Midwest Wind Development Plan

for the
Midwest Independent System Operator
Transmission Expansion Plan 2003-2007

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American Wind Energy Association

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Summary: Wind energy is the fastest-growing power technology. In the Midwest, over 800 MW of wind power is currently operational with another 1,000 MW in near term development (identified projects with identified sites, owners, and customers who have agreed on price, timing, and quantity.) There is nearly 6,000 MW of new wind power currently in the regional interconnection queues including over 2,000 MW in the MISO queue. The rapidly growing markets for new wind power development in the Midwest result from steadily improving economics, strong environmental benefits, growing utility loads, and increasing state and national policy support. In this context, the projections result in 5,500 MW of new wind power development in the Midwest between 2003 and 2007. Rapid construction time for wind energy will accelerate transmission impacts. Input to the projections included the wind power developers active in the region, analysis of regional wind resources, recent regional transmission studies, and assessment of growing markets.

Overview

Wind energy is the fastest-growing power technology. The global wind energy industry installed 6,500 new megawatts (MW) of wind power generating capacity in 2001, a record amount for the industry and more than 50% higher than the previous year's record. The wind energy market is projected to reach 60,000 MW worldwide over the next five years, more than doubling its present output.[1] Since 1995, world wind power has increased by 487%, or nearly five-fold.

The U.S. installed a total of 1,695 MW in 16 states in 2001, a year that easily surpassed previous records. Texas installed 915 MW of new wind capacity in 2001, more than had ever been installed before in the entire country in a single year. The Texas experience shows what can be achieved when a Renewable Portfolio Standard (RPS) is combined with the Production Tax Credit (PTC) and with nondiscriminatory transmission policies. The state more than tripled its wind capacity, and would rank sixth among the nations of the world in wind capacity.

In the Midwest, over 800 MW of wind power is currently operational with another 1,000 MW in near term development (identified projects with identified sites, owners, and customers who have agreed on price, timing, and quantity.) There is nearly 6,000 MW of new wind power currently in the regional interconnection queues including over 2,000 MW in the MISO queue alone. A range of 3 to 6% of the Midwest's electricity from wind power would be achieved with approximately 4,700 to 9,400 MW (nameplate) of wind power.

	Wind Power (nameplate), MW				Total Consumption, TWh	
			% of Total Generation in 2007[3]			1.75%
	Existing[1]	Total Potential[2]	3%	6%	Actual[4] 1999	Projected 2007
Illinois	0	6,980	1,539	3,077	137	157
Iowa	324	62,900	444	887	39	45
Kansas	118	121,900	381	761	34	39
Minnesota	320	75,000	638	1,276	57	65
Nebraska	3.5	99,100	257	515	23	26
Oklahoma	0	82,700	538	1,076	48	55
North Dakota	1.3	138,400	104	208	9	11
South Dakota	2.6	117,200	89	178	8	9
Wisconsin	53	6,440	745	1,491	66	76
Total	822	710,620	4,735	9,470	421	484

Notes:
1. American Wind Energy Association, April 2002, http://www.awea.org/
2. *An Assessment of Windy Land Area and Wind Energy Potential*, Pacific Northwest Laboratory,1991.
3. Wind power capacity equivalent of 3 to 6% of total consumed electricity.
4. Energy Information Administration, 1999, http://www.eia.doe.gov/emeu/states/_states.html

[1] AWEA's Global Wind Energy Markets report, http://www.awea.org/pubs/documents/GlobalWEMarket2002.pdf.

