U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy




20% Wind Energy By 2030

Meeting the Challenges

Proceedings of the Workshop

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

October 6-7, 2008
Arlington, VA

May 2009

About the Wind and Hydropower Technologies Program

The Wind and Hydropower Technologies Program (WHTP) within the Department of Energy's Office of Energy Efficiency and Renewable Energy (DOE-EERE) is leading the nation's efforts to improve the performance and operability of wind energy technologies and lower the costs, to investigate emerging water power technologies, and to enhance the environmental performance and efficiencies of conventional hydropower technologies. To find more information about the Wind and Hydropower Technology program, please visit http://www1.eere.energy.gov/windandhydro/wind_mvg.html.

Program Vision

One team managing the public investment in wind and water power technologies to maximize energy security, economic vitality, and environmental quality.

Program Mission

Responsible stewardship of national resources to increase the development and deployment of reliable, affordable, and environmentally sustainable wind and water power and realize the benefits of domestic renewable energy production.

This document presents the breakout session results at the October 2008 DOE-sponsored stakeholder workshop held to collect comments from all participants on research and development priorities and analytical pathways to achieve the scenario outlined in DOE's *20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply* report. The information provided herein is a documentation of the discussions held at the workshop and does not reflect any particular analyses or endorsement by the DOE.

Table of Contents

Executive Summary

The Wind and Hydropower Technologies Program (WHTP) within the U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy (EERE), has the lead responsibility for supporting the development of wind energy and its potential contribution to the national energy supply. Given the scale and the challenges of this potential contribution, the WHTP is undertaking a series of steps to address sustainable wind energy, including hosting multiple workshops to collect comments on DOE's report, *20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply*, released in May 2008 (hereafter referred to as *20% Wind Energy by 2030*).

Workshop Overview

On October 6–7, 2008, more than 130 wind energy professionals participated in the DOE-EERE WHTP workshop to discuss and provide individualized comments on possible research and development (R&D) technology areas and analytical pathways to achieve the scenario outlined in the *20% Wind Energy by 2030* report. The report outlines a scenario in which the United States could reach over 300 gigawatts (GW) of installed wind capacity by 2030. *20% Wind Energy by 2030* does not suggest a national policy, but only a study of the feasibility of one scenario for achieving 20% wind by 2030. Several of the major findings and challenges identified in this report set the stage for collecting comments on priority R&D needs. These comments include the following:

- Large wind turbine technology must reach higher capacity factors, lower costs, have improved maintenance and reliability, and produce higher volume and quality-controlled manufacturing outputs
- Distributed wind turbines have the potential to make a significant contribution to the 20% Wind Scenario as well as support community involvement and public acceptance
- Offshore wind deployments have the potential to contribute over 50 GW by 2030 and may be the only opportunity for significant renewable energy options for some states
- Increased transmission capacity and increased flexibility of electric system operation are desirable for delivering energy from often remotely located wind resources to urban load centers and for accommodating wind's variability
- Effective siting strategies that consider potential effects from gigawatt-scale deployments on land and sea must evolve quickly with early stakeholder involvement
- An integrated risk framework that identifies potentially important social and ecological impacts at a site or within a region would help to cost-effectively reduce uncertainties and prioritize related research
- Market development expansion will require long-term and predictable policies that also involve a sustained commitment to a broad range of stakeholder interests

Common Themes

Comments received from the Workshop participants suggested the following common themes and pathways aimed at a sustainable wind industry and moving toward the 20% wind energy by 2030 scenario.

- **Commit to sustained public engagement strategies and incorporate lessons learned:** The wind industry has a history of stakeholder collaboration. Commentors stated that proactive engagement with local citizens and decision makers is essential across the life cycle of wind developments—from technology R&D, to testing components and full systems, as well as siting strategies and transmission integration. Commentors indicated that, as with all new technologies, stakeholder engagement is the foundation of success in understanding how communities and agencies accept and/or do not accept wind energy projects within their communities and on public lands. Commentors stated that long-term engagement methods can foster a keener understanding of wind costs and benefits as well as establish two-way communication from a broad range of private and public interests, including manufacturers, utilities, government agencies, energy and environmental advocates, developers, etc.

- **Define and empower national leadership roles in critical areas:** Input received suggests federal agency leadership is the foundation of a national commitment to transform our national energy portfolio to a low-carbon future, including a national framework to accelerate wind energy to large-scale deployments within a decade. DOE has a fundamental role in technology R&D, siting strategies, analysis and studies, and public engagement.
- **Continue developing public-private partnerships:** The wind community has employed public-private partnerships in various areas of need, from R&D and testing activities to environmental and integration studies. Commentors stated that these partnerships need to continue and expand to address near-term technology R&D recommendations. Suggestions included that creative institutional and legal structures are still needed to address sensitive areas involving proprietary concerns and data sharing.
- **Collaborate with transmission siting partners:** The wind community will not be able to solve transmission and related infrastructure needs on its own. Participants commented that an essential ingredient of progress will be sustained commitment to collaborate with utilities and grid operators, including the definition of renewable energy's roles in relation to regional or national clean energy superhighways. Generally, the wind community has an interconnection-wide perspective in evaluating wind resources and acquisition strategies and is not limiting its view to a single state or utility system. Comments from participants stated that this perspective needs to be adopted by the electric sector.
- **Establish workforce training and education programs:** Participants comments stated that to ramp up wind development, an increased number of wind industry professionals and tailored curriculums from elementary to post-graduate will be needed. International cooperation should also be explored.
- **Ramp-up the domestic manufacturing sector:** There is a potential for the wind industry to create socio-economic benefits especially with a robust national supply chain. Commentors stated that building a stable manufacturing industry by ramping up to large scale production of turbine systems and components and solving logistics problems are essential for building a sustainable industry and realizing these benefits.
- **Commit to continuous improvement:** Input received suggested that DOE and the wind community need to revisit these recommendations as progress is made, in order to continue to capture lessons learned, design adaptive management strategies, and tackle new challenges as they arise. Individual participants indicated the importance of DOE and its partners remaining flexible and responsive to rapidly changing economics, environmental priorities, regulatory requirements, and social needs of the American people.

Points of Emphasis from Workshop Participants

Comments suggested that:

- As turbines continue to increase in size, a better understanding of wind turbine performance in a wind power plant environment is needed in order to improve the performance of both single turbines and wind power plants. Research and development (R&D) is needed to resolve turbine load and performance issues in a multi-array wind farm. It will be necessary to create and utilize advanced system modeling tools to allow better prediction of turbine loads and project performance. Maintainability and reliability challenges are increasing the cost of wind power and pointing to the need for technology advancements for specific components. These improvements can be facilitated and accelerated through research and collaboration among national laboratories and private industry. The wind community has initially targeted drive trains and blades to improve reliability, but value-based engineering models need to be developed and applied to a variety of challenges.

- For smaller, distributed wind turbines (which range in size from 1 kW to 1 MW), some of the same reliability, availability, and maintainability (RAM) challenges are also relevant; specifically, performance-enhancing R&D to reduce the cost of energy. Component and system R&D for low-wind conditions is essential because this is a large potential resource area for deployments. Consumer-friendly performance predictions and reliable resource maps are needed to ease the integration at the household level. R&D is needed on airfoils as well as novel tower and foundation designs to reduce the cost of energy and enhance reliability. Distributed wind technologies should build on numerous successful projects installed at educational institutions, farms, rural electric cooperatives, municipal utilities, and commercial and industrial facilities.

- To address the challenges of the offshore wind sector, a dedicated, comprehensive public-private R&D program focused on cost reduction and full system optimization needs to be established. A full-scale pilot program with federal support is needed to reduce the risks and strengthen collaboration across the myriad of government agencies responsible for our coastal and marine resources. A comprehensive offshore database with geographic information system (GIS)–layered information that incorporates wind resources and exclusion zones is sorely needed to map potential sites and exclude those that are not appropriate at early stages of the planning process.

- Although there are no insurmountable technical challenges to bringing 300 GW of wind energy online with respect to grid interconnection or integration, significant transmission infrastructure planning and development will be necessary, as will enhancements to grid operations. Suggested enhancements to the electric system operations and markets include the deployment of flexible power generation technologies, expansion of demand response, use of wind plant output forecasting tools, and real or virtual consolidation of balancing areas and area control error (ACE) sharing. Wind Plant models, tools, and analysis are needed, along with more detailed wind integration studies across larger geographic areas. An effort should be made to better educate and inform utility system operators on the issues associated with integration. Certainly, the most daunting challenge is building new transmission lines. Addressing this challenge will require national leadership and vision and developing new mechanisms for cost allocation and recovery.

- Environmental and human risks posed by wind turbine siting encompass broad stakeholder concerns ranging from potential military radar interference to bird/bat collisions and fragmentation of habitats. An integrated risk framework would help decision makers weigh the significance of these potential effects in comparison to other energy sources, make effective and responsible siting decisions, and identify cost-effective mitigation strategies wherever possible. Specific priority research activities were identified, including wind's contribution to climate change mitigation goals, deterrents for bat collisions, population-level bird impacts, and wider application of GIS mapping for siting strategies. An important gap in our national understanding of the consequences of transforming our energy portfolio is quantifying the full range of potential benefits from wind energy and comparing life-cycle effects of energy generation options. In addition, transmission siting, although required for all new energy supply options, will need to be considered along with the potential risks and uncertainties related to wind energy siting.

- Workshop participants were asked to identify a range of policy issues important to the wind community. Individual participants stated that predictable and long-term policies, such as the production tax credit and/or carbon pricing, are important building blocks for transforming our national energy sectors and scaling up to gigawatt-scale deployment of low-carbon technologies. According to individual workshop participants, the establishment of policies that encourage utilities (including power marketing administrations and other large buyers) to increase purchases of renewable energy, reduce the cost of renewables relative to conventional power options, and incorporate environmental impacts into energy prices is critical to reaching the 20% wind energy by 2030 scenario. Dissemination of technical, financial, and policy information needs to be coupled with sustained interactions with states, tribal and other local communities over the next generation of decision makers.

1. Introduction: The Stakeholder Process

The *20% Wind Energy by 2030* report, released in May 2008, was the product of over 100 stakeholders working through a two-year process to test and demonstrate the feasibility of integrating 20% wind energy on the U.S. electrical grid. Several workshops were held during these two years and subsequent to the release of the report that expands on the WinDS modeling and analyses and explores further issues that are important to a broad range of stakeholders.[1] Workshops held in June and August 2008 focused on resource mapping and characterization[2] and domestic manufacturing capabilities,[3] respectively. These discussions provided supplemental analyses related to key challenges and opportunities not addressed in detail in the 20% Wind Scenario. The October 2008 workshop brought together over 130 wind energy experts, including representatives from academia, wind developers, the federal government, national laboratories, regional transmission organizations, nongovernmental organizations (NGOs), utilities, and turbine manufacturers.

The main purpose of the "20% Wind Energy by 2030: Meeting the Challenges Workshop" was to collect individual comments from all participants on possible research and development (R&D) areas and analytical pathways to achieve the scenario outlined in the *20% Wind Energy by 2030* report. All participants reviewed and gave input on the R&D recommendations presented in the *20% Wind Energy by 2030* report, as well as commented on gaps, time frames, and roles and responsibilities across the nation's wind community. This proceedings document is a compilation of the comments of the 130 participants. More information is welcome.

The Workshop focused on six key wind energy issues:

- Large land-based wind technologies
- Distributed wind technologies
- Offshore wind technologies and siting strategies
- Grid system interconnection
- Environmental risks and siting strategies
- Market development and public policies

The workshop began with an opening plenary session in which DOE officials welcomed attendees. The keynote speech was presented by the President of the American Wind Energy Association (AWEA), who gave an overview of the 20% Wind Scenario and how wind energy can become able to produce 20% of the nation's electricity by 2030, an addition of 293 gigawatts (GW) of installed capacity. Panels of wind industry and issue experts presented information on major findings and potential paths forward on the six key issues. The workshop agenda is provided in Appendix B. A full list of the workshop participants is provided in Appendix C.

Workshop participants in six breakout groups reviewed scenarios and challenges pertaining to several key issues. Summaries of these issues (as presented by DOE staff at the start of the breakout groups) can be found in Appendix D of this document. Participants commented on key paths forward for addressing these challenges to achieving the 20% Wind Scenario. Workshop participants included in their comments detailed action agendas for each of these key paths forward. Detailed summaries of the comments from the individual participants in the six breakout groups are provided in this document. Contact information for the workshop coordination team is provided in Appendix E.

[1] See Appendix D in DOE's *20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply* for a complete description of these workshops and participants. See Appendices A and B in the full report regarding the WinDS modeling analyses.

[2] National Renewable Energy Laboratory, *DOE Workshop Report: Research Needs for Wind Resource Characterization*, sponsored by the DOE Office of Science and DOE, EERE, WHTP (Golden, Colorado: National Renewable Energy Laboratory, June 2008), NREL/TP-500-43521.

[3] "Proceedings from the Wind Manufacturing Workshop: Achieving 20% Wind Energy in the U.S. by 2030," sponsored by DOE, EERE, WHTP, August 27–28, 2008 (May 2009).

2. Large Land-Based Wind Technologies

Wind turbine technology has advanced to position wind energy for greater market penetration. Since the late 1970s, the technology has improved. Modern wind turbines have rotor diameters of 70–100 m mounted atop 60–80 m towers, typically producing 1.6–3.0 MW of power. These large machines are placed in arrays of 30 to 150 turbines. In August 2008, there were 20 GW of wind energy installed in the United States, accounting for just over 1% of the U.S. electricity consumption. The growth of turbines and the maturing of the industry have increased efficiency and decreased capital costs.

Notwithstanding the growth in the size and scale of wind turbines and arrays, there are still areas for improvement. The scale of wind arrays points to the need for system-level advances. The growth in turbine size has also created transportation and logistics issues throughout the supply chain and during turbine construction and has compounded drive train weight and reliability issues. Further technology improvements may be able to mitigate several of these barriers. While no major technology breakthroughs are necessary, the 20% Wind Scenario was based on improvements to technology that could enable a further reduction in capital costs by 10%, increased capacity factors by 15%, and mitigated risk. Also, improved system reliability was assumed to be necessary to achieve the 20% electric market penetration outlined in the 20% Wind Scenario.

Box 1. Large Land-Based Wind Technologies: Common Findings and Themes

Participants provided the following comments:

- Developing lower cost, higher reliability wind projects will require advanced system modeling tools to allow better prediction of turbine loads and project performance as well as development of innovative low cost, high reliability components
- A value-based engineering methodology and computational environment is needed to continuously position/prioritize research and development
- Manufacturing process development, optimization, and refinement is an essential element of wind technology advancement and must be considered synergistically
- Standardization and certification is needed to help mitigate risk across the industry
- Need to recognize that the concept design and process has to evolve from single wind turbine generators to wind power plants, including characterizing the operation and environmental inputs of the wind power plant
- Improved system performance and reliability, availability, and maintainability (RAM) requires a RAM database for verification

In general, comments indicated that manufacturing process development, optimization, and refinement is an essential element of wind technology advancement and should be considered synergistically with the research and development of components.[4] Individual participants stated that life-cycle considerations also need to be explored so that manufacturing issues are taken into account as R&D priorities are established. Comments from participants stated that standardization and certification are needed to help mitigate risk across the industry. Comments stated that users want improvements in reliability and lifetime; developers are making these improvements as technology matures, but this is an ongoing challenge.

Comments suggested that developing lower cost, higher reliability wind projects will require **advanced system modeling tools** to allow better prediction of turbine loads and project performance as well as development of innovative low cost, high reliability components. Improved tools are required for modeling atmospheric inflows, turbine and component loads, wind flow in complex terrain, turbine wakes, and project

[4] Details of manufacturing advancements are discussed in a separate document; see *"Proceedings from the Wind Manufacturing Workshop: Achieving 20% Wind Energy in the U.S. by 2030."* [May 2009]

energy losses and wakes. Comments stated that these tools need to be benchmarked against data from projects in a variety of wind regimes and topographies.

Box 2. Large Land-Based Wind: Key Technology Needs

Participant comments indicated that the following are key technology needs:

- Creation and utilization of advanced system modeling tools for evaluating wind turbines and projects
- Resolution of turbine load and performance in a multi-array wind power plant operation
- Development of higher efficiency, lower cost drive trains (including power electronics)
- Establishment of drive train reliability testing facility
- Prioritization of R&D through the development and application of a value-based engineering tool with both component and wind power plant attributes that would be used to assess how different technologies will impact system operations, cost, and other factors
- Establishment of research and development (R&D) partnerships for development of advanced components
- Reduction of aerodynamic and mechanical loads (including development of advanced blade sensors and controls)
- Development of advanced towers and foundations
- Characterization of materials in high cycle fatigue
- Establish reliability, availability, and maintainability database to improve system performance
- Development of diagnostic tools for condition-based monitoring

Comments reflected that **R&D partnerships** and a strategic framework are needed to accelerate the development of market-driven advanced components. Comments suggested that the use of timely, competitive, open solicitations and collaborative teams would improve the responsiveness and engagement of industry in the DOE R&D program. Individual comments stated that DOE should develop an "R&D framework" that defines a set of priority needs and recurring funding streams that original equipment manufacturers and universities could respond to, including research, development, and demonstration options. Input received suggests that establishing a strategic framework across disciplines and institutional arrangements would help solve complex design issues for the next generation of wind technologies. Participants further commented that the R&D framework should be developed by a core expert team and vetted with industry, updated on an annual basis, and made web-accessible.

Participants commented that a value-based engineering methodology and a computational environment are likely needed to continuously position/prioritize R&D so that funds are applied to the areas with the highest potential for impact. Comments suggested that a **value-based engineering tool** with both component and wind power plant attributes, and with inputs that include local environmental and economic considerations, must be developed. Outputs calculated from this tool would likely include net present value, cost of energy (COE), and comparisons with other technology combinations and system architectures and other turbines in industry (both off-the-shelf and in development). The tool could be used to assess how different technologies will impact system operations, cost, and other factors.

It was suggested that reduction of **aerodynamic and mechanical loads** on the turbine is likely needed and integrating blade controls with sensors could potentially improve the power to load ratio by at least 10%. As controls and sensors are developed, testing and demonstration will be necessary to mitigate the innovation risk. To integrate these systems, commentors stated that the following activities will be likely important:

- Issue competitive solicitations with multiple awards focused on advanced rotor control concepts, advanced drive train control concepts, robust sensors (e.g., for blades), improved aero-elastic models (including detailed drive train models), new controls beyond the proportional integral derivative, and improved tools for control development (e.g., test turbine).

- Develop tools that can improve and accelerate the design, development, and testing of controls (there are lots of ideas for controls, but they cannot be tested on an operating turbine).

Advancements in the drive train (gearbox, generator, and power converter) present an opportunity for lowering costs and increasing efficiency. Comments indicated that there are also perceived needs for **higher reliability drive trains**, based on field experience. Trends toward larger turbines, the use of permanent magnets, and other design innovations increase the need for improved power electronics. Such improvements could be facilitated through updated drive train design standards based on the latest (multi-array) data from the field. Input received suggests that the industry needs to agree on a common set of design standards and establish standard test and high-amplitude load testing procedures for testing drive trains.

DOE funds—and the National Renewable Energy Laboratory (NREL) currently hosts— a Gearbox Reliability Collaborative, intended to gain a better understanding of reliability issues, help reduce O&M costs, and develop necessary solutions. To further improve drive train reliability, comments suggested that **a new drive train reliability test facility** is needed to replace the current undersized dynamometer facility. These efforts could perhaps be pursued through the Gearbox Reliability Collaborative in the near to midterm.

The input received suggested that **advanced tower structures and foundations** are needed to reduce the costs of wind turbines and improve transportation and construction logistics. Rising material costs may limit the amount of steel used in tower structures. In addition, wind turbine generators and tubular towers must be larger and taller to increase energy capture. Participants commented that these towers should be logistics-friendly, have decreased life-cycle costs, include life extension strategies, and integrate joint structures. Currently, towers can only have a maximum outside diameter of 4.3 m before expensive transportation rerouting is triggered and utility and law enforcement assistance are needed along the roadways. Moreover, the size of turbines and towers is constrained by the cranes that are used to install them. Individuals stated that to address these issues, more advanced tower structures and foundations need to be developed.

Comments suggested that the **characterization of materials in high cycle fatigue** is needed to understand how actual parts and components will perform and wear. However, many current testing facilities are too small to allow the testing of full-size or near-realistic component samples (e.g., blades 3–10 m in size). Participants commented that test data for actual-size blades, hubs, and other components of the wind turbine generator need to be collected and vetted against computational codes. These data could also be compared against results from coupon testing, which tests product design and manufacturing integrity, in order to better understand the accuracy of such testing.

Wind turbines have largely been designed to optimize operation of a single wind turbine of or turbines in simple arrays. Individuals commented that a better **understanding of wind turbine performance in a wind power plant environment** is needed to improve the performance of single turbines and turbine arrays at wind power plants. Large field demonstrations of turbines are likely needed to characterize inflow conditions on turbines in complex terrain and multiple arrays (wakes) and understand what happens as the wind approaches and moves through the turbine array. This information would help engineers better understand turbine loading, turbine performance, and power plant performance and enable improvements in the design and operation of wind turbines as part of wind plants. Individuals suggested that key tasks could include the following:

- Establish different test sites with different topologies and wind levels
- Map wind flow in multiple wind plants in different conditions with detailed measurements
- Characterize turbine response and inflow simultaneously
- Develop and benchmark simulation tools against results
- Make database accessible to all participants

Because this likely would be a costly, large-scale effort with important benefits to wind technology, commentors stated that these field demonstration sites should be developed as collaborative, international partnerships with funding provided by both government and industry.

