

Windmill for electric power generation

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Smaller wind turbines are used for applications such as battery charging and remote devices such as traffic warning signs. Larger turbines can contribute to a domestic power supply while selling unused power back to the utility supplier via the electrical grid.

Wind turbines are manufactured in a wide range of sizes, with either horizontal or vertical axes, though horizontal is most common.

The windwheel of Hero of Alexandria (10-70 CE) marks one of the first recorded instances of wind powering a machine. However, the first known practical wind power plants were built in Sistan, an Eastern province of Persia (now Iran), from the 7th century. These "Panemone" were vertical axle windmills, which had long vertical drive shafts with rectangular blades. Made of six to twelve sails covered in reed matting or cloth material, these windmills were used to grind grain or draw up water, and were used in the gristmilling and sugarcane industries.

Wind power first appeared in Europe during the Middle Ages. The first historical records of their use in England date to the 11th and 12th centuries; there are reports of German crusaders taking their windmill-making skills to Syria around 1190. By the 14th century, Dutch windmills were in use to drain areas of the Rhine delta. Advanced wind turbines were described by Croatian inventor Fausto Veranzio in his book *Machinae Novae* (1595). He described vertical axis wind turbines with curved or V-shaped blades.

In Denmark by 1900, there were about 2500 windmills for mechanical loads such as pumps and mills, producing an estimated combined peak power of about 30 megawatts (MW). The largest machines were on 24-metre (79 ft) towers with four-bladed 23-metre (75 ft) diameter rotors. By 1908, there were 72 wind-driven electric generators operating in the United States from 5 kilowatts (kW) to 25 kW. Around the time of World War I, American windmill makers were producing 100,000 farm windmills each year, mostly for water-pumping.

By the 1930s, use of wind turbines in rural areas was declining as the distribution system extended to those areas.

A forerunner of modern horizontal-axis wind generators was in service at Yalta, USSR, in 1931. This was a 100 kW generator on a 30-meter (98 ft) tower, connected to the local 6.3 kV distribution system. It was reported to have an annual capacity factor of 32 percent, not much different from current wind machines.

In the autumn of 1941, the first megawatt-class wind turbine was synchronized to a utility grid in Vermont.



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The Smith-Putnam wind turbine only ran for about five years before one of the blades snapped off. The unit was not repaired, because of a shortage of materials during the war.

The first utility grid-connected wind turbine to operate in the UK was built by John Brown & Company in 1951 in the Orkney Islands.

In the early 1970s, however, anti-nuclear protests in Denmark spurred artisan mechanics to develop microturbines of 22 kW despite declines in the industry. Organizing owners into associations and co-operatives led to the lobbying of the government and utilities and provided incentives for larger turbines throughout the 1980s and later. Local activists in Germany, nascent turbine manufacturers in Spain, and large investors in the United States in the early 1990s then lobbied for policies that stimulated the industry in those countries.

It has been argued that expanding the use of wind power will lead to increasing geopolitical competition over critical materials for wind turbines, such as rare earth elements neodymium, praseodymium, and dysprosium. However, this perspective has been critically dismissed for failing to relay how most wind turbines do not use permanent magnets and for underestimating the power of economic incentives for the expanded production of these minerals.

Wind Power Density (WPD) is a quantitative measure of wind energy available at any location. It is the mean annual power available per square meter of swept area of a turbine, and is calculated for different heights above ground. Calculation of wind power density includes the effect of wind velocity and air density.

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