**Business & Technology Advisory**
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# DISTRIBUTED WIND CASE STUDY: KOTZEBUE ELECTRIC ASSOCIATION

*Replacing diesel fuel with a wind hybrid system in Alaska's Arctic Tundra*

KOTZEBUE ELECTRIC ASSOCIATION
*Energizing our community today and tomorrow*

## RADWIND Project

This is the eighth in a series of case studies on distributed wind projects at electric cooperatives and other rural utilities for NRECA Research's *Rural Area Distributed Wind Integration Network Development* (RADWIND) project. RADWIND's goal is to understand, address, and reduce the technical risks and market barriers to the adoption of distributed wind technologies by rural utilities. Distributed wind projects can use any scale of turbine from small kilowatt-scale units up to large multi-megawatt units, as long as they are connected on the distribution side of the electric grid. Turbines may be connected on the customer side of the meter to serve a local load, directly to the distribution grid as a utility generating asset, or directly powering an off-grid load. For more information on the project and additional resources, please visit the project landing page at www.cooperative.com/radwind.

The distributed wind project profiled in this case study is part of a front-of-meter wind farm connected to the co-op's distribution grid.

***This material is based on work supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Wind Energy Technologies Office Award Number DE-EE0008958.***

## Project Snapshot

| Cooperative | Project Ownership | Project Size | Turbine Size | Other System Equip. | Connection | Energy End Use |
|---|---|---|---|---|---|---|
| Kotzebue Electric Association (KEA) | Kotzebue Electric Association (KEA) | ~3.9 MW | Multiple - ranging from 20 to 900 kW | 1 MW / 1 MWh lithium-ion battery, 532 kW PV | Isolated distribution grid | Offsets KEA's diesel fuel usage |

## Cooperative Profile

Kotzebue Electric Association (KEA)[1] is an electric cooperative that serves the town of Kotzebue, Alaska, also known as Qikiqtaġruk, 32 miles north of the Arctic Circle. The town's electric grid is isolated and not tied to any larger grid, so the co-op generates all of its power and distributes it to the community of about 3,200, most of which is Inupiat, a group of Native Alaskans. KEA's territory is relatively small (see Figure 1) – about four square miles – but the community is central to the region. Kotzebue is the seat of the Northwest Arctic Borough and serves as a hub for transportation, education, and health care for 11 outlying villages.

