Wind101

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The Basics

Wind in the United States

Wind power is the third-largest source of electricity generation capacity in the United States and has been growing rapidly over the last two decades.

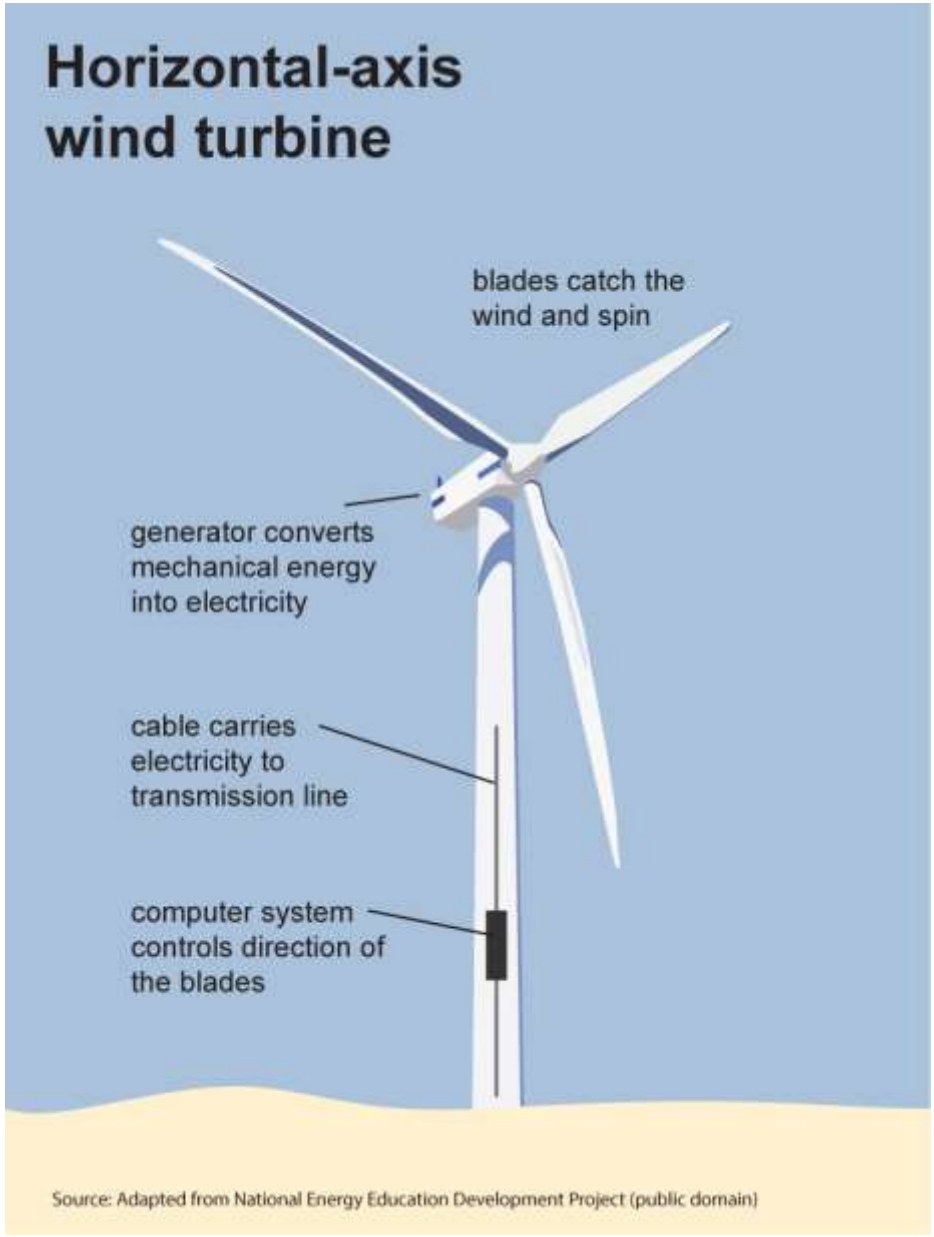
- *The total annual U.S. electricity generation from wind energy increased from about 6 billion kilowatthours (kWh) in 2000 to about 338 billion kWh in 2020.*
- *In 2020, wind turbines accounted for over 8% of all U.S. utility-scale electricity generation.*
    - *Utility scale = at least one megawatt (1,000 kilowatts) of electricity generation capacity.*

"Wind Explained: Electricity generation from wind" *eia.gov*, U.S. Energy Information Administration, 17 Mar. 2021, https://www.eia.gov/energyexplained/wind/electricity-generation-from-wind.php

How wind works

Wind turbines use rotating blades to collect the wind's kinetic energy, turning it into electricity using a generator.

