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Use Cases for Distributed Wind in Rural Electric Cooperative Service Areas

NRECA
America's Electric Cooperatives

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RADWIND PROJECT REPORT SERIES: Use Cases for Distributed Wind in Rural Electric Cooperative Service Areas

Prepared By:

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RADWIND Project

This is the first in a series of NRECA Research reports about wind as a distributed energy resource (DER). This report explains the primary ways, or use cases, that wind energy technologies can be deployed in electric cooperative service territories as a DER. This use case report lays the foundation for the future Value Case and Business Case reports.

NRECA Research's Rural Area Distributed Wind Integration Network Development (RADWIND) seeks to understand, address, and reduce the technical risks and market barriers to distributed wind adoption by rural utilities. The goal of the project is to reduce the barriers for distributed wind deployment, either as a standalone resource or as part of a hybrid power plant with other DER. For more information on the project and additional resources, please visit the project landing page at www.cooperative.com/radwind.

What Is Distributed Wind?

Distributed wind turbines are distributed energy resources connected at the distribution level of the electricity grid or in off-grid applications. Distributed wind technologies can range from a less than 1-kilowatt (kW) off-grid wind turbine at a remote cabin or oil and gas platform, to a 15-kW wind turbine at a home or farm, to several multi-megawatt wind turbines at a university campus, manufacturing facility, or connected to the distribution system of a utility. As a result, distributed wind is differentiated from wholesale power that is generated at large wind farms and carried over transmission lines to substations for distribution to distant end users.

Wind as a DER is an emerging opportunity for rural America. Many of the regions in the United States that offer quality wind resources and population densities acceptable for distributed wind development are in rural electric cooperative territories. Research from the U.S. Department of Energy suggests there is significant economic potential for distributed wind capacity additions on rural distribution grids (Lantz et al. 2016).

Rural electric cooperatives[1] and their consumer-members are utilizing distributed wind across the United States. The RADWIND team has identified over 200 megawatt (MW) of distributed wind capacity in about 80 cooperative territories. Some of this installed capacity are from consumer-member-owned wind turbines interconnected to cooperative distribution systems via net metering agreements, but most of the capacity is either owned by or under power purchase agreement (PPA) contracts by distribution and generation and transmission (G&T) cooperatives, as shown in Figure 1. Cooperative projects are typically larger projects (i.e. around 10 MW) consisting of multiple large-scale turbines (1 MW and greater in size), hence their greater representation in Figure 1.

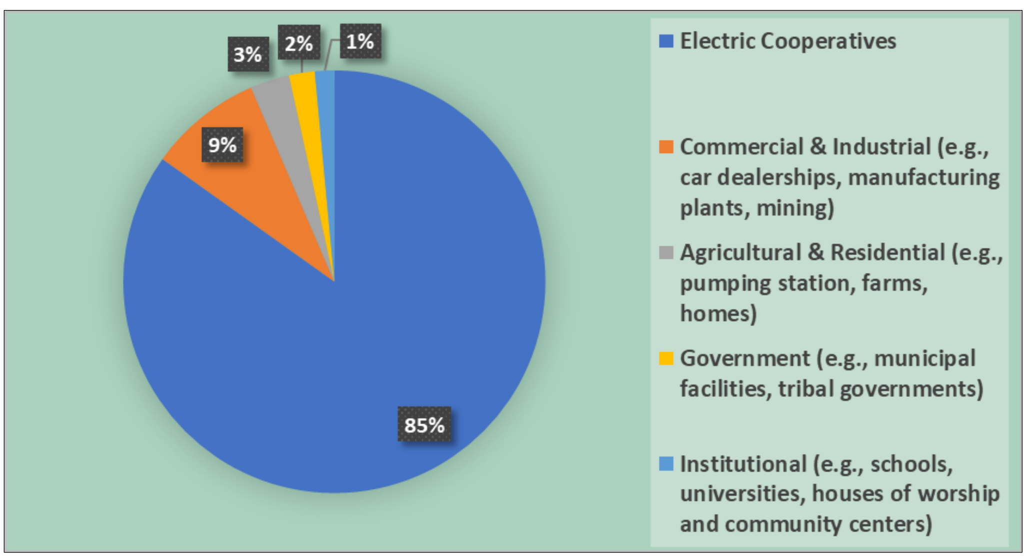

Figure 1: Percentage of Distributed Wind Capacity, in Megawatts, by Customer Type in Cooperative Territories, 2003-2019

