ACEP's Power Systems Integration Lab

Because of the unique needs of microgrid systems, particularly those incorporating renewable energy, the Alaska Center for Energy and Power has developed a Power Systems Integration Program to complement existing expertise in the Alaska industry.

The Power Systems Integration Lab operates on the same scale as a village power system and can be modified for individual test scenarios. The lab transforms a potentially chaotic field testing environment into a continuously improving process for optimizing efficiencies.

Designed for maximum flexibility, this system is capable of testing a wide range of islanded microgrid and distributed generation scenarios, as well as the performance of individual components. Examples include next generation utility energy storage such as innovative battery systems and flywheel technology, diesel-off operation, power electronics development and testing, and model verification.

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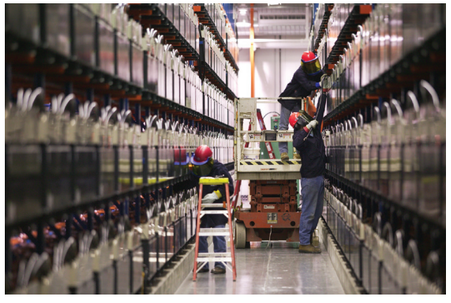
Alaska has been investing in storage technologies for a long time. The 27 MW Golden Valley Electric Association Battery Energy Storage System in Fairbanks was the largest battery in the world when it was commissioned in 2003 to improve reliability and reduce outages. Several smaller communities served by microgrids also use battery-based energy storage systems, including Metlakatla (hydro-powered microgrid), as well as Kwigillingok, Kotzebue, Kodiak, and Kokhanok (all wind-powered microgrids). Alaska is also home to two flywheels, installed in conjunction with wind power systems. St. Paul Island's wind-diesel hybrid system recently added a Beacon flywheel that will stabilize the grid and increase diesel-off times by up to 15%, and Kodiak has installed a 2 MW ABB flywheel system that complements an existing 3 MW battery system designed to stabilize 9 MW of installed wind capacity. This system, combined with existing hydropower, will allow Kodiak to be the first community in Alaska to achieve nearly 100% renewable generation year-round.

Alaska's Renewable Microgrids

Over the last decade, Alaska has emerged as a global leader in development and operation of microgrids. A particular focus for ACEP has been on maximizing the cost-effective integration of renewable energy for power and heat to reduce reliance on imported diesel fuel and decrease the cost of energy for consumers.

The State of Alaska has invested over $250 million over the past six years in developing and integrating renewable energy projects to serve these microgrids, the greatest per capita investment of any state in the U.S. The deployment of these advanced technologies in these rural systems has enabled Alaska utilities and developers to become experts in microgrid design, construction, and maintenance.



The 27 MW battery energy storage system (BESS) is one of Golden Valley Electric Association's initiatives to improve the reliability of service to residents of Fairbanks, Alaska.

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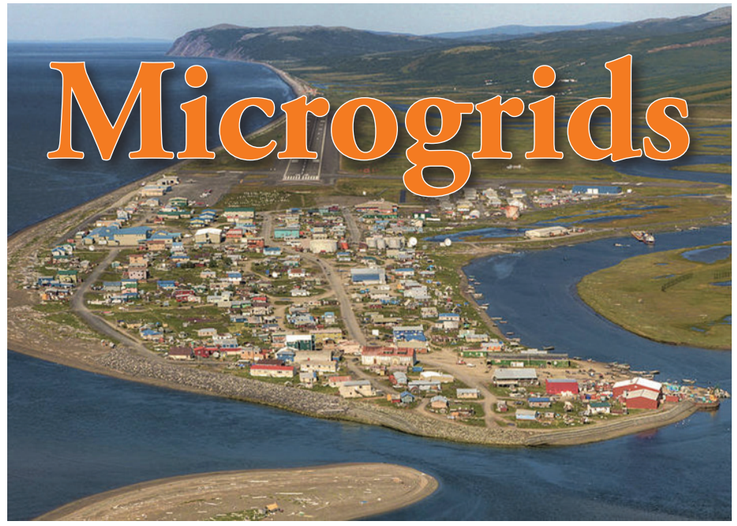
Microgrids



Unalakleet is a community in western Alaska of 500 residents. It has a typical load of 500 kW and is served by 600 kW installed wind capacity.

Microgrids in Alaska

As the U.S. strives to modernize its electric grid, microgrids are becoming a popular strategy for decentralizing electric power generation. The ability to provide a resilient, reliable power supply for remote regions or large metropolitan areas, especially during natural disasters, such as Hurricane Sandy, has made microgrids very appealing to municipalities and some utilities. Meanwhile, in areas of the developing world, greater access to renewable energy technologies has increased the electrification of many remote areas through the development of hybrid renewable microgrids.

