Wind Energy: An untapped Resource

American Wind Energy Association

The United States has tremendous wind energy resources. Although California gave birth to the modern U.S. wind energy industry, 16 states have greater wind potential.

Installed wind energy generating capacity now totals 9,149 MW, and is expected to generate about 24.8 billion kilowatt hours (kwh) of electricity in 2006. However, that is a still less than 1 % of U.S. electricity generation. By contrast, the total amount of electricity that could potentially be generated from wind in the United States has been estimated at 10,777 billion kwh annually--- three times the electricity generated today.

These new wind farms demonstrate how wind energy can help meet the nation's growing need for affordable, reliable power. With continued government encouragement to accelerate its development, this increasingly competitive source of energy will provide at least 6 percent of the nation's electricity by 2020 and revitalize farms and rural communities-without consuming any natural resource or emitting any pollution or greenhouse gas.

The top twenty states for wind energy potential as measured by annual energy potential in the billions of kwhs, factoring in environmental and land use exclusions for wind class of 3 or higher.

1. North Dakota----1 ,210
2. Texas ----------1, 190
3. Kansas ----------1,070
4. South Dakota-----1,030 .
5. Montana----------1020
6. Nebraska---------- 868
7. Wyoming---------- 747
8. Oklahoma---------- 725
9. Minnesota---------- 657
10.lowa ---------- 551
11 Colorado ---------- 481
12. New Mexico ------ 435
13. ldaho ----------73
14. Michigan----------65
15. New York----------62
16. lIlinois ----------61
17. California----------59
18. Wisconsin----------58
19. Maine----------56
20. Missouri----------52

. source: An assessment of the available windy land area and wind energy potential in the contiguous United States, Pacific Northwest Laboratory-1991 . For more information, see AWEA's web page at http://www.awea.org

Wind Energy---how does it work?

Wind energy is a form of solar energy, created by circulating patterns in the earth's atmosphere that are driven by heat from the sun.

People have made use of wind energy for thousands of years, fashioning sails and attaching them to boats for transportation or to wind mills to grind grain. The energy that the wind contains can either be used directly, as in these examples, or it can be converted into that high-value, highly flexible and useful form of energy we call electricity.

Perhaps the simplest way to describe a wind-electric turbine generator (or "wind turbine", as it is usually called) is to say that it works just like a hydroelectric generator. At hydropower stations throughout the United States and the world, the energy that is contained in falling or flowing water is used to spin the rotor of a turbine (a rotor that looks quite like an everyday electric fan), and the turbine rotor drives the shaft of a generator to produce electricity.

Wind energy actually works in a very similar fashion, especially similar to "run-of the-river" hydro stations that make use of the flowing water in a river or stream. In the case of wind,
of course, the "river" is an invisible one made of air, but the principle is the same. As the air flows past the rotor of a wind turbine (a rotor that looks like an airplane propeller), the rotor spins and drives the shaft of an electric generator.

What's different about wind?

First and most importantly, the fluid (air) that drives the rotor is much less dense than water and so the diameter of the rotor must be much larger than the rotor of a hydro turbine. A hydro turbine capable of generating one megawatt (MW) of power would be several feet in diameter-a 1-MW wind turbine's rotor would be roughly 175 feet across.

Second, wind energy is available over a much larger geographical range than hydropower about one-third of the US (an area stretching from Minnesota to Texas to Wyoming) has enough wind almost everywhere to generate electricity economically, and there are many hills and passes in other states that are windy enough as well. Altogether, 46 of the 50 states have some wind resources that could be developed.

Wind turbines come in all sizes, from those with rotors measuring a few feet across (often used for battery charging on sailboats or vacation homes) to those with rotors measuring hundreds of feet in diameter (used to generate "bulk" electricity that is fed into the utility transmission and distribution system). Turbine systems include:
* a rotor or blades which convert the wind's energy into rotational shaft energy;
* a nacelle containing a drive train, usually including a gear box* and a generator;
* a tower, to support the rotor and drive train; and
* electronic equipment such as controls, electrical cables, ground support

equipment, and interconnection equipment.
**some turbines operate without a gearbox.

