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Perspectives on an NWCC/NREL Assessment of Distributed Wind

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PERSPECTIVES ON AN NWCC/NREL ASSESSMENT OF DISTRIBUTED WIND

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Introduction

During 1998 and 1999, the National Wind Coordinating Committee (NWCC) conducted an assessment of distributed wind power. The project team was led by Princeton Economic Research, Inc., now known as Princeton Energy Resources International (PERI). Financial support was provided by the U.S. Department of Energy (DOE) through the wind energy program at the National Renewable Energy Laboratory (NREL) and the Electric Power Research Institute (EPRI). Project oversight and review were provided by NWCC's Distributed Working Group.

The NWCC is a consensus-based collaborative effort by representatives from all major sectors of the energy community to identify issues that affect the use of wind power, establishe dialogue among key stakeholders, and catalyze activities to support the development of a sustainable commercial market for wind power. Recognizing the expanding interest in and prospects for wind power as a distributed generation source, NWCC defined and undertook this assessment.

The overall objective for the NWCC assessment was to enhance understanding of business, policy, and technical issues associated with the deployment of wind-electric generating systems in the distributed-generation mode. In general, that mode is defined by placement of the generation close to customers–in contrast to large, distant central stations–and by electrical interconnection to the local distribution system–in contrast to higher voltage electrical transmission systems.

The result of the assessment is a publicly available document[1] that was reviewed, revised, and consensually accepted by NWCC. The document provides a substantial base of information addressing a broad range of relevant issues. It draws heavily from extensive experience with distributed wind power installations in Europe and from the more limited distributed wind experience base in the United States. The document does not recommend actions to be taken in support of wind power expansion and does not advocate for or against distributed wind. Instead, its aim is to provide information that others can use to define follow-up activities and action steps.

As a follow-up to the assessment, NWCC intends to prepare a consensus-based issue brief that summarizes its findings and highlights the major results and conclusions for each stakeholder sector. This brief will also identify key action steps that could be undertaken by each stakeholder sector to facilitate the growth of distributed wind.

[1] Distributed Wind Power Assessment, National Wind Coordinating Committee, May 2000.

The aim of this paper is to provide input to the NWCC for its consideration in developing the issue brief. Accordingly, this paper is in no way an NWCC consensus document. However, we the authors hope to assist in the issue-brief preparation process by providing a starting point for NWCC's consideration. One of the authors, Joseph Cohen, led the team that performed the NWCC assessment. The other two were involved in management of the assessment effort on behalf of the contracting organizations and are active members of the NWCC. We feel the perspectives offered in this paper are well-grounded in the findings of the assessment research and can help in moving the consensus process forward.

NWCC Assessment Summary

Objectives of *Distributed Wind Power Assessment*

Denmark and Germany have already achieved substantial market penetration with distributed wind systems defined loosely as wind energy installations connected to the utility grid at the distribution and subtransmission level without a substation. The *Distributed Wind Power Assessment* examines the European experience, discusses the similarities and differences between Europe and the United States, and highlights useful lessons learned in Europe. It explores the prospects for deploying significant amounts of distributed wind power in the United States. It also examines the economic and technical issues and challenges facing utilities, land owners, and others interested in adding distributed wind generation, and describes opportunities for encouraging the development of distributed wind power in the United States. The report has the following primary objectives:

- Provide information to serve as a common foundation of knowledge for the NWCC and others to understand and discuss issues associated with the adoption of distributed wind power
- Delineate the benefits, costs, and technical requirements associated with developing distributed wind projects
- Characterize the policy drivers and market, industrial, and social characteristics that fostered European distributed wind development and contrast these attributes with the current U.S. market and policy climate
- Describe where distributed wind may be either constrained or encouraged by market, institutional, or regulatory factors.

The report has the following secondary objectives:

- Identify attractive combinations of economic, technical, and social characteristics for distributed wind applications in the United States
- Provide information required to identify specific opportunities for distributed wind systems on a preliminary feasibility level
- Describe technical options that can enhance the value of distributed wind projects.

