NREL/CP-500-25692

Grid-Connected Wind Energy Technology: Progress and Prospects

Brian Parsons
National Wind Technology Center
National Renewable Energy Laboratory

Presented at the
North American Conference of the
International Association of Energy Economists
Albuquerque, NM
October 18-21, 1998

National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, Colorado 80401-3393
A national laboratory of the U.S. Department of Energy
Managed by Midwest Research Institute
for the U.S. Department of Energy
under contract No. DE-AC36-83CH10093

Work performed under task number WE903220

November 1998

NOTICE

Available to DOE and DOE contractors from:
Office of Scientific and Technical Information (OSTI)
P.O. Box 62
Oak Ridge, TN 37831
Prices available by calling (423) 576-8401

Available to the public from:
National Technical Information Service (NTIS)
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
(703) 487-4650

Printed on paper containing at least 50% wastepaper, including 20% postconsumer waste

WIND ENERGY MARKETS

Even as European wind development continues at a brisk pace, there are hints that a renewed interest in grid-connected wind power is emerging in the United States. The scarcity of new wind projects brought about by uncertainties about restructuring of the U.S. electricity industry and upheavals in the wind industry may have reached its low point in 1997. State mandates, the impending expiration of the federal wind energy production tax credit in mid-1999, and strategic planning by some state and industry officials are fostering efforts to repower existing wind power plants as well as build new ones. Other factors revitalizing the U.S. wind industry include lower wind energy costs, an improved understanding of project financing, and impending technology enhancements. How these factors will play out during and after the transition to restructured electricity markets is far from clear, however. Many factors will play a role in determining wind energy's long-term prospects in the United States and elsewhere. They include new capacity needs, the success of green pricing efforts, whether the U.S. government creates new policies in support of renewable energy, the impact of state renewable energy initiatives, electrification strategies in the developing world, and commitments to curb greenhouse-gas emissions.

Many energy analysts believe there is a major opportunity for wind energy in the U.S. bulk power market There appear to be few, if any, physical limits in the near term to wind penetration into the grid. Rather, limits appear to be economic. Anticipated improvements in systems operations, energy storage, and wind forecasting will address these limits in the next few years. In the meantime, entry into mainstream U.S. power markets will occur because the public, federal and state officials, and utilities recognize the value added from using wind as an energy resource. Most people recognize wind’s value as a fuel saver. Where wind resources and utility loads match reasonably well, wind also has potential capacity value and reliability benefits. Wind can provide fuel diversity to an industry becoming increasingly reliant on natural gas, help power companies comply with environmental regulations, and satisfy customer desire for clean power. As a domestic energy resource, wind also spurs economic development in rural areas, where new wind power plants are most likely to be sited. Wind plants provide long-term income to landowners and boost rents and sale prices while leaving most of the land free for agricultural or ranching purposes. They provide significant property tax revenues to sparsely populated townships, counties, and school districts.

Outside the United States, wind is the world's fastest growing energy resource, with annual growth rates of about 40% per year in Europe since 1991. Worldwide, the amount of installed wind capacity increased 24% in both 1996 and 1997. Last year more than 1500 megawatts (MW) of new capacity was installed around the world; Germany and other European nations accounted for three-fourths of the total. Europe now has about 4,500 MW of installed wind capacity, about three times that of the United States, which added just 11 MW of new capacity in 1997. Germany, Denmark, Spain, the United Kingdom, the United States, China, India, and Mexico are among the active participants in what is now a $1.5 billion per year global wind energy market.

The European Union (EU) has taken the lead in bringing wind technology into mainstream power markets during the past five years, as shown in Figure 1. With the European Wind Energy Association's revised installed capacity targets now standing at 8000 MW for 2000 and 100,000 MW for 2020, it is clear that wind is becoming a well established

form of power generation. A variety of policy and marketing incentives, together with EU support for research and development, are responsible for wind's rapid inroads into mainstream EU power markets. Incentives include premium prices for wind-generated electricity (in Germany, Denmark, and Spain), binding national targets for increasing wind capacity (in Denmark), bidding processes favorable to wind (in the U.K.), general public funding of national research and development programs, and direct investment subsidies for turbine installations.[1]

