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Introduction

Wind energy is electric power generated by wind-driven turbines. The wind turns the turbine blades⁴, which turn a drive shaft that connects to a gearbox that converts the rotor power, turning an electric generator, which produces electricity that is sent to the grid. In direct-drive turbines, the gearbox is left out and the rotors directly stimulate the generator. In both cases, electricity is generated when the blades spin.

Wind turbines can be placed on land, offshore in the form similar to onshore towers, or on floating structures⁵ for deeper water applications.

Wind energy currently accounts for approximately 9 percent of net electricity generation in the United States. According to 2020 data, wind accounts for⁶ 5.3 percent of worldwide electricity generation, and 2.2 percent of total global energy, which includes transportation and heating. The top three countries with the largest amount⁷ of wind energy are China with 328.97 gigawatts (GW) installed wind energy capacity, the United States with 132.74 GW, and Germany with 63.76 GW.

Growth

From 2000 to 2016, the installed global capacity⁸ of wind energy rose 2,592 percent, increasing from a cumulative global capacity of about 17,329 megawatts (MW) to nearly 466,505 MW.

In the United States, installed wind capacity increased 5,477 percent⁹ from 2000 to 2021, though the greatest number of new turbines were installed in 2020.

The rapid growth of wind power has primarily been driven by substantial subsidies given to the industry and laws mandating the use of electricity generated by wind. In the United States, federal government

Quick Bullets

- In 2021, wind energy accounted for 9.2 percent of net electricity generation¹ in the United States.
- Texas generates the most electricity from wind power², and Iowa had the highest share of in-state electricity supplied by wind (58 percent)³ in 2020.
- The installed capacity, or nameplate capacity, of wind facilities does not reflect the actual amount of electric power produced.

support for wind comes in the form of a Renewable Electricity Production Tax Credit¹⁰, which was recently restored, although slightly altered, by the Inflation Reduction Act¹¹. This tax credit grants a per-kilowatt hour credit for any electricity generated by approved renewable sources, such as wind power. Electricity from wind gets up to 2.5 cents per kilowatt hour¹².

Additionally, many states have individual renewable portfolio standards (RPS)¹³ that mandate increasing amounts of electricity delivered within the state from sources like wind power, regardless of the cost. Some states and localities also offer tax abatements or property tax reductions for new wind facilities.

Similar to U.S. mandates, the United Kingdom also requires electricity suppliers to use an increasing amount of renewables-generated electricity via its Renewables Obligation program¹⁴.

Because additions of large wind industrial facilities to the energy system of the United States are so