Major Findings of *Distributed Wind Power Assessment*

Although each location on the electricity grid has it own characteristics, there are likely to be many locations where wind turbines of appropriate size and technical characteristics can be added to the grid at the distribution level. The *Distributed Wind Power Assessment* revealed that distributed wind generation could provide primary power and reactive power on weak distribution lines. In limited circumstances, it could provide some transmission and distribution (T&D) support, peak shaving, substation capacity deferral, or power quality support (other than providing reactive power). There may also be circumstances where distributed wind turbines are more attractive than larger wind farms for marketing wind's environmental benefits through "green pricing or green marketing" programs. Denmark and Germany have resolved technical issues associated with interconnection to achieve large-scale integration of wind power on their distribution systems. They also developed approaches to paying for the resulting additional distribution system reinforcements required for such aggressive deployment of distributed wind generation. Despite these favorable findings, there are formidable challenges to achieving large deployment of distributed wind systems in the United States. Major findings from the *Distributed Wind Power Assessment,* including opportunities and challenges, are discussed in more detail below.

Some Lessons From Europe that Apply to the United States

Some key aspects of the successful experience in Denmark and Germany that apply to the United States include the following.

- *Distributed wind generation is a natural investment for farmers* - an extension of what farmers were already familiar with, i.e., the development of land-based natural resources to sell on the open market.
- *Availability of standard financing products and services*, which reduce transaction costs for project owners, is critical.
- *Presence of a strong market infrastructure* across all sectors, including manufacturing, project installation and operation and maintenance, financial services, etc. is critical. There are no inherent barriers to enhancement of the U.S. infrastructure to meet specific needs of a distributed wind market.
- *Active grass-roots political support for national policy* is critical for a model of project ownership by landowners to be successful.
- *Local financial participation is key to public acceptance and the largest possible market penetration.* According to the majority of European experts interviewed, this is because it enables benefits to accrue to the people who bear the localized costs of wind power. These experts report that local public perceptions are usually favorable if financial participation is present and often unfavorable if it is not. They believe that acceptable financial return is the most important key to local ownership. Local acceptance of wind power has been reported to increase or remain high after projects have been installed on both sides of the Atlantic.

Several other factors that can positively affect public acceptance include:

- *Environmental benefits* contribute to a sense of local pride.
- *Local economic benefits* (which are maximized with local ownership) are significant.
- *Tourism draw* can also generate local economic benefits and enhance local image.

Relevant Differences Between Europe and the United States

The lessons learned from Germany and Denmark must be interpreted carefully to apply them in the United States. Key differences between the United States and Europe include the following.

- *Differences in utility market structures, political processes, and social histories* limit the applicability of European experience to the United States. Electricity prices in the United States are much closer to the cost of production than they have been in Denmark and Germany.
- *Policies that restricted utility and private developer ownership and provided incentives for local, private, individual or cooperative ownership* combined with government financial policies (especially premium prices, known as feed-in tariffs) to support wind project development in general and provided strong incentives for distributed wind development in Germany and Denmark. European success was based on a policy aimed at increasing wind capacity in general and, in particular, supporting local, landowner project ownership. These goals were deemed more important than achieving conventional market-based economic efficiency or capturing the technical benefits of distributed generation.

- *Interconnection standards and requirements,* were well defined and fairly uniform. They facilitated resolution of technical integration issues.
- *The majority of integration and grid reinforcement costs* were paid from public funds obtained from taxes on retail electricity sales rather than imposed on the individual distributed projects.
- *European distribution systems are typically stronger electrically* than those in rural U.S. locations. Any undesirable electrical impacts of distributed wind will, in general, be more pronounced on the weaker U.S. distribution systems.

There are several key issues, specific to the U.S. market that were identified in the *Distributed Wind Power Assessment.* These are discussed below.