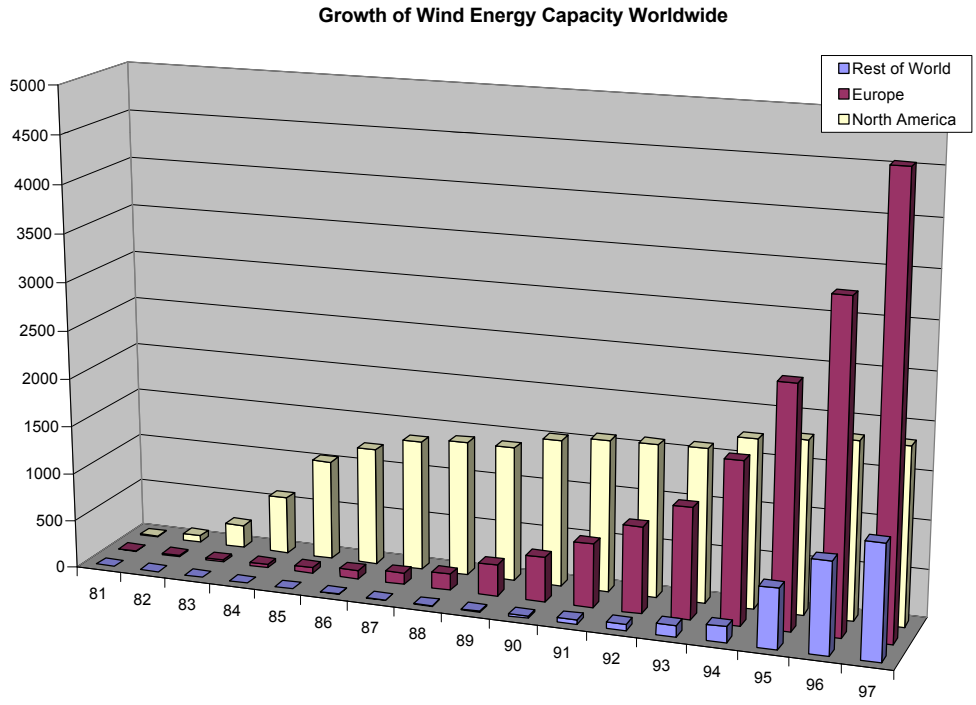

Figure 1

U.S. Markets

In recent years, the United States has lagged behind Europe in the promotion of grid-connected wind technology, particularly with respect to policy and marketing incentives at the federal level. Even funding for wind research and development has declined, falling from $49 million in 1995 to $28.6 million in 1997. The depressed U.S. wind market, under capitalization of wind companies, and difficulties with technology have forced several manufacturers into bankruptcy, leaving Enron Wind Corp./Zond Systems as the only manufacturer of large turbines actively competing in the U.S. wind power market. The result has been a near-paralysis in the entry of wind into U.S. power markets, particularly during 1996 and 1997. Between 1995 and 1997, the United States acquired only about 80 MW of new wind capacity. More recently, older turbines in California have begun to be replaced with newer machines to take advantage of the federal wind energy production tax credit. Eligible wind facilities receive a tax credit of $0.015/kWh for the first 10 years of operation. The tax credit applies to new wind power plants and existing facilities that update their wind machines. Eligible facilities must be on line by June of 1999 when the credit expires. There has been debate about extending the tax credit as well as creating a national Renewable Portfolio Standard to support the development of wind and other renewables. However, new federal laws or policies have not been forthcoming. In the private sector, utilities have been reluctant to commit to new power installations of any kind, preferring to wait and see what happens with electric industry restructuring.

The worst appears to be over. Thus far in 1998, wind development activity is greater than at any time since the hey-day of the California wind rush in the early 1980s. Three companies, Enron Wind Corp., SeaWest Energy Systems, and the FPL Group, Inc. have announced plans for more than a dozen wind projects totaling more than 800 MW. The projects are scheduled for completion this year or next. The projects include building new wind power plants in Colorado, Minnesota, Iowa, Oregon, Texas, and Wyoming and repowering existing wind facilities near Palm Springs and in the Altamont and Tehachapi regions of California. Developers are rushing to refurbish existing facilities and complete new projects before June of 1999 to take advantage of the federal tax credit.

State Mandates

Legislative mandates in Minnesota, Iowa, and Wisconsin are key ingredients in the U.S. wind power renaissance. In Minnesota, the so-called 1994 Prairie Island law required Northern States Power Co. (NSP) to build or buy 400 MW of wind power by 2002 in return for being allowed to store nuclear waste on the site of the utility's Prairie Island nuclear power plant. NSP's first 25-MW wind facility, completed near Lake Benton in southwestern Minnesota in 1994, does not count toward compliance with the mandate. The first phase of the mandated generation, a 107-MW facility, was dedicated in September near Lake Benton on the Buffalo Ridge. A contract for an additional 103.5 MW to be built in the same area was signed in April of this year. Three smaller projects totaling 33 MW are also under construction. NSP plans to release a Request for Proposal for the remaining 156 MW by the year's end. The 1994 law also mandates an additional 400 MW of wind capacity if wind is the least cost option and fits with the requirements of the state's integrated resource plan. NSP contends that because gas turbines cost less than new wind capacity, it should not be required to buy more wind power.

Wind development in Iowa is beginning in earnest, thanks to the state's 1983 Alternative Energy Production law. The law requires the state's regulated utilities to purchase 1.5% of their power from alternative energy facilities. Iowa utilities fought the law in court for more than a decade before reaching an agreement in 1997 to add wind power to their generation mix. Iowa's three largest utilities have signed agreements to purchase power from three wind power plants planned for completion by mid-1999: a 112-MW facility in Buena Vista County, a 76-MW facility near Storm Lake in northwest Iowa, and a 42-MW plant in Cerro Gordo County near Clear Lake. Enron Wind Corp. will build and operate the two larger facilities, while the FPL Group will build and operate the Clear Lake wind power plant. MidAmerican Energy Holdings Company of Des Moines, IES Utilities Inc. of Cedar Rapids, and Interstate Power Co., which serves Iowa, Illinois, and Minnesota, will purchase power from the facilities.

In late spring, the Wisconsin Legislature mandated that four investor-owned utilities (Wisconsin Electric Power, Wisconsin Power & Light, Wisconsin Public Service, and Madison Gas & Electric) add 500 MW of new power generation capacity to ensure statewide system reliability. A minimum of 10%, or 50 MW of this new capacity was set aside for renewable energy sources. In response to the mandate, Wisconsin Electric issued a Request for Proposal in August for 75 MW of renewable power generation, nearly three times its mandated share of 27 MW. The new solicitation is in addition to two wind turbines the utility is installing as part of its "Energy for Tomorrow" green pricing program. Madison Gas & Electric's new 11.25-MW wind power plant, scheduled for completion in 1999 as part of a green pricing program, will also count toward compliance with the new mandate.

