

Distributed Wind Market Report 2024 Edition Summary

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Distributed Wind Market Report: 2024 Edition

Purpose, Scope, and Data

- Summarizes U.S. distributed wind annual data through the end of 2023
- Analyzes distributed wind projects of all sizes
- Provides data and analysis that are separate from land-based and offshore wind
- Includes data from turbine manufacturers, project installers, state agencies, American Clean Power Association, U.S. Energy Information Administration, Federal Aviation Administration, U.S. Department of Agriculture, U.S. Wind Turbine Database, and others.

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Products and Availability

- This summary is complemented with an underlying report and data file
- All products available at: https://www.pnnl.gov/distributed-wind/market-report





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U.S. Distributed Wind Deployment





Cumulative distributed wind capacity reached 1,110 MW in 2023 from over 92,000 wind turbines deployed across all 50 states, the District of Columbia, Puerto Rico, the U.S. Virgin Islands, the Northern Mariana Islands, and Guam.



Distributed wind capacity in the United States

New distributed wind projects were documented in 16 states in 2023

In 2023, new distributed wind projects were documented in 16 states:

Alaska

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- Colorado
- lowa
- Illinois
- Kansas
- Maryland
- **Massachusetts**
- Minnesota
- Montana
- New York
- Ohio
- Oklahoma
- Utah •
- Vermont
- Virginia
- Wisconsin



U.S. cumulative (2003-2023) distributed wind capacity and capacity additions in 2023 for distributed wind by state



Ohio, Illinois, and Alaska led the United States in new distributed wind capacity additions in 2023



States with distributed wind capacity greater than 20 MW, 2003-2023

One large project each in Ohio and Illinois and one midsize project in Alaska collectively represent 78% of the distributed wind capacity installed in 2023.

One Energy Enterprises LLC installed a 4.5 MW wind project for a Martin Marietta lime manufacturing plant in Woodville,

Rivian installed a 2.8 MW project in support of their manufacturing plant in Normal, Illinois.

Ohio.

The Alaska Village Electric Cooperative added a 0.9 MW wind project to serve the Stebbins and St. Michael communities in Alaska.



Oklahoma and Alaska added the most small wind capacity in 2023



- Small wind projects use turbines with capacities less than or equal to 100 kW.
- Oklahoma added 210 kW of small wind Energy for America Program (REAP) investment.
- North Slope.

States with small wind capacity greater than 2 MW, 2003-2023

capacity across 12 agricultural and rural small business enterprises, all of which received U.S. Department of Agriculture (USDA) Rural

Alaska added 200 kW of small wind to help power a Doyon Drilling warehouse on the



U.S. Distributed Wind Projects and Sales



Eight developers have accounted for 87% of the distributed wind capacity from projects using midsize and large turbines since 2018

These developers work almost exclusively in a single state or region and may not install projects each year because large-scale projects can take two to four years to develop.

Project developers using midsize and large wind turbines, 2014-2023

Bluestem Energy Solutions

ConEdison Development

Foundation Windpower

Green Development

One Energy Enterprises LLC

Optimum Renewables

GE Energy has been the only consistent U.S.-based large-scale turbine manufacturer used in distributed wind projects over the last decade

Developers, particularly those that also operate the distributed wind projects they build and sell the power through power purchase agreements to customers, report that they source their wind turbines from one manufacturer to facilitate easier operations and maintenance across their fleet of projects.

Wind turbine manufacturers of midsize and large turbines with a U.S. sales presence, 2014-2023

Small wind sales and capacity in 2023 were similar to 2022

Small wind sales and capacity in 2022 and 2023 were the highest they have been in the last seven years.

Number of Units Sold in United States

U.S. small wind turbine sales, 2014-2023

23	
1,971	18,000,000
ales (MW)	16,000,000
ales (\$)	14,000,000
	12,000,000
<u> </u>	10,000,000
	8,000,000
_	6,000,000
0	4,000,000
	2,000,000
	0

2023

Sales in U.S. Market (\$)

Small Wind Certification

American Windpower

Seven small wind turbines were certified as of **June 2023**

		Date of Initial	Certified Power Rating ^a	Certification
Applicant	Turbine Model	Certification	@ 11 m/s (kW)	Standard
Bergey Windpower Company	Excel 10	11/16/2011	8.9	AWEA 9.1
Bergey Windpower Company	Excel 15	02/05/2021	15.6	AWEA 9.1
Eveready Diversified Products (Pty) Ltd.	Kestrel e400nb	02/14/2013	2.5	AWEA 9.1
Eocycle Technologies, Inc.	EOX S-16	03/21/2017	22.5/28.9	AWEA 9.1
HI-VAWT Technology Corporation/Colite Technologies	DS3000	05/10/2019	1.4	AWEA 9.1
SD Wind Energy, Ltd.	SD6	06/17/2019	5.2	AWEA 9.1
Wind Resource, LLC	Skystream 3.7	04/12/2023	2.1	AWEA 9.1

