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Business Case for Distributed Wind in Rural Electric Cooperative Service Areas

NRECA
America's Electric Cooperatives

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RADWIND PROJECT REPORT SERIES: Business Case for Distributed Wind in Rural Electric Cooperative Service Areas

Prepared By:

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1. Background

Business Case for Distributed Wind in Rural Electric Cooperative Service Areas is part of a series of NRECA Research Rural Area Distributed Wind Integration Network Development (RADWIND) project reports about wind as a distributed energy resource (DER).

1.1. The RADWIND Project

The RADWIND project seeks to understand, address, and reduce the technical risks and market barriers to distributed wind adoption by rural utilities. More than 20 co-ops and rural utilities have participated in the RADWIND program as project advisors or in other roles like case studies or calls with the project team. 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. Additionally, the RADWIND project aims to provide resources that enable cooperatives to be the first contact and trusted advisor for their member-owners[1] considering distributed wind.

Many co-ops participating in the RADWIND project indicate interest in deploying or supporting deployment of distributed wind in their territories to reduce energy costs, provide local energy security, increase economic development, and satisfy member-owner interest in local renewable energy. This report is designed to support electric cooperatives and other rural utilities[2] as they explore and pursue distributed wind deployments by identifying and describing business models that allow co-ops to harness the values of distributed wind.

This report complements the preceding RADWIND reports:

- *Use Cases for Distributed Wind in Rural Electric Cooperative Service Areas* (henceforth "*RADWIND Use Cases Report*")
- *Value Case for Distributed Wind in Rural Electric Cooperative Service Areas* (henceforth "*RADWIND Value Case Report*")
- *Financing Distributed Wind Projects in Rural Electric Cooperative Service Areas* (henceforth "*RADWIND Finance Report*")

These reports are available on the project landing page at www.cooperative.com/radwind.

[1] NRECA reports often refer to the "consumer-owners" of a cooperative, but other terms such as "member-owners," "customer-owners," or simply "members" are common in the literature. This report will refer to them primarily as "member-owners" and "members."

[2] While this report generally uses "cooperatives" or "co-ops," 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. Though business models differ, this report should be applicable to them as well as other rural utilities that are not NRECA members.

1.2. Defining Distributed Wind

As detailed in the *RADWIND Use Cases Report*, distributed wind projects can use any scale of wind turbine. "Small" turbines have less than 100 kW generating capacity. "Mid-sized" or "medium-sized" turbines can generate between 100 kW and 1 MW, and "large" machines have 1 MW or greater generating capacity (Orrell, 2021). A wind energy asset is considered "distributed" based on its proximity to end use and its interconnection point (Orrell, 2021). Front-of-the-meter (FTM) distributed wind projects are connected to the distribution grid and are part of the overall power supply portfolio for all grid-connected loads. Behind-the-meter (BTM) projects are located behind a co-op or other utility's member-owner's utility meter and primarily serve on-site loads; excess energy may enter the distribution grid depending on the project size, the relevant load profiles, and the cooperative's billing mechanisms. Off-grid distributed wind turbines can serve a variety of loads in a range of sizes, but they do not connect to a distribution or transmission grid.

2. Introduction

Distributed energy resources (DER) are fast becoming an integral, reliable, and cost-effective source of power supply in most areas of the country. DER also plays a growing role in the energy marketplace, and increasing deployment of distributed wind and solar generation offers a glimpse into the future of the electricity grid in the U.S that is more dynamic, distributed, and renewable. As DER deployments grow in rural areas, this transition of power supply from large central generation stations to smaller distributed power sources present rural electric cooperatives with an array of opportunities and challenges. What are the opportunities for cooperatives to supply reliable, resilient, secure, and cost-effective renewable electricity to their member-owners? How can cooperatives maintain their vital role as trusted energy advisors through this energy transition? And, for the purpose of this report, what roles can distributed wind play in this growth of DER? How can it complement other power supply resources?

The goal of this report is to identify and address market barriers to distributed wind adoption by laying out the business case for distributed wind in each use case established by the RADWIND project: front-of-the-meter (FTM), behind-the-meter (BTM), and off-grid. Technical barriers to distributed wind deployment in electric cooperative and other rural utility territories will be addressed in later RADWIND publications.

Distributed wind project lifecycles can be broken down into three phases: pre-development, development, and operations. Whether a cooperative takes an active role in developing a distributed wind asset or not, it is vital to establish the project's purpose, scope, financing, and business strategies at the outset. Projects proceed through a series of screening steps before the developing entity acquires funding, constructs the turbine(s) and other necessary equipment, and commissions the asset.

The value of a distributed wind asset has many facets beyond the contracted cost of the energy it generates, and some values streams it provides are challenging to quantify. By "stacking" all of the value streams a distributed wind asset provides, cooperatives can get a fuller picture of how the asset benefits the communities they serve compared to alternatives. Distributed wind can enhance distribution system resilience and security, contribute to local economic and workforce development, and be deployed more quickly than large wind farms that require new transmission infrastructure. The addition of energy storage can greatly enhance the value of a distributed wind asset.

FTM distributed wind and distributed wind hybrid assets provide cooperatives with significant value and many interesting business opportunities that can serve all member-owners connected to the distribution grid. As many cooperatives have entered into all-requirements contracts with their wholesale power providers (e.g., a generation and transmission cooperative [G&T] or the Tennessee Valley Authority), potential collaboration opportunities between distribution co-ops and their bulk power suppliers to develop distributed wind are particularly intriguing.

As DER grows in prevalence, many cooperative member-owners are taking interest in BTM generation. Such assets can range in size and technology from small, residential wind turbines and rooftop solar panels to large microgrid systems employing multi-megawatt wind turbines, solar farms, and battery energy storage. Historically, electric cooperatives have not benefitted directly from BTM generation as it can represent lost energy sales and/or net metering compensation to member-owners, but several business models are emerging that can improve the business case for BTM distributed wind in cooperative territories.

Electric cooperatives can support off-grid distributed wind development at various levels of involvement. A co-op can act as a pro-bono trusted advisor to a member-owner seeking to add an off-grid turbine to a remote load, or it can create business opportunities through energy advisory and development services.

Distributed wind can support a variety of energy services. Cooperatives can work with local, regional, or federal lenders to offer on-bill financing or tariffed on-bill programs so that member-owners can repay distributed wind capital expenses directly on their utility bills. Additionally, cooperatives can integrate demand side management technology alongside distributed wind to maximize the value of both. As electric vehicles become more popular, cooperatives can deploy distributed wind assets to power charging stations and to avoid the distribution upgrades that would be needed to serve them otherwise. Developing services to their full extent, a cooperative can incorporate aspects of the Energy-as-a-Service (EaaS) business model. This would help co-ops to remain the energy hubs of their territories by supplying energy while also owning and managing FTM and BTM energy assets.

This report covers a wide range of topics related to distributed wind business cases. Most sections are independent of others, so readers can get valuable information from reading all or part of the document and should feel free to access only those portions that address their interests. Various resources that cooperatives may find useful are distributed throughout the report. Additionally, the Appendix contains a list of acronyms used in this report, which may be useful when navigating its content.

3. Distributed Wind Project Lifecycle

Understanding a distributed wind project's development and operational lifecycle is valuable to an electric cooperative. Similar to other generation, transmission, and distribution projects, distributed wind projects also need to be monitored closely by the co-op for progress and reconciled with the assumptions made while developing the resource plan.

3.1. What is the Project's Purpose?

Over the years, renewable developers in the private and public sectors have refined the process for initiating a project and outlining its parameters. Though technical and financial details will be vital to the project's success, dedicating time to discuss the co-op's motivation and how it informs the project's goals early in the process is just as important. By clearly defining the goals for a project, co-op leadership can unite behind one message for their member-owners and narrow the wide array of distributed energy resource options down to the few that align with their plans. Clear purpose facilitates consensus-building and supports the sustained effort required to see a project through (Springer, 2013).

Consider these essential factors before commencing pre-development:

- **Baseline:** State the fundamental reason for doing this project. When defined in one or two sentences, the objective of a project gives clarity to later decisions.
- **Economics:** Consider an objective analysis of the energy economics for both existing sources and the proposed distributed energy source. At this early stage a basic, high-level framing of economic considerations is appropriate. Which value streams will the cooperative prioritize?
- **Policy:** Examine the federal, state, and local regulatory environment for any barriers and incentives.[3]
- **Technology:** Assess the wind resource and evaluate various technology options.[4]
- **Consensus:** Communicate and build consensus among stakeholders.

3.2. Which Members Will the Project Serve?

After the co-op outlines its motivation as well as the economic, policy, and technological parameters of its project, determining the organization's objectives for the project is the next priority. Where a distributed wind project provides energy can be broken down into categories based on the use cases established in the introduction:

- **Energy to all member-owners:** FTM installations that connect to the distribution grid.

[3] The Database of State Incentives for Renewables & Efficiency (DSIRE), maintained by North Carolina State University, provides a good starting point when researching incentives and regulations. A database search can be refined by state and by energy technology.

[4] Upcoming guidance documents from the RADWIND project are designed to explain wind resource modeling and wind turbine technology options.

- **Energy to some member-owners:** FTM or BTM installations that serve a site, a district, or a set of subscribers (e.g., through a community wind program). Isolated grids and microgrids may fit this description as well.
- **Energy to one agricultural site or agricultural electric load:** BTM or off-grid installations that provide energy on-site.
- **Energy to one commercial, industrial, or institutional member-owner:** BTM or off-grid installations that provide energy on-site. Microgrid applications may be especially relevant to member-owners in this category as they may need an uninterruptable power supply (e.g., a hospital or data center).
- **Energy to one residence or one electrical load:** BTM or off grid installations that provide energy on-site.

3.3. Distributed Wind Project Stages

A distributed wind project's lifecycle can be divided into three stages: pre-development, development, and operations. Figure 1 summarizes the key tasks in each stage. Discussion follows.

Pre-Development
- Screen wind resource
- Perform interconnection study
- Work toward local stakeholder approval
- Consider optimal ownership, financing, and business model options
- Refine project design
- Conduct detailed feasibility review based on expected annual energy production (AEP)
- Identify regulatory requirements
- Share plan with partnering/funding entities

Development
- Engage with local stakeholders
- Refine siting, design, and generation modeling
- Design and engineer the project
- Acquire permits
- Procure equipment
- Build the project and complete mechanical assembly

Operations: Commissioning, Optimization, and Maintenance
- Approve autonomous operation during oversight period
- Perform scheduled maintenance
- Submit warranty claims if necessary
- Schedule inspections prior to warranty ending
- Maintain open communication with neighbors

Figure 1: Key tasks in each stage of developing a distributed wind project

Pre-development involves the due diligence needed to determine a distributed wind project's technical and economic viability. Determining the right financing and business strategy is among the most important tasks in pre-development; the *RADWIND Finance Report* provides an overview of ownership options as well as sources of capital. The project design and expected AEP models are also refined during pre-development to assist in a detailed feasibility review.

The refinement of the project design is influenced by these factors:

- Wind energy resource. A distributed wind hybrid plant may need further resource evaluation, such as insolation for a co-located solar array.
- Availability of and access to sufficient and suitable land area that aligns with the wind resource.
- Placement of the wind turbine(s) relative to terrain and obstacles (i.e., "micro-siting") of the project.
- Proposed interconnection strategy including costs for any required system upgrades and new grid equipment.
- Potential environmental impact concerns at or near the proposed project site (e.g., sensitive habitat, threatened or endangered species, etc.)
- Zoning and permitting context of the site (including federal concerns such as aviation)
- Interaction with built environment (e.g., sound, flicker, etc.)
- System impact study which may reveal a need for additional grid infrastructure and/or new communication equipment.

Once the project design is refined sufficiently, the cooperative can issue a request for proposal (RFP) and the project design can be shared with potential funding and ownership entities. This ensures that these external entities will have sufficient information for their financial due diligence process. Such transparency is essential for an efficient transition from one project stage to the next.

If predicted cash flows are still favorable, the project progresses to the development stage (see Figure 1). At this point it is important to engage with local stakeholders including co-op member-owners, project neighbors, and local permitting authorities. Coordination between developers, lenders, landowners, and the co-op is also vital while the developer seeks construction financing and plans a construction timeline. Open and clear lines of communication are critical throughout the project's development so all stakeholder concerns can be understood and addressed as they arise. After construction and mechanical completion of the generating equipment, the asset is interconnected and commissioned.

When a project reaches commercial operation, there is typically a period of operational optimization that occurs. Modern wind turbines operate autonomously, but they still require active operational oversight before they are authorized to operate autonomously in all conditions. Depending on the season in which the wind turbine is installed, it can be days, weeks, or even months before all operational modes are approved for autonomous operation. This commissioning period is an essential bridge between when the developer can invoice for the project and when the project is expected to generate in accordance with pre-construction estimates.

Once a project is operational, it is still valuable to be attentive to project performance and, in the case of project ownership, to ensure timely service and repairs, and that all warranty claims are properly managed. Distributed wind projects have similar operational lifespans to commercial projects when they are well monitored and maintained, but cooperatives with distributed wind assets should assess their options for when the asset reaches the end of its design life. Turbines can be decommissioned and disassembled, or they can be “repowered” by refurbishing the existing machinery or by installing newer equipment.

4. Understanding Distributed Wind's Value

The RADWIND project outlined its definition of "value" as it pertains to distributed wind and other DER in the 2021 *RADWIND Value Case Report*. "Valuation," it states, "is 'the process of determining the relative worth, utility, or importance (i.e., value) of options or alternatives to allow their comparison in ways that are clear, transparent, and repeatable.'" While balance sheet measures like levelized cost of energy (LCOE) are often used to assign value, many costs and benefits of a distributed wind project are challenging to quantify. The values of sustainability or local economic impact, for example, are difficult to monetize in a uniform way. Furthermore, a distributed wind project's value can vary depending on its capacity and location.

The full value of distributed wind and other distributed generation cannot be assessed by simply comparing the cost of the distributed energy to the average cost of energy from a wholesale provider. Distributed wind, with good siting and wise technological design, can do more than offset the most expensive, marginal electricity purchased by a cooperative. Only by "stacking" all of the values a DER provides to a cooperative (e.g., deferred distribution upgrades + peak shaving + long-term price stability + grid resilience + community tax revenue + member-owner satisfaction for a sample FTM project) can the full benefit of the project be known.

In this paper and others in the RADWIND library, the term "value stream" refers to a cost or benefit experienced from a particular stakeholder perspective. These value streams can vary by region and market, and the ability to realize the value streams may depend on anticipated technological advances, market developments, and policy initiatives. RADWIND's mission is to facilitate rural distributed wind development; therefore, the value streams in this report are tailored to the benefits that distributed wind can bring to rural communities.

Tables that summarize the many value streams associated with distributed wind development are included for FTM, BTM, and off-grid use cases. The remainder of this section highlights and expands upon distributed wind values that were introduced in the *RADWIND Value Case Report*.

4.1. Distributed Wind's Impact on System Resilience and Security

Resilience is typically defined as the ability to recover rapidly from any disturbance to an acceptable state of operation (Bukowski et al., 2021). As such, resilience may be valued in terms of avoided costs of outages. With respect to grid systems, there are a variety of events that could disrupt grid operations. These can be categorized as natural events (e.g., extreme weather, natural disasters, and geomagnetic disturbances) and malicious events (e.g., physical attacks, cyberattacks, and electromagnetic pulse attacks) (Dyson & Li, 2020). Cybersecurity attacks on energy systems are a growing concern, especially considering the Colonial Pipeline cyberattack in 2021 (Turton & Mehrotra, 2021).

How to improve resilience depends on the specific details and scale of a grid system, the potential threats being considered, and the risk tolerance and perspectives of the decision makers. Distributed wind may contribute to system resiliency because of a few different characteristics. Distributed wind is a decentralized generation asset that can be sited at critical loads or locations, such as at the end of a weak feeder. While distributed wind is dependent on wind resource availability (and projects should therefore be sited in areas with consistent wind speeds), distributed wind is not dependent on the availability of a limited, physical fuel supply whose transport could be disrupted. In addition, distributed wind can provide grid services, enabled by smart inverters and advanced controls, such as voltage support, frequency response, and flexible ramping (Bukowski et al., 2021; Orrell, Homer, et al., 2021).

Distributed wind's resilience contributions may be enhanced when coupled with storage. With storage, distributed wind may have an increased ability to help with system black start. It could also enable shifting of generation (i.e., storing or discharging electricity) to mitigate outages (Orrell, Homer, et al., 2021).

Resources

- *Cybersecurity Guide for Distributed Wind* from Idaho National Laboratory (INL), 2021[5]
- *Cybersecurity Guide for Distributed Wind: What Operators Need to Know* from INL, 2021[6]

These resources were produced as part of the Microgrids, Infrastructure Resilience, and Advanced Controls Launchpad (MIRACL) project, and they are cross-linked on the RADWIND landing page.

4.2. Enhancing Distributed Wind's Value with Energy Storage

Energy storage encompasses many technologies. Electric vehicles and demand/grid response technologies, which can both be types of energy storage, are discussed later in Section 8.1. This section is focused on the emerging role of battery energy storage systems (BESS) and how they can enhance the value of a distributed wind project.

4.2.1. Background

Once a technology practical for only small, off-grid applications, BESS are now commonplace in a range of scales and for multiple grid applications. BESS are categorized based on size (in either power or energy capacity) and duration, defined as the amount of time the battery can discharge energy at the nameplate power capacity. Large-scale BESS (> 1 MW, grid-tied) are owned primarily by independent power producers and utilities while small-scale BESS (≤ 1 MW) are usually residential, and most of those are located in California (see Figure 2).