[1] While this report generally uses "cooperatives," NRECA's membership also includes more than 40 utilities that are not organized as cooperatives, mostly rural public power districts as well as small municipal, tribal, and mutual utilities. While business models differ, this report should be applicable to them as well as other rural utilities that are not NRECA members.

Distributed wind projects can utilize a variety of turbine technologies and can be deployed as standalone distributed generation projects or in combination with other DER. The remainder of this section discusses some technical considerations for distributed wind projects.

Distributed Wind Turbine Sizes

The RADWIND team considers wind turbines in the following three size segments:

- Small wind turbines are up through 100 kW in nameplate capacity[2]
- Medium wind turbines are 101 kW to 999 kW in nameplate capacity
- Large-scale wind turbines are 1 MW and greater in nameplate capacity

Distributed Wind Hybrids

Wind energy technology is increasingly being combined with other distributed energy resources and technologies, such as batteries, solar PV, or combined heat and power (CHP) on distribution systems. These combination projects can be referred to as distributed wind hybrids.

Distributed wind hybrid projects can generally be categorized based on their operational and locational characteristics. Distributed wind hybrids can be co-located resources only sharing a location, dispersed resources that are operated together as a virtual power plant, or resources that are both co-located and co-operated with shared components and control strategies (Murphy et al. 2021).

Co-located and co-operated energy resources are what most typically come to mind when one is asked to define a hybrid power plant. Applying a commonly-used hybrid power plant definition to distributed wind, a distributed wind hybrid is wind in combination with another or multiple technologies that are co-located and controlled by an owner/operator behind a point of interconnection on a distribution grid and offered to the market or system operator as a single resource at that point of interconnection (Ahlstrom et al. 2019).

Distributed Wind and Demand Response

While not considered a hybrid power plant, distributed wind and demand response can be a powerful combination. Front-of-meter distributed wind and a demand response program on the same distribution system is the most likely combination. For example, off-peak, or excess, wind power generation can

[2] The U.S. Internal Revenue Service defines small wind as up through 100 kW in nameplate capacity for the purpose of federal investment tax credit eligibility. As of January 2015, small wind turbines must meet either the American Wind Energy Association (AWEA) Small Wind Turbine Performance and Safety Standard 9.1-200916 or the IEC 61400-1, 61400-12, and 61400-11 standards to be eligible to receive the Business Energy Investment Tax Credit (26 U.S.C. § 48) (Orrell et al. 2019). A new standard, American National Standards Institute/AWEA SWT-1, is in the transition phase of being adopted for widespread use as of February 2021. SWT-1 defines small wind turbines as having a peak power of 150 kW or less and microturbines as having a peak power up to 1 kW. These definitions may be widely adopted in future policies, market reports, and technical research.

serve grid interactive electric water heaters (Hiedik et al. 2016) on the same distribution system or provide district heating such as in Alaska village heating systems.

Microgrids and Isolated Grids

A microgrid is a group of interconnected loads and distributed energy resources within defined electrical boundaries that can operate in either a connected or disconnected (“islanded”) mode from the local distribution grid (Ton and Smith 2012). A microgrid can be behind a customer’s meter or interconnected to the distribution grid as a front-of-meter project.

