Lower Yukon-Kuskokwim Priority Climate Action Plan

For the EPA Climate Pollution Reduction Grant

The 567 kW power plant in Napaskiak, Alaska. Credit: ANTHC Rural Energy.

Prepared by:

Dr. Anne Kelly, Alaska Native Tribal Health Consortium, aekelly@anthc.org
Sean Glasheen, Nuvista Light and Electric Cooperative
In collaboration with the communities of the Lower Yukon-Kuskokwim
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Definitions and acronyms

AEA - Alaska Energy Authority – The State of Alaska's energy office, and lead agency for energy policy and program development. Their mission is to 'reduce the cost of energy in Alaska'.

AHFC - Alaska Housing Finance Corporation – Established by the State of Alaska, AHFC is a public corporation to provide safe, quality, affordable housing to all Alaskans.

ANC - Alaska Native Corporation – Established in 1971, Alaska Native Corporations are for-profit entities representing 12 regions, 225 villages, and nonresident Alaska Natives. ANCs have surface rights to their lands, and develop economic opportunities to the benefit of their Alaska Native Shareholders.

ANTHC - Alaska Native Tribal Health Consortium – A non-profit Tribal health organization designed to meet the needs of Alaska Native and American Indian people living in Alaska. Established in 1999, ANTHC entered into a compact with Indian Health Service so healthcare could be provided under Alaska Native leadership to promote self-determination, self-governance, and higher quality health care for the Native people of Alaska.

AVCP – Association of Village Council Presidents – A nonprofit Tribal consortium, 'dedicated to supporting the interests of the 56 member Tribes of the Yukon-Kuskokwim Delta', promoting self-determination and providing community development, education, social services, and cultural programs to the region.

AVCP RHA – Association of Village Council Presidents Regional Housing Authority – Launched by AVCP but no longer a part of AVCP, AVCP RHA is the regional housing authority for the Lower Yukon Kuskokwim region. Its mission is to meet the housing needs of the AVCP region, including its 56 federally recognized Tribes.

AVEC - Alaska Village Electric Cooperative – A non-profit cooperative electric utility serving 59 communities across rural Alaska.

BESS – Battery Energy Storage System – Battery storage to retain energy produced that is above demand. The stored energy is then released to the grid when production drops below demand. These systems allow for more renewable energy to be utilized by the grid when production and/or demand is variable.

GHG – Greenhouse Gas – Gases that trap infrared heat in the Earth's atmosphere.

KANA – Kodiak Area Native Association – A regional nonprofit for the communities of Kodiak Island, providing community support and health services to the communities, Tribes, and families of the island.

Nuvista Light and Electric Cooperative – A non-profit cooperative serving western Alaska, with the mission to 'achieve a more resilient and connected region while empowering our communities with access to affordable, sustainable energy infrastructure.'

RHA – Regional Housing Authority – Regional housing authorities around Alaska work to meet the housing needs of residents within the region, including housing affordability and maintenance. They have the same powers, rights, and functions under state law as the Alaska Housing Finance Corporation.

Executive Summary

Purpose

The purpose of this Priority Climate Action Plan (PCAP) is to provide the Lower Yukon-Kuskokwim with high-level recommendations for projects and programs that the community can implement to reduce GHG emissions, focusing on three sectors: 1) energy generation and transmission, 2) residential energy efficiency, and 3) non-residential energy efficiency. These sectors represent the greatest categories of energy usage within rural Alaskan communities. This plan will outline the path for Tribal entities to reduce their greenhouse gas emissions in a way that is equitable, reduces the high energy cost burden faced by households, improves quality of life, and stimulates local economies.

Process overview

This PCAP was led by Anne Kelly at ANTHC Rural Energy, and developed in close coordination with Sean Glasheen at Nuvista Light and Electric Cooperative, with consultation with Griffin Plush at Alaska Municipal League on behalf of the State of Alaska Department of Environmental Conservation, Tyler Kornelis at Kodiak Area Native Association (KANA), and the ANTHC Rural Energy Program. ANTHC and Nuvista reached out to community leadership to identify community priorities and needs, as well as gain valuable data and knowledge to develop this PCAP.

Measures overview

1. Diesel generation and distribution efficiency: repair, replace, and upgrade existing diesel generation and electrical grid infrastructure to improve energy system efficiency.
2. Solar power: community solar and battery storage to displace diesel generation.
3. Wind: wind energy, wind-to-heat systems, and battery storage to displace diesel generation and heating fuel use.
4. Biomass heating: using sustainably harvested local timber to offset heating fuel usage.
5. River and ocean energy: using energy from rivers and tides to offset diesel generation and heating fuel usage.
6. Home weatherization and energy efficiency: upgrading homes to reduce energy use, reducing diesel generation and heating fuel usage.
7. Community building weatherization and energy efficiency: upgrading community buildings and outdoor spaces to reduce energy use, reducing diesel generation and heating fuel usage.
8. Independent Power Producer model: Tribally-owned renewables projects to both reduce diesel generation and offset utility costs to residents.
9. Electric vehicles: On grids with renewable energy penetration, electric vehicles offset gasoline and diesel use of vehicles.