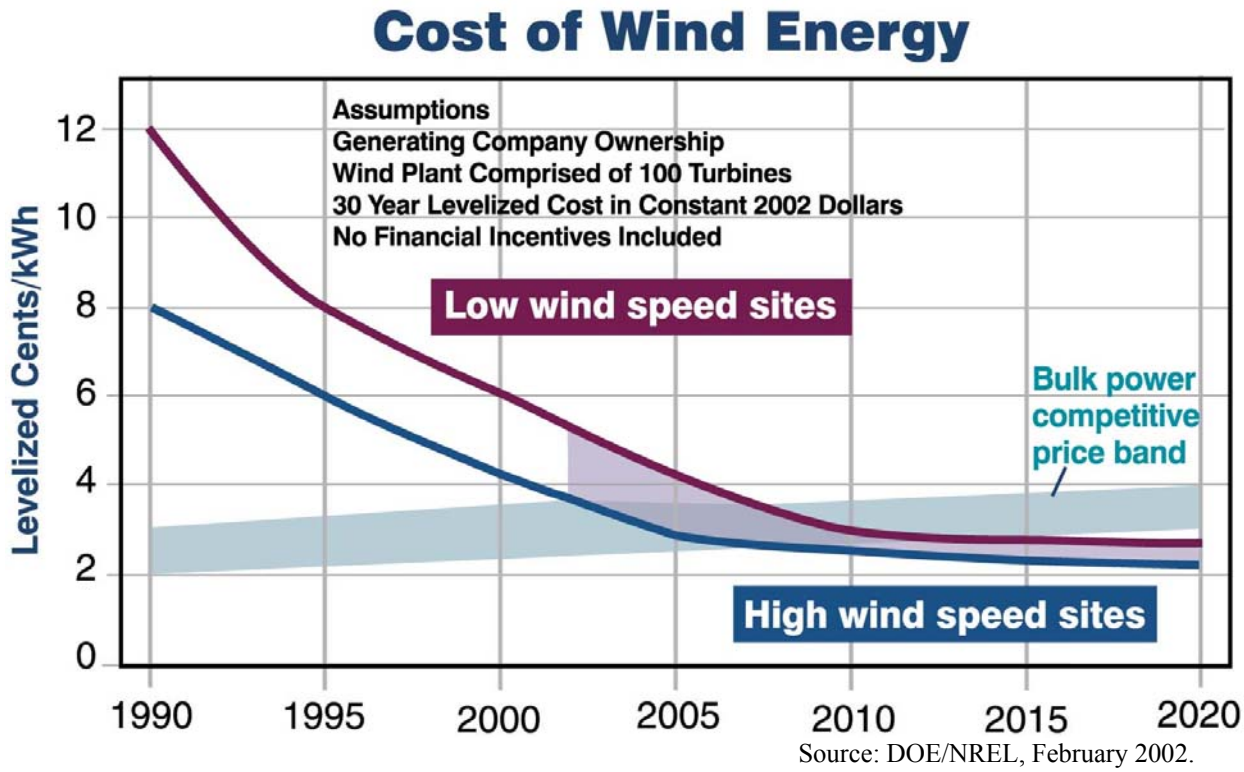
Markets

Economics

The economics of wind energy have improved dramatically over the past twenty years, and will continue to improve as the industry grows and matures. Key factors affecting the economics of wind power include wind speed, turbine design, and wind farm size.

Over the last two decades, state-of-the-art turbines have increased from less than 50 kW in capacity to 1,500 kW. Turbine rotors have mushroomed from less than 20 meters in diameter to over 70 meters. And availability of wind projects has increased from an average of 20% in 1982 to over 98% today. The result is that today's turbine will produce over 200% more electricity from the same amount of wind (per unit of rotor swept area) than in 1982. Improvements have been made in all areas of wind development – siting, size, blade design, generator design, materials, power conditioning, controls, operations and preventive maintenance.

Prices for wind-generated electricity have dropped by over 90% from the early 1980's to less than 4 cents/kWh at the bus bar in good wind resource areas (Class 4 and above) today. Contracted prices reported for projects in Minnesota have decreased by over 40% since the first large (25 MW) project was installed in 1994. The Department of Energy has established a goal of producing power from the wind at less than 3 cents/kW.h [*not* including the Production Tax Credit (PTC) benefits] by 2010, which would be equivalent to about 2.1 cents/kWh including PTC benefits.



Source: DOE/NREL, February 2002.

Growing Utility Loads and Potential Return of High/Volatile Natural Gas Prices

With declining costs, energy from wind power is becoming competitive with new natural gas in all source bids and other acquisitions by utilities with growing loads. U.S. and Canadian pipeline representatives at the recent North American Gas Strategies Conference agreed that existing natural gas supplies will not be sufficient to meet the North American market need for natural gas in the next decade. Supply constraints are likely to lead to higher natural gas prices and higher volatility, which, in turn, will lead to higher and more volatile electricity prices, they said. This uncertainty and volatility will highlight wind energy's price stability compared with natural gas, the current fuel of choice for many new power plants.