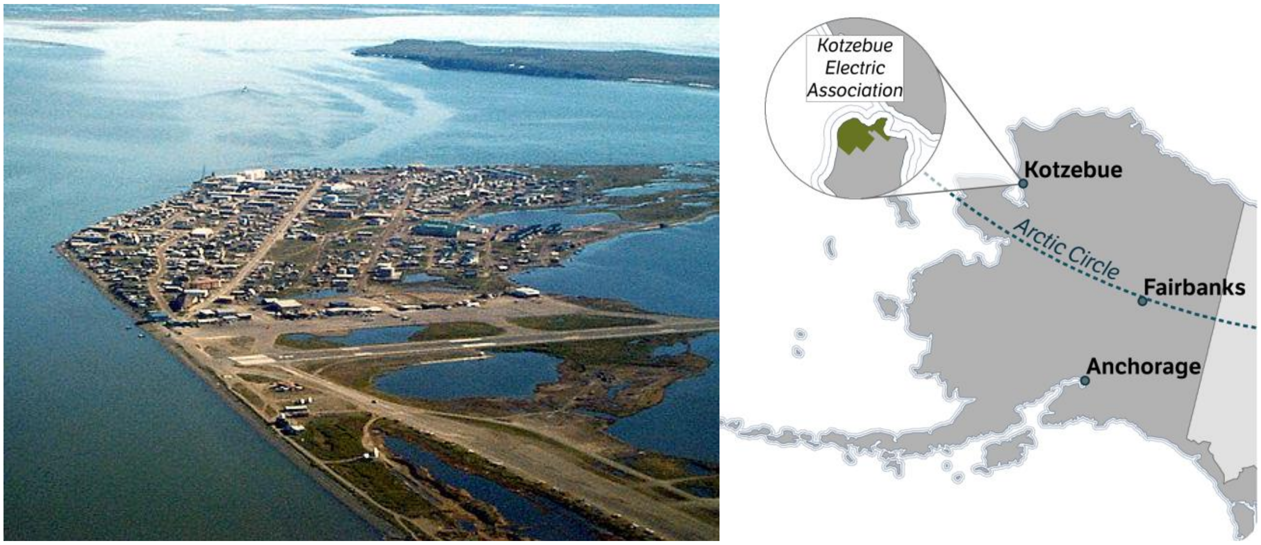


**Figure 1. Aerial view of Kotzebue, Alaska[2] and map showing KEA's territory (in green).**

KEA first generated power in 1954 with a 50 kVA diesel generator. The co-op's founders and first board of directors included the first commercially-licensed Alaska Native pilot in the U.S., a reindeer herd owner, a trading company proprietor, and a well-known Alaskan bush pilot.[3]

Keeping with that pioneering spirit, KEA established itself as a leader in wind energy. In 1997, the co-op built a wind farm that was groundbreaking in many ways:

- Northernmost wind farm in the U.S.
- First utility-scale wind farm above the Arctic Circle
- First utility-scale wind farm in Alaska
- First wind farm to use "freeze-back pilings" in the permafrost wind turbine foundations

For these accomplishments, the Alaska section of the Institute of Electrical and Electronics Engineers (IEEE)[4] named the co-op *Small Company of the Year* in 2006. In 2007, the IEEE again recognized KEA with the *Region 6 Outstanding Corporate Service to the Engineering Community Award*. Since that time,

[1] https://www.kea.coop/
[2] Source: U.S. Army Corps of Engineers, public domain image
[3] https://www.kea.coop/about/history/
[4] https://www.ieee.org/

KEA has expanded and updated its wind farm and added solar photovoltaic (PV) to their generation mix. Today, the co-op owns and operates 11 MW of diesel generation from six generators, 0.5 MW of solar PV, 2.4 MW of installed wind capacity, and a 1 MW/1 MWh lithium-ion battery.

## Project Background

Like most electric utilities serving isolated grids in Alaska, KEA was entirely dependent on diesel fuel prior to their wind farm. This left the co-op subject to volatile fuel prices, exacerbated by Kotzebue's climate and location, which make fuel delivery expensive and logistically challenging. Diesel fuel must be delivered to the community via barge, and Kotzebue Port is typically frozen for eight to nine months per year.

According to Brad Reeve, KEA's former general manger, KEA wanted to diversify its generation mix and sought to integrate technology "that increases the use of renewable energy and reduces diesel fuel consumption, not only for Kotzebue, but the rest of the region." In 1991, the co-op began investigating wind energy options with a $25,000 grant from NRECA Rural Electric Research. From there, KEA monitored potential wind sites, located a turbine manufacturer willing to do a project in rural Alaska, set aside budget for a wind project, and secured matching funds from the state.