The Lower Yukon-Kuskokwim Region

For the purposes of this document, we are defining the Lower Yukon-Kuskokwim (Lower YK) region as the Kusilvak and Bethel Census Areas. The Lower YK region is home to 27,000 residents. Outside of the major hub of Bethel (pop. 6,000), most residents reside in communities of 200-600 people. The region is 85% Alaska Native, and most residents speak Yup'ik fluently. Annual household income is less than half of the U.S. average, in a region where the cost of living is among the highest in the nation. Many families rely on traditional subsistence practices.

The region is flat, dissected by rivers, wetlands, and lakes. Communities are not connected by roads. People and goods mostly travel by air, and by water when the rivers are ice-free. Snow machines and four-wheelers are common for travel within and nearby to communities.

Most communities operate their own independent utilities, including electric microgrids. The difficulty of transportation and travel drives the high cost of goods in the region, including fuel prices ranging from $5-10 a gallon. Diesel generation is the primary source of electricity in the region, and buildings are generally heated by heating oil stoves. Water and sewer service is 60-120 times more expensive than the rest of the nation, due to the need for utility lines to be heated by these expensive energy sources. The small utilities, with a lack of redundancy in equipment and workforce, experience many challenges with reliability and maintenance. The high cost of fuel makes renewable energy and energy conservation high priorities for the region's communities.

1 Introduction

1.1 CPRG Overview

In ANTHC's community surveys, every community identified two major energy priorities: reducing reliance on diesel power and home heating oil, and reducing home energy and heating costs for residents. Alaska's rural communities run on diesel generation and oil-burning home heaters, with fuel costs at $3-$12 per gallon. On still days, pollution from these sources lingers in and around homes, and in many communities, the noise pollution of generators is often present. Alaska's rural residents may be more aware than any other Americans of their community's reliance on fossil fuels, and of their harmful effects on community health and wealth.

The Alaska Native Tribal Health Consortium has over 25 years of working with rural Alaskan communities to provide health services, including development of water and sanitation services for communities that have been unserved by home water and sewer service. As a non-profit Tribal consortium comprised of all 229 Federally-recognized Tribes in Alaska, ANTHC is committed to meeting the needs of our people. To make water and health services operational and affordable for residents, ANTHC also develops community-scale energy projects to ensure that utilities are affordable and available to all. Over two decades of work in rural Alaska has placed ANTHC as a trusted partner in community infrastructure development across the state.

The Rural Energy Program at ANTHC works with dozens of rural Alaskan communities to improve energy efficiency and reliability to reduce utility costs and promote healthier communities. As part of this mission, ANTHC Rural Energy led PCAP development for 78 rural Alaska communities. ANTHC surveyed community leadership, including Tribal leaders, city leaders, and utility managers to identify community energy priorities. ANTHC staff attended statewide conferences for Tribal and community leaders to present on the EPA CPRG grant, make personal contacts, and discuss the EPA CPRG program. ANTHC also modeled costs and energy savings of community-scale renewables and building weatherization for each community. A summary of proposed projects were sent to each community for review and feedback. The results of these surveys, models, and community conversations resulted in this PCAP.

1.2 PCAP Overview

ANTHC focused the PCAP on three sectors: energy generation, home heating and weatherization, and community building heating and weatherization. Rural Alaska communities are primarily powered by diesel generation, and building heat is generated by oil-fired heating systems. Reducing the need for diesel energy generation and heating oil is the most straightforward and cost-effective way of reducing GHG production in rural Alaska communities.

GHG Inventory

There are two major greenhouse gas sources in our sectors of interest in the Lower Yukon-Kuskokwim: the diesel power plant, and heating fuel for building space heating, totaling 450,000 tons of CO_2 per year. Heating fuel is the greatest source of GHG emissions in the community, demonstrating the need for increased building weatherization and improved heating efficiency. A more thorough discussion of the region's GHG inventory, future goals, and priority measures are found later in this document.

