NORTHWEST ARCTIC REGIONAL ENERGY PLAN 2022

April 11, 2022

Prepared for: The Northwest Arctic Borough & NANA Regional Corporation

Deerstone Consulting

Northwest Arctic Regional Energy Plan Communities

Serving the communities of:

English Name	Iñupiaq Name
Ambler	Ivisaappaat
Buckland	Nunachiaq
Deering	Ipnatchiaq
Kiana	Katyaak
Kivalina	Kivalieiq
Kobuk	Laugviik
Kotzebue	Qikiqtabruk
Noatak	Nautaaq
Noorvik	Nuurvik
Selawik	Akulibaq
Shungnak	Issingnak

Plan Prepared by:
DeerStone Consulting, LLC

Prepared For and in Coordination With:
Northwest Arctic Borough and NANA Regional Corporation

Regional Map & Plan Coverage Area

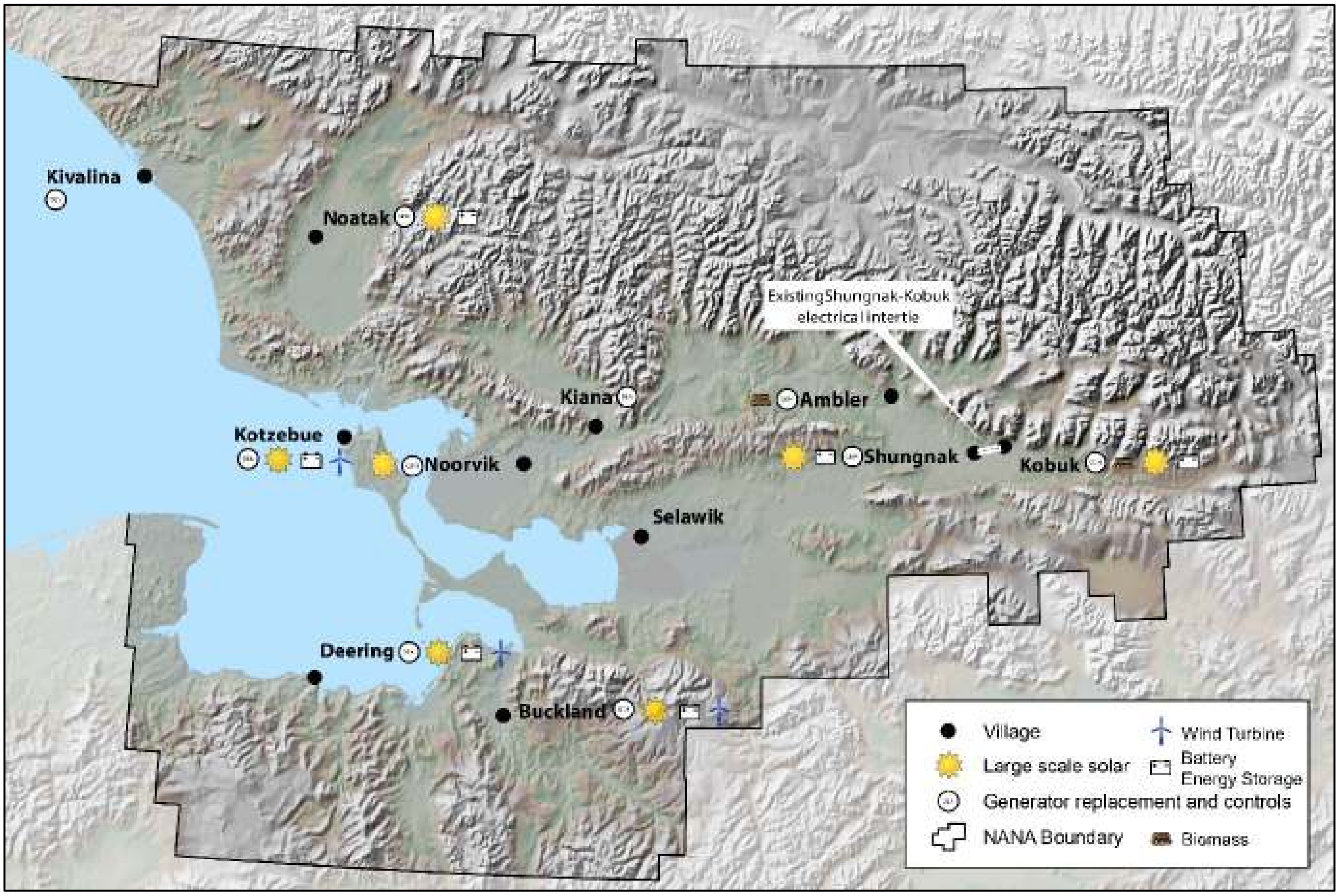

Figure 1. Energy Infrastructure in the Northwest Arctic

Acknowledgements

DeerStone Consulting developed this Northwest Artic Regional Energy Plan in coordination with the Northwest Arctic Borough, NANA Regional Corporation, and with the participation of many community energy stakeholders and individuals. We wish to thank everyone for their input and commitment to a resilient, sustainable, and affordable energy future.

Stakeholder Participants Include:

Ingemar Mathiasson, Energy Manager, Northwest Arctic Borough

Sonny Adams, Director of Energy, NANA Regional Corporation

Albie Dallemolle, Sr. Director of Village Economic Investment, NANA Regional Corporation

Terrell Jones, Energy Coordinator, NANA Regional Corporation

Ambler: Scott Jones

Buckland: Patricia Thomas, David Lee, Tim Gavin, Mike Sheldon (Power Plant Operator)

Deering: Daisy Weinard, Chris Moto (Power Plant Operator)

Kiana: Dolores Barr, Brad Reich, Eli Cyrus

Kivalina: Millie Hawley, Becky Norton, Austin Swan

Kobuk: Edward Gooden

Kotzebue Electric Association: Matt Bergen

Noatak: Jennifer Sage

Noorvik: Glen Skin

Selawik: Tanya Ballot, Mildred Greist

Shungnak: Billy Lee

Alaska Village Electric Cooperative: Bill Stamm, Dan Allis, Darren Westby, Forest Button

Acronyms and Abbreviations

AEA	Alaska Energy Authority
ACEP	Alaska Center for Energy and Power
AHFC	Alaska Housing Finance Corporation
ANCSA	Alaska Native Claims Settlement Act
ANTHC	Alaska Native Tribal Health Consortium
AVEC	Alaska Village Electric Cooperative
BIA	Bureau of Indian Affairs
BEES	Building Energy Efficiency Standard
BESS	Building Energy Storage System
CFL	Compact Fluorescent Light
DCCED	Department of Commerce, Community and Economic Development
DOE	U.S. Department of Energy
DOL	Alaska Department of Labor (and Workforce Development)
ECI	Energy Cost Index
EPA	U.S. Environmental Protection Agency
HUD	U.S. Department of Housing and Urban Development
ICDBG	Indian Community Development Block Grant
IPP	Independent Power Producer
KEA	Kotzebue Electric Association
kW	Kilowatt
kWh	Kilowatt-hour
MWh	Megawatt-hour
NAB	Northwest Arctic Borough
NANA or NRC	NANA Regional Corporation
NDC	NANA Development Corporation
NREL	National Renewable Energy Laboratory
NWABSD	Northwest Arctic Borough School District
NWALT	Northwest Arctic Leadership Team
PCE	Power Cost Equalization
PV	Photovoltaic
REAP	Renewable Energy Alaska Program
REF	Renewable Energy Fund
WTP	Water Treatment Plant

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Executive Summary

This document builds upon the previous regional energy planning efforts that have been previously completed in the Northwest Arctic, the most recent of which was published in 2016. To keep the plan current, the Northwest Arctic Borough and NANA Regional Corporation invested in a 2022 update.

This regional energy plan is a product of the Northwest Arctic Borough's and NANA Regional Corporation's commitment to a clean, affordable, and reliable energy future for the residents of the Northwest Arctic and NANA shareholders. The regional planning process began in earnest in 2008 when global oil prices spiked, causing large increases in stove oil, diesel fuel, and electricity prices throughout the region and elsewhere. A regional energy summit was convened in Kotzebue, which ultimately led to the creation of the Northwest Arctic Energy Steering Committee, diesel fuel reduction goals, and a continual focus on increasing regional energy security through use of clean, local energy sources.

The 2022 revision represents the continuing process of documenting the current status of energy opportunities, needs, and recommendations for reducing energy costs while maintaining or improving the current level of service.

The planning process consisted of the following activities:

DeerStone worked in coordination with the Borough and NANA to collect background data including past energy plans, relevant documents, studies, and tabulated data and then conducted a desktop review of the background information. The background review helped to inform the interviews with community leaders and key energy stakeholders. DeerStone interviewed City and Tribal leaders, electric utility stakeholders, fuel distributors, and other community and regional stakeholders to understand the current energy landscape, needs, and opportunities; in addition, the team sought an understanding of how each community wanted to prioritize energy projects and opportunities. Draft energy profiles and project and opportunities for each community were presented to stakeholders for feedback and revisions. The energy planning process resulted in the **Northwest Arctic Regional Energy Plan**, **Community Energy Profiles** for each community in the region and a comprehensive **Project and Opportunities Matrix** to cover the entire region.

Introduction

Alaska's Northwest Arctic communities have energy prices that are much higher than the national average and are amongst the highest in Alaska. The region's energy leadership and innovation have been partly in response to these high prices and challenges to energy security and are clearly demonstrated by the numerous studies, analyses, training events, experimental technologies, pilot projects, and widespread deployment of renewable energy and energy efficiency projects in all 11 communities in the Northwest Arctic. All of these initiatives have required time, effort, and funding. NANA Regional Corporation (NRC) and the Northwest Arctic Borough (NAB) have committed their own staff and financial resources to lead this effort, along with contributions from individual communities and organizational stakeholders for specific projects.

State and federal government support has also played an important role in the region's energy development success, including grant awards and technical assistance from agencies such as the US Department of Energy (DOE), the US Department of Agriculture (USDA), the Environmental Protection Agency (EPA), the US Department of Interior's Bureau of Indian Affairs (BIA), the Denali Commission, Alaska Energy Authority (AEA), and others.

Each and every community in the region has also contributed time, money, and a great deal of effort to advance their energy goals and share information with other stakeholders. This has created a regional dynamic establishing a high level of awareness and support for continued clean energy development and capacity building at the local level. This regional plan is another example of this dynamic and group effort.

Figure 2. Solar Installation Crew in Kotzebue (Photo Courtesy of Matt Bergan)

Many of the specific projects that have been deployed across the region have been captured in this report, especially in the *Community Energy Profiles* section, which provides a brief snapshot of individual projects, their cost, funding source(s), and current status. Past projects and lessons learned have informed future projects and opportunities as we plan for what comes next for the region. For example, designing and constructing large solar PV and/or wind and battery storage projects to enable several hundred hours annually of diesels-off operation are now commonplace across the region, however each deployment has built on the previous ones to reduce costs and improve performance. Based on such iterative improvements, the region was also evaluated to identify potential opportunities to bundle projects across communities to streamline efforts, reduce costs, and achieve economies of scale where possible. This effort is captured below in the *Project and Opportunities Matrix* that is part of this plan and has become an organizing strategy for accelerating development of multiple projects across the region.

It should also be noted that during the process of researching and drafting this document, global energy dynamics drastically changed in large part as a result of the Russian invasion of Ukraine in February and March of 2022, which caused oil prices to spike during the same time that most communities were purchasing a year's worth of fuel in preparation for summer delivery. The new price realities, such as $16/gallon for diesel fuel delivered by air to Noatak in early March 2022, are not fully factored into the economic evaluations included here since all of the detailed analysis for this plan was complete prior to this sharp uptick in energy prices. In general, all of the renewable energy efforts evaluated here will demonstrate better economic performance as a result of recent fossil fuel price spikes, but it is unknown how long such prices will last, and this is little consolation to residents paying high prices for the energy needs still met with fossil fuel.

This regional planning document consists of an overview of energy production and consumption in the region followed by a more detailed discussion on residential heating, housing, bulk fuel, and electricity. The plan then provides technology pricing and trends that have emerged in the region as a result of lessons learned from each past project and the institutional memory that has evolved from effective communication among project partners. Details of individual systems and a more generalized project development process that has been used across the region is presented. The core of the plan—energy opportunities for the region and for each community—are then described in various formats in the main narrative and as Appendices.

Figure 3. Regional Energy Planning Meeting in Noatak

Regional Energy Vision

The vision for the Northwest Arctic region is to be at least 50% reliant on regionally sourced energy for heating and power generation by the year 2050. Milestones toward this long-term vision include:

- 10% decrease of imported fuel by 2020 - accomplished
- 25% decrease of imported fuel by 2030
- 50% decrease of imported fuels by 2050

This vision was established at the first regional energy summit in Kotzebue in 2008 in response to the energy crisis at the time, which resulted in a rapid and sharp increase in fuel prices similar to the recent price escalation in February and March 2022. These values were considered (and remain) ambitious and visionary especially because reliable renewable energy in remote locations was still in early development in 2008 and exceedingly expensive. Currently, there are some examples of institutions and communities aiming for as high as 100% renewables by a certain time in the future. Considering the energy challenges in Northwest Arctic and all of rural Alaska, such a goal appears overly ambitious at the present time, but as global awareness and support for clean energy grows, there are increasingly sophisticated strategies and tools to measure progress as a community or region reduces its dependence on fossil fuels and increases its use of local renewable energy. Some of these tools and strategies will be discussed more below. As technology options continue to mature and drop in price, the region may want to re-visit their vision and more comprehensively measure their progress in the future against a baseline of fuel consumption identified in this and/or other reports.

