Report 2021
USA

In 2021, the Biden administration established a new target to deploy 30 gigawatts of offshore wind power capacity by 2030. In this photo, a wind turbine installation vessel floats beside a 6-megawatt turbine that's part of Dominion Energy's Coastal Virginia Offshore Wind pilot project located 27 miles off the coast of Virginia Beach, Virginia. *Photo by Lyfted Media for Dominion Energy*

Author *U.S. Department of Energy's Wind Energy Technologies Office and National Renewable Energy Laboratory.*

Wind energy plays a critical role in national climate targets established in 2021. These include reducing greenhouse gas emissions by at least 50% from 2005 levels by 2030, achieving 100% clean electricity by 2035, and reaching net-zero emissions economywide by no later than 2050 [1].

FIVE U.S. STATES updated or adopted new clean energy standards in 2021; 31 states and the District of Columbia already had such standards in place [2].

Wind power capacity in the United States continued to grow in 2021, adding nearly 14 gigawatts (GW) [3]. As the United States' top source of renewable energy production, wind power facilities accounted for 9.2% of electricity generation in 2021 [4]. As of the end of 2021, the United States had 135 GW [5] of electricity generation capacity from wind turbines. The nation's largest operating wind project, the 1,055-megawatt (MW) Western Spirit in New Mexico [5], came online in 2021, and construction began on Vineyard Wind [5], the nation's first commercial-scale offshore wind power plant.

Highlight(s)

- The new target of 30 GW of offshore wind by 2030
- Wind surpassed hydro power and became the top source of renewable electricity (x TWh)
- R&D highlight? Funding for an offshore platform for 10+MW?

Market Development

Targets and Policy

To support national clean energy goals, the Biden administration established a new target to deploy 30 GW of offshore wind power capacity by 2030. At the end of 2021, the United States had deployed 42 MW [6]. Meeting the target will spur more than 12 billion USD (10.5 billion EUR) per year in capital investments and up to 500 million USD (440 million EUR) in port upgrades [7]. The new offshore wind energy target supports the national clean energy goals mentioned earlier. National research goals, detailed in the R,D&D Activities section, aim to reduce the levelized cost of energy (LCOE) for offshore wind, land-based wind, and distributed wind energy by 2030.

The U.S. production tax credit, which provides a per-kilowatt-hour credit for electricity generated by eligible renewable sources, continued to drive a high number of capacity additions in 2021. The credit expired December 31, 2021, and applies to wind projects that began construction before that date. In addition, land-based wind energy projects that began construction in 2016 and 2017 remained eligible for the alternative Investment Tax Credit that provides a credit for up to 30% of investment costs at the start of the project. Offshore wind energy projects that begin construction by December 31, 2025, are eligible for a 30% Investment Tax Credit [8].

Progress and Operational Details

Wind power projects account for a significant portion of the clean energy currently under construction in the United States, with land-based wind accounting for 20% and offshore wind accounting for an additional 15%. The remaining projects are solar energy and battery storage [5].

On a per-project basis, wind facilities are growing in size. Of the land-based wind projects currently operating, 39% have between 100 and 200 MW of capacity. Most projects now in development—more than 70%—are set to have more than 200 MW of capacity [5]. A survey of wind energy experts published in 2021 found expected costs to be 50% lower by 2050 than predicted in 2015 [9].

General Electric wind turbines were the most commonly installed in 2021, making up half of the new land-based capacity. Vestas ranked second with 28% of new installations, followed by Nordex (12%) and Siemens Gamesa (10%) [5].

The leading states for land-based wind power projects in development at the end of 2021 were Texas (6,145 MW), Wyoming (3,000 MW), Illinois (just over 2,100 MW), and Oklahoma (1,748 MW). For offshore wind power, New York leads development on a capacity basis at 4,186 MW, followed by New Jersey with 3,758 MW, Massachusetts with 3,242 MW, and Virginia with 2,587 MW [5].

Matters Affecting Growth and Work to Remove Barriers

Research and development (R&D) efforts, outlined in the R,D&D Activities section, continue to advance technology and project efficiencies as well as address siting and environmental challenges.

To help advance offshore wind energy development, the United States announced plans for potentially seven new offshore lease sales by 2025, including offshore of California, New York, and Oregon [10].

The COVID-19 pandemic underscored the need to build robust domestic supply chains and manufacturing capabilities for clean energy [11]. The National Offshore Wind Research and Development Consortium announced a comprehensive U.S. offshore wind supply chain effort to analyze resources and gaps of current suppliers and to set a baseline for determining and planning for U.S. offshore wind supply chain needs [12].

Meeting the Biden administration's target for offshore wind energy will require the construction of 10 new manufacturing plants for offshore wind turbine components and new vessels to install offshore wind turbines [13].

R,D&D Activities

National R,D&D Priorities and Budget

The U.S. Department of Energy's (DOE's) Wind Energy Technologies Office (WETO) funds a diverse portfolio of wind energy R&D to advance offshore, land-based, and distributed wind energy. Congress directed DOE to allocate 110 million USD (96.7 million EUR) in funds for wind energy research. This was an increase of 6 million USD (5.3 million EUR) over 2020 funding [14].

DOE organized its 2021 wind energy research priorities into several categories:

Offshore wind: DOE aims to reduce the LCOE for fixed-bottom and floating offshore wind energy between 40% and 50% by 2030 [15]. DOE support included 13.5 million USD (12.1 million EUR) for four projects that will inform offshore wind facility siting, permitting, and protection of wildlife and fisheries [16].