- *From the Energy Information Administration:*
  1. *Wind flows over turbine blades, creating lift (similar to the effect on airplane wings),which causes the blades to turn.*
  2. *The blades are connected to a drive shaft that turns an electric generator, which produces (generates) electricity.*

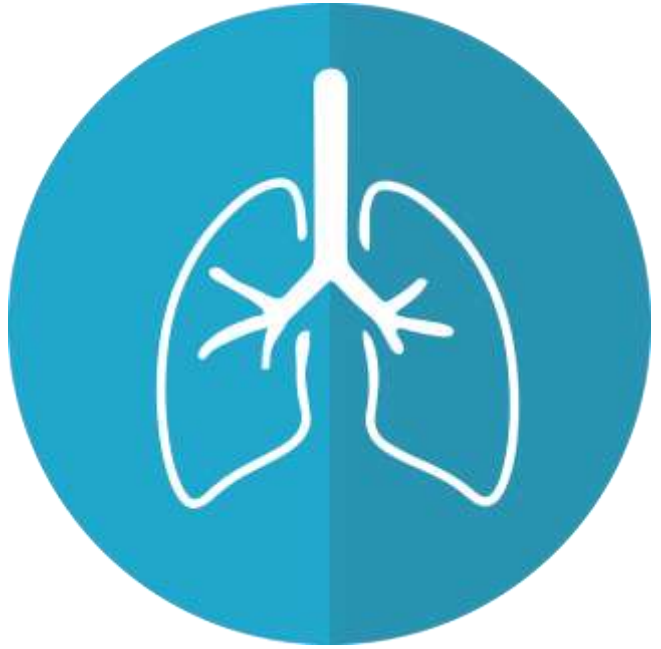


"Wind Explained: Electricity generation from wind" *eia.gov*, U.S. Energy Information Administration, 17 Mar. 2021, https://www.eia.gov/energyexplained/wind/electricity-generation-from-wind.php

Emissions-free electricity

Wind generation produces clean, low-impact renewable energy. Wind turbines do NOT produce harmful emissions and have several health benefits when compared to fossil fuels.

- *Wind energy avoided 198 million metric tons of CO2 emissions in 2019.*
  - *This is equivalent to 43 million cars worth of emissions.*
- *Reducing these emissions deters a wide variety of human health issues that stem from burning fossil fuels, including:*
  - *Early death*
  - *Heart attacks*
  - *Respiratory disorders*
  - *Stroke*
  - *Exacerbation of asthma*
  - *Absenteeism at school and work.*

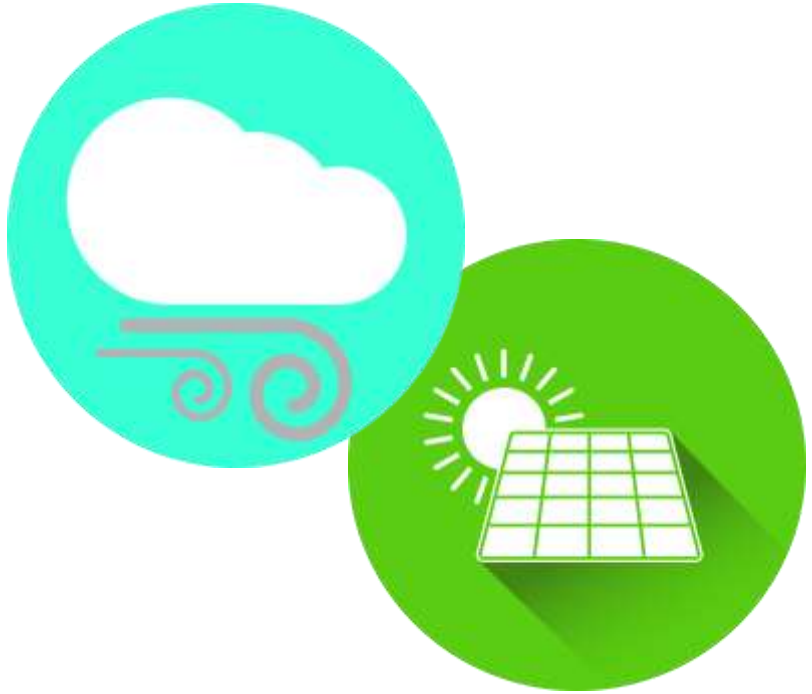


Wind Power Facts and Statistics. American Clean Power Association, 30 June 2021, https://cleanpower.org/facts/wind-power/.
"Fossil Fuels & Health." *C-CHANGE*, Harvard T.H. Chan School of Public Health, 9 Feb. 2021, https://www.hsph.harvard.edu/c-change/subtopics/fossil-fuels-health/.

