



POWER EFFICIENCY PROJECT

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How Wind Energy is Collected and Distributed

What is Wind Energy?

Wind energy is a form of **solar energy**. Earth's atmosphere is unevenly heated by solar radiation and the air is in constant motion to find equilibrium. Air is easily affected by pressure and temperature so methods of heat transfer such as **convection**, **conduction**, **radiation**, and **advection** relieve the temperature imbalances and are driving forces for wind. Wind is an intermittent source of energy with many factors affecting wind flow patterns, such as geological features of Earth's surface, bodies of water, vegetation, and the Earth's rotation.¹ Wind is harvested through wind turbines, which generate electricity by converting the **kinetic energy** of the wind into **mechanical energy**.

How is Wind Energy Harvested?

Today's wind-harvesting technology includes blades connected to a rotor, a gear box, a braking system, a turbine, and a generator. A **nacelle** is the compartment that houses the generating components of the wind turbine. Illustrated in **Figure 1**, the **rotor** connects the blades to a shaft within the nacelle, which connects to a generator. The **blades** are aerodynamically designed to create a lifting force as the wind flows towards the turbine, which causes the rotor to spin. The **rotational speed** of the turning blades is not fast enough to generate electricity, so a gear box is needed to increase the rotational speed of the shaft. The U.S. Department of Energy defines the **gear box** as connecting the "low-speed shaft to the high-speed shaft and increases the rotational speeds from about 30-60 rotations per minute (rpm), to about 1,000-1,800 rpm; this is the rotational speed required by most generators to produce electricity"². An **anemometer** and **wind vane** connected to the top of the wind turbine measure wind speed and direction to send signals to a **yaw-** and **pitch-system**. These mechanisms ensure that the wind turbine is facing the incoming wind flow (yaw) and the blades are tilted enough (pitch) to cause efficient

lift force from the wind. Additionally, if the wind speed becomes too turbulent, the anemometer sends a signal to the **braking system** to prevent damage to the rotor, gear box, and generator. Generally, you will find wind turbines grouped together to form a wind farm. They can generate bulk electrical power and can be sized to the site, application, and energy needs.

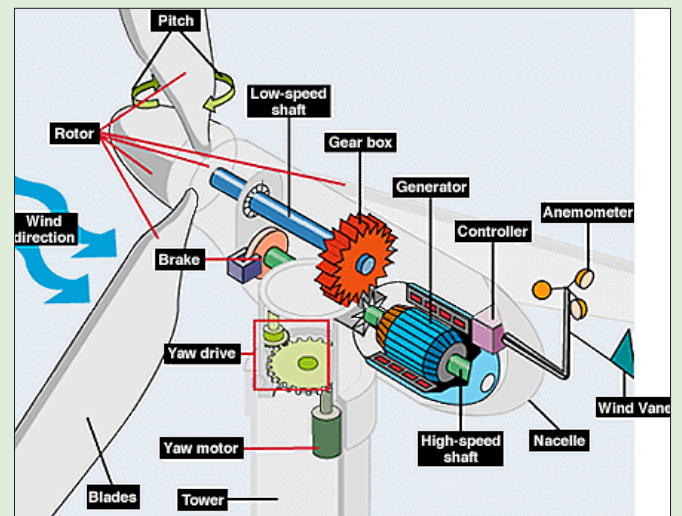


Figure 1:

Inside a wind turbine.

Source: <http://www.energy.gov/eere/wind/inside-wind-turbine-0>

Types of Wind Turbines

There are two variations of the wind turbine design: horizontal-axis turbines and vertical-axis turbines. Examples of these can be seen in **Figure 2**. Horizontal-axis turbines have characteristics similar to the propeller of an airplane and are

Wind Energy in Kansas

Despite the issues surrounding wind farms, wind energy generation is still viable, especially in Kansas. Kansas ranks fifth in 2016 on the *American Wind Energy Association* state ranking for installed wind energy capacity.⁶ The U.S. Energy Information Administration explained that “wind energy has grown from less than 1% of net electricity generation in 2005 to 24% in 2015, making wind the state’s second largest power provider, after coal”⁷.

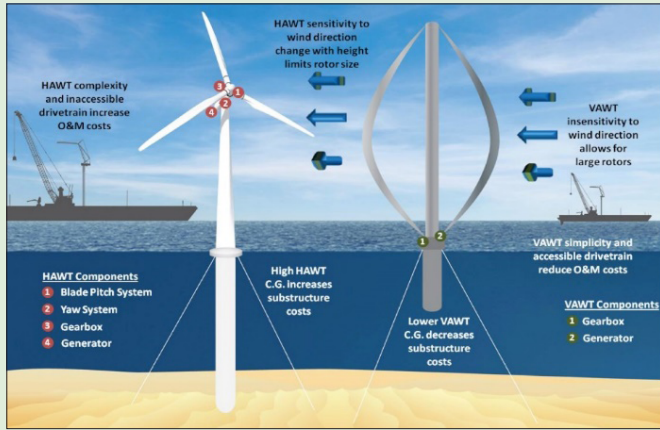


Figure 2:

Horizontal-axis wind turbine (HAWT) and vertical-axis wind turbine (VAWT) illustrated as a deep-water installation.