Distributed Wind Generation Benefits Will Often Be Limited

The interconnection of substantial amounts of wind generation to U.S. electric distribution systems is technically feasible. In limited instances, the addition of a single turbine or small cluster of turbines at a specific location with a good wind resource could provide some or all of the following benefits:

- Delay or eliminate the addition of distribution facilities
- Reduce transmission losses
- Serve additional loads
- Provide voltage support on weak distribution lines.

Often, however, wind will only provide the system benefit of energy generated, and reduced distribution losses for the portion of energy used within the distribution system may require reinforcements to the distribution grid.

Identifying opportunities where distributed wind projects can have positive impacts on the distribution system, i.e., non-energy "distributed benefits," is a very site-specific process involving wind resource assessment, analysis of the coincidence between loads and wind, and technical analysis of resulting impacts or benefits. Quantifying distributed benefits from wind turbines presents a challenge because the power produced by them is intermittent. Distributed benefits depend on the correlation between the wind generation and the load. At present, an engineer must evaluate each proposed installation of one or more large turbines to determine whether power quality impacts would be acceptable. In addition to the correlation between the wind generation and load, the extent to which one or a combination of benefits can be quantified at a given location depends upon a number of other factors:

- Turbine design, size, and location on the distribution system
- Wind resource characteristics
- Characteristics of the subtransmission and distribution systems and loads, load growth, and subtransmission and distribution system expansion plans near the proposed wind site
- Transmission system characteristics, in particular reliability criteria and loading levels
- Utility generation system characteristics, including generator types, installed capacity, native load shape and growth
- Ownership of turbines, generation, transmission, and distribution systems (i.e., vertically integrated utility, distribution utility, utility customer, regulated versus unregulated power company).

Cost of Evaluating "Distributed Benefits" from Wind Projects is a Barrier to Their Identification

An additional, and perhaps even more critical barrier to the ability to obtain value for distributed benefits (when they exist) from wind projects is the cost associated with the analytic process described above. This cost is inherently higher for distributed wind projects than for projects that produce firm (nonintermittent) power and may be prohibitive for most project owners and developers unless simplified evaluation approaches can be developed.

Simplified methods to identify locations in the distribution system where generation value is potentially highest are currently being examined by the distributed generation community. This will help to screen applications where total cost can be minimized, but the question of specifically quantifying and passing the value on to the wind generation owner remains problematic.

Grid Characteristics and Power Quality Limit Turbine Siting

Single and small clusters of turbines in Europe are connected to a relatively strong, robust distribution system consisting almost entirely of three-phase lines. These strong distribution systems were an important factor supporting distributed wind development. Circumstances are different in the United States. If only minimal upgrades were required for turbines to be added to the distribution system, then adding wind generation to a U.S. distribution system may be less expensive than adding it to a transmission system. The majority of distribution lines in rural areas (the locations most suitable for wind generation) are single phase and would require upgrading to three phase to connect wind turbines rated at more than about 25 kW. However, given the huge rural land mass, distributed wind generation limited to areas with existing three-phase lines could still achieve substantial penetration into the U.S. grid.

There are limitations to the amount of wind generation that existing distribution lines can accommodate. Analysis conducted for the NWCC suggests that distributed wind generation can be connected to the rural distribution lines in an amount about equal to the substation transformer capacity, assuming there is no other distributed generation. If power quality impacts are too high, or if the penetration level of wind turbines exceeds the allowed peak-load levels on the substations, then distribution system reinforcements could be required.

The most important consideration for adding wind turbines to a distribution system is the electrical strength or stiffness of the distribution system at the proposed point of interconnection. Strength refers to the ability to deliver or absorb power. The requirements, benefits, and penetration limitations of distributed wind generation depend on whether a specific project is connected to a strong, thermally-limited distribution system or a weak, voltage-limited distribution system. A strong distribution system can absorb significant amounts of intermittent wind generation with relatively modest impacts on the quality of power. Most rural distribution systems in the United States are voltage-limited.

A wide spectrum of distributed opportunities/challenges exist, ranging from strong thermally-limited distribution systems to single-phase systems.

