The UNIVERSITY of VERMONT

The Vermont Legislative Research Shop

Wind Power

Wind power, an overview

Wind power is the term given to electricity that is produced through the use of a wind turbine. A wind turbine is an apparatus that stands approximately 100 feet above the ground where the less turbulent winds can be harvested[1]. Most wind turbines have either two or three blades, this usually depends on the specific job that the turbine must accomplish. To generate electricity the blades need to turn at a high rate of speed without a lot of torque, and therefore the fewer the blades the better. Research is still being conducted to determine the most efficient design.[2]

Wind Power does not produce the green house gases and toxic emmisions that conventional energy sources produce. The American Wind Energy Association, (AWEA) says that the current wind power generating capacity "will reduce emissions of carbon dioxide—a leading greenhouse gas—by three million tons and other noxious gases by 27,000 tons."[3] This also virtually eliminates the danger that can be posed to the soil and waterways as well. It must be understood however that although the turbine itself is seen as being quite environmentally friendly, the necessary bi-products such as access roads and site excavation can pose certain risks.

Wind has been a less viable option in the past due to the relative expense of wind power when compared to other forms of electricity. Wind power cost approximately $2,500 per kilo-watt hour (kH) in the mid 1980's. However by the mid-nineties wind power's price was down to $1,000 per kH.[4] The California Energy Commision noted the prices of wind power when compared to other major wind sources in a report completed in 1996. The results are shown below in figure 1. Although these are averages, wind power can vary significantly ina averge cost. There are many variables that can affect cost. The average wind speed and overall size of

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[1]U.S Department of Energy *Wind Energy Basics* http://www.eere.energy.gov/RE/wind_basics.html visited on 03/24/2004

[2] British Wind Energy, *Why don't wind turbines have a lot of blades?* http://www.britishwindenergy.co.uk/ref/faq.html#blow visited on 04/04/2004

[3]National Geographic, *Ireland to build world's largest windfarm.* http://news.nationalgeographic.com/news/2002/01/0115_020115TVwindfarm.html visited on 04/07/2004

[4]State and local climate change program. *Harvesting the Wind* http://yosemite.epa.gov/oar/globalwarming.nsf/uniqueKeyLookup/SHSU5BWK54/$file/windenergy.pdf?OpenElement Visited on 03/24/2004

the windfarm can affect efficiency. Improved technology can bring machinenary production costs down and if enviromental impact is taken into account, overall cost is again reduced when compared to conventional energy sources.

Fuel	Levelized costs (cents/kWh) (1996)[5]
Coal	4.8-5.5
Gas	3.9-4.4
Hydro	5.1-11.3
Biomass	5.8-11.6
Nuclear	11.1-14.5
Wind	4.0-6.0

Figure 1: Cost per kilowatt hour by energy source (California Energy Commision)

Wind turbines vary in sizes, when considering both physical size and generating capacity. At the smaller end of the spectrum is a 500 watt machines and the bigger turbines can be as large as 900 Kilo-watts. There are three primary uses that turbines can be used for. The first is "Utility interconnected wind turbines generate power which is synchronous with the grid and are used to reduce utility bills by displacing the utility power used in the household and by selling the excess power back to the electric company. These machines are economically attractive where there is a good wind resource and where the local power costs are in excess of 15 cents per kilowatt hour." The second type is used to power remote homes that are not currently on an energy grid, to charge batteries with DC power. The third primary use for wind turbines is to power "remote water pumping generate 3 phase AC current suitable for driving an electrical submersible pump directly."[6]

An area must first be located where the wind blows consistently for at least a few seasons per year. For instance the state of California produces most of it's wind power during the spring and summer months. Studies of wind turbines in the United Kingdom showed that most turbines operated with an average complete efficiency of 30-40 percent.[7]

As discussed earlier, wind turbines vary in size, but the larger machines can produce a considerable amount of energy. One 600kW machine can produce enough electricity to power 375 households for 1 year.[8] Most large-scale wind turbines are a part of a wind farm. This is a collection of many turbines, sometimes numbering several hundred machines.

