2024 Distributed Wind Energy Summit

Distributed Wind 101

Pacific Northwest NATIONAL LABORATORY

NREL Transforming ENERGY

2024 Distributed Wind Energy Summit

An Introduction to Distributed Wind:
What, Where, and Who

September 17, 2024

Lindsay Sheridan
Earth Scientist, Pacific Northwest National Laboratory

Pacific Northwest NATIONAL LABORATORY

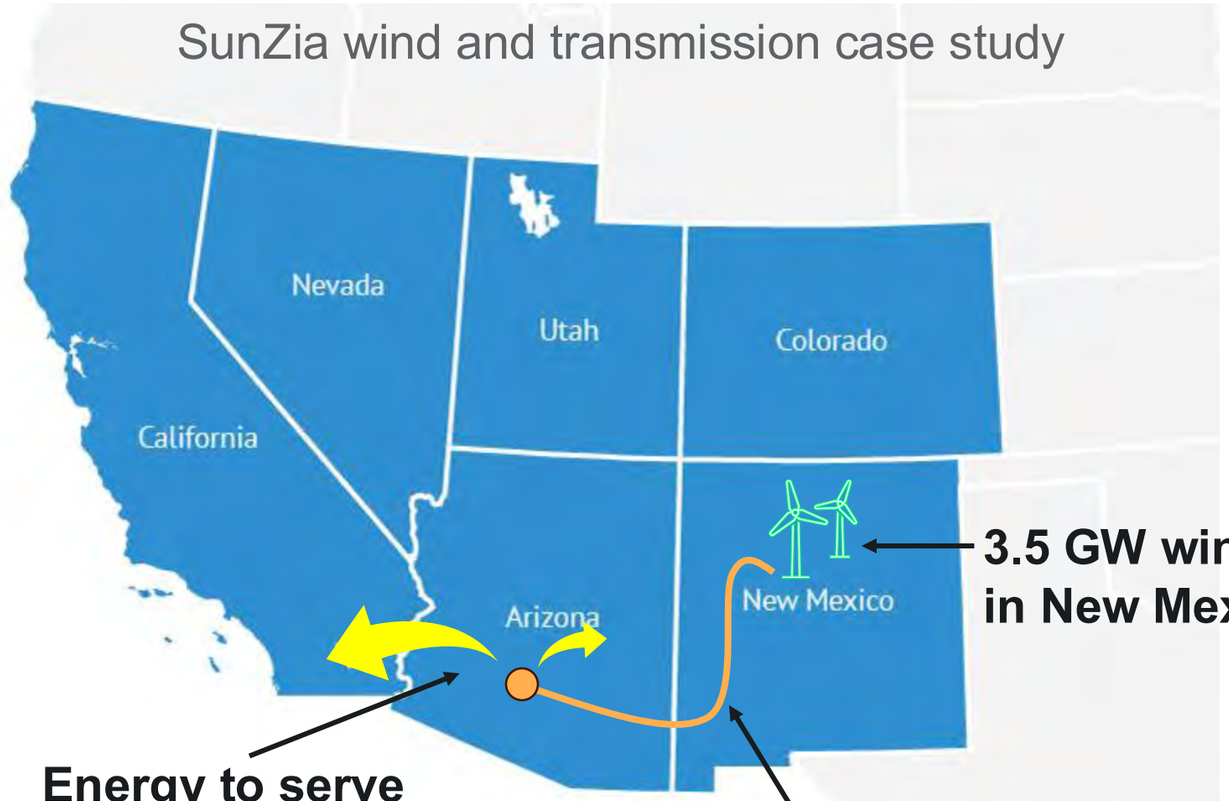
NREL Transforming ENERGY

PNNL-SA-203166

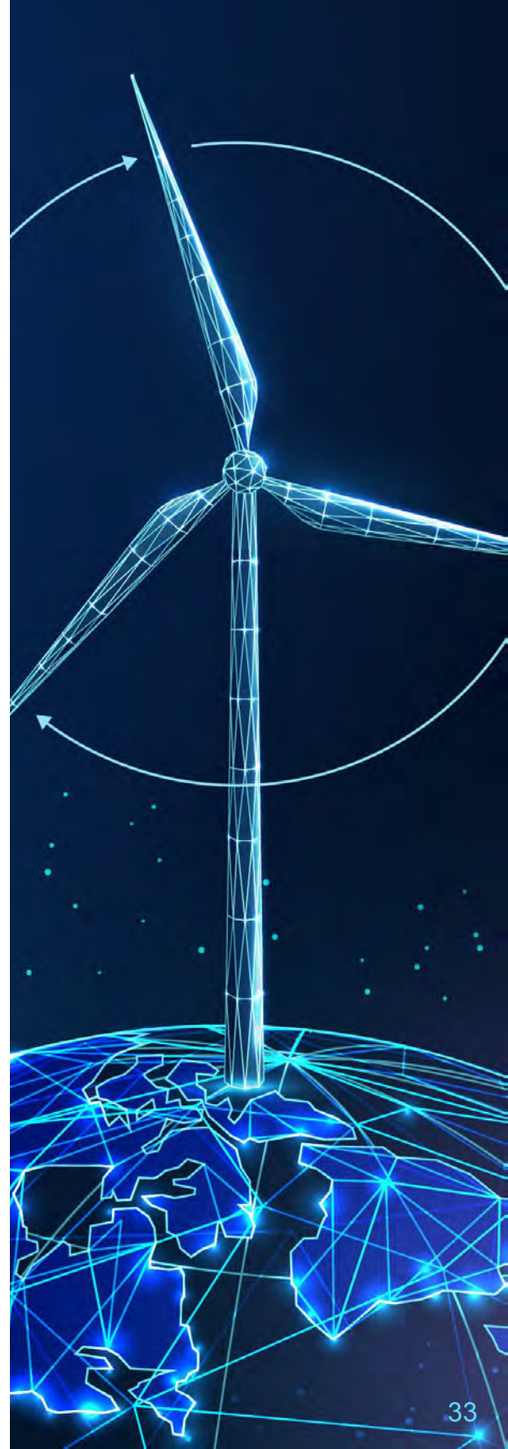
What is distributed wind?

First, what *isn't* distributed wind?

SunZia wind and transmission case study



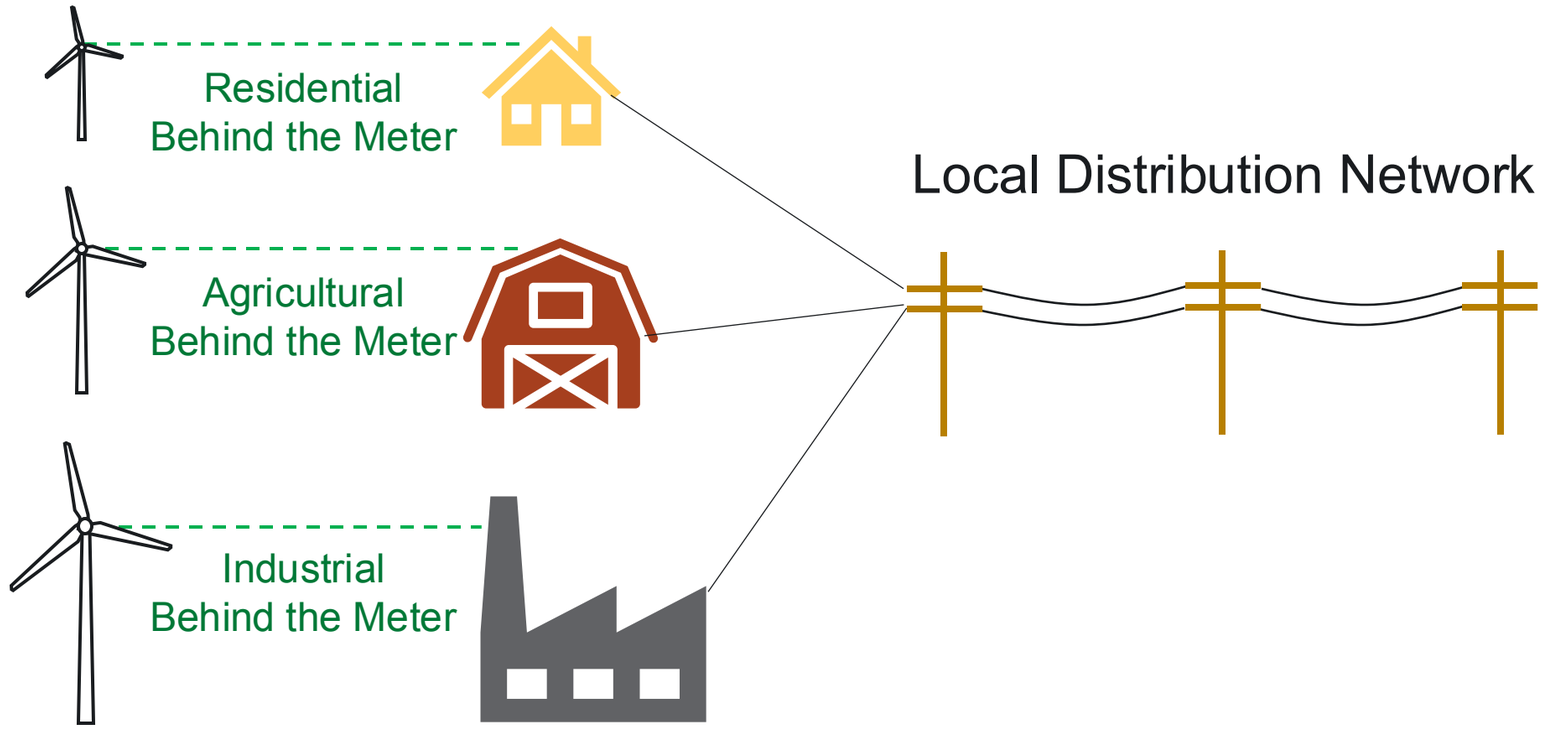
https://www.eenews.net/articles/california-approves-6-1b-transmission-plan/

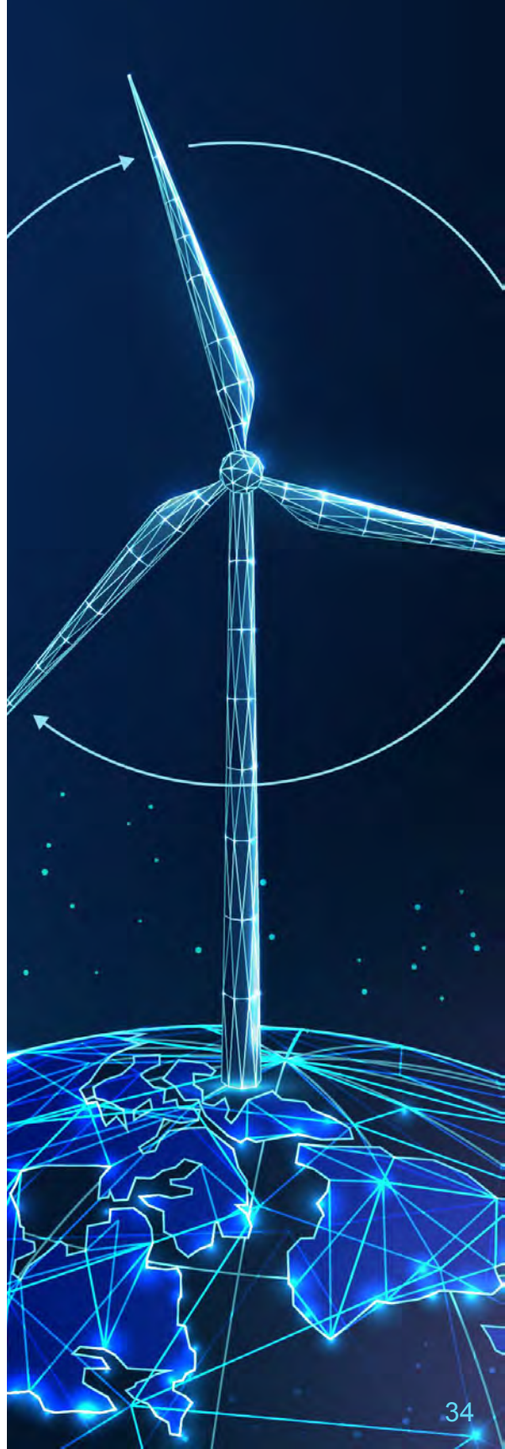


What is distributed wind?

Wind turbines installed to meet **local** energy needs:

1. Connected at the distribution level of an electricity delivery system to serve onsite energy demand behind the meter

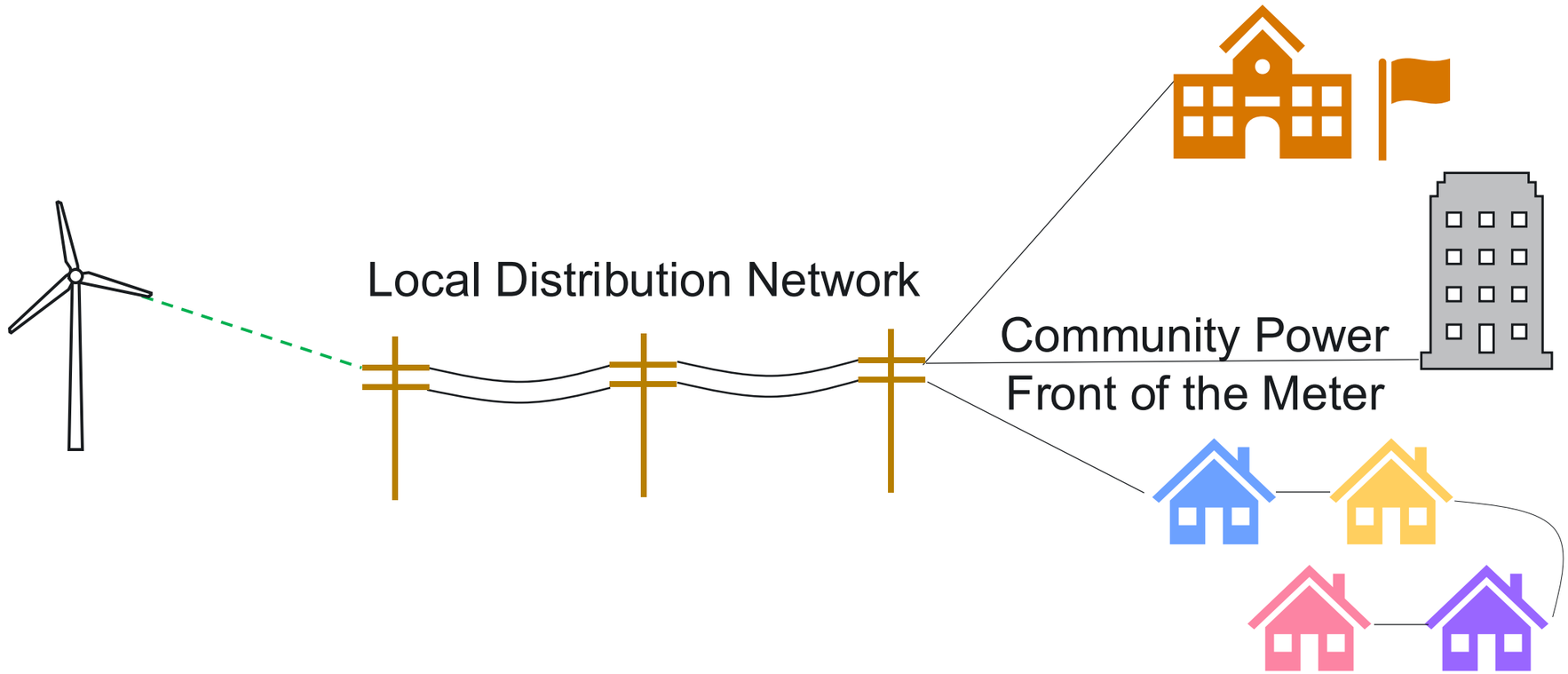


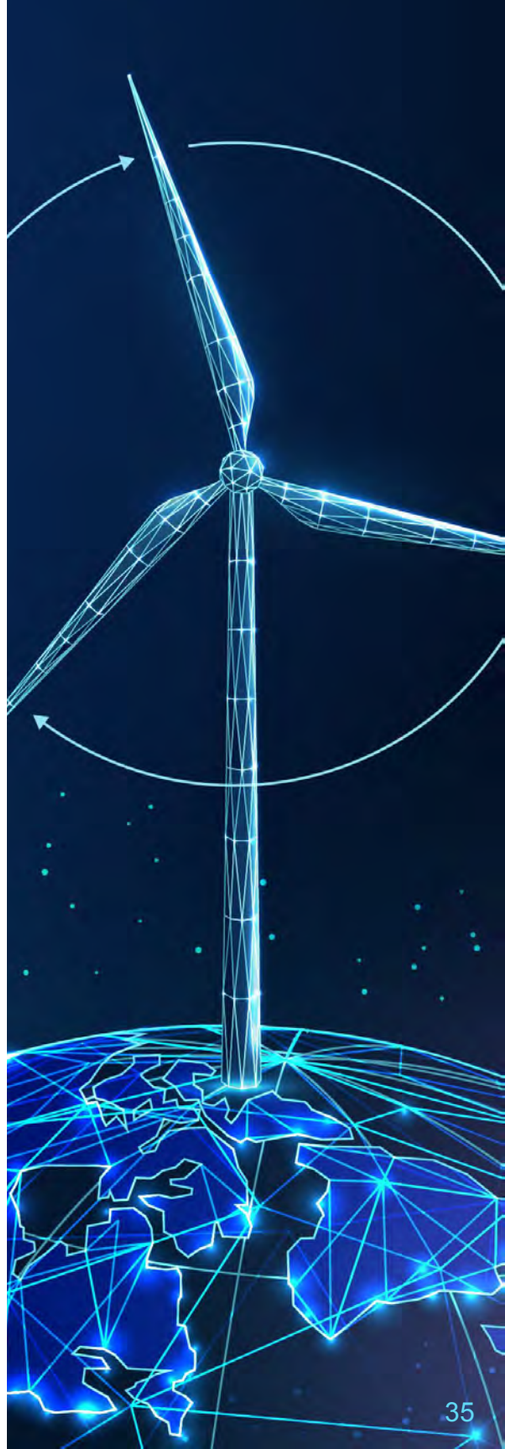


What is distributed wind?