Interconnection Standards Benefit Manufacturers, Utilities, and Owners

Utilities have the responsibility of maintaining power quality and safe, reliable systems. For this reason, individual utilities must have interconnection requirements for wind turbines (and other distributed generators). However, the requirements have not been standardized across utilities or across distributed generators. Because of a wind turbine's intermittent and fluctuating power output, it can cause more power quality problems on the distribution system than other distributed generation. In general, smaller wind turbines, those less than 100 kW, are less likely to cause power quality problems in most distributed applications. Thus, interconnection requirements could be simpler for smaller machines. At present, the lack of manufacturing design standards and certification accepted by both the wind industry and the U.S. utility industry obligates utility engineers to perform detailed evaluation of each proposed installation of large turbines to determine whether power quality impacts would be acceptable.

Infrastructure and Volume are Key to Cost Reduction

There is no inherent reason why costs for distributed wind projects cannot be reduced if demand for distributed wind generation grows. Desirable infrastructure developments would provide individuals and organizations with information and expertise in resource assessment, project development, wind technology, bulk purchases, financing, and operations and maintenance (O&M). Without these, capital and O&M costs for most distributed projects are likely to remain well above those for large wind farms. The U.S. implementation of performance-based or rate-cap regulation of distribution companies could speed up the development of an infrastructure to support distributed wind generation as well as other distributed resources.

Wind-Specific Issues Complicate Already Uncertain Evolving Regulatory and Market Arenas

General Issues. Restructuring of the electricity industry is proceeding at different rates throughout the country, making the effort to define the benefits and challenges of distributed wind generation that much more difficult. Some states are fully engaged in unbundling electric utility services, while others have eschewed the process entirely. Although it is likely there will eventually be federal restructuring legislation, it is not clear when this will happen or what form this legislation will take. Rather than having a single set of well-defined rules and relationships, the market of the future will be composed of a plethora of mechanisms and customer relationships for transaction of new products and services that could make distributed wind power more valuable. Depending on the outcome of market restructuring, there could be either enhanced or diminished opportunities for distributed wind generation.

There are questions about how distributed generation will be valued and regulated in the future. A primary challenge in all states, whether they have restructured markets or not, will be to create regulations that are consistent with, and encourage the fair allocation of costs or value associated with distributed generation. The legislative and regulatory paradigm developed in the 1980s uses a utility's avoided cost of providing electricity as the basis for valuing generation additions, either central or distributed, because distribution, transmission, and ancillary service costs associated with being connected to the grid are considered relatively fixed. Because that system bases the value of distributed generation on utility cost of (generation) service rather than the value placed on the service by the customer in a competitive marketplace, this paradigm will not meet the needs of future markets. A new system will require an economic accounting approach that is based on functions rather than on asset classes, followed by a pricing approach that reveals the incremental costs of serving customers to all market participants so that distributed resources can be deployed in the locations where they are most valuable. In addition, if the goal of public policy is to encourage end users to own distributed generation, then lawmakers and regulators will have to create new incentives to accomplish this.

Wind-Specific Issues. Certain characteristics of distributed wind generation will complicate efforts to establish new regulatory approaches. These characteristics include:

- *Valuation and Accounting of Distributed Benefits*–As discussed above, valuation is more difficult and costly for wind than most sources of distributed generation because of the intermittency of the resource. If distribution owners under price-cap or performance-based regulation systematically identify locations where the value of distributed resources is high, wind is still less likely to earn positive values. There is a wide range of opinions as to what extent, if at all, an economically-feasible regulatory system can be developed to enable widespread evaluation and subsequent accounting of distributed costs and benefits from wind generators. One thing that is clear is that the European approach of simply sweeping away all valuation issues by generously subsidizing its wind projects is not likely to occur in the United States.

- *Environmental Benefits* –Wind environmental benefits are real, but they tend to be undervalued or not valued at all. Should they be calculated and accounted for, and if so, how? Credit trading systems are under consideration, but care will be required to ensure that smaller, distributed plants are accounted for. In addition, can local environmental benefits be quantified relative to those that accrue from larger, distant wind power plants?