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[5] California Energy Commission *Energy Technology Status Report* http://www.energy.ca.gov/etsr/ visited on 03/24/2004

[6]Wind Power.com *All about renewable energy systems* http://www.wind-power.com/#Wind visited on 04/07/2004

[7]British Wind Energy *BWEA statement following release of CPRW document Wind Turbine Blight* http://www.britishwindenergy.co.uk/media/news/arc/cprw.html#cprw

[8] British Wind Energy, *How much energy can one wind turbine produce?* http://www.britishwindenergy.co.uk/ref/faq.html#blow visited on 04/04/2004

Wind power is a rapidly expanding energy source with about 39,294 MW of power being produced world wide as March 10th 2004.[9] Approximately 6,374 MW of that total comes from the United States.

National Experience:
As of January 22, 2004, the US has a total of 6,374 MW of wind energy produced per year, the majority of which was generated in California and Texas, but wind farms have been installed in 28 other states, refer to Figure 2.[10]

Wind Energy Projects Throughout US

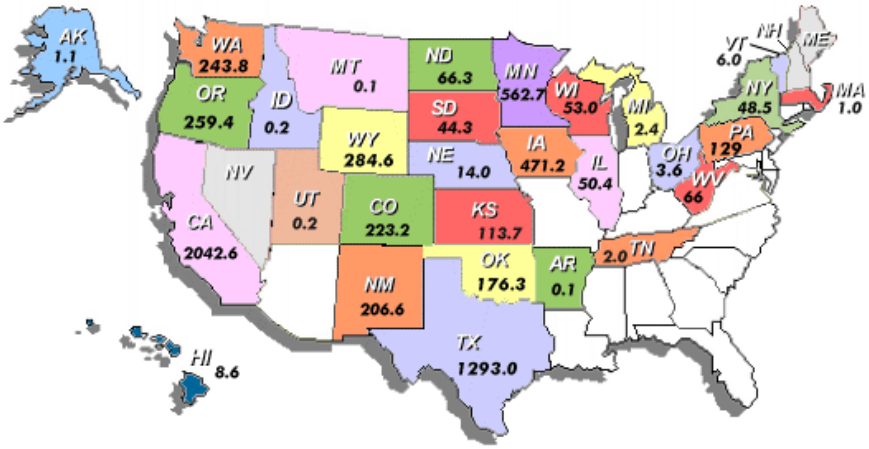

Figure 2: Total Installed Wind Energy Capacity: **6,374 MW as of Jan 22, 2004** (numbers represent total installed wind energy production capacity in megawatts for individual states)

Wind energy in California produced 1.5% of the state's total electricity in 1997 and 95% of that energy came from 3 major areas; Altamont Pass (east of San Francisco), Tehachapi (southeast of Bakersfield), and San Gorgonio (near Palm Springs, east of Los Angeles).[11]California has been on the forefront of wind power and in 1995 produced 30% of the world's wind energy, installed almost solely by independent companies in the 1980's. As technology improves, these older, less efficient turbines will need to be replaced by turbines that will produce 35-40% more electricity. Minnesota is another state that has been pinned as a viable wind energy resource and the US Department of Energy reported in 1991 that wind energy in Minnesota could produce 657 terawatt-hours (625 trillion watt-hours) of electricity annually from about 225 gigawatts of wind energy capacity.[12] According to potential wind farm plans, by 2012 wind energy could be

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[9]AWEA, *Global wind power continues to strengthen.* http://www.ewea.org/documents/0310%20FINAL3%20%20Global%20Markets%20Release1.pdf visited on 04/12/2004

[10] American Wind Energy Association, *Wind Energy Projects Throughout the United States of America*, http://www.awea.org/projects Visited on 03/22/2004

[11]US Environmental Protection Agency, *Climate Change Technologies: Wind Energy*, http://yosemite.epa.gov/oar/globalwarming.nsf/uniqueKeyLookup/SHSU5BWK54/$file/windenergy.pdf?OpenElement Visited on 03/24/2004