Regional Energy Goals

The energy goals for the region are informed across regional and community stakeholders and include:

- Lower costs of energy for heating, electricity, and transportation.
- Development of reliable and local and/or regional energy sources.
- Achievement of independence from imported fuel as much as possible.
- Regional collaboration and unification of energy related operations.
- Local economic development as a part of the energy solutions employed.
- Reduce the region's carbon footprint.
- Land stewardship and protection of subsistence resources to be considered during all project development and execution.

Energy Production and Consumption

The primary uses of energy in the region are for power generation, heat, and transportation. All of these uses are mostly provided by diesel fuel and some gasoline for light duty transportation vehicles. Renewable energy is meeting a small but growing share of these uses. Understanding the amounts of diesel fuel used in the region is critical to quantifying the opportunities for reducing the usage of diesel fuel or replacing it with a less costly alternative. Figure 4 shows the percentage of diesel fuel consumption by the three primary uses: power generation (46%), heat (44%), and transportation (10%).

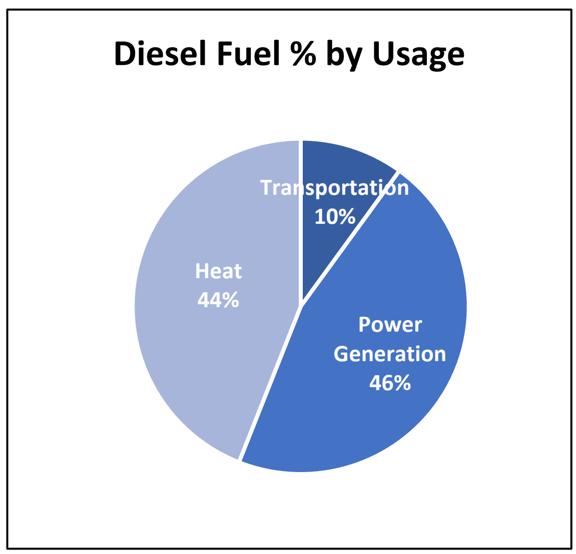

Figure 4. Diesel Fuel % by Usage

Data is readily available for diesel fuel used for power production in rural Alaska because electric utilities must file monthly reports on their diesel fuel usage to receive state PCE subsidies.

Accurate fuel use data for heating is often difficult to collect because it is not measured when it is consumed, and fuel providers do not publicly share their delivery data. Hence, heating fuel usage was estimated using data collected informally by the Northwest Arctic Borough's Energy Coordinator and from end use surveys across the state that concludes a "typical" rural Alaska village energy distribution is anywhere from 1.5 times to twice as much fuel consumed for heating as compared to electricity. Using this methodology, we estimate that diesel fuel for heat for the entire region ranges between 3.5 – 4.5 million gallons.

Figure 5 represents the region's combined usage of 2,342,692 gallons of diesel fuel in 2019 for producing electricity and the 3,500,208 gallons of diesel fuel used for heat. Figure 6 illustrates the breakdown of total energy usage by community. Not surprisingly, Kotzebue consumes 58% of the fuel used in the region since over half the population of the entire region lives in Kotzebue.

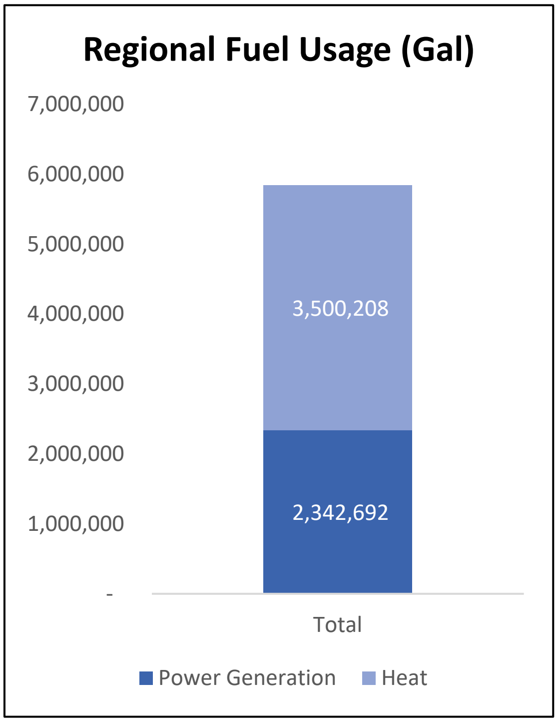

Figure 5. Fuel Usage for Power and Heat, in gallons

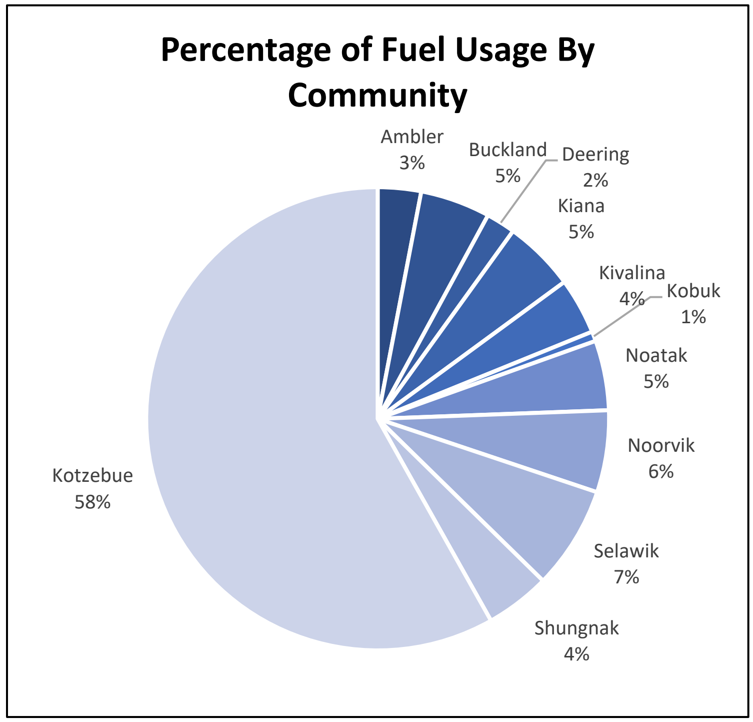

Figure 6. Fuel Usage by Community, %

These estimates are particularly useful to construct a baseline of energy consumption, and ultimately energy expenditures, in the region. With fuel prices provided by various sources, we can begin to determine total dollar amounts spent on fuel for heating and electricity.

The total amount spent on fuel for both heating and power production needs for the region is $30.7 million annually. The 2.3 million gallons of fuel required for the region to generate power costs $7.5 million annually based on 2020 PCE data including average price per gallon of fuel for each power utility. The estimated 3.5 million gallons of stove oil used for heating needs for the region costs $23.2 million annually based on spring 2020 retail stove oil prices by community. While the fuel costs account for most of the power generation expenditures, additional non-fuel costs—including utility labor, operation, maintenance, and administrative expenses—are paid by consumers. These additional non-fuel costs amount to approximately $6.6 million annually. For heating and power costs combined, including non-fuel costs for electricity generation, this equates to $37.3 million annually for the region.

***Table 1. Heating Fuel Costs*[1]**

	Ambler	Buckland	Deering	Kiana	Kivalina	Noatak
Heating Fuel Costs	$687,158	$997,679	$353,732	$1,008,991	$525,557	$1,442,226

	Noorvik	Selawik	Shungnak	Kotzebue	Kobuk	Region-Total
Heating Fuel Costs	$1,072,333	$1,789,245	$1,179,921	$13,756,838	$399,439	**$23,213,119**

***Table 2. Power Generation Costs*[2]**

	Ambler	Buckland	Deering	Kiana	Kivalina	Noatak
Gallons of Fuel	98,354	125,304	46,022	117,719	124,131	129,989
Fuel Costs	$405,319	$423,644	$140,244	$402,541	$410,984	$932,436
Non-Fuel Costs	$345,369	$43,494	$250,759	$334,447	$356,748	$355,099
Total Costs	$750,688	$467,138	$391,003	$736,988	$767,732	$1,287,535

	Noorvik	Selawik	Shungnak	Kotzebue	Kobuk	Region-Total
Gallons of Fuel	143,743	201,864	127,094	1,227,703	-	2,341,923
Fuel Costs	$493,916	$676,356	$594,780	$3,031,142	$0	$7,511,362
Non-Fuel Costs	$399,843	$553,422	$196,355	$3,611,073	$136,973	$6,583,582
Total Costs	$893,759	$1,229,778	$791,135	$6,642,215	$136,973	**$14,094,944**

The data above shows that of the combined fuel for power and heat, an estimated 40% is used for power generation, and accounts for only 23.9% of the combined fuel costs due to the lower cost of fuel for the electric utilities. Alternatively, almost 76% of all money spent on fuel in the region goes toward heating fuel.

As the region continues to make strides in reducing the cost to generate power through energy efficiency upgrades and renewable energy integration, it is important to recognize that the cost of heating fuel is a dominant component in the overall cost of energy and any efforts that reduce the cost of heating fuel will have an outsized impact in reducing the cost of energy for residents, households, and businesses in the Northwest Arctic/NANA region.

[1] Based on 2019 Heating Oil Prices, Provided by the Borough
[2] Based on 2020 PCE Data

Community Energy - Focal Points

Residential Heating

Nearly half of the residents in the region use a combination of heat sources including furnaces, wood stoves, Toyo or Monitor stoves, and boilers. Heating in the region consumes an estimated 3.5 million gallons, or more, of heating fuel[3] annually. Much of this fuel is used for residential heating and is purchased at retail prices as compared to some larger community buildings such as local schools that purchase heating fuel at much lower prices. An estimated 124,000 gallons of heating oil is displaced through the burning of local wood for heat[4].

Due to high retail heating fuel prices and cold winter temperatures, the financial burden of home heating in the region is immense. Table 3 shows the average annual price of heating fuel across the region. Table 3, enumerates the retail heating fuel prices for each community for each of the last six years. The prices in red indicate the highest stove oil price in each community over the last six years, and those in green, the lowest. As mentioned elsewhere, note that the 2022 extreme price escalations are not shown in this table.

Table 3. Heating Fuel Costs by Community, Highs and Lows

	2016	2017	2018	2019	2020	2021
Kotzebue	**$5.26**	$5.26	$5.97	$5.97	$5.92	$5.87
Ambler	$9.50	**$8.50**	$9.75	$9.53	**$10.30**	**$10.30**
Kobuk	**$7.50**	$8.24	$9.75	$9.27	$9.27	$9.27
Shungnak	**$8.42**	**$8.42**	**$8.42**	**$8.50**	**$8.50**	**$8.50**
Kiana	$5.67	$5.67	$5.67	$5.67	**$5.15**	$5.67
Noorvik	$5.42	**$5.64**	**$5.64**	**$5.64**	**$5.64**	**$5.00**
Selawik	**$8.25**	$7.99	$7.99	**$6.36**	**$6.36**	**$6.36**
Noatak	**$8.99**	$10.29	$10.29	$10.29	$9.26	$9.26
Kivalina	$4.49	$4.49	$4.49	$4.53	**$4.12**	$4.20
Deering	$4.89	$4.38	**$4.90**	**$3.35**	$4.12	$4.12
Buckland	**$6.89**	**$6.89**	**$6.89**	**$6.04**	$6.15	$6.15

NANA hired McKinley Research Group in January 2022 to conduct a survey on home heating of NANA shareholders and Borough residents to better understand and begin to quantify the depth of the home heating crisis in the region. This survey occurred at the end of a cold winter and just before the region began to see dramatic increases in fuel prices due to the Russia-Ukraine conflict. The retail price of heating fuel in Noatak in March of 2022 was reportedly $15.99 per gallon. These inflated fuel prices are

[3] Also known as "stove oil."
[4] 2016 Northwest Arctic Energy Plan

not captured here for all communities as most had not yet purchased fuel for the upcoming year when this report was published.

The home heating survey found that within the interval from August 2021 to January 2022, 37% of regional households reported going without heat at some point and 70% of regional households

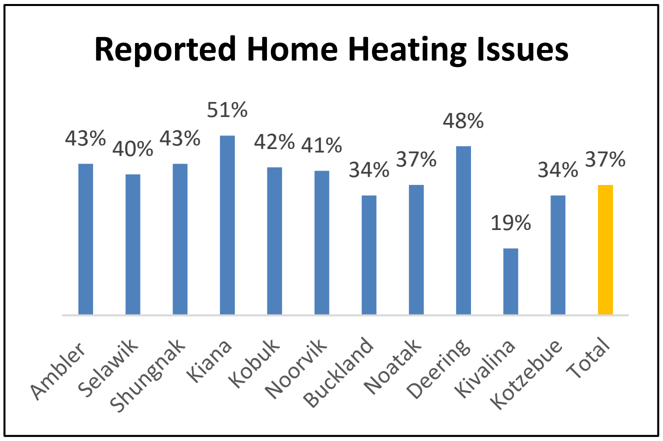

Figure 7. Reported Home Heating Issues (Aug 2021 - Jan 2022)

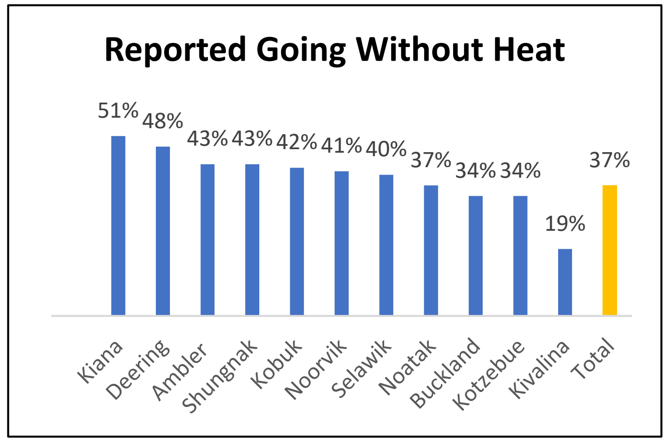

Figure 8. Reported Going Without Heat (Aug 2021 - Jan 2022)

reported having some type of home heating issues.[5] Home heating issues included non-functional furnaces, inability to afford heating oil or electricity, or inability to gather firewood, among other challenges. Figure 7 and Figure 8 describe the prevalence of home heating challenges and disruptions experienced between August 2021 and January 2022.