Voluntary Initiatives

Perhaps the most intriguing U.S. wind initiatives are coming from the State of Texas. State and utility officials are collaborating on significant renewable energy development, including wind, without being forced to do so by law or regulation. Strong public support for clean energy appears to be driving wind development in Texas, and Texas utilities are responding enthusiastically. The genesis of this support is coming from a new type of opinion poll, called "deliberative polling," being conducted by Texas power companies. The companies invite a small, representative sample of their customers to spend a weekend at company expense learning about and discussing electricity, sources of energy, and the environmental impacts of power generation. What company and state officials have learned from these structured discussions in Houston, Corpus Christi, and Beaumont is that Texans want more renewable energy, from sources like wind, and they are willing to pay a premium price for it. As a result, the Texas Public Utilities Commission has made a commitment to giving customers the choice to buy green power. And, utilities have already undertaken a sustainable energy development strategy founded on traditional supply and demand economics.

The Texas experience promises to show whether wind can deliver profits like any other energy business. The state's substantial wind resource and proud history of energy independence bode well for its forays into uncharted waters of free-market wind development. Currently, 110 MW of new wind capacity is under development in Texas. Central and South West Corporation (CSW) and three of its operating companies (West Texas Utilities Company, Central Power and Light Company, and Southwestern Electric Power Company) are in the bidding process for a large-scale wind power plant south of Odessa. The new facility will be included in the rate base of the three operating companies. CSW, the nation's second largest utility, built a 6.6-MW wind power plant in 1995 in west Texas near Fort Davis under the auspices of the Turbine Verification Program (TVP) sponsored by the Electric Power Research Institute and the U.S. Department of Energy (DOE). York Research Corporation of New York is building a 35-MW wind power plant in west Texas near Big Springs. The new facility, which will sell wind power to the Texas Utilities Company, is an associate member of the TVP. The TVP has also sponsored other, smaller wind projects in Alaska, Iowa, Nebraska, Vermont, and Wisconsin. The new Texas wind power plants join a 41-MW facility in Culberson County developed in 1995 in conjunction with the Lower Colorado River Authority.

Despite the renewed interest in wind in the United States, the long-term prospects for wind in Texas and elsewhere remain uncertain. The impact of electricity market restructuring on renewable energy development is not clear. Nor is the impact of the looming expiration of the wind energy production tax credit. There is substantial debate surrounding the need for federal renewable energy policies such as a Renewable Portfolio Standard, which would mandate a set percentage of renewable energy in all electricity sold. No one yet knows the extent to which new green pricing initiatives will further the cause of wind development, either. At present, individual states are experimenting with a variety of policies and mandates designed to encourage renewable energy development. In the meantime, the federal wind energy program and the U.S. wind industry are focusing on ways to communicate the value of wind to utilities, improve wind technology and manufacturing processes, and lower wind energy costs. Eventually, competitive costs will guarantee wind a strong market share in future power markets.

Costs

Costs for wind energy have declined steadily from $0.25 per kilowatt-hour (kWh) in the early 1980s, as shown in Figure 2. Today, wind power plants using new technology have energy costs ranging from $0.04 to $0.06/kWh. New wind plants in Minnesota and Iowa have utility contracts that pay approximately $0.045/kWh. Northern States Power awarded a wind energy contract in April 1998 to Enron Wind Corp. that reportedly includes an energy price of $0.03/kWh. Assuming the Minnesota project is completed on time, this price will be supported by an additional $0.015/kWh federal production tax credit.[2]

