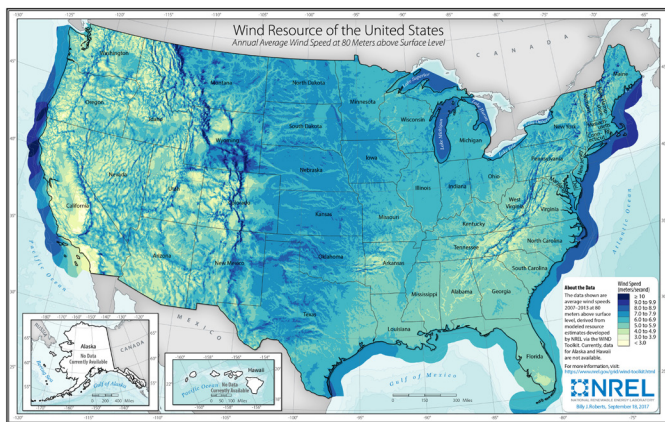


Wind Energy

Wind Resources and Potential

Approximately 2% of solar energy striking Earth's surface is converted into kinetic energy in wind.¹ Wind turbines convert this kinetic energy to electricity without emissions,¹ and can be built onshore or offshore.² Wind power is proportional to the cube of wind speed; high wind speeds yield more energy.³ Average annual wind speeds of 6.0 m/s or greater at hub height are considered commercially viable, though new technologies are expanding the wind resources accessible for commercial projects.^{4,5,6} In 2024, wind generated 10.3% of U.S. electricity.⁷

U.S. Wind Resources (80m height)⁸



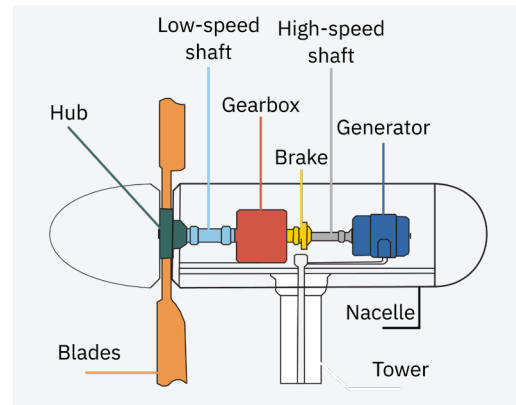
- Wind speeds increase with height above the Earth's surface. Average hub height is 106 m for U.S. onshore wind turbines,⁹ and 124 m for global offshore turbines.¹⁰
- Global onshore and offshore wind generation potential at 90 m turbine hub heights could provide 872 PWh of electricity annually,¹¹ >30x the 27 PWh used globally in 2023.¹² Continental U.S. wind potential of 43 PWh/yr (onshore and offshore)¹¹ exceeds 2024 U.S. electricity use of 4.1 PWh.⁷
- Wind could provide 20% of U.S. electricity by 2030 and 35% by 2050.¹³ Five of the eight Great Lakes states have offshore wind energy potentials that exceed their annual electricity demand (MI, WI, NY, OH, MN). Michigan's offshore resource could supply over 18 times its 2020 demand.¹⁴

Wind Technology and Impact

Horizontal Axis Wind Turbines

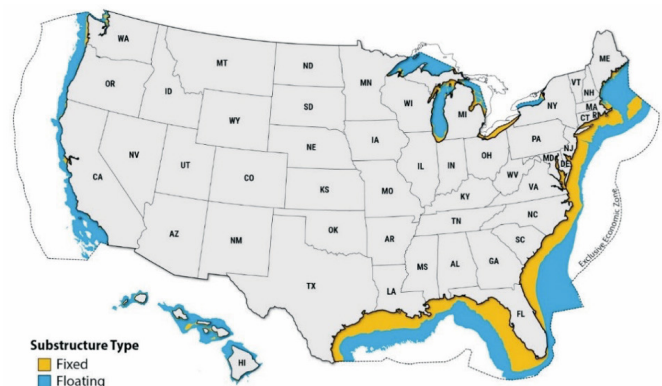
- Horizontal axis wind turbines (HAWT) are the predominant design, featuring blades (usually three) symmetrically mounted to a hub connected via a shaft to a gearbox and generator. The nacelle houses these components atop a tower.¹⁵
- HAWT range from 2.5 m diameter and 1 kW for residential to 100+ m diameter and 10+ MW for offshore applications. The theoretical maximum efficiency of a turbine (Betz Limit) is 59%. Most turbines extract ~50% of wind energy.¹³

Horizontal Axis Wind Turbine Diagram¹⁵



- Commercial onshore wind turbines become net energy positive after roughly 6 months of operation.¹⁶
- Capacity factor—the measure of how much of the potential energy of the turbine is actually produced—¹³ ranges from 5-50% for U.S. onshore turbines, averaging 38%.¹⁷
- Curtailment is a reduction in generator output below full potential due to supply-demand mismatches.¹⁸ U.S. wind curtailment averaged 5.5% in 2024, down from 11.1% in 2009 but up from 2.1% in 2016.⁹ Rates were highest in the Southwest Power Pool (10.5%) and lowest in the Pennsylvania-New Jersey-Maryland Interconnection (0.3%).⁹
- Offshore winds are stronger than onshore, with higher capacity factors (estimated 60% for new projects by 2050),^{19,20} but offshore facilities cost more to build and maintain.²¹
- Current offshore turbines operate in depths up to 40-50 m,²² but floating technologies could expand generation, as 58% of U.S. technical wind resources lie in waters deeper than 60 m.²³ Large floating turbine demonstrations in Japan and China are finishing construction in 2026.²⁴