Responses to the home heating survey also indicated that only 38% of households that completed the survey had received heating or energy-related financial assistance in 2020 or 2021, while 65% of survey respondents reported experiencing challenges accessing heating or energy assistance. The challenges sited included lack of internet, knowledge of programs, access to applications, or technical assistance. It is likely that many of the households that did receive assistance received it from a federal subsidy known as the Low Income Home Energy Assistance Program (LIHEAP) that covers some fuel costs for heating residences. This transfer payment is determined individually for each household based on a complicated formula that includes not just income level, but size of household and the type of housing structure lived in. The result is highly variable and difficult to predict payments that can occur once each annual heating season and are not uniformly available across a community because of the eligibility criteria.

Despite these drawbacks, the LIHEAP payment helps reduce home heating costs of some NANA shareholders and residents in the region, often by as much as $1,000 or more annually. It is clear from

[5] Home Heating Survey – NANA Regional Corporation. McKinley Research Group. March, 2022.

the survey results that there is an opportunity to expand the impact of this program in the region through additional awareness of this program and assistance with applications.

This subsidy is continually targeted for reduction or elimination at the federal level, which would disproportionally impact NANA shareholders and NAB residents and make heating of homes even less affordable. Supporting preservation of LIHEAP at the federal level through public outreach and education could prevent an increase in energy costs for the region**.** NANA already has an education, outreach, and lobbying arm in Washington, DC, and this issue could easily fold into the existing efforts to educate lawmakers on this important subject.

Although the home heating challenges experienced during the 2021-2022 winter were particularly acute, home heating is not a new challenge and targeted ongoing efforts will be required to reduce the financial burden and improve the comfort level of households throughout the region. Numerous studies have shown energy efficiency and weatherization to be the least costly and most immediate energy saving opportunity. Retail prices for diesel heating fuel are very high, so reducing heating demand has significant financial benefits for individual homes and businesses.

Starting with a total heating fuel use of 3.5 million gallons across the region, achieving a 15% uniform improvement in building performance from weatherization would result in 525,000 gallons of fuel saved annually. Though different entities pay different retail rates for heating fuel (and electricity), at a very basic level, if this 15% heating fuel savings were distributed evenly across all buildings and market participants, this would amount to a region-wide cost savings of approximately $3,450,000. Achieving such fuel savings through weatherization and energy efficiency would also have costs and require different approaches for different buildings. However, this represents significant economic impact roughly equivalent to the total amount of Power Cost Equalization (PCE) subsidy provided by the state to the communities and electric utilities operating in the region. (The PCE Program is discussed in more detail below.) Any fuel use reduction from weatherization and energy efficiency also represents other benefits beyond cost savings, such as reduced chance of fuel spills, carbon reduction, and a buffer from future cost increases. Implementing energy efficiency and weatherization programs has historically been led by the state's Alaska Energy Authority (AEA) and Alaska Housing Finance Corporation (AHFC), but with reduced state resources, this may be better facilitated at the regional level with a coordinated effort among regional stakeholders and continued outreach and collaboration with AEA and AHFC.

In the long-term, the region must take a multifaceted approach to reduce the cost of home heating and the reliance on price-unstable heating fuel. This effort should include addressing bulk fuel storage limitations in each community and working to develop a regional fuel purchasing strategy to ideally consolidate the fuel needs of each community into a unified high-volume fuel purchase, thus lowering the cost for all. Additionally, the long-term strategy should include investments in renewable energy and battery storage technologies that reduce the cost to generate electricity and therefore broaden the opportunity for the use of electric heating devices such as heat pumps and dispatchable ceramic heaters that can take advantage of excess wind energy.

Figure 9. A Clear Cold Winter Day in the Northwest Arctic (Photo Credit: Chris Arend, NANA)

Most renewable energy systems are site and community specific and much of the technology is still in the rapid development and cost reduction phase. Project development costs are often higher than existing diesel systems, but some technology, such as solar photovoltaic (PV), is beginning to reach a commodity stage. First-of-a-kind solar-wind-battery-diesel hybrid systems have been installed in Deering and Buckland and are showing promise for reducing the dependence on diesel fuel for power generation. These systems have successfully demonstrated powering a village microgrid with 100% renewable energy (diesels-off) for significant periods of time. From April through September 2020, for example, Deering powered its community exclusively from renewable energy and batteries, with no diesel inputs, for 21% of the time.

Figure 10. Solar PV and Wind in Kotzebue (Photo Courtesy of Matt Bergan)

In Kotzebue, the large-scale wind and solar systems, combined with batteries and diesel generators, are saving over 250,000 gallons of diesel fuel annually that was previously used for electricity generation and thousands of gallons of heating fuel no longer needed at the Maniilaq hospital.

Renewable energy also shows promise to support economic development in the more remote areas of the region. A proposed hydroelectric project could potentially be a more cost-effective solution for providing power to a proposed remote mine in the Upper Kobuk than diesel generators. As renewable energy technology continues to drop in price and improve in reliability, alternatives to diesel generation in remote locations is becoming more cost effective.

The regional home heating crisis is a symptom of the intersection of many other challenges: the cost of heating fuel, the cost to generate electricity, aging homes and heating infrastructure, limited job opportunities, and others. The complexity of this issue will require an equally interconnected and intensive set of solutions.

Housing

The region's housing related data from the 2018 AHFC Housing Assessment[6] for the NANA Region paints a picture of the overcrowded housing, a high cost of energy for housing relative to the size and energy consumption, and health concerns related to indoor air quality issues.

Based on that 2018 Assessment, there are 2,864 housing units in the NANA region. Of these, 2,002 are occupied and 788 are being used seasonally or are otherwise vacant. The average footprint of a single-family home in the region is 925 square feet, which is smaller than the statewide average of 1,995 square feet. Of the occupied units, 39% are estimated to be either overcrowded (18%) or severely overcrowded (21%). This is nearly 12 times the national average and the second most overcrowded in the state.

The Northwest Arctic region has the highest estimated average annual home energy costs in the state, which is a significant cost burden on residents. The region has a high participation rate in the Weatherization Assistance Program, with around 32% of occupied housing units having been weatherized. Approximately 47% of homes in the region were built before 1980, have not received energy efficiency retrofits and are in need of weatherization and efficiency retrofits. These homes exceed seven air changes per hour at 50 Pascals (ACH50). Of that 47%, 11% are using at least four times the energy of a new home built with modern standards and would be the best candidates for immediate retrofits.

[6] The 2018 AHFC Housing Assessment can be accessed at: https://www.ahfc.us/pros/energy/alaska-housing-assessment/2018-housing-assessment

A tight home with no or inadequate ventilation has an increased risk of issues with indoor air quality, moisture, and related mold issues. Approximately 41% of homes in the region are considered to be at risk for indoor air quality issues due to lack of continuous ventilation.

Roughly 224 homes, or 11%, of the occupied homes in the region are estimated to be 1-star homes. These homes use four times the energy than if they were built to AHFC's Building Energy Efficiency Standard (BEES).

The energy cost index (ECI), or annual energy cost per square foot, for a single-family home in the region averaged $6.75 in 2018, which at the time was the highest in the State of Alaska. This is nearly three times the statewide average of $2.31 per square foot and is about seven times the national average of $0.95 per square foot. Figure 11 illustrates that the single-family home in the region, while small and using less energy than an average home in the State of Alaska, has an exorbitantly higher cost of energy.

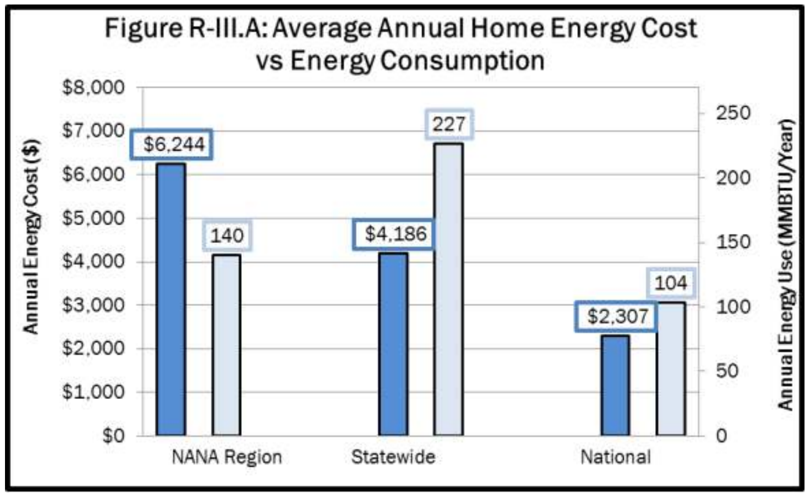

Figure 11. Average Home Energy Costs vs Energy Consumption, from the 2018 AHFC Housing Report for the NANA Region

The region has a clear need for more housing to address the current issues of overcrowding; ideally future housing would be energy efficient and have adequate ventilation. The region's existing housing stock is highly variable in terms of quality, construction techniques, size, age, heating appliances, and related energy burden. However, improving the building envelope, reducing air infiltration, adding insulation with appropriate ventilation to avoid mold, and properly maintaining boilers and furnaces can save significant amounts of fuel and money.

In rural Alaska, it has been demonstrated that the most effective programs for realizing home and building energy efficiency are organized, whole village efforts such as mobilizing a housing crew to perform weatherization tasks including caulking, roofing insulation, and repairing water heaters, boilers and stoves for residential and commercial facilities across a community. High value energy efficiency measures typically include installing items like new LED lights, set back thermostats, high efficiency refrigerators and freezers, and on-demand water heaters. Results have varied widely due to things like the quality of the original building stock and status of the equipment being replaced, but across the state, past weatherization and energy efficiency programs have demonstrated in excess of 30% improvement in energy savings. It would certainly be safe to assume a typical rural Alaska home such as those found in the Northwest Arctic could easily and cost effectively improve its energy performance by 15% annually with basic weatherization and energy efficiency efforts.

The Northwest Inupiat Housing Authority (NIHA, www.nwiha.com) provides housing construction, community improvement, and weatherization services throughout the region and has an important role to play in continued improvement of the housing stock. Additional support for this organization would allow for more services to be provided to more people in the region, especially low-income families least able to afford high heating costs. On a statewide basis, the Alaska Housing Finance Corporation (AHFC, www.ahfc.us) provides additional energy efficiency and weatherization support, including energy education, building monitoring, low interest loans, and weatherization improvements to income qualified residents. RurAL CAP (https://ruralcap.org/) also provides weatherization services to homes in rural Alaska. This service increases safety and energy efficiency through home improvements and client education at no charge to the participant.

Bulk Fuel

Bulk fuel storage is another area of high variability among communities with significant impact on overall fuel costs. This is a complicated issue for several reasons, including that in each community there are typically at least three different bulk fuel storage systems owned and operated by different entities, namely the local electric utility, the Northwest Arctic Borough School District, and a local fuel distributor for homes and businesses. These three different entities generally purchase bulk fuel at different prices, have different use patterns and O&M practices, and different economic incentive structures. For example, because of electric utility rate structures, fuel cost is considered a "pass through" and as fuel costs change, utilities simply add a "fuel surcharge" to their base rate and pass through the cost variability to their customers. Alternatively, most School Districts have a fixed energy budget on an annual basis, so if fuel costs rise, this impacts their ability to meet other needs whereas if fuel costs drop or they become more energy efficient, they have additional revenue to spend elsewhere. As for local fuel distributors selling home heating fuel, the difference between their purchase price of bulk fuel and their retail sale price to individuals is often their main source of revenue, so there is incentive to mark up this fuel to cover costs such as tank farm maintenance and provide revenue to their overall operation.

Some communities in the region such as Ambler are currently experiencing fuel availability limitations because of bulk fuel storage challenges. This has resulted in days—sometimes weeks—in the winter where there has been no residential home heating fuel available for the entire village. Ambler is currently addressing this issue with pursuit of a new tank farm for the community to meet local heating fuel demand but it is an expensive effort that without outside subsidies would likely add more than $1/gallon to every gallon of fuel stored in the tank over its entire lifecycle.

On a larger, sub-regional scale, the communities in the Upper Kobuk, i.e., Ambler, Shungnak, and Kobuk, are challenged with annual fuel barge deliveries because of the hydrology of the area. Specifically, when the Upper Kobuk River clears out from ice coverage in late spring/early summer, the bulk fuel that is targeted for this area has not yet arrived in Kotzebue and hence, is not available to be barged up the Kobuk River. By the time the large fuel barge arrives in Kotzebue and the fuel is transferred to a smaller river barge, the water levels in the Upper Kobuk River have often dropped to the degree that the Upper River is not navigable and these three villages cannot receive fuel by barge. When this occurs, fuel must be delivered by air shipment, adding as much as $2/gallon for all fuel delivered by this method. Air delivery instead of fuel barge delivery occurs approximately half the time but appears to be more frequent as precipitation and water levels drop as a result of climate change and other dynamics.