Wind turbines installed to meet **local** energy needs:

2. Connected at the distribution level of an electricity delivery system to support operation of local electricity distribution networks

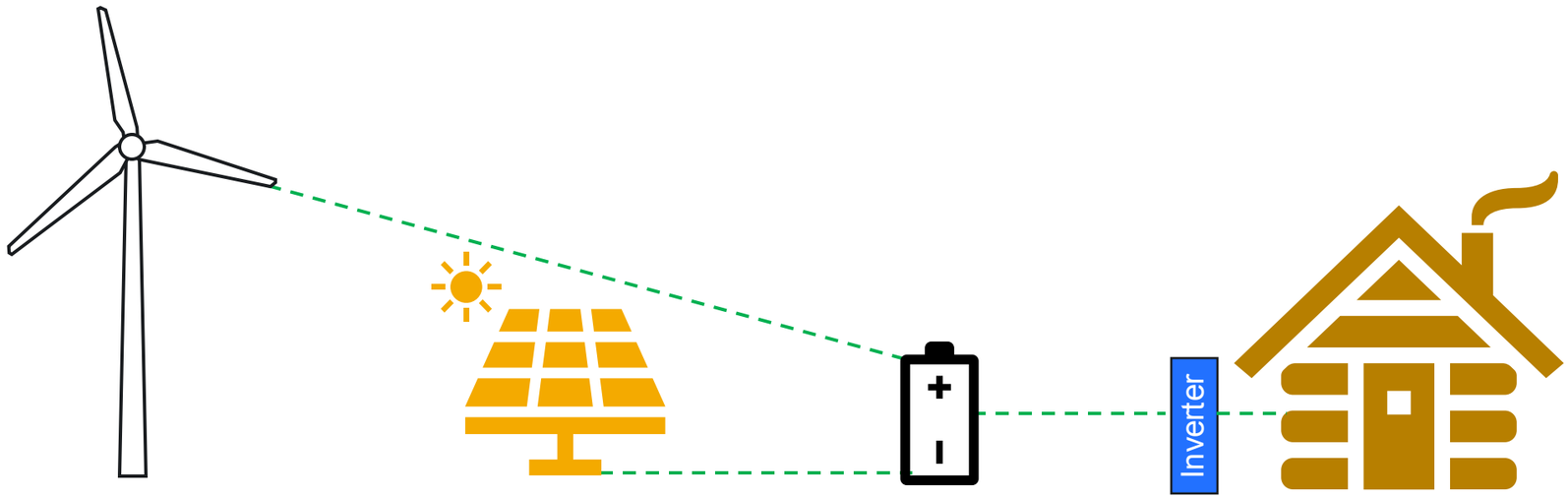


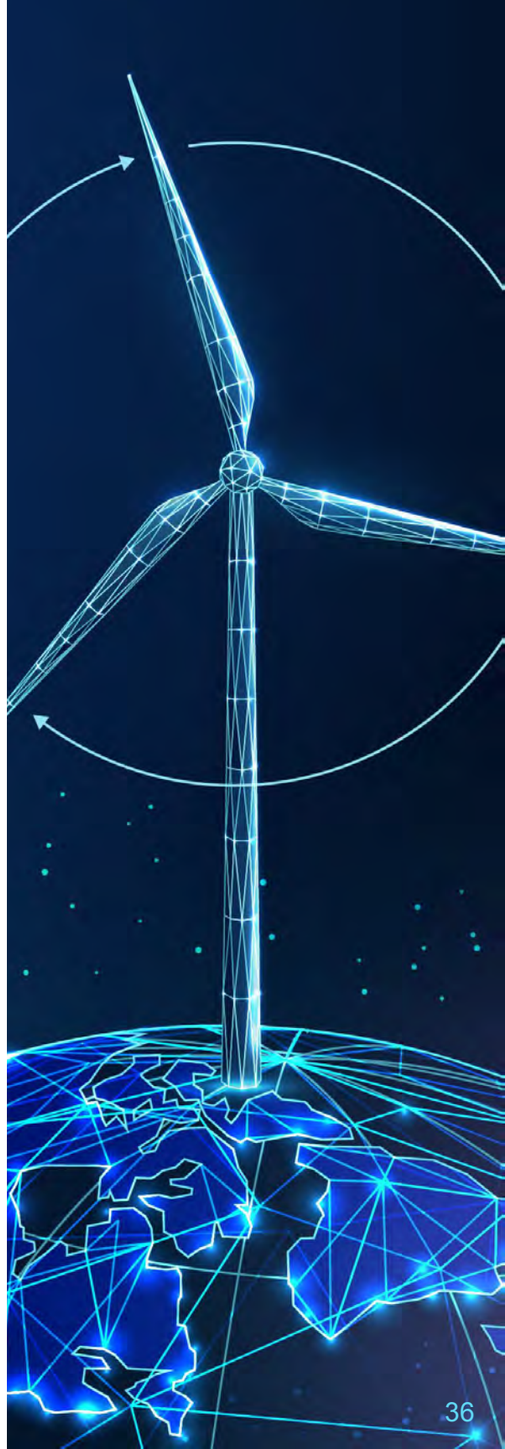


What is distributed wind?

Wind turbines installed to meet **local** energy needs:

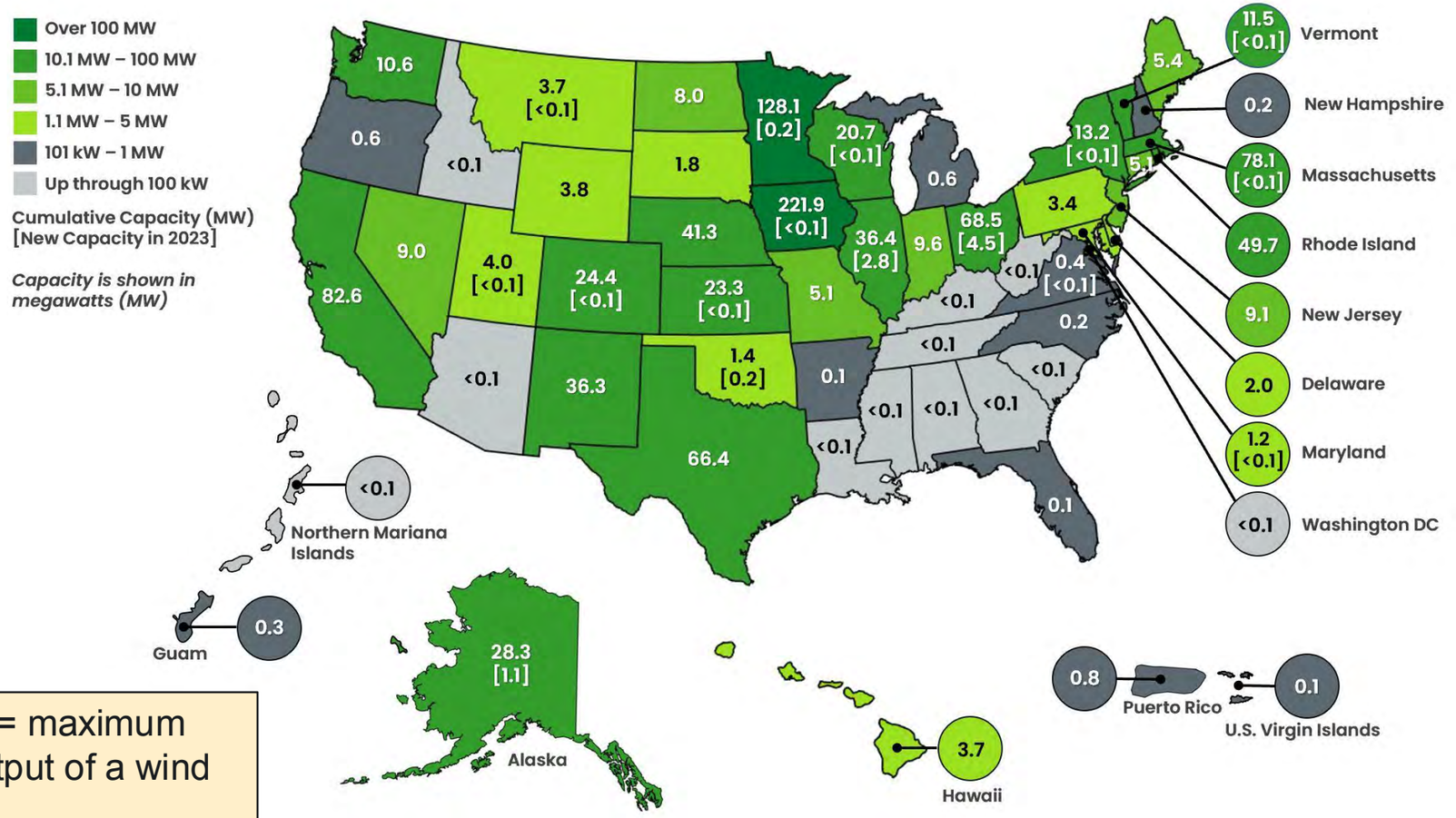
3. Off-grid applications



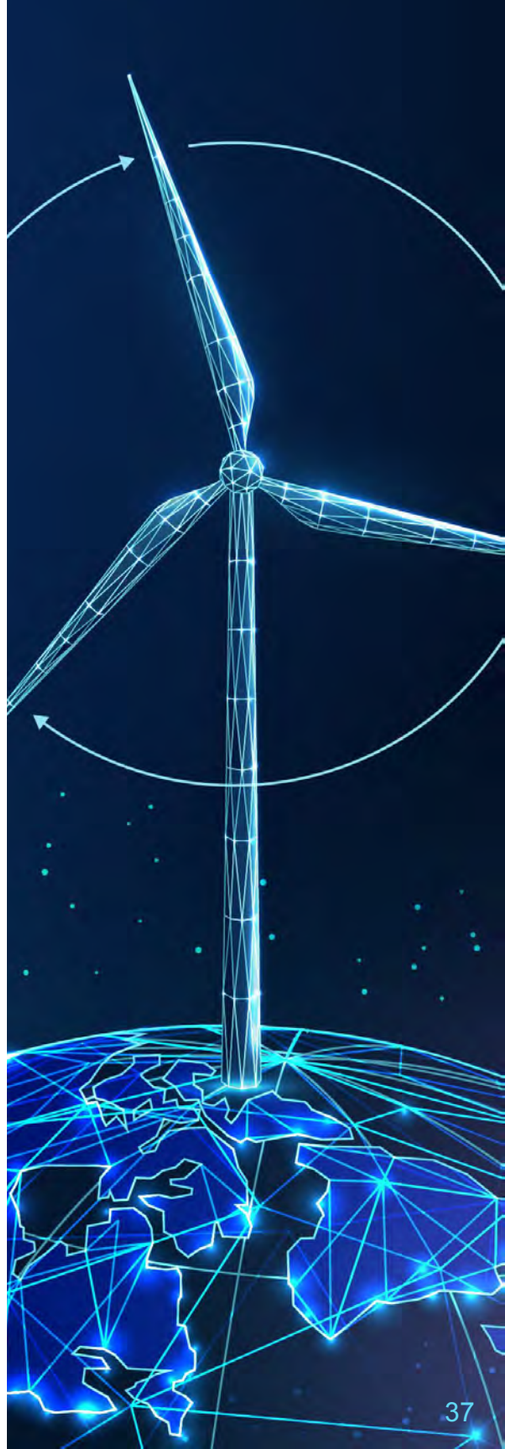


Where has distributed wind been installed in the United States?

Distributed wind turbines are deployed across all 50 states, the District of Columbia, Puerto Rico, the U.S. Virgin Islands, the Northern Mariana Islands, and Guam.