Improving the reliability, availability, and maintainability (RAM) of wind turbines and projects is probably important to increasing the market penetration of wind power systems and reaching the 2030 installation goals. Input received suggested that improved system performance and RAM will require the creation of **a RAM database** for verification and validation. Individuals stated that the RAM database should be populated with enough data samples to protect proprietary information and encourage industry participation. Commentors stated that high-fidelity data should be gathered in a wind plant environment to develop an industry-representative database on operations and maintenance (O&M), reliability of equipment over equipment lifetimes, impacts of environmental exposure, etc. The resulting database could be used to develop improved system modeling tools and address reliability and performance issues. This effort would likely require sustained data collection campaigns to collect high-fidelity/high-rate field measurements.

Individuals commented that to further improve RAM, it would be important to develop **diagnostic tools for condition-based monitoring** (CBM) to reduce O&M costs and extend turbine life. These tools will allow for the transition from schedule-based O&M to CBM maintenance by enabling the development of low-cost CBM systems. Ideal CBM systems would identify needs through data trending, include embedded sensor networks, and provide failure mode analysis for reliability-centered maintenance.

TABLE 2-1. LIST OF PARTICIPANTS – LARGE LAND-BASED WIND TECHNOLOGIES

Name	Organization
Rashid Abdul	Gamesa Technology Corporation
Sam Baldwin	U.S. Department of Energy – EERE
Michael Derby	National Aeronautics and Space Administration (NASA)
Jim Green	National Renewable Energy Laboratory
Thomas Key	EPRI/Renewable Energy
Dennis Lin	U.S. Department of Energy – EERE
Jonathan Lynch	Northern Power Systems
Michael Massey	Lone Star Wind Alliance, University of Houston
Robert Poore	Det Norske Veritas (DNV) Global Energy Concepts
Michael Reed	Sentech, Inc.
Michael Robinson	National Renewable Energy Laboratory
Jeremy Templeton	Sandia National Laboratories
Jonathan Wang	Mitsubishi Power Systems America
Carsten H. Westergaard	Vestas Wind Systems A/S
Larry Willey, Group Spokesperson	General Electric (GE) Energy – Wind
Jose R. Zayas	Sandia National Laboratories
Shawna McQueen, Facilitator	Energetics Incorporated

Table 2-2. Large Land-Based Wind Technology Needs

System Performance and Reliability	System-Level	Drive Train	Other Next Generation Components	Power Electronics	Advanced Tower Concepts	Blades and Rotors
• Create and utilize advanced system modeling tools Near- to long-term Led by: Univ., Industry Support: Federal Govt./National Labs – To improve predictability and reduce risk • Resolution of turbine load and performance in a multi-array wind plant operation Near- to mid-term Led by: Industry Support: Federal Govt./National Labs – Array effects – Complex terrain • Establish reliability database and analysis Near- to long-term Led by: Industry Support: Federal Govt./National Labs • Characterization of materials in high-cycle fatigue Near-term Led by: Univ. and National Labs Support: Industry • Develop diagnostic tools for condition-based monitoring Near- to mid-term Led by: Industry Support: Univ., National Labs – Failure mode analysis → reliability-centered maintenance – Condition	• Develop and apply value-based engineering to prioritize R&D Near-term Led by: Industry Support: Federal Govt./National Labs – Outputs: - Net present value - Cost of energy • Establish partnerships for advanced components (e.g., rotors, blades, towers, drive trains) Near- to mid-term Led by: DOE Support: Industry, Univ. – Develop better mechanisms to speed up targeted solicitations – Establish "UpWind"-type approach to conducting solicitations – Encourage collaborative teams on competitive solicitations – Develop framework for forming partnerships to include types of partners, mechanisms, etc. – Collaborative, multi-organization • Collaborate with DoD • Determine if DoD	• Develop higher efficiency, lower cost, reliable drive trains Near-to mid-term Led by: Industry Support: Univ., National Labs • Establish drive train reliability testing facility (large dynamometer facility) Near-term Led by: Industry Support: Federal Govt., State Govt. • Develop improved bearings • Develop drive trains with distributed gearbox topologies • Develop advanced generators, such as lower speeds and permanent magnets • Develop direct-drive drive trains • Develop drive trains with advanced gear tooth profiles	• Novel hub designs • Bedplates • Weather covers ("Nacelles")	• Develop drive trains with new circuit topologies Develop new semi-conductor device in drive trains • Develop drive trains with medium voltage equipment	• Develop advanced tower structure and foundations (high towers) Mid-term Led by: Industry • Self-erecting designs	• Develop advanced blade sensors and controls Near-term Led by: Industry Support: National Labs, Univ. • Reduce aerodynamic and mechanical loads (and tools for developing these technologies) Mid-term Led by: Federal Govt. Support: Industry, Univ., National Labs • Perform targeted applied research for rotors

System Performance and Reliability	System-Level	Drive Train	Other Next Generation Components	Power Electronics	Advanced Tower Concepts	Blades and Rotors
assessment/monitoring systems – In line life tracking and failure prediction • Conduct testing, certification, and standards activities • Track O&M needs to enhance experience • Evaluate turbine performance • End of life program for decommissioning (recycle/reuse)	technology is applicable • Reduce turbine weight through new materials • Up-to-date database of transportation codes and logistics					

TABLE 2-3. SELECT INDIVIDUAL SUGGESTIONS FOR ADDRESSING LARGE LAND-BASED WIND TECHNOLOGY NEEDS

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables (multi-year outlook)	Resources Including Special Labs, Tools and Data Needs	Suggested Total Funding $ 1-5 million >$5 million >$10 million	Immediate Next Steps
Establish R&D partnerships for developing market driven advanced components	• DOE/NREL provide OEMs and universities with framework and choices for what to work on and mechanisms for funding on a recurring basis	• Establish responsible parties at DOE/NREL • Form a core team (5 to 8 people, federal government, NGOs, university, industry) • Create strawman plan • Vet strawman plan at a workshop (100-150 people) • Update/publish annually (web site accessible)	• People	• <$1 million	• Assemble core team
Develop advanced tower structure and foundations	• Require more cost effective tower and foundation designs – Taller – Logistics friendly – Lower life-cycle costs – Life extension strategies – Joints • Background: – Steel prices going through roof – Larger wind turbine generators and taller tubular steel towers have 4.83 m max outside diameter and consequences	• Year 1 – Organize options – Industry survey – Assign leader • Year 2 – Potential prototypes with existing vendors – Consider partners (universities, NGOs, DOE/NREL) – Conceptual design and value assessments – Preliminary prototype designs – Testing of subcomponents • Year 3 – Prototypes	• People • Existing labs • Civil and geotechnical resources • Value-based engineering tool to assess system level impacts	• Year 1: $1-5 million • Year 2: $1-5 million • Year 3: ~$10 million	• Decide to do it • Assign DOE/NREL lead • Formulate program with stakeholder input • Obtain go-ahead from a technical panel • Hold regular reviews to assess progress to plan and make changes as appropriate

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables (multi-year outlook)	Resources Including Special Labs, Tools and Data Needs	Suggested Total Funding $ 1-5 million >$5 million >$10 million	Immediate Next Steps
	(logistics)	(assume 2)			
Characterize materials in high cycle fatigue	• Develop test data for full size or nearer-realistic component samples throughout the wind turbine generator (e.g., for blades of 3m-10m size)	• Define materials and properties to evaluate	• Lab space • Database for results • Test technicians • Program lead • Interface with mechanical designers and component owners • Analytical engineers and test results vs. computations (compare coupons) → larger test articles → full scale product	• >$5 million at the beginning • ~ $1-5 million in out years	• Assign DOE/NREL lead • Formulate program – Gather key inputs from stakeholders • Present to a panel for comments and approval • Proceed
Establish drive train reliability test facility	• Current dynamometer facility undersized to meet industry needs	• Develop and review facility requirements • Define optimum organization and funding approach • Fund and build facility	• Establish communication between national laboratories, DOE, and industries to define approach	• >$10 million	• Convene national lab and industries to begin task 1 (develop and review facility requirements)

Develop reliability database and analysis to further develop and advance existing system modeling tools	• Reliability database
	• Data
	• Sufficient data sample to protect and encourage participation
	  – Operations and maintenance
	  – Environment
	  – OEMs
	  – Plant configuration
		• Industry representative reliability database
		• Updated high fidelity system modeling tools
		• Modify and/or develop tools to address reliability and performance issues
			• Data collection campaigns
			  – Field measurements
			  – DAQs
			• High fidelity/high rate information needed
				• >$5 million/year	• Establish partnerships
					  – OEMs, operators, utilities
					• Begin field data gathering campaigns

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables (multi-year outlook)	Resources Including Special Labs, Tools and Data Needs	Suggested Total Funding $ 1-5 million >$5 million >$10 million	Immediate Next Steps
Develop higher efficiency, lower cost, reliable drive trains	• Perceived needs for higher reliability drive train from field experience	• Task 1: Establish updated design standards based on latest multi array data input • Task 2: Establish HALT procedures for industries drive train • Task 3: Support advanced drive train development programs for industries • Task 4: Support advanced power electronics to meet overall turbine design trends	• 2.5 MW dynamometer facility (new and current) • Industries and GRC • Identify and engage HALT expertise • DOE funding of partnership program	• Task 1: >$5 million • Task 2: >$5 million • Task 3: >$10 million • Task 4: >$10 million	• Identify HALT method being used by industries • Link current GRC with input from inflow characterization initiatives • Establish framework for advanced drive train and power electronics development partnerships with periodic entry opportunities and fast response for funding
Develop diagnostic tools for condition-based monitoring to reduce O&M costs and extend life	• Reduce life-cycle cost • Transition from schedule-based to condition-based maintenance • Identify needs through data trending	• Develop low-cost condition monitoring system • Embedded sensor networks	• Develop software algorithms • Testing labs for sensor evaluations	• $1-5 million/year	• Leverage operating data to identify critical components to monitor • Issue a solicitation

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables (multi-year outlook)	Resources Including Special Labs, Tools and Data Needs	Suggested Total Funding $ 1-5 million >$5 million >$10 million	Immediate Next Steps
Develop and apply value-based engineering to prioritize R&D	• Tool that has component and wind power plant attributes – Inputs include local, environmental, and economic considerations – Outputs include net present value and cost of energy, and comparisons with other technology combinations and other turbines in industry (both off-the-shelf and in development)	• Year 1 – Spreadsheet model – Loads engine • Year 2 – Programming prototype and production release • Year 3 – Updating for technologies and market economics, etc. – Version releases	• Technologists/ experts (not full time: 20-30% time from each technologist), e.g., – Blades – Drive train – Generator – Tower – Competitive assessment – BOP – Financial – Etc. • "Spreadsheet" team • "Computer programming" team • Alpha user group	• $1-5 million (years 1 and 2) • Outyears: $1-2 million/year	• Form project team • Form expert leadership team
Reduce aerodynamic and mechanical loads (including blade sensors and controls)	• Improve power to load ratio by at least 10%	• Task 1: Advance rotor control concepts • Task 2: Advanced drive train control concepts • Task 3: Robust sensors (i.e., for blades) • Task 4: Improve aero-elastic models (include detailed drive train) • Task 5: New controls beyond PID • Task 6: Improved tools for control development (i.e., test turbine)		• Task 1: $5 million/year • Task 2: $1-5 million/year • Task 3: $1-5 million/year • Task 4: $1-5 million/year • Task 5: $1-5 million/year • Task 6: look for ideas in RFP	• For all tasks: issue RFP and fund multiple awards (recipients could include universities, industry, and/or national labs)

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables (multi-year outlook)	Resources Including Special Labs, Tools and Data Needs	Suggested Total Funding $ 1-5 million >$5 million >$10 million	Immediate Next Steps
Resolution of turbine loads and performance in multi array wind farms	• Need to characterize inflow conditions on turbine in complex terrain and multiple arrays (wakes) in order to understand: – Turbine loading – Turbine performance – Power plant performance	• Map flow (measure) in multiple wind plants in different conditions (terrains) with detailed measurements • Simultaneously with inflow, characterize turbine response when embedded in plant • Develop and benchmark simulation tools against result		• >$10 million • 5-8 years	• Establish partnership – Labs (international/ domestic) – Industry (manufacturer and owner) to execute measurement and develop database • Issue RFP for simulation tools

3. Distributed Wind Technologies

Distributed wind technologies are an element of total wind energy development and deployment. Distributed wind technology (DWT) applications refer to turbine installations on the consumer side of the utility meter or near the point of use. These machines range in size from less than 1 kW to 1 MW and are typically used to offset electricity consumption at the retail rate. Small wind turbine (SWT) technology is a subset of DWT and refers to wind systems rated at 100 kW or less.

Today's SWTs are sophisticated yet simple designs that should allow them to operate reliably for up to a decade or longer without maintenance. They typically have operational lives of 20–30 years and can withstand high wind speeds and other weather incidents. Small wind turbines provided 55–60 MW of installed capacity by the end of 2007. There were 34,816 units of small wind machines installed nationwide.[5] Some industry stakeholders predict that small wind systems could potentially supply 30,000 MW by 2030, and wind turbines from 100 kW to 1 MW could supply 60,000 MW by 2030. Some industry stakeholders also predict that distributed wind turbines could potentially supply 90,000 MW of the 300,000 MW (300 GW) that is projected in the 20% Wind Scenario. Even if these stakeholder goals are not met, distributed wind is often a part of increasing public acceptance of wind energy. Local ownership and increased local impacts may broaden support for wind energy, engage rural and economic development interests, and build a larger constituency with a direct stake in the industry's success.

Box 3. Distributed Wind Technologies: Common Findings and Themes

Participants provided the following comments:

- Research and development will be needed on airfoils, gearboxes, mechanical brakes, induction generators, upwind rotors, active yaw control, stall rotor control, and variable-pitch and hinged blades; such technology enhancements will provide alternative power and load control strategies that will produce safer and quieter turbines
- For the United States to maintain its international market dominance, the distributed wind industry will need to deploy advanced manufacturing methods and technologies
- Distributed wind technologies will need to build on numerous successful projects installed at educational institutions, farms, rural electric cooperatives, municipal utilities, and commercial and industrial facilities
- Distributed wind turbines are a key element of the 20% Wind Scenario and have the potential to contribute in the following way:
  - Community education and acceptance
  - Machines up to 100 kW in size could potentially supply 30,000 MW by 2030*
  - Machines from 100 kW to 1 MW could supply 60,000 MW*
- Energy storage for distributed wind systems is an issue primarily for smaller, off-grid systems

* These figures are projections based on comments from industry stakeholders.

Despite market growth and accompanying technical advances, individual participants indicated that certain challenges stand in the way of DWT reaching its full potential. Among them is the lack of standardized testing and testing standards and certification, as well as consistent measurement techniques and tools. The development of third-party turbine testing strategies, as well as improved funding for instrumentation, was suggested as a priority. Component and system R&D also was suggested as a priority, especially for airfoils, gearboxes, mechanical brakes, induction generators, upwind rotors, controllers, and novel tower and

[5] American Wind Energy Association, "AWEA Small Wind Turbine Global Market Study" (American Wind Energy Association, June 2008), http://www.awea.org/smallwind/pdf/2008_AWEA_Small_Wind_Turbine_Global_Market_Study.pdf.

foundation designs, as well as technologies for low-wind conditions. Reliability continues to be a concern in these conditions, which individuals stated further the need for R&D on reliability in low-wind geographic areas.

Box 4. Distributed Wind: Key Technology Needs

Participant comments indicated that the following are key technology needs:

- Performance enhancement research and development (R&D) for reducing the cost of energy for distributed wind:
  - Component system R&D for low-wind conditions
  - Development of novel tower and foundation designs, including the use of case studies and lessons learned
  - Improved research and data on small wind machine reliability
- Development of design and testing standards with consistent measurements and tools
- Development of third-party turbine testing practices, including increased funding for instrumentation
- Development of consumer-friendly performance predictions and reliable resource maps
- Supportive public information and education efforts for small wind
- Dissemination of model zoning language and permitting best practices
- Development of true and standardized net metering policies
- Enhanced federal and state financial incentives for distributed wind
- Enhanced public information and education efforts

With respect to **performance enhancement R&D** for distributed wind, comments suggested that reducing the overall COE should be the first priority. In addition, comments suggested that enhanced R&D on components and systems for low-wind conditions is essential. Innovations in strategies for controlling power, load, and overspeed would need to be optimized for site conditions in order to create safer, quieter turbines that respond more predictably to high winds, gusts, and sudden wind direction changes. Also, individuals commented that R&D is needed on the development of airfoils and novel tower and foundation designs, such as self-erecting or lightweight tall towers in order to decrease costs and improve productivity and reliability. Tower and foundation costs account for a large portion of DWT installed costs. Participant comments suggested that distributed wind system integration should be evaluated for better efficiency; it is impossible to assess the ability of small, distributed wind systems to be used on the grid without research, development, and deployment of these systems and their integration with other energy components and systems in residential, commercial, industrial, and institutional facilities. Compiling case studies and lessons learned was suggested in order to share successful R&D with other researchers and stakeholders.

Input received suggested that developing **design and testing standards** is essential. Comments also suggested that consistent measurements and tools are needed for ensuring reliability, longevity, and durability. Comments suggested that the AWEA standard should be adopted and harmonized with international standards, and an industry-supported certification program should put into place. Additionally, comments suggested that once better standards are in place, they should be updated based on testing experience.

Other input received suggested that **third-party turbine testing facilities that are affordable and accessible to industry be developed.** Third-party testing would require trained personnel and a process for reporting to standards-setting bodies. Instrumentation for third-party testing sites likely would be put into effect, as should facilitation of ongoing training sessions for testing staff.

Comments suggested that it is essential to **address reliability concerns**, which would include controllers for overheads and lighting; blades; gearboxes; brakes; and corrosion of towers, materials, and magnets. To achieve a reduction in COE, individual participants suggested that the reliability of electronics (grounding and lighting) should be improved, rotor (blade) material must have a longer life and be able to handle higher loads, the reliability of gearboxes for small machines used in distributed systems must be improved, brake technology for smaller machines must be advanced, and corrosion-resistant material for components and magnets must be developed.

Comments suggested that **consumer-friendly performance predictors** need to be developed and **high-resolution wind speed maps** need to be created or revised. Participant comments suggested that it is essential to develop models that better incorporate the effects of local terrain, trees, and buildings on wind speeds and turbine performance at lower elevations (around 30 m). Then, the impacts of climate change model results on long-term wind speed trends could be evaluated. The creation of a web-based, user-friendly interface would allow homeowners to determine the wind speed and kWh production for various wind turbine options at their proposed sites. Individuals suggested that the wind speed models would need final testing and implementation, as well as periodic reviews and updates.

Development of **model zoning language and permitting best practices** is also a key need suggested by commentors. Zoning and permitting practices currently are inconsistent throughout the country, and they are often barriers to the development and deployment of distributed wind components and systems. As competing fuels become more expensive, consumers—whether residential, commercial, industrial, or institutional—will likely need to understand the zoning and permitting process and identify ways to overcome potential resistance to wind projects. Comments also suggested that standardized permitting and zoning policies across local and state jurisdictions could also allow manufacturers and developers to cost-effectively build and install systems in multiple sites, which would in turn drive down COE.

Comments suggested that **the establishment of true net metering policies in rural communities** is essential to help overcome market entry barriers associated with new technologies and increase deployment of small wind systems. Rural utilities that adopt true net metering could be rewarded. Individual comments suggested that to accomplish this, incentives for the Rural Utilities Service (RUS) to implement true (annualized) net metering in co-op territories should be established. For these incentives to be realized, relations with RUS players would likely need to be developed. In addition, suggestions indicated that it is essential to create cost/benefit ratios and analysis. Further comments suggested that a low-interest loan strategy executed in partnership with the United States Department of Agriculture is needed.

In regard to **federal and state financial incentives** for distributed wind, individuals commented that it is essential to implement a federal 30% ITC with no cap, in parity with the tax credit for solar power projects. In addition, comments suggested that the ITC should include a provision to extend the production tax credit (PTC), which expires at the end of 2008, to encourage further growth in U.S. wind installations. To accomplish this, participants indicated that installation and cost data must be collected, tax implications calculated tax language in selected states researched, and alliances forged with wind and renewables groups.

Individual comments suggested that a high-priority need is the development and deployment of **enhanced public information and education efforts** for small wind. Participants suggested that it is essential to educate all levels of stakeholders (consumers, end-users, regulators, financiers) about benefits and challenges of distributed wind technologies and systems. Clear, concise, and reliable information would support stakeholder use of distributed wind technologies. Input received suggests that various outreach strategies and materials—including webinars, workshops, and case studies—should be developed and disseminated through stakeholder organizations, on the Web, and in wholesale and retail outlets that are frequented by these stakeholders in order to increase awareness of the technology.