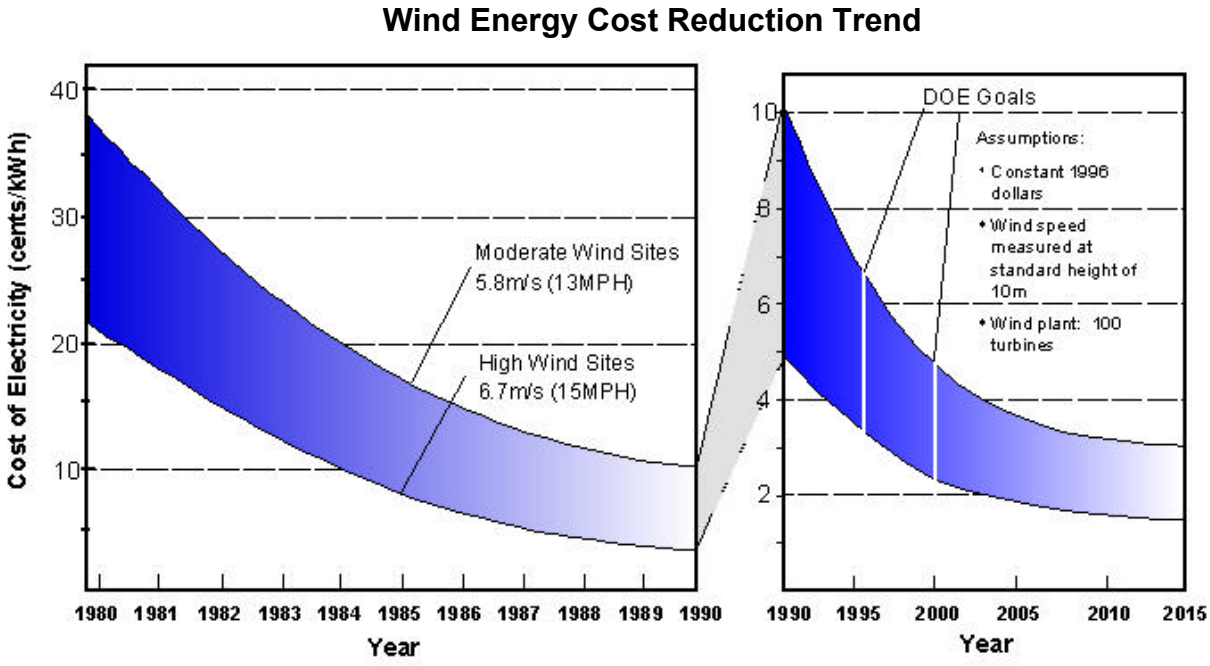

Figure 2

The prices quoted above cannot be generalized to every new project, however. Market prices for wind energy vary as a function of project specific factors such as the quality of the local wind resource, the type of financing the project developer can obtain, and project size. With or without an extension of the federal tax credit, wind energy costs are expected to decline gradually over the next decade as a result of incremental improvements in technology and increasing production volumes. Without a federal tax credit, however, lower wind costs will be necessary to enable the technology to compete head-to-head with new natural gas plants, which have a bus bar power cost of $0.025 to $0.03/kWh.

Because wind has high front-end capital costs, ownership and financing strategies have a significant impact on the cost of energy. Financing strategies differ among public power companies, which include municipal utilities and rural cooperatives; investor-owned utilities; and independent power producers. Wind projects are easier and less expensive to finance if the project's owner can take advantage of the low-cost financing available to large utilities.[3,4] Public power companies can secure the lowest cost financing. Neither municipal utilities nor rural electric cooperatives are subject to federal income or local property taxes. They can finance a wind power plant with 100% debt financing by selling tax-free

bonds. In contrast, investor-owned utilities and independent power producers must have 20%-to-50% equity to secure financing. However, the investor-owned utilities still have a significant financial advantage over an independent power producer. The utility can rely on corporate financing for a wind project and either include the wind power plant in its rate base or offer wind power at a premium price to its customers. Because independent power producers typically secure financing on just one project (rather than on a pool of projects or total corporate assets), lenders consider their projects to be high risk. Consequently, independent power producers pay higher interest rates on loans and have shorter payback periods on debt. Until independent power producers can obtain similar financing terms to large utilities, their wind projects will inevitably be more costly. Table 1 compares the cost of wind energy for three types of project ownership and two wind power classes.[5]

Wind Cost of Energy (1998 constant ¢/kWh)				
Wind Power Class	1998	2000	2005	2010
PUBLIC POWER COMPANY				
Class 4	3.87	2.67	2.01	1.86
Class 6	3.12	2.20	1.67	1.56
INVESTOR-OWNED UTILITY (Corporate Finance)				
Class 4	5.80	3.92	3.04	2.78
Class 6	4.54	3.13	2.47	2.28
INDEPENDENT POWER PRODUCER (Project Finance)				
Class 4	7.35	4.92	3.89	3.66
Class 6	5.67	3.87	3.12	2.90

Table 1. Impact of Project Financing on Wind Cost of Energy

The rapid growth of the wind industry in Europe has opened the door to more favorable financing arrangements than exist in the United States. European banks have become familiar with wind project development and no longer see wind as high risk. Some are even willing to assume project risks with as little as 20% equity financing. Several nations offer government-backed loan guarantees. Cooperative ownership of wind projects is a novel financing arrangement widely used in Denmark. There, approximately 5% of the population own shares in a wind power project. Cooperative ownership provides project financing, educates the public on the benefits of wind energy, and ensures significant policy support for wind energy development.

TECHNOLOGY & INDUSTRY STATUS

Technology enhancements and increasing volume production for wind turbines should lower the cost of wind energy by about 40% from current levels by 2030.[6] Government-sponsored research and development are expected to play a key role in developing technology enhancements. The U.S. wind industry is still small enough to need shared research, development, and testing to improve such turbine subsystems as rotors and towers. Policy commitments to renewable energy in Europe are assuring this support for the European wind industry. Most analysts agree that the resultant technology improvements will be evolutionary, not revolutionary. Improved technologies are predicted to account for one-fourth to one-half of the projected cost reductions for the installed cost of new machines. The remainder of the projected cost reduction will come from increasing volume production. Turbine costs are projected to fall by about 5% every time industry production doubles, with four to five doublings expected by 2030.

A new generation of U.S. utility-scale wind turbines is expected to be commercially available by about 2002. The turbines will feature taller towers and larger rotors, both of which will help lower overall costs. Other technical improvements, such as larger, multi-speed or variable-speed generators, variable pitch rotors, and advanced power electronics for improved power quality and sophisticated control systems, will enhance overall turbine performance. However, because many technical improvements currently on the drawing board will require new, custom-made turbine components, they won't significantly lower costs until volume production begins to increase after 2005.