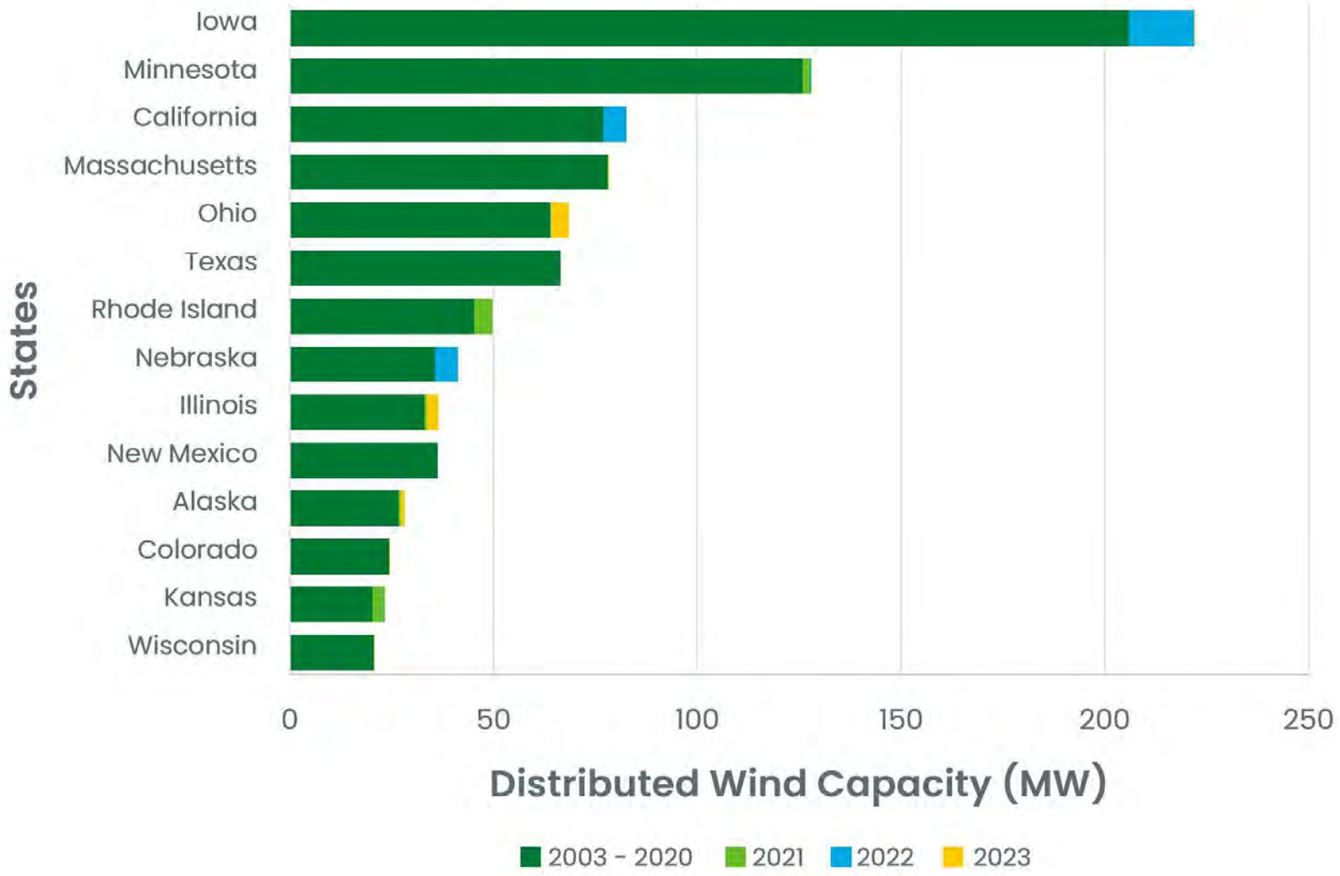


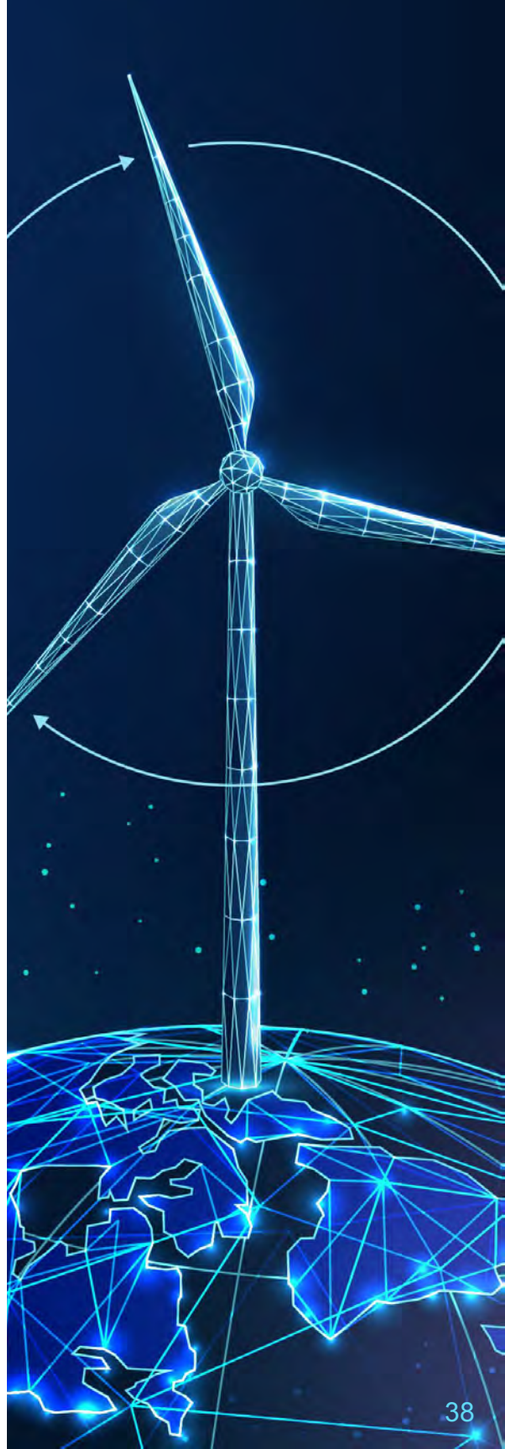
Capacity = maximum power output of a wind turbine



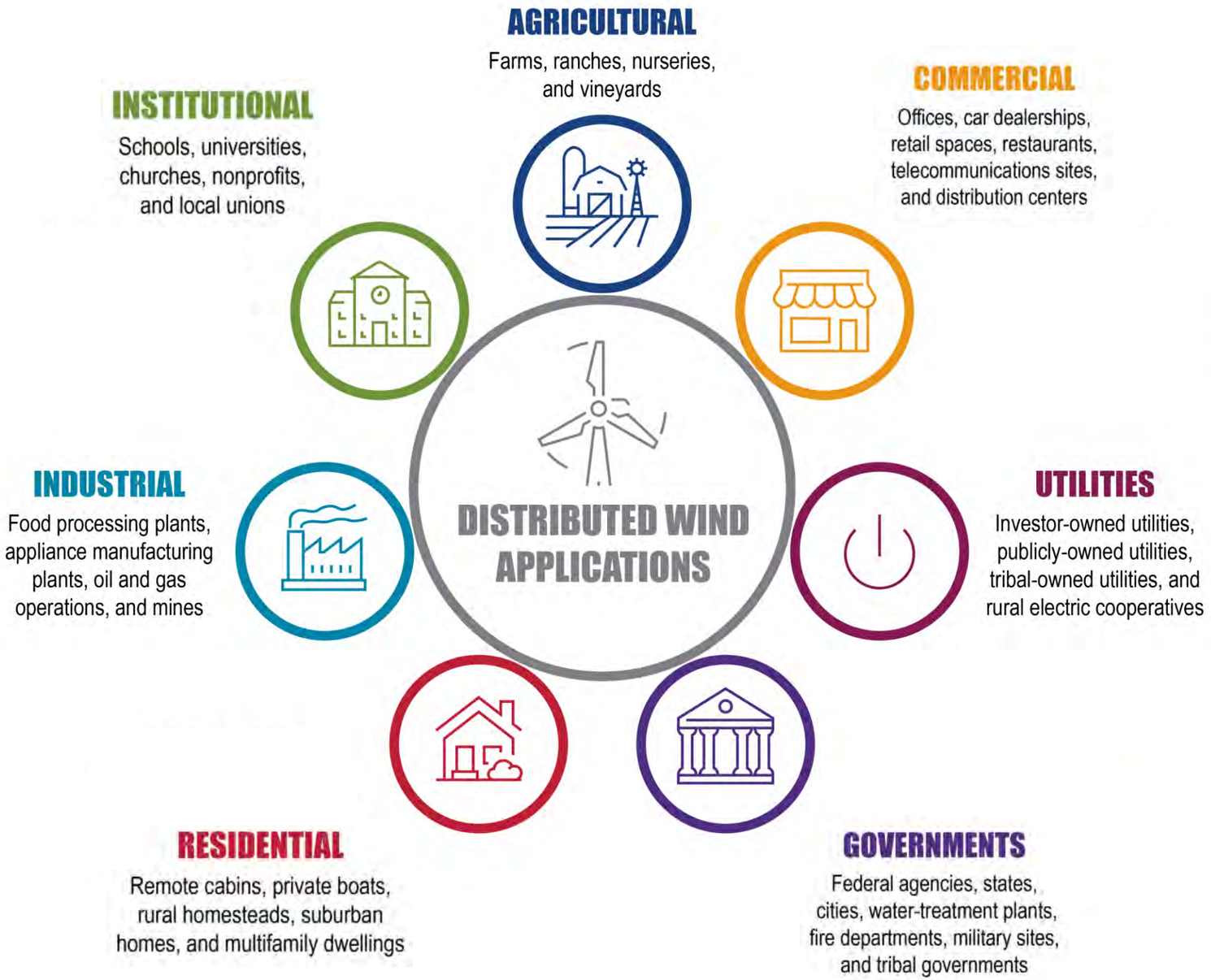
Where has distributed wind been installed in the United States?

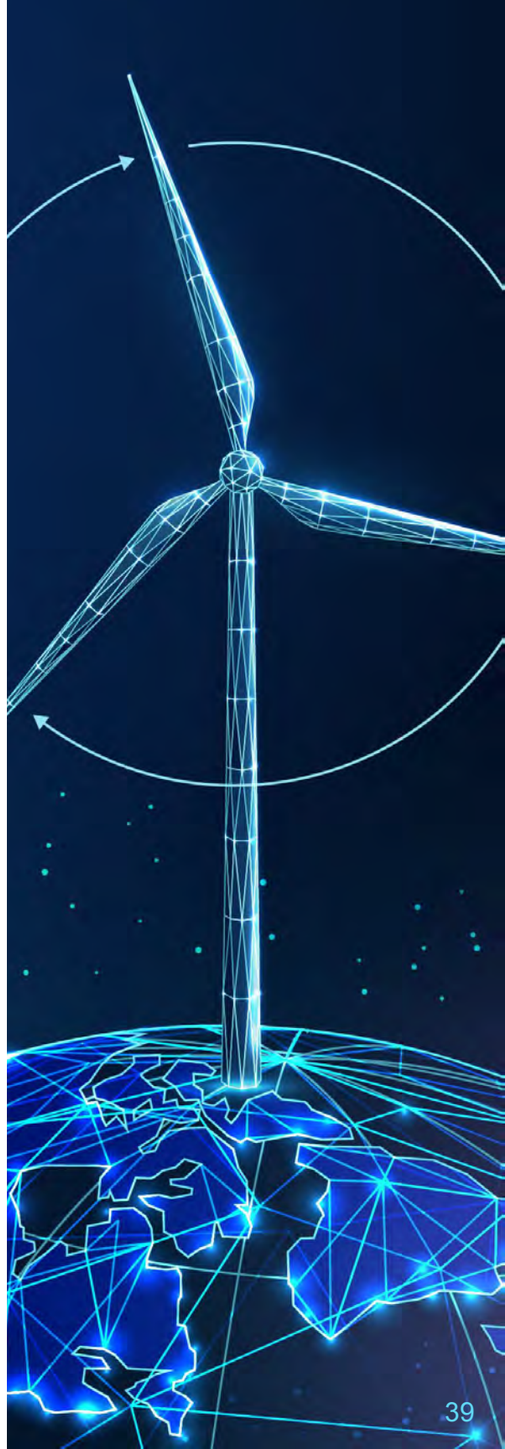
- Iowa and Minnesota lead the United States in distributed wind installed capacity.
- Both states have strong wind resources, active project developers, and have received large shares of funding for wind projects.





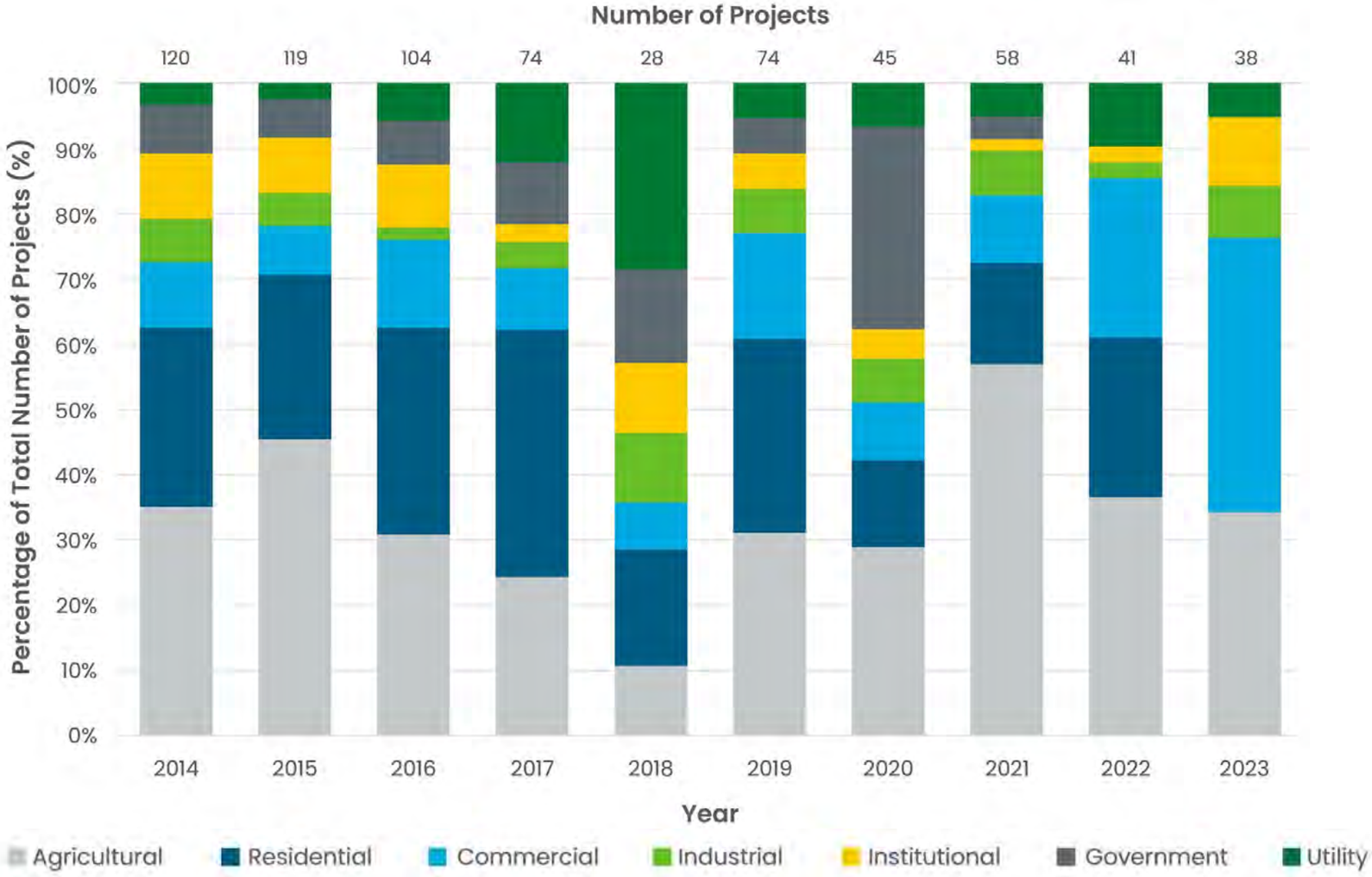
Who installs distributed wind and why?

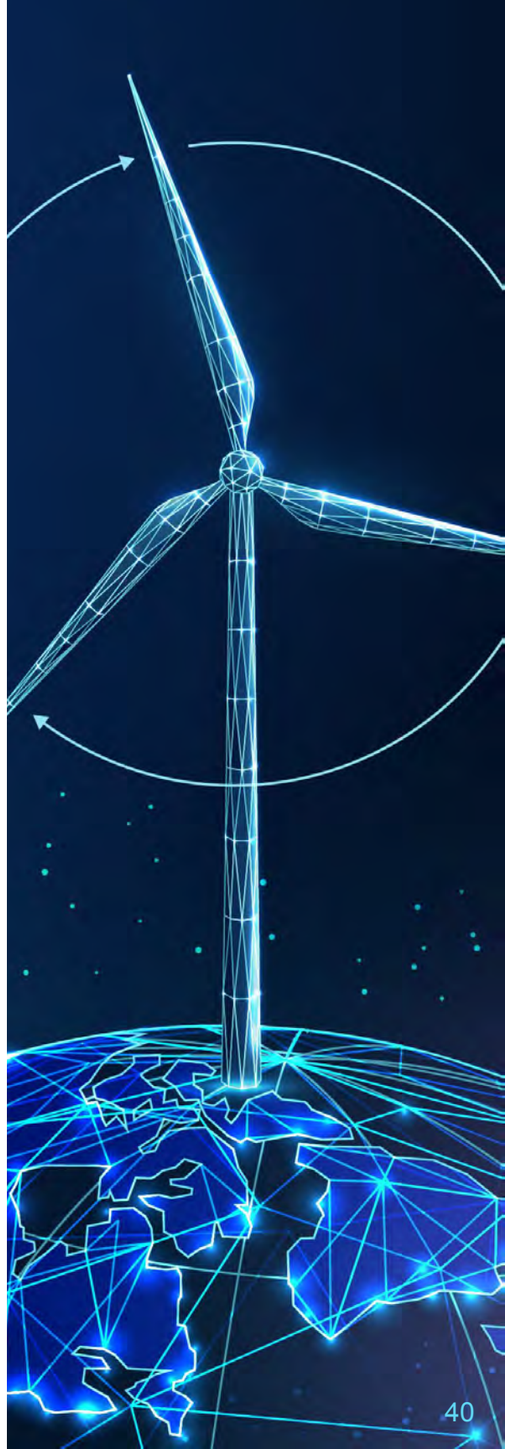




Who installs distributed wind and why?

Agricultural and commercial customers installed the most distributed wind projects in 2023, though recent years have also seen a significant number of residential wind projects.