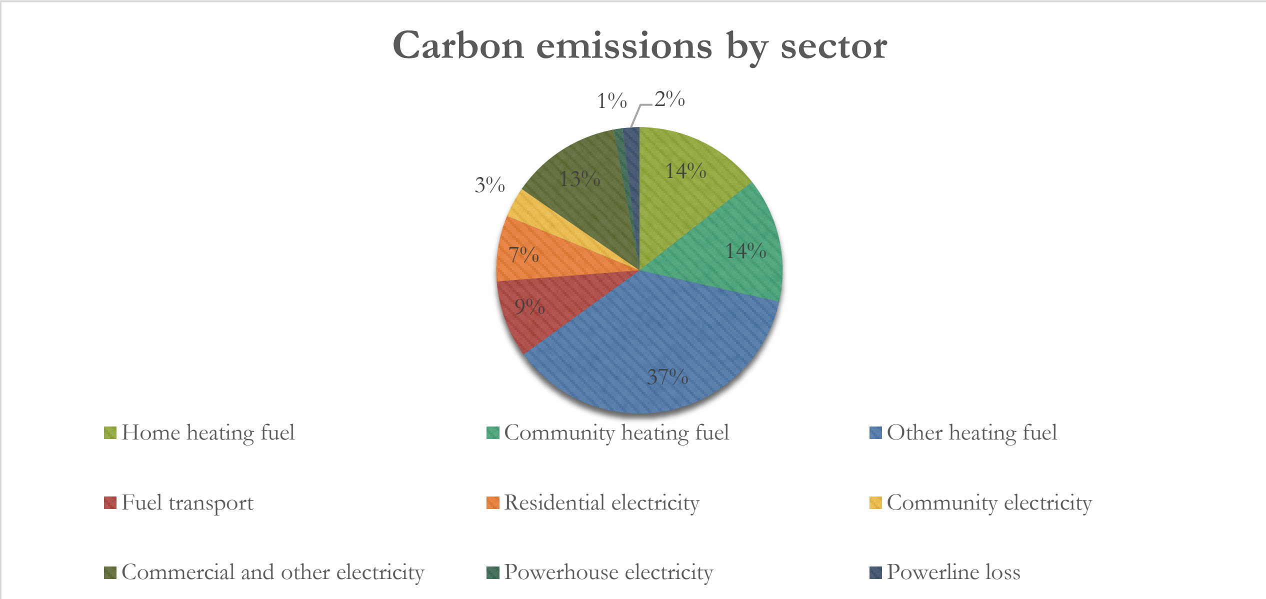

Figure 1. Distribution of carbon emissions by sector for the Lower Yukon-Kuskokwim region.

Data are lacking on the amount of fuel used to transport fuel to rural Alaska. In this region, fuel is barged and flown in, with deliveries dependent on ice and weather conditions. Based on a fuel price delivery report[1], we estimate fuel delivery surcharges are about a third the total cost of fuel. We estimate that every 1,000 gallons of fuel transported results in just over one ton of CO_2 released to the atmosphere.

1.3 Approach to Developing the PCAP

ANTHC led development of PCAPs for 78 communities across the state. These communities were not covered by any other Tribal entity's PCAP, and ANTHC took on this role as an effort to ensure that all communities in Alaska are eligible to participate in the EPA CPRG implementation grant opportunity. ANTHC's approach has been to solicit and follow community and Tribal leadership in PCAP development, and leverage the expertise of internal energy experts and the expertise of partners across the state.

Identifying and Engaging Key Stakeholders

Community authority and governance is complicated in rural Alaska. Communities typically have one or more federally-recognized Tribal governments, a municipal government, and an Alaska Native Village Corporation. Alaska Native communities typically also have relationships or memberships with regional partners, such as Regional Native Corporations, regional non-profit Tribal Consortia, Tribally-Designated Housing Entities/Housing Authorities, and non-profit Community Development Quota groups. Utilities may be owned and operated by the city, a private business, a cooperative, or a combination thereof. Tribal entities that serve the community operate at the community, regional, and state levels. State agencies like the Alaska Energy Authority and the Alaska Housing Finance Corporation also serve these communities.

For the development of this PCAP, we spoke to local power producers, regional Tribal entities, and other groups that might be part of grant applications as applicants or entities whose cooperation would be required

[1] (Institute of Social and Economic Research, Univ of Alaska Anchorage, 2008)

for implementation. We sent community needs surveys to community leadership, specifically targeting Tribal leadership (presidents and administrators), city leadership (mayors and administrators), and utility owners and operators. We also engaged with local and regional Tribal entities including the regional housing authority and regional non-profit Tribal Consortia via organized phone calls, and attending conferences and workshops. Similarly, we worked closely with the Alaska Municipal League to reach out to municipal leadership and state agencies regarding EPA CPRG opportunities.

UNDERSTANDING THE GHG INVENTORY

ENERGY GENERATION – The Alaska Energy Authority compiles annual energy generation data from most rural Alaska communities as part of its Power Cost Equalization Program[2]. This report breaks down annual diesel and other energy generation, fuel use, prices, and customer consumption. This report provides straightforward data for calculating the GHG emissions of community energy generation.

HEATING – Heating fuel use is a large portion of community energy consumption. While heating fuel sales data is not available for rural communities, approximately 30% of households in Alaska have had a home energy audit. These audits are conducted by an energy auditor, who creates a detailed model of each home's insulation, air tightness, electrical loads, and heating system characteristics to estimate energy consumption. An actual-versus-modeled study was conducted to validate the models, which showed a high correlation between the modeled energy consumption and actual heating energy consumption from billing data[3]. We used the heating data by census area to calculate the household energy usage for each community/region.