Figure 12. Braided River Illustrates the Hydrology Challenges of Fuel Delivery

Options that have been identified to address this challenge include building bulk fuel storage partway up the Kobuk River, such as in Noorvik or Kiana, and filling the bulk fuel storage facility in the fall before the Kobuk River freezes up, and then delivering this fuel the next spring as soon as the River thaws and there is still sufficient high water, thus avoiding the bottleneck of fuel delivered to Kotzebue too late in the summer to reach the Upper Kobuk. As well, a dedicated river fuel barge would be required for such an operation, thus adding further costs. Additional economic and logistical analysis would be required to fully evaluate this option to determine if it would be more cost effective than the current status quo, taking into account the frequency of air delivered fuel and possible fuel mitigation options such as hydropower development on the Kogoluktuk River

Figure 13. Aging Fuel Tanks in the Region

near Kobuk that could theoretically power all three communities if an inter-tie were constructed between Shungnak and Ambler (an inter-tie already exists between Shungnak and Kobuk).

In general, the transportation and storage costs associated with delivery of bulk fuel to the region will continue to increase and become a larger portion of the overall cost as ships and tank farms age, even though the base price of the fuel being delivered has increased and decreased over the years based on global conflicts and changing supply and demand each year.

Electricity

Utilities have a major role to play in maintaining or, ideally, reducing the cost to generate power. Utilities often aim to improve the reliability of their power systems and reduce the cost to generate power by performing routine gen-set maintenance, maintaining distribution system infrastructure, upgrading obsolete switchgear controllers, selecting high-efficiency replacement engines, and maintaining redundant generation systems through prompt repairs. The reliability of a community electric system is essential to keep the lights on and to keep the local water systems from freezing in the winter.

In the Northwest Arctic region there are four electric utilities: Buckland Electric Utility, serving Buckland; Ipnatchiaq Electric Utility, serving Deering; Kotzebue Electric Association (KEA), serving Kotzebue; and the Alaska Village Electric Cooperative (AVEC), serving all eight remaining villages in the region. According to reported PCE data, the utility cost to generate power in each community is shown in Figure

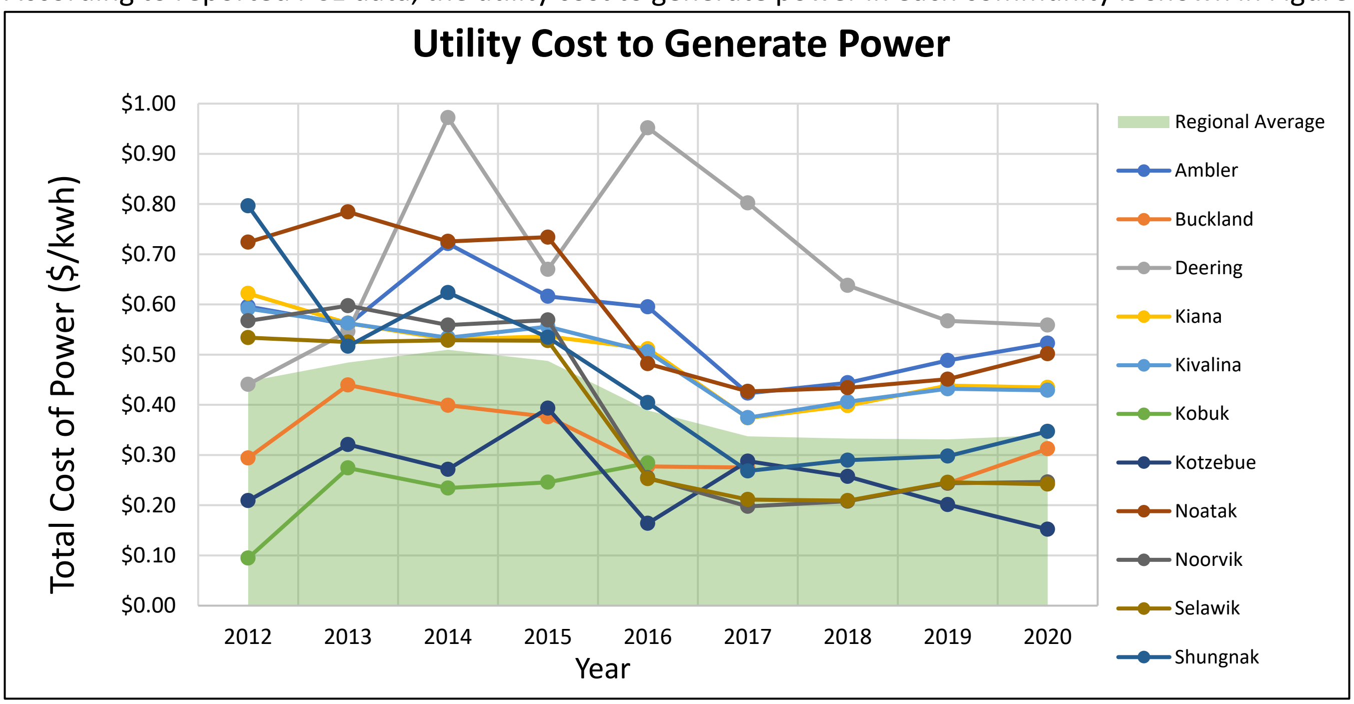

Figure 14. Utility Costs to Generate Power (per $/kWh)

14. The regional average cost is indicated by the upper boundary of the green shaded area. All lines in the green area represent utility costs to generate power that are below average for the region.

AVEC's cooperative model shares the non-fuel operation and maintenance costs evenly across the 58 communities they serve within the state. Therefore, the differences in the cost to generate power across the communities that are served by AVEC reflect the variation in the fuel costs for each community. KEA has a long history of generating low-cost power by regional standards. This is due to both the larger scale of the utility and the long term operational and managerial expertise at KEA. The smaller standalone utilities, Buckland and Deering, have both been very innovative in terms of early adopters of wind-solar-battery-diesel hybrid systems that resulted in diesels-off operation while still confronting cost and reliability challenges.

High diesel gen-set fuel efficiency and low line loss are two key indicators of a well-maintained power system where the utility is taking proactive measures to maintain and optimize the efficiency of the generation system. Figure 15 shows the fuel efficiency and Figure 16 shows the line loss for each community's power system as reported to the PCE program. In this case, line loss values are calculated by subtracting the total power sold and the station service power consumed by the power plant from total power generated. Line loss values are not measured. As above, in each figure the regional average

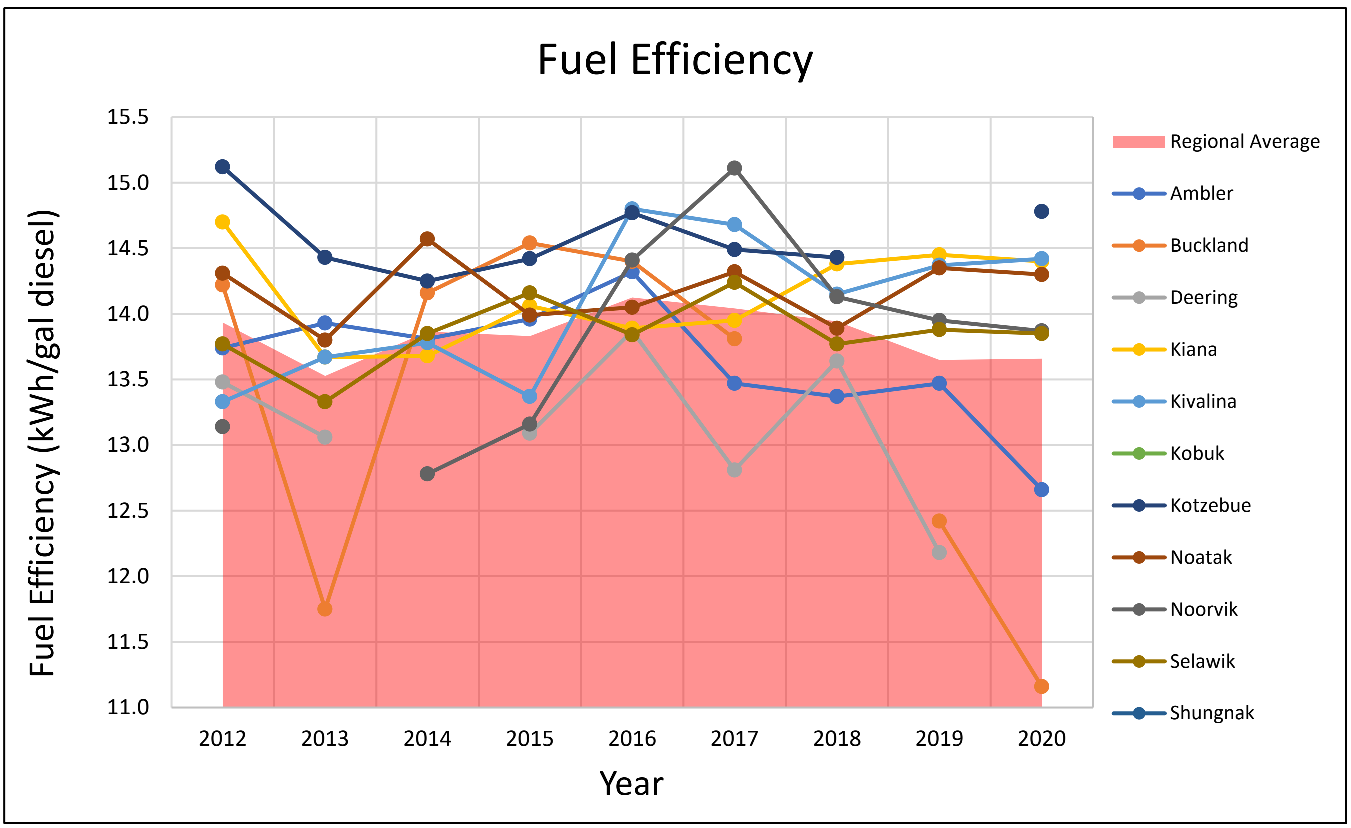

Figure 15. Fuel Efficiency (kWh/gal)

is indicated by the upper boundary of the shaded area. In the Fuel Efficiency Figure 15, lines above the red shading indicate higher than the regional average fuel efficiency; in the Line Loss Figure 16, lines within the green shading indicate lower than the regional average line loss.

The cost of electricity in rural Alaska is heavily influenced by the Power Cost Equalization program (PCE).

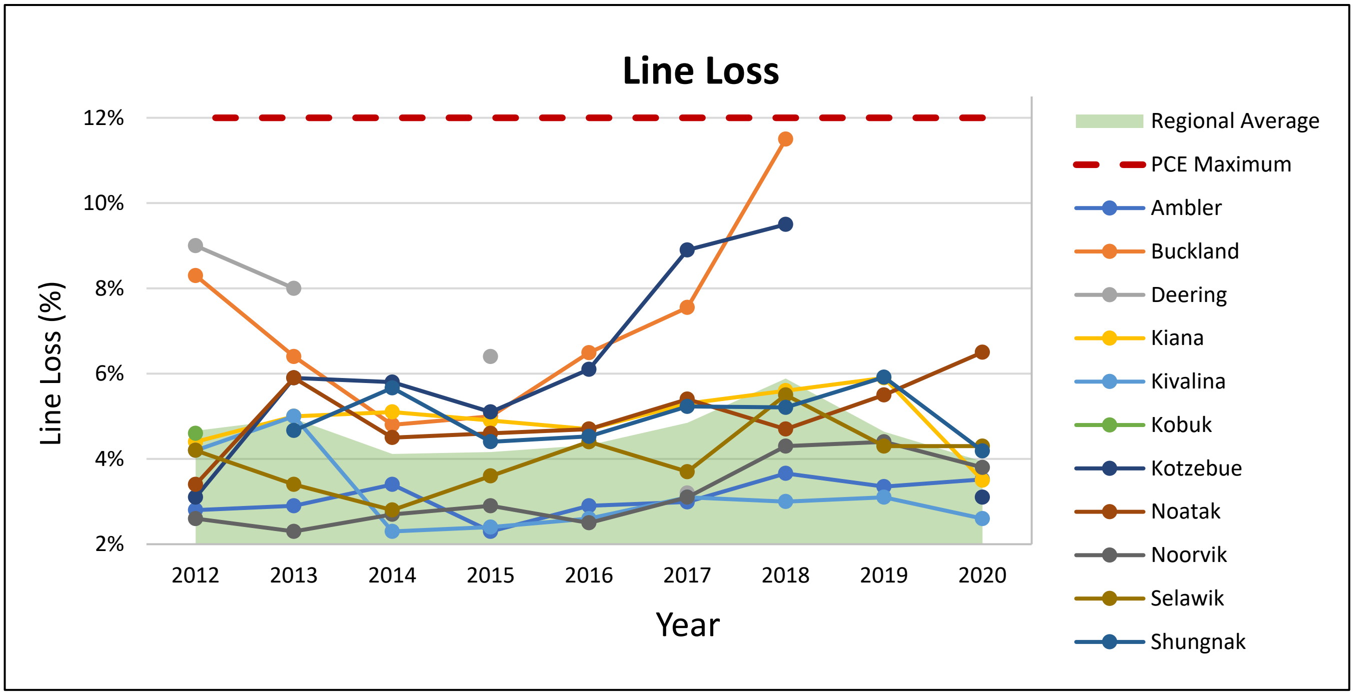

Figure 16. Line Loss %

The state government currently subsidizes electricity costs in rural Alaska under the PCE program, where electricity rates are often three to eight times higher than in urban Alaska. Established in the 1980s, the PCE program aims to reduce high rural electricity costs for remote, diesel-dependent Alaska communities so that it is nearly equal to the average cost of power in Anchorage, Fairbanks, and Juneau.