Source: <http://energy.sandia.gov/energy/renewable-energy/wind-power/offshore-wind/innovative-offshore-vertical-axis-wind-turbine-rotors/>

the most common wind machine used. Vertical-axis turbines have blades that connect at the top and the bottom of a vertical rotor. These machines look more like an egg beater or whisk.³ Horizontal-axis turbines are more often utilized in large wind farms as more electricity can be produced from a given amount of wind. Vertical-axis turbines are more likely to be used in residential applications or smaller wind farms as they perform well in tumultuous conditions and are ideal for sites without consistent wind patterns or where turbines cannot be placed high enough for steady winds.⁴

Supply & Demand of Wind Energy

Wind energy is a great alternative to fossil fuels because it is a free, clean and renewable source of energy. However, the wind industry faces some important issues. Wind is intermittently available, so wind farms cannot always be relied upon to meet utility energy needs. Wind farms can be troublesome when located near residences due to aesthetics, noise disturbances caused by the turbine, and shadow flickering caused by the rotating blades as they interrupt sun rays. There are also supply and transport issues related to wind energy. Because of the large size of wind turbines, manufactured items (blades) are difficult to transport to the project site (**Figure 3**).



Figure 3:

Truck transporting a wind turbine blade.

Source: <http://www.nrel.gov/news/features/2009/1927>

Curriculum & Activity Links

Primary

- Wind Energy Fact Sheet, Grades K-2, <http://www.need.org/files/curriculum/infobook/WindP.pdf>
- Wind Energy Fact Sheet, Grades 3-5, <http://www.need.org/files/curriculum/infobook/WindE.pdf>
- Wind is Energy: Teacher Guide, Grades K-2, <http://www.need.org/files/curriculum/guides/Wind%20Is%20Energy.pdf>
- Wonders of Wind: Teacher Guide, Grades 3-5, <http://www.need.org/files/curriculum/guides/Wonders%20of%20Wind%20Teacher%20Guide.pdf>
- Hands-on Activity: Wind Energy, Grades 3-5, https://www.teachengineering.org/activities/view/cub_earth_lesson04_activity2

Intermediate

- Wind Energy Fact Sheet, Grades 6-8, <http://www.need.org/files/curriculum/infobook/WindI.pdf>
- Energy from the Wind: Teacher Guide, Grade 6-8, <http://www.need.org/files/curriculum/guides/Energy%20from%20the%20Wind%20Teacher%20Guide.pdf>
- Wind for Schools: Teacher Guide, Grades 6-12, <http://www.need.org/files/curriculum/guides/WindForSchools.pdf>

Secondary

- Wind Energy Fact Sheet, Grades 9-12, <http://www.need.org/files/curriculum/infobook/WindS.pdf>
- Exploring Wind Energy: Teacher Guide, Grades 9-12, <http://www.need.org/files/curriculum/guides/Exploring%20Wind%20Teacher%20Guide.pdf>
- Wind for Schools: Teacher Guide, Grades 6-12, <http://www.need.org/files/curriculum/guides/WindForSchools.pdf>
- Wind Power: Lesson Plans and Activities, Grades 9-12, http://wind.jmu.edu/eduandwork/activities/wind_power.pdf

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2. “The Inside of a Wind Turbine.” Energy.gov. US Department of Energy. Web. 21 Sept. 2016. <http://www.energy.gov/eere/wind/inside-wind-turbine-0>
3. “Types of Wind Turbines.” US Energy Information Administration. US Department of Energy, 2 Nov. 2015. Web. 21 Sept. 2016. https://www.eia.gov/energyexplained/index.cfm?page=wind_types_of_turbines
4. “Vertical Axis Wind Turbines vs Horizontal Axis Wind Turbines.” Windpower Engineering. Windpower Engineering and Development, 10 Nov. 2009. Web. 21 Sept. 2016. <http://www.windpowerengineering.com/construction/vertical-axis-wind-turbines-vs-horizontal-axis-wind-turbines/>
5. Verrengia, Joseph B. “Bigger and Better: Lab Aims to Improve Giant Wind Turbines.” NREL. National Renewable Energy Laboratory, 30 Jan. 2009. Web. 21 Sept. 2016. <http://www.nrel.gov/news/features/2009/1927>
6. “Kansas Wind Energy.” AWEA. American Wind Energy Association. Web. 20 Mar. 2017. <http://awea.files.cms-plus.com/FileDownloads/pdfs/Kansas.pdf>
7. “Kansas State Profile and Energy Estimates.” U.S. Energy Information Administration (EIA). US Department of Energy, 18 Feb. 2016. Web. 21 Sept. 2016. <http://www.eia.gov/state/?sid=KS#tabs-5>