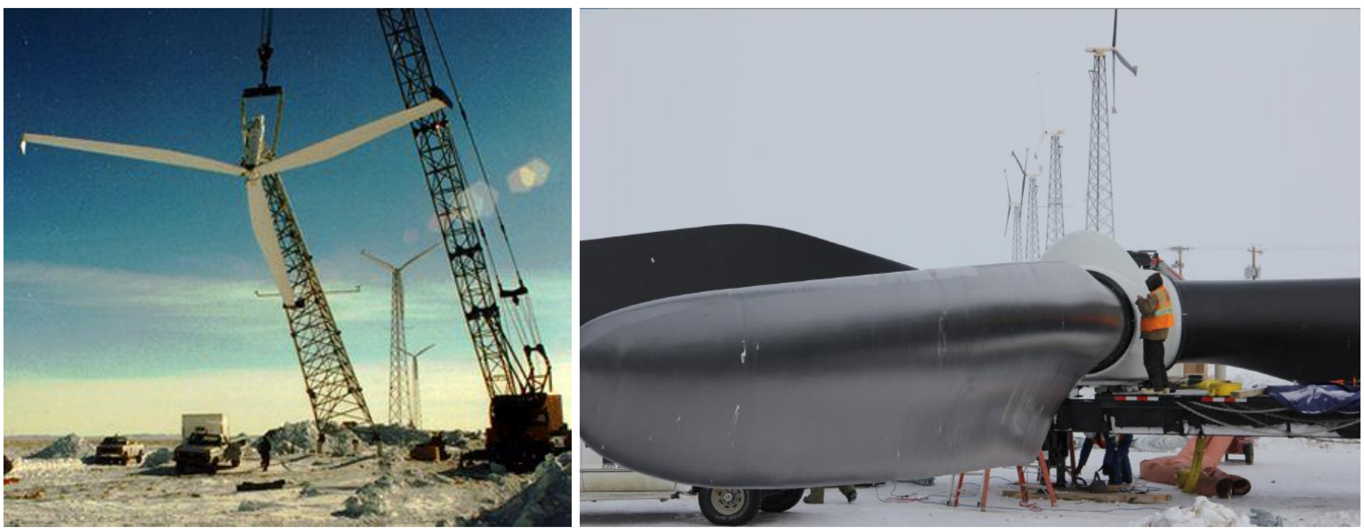

**Figure 2. Wind turbine installations.** Courtesy of Kotzebue Electric Association.

Eventually, the co-op purchased and installed three 66 kW Atlantic Orient Corporation (AOC) wind turbines in 1997 (see Figure 2). Three years later, it added eight more turbines for a total of 726 kW of wind capacity. By 2011, KEA's wind farm consisted of 17 turbines, and the co-op was the first Alaska utility to exceed 1 MW of total owned wind capacity. The next year, KEA commissioned two 900 kW turbines, tripling their wind capacity. In 2015, KEA connected a 1 MW/1 MWh lithium-ion battery to their system.

## Technical Details

KEA's wind farm has evolved over time, with the co-op adding new turbines and decommissioning others based on maintenance needs and availability of newer models (see Table 1). In total, KEA has owned and operated 20 individual wind turbines since 1997. As of 2021, two 900 kW models are operational, nine wind turbines have been decommissioned and replaced with a 532 kW (AC) solar array, and nine smaller models are not operating, but could be repaired. However, the co-op would like to replace the non-operational models, which range from 50 to 100 kW, with two 1,000 kW wind turbines as part of its strategy to replace diesel entirely with reliable renewable generation.

KEA plans to use two 1,000 kW (1 MW) models instead of a single 2.5 MW model for several reasons. First, the cranes available on the west coast of Alaska are not large enough to install a 2.5 MW turbine. Second, the permafrost foundations would be difficult and costly to develop at the size needed for a 2.5 MW model. Finally, maintaining power quality is an issue. As Matt Bergan, project engineer at KEA, explained, the temporary loss, or trip, of a 2.5 MW turbine (serving a 3 MW load) would have significant power quality effects on KEA's grid compared to a trip of a 1 MW unit.

**Table 1. Status of Kotzebue Electric Association Wind Turbines (2021)**

| | Quantity | Make | Model | Capacity (kW) | Installation Date |
|---|---|---|---|---|---|
| **Operating** | | | | | |
| | 2 | EWT | DW54 | 900 | 2012 |
| **Not operating but repairable** | | | | | |
| | 1 | Vestas | V15 | 50 | 2005 |
| | 3 | AOC | 15/50 | 66 | 1997 |
| | 1 | AOC | 15/50 | 66 | 2002 |
| | 3 | Entegrity | EW 15/50 | 50 | 2005 |
| | 1 | Northern Power | NW100 | 100 | 2002 |
| **Decommissioned and replaced with PV** | | | | | |
| | 8 | AOC | 15/50 | 66 | 2000 |
| | 1 | Eocycle | 1st generation | 20 | 2015 |

The associated battery electric storage system (BESS) is a 950 kWh Saft lithium-ion battery with a 1.225 MW ABB PCS100 power converter; the system performs as a 1 MW/1 MWh (i.e., 1 hour) resource. The battery has been working well for the co-op as a spinning reserve. According to Bergan, "We're using it to essentially smooth out fluctuations from our renewable generation." If a wind turbine goes offline unexpectedly, a diesel generator running concurrently with the wind turbine could suddenly become overloaded. This can cause a drop in grid frequency that could lead to an outage. However, the battery can detect a drop in frequency and automatically provide power to the grid to correct the frequency. The combination of wind turbines operating together with solar panels and a BESS makes KEA's a distributed wind hybrid system.[5]