TABLE 3-1. LIST OF PARTICIPANTS – DISTRIBUTED WIND TECHNOLOGIES

Name	Organization
Keith Bennett	U.S. Department of Energy – Golden Field Office
Nolan Clark	U.S. Department of Agriculture – Agricultural Research Service
Trudy Forsyth	National Renewable Energy Laboratory
John Hansen	Nebraska Farmers Union
Jay Keller	Sandia National Laboratories
Dave Laino	Endurance Wind Power
Chris McKay	Northern Power Systems
John Patten	Western Michigan University
Robert Preus	Abundant Renewable Energy
Capt. Peter Richards	Avionex/USA Corporation
Robi Robichaud	National Renewable Energy Laboratory
Larry Sherwood	Small Wind Certification Council
Ron Stimmel	American Wind Energy Association
Tom Wind, Group Spokesperson	Wind Utility Consulting
Jan Brinch, Facilitator	Energetics Incorporated

TABLE 3-2. DISTRIBUTED WIND TECHNOLOGY NEEDS

Site Analysis Tools	Policy Options	Testing Data	Reliability	Financing Options	R&D	Education Options
• Develop consumer friendly performance predictions – Near-term; Dept. of Commerce led; federal government and industry support – Need real performance numbers, actual kWh generated • Revise resource maps for DW – Near- to mid-term; federal government and industry led – Revise wind resource with more resolution and seasonal distribution – Revise resource maps • Develop wind energy resource (hourly) data for time of day pricing • Fund wind data equipment loan programs	• Develop PTC-like incentives for those who do not qualify for PTC • Revamp restrictive FAA rules • Develop model net metering laws • Federal sector streamline NEPA requirements • Promote net metering and aggregate state policies • Extend federal subsidies to consumer-owned wind turbines (like PTC)	• Design and testing standards – Near-term; NGO led; AWEA and federal government support – Consistent measurement techniques and tools – Adapt AWEA certification standards – Implement certification program • Develop third party turbine testing – Near- to mid-term; federal government and "all" led – Training workshops – Provide funding for instrumentation • Develop SWT reliability program to focus on testing	• Improve maintenance support	• Finance small wind systems • Federal sector institute revolving renewable energy project fund for feds.	• Conduct component and system R&D for distributed wind – Mid-term; federal government and industry led – Update/replace components (re-tool) • Improve technologies for low wind conditions – Mid-term; federal government and industry led – Develop a long term vision for CO_2 offsets • Research reliability concerns – Mid-term; state and federal governments and national labs led; industry (all) support • Research and develop novel tower and foundations – Mid-term; federal government and industry led – Case studies for lessons learned and what works – Reduce tower costs • Develop near-term commercial mid-size turbines • Incorporate large wind technology advances • Develop small wind design program • Improve analytical design tools	• Support public information efforts for small wind – Near-term; federal government and non-governmental organization led • Disseminate model zoning language and permitting best practices – Near-term; federal and state governments and non-governmental organization led – Zoning database (local)

Site Analysis Tools	Policy Options	Testing Data	Reliability	Financing Options	R&D	Education Options
					– Engineering comp. design tools – Integrated system design tools • Develop packages with other distributed systems – Subset of developed packages with - Black-out protection - Hydrogen-based • Continue research on small wind technologies	

TABLE 3-3. SELECT INDIVIDUAL SUGGESTIONS FOR ADDRESSING DISTRIBUTED WIND TECHNOLOGY NEEDS

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables (multi-year outlook)	Resources Including Special Labs, Tools and Data Needs	Suggested Total Funding $1-5 million >$5 million >$10 million	Immediate Next Steps
Performance enhancement R&D for decreased cost of energy (COE)	• Air foil dev. for increased performance especially low Re # airfoils	• Blades	• Federal government especially NREL	• $30 million over 5 years	• Funding and RFP
	• Innovations in controlling: – Power – Load – Overspeed • Design and testing	• Control strategies	• Federal government NREL/ with industry	• $30 million over 5 years	• Funding and RFP
	• System integration for optimum system efficiency design tools (software)	• Turbine system integration	• NREL/industry	• $30 million over 5 years	• Funding and RFP
	• Optimization for site conditions (high wind – low wind) software tools and demonstration	• System tailoring for site	• NREL with industry	• $30 million over 5 years	• Funding and RFP
COE reduction through reliability improvements	• Problem with controller due to overheads, lighting • Problem with blade • Gearboxes • Brakes • Problem with corrosion of towers, materials, and magnets	• Improve reliability of electronics (grounding and lighting) • Improve rotor (blades) material for longer life and higher loads • Improve reliability of gearboxes for small machines used in distributed systems • Improve brake technology for smaller machines • Develop corrosion	• Joint effort between state and federal governments in cooperation with industry • Testing done by national laboratories • Need to use feedback from certification testing	• $25 million/year	• Needed soon

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables (multi-year outlook)	Resources Including Special Labs, Tools and Data Needs	Suggested Total Funding $1-5 million >$5 million >$10 million	Immediate Next Steps
		resistant material for components and magnets			
Cost reduction of towers, foundations, blades, and variable speed mechanisms	• "Novel Designs" - materials and fabrication processes	Targets • Identify cost reduction targets by turbine size (small, medium, large) by 2010	Federal government and industry • RFP – competition for reduced Cost of Energy (COE)	• $5 million study and evaluate (tech level)	• Identify targets (COE) and year – Small 1-5 kW – Med 5-25 kW – Large 25-100 kW
	• Reduce tower and foundation costs	• Determine year to year (or multiyear) reductions to meet targets by X	• RFP for integrated analysis tools (static dynamic, loads, etc.)	• $5-10 million detailed analysis (engineering)	• Draft RFPs for – Towers and Found. – Blades - materials and processes – Variable speed mechanisms
	• Reduce cost of variable speed mechanisms	• Select most promising opportunities for aggressive development by Y build and test by Z year (ROI)	• RFP for qualified data (experimental) to be used in models (tools)	• >$10 million build and test (beds)	
Federal and state financial incentives, better than 30% ITC (without cap)	• Parity with solar	• Develop grassroots contacts & alliances to improve relationships • Include better incentives and removal of cap with next push to extend PTC	• Solar PV and small wind market data	• $1 million over 5 years	• Develop policy options documentation and their $ impacts

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables (multi-year outlook)	Resources Including Special Labs, Tools and Data Needs	Suggested Total Funding $1-5 million >$5 million >$10 million	Immediate Next Steps
Develop incentives for Rural Utility Services (RUS) to implement true (annualized) net metering in co-op territories	• Reward rural utilities that adopt true net metering	• Develop relations with RUS players and develop cost/benefit ratios and analysis • Develop low-interest loan strategy in conjunction with USDA	• Active consumer education network	• $1 million over 5 years	
Simplify and remove restrictions placed on small wind by the National Environmental Policy Act (NEPA)	• Make NEPA work for small wind	• Educate Fed. Agency environmental officers	• Position paper of more appropriate treatment	• $1 million over 5 years	
Financial incentives for wind, including low-interest loans/revolving fund	• Cheap money	• Form alliances with agricultural interest groups		• $10 million/ $10 million	
Design and testing standards	• Develop and maintain small wind turbine design and testing standards	• Adopt AWEA standard • Support implementation of certification program • Update standard based on testing experience • Harmonize AWEA and international standards	• NREL test data and expertise fund IEC meeting participation (time and travel) facilitate stakeholder meetings	• ~$1 million / year	• Assess effectiveness of and recommend updates to standard based on testing experience and data • Implement certification program based on turbine testing
Third party turbine testing program	• Develop third-party testing facilities and capabilities that are affordable and accessible to industry	• Conduct turbine testing at NREL and elsewhere • Train personnel at new third party test sites • Fund instrumentation	• Federal testing labs and equipment • Personnel	• > $5 million	• More turbine test • Find candidates • Third party test sites

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables (multi-year outlook)	Resources Including Special Labs, Tools and Data Needs	Suggested Total Funding $1-5 million >$5 million >$10 million	Immediate Next Steps
		for new third party test sites • Round robin testing between test sites • Report to standard bodies on effectiveness of standards • Facilitate on-going meetings and training for third party test sites			
Standardized zoning and permitting practices and regulations	• Need for standardized zoning and permitting practices across state and local jurisdictions	• Develop standard zoning and permitting language • Develop lessons learned and case study materials	• Research on distributed wind zoning and permitting language, policies, and case studies • Policy research skills and data available through DSIRE, EERE, and other databases	• <$1 million	

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables (multi-year outlook)	Resources Including Special Labs, Tools and Data Needs	Suggested Total Funding $1-5 million >$5 million >$10 million	Immediate Next Steps
Education and information dissemination on distributed wind technologies	• Education and information to all stakeholders at all levels	• Simplify the decision-making process for stakeholders (consumers, businesses, etc.) through better education, outreach, and information • Case studies for installations for a variety of applications, sizes, end-users, etc. • CDs of white papers, PPT presentations, case studies • Develop PR strategies	• Factsheets: – Opportunities – Resource assessment – Interconnection • Identify outreach organizations (NGOs, state energy offices, WPA, NREL) • Robust rounded education and outreach materials and strategies • Webinars, workshops, case studies • Resource assessment	• $15 million over 5 years	
Promote Federal Distributed Wind	• Putting DWTs on national map	• Target Federal groups/and venues	• Workshops, webinars, case studies	• $1 million over 5 years	
Revise resource maps for DW	• Create high resolution wind speed maps and performance predictions that are appropriate for small wind turbine siting	• Develop models that better incorporate the effects of local terrain, trees, and buildings on wind speeds and turbine performance at lower elevations (typically 30 m) • Evaluate impacts of climate change model results on long-term wind speed trends • Implement web-based user-friendly interface to allow	• National Lab evaluation of existing computer wind flow models and techniques for incorporating existing databases • Development of interactive web-based computer model • Validation of computer model and results	• $2 million over 3 years – near-term	• Develop scope of project and RFP for models and web-based application

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables (multi-year outlook)	Resources Including Special Labs, Tools and Data Needs	Suggested Total Funding $1-5 million >$5 million >$10 million	Immediate Next Steps
		homeowners to determine the wind speed and kWh production at their proposed sites for various wind turbine options • Final implementation and testing of the model on the web • Periodic review and update of wind speed models and trends			

4. Offshore Wind Technologies and Siting Strategies

In the 20% Wind Scenario, approximately 18% (54 GW) of the total wind capacity needed would be from offshore facilities. While many of the issues associated with large-scale deployment of wind power are common to land-based and offshore wind installations, offshore wind presents unique technical, regulatory, siting, and grid interconnection issues that must be addressed in relation to ocean environments and coastal communities.

Twenty-eight coastal states use approximately 78% of the nation's electricity. Currently, only six of these states could use land-based wind power to achieve 20% of their electricity requirements. Based on the 20% Wind Scenario, by capitalizing on shallow-water offshore wind technologies, 26 of the 28 coastal states could reach 20% wind by 2030. Some states seeking to implement significant renewable energy have no alternative but to deploy offshore wind as their land-based wind resources or other renewable options are too limited and/or not feasible. To date, there are no operational offshore wind projects in the U.S. However, Europe has installed about 30 offshore wind projects (totaling almost 1500 MW of capacity), most of which are located in shallow water. Deep-water installations present additional technical, logistical, and cost challenges.

Regulatory oversight for offshore wind is under the lead jurisdiction of the Minerals Management Service (MMS) for siting on the Outer Continental Shelf and state government agencies, the Army Corps of Engineers, and Canadian Provinces for siting on the Great Lakes; however, a lack of policy coordination among government agencies has the potential to complicate significant offshore wind deployments.

Box 5. Offshore Wind Technologies and Siting Strategies: Common Findings and Themes

Participants provided the following comments:

- By the end of 2008, over 2,500 MW of offshore will be installed globally
- Referencing "40% higher costs than land-based wind" is not accurate
  - Costs are heavily site-specific
  - Saying "generally higher than land-based wind" is acceptable
  - Comparing offshore to land-based wind *plus* adding in the transmission costs to reach coastal load centers may change these costs references
- Mentioning 40–50% capacity factors may set expectations too high
- 28 coastal states use 78% of U.S. electricity
- Offshore wind may be the only opportunity for significant renewable energy deployments for some states
- Many additional barriers/challenges identified are specific to offshore wind

To address these challenges, individual participants have suggested technology and siting needs that would require action in the near, mid, and long term. These needs fall into categories that range from technology development to education and workforce training, regulations and policies, grid interconnection issues, mapping and data needs, assessing environmental risks, and federal and state collaboration.

Comments suggested that it is important to establish a dedicated, **comprehensive offshore R&D program to encourage offshore technology development**. As outlined by comments, this R&D program would focus on the technical barriers that would prevent offshore wind from making the necessary contributions to the 20% Wind Scenario. This program would focus on issues unique to offshore wind in order to optimize designs, including foundations, towers, turbines, and O&M requirements. The results of the research should enhance individual components performance while also optimizing the entire system at a reduced overall cost. Participant comments suggested that this R&D program should engage the capabilities and resources of federal and state governments, industry, academia, and national laboratories to deliver the necessary mix of funding, capacity, and expertise. Certifications and standards for offshore wind may also be part of this overall technology development effort.

Box 6. Offshore Wind: Key Siting and Technology Needs

Participant comments indicated that the following are key siting and technology needs:

- Creation of a comprehensive offshore research and development (R&D) program focused on cost reduction, optimization of components, and full system design
- Articulation of why offshore wind is critical to achieving the 20% Wind Scenario and initiation of a significant education and workforce training program
- Development of approaches for grid interconnection for offshore wind
- Management of a full-scale offshore pilot program with federal support to buy down costs
- Improved collaboration among the Minerals Management Service, the U.S. Department of Energy, and Army Corps of Engineers
- Prioritization and coordination of environmental research needs; addressing needs via state-federal collaboration
- Development of a comprehensive offshore database with geographic information system–layered information
- Creation of supportive incentives and policies for offshore wind
- Offshore reliability will be very important and Reliability, Availability, and Maintainability (RAM), R&D, modeling, and diagnostic tools for condition based monitoring should be developed for offshore applications

Input received suggested that enhanced **data and resource mapping** is also needed to facilitate offshore wind planning and deployment. Specifically, a comprehensive offshore GIS database that incorporates wind resources, exclusion zones (including navigation routes), and external risk factors (such as wave and storm frequencies, as well as sea ice in the Northern regions) would likely be needed to inform wind developers and insurance providers. One approach suggested by individuals for gathering additional data for this database is to deploy 30-meter meteorological towers offshore to gather data on waves, wind, bird migration, and other important factors. Robust boring samples at the same depths and distances would also inform research and development efforts focused on tower foundations.

Comments suggested that **pilot and full-scale demonstrations** are essential for providing full-scale testing capabilities of new components and systems to validate performance. Because the costs and risks of such demonstrations are significant, individuals suggested that government-industry partnerships are needed to provide these testing platforms. Regional demonstrations likely would assist the industry in understanding the unique issues associated with offshore wind in the many different environments that it is likely to be deployed (e.g., New England, the Mid-Atlantic, the South Atlantic Bight, the Gulf of Mexico, the northern and southern Pacific coasts, and the Great Lakes).

Grid interconnection is an issue for many wind projects, including offshore wind installations. Input received suggested that in the near term, regional offshore wind grid integration studies are needed to understand the range of options for connecting offshore wind to the grid. Such studies should consider novel approaches, such as a backbone grid for offshore running along the coastlines and a high-voltage direct current offshore "supergrid" that incorporates power conditioning and infrastructure offshore.

Individuals commented that **federal and state collaboration** will be essential for the nation to achieve the 20% Wind Scenario. In the case of the Great Lakes, bi-national coordination with Canada will also be necessary. At the federal level, individual comments suggested that collaboration among DOE, MMS, and the Army Corps of Engineers will help to minimize siting delays and accelerate offshore wind development and deployment. Likewise, comments suggested that coordination between the various federal agencies and appropriate state agencies can help to minimize unnecessary delays or costs while ensuring that all federal and state requirements are met. Finally, participants suggested that coordination among states on shared infrastructure requirements for offshore wind is needed over the near, mid, and long term.

Participants suggested that a better understanding of significant risks is needed for preparing **environmental impact statements** and other assessments that weigh risks and sensitivities associated with deploying turbines in the ocean. Individuals suggested that studies that evaluate the impact of these turbines on marine ecology should be prioritized and coordinated across federal and state governments and industry. A comparison of studies performed with similar methodologies and parameters should be made in order to draw more meaningful conclusions. Coordinating—and in some cases combining—studies would reduce duplication and redundancy and provide a more comprehensive understanding of the environmental and human risks of offshore wind.

Finally, for the offshore wind industry to expand to 54 GW, comments suggested that significant **education and workforce development and training** initiatives are needed. First, individual participant comments suggested that an explanation of offshore wind's benefits and role in the nation's ability to achieve the 20% Wind Scenario should be made to inform and educate all stakeholders in industry, government, nongovernmental organizations (NGOs), and the public at large. Second, participants suggested that university curricula, employee training and certification programs, and management training are all needed to build a capable workforce with the knowledge and skills needed to develop, deploy, finance, operate, and maintain offshore wind at significant scales.

TABLE 4-1. LIST OF PARTICIPANTS – OFFSHORE WIND AND SITING STRATEGIES

Name	Organization
Benjamin Bell	Garrad Hassan America, Inc.
Jack Cadogan	Cadogan Consulting
Habib Dagher	University of Maine – AEWC Composites Center
Sara Dillich	U.S. Department of Energy
Peter Goldman	PRG Consulting
Mary Hallisey Hunt, Group Spokesperson	Georgia Institute of Technology
Steve Lockard	TPI Composites
Peter Mandelstam	Bluewater Wind
Amir Mikhail	Clipper Windpower
Gary Nowakowski	U.S. Department of Energy – Golden Field Office
Mark Sinclair	Clean Energy Group
Brian Smith	National Renewable Energy Laboratory
John Ulliman	American Superconductor Corporation
Richard Vander Veen	Mackinaw Power
Paul Veers	Sandia National Laboratories
Greg Watson	Massachusetts Office of Energy and Environment
Robert Whitson	Sentech, Inc.
Terry Yonker	Great Lakes Wind Collaborative
Ross Brindle, Facilitator	Energetics Incorporated

TABLE 4-2. OFFSHORE WIND TECHNOLOGY AND SITING NEEDS

Data/Mapping	Demonstrations	Identifying Market Opportunities Part of Education
• Develop comprehensive offshore database with layered information – Near-term: identify existing data and gaps; Mid-term: add layers of information; Long-term: add climate-related changes – Government lead (MMS, national labs) with support from NOAA, marine institutes, states, universities – Used for both developer decisions and broad ocean management strategic planning – Done with federal support to allow open access – Feed into national level pre-approval process – Inform MMS five-year leasing planning process – Conduct continental shelf survey • Create offshore Wind “Atlas(es)” to aid decision-making – Comprehensive, layered mapping • Better maps to see waves, storm frequencies, etc. to inform risk, insurance • Combined GIS database for wind speed and exclusion zones that are resource and navigation based • Develop resource and predictor models for wind plant arrays • Put out 30 m meteorological towers offsite to gather data and base decisions (waves, birds, wind, etc.) – Every 300 miles – Have distance range 10-25 nautical miles – NOAA cable project (focused on earthquakes, tsunamis) → potential coordination? • Conduct robust borings samples to get 30 m/10-20 mi offshore samples • Conduct state-by-state market assessment (e.g., RPS, etc.) • Look to learn from Europeans who are ahead of U.S. in offshore • Define offshore resource exclusion zones • Authoritative process to identify and agree upon exclusion zones and water to avoid (wind industry to actively participate)	• Conduct regional U.S. pilot program for offshore wind with federal support to buy down cost – Mid-term – Full-scale testing • Establish national facility for offshore wind technology (offshore test facility for components and systems) • Floating machines pilot demonstration program $100 million state/federal/industry partnership	• Further define the 18% offshore of 20% wind in terms of region (Mid-Atlantic, Gulf, West, Great Lakes, etc.) • Economic incentive identification • Evaluate transmitting distant wind to coastal loads – Conduct study: land based wind plus transmission to NYC = $x.xx for offshore wind off coast

TABLE 4-2. OFFSHORE WIND TECHNOLOGY AND SITING NEEDS (CONTINUED)

Federal and State Collaboration	Environmental and Other Impacts	Technology Development (R&D)
• Need for better collaboration between MMS and DOE, and Army Corp. of Engineers – Near-term: baseline studies (Danish); Mid-term: Studies on systems in water; Long-term (environmental effects) – Fed/State government lead • EERE wind programs should take leadership role in pushing offshore agenda • Fund offshore wind collaboratives – Public, private, and university partners • Encourage/expand federal-state coordination for siting in offshore wind • North American collaboration to share costs with Canada • If DOE does not receive a mandate to support offshore wind, states and collaboratives need to step up • Work with MMS to ensure safety, certification is informed by industry, FAA, DOE, etc. • Coordination among states on critical issues such as infrastructure and generic R&D	• Prioritize and coordinate environmental research needs – state and Federal collaborative – allow for studies to be exchangeable – Mid- to long-term; MMS/DOE lead; states, NOAA, NGOs support • Evaluate marine ecology • Include wind industry in water use decision making • Study effects on coastal tourism • Use innovative risk management strategies to address impact on marine environment	• Comprehensive offshore R&D program focused on achieving 20% by 2030 in U.S. – Mid-term until results have impact; Lead: DOE; support: industry, states, universities, labs, consortia • Look at design issues unique to offshore (e.g., noise is not an issue) to optimize offshore design – Focused on high-risk, high-return cost reduction R&D for offshore – Foundations, turbines, towers, O&M – Components and full system design for offshore – Develop design codes, tools, and methods – Perform design evaluations for floating offshore machines • Develop and verify remote sensing technologies (SODAR/LIDAR) • Perform design evaluations for 5-10 MW offshore machines • Conduct R&D to enhance strategies for manufacturing, deployment, operations, and maintenance • Develop low-cost foundations, anchors, and moorings • Conduct R&D to incorporate offshore service and accessibility features • Develop manufacturing processes and improvements to reduce labor and materials and improve quality • Develop certification and standards for offshore – Harmonize the IEC-G1400 with API (harmonize land-based and offshore codes) • Increase reliability, learn from land-based advances to give very high offshore turbines • Develop advanced concepts in offshore wind turbine design including infrastructure