[5] https://resilience.inl.gov/wp-content/uploads/2021/11/21-50152_CG_for_DW_R5.pdf

[6] https://resilience.inl.gov/wp-content/uploads/2021/11/21-50610_R3_Operators.pdf

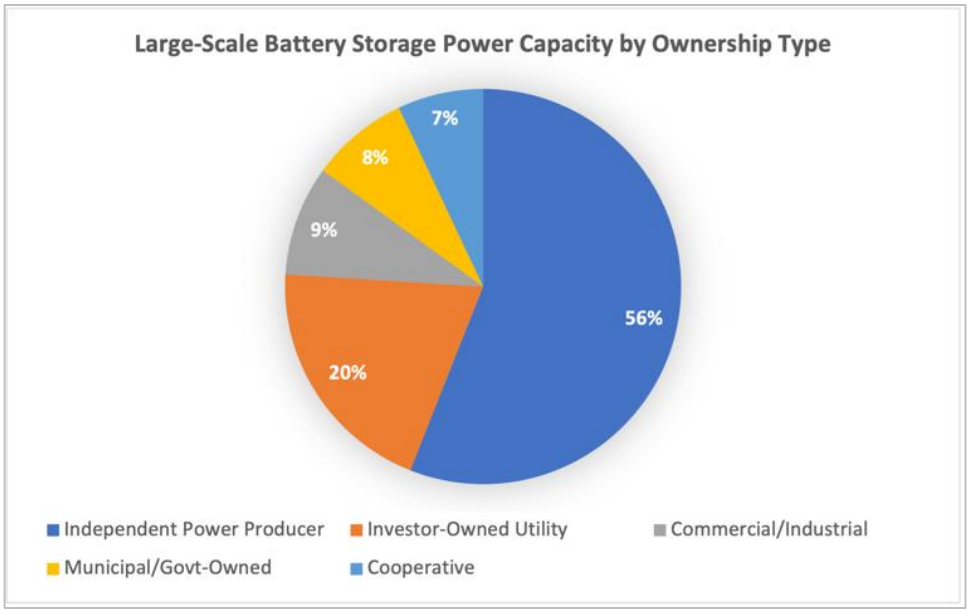

Figure 2-a: Ownership proportions for large-scale BESS in the U.S.
(Adapted from U.S. Energy Information Administration, 2021b)

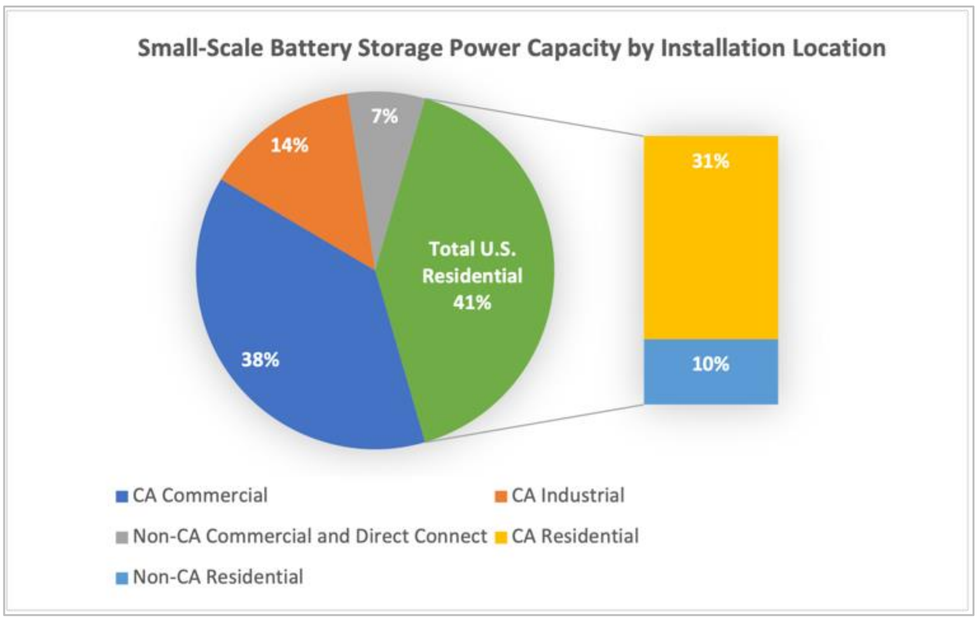

Figure 2-b: Locations for small-scale BESS in the U.S.
(Adapted from U.S. Energy Information Administration, 2021b)

The first large-scale BESS in the United States was installed in 2003. Since then, 1,044 MW of large-scale BESS capacity has come online—82% of that capacity was added between 2015 and 2019 (U.S. Energy Information Administration, 2021b). Technology improvements and cost reductions are driving this increase. From 2016 to 2019, the levelized cost of storage (LCOS)[7] for a benchmark large-scale BESS fell by about 70% (National Rural Electric Cooperative Association, 2020b). The National Renewable Energy Laboratory (NREL) estimates that BESS capital costs will decline by 14-38% by 2025 (Cole et al., 2021).

Further declining costs and the increasing role of DER point to an extraordinary increase in BESS deployment in the near future. Based on planning data collected by the U.S. Energy Information Administration (EIA), 10,000 additional megawatts of large-scale BESS capacity will likely be installed from 2021 to 2023. This represents 10 times the capacity of all BESS on the grid in 2019 (U.S. Energy Information Administration, 2021b).

4.2.2. Valuation

BESS can enhance distributed wind energy project values just as they do with solar photovoltaics (PV). BESS offer several advantages to utilities with FTM distributed wind and wind-solar hybrid systems:

- Allow wind energy to be deployed during periods of highest demand by reintroducing energy to the grid when needed or when profitable, thereby reducing the need to curtail distributed wind generation
- Improve local grid regulation and resiliency
- Provide relief for transmission or distribution system congestion and deferral of upgrades
- Improve reliability for member-owners

BTM and off-grid BESS also enhance the value of distributed wind for individual co-op member-owners. Off-grid wind energy systems require some form of energy storage to provide uninterrupted electrical service to their loads. Grid-tied BESS located behind-the-meter can store energy during off-peak hours—either from their own distributed wind system or from the distribution grid—and then use it to offset demand or time-of-use (TOU) charges (Stenclik et al., 2017). If net metering tariffs are insufficient to justify selling extra wind energy to the grid, a member-owner's BESS allows them to store excess energy for later self-use.

Table 1 expands upon the services a BESS can provide to an electric cooperative and highlights where those services overlap with successful deployment of distributed wind assets.

[7] Like LCOE, levelized cost of storage (LCOS) is determined by discounting yearly capital, O&M, and fuel costs to the present day and dividing by the discounted yearly energy output of the BESS. Fuel cost is the cost of electricity used to charge the BESS.

Table 1: Selected BESS services with distributed wind

Adapted from Akhil et al., 2015; Bowen et al., 2019; National Rural Electric Cooperative Association, 2020b

Value Stream	BESS Service	Distributed Wind Value Intersection	Service Availability
Bulk Energy	**Electric energy time-shift:** Store off-peak, cheaper energy for use or sale later. Provide reliable peaking capacity to meet peak system demand. Reduce the need for new peaking power plants and other peaking resources.	Aka “capacity,” “arbitrage,” or “peak shaving.” Distributed wind energy’s typical generation profile has great potential to meet this need. Inexpensive nighttime and winter generation can be stored and then dispatched as needed for grid capacity needs or during higher-priced peak times.	Near-future BESS service that will enable distributed wind to operate as “baseload”
Ancillary Services	**Regulation:** Frequency support and fast response to random, unpredictable variations in demand and generation.	Sometimes referred to as “renewables firming” or “renewables integration,” these BESS services allow distributed wind’s variable generation to synchronize better with the grid.	Renewable energy integration is the current primary use for BESS
	Ramping/Load following: Follow longer-term (hourly) changes in electricity demand.		
Transmission & Distribution Services	**Transmission/Distribution congestion relief:** Store energy when the transmission or distribution system is uncongested and provide relief during hours of high congestion by serving loads beyond historical bottlenecks.	A wind-BESS hybrid can be located to relieve congestion. If combined with a BESS, the wind asset’s generation profile does not need to exactly match congestion time.	Some cooperatives are already exploring DER and storage to defer transmission upgrades, and this model is expected to grow as electric vehicle charging loads and other electrification efforts compel infrastructure upgrades.
	Transmission/Distribution upgrade deferral: Reduce loading on a specific portion of the distribution system, thus delaying transmission or distribution system upgrades to accommodate load growth or regulate voltage.	A strategically placed wind-BESS hybrid project can be an alternative to upgrading or expanding the transmission and distribution (T&D) system to meet local demand. Co-locating a BESS with distributed wind also allows right-sizing of components instead of designing for max output.	
Member-Owner Services	**Power reliability:** Reduce or eliminate power outages to member-owners.	BTM or off-grid BESS can store excess distributed wind energy on site for a member-owner’s use.	Many commercial entities maintain BTM BESS to reduce demand charges. Residential BESS are already in use.
	Time of use (TOU) charge reduction: Reducing member-owner charges for electric energy when the price is specific to the time (season, day of week, time-of-day) when the energy is purchased.		
	Demand charge reduction: Reduce the maximum utility-sourced power drawn by electric load.		
	Off-grid or microgrid power		

Determining the financial value of a BESS with or without distributed wind is a challenging task. With battery technology rapidly advancing, BESS costs are decreasing. Furthermore, the value a BESS presents to any given cooperative as revenue and/or cost savings is also a moving target. New markets are developing for services provided by BESS, and the value of each use case varies with location, market, structural, and regional factors (Balducci, 2020). As a result, the cost effectiveness for a BESS is unique to each situation. As a starting point, the Energy Storage Cost and Performance Database[8] developed by the Pacific Northwest National Laboratory (PNNL) provides cost estimates for energy storage systems at various capacities and durations.

Table 2 compares costs and values of battery storage and the technologies that constitute the bulk of new capacity additions. Battery storage currently has an LCOS nearly four times the LCOE of the most commonly deployed generation technologies*, but because it can be rapidly dispatched at economically valuable times, it also displaces the most expensive energy as determined by levelized avoided cost of energy (LACE).* Thus, its value-to-cost ratio is comparable to generation technologies.

Table 2: Cost and value comparison of battery storage and generation technologies entering service in 2026

Estimated capacity-weighted amounts in 2020 dollars per MWh (U.S. Energy Information Administration, 2021b)

		Average LCOE or LCOS w/ Tax Credits	Average LACE	Average Value-to-Cost Ratio (LACE/LCOE or LACE/LCOS)
Dispatchable Technologies	Gas Combined Cycle	$34.51	$34.58	1.00
	Gas Combustion Turbine	$107.83	$93.59	0.87
	Battery Storage	$121.84	$97.53	0.80
Non-Dispatchable Technologies	Onshore Wind	$31.45	$30.71	0.98
	Standalone Solar PV	$29.04	$30.63	1.06

Part of determining a BESS's value is understanding which federal tax incentives can be utilized to reduce its cost. Confusion on this point arises because the four federal tax incentives primarily utilized by renewable energy projects—the Business Energy Investment Tax Credit (ITC), Renewable Electricity Production Tax Credit (PTC), Residential Renewable Energy Tax Credit (Residential ITC), and Modified Accelerated Cost-Recovery System (MACRS)—have lapsed, been restored, partially phased out, or totally phased out in the last two decades (see the *RADWIND Finance Report* for more information). Furthermore, the conditions under which BESS qualify for tax incentives are not well-defined. Because of this, taxpayers have requested several Internal Revenue Service (IRS) private-letter rulings to clarify when BESS qualify for federal tax incentives. Private-letter rulings apply directly to only the case at hand, but they provide insight into how the IRS could handle similar cases. Private-letter

[8] https://www.pnnl.gov/ESGC-cost-performance

rulings handed down between 2011 and 2018, relevant Treasury Regulations, and the original legislative text suggest these guidelines:[9]

- BESS do not qualify for the PTC. Standalone BESS do not qualify for tax credits, but owners can depreciate the asset on the MACRS 7-year schedule.
- A BESS can qualify for the Residential ITC if 100% of the energy used to charge it comes from co-located solar PV (Friedman, 2018). While there is no specific ruling on wind turbine-charged BESS, it is reasonable to assume that they would qualify for the Residential ITC as "qualified solar electric property expenditures" and "qualified small wind energy property expenditures" are defined with identical language in the tax code (*26 U.S. Code § 25D - Residential Energy Efficient Property*, n.d.).
- A BESS can qualify for the ITC provided at least 75% of the electricity used to charge it comes from a co-located solar energy system (Friedman, 2013). The BESS owner receives the percent of the ITC corresponding to the percent of charging electricity that comes from the solar panels (e.g., if 82% of the electricity to charge the BESS comes from solar panels, the BESS owner can claim 82% of the ITC). These guidelines appear to apply to wind projects as well. Private-letter rulings from 2011 and 2012 confirm that BESS included in a new wind farm and added to a pre-existing wind farm both qualify for the ITC (Friedman, 2011, 2012). Treasury Regulations indicate that a BESS charged by wind energy would have to comply with the same 75% "cliff" and proportional award as a solar project (*26 CFR § 1.48-9 - Definition of Energy Property.*, n.d.).
- MACRS is available as a corporate tax deduction for BESS co-located with solar or wind. If the BESS is charged less than 75% by solar or wind, it qualifies for a 7-year depreciation schedule. If it is charged 75% or more by solar or wind, then the BESS qualifies for a 5-year depreciation schedule. When claiming the ITC, the MACRS depreciation basis is reduced by half the value of the ITC.[10]
- Interpretations of private-letter rulings and other tax documents indicate that a BESS co-located with a wind or solar farm is considered a "qualified property at a qualified investment credit facility" (Cooper et al., 2017). Thus, a BESS being charged by wind turbines is a "project within a project" that should be creditable under the ITC whether the wind facility originally claimed the ITC or the PTC. As a separate property, it can be installed in the same year as the wind project or at a later date and still qualify for the ITC (Cooper et al., 2017). Developers may be able to maximize their tax benefits by taking the PTC for the wind farm and the ITC for the co-located BESS.

The PTC, usually taken by wind farm owner-operators, lapsed at the end of 2021 whereas the ITC is available until the end of 2023, so the primary tax credit for solar installations remains in place as BESS costs drop to financially attractive levels and more markets for their services develop. This helps explain why about half of BESS co-located with renewable generating facilities through December 2020 were paired with wind turbines, but 80% of BESS storage capacity planned for deployment between 2021 and 2023 will be co-located with solar instead (U.S. Energy Information Administration, 2021b). Congress

[9] These guidelines are meant as references to understand the interplay of federal tax incentives and BESS costs. They are not binding, nor are they meant as advice for a cooperative seeking definitive statements during BESS valuation. Cooperatives should seek professional legal advice as they evaluate BESS economics.

[10] An explanatory graphic can be found in [*Federal Tax Incentives for Energy Storage Systems*](https://www.nrel.gov/docs/fy18osti/70384.pdf) from NREL, 2018. https://www.nrel.gov/docs/fy18osti/70384.pdf

is considering legislation to restore and extend renewable energy tax credits and to approve the ITC for standalone BESS (Stromsta, 2019). The ability to construct standalone BESS that qualify for the ITC would allow for more flexible and strategic deployment of energy storage on distribution and transmission grids (Visweswariah, 2019).

4.2.3. Challenges

Very long-duration energy storage will be critical to completely integrate large amounts of DER providing variable renewable energy. In areas that lack firm, zero-carbon resources like nuclear or hydropower, solar and wind power will need very long-duration storage to provide reliable power, yet lithium-ion batteries are unlikely to economically scale up to the needed durations (National Rural Electric Cooperative Association, 2020b). Researchers are working to develop new battery technologies capable of multi-day storage at competitive costs. For example, beginning construction in 2023, the Minnesota-based G&T cooperative Great River Energy will host a test project using Form Energy's iron-air BESS designed to deliver 100 hours or more of inexpensive energy storage (Plautz, 2021).

The multiple services provided by a BESS require a multi-dimensional co-optimization strategy because batteries are energy limited and cannot provide all services simultaneously (Balducci, 2020). Research on BESS valuation has quantified some variables, however. The location of the system within the transmission network, within the distribution network near load centers, or co-located with a distributed wind asset plays a large role in determining which services it can provide and the services' financial values. Research from LBNL shows that distributed energy resources such as BESS should generally be located where the investment for a needed upgrade would not be recouped due to low load growth in the area (Frick et al., 2021).

4.2.4. Opportunities

Large-scale BESS are a relatively new tool in power grid development, but their potential has spurred research by MIT, NREL, and others into how their value will impact the grid in the near and long term. A key finding is that more variable generation and uncertainty in the power system will emphasize BESS frequency control services (Bowen et al., 2019). Variable renewable energy levels approaching 30% can also change the shape of the net load curve, which would accentuate BESS projects that provide arbitrage, load following, and/or peaking capacity services (Bowen et al., 2019). As storage expands, those high-value markets may become saturated, and the value of BESS could shift to capacity deferral and capacity avoidance (Spector, 2020). Specifically, BESS will reduce variable renewable investments by shifting renewable generation that would otherwise be curtailed, replacing thermal generation (like gas peaker plants) for peak demand electricity delivery, and deferring transmission upgrades (Spector, 2020). With many coal plants soon retiring, distributed wind projects—existing or new—could be paired with storage and other complimentary resources like solar to reduce intermittency and start offering capacity services to replace some coal-fired baseload energy. As Jesse Jenkins, co-author of the MIT study states, "Storage, as an asset, allows you to make better use of other fixed assets in the system" (Spector, 2020).

Small-scale BESS installed at homes and workplaces present many opportunities for member-owners, especially when paired with onsite distributed wind. By storing excess wind energy in a BESS and discharging it at opportune times, a member-owner can offset demand charges and minimize the electricity they export to the distribution grid. Cooperatives can realize value from BTM distributed wind with BESS by controlling the charging and dispatch of the system to benefit the grid as a whole via an Energy-as-a-Service arrangement (see Sections 8.2 and 8.2.4.2 for a description and a relevant example, respectively).

Western Farmers Electric Cooperative
Developing the Largest Hybrid Renewable Power Plant

One project making a significant contribution the hybrid renewable power plant space is Western Farmers Electric Cooperative's (WFEC's) Skeleton Creek co-located wind/solar/BESS project in Oklahoma. WFEC, a G&T cooperative, is working with a subsidiary of NextEra Energy Resources to develop what is expected to be the largest project of its kind in the U.S. when it is fully operational in 2023. The first phase of the project—a 250 MW wind farm—came online in 2020. By the end of 2023, the project plans to have 250 MW of solar online, along with a 200 MW – 4-hour BESS (Western Farmers Electric Cooperative, 2020).

As part of the financing, the project used the federal Production Tax Credit (PTC) for the wind portion, and the federal Investment Tax Credit (ITC) for the solar combined with the BESS. The result is that "the cost of these new resources is lower than that of a new, natural gas peaking unit" (NRECA 2020, *Optimizing Generation by Coupling Renewable Energy with Battery Storage*,[1] p. 4). By leveraging the complimentary nature of wind and solar and adding storage, WFEC offers its members an energy mix of nearly 50% renewables while keeping its wholesale prices low.

Image 1: Turbines in the Skeleton Creek Wind Farm near Enid, OK
(Credit: Oklahoma's Electric Cooperatives, https://oaec.coop/2020/12/wfec-skeleton-creek-wind-project)

4.2.5. Resources

- *Battery Energy Storage Overview* from NRECA, 2020[11]
- *The Value of Battery Energy Storage for Electric Cooperatives: Five Emerging Use Cases* from NRECA, 2021[12]

4.3. Local Economic and Workforce Development

Distributed wind energy projects create local construction, installation, and operations/maintenance jobs which stimulate rural economies.[13] Local cement masons and finishers, crane operators, and electricians are among the skilled tradespeople hired to support the construction and installation phases of projects. After projects are operational, wind turbine technicians and engineers are needed to perform regular inspections and maintenance. The need for these skilled, technical workers provides opportunities for industry educational partnerships with local community/technical colleges.

Distributed wind energy projects also contribute to rural economic development by providing increased revenue for local businesses. Concrete and rebar for tower foundations, construction equipment, and electrical wire and conduit are commonly acquired locally. Workers who relocate to or temporarily live near project sites support local businesses. The hospitality and retail sectors are among those that can see an increase in business as more people seek their goods and services. Distributed wind energy projects can also provide a new source of revenue for landowners in the form of lease payments and can contribute to community tax revenue (Orrell, Homer, et al., 2021).

4.4. Deployment Speed and Avoiding the Transmission Interconnection Queue

Federal Energy Regulatory Commission (FERC) interconnection policies created in 2003 were designed for gas power plants, the dominant generation technology at the time. Wind and solar plants are more location-dependent, however, so new transmission lines or added transmission capacity on existing lines are required to reach areas where wind turbines and solar panels are most productive. Current FERC policy allows independent system operators (ISOs) and regional transmission organizations (RTOs) to make generators pay for the needed transmission upgrades, and these costs often make projects unprofitable for developers. When the developer withdraws their untenable proposal from the queue, the long evaluation process starts all over again. Additionally, transmission buildouts are expensive and rife with bureaucratic inefficiencies and competing institutional authorities (Zevin et al., 2020). The result is predictable: at the end of 2019 there were 734 gigawatts of proposed generation waiting in interconnection queues across the United States. Ninety percent of the backlog is from wind, solar, and energy storage projects (Caspary et al., 2021).

[11] https://www.cooperative.com/programs-services/bts/Documents/Reports/Battery-Energy-Storage-Overview-Report-Update-May-2020.pdf

[12] https://www.cooperative.com/programs-services/bts/Documents/Reports/Battery-Energy-Storage-Use-Cases-January-2021.pdf

[13] NREL's Jobs and Economic Development Impacts (JEDI) Distributed Wind model can estimate distributed wind project economic development impacts including annual jobs, earnings, output, and value added by inputting project-specific data.