[5] For more information on hybrid distributed wind systems, see the April 2021 RADWIND report *Use Cases for Distributed Wind in Rural Electric Cooperative Service Areas,* available from: https://www.cooperative.com/programs-services/bts/radwind/Documents/RADWIND-Use-Cases-Report-April-2021.pdf

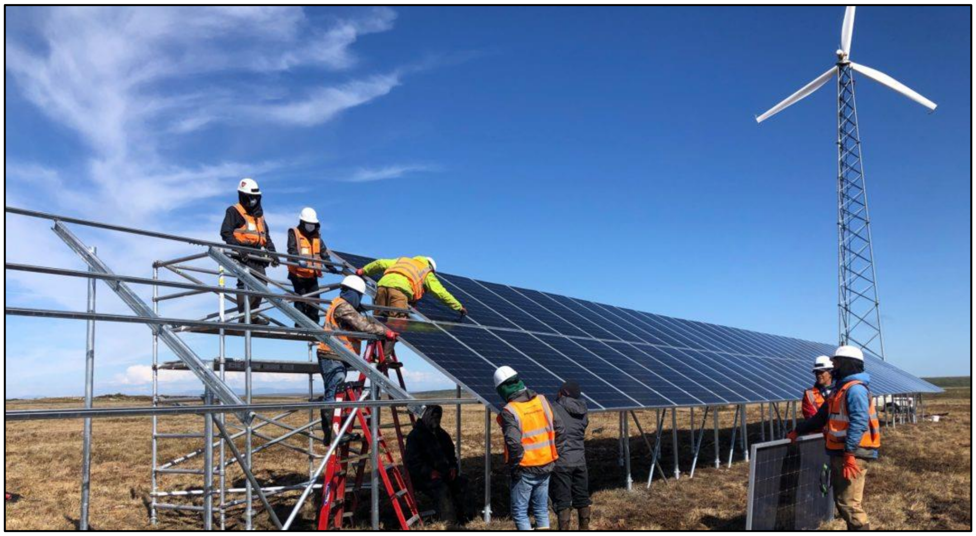

**Figure 3. Workers install a solar array next to wind turbines as part of Kotzebue Electric Association's hybrid distributed wind project.**

Courtesy of Matt Bergan, Kotzebue Electric Association

## Siting and Interconnection

KEA located its wind farm at the end of a 4-mile 7.2/12.5 kV distribution line that was originally built to power the community's AM radio station, KOTZ 720AM. In 1994, the co-op signed a lease with Kikiktagruk Inupiat Corporation, a Native village corporation, for use of the land. The area near the radio station was a suitable site in part because it met Federal Aviation Administration (FAA) requirements for distance from an airport, but also because the distribution line serving the radio station had extra capacity.

KEA's territory, located on the edge of the Chukchi Sea and north of the Arctic Circle, has abundant wind resources most of the year. Windspeeds average 12 mph, but gusts of 30 to 60 mph are not uncommon. Because KEA's grid is isolated, there are no substations or other connections to a high-voltage transmission grid, so that interconnection was not a factor in this project.

## Metering

KEA has a meter on each turbine to track its production individually. Because the co-op serves an isolated grid and self-supplies all of its power, there is no additional metering for a power supplier or other third party.

## Production

In 2020, the two 900 kW wind turbines generated just over 4,000 MWh combined. This was about 20% of the co-op's total annual load, but at times KEA meets up to 80% of its demand with wind.

According to Bergan, the amount of wind energy generated is more dependent on seasonal weather patterns than the diurnal patterns often seen in other states. Winter and spring typically have the most wind, which makes the co-op's summer-peaking solar PV an excellent complement to the wind farm. During the months with the least amount of wind — June, July, and August — the sun shines around the clock in the arctic latitudes. Conversely, solar PV in this region does not produce electricity during winter when generation from wind turbines is high.