- *Costs or benefits of ancillary or other services*–If transmission and distribution charges for rural areas, which are usually more expensive to serve, are unbundled as a result of restructuring, the impact on the value of distributed wind projects could vary widely. In general, geographic deaveraging of costs and rates would benefit distributed generators with respect to central station plants. However, it may be that the majority of distributed wind sites would incur disproportionate costs compared to other distributed generators for non-energy services required by the wind plant.

- *Distribution Wheeling Charges*–These charges could eliminate the economic value of wheeling power out of the distribution system at low load periods, which, because of the intermittent wind resource, could be a disproportionately higher source of revenue for wind projects compared to other distributed generation sources. The end result would be a decrease in the value of distributed wind compared to those other sources.

Major Messages for Key Sectors of the Wind and Energy Communities

The results and findings from the NWCC Distributed Wind Assessment lead to specific conclusions and potential opportunities and actions for key stakeholder sectors of the wind and energy communities. We have made an initial attempt to articulate these conclusions, opportunities, and actions. We are not advocating for or against these actions. We are simply identifying actions that could be taken within stakeholder sectors if there is a desire to facilitate the expansion of distributed wind.

Again we emphasize that we are not presenting NWCC consensus findings, but that we are hopeful of initiating movement toward consensus. We have organized our thinking in terms of messages to the following stakeholder sectors:

- Project developers or owners, including utilities (both generation and distribution) and independent power producers
- Distribution utilities
- Wind-equipment manufacturing and service industries
- Land owners, communities, economic-development, and local-government officials
- Regulators, government officials, and other policy makers
- Financial community representatives
- Environmentalists

Project Developers and Owners—Including Utilities, both Generation and Distribution, and Independent Power Producers

Conclusions

- Distributed wind deployment may reduce interconnection costs relative to those associated with interconnection at transmission voltage levels, particularly for smaller projects (<5 MW).
- Distributed wind installations can involve a broader range of participants and partners because the levels of power, investment, and risk are reduced relative to larger, central-station-size plants.

- Distributed wind plants offer potential for local financial participation, and as a result, may enjoy increased community support.

Actions and Opportunities

- Involve local communities in projects as early as possible.
- Structure projects so that there are equitable economic benefits to landowners and local communities.
- Pursue geographic concentration through aggregation strategies, thereby reducing project and O&M costs through economies of scale.
- Invest in modest distribution system upgrades or short-term storage when it can enhance value enough to make a project economically attractive.
- Search for areas with predictable wind and load growth requiring distribution equipment system upgrades or additions.

Distribution Utilities

Conclusions

- Acceptable penetrations of distributed wind can often approach the local load demand (approximately the power rating of the substation transformer).
- Allowable wind penetrations can often be increased significantly with modest upgrades in the distribution system.
- Wind turbines larger than about 25 kW require three-phase distribution lines. This will limit deployment in some rural U.S. locations.
- Utility-system benefits from distributed wind, beyond delivered power and energy, are likely to be minimal or negative. Nonetheless, there is some potential for added value in areas with predictable wind and load growth that also need distribution-system upgrades.
- Distributed wind systems, because of their proximity to the community, offer opportunities to localize green power and enhance customer and community acceptance.
- Requirements for and costs of detailed system impact studies can be a significant impediment to distributed wind deployment.

Actions and Opportunities

- Develop simple, impact-based interconnection standards that recognize various machine sizes and technologies.
- Invest in modest distribution-system upgrades to allow expanded deployment of distributed wind.
- Develop widely applicable, simplified approaches to quantifying appropriate levels of reinforcements.
- Participate in the development of standard, simplified power-purchase agreements.
- Participate in the development of simplified approaches to quantifying distribution-system benefits of distributed generators.
- Participate in the development of power quality standards for distributed deployment hardware and electronics.