Taller towers will be responsible for the most significant gains in turbine performance and cost reduction. Wind speed increases with height above the ground. As shown in Figure 3, taller towers expose turbines to stronger winds, enabling them to produce more electricity. Winds aloft are also more consistent, which increases the percentage of time a machine produces power. Reductions in turbine weight combined with innovative tower designs are making it possible to build taller towers at reduced cost. Between now and 2005, average tower height is expected to increase from 40- to 50-meters (m) to 70 m. Placing rotors at higher hub heights increases the energy output of the turbine. In addition, new and larger rotors are being designed to maintain high performance efficiency over a larger range of wind speeds, in particular the lower wind speeds. For instance, Enron Wind Corp./Zond Systems now offers a custom rotor diameter for its new

Z-750 wind turbine. The turbine comes with a 46-m, 48-m, or 50-m diameter rotor designed for excellent, good, or moderate-to-low wind regimes, respectively.

There is a limit to cost reductions associated with larger machines, however. Turbines ratings much larger than 1 MW make economic sense only for offshore installations, which require very expensive foundations. The logistics of installing big machines several kilometers offshore drive installation costs up 20% to 30%. European industry analysts contend, however, that because winds are stronger offshore, increased power production will offset the high installation costs over the life cycle of an offshore facility. Either way, very large turbines are likely to be cost effective for this application. Because the United States has an abundance of sparsely populated land with excellent wind resources, next-generation turbine development in this country emphasizes the more affordable 1-MW machines. In contrast, there are major government-sponsored turbine development programs underway in Europe that emphasize much larger machines than U.S. designs. Not surprisingly, densely populated European countries are running out of potential wind development sites with good wind resources. Because these countries have generous market incentives for wind development, they are pursuing significant offshore wind development for larger machines.

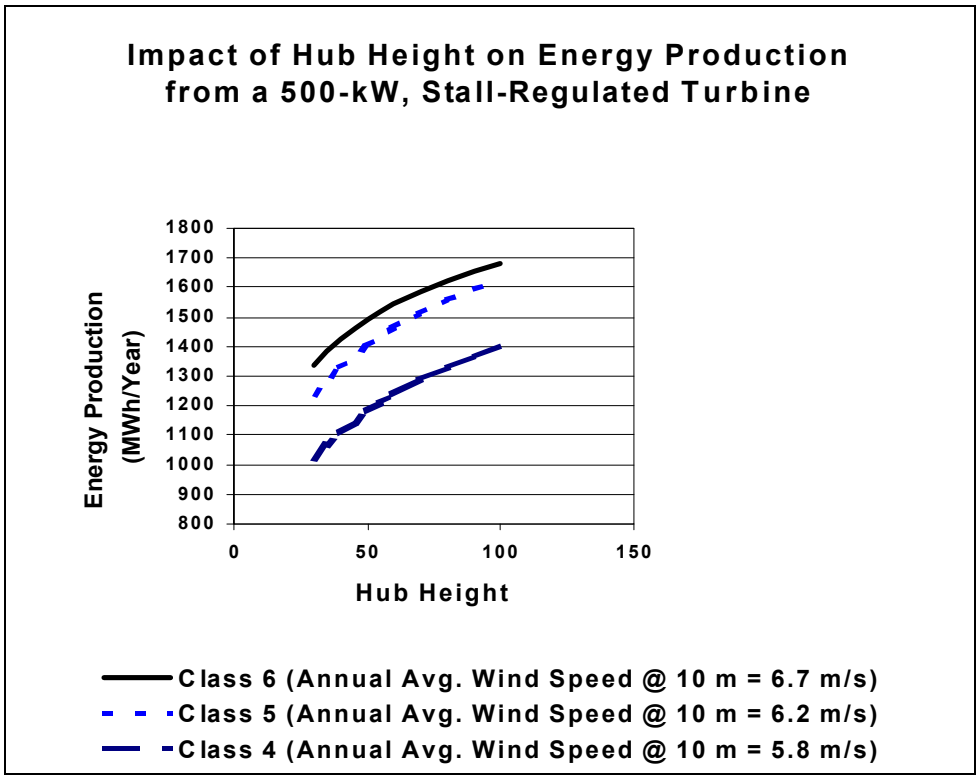

Figure 3

Generally speaking, improvements in turbine performance and cost after about 2005 are likely to be incremental. Lower cost power electronics, more sophisticated turbine controls, and advanced designs that allow machines to avoid damaging wind forces will be introduced. Taller towers will continue to increase energy production with only a modest increase in installed costs. The introduction of low-speed, direct-drive generators should result in large cost savings by eliminating costly gearing and transmission. By 2005, permanent magnet, direct drive generators should be available for 1-MW machines, helping to lower costs.

European turbine manufacturers provide the bulk of private research and development investment as well as supply most of the world market for utility-scale wind turbines. Enron Wind Energy Corp./Zond Systems is the only U.S. turbine manufacturer currently competing in this market. The firm's new Z-750 turbine is the first U.S. machine in several years to be installed in large numbers in utility wind power plants. Enron Wind, which purchased California turbine manufacturer Zond Systems in 1996 and German turbine manufacturer Tacke in 1997, appears to be positioning itself to take advantage of domestic and international markets for wind technology. The firm has announced plans to develop a 1-MW next-generation turbine by 2002. Another U.S. firm, The Wind Turbine Company, has also announced plans for a new 1-MW machine. Both Enron Wind and The Wind Turbine Company are participating in DOE's Next-Generation

Turbine Development Program. European firms currently have approximately 10 turbine designs in the megawatt range with commercial prospects.[7]

U. S. MARKET TRENDS

Electric industry restructuring, global efforts to combat climate change, and the increasing financial competitiveness of wind technology will play major roles in shaping future wind markets. The electrification of the third world and growing concerns about air quality are also likely to impact wind markets. In the United States, worry about energy security, the need for new generating capacity, the fate of the wind energy production tax credit, the impact of fledgling green marketing programs, and the fate of proposed federal legislation favorable to renewables will influence the rate and extent of wind development. Wind development in Europe will likely continue at a rapid pace during the next decade despite the uncertainties inherent in future wind markets. Wind development in the United States, however, is going to be much harder to predict.