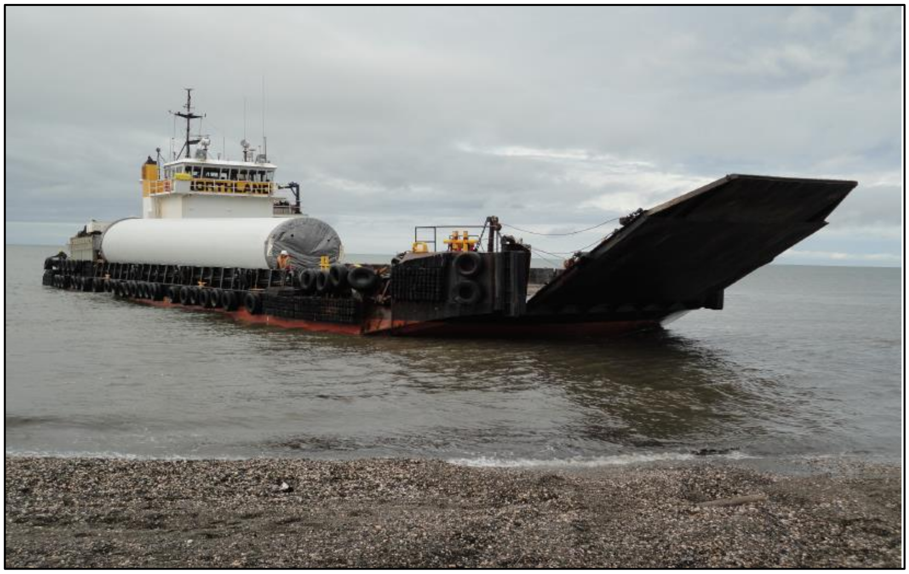

**Figure 4. Barge transporting wind turbine tower segment.** Courtesy of Kotzebue Electric Association.

## Planning & Engineering

KEA did not need to collaborate with power suppliers or transmission authorities to install their wind farm, because their grid is isolated. However, the project had other engineering challenges to resolve. As with most goods used in Kotzebue, the wind turbines had to be delivered by barge during the three-month window when Kotzebue Port is not frozen (see Figure 4).

One of the key engineering challenges was ensuring the turbines' foundations would remain stable in the permafrost. The ground in Alaska's arctic tundra region is known as permafrost because it is frozen for much of the year. Average winter air temperatures hover around -30°F, but average summer temperatures can range from 37 to 54°F.[6] In the winter, the permafrost ground temperature is typically around 25°F, but can rise above freezing during the summer. As the builder of the first wind farm on the tundra north of the Arctic Circle, KEA had to figure out a way to ensure the wind turbines would remain stable when the permafrost's active layer[7] thaws in the summer.

The co-op consulted Arctic Foundations, Inc.,[8] an Anchorage-based geothermal engineering and construction firm that was experienced with "freeze-back pilings." Freeze-back pilings[9] are long cylindrical concrete or steel foundations surrounded by thermal siphon coils (see Figure 5). The coils contain gasses that can absorb extremely cold temperatures from the ground during winter, then use the stored cooling capacity to keep the ground surrounding the foundations frozen throughout the warmer summer months.

[6] https://www.conserve-energy-future.com/tundra-biome.php

[7] The top layer of permafrost that thaws during summer and freezes again during autumn. https://polarpedia.eu/en/active-layer/

[8] https://arcticfoundations.com/

[9] Also referred to as "pile foundations."

