Distributed wind energy brings value to remote and rural communities

March 13 2023

Heartland Community College in Normal, Illinois, uses power generated by a 1.65-MW Vestas wind turbine. Credit: Harvest the Wind Network

No roads lead to St. Mary's, Alaska.

To get there, most people boat down the nearby Yukon River, which is almost as wide as the village itself. That same route is used to bring in supplies, like the diesel fuel needed to power and support residents' lives, 90% of whom are native Alaskans. But freezing winters and whipping winds can prevent shipments any time other than the calmer summer months.

Luckily, Alaska's powerful winds can also make clean, local, and affordable energy. Distributed wind energy—produced by wind turbines that serve local customers, like small towns, farms, businesses, or even individual homes—could provide long-term economic, societal, and environmental benefits to remote and rural areas, like St. Mary's.

St. Mary's installed a single 900-kilowatt wind turbine in 2019. That turbine produces about 50% of their power.

While distributed wind energy projects are already saving St. Mary's and other communities money and bringing other benefits, their adoption has been limited, with only 1,075 megawatts of cumulative distributed wind capacity deployed nationwide between 2003 and 2021. A lack of awareness of distributed wind energy's economic value, clean energy value, and energy resilience could have contributed to its slow adoption.

Now, thanks to the four-year Microgrids, Infrastructure Resilience, and Advanced Controls Launchpad (or MIRACL) project, those data exist and confirm distributed wind energy could be a cost-effective source of clean power to many communities, especially those in remote and rural areas, as well as a key component in reliable and resilient energy systems.

"There is strong resource potential for distributed wind across the United States," said Ian Baring-Gould, a researcher at the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) and member of the MIRACL research team. "As a renewable resource, it can help offset carbon emissions and provide a clean source of power for communities. For some remote or rural areas, it may be the best source of clean energy available."

Launched in 2018 by the U.S. Department of Energy's Wind Energy Technologies Office, the MIRACL project set out to evaluate how communities could safely, effectively, and efficiently integrate wind energy into distribution, islanded, hybrid, or microgrid systems (like St. Mary's, which is an isolated microgrid that is not connected to a larger electrical grid).

To do so, a collaborative team of researchers from NREL, the Pacific Northwest National Laboratory (PNNL), Sandia National Laboratories (Sandia), and Idaho National Laboratory (INL) came together to better advance distributed wind energy's many benefits—from energy cost savings to enhanced resilience—for communities across the United States.

"When people think of distributed wind energy, many think of a single little turbine out in a field," said Caitlyn Clark, the lead investigator on the MIRACL project and a researcher at NREL. "But there are a lot of applications where distributed wind can be used. The MIRACL project asked, "What barriers keep distributed wind from being developed? And what can we do to overcome those barriers?'"

The MIRACL team identified four main use cases for distributed wind energy on its own or combined with other types of power, including in isolated grids and microgrids.

Even though small-wind-turbine manufacturers have seen increased interest in microgrids and hybrid systems—which pair wind energy with other renewable energy sources, like solar panels and energy storage, newly added distributed wind energy capacity dropped from about 22 megawatts in 2020 to 12 megawatts in 2021, said Alice Orrell, the distributed wind research lead at PNNL and an investigator on the MIRACL team. That is almost a 50% reduction.

Addressing key knowledge gaps

Part of that drop could be attributed to a lack of knowledge about distributed wind energy's value in terms of economic benefits, grid services, reliability and resilience, and energy security. The MIRACL team's work is focused on filling those gaps.

Experts at PNNL designed a first-of-its-kind framework to estimate distributed wind energy's actual value across a diverse range of case studies and scenarios.

NREL and Sandia team members examined advanced controls, which operate a wind turbine's electrical and mechanical systems using a network of sensors connected to a central processing system. These modern methods of controlling individual wind turbines can compensate for—or even forecast—changes in wind speeds to improve the way wind turbines operate in coordination with other distributed energy technologies, such as solar power and storage, to harness as much energy as possible.

INL's experts also looked at how distributed wind energy could provide greater reliability and resilience to communities that experience extreme weather events.

The resilience framework they developed can help compare the resilience impact of different system upgrades, quantify the impact of distributed wind energy to overall system resilience, and guide investment decisions using a risk-based analysis. The framework is now being developed into a tool that automates the analysis, improving accessibility to the research.

Additionally, a team based at INL evaluated the potential threat cyberattacks might pose to distributed wind energy systems. Their findings could help manufacturers and operators protect wind turbines from those attacks.

"Cyber threats to electric power infrastructure overall, and to wind energy specifically, are continuing to grow," said Megan Culler, an engineer at INL and MIRACL project investigator. "For distributed wind energy, cyber risks can include ransomware, untargeted malware, and other attacks that target often unprotected architecture."

The MIRACL team also found that coupling distributed wind energy with solar power and energy storage can greatly enhance consistency in power generation. Because these sources complement each other, such hybrid systems can better match energy demand.

"Compared to solar power, distributed wind energy provides a different generation profile that can potentially serve customers better both on its own and in hybrid systems," Clark said.

They also explored the potential of distributed wind energy, including as part of these hybrid systems or connected to isolated grids or microgrids, to help communities build resilience and keep the lights on during cold snaps, natural disasters, or cyberattacks.

Real-world implementation

The MIRACL team worked directly with communities to analyze how distributed wind energy could help reduce their energy costs or maintain power even during extreme weather events.

Working with the Alaska Center for Energy and Power and the local power cooperative for St. Mary's, the Alaska Village Electric Cooperative, the MIRACL team also identified hybrid system technology advances to increase fuel savings further.

In addition to the work in Alaska, the team engaged with Iowa Lakes Electric Cooperative, a cooperative in northern Iowa that installed two seven-turbine distributed wind power plants in 2009, each totaling 10.5 megawatts, which were sized and sited to serve two local ethanol plants. The team considered the specific resilience needs of the ethanol plants and used the valuation framework, resilience framework, and hybrid design tools to demonstrate the benefits of the existing plants and explore ways to maximize their potential.

The team is also working with the city of Algona, Iowa, helping them explore potential hybrid wind energy projects that could supplement their current energy supply.

These partnerships can help build trust in and awareness of distributed wind energy's great value.

For Rachid Darbali Zamora, an engineer at Sandia, these community partnerships are what excites him most about the MIRACL project. Alongside local utilities, the team is "finding real-world solutions to maximize clean energy impacts," he said.

Provided by National Renewable Energy Laboratory

Citation: Distributed wind energy brings value to remote and rural communities (2023, March 13) retrieved 24 April 2024 from https://techxplore.com/news/2023-03-energy-remote-rural-communities.html