Currently, residential customers and community facility buildings in nearly 200 communities across the state—including all communities in the Northwest Arctic —are eligible for the reduced rate up to a certain amount of kWh per month[7]. Based on the PCE reporting data, the figure below shows the amount of electricity sold by sector for all NANA villages except Kotzebue. Both residential and Community Facility sectors are eligible for PCE payments within certain limits. The "Other kWh Sold (Non-PCE)" sector includes local businesses, government facilities like the Post Office, and the local school. Note that including Kotzebue in this graph would have required a significantly different scale for all the

[7] According to the PCE formula, individual households are eligible for a reduced rate through the PCE subsidy on the first 500 kWh/month of electricity consumed, while monthly electric bills for "community facilities," such as City and Tribal Council buildings and streetlights, are eligible for the PCE subsidy based on total population of the community times 70 kWh/month/person.

communities to fit on the same page and the details for the small communities would not have been visible.

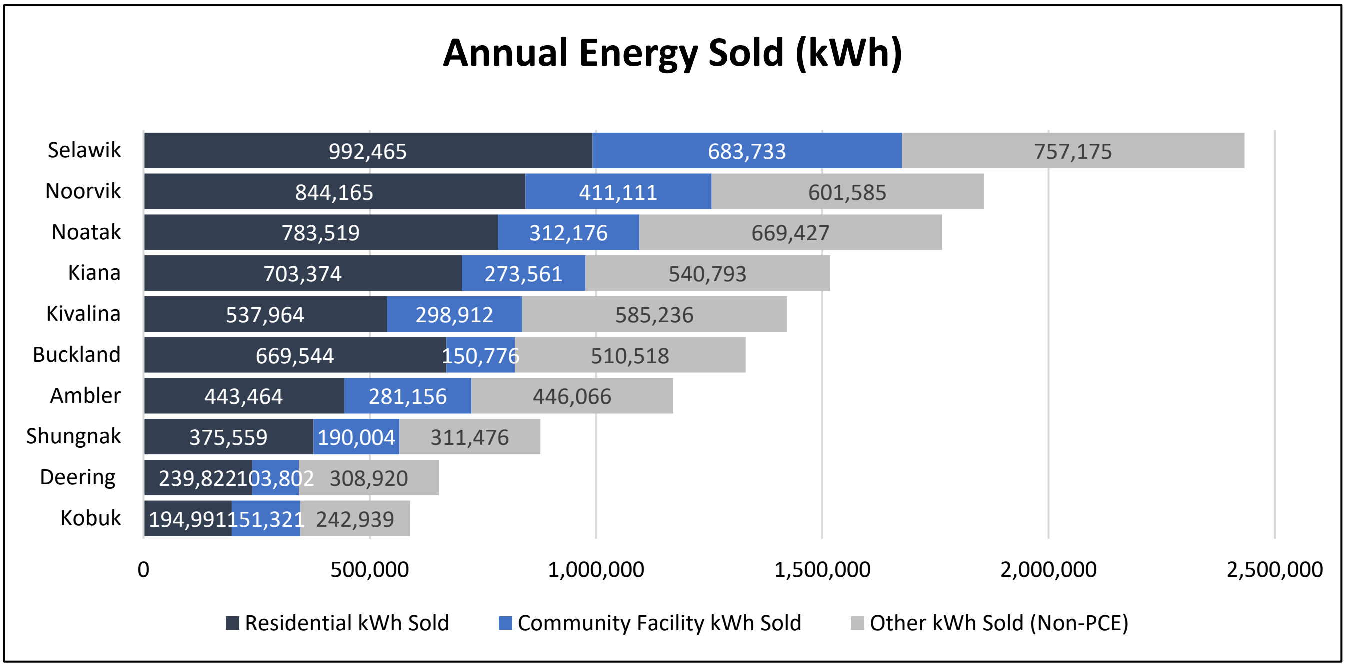

Figure 17. Annual Energy Sold (kWh), Broken Down by Customer Type (Not Including Kotzebue)

PCE payments from the state are largely calculated from a utility's total diesel fuel costs. If the utility takes action to reduce its diesel fuel usage—such as from implementing renewable energy or investing in powerplant efficiency upgrades—the PCE subsidy will be reduced. This essentially creates a disincentive for the utility to reduce diesel fuel consumption since eligible end-users do not receive a rate reduction when diesel fuel use is reduced. Common sense would suggest that, all else being equal, if less diesel fuel is used to produce the same amount of kWh, the price per kWh should go down. But this is often not the case because of the PCE formula that is written into Alaska state statute.

Within the PCE calculation for reimbursement to an electric utility, an eligible expense is the cost of power purchased from another entity. In other words, if a PCE eligible utility buys electricity in bulk from another entity in the community and then sells that power on a retail basis to its residential and commercial rate payers, the utility's cost of that purchased power can be included as a PCE-eligible expense. This is considered similar to purchasing diesel fuel, and it will be reimbursed by the state under the PCE formula. Hence, renewable energy development, and resulting diesel fuel reduction, can be incentivized—or, at a minimum, not penalized—by establishing an Independent Power Producer (IPP) in the community that develops and sells the renewable energy to the utility. As a result, the utility can include this power purchase as a generation cost (instead of diesel fuel) and preserve its PCE subsidy from the state. In other words, as a result of renewable energy generated and sold by an IPP, the utility's diesel fuel costs decrease, but its overall PCE eligible costs roughly stay the same or increase, and the net result is the same PCE payment to the utility. In addition, there is now an IPP in the community that has revenue it receives from selling renewable energy-generated power to the utility. This IPP revenue can be the basis for new economic development if the money stays in the community.

The economic contribution of PCE in any given community, or combined across the region, is considerable. The following table illustrates this in detail.

Table 4. PCE Subsidy Summary by Community, 2019

Community	Total kWh Generated	Amount of PCE Eligible kWh	% Eligible PCE kWh vs Total kWh	Average PCE payment per eligible kWh	Total PCE $ Provided by State[8]
Kotzebue	19,495,001	5,193,926	26.6	$0.17	$882,967
Ambler	1,203,842	512,557	42.6	$0.35	$179,395
Kobuk	589,251	244,188	41.4	$0.37	$90,349
Shungnak	935,175	401,851	43.0	$0.37	$148,684
Kiana	1,559,473	704,591	45.2	$0.36	$253,652
Noorvik	1,889,048	941,454	50.0	$0.30	$282,436
Selawik	2,474,856	1,194,311	48.3	$0.31	$370,236
Buckland	1,370,629	559,286	40.8	$0.11	$61,521
Deering	679,579	288,781	42.3	$0.34	$98,185
Kivalina	1,462,209	504,690	34.5	$0.34	$171,594
Noatak	1,809,413	814,374	45.0	$0.54	$439,762
Total	33,468,477	11,360,009	33.9%	--	$2,978,785

From Table 4, we can see that approximately $3 million was directed to the region through the PCE program in 2019[9]. About one-third of all kWh generated received the PCE subsidy (33.9%). For all PCE eligible kWh generated, the PCE subsidy cut the cost of those kWh often by more than 60%, depending on the community.

While diesel-based power generation is the backbone of all electricity systems in the region, renewable energy production primarily from wind and solar power are increasingly common and contributing significantly more to communities' overall electricity needs. Below we examine several case studies from the region to identify successes and areas that still need improvement.

[8] *Total does not add exactly because of rounding error.*

[9] Statewide, the PCE program provides about $26 million to eligible rural Alaska communities.

Renewable Energy and Battery Storage Microgrid Case Studies

Deering

The Ipnatchiaq Electric Company in Deering, Alaska, owned by the City of Deering, currently operates an electric utility system utilizing diesel, wind, and solar generation resources. The system also contains a battery and power converter system that helps to maintain high quality power and store energy during times of high wind and solar power output. The wind generation system is rated at 100 kW peak output, the solar photovoltaic (PV) system is rated at 48.5 kW (DC panel output), the battery has a storage capacity of 109 kWh, and the converter has a maximum power output of 195 kW. Average generation requirements, i.e., electrical system load or community demand, are about 75 kW for the community, while the peak generation requirement during the highest demand time of the winter is about 185 kW. Figure 18 summarizes these component sizes.

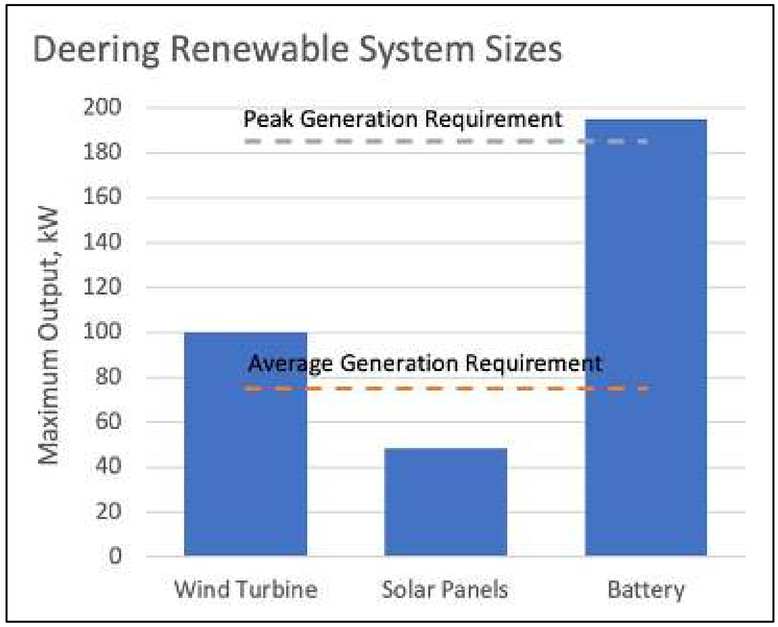

Figure 18. Deering Renewable Component Sizes Relative to Average Community Demand

These are maximum generation outputs; wind and solar generation are intermittent and only produce at these levels when there is sufficient wind blowing or sun shining, so they cannot produce at maximum output for the entire year. When there is less wind or less sun, these technologies still produce electricity but at a percentage of their total rating, depending on the amount of wind or sun available. Figure 19 below shows the portion of the total generation requirements that are satisfied by wind and solar for each month in the data collection period.

Wind and solar generation accounted for 13.0% of total generation between October 2019 and February 2022 and displaced roughly an equivalent amount of diesel fuel.

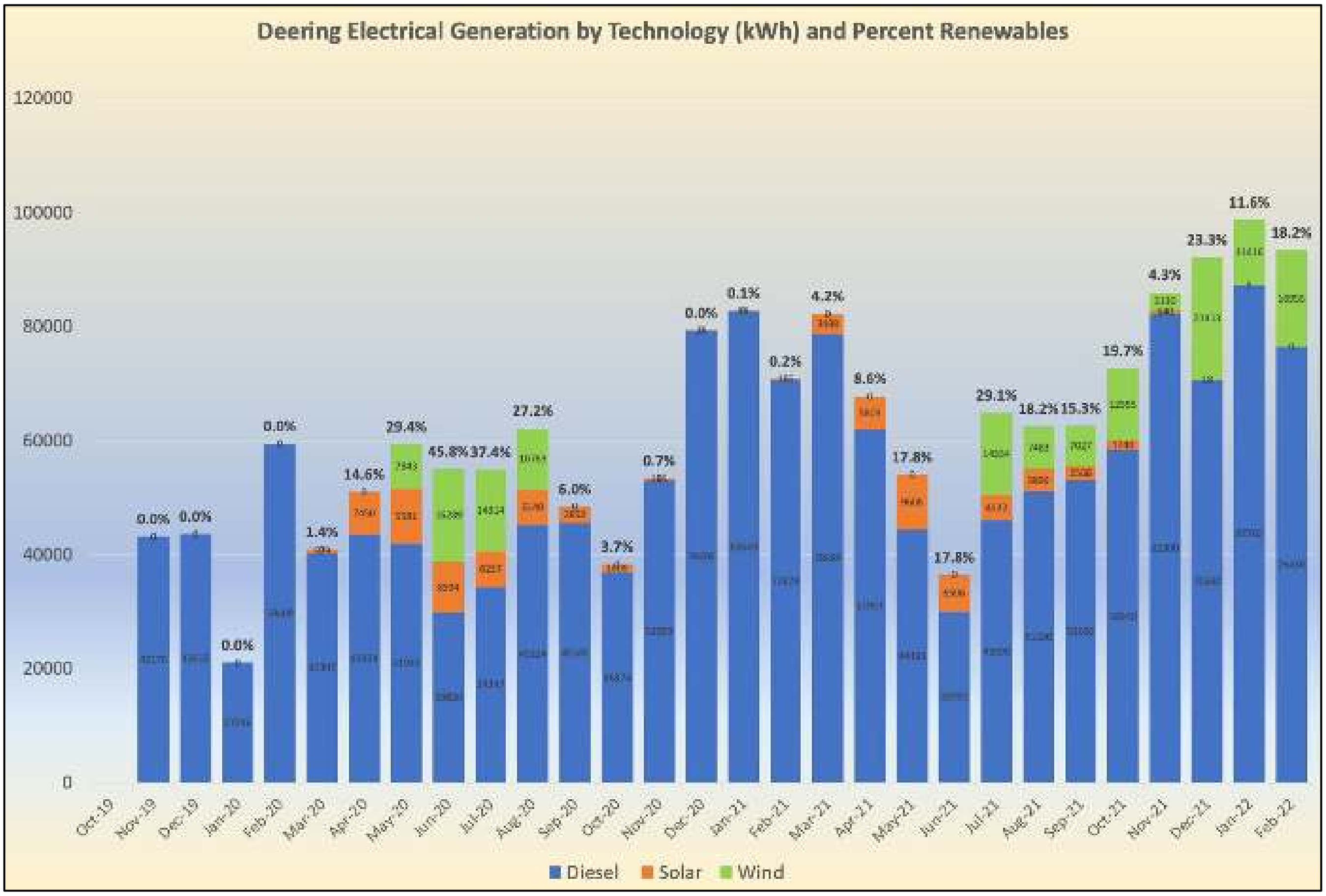

Figure 19. Deering Percent Renewable Generation by Month

Over the course of the hybrid system's short lifetime there have been various challenges, such as digital communication among all the various generation assets and wind turbine downtime, that have resulted in sub-optimal performance. These issues continue to be identified and resolved through combined efforts of NANA, NAB, contractors, and the dedicated staff of Ipnatchiaq Electric Company in Deering and are showing ongoing performance improvements. Preliminary modeling indicated—and short-term performance has demonstrated—potential for up to 40% fuel displacement annually. Reaching this milestone will be a significant contribution toward lowering fuel costs and increasing reliability of the system.