ISOs/RTOs and FERC have implemented some remedies, but there is increasing pressure for the federal government to reclaim some of its dormant authority in transmission planning to help accelerate zero-carbon energy resource deployment (Zevin et al., 2020). More equitable cost-sharing is seen as a key step toward approving more projects, as well as inter-regional coordinated transmission planning (St. John, 2021). In January 2022, the Department of Energy (DOE) launched its "Building a Better Grid Initiative" from the 2021 Bipartisan Infrastructure Law meant to enhance and expedite transmission planning, transmission infrastructure financing, and transmission permitting (*DOE Launches New Initiative From President Biden's Bipartisan Infrastructure Law To Modernize National Grid*, 2022).[14]

Cooperatives seeking to increase the amount of renewable energy in their portfolios can avoid the long wait for more wind energy to enter the wholesale supply by developing distributed wind projects. Multiple utility-scale distributed wind projects can add significant new generating resources. They can be installed near local loads, thus avoiding the energy losses that come with long-distance transmission. Furthermore, these projects can be approved, designed, completed, and interconnected faster than larger scale wind installations that require new transmission lines, though local ordinances play a significant role in determining the pace of development.

Investments in high-voltage transmission to accommodate a higher share of bulk-scale renewables are on the horizon, and the regulatory changes needed to accelerate its construction are gaining traction. However, even if reforms are adopted, rapid expansion of transmission infrastructure is likely to remain a challenge. In the meantime, electric cooperatives can realize value for their member-owners by deploying distributed wind on their own timelines.

[14] https://www.energy.gov/articles/doe-launches-new-initiative-president-bidens-bipartisan-infrastructure-law-modernize

5. Front-of-the-Meter Business Cases

A front-of-the-meter wind turbine is connected to a distribution system and serves as a general power supply for interconnected local loads on the same distribution system. From 2010 to 2020, 10% of distributed wind projects were FTM. Because these projects tend to use higher-capacity, large-scale wind turbines (i.e., 1 MW and greater), more than half (55%) of distributed wind generating capacity falls into the FTM category (Orrell, Kazimierczuk, et al., 2021).

5.1. Overview

Installations of this type require significant capital investment, thus the majority of FTM distributed wind is owned or purchased by utilities, which can be investor-owned, publicly owned, or rural electric cooperatives. The *RADWIND Finance Report* details the variety of methods co-ops and developers can use to acquire capital and to structure the wind asset's ownership to maximize value and minimize risk. A rural cooperative may own the asset outright, own it through a taxable subsidiary, purchase wind power from a third-party owner via a PPA, or host a project owned or under PPA by their G&T cooperative or other wholesale provider. The conditions of the co-op's wholesale power contracts will of course be an important determinant of which options a distribution co-op might pursue.

Business models applied to an FTM asset will typically involve passing the costs and savings through to owner-members. That said, how the value of the wind energy entering the distribution grid is delivered and captured is not set in stone. Some innovation and incorporation of new services beyond the selling and distributing of energy might provide the most benefits to the communities the co-op serves.

Ultimately, the best business strategy for a co-op to incorporate distributed wind reflects the co-op membership's interest and the organization's goals. Introducing distributed wind through a subscription or community program may be the best way to bring wind energy to a membership base that is divided on wind's merit. For other cooperatives, developing a large wind/storage hybrid project may meet their members' demands for more clean electricity, local investment, and/or rate stability.

Regardless of which business model a cooperative adopts for its distributed wind assets, some project elements with significant impact on the project's overall value should be evaluated before venturing far down the path toward FTM distributed wind development:

- **Wind resource:** The wind project needs to generate enough value to pay for itself over a specified time interval, at minimum. Are there locations within the service territory with sufficient wind resources?
- **Interconnection:** Where can the wind project connect to the distribution grid, and will new required infrastructure (cable, substation, etc.) be cost prohibitive?
- **Land:** Is land for the project available, and can it be accessed for reasonable cost?
- **Locational value:** Will the wind project's location on the distribution system amplify its value by reducing congestion and/or deferring infrastructure outlays and upgrades?

These elements are crucial, but the order in which the cooperative clarifies them can vary. For example, cooperative staff may become aware of available land first, and then a wind resource assessment is in order. Alternatively, a system assessment may point to a location that would benefit greatly from a distributed wind or distributed wind hybrid asset; the cooperative may then start looking for available land or for interested landowners in the vicinity. A wind resource that provides enough energy for generation is most essential, however. When these aspects align, the project has the best chance to succeed.

5.1.1. Value Streams

The tables below outline potential value streams that FTM distributed wind deployment can provide to electric cooperatives and their member-consumers. Further discussion of these value streams can be found in the *RADWIND Value Case Report*.

Table 3: Potential FTM distributed wind value streams for an electric cooperative

Cost-Saving Benefits	**Energy purchase savings**	Energy purchase savings can be realized when the LCOE is lower than the contracted wholesale energy purchase price or other alternatives.
	Deferred generation, transmission, and/or distribution infrastructure investment	By producing power at the times of peak demand and/or at nodes of highest demand, distributed wind can potentially relieve line congestion and defer the need for additional generation, transmission, and or distribution system infrastructure upgrades. This value stream is enhanced significantly when energy storage (e.g., BESS) is paired with a distributed wind asset.
	Peak shaving, avoiding demand charges, reduced capacity costs	If wind energy generation is coincident with peak demand (or paired with energy storage), the distributed wind project has the potential to reduce the peak demand and capacity costs. Demonstrating lower capacity need may reduce capacity charges over time, depending on the power purchase contract's structure.
	Less transmission cost	Lack of transmission is a major hurdle to adoption of utility-scale renewables. Placement of wind or wind-hybrid assets near point-of-use could avoid large investments in transmission. In addition, the benefits of a distributed asset could be realized sooner than waiting for a multi-year wind project queue to clear.
Revenue Benefits	**Tax credits and depreciation**	Taxable subsidiaries of cooperatives can realize benefits from tax credits and depreciation if they own distributed wind assets. Alternatively, for-profit developers with tax appetites can use federal tax credits to provide a lower PPA rate to a cooperative, which would need to be addressed in the PPA negotiations.
	RECs and carbon credits	Additional direct revenue streams, such as renewable energy certificates (RECs) or carbon credits, can improve a distributed wind project's cash flow. RECs can also be offered to member-owners through a green tariff program, which can increase member satisfaction as well as providing an alternate source of revenue for the credits.

Other Benefits with Financial Implications	**Energy price stability**	Long-term fixed-price PPA contracts and/or ownership of a long-lived wind or wind-hybrid asset with predictable operation and maintenance (O&M) costs can offer the security of stable energy costs.
	Hedge against rising fuel/energy costs	Because distributed wind has no fuel cost, it could serve as a hedge against future fuel supply cost increases. A portfolio of generating assets with wind is partially protected against volatility in fuel costs and increased energy prices, generally.
Additional Benefits	**Grid resilience, reliability, avoiding service interruptions**	Distributed wind has the potential to improve power quality and reduce the potential for congestion, line losses, and fires, all of which enhance system power supply reliability.
	Member-owner demand/satisfaction	Including renewable energy, such as distributed wind, in a cooperative's portfolio to meet member demand can lead to higher levels of member satisfaction. (See Table 4)
	Meet net-zero requirements	Distributed wind, as a zero-emissions generating technology, helps utilities meet regulations requiring net-zero emissions by a certain date.
	Meet state-level mandates	Distributed wind generation provides the opportunity to meet not only local energy demand needs, but also state-level clean energy mandates.
	Grid services	With the aid of smart inverters, distributed wind turbines can provide services like voltage support, frequency regulation, and potentially even black start, although markets for some of these services do not yet exist.
	Gaining experience with distributed generation	The electric grid nationwide is incorporating more distributed assets. Cooperatives can gain experience in developing and utilizing distributed wind assets to understand distributed energy resources generally.
	Attracting new businesses/economic development to the community	Because distributed wind is local, building, operating, and maintaining distributed wind can support local economic development. Distributed wind energy could also attract energy-intensive businesses with corporate sustainability goals to the area.
Costs	**Pre-development costs**	Project screening and viability assessments.

	Development and ownership costs	If the cooperative builds, owns, and operates the FTM distributed wind project, the cooperative is responsible for all project costs. These costs range from the wind resource assessment during the development phase to O&M during the performance phase.
	Liability related to member-owner public health concerns	Distributed wind projects may have costs because of wildlife impacts, environmental effects, and human-environment interactions, such as turbine sound and shadow flicker. For example, Fox Islands Electric Cooperative has had to make operational and equipment adjustments to its wind turbines to address some community members' concerns about sound (see the RADWIND case study for more information).

Table 4: Potential FTM distributed wind value streams for co-op member-owners

Cost-Saving Benefits	**Lower electricity rates**	When the LCOE of a distributed wind project is lower than purchased power prices (either wholesale or retail, as applicable) or the cost of new alternative projects, then the value contribution of the distributed wind project is its ability to reduce costs to the cooperative (and those savings can be passed on to members) or the owner of the project.
Revenue Benefits	**Community tax revenue**	Distributed wind and wind-hybrid projects could contribute to community tax revenue.
	Landowner lease payments	Distributed wind and wind-hybrid projects could provide a new source of revenue for landowners in the form of lease payments.
Other Benefits with Financial Implications	**Price stability**	The co-op's long-term PPA contracts for wind energy mean less price volatility for members and less uncertainty for member-owned businesses where energy costs are significant in the budget.
	Local economic development and improved economic resilience	Construction of distributed wind and wind-hybrid projects could use local labor, local materials, and local workers to conduct maintenance.
	Attracting new businesses to the community	Distributed wind energy could attract energy-intensive businesses with corporate sustainability goals to the area, creating new job opportunities for member-owners.
Additional Benefits	**Member-owner demand/satisfaction**	As members own their cooperative, they can drive change in the organization and have higher levels of satisfaction when the change is implemented.

	Grid reliability and resilience	Distributed generation can help mitigate outages and improve community resilience. Strategically sited distributed wind can reduce power supply interruptions due to transmission and distribution outages. It can also play a role in resilience planning for critical community infrastructure and facilities, such as wastewater-treatment plants or communications facilities.
	Environmental improvement	A distributed wind project does not require mining, drilling, or transportation of fuel, and it does not have the risk of large-scale environmental contamination. Distributed wind projects also require minimal amounts of water to operate.
	Educational resource	The presence of a wind energy project may help expand local technical and service training programs. Additionally, local teachers can use the turbines to introduce K-12 students to physics and energy concepts.
Costs	**Impact on wildlife**	Wind energy projects can have ecological and environmental effects, the most notable being the loss or degradation of wildlife habitat and avian fatalities from collisions with land-based structures. Potential wildlife concerns are typically mitigated upfront through the turbine siting process. If necessary, some potential wildlife impacts can be addressed through operations practices, such as curtailment of wind project operations during migratory periods.
	Member-owner public health concerns	There may be public health concerns around turbine sound and shadow flicker. Although there are no peer-reviewed articles or data that demonstrate a direct causal link between wind turbine sound or shadow flicker and physiological health effects, siting software can be used by developers to model and calculate expected shadow flicker and sound levels for stakeholder engagement purposes or to know when turbines may need to be curtailed to mitigate concerns.

5.1.2. Active Business Models

Several business models for FTM wind developments are actively used by electric cooperatives today.

5.1.2.1. Co-op Ownership, Rate Adjustments for all Member-Owners

Cooperatives set rates on a cost-of-service basis. When a distributed wind project is commissioned, rates can be adjusted to factor in the new overall cost of energy and capacity, the long-term energy price stability afforded by wind, and any other savings from deferred infrastructure investments. Alternatively, the project may allow the cooperative to stabilize rates or to slow the rate of increase.

5.1.2.2. PPA with Third-Party Owner, Rate Adjustments for all Member-Owners

Several co-ops have successfully worked with third-party owners to develop projects in their territories and then purchase the generation through PPAs. This arrangement reduces the cooperative's risk exposure by outsourcing the wind project's financing, ownership, and operations to outside entities.

5.1.2.3. Collaboration with Wholesale Power Provider (e.g., G&T)

A distribution cooperative may find it advantageous to coordinate with its G&T to develop and operate distributed wind assets. G&Ts often have the capacity to borrow more money at lower rates and generally have experience developing generating assets and negotiating power purchase agreements. Moreover, wholesale power purchase contracts may preclude or limit how much distributed generation a distribution cooperative develops in its territory, but there are business models that can benefit both organizations through coordination. The G&T may own or negotiate a PPA for a distributed wind asset within a distribution cooperative's territory. In this case, the wind energy enters the distribution grid directly, and the distribution cooperative pays the G&T for this energy as part of its purchasing contract. Alternatively, the distribution cooperative can own the asset. In this scenario, the G&T purchases the energy and sells it back to the distribution cooperative via a PPA, while local economic and community benefits accrue to the distribution co-op (Schmitt et al., 2021).

The benefits of distributed wind and other DER are best realized at the local level. Finding ways for both distribution cooperatives and wholesale providers to benefit from distributed wind development manifests those benefits for member-owners. This type of collaboration may become more common as cooperatives and the industry move towards greater integration of distribution and integrated resource planning. See the NRECA resources in Section 5.1.4 for more insights into inter-cooperative collaboration on DER deployment.

5.1.2.4. PPA with Local Commercial/Industrial Member

If the cooperative has one or more members with large energy appetites, it may consider contracting with them to purchase most of the energy from an FTM distributed wind project. With some of the revenue risk mitigated in a long-term PPA, the cooperative may be free to build an oversized project where the excess energy can be part of a community wind project or simply calculated into the rate structure for other member-owners. An anchor off-taker can also mitigate some of the challenges associated with maintaining sufficient subscription levels in a pure community wind business model.

5.1.2.5. Value Stacking Compensation of Third-Party Developers/Owners

The New York State Research and Development Authority (NYSERDA) uses an intriguing method to compensate the owners of DER, including distributed wind, on its grid.[15] The value of DER is determined based on when and where they provide electricity. Each resource is scored based on Energy Value, Capacity Value, Environmental Value, Demand Reduction Value, and Locational System Relief Value. Community projects can also qualify for additional credit. This methodology, called the "value stack," works like this:

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[15] https://www.nyserda.ny.gov/All-Programs/NY-Sun/Contractors/Value-of-Distributed-Energy-Resources

1. Developer builds and connects DER to the grid.
2. Electricity produced is injected into the grid.
3. Utility determines the value of the energy based on the value stack methodology.
4. Utility allocates the monetary value of the energy produced to the offtaker's bill. For a community project, the developer tells the utility how to split the credits among many offtakers.
5. Offtakers pay a subscription fee to the DER developer. Repeat each month.

While rural cooperatives may not have the demand or capacity requirements to sustain a full value stack system, the NYSERDA method provides insight into how cooperatives can more accurately assess the value of DER on its grid, either in front of or behind the meter. See Section 6.1.3 to learn about an analogous method to value BTM generation.

5.1.3. Potential Business Models

Other business models currently used for distributed solar PV can also support FTM distributed wind.

5.1.3.1. Community Wind

Community solar has gained popularity across the country as a way for energy consumers to utilize solar power in the absence of property or rooftop space to accommodate on-site solar panels. At one time, "community wind" meant that an FTM wind project for all community members was owned by a local resident, but as turbines have increased in size, individuals cannot usually attain enough low-cost capital for such an endeavor. Lacking projects that exemplify the earlier definition, the RADWIND project regards "community wind" as an analog of "community solar": clean energy delivered to the grid and sold via lease or subscription to consumers elsewhere. In the same way that member-owners can purchase blocks of solar energy or the energy from a single solar panel, they can purchase blocks of wind energy or a "slice" of a turbine's rotation. This model allows interested member-owners to participate in renewable energy development even if they cannot have their own BTM project, such as renters or property owners without a good wind resource. A larger wind project designed for community use would generally be more efficient with lower per-kWh costs than smaller BTM installations due to optimal siting and sizing. Thus, member-owners who participate in the community project often see lower energy bills than if they had built a wind turbine for themselves. The optimal siting of such a project could also deliver additional value to both program participants and to the co-op as a whole (e.g., peak reduction, grid support).

Both community solar and wind projects may also offer co-ops an opportunity to better serve low- to moderate-income (LMI) members. Because community projects generally allow renters and those who lack upfront capital to own or lease shares of a larger project, these programs may be appealing to LMI members who value renewable energy but are not in positions to own their own systems. NRECA is exploring how electric cooperatives can facilitate LMI-member access to solar in its Achieving Cooperative Community Equitable Solar Sources (ACCESS) project.[16] Further, the addition of a BESS

[16] https://www.cooperative.com/programs-services/bts/access/Pages/default.aspx

to a community wind and/or solar project may allow deployment patterns that alleviate health and energy reliability issues borne by poor and vulnerable communities (*Energy Storage as an Equity Asset*, n.d.). PNNL's Energy Storage for Social Equity Initiative[17] is a way to learn more.

5.1.3.2. Distributed Wind "Farm"

Corporate entities commonly purchase wind energy from large wind farms via offsite or virtual PPAs. Single distributed wind turbines would not attract the interest of corporate buyers, but an aggregation of smaller projects spread across one or more rural cooperatives may make corporate purchasers take note. By involving a G&T in the planning and execution of this multi-turbine system, a project may be able to site wind turbines across the larger footprint of the G&T's membership. The purchaser would receive the energy production stability of the "portfolio effect"; scattering wind turbines widely over the land mitigates the risk of unfavorable local meteorological conditions impairing the entire fleet's production potential. On the co-op's end, an external entity pays for clean energy that serves its member-owners and reduces the demand for wholesale energy purchases.

5.1.4. Resources

- *Financing Distributed Wind Projects in Rural Electric Cooperative Service Areas* from NRECA, 2021[18]
- *DER Growth Heightens Need for Increased T&D Collaboration and Focus on Bulk Power System Reliability* from NRECA, 2020[19]
- *Unlocking the Flexibility of Hybrid Resources* from Energy Systems Integration Group, 2022[20]

5.2. Standalone Distributed Wind Projects

While most distributed wind projects are interconnected for on-site use (i.e., small wind turbines at homes and farms), utility-scale projects that serve local loads represent more of the installed distributed wind capacity due to the projects' use of larger turbines. FTM projects accounted for 55% of the total installed distributed wind capacity documented from 2010 through 2020 (Orrell, Kazimierczuk, et al., 2021).

5.2.1. Examples

Several distribution cooperatives and public power districts across the country offer examples of successful FTM wind projects.

[17] https://www.pnnl.gov/projects/energy-storage-social-equity-initiative
[18] https://www.cooperative.com/programs-services/bts/radwind/documents/radwind-finance-methods-report-august-2021.pdf
[19] https://www.cooperative.com/programs-services/bts/Documents/Advisories/Advisory-GT-DER-Collaboration-Sept-2020.pdf
[20] https://www.esig.energy/wp-content/uploads/2022/03/ESIG-Hybrid-Resources-report-2022.pdf

5.2.1.1. Co-op Ownership, Strategically Sited Near Commercial & Industrial Member

In 2009, Iowa Lakes Electric Cooperative (ILEC), a 13,000-member distribution cooperative in northwest Iowa, took advantage of two large (15 MW) substations in its territory to add FTM wind farms to its distribution system. Together, the two 10.5 MW wind farms, Lakota and Superior, yield an average annual output of 72,000 MWh.

ILEC sells all of its wind generation to Basin Electric, a G&T, through a 20-year PPA. In practice, however, ILEC's wind energy is used locally by two large ethanol plants (6 MW and 7 MW loads with 24-hour production schedules) for which the 15 MW substations were built. ILEC sized the wind farms to match the ethanol plants' loads; therefore, excess production and backfeed to the transmission grid are not issues. Over the 20-year PPA term, the co-op estimates the wind farms will earn them well over $300,000 a year in margin.

This project highlights the opportunity for distributed wind projects to leverage existing infrastructure that serves large commercial and industrial (C&I) member-owners. For more details, see the complete RADWIND case study on this project.

