Building Resilience With Distributed Wind

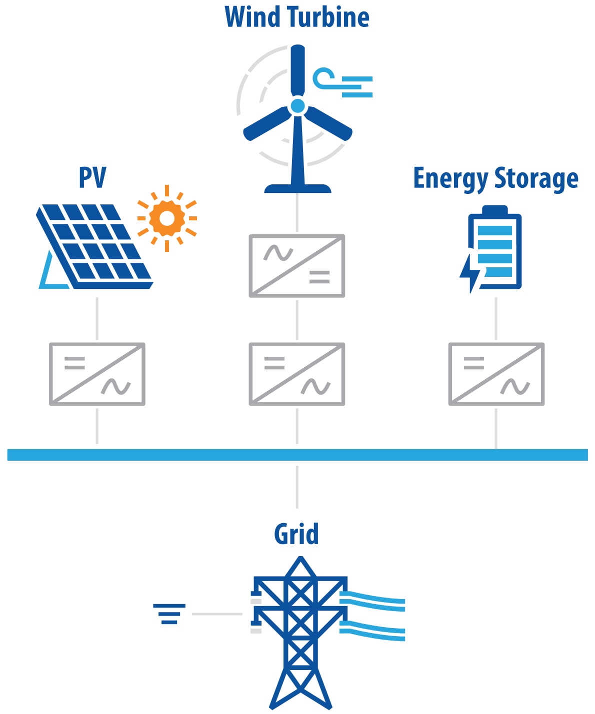
Distributed wind has several properties that can increase resilience of local electric systems.

Distributed wind is an often overlooked resource that uses wind technologies as a distributed generation resource. Distributed wind projects can use a wide range of turbine sizes from the small kilowatt scale up to multi-megawatt units that can contribute to local energy and resilience needs. Although wind is a variable resource, several key features of distributed wind and wind hybrids can improve system resilience through grid services, backup power, peak shaving, transmission congestion relief, and local power production.

The 900 kW wind turbine constructed in Pitka's Point, AK, serving three local communities, helps offset diesel fuel use and mitigate risk of fuel shortage [1].

Local Generation Resource

One of the biggest benefits distributed wind provides is the ability to provide power locally without importing fuel and in areas where solar resources are not adequate. In this way, it can be used to offset fossil fuel consumption and support local backup power needs in the case of a wider grid outage, assuming the infrastructure has been set up to enable islanding and microgrid formation. As a local generation source, it can help relieve transmission congestion and decrease line losses. It can also act as a peak shaving resource using curtailment or paired with energy storage for the asset owner or purchaser, whether that is a distribution utility managing their overall load or a consumer with a resource behind-the-meter.



Distributed wind-hybrid systems may include solar, battery, or other resources. Inverter-based resources may share the same inverter or each use their own.

Advanced Control Functionality

As an inverter-based resource, distributed wind systems have the power electronics to provide grid support services with the right controller features to perform curtailment. Through controllability of real and reactive power output, distributed wind can provide voltage and frequency support. Ride-through capabilities can help keep the system online during grid disturbances and help prevent cascading events.

Grid-forming inverters are less common on distributed wind turbines, but if outfitted with this capability, distributed wind can act as a local source of energy even if other resources are cut off. Beyond just grid-forming capabilities, the ability to perform automatic islanding may provide even greater resilience benefits. Automatic islanding happens when the system detects that the grid-forming source has been lost and automatically switches from grid-following to grid-forming mode without dropping load in the process.

Distributed Wind Hybrids

A hybrid energy system can be defined as one that combines multiple complementary types of energy generation and/or storage technologies. Distributed wind has many beneficial properties on its own, but combining wind with technologies like solar, storage, or even fuel-based generators offers several advantages over any single source systems. These hybrid systems deliver combined value that is greater than the sum of their parts if deployed separately.

When combined with other resources to form a hybrid system, distributed wind contributes towards combined hybrid properties that increase system resilience. Wind and solar resources were found to be complementary both on hourly and annual frequencies across the United States [2]. Wind tends to blow stronger at night and during the winter, complementing solar production during the day and summer to produce overall smoother daily and seasonal energy profiles and increasing the capacity value of the hybrid project.