Wind Equipment Manufacturing and Service Industries

Conclusions

- Distributed wind applications represent a potential market for utility-scale machines worthy of serious attention.
- Machine designs conducive to simple, inexpensive installation are preferred.

Actions and Opportunities

- Develop and offer machines tailored to the distributed market. Particular attention needs to be paid to installation, interconnection requirements, and power quality.
- Develop needed support infrastructure, such as regional maintenance facilities. Offer comprehensive operation and maintenance support as part of the project package.
- Participate in the development of interconnection and power-quality standards.
- Develop approaches to obtain sufficiently accurate wind resource assessments that are affordable for smaller projects.

Landowners, Communities, Economic-Development and Local-Government Officials

Conclusions

- Wind power offers a new, economically attractive product for farmers and ranchers. As such, it bears similarity to agricultural crops.
- Local wind power projects will provide property-tax, income, and other economic benefits to the community.

Actions and Opportunities

- Examine and formulate wind-rights and hardware-ownership structures conducive to local participation, including wind-ownership cooperatives.
- Develop permitting and zoning requirements that standardize processes and recognize wind development needs and conditions.
- Scale project-approval processes to recognize transaction-cost impediments for small projects.

Regulators, Government Officials, and Other Policy Makers

Conclusions

- Distributed wind will be facilitated by policies that promote long-term stability of project cash flows and acceptable economic returns.
- Wind projects require access to the distribution system with clear, fair interconnection procedures. Interconnection requirements should be based on reasonable safety and system-operations requirements.
- Valuation of generated power has traditionally been based on avoided generation *cost*. A new method is needed that quantifies the actual *value* to customers and utilities of receiving energy from distributed generators.

Actions and Opportunities

- Develop and implement policies that promote long term stability of project cash flows and acceptable economic returns.
- Promote the development of simple, impact-based interconnection standards that recognize various machine sizes and various machine technologies.
- Support the development of publicly funded infrastructure for wind (for example, reinforcing the distribution and transmission systems) in direct analogy to building and maintaining transportation infrastructure (roads) for bringing other farm "products" to market.

- Support the development of simplified energy-valuation methods based on customer *value* at the point of use rather than avoided generation *cost.*

U.S. Financial Community Representatives

Conclusions

- Financing institutions in Europe are sufficiently comfortable with wind technology and distributed-wind projects to provide financing with procedures and terms similar to those for standard farm equipment.

Actions and Opportunities

- Assess viability of wind technology to evaluate risk levels appropriate for distributed project financing.
- Develop standard financing processes and products to minimize transaction costs.
- Work with project developers, owners, distribution utilities and power marketers to develop power-purchase mechanisms and project ownership structures that reduce risk of project investment.

Environmentalists

Conclusions

- Europeans tend to view distributed wind as consistent with their strong environmental ethic that favors clean power technologies.
- Even in the United States, consumers generally view local distributed wind projects favorably from an environmental standpoint.
- Local acceptance of wind projects is strongly influenced by the presence and magnitude of local economic benefits.
- Distributed wind deployment offers an alternative to large wind farms and the transmission-system expansion or upgrades they often require.

Actions and Opportunities

- Form alliances with wind project developers and others in the wind community to pursue concurrent economic and environmental progress.
- Participate in community wind projects to provide relevant assistance and information to energy providers and customers in the interests of all, and to assist in the identification and resolution of issues that arise.

Next Steps

Over the coming months, the NWCC and its Distributed Wind Working Group will work to refine and summarize conclusions and recommendations from the NWCC *Distributed Wind Power Assessment*. NWCC, through its ongoing outreach activities, will then actively disseminate this information to those who can make use of it. As members and interested parties, we look forward to close involvement with the NWCC during this process; and we hope that this paper provides a useful step along the way.

Readers of this paper that would like to offer input to the NWCC process or keep abreast of related developments should contact the NWCC Senior Outreach Coordinator, Gabe Petlin, at gpetlin@resolv.org or 1- 888-764-WIND. They can also access the NWCC web site at www.nationalwind.org .

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