Integrating Renewable Energy: What You Need to Consider in Rural Alaska


photo by Amanda Byrd, ACEP

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Integrating Renewable Energy:
What You Need to Consider in Rural Alaska

Many rural Alaska communities are interested in integrating locally available renewable energy resources into their electrical grids. This document provides general information to help communities understand the benefits and challenges of introducing renewable energy into an electrical grid, although communities will still need to consider their unique local factors when deciding whether renewable energy makes sense for them.

The cost of renewable energy generation devices has decreased significantly over the past decade, particularly solar photovoltaic (PV) panels, though wind turbine generators have seen cost reductions as well. This makes renewable energy systems an attractive option for consumers in remote areas operating with high energy costs. Don't let the decreasing costs of renewable energy fool you — there can be hidden costs associated with integration.

Remote areas maximize the economic benefit of integrating renewable energy systems when they're able to move entirely away from generators running on imported diesel fuel and remove the associated fixed and variable costs. **Fixed costs** of a generator apply whenever it is running; some maintenance needs to happen regularly no matter how much power is produced. Other fixed costs for electricity include those associated with the distribution network or billing. **Variable costs** change with the amount of power produced, such as fuel consumption. When renewable energy displaces only a small amount of diesel generation, the variable cost is lessened while some of the fixed costs remain. To reduce the fixed costs, the diesel generator must be shut off entirely. This can create a new set of challenges for a community not ready to pull the plug on diesel.

This paper explores challenges to renewable energy integration, including:

- Operating reserve capacity is needed for sudden load increases
- Intermittent renewable energy resources also need operating reserve capacity
- Who owns the renewable energy will influence the costs and solutions

These challenges can be overcome, but the solutions come with costs of their own. Potential methods for integrating more renewable energy include:

- Capping renewable production
- Using the renewable energy off grid
- Pairing a dispatchable load with renewables
- Adding energy storage

Challenges to Renewable Energy Integration

Without carefully planned integration, renewable energy production can create unintended problems for grid customers and operators.

Grids Need Operating Reserve Capacity to Pick Up Quick Load Increases

All electrical grids must operate with some amount of additional generation capacity beyond what is being served at any moment. This **operating reserve capacity** allows the grid to compensate for sudden increases in load — otherwise, power failures could occur in the interim before additional generators are turned on.

For example, if a fish processing plant starts all their equipment without coordinating with the utility, the unexpected power demand may be more than what is available at that moment. Traditionally, this reserve capacity is entirely comprised of the difference between how much power a rotating generator, i.e. diesel generator, is currently producing and the maximum power it can produce, although non-rotating energy storage systems such as batteries are now capable of providing reserve capacity as well.

photo by Clay Good, REAP

One advantage large electrical grids have over microgrids is that there are many generators to provide reserve capacity during sudden increases in load. When power demand increases, each generator can provide a small amount of its capacity and none are overly taxed, allowing for a smooth transition if more generators are needed to be brought online. In microgrids, however, fewer generators are available, so each one must provide a larger percentage of operating reserve capacity.

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Intermittent Renewable Energy Works Against Operating Reserve Capacity

Renewable energy resources such as wind, solar and even some hydropower are **intermittent**, meaning their output varies over short periods of time and can be hard to predict accurately. The wind may suddenly die down bringing wind turbines to a halt or a large cloud may cover the sun over a microgrid where many homes have installed grid-tied solar PV panels. These scenarios will cause an unexpected decrease in renewable generation. Electrical grids with intermittent renewable resources must have enough operating reserve capacity to handle typical swings in renewable power and in load — as in the fish processing plant scenario.

When modest amounts of intermittent renewable resources are added to a grid, the existing operating reserve capacity is typically sufficient. In rural Alaska microgrids, variable renewable generation is often capped at 5% of the capacity of the smallest generator serving the grid. For example, each of the diesel generators serving Kake, Alaska, are rated to a capacity of approximately 500 kW, so the variable renewable generation on that microgrid would be limited to less than 25 kW. This limit should only be exceeded if some of the steps described below are taken to ensure grid stability. Homeowners must coordinate with their local utility before installing renewable energy systems to ensure the limit is not exceeded.

Utility vs. Customer Ownership of Renewables: Pros and Cons

In addition to technical challenges, rural Alaska communities must also consider ownership of the renewable energy resource when integrating into microgrids. When customers add independently owned variable renewable generation, they typically reap most of the benefits by avoiding the full retail energy rate for their self-generated power.[1] However, if the retail energy rate helps recover utility fixed costs, then those fixed costs must be spread over fewer sales, which increases the energy rate and drives up electric bills for those who do not self-generate.[2]

When the utility owns the renewable energy, the benefits of reduced diesel consumption can be spread across all customers as long as the renewable energy generation is properly maintained.[3] Additionally, a utility with direct control over the resource has more options to respond in case of rapid swings or excess production. Utilities with control and response flexibility can incorporate more renewable energy sources to the grid while keeping it stable.

Methods of Incorporating More Renewable Energy

A combination of one or more of the following solutions can be used to integrate more renewable energy generation into the grid.

Capping Renewable Production

One technique to respond to large energy swings is to **cap** the amount of power the renewable resource produces, which can help ensure the grid does not become unstable due to large swings in renewable production. However, this is only possible if the utility has control over the renewable. For example, Cordova Electric Cooperative is able to control the amount of water diverted into the penstock at their Power Creek facility. If there is more water available than needed for the load, it

[1] The benefits of reduced air pollution and CO2 emissions accrue to all customers regardless.