5.2.1.2. Co-op Ownership for Rate Stabilization

Even a single distributed wind turbine can make a difference. Illinois' Rural Electric Convenience Cooperative (RECC) has saved as much as $120,000 annually since its 900 kW wind turbine went online in 2009. These savings are largely because the wind turbine's per kWh generation cost is below the co-op's wholesale power purchase price. For more details, see the complete RADWIND case study on this project.

5.2.1.3. Co-op Ownership with Tax Equity Partner

Fox Islands Electric Cooperative (FIEC) serves two remote island communities off the southern coast of Maine. For many years, the bulk of the islands' electricity was supplied by ISO New England over an 11-mile-long submarine power cable that runs underneath the ocean floor from the mainland to the islands. This arrangement allowed FIEC to meet the islands' electricity needs but left residents at the mercy of a single transmission cable with significant line losses. Further, the regional energy market sometimes caused electricity prices on the islands to spike to more than double what mainland residents paid.

Image 2: Fox Islands Wind Farm near Vinalhaven, ME
(Credit: Cianbro, https://www.cianbro.com/Projects-Markets/ProjectDetails/pid/495)

To address volatile pricing and energy security, the co-op formed a for-profit subsidiary called Fox Islands Wind, LLC (FIW) to bring a 4.5 MW wind farm online in 2009 that would supply power to its distribution network. The three-turbine wind farm is located on one of the islands served by FIEC so that the community now has a local source of energy that is not subject to fuel price fluctuations or transmission line loss when the energy is used locally. As of 2021, the co-op delivers more than 65% of its electricity from the wind farm and meets the remainder with electricity from the mainland. For more details, see the complete RADWIND case study on this project.

5.2.1.4. PPA with C&I Member-Owner

Completed in 2015, the 12.5 MW Aerojet Rocketdyne solar array near East Camden, Arkansas, demonstrates a successful collaboration of private and cooperative clean energy interests. The solar farm is owned by a private developer (Silicone Ranch of Nashville, Tennessee). Aerojet Rocketdyne purchases the project's electricity from Silicone Ranch through a PPA and uses it in plant operations. Excess energy is purchased through a separate PPA by Arkansas Electric Cooperative Corporation for the wholesale market. This allows both private and public entities meet sustainability goals (Aerojet Solar Farm Partnership Benefits Arkansas' Electric Cooperatives, 2018).

5.2.1.5. Collaboration with Wholesale Providers

One example of a distribution cooperative's distributed wind collaboration with a G&T can be found in Colorado. San Isabel Electric Cooperative has a 25-year PPA with the owner/developer of its 8 MW wind farm to purchase all of the wind farm's energy and its RECs. San Isabel's G&T, Tri-State Generation and Transmission Association (Tri-State), then provides a bill credit to San Isabel for the electricity that San Isabel purchases from the project. Further, San Isabel sells the RECs to Tri-State. The negotiated PPA pricing along with the sale of RECs to Tri-State made the project financially viable by helping San Isabel meet its financial goal of reducing the co-op's wholesale power purchase costs and providing rate stability for San Isabel's member-owners while also meeting its obligations under Colorado's renewable portfolio requirements. For more details, see the complete RADWIND case study on this project.

Several other G&Ts and distribution cooperatives collaborate on small-scale, distributed solar projects. These models are transferrable to distributed wind. For example, Old Dominion Electric Cooperative (ODEC), a Virginia-based G&T, has plans to develop 60 MW of distributed solar projects across 15 sites throughout its territory in response to member input.[21,22] In one of these projects, ODEC is collaborating with BARC Electric Cooperative, one of its distribution members, to develop a 2.5 MW solar project. ODEC will purchase the project's generation through a PPA with the developer. BARC will then buy half of the project's generation to supplement its existing community solar program. The other half of the project's generation will support a shared savings arrangement that reduces peak demand costs for both the distribution co-op and the G&T (Moorefield & Roepke, 2021).

A distribution cooperative in California, Anza Electric Cooperative (AEC), has a PPA with Arizona Electric Power Cooperative (AEPCO) for all of the production of 3.4 MW PV array with battery storage owned by the G&T.[23] AEPCO built the array in Anza's territory to bolster the distribution co-op's resiliency and power supply. Anza is served by a single radial transmission line which is at risk of being overloaded or incapacitated by wildfires. This mutually beneficial project helps the G&T defer

[21] https://www.cooperative.com/programs-services/bts/Documents/Advisories/Advisory-New-Energy-Resource-Model-Case-Study-ODEC-Dec-2020.pdf

[22] https://www.odec.com/generation-transmission-overview/renewables/

[23] https://www.anzaelectric.org/sunanza

transmission line upgrade costs and provides Anza the capability to have an islanded microgrid if needed during an extended power outage on the transmission system (Ahlen & Gibson, 2021).[24]

5.2.1.6. PPA with Third-Party Owner

In 2019, Nebraska's Cuming County Public Power District (CCPPD) turned to locally generated wind energy in an effort control costs for its member-owners. Given the tax incentives and financing options in the years leading up to the project, CCPPD decided to work with Bluestem Energy Solutions,[25] a well-regarded developer in the region with experience working with rural utilities.

Collaborating with CCPPD for site selection and interconnection, Bluestem installed a 2.5 MW wind turbine on a farm owned by a CCPPD member-owner. CCPPD has a 30-year PPA to purchase all of the wind turbine's production. This arrangement now saves CCPPD 3% to 4% on annual energy costs. The wind turbine's production is particularly valuable during peak demand times because CCPPD's power costs are about 50% energy and 50% demand. CPPPD is interested in adding a BESS to the project in the future to offset peak demand at the substation. With this in mind, the project was built with a junction box where a battery can be plugged in if desired. For more details, see the complete RADWIND case study on this project.

5.2.2. Standalone Distributed Wind Project Scenario

This section discusses a hypothetical issue at a rural distribution utility that an FTM distributed wind project could alleviate.

Background Story

Cooperative member-owners have been seeing more rooftop solar installations in the area, and several of them have been calling their co-op's office to express their desire for the cooperative to consider large-scale clean energy resources as well. Consequently, this member-driven interest led the cooperative leadership to explore ways renewable energy could lower rates for all member-owners, hedge against increasing energy costs, and meet member-owner demands.

Selected Value Streams for the Cooperative

- Energy purchase savings
- Peak shaving
- Energy price stability
- Hedge against fuel prices
- Grid resilience
- Member-owner satisfaction

Business Cases

Opportunity 1: Cooperative leadership assess their member-owners' requests and sees there is high interest for locally generated, clean energy. After doing preliminary research, they find that their

[24] For more information on these and other projects see *Electric Cooperative Solar Market Analysis and Trends* from NRECA, 2021.
[25] https://www.bluestemenergysolutions.com

territory has a good wind resource, making the economics for a large-scale, FTM wind turbine favorable. Since this is its first experience with FTM distributed generation, the cooperative decides to seek a PPA with a third-party owner to minimize the co-op's financial risk. The co-op plans to put the wind energy into the general energy mix and use the rate stability and wholesale energy purchase savings to stabilize rates for their member-owners in the long term.

Opportunity 2: Recognizing that there are a few C&I members that may be interested in purchasing wind energy to meet sustainability goals, cooperative leadership engages with their management to arrange a PPA for energy produced by a FTM wind asset. The cooperative organizes an arrangement between a third-party owner of the wind farm, the C&I members, and the cooperative such that there is sufficient production to supply the C&I members and to establish a community wind program with a focus on LMI member participation.[26]

5.3. Distributed Wind Hybrid Projects

Wind energy technology is increasingly being combined with other distributed energy resources and technologies, such as BESS, PV, or combined heat and power (CHP) on distribution systems. These hybrid projects generally have resources that are both co-located and co-operated with shared components and control strategies (Murphy et al., 2021; Ahlstrom et al., 2019).

Distributed wind's generation profile can be complementary to solar PV generation. Researchers at NREL examined the complementarity of wind and solar resources to identify areas in the United States that are particularly suited for wind-solar hybrid power plant development (Clark et al., 2022). Figure 3 shows the annual, daily-averaged complementarity (represented by the Pearson correlation metric[27]) for the year 2013 in the contiguous United States. The red color, indicating a negative correlation, specifies that the wind and solar resource profiles are perfectly complementary, occurring inversely at those locations. The blue color, primarily in the Southwest and California, indicates a positive correlation and areas that are thus less likely to benefit from the complementarity aspect of wind-solar hybrid power plants.

Wind can generate throughout the day, but output tends to be higher during the night. Seasonally, more wind power is generated during the winter. Conversely, solar only generates during the day and tends to have lower output during shorter winter days. As such, a hybrid power plant combining multiple technologies may be able to provide more services to the market than wind alone. For example, wind-storage or a wind-solar-storage hybrid may be useful in ensuring that power plant output is more predictable. This predictability at the right peak times may allow system upgrades to be deferred or offset or allow excess or off-peak generation to be shifted to times when demand is higher and/or the

[26] Clean energy developer Borrego is initiating a community wind program in New York. https://www.borregoenergy.com/blog/leasing-land-for-wind-energy

[27] The Pearson r coefficient is on a scale from -1 to 1, with a score of -1 representing perfect negative correlation, a score of 0 representing no correlation, and a score of 1 representing perfect positive correlation. A perfect positive correlation means that the wind and solar resource profiles occur at the same time in a given location, while a perfect negative correlation means that the wind and solar resource profiles are perfectly complementary, occurring inversely at a given location.

power is more valuable. For these reasons, interest in distributed wind hybrids, and hybrid power plants in general, is increasing.

According to an LBNL report, there were at least 226 co-located hybrid plants of various configurations, with sizes greater than 1 MW, operating across the United States at the end of 2020, totaling more than 29 GW of aggregate capacity. Of these operating hybrid plants, 38 of them include wind. At the end of 2020, there was 209 GW of wind capacity in interconnection queues, with 13 GW of that (~6%) proposed as hybrid power plants (most often paired with storage) (Wiser et al., 2020). While these numbers represent power plants with a capacity greater than 1 MW, hybrid projects are being installed at all scales, including at the distribution level.

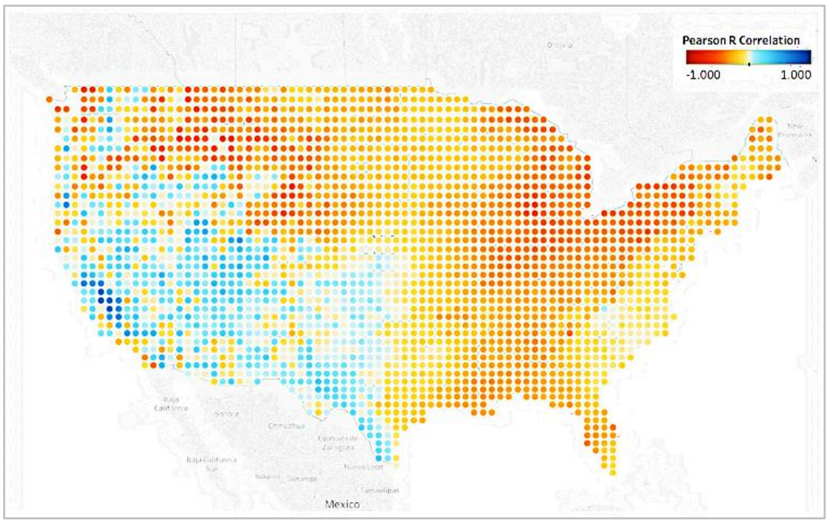

Figure 3: Annual, daily-averaged complementarity of solar and wind resources (represented by the Pearson correlation metric) for 2013 in the contiguous United States (Clark et al., 2022)

5.3.1. Examples

Co-ops are gaining experience with distributed, hybridized developments.

5.3.1.1. PPA with Third-Party Owner

Lake Region Electric Cooperative's (LREC) distributed 2-MW wind-solar hybrid project, mentioned later in Section 8.1.2. for its associated grid-responsive water heater pilot, shows how a distribution cooperative can optimize multiple sources of renewable energy to benefit its member-owners. The 2 MW project became operational in 2019 and consists of a co-located 2.3 MW General Electric (GE) wind turbine, a 500 kW PV array, and a 2 MW GE inverter that uses GE's Wind Integrated Solar Energy (WiSE) platform. The inverter dictates the overall system output at any given time—thus a 2 MW system rating—and the WiSE platform integrates the solar production through the wind turbine's converter, improving net capacity and annual energy production. The hybrid system allows the co-op to offset winter peaks with wind and summer peaks with solar. The co-op did not include battery storage in the original design to reduce up-front costs and simplify regulatory burdens, but LREC is keeping an eye on battery technology and prices and may decide to add a BESS to the project at a later date.

LREC has saved well over the predicted $200,000 per year on wholesale energy purchases since the project was installed. In addition, the 20-year power purchase agreement (PPA) with the project developer, Juhl Energy, is a hedge against potential future increases to LREC's wholesale rates.

Although the project provides power primarily to member-owners on its substation, the co-op considers the project beneficial for all member-owners because it:

- responds to members' interest in renewable energy;
- reduces the co-op's wholesale power purchase costs; and,
- saves members money—annual savings from the project support retail rate stabilization.

For more details, see the complete RADWIND case study on this project.

5.3.1.2. Co-op Ownership

Alaska's Kotzebue Electric Association (KEA) successfully puts a distributed wind-solar hybrid system to the test on its remote, isolated grid. KEA has been a pioneer in distributed wind since the 1990's when it developed the first utility-scale wind farm in Alaska and the northernmost wind farm in the U.S. To continue to reduce its dependence on expensive diesel fuel, KEA has diversified its generation fleet to a fully functional hybrid system with a BESS. As of 2021, the co-op owns and operates 0.5 MW of solar PV, 2.4 MW of installed wind capacity, 11 MW of diesel generation capacity, and a 1 MW/1 MWh lithium-ion BESS. In addition to storing excess energy, the BESS can also provide frequency support to grid as needed, for example, if a wind turbine goes offline unexpectedly. The complimentary nature of wind and solar generation serves the co-op well. The PV array yields peak production in the summer but no winter generation. Conversely, wind generation peaks during winter and spring when solar production is low, and typically declines during the summer when PV contributes the most.

The project saves the co-op money. A 2015 study of just the two newest 900 kW turbines by the Alaska Energy Authority found that these two turbines alone saved KEA 229,000 gallons and over $800 thousand on an annualized basis in diesel costs during the first year and a half of operation. With an estimated benefit/cost ratio of 1.36 over the project's planned 20-year lifetime, the project will more than pay for itself with fuel cost savings (Tressel, 2015). Other benefits include local resiliency and a hedge against potential increases to fuel and fuel delivery costs. For more details, see the complete RADWIND case study on this project.

5.3.1.3. Co-op Ownership with Tax Equity Partner

FIEC is actively pursuing the addition of battery storage to increase the value and local utilization of its wind project. From the RADWIND Fox Islands case study: "Adding battery storage to the wind farm could have a significant impact on the co-op and the community. If FIW stored excess generation for use when demand is greater than generation, the co-op could reduce its wholesale purchase to under 2,000 MWh in a typical year, which is less than half of its current annual wholesale power purchase need of about 5,000 MWh. Energy storage would insulate members from future wholesale price swings and allow the islands to operate almost entirely off of renewable energy, increasing resilience and energy independence. Furthermore, using the wind energy locally would avoid the 6% line loss associated with transmitting power to and from the mainland" (p. 9).

5.3.2. Distributed Wind/Solar/Storage Hybrid Project Scenario

This section discusses a hypothetical challenge at a distribution cooperative where an FTM distributed wind hybrid project would be a viable solution.

Background Story

A cooperative has experienced significant population growth in an exurban area of its service territory. As the demand for energy has thus increased, the cooperative is experiencing line congestion during peak usage hours. An earlier exploration of the wind resource in the area showed potential for a viable distributed wind project, but the forecasted generation is not expected to be coincident with the peak usage hours. As a result, the cooperative's leadership decided to explore how the complementary nature of wind and solar energy generation together could alleviate these concerns. Including energy storage could allow wind and solar energy to be harvested, stored, and then injected back into the distribution grid to relieve congestion during peak usage hours.

Selected Value Streams for the Cooperative

- Energy purchase savings
- Deferred distribution infrastructure investment
- Peak shaving
- Energy price stability
- Hedge against fuel prices
- Grid resilience
- Member-owner satisfaction
- Attracting new business to the area

Business Cases

<u>Opportunity 1:</u> Cooperative leadership seeks a developer to assess the wind and solar resources at an interconnection point that would alleviate congestion. The combined resources have strong complementarity, and the developer designs an asset that includes energy storage. The cooperative has an all-requirements contract with their bulk power supplier, but there is a carve out allowing the distribution co-op member to self-supply a certain share of energy and/or capacity. The co-op informs the developer to size the hybrid system to fit within its distributed generation allowance. The developer and cooperative sign a PPA for the energy from the hybrid system.

<u>Opportunity 2:</u> Cooperative leadership seeks a developer to assess the wind and solar resources at an interconnection point that would alleviate congestion. The combined resources have strong complementarity, and the developer designs an asset that includes energy storage. When sized to maximize value to the distribution system, the hybrid power plant exceeds the allowances under the co-op's contract with its G&T. The distribution co-op reaches out to the G&T to find an arrangement that would benefit all stakeholders. They strike an agreement whereby the G&T owns or signs a PPA contract for the distributed wind hybrid asset and sells its energy to the member cooperative.

6. Behind-the-Meter Business Cases

A BTM wind turbine is connected to the local distribution grid behind a member-owner's utility meter typically to meet all or some of the onsite energy needs. BTM wind turbines offset retail electricity demand and may provide excess generation to distribution grid through net-metering or other billing mechanisms. BTM distributed wind projects are more difficult to track than FTM projects because the majority of them are small wind turbines for homes, farms, and schools although there are a number of C&I member-owners that use BTM distributed wind, often utilizing one or more mid-sized or large turbines. Of the almost 950 MW of distributed wind projects PNNL has documented from 2003 through 2020, at least 344 MW (or 36%) of that capacity is considered to be BTM.

6.1. Overview

The growth of BTM distributed generation has caused electric cooperatives to reevaluate rate structures. Typical rates are comprised of a fixed charge, or "customer charge," and a variable energy charge for the number of kilowatt-hours consumed. The fixed customer charge has historically been insufficient to cover the true fixed costs of providing energy service to the co-op's member-owners such as building generation, transmission, distribution, communications infrastructure (see Figure 4).[28] Thus, these costs must be recouped through the variable charge via energy sales, and the per kWh rates are calculated accordingly (National Rural Electric Cooperative Association, 2014).

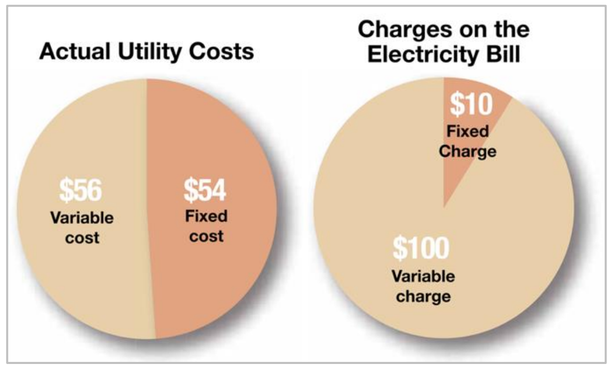

Figure 4: Common proportions of variable and fixed costs in utility budgets vs. proportions on member-owner bills
(Zummo, 2015)

BTM generation exacerbates inherent flaws in simple two-part rates. If a member-owner generates their own energy, they offset purchased energy from the utility and the reduced volumetric payments may not be adequate to recover their portion of fixed charges. Additionally, the variable charge is meant to reflect each member-owner's level of electricity use and thus their share of the cooperative's cost to provide services to the community. If the cooperative raises energy rates to recover their annual revenue requirement, the subset of member-owners with BTM generation will bear a proportionally smaller burden than their fellow co-op members. This unfairly shifts costs to those who do not generate any of their own electricity, many of whom may be LMI members who already experience financial stress (National Rural Electric Cooperative Association, 2014). For these reasons and others, cooperatives sometimes hesitate to embrace BTM generation. The goal of this section is to help cooperatives realize distributed wind's value as a BTM resource while maintaining or even growing the co-op's business. Beyond finding a way to accommodate BTM distributed wind, a cooperative can design its rates, billing

[28] United Power (CO) provides an excellent summary of utility cost components. https://www.unitedpower.com/sites/unitedpower/files/Documents/Energy%20Programs/Demand/DemandRate_UtilityCosts.pdf

methods, and program offerings to accommodate distributed wind development while improving service for member-owners and supporting its finances.