- The American Clean Power Association (ACP), the successor to AWEA, published its new American National Standards Institute (ANSI) consensus standard, ANSI/ACP 101-1-2021, in October 2022 to facilitate easier certification compliance.
- The Distributed Wind Energy Association and the U.S. Department of Energy have recommended that the Internal Revenue Service recognize legacy certifications to AWEA 9.1-2009 and new certifications to ANSI/ACP 101-1 going forward for Business Energy Investment Tax Credit eligibility.
- The Inflation Reduction Act extended the Residential Renewable Energy Tax Credit through 2034 and the Business Energy Investment Tax Credit through 2024.
- Certification testing is supported by DOE through the Competitiveness Improvement Project.

Policies, Incentives, and Market Insights

The combined value of USDA REAP grants, state-level incentives, and state-level production tax credits allocated to distributed wind projects in 2023 was \$12 million across 10 states

The 10 states were:

-\$

Awards

of

Total Value

- California
- lowa
- Kansas
- Maryland
- Minnesota
- Missouri
- Nebraska
- New Mexico
- Oklahoma
- Vermont

U.S. distributed wind incentive awards, 2014-2023

In 2023, a total of \$3.4 million in USDA REAP grants was awarded to 40 wind projects, \$2.4 million of which was for 39 distributed wind projects

The 39 distributed wind projects were in eight states:

- lowa
- Kansas
- Maryland
- Minnesota
- Missouri
- Nebraska
- Oklahoma
- Vermont

The 2023 USDA REAP funding amount for wind projects was substantially greater than the \$1.1 million awarded in 2022. The increase in funding can largely be attributed to the Inflation Reduction Act (IRA).

USDA REAP grants by technology, 2014-2023

Technology Energy Efficiency

Solar

2022 2023

Distributed Wind Costs

The average installed cost for new small wind projects in 2023 was \$7,370/kW

The overall average installed cost for new small wind projects for 2014 through 2023 was \$11,410/kW

Annual average and project-specific new and repowered small wind installed project costs, 2014-2023

2023

19

The overall average capacity-weighted installed cost for projects using midsize and large turbines for the period of 2014 through 2023 was \$4,160/kW Northwest

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Annual average and project-specific new and repowered installed costs for projects using midsize and large turbines, 2014-2023

2022 2023

Distributed Wind Performance

The average capacity factor in 2023 from a sample of small wind projects was 13%

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Small wind capacity factors in 2023

The sample includes 100 small wind projects totaling 1.3 MW in rated capacity from turbines ranging from 2 kW to 78 kW installed from 2009 through the beginning of 2023.

The wide range of observed small wind capacity factors reflects, among other variables, the assessment and siting challenges for small wind. The same turbine model sited in different locations can achieve very different capacity factors, due to differences in the local wind resource and turbulence created by nearby obstacles and complex terrain. In addition, low turbine availability due to a turbine not operating for extended periods because of mechanical problems or other reasons, can lower the turbine's overall capacity factor. Poor measurement and reporting techniques for energy production may also be contributing factors.

The average capacity factor in 2023 from a sample of distributed wind projects using midsize and large turbines was 21%

The sample includes 36 projects using midsize and large turbines installed from 2005 to 2021, across 15 states, totaling 117 MW in combined capacity.

Turbine nominal capacities used in the projects ranged from 600 kW to 3 MW.

Capacity factors in 2023 for projects using midsize and large turbines

In multiple regions of the continental United States, the wind Pacific Northwest resource was lower in 2023 than in 2022

The year 2023 was largely dominated by El Niño, which tends to be associated with weaker jet stream patterns and decreased wind speeds across the center of the continental United States.

Ratio of ERA5 100 meter (m) annual average wind speed in 2023 to 2022

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Only 13% of the distributed wind projects PNNL analyzed had higher capacity factors in 2023 than in 2022

Distributed wind capacity factors, 2022-2023

- Of the 104 projects analyzed in 2023, only 14 (13%) of the projects exceeded their capacity factors in 2022, while 75 projects (72%) underperformed in 2023 relative to their capacity factors in 2022 and 15 projects performed similarly between the two years.
- Across the projects, the average capacity factor in 2022 was 17% and the average capacity factor in 2023 was 15%.
- Of the projects that overperformed in 2023 relative to 2022, 10 reported outages of 1 month or greater in 2022.
- The interannual wind resource, with El Niño leading to reduced wind speeds in the Midwest, Southern Plains, and Northeast, was the main contributor to distinctions in distributed wind performance trends between 2022 and 2023.