Diversifying our energy market

Relying on multiple forms of electricity ensures reliability and cost effectiveness.

- *More types of energy available mean ensured electric power 24-7-365.*
- *A diverse grid offers a safety net during extreme weather or other circumstances.*
- *Regional Transmission Operators deploy energy resources in least-cost order until the demand is met.*
    - *Wind and solar are chosen first because they're zero fuel-cost sources.*



"The Diversity of Our Energy Market." *Sustainable Energy Fund*, 17 June 2020, www.thesef.org/diversity-of-energy-market/. Singh, Hardika. "Utility-Scale Solar Could Provide Significant Economic Impacts to Ohio, Study Finds." *OHIO News*, Ohio University, 7 Oct. 2020, www.ohio.edu/news/2020/10/utility-scale-solar-could-provide-significant-economic-impacts-ohio-study-finds. "Lazard's Levelized Cost of Energy Analysis—VERSION 12." *Lazard*, Nov. 2018, www.lazard.com/media/450784/lazards-levelized-cost-of-energy-version-120-vfinal.pdf.

Market demand for wind

Wind development continuously increases as companies, governments, and electricity-consumers demand it.

- *According to EIA, federal, state, and local governments and electric utilities encourage investing in and using renewable energy and, in some cases, require it.*
- *There is commercial wind operating in 41 U.S. states.*
- *The Levelized cost of energy (LCOE) of wind power plants has dropped to just $40/MWh in 2020.*
    - *Wind and solar offer the lowest LCOE of any generation type in most parts of the country, unsubsidized.*

"Renewable Energy Explained: Incentives." *Eia.gov,* U.S. Energy Information Administration, 20 Nov. 2020, https://www.eia.gov/energyexplained/renewable-sources/incentives.php

"Clean Power Annual 2020 Report." *American Clean Power*, 2020, https://cleanpower.org/resources/clean-power-annual-report-2020/.