[12]US Environmental Protection Agency, *Climate Change Technologies: Wind Energy*, http://yosemite.epa.gov/oar/globalwarming.nsf/uniqueKeyLookup/SHSU5BWK54/$file/windenergy.pdf?OpenElement Visited on 03/31/2004

responsible for the offset of nearly 1.7 million tons of CO2 emissions from fossil fuel power plants annually.[13]

Previous legislation on wind power has both promoted and acted as a deterrent to wind energy projects, most notably the Federal Production Tax Credit (PTC) introduced through the Energy Policy Act (EPACT) of 1992. The PTC grants 1.5¢ per kilowatt-hour for the first ten years of operation to wind plants brought on line before June 30, 1999. The PTC was originally enacted to provide a low-cost incentive for development of clean, renewable, domestic wind energy, but has since expired.[14] This has had a detrimental effect on those companies and wind supporters that are planning future wind power projects and farms. The PTC and its pending extension is the breaking point for some states and future wind energy projects. The American Wind Energy Association has ranked Illinois as number 16 in wind energy potential and if all planned projects were to go through, it would put Illinois as one of the top 5 states for wind energy.[15]

State Activity

Individual states have created incentives, mainly financial, for renewable energy, which include tax breaks for private citizens and companies. Texas has been another entrepreneur in wind energy development and to encourage further renewable energy development the state enacted an electricity restructuring law in January 2002 that will require that 2,000 MW of new renewable energy capacity, generating approximately 3% of the state's total power, be developed by 2009.[16] Texas has also made it possible for individual citizens and small companies to own turbines. The meters on these turbines can either add or subtract, for example, if your system produces too much electricity, the surplus flows back through your meter into the power grid, and the electric company credits or pays you for the surplus at the same price they charge. Conversely, if there isn't enough wind to power your system, you can pay the electric company only for what you need.[17] Minnesota has offered exemption from all real and personal property of a wind energy system from property taxes, Minnesota state sales tax and offers net metering (meters that can add or subtract) for those systems less than 40kW in size.[18]

The Nebraska Energy Office offers low-interest loans to residential and commercial energy efficiency and renewable energy projects. A renewable energy project must meet a specified list

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[13]US Environmental Protection Agency, *Climate Change Technologies: Wind Energy*, http://yosemite.epa.gov/oar/globalwarming.nsf/uniqueKeyLookup/SHSU5BWK54/$file/windenergy.pdf?OpenElement Visited on 03/31/2004

[14]Union of Concerned Scientists, *Letter on Extending the Federal Production Tax Credit*, http://www.ucsusa.org/clean_energy/archive/page.cfm?pageID=169 Visited on 03/31/2004

[15] Peoria Journal Star, *Pending Legislation Seen As Crucial to Unlocking Illinois' Energy Producing Potential*, http://www.pjstar.com/news/topnews/b2kib2kk017.html Visited on 04/05/2004

[16] US Environmental Protection Agency, *Wind Power Surges in Texas*, http://www.epa.gov/earth1r6/6xa/clean_wind.htm Visited on 04/07/2004

[17] US Environmental Protection Agency, *Wind Power Surges in Texas*, http://www.epa.gov/earth1r6/6xa/clean_wind.htm Visited on 04/07/2004

[18] Minnesota Department of Commerce, *Renewable Energy Production Incentives*, http://www.state.mn.us/cgi-bin/portal/mn/jsp/content.do?contentid=536885915&contenttype=EDITORIAL&agency=Commerce Visited on 04/12/2004

of requirements that will, overall, prove to create wind energy savings.[19] Nebraska also offers building easements to protect access to sunlight and wind under the state's solar and wind access law.[20]

Aside from lack of tax benefits to wind farm projects, lack of wind condition information in an area is also a barrier to wind energy development. In New York, wind developers drafted a wind resource map, which includes surface and upper-air wind data to produce detailed estimates of wind energy potential throughout the state. This wind map was designed to provide extensive information on both large and small-scale wind generation for a variety of users such as government planners, private energy developers, electric utilities, private individuals and businesses, and university researchers. [21]