If energy supply from the local distribution grid is disrupted because of a weather-related or man-made event, a grid-connected microgrid can disconnect from the distribution grid to maintain electricity supply to its critical loads. Distributed wind, or a distributed wind hybrid, in a microgrid can use any size turbine, depending on the size of the interconnected loads and other DERs.

Isolated electrical grid systems, such as for a remote village, are not connected to a larger grid system and therefore the RADWIND team distinguishes them separately from microgrids.

Distributed Wind Use Cases

Distributed wind use cases are classified by where they are installed in relation to the local distribution grid (Reilly et al. 2021). The three major use cases covered in this report are:

- **Front-of-meter**: A wind turbine that is always connected to a distribution grid and serves as a general power supply for interconnected local loads on the same distribution system.
- **Behind-the-meter**: A wind turbine that is always connected to the local distribution grid behind the consumer-member’s utility meter typically to meet on-site load, and which may provide excess generation to the distribution grid through net-metering or other billing mechanisms.
- **Off-grid**: A wind turbine that is not connected to the local distribution grid.

Front-of-Meter Use Case

A wind turbine connected to a distribution grid as a generating resource is considered a front-of-meter installation. Front-of-meter wind projects provide energy and grid support to the distribution system and serve the interconnected local loads on the same distribution system. Front-of-meter wind projects can be owned by community members, utilities, or third parties. The energy from a front-of-meter wind project owned by a third-party or a community group can be purchased by a utility through a power purchase agreement. Community wind project owners can be individuals who form independent power producer groups or LLCs to sell the energy. Front-of-meter wind projects typically include multiple turbines greater than 100 kW in size, and more likely, greater than 1 MW in size.

Examples of distributed wind front-of-meter applications in cooperative service territories include:

- Community-owned single or multiple turbines sited on a distribution grid that also has interconnected biodiesel or ethanol production facilities
- A cooperative-owned small project providing power to the cooperative's service territory
- A cooperative-owned wind turbine connected to a remote village isolated grid

Image 1: San Isabel Electric Association in Colorado purchases energy from the 8-MW Huerfano River Wind Farm. The front-of-meter project includes four 2-MW Sany wind turbines.
Photo credit: San Isabel Electric Association

Image 2: The Lake Region Community Hybrid project located in Trondhjem Township, Minnesota includes a 2.3-MW GE wind turbine and 500-kW of solar PV. The energy produced is purchased under a PPA and distributed over local co-op power lines from a single rural substation to Lake Regions Electric Cooperative members. The cooperative is also piloting control technology on 40 large residential electric water heaters to allow them to be charged with off-peak wind power. Real-time data ensures that power from the co-op's wind turbine is serving the program's 80- and 100-gallon water heaters. Photo Credit: Lake Region Electric Cooperative