Table 4-2. Offshore Wind Technology and Siting Needs (continued)

Infrastructure and Project Development	Education	Workforce Development and Training	Regulatory and Policy	Grid Interconnection Approaches for Offshore
• Survey active and mothballed shipyards to build Jones-Act installation vessel, work to make shipyards available	• Articulate why offshore wind is critical to reaching 20% electricity from wind – Near-term; collaborative lead (state, Fed, industry) – Draw on existing work that has been done – Can impact electricity and imported oil via PHEV • Stakeholder education on requirement to issue competitions for financeable long-term power purchase agreements	• Establish university curricula and co-op opportunities with industry for offshore wind experts • Employee certification for offshore must be developed with training • Identify links with maritime workforce for training programs • Develop professional workforce at all levels for offshore wind	• Create supportive and incentive policies for offshore (e.g., district PTCs, MMS royalty holiday, ITC, etc.) – Near-term; Fed/state government lead – Industry, collaborative support • Policies should be holistic and encompass all regions • Design federal/state program to support financing and procurement of offshore wind • Proactively identify BMP and mitigation approaches for offshore siting	• Regional offshore wind grid integration studies – Near-term – Fed. lead – National labs, industry, states, universities support • Concept design for backbone grid for offshore wind along coastlines – High voltage direct current offshore super grid – Develop marine grid, power conditioning, and infrastructure

TABLE 4-3. SELECT INDIVIDUAL SUGGESTIONS FOR ADDRESSING OFFSHORE WIND TECHNOLOGY AND SITING NEEDS

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables	Resource Requirements	Suggested Total Funding $ 1-5 million >$5 million >$10 million	Immediate Next Steps
Create supportive incentives and policies for offshore wind	*Creation of incentives and policies for offshore wind*	• Analysis and assessment of policy (including international) options to accelerate deployment of offshore wind (Deliverable: Report) • Education of policy makers at state and federal levels • Legislation of federal and state policy and incentives	• DOE, national labs, OMB and IRS participation at the federal level • State legislatures and public commissions at the state level – Ind. Trade organizations like AWEA would also be involved • (LBNL has experience in analysis of wind policy)	• $1-5 million per year for three years	• Allocate budget to begin scoping study
Improve collaboration among MMS, DOE, and Army Corps of Engineers and States	*Improve collaboration among MMS, DOE, Army Corps, and States*	• MOU between interested agencies • Develop strategies for addressing challenges and achieving success – Advance technology development – Achieve environmental compatibility – Achieve economic and financial viability – Clarify and coordinate regulatory responsibilities • Regular coordination meetings	• Commitment to participate by agencies with mandates and/or interest • Minimal resources to support federal and state organizations	• $1-5 million	• Bring players together for initial meetings on structuring a collaboration process (DOE) • Draft MOU and conduct outreach

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables	Resource Requirements	Suggested Total Funding $ 1-5 million >$5 million >$10 million	Immediate Next Steps
Articulate why offshore is key to 20% goal	*Committed to developing offshore right* • "20% of the 20% must come from offshore wind resources" • Most cost-effective means for supplying coal states because of offshore wind's proximity to major U.S. coastal load centers • U.S. coastal states use 78% of the electricity in country *Coastal means Great Lakes 3,000 MW/year	• USOWC convenes offshore wind stakeholders to develop detailed play (1-2 days) • Comparison of land-based to offshore costs (land and transmission) • Develop campaign materials to communicate message • Recruit high-profile personalities to aid in campaign	• Need to complete studies that validate offshore potential and opportunities	• $1.5 million	• Convene meeting of offshore stakeholders and conduct studies
Develop comprehensive database with layered information	*Develop comprehensive database with layered information*	• Coordinate gathering of existing data/information on the offshore environment relevant to wind development • Tap all stakeholders • GIS-based layered database providing flexible use to analyze offshore wind sites/opportunities	• State and federal agencies • NGOs	• $1.5 – $2 million	• Conduct preliminary interviews and search • Analyze what exists

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables	Resource Requirements	Suggested Total Funding $ 1-5 million >$5 million >$10 million	Immediate Next Steps
Comprehensive offshore R&D program focused on achieving 20% by 2030 via cost reduction and optimization of components and full system design	• Costs have to come down • High payoff	• Delivered cost of energy competitive with other sources • Develop U.S. industrial base	• Design tools – Offshore environment – Larger scale • Advanced materials • Lighter weight • Foundations • Reliability and maintainability • See report Mosiac and Ram Draft 3/29/07	• $200 million/year for 10 years: combination DOE, state, and industry	• Identify offshore as critical technology development priority, and start in FY10 budget • Start system analysis to target priorities
Establish an offshore demonstration program • Conduct offshore pilot program with federal support to buy down costs	• Prove the technology	• Regionally focused demonstration projects	• $	• $100 million per project • Approximately 5-10 projects	• Define needs and requirements for good quality demonstration projects

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables	Resource Requirements	Suggested Total Funding $ 1-5 million >$5 million >$10 million	Immediate Next Steps
Develop approaches for grid interconnection for offshore wind	• Need for transmission is one of the largest impediments to producing 20% of our nation's electricity demand with wind energy • Expansion of U.S. transmission offshore is critical in the exploitation and successful development of offshore wind energy in the United States	• Establish national and international forums to exchange technical information on system operation with offshore wind plant interconnection • Assessing the various technical options for interconnecting offshore grid • Concept design for backbone grid for offshore wind energy development • Develop marine grid power conditioning and infrastructure	• DOE, FERC, ISOs, RTOs, national labs, industry, utilities, MMS and states • System impact and integration modeling software • Data needs include current infrastructure for land applications and bathymetry and geotechnical/ physical characteristics offshore	• >$10 million per year	• Exchange technical information on system operation with offshore wind plant interconnection and develop an MOU between stakeholders

5. Grid System Interconnection

Achieving 20% wind by 2030 will be a major undertaking for the electric power industry. To achieve the 20% Wind Scenario, it is estimated that over 12,000 miles of new power lines would need to be built, along with a system to reliably balance electrical generation and load from wind (which is considered a non-dispatchable resource). Some modernization effort is underway to expand the capacity and enhance the flexibility and functionality of electric transmission and distribution across the entirety of the North American power grid. This modernization effort would likely be accomplished at the same time that large numbers of wind turbines come online. If accomplished properly, grid modernization has the potential to greatly expand the opportunities for wind energy and other clean power generation systems, energy storage, and demand-side measures, such as demand response and end-use efficiency. No significant technical challenges with integrating large numbers of wind generation exist. Substantial progress has already been made in addressing these technical challenges for the following reasons:

- The level of communication and interaction between wind developers and electric system planners and operators has grown enormously, which has led to a much greater level of understanding about the root causes of the interconnection and integration challenges and what needs to be done to address them.
- The expanded installation of wind energy facilities in the past decade has increased knowledge about the technical issues surrounding installation. This increase in knowledge has reduced speculation.
- The major entities responsible for operating the North American electric grid, including several independent system operators and Regional Transmission Organizations and the North American Electric Reliability Corporation, have become increasingly involved in wind integration studies and analysis.

Box 7. Grid System Interconnection: Common Findings and Themes

Participants provided the following comments:

- There are no insurmountable technical challenges to bringing 300 GW of wind energy online over the next 22 years with respect to grid interconnection or integration
- Substantial progress has been made over the last decade in reaching a common understanding of the interconnection/integration issues and what needs to be done to address them
- One lesson gained is the importance of adopting an interconnection-wide perspective in evaluating wind resources and acquisition strategies and not limiting the view to a single state or utility system
- A paradigm shift will be needed in grid planning and operations that will require new data, tools, models, techniques, standards, and ways of doing things
- While more-effective resource planning and acquisition processes are needed, and greater flexibility and functionality in electric system operations is essential, bringing more transmission capacity online is paramount for delivering energy from remotely located wind resources to urban load centers

Significant technical and other challenges need to be addressed. Comments suggested that, for example, to accommodate greater penetration of wind power and other variable-generation resources (such as solar), a paradigm shift is needed in grid planning and operations that will require new data, tools, techniques, standards, and ways of doing things, including cost allocation and recovery for transmission expansion projects. In addition, individual participant comments suggested that more effective electric system plans and resource acquisition processes are needed, as well as greater flexibility in managing daily grid operations.

Participant commented that, in general, there is an urgent need to ramp up information exchange efforts from wind integration and other renewable and variable energy sources activities and studies from across the country and around the world. Significant lessons are being learned, and input received suggests that it is critical during this phase of wind energy development to determine best practices, replicate what works, and discontinue what does not. For example, many of the recent grid integration studies and activities in the United States have been confined to single utilities or states. While it may be necessary to initially address wind energy interconnection and integration in this way, ultimately—as installations increase— participants suggested that it will be necessary to evaluate wind energy development in terms of its role in regional systems, if not interconnection-wide deployments.

Box 8. Grid System Integration/Interconnection: Key Needs

Participant comments indicated that the following are key needs:

- **Electric System Operations and Markets**
  - Utilization of wind plant output forecasting tools
  - Deployment of flexible system management technologies for load control on an economic basis (e.g., configuring the existing generation fleet with increased ramping and cycling capabilities; obtaining more flexibility in hydro system operation, fuel contracts, and gas storage; and pursuing R&D on storage and demand response)
  - Consolidation of balancing areas and area control error sharing
  - Incorporation of the knowledge gained from integration studies into operations
  - Increased frequency of scheduling transactions from hourly to 5–10 minutes
- **Electricity Models, Tools, and Analysis**
  - Development of new tools and techniques for system planning and operations
  - Creation and maintenance of mesoscale wind resource data sets
- **Electric System Planning and Resource Acquisition**
  - Enhanced comprehensive regional planning processes
  - Performance of more detailed wind integration studies
- **Electric Infrastructure**
  - Building of more transmission
- **Electricity Regulatory Framework**
  - Creation of mechanisms for cost allocation and recovery for transmission projects

Comments suggested that with respect to **electric system operations and markets,** a number of changes in the way grid operators view and evaluate wind power and other renewable resources need to be made. Renewables, including wind and solar, are energy resources; most traditional planning methods focus on capacity resources, rather than energy resources. Individuals commented that, for example, there is a need to acquaint grid operators with the use of forecasting tools for the output of wind power plants and to develop processes for the incorporation of these tools into daily operations. Input received suggests that there is also a need to deploy electric resources that improve the flexibility of system operations. Several suggested options to improve system flexibility include research of electric and energy storage systems, demand response programs, and new communications and controls for conventional generators (e.g., gas turbines and steam units) to enable them to ramp up and down more easily with minimal impacts on their efficiency and performance. Storage may be a useful strategy when looking at the entire system, but not necessarily at the wind plant level. Participants also suggested that balancing area consolidation and area control error (ACE) sharing will decrease the per-unit variability requirements for integrating large amounts of wind.

With respect to **models, tools, and analysis**, comments suggested that a new family of tools and techniques for electric system planning and operations needs to be developed in order to enable greater flexibility in the system to address the variable nature of wind and other renewables. These would include efforts to improve and validate both steady-state and dynamic models and to develop analysis tools and data to match incremental load with incremental resources and determine the optimal mix of wind power and other types of resources. Individual comments suggested that flexibility can also be enhanced through adoption of risk management strategies that account for the variable nature of wind power output. Input received suggested that the development of better and more up-to-date mesoscale wind resource data sets is needed; this would involve the construction of a nationwide network of tall towers to capture wind speed at various heights above the ground for “truing up” mesoscale wind resource models. Efforts in this area are currently underway. For example, DOE recently hosted a workshop entitled *Research Needs for Wind Resource Characterization*.

With respect to **system planning and resource acquisition**, individuals commented that comprehensive regional processes need to be enhanced and expanded. This would be a national effort that individuals suggested would require strong and consistent state leadership within the context of a national vision. It likely would require a comprehensive effort to bring together key stakeholder groups across the country and establish more effective techniques for dispute resolution and better models that can evaluate the relative merits of all resource options, supply- and demand-side, conventional and renewable, and distributed and central-station. Individuals commented that consideration needs to be given to the idea of Competitive Renewable Energy Zones and to the role of the federal power marketing administrations (PMAs).

Comments suggested that more wind integration studies should be conducted, and their coverage should expand from individual utilities and states to multistate regions and multiregional interconnections. In doing this, there would be a need to develop common methodologies and metrics to enhance comparability and facilitate the sharing of information. Unit commitment and dispatch tools should be enhanced to support the inclusion of wind resources and to develop standardized data formats for wind output and integration.

With respect to **electric infrastructure**, comments suggested that the top priority need is simple: build more transmission. This is easy to say but hard to do. It would require progress in all of the areas mentioned above, as well as progress in creating collaborative processes that build the political will to overcome local issues and “not-in-my-backyard” syndrome. Individuals commented that a promising concept for breaking through the siting and permitting issues could involve the development of “Clean Energy Superhighways.” This would involve construction of a national backbone of high-voltage electric transmission lines that would be built to deliver low-carbon energy (such as from wind, solar, and geothermal) from remote areas to the load centers where the power is needed. Individual participants indicated that making progress on this front would be a long-term effort and would require unprecedented coordination between federal, state, and regional government agencies and stakeholder organizations.

Comments suggested that another challenge to tackle is improving the **regulatory framework** and developing better mechanisms for cost allocation and recovery for new transmission facilities. This would involve finding ways to allocate costs equitably and efficiently among those who benefit most from the project. Individuals commented that, in this regard, federal-state jurisdictional issues need to be addressed, and stakeholder processes that are more effective in addressing public concerns and streamlining siting and permitting activities need to be developed.

TABLE 5-1. LIST OF PARTICIPANTS – GRID SYSTEM INTERCONNECTION

Name	Organization
Antonio Alvarez	Pacific Gas and Electric Company
Steve Beuning, Group Spokesperson	Xcel Energy
Gil Bindewald	U.S. Department of Energy – OE
Stan Calvert	U.S. Department of Energy – EERE
Jim Cikanek	WindLogics
Charlton Clark	Sentech, Inc.
Peter Devlin	U.S. Department of Energy – EERE
John Dumas	Electric Reliability Council of Texas ISO
Hamid Elahi	General Electric (GE) Energy
Rob Gramlich	American Wind Energy Association
David Hawkins	California ISO
Sasan Jalali	Federal Energy Regulatory Commission (FERC)
Ben Karlson	Sandia National Laboratories
Doug Larson	Western Interstate Energy Board
Michael Milligan	National Renewable Energy Laboratory
Darrick Moe	U.S. DOE - Power Marketing Administration Liaison Office
Frank Novachek	Xcel Energy
Mark O'Malley	University College Dublin, Ireland
Dale Osborn	Midwest ISO
Brian Parsons	National Renewable Energy Laboratory
Hal Romanowitz	Oak Creek Energy
Matthew Schuerger	National Renewable Energy Laboratory – ESCS
Aaron Severn	American Wind Energy Association
Susan Shoenung	Longitude 122 West, Inc.
Charlie Smith	Utility Wind Integration Group (UWIG)
Beth Soholt	Wind on the Wires
Rich Scheer, Facilitator	Energetics Incorporated

Table 5-2. Grid System Interconnection Needs

Electric System Operations	Models, Tools, and Analysis	Electric System Planning and Resource Acquisition
• Deploy flexible system management technologies – Near-term; industry led; federal and state government, national labs, universities, and NGOs support – Develop price and demand response markets and expand access – Improve wind plant capability, flexibility, inertia, frequency, reactive control – Investigate energy storage potential for optimization, options analysis, benefit-cost analysis – Investigate mechanisms for making conventional generators more flexible • Use wind forecasting tools – Near-term; industry led; federal government, national labs, and universities support – Improve short and long term wind models for ramp up and down situations • Implement knowledge gained from wind integration studies in operations – Near-term; industry led; federal government, national labs, and universities support • Consolidate balancing areas and ACE sharing – Near-term; industry led; NERC, ISO/RTO, FERC support • Increase the frequency of scheduling transactions from hourly to 5-10 minutes in limited market regions – Near-term; industry led; NERC, ISO/RTO, FERC support • Aggregate wind plant output over large regions – Near-term; Industry led; NERC, ISO/RTO, FERC support • Use transmission wisely – Near-term; industry led	• Develop tools and techniques for better planning and operations – Near-term; industry led; federal and state government, national labs, universities, and NGOs support – Improve and validate steady state and dynamic models – Develop tools and data to determine incremental amounts/type of resources to integrate incremental wind resources • Create and update mesoscale wind resource data sets – Near-term; federal government led; national labs support • Build tall network to "true-up" meso/wind resource models	• Enhance and expand comprehensive regional planning processes – Near-term; federal government led; industry, state governments, national labs, universities, NGOs support – Obtain strong consistent state leadership with a national vision – Encourage Competitive Renewable Energy Zones (CREZ) – Assess long term costs of under building transmission access to wind and other clean resources • Perform detailed wind integration studies – Near-term; federal government led; industry, state governments, national labs, universities support – Develop common methodologies and metrics – Enhance unit commitment and dispatch tools – Develop standard data formats for plant output and evaluation of retrospective studies • Develop and analyze sources of system flexibility – Near- term; industry led; federal and state governments, national labs, universities, and NGOs support • Integrate distributed wind systems into the grid – Near-term; industry led; federal and state governments, national labs, universities, and NGOs support

TABLE 5-2. GRID SYSTEM INTERCONNECTION NEEDS (CONTINUED)

Infrastructure	Regulatory Framework	Collaboration	Research and Development
• Build transmission – Mid- to long-term; industry led; federal and state governments, NGOs support – Sell the public on the vision for clean energy superhighways – Deploy overlay transmission system with managed flow controls, instead of relying on impedance • Support workforce development to develop experts with renewable and grid integration – engineers, economists, business analysts – Mid- to long-term; federal and state government led; universities and NGOs support – Training and funding for graduate students in systems engineering and R&D projects • Develop new standards for the design of transmission systems and electric grid components for integration with wind projects – Mid- to long-term; industry led	• Create mechanisms for cost recovery – Near-term; federal and state government led; industry and NGOs support – Separate revenue requirements from spot market access – Need to agree on rules to allocate responsibility and cost of integrating incremental renewable resources • Enable rights-of-way procurement in a timely manner – Near-term; federal and state government led; industry and NGOs support • Create an “Ombudsman” to facilitate resolution of issues that interfere with wind integration – Near-term; federal and state government led; industry and NGOs support • Improve grid codes – Near-term; federal and state government led (NERC, FERC); industry and NGOs support • Reassess transmission financing – Near-term; federal and state government led; industry and NGOs support • Adopt market rules and tariff provisions for wind – Near-term; federal and state government led; industry and NGOs support • Eliminate pancaked rates for transmission – Near-term; federal and state government led; industry and NGOs support	• Engage federal leadership – Near-term; federal government led – Do not quit supporting program activities that contribute to progress – Increase federal activities with the States to encourage wind integration – Help educate Congress – Explore expanded role for Power Marketing Agencies • Conduct more forums to share experiences – Near-term; industry led; federal and state governments, NGOs, national labs, and universities to support • Encourage a wide open exchange between all market participants	• Conduct R&D program for development of smart grid systems that accelerate wind integration – Mid-term; industry led; federal and state governments, national labs, and universities support – Develop intelligent on-ramp metering to limit delivery of wind generation to minute-to-minute transmission or distribution capacity availability • Improve cost and performance of energy storage in remote power applications – Long-term; federal government led; state governments, national labs, universities support

TABLE 5-3. SELECT INDIVIDUAL SUGGESTIONS FOR ADDRESSING GRID SYSTEM INTERCONNECTION NEEDS

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables	Resource Requirements	Suggested Total Funding $ 1-5 million >$5 million >$10 million	Immediate Next Steps
Infrastructure Development – Build Transmission	*National Clean Power Superhighway*" DOE led national effort	• White House, U.S. DOE Office of the Secretary of Energy, Congress to make national commitment, pass legislation, develop staged plan • Governors partner with the federal government to ensure rights-of-way, permitting, public acceptance • FERC rules for planning, reliability, cost allocation	• Power marketing authorities • American Governors Association	• For regional planning • $5-10 million annually	• Industry to prepare a white paper for the new administration in collaboration with other stakeholders • For a national coalition with environmental groups, renewable energy developers, electric power industry, and states
Regulatory Framework – Mechanisms for Cost Allocation	*National Clean Power Superhighway Cost Allocation and Recovery policy*	• Overcome cost allocation which is the biggest barrier to regional transmission development • Relatively low costs for transmission must be calculated, clarified, and communicated • Simple and transparent methods for equitably allocating costs among load serving entities and beneficiaries	• Federal legislation for national infrastructure to allocate costs under FERC rules • Partnerships with Governors • Federal financial incentives, possibly • PMA bonding authority as a backstop		