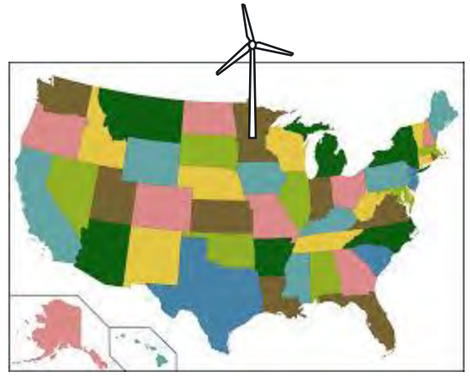


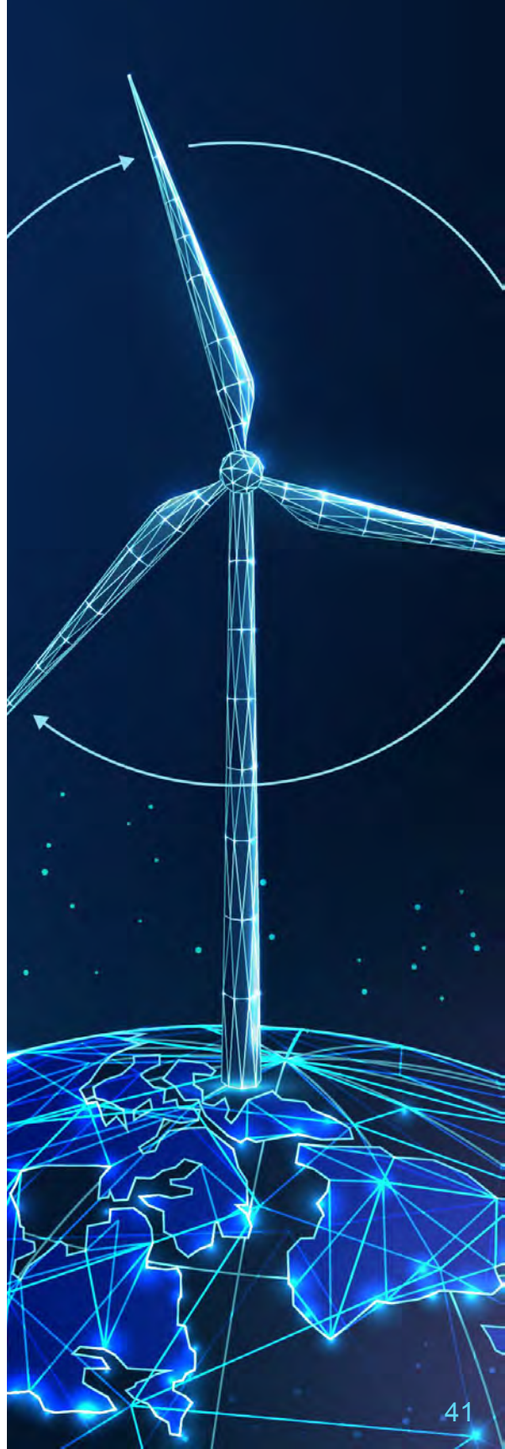


Who installs distributed wind and why?

Distributed wind can reduce electricity costs for farmers, business owners, and residents with at least one acre of land

- After leasing some of his land to large wind farms, this farmer decided he wanted a wind turbine of his own.
- The farmer saves 30-50% of his electricity bill with one 25-kW Eocycle wind turbine.

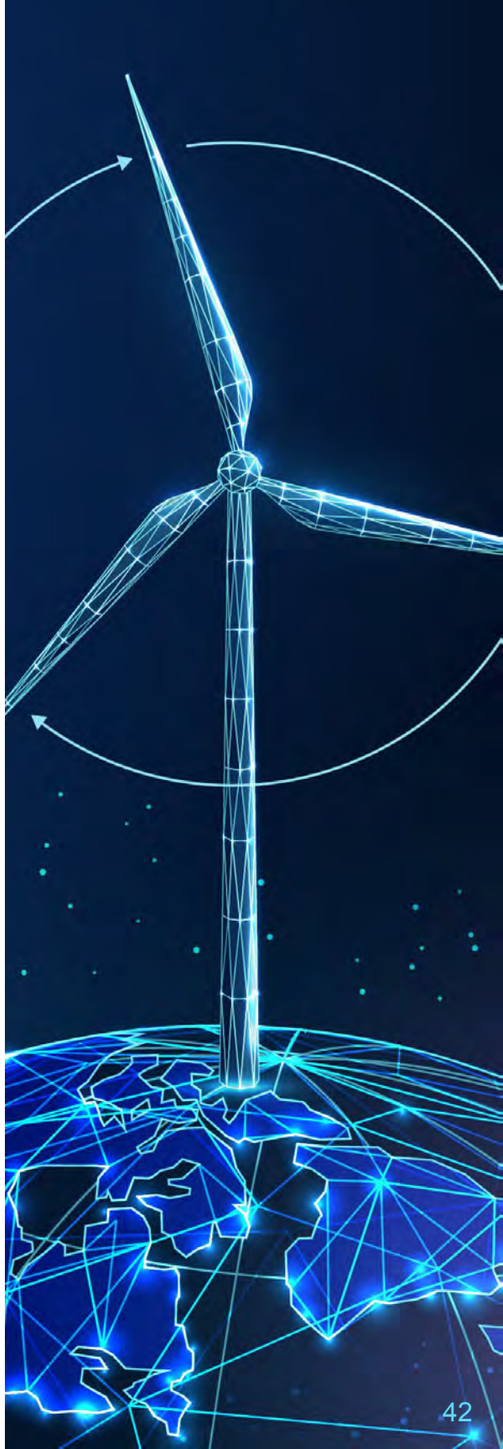




Who installs distributed wind and why?

Distributed wind can reduce dependency on expensive fossil fuels for isolated communities

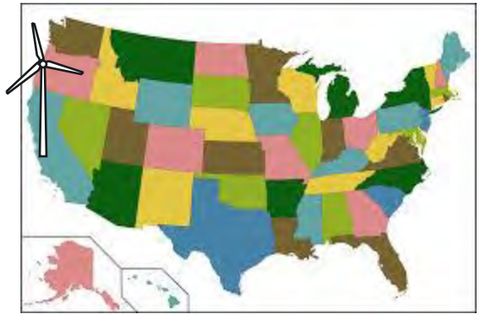
- To reduce dependency on expensive diesel, the isolated native community of St. Mary's, Alaska installed one 900-kW EWT wind turbine to produce 50% of their energy needs.

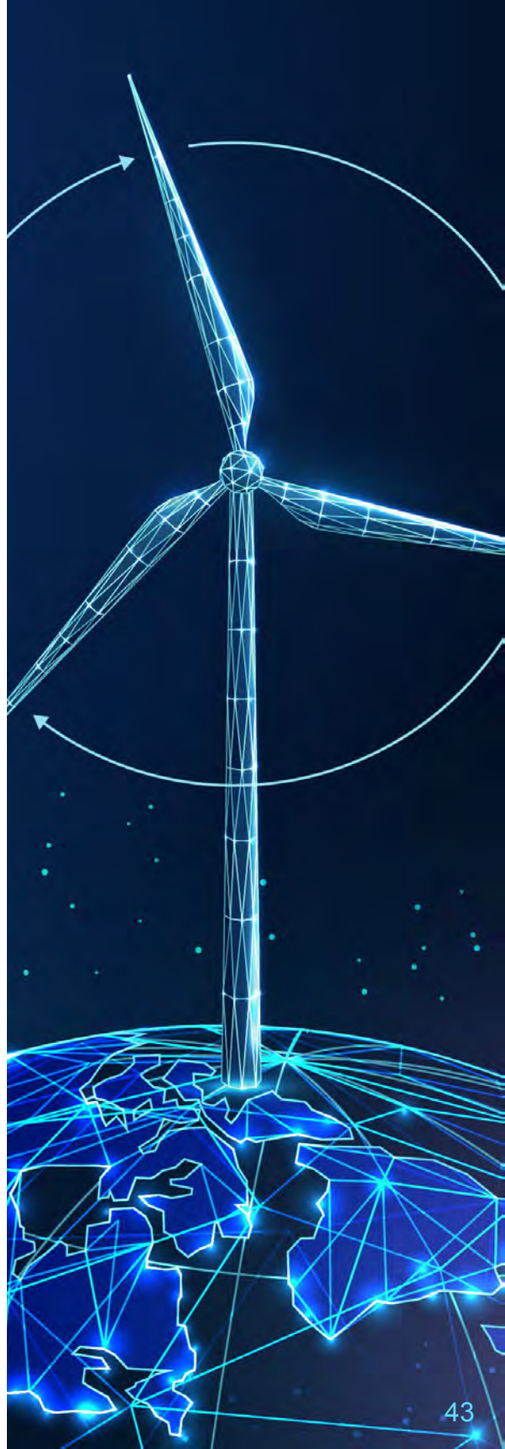


Who installs distributed wind and why?

Distributed wind can power agricultural and commercial operations

- Scheid Family Wines has been supplied with 100% of the power needed to run their winery and bottling operations for 7 consecutive years with this GE 1.85-MW wind turbine .
- The turbine also produces surplus power, which is supplied to the local utility to power an additional 125 nearby homes.

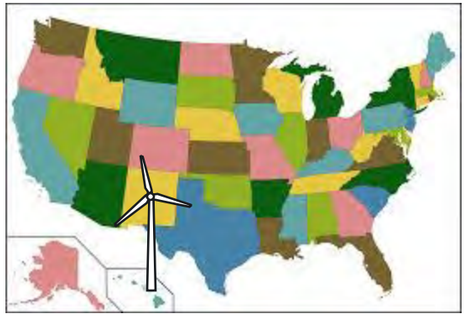


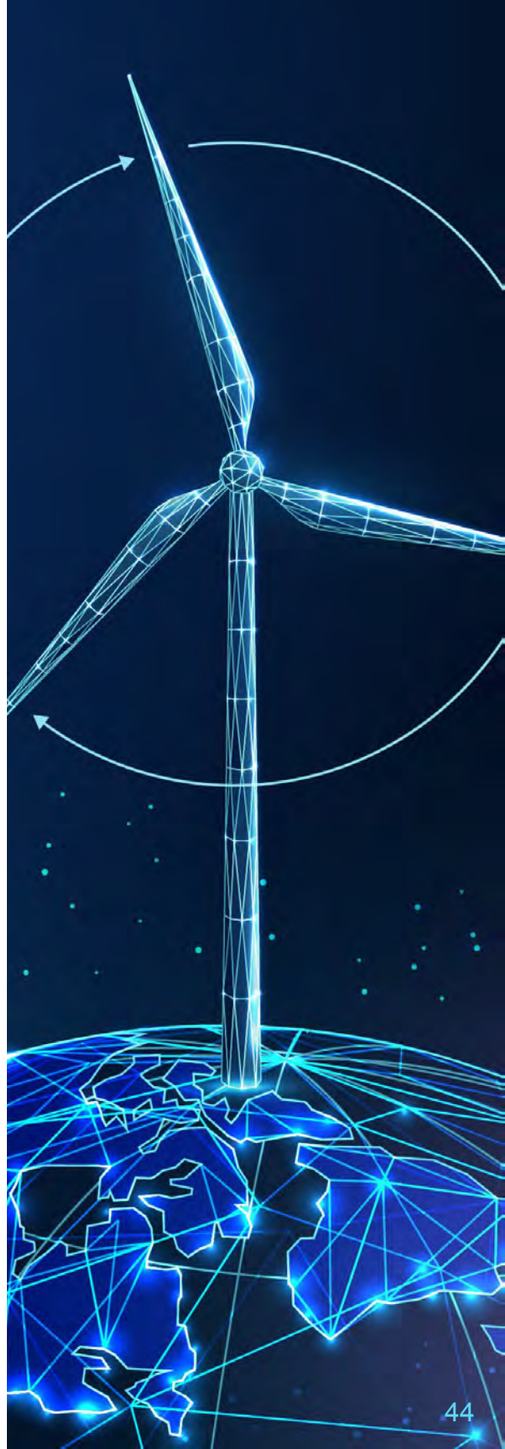


Who installs distributed wind and why?

Distributed wind can power industrial and government facilities

- Three Bergey Excel 10 wind turbines offset 66-90% of energy consumption
- The turbines save the landfill and recycling facility approximately $18,000 annually.

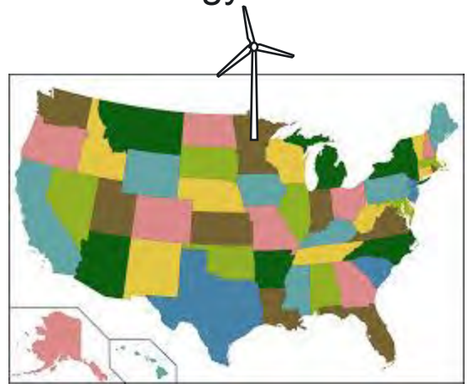


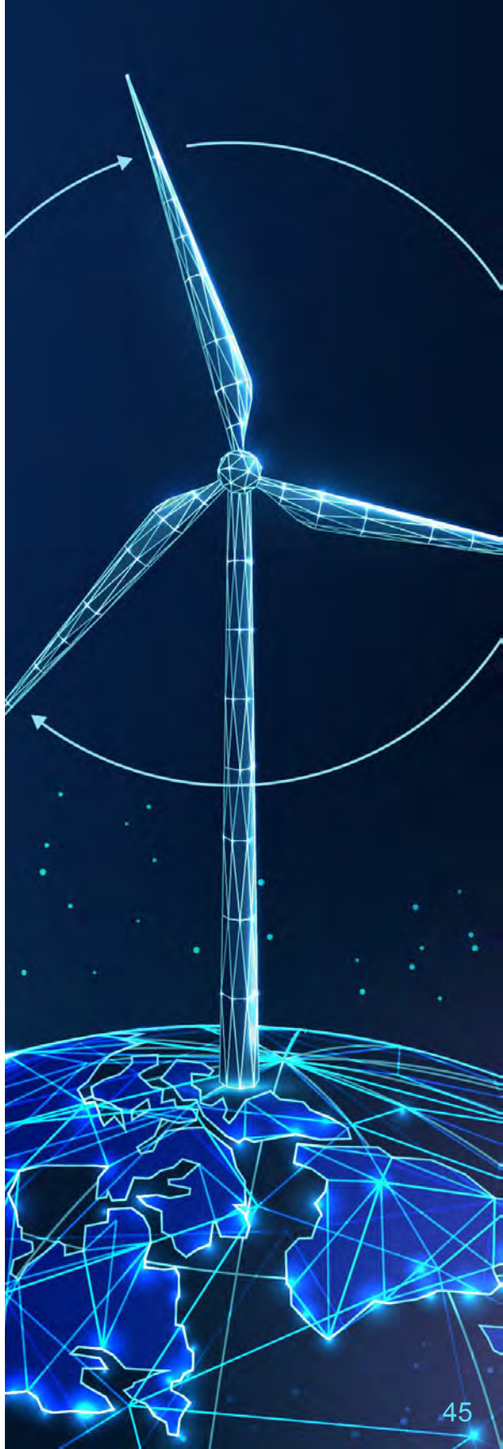


Who installs distributed wind and why?

Distributed wind can supply power for communities and demonstrate commitment to clean energy

- In 13 cities throughout Minnesota, one 160-kW wind turbine was deployed to provide community power generation and advertise local commitment to the environment and clean energy.





What size turbines are used in distributed applications?

Large (>1 MW)
- Large-scale agriculture
- Community power
- Commercial
- Industrial
- Utility

Midsize (101 – 1,000 kW)
- Community power
- Commercial
- Industrial
- Institutional
- Government
- Agriculture

Small (≤100 kW)
- Homes
- Farms
- Businesses
- Remote applications

80 m

50 m

30 m

Thank you!