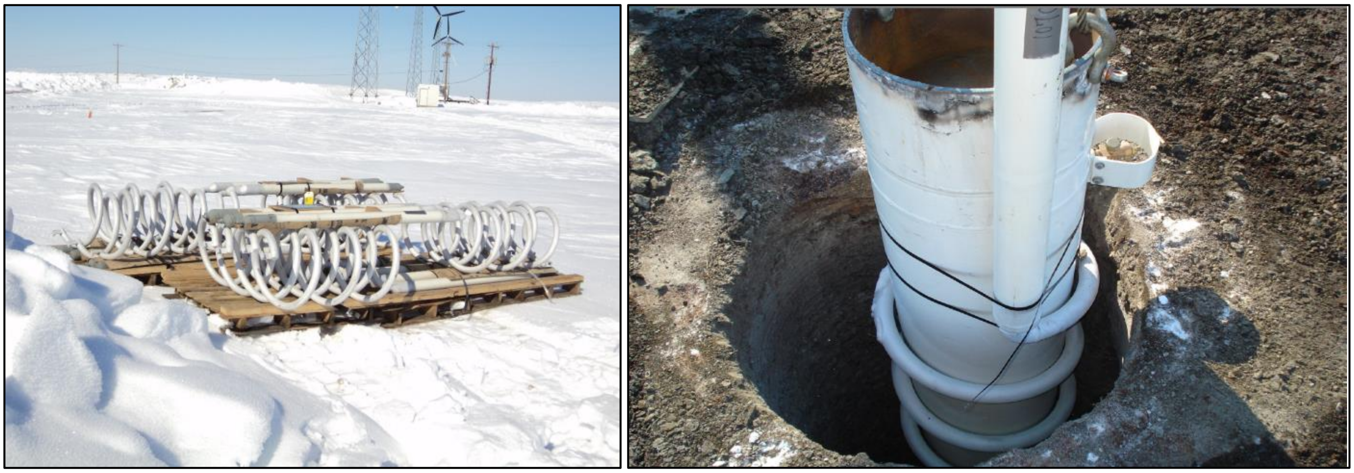

**Figure 5. Thermal siphons to be installed as part of freeze-back pilings, and freeze-back piling installation.** Courtesy of Kotzebue Electric Association.

“We use the permafrost to our advantage in that it's sort of a low grade of concrete, if you will. As long as you keep the ground frozen, you can use it as a as a structural component,” said Bergan. “If the normal permafrost temperature is, say, 25 degrees Fahrenheit, the thermal siphon may cool the ground around those pilings to 15 or 20 degrees Fahrenheit instead. We're sort of making extra cold permafrost in the winter and then through the summer, the ground will start warming. The idea is to let the ground warm, but not to the point of melting. We want to keep the temperature below 25 or 26 degrees under the foundation.” This technology is working well at KEA’s wind farm and has since been employed at other wind farms in Alaska.

## Operations & Maintenance

KEA staff are able to perform operations and maintenance (O&M) on the smaller wind turbines. Given the age of some of the machines, the fact that several of the models are no longer in production, as well as the harsh climate, sometimes the repairs are effective for only a few days or weeks. This is why many of the smaller wind turbines are currently not operating.

For the two 900 kW wind turbines, KEA has a maintenance contract with the manufacturer, EWT,[10] which has a technician based in Fairbanks, Alaska. EWT performs preventative maintenance twice a year, sometimes bringing in crews from Europe or the lower U.S. to perform the work. According to Bergan, the larger machines are much more reliable in the arctic climate, which is why KEA will gradually replace its smaller wind turbines with larger models and solar PV.

An unexpected O&M issue at the wind farm has arisen due to warming temperatures in the region. In 2019, the International Arctic Research Center found that air temperatures in Alaska were 3 to 4°F higher, on average, compared to the early- to mid-1900s.[11] Near Kotzebue, Bergan has observed that ground temperatures in the area have risen by 1°F in recent years. While the turbines continue to be stable due to the freeze-back pilings, the warming ground in other areas of the wind farm is causing access roads to sink and buildings on site to lift from frost heave. This, in turn, causes the cables that run under these roads and connect to the turbines’ electrical enclosure boxes to become taut. Crews now must continually

[10] https://ewtdirectwind.com/services/service-maintenance/

[11] https://uaf-iarc.org/our-work/alaskas-changing-environment/

manage this situation by moving connection boxes to maintain slackness in the lines to prevent lines from breaking.

## Economic Details

KEA secured financing for its wind turbines using its own budget and creative partnerships over many years, including:

- 1991 – $25,000 grant from NRECA Rural Electric Research for a feasibility study
- 1993 – $250,000 committed by KEA's board to develop a wind project
- 1993 – Match funding from State of Alaska to purchase and install the first three wind turbines
- 1998 – Support to purchase seven turbines for cold weather deployment and testing from Department of Energy's Sustainable Technology Energy Program
- 2002 – Partial funding from National Science Foundation to install and test Northern Power's first commercial Northwind 100 kW wind turbine
- 2010 – Grant from State of Alaska – Renewable Energy Fund that was leveraged into an $11 million project, including $3 million of Clean Renewable Energy Bonds (CREBS), to develop a wind project with battery storage[12]