Renewable Portfolio Standard

A number of states in the region, including Illinois, Iowa, Minnesota, and Wisconsin, have requirements or goals for renewables. Debate is under way for a national Renewables Portfolio Standard (RPS) -- a minimum renewable energy content requirement for utilities that grows over time -- of 10% by 2020. The policy also would establish a trading program of renewable energy credits that could be sold or exchanged, enabling companies that chose not to produce electricity with renewables to meet the requirement by purchasing or exchanging credits from companies that do. Growing federal policy support for renewables could result in a significant opportunity for wind rich Midwestern states to develop and export a greater proportion of wind power.

Green Pricing

Over 200 utilities in the nation offer their customers an optional green service to support renewable energy development. Minnesota's biggest electricity provider, Minneapolis-based Xcel Energy, is planning to introduce a "green pricing" program this summer, modeled after a similar program in Colorado. Because of a state law passed last year requiring that customers be given an option at least annually for green power, virtually every utility is going to be offering their customers wind power. Xcel estimated that based on the cost of building new generating plants, wind costs 2.5 to 3.5 cents per kilowatt hour, compared with 3.5 to 5 cents per kilowatt hour for a new coal-fired plant and 3.5 to 4.5 cents per kilowatt hour for a new combined-cycle natural gas-fired plant.[2]

Voluntary Government, Corporate, and Institutional Purchases

Voluntary purchases of renewable energy is on a dramatic up swing in government, corporate, and institutional sectors. Examples include Illinois governor George H. Ryan's recent announcement that the state will purchase at least 5% by 2010 (15% by 2020) of all electricity for buildings owned or operated by agencies under the governor's control from renewable sources; In Colorado, IBM signed up for Windsource (Xcel Energy's green pricing program) in January for its Boulder plant; outdoor clothing manufacturer Timberland announced recently that it will support purchase of green tags[3] from a wind farm in South Dakota; and twenty five Pennsylvania colleges and universities have committed to purchase wind-generated electricity from wind farms.

[2] *Xcel to Introduce 'green pricing' Wind Power Program*, Minneapolis Star Tribune, May 12, 2002

[3] Green tags are tradable renewable certificates that result from dividing renewable electricity generation into two separate products: generic commodity energy, and environmental attributes.

Projections for New Wind Power Development

The rapidly growing markets for new wind power development in the Midwest result from steadily improving economics, strong environmental benefits, growing utility loads, and increasing state and national policy support. In this context, the projections result in 5,500 MW (nameplate) of new wind power development in the Midwest between 2003 and 2007. Input to the projections included the wind power developers active in the region, analysis of regional wind resources, recent regional transmission studies, and assessment of growing markets.

The 5,500 MW of projected wind development is only a tiny fraction of the over 700,000 MW of "proven reserves" of wind power in the nine state region.[4] The projected wind power development results in just 3.5% of the total electricity consumption of the region in 2007 (projected at 1.75% annual growth). An additional 4,500 MW could be developed in central South and North Dakota with robust transmission solutions. The resulting 10,000 MW of wind power would still only account for 6.5% of regional electricity consumption.

The substantial benefits of geographic dispersion, advances in wind forecasting, and new wind turbine technology will positively impact the implementation of the projected wind power development. The geographic dispersion of wind power sites in these projections will provide significant smoothing of the variations of individual wind turbine output. Advances in recent years in wind forecasting models has shown that wind forecasts can be quite accurate for one to four hours, and can even be forecast up to several days. New wind turbine technical advances include the potential ability to control and regulate voltage through sophisticated power electronics, allowing them to provide support to transmission and distribution systems.

The economics of wind power correlate strongly to average annual wind speed and therefore wind power is very site dependent. Rapid construction time for wind energy relative to other generation technologies will further amplify transmission impacts. A project by project approach to transmission expansion like the current queue process can be punitive for site dependent resources like wind power that tend to get developed in smaller increments. These projections form the basis for comprehensive, integrated, forward looking planning for transmission expansion for wind power.

The table on page 6 summarizes the projected wind power development including injection points, markets, and the busbar cost. The injection points are based upon existing substations, few of which have transmission capacity available without new transmission projects. While some of the new wind power projects will get absorbed by local load, the markets for the majority of the energy will be in major metropolitan areas. The busbar costs are at the injection point and do not include transmission costs. The map on page 7 illustrates the projected wind power development.

