How reliable is wind energy?

What The Science Says:
As with solar energy, complete reliance on wind energy would pose intermittency challenges. However, wind, solar, and storage together can provide the majority of the country's electricity without compromising reliability.

Climate Myth: Wind energy is unreliable
"[B]ecause of the wind's intermittency and high variability, they do next to nothing to reduce the need for other fuels." (Wind Watch)

As with solar energy, complete reliance on wind energy would pose intermittency challenges. However, wind, solar, and storage together can provide the majority of the country's electricity without compromising reliability[1], and energy efficiency and grid flexibility mechanisms can support a renewable energy-based grid. (Lovins 2017) Hydropower has also been found to support wind and solar by compensating for intermittency in those sources (Shan et al. 2020). Moreover, building more long-distance transmission infrastructure can enable greater reliance on wind and solar generation[2], and linking offshore wind projects through offshore transmission networks is also expected to enhance grid reliability.[3] A National Renewable Energy Laboratory report concluded that "wind power can support power system reliability" by providing "active power controls,"[4] which are mechanisms for balancing the power generated by wind farms with the power consumed on the electricity grid (van Wingerden et al. 2017). And although the reliability of wind and solar energy was questioned following Texas' widespread power outages in the winter of 2021, Texas' grid failure was primarily caused by freezing natural gas infrastructure, rather than failures at wind and solar farms, though nuclear, coal, and wind also experienced disruptions at a smaller scale.[5] (also Busby et al. 2021)

Wind energy has already been successfully incorporated into the United States' electric grid at significant scale.[6] Domestic energy production from wind more than tripled between 2011 and 2022, from 120 billion kilowatt-hours (2.9% of total energy production) to 435 billion kilowatt-hours (10.3% of total energy production).[6] Some states have seen even more rapid growth. In 2021, wind energy accounted for 58% of electricity production in Iowa, and 43% of electricity production in Kansas.[7]

Wind power has enabled Iowa not only to reduce energy costs, but to generate additional revenue by selling excess power to neighboring states during shortages.[8] Today, Iowa is considered one of the states with the most reliable energy systems.[9] In California, electricity generated from wind power increased from roughly 3% in 2009, to roughly 7% in 2022.[10] Electricity generated from natural gas declined from roughly 56% in 2009, to roughly 47% in 2022. Yet even with this increased reliance on wind power, California's grid reliability has remained consistent, and largely above national averages.[11] California has even been able to briefly meet 103% of its energy demands exclusively from renewable sources, demonstrating that a large economy can by powered by renewable energy.[12] The UK has also made substantial progress utilizing wind power, which was responsible for 26.8% of overall energy production in 2022, and which helped stave off the worse impacts from the energy crisis following Russia's invasion of Ukraine.[13]

Footnotes:

[1] Eric Larson et al., Net-Zero American: Potential Pathways, Infrastructure, and Impacts: Final Report, Princeton University, 247 (Oct. 29, 2021), at 88 (noting that, "[t]o ensure reliability, all cases maintain 500-1,000 GW of firm generating capacity through all years," compared to 7,400-9,900 GW for wind and solar in net-zero scenarios for 2050).

[2] See Shan et al. (2020) at 97 (noting that "[l]imiting inter-regional transmission capacity to a maximum of 2x current capacity . . . leads to slightly more gas w/ [carbon capture] and less wind").

[3] Office of Energy Efficiency & Renewable Energy, U.S. Dep't of Energy, Atlantic Offshore Wind Transmission Study, at vii (March 2024).

[4] Erik Ela et al., Active Power Controls from Wind Power: Bridging the Gaps at xi, Nat'l Renewable Energy Laboratory, Jan. 2014; see also NREL Report Redefines Wind as a Grid Stabilizer, Not a Liability Nat'l Renewable Energy Laboratory, Jan. 2014; Weihang Yan et al., Synchronous Wind: Evaluating the Grid Impact of Inverterless Grid-Forming Wind Power Plants, Nat'l Renewable Energy Laboratory, 2023 (preprint).

[5] Adriana Usero & Salvador Rizzo, Frozen windmills' aren't to blame for Texas's power failure, Wash. Post, Feb. 18, 2021; Dionne Searcey, No, Wind Farms Aren't the Main Cause of the Texas Blackouts, N.Y. Times, Feb. 17, 2021 (updated May 3, 2021).

[6] Wind Explained: Electricity Generation from Wind, U.S. Energy Information Administration (last visited March 25, 2024).

[7] Niccolo Conte, Which US State Generates the Most Wind Power? There's a Clear Winner, World Economic Forum (April 26, 2022).

[8] Chazz Allen, Iowa Leads in Homegrown, Reliable, Renewable Energy, Gazette (November 12, 2022).

[9] Energy Rankings: Measuring States' Energy Infrastructure, U.S. News and World Report (last visited March 25, 2024).

[10] Total System Electric Generation 2009-2022 with totals, California Energy Commission, (2022).

[11] Electric System Reliability Annual Reports, California Energy Commission, (2022).

[12] Lauren Sommer, California Just Ran on 100% Renewable Energy, but Fossil Fuels Aren't Fading Away Yet, NPR (May 13, 2022).

[13] Georgina Rannard, Wind Generated a Record Amount of Electricity in 2022, BBC News, (January 6, 2023).

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