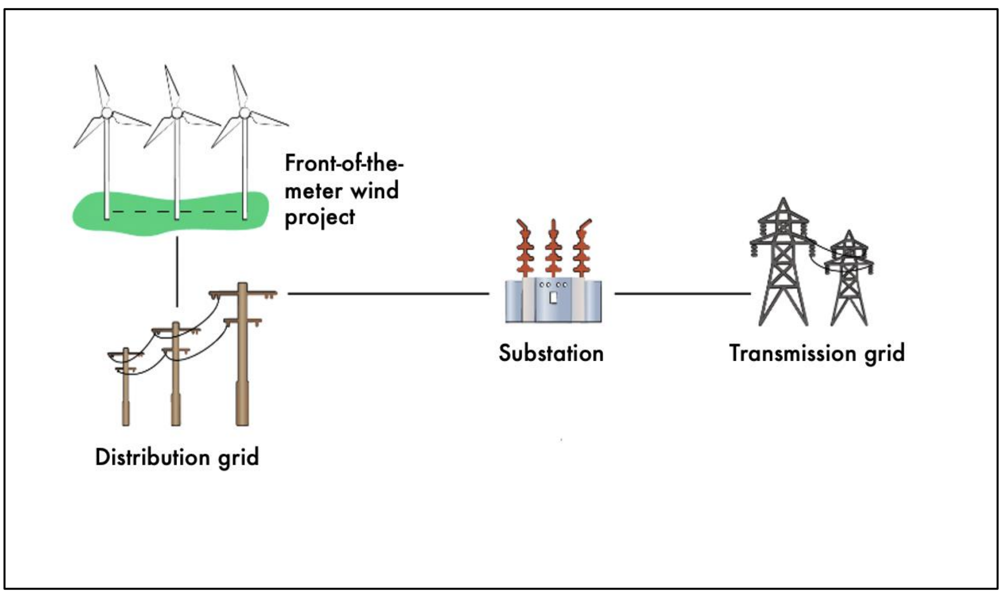

Figure 2: Front-of-Meter Use Case.
Distributed wind projects interconnected directly to the distribution grid are considered front-of-meter projects.

Behind-the-Meter Use Case

A behind-the-meter wind turbine is one that is always connected to the local distribution grid behind a consumer-member's utility meter typically to meet all or some of the onsite energy needs. Behind-the-meter wind turbines offset retail electricity demand and can be net metered if excess output will be sold onto the grid. Virtual (or remote) net metering allows a member to receive net metering credit from a remote renewable energy project as if it were located behind the member's own meter. Behind-the-meter wind turbines are sized to meet the onsite load, or part of it, so they can be any size.

Examples of distributed wind behind-the-meter applications in cooperative service territories include:

- Residences and small farms
- Institutions such schools, universities, houses of worship and community centers
- Commercial and industrial facilities such as John Deere dealerships and manufacturing plants

Image 3: The Honda transmission plant in Russells Point, Ohio has two behind-the-meter 1.7-MW GE wind turbines to power its facility. Honda has an interconnect agreement with Logan County Electric Cooperative and a power purchase agreement with Buckeye Power, Inc.
Photo credit: North American Wind Power

Image 4: The Heritage Dairy Farm owner uses two Northern Power Systems 100-kW wind turbines to provide behind-the-meter energy for the farm's operations in Colorado. The owner also has a 25-kW Eocycle wind turbine at another nearby cattle facility. All three turbines are interconnected to the Y-W Electric Association. Photo credit: Hoss Consulting