Starting in 2005, 0% interest CREBs were made available to electric cooperatives as part of the federal Energy Policy Act of 2005. In 2010, KEA used this program to help finance its larger machines and storage.[13] The CREBs program helped electric cooperatives, municipal utilities, and other entities that could not take advantage of federal tax credits[14] finance renewable energy projects. CREBs are no longer available; the program was eliminated under the Tax Cuts and Jobs Act of 2017.[15]

## Members and Community

Increasing wind energy on KEA's grid insulates the co-op and its members from the high and volatile costs of diesel fuel. KEA purchases fuel in bulk once a year, in June or July when their port is not frozen, in coordination with several other electric cooperatives in western Alaska. Fuel pricing is based on the world oil market price at the time of purchase, but also steadily increases from inflation, and cost of transportation and delivery into local storage tanks, and environmental protection costs for oil spill protection. The once-a-year purchase locks the co-op into the June/July price for the entire year, which means that they are not able to purchase fuel strategically if pricing is lower at other times during the year.

In 2016, Reeve estimated that the wind energy displaced the need for about 250,000 gallons of diesel fuel every year. While the COVID-19 pandemic has depressed the price of power generation diesel in Kotzebue to about $3/gallon in 2021, at times it has reached $5/gallon.[16] A 2015 study of just the two newest 900 kW EWT turbines by the Alaska Energy Authority found that the turbines had saved KEA

[12] Presentation by Brad Reeve, Kotzebue Electric Association, to the Islanded Grid Wind Power Conference, March 5, 2015

[13] Presentation by Brad Reeve, Kotzebue Electric Association. Renewable Capacity: Kotzebue Electric Association, Inc., available from: https://www.arctic.gov/uploads/assets/watersan-capacity-reeve-sm.pdf

[14] https://windexchange.energy.gov/projects/tax-credits

[15] https://www.energy.gov/sites/prod/files/2018/02/f48/QECB_CREBs_Eliminated_Fact_Sheet.pdf

[16] KEA uses #2 Ultra Low Sulphur Diesel (#2ULSD) for power generation, which is different from home heating diesel.

229,000 gallons and over $800 thousand on an annualized basis in diesel costs during the first year and a half of operation. With an estimated benefit/cost ratio of 1.36 over the project's planned 20-year lifetime, the project would more than pay for itself with fuel cost savings.[17] Using a renewable source of energy also protects members from potential shortages caused by supply chain and transportation issues.

Some local non-profits benefit further from the wind farm because KEA allows them to purchase excess wind energy at discounted rates at times when member demand is fulfilled, and the battery is fully charged. Kotzebue's hospital, operated by the non-profit Maniilaq Association,[18] purchases excess wind energy from KEA at a discounted rate to power a large electric boiler for space heating. Following that model, the local National Park Service's Northwest Arctic Heritage Center[19] is installing an electric boiler, so that it can also reduce its heating costs with KEA's excess renewable energy.

Finally, the shift to renewable energy is particularly meaningful for Kotzebue and other Arctic residents as they face daily challenges from a warming climate. In Bergan's nearly 24-year tenure at KEA, he has observed "noticeable visual changes to the tundra." Where it used to be a broad, smooth expanse, it is now "much more undulating, with a lot more vegetation and a lot more small ponds and lakes forming." This temperature increase is widely recognized for its detrimental impacts to health and the economy. According to Alaska's Department of Commerce, Community, and Economic Development:

> *Every new day brings with it new evidence of climate change in Alaskan communities – warmer, record breaking temperatures have resulted in thawing permafrost, thinning sea ice, and increasing wildfires. These changes have resulted in a reduction of subsistence harvests, an increase in flooding and erosion, concerns about water and food safety and major impacts to infrastructure: including damage to buildings, roads and airports.*[20]

While one co-op cannot singlehandedly reverse this trend, it can reduce the negative impacts of burning fossil fuel locally in alignment with the Concern for Community cooperative principle.

