



Wind Energy Development Programmatic EIS

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Wind Energy Basics

Basic information on wind energy and wind power technology, resources, and issues of concern.

Wind Energy and Wind Power

Wind is a form of **solar energy**. Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth. Wind flow patterns are modified by the earth's terrain, bodies of water, and vegetative cover. This wind flow, or motion energy, when "harvested" by modern **wind turbines**, can be used to generate **electricity**.

How Wind Power Is Generated

The terms "**wind energy**" or "**wind power**" describe the process by which the wind is used to generate **mechanical power or electricity**. Wind turbines convert the kinetic energy in the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity to power homes, businesses, schools, and the like.

Wind Turbines

Wind turbines, like aircraft propeller blades, turn in the moving air and power an **electric generator** that supplies an electric current. Simply stated, a wind turbine is the opposite of a fan. Instead of using electricity to make wind, like a fan, wind turbines use wind to make electricity. The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity.

Wind Turbine Types

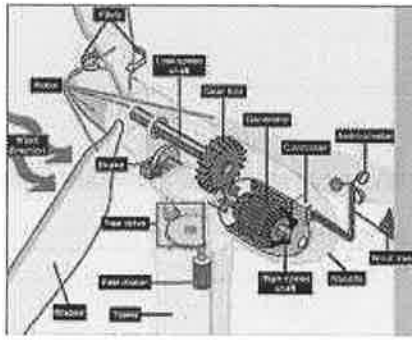
Modern wind turbines fall into two basic groups; the **horizontal-axis** variety, like the traditional farm windmills used for pumping water, and the **vertical-axis** design, like the eggbeater-style Darrieus model, named after its French inventor. Most large modern wind turbines are horizontal-axis turbines.

Turbine Components

Horizontal turbine components include:

- **blade** or **rotor**, which converts the energy in the wind to rotational shaft energy;
- a **drive train**, usually including a gearbox and a generator;
- a **tower** that supports the rotor and drive train; and
- other equipment, including controls, electrical cables, ground support equipment, and interconnection equipment.

[Wind turbine diagram - click for enlarged image.](#)



Turbine Configurations

Wind turbines are often grouped together into a single wind power plant, also known as a **wind farm**, and generate bulk electrical power. Electricity from these turbines is fed into a utility grid and distributed to customers, just as with conventional power plants.

See [Wind Energy Photos](#) page for wind farm photographs.

Wind Turbine Size and Power Ratings

Wind turbines are available in a variety of sizes, and therefore power ratings. The largest machine has blades that span more than the length of a football field, stands 20 building stories high, and produces enough electricity to power 1,400 homes. A small home-sized wind machine has rotors between 8 and 25 feet in diameter and stands upwards of 30 feet and can supply the power needs of an all-electric home or small business. **Utility-scale turbines** range in size from 50 to 750 kilowatts. Single small turbines, below 50 kilowatts, are used for homes, telecommunications dishes, or water pumping.

See [Wind Energy Photos](#) page for wind turbine photographs.

Wind Energy Resources in the United States

Wind energy is very abundant in many parts of the United States. Wind resources are characterized by **wind-power density classes**, ranging from class 1 (the lowest) to class 7 (the highest). Good wind resources (e.g., class 3 and above, which have an average annual wind speed of at least 13 miles per hour) are found in many locations (see [United States Wind Energy Resource Map](#)). Wind speed is a critical feature of wind resources, because the energy in wind is proportional to the **cube** of the wind speed. In other words, a stronger wind means a lot more power.

Advantages and Disadvantages of Wind-Generated Electricity

A Renewable Non-Polluting Resource

Wind energy is a **free, renewable resource**, so no matter how much is used today, there will still be the same supply in the future. Wind energy is also a source of **clean, non-polluting, electricity**. Unlike conventional power plants, wind plants emit no air pollutants or greenhouse gases. According to the U.S. Department of Energy, in 1990, California's wind power plants offset the emission of more than 2.5 billion pounds of carbon dioxide, and 15 million pounds of other pollutants that would have otherwise been produced. It would take a forest of 90 million to 175 million trees to provide the same air quality.

Cost Issues

Even though the cost of wind power has decreased dramatically in the past 10 years, the technology requires a **higher initial investment** than fossil-fueled generators.

Roughly 80% of the cost is the machinery, with the balance being site preparation and installation. If wind generating systems are compared with fossil-fueled systems on a "life-cycle" cost basis (counting fuel and operating expenses for the life of the generator), however, wind costs are much more competitive with other generating technologies because there is no fuel to purchase and minimal operating expenses.

Environmental Concerns

Although wind power plants have relatively little impact on the environment compared to fossil fuel power plants, there is some concern over the **noise** produced by the rotor blades, **aesthetic (visual) impacts**, and birds and bats having been killed (**avian/bat mortality**) by flying into the rotors. Most of these problems have been resolved or greatly reduced through technological development or by properly siting wind plants.

Supply and Transport Issues

The major challenge to using wind as a source of power is that it is **intermittent** and does not always blow when electricity is needed. Wind cannot be stored (although wind-generated electricity can be stored, if batteries are used), and not all winds can be harnessed to meet the timing of electricity demands. Further, good wind sites are often located in **remote locations** far from areas of electric power demand (such as cities). Finally, wind resource development may compete with other uses for the land, and those **alternative uses** may be more highly valued than electricity generation. However, wind turbines can be located on land that is also used for grazing or even farming.

For More Information

Much additional information on wind energy science and technology and wind energy development issues is available through the Web. Visit the [Wind Energy Links](#) page to access sites with more information. In particular, the [DOE Wind Energy Technologies page](#) has good information on wind energy basics, and is the source for much of the information presented here. The American Wind Energy Association web site has an excellent [FAQ page](#) with information about wind technology, and the [The Danish Wind Industry Association](#) web site has extensive information about wind energy and technology, including a 28-minute video introducing wind technology.

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