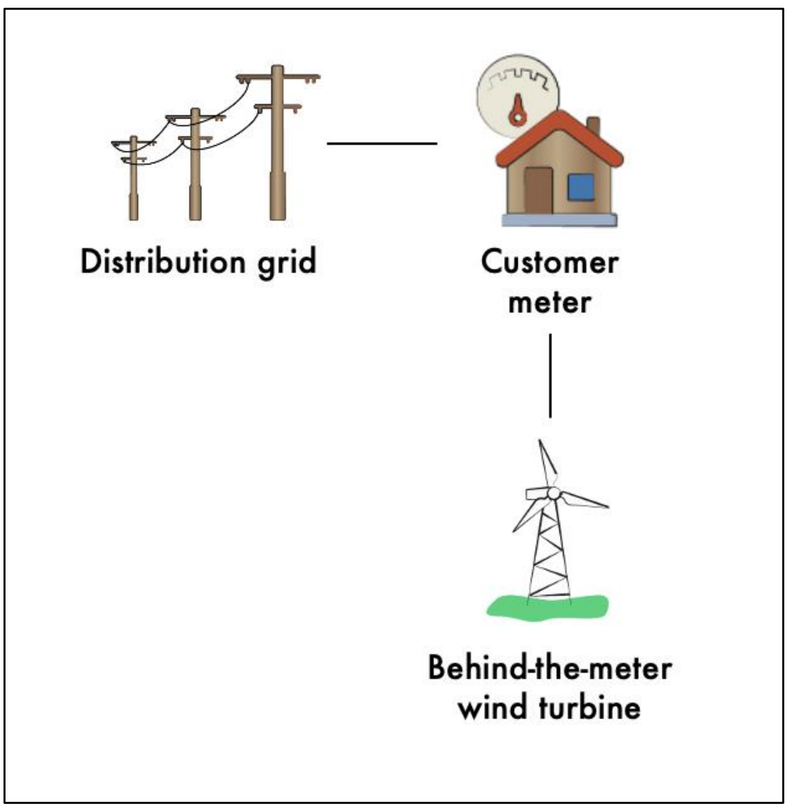

Figure 3: Behind-the-Meter Use Case. ***A behind-the-meter wind turbine is installed to meet part or all of a customer's onsite energy needs.***

Off-Grid Use Case

A wind turbine can be off grid in a remote location as a distributed energy source for on-site energy needs. An off-grid DER is not connected to the local distribution grid. Off-grid distributed wind is typically deployed with battery or other form of energy storage because the wind turbine is not connected to a local cooperative's distribution grid that could provide backup energy or a sink for excess energy. An off-grid wind turbine can also be deployed with solar PV or other DER. Wind turbines used in off-grid applications are typically small, less than 100 kW in size and can be used as an alternative to extending distribution infrastructure to isolated or hard-to-reach areas.

Examples of distributed wind off-grid applications in cooperative service territories include:

- Small agricultural operations, such as a pumping station
- Remote, residential cabins
- Oil & gas industrial operations and pipelines
- Telecommunication towers

Image 5: Distributed wind can be deployed to power off-grid energy needs. This Primus Wind Power small wind turbine, less than 1 kW in size, powers a remote cabin. Photo credit: Primus Wind Power

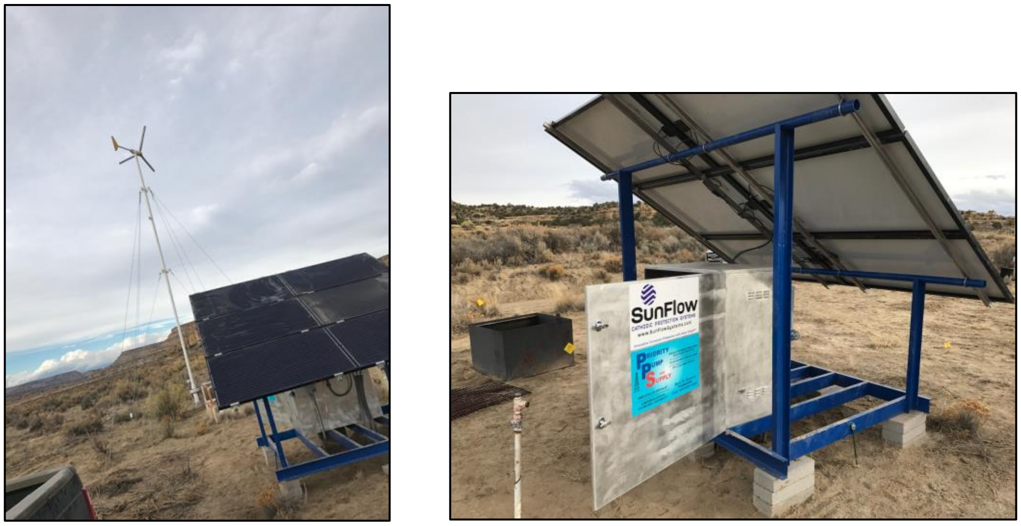

Image 6: This solar PV and wind hybrid with a Bergey WindPower wind turbine is used for oil pipeline cathodic protection in Jemez Mountain Electric Cooperative territory.
Photo Credit: Priority Pump and Supply

