to have added tremendous value. • In general, planned future research appears sound and a logical extension of work carried out so far. • The Regional Resource Centers have high value. The program should think carefully about means for continued funding, such as receiving partial funding from other projects to act as WETO's primary information distribution platform. WindExchange efforts could leverage the Regional Resource Centers to improve stakeholder outreach efforts.	• For Wind for Schools, 2013-2014 Office of Management and Budget-directed funding was ended, then subsequently reinstated, which does not help build networks or improve reliability of DOE educational initiatives; this is unacceptable for effective program planning. • In the baseline analysis, although the literature review was very broad, it did not include complex definitions of acceptance and annoyance (but to be fair, there is not a lot of information about this in any wind agency around the world) and could use more information on larger turbines (>3 megawatts. • Need additional resources for more innovative education initiatives, particularly with a multidisciplinary focus and linking to other educational initiatives (e.g., WFS). • For WindExchange, implementation of metric-based impact tracking would be valuable in evaluating the effectiveness of the program.

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