The business model a co-op chooses varies based on the organization's goals and the desires of its members. Designing rates and establishing billing practices requires balancing system needs and member-owner needs while keeping an eye on the bottom line. Many utilities, including co-ops, follow established rate-making principles updated for the challenges of modern grids (Bonbright, 1961). These principles should produce utility rates that:

- Are fair and non-discriminatory
- Minimize volatility impact
- Send proper pricing signals
- Are understandable and transparent
- Encourage efficient and responsible usage
- Manage evolving consumer expectations
- Allow for the integration of new technologies
- Are tailored to local conditions
- Minimize cross-subsidies

Adopting advanced metering infrastructure (AMI) technology gives cooperatives the tools to implement new rate designs as well as offer programs and services that may include financially attractive deployment of distributed wind (National Rural Electric Cooperative Association, 2021).

A member-owner can work directly with a project developer or installer to construct their BTM wind turbine but is likely to check what informational resources are available from their cooperative and what requirements the cooperative has for distributed generation interconnection. This provides the cooperative with another opportunity to act as a trusted energy advisor. This role can involve providing educational information, answering questions, vetting vendors and technologies, or advocating for member-owners through the process. Many cooperatives already do this. United Cooperative Services' "Let Us Help You With Your Renewable Project"[29] and United Power's "So, You're Considering Solar?"[30] webpages are examples. The RADWIND project provides additional resources that cooperatives can use to assist and advise members on BTM distributed wind.

Another opportunity to be more involved in BTM installations is through the Energy-as-a-Service business model, detailed in Section 8.2. The EaaS business model would entail a greater degree of cooperative involvement up to and including owning, managing, and maintaining a BTM wind asset.

6.1.1. Value Streams

The following tables outline potential value streams that BTM distributed wind deployment can provide to electric cooperatives and their member-consumers. Further discussion of these value streams can be found in the *RADWIND Value Case Report*.

[29] https://ucs.net/renewable-energy

[30] https://www.unitedpower.com/going-solar

Table 5: Potential BTM distributed wind value streams for an electric cooperative

Cost-Saving Benefits	**Peak shaving**	If wind energy generation is coincident with peak demand (or paired with energy storage), the distributed wind project has the potential to reduce peak demand.
	Deferment of distribution and transmission line investments	By producing power at times of peak demand (or being paired with energy storage), distributed wind can potentially defer the need for transmission and/or distribution system investments and infrastructure upgrades.
	Reduced line congestion	By providing power close to loads, BTM wind generation could help avoid or mitigate distribution and transmission congestion and associated costs.
	Decrease demand for purchasing wholesale power	When member-owners install BTM wind power, it will displace their energy purchases from the distribution co-op. In turn, the distribution co-op will reduce its wholesale power purchases.
	Less transmission cost	Lack of transmission is a major hurdle to adoption of utility-scale renewables. Placement of wind or wind-hybrid assets behind the meter could avoid large investments in transmission.
Other Benefits with Financial Implications	**Local economic development**	Building, operating, and maintaining distributed wind projects can support local economic development.
	Avoid transmission losses	Distributed wind assets located near loads avoid energy losses resulting from long-distance transmission.
Additional Benefits	**Member-owner demand/satisfaction**	Supporting member demand for BTM wind installations is crucial for member-owned cooperatives and the support can lead to higher levels of member satisfaction.
	Input on energy infrastructure within service area	Related to member demand and satisfaction, a cooperative's support of BTM wind and wind-hybrid installations allows the cooperative to have input on what energy infrastructure is implemented in its service area.
	Improved member-owner relationship	Cooperatives assisting members with their own distributed wind projects can enhance member-owners' perception of the cooperative as a trusted, helpful partner.
Costs	**Lost electricity sales revenue**	Lost revenue due to electricity self-supply from BTM installations can be considered a financial cost to a cooperative. This can be mitigated through proper rate design.

	Administrative costs	If a cooperative starts a new DER compensation or interconnection program for BTM installations, there will likely be administrative costs to implement and maintain the program. Administrative costs can include marketing, program application evaluation, interconnection review, insurance, and measurement and verification.
	Interconnection costs	In addition to administrative costs, there can be capital costs associated with equipment and technologies needed to interconnect the DER. These costs can sometimes be passed on to the member-owners participating in the program.

Table 6: Potential BTM distributed wind value streams for co-op member-owners

Cost-Saving Benefits	**Lower electricity bill charges**	BTM wind projects can provide economic savings (primarily through the reduction of utility bill charges) for the owner.
	Reduce peak demand and demand charges	The generation from a BTM project for a C&I member-owner could be coincident with the facility's load and thereby reduce the member's demand charges. A distributed wind hybrid with solar or storage has the potential to further reduce peak demand and associated demand charges.
Revenue Benefits	**Incentives and tax credits**	Member-owners of BTM distributed wind can monetize federal, state, and utility incentives that will lower their project capital costs. Owners can benefit from federal tax incentives or credits for qualifying distributed generation projects.
	RECs and carbon credits	A member-owner with BTM distributed wind may be eligible to sell the RECs or carbon credits from the project. This would create an additional revenue stream for the project. The member-owner's cooperative could purchase the RECs to help it meet state renewable portfolio standard requirements.
Other Benefits with Financial Implications	**Long-term stable or fixed energy prices**	If a member-owner enters a long-term PPA with a third-party owner of the wind asset, their electricity prices will remain steady over a long time horizon. This benefits any member, but C&I members may find the predictability of energy costs especially favorable for business planning.
	Hedge against increasing retail electricity rates	Because distributed wind has no fuel cost, its energy generation can serve as a long-term hedge against future fuel supply cost increases. BTM distributed wind can also provide an alternative to purchasing electricity at variable, or rising, retail rates.

Additional Benefits	**Member demand/satisfaction**	As members own their cooperative, they can drive change in the organization and have higher levels of satisfaction when the change is implemented.
	Public relations and meeting sustainability goals	C&I member-owners can use distributed wind to achieve corporate sustainability goals. Corporate entities can tout their use of green power from BTM projects they own and operate themselves (or also through PPAs with other entities).
	Local economic development	Installation of wind turbines may use local materials and labor, especially in the size range of typical BTM assets.
Costs	**Installation costs**	Member-owners are responsible for purchasing their BTM distributed wind turbines and paying for them to be installed, or for entering into an agreement with a third-party for these services. However, utility, state, and federal incentives may be available to lower the upfront capital costs. If the member-owner relocates, they might not be able to realize the full return on investment for the installation.
	Interconnection costs	Member-owners may be expected to pay for equipment, technologies, or studies necessary to interconnect their BTM installations.
	O&M costs	Member-owners are responsible for operating and maintaining their BTM distributed wind projects or contracting to a provider for this service. If the BTM installation is owned and operated by a third-party, the third-party is responsible for O&M, and these costs are captured in the PPA rate.

6.1.2. Active Business Models

Cooperatives and other utilities employ a variety of rate structures and billing methods to align revenue with costs while opening the market for BTM distributed generation.

6.1.2.1. Net Metering

Retail net metering means that member-owners with self-generation capabilities have a meter that rolls forward when they use electricity from the grid and backward when excess generation is exported to the grid. The member, therefore, is compensated at the retail rate for their generation by offsetting retail purchasing and by payments for excess, exported energy that may be equal to the retail or wholesale per kWh charge, or somewhere in between, depending on the program. Member-owners must also pay their fixed cooperative customer charge and any other non-volumetric charges depending on the rate structure and class at their cooperative. Almost all states allow net metering, but the rules for each state vary widely with regards to customer payment caps, eligible technologies, allowable generating unit size, and even total net metering program participants.

Image 3: Net Metered Small Wind Turbine at a Member's Business in Homer, AK

(Credit: Homer Electric Association, https://www.cooperative.com/programs-services/bts/radwind/Documents/RADWIND-Case-Study-Homer-Electric-July-2021.pdf)

Cooperatives have discovered significant challenges in maintaining net metering programs. Net metering rules demand that utilities pay for often variable, low-value power and exacerbate cost shifting. To mitigate these problems, some co-ops have put restrictions on which member-owners and technologies qualify for net metering. Co-ops may also consider adjusting other rate components to better align costs with revenue (see Section 6.1.2.3 below).

6.1.2.2. Variations on Net Metering

- **Aggregated Net Metering:** One member-owner who receives service via multiple meters or accounts at their property can combine their loads such that a BTM generator (wind turbine, solar PV, etc.) can offset electricity purchases for the entire aggregate account.
- **Community Net Metering:** Multiple members of the same cooperative can share the output of a generating asset and offset utility power purchases using each member-owner's share of the generator's output. This is similar to the "community wind" model described in Section 5.1.3 except community net metering assets are typically located BTM versus the FTM interconnection implied by "community wind."
- **Virtual Net Metering:** A member-owner can combine loads from multiple meters at different facilities on different properties into a single aggregate to be served "virtually" by a BTM generating asset.

6.1.2.3. Retail Rate Structures

- **Straight-Fixed Variable Rate:** This rate design brings the fixed and variable components of members' bills in line with the cooperative's true cost of supplying electricity: fixed costs are recovered through fixed charges and variable costs through variable charges. A detailed cost of service study can delineate the cooperative's cost structure, and then the fixed customer charges can be increased and the per kWh charge decreased accordingly. Rebalancing the rates in this way safeguards the utility's financial stability and avoids cross subsidization when members install distributed generation.

- **Residential Demand Charges:** Demand charges are widely used in the C&I rate class, and they are gaining popularity for residential rates as well. Member-owners are charged a fee according to the strain their load places on system resources as measured by their maximum power demand during a specified time interval. Demand charges can encourage members to space out appliance use to flatten load profiles or to reduce their load during distribution system peak periods.
- **Standby Charges:** Used to charge C&I members for providing backup energy when on-site combined heat and power systems are down, standby charges are now being considered for member-owners with DER such as wind turbines. They can be fixed or variable.

6.1.2.4. Time-Of-Use Pricing or Time-Varying Pricing

Time-of-Use (TOU) pricing and Time-Varying Pricing (TVP) both describe the diverse methods of pricing electricity differently during discrete periods of the day. Utilities can set rates that reflect the true cost of delivering electricity services throughout the day, and since net metering rates are equal to retail rates, member-owners with distributed generation would be compensated in a way that reflects the energy's real value at the moment of export. TOU/TVP pricing can be as simple as a two-tier on-peak/off-peak structure or more complicated with many pricing periods.

6.1.2.5. Net Billing

Under a net billing regime, the utility measures the cooperative-supplied energy consumed by the member and—with a separate meter—measures the amount of energy exported to the grid by any member-owned distributed generation. Consumed energy is charged at the retail rate while exported energy is credited using a different rate set by the cooperative. The co-op may use wholesale power cost, avoided cost, or some other credit rate. The energy charges and energy credits are netted to calculate the member's monthly bill. Net billing allows cooperatives to credit distributed generation at its actual system value, but since any self-generation used on-site is not accounted for, a member-owner's variable charge will still decrease compared to their bill before installing distributed generation.

6.1.2.6. Buy-All, Sell-All or Separate Billing

In contrast to net billing, cooperatives using Buy-All, Sell-All arrangements move the two meters such that one measures all consumed electricity regardless of origin and the other measures electricity produced by the member's BTM asset regardless of destination. The member then agrees to purchase all consumed energy at the retail rate ("buy-all," from the member-owner perspective) and the cooperative agrees to purchase all member-generated electricity at a pre-determined, different rate ("sell-all"). The energy charges and energy credits are netted to calculate the member's monthly bill. All electricity is accounted for in this billing structure.

6.1.3. Potential Business Models

There are alternative rate structures that can be employed to incorporate BTM distributed wind into a cooperative's portfolio.

6.1.3.1. Value of DER Tariff

Value of solar (VOS) is a method of measuring and valuing the output of BTM, member-owned distributed solar generation when it exports energy to the utility. This method has grown as an alternative to net metering. It mirrors the Value Stack employed by NYSERDA for FTM generation (see Section 5.1.2). As a billing technique, VOS has so far only been applied to solar PV, but a cooperative could modify the same framework into a "Value of Wind Tariff" or a "Value of DER Tariff." As an illustration of this concept, "wind" will replace "solar" for the remainder of this description.

While net metering requires compensating members at the retail rate for their excess energy, the VOS method evaluates that energy for its worth to the distribution system and determines the compensation rate accordingly. Energy use by the member-owner is metered and billed at the retail rate. Energy production is separately metered and evaluated on several criteria, which may include:

- **Energy:** Time-specific avoided cost from buying from the wind energy unit instead of the alternative.
- **Generation Capacity:** Value attributed to generation capacity deferral if wind generation correlates with utility system peaks.
- **Transmission & Distribution:** Value of the wind energy's ability to defer T&D expenses.
- **System Losses:** Avoided energy loss from transmission because the wind energy system is sited at the load.
- **Environmental Benefits:** Distributed wind may reduce emission compliance costs or other regulatory costs.
- **System Integration:** Costs allocated to variable generation.

These criteria are not limited to assessing the wind energy's instantaneous monetary value. They can be designed by the utility to reflect the full value of distributed generation on its system or to encourage distributed wind deployment.

6.1.3.2. Granular Rates or "Á La Carte"

Granular pricing means unbundling and separately pricing each service provided to or procured from member-owners. Members can choose which services they will purchase and which they will supply to the cooperative through their DER. In this way, members can avoid paying for services that they can get through their own on-site assets and/or they can be compensated for their asset's grid contributions. This type of rate structure provides maximum flexibility for the member, but its inherent complexity may restrict its use to only the largest and most savvy electricity consumers in the cooperative's territory.

6.1.3.3. Procurement Billing

From LBNL:

The pricing of services the utility provides customers with DERs is in the form of a bundled utility price. The services DERs provide to the utility are procured on a competitive basis, with third-party aggregators likely playing a role in presenting a value proposition to both the utility and the DER owner/host that meets their financial and other criteria ...Third-party aggregators maintain the direct business relationship with DER customers, pricing services on a competitive basis....Utilities procure *distribution services from non-regulated third parties who aggregate the services provided by individual DER customers and compensate those customers accordingly.* (Hledik & Lazar, 2016, pp. 1, 7, 16)

6.1.3.4. DER-Specific Rates

From LBNL:

The utility applies separate rates to customers with DERs, both for supplying backup and supplemental service and for procurement of services from DERs. Each type of DER faces a different type of rate, based on the characteristics of the resource and technology…Customers with DERs pay separate tariffs for service, based on the unique service characteristics of their requirements. Standardized credits are calculated for services provided by DER customers on a technology-by-technology level.… A different rate is offered to each class of DER customer to reflect the costs of serving that type of customer as well as the value of the services that the specific class of DER customers provide. (Hledik & Lazar, 2016, pp. 2, 7, 16)

6.1.3.5. Co-op Owned and Managed or "Energy-as-a-Service"

See Section 8.2

6.1.4. Resources

- *Distributed Generation: Finding a Sustainable Path Forward* from NRECA, 2014[31]
- *Minnesota "Public Power Forward" Toolkit* from the Minnesota Municipal Utilities Association, 2018[32]
- *Rate Design for Distributed Generation: Net Metering Alternatives with Public Power Case Studies* from the American Public Power Association, 2015[33]
- *Survey: Electric Cooperative Fixed Cost Recovery* from Power Systems Engineering, Inc., 2014[34]
- *Rate Case Studies* from NRECA, 2016[35]
- *Distribution System Pricing with Distributed Energy Resources* from LBNL, 2016[36]
- *Developing Rates for Distributed Generation* from NRECA, 2001[37]
- *Microgrids for Energy Resilience: A Guide to Conceptual Design and Lessons from Defense Projects* from NREL, 2020[38]

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[31] https://www.cooperative.com/programs-services/bts/distributed-energy-resources/documents/dg-booklet.pdf

[32] https://www.mmua.org/userfiles/ckfiles/files/MN%20PPF%20Toolkit.pdf

[33] https://www.publicpower.org/system/files/documents/ppf_rate_design_for_dg.pdf

[34] https://www.powersystem.org/wp-content/uploads/2018/04/Survey-Electric-Cooperative-Fixed-Cost-Recovery.pdf

[35] https://www.cooperative.com/programs-services/bts/Documents/DG-Toolkit/NRECA_RateCasestudies.pdf

[36] https://eta-publications.lbl.gov/sites/default/files/feur_4_20160518_fin-links2.pdf

[37] https://www.cooperative.com/programs-services/bts/Documents/DG-Toolkit/RatesForDistributedGeneration.pdf

[38] https://www.nrel.gov/docs/fy19osti/72586.pdf

6.2. BTM Distributed Generation Business Models in Action

Industrial, commercial, institutional, and large agricultural facilities can be powered by distributed wind installed behind the meter. Distributed wind can be used to power industrial facilities that manufacture goods or perform engineering processes, such as food processing plants, appliance manufacturing plants, and oil and gas operations. Facilities with both a good wind resource and the requisite electricity demand and property size to deploy larger MW-scale turbines are good candidates for BTM distributed wind. PNNL estimates there are at least 77 MW of BTM distributed wind installed for industrial customers across the United States (Orrell, Kazimierczuk, et al., 2021).

Residential customers with BTM distributed wind typically use small wind turbines (those up through 100 kW) because the projects are normally sized to meet the onsite load, or part of it. In 2020, 1.6 MW of small wind was deployed in the United States, representing 1,487 units and $7.2 million in investment. Residential projects account for most of the documented distributed wind turbines in the United States (Orrell, Kazimierczuk, et al., 2021), but because they are small capacity, they do not represent a large share of the overall installed distributed wind capacity.

As discussed in Section 6.1, while cooperatives will generally not have a direct role in BTM projects, they can serve as trusted energy advisors to members who are interested in pursuing them. The co-op can play an important role in educating their member-owners and helping to optimize BTM distributed wind installations and integrate them with the cooperative's planning processes. If the co-op can engage early with members and developers, then the outcome of these BTM projects can be improved for all stakeholders.

6.2.1. Examples

Cooperatives and other utilities around the country are innovating how they structure their business as DER deployment grows.

6.2.1.1. BTM C&I Projects Designed to Meet Onsite Needs

Honda Motor Corporation set out to reduce factory carbon dioxide emissions by 10% before 2020. Since the Honda Transmission Manufacturing plant near Russells Point, OH, could not reduce its electricity consumption, the leadership there chose to find a cleaner energy source. In 2014, the plant commissioned two GE 1.7 MW wind turbines behind their utility meter on factory property. Since then, the turbines have exceeded expectations by generating more than 10% of the plant's electricity demand (Lillian, 2019). A third-party owns the project, maintains the interconnect agreement with Logan County Electric Cooperative, and has a PPA with Buckeye Power, Inc. (NAW Staff, 2014).

Similarly, the Anheuser Busch Plant in California uses two large BTM GE turbines to power the brewery's onsite energy needs. The 1.5 MW and 1.6 MW turbines were installed in 2011 and 2014, respectively, and produce an estimated 7,400 MWh of energy annually. Together, these two turbines generate enough energy to brew, package, and ship over 57,000 cases of beer each day (*Anheuser Busch - Fairfield, CA*, n.d.). When resource conditions are favorable, the onsite wind and solar energy technologies are capable of providing 30% of the brewery's electricity needs. The $10,000,000 cost to install these two turbines was partially defrayed by incentives from California's Self-Generation Incentive Program (SGIP), totaling $3,000,000 in collective awards (*SGIP Program Statistics*, n.d.).