In homes and small buildings, heating is often provided by fuel oil direct-vent space heaters, which are commonly referred to as Toyostoves, the name of a popular brand in Alaska. Larger buildings may use one or a combination of Toyostoves, boilers, and forced-air heating, powered by fuel oil. BTUs per gallon generated by these systems are roughly similar, and therefore we assume that GHG production is similar across different heating systems for the same type and size of building. Across much of the region, there is no reliable source of quality firewood, and heating by firewood is not a significant contributor to home heating. In some parts of the Lower Yukon-Kuskokwim, firewood is harvested sustainably from local spruce timber and driftwood, and is thus not a net GHG contributor.

Community and commercial building heating estimates are more challenging, as fewer data and studies exist across rural Alaska on building sizes and heating fuel use. A thorough study from the Alaska Housing Finance Corporation did a statewide survey by climate zone of community and commercial buildings sizes, heating uses, and weatherization improvements[4]. The survey found that heating fuel use accounted for over 70% of total building energy use. We used this report and the AEA report[2] to estimate the total heating fuel usage of the community and commercial buildings in the Lower Yukon-Kuskokwim.

GHG REDUCTION GOALS

According to community surveys, community GHG goals across rural Alaska are "as much reduction as possible". Communities do not want to continue to purchase expensive and polluting diesel and home heating fuel. If all PCAP measures are implemented in all communities in the region, GHG reduction could be greater than 50% of total emissions. This reduction is the maximum possible with the best proven technologies in diesel generation, renewable energy, building weatherization, and energy efficiency improvements. In addition to reduced GHG emissions, implementation of these measures would reduce the high energy cost burden for community organizations and households, and provide opportunities for employment of residents in project implementation and maintenance. These measures will also improve

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[2] (Alaska Energy Authority, 2022)
[3] (Alaska Housing Finance Corporation, 2018)
[4] (Cold Climate Housing Research Center, 2014)

quality of life through improved electrical and sanitation reliability, lower local air pollution, and safer and more comfortable homes and community buildings.

Identifying measures to reduce GHG emissions

Because fuel costs are so high and fuel logistics are often unreliable in rural Alaska, the state has a lot of experience in effective GHG reduction measures in rural communities. Based on the experience of state and Tribal agencies, as well as research into energy use and savings from groups like the Cold Climate Housing Center, we identified three major sectors for cost effective GHG emission reduction: energy generation and distribution efficiency improvements, renewable energy, and weatherization and energy efficiency for homes and community buildings. Measures in these three sectors have been developed, tested, implemented, studied, and improved over the past few decades in rural Alaska, and we draw from this experience to develop our primary recommendations to communities for GHG emissions reductions. These measures also contain many co-benefits of improving critical energy reliability, and improving quality of life. An EPA report to Congress in 2020 also identified these as important sectors for GHG emissions sources and reductions[5].

Prioritizing and selecting GHG reduction measures

Priority GHG reduction measures are ultimately determined by community leadership. ANTHC provided data, including measure scope, measure costs, measure GHG benefits, and measure fuel cost savings. ANTHC also incorporated GHG reduction projects from community energy plans, energy audits, project feasibility studies, unfunded grant applications, and direct community feedback.

Estimating potential GHG reduction measure impacts

The measures listed fall into two broad categories: energy generation and energy conservation. Greenhouse gas reduction is straightforward to estimate with renewable energy generation projects. A kilowatt-hour generated by wind or solar will be one less kilowatt-hour generated by a diesel generator. AEA publishes annual data on diesel generation and generation efficiency by community, which allowed ANTHC to calculate emissions reductions of a renewable energy project.

Emissions reductions form weatherization and energy conservation measures are more challenging to estimate. Weatherization is a major area of research and practice across Alaska. Our best studies show that building energy use and the benefits of weatherization have large variability between buildings, communities, and regions. Hundreds of buildings have been studied by region across the state, and these data in aggregate provide a good picture of both building energy use and energy savings of weatherization, and thus GHG emissions and emissions reductions of a 'standard package' of weatherization measures.

More challenging to estimate, but no less important, are the many ways that communities will implement their priority energy savings projects that are highly specific to their community needs. Some communities are prioritizing converting outdoor lighting to LED, and many have already done some conversion. Some communities may have recently replaced aged and drafty home windows, but are seeking funding to upgrade inefficient heating stoves. Weatherization measures should not and will not be identical between buildings, but prioritize the greatest needs. We did not provide GHG emissions estimates for these projects individually, but instead express the goal of these projects in terms of cumulative energy savings goals for the community and region.