Buckland

In Buckland, Alaska, the City owns and operates the Buckland Electric Utility system which utilizes diesel, wind, and solar generation resources. The system also contains a battery and power converter system that helps to maintain high quality power and store energy during times of high wind and solar power output. The wind generation system is rated at 200 kW peak output, the solar photovoltaic (PV) system is rated at 46 kW (DC panel output), the battery has a storage capacity of 218 kWh, and the converter has a maximum power output of 277 kW. Average generation requirements, i.e., electrical system load or community demand, are about 215 kW for the community, while the peak generation requirement during the highest demand time of the winter is about 350 kW. Figure 20 summarizes these component sizes relative to community demand.

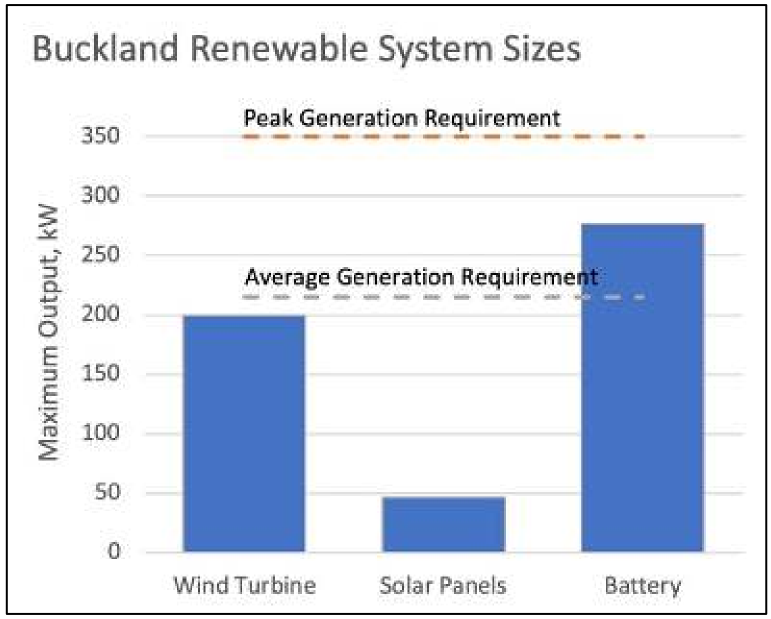

Figure 20. Buckland Renewable Component Sizes Relative to Average Community Demand

These are maximum generation outputs; wind and solar generation are intermittent and only produce at these levels when there is sufficient wind blowing or sun shining, so they cannot produce at maximum output for the entire year. When there is less wind or less sun, these technologies still produce electricity but at a percentage of their total rating, depending on the amount of wind or sun available. Figure 21 below shows the portion of the total generation requirements that are satisfied by wind and solar for each month in the data collection period.

Wind and solar generation accounted for 13.6% of total generation between January 2021 and February 2022.

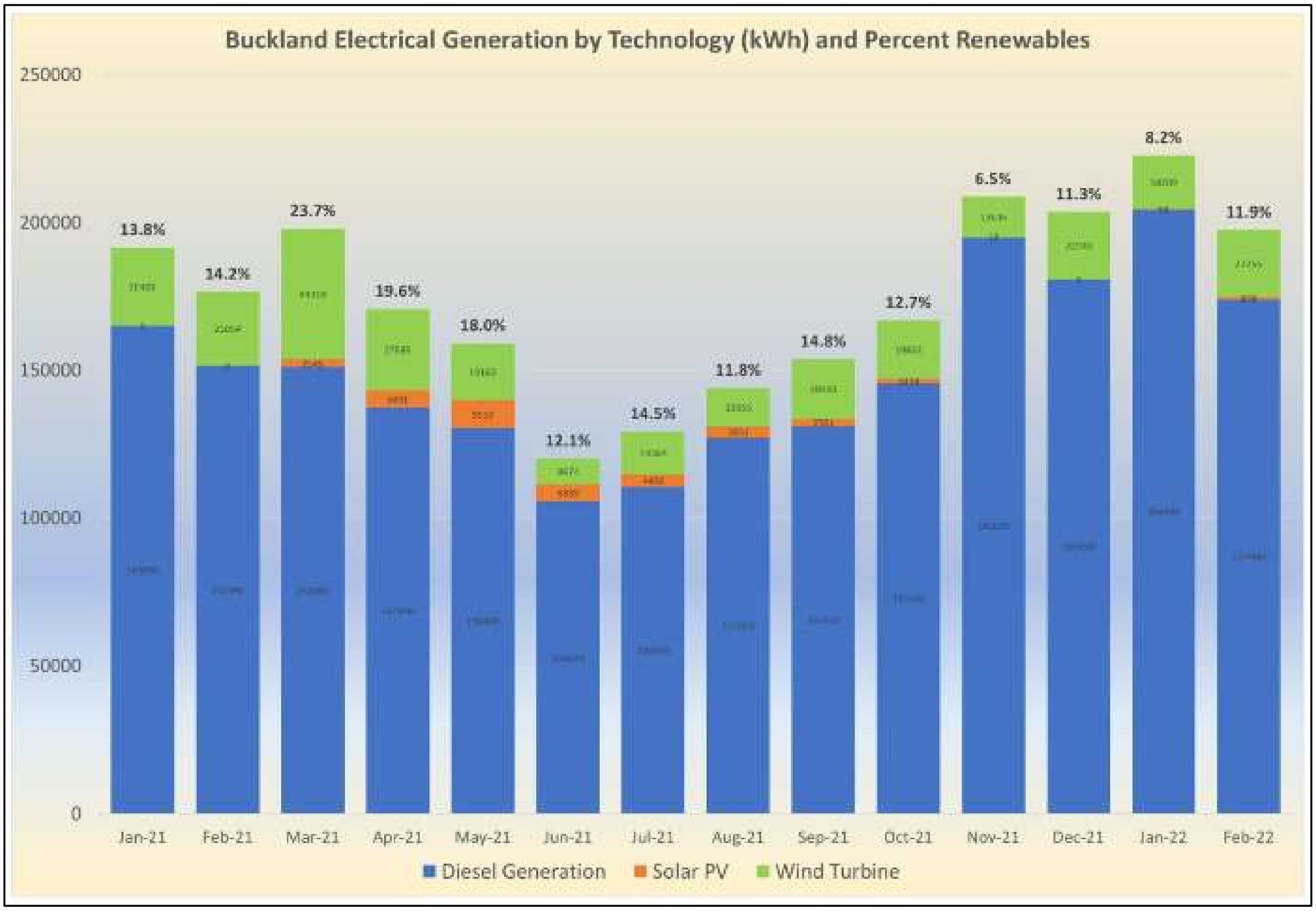

Figure 21. Buckland Percent Renewable Generation by Month

Batteries are reducing black and brown-outs within the community. There are significant cost savings related to the prevention of black-outs. Black-outs lead to accelerated failures of appliances and electronics and increase the number of freeze-ups of water and sewage systems as well as residential service lines. The renewable energy, storage, and power conversion systems are similar in Buckland and Deering. Modeling prior to full installation estimated approximately 35% fuel displacement at optimized performance levels. Some of the same challenges with digital communication, wind turbine uptime, and diesel generator performance have reduced the fuel savings to date, but the lessons learned with optimizing software controls, operator training, and other measures are resulting in improved performance over time and are providing a positive feedback loop by sharing information with Deering.

Shungnak & Kobuk

AVEC currently operates an electric utility system utilizing diesel and solar generation resources that is based in Shungnak but also powers Kobuk through a 10-mile intertie, hence serving two communities.

The system also contains a battery and power converter system that helps to maintain high quality power and store energy during times of high solar power output. The solar photovoltaic (PV) system is rated at 224 kW (DC panel output), the battery has a storage capacity of 384 kWh, and the converter has a maximum power output of 250 kW. Average summer generation requirements are about 229 kW for the two communities combined (when the solar PV is generating most of its power on an annual basis), while the peak generation requirement during the highest demand time of the winter is about 300 kW. Figure 22 summarizes these component sizes.

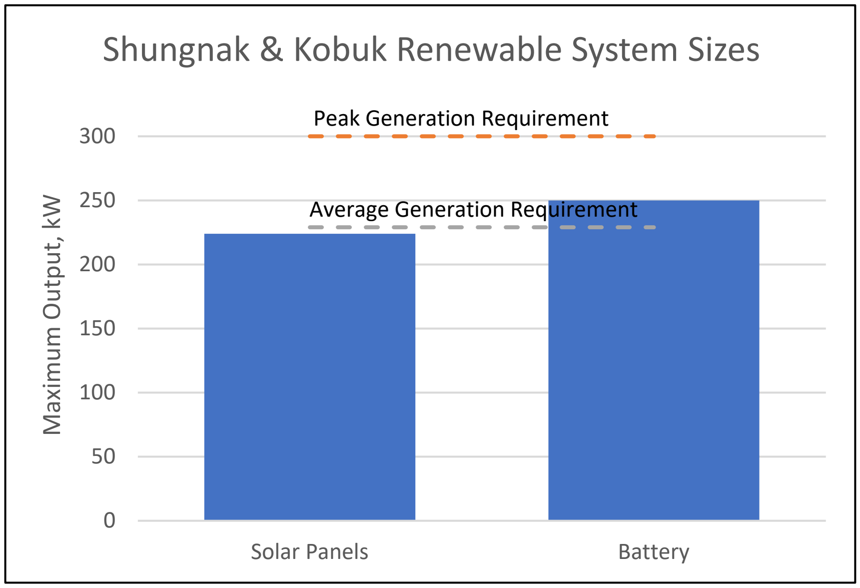

Figure 22. Shungnak/Kobuk Renewable Component Sizes Relative to Average Community Demand

Figure 23 below shows the power production at a system level for the first two weeks of March 2022. The red line indicates the power produced by the diesel generators. The green line indicates the power produced by the solar PV. The yellow line is for the battery, indicating power stored by negative values and power released to the grid by positive values. The orange line is the power demand of the system. As the solar resource rapidly increased in early March the solar power generation increased each day, offsetting increasingly larger amounts of power that would have been generated by the diesel generators, as seen by the sharp dips in the red trend line in the middle of each day, despite the system demand maintaining a value near 250 kW. The power being stored or released by the battery fluctuates throughout the sunny hours of the day to stabilize the grid, especially when clouds occlude the solar panels causing a sudden drop in solar PV generation.

Figure 23. Shungnak Solar Production Over a Two-Week Period in March 2022

A more detailed example of the daily power production trends is shown in Figure 24. This more granular data provides a more detailed understanding of the solar, diesel, and battery interaction over a single day with cloud coverage impacting the solar output (in green).