Storage systems are also a strongly complementary resource for distributed wind-hybrids, offering a level of dispatchability, increased capacity, and smoothing by charging when wind output is high and discharging when wind output is low. This reduces intermittency of variable resource generation.

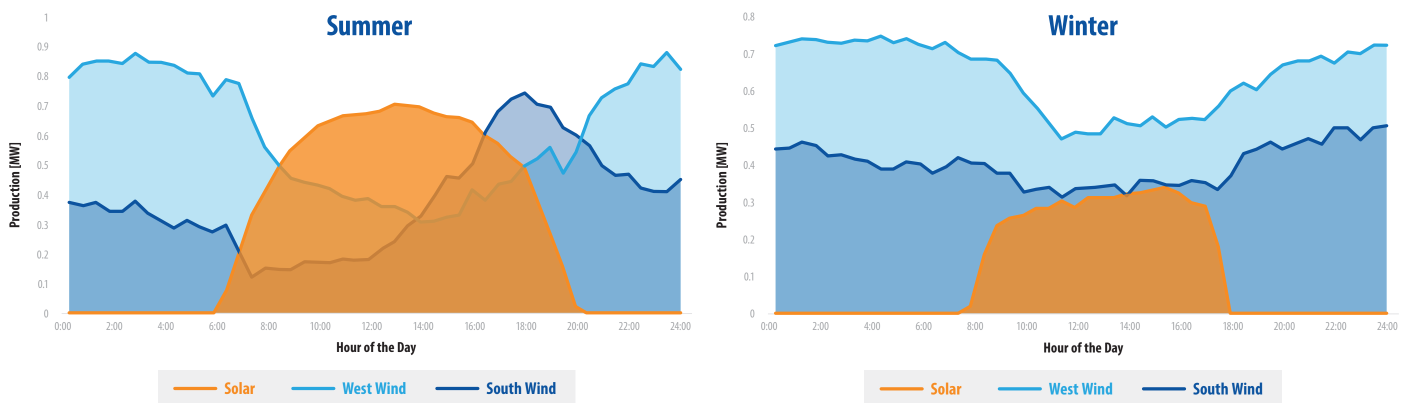
Other resources, like diesel generators, hydrogen generation, and even microreactors could be paired with distributed wind to strengthen local generation capabilities during normal operation and especially during times of grid stress.

Tradeoffs With Resilience

While distributed wind and distributed wind-hybrids can be an important asset for resilience, there are operational tradeoffs for managing this resource as a resilience asset. Selling power back into the grid may be more profitable than reserving capacity for backup power. Providing grid support functions may limit the energy outputs that is used purely to support load.

In practice, dynamic resilience strategies may be employed to operate the system. For example, operators may choose to dispatch a wind-hybrid system for maximum economic benefits until the area experiences a hurricane warning, then switch to a resilient dispatch strategy that prioritizes backup capacity for local loads. Built-in functionality for this type of optimized dispatch is becoming more common in smart controllers and distributed energy resource management systems (DERMS).

For further information, see ***"Resilience for Advanced Distributed Wind Systems"*** *[3].*



Wind and solar have a high degree of complementarity, both on a daily basis, as seen in the daytime peak for solar and the nighttime peak for west wind and south wind, and on an annual basis, as seen in the difference between summer and winter (lower solar peaks in the winter supplemented by more consistent wind). Figure adapted from [4].

References

[1] *"Closeout Report for USDOE Office of Indian Electricity award DE-IE0000035," Alaska Village Electric Cooperative, Inc. (AVEC), March 30, 2020.*

[2] *C. E. Clark, A. Barker, J. King and J. Reilly, "Wind and Solar Hybrid Power Plants for Energy Resilience," National Renewable Energy Laboratory, Golden, CO, 2022.*

[3] *M. Culler and S. Bukowski, "Resilience for Advanced Distributed Wind Systems," Idaho National Laboratory, INL/RPT-22-67919, July 2022.*

[4] *A. Naeem, N. Hassan, C. Yuen, S. Muyeen, "Maximizing the Economic Benefits of a Grid-Tied Microgrid Using Solar-Wind Complementarity," Energies 12(3):395, Jan. 2019; DOI: 10.3390/en12030395.*

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