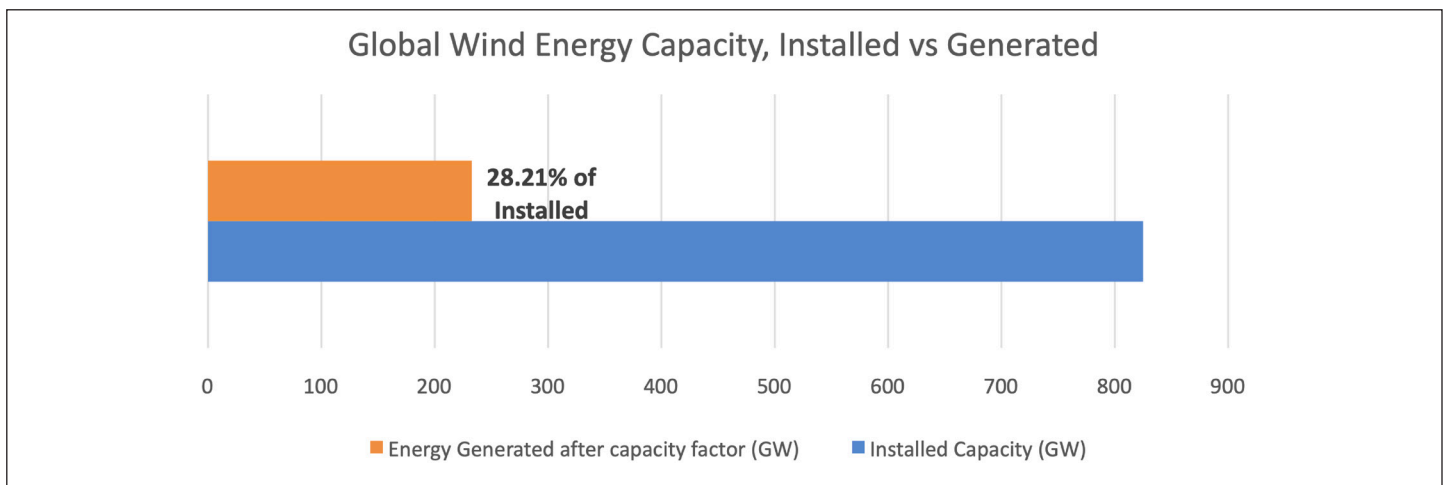


Figure 1 Data from Wind energy generation vs. installed capacity. Our World in Data. (n.d.). Retrieved September 15, 2022, from <https://ourworldindata.org/grapher/wind-energy-consumption-vs-installed-wind-energy-capacity?tab=table>

dependent on the Renewable Electricity Production Tax Credit and similar policies, the Energy Information Administration projects¹⁵ that wind will make up a very small percentage of the new additions to the U.S electricity generation capacity in the future.

Cost

Levelized average costs¹⁶ of electricity that is generated from wind turbines are comparable with other new generation technologies like solar and geothermal. Exceptions to this are offshore wind and battery storage, which produce energy at a much higher cost than other new generation technologies.

Offshore wind has the lowest¹⁷ value-to-cost ratio of all new generation resources.

However, sources that claim to predict costs of electricity from these resources should be taken with a grain of salt. Organizations promoting renewables do not always take actual capacity factors¹⁸ into account, instead relying on the idealized 40 percent range for wind. In reality, the capacity factor for onshore wind especially will be lower. Additionally, levelized costs may not include all the repair, replacement, and removal costs of turbines.

Because wind turbines tend to be located in remote areas far from where the power is needed, new transmission lines, transformers, and other infrastructure must be built, adding to the cost¹⁹. Transporting parts to these distant places to build the turbines also has a significant price tag, making up about 10 percent of the upfront capital cost.

Nameplate Capacity Versus Actual Power Generation

When “installed capacity” is discussed, what is being referenced is what is usually called “nameplate capacity.” This is the amount of power that can be produced by the turbine generators under ideal conditions. For wind, this usually entails sustained winds over a certain speed. The optimal wind speed is different depending on the size and type²⁰ of turbine. Larger rotor blades can make use of lower wind speeds.

Installed capacity²¹ is usually calculated by taking the nameplate capacity of each turbine at an industrial wind facility and adding them together.

The reality is that wind power is intermittent because the wind does not blow constantly. Therefore, wind turbine power generation varies and cannot be depended on to provide a consistent, reliable flow of electricity on demand. Consequently, grids connected to wind turbines require a dispatchable backup energy source²² to keep the grid load balanced. This requires keeping redundant power sources on standby or operating as spinning reserve in order to provide power quickly when the wind currents are insufficient or too powerful to generate power from turbines. In addition, other generating sources must operate at inefficient levels to ramp up or down quickly to regulate the variable amount of power wind turbines supply to the system as wind currents wax and wane.

Doing simple math using numbers from Our World in Data²³ on installed global wind energy capacity (at 824.87 GW) and wind power generation (1,861,940 GWh), we can estimate an average capacity factor of about 28.21 percent worldwide for wind power.

Endnotes

- ¹ *Wind explained*. U.S. Energy Information Administration (EIA). (n.d.). Retrieved September 15, 2022, from <https://www.eia.gov/energyexplained/wind/electricity-generation-from-wind.php>
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- ³ *Ibid.*
- ⁴ *Wind Power Facts and Statistics*. CleanPower.org. Retrieved September 15, 2022, from <https://cleanpower.org/facts/wind-power/>
- ⁵ *NREL floats new offshore wind cost optimization vision*. NREL.gov. (n.d.). Retrieved September 15, 2022, from <https://www.nrel.gov/news/program/2020/nrel-floats-new-offshore-wind-cost-optimization-tool.html>
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- ⁷ BP Statistical Review of World Energy. (n.d.). *Installed Wind Energy Capacity*. Our World in Data. Retrieved September 15, 2022, from <https://ourworldindata.org/grapher/cumulative-installed-wind-energy-capacity-gigawatts?country=ESP~IND~AUS~DEU~JPN~ITA~USA~GBR~CHN~NLD>
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- ¹⁷ *Ibid.*
- ¹⁸ Eschenbach, W. (2021, June 25). *The real cost of wind and Solar*. Watts Up With That? Retrieved September 15, 2022, from <https://wattsupwiththat.com/2021/06/25/the-real-cost-of-wind-and-solar/>
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