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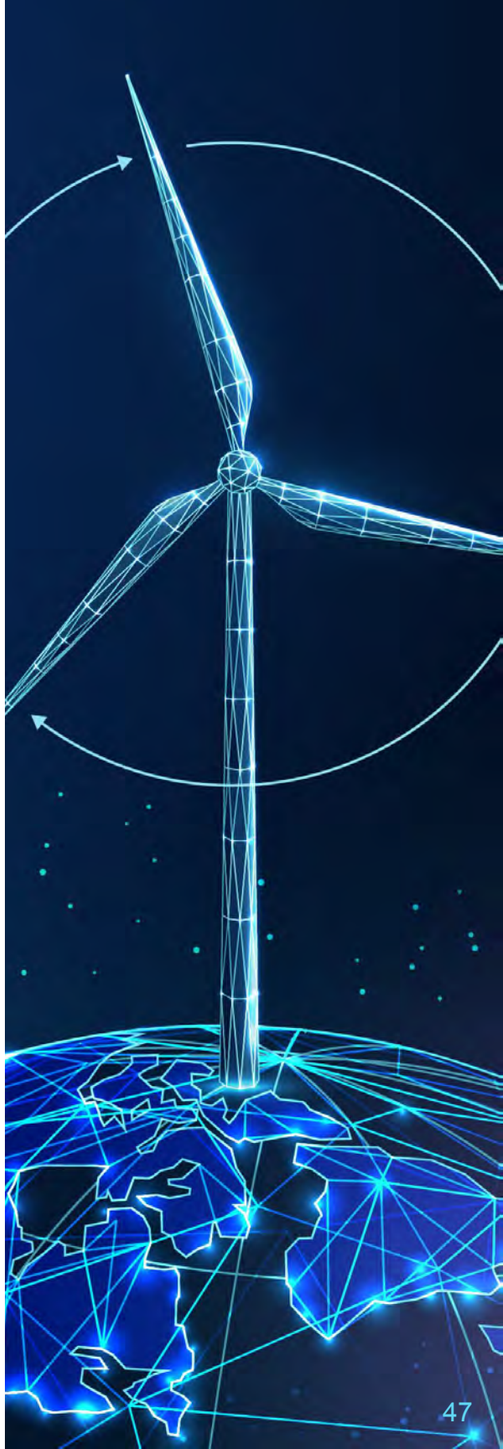

2024 Distributed Wind Energy Summit

Technology Improvements and the Importance of Certification

September 17, 2024

Brent Summerville
NREL

Pacific Northwest NATIONAL LABORATORY

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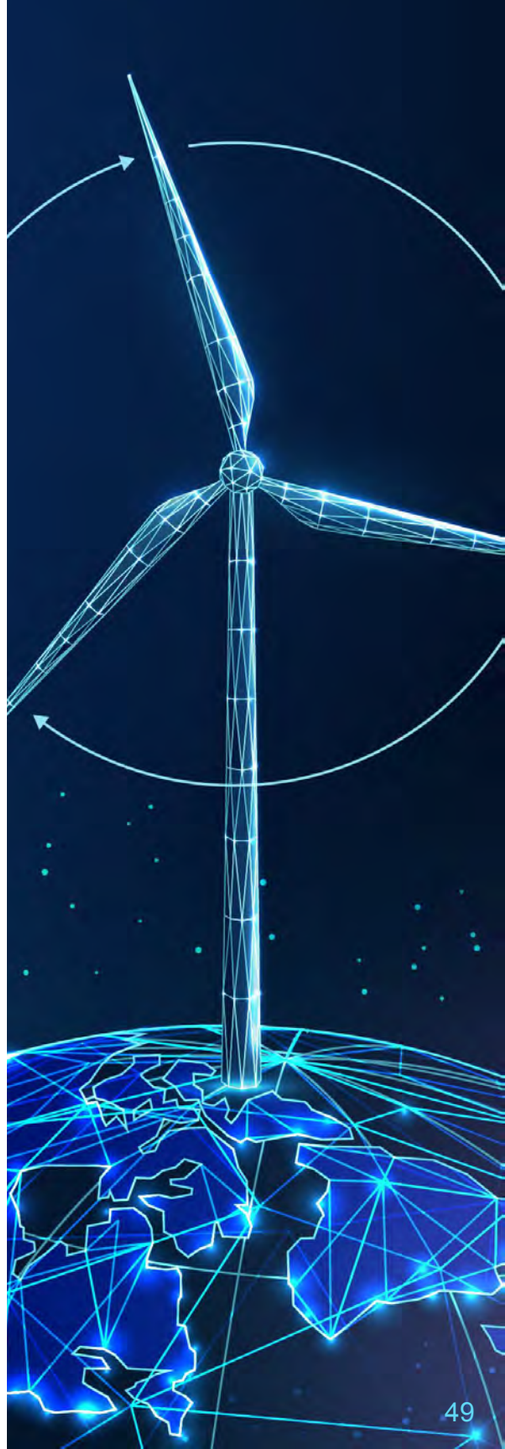
Technology Advances in Distributed Wind

Over the last decade, we have seen advances across the full range of wind turbine technology used in distributed applications

- More productive
- Competitive cost
- Quiet, reliable operation
- Compatible with hybrid systems

Small-scale wind + solar hybrid system. Courtesy PNNL.

Large-scale wind + solar hybrid system. Courtesy PNNL.

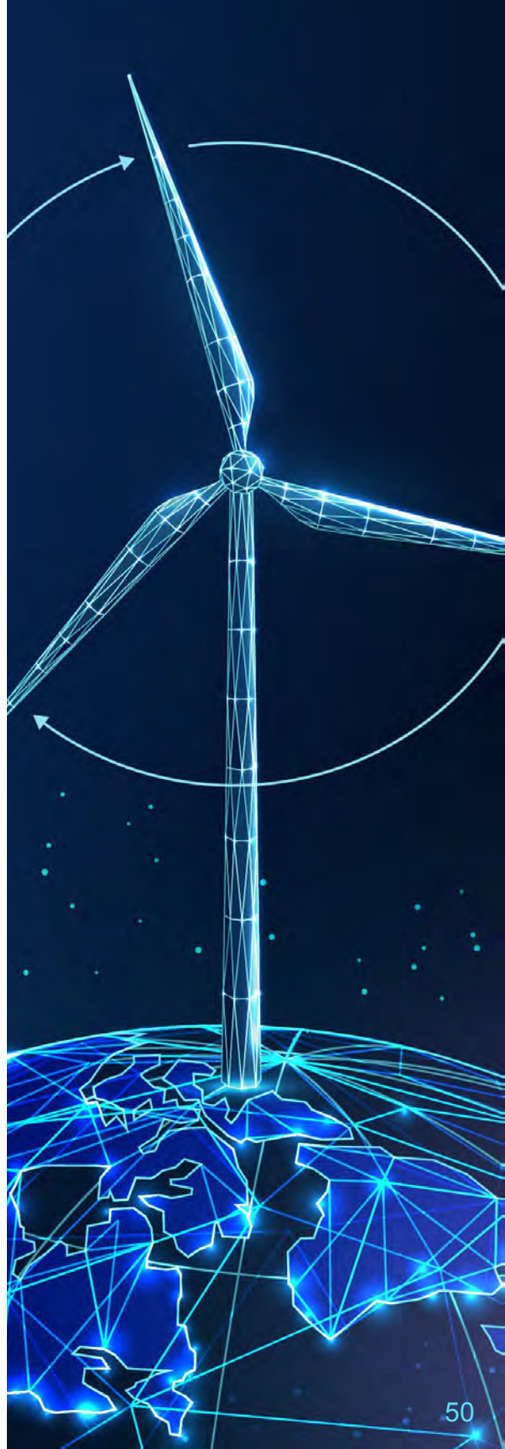


Micro Wind Turbine Improvements

- **Compatible** with modern batteries
- **Quiet** operation with advanced blade technology
- **Bluetooth** communication

Remote, battery-charging wind turbine. NREL PIX 44231

Primus WindPower (now Ryse Energy) Air 30 wind turbine. NREL PIX 44233



In collaboration with the U.S. Department of Energy/National Renewable Energy Lab, over the course of this effort...

2x

Bergey Windpower Company (BWP) doubled annual energy production with the Excel 15 turbine...

which reduced the levelized cost of energy by

50%+

(~$0.13/kWh)

2012

BWP produced this 10-kW work-horse wind turbine for 30 years.

2013

Under CIP, BWP conducted a complete redesign of the turbine.

2014

Under CIP, BWP partnered with Intergrid and greatly expanded the control and functionality of the turbine power electronics with a small additional cost.

2015

BWP started certification testing of a new 15-kW model to U.S. standards.

2017

BWP developed a new foundation design to reduce installed costs.

2019

BWP requested CIP funding to expand the applications for use of the 15-kW turbine focusing on microgrid markets.

2021

BWP focused on optimizing their permanent-magnet alternator, reducing its cost by 26%, leading to an 8% reduction in total system manufacturing costs.

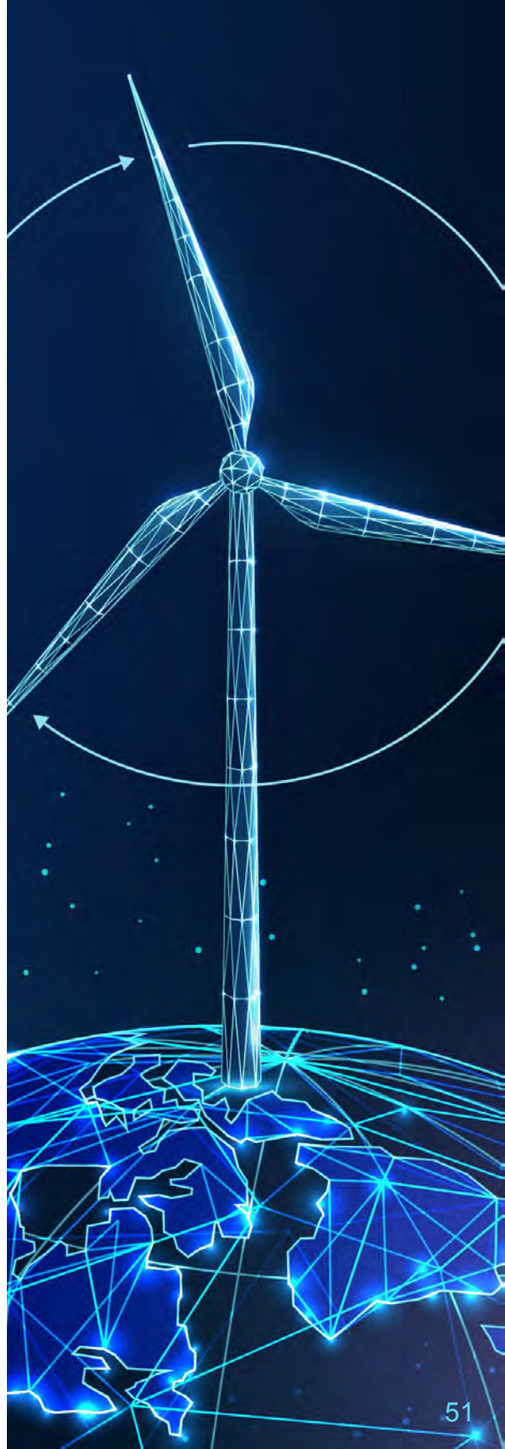
2022

Taking advantage of the newest CIP topic area, BWP will develop a financing solution to accelerate the pace of rural residential market sales.

Turbine Design and Components	Certification	Cost Reductions and New Applications

Continuous Innovation through NREL's Competitiveness Improvement Project

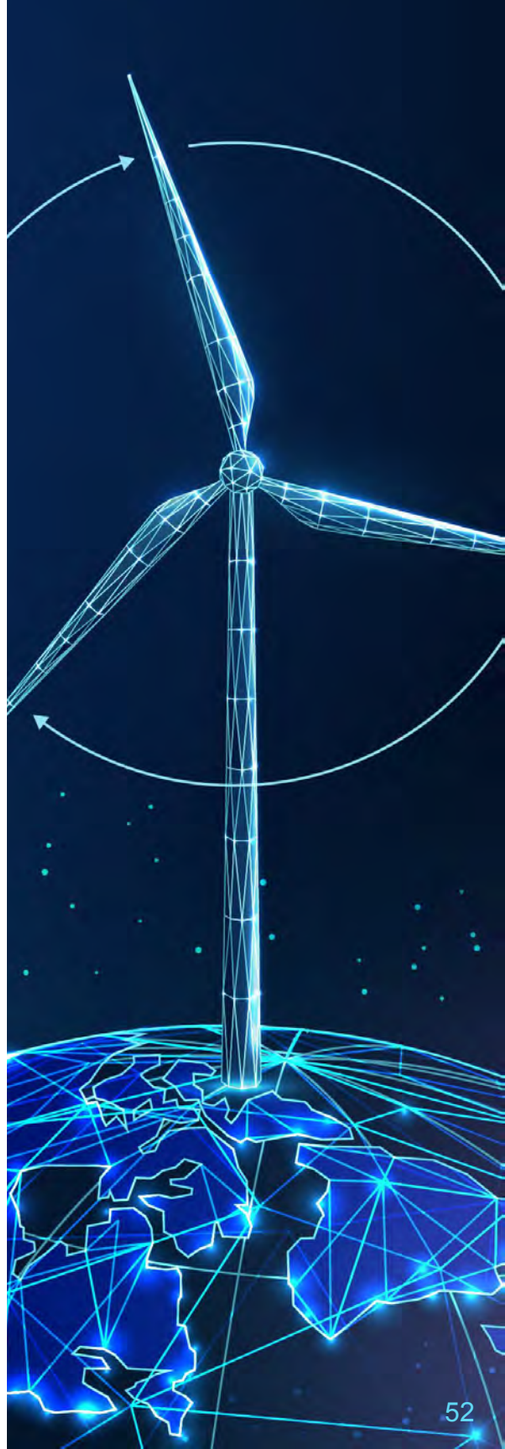
https://www.nrel.gov/wind/competitiveness-improvement-project.html



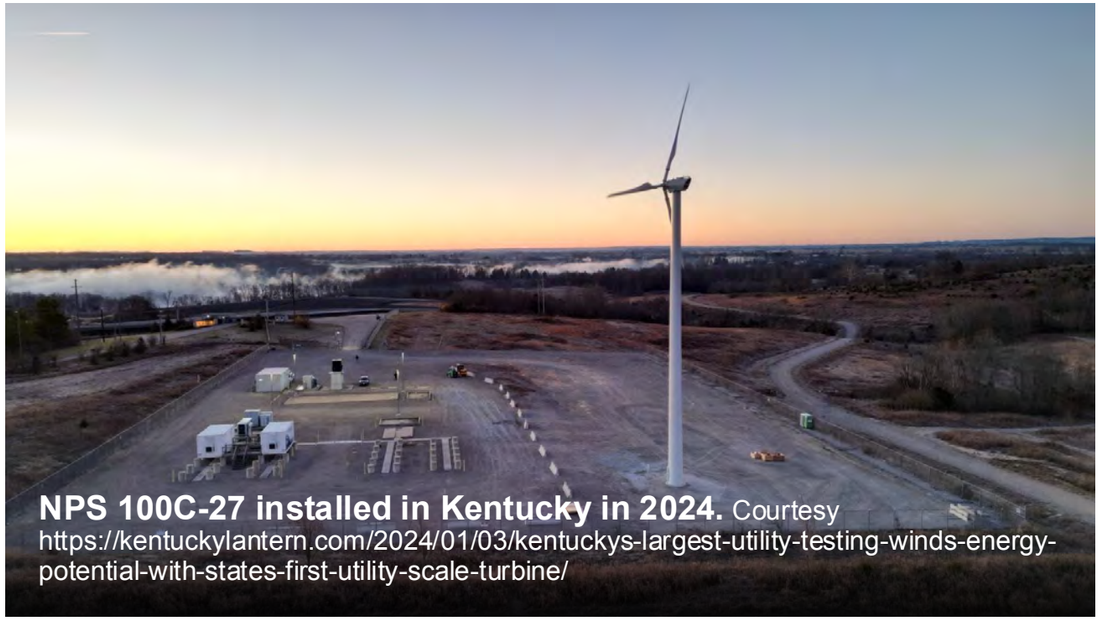
Northern Power Systems evolved their design from the arctic to a global market

- **Larger rotors** with longer, modern blade designs (19-m to 27-m rotor diameter)
  - ✓ **Increased energy production**, optimized for a range of wind conditions
- **Advanced power electronics**
  - ✓ **Reliable and efficient**
  - ✓ **Integrated** with other distributed energy resources such as solar and battery storage
- **Remote monitoring**
  - ✓ **Streamlined operations & maintenance**

North Power Systems 100A at NREL. NREL PIX 10015



Turbine designs evolve for a wide range of applications



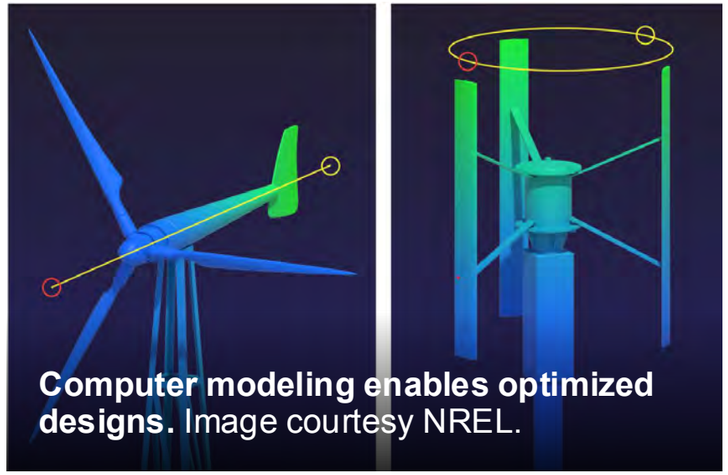
NPS 100C-27 installed in Kentucky in 2024. Courtesy https://kentuckylantern.com/2024/01/03/kentuckys-largest-utility-testing-winds-energy-potential-with-states-first-utility-scale-turbine/