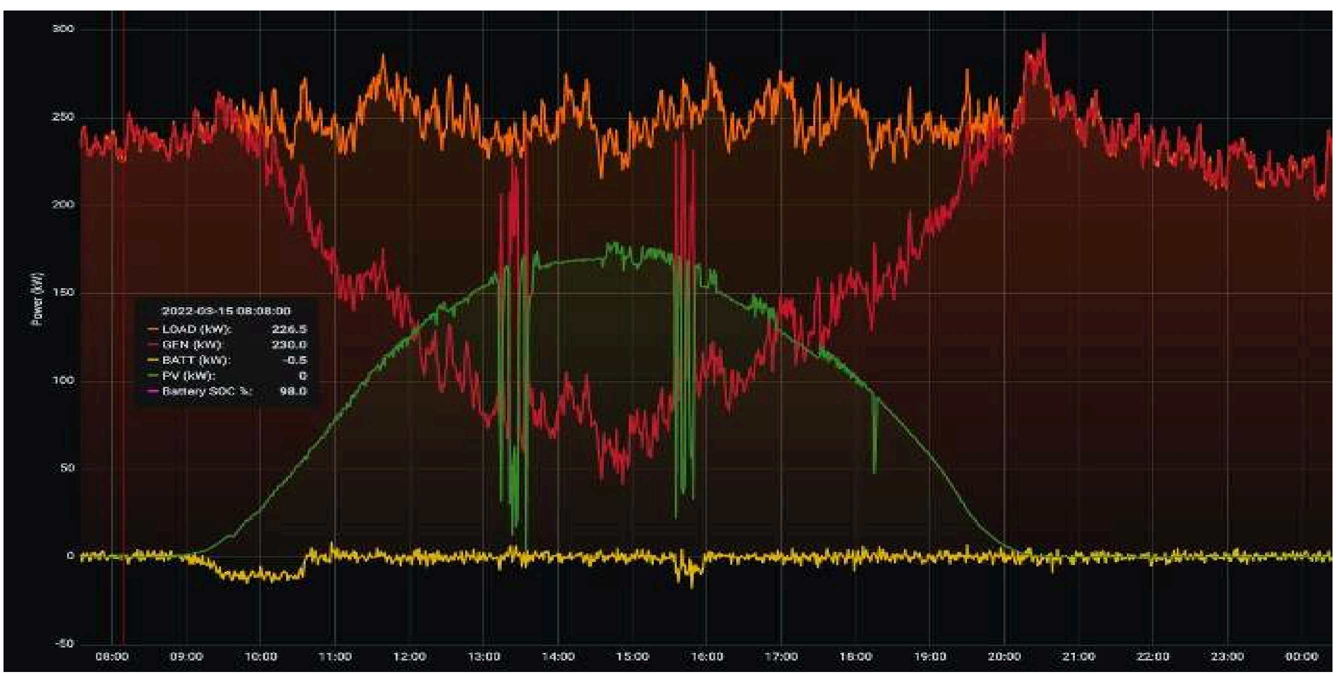

Figure 24. Detailed Data for Solar, Diesel, Battery Over a Single Day

The diesel generators, solar PV, and battery storage (via the converter) are automatically controlled such that they work together to provide a dynamic response to changes in power demand and power generation, optimizing the available solar energy and minimizing the diesel fuel consumption. From its installation in September of 2021 through April of 2022, the Shungnak solar PV with battery storage system has offset an estimated 39 tons of CO_2 and saved an estimated $24,800.

Figure 25. Shungnak Solar Array (Photo Courtesy of Ingemar Mathiasson, NAB)

Kotzebue

Kotzebue Electric Association in Kotzebue, Alaska currently operates an electric utility system utilizing diesel, wind, and solar generation resources. The system also contains a battery and power converter system that helps to maintain high quality power and store energy during times of high wind and solar power output. The wind generation system is rated at 1.8 MW peak output, the solar photovoltaic (PV) system is rated at 576 kW (DC panel output), the battery has a storage capacity of 950 kWh, and the converter has a maximum power output of 1.225 MW. Average generation requirements are about 2.5 MW for the community, while the peak generation requirement during the highest demand time of the winter is about 3.4 MW. Figure 26 summarizes these component sizes.

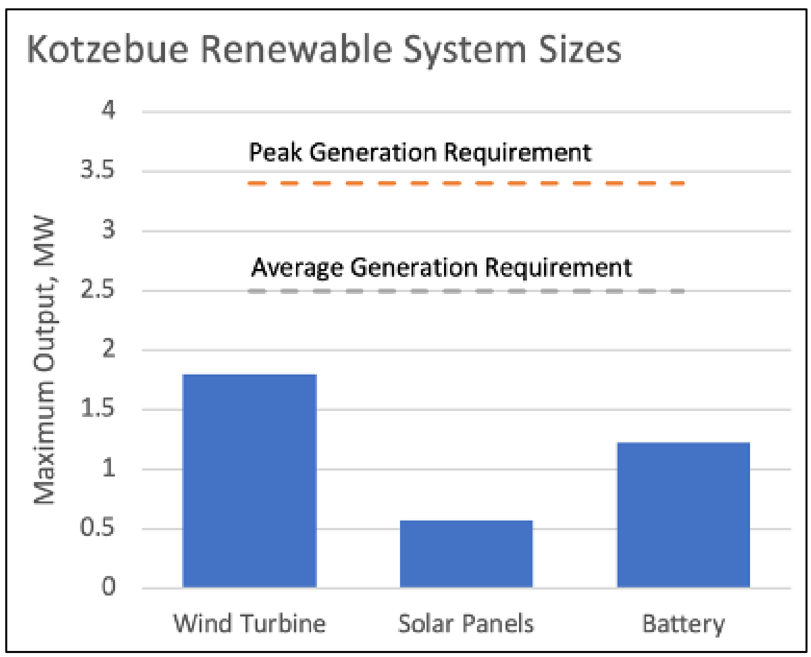

Figure 26. Kotzebue Renewable Component Sizes Relative to Average Community Demand

Figure 27 below shows KEA's solar energy production for all of 2021 and lifetime energy generated by the system from installation in May of 2020 through April 10, 2022.

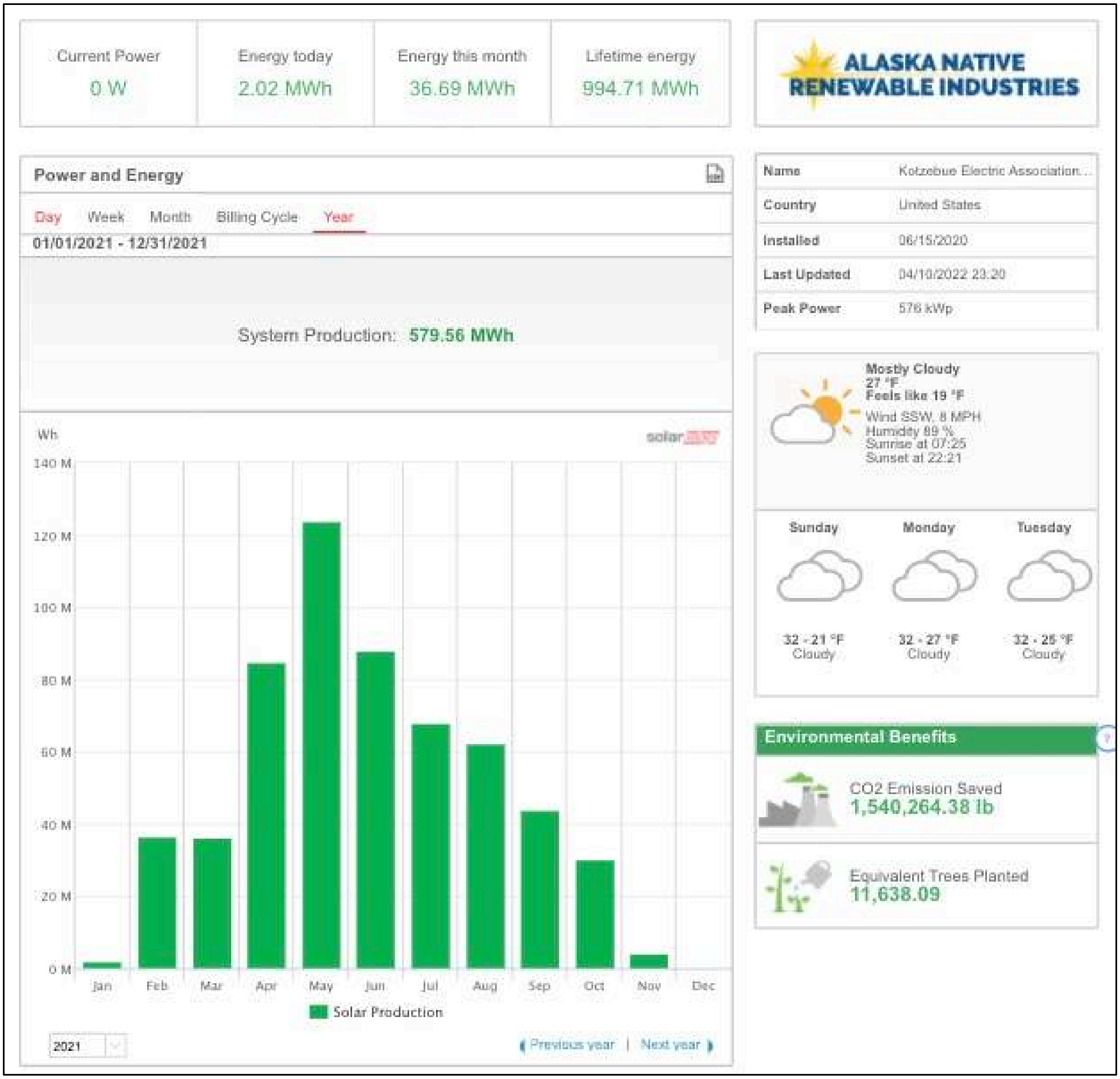

Figure 27. KEA Solar PV Production in 2021 and over Project Lifetime

Technology Pricing & Trends

Within the energy industry globally, use of fossil fuels and diesel generators are among the most mature and widespread technologies. This applies to essentially all of rural Alaska including the Northwest Arctic, i.e., diesel generation systems form the backbone of remote power infrastructure. However, renewable energy and storage technologies such as solar PV, wind turbines, and lithium-ion batteries are increasingly common in the contiguous United States and starting to appear in the Northwest Arctic and other regions of Alaska. Most recent and future renewable electricity generation projects are expected to include the renewable technology plus battery storage. This results in technology prices for solar, wind, and batteries that are decreasing significantly over time, especially over the last decade as mass production and product reliability have increased. However, very recent global supply chain disruptions and sharp fossil fuel price escalations have altered this downward trend.

Figure 28. Buckland Solar Array

Within the Northwest Arctic, overall renewable energy project costs have declined as lessons learned from each project have been incorporated into each subsequent project. For example, Buckland and Deering have very similar PV installations and were funded from the same grant award, but Buckland was designed and constructed a year before Deering. Although the PV configuration was similar – both communities used three BoxPower 20-foot shipping containers with their proprietary racking design—in Buckland, the system used three individual string inverters (one for each shipping container) and an electrical combiner, whereas in Deering the system used a single, larger inverter that incorporated all three shipping containers' production into a single output. This one modification saved several thousand dollars on the inverter and combiner system hardware and installation labor while making the required integration with the existing diesel and microgrid control system much simpler and more cost effective in Deering. Further, because the solar PV industry continues to innovate and squeeze more power conversion capacity onto the same size solar panel each year, the total nameplate capacity for the Deering system (48.5 kW) is larger than the Buckland system (46 kW) despite the same amount of solar panels and a lower cost per panel for Deering since it was installed a year later. Such trends point to inherently lower installed costs on a dollar/kW basis for future systems.

The Kotzebue solar PV system, which was installed the year after the Deering system, benefitted further from the solar PV industry's ongoing efficiency improvements by installing bi-facial panels, with a higher capacity, for essentially the same price as single-sided panels in all previous installations. All projects since Kotzebue have been specified with bi-facial panels, which continue to improve in energy density for the same size solar panel each year. Similarly, the Shungnak-Kobuk solar PV system, which was installed a year after Kotzebue's and used identical ground screws for mounting the solar panels, benefitted significantly from an improved drilling technique and more specialized equipment to more easily place the ground screws in permafrost than what was used in Kotzebue.

All of these lessons were transferred and applied to the next project because of the consistency of the main project overseers and good communication among stakeholders, especially NAB and NANA Energy Program staff and contractors, the local utilities, and the Northwest Arctic Energy Steering Committee.

Figure 29. Shungnak Battery Building (Photo Couretsy of Ingemar Mathiasson)

Figure 30. Batteries for Shungnak, Prior to Installation (Photo Courtesy of Ingemar Mathiasson)

Another important innovation and trend that has benefitted from technology transfer among projects is the overall performance and efficiency of the battery energy storage system housing, which is necessary to protect the BESS from extreme temperatures and provide a safe working environment for basic maintenance and repairs. Specifically, the Buckland and Deering BESS housing includes a large isolation transformer, which generates a significant amount of heat such that even for much of the winter, the BESS building requires cooling to keep the batteries at proper operating temperature. By the time the BESS building in Shungnak was constructed, it was determined that the isolation transformer could be placed outside the building, thus reducing cooling loads and improving use of renewable energy.

More broadly, as multiple renewable energy projects have now been developed across the region, a generic project development process has been identified that helps to streamline future projects and workplans and translates into reduced construction costs and shorter development timelines.

The overall development process for installing and integrating a renewable energy hybrid system into an existing diesel electric grid consists of the following:

- Communication and coordination with all stakeholders, including community leadership and local electric utility
- Identify funding
- Upgrade power plant controls if needed
- Upgrade switchgear if needed
- System design, including sizing to optimize renewable production, battery charging, power conversion, and alternative heating
- Siting – technical considerations and community preference
- Geotech and soils
- Permitting
- RFP process
    - Contractor selection
    - Equipment procurement
    - Logistics, shipping
    - Local support, training and workforce development
- Public education, reporting, performance monitoring

Another notable trend that has evolved as the renewable energy projects have continued proliferating across the region, and is expected to continue with future projects, is the establishment of community-based Independent Power Producers (IPPs) to develop the projects and sell power to the local utility. This structure has emerged as a method to preserve Power Cost Equalization (PCE) payments in communities that implement more renewables and are at risk of losing PCE support as their diesel fuel consumption decreases. Pioneered in the communities of Deering (with a City-owned local electric utility) and in Shungnak-Kobuk (with a statewide electric cooperative, AVEC, as the local electric utility), this IPP structure appears to be effective at enhancing community engagement and ownership in the new projects, creating local jobs, and improving regional cohesion and accountability as the NAB and NRC maintain an oversight and coordination role in the overall process and implementation.