Trends in wind resource quality at locations of distributed wind deployment have been consistent over the last decade

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Wind resource quality by year of installation, 2014-2023

- 6.7 m/s.

For a sample of 319 distributed wind projects for which PNNL has specific geographic coordinates, the estimated annual average wind speed at 50 m above the ground was sourced from the high-resolution Global Wind Atlas.

The height of 50 m was selected because it is a central height between the higher hub heights of large distributed wind installations and the lower hub heights of small wind installations.

For each year between 2014 and 2023, the median annual average wind speed has ranged between 6.2 meters per second (m/s) and

Distributed Wind Markets

Sarah Gates

Projects for commercial customers accounted for 42% of the number of all projects installed in 2023, followed by agricultural customers at 34%

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Distributed wind end-use customer types by number of projects, 2014-2023

Distributed wind deployed for industrial customers represented 83% of the total capacity installed in 2023

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Distributed wind end-use customer types by capacity of projects, 2014-2023

In 2023, 82% of distributed wind projects were interconnected to provide energy for on-site use

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Two primary interconnection types exist for distributed wind:

Distributed wind for on-site use and local loads by number of projects, 2014-2023

On-site use (i.e., behind-themeter, remote net-metering, grid-connected microgrid, and off-grid applications) Local use (i.e., load-serving distribution line and isolated

grid applications)

Of the on-site use projects, 93% were deployed as behind-the-meter installations and 7% were deployed as off-grid installations.

In 2023, 89% of distributed wind capacity was deployed for on-site use, while 11% was for local use

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 Projects for local use have traditionally represented more of the installed distributed wind capacity due to the projects' larger sizes and use of larger wind turbines.

The year 2023 marks a departure from this trend due to two large on-site use projects supporting industrial loads.

Distributed wind for on-site use and local loads by capacity of projects, 2014-2023

Distributed Wind Technology

In 2023, the average capacity of midsize and large turbines used in distributed wind projects was 1.6 MW

Size of midsize and large turbines in distributed wind projects, 2003-2023

Turbines in the size segment of 11 – 100 kW represented 70% of the small wind sales capacity in 2023 for a total of 1.6 MW

U.S. small wind sales capacity by turbine size, 2014-2023

The market typically experiences notable year-to-year variation in the size segments of small wind turbines sold in the U.S., but there was minimal change from 2022 to 2023

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U.S. small wind sales percentage of capacity by turbine size, 2014-2023

Future Outlook and Market Potential

Future Outlook and Market Potential

- The Distributed Wind Energy Futures Study, released in May 2022, determined substantial economic potential for distributed wind (defined as a project with a positive rate of return). The 2022 baseline scenario economic potential was 919 GW for behind-the-meter installations and 474 GW for front-of-the-meter installations.
- Future scenarios that include increased policy support point to even greater potential for the industry. With the IRA's extension of the existing investment tax credit (ITC) and provision for the future Clean Energy ITC, the distributed wind industry has federal policy support.
- In addition to the ITC, the IRA allocated \$144 million in grant funding for underutilized technologies through • USDA REAP, including distributed wind energy.
- A joint initiative between USDA and DOE was launched in February 2024 to help farmers cut costs and increase income through REAP-supported distributed wind projects. The Rural and Agricultural Income & Savings from Renewable Energy (RAISE) initiative includes an additional \$4 million investment from DOE to test and commercialize distributed wind technologies and develop business models that allow farmers to earn revenue from deploying these technologies. USDA has set an initial goal to help 400 individual farmers install distributed wind turbines through the RAISE initiative. This could significantly influence the rural and agricultural market segments in the coming years.
- Additional federal initiatives are poised to decrease well-known deployment barriers across the distributed wind market at large. Namely, momentum is building to address common siting and permitting challenges. In September 2023, DOE announced a \$4.5 million award to the International City County Management Association to support innovative zoning and permitting approaches.

See the full report for additional findings and details: https://www.pppl.gov/distributed-wind/marke

https://www.pnnl.gov/distributed-wind/marketreport

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For PNNL's Project Database, visit: https://www.pnnl.gov/distributed-wind

For PNNL's Photo Gallery, visit:

https://epe.pnnl.gov/research_areas/distributed _wind/photos2.stm

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