Turbine certification provides confidence

Certification required for wind turbine incentive eligibility

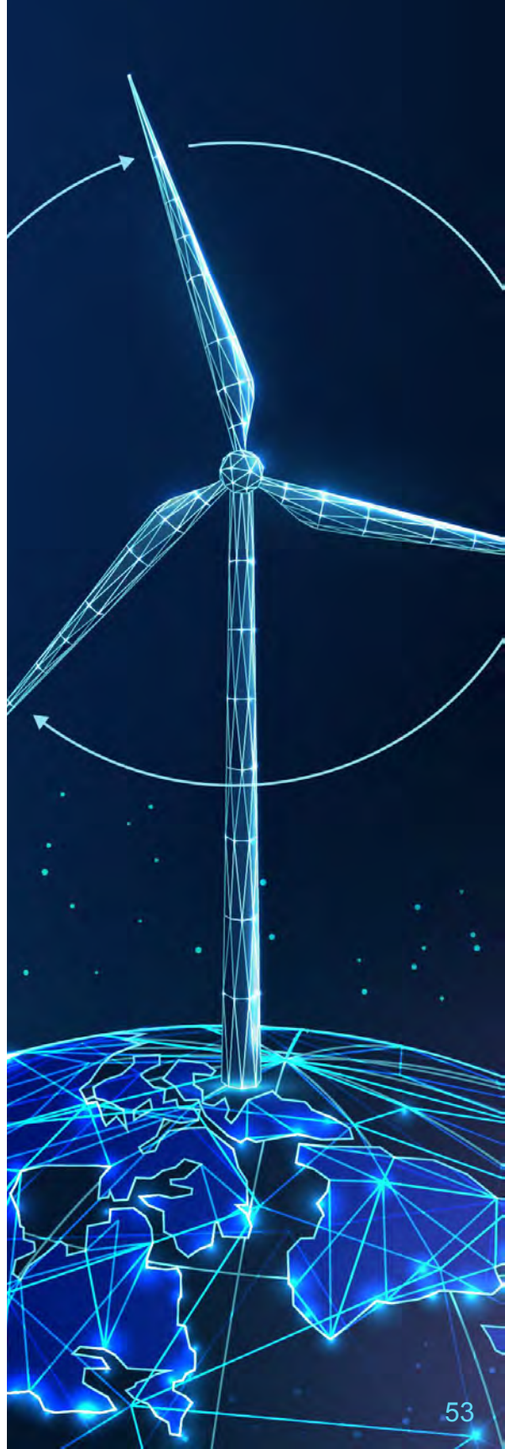
- **Design**
  - ✓ Modern engineering tools
  - ✓ Third-party review
- **Testing**
  - ✓ Turbines tested in real-world conditions
  - ✓ Validate performance, safety, function

- **Confirms turbine design meets requirements in standards**
- **Provides consumer protection and enables turbine comparison**
- **PNNL tracks certified turbines for market reporting**
  - https://www.pnnl.gov/distributed-wind/market-report/small-wind-turbine-certifications



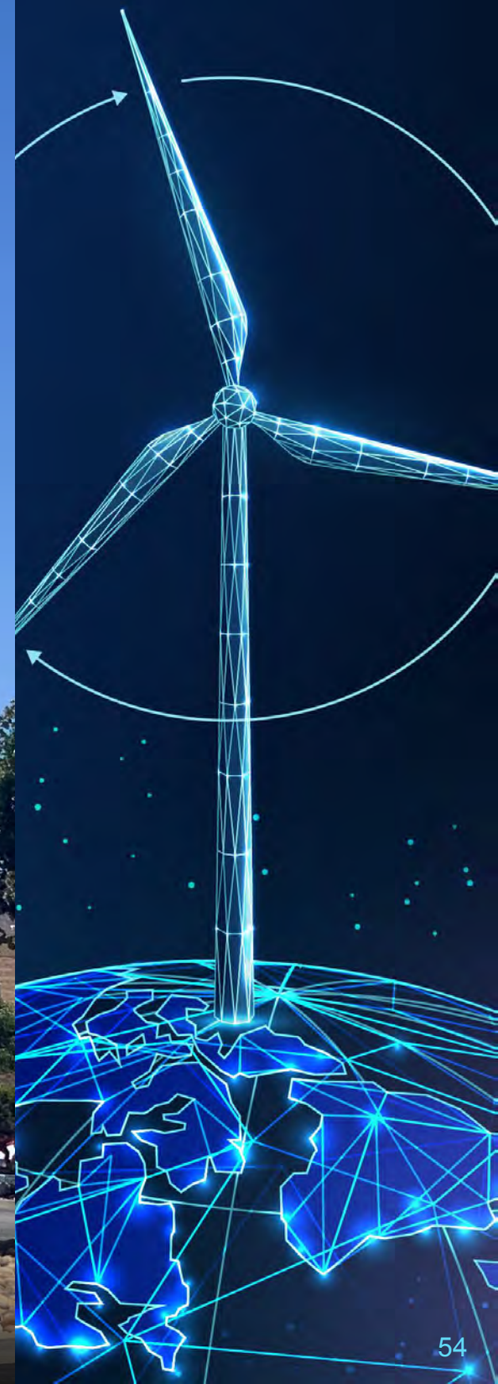
Computer modeling enables optimized designs. Image courtesy NREL.

Field testing validates turbine performance. Photo courtesy Brent Summerville, NREL.



Modern, certified distributed wind turbines enable owners to reap the benefits

- ✓ Reliable, productive, cost-effective turbines to meet the demands of on-site production
- ✓ Third-party certification to ensure investments are made in well-engineered, tested designs



Two General Electric 2.8-Megawatt wind turbines at a Dole salad processing plant in Soledad, CA. Courtesy PNNL.

Thank you

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Local Benefits of Distributed Wind

September 17, 2024

Devyn W. Powell

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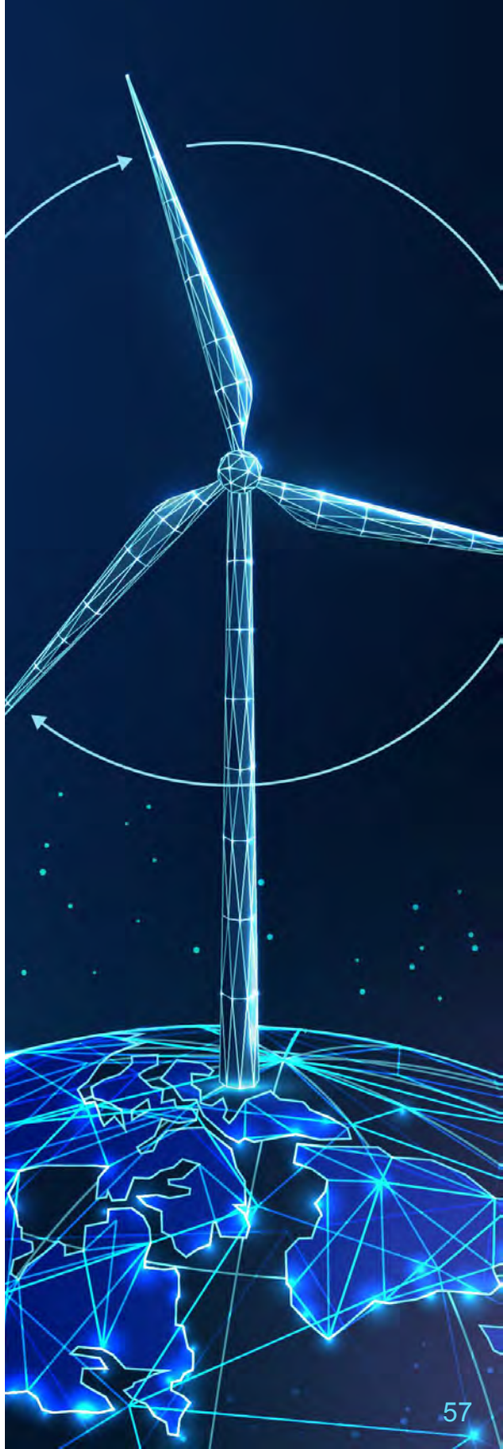
PNNL-SA-203612

Overview: Local Benefits of Distributed Wind

- **Distributed wind energy offers a range of benefits to local communities, including:**
  - Affordability
  - Local ownership and decision-making power
  - Jobs and economic benefits
  - Grid resilience and reliability
  - Climate and environmental sustainability

Small wind turbine in Blowing Rock, North Carolina (Photo: Jordan Nelson, Nelson Aerial Productions)

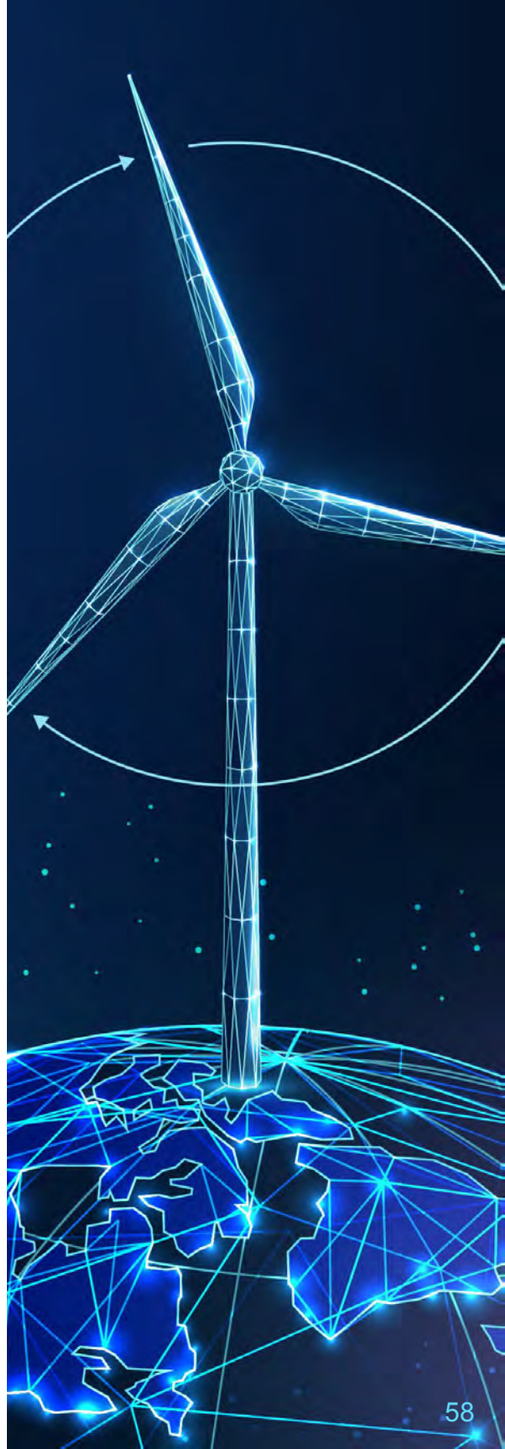


Distributed wind is…

An affordable energy option

- Distributed wind can be an **affordable source of electricity**, saving individuals and businesses money on their electricity bills.
- Distributed wind turbines can be cheaper and cleaner **alternatives to diesel-powered generators** for an off-grid home or remote community.
- In areas that offer policy incentives like net metering, locally generated wind power can provide **even greater utility bill savings**.
- These affordability benefits can make a significant difference in **rural communities, where residents often face disproportionately high energy burdens** and spend a relatively higher percentage of their household income on energy bills.

The St. Mary's Community Wind Turbine, Alaska (Photo: US Department of Energy)

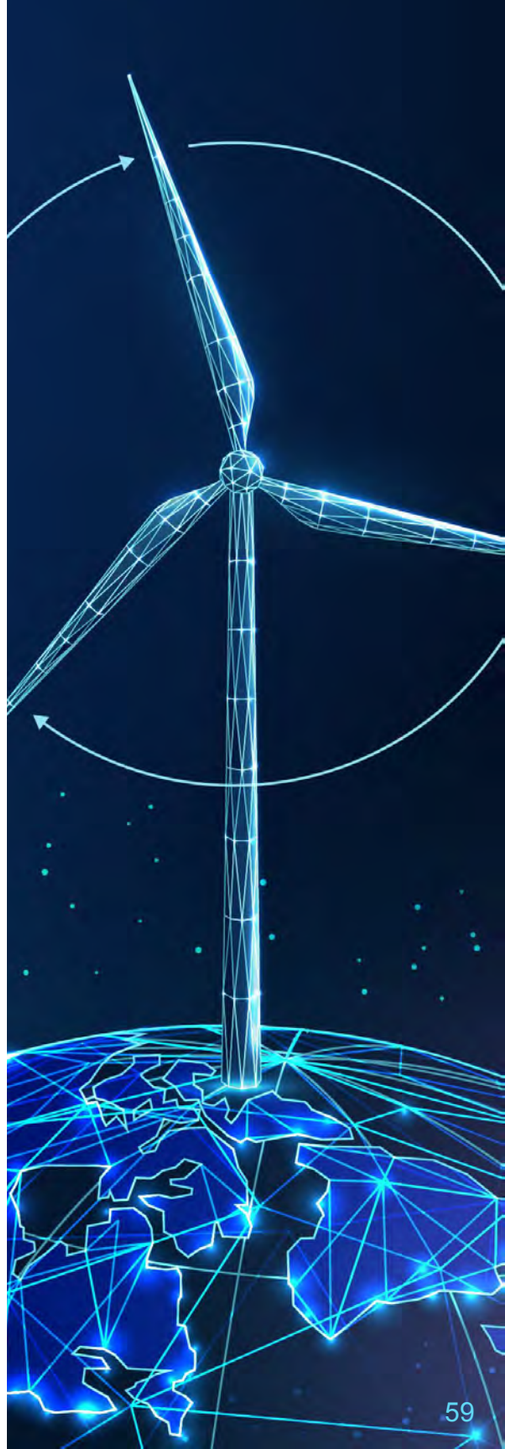


Distributed wind is…

A place-based solution

- Distributed wind systems are **flexible** and offer people and communities **greater decision-making power over their energy**.
- Communities or individuals can select turbines that **match the amount of energy consumed nearby**.
- Communities have the power to site the turbines in accordance with local zoning ordinances and preferences, which can **minimize conflicts with other land uses** (e.g. agriculture).
- For example, projects can be built with turbines in a **range of sizes and include either a single turbine or multiple turbines.**

Small wind turbine on a farm in Washington (Photo: Alice Orrell, PNNL)

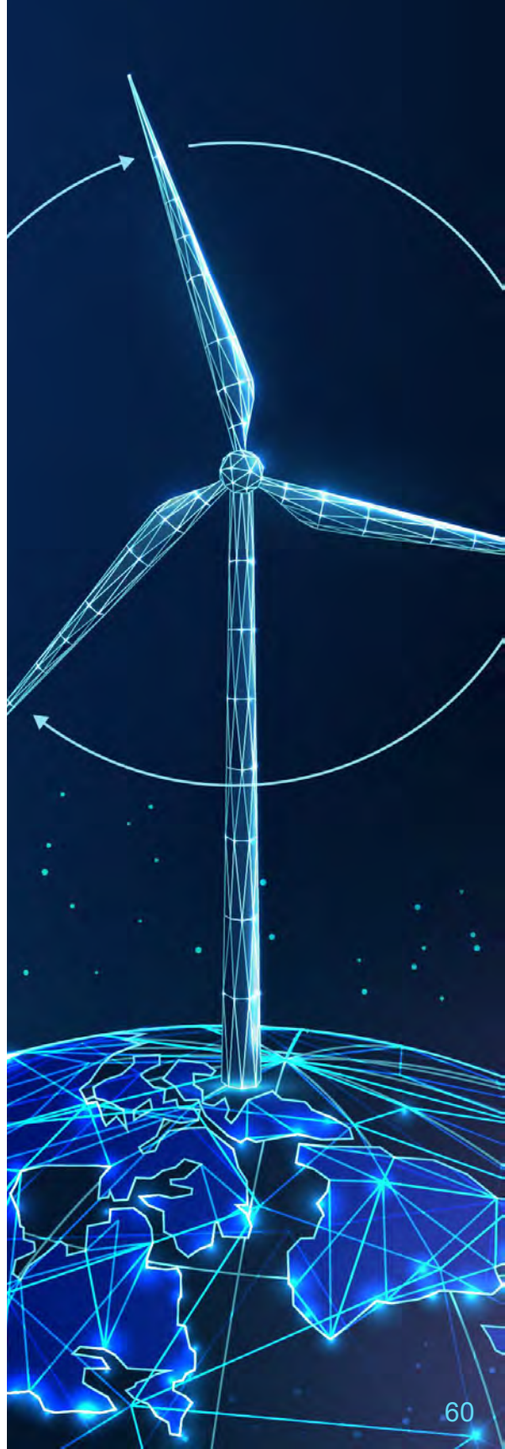


Distributed wind is…

A local energy source

- Unlike utility-scale wind farms, which often provide electricity to distant cities or towns, the electricity generated by distributed wind turbines is generally **used on-site or to serve local loads on the same distribution system**.
- These turbines can provide **clean, affordable electricity** to farms, local businesses, schools, or customers from rural electric cooperatives or other local utilities.
- In some cases, distributed wind turbines are also **owned directly** by community members, small businesses, or other local entities.