Regional Energy Opportunities

The Northwest Arctic Borough and NANA region have diverse energy needs and interests. Below is a detailed list of the technology options region-wide. The descriptions summarize the opportunities and limitations associated with each technology as well as the communities where each technology is viable or has already been implemented. The Projects and Opportunities Matrix, included in the Appendix, provides additional details regarding the current status of each technology in each community as well as a regional perspective for aggregating projects and opportunities.

Reduce Cost of Home Heating

- Weatherize aging homes
    - 47% built before 1980 and have not received any weatherization upgrades
        - Of these homes, 11% consume 4x the energy of a modern home – highest priority for weatherization efforts
- Maintain & upgrade heating infrastructure
- Develop a regionalized stove oil purchasing strategy
- Develop renewable energy & battery storage projects to increase electric thermal options
    - Heat pumps
    - Dispatchable electric heating

Limitations:

- Region-wide weatherization will be a major undertaking given the pervasive need
- Renewable energy & battery storage projects cannot provide short-term relief
- Heat pumps are only cost-effective when the ratio between high fuel costs and low electricity costs is above a certain threshold
- Heat pump efficiency decreases as ambient temperatures drop such that deep winter heating is generally not a realistic option

Opportunity: All communities

Wind

- Power is generated from wind energy year-round
- Excess wind energy can be dispatched for home heating and/or water system heating

Limitations:

- Power generation is intermittent
- A control system is required to integrate the wind turbine into the power system
- Expensive annual preventative maintenance is required for wind turbine
- Wind resource must be characterized through on-site measurement
- Appropriate wind turbine must be identified based on wind regime—there are limited models of small (< 1 MW) wind turbines and high per unit costs
- Wind resource is not present throughout the region

Possible Opportunity: Ambler, Kiana, Kivalina, Kobuk, Noatak, Noorvik, Selawik, Shungnak

Accomplished: Buckland, Deering, Kotzebue

Utility Solar

- Power is generated on a predictable schedule during daylight hours with clear skies
- Minimal preventative maintenance is required for a solar PV array
- Solar resource data is used to model power generation from a solar PV array—no data collection is required
- Solar PV array sizing can be determined based on modeling

Limitations:

- No power is generated during the coldest part of the year nor whenever the sun is not present
- A control system is required to integrate the solar PV array into the power system

Opportunity: All communities

Accomplished: Buckland, Deering, Kobuk, Kotzebue, Noatak*, Noorvik, Shungnak (*In progress at time of publication)

Battery Storage

- Pair battery storage with renewable energy generation to stabilize the power system and enhance the effectiveness of renewable energy systems
- Identify appropriate battery storage and converter size based on energy system modelling

Limitations:

- Battery storage is expensive and not a power generation source

- A control system is required to integrate the battery storage system into the power system

Opportunity: Ambler, Kiana, Kivalina, Noorvik, Selawik

Accomplished: Buckland, Deering, Kobuk, Kotzebue, Noatak*, Shungnak (*In progress at time of publication)

Hydroelectric

- Power is generated from hydro energy year-round
- Excess hydro energy can be dispatched for home heating or water system heating
- Upper Kobuk Cosmos Hills hydroelectric project would provide power to Ambler, Shungnak, and Kobuk if intertie is constructed between Shungnak and Ambler

Limitations:

- Upper Kobuk Cosmos Hills hydroelectric project is a high-cost project due to the large scale
- Power generation from Upper Kobuk Cosmos Hills hydroelectric project would vary seasonally
- Viability of Upper Kobuk Cosmos Hills hydroelectric project depends on construction of an electrical intertie between Shungnak-Kobuk and Ambler, adding additional costs
- Financial viability of Upper Kobuk Cosmos Hills hydroelectric project depends on outcomes of feasibility study to estimate heat loads in Ambler, Shungnak, and Kobuk
- Hydropower production is much restricted in winter

Opportunity: Ambler-Kobuk-Shungnak, Kotzebue (may also have seasonal hydropower resource)

Accomplished: None

Community-Scale Biomass

- Heat is generated from biomass energy year-round
- Revenues from biomass fuel stay in the community

Limitations:

- Assessment of wood biomass energy resources must be conducted
- A biomass harvest plan must be developed that accommodates all local stakeholders
- Community must be invested in harvesting the required biomass fuel annually
- A storage facility must be constructed or allocated to store wood and keep wood dry
- Wood resource is limited, especially in the lower Kobuk

Opportunity: Kiana, Kotzebue, Noatak, Noorvik

Accomplished: Ambler*, Kobuk (In progress*)

Intertie

- Expansion of opportunities to install large-scale renewable generation sources to serve multiple communities
- Reduction of power plant operations and maintenance costs for system if extra power plants are downgraded to back-up power plants

Limitations:

- Routine maintenance is required for long-term upkeep of tie-line
- Long tie-lines will result in line loss
- Tie-lines are expensive and serve relatively small loads

Opportunity: Ambler-Kobuk-Shungnak, Kiana-Noorvik-Selawik

Accomplished: Shungnak-Kobuk

Independent Power Producer (IPP)

- Tribe or City can own energy infrastructure and generate jobs and revenue for maintenance or expansion of energy infrastructure
- Eliminates negative incentive of reduced PCE subsidy associated with addition of renewable energy generation to power system

Limitations:

- Agreement must be formed between Tribe or City and the local utility to sell and purchase power
- State of Alaska must approve power purchase agreement for PCE qualification

Opportunity: Ambler, Kiana, Kivalina, Kotzebue, Noatak, Noorvik, Selawik

Accomplished: Buckland*, Deering*, Shungnak, Kobuk (*In progress)

Generator Upgrades

- Enhanced fuel efficiency can be achieved through new and appropriately sized generators
- Engines with marine manifolds expand the opportunity for heat recovery
- Many communities are eligible for the EPA DERA program regardless of utility ownership

Limitations:

- Integration of renewable energy sources may reduce the fuel efficiency of generators if not sized correctly
- Generator replacement is expensive and up to the discretion of the utility

Opportunity: Kobuk, Kotzebue, Noatak, Selawik

Accomplished: Ambler, Buckland*, Deering*, Kiana, Kivalina*, Noorvik*, Shungnak (*In progress)

Automated Switchgear

- Facilitates smooth, automatic switching between generators to enhance grid stability and improve fuel efficiency

Limitations:

- Often a requirement for integration of renewable energy sources and control system
- Can be high cost

Opportunity: Ambler, Kiana, Kivalina, Kotzebue, Noorvik, Selawik

Accomplished: Buckland, Deering, Noatak, Shungnak

Recovered Heat

- Utilizes excess heat from generators to provide heat to buildings and/or water system
- Inexpensive source of heat

Limitations:

- Heat is most efficiently used when buildings served are nearby the power plant
- Power plant cannot rely on recovered heat system to dissipate excess heat from generators
- Can be high cost

Opportunity: Ambler, Buckland, Kotzebue, Selawik

Accomplished: Deering*, Kiana, Kobuk, Noatak, Noorvik, Shungnak (*In progress)

Energy Efficiency

Community

- LED street light upgrades, where not already complete
- Weatherization of aging community buildings
- Energy audits of community buildings and completion of recommendations
- Energy audit of water treatment plant and completion of recommendations

Residential

- Residential LED lighting upgrades
- Upgrade residential heat trace to circulation pumps
- Weatherization of aging homes
- Residential heating infrastructure repair and/or replacement

Limitations:

- Region-wide weatherization will be a major undertaking given the pervasive need

- Funding for energy efficiency upgrades may be more difficult to obtain than funding for capital projects

Opportunity: All communities

Accomplished: All communities

Heat Pumps

- Technology has been proven to be effective for home heating in Arctic environments
- Heat pump calculator developed for NAB/NANA region to determine site-specific cost-effectiveness[10]
- Additional benefits of providing cooling in the summer months and improved indoor air quality from filtering system

Limitations:

- Cannot be efficiently operated in temperatures below -5 °F
- Heat pumps are only cost-effective when the ratio between high fuel costs and low electricity costs is above a certain threshold
- Potential impacts to electric grid from increased peak demand if all heat pumps operating simultaneously

Opportunity: Deering, Buckland, Kiana, Kivalina, Kobuk, Kotzebue, Noatak, Noorvik, Selawik, Shungnak

Accomplished: Ambler

Energy Related Training and Regional Services

- Conduct outreach program to expand awareness of residential energy consumption and methods for reduction
- Establish local or regional expert to service boilers, oil stoves, heat pumps, etc.
- Establish electricians and mechanics available to be hired to work on energy systems throughout regions—utilize Kotzebue as regional hub

Limitations:

- Entity would be needed to manage program offering regional technician services, electricians and mechanics
- Limited regional availability of trained technicians, electricians, and mechanics

Opportunity: All communities

Accomplished: None

[10] https://heatpump.cf/

Projects and Opportunities Matrix

Through this effort to update the Regional Energy Plan, the need was identified for a comprehensive record of the current project status and future project opportunity for each energy efficiency or renewable energy generation technology in each community. The Projects and Opportunities Matrix captures this information at a detailed level in a condensed, color-coded format. The categories captured in this spreadsheet include wind, utility solar, water plant solar, battery storage, hydro, community-scale biomass, geothermal, intertie, IPP, generator upgrades, automatic switchgear, recovered heat, residential biomass, and energy efficiency. Additionally, the matrix captures the top three highest priority projects for each community. These projects were identified because of the intersection of technical feasibility, community support, and funding opportunities. The Projects and Opportunities Matrix is meant to be a living document that is updated regularly to reflect updated project statuses, completed opportunities, and changing funding opportunities. The Projects and Opportunities Matrix is included in the Appendix.

Community Energy Profiles

As part of this Regional Energy Plan update, a Community Energy Profile was developed for each community. Each profile captures the basic energy system information for each community, recent energy-related projects, future energy-related projects, and community energy goals. The profiles also include a selection of energy trends that use data from PCE Program reporting to show trends in energy data for each community over the last ten years. The trends include population, fuel efficiency, line loss, utility cost to generate power, contribution of fuel and non-fuel costs to the overall cost of power generation, annual power generation, annual power generation per capita, and PCE impact on average annual residential cost of electricity per capita. Each profile was developed through a process of reviewing past studies and documents, collecting energy system information from the utilities, collecting past project data from local and regional stakeholders, trending reported data from the PCE program, conducting a community meeting to understand the goals and perspectives of each community, and conducting a review of the draft profiles with each community, where possible. All of the Community Energy Profiles are included in the Appendix.

Conclusions

The Northwest Arctic continues to demonstrate innovation and commitment to clean energy development and enhanced energy security for all stakeholders and community members. The NAB and NANA Village Energy Programs have provided the technical leadership, fundamental resources, and consistency over many years to apply lessons learned and continually improving technology for the betterment of the region and improved quality of life. The nation's first arctic wind energy deployments, the first wind-solar-battery-diesel hybrid systems operating in diesels-off mode, the establishment of community-based IPPs with regional support, hundreds of thousands of gallons of diesel fuel saved annually, and currently the largest solar PV array in rural Alaska are among the region's energy successes.

Despite these impressive accomplishments, energy costs remain high and long-term regional energy goals still require significant and prolonged effort if they are to be achieved. With extreme weather experienced in the 2021-2022 winter, combined with extreme energy prices in early 2022, the region is in the midst of a home heating crisis with limited quick-fix options. Energy efficiency measures and potentially heat pumps could provide some relief, but lower cost renewable energy owned by local IPPs and more control over fossil fuel deliveries to the region will be necessary to leverage the full portfolio of solutions to the persistent energy challenges in the region.

More broadly, achieving the region's energy vision and specific fuel and cost reduction goals will require a combination of investment, technology and human capacity building. Regional efforts based in Kotzebue and supported by various institutional partners, with technical support and outreach to the surrounding communities, presents a promising model for service delivery and improved system efficiency and reliability. As hybrid systems continue to increase in complexity such a regional support model will only become more important. Economies of scale that can be leveraged to reduce capital as well as operation and maintenance costs are also enhanced by collaboration within and among communities.

No plan is ever complete and will always require adjustments based on new information. However, this energy plan has attempted to combine the lessons and accomplishments of the past to inform activities and recommendations for the future. The leadership, institutions, shareholders, and citizens in the Northwest Arctic Borough/NANA region continue to invest time, energy, and resources to support the vital lifestyles and aspirations of the unique people and landscapes that make the Northwest Arctic an inspiring and special place to live.

Appendices

A. PROJECTS AND OPPORTUNITIES MATRIX
B. AMBLER COMMUNITY ENERGY PROFILE
C. BUCKLAND COMMUNITY ENERGY PROFILE
D. DEERING COMMUNITY ENERGY PROFILE
E. KIANA COMMUNITY ENERGY PROFILE
F. KIVALINA COMMUNITY ENERGY PROFILE
G. KOBUK COMMUNITY ENERGY PROFILE
H. KOTZEBUE COMMUNITY ENERGY PROFILE
I. NOATAK COMMUNITY ENERGY PROFILE
J. NOORVIK COMMUNITY ENERGY PROFILE
K. SELAWIK COMMUNITY ENERGY PROFILE
L. SHUNGNAK COMMUNITY ENERGY PROFILE