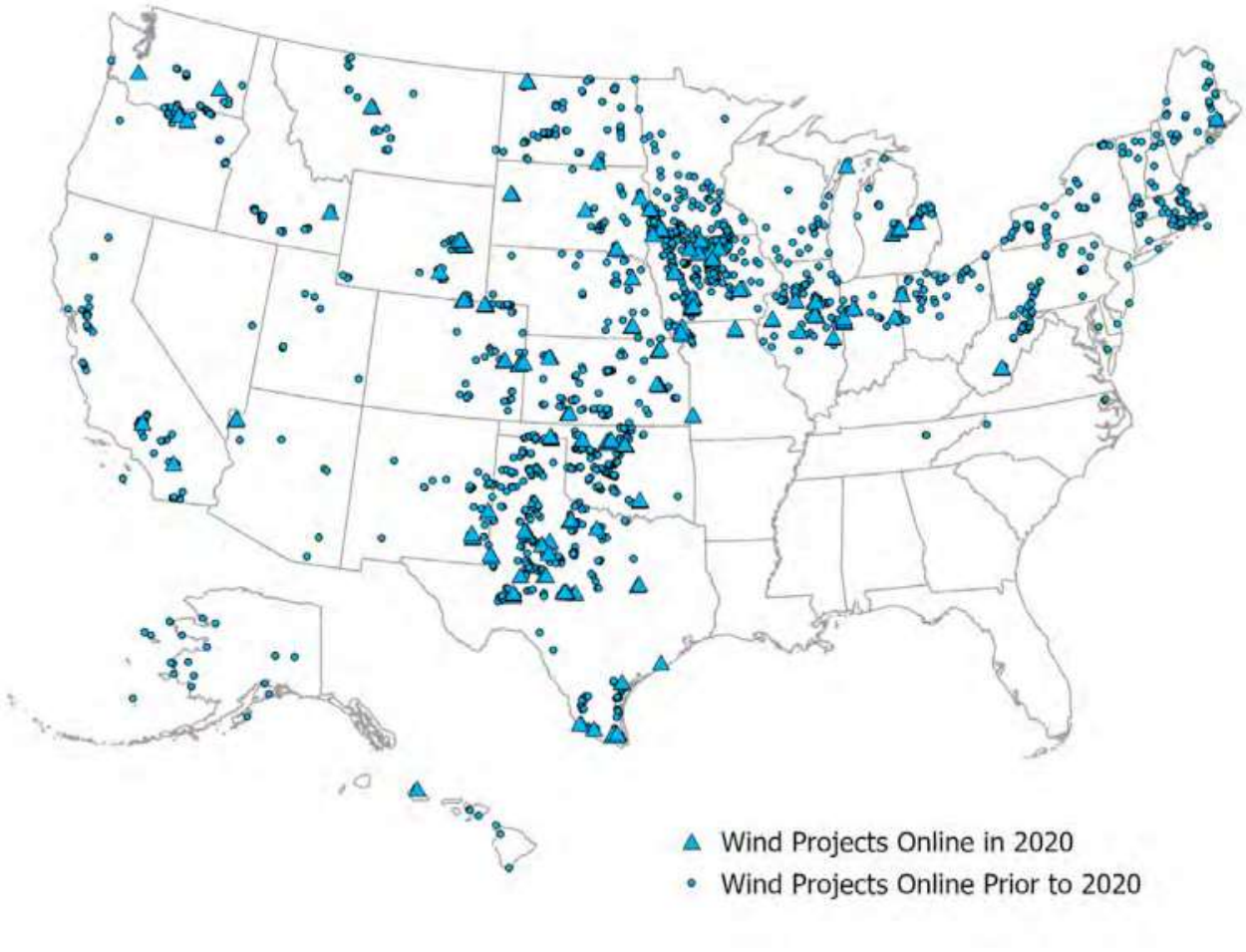
Wind projects span

41 states

across the U.S.

Land-Based Wind Projects

Over 1,200 wind projects across 41 states



Wind turbine manufacturing

U.S. manufacturers have risen to the demand of the growing industry, with the capacity to manufacture necessary wind turbine components domestically.

- *As of the end of 2020, 18 wind-related manufacturing plants located in 11 different states produce major wind turbine components.*
  - *Those plants include 6 utility-scale blade facilities, 9 tower facilities and 3 turbine nacelle assembly facilities.*
- *U.S. manufacturers have the annual capacity to assemble:*
  - *Blades: 9.21 GW*
  - *Towers: 10 GW or more of capacity (and even more as nameplate capacities increase).*
  - *Nacelles: 15,000 MW*

"Clean Power Annual 2020 Report." *American Clean Power*, 2020, https://cleanpower.org/resources/clean-power-annual-report-2020/.

Creating good-paying jobs

The wind industry creates ample job-growth across the nation, employing more than 116,801 Americans as of 2020.

- *Wind turbine service technician is the country's second-fastest growing job, expecting to increase 68% by 2030.*
- *On average, wind turbine service technicians make an annual salary of $56,230.*

"Clean Power Annual 2020 Report." *Cleanpower.org*, American Clean Power, 1 Sept. 2021, https://cleanpower.org/resources/clean-power-annual-report-2020/.
Fastest Growing Occupations : Occupational Outlook Handbook. U.S. Bureau of Labor Statistics, 8 Sept. 2021, https://www.bls.gov/ooh/fastest-growing.htm.
Photo by Dennis Schroeder, NREL 53926

Wind Siting

Siting factors

There are several factors that affect our ability to site wind projects, including leasing, landscape, and access to transmission.

Leasing

- *Utility-scale wind requires willing landowners with supportive communities around them to back project development.*

Landscape

- *Certain locations are better for wind development due to natural factors such as the wind in the area. Developers must carefully consider how fast and how often the wind blows at the site when planning a project.*

Transmission

- *Ideal wind sites are often located in remote or rural areas, far from cities where much electricity is needed. Wind projects can be developed near existing lines, but new transmission must be built to bring electricity across the grid.*

"Advantages and Challenges of Wind Energy." *Energy.gov*, Wind Energy Technologies Office, https://www.energy.gov/eere/wind/advantages-and-challenges-wind-energy "Wind explained: Where wind power is harnessed." *U.S. Energy Information Administration,* https://www.eia.gov/energyexplained/wind/where-wind-power-is-harnessed.php Photo by Dana Levine, NREL 24351

Landowner and community benefits

Wind projects generate tax revenue that can be invested into communities, keeping taxes low for all residents.

- *The wind industry has generated more than $1 Billion in taxes paid that can be reinvested into local projects such as:*

Schools

Hospitals

Infrastructure

- *Landowners receive land-lease payments for the life of the project, totaling $706 million during 2019.*
- *The Construction phase provides hundreds of jobs and opportunities for local businesses to provide goods and services, creating a ripple-effect of economic development.*

"U.S. Wind Energy Generates More Than $1 Billion in Tax Revenue Payments." Center for Rural Affairs, May 30, 2019, https://www.cfra.org/blog/us-wind-energy-generates-more-1-billion-tax-revenue-paymentshttps://www.cfra.org/blog/us-wind-energy-generates-more-1-billion-tax-revenue-payments
"Wind Energy's Economic Impacts to Communities." WINDExchange, *Office of Energy Efficiency and Renewable Energy,* https://windexchange.energy.gov/projects/economic-impacts

Safety and security: Wind setbacks

Wind turbine setbacks are distancing requirements that separate residences and private property from wind projects and preserve safety and security.