Alaska's remote communities, spread out across the state's geographically diverse regions, have spurred a small industry based on developing and supporting more than 200 microgrids. Since the 1960s, electricity in these communities has been heavily reliant on diesel generators. Over the past decade, investment in renewable energy generation has increased dramatically to meet a desire for energy independence and reduce the cost of delivered power. Today, more than 70 of Alaska's microgrids, which represent approximately 12% of renewably powered microgrids in the world, incorporate grid-scale renewable generation, including small hydro, wind, geothermal, solar, and biomass. Globally, growth in the microgrid market is accelerating. A recent report by Navigant Research estimates the microgrid market will grow nearly fivefold, to an estimated $40 billion in revenue by 2020.

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Cordova, Alaska is a small fishing community of 2,300 residents, whose microgrid is served by two run-of-river hydro projects and a diesel powerhouse.

Nome, Alaska has an average load of about 4 MW. It currently has 2.7 MW of installed wind capacity and is considering adding 2 MW of geothermal to their generation mix.

The Alaska Center for Energy and Power (ACEP) based at the University of Alaska is dedicated to applied energy research and testing focused on lowering the cost of energy throughout Alaska and developing economic opportunities for the state, its residents, and its industries.

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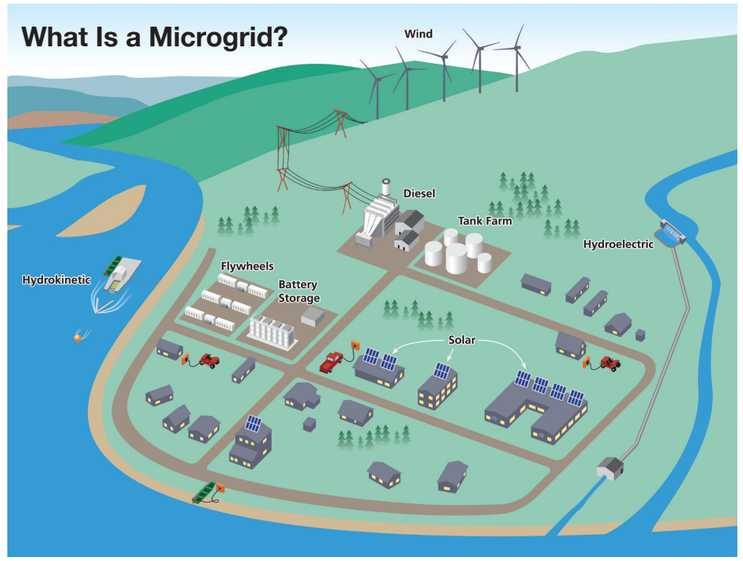
In its 2013 report, "Microgrids: Commercial/Industrial, Community/Utility, Campus/Institutional, Military, Remote, Grid-Tied Utility Distribution, and Direct Current Microgrids: Global Market Analysis and Forecasts," Navigant Research defined five main types of microgrid segments in the world markets: commercial/industrial, community/utility, institutional/campus, military, and remote. North America maintains the lead in capacity of microgrids by region (49%) with a 30% annual growth rate projected. California leads the states in penetration of renewables, high retail pricing, and energy storage, whereas Alaska leads in current capacity and vendor revenue as the majority of communities are served by remote microgrids. Hawaii, Connecticut, and New York round out the top five in the U.S.



A microgrid is an electricity distribution system that balances loads and energy resources and can be operated connected to larger, main power networks (macrogrids), or in a controlled, coordinated way as a remote islanded grid (either intentionally or unintentionally disconnected from macrogrids for short periods). In Alaska, microgrids typically cannot be connected to the greater transmission grid because of their geographical remoteness and therefore they are not designed with that operational capability. The image above shows components that may be part of a microgrid system in Alaska, including both distributed and centralized generation from one or more sources, energy and power storage in the form of flywheels or battery storage, and managed loads such as plug-in electric vehicles.

India boasts the second largest growing remote microgrid capacity (46 MW added in 2014), which includes many solar PV pay-as-you-go business systems, but it falls to seventh in cumulative total capacity (China leads with 168 MW installed in 2014). Australia is a growing market with a cumulative total microgrid capacity growth of 64.5 MW in 2014 and a projection of over 200 MW by 2020.

Germany, leading the grid-tied microgrid market, grew by 20 MW in 2014 with its high penetration of renewable distributed energy generation (RDEG), which contrasts sharply with the traditional large-scale power plants that require transmission to population centers. RDEG accounts for only around 1% of the worldwide installed energy-generating capacity, though it is proving to be more cost-effective than some centralized facilities.

What's So Special?

While microgrids are attracting increased interest, they are not new. In fact, microgrids are ubiquitous in rural communities, university campuses, military installations, and other locations. In the developed world, microgrids are a means to increase redundancy of the electricity supply and to achieve local power generation. In developing countries and remote areas in the developed world, they are a means of providing electricity, often for the first time, without the added investment of transmission lines. In Alaska, microgrids have been used for distributed energy since rural parts of the state were electrified beginning in the early 1900s. Even the state's second largest community, Fairbanks, was a microgrid until 1985, when it was connected to Anchorage by transmission lines.