As a final example, the Renewable Energy Group (REG) brought a 2.5 MW GE wind turbine online near its Albert Lea, Minnesota, biodiesel plant in December 2020. The wind energy produced is meant to help REG meet its sustainability goals and to decrease the carbon score (a measure carbon impact) of its product. Biofuel carbon impact measurement rules are strict. In order for the turbine to reduce the REG plant's carbon score, the wind turbine had to be connected directly to the plant to offset electricity use from fossil fuel sources. As a result of this distributed wind project, the diesel fuel from the Albert Lea facility has less than one-third the carbon impact of conventional diesel fuel (*A Q&A with Juhl Clean Energy Assets, Inc.*, 2021). Clay Norrbom, Managing Director of Juhl Clean Energy Assets, Inc., which developed and owns the wind facility, said of the REG project:

Image 4: GE 2.5 MW turbine with direct connection to nearby biodiesel plan near Albert Lea, MN

(Credit: Juhl Clean Energy Assets, https://www.juhlcleanenergyassets.com/ projects/)

Here, the REG facility is served by Freeborn-Mower Electric Co-op – another example of where we can go in and work with the co-op instead of cutting them out. We need to continue to work with rural co-ops to build renewable energy within their own distribution networks instead of buying from bigger facilities. That way, more dollars stay in the co-op territory and benefit all members with cleaner [energy] and lower electricity costs. (*A Q&A with Juhl Clean Energy Assets, Inc.*, 2021)[39]

6.2.1.2. Net Metering at a Family Farm

The Minnick family installed an Eocycle 25 kW turbine behind their utility meter to lock in a low, fixed energy price when their Cosmos, Minnesota farm's energy demands increased. Local, state, and federal financial incentives made the project economics even more favorable. A project profile is available on Eocycle's website.[40]

6.2.1.3. Community Net Metering

Massachusetts allows for community net metering for distributed wind, solar, and other types of generation. The asset's host can be any utility customer, so the asset may be located behind the utility meter on almost any property. If a host customer receives a net metering credit for a billing period, they can allocate that credit to other customers of the electric company within the same load zone by submitting a form to the electric company. Rates vary with the size and type of host facility, but the

[39] https://www.cleanenergyeconomymn.org/blog/qa-juhl-clean-energy-assets-inc

[40] https://eocycle.com/minnick-farm

upshot is that any customer can become the host of a distributed wind power plant that serves a subset of subscribers.[41] Vermont, Maine, and other states allow similar models.[42]

6.2.1.4. Demand Charge

Several co-ops now include a demand charge in some or all of their residential rates. For example, United Power, a Colorado distribution cooperative, offers four residential rate options, all with varying levels of demand and kWh charges. Because members may not be familiar with what demand is and how to control it, a significant outreach and education effort prior to a demand charge taking effect is recommended. United Power's website includes multiple educational videos and written explanations.[43]

6.2.1.5. Buy-All, Sell-All Value of Solar Tariff

As an alternative to net metering, Austin Energy in Texas implemented a "buy-all, sell-all" value of solar (VOS) rate in 2012 (Zummo, 2015). In this business model, the distributed generation customer buys electricity from the distribution utility at one rate and sells distributed generation output to the utility at the VOS rate. This VOS tariff measures electric system attributes and how distributed solar energy positively and negatively affects the value of each. Benefits of the VOS rate include a fairer rate, reduction in the payback period for solar customers, and greater energy conservation and energy efficiency (as a result of decoupling the credit from the customer's energy consumption). Since Austin Energy implemented the tariff, it has made a number of key modifications to reduce volatility associated with fuel price hedge values (e.g., natural gas future prices) and barriers to participation by eliminating the residential system size eligibility cap (Zummo, 2015). This type of rate design approach could be applied to distributed wind generation customers.

6.2.1.6. Time-Based Pricing

TOU/TVP rates are increasingly common at electric cooperatives and other utilities. To better recover its cost of service, the Sacramento Municipal Utility District (SMUD) increased its residential base rate and migrated to time-based energy pricing for all residential customers.[44] While TOU/TVP rates may not directly address BTM generation, such rates may impact the value of customer or member-owner generation based on the time of day it is produced (Zummo, 2015).

6.2.1.7. Net Billing

In 2012, St. Croix Electric Cooperative (SCEC) in Wisconsin began reevaluating its net-metering policy for member-owned distributed generation systems due to concern over the cooperative's ability to equitably provide power to all members with its current net-metering rate design. SCEC determined that continuing to compensate members for DG system excess generation at the retail rate would not be economically sustainable as interest in installing DG systems continued to grow. In a first round of changes, the maximum size of DG systems that could qualify for net-metering was reduced from 40 kW to 20 kW; net-metering members were moved to a monthly true-up rather than rolling excess generation

[41] https://www.mass.gov/guides/net-metering-guide

[42] https://ilsr.org/rule/net-metering/updated-states-supporting-virtual-net-metering/

[43] https://www.unitedpower.com/demand

[44] https://www.publicpower.org/system/files/documents/ppf_rate_design_for_dg.pdf

forward throughout the year; and excess generation was compensated at SCEC's avoided cost rather than the retail rate. In a second round of changes, a third-party rate study guided SCEC in developing enhanced avoided cost rates that consider daytime solar hours, in addition to capacity credits during peak billing months. The study also informed the basis for a grid charge for net-metered systems that was implemented to ensure recovery of fixed costs. By proactively addressing the issue early, conducting a third-party rate study, providing opportunities for member input, and communicating directly with members about upcoming policy changes, SCEC achieved a smooth transition toward the new policies (National Rural Electric Cooperative Association, 2016).

6.2.1.8. Bergey WindPower BTM Microgrid Project

Bergey WindPower is a small wind turbine manufacturer headquartered in Norman, Oklahoma. Its manufacturing facility, where it produces 10- and 15-kW wind turbines, is serviced by Oklahoma Electric Cooperative. Bergey WindPower, in partnership with Oklahoma Electric Cooperative and other business partners, is developing a DER sales business model which would enable rural electric utilities to offer DER solutions directly to utility customers.

In this business model, a rural electric utility would finance and sell a hybrid distributed wind-solar-storage BTM microgrid system to its utility customers. Low-cost, long-term financing by the utility is a critical aspect of the business model, as microgrids for homes are expensive.

The customer would benefit from Federal tax credits, utility bill savings, and the resilience (backup power) the islandable microgrid would enable in the event of grid failure. The business model would be a revenue-positive venture for rural electric utilities because they would benefit from peak-shaving, grid support capabilities, and potential deferral of distribution system upgrades. The project team plans to estimate the value of peak-shaving and upgrade deferrals with real data from Oklahoma Electric Cooperative.

6.2.2. BTM Industrial Project Scenario

Distributed wind can serve many types of member-owners when installed behind the meter. Industrial facilities often have large electrical loads and thus represent an opportunity for BTM distributed wind development.

Background Story

A scrap metal recycling facility in co-op territory is expanding due to increased value of various metal products. It will install new furnaces and utilize more energy, so it would need electricity service upgrades. At the same time, their parent company has recently stated sustainability goals. The CEO decides this is a great opportunity to add renewable energy to their portfolio, and they call the cooperative to arrange a meeting about the best way to move forward. There is some land available for development on the facility's property, and the wind resources in the area is significant.

Selected Value Streams for the Cooperative

- Peak shaving
- Infrastructure deferment
- Reduced congestion
- Local economic development
- Member-owner demand/satisfaction
- Improved relationship with member-owner

Business Cases

Opportunity 1: Seeking to minimize difficulties when the scrap metal facility installs large-scale BTM wind turbines, the cooperative remains in an advisory role and suggests limiting the wind asset's size to a fraction of the plant's onsite load. This will avoid energy export and net metering challenges while the cooperative modestly upgrades the plant's electrical service infrastructure to meet its remaining needs.

Opportunity 2: To help maximize their member's value from adopting BTM distributed wind, the cooperative decides to collaborate with the company to size the wind asset to best meet their needs and available land. To compensate the facility for its energy, the cooperative adopts a buy-all/sell-all value of DER tariff so that the exported energy's rate more closely matches its value to the grid.

6.2.3. BTM Institutional Project Scenario

Institutions such as hospitals, K-12 schools, universities, and government agencies within cooperative territories may feel their mission statements align with using locally generated, clean energy. Additionally, BTM generation could lower costs for these facilities, which often operate with fixed budgets. This scenario demonstrates how cooperatives can partner with institutional members to deploy distributed wind in service of those missions.

Background Story

The high school in a cooperative-served community contacts the cooperative about BTM wind and solar energy. Energy costs in an environment with decreasing education funding is a concern, and the school board sees an opportunity to create an educational opportunity for students by developing renewable energy assets right on the school grounds. The area around the school is seeing population growth.

Selected Value Streams for the Cooperative

- Peak shaving
- Infrastructure deferment
- Reduced congestion
- Local economic development
- Member-owner demand/satisfaction
- Improved relationship with member-owner

Business Cases

Opportunity 1: The cooperative offers its expertise in an advisory role to help vet contractors for the project. Since the school represents a significant load, the cooperative decides to reevaluate its rate structures with two goals in mind: 1) help avoid the cost-shifting that will accompany any further adoption of BTM generation by other members, and 2) align its fixed and variable costs with the proportions of each on member-owners' bills.

Opportunity 2: As the school is in an area with increasing population and increasing electricity demands, the cooperative decides on a novel strategy. It approaches the school with a proposal to let the cooperative own and manage the onsite energy assets once they are installed. This includes rooftop solar panels, a large-scale wind turbine sited behind the practice fields, and a new electric school bus with vehicle-to-grid (V2G) bidirectional flow capability. The predictable bus schedule allows the cooperative to plan for its use during the day to integrate the variable renewable energy output. This is in line with an EaaS business model (see Section 8.2).

6.2.4. BTM Agricultural Project Scenario

This scenario demonstrates how a cooperative can facilitate distributed wind deployment in the agricultural sector.

Background Story

Many member-owners in a co-op's territory are ranchers with open land. One, seeking to cut costs in their operations, wants to lower energy expenditures and calls the co-op office looking for guidance. They are not sure if a small wind turbine makes sense for them with the high upfront costs, but they have some land and (anecdotally) lots of strong wind.

Selected Value Streams for the Cooperative

- Local economic development
- Member-owner demand/satisfaction
- Improved relationship with member-owner

Business Cases

Opportunity 1: The cooperative provides advisory services on how to calculate cash flow and payback time for a small, BTM wind turbine so that the rancher can make an informed purchasing decision.

Opportunity 2: Since the rancher seeks lower energy costs, they could benefit from both energy efficiency upgrades and onsite distributed wind generation. Other cooperative member-owners across many categories (residential, industrial, etc.) would likely benefit from such services as well. The cooperative determines that a tariffed on-bill financing program (see Section 8.1.1) run through their office with capital from local lenders could reach a large number of local residents. The rancher agrees to an energy audit to determine the best course of action.

7. Off-Grid Business Cases

An off-grid wind turbine, or other DER, serves an on-site energy need and is not connected to the distribution or transmission grid. Off-grid distributed wind installations are typically deployed with energy storage so that there is backup energy, or a sink for excess energy, which the distribution grid would provide for a grid-connected wind turbine. In addition to storage, an off-grid wind turbine can be deployed with other DER, such as solar PV, to increase energy reliability.

7.1. Overview

Off-grid distributed wind installations typically use small wind turbines, particularly microturbines (those less than 1 kW in capacity). Microturbines are used to power remote homes, oil and gas operations, telecommunications facilities, boats, rural water or electricity supply, and military sites. Because of their wide use but small capacity ratings, they account for the bulk of wind turbine *units* deployed in U.S. distributed wind applications, but less than 1% of documented *capacity* (Orrell, Kazimierczuk, et al., 2021).

Off-grid distributed wind can be an alternative to extending distribution infrastructure to isolated or hard-to-reach areas. It can also reduce or eliminate the shipping and logistics challenges of using high-cost diesel or other fuel for on-site generation. Either way, the need for remote power is critical, so demand for remote power is typically less sensitive to market conditions (i.e., incentive availability), but least-cost options are still desirable.

An off-grid distributed wind owner does not need to apply for an interconnection and is unlikely to be eligible for production-based or similar incentives. For these reasons, the owner's electric cooperative may not be aware of the off-grid DER installation and others in its service territory. To increase its awareness and to create a business opportunity, the electric cooperative could expand its role as a trusted energy advisor to work with stakeholders who need off-grid remote power. Various active and potential business models are described in Sections 7.1.2 and 7.1.3, respectively.

7.1.1. Value Streams

The following tables outline potential value streams that off-grid distributed wind deployment can provide to electric cooperatives and their member-consumers. Further discussion of these value streams can be found in the *RADWIND Value Case Report*.

Table 7: Potential off-grid distributed wind value streams for an electric cooperative

Cost-Saving Benefits	**Serve remote loads**	Off-grid distributed wind and wind-hybrid installations may avoid the need to run and maintain a distribution line or fuel transport mechanism to service a remote load.
	Deferred/avoided infrastructure investments	Off-grid distributed wind may prevent overloading an existing remote line and defer or avoid distribution system upgrades.

Other Benefits with Financial Implications	**Local economic development**	Building, operating, and maintaining distributed wind projects can support local economic development.
Additional Benefits	**Gaining experience with distributed and renewable resources**	The experience of developing off-grid distributed wind and hybrid projects can be used to inform the development of larger distributed wind and wind-hybrid projects.
	Safety	Off-grid projects are "no-lines" development that may be safer with respect to fires in remote areas.
	Input on energy infrastructure within service area	A cooperative's support of off-grid distributed wind and wind-hybrid installations allows the cooperative to have input on what energy infrastructure is implemented in its service area.
	Member satisfaction	Helping member-owners acquire and install off-grid energy resources increases their satisfaction with the cooperative's services and enhances the co-op's role of trusted advisor in the community. Furthermore, solving a challenging technical problem like serving a remote load demonstrates the co-op's flexibility and ability to innovate.
Costs	**Being unaware of energy development in territory**	One potential downside to off-grid distributed wind in a cooperative's territory could be the cooperative's lack of awareness about these installations if the cooperative is not part of the development process. Although off-grid installations are not interconnected with a cooperative's distribution system, general awareness of them would benefit the cooperative.

Table 8: Potential off-grid distributed wind value streams for co-op member-owners

Cost-Saving Benefits	**Lower electricity costs for all members**	Off-grid distributed wind and wind-hybrid projects may provide the cooperative with the ability to serve more remote areas and more member-owners for less infrastructure cost, ultimately lowering electricity costs for member-owners.
	Cheaper than alternative for individual member	Installing off-grid distributed wind, or a wind-hybrid, at a remote site not served by the distribution system may be less costly than extending a distribution line to the site.

Other Benefits with Financial Implications	**Price stability**	Off-grid distributed wind, especially paired with other DER for a hybrid installation, can provide member-owners with energy price stability by eliminating or reducing their need for fuels such as propane or diesel.
Additional Benefits	**Flexibility in where member builds load**	The ability to install distributed wind, and wind-hybrids, off-grid means member-owners have flexibility in siting their load rather than being constrained to locations on the distribution system.
	Self-sufficiency	Member-owners may be interested in energy self-supply to enable more self-sufficiency.
Costs	**Installation costs**	Member-owners are responsible for purchasing their off-grid distributed wind turbines and paying for them to be installed. Utility, state, and federal incentives are typically not available for distributed energy resources not interconnected to a grid system.
	Operations and maintenance costs	Member-owners are responsible for operating and maintaining their off-grid distributed wind projects and the associated costs. It may be difficult to contract maintenance service in remote locations.

7.1.2. Active Business Models

Most cooperatives are not involved in off-grid energy development in a significant way. However, the solar installation service for water pumping provided by Verendrye Electric Cooperative and Central Electric Cooperative is a business model that could be replicated for distributed wind. This business model is explained in Section 7.2.1.2.

7.1.3. Potential Business Models

Off-grid distributed wind development represents an interesting new market for cooperatives. For co-ops with a critical mass of remote loads and interested members, there are many ways they could become more involved. One or more of the following potential business models could be a good fit for off-grid development, depending on the type of remote load. Remote load opportunities could include telecommunication towers, military training sites that are geographically separated from the main base,[45] movable loads, and isolated small communities.

[45] The U.S. Department of Energy's Defense and Disaster Deployable Turbine project is evaluating rapidly deployable wind energy technologies.

7.1.3.1. Energy Advisory Service

For a fee, the cooperative can assist residents in identifying their electricity needs, screening technology options, and acquiring development services from third parties.

7.1.3.2. Identify Remote Loads and Bring in Developers

Similar to the strict advising role but more proactive, cooperatives can determine which remote loads could be served with off-grid installations and assist members in finding solutions.

7.1.3.3. Develop Off-Grid Systems In-House

If a large enough group of member-owners shows interest in off-grid development, a cooperative may find it beneficial to cultivate in-house expertise and development capabilities.

7.1.3.4. Own and Manage Off-Grid Systems

Off-grid electricity systems management can become one service offered in an EaaS business model. See Section 8.2.

7.2. Off-Grid Distributed Wind Projects

This section presents examples of cooperative participation in off-grid wind and solar development as well as a potential scenario where off-grid distributed wind could serve a remote load.

7.2.1. Examples

While off-grid distributed generation systems are often installed by member-owners without significant cooperative involvement, some co-ops support off-grid wind and solar development directly.

7.2.1.1. Distributed Wind Power for Oil Pipeline Cathodic Protection

Prevention or reduction of corrosion in oil pipelines is typically performed by cathodic protection systems. One method of cathodic protection requires a direct current or voltage source. Distributed wind and other distributed energy resources can provide the power needed for oil pipeline cathodic protection in remote areas. Priority Pump & Supply, based in Texas, is one company that provides remote power systems for cathodic protection. For example, the company has installed 30-amp, 30-volt wind-solar-battery hybrid systems to power cathodic protection at remote oil pipeline stations in the territories of Jemez Mountain Electric Cooperative and Nueces Electric Cooperative.

7.2.1.2. Assistance to Ranching Member-Owners with Solar-Powered Pumps

Both Verendrye and Central Electric Cooperatives assist their ranching member-owners with installation and maintenance of solar-powered pasture well pumps.[46,47] These systems provide a valuable service without incurring the costs associated with running a powerline or distributing fuel to small pumping

[46] https://verendrye.com/solar-pasture-wells

[47] https://www.centralec.coop/solar-well-pumps

motors. A small wind turbine can provide the same service, especially if it is paired with a small BESS to deliver stored wind energy to the pump at times when the wind is not blowing.

Image 5: Solar-powered well pump filling a livestock trough in Verendrye Electric Cooperative territory (https://verendrye.com/solar-pasture-wells)

7.2.2. Off-Grid Distributed Wind Project Scenario

This scenario highlights how distributed wind could be employed to serve an off-grid, remote load.

Background Story

A cooperative is interested in expanding broadband coverage in its territory. More cellular towers are needed to cover most or all member-owners, but running and maintaining lines to provide power to those towers would be an expensive undertaking. Recouping that investment may require broadband rates that are prohibitively expensive for some member-owners. To avoid running new lines, the co-op explores powering the cell towers with off-grid distributed generation.

Selected Value Streams for the Cooperative

- Serve remote loads, flexibility in location
- Deferred infrastructure investment
- Local economic development
- Gaining experience with DER
- Safety (no lines)
- Input on energy infrastructure within service area

Business Cases

Opportunity 1: After examining the number and power requirements for the new fleet of cellular towers, the cooperative decides to remain in an advisory role while cell companies lead the effort to site and power the cell towers.