Land-based wind: With a research objective to reduce LCOE by 40%–45% by 2030 [15], DOE-funded land-based wind research projects in 2021 included new modeling tools for predicting wildlife impacts [17] and wind turbine power performance [18], as well as two new land-based wind siting resources for local deci-

DOE funded eight small businesses with about 2.2 million USD (1.9 million EUR) in 2021 through its Competitiveness Improvement Project, which provides financial and technical support to manufacturers of small wind turbines like the one pictured here. *Photo by Jordan Nelson, Nelson Aerial Productions*

sion makers [19]. Researchers also summarized the options and costs of design and end-of-life alternatives to avoid wind turbine waste [20].

Distributed wind: DOE awarded eight small businesses about 2.2 million USD (1.9 million EUR) in 2021 to develop wind technology as a distributed energy resource [21] as part of a goal to halve the LCOE for a 100-kilowatt wind turbine by 2030 [15]. DOE also produced a set of flexible guidelines that organizations can use to manage risk and inform capital investments [22] and offered resources related to how distributed wind projects could benefit rural electric utilities and the communities they power [23].

Systems integration: DOE's goal is to enable cost-effective, cybersecure, reliable, and resilient operation of the energy system with increasing levels of wind [15]. Research released in 2021 projected that, with more than 755 GW of electric-generating capacity and an estimated 200 GW of storage capacity seeking access to the U.S. transmission system, there is a potential bottleneck in the transition to zero-carbon electricity [24].

Siting and environmental challenges: DOE's research priorities for both land-based and offshore wind energy include wildlife and environmental impacts and solutions, radar impacts and solutions; and mitigation of use conflicts [15]. Current research in this area includes a real-time acoustic monitoring platform to detect right whale calls [25] and a detection system designed to reduce wind energy's impact on bats while increasing energy production compared to blanket curtailment [26].

National Research Initiatives and Results

- The National Renewable Energy Laboratory (NREL) developed a conceptual design that would make it possible to ship longer blades via rail, which would lower the cost of deploying such blades [27].
- Through the Atmosphere to Electrons national research initiative [28], an updated weather model was developed to identify cold-pool events that affect wind power plant production [29].
- DOE published the Atlantic Offshore Wind Transmission Literature Review and Gaps Analysis, summarizing the current publicly available transmission analyses along the Atlantic Coast, as well as gaps in existing analyses [30].
- The National Offshore Wind R&D Consortium selected 15 projects in 2021 to receive 8 million USD (7.1 million EUR) for offshore wind innovation [31].

Students from Virginia's James Madison University prepare their turbine for a tunnel test during the 2019 Collegiate Wind Competition, a workforce development competition that challenges teams of undergraduate students to offer a unique solution to a complex wind energy project. *Photo courtesy of Werner Slocum, NREL*

Test Facilities and Demonstration Projects

WETO announced 15 million USD (13.2 million EUR) in funding for two projects supporting offshore wind technology demonstration: one to develop a full-scale design of a floating offshore wind platform capable of supporting a turbine of 10+ MW; and another to design, demonstrate, and validate a synthetic rope mooring for floating offshore wind turbines, which is expected to reduce the impact of offshore wind development on commercial fishing and reduce costs [32].

Also in 2021, DOE commissioned the National Rotor Testbed, an open-source wind turbine designed at Sandia National Laboratories. The turbine will help wind power plant operators understand how they can lower energy costs using wake control approaches [33].

Collaborative Research

U.S. representatives participated in research for 18 of the IEA Wind Technology Collaboration Programme (IEA Wind) Tasks in 2021. WETO funded a study led by NREL involving several members of IEA Wind Task 26 (Cost of Wind Energy) that explored the drivers of repowering land-based wind energy [34]. DOE researchers also collaborated with others working under IEA Wind to develop a new approach to evaluating renewable energy project revenue and value holistically, applying it to eight global offshore wind projects [35].

The United States and Canada launched an updated memorandum of understanding identifying 15 areas for strategic bilateral energy cooperation with the goal of accelerating the clean energy transition and providing reliable, efficient, and resilient grid operations. The countries also released the North American Renewable Integration Study, a first-of-a-kind effort to characterize the benefits of cross-border grid integration [36].

Impact of Wind Energy

Economic Benefits and Industry Development

The Bureau of Labor Statistics ranks wind technicians among the nation's fastest-growing jobs [37].
Meeting the 30-GW offshore wind energy deployment goal would require an estimated 44,000 workers employed in offshore wind in 2030, with an additional 33,000 jobs in communities with offshore wind activity [38].

The Collegiate Wind Competition, a workforce development competition that challenges teams of undergraduate students to offer a unique solution to a complex wind energy project, announced Pennsylvania State University as the overall first-place winner of the 2021 competition [39].

Next Term

Another 7.6 GW of wind energy capacity is expected to come online in 2022 [40].

New York's first offshore wind farm, the 132-MW South Fork Wind project, began construction in February 2022 and is set to be fully operational by the end of 2023 [41].

An international, multi-institutional wind energy field campaign called the American WAKE experimeNt (AWAKEN) will amass the world's most comprehensive data set of atmospheric phenomena (including wakes) in and around wind turbines [42].

The Bipartisan Infrastructure Law established in late 2021 provides 100 million USD (89.7 million EUR) to WETO for research, development, demonstration, and deployment activities, including for wind system recycling [43]. The law also funds the creation of an Office of Clean Energy Demonstrations that will issue funding opportunities for projects that may have wind energy applications or tangential benefits to the wind industry [44].

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