Household wind systems have rotors up to perhaps 25 feet in diameter and can be an attractive choice if you live in a windy area or have high electricity prices (one often-quoted rule of thumb is that it is worth looking into a household system if you have average winds of 10 miles per hour and are paying 10 cents or more per kilowatt-hour for electricity). The economics of a home system can be substantially improved if:

(1) Your state has a "net metering" law that requires your utility to credit any excess electricity you generate and feed to the utility system against any electricity you use during times when winds are low; or
(2) You have a farm, an all-electric home, or some other situation that makes your electricity consumption higher than normal, so that most or all of the wind turbine's output can be used on site.

Good wind speeds are important! The energy that the wind contains is a function of the cube of its speed. This means that a site with 12-mph average wind speed has more than 70% more energy than a site with 10 mph average wind speed.

Utility-scale wind systems typically generate electricity at a lower cost-as low as 3-7 cents per kilowatt-hour. Most regions of the U.S. are served by "power pools" of utilities, which join together to generate electricity and transmit it to where it is needed. The name "power pool" is an apt one-electricity coming from many different sources (a coal fired power plant, a hydro plant and others) flows into a "pool" from where it is distributed to thousands of endusers. A power pool can easily absorb the electricity from a wind plant and add it to all of the rest. Wind plants could be installed in many parts of our country, providing income, jobs and electricity for homes and businesses.

Experience also shows that wind power can provide at least up to a fifth of a system's electricity and the figure probably could be higher. Wind power currently provides more than 20% of the electricity distributed by Energia Hidroelectrica de Navarra, the regional electric utility of the industrial state of Navarra in northern Spain. In western Denmark, wind supplies more than 25% of the electricity that is used during windy winter nights. If wind energy in the US were combined with serious efforts to increase energy efficiency, we could substantially reduce our national use of fossil fuels to generate electricity.

Today, utility-scale wind turbines worldwide total about 17,000 megawatts of generating capacity. Yet this is but a tiny fraction of the wind's potential. A recent study performed by Denmark's 8TM Consult for the European Wind Energy Association and Greenpeace found that by the year 2017, wind could provide 10% of the world's electricity supplies, meeting the needs of 500 million average European households.

One key issue for utility-scale wind plants that must be resolved in the coming years is transmission line capacity. Utility transmission lines are like a "pipeline" that is

needed to carry wind-generated electricity from the vast sparsely populated areas of the Great Plains, where the wind is most abundant, to large cities like Minneapolis, Milwaukee, Chicago and Dallas where the demand for electricity is high. At this moment there are not many transmission lines that connect cities with the windiest parts of the plains.

Wind energy is a particularly appealing way to generate electricity because it is essentially pollution free. More than half of all the electricity that is used in the United States is generated from burning coal and in the process, large amounts of toxic metals, air pollution and greenhouse gases are emitted into the atmosphere.

Development of 10% of the wind potential in the 10 windiest states would provide more than enough energy to displace emissions from the nation's coal-fired power plants and eliminate the nation's major source of acid rain; reduce total US emissions of carbon dioxide (the most important greenhouse gas) by almost a third and world emissions CO_2 by 4%; and help contain the spread of asthma and other respiratory diseases aggravated or caused by air pollution in this country. If wind energy were to provide 20% of the nation's electricity-a very realistic and achievable goal with the current technology-it could displace more than a third of the missions from coal fired power plants, or all of the radioactive waste and water pollution from nuclear power plants.

Also, wind farms can revitalize the economy of rural communities, providing steady income through a lease or royalty payments to farmers and other landowners. Although leasing arrangements can vary widely, a reasonable estimate for income to a landowner from one single utility-scale turbine is about $2,000.00 a year. For a 250-acre farm, with income from wind at $55.00 an acre, the annual income from a wind lease would be $14,000.00, with no more than 2-3 acres removed from production. Farmers can grow crops or raise cattle next to the towers. Wind farms may extend over a large geographical area, but their actual "footprint" covers only a very small portion of the land, making wind development an ideal way for farmers to earn additional income. In west Texas, for example, farmers are welcoming wind as lease payments from this new clean energy source replacing declining payments from oil wells that have been depleted.

Farmers are not the only ones in rural communities to find that wind power can bring in income. In Spirit Lake, Iowa, the local school is earning savings and income from the electricity generated by a turbine. In the district of Forest City, Iowa, a turbine recently erected as a school project is expected to save $1.6 million in electricity costs over its lifetime.

Greater uses of wind energy means a cleaner environment with healthier air, and more income to landowners and economically depressed counties and communities in the Great Plains. It means relying more on an energy source whose "fuel" is free and will never be exhausted or embargoed.