International Activity

Wind Energy worldwide has also seen huge growth, which spurred the first global wind energy event, being held in Chicago, March 28-31, 2004. This conference came at a crucial time in wind energy growth and expansion. Currently Europe leads the world in its use of wind power. The European Union has set a target of 12% of all energy and 22.1% of electrcity from renewable energy by 2010.[22] Denmark generates 15% of its energy using wind power with Germany and Sweden close behind. By 2020 Denmark expects to generate 50% of its power demands using wind power.[23]

Wind Power In Vermont

As a renewable source wind is classified according to power classes, which are based on typical wind power speeds. These classes range from class 1 (the lowest) to class 7 (the highest). In general wind power class 3 or higher can be useful for generating wind power with large (utility scale) turbines, and small turbines can be used at any wind speed, class 4 and above considered good resources (see figure 3). An extensive area in New England, including most of Vermont has an annual wind power of class 3 or higher on exposed locations. In Vermont, the highest powers class 5 and 6 occur on the best-exposed mountain and ridge tops in the Green Mountains.[24] The Department of Energy has estimated that approximately 3% of Vermont's land area may be suitable for wind power development. This estimate excluded the land that has a wind power class of less than 2, land with urban development, and land that is environmentally sensitive. Also, 50% of forestland, 30% of farmland, and 10% of rangeland were excluded from

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[19] Nebraska Energy Office, AWEA, *State Incentives for Wind Energy*, http://www.awea.org/policy/documents/Incentives/nebr_incen.PDF Visited on 04/12/2004

[20] Nebraska Energy Office, AWEA, *State Incentives for Wind Energy*, http://www.awea.org/policy/documents/Incentives/nebr_incen.PDF Visited on 04/12/2004

[21] True Wind Solutions, *Welcome to the New York State Wind Resource Map*, http://truewind.teamcamelot.com/NY/ Visited on 04/05/2004

[22] 10 Downing Street Website (UK Government Online), *Renewable Energy*, http://www.pm.gov.uk/output/Page1452.asp, Visited on 04/12/2004

[23] National Geographic, *Ireland to Build World's Largest Wind Farm*, http://news.nationalgeographic.com/news/2002/01/0115_020115TVwindfarm.html Visited on 04/12/2004

[24] EPA, Wind Power in Vermont, http://www.epa.gov/region1/eco/energy/assets/pdfs/Windpower_FactSheet_VT.pdf, visited on 3/22/04

the estimate.[25] If all the wind energy potential was developed with utility-scale wind turbines, the power produced each year could equal 6,000,000 megawatt-hours or 115% of the entire state's electricity consumption.[26]

Migratory Birds

Studies show wind power turbines do not significantly effect birds. These studies examined four units: night migrating songbirds, diurnal hawk migration, carcass searches, and breeding birds. The migratory behavior changes were not found to be negative as a result of turbine construction. Maintenance workers found no carcasses on site during the carcass searches. Casual travel through the site suggests that large numbers of birds are not colliding with the turbines and it is likely that only a few, if any birds have been killed. This was reinforced by the fact that scavenging was minimal and indicated that carcasses were not being systematically removed from the site. [27]

WIND POWER CLASS	50m (164 ft) WIND POWER* W/m²	SPEED m/s †	SPEED mph
1	0	0	0
2	200	5.6	12.5
3	300	6.4	14.3
4	400	7.0	15.7
5	500	7.5	16.8
6	600	8.0	17.9
7	800	8.8	19.7
	2000	11.9	26.6

RIDGE CREST ESTIMATES (LOCAL RELIEF > 1000 FT)
* Wind Power Density - watts per square meter
† meters per second

(Figure 3)

Public Opinion

A report by the Vermont Department of Public Service surveyed public acceptance of the Searsburg Wind Power Project. This was a survey administered in two parts pre-construction and post-construction. The results of the survey show a substantial increase in support for the project; however, the positive shift was not as strong among Searsburg residents closer to the turbines.[28] As part of both surveys respondents evaluated scenic quality of 4.5-by-6.5 inch monochrome images of the Searsburg site from 1.25 miles and 4 miles away before and after turbine construction. The second survey showed reduced numbers on the negative visual impact of the turbines illustrating respondents' acceptance.[29] Support for wind power was mixed in the pre-construction survey. By the post-construction survey, a year and a half later, over half of the respondents were in support of wind power compared to 30% in the first survey. The number of non-supporters dropped 15% from 35% to 20% (see figure 4).[30]

