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Changing the World's Energy Future

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Distributed Wind Hybrid Energy Systems for Rural Applications

Distributed-wind-based hybrid energy systems can smooth the power output from renewable energy resources. The number of these systems is growing because of their ability to contribute to local energy and resilience needs.

Distributed wind hybrid systems combine wind energy with different generation sources and/or storage technologies (e.g., solar, geothermal, concentrating solar power, battery storage, and thermal energy storage) to provide power services at a single point of connection [1]. Distributed wind hybrid systems may be connected on the customer's side of the meter to serve a local load, to the distribution grid as a generation asset, or directly connected to power an off-grid load. Learn how distributed wind hybrid systems can support industrial loads below.

Industrial Load Energy and Resilience Needs

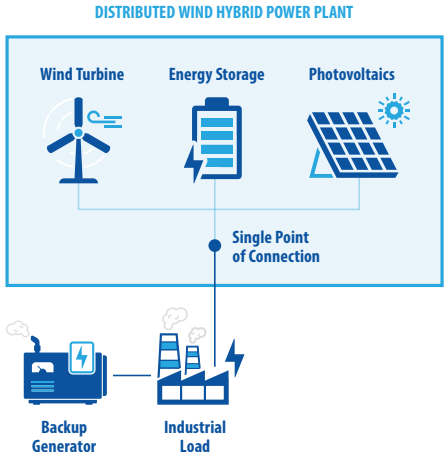
The demand for industrial energy is increasing due to the growth of domestic manufacturing and the expansion of data centers to support artificial intelligence [2]. Industrial energy use is distinct because it typically operates nonstop, at high temperatures, and requires large amounts of power, and is frequently located in remote areas. Interruptions, like power outages, can result in serious consequences, including equipment damage and high costs associated with downtime and process interruptions. The cost of an outage can vary significantly depending on the industrial process, but expenses generally increase with the outage's duration. Even short outages, lasting just a second, can lead to losses exceeding $1,000 [3]. Additionally, power quality issues can cause problems, such as increased equipment failures or controller malfunctions. These power disturbances can have broader impacts, including serious safety concerns and disruptions to downstream supply chains and overall business operations.

Given the high stakes in industrial operations, ensuring a reliable power supply is crucial for minimizing these risks and achieving efficient, safe, and cost-effective operations. Maintaining on-site backup power, provided by distributed wind hybrid systems, for example, along with universal power supply equipment to prevent loss of power during the transition from grid power to backup sources, can ease safety concerns and avoid sudden, unexpected interruptions. By maintaining a minimal level of power for critical loads, distributed wind hybrid systems can also lead to significant cost savings by avoiding complete shutdowns and enhancing overall operational resilience.

Lake Region's 2-MW Wind-Solar Hybrid Project [4].

Why Distributed Wind Hybrid Systems?

Distributed wind hybrid systems offer major benefits for industrial loads, including enhanced energy reliability, cost efficiency, and sustainability. By combining wind and solar energy with storage or backup systems, these configurations ensure a steady power supply, which is crucial for industries with high, continuous energy demands. As grid demand and prices rise, industrial users can reduce reliance on grid power during peak times by using distributed wind hybrid systems, which lower demand charges and improve stability. Batteries within these systems also enhance power quality by stabilizing voltage and smoothing fluctuations.



Example of an off-grid distributed wind hybrid power plant (Graphic adapted from [1]).

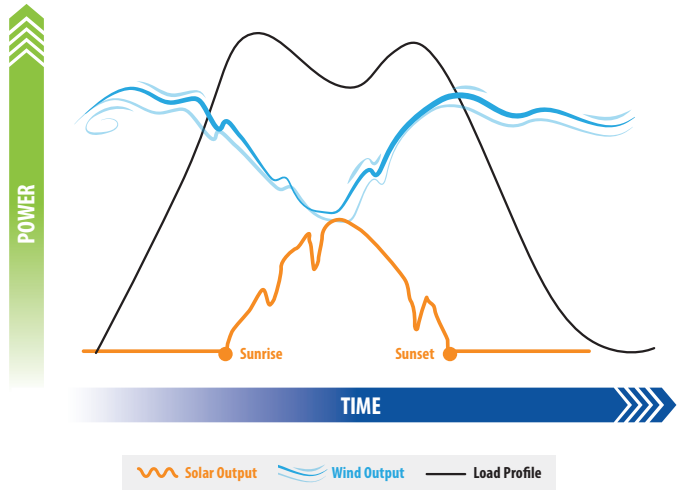
For example, Iowa Lakes Electric Cooperative's 21-megawatt (MW) distributed wind farm supports the substantial energy loads of local ethanol plants by connecting with their industrial substations, whereas a novel, 2-MW wind-solar hybrid project maximizes energy delivery by integrating both resources at a single point of interconnection [5]. By integrating solar with wind energy assets, operators can maximize the use of grid infrastructure. Moreover, incorporating energy storage into these systems could be cost-effective considering the high costs associated with potential outages for industrial loads.

When Are Distributed Wind Hybrid Systems the Right Choice for an Industrial Load?

The following key factors should be considered when deciding if a distributed wind hybrid system is a good candidate to support industrial loads:

Are the wind and solar resources complementary?

Before investing in distributed wind hybrid energy, a study should be conducted to determine how the wind and solar resources vary daily and seasonally and if the combined resource is sufficient to generate the expected energy over the course of a year [6]. NREL's Wind Integration National Dataset Toolkit and National Solar Resource Database are good places to start. For smaller projects, modeled data may be enough to assess feasibility. Larger wind turbines may justify obtaining meteorological tower measurements, though they can be costly and time-consuming.



Example of daily variation in wind and solar energy generation.

How much revenue would a distributed wind hybrid plant generate?

Financing and many location-specific factors impact the profitability of a distributed wind hybrid plant. To estimate potential revenue, tools such as NREL's Hybrid Optimization and Performance Platform and System Advisor Model can be used.

Can the hybrid plant be sited locally?

Land use, building obstructions, terrain, and siting permits must be considered to decide whether it is feasible to place a wind turbine and other renewable energy technology in a location where it can connect to the local distribution system and serve the intended loads. Both behind-the-meter and front-of-the-meter installations may be used to support industrial loads. Land leasing is often an option to support siting in rural areas. Tools Assessing Performance for distributed wind energy provide computational resources to assess siting constraints with local obstacles.

Is there feeder capacity for renewable generation?

Feeder capacity may be limited by power line sizing, transformer sizing, local regulations, or other constraints. The local utility can help determine if capacity can be added to a particular feeder.

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