Restructuring of the U.S. electricity market has gotten underway in a more or less piecemeal fashion. On April 1, the nation's largest electricity market, California, opened its gates to competition, with Pennsylvania and Massachusetts following close behind. Within five years, most of the country will have undergone some form of restructuring. Restructuring will primarily allow competition in electrical generation. This competition will almost certainly bring down the cost of electricity, which could pose problems for wind development. Wind's environmental benefits will not necessarily figure in pure market-based decisions. A new wind power plant costs more than a new natural gas fired power plant. In addition, restructuring introduces significant risk into the financing of any kind of new power generation. In a restructured environment, power purchase contracts will typically last two or three years, five years at the outside. Debt repayment for new wind generation capacity, on the other hand, could last anywhere from 10 to 20 years. The discrepancy between income guarantees and debt repayment schedules will seriously impact wind development because it is capital intensive and relies on up front financing. These factors will make it particularly difficult for wind development to evolve through merchant plants, which will be built on speculation to supply electricity for spot markets. In gauging the seriousness of these considerations, it's important to note that the mere threat of impending restructuring brought new power generation, including wind development, to a virtual standstill in 1996 and 1997.

The good news is that restructuring also gives customers choices about suppliers and the resources used to generate power. Because utility customer surveys consistently show that more than two-thirds of Americans support the development of renewable energy, wind may fare better under restructuring than would be predicted in terms of cost alone. In addition, restructuring will give electricity suppliers the opportunity to bundle power from renewables with other valued products and services. For instance, the cost savings inherent in bundling cable TV, internet services, and electricity would allow enterprising firms to offer green power at no extra cost. It's simply too early to know how things will evolve, particularly since the federal government could weigh in at any point with policies to support renewable energy or curb greenhouse-gas emissions.

If the United States decides to meet the 1997 Kyoto Protocol, it would require a shift in energy policy and in the direction of the U.S. energy economy. At the present time, electricity generation is responsible for 36% of man-made carbon emissions.[8] Any commitment to curbing these emissions would, of necessity, accelerate the commercialization of renewable technologies.[9] As one of the most cost-effective of the renewable options, wind technology is in an excellent position to benefit from such a commitment. Significant carbon offsets are possible in 34 of 50 states that have high quality wind resources. In addition, wind is an important technology for rural electrification in regions of the developing world with good wind resources. The provisions of the Kyoto Protocol allow industrial nations to meet their goal of reducing carbon emissions by assisting developing countries in finding development paths that replace fossil fuels with renewables. Thus, a U.S. commitment to reducing carbon emissions would likely to stimulate wind markets at home as well as in South America, China, India, and the Pacific Islands.

The replacement of fossil fuel generation with grid-connected wind energy systems or wind-diesel hybrid village power systems could help address growing concerns with air quality in the developing world. Air pollution from electricity generation and transportation endangers human health and agriculture as well as threatening climatic stability. For this reason, environmental issues will continue to drive wind development until wind can directly compete with natural gas. So long as natural gas supplies remain plentiful, inexpensive, and readily available, the pace of wind development will likely remain at current levels, and concerns about energy security will stay on the back burner. However, as the industrial world increasingly turns to natural gas to meet tougher emissions standards, supply disruptions or price hikes could become more commonplace. Should this occur, energy security could rapidly become a driver for new wind development.

New Capacity Needs

The need for new capacity in the United States is going to encourage new wind development. Load growth has caught up with capacity surpluses created more than a decade ago in many areas of the country, including Texas and Colorado. Public Service Company of Colorado encountered unanticipated power shortfalls during a recent summer heat wave. At the time, the utility was basking in the success of its WindSource green marketing program, which had garnered a premium of more than $1 million to purchase power from the utility's new 12-MW Ponnequin wind power plant. By September, the utility had agreed to build an additional 25-MW wind power facility to help meet its new capacity needs. Once the utility recognized that customers wanted green power, it decided to include wind in its rate base. As discussed earlier, Texas's Central and South West Corp. has also undertaken significant efforts to develop wind power.

Electric industry restructuring appears to be encouraging utilities to retire their nuclear power plants early. About 20% of the nation's nuclear power facilities will be decommissioned sooner than planned, and more than half will be off-line by 2020.[10] Utilities plan to take advantage of the stranded cost recovery allowed under most state restructuring rules, then shut down these expensive and unpopular power plants. Natural gas and renewables such as wind will be brought on-line to replace them. In contrast, restructuring appears to favor keeping older coal-fired plants on-line because they are so much less expensive to operate than building new power plants. The fact that these older plants are responsible for significant emissions of carbon dioxide and air pollutants could also bode well for wind development. Utilities that choose to keep older, polluting power plants on-line are going to have to invest in clean power generation themselves or purchase emissions credits in order to comply with national air quality standards. Either way, there may be added incentives for investments in wind generation.