Turbines power a facility in Soledad, California (Photo: Foundation Windpower, LLC)

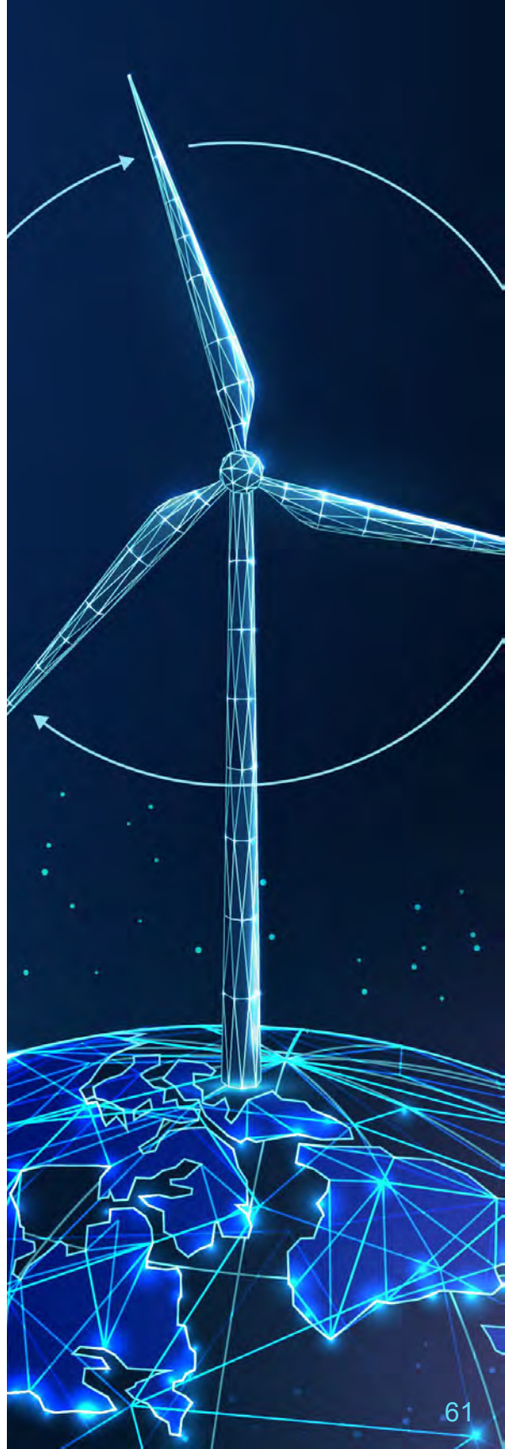


Distributed wind…

Creates jobs and economic benefits

- Distributed wind energy installations can create good-paying **local jobs** in the construction, operation, and maintenance of turbines.
- These projects can **strengthen rural economies and create new job opportunities** in those areas.
- Building distributed wind energy projects can also **strengthen the domestic economy.** Small wind turbine manufacturing was a $15.2 million sector in 2023.
- Local ownership of distributed wind projects offers additional long-term economic benefits by **keeping revenues local.**

Construction crews install a 15.6 kW wind turbine (Photo: Joe DelNero, NREL)

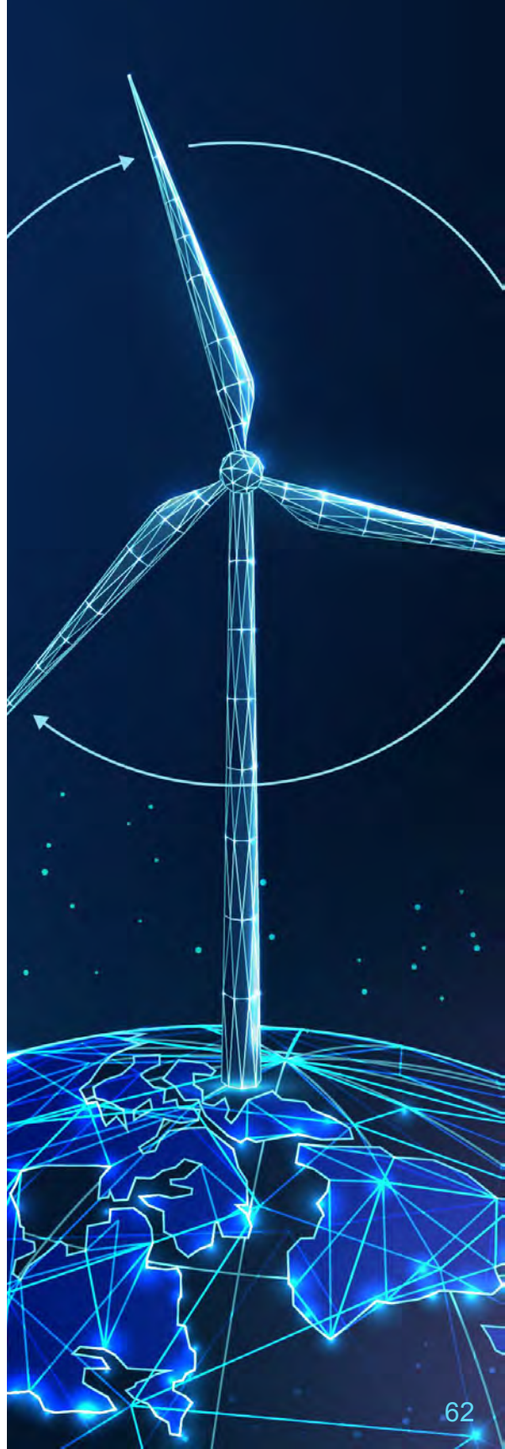


Distributed wind is…

Clean energy with low environmental impact

- Compared to other sources of energy, distributed wind has **minimal impacts on land, water, air, and the climate.**
- Wind turbines have a **small direct land use footprint** when compared to other energy sources, like large solar farms.
- Turbines can easily be **built alongside existing land** uses, such as crop or grazing land.
- Wind energy is a clean, pollution-free source of electricity that can help give a community **cleaner air and contribute to climate goals**.
- Installing and operating distributed wind turbines uses **minimal amounts of water**, especially when compared to thermal generators like coal, oil, or gas.
- Distributed wind projects can be built on brownfields, which can provide **additional sustainability and economic benefits**.

A small wind turbine in a city park in Cleveland, Ohio (Photo: Lindsay Sheridan, PNNL)

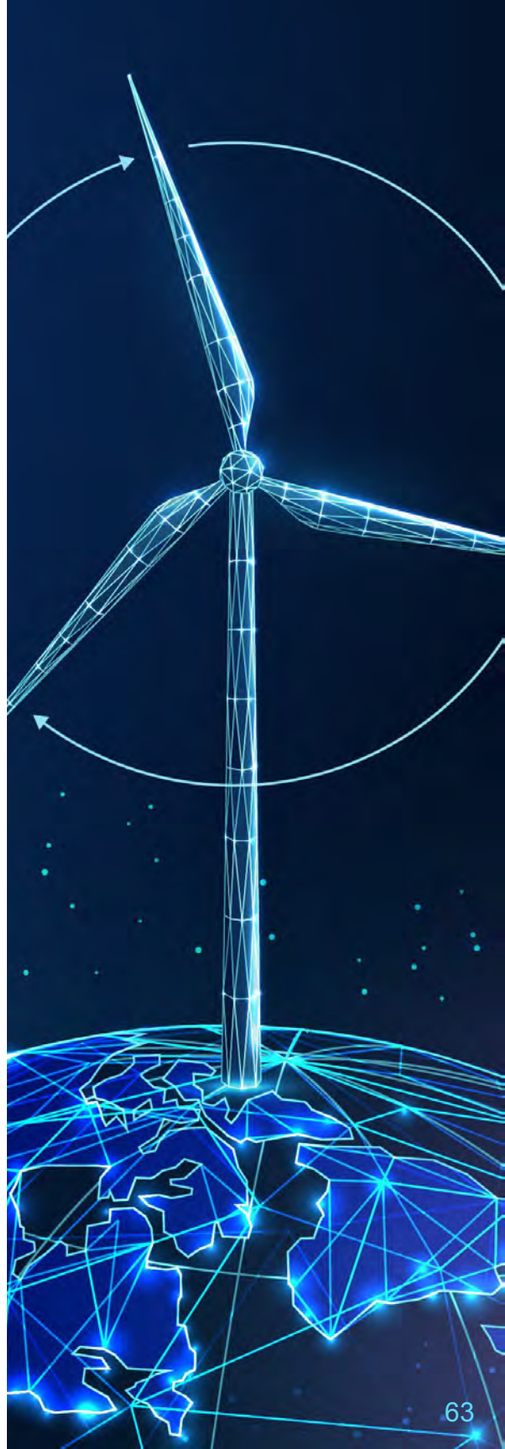


Distributed wind…

Supports a reliable and resilient grid

- Distributed wind can provide **backup sources of power during grid outages** caused by natural disasters, cyberattacks, or other challenges.
- **Rural communities** served by aging grid infrastructure are more **vulnerable to power outages**, and distributed wind turbines can help prevent disruptions by keeping the lights on.
- These benefits can be even greater when distributed **wind turbines are paired with solar panels or battery storage** in what is commonly known as a hybrid system.

A small hybrid system with a wind turbine and solar panels (Photo: Todd Hannen)



Thank you!

Beachfront wind in Martha's Vineyard, Massachusetts
(Photo: Gary Harcourt, Great Rock Windpower)

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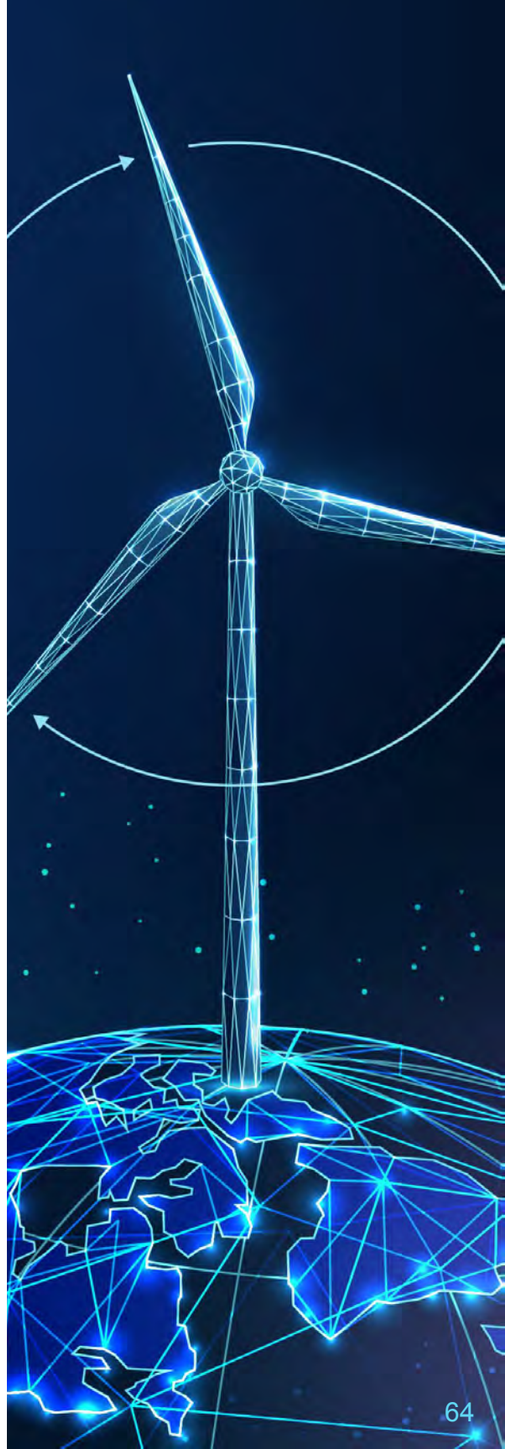

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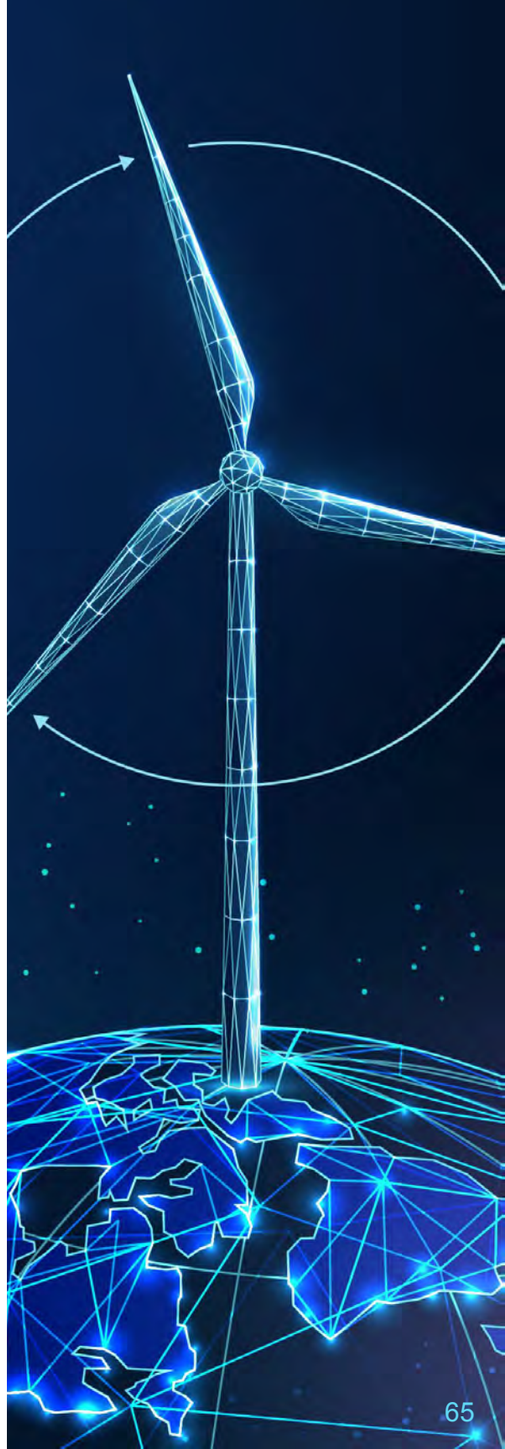

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Sandia National Laboratories

2024 Distributed Wind Energy Summit

An Assessment of Wind-Hybrid Microgrids in Puerto Rico

September 19, 2024

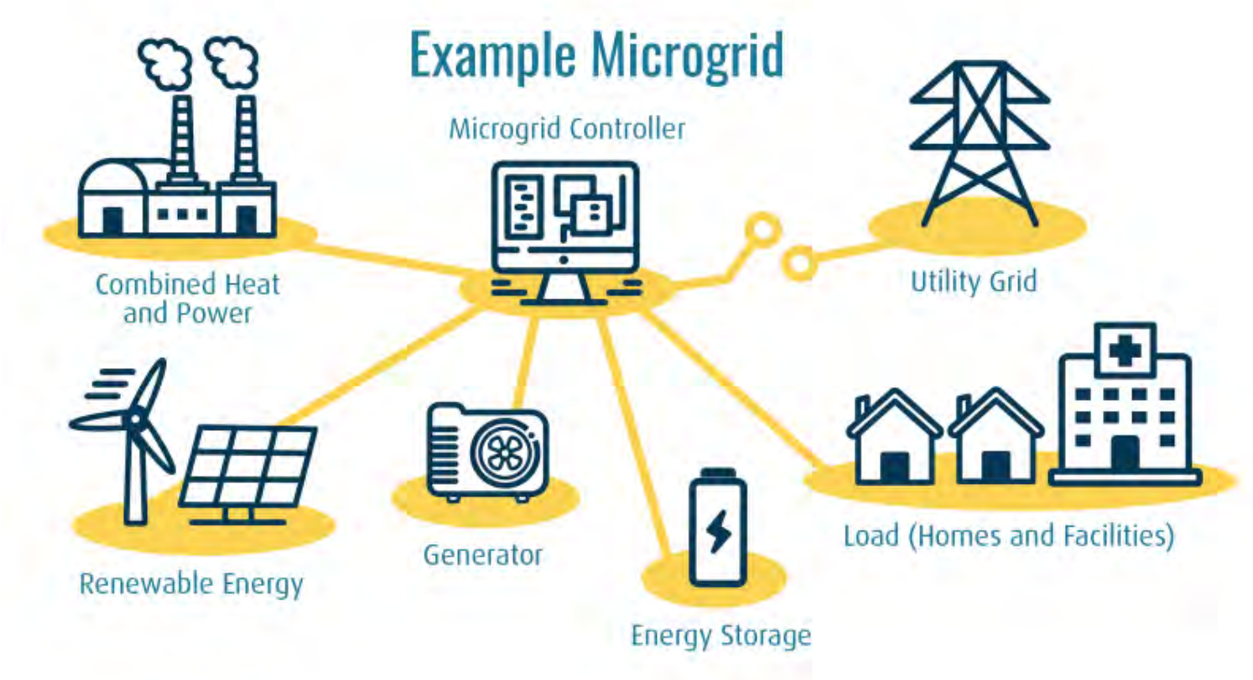
Jimmy E. Quiroz
Sandia National Laboratories

Pacific Northwest NATIONAL LABORATORY

NREL Transforming ENERGY

What is a Microgrid?