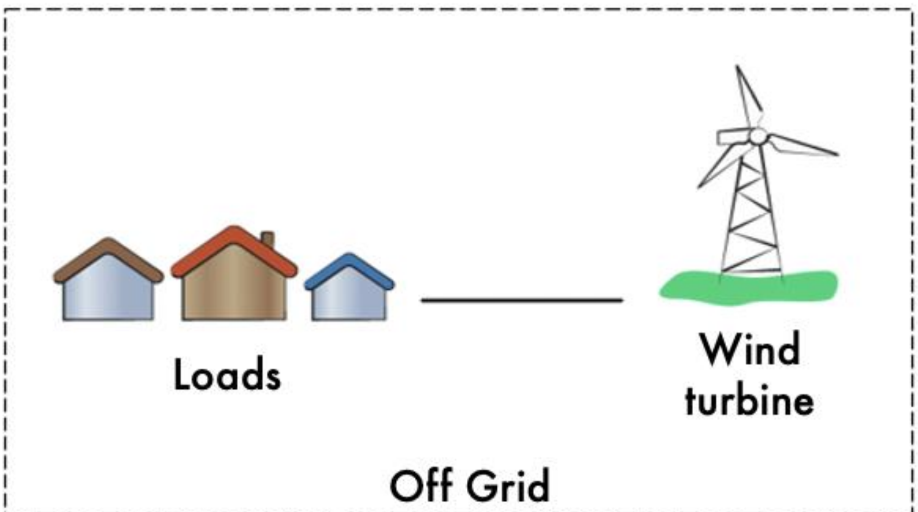

Figure 4: Off-Grid Use Case*.*
An off-grid wind turbine can be used for remote, on-site energy needs.

Putting It All Together

Distributed wind projects can take many forms. Figure 5 provides an illustration of the different use cases and design choices described in this report.