Opportunity 2: Seeking to expand some of its capabilities and gain familiarity with distributed generation, the cooperative elects to lead the development effort to power the cell towers. Aware that they will be maintaining the power systems in the coming years, the co-op works with the cellular company to site the towers where they can be accessed, where they provide good coverage, and where some of them can utilize small wind turbines for power.

8. Additional Services Supported by Distributed Wind

Electric cooperatives around the country have expanded their services to member-owners beyond energy supply. The cooperative model has unique and powerful benefits to communities. A co-op is local by nature, focused on meeting member-owner needs, and small enough to rapidly adapt to changing market conditions. With technological advancements driving innovation and giving member-owners greater control of their energy use and production, distribution co-ops are starting to adopt "smart integrator" roles like balancing distributed generation, adopting new technologies, and rolling out energy services (National Rural Electric Cooperative Association, 2020c). This section first highlights distributed wind-related services that co-ops already offer, which leads to a discussion of the "Energy-as-a-Service" (EaaS) business model and the opportunities to use distributed wind to expand what an electric cooperative is capable of.

8.1. Services Presently Offered by Cooperatives

Cooperatives innovate to help improve their members' quality of life. These services have grown among co-ops, and they have potential to dovetail with distributed wind development.

8.1.1. On-Bill Financing and Tariffed On-Bill Programs

Co-ops and other rural utilities may be able to realize multiple benefits of distributed wind through on-bill financing (OBF) and tariffed on-bill (TOB) programs for customer-sited DER. The Environmental and Energy Study Institute (EESI) reports that more than 110 electric cooperatives, municipal utilities, and investor-owned utilities across the country offer OBF or TOB programs (*Interactive Map of Utilities with On-Bill Financing Programs*, n.d.). Currently, about 100 electric cooperatives offer these programs (Ifebigh & Roepke, 2019). While OBF and TOB programs can reduce or remove upfront cost barriers for member-owners, they also offer several benefits to utilities. Through these programs, utilities may be able to reduce bills for member-owners or customers, reduce wholesale peak power purchases, defer or eliminate the need for transmission upgrades, and spur investment in cost-effective DER and EE measures that improve grid reliability and resiliency. Further, in some states, OBF and TOB programs may help fulfill DER and energy efficiency goals (Stanton et al., 2020).

Historically, these programs have supported weatherization and energy efficiency measures, but several now include solar and battery storage indicating that the model could also support distributed wind in some areas. For example, Mountain Parks Electric, Inc.[48] and La Plata Electric Cooperative,[49] both Colorado distribution cooperatives, include member-owned solar arrays in their TOB and OBF programs, respectively. Customers of Hawaii Energy Companies (not a co-op) can receive site-located PV and other measures through the Green Energy Money $aver[50] TOB program. Participants reimburse the utility's investment in these measures through monthly bill tariffs.

[48] https://www.mpei.com/electrify-everything-program

[49] https://www.lpea.coop

[50] https://gems.hawaii.gov/participate-now

The USDA Rural Energy Savings Program (RESP)[51] funding is a resource for OBF and TOB programs. To date, 30 rural utilities have borrowed more than $100 million total in 0% interest RESP loans to finance OBF and TOB programs for energy efficiency, beneficial electrification, and renewable energy measures. RESP funding has been reauthorized through 2023.

Explanation of OBF vs. TOB Programs

In an On-Bill Financing (OBF) program, the utility loans money to a member-owner for the purchase of approved energy saving measures. The member-owner then repays the loan over time on their energy bill. Loans may be tied to the member or the meter, depending on program design and state laws.

In a Tariffed On-Bill (TOB) program, the utility pays for the approved measure at a member-owner site, then adds a tariff for an agreed-upon term to the utility bill. There is no consumer loan or debt. The tariff is tied to the meter so that if an occupant moves, the next occupant assumes the tariff and receives the savings from the associated measures.

Pay As You Save (PAYS)® is a TOB program design used by several co-ops that caps the member's monthly payment at 80% of the savings for 80% of the measure life.

Regardless of program type, at the end of term, equipment ownership transfers to the property owner.

For more information, see: United States Department of Energy, n.d.; Stanton et al., 2020; and Hummel & Toth, 2019.

8.1.2. Integrating Demand Side Management Technology

For years, electric cooperatives have promoted demand side management with technologies like electric thermal storage space and water heaters intended to be heated up overnight on discounted, off-peak rates. Through programs like Beat the Peak,[52] many co-ops offer incentives to members who give the cooperative permission to temporarily switch off large, non-critical loads like water heaters and air conditioners through automatic controls. These kinds of demand-response (DR) programs help shift energy consumption to off-peak times, reducing the need for expensive on-peak generation. In recent years, some co-ops have updated DR programs to interface with smart thermostats and other smart home devices, and a few have designed DR programs specifically to shift loads off peak to leverage abundant and inexpensive nighttime wind energy.

[51] https://www.rd.usda.gov/programs-services/electric-programs/rural-energy-savings-program

[52] https://www.electric.coop/delaware-electric-beat-the-peak

Lake Region Electric Cooperative, mentioned in earlier Examples sections, is piloting a program to use overnight wind energy from the LREC-owned 2 MW distributed wind-solar hybrid project. The co-op is measuring the savings and storage opportunity of grid-enabled water heaters in members' homes. Through this pilot, LREC installed grid-enabled thermal storage (GETS) controllers on existing water heaters in 40 members' homes on the same substation as the wind-solar hybrid project. According to Steffes, manufacturer of the controllers, the GETS system "precisely controls a large fleet of water heaters and makes them appear to the system operator as a single flexible fast-ramp asset (a virtual generator or battery)" (Steffes, 2017). The water heaters will heat water, or "charge," when the wind-solar hybrid system is producing energy in excess of demand, typically from overnight wind generation. When the wind-solar hybrid system is not producing enough energy to meet the substation's load, the water heaters will discontinue heating unless a member overrides the controller. In a related energy storage effort, LREC is also piloting Aquanta water heater controllers.[53]

8.1.3. Distributed Wind-Powered Electric Vehicle Charging

Many cooperatives support member-owner interest in EVs by providing public charging stations, interconnecting third-party charging stations, and offering rebates for home chargers. However, given significant planned national investments in EV infrastructure, cooperatives everywhere may want to consider resource planning to accommodate sizeable growth in EVs, beyond the tech-savvy early-adopters. Initially, such growth could be concentrated in certain geographic areas and along certain feeders, thus increasing the chance of overloading (Tate, 2018). Distributed wind could be a very valuable tool as co-ops seek to add generation concurrent with EV charging schedules, and to avoid costly investments in EV-related transmission upgrades.

Because EV charging typically takes place overnight, EV owners can benefit from inexpensive off-peak electricity. Wind generation profiles often match this routine; excess wind energy can be absorbed by EV batteries overnight at homes, multi-family residences, or fleet fueling centers. However, as EV charging demand grows, new distributed wind projects could be strategically sited near substations with high residential or commercial EV charging loads.

Some cooperatives are already taking advantage of the complimentary nature of EVs and wind energy. Great River Energy, a Minnesota-based G&T cooperative, found synergies between EVs and its goal of relying on wind for the majority of its generation portfolio by 2023. Through the ChargeWise program,[54] which is implemented by GRE's distribution cooperative members, members with EVs are encouraged to charge their cars overnight when wind energy is abundant and underutilized. In exchange for having ChargeWise equipment installed that limits the charging period to an off-peak, overnight window (typically 11:00 p.m. to 7:00 a.m.), program participants receive deeply discounted electricity rates exclusively for car charging. The program enables GRE to build load with EVs, store excess overnight wind energy in car batteries distributed throughout its territory, and improve EV payback for members.

[53] https://www.lrec.coop/products-service/off-peak-water-heating

[54] https://greatriverenergy.com/smart-energy-use/demand-response/great-river-energy-load-management-programs

While this program relies on wind generation from multiple, very large utility-scale wind farms, similar concepts could be used by distribution co-ops with distributed wind farms. For example, a scaled-down version of this approach could be used at a commercial/industrial site or school located on the same substation as a distributed wind project. Fleet vehicles, municipal trash trucks, and school busses are ideal candidates for overnight charging with wind energy. Further, depending on their duty cycles, some of these vehicles may be good candidates for V2G programs to provide power to the grid during peak times or to a specific site during a power outage.

To maximize the benefits of EVs, cooperatives can also explore innovative partnerships with commercial interests and real estate developers in their territories. EVs plugged into V2G charging stations at workplaces or public sites may provide some grid regulation services during the day. Collaborating with distribution centers and other workplaces with nighttime employees could yield benefits for the cooperative by having EV-owning workers charge while working. In return, the cooperative could offer EV incentives and low-cost, distributed wind-fueled charging. Finally, partnering with a municipality or residential developer to put chargers at multi-family affordable housing developments on the same line as a distributed wind project would allow the project's excess nighttime energy to charge residents' EVs.

As co-ops innovate around distributed wind and EVs, properly designed rates can help target EV charging to desired hours. Which rate structure a cooperative adopts to accommodate EVs depends, in part, on how it views the EV charging load within its business. For a discussion EV-related rate design, see: *Electric Vehicle Charging Stations: Rate Considerations for Cooperatives*.[55]

8.1.4. Resources

- *How-to Guide: Launching an On-Bill Financing Program* from EESI, 2017[56]
- *Consumer-Centric Energy and Demand Programs: The New Business Case Guidebook* from NRECA, 2021[57]
- *Rate Options that Support Electric Vehicle Adoption* from NRECA, 2018[58]
- *Electric Vehicle Charging Stations: Rate Considerations for Cooperatives*, from National Rural Utilities Cooperative Finance Corporation (CFC), 2018[59]

Examples of V2G projects:

- La Plata Electric Association's School Bus[60]
- Roanoke Electric Cooperative's EV-to-Grid Charger[61]

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55 https://www.cooperative.com/cfc/Documents/White-paper-Series-2.pdf
56 https://www.eesi.org/obf/howtoguide
57 https://www.cooperative.com/programs-services/bts/Documents/Reports/new_dsm_business_case_guide_final.pdf
58 https://www.cooperative.com/programs-services/bts/Documents/TechSurveillance/TS-EV-Rate-Options-June-2018.pdf
59 https://www.cooperative.com/cfc/Documents/White-paper-Series-2.pdf
60 https://lpea.coop/e-bus
61 https://www.cooperative.com/news/Pages/Roanoke-Electric-Tests-Innovative-EV-to-Grid-Charger.aspx

- [Electric School Busses in Multiple Cooperatives](https://www.cooperative.com/remagazine/articles/Pages/co-ops-see-electric-school-bus-builds-interest-electric-vehicles.aspx)[62]
- [Electric Garbage Truck in Hyattsville, MD](https://www.hyattsvillewire.com/2021/10/06/hyattsville-electric-garbage-truck/)[63]

8.2. The Role of Distributed Wind in an Energy-as-a-Service Future

Distributed wind could be an important tool for many electric cooperatives in the industry-wide trend of EaaS. EaaS is a business model where a provider offers an array of energy-related services rather than only supplying electricity. For example, to offer EaaS, an electric utility may "bundle energy advice, asset installation, financing and energy management solutions to offer a suite of services to the end consumers" (International Renewable Energy Agency, 2020). Many co-ops already offer services outside of electricity supply to their member-owners. Designing, owning, and/or operating distributed wind systems on behalf of members could be a very effective way for co-ops to expand services, explore EaaS, increase revenue, and help keep rates low for other members.

8.2.1. Market Snapshot

For almost the entire 20th century, U.S. Gross Domestic Product (GDP) grew in lock step with electricity consumption. The ratio of energy use per dollar of GDP—or *energy intensity*—was constant until the mid-1990s when GDP continued to grow while electricity demand waned and eventually nearly flattened (U.S. Energy Information Administration, 2021a). Thus, the U.S. and many other developed countries are witnessing a decrease in energy intensity (see Figure 5). The reasons for this decoupling are both technological and demographic. Increased urbanization, a shift in the U.S. economy toward

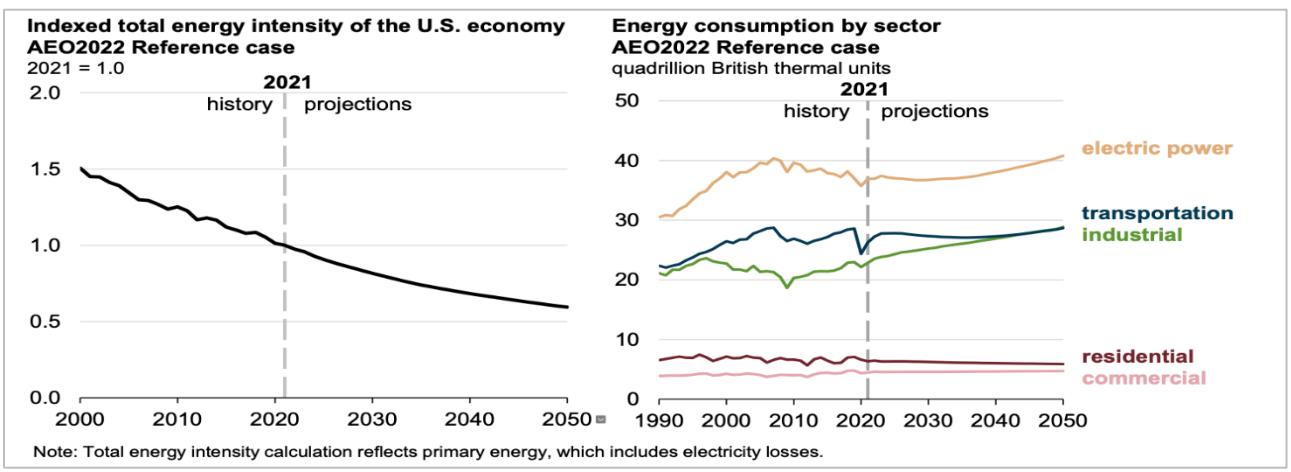

Figure 5: (Left) Historic and predicted decline in U.S. energy intensity; (Right) Historic and predicted U.S. energy consumption (U.S. Energy Information Administration, 2022)

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[62] https://www.cooperative.com/remagazine/articles/Pages/co-ops-see-electric-school-bus-builds-interest-electric-vehicles.aspx

[63] https://www.hyattsvillewire.com/2021/10/06/hyattsville-electric-garbage-truck/

services and advanced manufacturing industries, and federal programs (e.g., ENERGY STAR®), and laws that promote energy-efficient appliances and phase out inefficient models have all contributed to this trend.

At the same time, many renewable energy sources are now cost-effective. Wind and solar costs have declined, and the market value of their energy has increased such that they are competitive with conventional fuel projects– even without tax incentives in some markets – giving some utilities different options for generation procurement (U.S. Energy Information Administration, 2021a). Thus, the share of total renewable generation is predicted to grow, and since renewable energy technologies like solar PV and wind turbines are suitable for distributed generation, the share of on-site generation should also rise.

The EaaS business model has garnered attention across the utility industry as a way to succeed in a situation where electricity demand becomes less predictable, distributed generation grows in market share, and communication technologies disrupt the traditional ways of doing business. Guidehouse Insights predicts the EaaS market to grow at a compound annual growth rate of 32.1% to $37 billion in North America by 2030 (Gonzalez & Wedekind, 2021). The balance of this report is dedicated to describing how EaaS and distributed wind deployment could benefit cooperatives and their communities.

8.2.2. What is EaaS?

EaaS is a business model where a provider offers an array of energy-related services in addition to supplying electricity. Typically, an EaaS company will use a service contract to deliver technologies that were historically paid for by the consumer upfront with debt. These contracts have two key characteristics (Wedekind, 2021):

1. The client cedes control of the energy assets covered by the contract and outsources asset management to the EaaS provider.

2. Fee payments are subscription-based operational expenses resulting in potential off-balance sheet treatment.

In many EaaS designs, consumers allow the service provider to develop, own, and manage any energy-related component of their property and pay a subscription fee for its management. Figure 6 demonstrates the key differences between traditional energy upgrades and EaaS contracts, and it also shows the differences between energy service performance contract (ESPC) often employed by energy service companies (ESCOs) and EaaS models. The following diagrams are sourced from the Department of Energy's Better Buildings resources on Efficiency-as-a-Service, so they refer to "efficiency" in lieu of "energy." The concepts are identical.

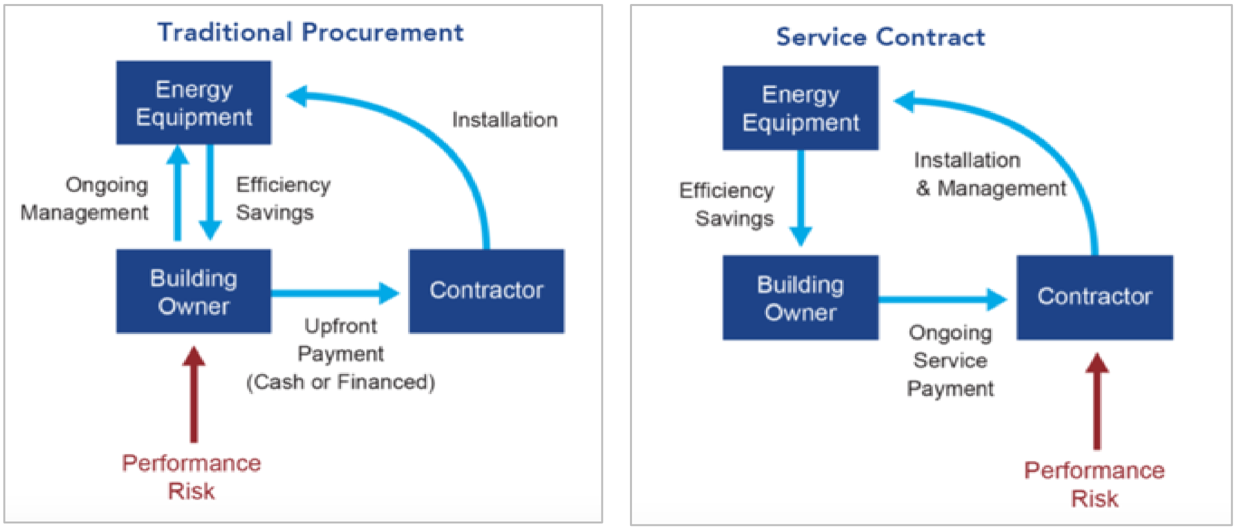

Figure 6-a: Comparing business arrangements for traditional energy equipment procurement and EaaS service contracts (U.S. DOE, 2021)

Category	ESPC	EaaS
Ownership	**Customer owns** the equipment and can choose to pay for the installation with cash or financing.	**Service provider owns** any installed technology or equipment and pays for 100% of any installation costs.
Accounting Implications	Typically **on-balance sheet**. The building owner can expense equipment depreciation and any cost of financing.	Typically **off-balance sheet**. The building owner can expense 100% of service payments to the provider.
Contract Complexity	**High**. Creating an ESPC can involve extensive contract negotiation to tailor the Performance Guarantee and define how savings will be measured. Time to project close may be a year or more.	**Medium-High**. EaaS contracts can be simpler and faster to negotiate, though more complex than traditional financing such as loans or leases. Time to project close is typically <9 months.
Project Size and Contract Length	Typically used for **larger projects** (>$1 million) with **longer contract terms** (10-20 years).	Can be used for **both** for large projects (>$1 million) and smaller projects (as low as $25,000) and can support **shorter terms** (5-20 years).
Common Sectors	Most common in municipal, university, school, and hospital (MUSH) markets. Growing in private commercial market.	Most common in private commercial, higher education and healthcare markets. Growing in MUSH and other markets.
Standardization	Highly standardized, with long operating history and federal procurement adoption.	Less standardized, with a wider variety of approaches and service providers available.