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables	Resource Requirements	Suggested Total Funding $ 1-5 million >$5 million >$10 million	Immediate Next Steps
Electric System Planning and Resource Acquisition – Enhance Comprehensive Regional Planning Processes	*Joint Transmission Planning for a Secure, Efficient, Sustainable, Affordable, and Low-Carbon Future* Regional but North American in scale and scope	• Hold regional forums of key stakeholders • Conduct studies of economics and other impacts/benefits • Develop common planning tools • Develop sets of future scenarios for analysis	• Mesoscale data for wind and solar • CREZ designations • Regional modeling of power flows, dynamics, economic dispatch, emissions	• Industry – $10-15 million/yr • Feds – $6-8 million/yr	• Organize forums, define the future scenarios, conduct the planning studies and analysis
Electric System Planning and Resource Acquisition – Perform Detailed Wind Integration Studies	*Obtaining Reliable Power from Variable Generation*	• Expand the scope of integration studies to interconnection-wide • Perform detailed sub-hourly studies • Identify technology and rule changes to minimize integration costs and maximize asset utilization and define ancillary service needs and balancing requirements • Expand scope of integration studies to North America	• Sub-hourly unit commitment analysis tool • Generator performance characteristics • Short term wind, solar, and load data	• Industry – $10-15 million/yr • Government – $5-10 million/yr	• Define the scope of analysis tool enhancement and get industry acceptance • Develop execution plan for the studies • Do the studies
System Operations – Forecasting	*Managing the Variability of Wind Output Including Uncertainties in Time Frames for Load Following and Unit Commitment*	• Integrate into unit commitment (energy) both day-ahead and intra-hour • Predict extreme events – situational awareness • Short term (15 minutes) implemented into SCADA • Develop operating reserves methodology	• More accurate data • More frequent data • Tools to apply forecasting into system operations		

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables	Resource Requirements	Suggested Total Funding $ 1-5 million >$5 million >$10 million	Immediate Next Steps
System Operations – Congestion Management	*Real Time Grid Management*	• Evaluate the reliability impact of physical flows from wind – intra-hour • Direct operations so as to prevent reliability impacts	• Regulatory support • Better tools for regional state estimated contingency analysis		
System Operations – Flexible System Management	*Greater Flexibility with Existing Generation and New Resources*	• Implement more demand response • Configure the existing generation fleet with increased ramping and cycling capabilities • Obtain more flexibility in fuel contract and gas storage • Promote R&D for additional electric resources that add flexibility e.g., energy storage	• Regulatory support including policies for decoupling earnings from revenues • Compatible market designs		
Models, Tools, and Analysis – Develop Tools and Techniques for Planning and Operations	*Risk Based Tools and Methods*	• Planning models: wind forecasts and wind variability; load forecasts and load variability • Stochastic unit commitment • Rolling unit commitment • Multi-year reliability impact analysis • Higher time resolution for economic dispatch models • Extreme event applications/tools • Dynamic generation models for interconnection	• Capturing historical data: weather, loads, generators • Load/wind forecasting data • New/evolved models and tools that are capable of assessing regional and interconnection-wide footprints	• Industry – $5-7 million • Government – $3-5 million • Over 5 years	• Capture historic data • Engage model developers • Define modeling approaches

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables	Resource Requirements	Suggested Total Funding $ 1-5 million >$5 million >$10 million	Immediate Next Steps
Models, Tools, and Analysis – Create and Update Mesoscale Wind Resource Data	*Enhancing Wind Resource Assessments*	• Annual updates • Meso model to wind plant translation • R&D on numerical wind models • Tall tower network for modeling and "true up" (SODAR, LIDAR)	• Computing power • NWP enhancements • Hardware deployments • Engage NCAR and NOAA • Data storage	• Annual updates $1-2 million/yr • Government augmentation of industry modeling $0.5 million/yr • $1 million per state for tower/ LIDAR/SODAR network	• Identify priority locations

6. Environmental Risks and Siting Strategies

The pathway toward the 20% Wind Scenario entails diverse challenges related to environmental risks and siting strategies. According to the 20% Wind Scenario, while wind energy typically enjoys broad public support, an estimated 10–25% of projects are either never built or are significantly delayed because of siting and environmental concerns. Increased awareness, knowledge, and site planning about environmental risks and community concerns would likely decrease the number of projects proposed in sensitive areas, saving time and resources. This approach to decision-making would help build a sustainable wind industry.

A number of environmental and human effects, including habitat and wildlife, viewshed, noise, socioeconomic developments, and airspace, must be considered when siting a land-based large turbine. However, these effects should also be compared with potential benefits of wind energy, including climate change benefits from the reduction of carbon emissions, economic development, and enhanced energy security. According to the 20% Wind Scenario, the cumulative total avoided CO_2 emissions by 2030 would be 7,600 million metric tons. While the 20% Wind Scenario shows that most wind facilities pose only minor risks to local communities, wildlife, and habitats, siting and operational considerations are needed to avoid and minimize negative impacts. A greater understanding of the significance of these risks and how to reduce uncertainties would be useful for project evaluation, along with a comparison to other energy sources. Another dimension of risk involves transmission siting. Since transmission will be required for all new energy supply options, comments suggested that the wind community needs to proactively consider transmission corridor implications along with wind facility siting decisions.

An installed wind capacity of 305 GW would require about 61,000 square kilometers of project land, including the marine seabed. The actual footprint of disturbed land, however, ranges from 2–5% of the total project land. The issues of bird and bat habitats and collisions with turbines have received considerable attention. According to a National Wind Coordinating Collaborative (NWCC) fact sheet[6], fatality estimates for birds average 2.3 fatalities per year, per turbine. Bat deaths at several wind plants in the Mid-Atlantic region have been higher than expected, which has caused concern and spurred public-private research initiatives. Participants suggested that care should also be taken to minimize fragmentation of important habitats. They also suggested that impacts on wildlife and their habitats should be avoided, minimized, or mitigated to the extent possible; several participant organizations have activities in this area, including the following:

- Bats and Wind Energy Cooperative
- National Wind Coordinating Collaborative (NWCC) --- Wildlife Working Group
- Grassland/Shrub-Steppe Species Collaborative
- Fish and Wildlife Service Wind Turbines and Wildlife Federal Advisory Committee

Individual participants suggested that there is a need for **assessment**, **outreach, and education on the benefits of wind energy**. It was suggested that this effort should include the broad range of benefits, such as reducing GHGs and other emissions, deploying carbon-neutral transportation, and energy security. Participants further commented that public engagement should include consensus-seeking, **early consultation on wind projects with local communities**, environmental organizations, and other NGOs and agencies. Input received suggested that early consultation in addressing the needs for expanding transmission for wind-generated electricity is also needed. Input received suggests that the plan to expand assessment and dissemination of the benefits of wind energy, a major environmental driver for achieving the 20% Wind Scenario, would include the identification of credible and quantifiable information on wind benefits. Suggestions included that materials and workshops should be targeted to the specific needs of different groups, such as K-12 students, the media, government decision makers, and the general public. Participants commented that DOE could lead this effort, which would include partnering with national laboratories and universities, and prepare peer reviewed reports about wind contributions to carbon-neutral transportation technologies.

[6] NWCC. 2004. Wind Turbine Interactions with Birds and Bats: A Summary of Research Results and Remaining Questions. Washington DC: NWCC.

Individuals commented that **comprehensive life-cycle analyses** to compare wind energy with the use of other energy resources are needed in order to better understand risks, benefits, and siting strategies across the energy portfolio. Comparing different energy options would provide decision makers additional information about their supply options and potential tradeoffs.   Suggestions included that analyses should include emissions and water usage issues and should take into account the impact of the energy resource on climate change.

Box 9. Environmental Risks and Siting Strategies: Common Findings and Themes

Participants provided the following comments:

- There is currently no comparative, comprehensive life-cycle analysis comparing national energy alternatives (e.g. climate change issues, emissions, and water impacts)
- It is important to avoid, minimize, or mitigate impacts on wildlife and their habitats to reduce the uncertainties of wind turbine impacts where possible
- There is often a lack of transparency on siting issues; not enough technical information is readily available to the public and siting authorities, as they lack adequate staff and technical knowledge, and community concerns are often not well identified
- Information on siting, wildlife, and habitats is incomplete and/or inaccurate
- There is typically a lack of early and proactive involvement of communities and regional stakeholders
- Vague regulatory authority can cause arbitrary decisions at local levels
- A consistent risk framework to evaluate and compare the range of potential effects (e.g., habitat corridors, radar interference, and aesthetics) is lacking

Comments suggested that **clear and consistent guidelines** for developers to avoid, minimize, and mitigate siting, wildlife, and other risks are needed. Comments suggested that these guidelines should facilitate selection of sites that compare risks across locations, clearly define the acceptability of risks, and thereby make better decisions that can reduce potential risks and/or use conflicts among stakeholders. One of the challenges for the siting process is that much of the technical information used in its development is not publicly accessible. In addition, input received suggests that siting authorities often lack both technical knowledge and sufficient staff. Participants expressed concern that it can also be difficult to determine who has regulatory authority for siting, which can result in arbitrary and uninformed decisions at the local level and create bureaucratic costs and delays for the developer. Finally, participants stated that there is often a lack of early, proactive and continuing involvement of the local community as well as regional stakeholders when a wind facility is to be sited.

To successfully address the major environmental risks and siting challenges, participants commented that **an integrated risk framework** is needed to make decisions about wildlife and habitats, aesthetics and property values, and radar and other issues. This risk framework would be to assist decision makers in identifying priority research related to potential impacts, uncertainties, and mitigation strategies. Comments suggested that the framework should be developed in a collaborative manner that involves several government agencies, NGOs, national laboratories, industry, and other stakeholders. Identification of these stakeholders from the aforementioned groups likely would be an immediate next step.

Input received suggested that **additional research on the effect of wind plants on wildlife, habitat** and other risks is also needed, along with research on how to minimize these risks through appropriate siting and operational practices that are cost effective (such as the use of deterrents or alteration of cut-in speed to reduce bat mortality). There is a need to summarize what is known and not known and what the major uncertainties are. Then, comments suggested, the needed areas of research must be identified and prioritized, and the research must be conducted. Comments suggested that research priorities should continue to be addressed by **public-private partnerships** with ongoing stakeholder involvement. Some comments included the development of mapping tools for landscape-level planning, analysis of wildlife and habitat issues, and major uncertainties. These efforts would continue to inform decision makers and communities about the benefits and impacts of wind energy.

Another remaining uncertainty as identified by comments is the technical solutions to **wind turbine effects on electromagnetic fields (EMFs), on radar,** and physical effects on navigation facilities. Rapid deployment of wind turbines could impact our national air space, national defense, and weather forecasting capabilities. The interplay between wind infrastructure and airspace can result in delays. Comments suggested that improved standards and guidelines for wind turbines that will minimize interference with EMFs and radar should be considered. One comment indicated that modern radar systems have the capability to be updated to identify turbine blades and mitigate the effects of wind farms. Further R&D on radar systems likely would help alleviate this issue. Participants suggested that working with the Federal Aviation Administration (FAA) should be considered.

Box 10. Environmental Risk and Siting Strategies: Key Needs

Participant comments indicated that the following are key needs:

- Expansion of assessments, public engagement, and education on wind benefits, including greenhouse gas reduction, carbon-neutral transportation technology, and energy security
- Promotion of early consultation with local communities, state agencies, and nongovernmental organizations (NGOs) about wind projects to foster greater consensus
- Comparison of life-cycle effects of energy generation options
- Development of clear and consistent guidelines for developers to avoid, minimize, and mitigate siting, wildlife, habitat, and other risks
- Development of an integrated risk framework to guide siting decisions and risk management approaches
- Identification and implementation of needed research on wildlife and habitat effects; continuation of summarizing what is known and not known about wildlife and habitat impacts and identification of priority research needs
- Expansion of research on high-priority siting and risk issues through public-private partnerships
- Development of mapping tools for landscape-level planning and analysis of wildlife, habitat, and other risk issues
- Assessment and mitigation of radar and electromagnetic fields, assessment of technical solutions to mitigate wind turbine degradation of the national air space, and definitions of standards or guidelines for radar and electromagnetic fields
- Engagement of NGOs, transmission planners, and renewable energy advocates in early dialogue about needs and interests in expanding transmission

Comments from participants suggested that these risks and uncertainties are critical enough to the 20% Wind Scenario that they would require completion in the short term (by 2012), although several of them will also need an additional ongoing sustaining component. Comments suggested that there is a need for federal leadership in several areas, including expanding assessment and education on wind benefits, providing funding for the development of guidelines for wind plant developers to address the impacts to wildlife and habitat, comparing life-cycle effects of different energy generation options including wind, developing an integrated risk framework to guide analysis and management options, and assessing and mitigating the effect of wind turbines on radar detection and electromagnetic fields.

TABLE 6-1. LIST OF PARTICIPANTS – ENVIRONMENTAL RISKS AND SITING STRATEGIES

Name	Organization
Abby Arnold	Kearns and West and RESOLVE
Ray Brady	Bureau of Land Management
Brian Connor	U.S. Department of Energy
Mike Daulton	National Audubon Society
Aimee Delach	Defenders of Wildlife
Ed DeMeo	Renewable Energy Consulting Services, Inc.
Patrick Gilman	U.S. Department of Energy
Kevin Haggerty	Federal Aviation Administration
Roger Hamilton	Western Grid Group
Ronald Helinski	American Wind and Wildlife Institute (AWWI)
Roger Hill	Sandia National Laboratories
Laurie Jodziewicz, Group Spokesperson	American Wind Energy Association
Marne Koerber	Capstone Solutions, Inc.
Steve Lindenberg	U.S. Department of Energy
Gary Seifert	Idaho National Laboratory
Jennifer States	Pacific Northwest National Laboratory
Bob Thresher	National Renewable Energy Laboratory
Wendy Wallace, Rapporteur	Energetics Incorporated
Ed Skolnik, Facilitator	Energetics Incorporated

TABLE 6-2. ENVIRONMENTAL RISK AND SITING STRATEGY NEEDS

Planning Regulatory and Legislative	Research	Tools	Education and Outreach	Crosscutting
• Landscape-level planning and analysis of wildlife and habitat issues – Land-use planning: review existing federal agency land use plans to identify constraints to wind energy development – Near-term NGO, – Federal Govt., Industry (Top Tier Supporting role), – State Govt., Local Govt., Univ. • Consult local communities early in development process – Consult local communities and wildlife agencies/NGOs about impacts of wind project to address consensus early in the process – Near-term (Ongoing) – Industry, Federal Govt., State Govt., Local Govt., whoever has land responsibility • Develop/draft model guidelines or regulations to assist local land use agencies • Engage national leadership to provide guidelines or produce balance test for wind turbines vs. national air space	• Assess and mitigate radar and electromagnetic fields – Assess tech solutions to mitigate wind turbines degradation of the national air and space system including radar and electric fields – Define standards for radar and EMF (or guidelines) – Near-term Federal Govt., Industry, Univ., National Labs • Expand research through public-private partnerships – Contribution to climate change goals – Bat deterrents – Night-migrating song birds – Public-private partnership research on high priority (not just bat and night song bird deterrents) – Near-term (Ongoing) Federal Govt./Industry NGOs, Univ., National Labs • Continue research on wildlife and habitat effects – Identify and conduct needed research on wildlife and habitat effects – Continue to summarize what is known and not known about	• Develop clear and consistent guidelines for developers to avoid, minimize, and mitigate wildlife and habitat impacts – Near-term Federal Govt. Univ., Industry, NGOs, Local Govt., National Labs, State Govt. • Develop a risk framework to guide siting decisions – Near-term Federal Govt., Industry, NGOs, National Labs • Apply adaptive management principles to address uncertainties • Create national wind siting database • Mitigation option needs (example: habitat banking) • Develop protocol for assessing habitat impacts • Develop visual resource management (VRM) tools to address aesthetic issues	• Expand local outreach and education – To "expand outreach, and education" add wind benefits, including GHG reduction, PEVs, and energy security – Near-term (Ongoing) – Federal Govt., NGO, Industry, Univ., National Labs • Create team of experts, clearinghouse, web, forums on siting issues/technology, what is known and not known to state/local governments – others • Expand education and training programs to meet the wind industry's workforce needs in siting, operating, and maintaining wind projects • Engage national leadership to make public aware	• Compare life-cycle effects of energy generation options – Near-term – Federal Govt., – Univ., Industry, National Labs • Engage NGOs/transmission planners/renewable advocates in early dialogue about needs/interests in expanding transmission • Need tools and education assistance for government decision makers

Planning Regulatory and Legislative	Research	Tools	Education and Outreach	Crosscutting
• Establish a national goal or mandate for wind energy on federal lands (land-based and offshore) • Fund deployment of state-of-the-art radar equipment that can differentiate between wind turbines and real threats • Coordinate land-use planning • Need consistency among federal, state, and local regulatory and permitting agencies to improve efficiency (time and costs) for project evaluation and determination	wildlife/habitat impacts – Identify priority research needs – Near-term (Ongoing) – NGOs, Federal Govt., Industry (Top Tier), – Univ. , National Labs, State Govt., Local Govt. (Additional Support) • Continue research to develop and validate models to predict wildlife and habitat impacts prior to building wind facilities and transmission • Conduct research to define range of risks (human and ecological) • Verify ground data models – Create detailed, reliable, accessible databases of wind, wildlife, and habitat and geographic data at appropriate scale • Study sound levels • Collaborate to deal with uncertainty • Continue R&D to develop and validate methods for on-site and off-site mitigation			

TABLE 6-3. SELECT INDIVIDUAL SUGGESTIONS FOR ADDRESSING ENVIRONMENTAL RISK AND SITING STRATEGY NEEDS

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables (multi-year outlook)	Resources Including Special Labs, Tools and Data Needs	Suggested Total Funding $1-5 million >$5 million >$10 million	Immediate Next Steps
Expand outreach and education on wind energy benefits, including greenhouse gas (GHG) reduction, carbon-neutral transportation technology, and energy security	• "Wind energy's role in a carbon constrained world"	• 1) Identify the credible and quantifiable information for wind energy benefits (link to life-cycle analysis) • 2) Develop targeted packages of outreach materials – Education (K-12) – Media – Government decision makers – General public • 3) Hold targeted workshops and seminars – Education (K-12) – Media – Government decision makers – General public • 4) DOE to identify responsible parties to develop materials and deliver the messages	1) Data Needs • Need life-cycle analysis information • National lab and university reports on wind contribution to carbon-neutral transportation technology 2) Tools • Media packages – Press releases – Talking points • Education Materials – Educator packets – Curriculum projects • Government – Talking points – Support materials • General Public – Q's and A's – Fact Sheets – Video * Develop a Clearinghouse for identifying the outreach workshops and seminars 3) Opportunities	1) Data Needs • <$1 million 2) Tools • Near Term Costs >$5 million 3) Delivery • Long Term Costs >$10 million	• Collect credible data • Develop outreach materials • Identify outreach opportunities • DOE – identify responsible party for tasks

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables (multi-year outlook)	Resources Including Special Labs, Tools and Data Needs	Suggested Total Funding $1-5 million >$5 million >$10 million	Immediate Next Steps
Compare life-cycle effects of energy generation options	• Quantify and compare the economic and environmental costs and benefits of current and prospective mainstream energy options	• 1) Identify all costs and all benefits of each energy option from cradle to grave – Determine what is known and not known • 2) Quantify the costs and benefits → environmental, economic, and energy payback • 3) Compare features in a portfolio approach (total system) • 4) Document the work and develop an outreach plan	• Review existing studies – National Academy of Sciences Committee – National Lab reports and models – ExternE (Europe) – International Panel on Climate Change • Uniform approach needed to characterize data and data collection	• >$5 million	• 1) Develop broad-base of support for the project • 2) Assemble team to begin the first task, identifying costs and benefits, and what is known and not known
Develop clear and consistent guidelines for developers to avoid, minimize, and mitigate wildlife and habitat impacts	• Consistent and clear guidelines, applicable at federal, state and local level, to avoid, minimize, and mitigate wildlife and habitat impacts from wind power facilities	• 1) Framework for guidelines	• 1) Federal and state wildlife agencies (Fish and Wildlife Service, Wind Turbine Guidelines Advisory Committee)	• FWS budget (currently)	• FACA agreement on framework
		• 2) Protocols to help achieve guidelines – Handbook on how to use the guidelines – Toolbox – Monitoring – Research – Mitigation – Lessons learned – Feedback/revisions	• 2) Various groups: – Industry – AWWI, BWEC, universities, – National Academy of Sciences – Wildlife society, AFWA – NWCC, GS3C	• $5-10+ million	• Write implementation tool box components • Set up monitoring • Secure funding stream
		• 3) Outreach and education at each level: Fed, state, local, industry, county	• 3) Multi-pronged – Federal, state, NGO and industry National Association of counties, American Planning Association, web	• $1 million per year 5+ years	• NWCC – develop outreach approach/materials, engage stakeholders