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[5] (U.S. Environmental Protection Agency in Consultation with the U.S. Department of Energy, 2020)

1.4 Implementation authority and establishing an administrative process for measure implementation

There are a variety of Tribal entities in the region that have authority to implement the measures outlined in this PCAP. In many cases, these Tribal entities will need to formally partner with non-Tribal entities for successful project implementation. Alaska Native people make up the majority of the population in most of the communities included in this PCAP, and so providing benefits to households, community buildings, and utilities is often synonymous with providing benefits to Tribal members regardless of organization type.

Eligible Tribal entities for Climate Pollution Reduction Grants program implementation funds include Federally-recognized Tribes, regional and statewide intertribal consortia, such as the Yukon-Kuskokwim Health Corporation (YKHC), Alaska Village Council Presidents (AVCP), or ANTHC, and Tribally-designated organizations, such as the AVCP regional housing authority (a Tribally-designed housing authority) or Nuvista (part of a Tribal Energy Development Organization). Each community in this PCAP has at least one Federally-recognized Tribe, with some having multiple due to community consolidation over time.

To implement the measures in this PCAP, in many cases the lead Tribal entity will have to partner with the owner of the community-serving infrastructure, which is often one or more of the following organizations: the local electric utility, the local municipality, or non-residential community building owners. Additionally, if a project will construct new infrastructure, the lead entity will also have to secure site control which often means partnering with the local Alaska Native Village Corporation or municipality and entering into a long-term lease agreement.

The following administrative process outlines best practices for implementing energy projects in rural Alaska Native communities:

- **Develop partnerships:** The first step is to find the right partners for the project. Local organizations often operate with minimal staff and a broad scope of work and so partnering with regional or statewide organizations can provide additional technical support as well as grant writing and management expertise. It is also essential to ensure that local electric utilities, building owners, landowners, and other key partners are supportive of the project right away.
- **Obtain council resolutions:** Federally recognized Tribes and local municipalities participating in the project should pass formal resolutions approved by the council that grant approval to apply for, manage, and construct/implement the project, or that provide that authority to a partner organization.
- **Obtain letters of commitment:** Before submitting a grant application, any organizations that are providing services or are agreeing to future land-leases or purchase agreements should provide formal letters of commitment signed by whoever has signatory authority at that organization.
- **Obtain letters of support:** Community projects in rural Alaska benefit from formalized support from each of the major local entities, typically consisting of the Federally-recognized Tribe, the municipal government, and the Alaska Native village corporation. A letter of support signed by the leadership of each organization before the grant application is best practice. Additional letters of support from regional Tribal consortia and other supporting organizations can also highlight the importance of the project to funding agencies.
- **Secure site control:** Alaska Native Village Corporations and local municipalities are often the major landowners in small rural communities. Long-term lease agreements should be discussed with major landowners once a project site is identified and letters of support or commitment should be in place with the grant application. Final long-term lease negotiations can depend on final design and

permitting and generally happens on a longer timeline than available for grant development and are therefore usually finalized post award.

- **Execute cooperative project agreements or memoranda of agreement:** After a grant agreement is executed, a formal agreement outlining roles and responsibilities, project ownership, and high-level project details should be developed and signed by all participating parties before the project kick-off meeting.
- **Finalize agreements:** Detailed agreements between entities are often needed for energy projects, such as power purchase agreements or heat sales agreements. These agreements can be complex and often require negotiation and legal review ; they are not typically complete prior to grant submission as the timelines are often too short and entities are hesitant to commit the significant resources to finalizing these agreements before full funding is secured. These agreements should be started post-award and finalized as soon as is feasible during the project.

1.5 Scope of the PCAP

The ANTHC Rural Energy program has experience in reducing fossil fuel use in rural Alaska to provide cost savings to households and communities. Program experience includes design, construction, and maintenance of appropriate renewables projects in harsh climates, as well as other energy efficiency projects like capturing generator waste heat recovery and building weatherization. The Rural Energy program supports communities by working with state agencies, national labs, cold climate engineers, and many other groups to implement the most effective and reliable energy-saving projects. This experience led to ANTHC focusing on three major areas for the PCAP: energy generation and distribution efficiency improvements, renewable energy, and weatherization and energy efficiency improvements for homes and community buildings.

The geographic scope of this PCAP is the Bethel and Kusilvak Census Areas of southwestern Alaska. For the purposes of this PCAP, we are referring to the region as the 'Lower Yukon-Kuskokwim'.

All projects considered in this PCAP should be able to be fully implemented by December, 2029. Projects considered have enough foundational work to be completed within that timeline. Generally, we expect 2025 to be a planning year, with 2026-2029 to be implementation years. In conversation with community leadership, we focused on projects that can follow this approximate schedule.

Communities in the Arctic Slope region share similar technical characteristics with those in the Yukon Kuskokwim Delta region: they have isolated microgrids primarily powered by diesel generators, the communities are remote and not connected by road to other areas, they have high energy needs due to the extremely cold climate in the region, and fuel must be barged or flown in. There are differences in cultures and practices in the two regions, but the measures proposed here could also serve to reduce fuel imports and usage in the Arctic Slope region in a similar way.