Figure 6-b: Comparing ESPC and EaaS (U.S. DOE, 2021)

The role a cooperative can play within an energy services market exists on a spectrum. It can range from a vertically integrated entity that owns and operates all or most assets, to a coordinating role that operates a wide-open marketplace for peer-to-peer energy transactions (Kiesling, 2015). Where a cooperative exists on this spectrum is a choice unique to each organization, but Figure 7 illustrates how an electric cooperative can continue in its primary role of providing affordable and reliable electricity to member-owners while expanding into other energy services.

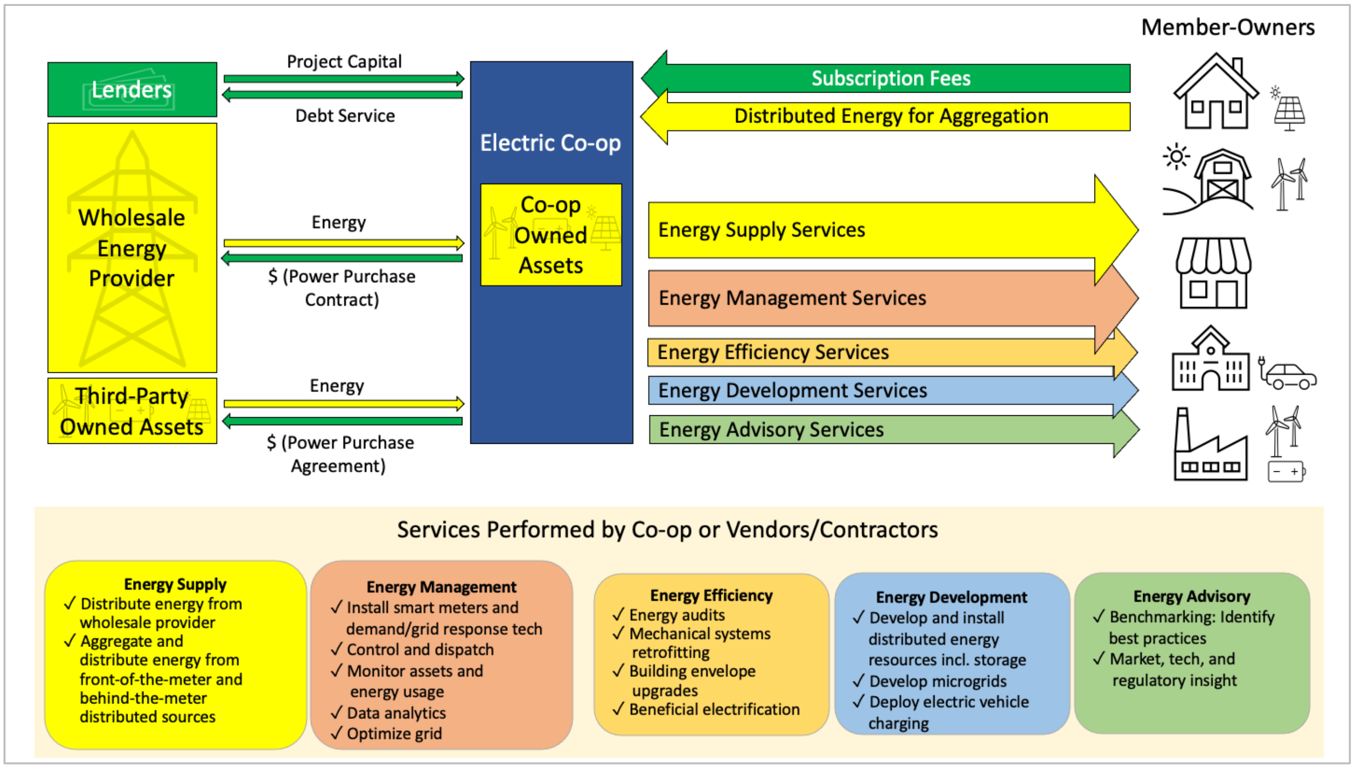

Figure 7: Energy-as-a-Service business model for electric cooperatives
(Adapted from International Renewable Energy Agency, 2020; Bornstein, 2019; American Council for an Energy-Efficient Economy, 2019)

The apparent complexity of Figure 7 conceals a simplified, beneficial outcome. An EaaS business model places the service provider at the center of an energy ecosystem in its territory. A distributed energy system necessitates an expert grid operator like an electric cooperative that can consolidate and integrate most aspects of asset ownership, software, analytics, and operations/maintenance under one roof. Member-owners would enjoy having multi-faceted service offerings paid for in one fixed, monthly fee (Bornstein, 2019). Co-ops could choose which services they will provide and how to compensate for energy and services that exist outside the boundaries of the firm. As the prime coordinator, cooperatives contract with ESCOs and other contractors to complete work beyond their expertise.

Expanding EaaS offers an efficient and intriguing way to capture the value of distributed energy resources and other technical advances for rural communities. Here, each service category in Figure 7 is discussed in greater detail:

Energy Supply Services

Energy from the co-op's wholesale provider, third-party owned assets, co-op owned assets, and distributed assets is aggregated and distributed by the cooperative, a role any co-op is familiar with. Distributed wind turbines—either FTM or BTM—can provide energy to this mix from any of the aforementioned entities, but EaaS provides the cooperative the opportunity to own and manage distributed wind assets on the property of any subscriber.

Energy Management Services

EaaS extends the co-op's role beyond commodity energy sales. To balance a grid containing distributed resources most effectively, the cooperative can install smart grid and demand/grid response technology and then manage any or all of a member-owner's energy assets. These could include distributed wind, onsite energy storage, EV charging, and smart thermostats or appliances. In short, the co-op agrees to manage a member's energy portfolio in accordance with their needs in exchange for a subscription fee and the use of the member's DER as grid assets.

Optimizing and coordinating many distributed assets across a cooperative's service territory can be accomplished using distributed energy resource management software (DERMS). As these tools improve, they could reduce the technological barriers that prevent maintaining power quality and reliability in a distributed generation ecosystem.

Energy Development Services

Member-owners interested in adding distributed wind to their property can benefit by having the cooperative work with them to plan, develop, install, and manage the distributed wind asset. Institutions and other member-owners with critical power needs may seek microgrid development services from the cooperative; distributed wind, with a generation profile that complements solar PV, can be a vital part of a system that can island from the distribution grid and maintain power for extended periods of time.

Energy Advisory Services

Already the trusted energy advisor in their communities, cooperatives can continue working with member-owners to determine how their life best interacts with energy services and tailor services to their needs. Co-ops can advise their members on best practices and vet new technologies on their behalf, including wind technologies.

Energy Efficiency Services

Member-owners interested in improving their property's energy efficiency could work with the cooperative to set up an energy audit. The audit identifies which systems on the property could be upgraded or electrified for maximum impact. An energy services arrangement would have the member-owner pay for the "efficiency service" of having upgrades installed via their subscription. Many cooperatives offer efficiency upgrades prior to adding distributed generation.

8.2.3. Benefits and Challenges of EaaS with Distributed Wind

The benefits that co-ops and their members may realize from adding more service offerings are compelling, and integrating distributed wind systems with these services can add even more value.

- Recent electricity demand growth has not been as predictable as in past decades, and the combined trends of increasing energy efficiency and increased distributed generation may leave cooperatives wanting for more diversified revenue streams. The EaaS model opens opportunities for co-ops to create new revenue streams and diversify their income as a hedge against lagging electricity sales.

- Energy services vendors can enter the market and displace the co-op from its traditional provider role if they offer a compelling menu of services. Alternatively, a cooperative can strengthen its trusted advisor role and enhance its long-term value if it finds ways to provide helpful energy services to its members.
- An EaaS business model allows a co-op to maintain control over the use of its power and wire assets. Such control provides monetary benefits to the co-op that can be used to underwrite the costs of EaaS for member-owners and bring service prices down.
- DER assets like distributed wind will be accounted for and monitored if a cooperative utilizes EaaS. In turn, those assets can be more easily incorporated into an integrated distributed resource planning (IDRP) process that fully captures DER's value to the cooperative (National Rural Electric Cooperative Association, 2020a).

At the same time, adopting components of the EaaS model would come with challenges.

- Digitalization of the power system at the distribution level is vital to managing DER and energy services. Cooperatives already lead the utility industry in adoption of Advanced Metering Infrastructure (AMI). "Smart meters," as AMI is usually known, integrate with data management systems and communications networks to allow two-way transmission of data like energy pricing, energy use profiles, and command/control signals. According to 2020 EIA data, 78% of co-op meters employ AMI (National Rural Electric Cooperative Association, 2022).
- Bringing in sufficient EaaS subscription fees from the community to recoup investments presents programmatic challenges. While performance contracts link repayment to measurable performance metrics, the subscription value of EaaS can be more challenging to define and justify. Furthermore, the cooperative must address member concerns about managing financial and liability risks inherent in owning and servicing energy assets. Leveraging the co-op's role as a trusted advisor to educate member-owners on new service arrangements would be crucial to building sufficient member buy-in and participation.
- A cooperative may need to expand its staff and find additional qualified vendors to perform energy development, management, and maintenance tasks.
- Can a distribution cooperative adopt an EaaS business model within the constraints of its wholesale power purchase contracts? Restrictions on how much generation a cooperative can generate or own may limit how it deploys services to its member-owners. Collaborating with the wholesale power provider may allow for innovate ways to make the system work for all involved. Perhaps the G&T cooperative could own the distributed assets and arrange PPAs with distribution co-op, or the distribution co-op could sell its distributed generation assets to the G&T once it has reached is prescribed maximum.

Table 9 summarizes many of the benefits that cooperatives and their member-owners can realize within an EaaS regime. Corresponding value streams from distributed wind are included as well.

Table 9: Potential benefits of EaaS with distributed wind for electric cooperatives and their member-owners

Adapted from American Council for an Energy-Efficient Economy, 2019

		Potential Energy-as-a-Service Impacts	Distributed Wind Value Intersection
Benefits for the Cooperative	Financial	• Adds to available revenue streams • Diversified revenue streams, hedge against decreasing/flat electricity sales • Digitization reduces costs	Distributed wind assets exemplify the type of resource that cooperatives can develop and manage for a fee. Behind-the-meter generation can become revenue positive for the co-op.
	Grid Management	• Increased deployment and better management of distributed wind and other DER • Resource planning: more property available for development if co-op can locate, own, and manage assets on member's property for a fee • Increased flexibility through demand side management. Ability to utilize member's homes, vehicles, and appliances as grid management tools.	Distributed wind assets—including BTM turbines—can be developed and located for optimized grid stability and resilience. Adding storage with distributed wind enhances capacity.
	Member-Owner Relationships	• Role as trusted advisor grows as co-op becomes partner in multiple energy services • Systematic way to reach LMI members and update older/less efficient buildings	Wind generation adds to portfolio of offerings for interested member-owners.
Benefits for Member-Owners	Quality of Life	• Rich array of services with the convenience and simplicity of a single bill. • Co-op is the single point of contact. No hunting for contractors or lenders. • Peace of mind knowing energy matters being evaluated, managed, and updated by experts • Digitization and shared data explain energy usage patterns, informs which services would be of use.	Distributed wind provides clean energy with many health and environmental benefits.
	Financial	• First-cost (i.e., capex) savings: no outlay of capital, payoff through operational costs • Off-balance-sheet financing: upgrades and onsite generation can be accounted as operations costs instead of debt • Operations and maintenance savings	Member-owners with wind resources can use the co-op to develop wind assets with fewer financial barriers.
	Other	• Members with limited knowledge/time/income, etc., can participate in clean energy and environmental goals • Flexible enterprise-scale retrofits for C&I members: contracts for updates are life-long	Community wind can create clean energy for buildings with LMI tenants who may not have property or money to take part. C&I members can work through the co-op to install distributed wind on site.

8.2.4. Examples of Electric Cooperatives Using EaaS

8.2.4.1. North Carolina Electric Membership Cooperative

North Carolina Electric Membership Cooperative (NCEMC), a Raleigh, NC-based G&T, collaborates with its 25 member cooperatives to develop and implement a variety of energy services. The "Connect to Save" program provides discounted Wi-Fi-controlled home thermostats and adjusts them remotely during peak energy use hours.[64] Member-owners with existing smart thermostats can subscribe to the same remote-control service. NCEMC has also collaborated with member cooperatives and communities to develop five microgrid projects throughout North Carolina. Particularly noteworthy are NCEMC's two Distribution Operator pilots, both completed in 2020. These pilots were an effort to optimize performance, improve reliability, reduce costs for member-owners, and create a single point of contact that coordinates distributed resources throughout the grid (*Advanced Grid Operations*, n.d.). The Distribution System Operator (DSO) model tested here is a way to combine the Energy Supply and Energy Management Services outlined in Section 8.2.2. For more insight into the array of programs at NCEMC, visit their "Advanced Grid Operations" website.[65]

8.2.4.2. Holy Cross Energy

Member-owners of Colorado's Holy Cross Energy (HCE) can participate in the Power+ program which incorporates members' residential BESS as grid assets.[66] HCE will pay for the BESS and its installation, and these upfront costs are repaid via a monthly bill charge; the charge is partially offset by bill credits HCE pays back to member-owners for control of the BESS. By optimizing the charging and discharging of the participating BESS, HCE can reduce its peak demand power purchases and pass the savings on to the entire cooperative membership (*Power +*, n.d.). Power+ participants also gain some resilience against outages from extreme weather events like wildfires or snowstorms by having onsite energy storage.

8.2.4.3. Roanoke Electric Cooperative

Along with installing a V2G charger at its headquarters (see Section 8.1.4), North Carolina's Roanoke Electric Cooperative has developed an EV charging service that uses subscription pricing.[67] The 240 V Level 2 charger in a member-owner's home is owned and maintained by the cooperative, and the co-op also regulates the EV charging cycle for a flat monthly fee (National Rural Utilities Cooperative Financial Corporation, 2021).

[64] https://marketplace.connecttosavenc.com

[65] https://www.ncelectriccooperatives.com/energy-innovation/grid-operations/

[66] https://www.holycross.com/powerplus/

[67] https://www.roanokeelectric.com/electric-vehicle-program

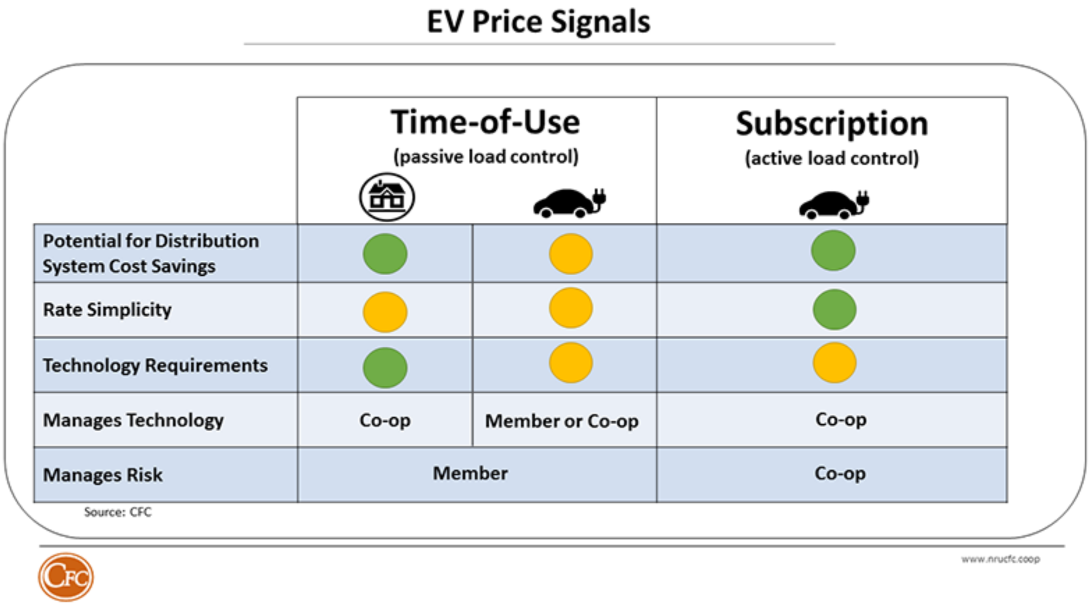

Figure 8: Comparison of TOU and subscription EV charging services
(National Rural Utilities Cooperative Financial Corporation, 2021)

8.2.5. Resources

- *Energy as a Service* from ACEEE, 2019[68]
- *Energy-as-a-Service: The lights are on. Is anyone home?* from Deloitte, 2019[69]
- *Innovations in Pricing: Energy Service Subscription Pricing* from NRECA, 2019[70]
- *Energy as a Service: Innovation Landscape Brief* from IRENA, 2020[71]
- *Looking ahead: future market and business models* from PricewaterhouseCoopers, 2014[72]

[68] https://www.aceee.org/sites/default/files/eo-energy-as-service.pdf

[69] https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/energy-resources/deloitte-uk-energy-as-a-service-report-2019.pdf

[70] https://www.cooperative.com/programs-services/bts/Documents/Advisories/Advisory-Energy-Service-Subscription-Pricing-Feb-2019.pdf

[71] https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Jul/IRENA_Energy-as-a-Service_2020.pdf?la=en&hash=E81F973296F812182DB6E4480469 5344CEADE848

[72] https://www.pwc.com/gx/en/utilities/publications/assets/pwc-future-utility-business-models.pdf

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Appendix: List of Acronyms

ACEEE	American Council for an Energy-Efficient Economy
AEP	Annual Energy Production
AMI	Advanced Metering Infrastructure
BESS	Battery Energy Storage System(s)
BTM	Behind-the-Meter
C&I	Commercial and Industrial
CHP	Combined Heat and Power
DER	Distributed Energy Resource(s)
DERMS	Distributed Energy Resource Management Software
DOE	Department of Energy
DR	Demand Response
DRM	Demand Response Management
DSIRE	Database of State Incentives for Renewables & Efficiency
DSO	Distribution System Operator
EaaS	Energy-as-a-Service
EESI	Environmental and Energy Study Institute
EIA	Energy Information Administration
ESCO	Energy Service Company
ESPC	Energy Savings Performance Contract
EV	Electric Vehicle
FERC	Federal Energy Regulatory Commission
FTM	Front-of-the-Meter
G&T	Generation and Transmission Cooperative
GDP	Gross Domestic Product
GETS	Grid-Enabled Thermal Storage
GW	gigawatt
INL	Idaho National Laboratory
IRS	Internal Revenue Service
ISO	Independent System Operator
ITC	Investment Tax Credit
kW	kilowatt
kWh	kilowatt-hour
LACE	Levelized Avoided Cost of Energy
LBNL	Lawrence Berkeley National Laboratory
LCOE	Levelized Cost of Energy
LCOS	Levelized Cost of Storage

LMI	Low- to Moderate-Income
MACRS	Modified Accelerated Cost-Recovery System
MIRACL	Microgrids, Infrastructure Resilience, and Advanced Controls Launchpad
MW	megawatt
NRECA	National Rural Electric Cooperative Association
NREL	National Renewable Energy Laboratory
NYSERDA	New York State Energy Research and Development Authority
O&M	Operations and Maintenance
OBF	On-Bill Financing
OBR	On-Bill Repayment
PNNL	Pacific Northwest National Laboratory
PPA	Power Purchase Agreement
PTC	Production Tax Credit
PV	Photovoltaic
RADWIND	Rural Area Distributed Wind Integration Network Development
REAP	Rural Energy for America Program
Residential ITC	Residential Renewable Energy Tax Credit
RESP	Rural Energy Savings Program
REC	Renewable Energy Certificate
RESP	Rural Energy Savings Program
RTO	Regional Transmission Organization
T&D	Transmission and Distribution
TOB	Tariffed On-Bill
TOU	Time-of-Use
TVP	Time-Varying Pricing
USDA	United States Department of Agriculture
V2G	Vehicle-to-Grid
VOS	Value of Solar
WIRED	Wind Innovations for Rural Economic Development