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables (multi-year outlook)	Resources Including Special Labs, Tools and Data Needs	Suggested Total Funding $1-5 million >$5 million >$10 million	Immediate Next Steps
			tool/think tank clearinghouse		
		• 4) Mechanisms for adoption (mandatory, incentives, certification, etc. - possibilities)	• 4) Federal state agencies MOUs – Financers – Third-party certification – Industry	• $1 million	• Develop mechanism for encouraging adoption (FWS Wind Turbine Guidelines Advisory Committee)
		• 5) Feedback/revision on entire process	• Public/private partnership (NWCC?)	• <$1 million	• Develop evaluation criteria
Expand research through public-private partnership on high-priority needs (wildlife)	• Expand research on high-priority research needs (i.e., birds, bats, habitat fragmentation) through public-private partnerships (including industry, NGOs, and government)	• Form public-private partnerships (i.e., AWWI) • Build capacity for partnership • Deliver well-funded research projects on high-priority needs • Communicate findings through effective public outreach efforts • Participate in seminars and public forums to communicate results at federal, state, and local levels	• Dedicated full-time staff to direct research and raise funds • Investments as necessary in cutting edge research tools (advanced radar, wide-field infrared cameras) • Database to provide access to research results	• >$10 million/year (NREL studies of Altamont Pass averaged $2-3 million per year)	• Organize partnerships • Identify highest priority needs • Get started with studies
Assess and mitigate radar and electromagnetic fields; Assess technical solutions to mitigate wind turbine degradation of the National Air Space including radar and EMF; define standards	• Develop technical mitigation strategies and instrumentation upgrades to allow productive coexistence between wind projects and competing needs for National Air	• Establish a committee that can develop a long-range R&D agenda • Develop, test, and evaluate mitigation technologies: – Long-range radar – AIA – traffic control radar – NEXRAD (weather radar) • Provide independent, third-party technical assistance • Develop wind radar siting	• Need good, predictive, analytical models • Lab technical expertise (FAA/INL/SNL/DHS) • Interagency work group coordination • Obtain private sector radar expertise • Develop steel tier turbines, improved radar, and upgraded software	• $2-5 million in first year growing to $5-10 million over the next four years	• DOE to project technical support and R&D efforts • Developer to form siting guidelines • Demonstrate mitigation solutions • Charter an interagency radar group

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables (multi-year outlook)	Resources Including Special Labs, Tools and Data Needs	Suggested Total Funding $1-5 million >$5 million >$10 million	Immediate Next Steps
	Space	guidelines for developers • Leverage existing agency skills with additional private sector expertise	• Identify non-punitive funding mechanisms		
Identify and conduct needed research on wildlife and habitat effects, continue summarizing known and unknown facts regarding impacts, and identify priority research needs	• Create a forum(s) for ongoing dialogue on wildlife and habitat research needs	• Continue ongoing dialogue with key partners through NWCC, AWWI • Identify and recruit additional partners (state and local governments, NGOs, and universities) • Publish reports, documents, and studies on research needs and research results • Conduct national and regional seminars and events	• Full-time staff dedicated to organizing and event planning • Travel costs and expenses • Funding for high-quality publications (print and web)	• $1-5 million per year, ongoing	• Continue and expand current efforts with NWCC and AWWI, BWEC, WGA to ensure continued success • Identify priority events and speakers for national and regional efforts
Risk assessment framework to guide siting decisions	• Develop a risk assessment framework to identify and evaluate siting questions related to: – 1) Wildlife and habitat – 2) Aesthetic and community property values – 3) Radar and safety – 4) Other concerns that arise (e.g., sound) in	• Wildlife habitat ("1") being addressed by FWS Wind Turbines Guidelines Advisory Committee/NWCC/AWWI BWEC processes • Need to complete risk assessment framework for 1 • 2-4 need to be initiated in collaborative process with stakeholders	• Resources: FAC, NREL, NWCC with federal, siting subcommittees, state and local governments, experts, Idaho National Lab, FAA, DOD, DHS, Industry, NGOs • Data needs: – 1) Covered on other sheets (Guidelines, research) – 2) Data needs may require identification (sound, EMF, visual, radar)	• >$10 million	• Identify leader/convener – Identify stakeholders, tech resources

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables (multi-year outlook)	Resources Including Special Labs, Tools and Data Needs	Suggested Total Funding $1-5 million >$5 million >$10 million	Immediate Next Steps
	order to guide siting decisions				
Landscape-level planning and analysis of wildlife and habitat issues	• Develop maps and other tools to enable landscape level planning	• Develop national and regional maps of high priority wildlife and habitat areas • Develop national and regional maps of current and planned wind projects and transmission needs • Deliver initial version of maps within one year • Develop web-accessible database of mapping information • Provide training to interested parties on use/application • Update maps/database regularly with new data	• Full-time staff dedicated to organizing and implementing mapping effort • Permanent support staff for database • Permanent facility for database	• $1-5 million per year	• Coordinate with AWWI, BWEC, and WGA to support immediate implementation of mapping effort • Establish database home and support staff
Consult local communities, wildlife agencies, and NGOs on impacts of wind projects to address consensus early in the process	• Promote consultation with local communities, wildlife agencies, and NGOs on the positive and negative impacts of wind projects to enable consensus early in the process	• 1) Identify all of the stakeholders to involve and appropriate time frames for doing so • 2) Develop case studies on successful and unsuccessful approaches • 3) Develop effective outreach plan and process • 4) Implement the plan and refine, over time, with the aim of institutionalizing the information and creating a sustaining infrastructure	• Much of needed outreach infrastructure exists (e.g., AWEA, Wind Powering America, NWCC, Wind Working Groups, state energy agencies, regional advocates)–those who "prepare the ground" but comprehensive plan and products have not been developed	• $1-2 million to develop products • $1-2 million annually for 5 years	• Identify and involve stakeholders • Develop support base for need for the task • Initiate case studies
Engage NGOs, transmission planners, and	• "If you love wind, you need to like transmission"	• 1) Identify stakeholders • 2) Educate stakeholders to be able to actively	Tools: • Establish and facilitate stakeholder roundtables	• Total Cost $1-5 million	• Immediate – Identify stakeholders

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables (multi-year outlook)	Resources Including Special Labs, Tools and Data Needs	Suggested Total Funding $1-5 million >$5 million >$10 million	Immediate Next Steps
renewable advocates in early dialogue about the needs and interests with expanding transmission		participate in the transmission planning process • 3) Engage the stakeholders in the transmission planning process • 4) Advocacy with the Public Utility entities in utility rate cases and public benefits of wind energy	• Develop a life-cycle costs and benefits of wind energy transmission expansion Special Need: • Acquire expert testimony resources to engage in transmission planning and cost recovery		– Educate stakeholders – Engage stakeholders • Ongoing – Advocacy role

7. Market Development and Public Policies[7]

As projected in the 20% Wind Report, achieving 20% wind by 2030 would likely require continued market development and a range of public policy initiatives. Public policies supportive of wind power have been important in furthering the dramatic growth of wind development in the United States and abroad. Wind power development is influenced by policies affecting demand, policies to reduce the cost of renewables, and policies to incorporate environmental risks into energy prices.

Individual participants pointed out that previous success in public-private partnerships have been demonstrated with the leadership of the DOE-funded Wind Powering America Program at NREL and NWCC, and other groups that have served to disseminate technical information and to build partnerships. Participant comments indicated that their involvement has been important in convening stakeholders and building trust among developers, state and local officials, and members of the local community where projects will be located.

Box 11. Market Development and Public Policies: Common Findings and Themes

Participants provided the following comments:

- Engaging stakeholders effectively would require analyses and studies tailored to different markets, stakeholder groups, and interested parties
- There are diverse, effective policy options on state and federal levels that would lead to a scale-up of wind deployments
- To meet the aggressive deployment targets by 2030, a more stable national energy policy would likely be needed to address the gap between the 20% scenario and current policies
- The U.S. Department of Energy needs to continue sponsoring programs that provide reasonable and accurate technical information relating to wind energy
- Current federal incentives are neither long-term nor stable, and thus do not encourage broad participation and capital formation
- Rigorous comparative energy supply information, analysis, and the resources to disseminate this information are needed
- Power marketing administrations offer a significant opportunity to jump-start progress toward a 20% scale-up

With respect to **national and state policies**, comments suggested that current incentives are not considered long-term or stable, and thus do not likely encourage consistent market participation or capital formation. Individuals stated that consideration and implementation of policies that encourage utilities and other buyers to increase purchases of renewable energy could likely reduce the cost of renewables relative to conventional power options, and incorporation of environmental risks into energy prices would help support the 20% by 2030 scenario.

One policy option that individuals commented on is the establishment of a national climate initiative that would highlight wind (and other renewables) as being an affordable, near-term mitigation strategy to reduce greenhouse gases and other emissions. Complementary policies such as cap and trade programs, a carbon tax, a national renewable electricity standard, and a long-term PTC were suggested by individual

[7] This section presents the documentation of comments received in the breakout group. It does not reflect any particular analyses or endorsements of these policies by DOE.

participants. Comments suggested that a national policy should be considered that would more effectively limit GHG emissions in the electricity sector.

Some participants considered the PTC a needed bridge to a long-term, stable financial mechanism to meet the 20% target. The PTC reduces the effective cost of wind energy production and makes it more cost-competitive with other power sources. The PTC, established in 1992, has expired and been renewed a number of times. In the years that the PTC has been in effect, wind power has grown significantly; however, in years when the PTC has expired, there has been limited investment. Some participants stated that they believe that an affordable, long-term, stable policy with a PTC of longer than 10 years would help ensure sustained growth for a domestic wind manufacturing base. Several individuals considered advocacy for this type of policy instrument important, in addition to conducting an analysis of alternative policy designs. Comments suggested that there is also a need to broaden eligibility for participation in the PTC. For example, if the average residential consumer could utilize the PTC, there would likely be more interest and wider deployments of wind energy.

Box 12. Market Development and Public Policies: Options

Participant comments indicated that the following are policy options:

- Develop options related to a national transmission policy to increase transmission capacity for wind and other renewables
- Establish near-term green power preferences for federal power marketing administration supplemental power purchases
- Develop policy options related to national climate change policies (e.g., carbon tax) and conduct analyses on how it would affect the costs and benefits of wind power
- Establish a longer term (10-year) production tax credit
- Establish a strong national renewable electricity standard
- Develop broad and robust educational programs for K-12, universities, community colleges, tribes, etc.
- Gather a more detailed understanding of stakeholder interests and perceptions to tailor specific messages and dissemination strategies
- Analyze and compare costs and benefits of wind and other electricity sources
- Expand and maintain a pool of technical, financial, and policy expertise to support state, local, and tribal efforts wanting to deploy wind

With respect to **stakeholder education and outreach**, participants suggested that materials, educational programs, outreach plans, and messages through programs such as Wind Powering America should be shared with a wide variety of stakeholders. Individuals stated that it is important to identify and characterize stakeholders and to prioritize the stakeholder groups for outreach efforts. For example, training needs may differ from densely populated areas to remote areas. For specific stakeholder groups, comments suggested that targeted information should be provided, with the possibility of using mainstream media advertising as an outlet. Lessons learned, case studies, fact sheets, wind resource data, and analytical reports are examples of resources that could be made available. Additionally, comments suggested that expanded and new educational and training programs, such as the Wind for Schools program and Wind Application Centers at universities, could help facilitate workforce developments and more student interest in wind power. Participants suggested that university-based coordinators could be engaged to help create and support these centers, which could develop a broad and robust curriculum for K-12 students, community colleges, technical schools, and university programs. These centers could help to host webinars, webcasts, conferences, and workshops. Many engineers currently working in the electrical power industry will soon be retiring, adding to the urgency of wind energy training.

With respect to **technical assistance**, input received suggested that additional support for programs such as Wind Powering America could help maintain and expand the technical and facilitation expertise at the national laboratories and DOE project management centers to support state, local, and tribal efforts for wind power development. The utilization of their expertise to address integration costs, transmission siting and permitting, plug-in hybrids, and distributed wind could help with the deployment of wind power. Individuals commented that these groups should also continue to convene advocates at state summits to help disseminate information, facilitate dialogue on public policies, and engage key stakeholders. It is recommended that DOE provide a long-term commitment for these efforts, along with financial opportunities to sustain dialogues with a broad range of citizen groups and stakeholders.

With respect to **analytical tools**, input received suggested that efforts should be initiated to compare the costs and benefits of various renewable electricity sources, including wind power. Currently, comments indicated that there is a perceived lack of rigorous comparative information and analyses. Participant comments suggested that costs and benefits should be quantified for issues such as water use, integration costs, fuel price stability, emissions, land use and environmental wildlife impacts, subsidies, and human health impacts. As a first step, a literature review to collect and assess existing information could be conducted. Individuals suggested that a framework should be established to compare the various technologies and to identify research gaps and priorities for continued research. Comparing the costs and benefits of various generation technologies could support the decision-making process for investment and development of wind power.

With respect to **federal leadership**, comments suggested that PMAs are in a unique position to help foster the growth of wind power. Each PMA operates as a utility that owns extensive amounts of transmission lines that comments suggested could potentially be used to connect wind generation. For instance, the Western Area Power Administration and Bonneville Power Administration have a large network of transmission lines in areas with significant wind potential. Participant comments suggested that federal legislation encouraging preferences for green power purchases could help to exploit the vast wind resources of PMAs. State-of-the-art mapping resources could also locate key areas where large wind resources exist.

TABLE 7-1. LIST OF PARTICIPANTS – MARKET DEVELOPMENT AND PUBLIC POLICIES

Name	Organization
Jim Ahlgrimm	U.S. Department of Energy
Dwight Bailey	U.S. Department of Energy – National Energy Technology Laboratory
Peggy Beltrone	Cascade County (Montana)
Steve Clemmer	Union of Concerned Scientists
Mike Costanti	Western Community Energy
Seth Dunn	General Electric (GE) Energy
Larry Flowers	National Renewable Energy Laboratory
Robert Gough	Intertribal Council on Utility Policy - WPA Native American
Tom Gray	American Wind Energy Association
Maureen Hand	National Renewable Energy Laboratory
Nancy Jackson	Climate and Energy Project
Ron Lehr	American Wind Energy Association
Larry Mansueti	U.S. Department of Energy - OE
Brian O'Hanlon	U.S. Department of Commerce
Amanda Ormond	Western Grid Group
Ben Paulos	Energy Foundation
Kevin Rackstraw	Clipper Windpower
Allen Rider	25 x 25
Chris Rose	Renewable Energy Alaska Project
Liz Salerno, Group Spokesperson	American Wind Energy Association
John Sarver	Michigan Energy Office
Dennis Scanlin	Appalachian State University
Roya Stanley	Iowa Office of Energy Independence
Samir Succar	National Resources Defense Council
Jim Walker	enXco, American Wind Energy Association
Wayne Walker	American Wind and Wildlife Institute (AWWI)
Ryan Wiser	Lawrence Berkeley National Laboratory
Brian Marchionini, Facilitator	Energetics Incorporated

TABLE 7-2. MARKET DEVELOPMENT AND PUBLIC POLICY NEEDS

National and State Policies	Leadership	Technical Analysis and Assistance to Policy Makers and Energy Stakeholders	Cost and Benefit Analysis Tools	Stakeholder Education and Outreach
• Pursue national climate policy (e.g. cap & trade, carbon tax) – Near-term; Leads: NGOs, AWEA and Allies; Supporting: DOE supporting analysis, State and local governments pursuing climate policies – Seamless policy on pre-climate change in the mid-term – Long-term PTC and RES to send market signal • National transmission policy to increase transmission capacity for wind and other renewables – Near-term; Leads: DOE/FERC; Support: state government and PMAs • Establish a 10-year PTC – Near-term; Leads: Leg. champions in Congress, AWEA ← Advocacy lead, Industry and Allies ← Analysis lead, NGOs ← both advocacy and analysis; Supporting analysis: DOE • Establish a strong national renewable electricity standard (Need – long-term, stable policy) – Near-term; Leads: NGOs and AWEA → Advocacy outreach, Legislative champions – Policy proposals; Supporting analysis: DOE and NGOs • Manufacturing policies – Develop domestic supply – Potential for export – Analyze effects of incentives – Partner with federal, state, and private manufacturers • Allow for greater "middle-class" investment in wind development "New Energy Bonds" re: incentives • Develop state and federal policy to facilitate	• "Greenpower" preference for federal PMA supplemental power purchases – Near-term; Lead: DOE; Support: industry, NGO consumer advocate • Examine new and improved roles for PMAs • Establish inter-agency wind coordinating group, e.g., siting benefits • Technical DOE people to carry message to stakeholders – Increase proven education and advocacy capacity at wind powering America • Blown down federal silos • Need national leadership • Provide impartial data in siting processes, DOE (DOE being a reference)	• State/local policy support including state wind working groups (robust technical and financial assistance) – Near-term; Lead: States, Support: DOE • Targeted information to consumer owned utilities decision makers • Deployment – beef up NREL/WPA's existing capacity to coordinate/catalyze efforts in and between/among states • Identify and remove barriers to offshore wind • Review the roles and requirements for Electric Cooperatives and Municipalities – Evaluate and utilize vast rural distribution grid • Revise federal lending rules that incentivize wind energy loans	• Quantify impacts/benefits of wind energy relative to other technologies – Near-term; DOE lead; universities and national lab support • Industry needs to survive without incentives • Analyze costs and benefits of 25x'25 RPS (esp. benefits, in response to EIA analysis of RPS cost impacts) – Articulate comparative energy impact information • Comprehensive analysis on all energy subsidies	• Define stakeholders, their interests, and craft specific messages; outreach plans – Near-term; Lead: DOE; Support: Industry and states • Empower states to grow their strengths, i.e., offshore workforce dev. – by focusing WPA technical assistance – Near- to mid-term; Lead: DOE, Support: States and NGOs • Broad and robust educational program from K-12, university, and community collects and tribes – Near-term; Lead: DOE; Support: Industry and states • Engage regional and national groups • State PUC decision-support information gathering • Metrics to gauge effectiveness of education and outreach programs • Disseminate information for market acceptance of distributed wind

National and State Policies	Leadership	Technical Analysis and Assistance to Policy Makers and Energy Stakeholders	Cost and Benefit Analysis Tools	Stakeholder Education and Outreach
electric hybrid vehicles integration with grid and wind energy – Analyze impact of hybrid electric plug-ins on 20% scenario • Pursue and develop a national renewable electricity standard (RES) • Work with Department of Treasury to analyze and evaluate financing options for long-term (multi-year) PTC – Analyze and evaluate a national RPS • Analyze and evaluate a state RPS on the market • Develop effective small wind policies – Establish consumer friendly consumer financing programs • Set a price floor for oil • Make transmission interconnection and delivery hurdles higher in exchange for value (current queue process not conducive for 20%) • Consider public benefits funds – Feed in tariffs • Develop model zoning ordinances • Need to retire coal in place of wind				– Define what community wind is and then create community wind specific incentives • Tailored stakeholder education (there are 12 stakeholder groups in 20% document) – Wind for counties and townships • Advertising about wind power in main stream media

Table 7-3. Select Individual Suggestions for Addressing Market Development and Public Policy Needs

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables (multi-year outlook)	Resources Including Special Labs, Tools and Data Needs	Suggested Total Funding $1-5 million >$5 million >$10 million	Immediate Next Steps
Compare costs/benefits of electricity sources	• Quantify costs and benefits of wind and other electricity generation technologies including criteria such as – Water use – Integration costs – Fuel supply stability – Emissions – Land use including environmental wildlife impacts – Subsidies – Human health impacts	• 1) Compile and assess existing information including National Academies of Sciences study – comparative table • 2) Establish framework for comparing technologies • 3) Identify research gaps and areas for continued research • 4) Transparent methodology and comparison of generation technologies	• DOE National Laboratories • National Academy of Sciences • National Institutes of Health • Data Needs – Human health impacts – Wildlife impacts – Habitat impacts – Life-cycle impacts including supply chain and production, extraction, and waste treatment and storage	• $3 million annual for five years • ~8 FTE annually • Does not include fundamentally new research studies	• Convene scoping group – Explore linkages with National Academy of Sciences and similar efforts
PTC long term extension (e.g., 10 years) • Bridge to other/permanent national policies (e.g., national RPS, climate policy)	• Need affordable, long-term, stable policy to enable sustained growth in U.S. manufacturing and development • Proven tool to be used as a bridge to long-term policy • Easy to use, broad participation (other principles)	• 1) Advocate and build support for policy • 2) Analysis of different approaches – Duration – Tradability – Accessibility – Declining value over time – How to pay for it (CO_2 allowance revenues, SBC, budget offset) – Other types of incentives – Combined with other policies	• DOE/lab staff time and expertise to analyze alternative designs	• Analysis – $1-5 million • Advocacy > $5 million	• All tasks • Need to pursue extension in the next Congress and Administration