Although microgrid systems are often completely (or temporarily) islanded, they are not immune to the volatility of fuel prices or supply interruptions. Many communities in Alaska receive their bulk fuel delivery by barge once or twice a year, often within a small, four-month window of opportunity. Missing that opportunity can mean expensive delivery by airplane. Integrating local resources, often renewable energy, into the system reduces the use of imported fuel and lowers the risk of supply interruptions.

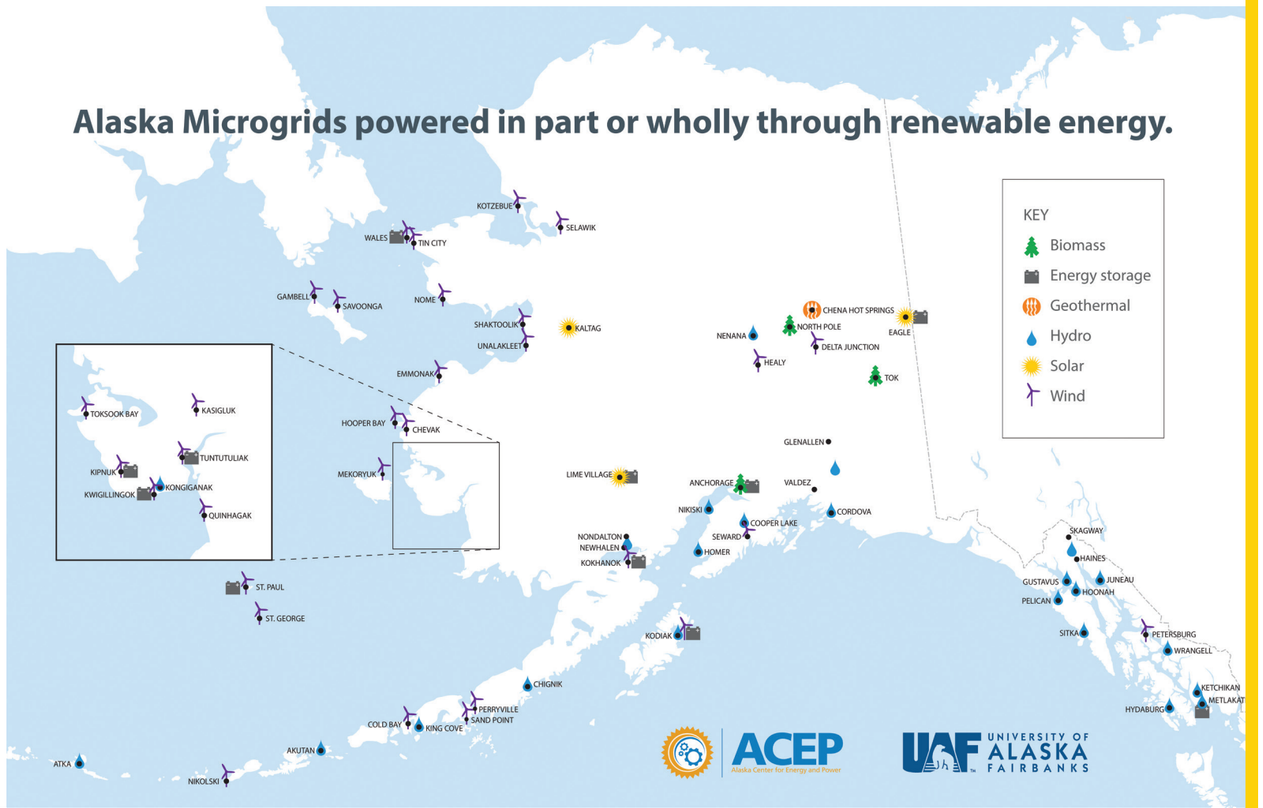
Microgrids often combine multiple smaller-sized generators as a system to maximize efficiency with a varying load. Having smaller generators increases the ability to integrate renewables into the system while maintaining a reliable baseload. Alaska's investment in renewable energy has been complemented by both state and federal investment in powerhouse upgrades, bulk fuel storage projects, and energy-efficiency and weatherization programs.

Energy Stabilization Solutions

Balancing energy inputs and loads in a weak microgrid for uninterrupted power often requires demand-side management and/or an energy storage system to act as a buffer in times of high energy loads and in times of high energy generation and low loads.

Demand-side management reduces the added energy generation required to meet rising peak demands by controlling a subset of electric demand from the utility. This can be achieved when consumers relinquish control of certain loads or appliances — such as outdoor lighting, pumps, and other nonessential equipment — to the utility. The utility's control system then has the ability to decide which demand is served based on the overall load of the system compared to available generation. This can reduce the need for additional energy generation at peak times.

Depending on a particular application, specific energy storage systems can provide significant services to a microgrid. For example, flywheels and some battery types can be used to improve power quality by injecting/absorbing large amounts of power almost instantaneously. Batteries, compressed air energy storage, and pumped hydro storage can provide smoothing of highly variable renewable generation on the timescale of minutes and peak shifting services on the timescale of hours, depending on the energy capacity of the particular storage technology. Also of interest are devices that convert electricity into thermal energy (heat or cold) that can be dispatched at a later time.



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