The recommended measures in this PCAP can generally be applied to communities in the Arctic Slope region and will lead to similar results, although costs and benefits will be allocated differently due to regional subsidies. If Tribal entities in the region wish to pursue any of the recommended measures in this PCAP, they will likely need to partner with either 1.) the North Slope Borough, which operates the power system in each community, or 2) Taġiuġmiullu Nunamiullu Housing Authority, the housing authority for the region.

PCAP PROCESS

In October 2023, ANTHC sent out surveys to community and Tribal leadership regarding community priorities and existing GHG reduction projects. ANTHC also performed preliminary analyses of several GHG reduction measures, including wind power, solar power, home weatherization, community building weatherization, and power generation/distribution efficiency. Combining these analyses and community feedback, we prepared a draft of priority measure recommendations and shared them with the community for further review and feedback. Throughout this process, ANTHC engaged with other Alaska Tribal PCAP developers and the state of Alaska PCAP writers to share information, resources, and ideas. We also reached out to other potential partners in the community to assist or lead aspects of the project, including any whose authority is required for implementation. We then used the community-identified priority measures to create the PCAP and sought Tribal council approval for the PCAP.

2 Tribal/Territorial Organization and Considerations

2.1 Tribal organization

Governance in the Lower Yukon-Kuskokwim region is a web of entities at community-to-federal scales. Most communities have Federally-recognized Tribal government as well as a municipal government. The non-profit Tribal consortium, Association of Village Council Presidents (ACVP), provides many community services in the region, and the regional housing authority, AVCP Regional Housing Authority, was spun off from AVCP. AVCP RHA works to provide quality affordable housing for Tribes and local residents. Some communities have their own Tribal housing authorities. Alaska Native Corporations (ANCs) provide shareholder revenue to Alaska Native members, and provide some community support services. Some communities have community-level ANCs, and the Lower Yukon-Kuskokwim is also served by the Calista Corporation. The ANCs operate some of the construction and infrastructure services in the region. While these organizations are not all federally recognized as Tribal entities for the purpose of the EPA CPRG grant, they are part of the complex and robust governance and leadership structure in the region that promotes local decision-making and Alaska Native sovereignty. The approval and cooperation of some combination of these organizations will be part of a successful EPA CPRG measure.

2.2 Special Considerations for Tribal/Territorial Entities

The Lower Yukon-Kuskokwim region sits in southwestern Alaska, within braided rivers and wetlands stretching to the Bering Sea. The geography of the region is very flat and generally treeless. Transportation is a major infrastructural challenge, as rivers and wetlands prevent overland travel in all but the frozen winter months, and the region is essentially roadless outside of communities. Barges haul cargo along the major rivers and oceanfront communities during the ice-free period, and cargo is hauled by air when rivers and the ocean are impassible. The geography and climate of this region make fuel transportation logistics challenging, which is a major consideration in this PCAP.

The region supports 27,000 residents, at a population density of just 0.5 people per square mile. The region's major hub is Bethel, a town of just over 6,000 residents about 90 miles up the Kuskokwim River from the Bering Sea. A secondary hub in the Kusilvak Census Area is Hooper Bay, a town of 1,400 on the Bering Sea on the southern Yukon Delta, The region is over 85% Alaska Native, and Yup'ik is the primary language in 60% of homes. Community sizes are typically from 200-600 people, and most communities operate their own diesel power plant and microgrid, a school, and a clinic. A handful of communities are able to intertie their electrical distribution in groups of two or three communities sharing a grid.

Like their electrical utilities, the water and sewer utilities are also isolated. Each community has some form of municipal water and sewer system. The spectrum of services ranges from fully piped water and sewer systems on the high end, to watering points and honeybucket service on the low end. Regardless of the level of service, a water system in an arctic or subarctic climate is energy-intensive to operate due to the need to circulate and heat raw water intakes, water storage tanks, and distribution systems. Combined with high fuel and electricity costs, this leads water and sewer costs in rural Alaska to be roughly 60-260 times the national average. Further, the median per capita income in the region is $18,500, 56% below the national average. As a result, rural Alaska Native communities face some of the highest utility costs in the U.S. and many communities have the lowest capacity to afford these bills.

Many communities in this low-lying area are struggling with the effects climate change, as sea levels rise, storms intensify, rivers erode their banks, and permafrost melt undermine the community. Local subsistence foods are a major component of household diets in this region where grocery costs are the highest in the nation. Local food sources are declining or have collapsed due to environmental stressors.

In the words of one local partner, the region is "the highest cost of living, the most remote, and the most impoverished region in the United States". While not exactly at the top spot in all of these categories, the region is in the top five U.S. census areas in remoteness, poverty, and cost of living. This region is also one of the most threatened by the impacts of climate change. The combination of these challenges keeps energy costs and reliability a top concern for community leaders and residents in the region.