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables (multi-year outlook)	Resources Including Special Labs, Tools and Data Needs	Suggested Total Funding $1-5 million >$5 million >$10 million	Immediate Next Steps
		• 3) Analysis of comparative subsidies and benefits of longer term extension			
Pursue national climate policy (e.g., cap and trade, carbon tax)	• Wind is an affordable near-term climate solution • 20% wind by 2030 will make important contribution to U.S. climate targets • Need to combine with other policies to bridge to climate policy as carbon prices increase	• 1) Advocate and build support for specific provisions for wind in climate bill – Allowance revenues to fund transmission, deployment, PTC, manufacturing incentives, working training, R&D, storage • 2) Allocation of allowances need to recognize benefits of wind • 3) Analysis of different proposals and design variations that benefit wind • 4) Outreach to key constituencies	• Staff time for policy and cost benefit analysis • Outreach • Ad/media budget • Models/tools needed to analyze impacts	• >$10 million	• Description of specific provisions needed for wind • Legislative champions for wind provisions
Establish strong national renewable electricity standard	• Affordable, long-term, stable policy to establish U.S. manufacturing, make a down payment on climate, and enhance national security	• 1) Advocate and build support for policy • 2) Analysis of costs and benefits and impacts • Analysis of how RES could work with PTC extension, climate policy, and state RESs • 4) Impact on building U.S. manufacturing	• Staff time for analysis • Analytic budget • Ad/media budget • Outreach to key constituencies (agriculture, labor, utilities, wind industry) • DOE/EIA/Labs modeling of impacts/benefits	• >$10 million	• Analysis of potential proposals • Identify and cultivate champions in Congress • Outreach to build support

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables (multi-year outlook)	Resources Including Special Labs, Tools and Data Needs	Suggested Total Funding $1-5 million >$5 million >$10 million	Immediate Next Steps
		capacity/jobs • 5) Analysis of different approaches/designs • 6) Outreach to key constituencies (e.g., labor, manufacturing, utilities, etc.)	– Improvements to models and assumptions needed		
Broad and robust educational and training programs from K-12, university, technical, and community colleges including: – BIA (tribal) – Land grant colleges	• Broad and robust educational and training program	• Expand "Wind for School" program to 35 states • Establish "Wind Application Centers" at 35 state universities • Develop broad and robust curricula for K-12, community colleges, technical schools, and university programs • Develop multi-level programs • Use technology to disseminate information • Energy state-based facilitators to create and support the development of state-based program • Engage university based coordinators to create and support the development of "Wind Application Centers" • Use established federal, regional,	• Broad and robust curricula and lesson plans • Teacher workshops • Webinars, webcasts • National conference • Local, state, and national forums for technology transfer • National Renewable Energy Education Initiative • Educational scholarships • Teacher scholarships • Union re-training programs	• $2M/year over 10 years; >$10M • Timeline: short time frame start-up/continuation need with long term, predictable support	• Scale-up and expand "Wind for Schools" program

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables (multi-year outlook)	Resources Including Special Labs, Tools and Data Needs	Suggested Total Funding $1-5 million >$5 million >$10 million	Immediate Next Steps
		state, and local agencies and organizations			
Define stakeholders, their interests, and craft specific messages; outreach plans	• Identify and impact national, state, local, and regional stakeholders and supply them with targeted information	• Identify and characterize stakeholders • Prioritize groups for outreach • Supply targeted information • Collaborate with established state, regional, and local networks • Evaluate outreach effectiveness • Leverage other federal Agency support to collaborate	• Objective, peer-reviewed data and information • Effective website • Analytical tools • Tailored reports • Wind resource data • Cost and benefit comparison • Industry experts • Lessons learned • Wind Working Groups • Industry Reports (Objective) • Effective human capacity of national, regional, state, and local levels • Technical resources (UWIG, NWCC, ASEA and specialists) • "Technical Assistance Program" (TAP) • Inter-Agency working group	• $5 million/year over 10 years; $50 million • >$10 million • Timeline: short time frame start-up/continuation need with long-term, predictable support	• Scale-up and expand Wind Powering America Program • Convene Inter-Agency Working Group • Collaborate with regional organizations <u>Stakeholders</u> Legislators Regulators Advocates Ag Sector Utilities Landowners Governors Mayors State Energy Offices County Commissions Supply Chain Developers Universities/Educators Native Americans

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables (multi-year outlook)	Resources Including Special Labs, Tools and Data Needs	Suggested Total Funding $1-5 million >$5 million >$10 million	Immediate Next Steps
National transmission policy to increase transmission capacity for wind and other renewables	• "WPA II" • "Rebuild America, First" • "Green-build America, First" • "If you love wind, you've gotta (at least) like transmission" • It's national security • It's energy security • "Protecting natural resources for/with future generation(s)" • New National Transmission can also "electrify" railroads (freight and passenger trains)	• Define: "A National Highway Equivalent" • Strengthen Fed/state partnerships • Assure rights of way and cost allocation recovery • "Multi-jurisdictional rights of way"	• Design by transmission planners under order 890 FERC rules • WGA → WECC • MGA → MISO/PJM • MISO "20% plans" and co-locating new national transmission with existing railroads, highway, transmission rights of way	• $50-100 BB • 1/7th of "Bailout" • 1/7th of Annual $700 BB foreign oil (Pickens Plan)	• Identify stakeholders • Make this a White House priority by 2009 • Develop federal policies and Congressional legislation by 2009 • U.S. DOE/FERC rules and $ funding by 2009-2010 • Siting by 2011 • Cost allocation/recovery by 2011-2012 • New transmission policy to support 20% wind by 2012
Green power preference for federal PMA supplemental power purchases	• "Recharging national energy grid" • "Deliver power from government instrumentalities" • "Wind preference is good for all Americans" • "It's national and energy security" • "Green Power Preference" • "Saving water and protecting natural resources for future generations"	• State federal preference through federal legislation • Expanding BPA, TVA, WAPA authorities: – Borrowing/bonds – Trans. policy – Siting requirements – Purchasing wind power with financeable power purchase agreement – Delivering wind power	• NREL resource mapping		• "Reed/Ensky" approach let the private sector build It • If you don't get it done – BPA, TVA, WAPA will • Require integrated resource planning

Suggested Actions	"Sound bite" Descriptions	Key Tasks and Deliverables (multi-year outlook)	Resources Including Special Labs, Tools and Data Needs	Suggested Total Funding $1-5 million >$5 million >$10 million	Immediate Next Steps
Maintain and expand the technical and facilitation expertise at the national labs and project management centers to support state, local, and tribal efforts; Provide financial support to support state, local, and tribal efforts	• Expand existing capacity, i.e., Wind Powering America, to coordinate and support state, local, and tribal efforts to achieve 20% wind vision • Need a "surge"	• Maintain support and expand wind working groups and regional collaborations, e.g., transmission and workforce development • Strong state WWGs set and achieve MW goals, spurred by DOE analysis • Transmission plans completed in and among states (regions) • Training and education programs for wind engineers, manufacturing, O&M in place at universities and technical colleges	• National lab expertise in a variety of areas, e.g., integration costs, transmission, siting, plug in hybrids, distributed wind • Continue to convene states (and advocates) at State summits . . . crucial connection/ information opportunity	• >$10 million over five years	• DOE long term commitment for state, local, and tribal support and expertise and capacity at national labs • Beef up technology acceptance efforts focused on state, local, and tribal organizations

Appendix A – List of Acronyms and Abbreviations

ACE – area control error
AEWC – Advanced Engineered Wood Composites
AIA – Aerospace Industries Association
AFWA – Association of Fish and Wildlife Agencies
API – American Petroleum Institute
ASEA – American Society of Engineers and Architects
AWEA – American Wind Energy Association
AWWI – American Wind Wildlife Institute

BB – billion
BIA – Bureau of Indian Affairs
BMP – best management practices
BPA – Bonneville Power Administration
BOP – Balance of Plant
BWEC – Bats and Wind Energy Cooperative

CBM – condition-based monitoring
COE – cost of energy
CREZ – Competitive Renewable Energy Zones

DAQ – data acquisition
DB – database
DHS – U.S. Department of Homeland Security
DNV – Det Norske Veritas
DOD – U.S. Department of Defense
DOE – U.S. Department of Energy
DSIRE – Database of State Incentives for Renewables and Efficiency
DT – drive train
DW – distributed wind
DWT – distributed wind technology

EERE – Office of Energy Efficiency and Renewable Energy
EIA – Energy Information Administration
EIS – environmental impact statement
EMF – electromagnetic fields
EPRI – Electric Power Research Institute
ESCS – Energy Systems Consulting Services

FAA – Federal Aviation Administration
FAC – Federal Advisory Committee
FACA – Federal Advisory Committee Act
FERC – Federal Energy Regulatory Commission
FTE – full-time equivalent
FWS – Fish & Wildlife Service

GHG – greenhouse gas
GIS – geographic information system
GRC – Gearbox Reliability Collaborative
GS3C – Grassland/Shrub-Steppe Species Collaborative
GW – gigawatt

HALT – high amplitude load testing
HCF – high cycle fatigue

IEC – International Electrotechnical Commission
IEEE – Institute of Electrical and Electronics Engineers
INL – Idaho National Laboratory
IRS – Internal Revenue Service
ISO – independent system operator
ITC – investment tax credit

kW – kilowatt
kWh – kilowatt-hour

LBNL – Lawrence Berkeley National Laboratory
LiDAR – light detection and ranging

m – meter
MGA – Midwestern Governors Association
MISO – Midwest Independent System Operator
MMS – Minerals Management Service
MOU – Memorandum of Understanding
MW – megawatt

NASA – National Aeronautics and Space Administration
NCAR – National Center for Atmospheric Research
NEPA – National Environmental Policy Act
NERC – North American Electric Reliability Corporation
NEXRAD – next-generation radar
NGO – nongovernmental organization
NOAA – National Oceanic and Atmospheric Administration
NREL – National Renewable Energy Laboratory
NWCC – National Wind Coordinating Collaborative
NWP – numerical weather prediction
NYC – New York City

O&M – operations and maintenance
OE – Office of Electricity Delivery and Energy Reliability
OEM – original equipment manufacturer
OMB – Office of Management and Budget

PEV – plug-in electric vehicle
PHEV – plug-in hybrid electric vehicle
PID – proportional-integral-derivative
PJM – PJM Interconnection
PMA – power marketing administration
PPA – power purchase agreement
PPT – PowerPoint
PR – public relations
PTC – production tax credit
PUC – Public Utility Commission
PV – photovoltaic

R&D – research and development
RAM – reliability, availability, and maintainability
RES – renewable electricity standard
RFP – request for proposal
ROI – return on investment
RPS – renewable portfolio standard

RTO – Regional Transmission Organization
RUS – Rural Utilities Service

SBC – system benefits charge
SCADA – supervisory control and data acquisition
SNL – Sandia National Laboratories
SODAR – sound detection and ranging
SWT – small wind turbine

TAP – Technical Assistance Program
TVA – Tennessee Valley Authority

USDA – U.S. Department of Agriculture
USOWC – U.S. Offshore Wind Collaborative
UWIG – Utility Wind Integration Group

VRM – visual resource management

WAPA – Western Area Power Administration
WECC – Western Electricity Coordinating Council
WGA – Western Governors' Association
WHTP – Wind and Hydropower Technologies Program
WPA – Wind Powering America
WWG – Wildlife Workgroup

Appendix B – Workshop Agenda

Wind and Hydropower Technologies Program Workshop

20% Wind Energy by 2030: Meeting the Challenges Workshop

October 6-7, 2008
Doubletree Hotel Crystal City-National Airport

Agenda

PURPOSE OF THE WORKSHOP
To collect comments from all participants on possible solutions and actions that identify the challenges, needs, priorities, timeframes, and the respective roles of government, industry, universities, and other stakeholders supporting the achievement of 20% wind energy by 2030.

DAY ONE: MONDAY, OCTOBER 6, 2008

7:30 a.m. **Registration and Continental Breakfast**, *Salon BC*

9:00 a.m. **Welcome**
Steve Lindenberg, Senior Advisor, Renewable Energy, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy (DOE)

. **Opening Remarks**
John Mizroch, Acting Assistant Secretary for Energy Efficiency and Renewable Energy for DOE

9:15 a.m. **Overview of DOE's Wind Energy Program**
Megan McCluer, Program Manager, DOE Wind and Hydropower Technologies Program

9:30 a.m. **Results of the U.S. Wind Manufacturing Workshop**
Lisa Barnett, DOE Wind and Hydropower Technologies Program

9:45 a.m. **Keynote: 20% Wind Energy by 2030**
Jim Walker, Vice Chairman of the Board, enXco, Inc., and President, AWEA Board of Directors

10:15 a.m. **Break**

10:45 a.m. **Wind Energy – Perspectives on Where we are Today and Possibilities for the Future**
(A panel of industry expert presenters)

- **Large Land Based and Distributed Wind Technologies**
  Robert Poore, President, Global Energy Concepts
- **Grid System Interconnection**
  Charlie Smith, Executive Director, Utility Wind Integration Group
- **Environmental Risks and Siting Strategies**
  Wayne Walker, American Wind and Wildlife Institute
- **Market Development and Public Policies**
  Ron Lehr, Attorney, American Wind Energy Association
- **Offshore Wind Technologies and Siting Strategies**
  Peter Mandelstam, President, Bluewater Wind

12:15 p.m. **Breakout Session Instructions**
Bonnie Ram, Energetics Incorporated
Participants will move into their breakout groups following lunch.

12:30 p.m. **Lunch**, *Lincoln Hall*

1:45 p.m. **Breakout Session #1 – Situation Analysis and Review of Barriers to Achieving 20% Wind Energy by 2030**

- **Land-Based Large Wind Technologies**, *Red Group, Van Buren Room*
  Focuses on land-based utility-scale wind technology R&D which will enable wind to enter the electric power mainstream and enable the technological advancements required under the 20% Wind Scenario.
- **Distributed Wind Technologies**, *Blue Group, Wilson Room*
  Focuses on the diverse number of distributed wind technologies thriving as well as continued technological advancements necessary to achieve the 20% Scenario.
- **Offshore Wind Technologies and Siting Strategies**, *Black Group, Madison Room*
  The discussions will address a broad vision that includes technology R&D needs as well as regulatory approaches, environmental research, and siting strategies which would be necessary to implement offshore wind.
- **Grid System Interconnection**, *Yellow Group, Pentagon I & II*
  The 20% Wind Scenario would require the continuing evolution of transmission planning and system operations, in addition to expanded electricity markets and cost-effective storage options.
- **Environmental Risks and Siting Strategies**, *Green Group, Monroe Room*
  In today's carbon-constrained world, wind plant siting and approval processes must accommodate increased rates of installation while addressing environmental risks and concerns of local stakeholders.
- **Market Development and Public Policies**, *Orange Group, Jefferson Room, 15th Floor South Tower*
  Wind power serves almost all large-scale utility markets and smaller scale community-based projects are playing an increasing role in some regions. However, markets would need to expand significantly to achieve the 20% Scenario. Public policies enabling a scale-up of wind developments are critical for success and will be a focus of this session.

2:45 p.m. **Break**

3:00 p.m. **Breakout Session #2 – Reviewing/Determining the Needs to Achieve the 20% Scenario**
Participants will continue in the breakout groups.

5:30 p.m. **Adjourn Day 1**

5:45 p.m. **Evening Reception**, *Windows Over Washington*
Sponsored by the American Wind Energy Association (AWEA)

DAY TWO: TUESDAY, OCTOBER 7, 2008

7:30 a.m. **Continental Breakfast**, *Salon BC*

8:30 a.m. **Breakout Session #3 – Executing the Priority Needs: Preparing the Action Agenda for Addressing the Needs to Achieve the 20% Scenario**

10:00 a.m. **Break**

10:15 a.m. **Breakout Session #3 (continued) – Continue Preparing Action Agenda**

10:45 a.m. **Breakout Session #4 – Prepare Breakout Session Summary Reports**

12:00 p.m. **Lunch and Closing Plenary Session**, *Salon BC*

- Breakout Session Summary Reports
  - **Land-Based Large Wind Technologies**
    Larry Willey, Manager of Wind Conceptual Design, General Electric
  - **Offshore Wind Technologies and Siting Strategies**
    Mary Hunt, Director of Special Projects, The Strategic Energy Institute at Georgia Tech
  - **Distributed Wind Technologies**
    Tom Wind, Owner, Wind Utility Consulting
  - **Grid System Interconnection**
    Steve Beuning, Director of Market Operations, Xcel Energy
  - **Environmental Risks and Siting Strategies**
    Laurie Jodzewiecz, Manager of Siting Policy, American Wind Energy Association
  - **Market Development and Public Policies**
    Elizabeth Salerno, Policy Analyst, American Wind Energy Association
- General Discussion of Gaps and Overlaps

2:15 p.m. **Closing Remarks: Way Forward**
Megan McCluer, Program Manager, DOE Wind and Hydropower Technologies Program

2:30 p.m. **Adjourn**

Appendix C – Workshop Participant List

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Appendix D – 20% Summaries: Situation Analysis and Barriers[8]

D.1 Large Land-Based Wind Technologies: Introduction to the Breakout Session

Key Targets/Situation Analysis:

- Reduce capital cost by 10%
- Increase capacity factor by 15%
- Increase installed capacity from today's 5GW/yr to 16GW/yr in 2018
- Improve overall technology, not a huge leap from current level

Key Barriers:

- Blade:
  - Transportation logistics is a challenge
  - No domestic facility to test 50m+ blades
  - Lack of facilities to test advanced blade prototypes
  - Fiberglass demand far exceeds supply; no cost-effective alternative
- Rotor:
  - Increasing swept area also increases loads
  - Cost of larger turbine grows faster than resulting energy output
  - Larger rotor will create transportation constraints
  - Large crane lifting and terrain limitations
- Controls:
  - System dynamics are complex
  - Feed-forward and adaptive controls are not mature
- Drive Train:
  - High gearbox failure rate
  - Limited operational and R&D data in the public domain
  - Bearing dynamics and reliability are not well understood
  - Limited domestic test facility for large components
- Tower:
  - Tall and wider tower complicates transportation and logistics
  - No cost-effective, light towers

[8] Appendix D contains materials presented by DOE Staff in the workshop breakout sessions. Comments made by individual workshop participants on these materials are summarized in the tables presented in this Appendix.

TABLE D-1. GENERAL COMMENTS ON THE SITUATION ANALYSIS AND BARRIERS – LARGE WIND

Comments on the Targets/Situation Analysis	Comments on the Barriers

• Rapid advances are needed to improve reliability and lifetime
• Doubling the life of drive train is *not* “incremental”
  – however, this is a natural engineering progression
• Set target for lifetime?
• Step-function improvements in reliability can be achieved by incremental changes in technology
• Reliability and lifetime will be an ongoing challenge
	• Actual lifetime ≠ rated capacity
	• Do not have good characterization of inflow to turbine
	• Unclear what is causing blades to fail
	• Structural models used today do not scale with size
	• Lack of detailed field information of how turbines perform in large arrays
	• Inflow in wind power plants → more data needed
	  – Simultaneous and comprehensive
	  – Government/NGO/industry collaboration project?
	• We do not understand what to ***design to***
	  – How turbines interact with each other
	  – Inflows, etc.
	  – Siting impacts (microclimatology)
	  – Impacts on performance and reliability
	  – Large wind plant analysis that whole industry can benefit from
	  – Collecting this data is expensive
	• Air acoustics will become more of an issue with siting closer to load centers
	• Lack of good engineers! → Improve education

D.2 Distributed Wind Technologies: Introduction to the Breakout Session

Definitions:
Distributed Wind Technology (DWT) applications refer to turbine installations on the customer side of the utility meter or near the point of use. These machines range in size from less that 1 kW to multi-megawatt, utility-scale machines and are typically used to offset electricity consumption at the retail rate.

Small Turbine Technology is a subset of DWT and refers to wind systems rated at 100 kW or less.

Key Targets/Situational Analysis:

- Under the 20% scenario, DWT is part of the land-based deployment, contributing to over 300 GW of wind capacity by the year 2030.
- Utility scale DWT requirements are similar to those for other large-scale turbines; however they also have unique operating requirements.
- U.S. manufacturers are world leaders in small wind system in terms of market share and technology.
- Small wind systems R&D will develop new technologies to include gearboxes, mechanical brakes, induction generators, upwind rotors, active yaw control, stall rotor-control, variable pitch or hinged blades.
- Significant developments in DWT systems will provide:
  - Alternative power and load control strategies to produce safer and quieter turbines
  - Advanced manufacturing methods and technology to ensure that U.S. factories are competitive in the international market
- DWT will assist community stakeholders to develop, revitalize and diversify the local economy.
- DWT will build on numerous successful DWT projects installed by schools, universities, rural electric coops, municipal utilities.

  Examples are:
  - Wind/diesel projects in Alaska, such as Kotzebue
  - Iowa Lakes Community College
  - Mass Maritime Academy on Cape Cod, MA

Key Barriers:

- Tower and foundation costs are a large portion of DWT installed cost, especially for < 20 kW turbines.
- Reliability of single, widely scattered installations require simple design, ease of repair, with long maintenance and inspection intervals.
- Acoustic emissions are significant acceptance and zoning issues because DWT installations are usually close to workplaces and residences.
- Technology for low-wind speed applications must be improved because DWT is usually located in areas with low wind speeds that are unsuitable for utility-scale applications.
- Financing is problematic for small developers and small communities; for example, REPI is over allocated.
- Boom and bust economic cycles/policies result in inconsistent markets.
- Education and training is not providing a cadre of wind-smiths, engineers, and policy makers.
- Supply of large turbines is inadequate and minimum number required for turbine purchase order is excessive.
- A newly designed DWT specific mid-size turbine, 200 kW to 1.0 MW, is required.