[2] There are multiple rate structures utilities can implement to recover fixed costs, in which case rates need not rise when some install renewable energy generation. Additionally, if customers sell some of their renewable energy back to the utility and the buyback price is lower than the cost of diesel power, the utility's overall cost of service drops and all customers can save money.

[3] Poorly managed renewable generation can lead to increased costs — if the device stops working, customers must pay for the broken renewable generation without the benefits of displaced diesel generation.

photo by Clay Good, REAP

can spill over instead. This is a simple and inexpensive method when the utility owns the renewable generation, but potential value is lost when there is excess renewable energy — the water flowing past the penstock cannot be recaptured for future electricity generation.

Using the Renewable Energy Off Grid

Another technique to incorporate renewables is to use the renewable energy **off grid**, in which typical swings in energy production don't affect grid stability. The utility does not need any control of the renewable in this case, though there may still be lost value from curtailed production depending on how well the off-grid load and generation are matched. For example, Ingemar Mathiasson, energy & resource coordinator with the Northwest Arctic Borough, is working with the Alaska Village Electric Cooperative to install HotSpot air source heat pumps and Sun Bandit water heaters in the rural Alaska communities of Ambler and Kotzebue to provide supplemental heating during the spring and fall shoulder seasons. When there is sufficient light, these products are capable of operating entirely from the included solar PV panels without feeding any power to the grid. The heat pump units do not operate efficiently at temperatures below 10-20° F, so they are switched off during the middle of winter. This project is currently ongoing and results will be provided when available.

Pairing a Dispatchable Load With Renewables

Similarly, pairing a **dispatchable load** with the renewable energy resource can help moderate swings in power output. A dispatchable load is an appliance or device the utility controls to use more or less power — for example, a hot water boiler. Dispatchable loads are flexible and can be shut off automatically when renewable power drops significantly and on again when there is excess electricity. Rather than capping the renewable energy production, the energy that would be capped is used by the dispatchable load instead.

For example, rural Alaska communities such as St. Mary's, Kotzebue and others use electric boilers as dispatchable loads to heat water while there is excess wind power produced. Steffes stoves in Kongiganak, Kwigillingok and Tuntutuliak operate similarly to the electric boilers, but they heat ceramic bricks instead of water with the excess electricity. Since the customer does not have control over when it operates, the electricity used to power the stove is sold at a reduced rate bringing the total cost of heating down. An oil-fired boiler or stove triggered by a thermostat is still used when the electric stoves are turned off, making a seamless heating transition.

Adding Energy Storage

Lastly, adding an **energy storage system** to the grid can maintain stability while maximizing value from the renewable resource. These systems are composed of a storage medium — such as batteries, fuel cells or flywheels — and a power converter that intelligently moves energy between the grid and the storage device. Over the past decade, the rise of the electric vehicle market in the Lower 48 has led to relatively inexpensive lithium-ion battery technology for grid applications, though batteries still represent a significant upfront cost without additional grant funding. A 100 kVA 100 kWh Li-ion battery was installed as part of the Gunnuk Creek hydroelectric project in Kake to help stabilize electrical output when input water flow rate varies. Similarly, Kodiak uses a battery system to stabilize their grid after adding wind turbines, and a flywheel energy storage system to balance the power used by an electric crane — a draw that can increase from 0 to 2 MW in seconds.

Michelle Wilber, a researcher with the Alaska Center for Energy and Power, conducted a study on the addition of utility-owned electrical storage and solar PV systems to the community of Kake. Using HOMER Pro modeling software, she simulated a microgrid with loads similar to Kake throughout the year. The base case of the simulation included a 500 kW hydroelectric turbine and a 500 kW diesel generator.[4] Two different stream flow profiles, from 2006 and 2007, were used for the hydroelectric turbine. Adding storage to the grid reduced fuel usage by 5% and 8% for the 2006 and 2007 water flow scenarios, respectively. Despite the reduction of fuel consumption, the upfront expense of purchasing and installing batteries without grant funding increased the cost of electricity generation by 0.4 cents per kWh in 2006 and didn't affect the cost in 2007, depending on the

[4] Although the Kake powerhouse actually has four identical generators, they are not typically run simultaneously, so one was sufficient for the purpose of the simulations.

availability of water. Adding solar PV (<20 kW) increased the cost of generation further by 0.1-0.2 cents per kWh. If grant funding could be secured to reduce the upfront costs of storage and solar PV by 70%, then larger batteries and solar PV arrays were optimized by the software while reducing the cost of electrical generation by 0.3-0.8 cents per kWh.

Takeaways

Each community must consider the type of renewable energy, the demand profile of the community and the associated costs when deciding if — and to what extent — integrating renewable resources is right for them. As renewable energy becomes cheaper, it will become more heavily incorporated into grids both big and small. To stabilize grids, managing utilities must provide additional reserve capacity and/or add dispatchable loads in order to control swings in an intermittent renewable resource. Unless significant grant funding is secured, these options may increase the cost of electricity due to the required purchase of additional equipment. Each community must make a unique balance between reducing fuel consumption and buying new hardware to keep the grid reliable.

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