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[25] EPA, Wind Power in Vermont, http://www.epa.gov/region1/eco/energy/assets/pdfs/Windpower_FactSheet_VT.pdf, visited on 3/22/04

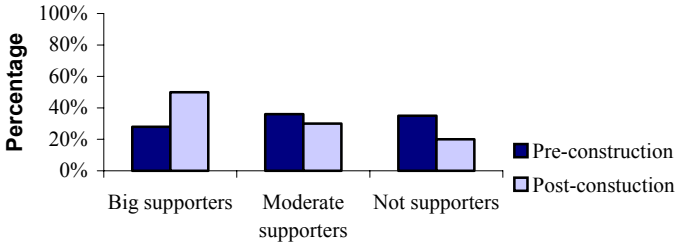
[26] EPA, Wind Power in Vermont, http://www.epa.gov/region1/eco/energy/assets/pdfs/Windpower_FactSheet_VT.pdf, visited on 3/22/04

[27] U.S. Department of Energy, National Renewable Energy Laboratory, An Assessment of the Impacts of Green Mountain Power Corporation's Wind Power Facility On Breeding and Migrating Birds In Searsburg, Vermont http://www.nrel.gov/docs/fy02osti/28591.pdf visited on 3/22/2004

[28] Vermont Department of Public Service, Public Acceptance of the Searsburg Wind Power Project http://www.state.vt.us/psd/Menu/EE_and_Renewable/wind/PUBLICACCEPTANCESUMMARY.pdf visited on 3/22/2004

[29] Vermont Department of Public Service, Public Acceptance of the Searsburg Wind Power Project http://www.state.vt.us/psd/Menu/EE_and_Renewable/wind/PUBLICACCEPTANCESUMMARY.pdf visited on 3/22/2004

[30] Vermont Department of Public Service, Public Acceptance of the Searsburg Wind Power Project http://www.state.vt.us/psd/Menu/EE_and_Renewable/wind/PUBLICACCEPTANCESUMMARY.pdf visited on 3/22/2004



Support for The Searsburg Wind Power Project
Figure 4

In a report on Wind Energy and the Vermont's Scenic Landscape addressing aesthetic considerations of wind power, public surveys concluded that a well-designed and sited turbine is acceptable. Visitors to these wind sites often find them attractive and interesting.[31] Ridgelines are the focus of wind development in Vermont and this may result in conflicts between wind resources and scenic resources. Important factors to site selection for a wind project include visual character of the project site and the viewpoints a project will be seen. Wind turbines appear more prominent if they are seen within a half-mile, in the center of an important view, and/or in close visual association with an important natural or cultural focal point.[32] Aesthetic issues can be alleviated by considering these factors prior to turbine construction. The collateral development associated with wind turbines includes roads, power lines, and substations. These must be carefully designed and sited to minimize offsite visibility.[33]

Prepared by Jared Bombaci, Stephanie Nemore, and Dave Vega under the supervision of Professor Anthony Gierzynski on April 19, 2004.

[31]Vermont Department of Public Service, *Wind Energy and Vermont's Scenic Landscape* http://www.state.vt.us/psd/Menu/EE_and_Renewable/wind/VISSERINGSREPORT.PDF visited on 3/29/2004
[32]Vermont Department of Public Service, *Wind Energy and Vermont's Scenic Landscape* http://www.state.vt.us/psd/Menu/EE_and_Renewable/wind/VISSERINGSREPORT.PDF visited on 3/29/2004

[33] Vermont Department of Public Service, *Wind Energy and Vermont's Scenic Landscape* http://www.state.vt.us/psd/Menu/EE_and_Renewable/wind/VISSERINGSREPORT.PDF visited on 3/29/2004