Green Power Marketing

Approximately 15 utilities offer either contribution or energy-based green pricing programs for wind energy (see Table 2). In contribution programs, customers contribute to a fund for renewable energy project development in a utility's service territory. The projects funded may or may not supply green power to the customers paying for them. In energy-based programs, customers purchase all or part of their electricity from renewable resources. Green power is typically sold in blocks, such as 100 kWh per month, or as a percentage of total consumption. In most instances, consumers pay a premium price for it. Most utility green pricing programs attract less than 3% of residential customers and even fewer commercial and industrial sponsors. However, pilot programs for retail competition in Massachusetts and New Hampshire demonstrated that environmental factors do influence consumers to pick a particular electricity provider. Successful green pricing programs, such the Colorado WindSource program, benefit from the support of local environmental groups who work to generate customer commitment to new wind development.

A major issue being addressed in restructuring legislation is disclosure. Good disclosure requirements should go a long ways toward keeping green marketing and pricing efforts honest. Rather than asking consumers to get an in-depth education in electricity generation and marketing, most disclosure rules favor something like the nutritional labels on food. Electricity "labels" would provide information on cost, the resources used to generate power, and information about emissions produced. The Green-e program, a well-respected disclosure initiative, was created in 1997 by the San Francisco-based Center for Resource Solutions. The Green-e logo certifies environmentally sound green power products and helps create customer confidence in renewable energy through a code of conduct, disclosure provisions, and consumer education. The Green-e logo assures the public that a specific green power product consists of at least 50% electricity generated from such renewable resources as solar, wind, geothermal, biomass, or small hydro. The other 50% of the electricity cannot have produced more pollution than the average generation mix in California, which consists of 16% coal, 32% gas, 27% hydro, and 9% renewables. To date, California and Pennsylvania participate in the Green-e program. Several other states have mandated their own information disclosure and consumer education requirements. Successful green pricing programs and the Green-e program are definitely bright spots in the current U.S. wind renaissance. However, it is probably overly optimistic to expect green pricing alone to foster the development of a long-term, robust U.S. wind market.

State and Federal Policies

State and federal laws and regulations will dictate the pace and ultimate success of green power marketing. At the present time, policies favoring wind development are coming from individual states where restructuring is proceeding at a rapid pace. More than 10 states have laws, regulations, or other incentives for the development of renewables such as wind. The two most popular state mandates are Renewable Portfolio Standards, which specify that a set percentage of electricity must come from renewable resources; and systems benefit charges, which are levied on utility customers. Systems benefit charges can be used for direct subsidies to renewable energy projects, for research and development, for energy efficiency, or for low-income customers. Both the Renewable Portfolio Standard and the systems benefit charge establish a minimum public obligation for funding the development of renewable energy in a changing electricity

industry. Other state policies promoting renewable energy include purchase incentives (California), government purchase policies (Nebraska and Colorado), and utility green pricing service requirements (Texas). Whether state regulations actually encourage customers to purchase green power or suppliers to invest in it appears to depend on the rules themselves. Overly complex regulations, particularly those that provide little incentive for customers to switch to new suppliers, can hinder the very technologies they were designed to promote. For example, California gives residents a guaranteed rate cut with no incentive to change electricity supplier. In contrast, Pennsylvania offers rate cuts only if customers actively choose an electricity supplier. Thus, in Pennsylvania customers can choose green power and save money. Not surprisingly, more than a million people have opted to do so, whereas only about 80,000 California customers (less than 1%) have taken advantage of green power offerings there.

UTILITY	SIZE	PREMIUM (¢/kWh)	START DATE	NOTES
Bonneville Power Administration	N/A	1.0	1998	Power from new wind project goes into pool of "environmentally preferred resources."
Cooperative Power Association	2.0 MW	2.0	1998	New project contract for distribution cooperatives
United Power Association	0.7 MW	2.0	1997	Buys wind energy from Cooperative Power for "It's A Breeze" program
Fort Collins Light & Power	1.2 MW	2.0	1997	Two 600-kW turbines (Medicine Bow, WY) "Wind Power Pilot Program"
Lincoln Electric System	0.75 MW	6.0	1999	New project
Los Angeles Department of Water and Power Board	20 MW (?)		1999 (?)	"Green Plan" customers pay $3-$5 extra per month to develop new wind projects
Madison Gas and Electric	11.25 MW	4.0-5.0	1999	New project
Moorhead Public Service	0.75 MW	0.5	1999	New project "Capture the Wind"
Public Service Company of Colorado (PsCo)	12-20 MW	2.5	1998	12-MW facility under construction in 1998
Holy Cross Energy	2.75 MW	2.5	1998	Wholesale purchase from PsCo
Colorado Springs Utilities	0.5 MW	3.0	1998	Wholesale purchase from PsCo
Southwestern Public Service (New Mexico)	0.7 MW	3.0	1997	"WindSource" program initiated as condition of regulatory approval of new gas turbine
Traverse City Light and Power	0.6 MW	1.58	1996	One 600-kW turbine"Green Rate"
Western Resources	1.5 MW		1998	Two 750-kW turbines
Wisconsin Electric Power Co	1.2 MW	2.0	1998	New, two-turbine project part of "Energy for Tomorrow" program

Table 2. Green Pricing Programs Offering Wind Power

Many state restructuring laws include provisions for net metering. Net metering policies allow individual utility customers to install a renewable energy system such as a wind turbine on their side of the electric meter and be compensated at retail rates for the electricity they produce. Net metering systems calculate monthly customer charges by subtracting the value of some or all of the electricity fed into the grid from the amount of electricity used. The process encourages consumer investment in wind technology by improving the economics of individual wind systems connected to a utility grid. Without net metering, customers pay full retail rates for electricity they use from the grid, but are reimbursed for electricity they sell at the utility's avoided cost, which is significantly less than retail rates. Because net metering is only available to rural residents in 11 states, its impact on wind development has been limited thus far.