2.3 Funding landscape

There is a wide variety of funding for rural Alaska communities and Tribes for energy and other infrastructure projects. Not surprisingly, funds are not available in the quantity needed. However, communities have been successful in leveraging multiple funding sources to accomplish large projects with holistic community benefits. Both federal (Table 16) and state/regional (Table 17) funding opportunities are available for projects in the energy sector, these are described in Appendix A.

3 PCAP elements

3.1 Greenhouse gas (GHG) and co-pollutant inventory – total community emissions

For the greenhouse gas inventory, we focused on energy generation and heating. We are not considering human transportation or non-fuel cargo transportation, as discussed previously. The major emitters in the region are diesel-powered electricity generation and heating oil, as well as the estimated diesel emissions of hauling fuel into the region.

We used the EPA's emissions factors for diesel generation and heating oil stoves, as well as EPA's CO_2-equivalence factors to calculate emissions of methane, nitrous oxide, hydrofluorocarbons, and sulfur hexafluoride. We included three other co-pollutants important to human health and toxic at any level: PM2.5, PM10, and benzene. Perfluorocarbons and nitrogen trifluoride have no known sources in the region, as they originate in the industrial manufacturing of electronics and metals. In total, electricity generation, heating oil, and fuel hauling sum to 450,000 tons of CO_2 per year for the region. All emissions in the region are direct emissions; electricity is produced within the region and not purchased elsewhere. In the few cases of intertied communities, emissions are calculated as a percentage of total emissions, partitioned by population sizes between the communities, and are considered direct emissions.

Table 1. Total emissions of greenhouse gases and other important co-pollutants for the Lower Yukon-Kuskokwim region.

	TOTAL COMMUNITY EMISSIONS (LBS)	EMISSIONS IN CO_2E (LB)
CO_2	**900,200,000**	**900,200,000**
CH_4	18,200	511,000
N_2O	7,200	2,140,000
HFCS	257	13,600
SF_6	0	0
PFCS	0	0
NF_3	0	0
PM 2.5	243,000	Human cardiopulmonary damage at any level
PM 10	289,000	Human cardiopulmonary damage at any level
BENZENE	7,000	Human carcinogen at any level
TOTAL CO_2E		**903,000,000**

3.1.1 Scope of GHG inventory

Base years vary by sector, depending on the richness of data available. Energy production data come from the Alaska Energy Authority 2022 Power Cost Equalization Program report[6]. These data include electricity use by sector, including residential, community, and commercial/other, as well as diesel fuel purchased. Based on data from 2019-2022, 2022 was a representative year for energy use across the state.

Heating fuel data are few and far between in rural Alaska, and we relied on meta-analyses to estimate home and commercial heating fuel use. The base year for home heating fuel use is 2018, and these data come from an AHFC report on home heating.[7] Nonresidential building heating fuel data come from a similar 2014 AHFC reports on school[8] and community buildings[9]. We expect heating fuel use to remain relatively static between the base years and today, based on population and climate trends.

We excluded from this inventory human transportation and cargo transportation. The region is off the road system, and few communities have connecting roads between them. Daily transportation is by off-road vehicles like four wheelers, snow machines, and small boats, depending on the season. Small planes serve the communities, and in summer, barges access communities along the larger rivers. This wide variability in transportation types, which also vary by season, makes a comprehensive or accurate emissions inventory extremely challenging.

[6] (Alaska Energy Authority, 2022)
[7] (Alaska Housing Finance Corporation, 2018)
[8] (Cold Climate Housing Research Center, 2014)
[9] (Cold Climate Housing Research Center, 2014)

We also excluded household waste from this inventory for three reasons. First, waste data are nearly nonexistent. Second, due to remoteness and the expense of cargo transportation, options for waste handling are few. Without a road system in this remote area, efforts like collecting recyclables for processing would require large transportation emissions and cost. Third, household waste is generally well below the U.S. average, as people simply purchase fewer goods due to the high cost and difficulty of access to shopping.

3.1.2 Data sources

See *Works Cited.*

3.1.3 GHG accounting method

DIESEL ENERGY GENERATION

Diesel energy generation data are publicly available on an annual basis[6]. This report includes total kWh generated, which is also broken down by residential, community and commercial use, powerhouse consumption, and line loss. These reports include gallons of diesel used per year, which we can then directly use to calculate CO_2 and other emissions. In the case where communities are intertied, we allocate community energy production proportional to the population of the respective communities. Our base year is 2022 for all emissions calculations unless otherwise noted.

HOME HEATING FUEL USE

Home heating fuel use data come from a 2018 AHFC housing assessment report[10]. This report estimates home heating by region. Home heating fuel use data are virtually nonexistent at the household or community level, except in spotty studies, so we use this report to estimate heating fuel use for the standard home across the region. The number of households per community came from the AEA report[12] and 2020 U.S. Census data, and was verified or corrected by community leadership.