Additional Resources:

- AWEA Small Wind Roadmap
- AWEA 2008 Small Wind Global Market Study
- NREL Distributed Wind Market Applications

TABLE D-2. GENERAL COMMENTS ON THE SITUATION ANALYSIS AND BARRIERS – DISTRIBUTED WIND

Comments on the Targets/Situation Analysis	Comments on the Barriers	Other Comments

• Storage is an issue for small off-grid systems
• Airfoil development for small wind systems (R&D)
• Feed-in tariff – for small wind .25/kWh
• Midsize 60 GW
  – 100 kW → 1GW by 2030
• Small: 30 GW
  – up to and through 100 GW by 2030
	• Lack of small wind standards (testing and certification)
	• Lack of net metering policy – economics
	• Lack of aggregated net metering policies
	• Lack of zoning – requests for zoning permits (good zoning)
	• Lack of federal government subsidies
		• 2030 is a near term milestone – look to longer term milestones (storage)

D.3 Offshore Wind Technologies and Siting Strategies: Introduction to the Breakout Session

Key Targets/Situation Analysis:

- Under the 20% scenario, offshore wind technology would account for about 18% or 54 GW of total wind capacity by 2030
- With EPACT2005, Congress delegated authority to grant easements, leases, or rights-of-way in coastal waters to the MMS under the DOI
  - MMS in process of developing proposed rulemaking along with programmatic EIS
- Currently, 26 projects are installed in the North and the Baltic Seas in eight nations with a combined capacity of more than 900 MW
  - More than 280 research studies and assessments are examining environmental and human effects from installed offshore wind installations
- The U.S. does not yet have any commercial-scale offshore wind power sites
  - Proposed offshore wind energy applications include:
    - Nantucket Sound
    - Long Island Sound
    - Galveston, TX
    - Delaware
    - Boston Harbor
    - Buzzards Bay, MA
    - Off coast of Savannah, GA
- Larger turbines are expected to become more common (4 to 6 MW) for offshore wind turbines with capacity factors between 40% and 50%

Key Barriers:

- Cost of offshore wind power is 40% higher than land-based wind turbines
- Higher power costs attributed to added complexity of siting turbines in a marine environment, higher foundation and infrastructure costs, and higher M&O
- Technology, markets, and policy uncertainties are limiting deployment of offshore wind
  - Uncertainties with regards to permitting requirements in federal waters

TABLE D-3. GENERAL COMMENTS ON THE SITUATION ANALYSIS AND BARRIERS – OFFSHORE

<table>
<tr><th>Comments on the Situation Analysis</th><th>Additional Barriers</th></tr>
<tr><td>

Avoid referencing 40-50% capacity factors; this is high and may set unrealistic expectations
Avoid specifically stating a figure for % higher cost for offshore wind, as costs are heavily site-specific – saying “generally higher” is acceptable

</td><td>

Power system integration requirements may be much more severe for offshore fields vs. land-based systems
Problem should be resolved at offshore substation
Insufficient data, models, planning tools to assess energy delivered to grid of wind project (this is an inexact science today)
Great Lakes: coordination with Canadian government and regulations add complexity
Access to financing and insurance for offshore wind a barrier?
Coastal region in U.S. is highly diverse → multiple environments for offshore wind
Lack of national safety standards for offshore wind
Lack of scientific information about how offshore wind affects marine environment
Potential to hold up industry by requiring general EIS and then requiring a site specific EIS
Lack of real data on unique freshwater issues (e.g., ice, bird migrations)
Huge array of siting issues (e.g., duration, scope studies, animal impacts, competing use, etc); MMS document is key interface
Mapping for offshore is very inconsistent
Inconsistent processes and rules across federal, state authorities
Clash between planning vs. developers choosing sites. Will developers have to plan for all offshore/ocean issues?
Availability of equipment and manufacturers for offshore is constrained by land-based boom
DOE has not emphasized offshore in wind program
Must work with MMS as lead agency
Barrier is to ensure MMS understands wind and is not pushed around by oil/gas ties
Great Lakes (Army Corps, not MMS) are considering programmatic EIS for Lakes. Each state will also do distinct review for site-specific EIS.
Cabling in marine environment has barriers
Lack of knowledge and understanding about offshore wind among public
Lack of open, transparent competitions that result in PPAs that can be financed
Workforce is not trained for building efficient projects
RPS, trading programs are not inclusive of offshore wind
Ocean commissions may not be aware of or engaged in offshore wind plans
Lack of offshore-specific R&D and testing, especially targeting large turbines and deepwater
Logistics and maintenance costs require increased reliability for offshore systems
Do not understand priority of offshore wind and so cannot/does not attract resources
European lesson: engage local community in process
Some coastal regions will need offshore wind but require development to reduce costs
Some states have no state/local ordinance for offshore wind
Great Lakes – some Army Corps of engineers, other laws that may limit offshore wind
Limited availability of vessels/ships for installation – these must be U.S. built, U.S. flag carriers
Ports and facilities may not be adequate for construction on a state and regional basis (may require $50-90M to create needed infrastructure)

</td></tr>
</table>

D.4 Grid System Interconnection: Introduction to the Breakout Session

Preface:
This breakout session focuses on the challenges covered in Chapter 4, 'Transmission and Integration into the U.S. Electric System'. These talking points strive to provide a useful framework for the breakout session discussions, while recognizing that the framework will not 'cleanly' accommodate the type of needs and recommendations to be discussed; overlaps are inevitable and expected. Further, approaches to address these barriers will be in many cases driven by and provide benefit to broader interests in the nation's electric grid systems.

The challenges of wind energy interconnection are categorized into three major categories: Operations, Planning, and Education and Workforce Development.

Targets/Situation Analysis:

<u>Operations</u>

1. Electric grid system control regions operating with wind energy at levels consistent with achieving 20% wind report levels (over 20% by control area in some cases) must comply with all applicable system reliability standards and criteria.

2. Minimize cost to achieve reliable integration of wind energy at 20% wind report levels.

<u>Planning</u>

1. Maximize use of existing national transmission and distribution system assets to accommodate at least 40 gigawatts of the wind capacity needed for 20% wind report levels.

2. Expand national transmission system capacity to efficiently access remaining wind capacity needed for 20% wind report levels (e.g., approx. 12,000 miles of conventional voltage transmission development; or investment in high voltage interstate transmission backbone with less conventional transmission).

<u>Education and Workforce Development</u>

Ensure sufficient trained personnel available for planning, designing, and operating electric power systems with wind energy penetration at 20% wind report levels.

Barriers:

<u>Operations</u>

Utility analysis methods, operating rules, and practice do not fully exploit most economic opportunities for addressing wind energy variability, uncertainty, dispatchability limitations, and location attributes in each time frame important to utility operations [1. regulation (seconds to minutes), 2. load following [(minutes to hours), and 3. scheduling and unit commitment (hours to days)]

a) Aggregation and geographic diversity
b) Fully utilizing existing system operational flexibility (generation, delivery, and load)
c) Mitigation technologies (e.g., forecasting (esp. utility application), energy storage, advanced grid control (e.g., SmartGrid), wind turbine/plant control and ancillary services)
d) Market and policy mechanisms

<u>Planning</u>

1. Planning for increasing capacity of existing transmission and delivery (T&D) infrastructure requires attention to the characteristics of wind energy.
   a) Policy, regulation, and market rules
   b) Technical ratings process
   c) Advanced technologies

2. T&D infrastructure planning methods, tools, and practice do not yet adequately address operational reliability and planning considerations for wind energy.
    a) Wind plant performance data and models
    b) Validated planning models – probabilistic planning tools
    c) System adequacy and reliability standard compliance

3. T&D infrastructure business case development practice does not yet fully account for wind energy characteristics.
    a) Different line loading and market operation
    b) Cost allocation

4. National, regional, and sub-regional T&D infrastructure planning processes do not yet fully accommodate wind energy development potential.
    a) Regional planning process participation
    b) Regional wind/renewable integration studies

Education and Workforce Development

1. Many current utility planning and operations staff, regulators, policymakers, and other electric power system stakeholders are not sufficiently competent in methods, tools, and experience for most reliable and economic integration as-available generation.

2. Current academic and workforce training pipelines are not positioned to deliver sufficient appropriately trained personnel to meet projected demand for wind energy integration expertise.

TABLE D-4. GENERAL COMMENTS ON THE SITUATION ANALYSIS AND BARRIERS – GRID SYSTEM INTERCONNECTION

Comments on the Situation Analysis	Comments on the Barriers
• While there is a long way to go and many improvements are needed, it is critical to recognize the progress that has been made. Now is the time to build on the successes, not abandon it. For example: – Major improvements have been made since ~2002 due to heightened awareness and growing numbers of installations, integration studies, and working group discussions. – Communications is expanding between wind developers and grid operators with a much greater understanding about what needs to be done. – NERC, ISOs, and IEEE are engaged to a greater extent than ever before. – We are gaining more experience regionally, such as the efforts in Texas, which is a single control area, and where frequency swings have been a cause for concern with rising wind installations. – Progress has also been made in Southern California with experience gained in sizing and operating substations that connect to wind plants in the Tehachapi Pass. • More long distance transmission is obviously a major requirement, but it takes at least seven years to bring a major project on line. • ACE diversity interchanges in the West have been helpful for evaluating/operating wind resources. • Information sharing activities have tremendous value in replicating successes and avoiding repetition of mistakes.	• In the west, a proliferation of balancing authorities/control areas exists, and even "wind only" balancing authorities have emerged. • Regional planning is coming more slowly than needed; efforts are still too fragmented due to a dearth of leadership in bringing stakeholders together. • ISOs/RTOs tend to continue to evaluate wind development from a narrow perspective rather than system-wide. • While there is significant progress in utility-specific wind integration studies, more regional ones are needed. • Existing electric resource planning models and grid analysis tools have significant limitations in assessing wind power deployments. • Transmission planning, siting, permitting, cost allocation and recovery, and tariff structures have problems that interfere with the development of wind power. • Conventional generators lack flexibility for ramping up and down to accommodate greater penetration of wind power and other variable resources.

D.5 Environmental Risks and Siting Strategies: Introduction to the Breakout Session

Situation Analysis:

- The cumulative life-cycle impacts of wind generation compared to fossil fuel and nuclear projects are not well documented and quantified.
- The local and regional impacts of turbine collisions on birds and bats and their reproductive habitats will be much lower than the global extinction of whole species from climate warming.
- Decision-making processes need more flexible adaptive management strategies to account for technological advances and lessons learned.
- The aesthetic reactions to wind turbine plants are mixed and subjective.
- While private property land values and revenues will increase for the “haves” from lease payments, the “have-nots” fear declining property values from the visual impacts of wind plants on neighboring properties.
- Local, state, and federal siting authorities and decision-makers frequently lack the highly technical knowledge to evaluate wind projects for new projects in their jurisdictions.

Key Barriers:

- Incomplete/inaccurate information and needed scientifically-credible siting studies
- Showcase projects in “stuck states” that can dispel wind turbine myths such as excessive sound levels
- Better organized and funded project opponents and/or poorly organized and underfunded supporters
- Shortage of articulate and independent honest-broker sources of technical information
- Early and proactive involvement of affected communities in identifying concerns and addressing them
- Inadequately trained and understaffed governmental decision-making bodies at all levels of government
- Multiple governmental regulatory and permitting agencies with inconsistent, evolving, cumbersome, time-consuming, and/or cost-prohibitive requirements

Table D-5. General Comments on the Situation Analysis and Barriers – Environmental Risks and Siting

Comments on the Situation Analysis	Comments on the Barriers
• It is important to avoid, minimize, or mitigate the impacts on wildlife or wildlife habitats. • Life-cycle positive and negative impacts including carbon emissions and water consumption on electricity generation are not well documented or quantified. • Siting authorities lack adequate staff and technical knowledge. • No national strategy or goal for wind energy exists. • Authorities have no mechanism for landscape – level cost/benefit analysis. • Not enough honest technical information for siting is readily available for the public. • A lack of transparency to address multiple siting issues exists.	• Incomplete/inaccurate information in siting wildlife and habitat impacts • Lack of legislation preventing arbitrary decisions at all levels • No evaluative method for the impact on and reactions by the public • Vague regulatory authority and lack of consistent framework to evaluate habitat impact • Lack of early and proactive involvement of affected communities in identifying concerns and addressing them

D.6 Market Development and Public Policies: Introduction to the Breakout Session

Situation Analysis/Targets:

- Projected 40 percent demand increase for electricity by 2030
- Existing generation facilities are aging and being retired
- Industry susceptible to fossil fuel price volatility (e.g., natural gas)
- Customer preference for renewable energy increasing
- Wind industry trend toward larger wind turbines and bigger projects
- Growing interest in offshore wind energy development
- Possible shift toward using electricity for transportation
- Policy options
    - Compliance driven – renewable portfolio standards and renewable purchase goals from federal government (current state RPS policies call for 55 GW of new renewable by 2020)
    - Policies to reduce renewable energy cost – production tax credits, investment tax credits, accelerated depreciation
    - Voluntary or green power markets – purchasing of renewable energy credits by large nonresidential customers
    - Air quality markets – cap and trade programs to control air pollution

Challenges:

- Global perspective – many countries considering large amounts of wind energy
- Stable, consistent policy
- Workforce development
- Current policies do not take full account of wind's clean energy benefits
- Federal government is largest electricity consumer in world (equates to 18 GW of wind at 35 percent cap factor)
- Community wind – strengthens communities, galvanizes support but smaller projects
- Small wind incentives and policy
- Regulatory framework for offshore wind still under development
- Siting and zoning

TABLE D-6. GENERAL COMMENTS ON THE SITUATION ANALYSIS AND BARRIERS – MARKET DEVELOPMENT AND PUBLIC POLICIES

Comments on the Targets/Situation Analysis	Comments on the Barriers
• No single market for wind exists – stakeholders are interested in wind for different reasons. • Diverse effective policy options on state and federal levels address numerous wind markets. • Federal incentives are not long-term, stable, and do not encourage broad participation and capital formation. • Despite a rising interest in wind power, a lot of bad publicity still exists. • Consumers are also susceptible to fossil fuel price volatility – need to have stable $. • Fuel cycles can kill wind. • Wind power can benefit – water management should communicate benefit. • Carbon caps are already in place in California. • Wind is very policy-driven – market intervention could help to level playing field. • Wind is the only technology with one year incentives (solar is more).	• Tremendous gap between 20% goal and current policy • Tribes do not have a level playing field • Trying to figure out what overall mix of fuels will do to policies • Finding ways to engage middle class for wind investment • Federal incentives for community wind projects • Make sure wind is part of climate policy • Still a lot of gaps/barriers in small-medium wind energy • A lot of interest in wind and resources are limited to be able to do outreach including give presentations at state offices, etc. • Wind turbines don't consume water, and we are not communicating this benefit • Cost of wind relative to competitors is uncertain • Different stakeholders have different perspectives • Lack of knowledge about renewables (benefits, etc.) • Public power shift to wind from coal • Do not have ample data to be able to calculate wind integration costs • Do not know what wind integration costs are • Aging radar system not able to deal with thousands of new turbines – air safety, homeland security

Appendix E – Contact Information

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Appendix F – Public Comments Sought under February 26, 2009 Request for Information on Draft Proceedings

The Department of Energy (DOE) Wind and Hydropower Technologies Program (WHTP) sought additional input from the public regarding the 20% Wind Energy by 2030 Workshop and the Wind Manufacturing Workshop proceedings under Request for Information DE-PS36-09GO039008-RFI. Public comments were submitted under the Request for Information (RFI) from February 26 through April 3, 2009.

The WHTP solicited comments and suggestions on all key topics, findings, themes, and suggestions found in the Proceedings of the two workshops. Input was encouraged on possible analytical and R&D pathways which could contribute to the achievement of the 20% Wind by 2030 scenario, particularly in the following areas:

1. Design and manufacture of large wind components
2. Modeling and prediction tools for large wind performance and reliability
3. Design and manufacture of distributed wind systems
4. Offshore wind: reliability, system design and optimization
5. Models and analysis, forecasting tools, and flexible system management technologies for grid system interconnection
6. Integrated risk assessment framework for environmental and siting challenges

The Program received almost 80 responses under the RFI from various entities including developers, investors, industry, other federal and state governments, renewable energy equipment suppliers, electric utilities, independent power producers, environmentalists, academics, and public, private, or non-profit entities.

The information collected may be used for internal DOE planning and decision-making to align future activities under the WHTP with President Obama’s goals for increased use of renewable energy and the creation of domestic jobs.

The full text of the RFI is below.

Request for Information
DE-PS36-09G039008

<u>Program Manager / Area:</u> Megan McCluer, Program Manager, Wind & Hydropower Technologies Program

<u>Information Requested on:</u> Input from the public regarding the proceedings of the 20% Wind Energy by 2030 Workshop and the proceedings of the U.S. Wind Manufacturing Workshop.

<u>Description:</u> The Wind and Hydropower Technologies Program (WHTP) within the Department of Energy's Office of Energy Efficiency and Renewable Energy (DOE-EERE) is leading the nation's efforts to improve the performance and operability of wind energy technologies and lower the costs, to investigate emerging water power technologies, and to enhance the environmental performance and efficiencies of conventional hydropower technologies. To find more information about the WHTP, please visit http://www1.eere.enewpov/windandhydro/wind mvg.html.

The WHTP led the preparation of the *20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply* report. The report, which was released in May 2008, illustrates the feasibility of integrating 20% wind energy with the U.S. electrical grid. The report outlines a scenario in which the United States could reach over 300 gigawatts (GW) of installed wind power by 2030. The scenario presented in the *20% Wind Energy by 2030* report for achieving 20% wind energy by 2030 is by no means a suggested national policy. Given the scale of the scenario and the challenges discussed in this report, the WHTP decided to host two workshops to collect additional individual comments and to build on the recommendations. On August 27-28, 2008, more than 80 wind and manufacturing experts participated in a DOE-EERE WHTP technical workshop on what is needed to strengthen the U.S. wind manufacturing sector in order to support the machines and components for 300 GW of installed wind power by 2030. This workshop addressed challenges for manufacturing large wind blades, rotor s, tower s, foundations, and drive t rains, as well as manufacturing entire systems for distributed wind. The second DOE-EERE WHTP workshop occurred on October 6-7, 2008 with more than 130 wind energy professionals discussing possible research and development (R&D) technology areas and analytical pathways to achieve the scenario outlined in the *20% Wind Energy by 2030* report. This workshop focused on six key wind energy issues: large land-based wind technologies, distributed wind technologies, offshore wind technologies and siting strategies, grid system interconnect ion, environmental risks and siting strategies, and market development and public policies.

The Department of Energy (DOE) is seeking additional input from the public regarding the proceedings of the 20% Wind Energy by 2030 Workshop and the proceedings of the U.S. Wind Manufacturing Workshop. The information presented in the workshops can be found, as attachments, on the IIPS cover page, under the "Supporting Documents/Amendments for this Financial Assistance Opportunity" heading.

The information collected may be used for internal DOE planning and decision-making to align future activities under the Wind & Hydropower Technologies Program with the Administration's goals for increased use of renewable energy and the creation of domestic jobs. Interested parties might include, but are not limited to: developers, investors, industry, Native American Tribes, renewable energy equipment suppliers, electric utilities, independent power producers, environmentalists, academics, and public, private, or non-profit entities.

Request for Information Guidelines: The sole purpose of this Request for Information (RFI) is to gain input from the public regarding the proceedings of the 20% Wind Energy by 2030 Workshop and the proceedings of the U.S. Wind Manufacturing Workshop. This does not constitute a request for specific project proposals. **DOE will not pay for information provided under this RFI, and there is no guarantee that future funding opportunities or other activities will be undertaken as a result of this RFI.**

Please send your response (one attachment only) via email, with the title, "RFI Response" to WindRFI@go.doe.gov. Your response should be limited to 3 pages, submitted in Microsoft Word as an email attachment to the address above and received **no later than 8:00 PM Eastern Daylight Time on 4/03/2009.**

Please include as part of your response, contact name(s), phone number(s), email addresses, organization name, address, and type of business or institution.

RESPONSES WILL NOT BE CONSIDERED CONFIDENTIAL. DO NOT INCLUDE ANY CONFIDENTIAL OR PROPRIETARY INFORMATION IN YOUR RESPONSE.

Questions: Questions regarding the content of this RFI should be submitted via email to http://e-center.doe.gov at the location of this numbered RFI. "RFI Question" should be included as part of the subject line.

DOE reserves the right not to reply to any or all comments or questions submitted under this RFI.

Rationale or Justification: The main purpose of the two Workshops described above was to collect comments from individual participants on possible research and development (R&D) areas and analytical pathways to achieve the scenario outlined in the *20% Wind Energy by 2030* report. The documents from the two proceedings are compilations of these comments and opinions of the participants at these Workshops. More input is invited. The information being sought under this RFI is intended to assist DOE in further assessing barriers and opportunities to the 20% Wind Energy by 2030 scenario.

Requested Information: DOE-EERE WHTP invites comments and suggestions on all key topics, findings, themes, and suggestions found in the Proceedings of the subject workshops. Input is especially encouraged on possible analytical and R&D pathways which could contribute to the achievement of the 20% Wind by 2030 scenario, particularly in the following areas:

1. Design and manufacture of large wind components
2. Modeling and prediction tools for large wind performance and reliability
3. Design and manufacture of distributed wind systems
4. Offshore wind: reliability, system design and optimization
5. Models and analysis, forecasting tools, and flexible system management technologies for grid system interconnection
6. Integrated risk assessment framework for environmental and siting challenges

Thank you. The Department appreciates the time and effort you have put forth in responding to this Request for Information.'

Page 2 of 2