Although state policies are currently defining restructuring, industry analysts believe that federal policy and marketing incentives will be necessary to ensure the survival of the U.S. wind industry. They contend that, should Congress allow the production tax credit to expire in June 1999, wind development in the United States could come to a virtual standstill.[11] Because wind energy is significantly more expensive than natural gas, it is not clear that green power marketing alone could sustain the current momentum of U.S. wind development. In contrast, a temporary extension of the tax credit for five years would help shore up a weakened U.S. wind industry, encourage the installation of an additional 1000 MW of wind, and help position U.S. firms to capture about a quarter of the projected international wind market by 2005. However, prospects for an extension remain uncertain despite support from the Edison Electric Institute and 12 members of the House Ways and Means Committee. Congress is apparently not going to consider a tax bill or other legislation to extend the tax credit this year.

Little is happening on the federal level right now with respect to restructuring legislation. Four restructuring bills, along with the Administration's Comprehensive Electricity Competition Plan, were introduced and discussed during the 105th Congress. Each would have created a national Renewable Portfolio Standard. The Renewable Portfolio Standard is a flexible, market-driven policy to accelerate market penetration of renewable technologies like wind that are already near commercialization. The various proposals would have required renewable energy resources to produce

between 4% and 10% of the nation's electricity by 2010. Most included provisions for tradable renewable energy credits, which would allow electricity generators to purchase compliance if they chose not to invest directly in renewable energy themselves. If enacted, a national Renewable Portfolio Standard would create certainty and stability in domestic wind markets. Supporters of the standard argue that restructuring is unlikely to create market opportunities for renewable energy and may actually increase competition to the point renewable energy cannot compete. They believe that a federal policy is necessary to keep renewable energy from being shut out of tomorrow's electricity markets. Opponents of the standard are concerned about the possible costs of implementing it and believe it is at odds with creating a truly competitive market. Because Congress failed to act on any restructuring legislation this session, the fate of wind development remains uncertain. Because this year's pending bills died at the end of this session, a new Congress will resume debate on restructuring next year. For wind to succeed in tomorrow's electricity markets, there appears to be a need for supportive policies during and after the transition to electric industry restructuring and for market rules favorable to renewable energy technologies. Such policies could include net metering, systems benefit charges, increased support for research and development, and various tax incentives, including an extension of the production tax credit.

---

[1] "Wind Energy in Europe-The Facts." Executive Summary. European Wind Energy Association – Publications. http://www.ewea.org/summary.htm (25 August 1998).

[2] "How much does electricity from wind turbines cost?" American Wind Energy Association FAQ: Cost of Wind Energy. http://www.igc.apc.org/awea/faq/cost.html (25 August 1998).

[3] Wiser, R. and Kahn, E. "Alternative Windpower Ownership Structures: Financing Terms and Project Costs." From Wind Energy Weekly #709, 12 August 1996. American Wind Energy Association FAQ: Cost of Wind Energy. http://www.igc.apc.org/awea/faq/cost.html (25 August 1998).

[4]The Electric Power Research Institute. *Renewable Energy Technology Characterizations*. TR-109496. Palo Alto, CA: Electric Power Research Institute December 1997. Prepared by the Office of Utility Technologies, Energy Efficiency and Renewable Energy, U.S. Department of Energy and EPRI.

[5] Seven wind power classes are used to express the energy contained in wind, with Class 1 containing the least energy and Class 7 the most. To date, the nation's abundant Class 4 winds are the least energetic winds commonly harnessed for wind power. The high-energy Class 5 and 6 winds are more economical to harvest, but less abundant and often farther away from population centers where electricity is needed.

[6] The Electric Power Research Institute. *Renewable Energy Technology Characterizations*. TR-109496. Palo Alto, CA: Electric Power Research Institute December 1997. Prepared by the Office of Utility Technologies, Energy Efficiency and Renewable Energy, U.S. Department of Energy and EPRI.

[7] "Wind Energy in Europe-The Facts." Executive Summary. European Wind Energy Association – Publications. http://www.ewea.org/summary.htm (25 August 1998).

[8] Swezey, B. G., Houston, A. H., and Porter, K. L. "Green Power Takes Off with Choice in Electricity." *Public Utilities Fortnightly* August 1998; pp.46-51.

[9] Flavin, C. and Dunn, S. *Climate of Opportunity: Renewable Energy After Kyoto*. Issue Brief No. 11. Washington, D.C.: Renewable Energy Policy Project July 1998.

[10] "Nuclear Power." Energy Information Agency Market Trends – Electricity. 1997. http://www.eia.doe.gov/oiaf/aeo98/ele_nuc.html (29 September 1998).

[11]Cadogan, J. Personal Communication. Department of Energy, Washington, D.C. 29 September 1998.