- A microgrid is a localized energy system that can operate connected to the main grid or independently. It integrates multiple energy sources and uses smart controls to manage energy flow.
- **Key Components:**
  - Generation (renewable and non-renewable sources)
  - storage (batteries)
  - Distribution (smart grid technology)
  - Controls

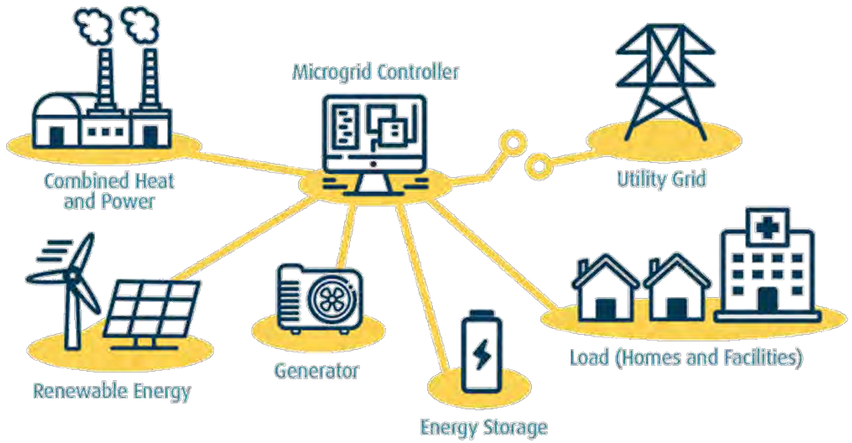


https://www.naseo.org/issues/electricity/microgrids

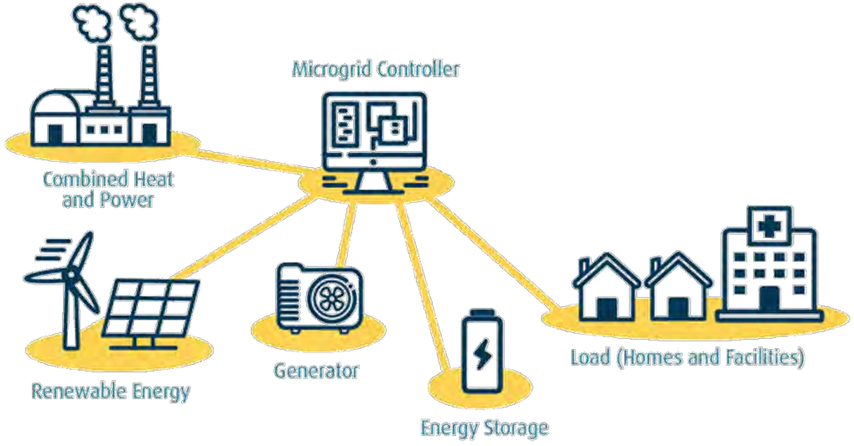
Types of Microgrids

- **Grid-Connected Microgrids:** These operate in tandem with the main grid but can isolate to function autonomously during outages or grid disturbances.

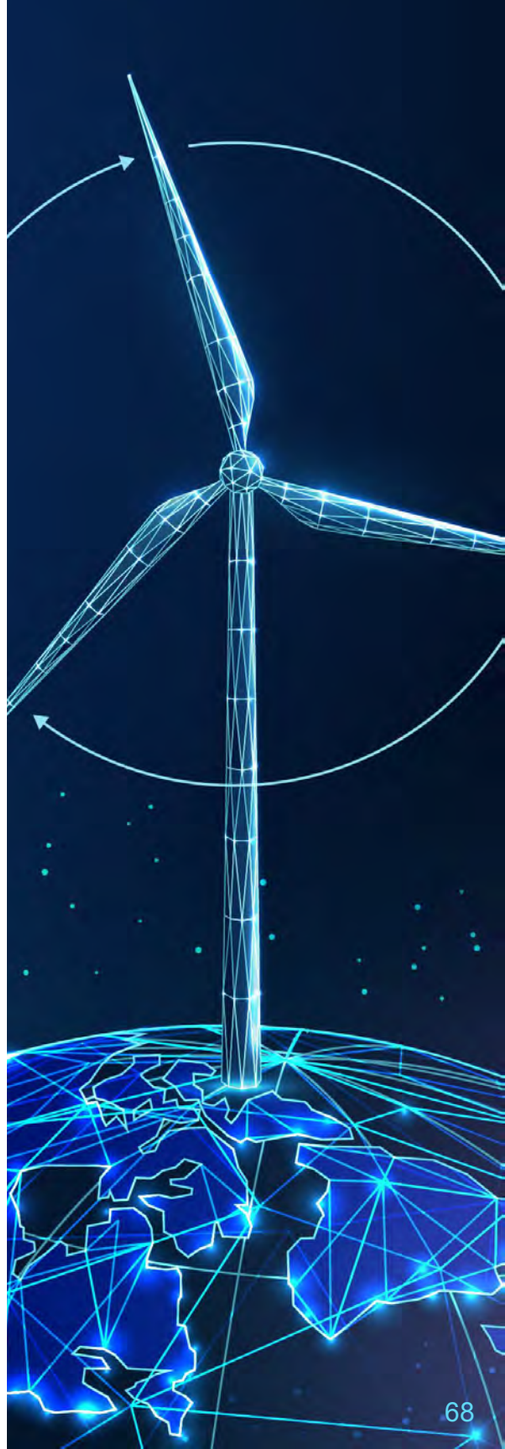
- **Off-Grid Microgrids:** Completely independent from the main grid, these systems rely on local energy generation and storage, ideal for remote or rural areas.



Grid-Connected Microgrids

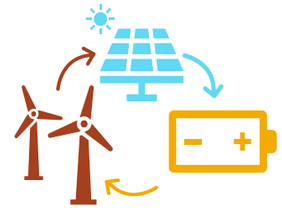


Off-Grid Microgrids



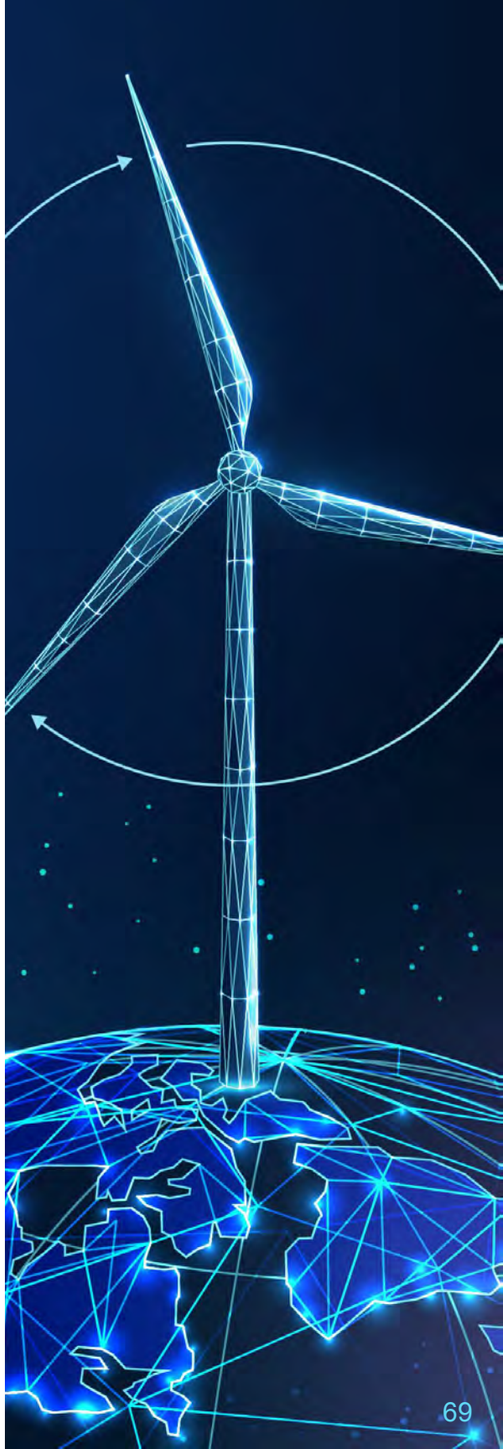
Benefits of Microgrids

- **Sustainability:** Supports the integration of renewable energy sources, reducing carbon footprint and dependence on fossil fuels.



- **Reliability:** Provides uninterrupted power supply, crucial during emergencies or peak demand times.

- **Resilience:** Enhances the ability to maintain power during grid outages, making it ideal for critical facilities and remote locations.



Key Components of a Hybrid Microgrid

- **Solar Power:** Solar PV panels capture sunlight and convert it into electricity.
- **Wind Power:** Wind turbines generate electricity from wind, adding another renewable source.
- **Energy Storage:** Batteries, such as lithium-ion, store excess energy from solar and wind, ensuring availability during periods of low generation or high demand.
- **Control Systems:** Advanced software manages energy flows, balances supply and demand, and ensures optimal operation of all components, including when to use stored energy or when to connect to the main grid.

Applications of Hybrid Microgrids

- **Commercial and Industrial:** Used by factories, campuses, and data centers to ensure energy reliability and reduce operating costs through renewable energy integration.
- **Community:** Provides power to remote villages, islands, or communities, reducing reliance on imported fuels and enhancing local energy independence.
- **Critical Infrastructure:** Powers hospitals, emergency services, and shelters, ensuring they remain operational during grid failures.


Commercial and Industrial


Community


Critical infrastructure

The Case of Puerto Rico

- **Background:** Puerto Rico's reliance on a centralized grid has proven vulnerable, especially to natural disasters like Hurricane Maria. Microgrids, particularly hybrid ones, have emerged as a crucial solution for enhancing energy resilience and sustainability on the island.

  Example of Hurricane Maria (2017):
  - *Maria was a category 5 hurricane that hit Puerto Rico on September 20, 2017, knocking out power to the entire island.*

- **Need for Resilience:** The frequent power outages and long recovery times post-disasters underscore the need for localized, independent power systems that can operate autonomously.

  Example of Post-Hurricane Maria (2017):
  - *Power was restored to 99% of customers beginning of August 2018. The aftermath indirectly caused 2,975 fatalities.*

Examples of Microgrids in Puerto Rico

1. Castañer Community Microgrid

- **Location:** Castañer, a rural community in the mountains of Puerto Rico.
- **Configuration:** Solar, battery storage, and backup diesel generators.
- **Benefits:** Provides energy resilience, supports emergency response, and reduces reliance on the centralized grid. The microgrid ensures that the community remains operational during disasters, offering a reliable power source for critical needs.

2. Puerto Rico Children's Hospital Microgrid

- **Location:** San Juan, Puerto Rico.
- **Configuration:** Solar, battery storage, and diesel backup generators.
- **Benefits:** Ensures that the hospital can maintain full operations during grid failures, protecting patients and supporting critical healthcare delivery.

3. Casa Pueblo Microgrid

- **Location:** Adjuntas, Puerto Rico.
- **Configuration:** Solar and battery storage.
- **Benefits:** Provides energy independence and resilience for the organization, serves as a model for other community-led energy projects, and plays a crucial role in local disaster response by providing reliable power and communication capabilities.


Castañer Community Microgrid


Puerto Rico Children's Hospital Microgrid


Casa Pueblo Microgrid

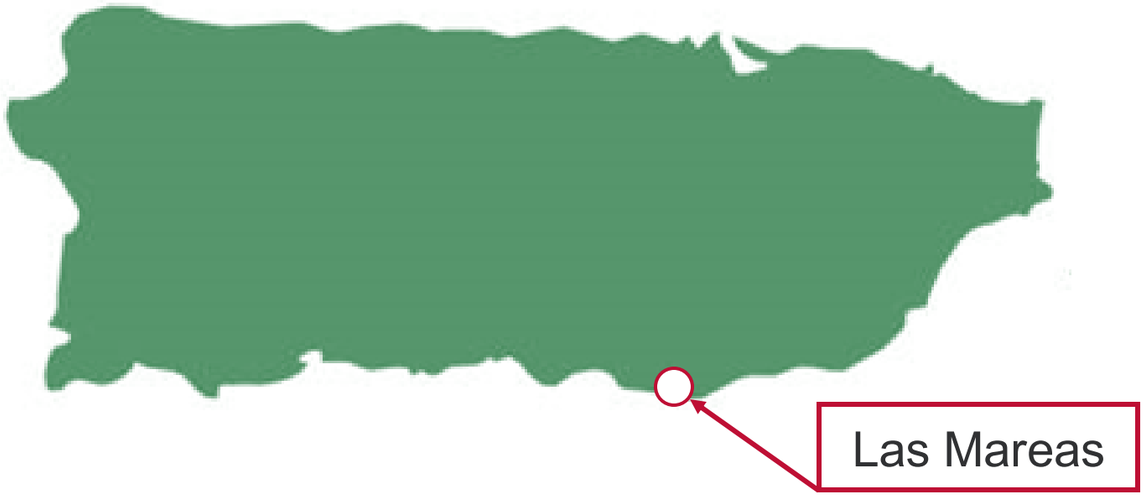
The Value of Different Microgrid Configurations

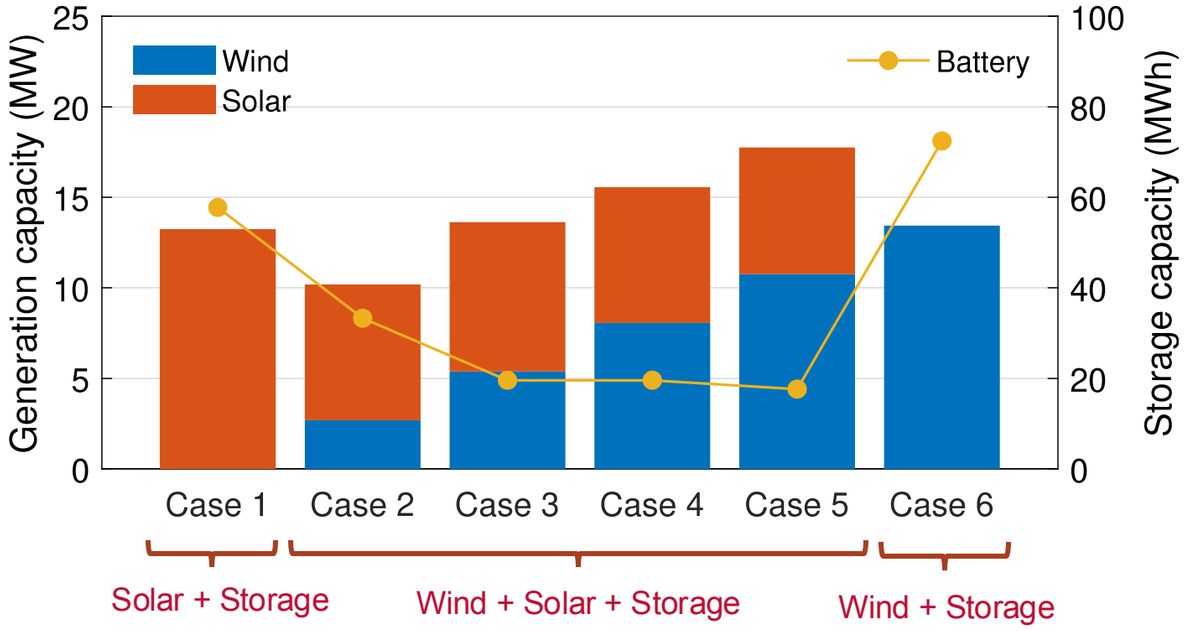
Different microgrid configurations provide unique benefits, enhancing resilience, sustainability, and energy independence:

- **Solar-Only Microgrids:** Ideal for sunny regions, they can provide power during daylight hours. However, their effectiveness is limited by nighttime energy demands, making storage essential.
- **Wind-Only Microgrids:** Well-suited for areas with strong and consistent wind, they can operate day and night, providing power when sunlight is low. However, wind energy can be variable and unpredictable, requiring storage.
- **Hybrid Microgrids (Solar + Wind):** Due to their complementary nature, these microgrids maximize energy production and reduce reliance a single resource. It enhances resilience by diversifying energy generation, but still requires storage solutions to manage intermittency.
- **Hybrid Microgrids with Storage (Solar + Wind + Storage):** The most resilient and flexible configuration, these microgrids integrate solar and wind generation with storage, allowing users to store excess energy and use it when generation is low or demand is high, supporting round-the-clock energy availability.

Example of a Hybrid Microgrid with Storage

- An analysis on different microgrid configurations is performed in Las Mareas, Puerto Rico.
- The integration of distributed wind resources results in a reduction in the required energy storage size to some extent
- Case 5 yields the smallest battery storage size.





Thank you

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