## Project Experience, Opportunities, and Challenges

Being an innovator rarely comes without obstacles. As a pioneer in wind farm location and technology, KEA has found opportunity in some of their challenges. For example, some of the smaller wind turbines required more maintenance than anticipated, and manufacturer support for them dwindled as companies went out of business and technologies changed. However, decommissioning some of the low-performing wind turbines gave KEA an opening to add solar to their generation mix. The co-op found that solar complements their wind generation well; and while solar in this region produces less energy per installed kW compared to wind, its maintenance needs are lower.

KEA's wind farm is a success for the co-op, its members, and the region. KEA is very pleased with the amount of diesel they offset with the wind farm. In addition, other Alaska utilities—including Alaska Village Electric Cooperative, Unalakleet Valley Electric Cooperative, and utilities in the nearby villages of Buckland and Deering—have followed suit. KEA hopes to add two 1,000 kW wind turbines and upgrade their battery to a 4 MW/4-8 MWh model, all at their existing site. To accommodate this

[17] https://www.akenergyauthority.org//Portals/0/Programs/Wind/Case%20Studies/KotzebueWindFarmExpansion2016.pdf?ver=2019-06-19-133904-677&ver=2019-06-19-133904-677
[18] https://www.maniilaq.org/about-us/
[19] https://www.nps.gov/kova/planyourvisit/northwest-arctic-heritage-center.htm
[20] https://www.commerce.alaska.gov/web/dcra/ClimateChange.aspx

expansion, the co-op is also planning to raise the wind/PV site's distribution line's voltage from 15 kV to 25 kV to increase the capacity to bring more renewable energy to the community. These additions and upgrades would eliminate their need for diesel fuel entirely at times when sufficient renewable power is available. "We have plans. We're shovel ready. We've got the design worked out on all the geotechnical and everything. We're just trying to figure out funding," said Bergan.

Looking farther ahead, KEA is evaluating the possibility of installing a 2+ MW turbine at a deep-water port about 15 miles south of Kotzebue. While a turbine of this size is not feasible at their existing inland tundra site, adding a 2+ MW wind turbine at the port would enable the co-op to displace even more diesel and possibly to produce hydrogen.

## Key Lessons and Insights

Bergan joined the co-op just one year after the wind farm began and has learned a lot along the way. For cooperatives and other utilities in Alaska and elsewhere interested in bringing their own wind turbines online, he recommends starting off early with community involvement and careful site selection. "Definitely have some community meetings and talk about where these resources might be installed." If possible, look for locations where a power line already exists, because "building a power line across four miles of wet tundra could be an expensive endeavor." Further, engage the FAA during the site selection process, especially in Alaska where most communities have small airports. The FAA has review requirements[21] for wind turbines near airports and for any structure exceeding 200 feet above ground level.

Bergan and others at KEA are happy to share their experiences and lessons learned to help everyone in the region replace diesel fuel with clean, local renewable energy. "Our phone lines are always open. If anyone wants to call or come visit, we're always interested in sharing knowledge." This spirit of sharing aligns with the electric cooperative principles and is integral to remote communities like Kotzebue. While the co-op provides electricity, other organizations provide education, healthcare, and transportation. "We're all kind of working for each other up here in one way or another," said Bergan. With its innovative spirit and concern for community, KEA shows how a wind farm can work for a community on many levels.

## Contacts for Questions

**Matt Bergan, PE**
Project Engineer
Kotzebue Electric Association
m_bergan@kea.coop
Ph: 907-442-3491

**Michael Leitman (Project Manager)**
Director, System Optimization
National Rural Electric Cooperative Association
Michael.Leitman@nreca.coop
Ph: 703.907.5864

*This case study was researched and written by Laura Moorefield, Moorefield Research & Consulting, LLC, lmoorefield@gmail.com, Ph: 970.903.3044.*

[21] https://oeaaa.faa.gov/oeaaa/external/searchAction.jsp?action=showWindTurbineFAQs

### Additional Information on NRECA Research's RADWIND Project

For more information on the RADWIND project and additional resources, please visit the project landing page at www.cooperative.com/radwind.

Want to stay informed of our progress with the RADWIND project, and provide your input and feedback? We welcome all NRECA voting members to join the project as advisors. Contact our team at: RadwindProject@nreca.coop.