[4] *An Assessment of Windy Land Area and Wind Energy Potential, Pacific Northwest Laboratory*, 1991.

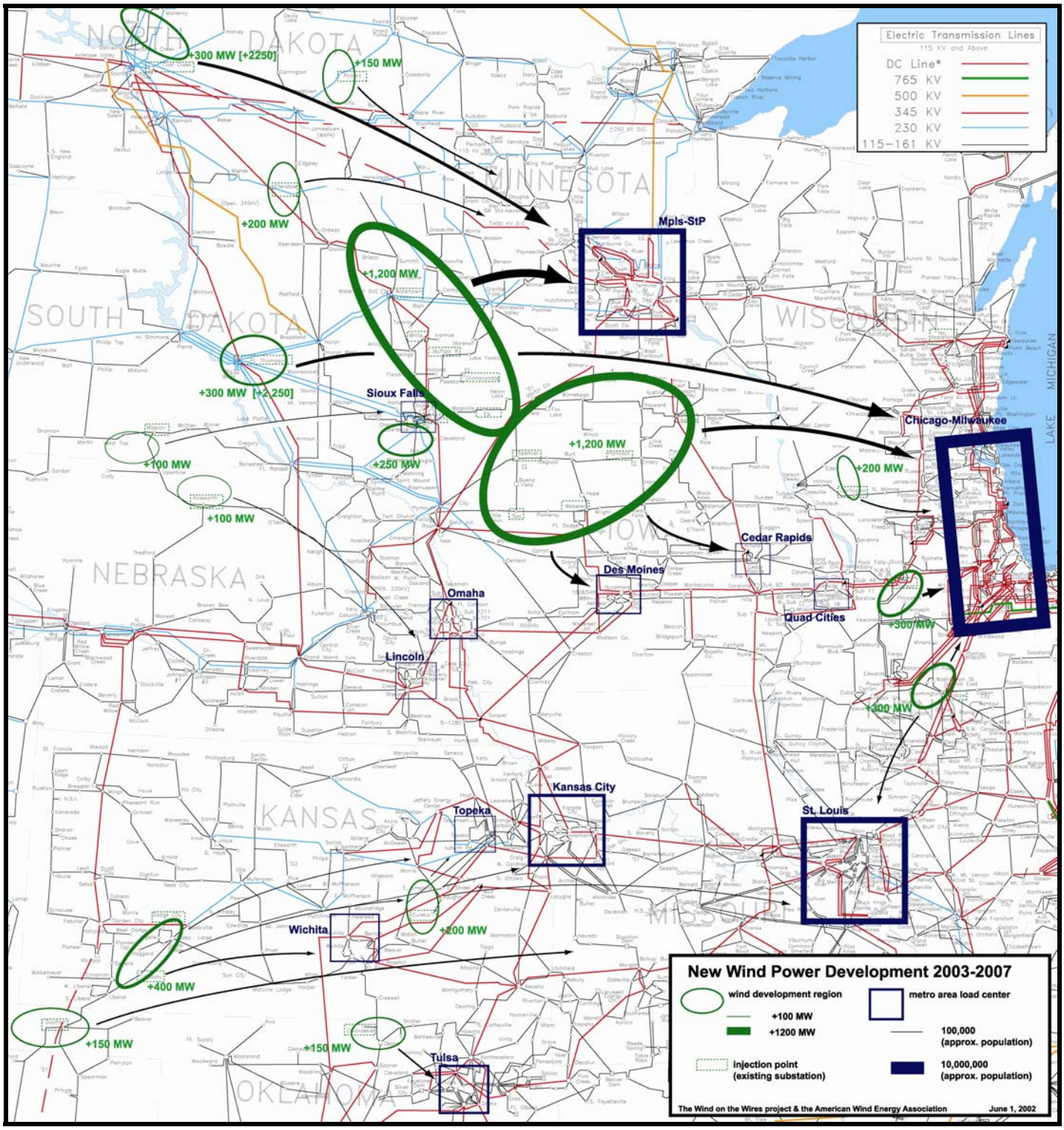
New wind power development 2003-2007:

	MW (nameplate)	Injection Point (existing substation)		Market	Wind Class	Net Annual Cap. Factor[1]	Busbar Cost ($/MWh)[2]
Illinois							
North	300	Nelson	115/345 kV	Chicago	4±	30%	25-30
Central	300	Brokaw	115/345 kV	Chicago/St. Louis	4±	30%	25-30
Iowa							
North	1200	Spencer	161 kV	Chicago-Milwaukee	4-5	35%	23-27
		Hancock	161 kV	Chicago-Milwaukee	4-5	35%	23-27
		Adams	161/345 kV	Chicago-Milwaukee	4-5	35%	23-27
		Sac	161 kV	Des Moines	4-5	35%	23-27
		Webster	161/345 kV	Cedar Rapids	4-5	35%	23-27
Kansas							
East	200	Eureka	115 kV	St. Louis/Kansas City/Topeka	4±	30%	25-30
South Central	400	Cudahy	115 kV	Witchita/Kansas City/St. Louis	4±	30%	25-30
		Dodge City	115 kV	Witchita/Kansas City/St. Louis			
Minnesota							
Southwest+	1200	Elk	161 kV	Minneapolis-St. Paul	4-5	35%	23-27
		Chanarambie	115 kV	Minneapolis-St. Paul	4-5	35%	23-27
		Buffalo Ridge	115 kV	Minneapolis-St. Paul	4-5	35%	23-27
		White	115/345 kV	Minneapolis-St. Paul	4-5	35%	23-27
		Watertown	230/345 kV	Minneapolis-St. Paul	4-5	35%	23-27
Nebraska							
North Central	100	Ainsworth	115 kV	Omaha/Lincoln	4±	30%	25-30
Oklahoma							
Northwest	150	Guymon	115 kV	Kansas City/St. Louis	4±	30%	25-30
North Central	150	Chickaskia	115 kV	Tulsa	4±	30%	25-30
North Dakota							
Central	300	Coal Creek	230/345 kV	Minneapolis-St. Paul	4-5	35%	23-27
South Central	200	Ellendale	115/230 kV	Minneapolis-St. Paul	5-6	40%	20-25
East	150	Pickert	230 kV	Minneapolis-St. Paul	4±	30%	25-30
South Dakota							
Central	300	Ft. Thompson	230/345 kV	Chicago-Milwaukee	5-6	40%	20-25
Southeast	250	Split Rock	115/345 kV	Sioux Falls/Minneapolis-St.P	4±	30%	25-30
South Central	100	Mission	115 kV	Sioux Falls/Minneapolis-St.P	5-6	40%	20-25
Wisconsin							
Southwest	200	Darlington	115 kV	Chicago-Milwaukee	3±	20%	50-55
TOTAL	**5500**						

Additional new wind power for high transmission case:

North Dakota							
Central	2250	Coal Creek	345/230 kV	Minneapolis-St. Paul	4-5	35%	20-25
South Dakota							
Central	2250	Ft. Thompson	345/230 kV	Chicago-Milwaukee	5-6	40%	15-20
TOTAL	**4500**						

Notes:
1. Net Annual Capacity Factor - includes reductions for collector system & transformer losses, availability losses, array losses, etc.
2. Projected 2007 busbar cost; 30 year levelized cost in constant 2002 $s; includes the Production Tax Credit.


Electric Transmission Lines
115 KV and Above
DC Line*
765 KV
500 KV
345 KV
230 KV
115-161 KV
NORTH DAKOTA
SOUTH DAKOTA
MINNESOTA
WISCONSIN
MICHIGAN
LAKE
IOWA
NEBRASKA
KANSAS
MISSOURI
OKLAHOMA
+300 MW [+2250]
+150 MW
+200 MW
+1,200 MW
+300 MW [+2,250]
+100 MW
+100 MW
+250 MW
+1,200 MW
+200 MW
+300 MW
+300 MW
+200 MW
+400 MW
+150 MW
+150 MW
Mpls-StP
Sioux Falls
Chicago-Milwaukee
Cedar Rapids
Des Moines
Omaha
Quad Cities
Lincoln
Kansas City
Topeka
St. Louis
Wichita
Tulsa
New Wind Power Development 2003-2007
wind development region
metro area load center
+100 MW
+1200 MW
100,000
(approx. population)
injection point
(existing substation)
10,000,000
(approx. population)
The Wind on the Wires project & the American Wind Energy Association
June 1, 2002