Wind Power

A wind turbine converts the energy in the wind into electrical energy or mechanical energy to pump water or grind grain.

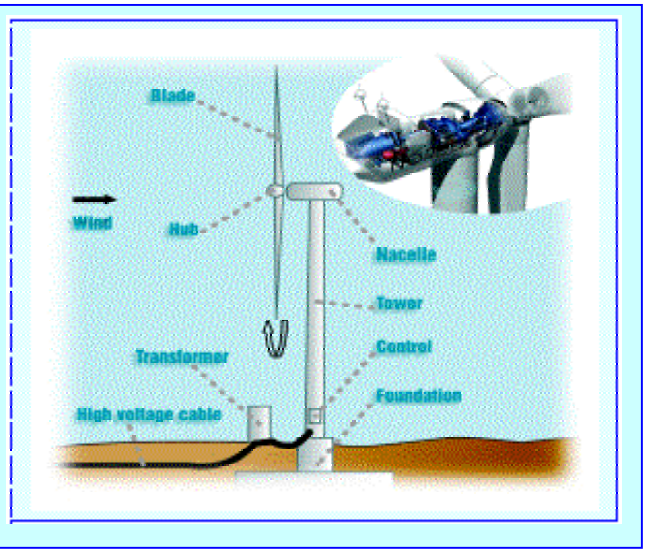
The Technology

The most common wind turbines in operation today generate power from two or three blades revolving around a horizontal axis and are mounted on towers. Such horizontal-axis wind turbines usually include a gearbox, generator, and other supporting mechanical and electrical equipment (see diagram below).

Wind turbines are rated by their maximum power output in kilowatts (kW) or megawatts (1,000 kW, or MW). For commercial utility-sized projects, the most common turbines sold are in the range of 600 kW to 1 MW – large enough to supply electricity to 600-1,000 modern homes. The newest commercial turbines are rated at 1.5-2.5 megawatts. A typical 600 kW turbine has a blade diameter of 35 metres and is mounted on a 50 metre concrete or steel tower.

The power that can be generated from a modern wind turbine is practically related to the *square* of the windspeed, although theoretically it is related to the cube of the windspeed. This means that a site with *twice* the windspeed of another will generate *four times* as much energy.

Consequently, the availability of good windspeed data is *critical* to the feasibility of any wind project. Data is usually gathered over a period of time using ane-



A modern windfarm can generate electricity in a wide range of environments. (Photo courtesy NREL).

Costs

Capital cost - equipment:	*$600 - 800/kW*
Capital cost - project:	*$800 – 1,250/kW*
Maintenance costs:	*< $0.01/ kWh*
Levelised Cost:	*$0.04 - 0.08/kWh*
Operating Life:	*20 years*

(note: all monetary amounts in US dollars)

Key Points:

- *Wind is an intermittent but predictable resource.*
- *Good windspeed data is critical to determining the economic feasibility of a wind project.*
- *Prime sites have average windspeeds greater than 7.5 metres/sec (27 km/hr).*
- *Most common wind turbines in commercial operation average 600 kW in power capacity.*
- *Capacity factors range from 20 to percent; availability is greater than 95 percent.*
- *Wind is a modular technology that can be erected quickly.*
- *Wind turbines can be integrated into existing grid and off-grid applications.*
- *Possible environmental issues include, visual, cultural, land use, and bird impacts, and noise.*
- *Planning approval and environmental assessment are usually necessary.*

mometers installed at the prospective site. Normally, one year is the minimum time a site is monitored.

Most commercial wind turbines operating today are at sites with average windspeeds greater than six metres/second (m/s) or 22 km/h. A prime wind site will have an annual average windspeed in excess of 7.5 m/s (27 km/h).

Utility-sized commercial wind projects are usually constructed as windfarms where several turbines are erected at the same site. Wind projects have been successfully built to power a wide range of applications in diverse and often extreme environments. One of the newest applications is to place windfarms in shallow offshore areas where environmental impacts are often lower and the availability of a steady, non-turbulent windflow allows turbines to operate more efficiently and generate more power.

In off-grid applications, wind generators can be combined with other energy sources, such as diesel generators.

Although the wind resource for any site is intermittent, it can be highly predictable and thus the output from wind turbines can be integrated into existing electrical grids with a high degree of confidence. A modern wind turbine's "capacity factor" (the percentage of time a wind turbine generates power) is in the range of 20-40 percent.

Electrical utilities can generally absorb up to twenty percent of their generating capacity from intermittent sources such as wind. Quickly dispatched capacity such as hydro can allow a larger percentage of the overall capacity to come from windplant. The newest variable speed wind turbines can also help to stabilize grids in remote locations.

The feasibility of a wind project, however, can be influenced by access to the electrical grid. The need to install or upgrade high voltage transmission equipment can significantly add to the cost of a wind project. For off-grid and mini-grid applications, the combination of wind/diesel or other sources can provide a greater percentage of overall capacity.

Wind turbines are also a *modular* technology, which means they can be installed as the capacity is needed. A small windfarm can usually be constructed within a year. Windfarms can be constructed as either "build-own-operate" facilities under long-term power purchase contracts or as turnkey facilities.

Project Risks

***Technology**: With an availability factor greater than 95 percent (the percentage of time they are available to generate electricity when there is enough wind to do so), the technology risk for commercial wind turbines is low.*

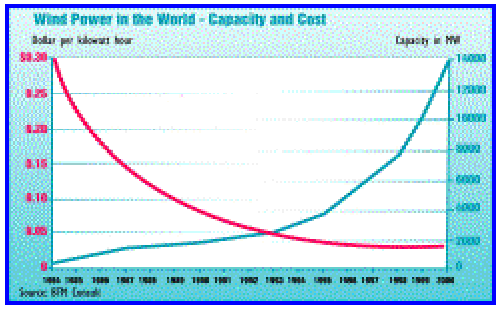
***Environmental**: An environmental impact assessment is usually required to mitigate any environmental issues such as visual, noise, land use, or cultural problems, or impacts on birds.*

***Planning**: Windfarms usually require local permits. If the power is to be sold to the grid, a long-term power purchase agreement is necessary. Delays in these processes often constitute the greatest risk to a developer.*

The Industry and Market Trends

Throughout the 1990s, the wind energy industry grew by 15 to 20 percent per annum. At the beginning of 2001, 17,500 MW of wind power has been installed in more than 30 countries. Ten major international manufacturers currently produce 97 percent of all wind turbines in power outputs ranging from a few hundred watts to several megawatts.

Since the current phase of development began in the 1980s, the price for wind-generated electricity fed into major grids has reduced by an average of three percent per annum. This is in part due to economies from increasing generator capacities, which grew from an average 220 kW in 1992 to about 700 kW today.



The research and development trend among major manufacturers is towards even larger turbines on taller towers as windspeeds increase with greater height above the ground. Most manufacturers are developing or deploying variable speed turbines while continuing to improve the durability of components. Interest is also strong to deploy wind turbines in shallow offshore areas where the wind resource is more predictable and environmental impacts can be substantially less.