- *Wind setbacks establish the distance wind turbines must be positioned away from nearby residences.*
- *Wind projects must be set back from structures to ensure access, traffic safety, and compliance with local ordinances.*
- *Setbacks are typically determined locally, allowing communities to determine the best practices for their area and landscape.*

"Community Impacts of Wind Energy." *WINDExchange*, Office of Energy Efficiency and Renewable Energy, https://windexchange.energy.gov/projects/community

Wind and property values

Utility scale wind projects have no measurable negative impact on property values.

- *Large-scale wind projects often have no tangible decrease on the value of adjacent properties.*
- *The Lawrence Berkeley National Laboratory found that if property value decreases from wind turbines exist, they are too small and/or too infrequent to result in widespread or statistically observable impact.*

"Wind Energy Projects and Property Values." *WINDExchange,* Office of Energy Efficiency and Renewable Energy, https://windexchange.energy.gov/projects/property-values

Wind and the Environment

Shadow flicker

Shadow Flicker occurs when rotating wind turbine blades pass between the sun and a structure, casting an intermittent shadow and a perceived flickering.

- *Cumulatively, shadow flicker only occurs a few hours per year, generally around sunrise and sunset.*
- *Shadow flicker can be mitigated through proper planning and siting, strategically avoiding the creation of shadows on neighboring homes.*
- *Annual shadow flicker hours can be calculated with existing wind-development software to reduce the impact on residents.*
- *It is important to note that placing tight restrictions on shadow flicker hours can limit the development of wind energy, jeopardizing the resulting benefits to communities.*

"Wind Turbines and Shadow Flicker: Facts and Proven Mitigation Strategies." *Cleanpower.org*, American Clean Power, Nov. 2020, https://cleanpower.org/wp-content/uploads/2021/02/Final_Shadow-Flicker-Fact-Sheet.pdf.

Impact on wildlife

Wind turbines, like any development, have an impact on the environment in which they're built. The industry continually works to mitigate this impact.

- *Development of wind turbines is often accompanied by wildlife surveys that work to ensure the protection of the surrounding animals and environment prior to development.*
- *Efforts are continually being made to reduce the wildlife risks posed by wind turbines.*
- *Addressing impact minimization, siting, and permitting issues are among the wind industry's highest priorities.*

"Environmental Impacts and Siting of Wind Turbines." *Wind Energy Technologies Office,* Office of Energy Efficiency and Renewable Energy, https://www.energy.gov/eere/wind/environmental-impacts-and-siting-wind-projects

Wind turbine reliability

Wind turbines are manufactured to withstand decades of weather and use, and are continually being improved to ensure even greater reliability.

- *Organizations like the NREL Drivetrain Reliability Project research wind turbine reliability and gather data on where improvements can be made.*
- *According to NREL, blade manufacturers require tests of blade properties, static mechanical tests, and fatigue tests to certify wind blade and wind turbine designs.*
- *Wind turbines destined for cold climates are weatherized to prevent icing and other winter-related risks.*

"Wind Power Reliability Research." *National Renewable Energy Laboratory (NREL)*, U.S. Department of Energy, https://www.nrel.gov/wind/reliability.html
Myers, Andrew. "Stanford study finds that wind energy output increases when people need heat the most." *Stanford News,* 17, Mar. 2021, https://news.stanford.edu/2021/03/17/coldest-times-wind-energy-production-heats/

Project End Steps

Picture by Werner Slocum, NREL 62414

Wind turbines at end of life

After the end of a project's life, wind turbines must be removed and the land restored to its original use.

- *After a project ends, it is common that local governments require foundation removal, removal of access roads, and replacing soil and vegetation at the site.*
- *Manufacturers are working to create wind turbines that last longer but require fewer materials and have components which are equipped for reuse.*
- *When wind turbine components are broken down and reused or recycled, we reduce waste and create a "circular economy."*

"No Time to Waste: A Circular Economy Strategy for Wind." *Wind Energy Technologies Office,* Office of Energy Efficiency and Renewable Energy, 2 June 2021, https://www.energy.gov/eere/wind/articles/no-time-waste-circular-economy-strategy-wind-energy

THANK YOU

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