Map of U.S. Offshore Wind Resources²⁵



Economics

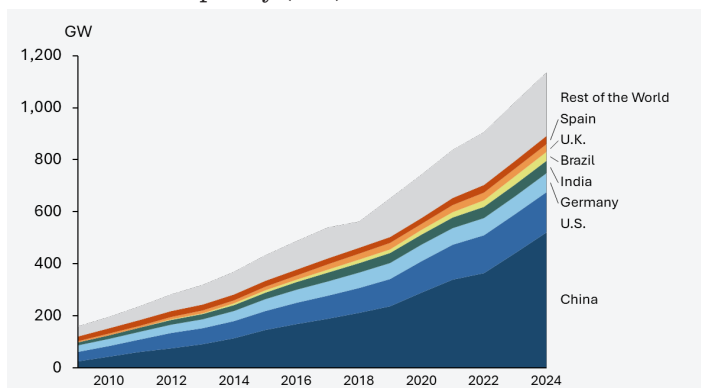
- Wind project costs declined 71% from \$5,326/kW in 1983 to \$1,694/kW in 2023.¹⁷ The average levelized cost of energy onshore fell to \$49/MWh in 2022, down 58% since 2012.¹⁷
- The installed cost of a small turbine (~100 kW) averaged \$6,680/kW in 2024,²⁶ 15% less than in 2022.⁹

- Large wind projects require ~85 acres per MW but occupy only 1% for infrastructure and equipment, leaving the remainder available for other uses such as farming.¹³
- The wind industry supports over 380,000 U.S. jobs and generates more than \$2.7B in tax revenue per year.²⁷
- For farmers, annual lease payments provide a stable income of around \$6,700/MW of turbine capacity.²⁸

Installation

- Global wind capacity increased 18% annually since 2001, reaching 1,299 GW in 2025. China led in new and cumulative capacity, followed by the U.S. and India.²⁴
- More than half of added wind capacity in 2024 was in China, which holds 46% of the total global wind capacity. The U.S. and Germany, the next two highest, both added 5% as much capacity as China in 2024.⁹
- Wind supplies 57% of Denmark's electricity generation and over 20% in ten other countries.¹⁷
- Global wind additions reached a record 165 GW in 2023. In 2025, global onshore installations surpassed 100 GW for the third consecutive year; the U.S. onshore wind power installations total nearly 7 GW. Offshore additions in 2025 totaled 9 GW worldwide, an increase from the 8 GW of 2024, but a decrease from the 21 GW of 2021.²⁴
- The U.S. commissioned the 132 MW South Fork Wind Farm in 2024, increasing total U.S. offshore capacity to 174 MW.²⁹
- No companies were awarded contracts for additional offshore wind capacity in the U.S. in 2025.²⁴
- U.S. wind capacity grew from 45 GW in 2010 to 154 GW in 2024, a 10.4% average annual increase.^{9,30}
- U.S. average onshore turbine size reached 3.5 MW in 2024, up 386% since 1999. Average blade diameter and hub height have increased 182% and 87%, respectively, during the same period. Fleet-wide capacity factor averaged 34.2% in 2024, with plants built in 2024 achieving 37.1%, compared to 31% for projects installed from 2004-2012.^{9,27}
- Texas leads in installed wind capacity (42.7 GW), followed by Oklahoma (13.1 GW) and Iowa (13.0 GW). Texas (1.271

Global Wind Capacity (GW)²⁴



MW) installed the most new wind capacity in 2024, more than double any other state.⁹

- Iowa generated 63% of its electricity from wind in 2024, while twelve states achieved at least 20%.⁹

Environmental Impacts

- U.S. wind energy generation avoids 351 Mt of CO₂ emissions annually.³¹ If 35% of U.S. electricity was wind-generated by 2050, the electricity sector would reduce GHG emissions by 23%, eliminate 510 Mt of CO₂ emissions annually, and decrease water use by 15%.¹³
- Annual avian mortality from collisions with turbines is 0.2M, compared to 130M due to power lines, 300-1,000M from buildings, and 1,400-3,700M from cats. Careful siting can minimize mortality.^{13,32}
- Bat mortality ranges from 1.0 to 14.6 bats/MW/year in different regions of North America, with 78.4% of fatalities occurring in migratory species.³³ The wind industry is testing methods that could reduce bat mortality by over 50%.¹³
- Noise levels at a 350m distance from a typical wind farm is 35-45 dB—comparable to a quiet bedroom (35 dB) and quieter than a car traveling 40 mph at 100m distance (55 dB).³⁴ Multiple studies through 2013 conclusively determined that wind turbine sound has no impact on human health.¹³
- Over 2 Mt of wind turbine blades are expected to be retired in the U.S. by 2050. While current landfilling costs are relatively low, improved design, materials, recycling technology, and waste management policies are needed to enhance blade end-of-life performance.³⁵

Solutions and Sustainable Actions

- The Inflation Reduction Act (IRA) of 2022 provided a 30% Investment Tax Credit and Production Tax Credit (PTC) of 2.75¢/kWh for qualified wind systems through 2027.^{36,37}
- 2025 legislation modified the IRA end date for the 30% Investment Tax Credit from December 31, 2035 to December 31, 2025 and restricted the PTC to systems that start construction by July 4, 2026 or start service by December 31, 2027.^{38,39}
- Microsoft, Google, and T-Mobile were the top three corporate buyers of green power in 2024.⁴⁰
- Among universities, University of California, University of Iowa, and Arizona State led green power use, with University of Iowa obtaining 84% of electricity from green sources in 2024. At least six universities achieved 100% green power.⁴¹
- Customers can self-supply renewable electricity by owning on- or off-site renewable equipment connected through the grid.⁴²
- Make your lifestyle more efficient to reduce the amount of energy you use.