Distributed Wind for Rural Homes

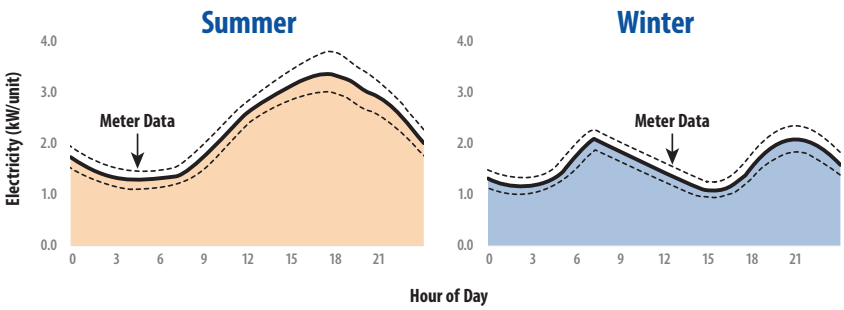
Distributed wind can be a powerful local energy generation source in residences across the country.

Wind technologies are often overlooked as distributed generation resources. Distributed wind projects can use a wide range of turbine sizes, from the small kilowatt scale up to multi-megawatt units interconnected on the distribution side of the electric grid. Distributed wind can serve a variety of functions both in front-of-the-meter and behind-the-meter applications that can contribute to local energy and resilience needs. Learn how this resource can support residential energy needs below.

Residential Energy Use

U.S. households use numerous devices and appliances that consume energy, but according to the EIA, more than half (52% in 2020) of household energy consumption is used for space heating and air conditioning, which has noticeable seasonal trends [2]. The breakdown of heating vs. cooling varies significantly based on geographic location, season, and home size and structure.

Rural areas have higher shares of single-family detached houses, as compared to urban areas that may have more apartments or attached homes, and larger shares of manufactured housing, which tends to be less energy efficient [3]. On average, this means they use a higher percentage of energy for space heating and air conditioning, but a lower percentage for water heating [2].



Residential loads have a characteristic bimodal shape during the winter: a lower peak in the mornings and a higher evening peak. Summer loads typically have a single peak driven primarily by electric cooling [4].

The Need for Energy Resilience in Homes

Residential loads support basic human needs which cannot go unmet for extended periods of time. Heating, cooling, food preservation, and critical health services top the list of important functions, which may be able to tolerate intermittent interruptions, but will impact human health and safety if offline for long durations.

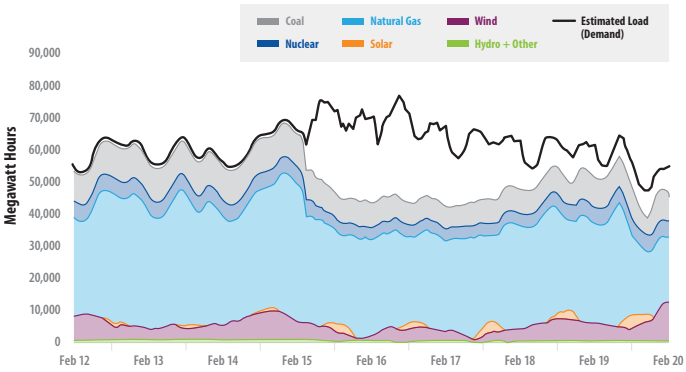
Lake Region Electric Cooperative wind turbine supports the local community [1].

Recent events highlight the reliance we have on power for these applications. During the 2021 winter storm in Texas, some residents ran out of food because items started to spoil [5]. 161 deaths during that storm were attributed to cold-exposure, and one of the key factors for cold-exposure was refusal to evacuate homes to a heated shelter or warming center [6]. Additionally, 25 deaths were attributed to exacerbation of existing illness, the cause of which was related to disruptions to dialysis or oxygen treatment, the freezing of medical devices and medication, disruption of hospice care, or loss of power while on electricity dependent equipment required to sustain life, among other factors [6].

Even shorter duration outages can have notable health impacts. Loadshedding in South Africa has been noted to have extreme consequences. Deaths have been attributed to lack of power for stationary oxygen machines, and even simple tasks like cooking become difficult when power is required even to boil water [8]. Beyond impacts to domestic activities, the rolling blackouts have been blamed for higher crime rates, as home security systems fail when the power goes out, and police officers are unable to reach crime scenes quickly due to traffic light outages creating traffic congestion [8]. It is clear that, while they may be able to tolerate short interruptions in power, residential communities rely heavily on reliable and resilient electricity.

Planning for the Future: The Growth of Electric Vehicles (EVs)

The growth of EVs in residential use has the potential to dramatically change the typical loads profiles. EV charging may create new peak load setting, adding load in the evenings as people return from work, a time that already sees high load, and overnight. Studies have found that the growth in EVs has the potential to create thermal line overloading and low power violations [9]. In fact, to meet California's 2030 EV goals, 20% of the distribution feeders in PG&E's territory would require upgrades, but only 20% of the lines that need upgrades actually have changes planned [10].



***NOTE:** Estimated Load is the Electric Reliability Council of Texas' (ERCOT's) modeled electricity demand without forced load shed (blackouts). **SOURCES:** ERCOT; Energy Information Administration.*

The gap between estimated load and available generation in Texas during the 2021 winter storm. Outages lasted several days, and the situation did not improve until temperatures rose above freezing four days after outages began. [7]

Why Distributed Wind?

While some households are willing to invest in individual resilience solutions, such as home backup generators, most households are unlikely to put in the effort and cost required to invest in the power source and upgrades necessary to use that kind of solution with the sole purpose of resilience. However, homeowners may be willing to invest in solutions that benefit them in more than one way or buy in to community solutions to support resilience. Community distributed wind or wind-hybrid plants can provide benefits to many residents while reducing the burden on individual consumers.

As deployment of EVs and the use of home EV charges grow, the stress on the local distribution system can be mitigated through the use of distributed wind providing local power, which can reduce the burden on transformers and lines. Additionally, wind typically blows stronger at night, which makes it well-suited to match the expected growth in evening and overnight load due to charging.

In addition to providing backup power in case of an emergency, with the help of grid-forming inverters, distributed wind can help offset peak energy consumption, reducing energy bills and providing savings directly to consumers.

When Is Distributed Wind the Right Choice for a Homeowner?

There are a few key things to evaluate to decide if distributed wind is a good candidate to support residential loads:

Is there sufficient wind resource?

Before investing in distributed wind, a study should be conducted to determine if the wind resource is sufficient to generate expected energy over the course of a year. The Wind Integration National Dataset (WIND) Toolkit is a good place to start. For smaller projects, modeled data may be enough to assess feasibility. Larger turbines may justify meteorological tower measurements, though these can be costly and time consuming to use.

Can the turbine(s) be sited locally to residential areas?

While it's unlikely that most homes will be able to install a distributed wind turbine in their backyards, rural areas have higher potential for available land, favorable terrain, and lack of building obstructions to make turbine placement feasible. Wind turbines require less space that solar installations, and land leasing is often an option to support siting in rural areas. Tools Assessing Performance (TAP) for Distributed Wind provides computational resources to assess siting constraints.

Is there feeder capacity for renewable generation?

Feeder capacity may be limited by power line sizing, transformer sizing, local regulation, or other constraints. The local utility can help determine if wind capacity can be added to a particular feeder or if a substation has hosting capacity for a residential load.

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