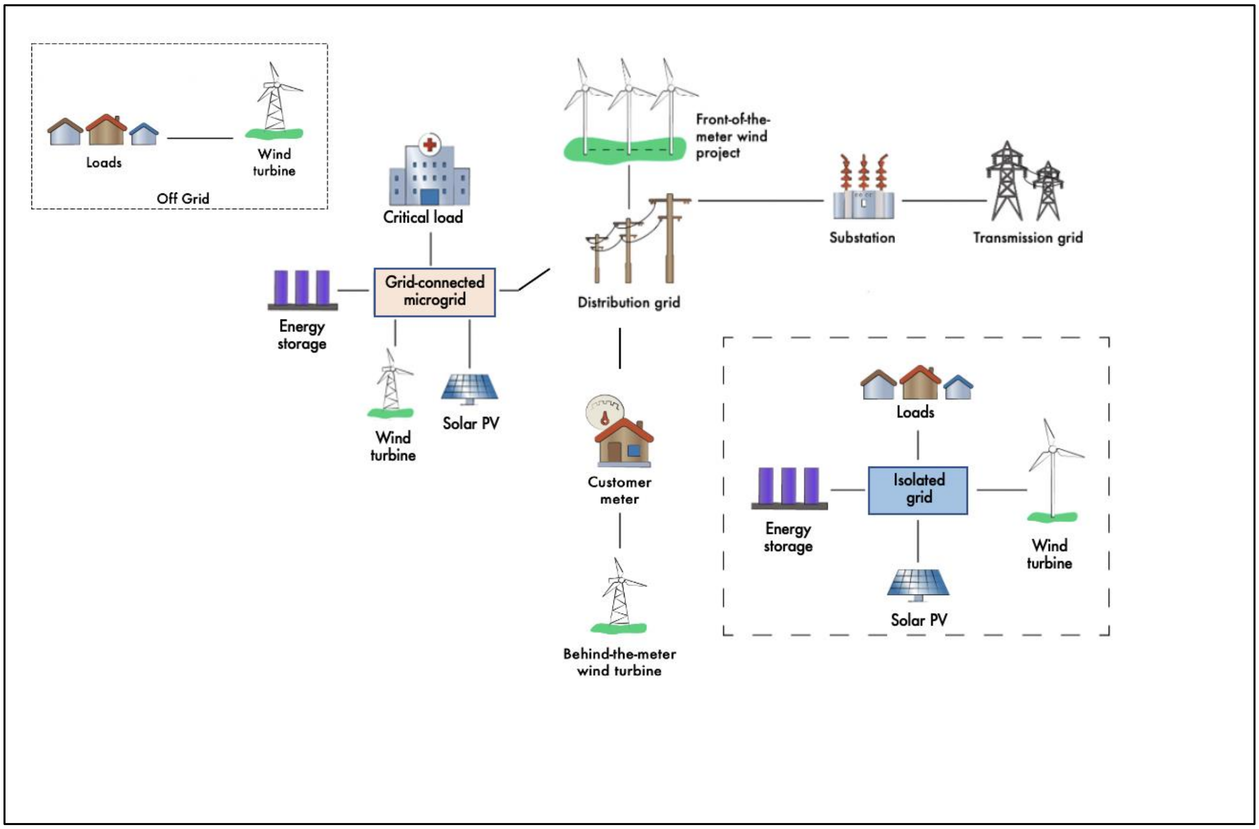

Figure 5: Distributed Wind Use Cases and Design Choices

Table 1 provides examples of some common or likely combinations. The examples in Table 1 are from the perspective of selecting a use case first (i.e., front-of-meter, behind-the-meter, or off-grid) and then selecting a customer type (i.e., agricultural, residential, commercial, institutional, commercial, industrial, or government). From there, the common wind turbine size options, additional DER options, and likely project size ranges are shown for each use case and customer type(s) combination. These examples are not exhaustive, as wind turbine size, DER type and size, and ultimately the overall project size are dependent on the customer's load and project objectives.

Table 1: Distributed Wind Use Case Examples

Use Case	Customer Type	Wind Turbine Size	Likely DER Options for Distributed Wind Hybrids or Microgrids	Common Project Size[3]
Front-of-Meter	Cooperative/ Rural Utility	Medium/Large	Solar PV Other renewable energy Battery or Energy Storage Demand Side Management	1 MW+
	Government	Medium/Large	Solar PV Demand Side Management	101-999 kW/1 MW+
Behind-the-Meter	Residential Institutional	Small	Solar PV Battery or Energy Storage Demand Side Management	Up through 100 kW
	Commercial Industrial Agricultural Institutional	Small/Medium	Solar PV Fossil Fuel Backup Generator Fossil Fuel Baseload Generator Other renewable energy (e.g., biomass, hydro, geothermal) Battery or Energy Storage	Up through 100 kW/101-999 kW
	Commercial Industrial Government	Medium/Large	Solar PV Fossil Fuel Backup Generator Fossil Fuel Baseload Generator Battery or Energy Storage	1 MW+
Off-Grid	Agricultural	Small	Solar PV Fossil Fuel Backup Generator Ag Digestor	Up through 100 kW
	Residential Commercial Institutional	Small	Solar PV Battery or Energy Storage Fossil Fuel Backup Generator Fossil Fuel Baseload Generator	Up through 100 kW
	Commercial Industrial	Medium/Large	Solar PV Battery or Energy Storage Fossil Fuel Backup Generator Fossil Fuel Baseload Generator	101-999 kW/1 MW+

[3] The project size will ultimately be dictated by the wind turbine and DER sizes selected to meet the customer's load and energy generation objectives.

Next Steps

The Value Case and Business Case reports are the next reports in this series. The Value Case report will qualitatively identify the value streams of the use cases. The Business Case report will quantify, to the extent possible, the value of the use cases and create a framework that rural electric cooperatives can use to explain a distributed wind solution to its board or members.

Additional Information on NRECA Research's RADWIND Project

For more information on the RADWIND project and additional resources, please visit the project landing page at www.cooperative.com/radwind.

Want to stay informed of our progress with the RADWIND project, and provide your input and feedback? We welcome all NRECA members to join the project as an advisor. Contact our team at: RadwindProject@nreca.coop.

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