COMMERCIAL AND COMMUNITY BUILDING HEATING FUEL USE

A comprehensive statewide survey[11] in 2014 measured average community and commercial building sizes and heating efficiencies. We used the Energy Use Intensity (EUI) metric (kBTU/yr./sq. ft.) to calculate total energy use by the median building in the region. This study was biased towards larger towns, and our internal studies of community building energy audits shows us that the average size of community and commercial buildings is around 2,000 square feet. We then used their measurement that 72% of total energy usage is for building heating. Since different building heaters roughly use a similar amount of gallons per BTU (at 80% efficiency, 111,000 BTU per gallon for Toyo stoves), we can estimate the gallons of heating oil needed to meet the energy usage of the community and commercial buildings. We then took the number of commercial and community buildings available in the AEA report[12] to calculate the total energy use in BTU/yr. of the community and commercial buildings in the region.

The schools and water treatment plants are much larger and more energy intensive. We used school EUI from a study on Alaska schools[13] along with average school square footage by climate region to calculate heating fuel use for the community school. ANTHC has conducted water treatment plant energy audits across rural Alaska, and we used our internal data to estimate water treatment plan energy usage. The average water treatment plant size is around 2,100 square feet, and uses around 8,000 gallons of heating oil per year.

[10] (Alaska Housing Finance Corporation, 2018)
[11] (Cold Climate Housing Research Center, 2014)
[12] (Alaska Energy Authority, 2022)
[13] (Cold Climate Housing Research Center, 2014)

FUEL TRANSPORTATION FUEL USE

Fuel in rural Alaska is transported by barge, and sometimes by air when conditions prohibit barge delivery. A fuel price report[14] showed that fuel delivery costs are about 30% of fuel costs in the Lower Yukon-Kuskokwim region. Conservatively assuming that fuel costs of shipping are about 1/3 of that total price, we can estimate that fuel use of shipping is about 10% of the total fuel shipped. This adds about 10% of diesel GHG emissions to all community fuel use, since all fuel is shipped by barge or by air when the barges cannot transit the river.

HYDROFLUOROCARBON (HFC) EMISSIONS

We estimated HFC emissions by estimating a 15-year lifespan of home refrigerators/freezers. Many homes have both a refrigerator and a chest freezer to store subsistence foods and bulk frozen foods, like frozen vegetables and berries, fish, or caribou. We can estimate that there are twice the number of home refrigerators/freezers as there are households, and that 1/15 of them fail every year. In rural Alaska, there are no HFC recapture programs so we can expect that all the gases are released to the atmosphere as the appliance degrades in the dump. Our value of 127 g of HFCs per unit allows us to model annual emission. We expect this is an overestimate of HFCs, as not every home has two units. However, commercial spaces and offices will also have some refrigerator and freezer units.

NEGLIGIBLE GHG EMISSIONS

- SF_6 – The only potential source of sulfur hexafluoride in a rural, non-industrial community could be switchgear. However, SF_6 is only found in very high voltage switchgear. The switchgear in these communities are designed for much lower voltages and do not use SF_6. There is no other potential source in the region.
- PFCs – There are no significant artificial sources of PFCs in the region, as there is no aluminum manufacturing industry.
- NF_3 – There are no significant sources of nitrogen trifluoride in the region, as there is no electronics manufacturing industry.

3.1.4 GHG by sector and gas

Table 2. Fossil fuel emissions by sector for the Lower Yukon-Kuskokwim region (lb./yr.)

	CO_2	CH_4	N_2O	HFCs	PM2.5	PM10	Benzene
Diesel electrical generation	165,000,000	6,700	1,800	0	104,000	104,000	1,400
Home heating fuel	119,000,000	2,200	1,800	0	19,100	10,200	1,100
Non-residential heating fuel	259,000,000	2.,500	2,000	0	41,500	22,200	2,500
Fuel transportation	64,300,000	2,600	504	0	40,100	40,100	550
Refrigerators & freezers	0	0	0	228	0	0	0

[14] (Institute of Social and Economic Research, Univ of Alaska Anchorage, 2008)

3.2 GHG Reduction Measures

3.2.1 Measure 1 – Diesel generation and transmission upgrades

Summary

Every community in the Lower Yukon-Kuskokwim area operates or utilizes diesel generation, and diesel power provides 90% of the region's electricity. The combination of costly logistics and aging infrastructure means that many of these community grids are not operating efficiently. Replacing or rebuilding diesel generators, upgrading switchgear and controls, adding and replacing transformers, and other upgrades to the basic diesel generation and distribution infrastructure offers a cost-effective method of greenhouse gas reduction. Other related infrastructure improvements could also benefit GHG emissions reductions from the electrical infrastructure, such as replacing aged and leaking bulk fuel storage. For example, bringing generation efficiency of 11.8 kWh/gal diesel up to an achievable 14 kWh/gal diesel would reduce community diesel use and associated emissions by 20%.

Costs are variable, depending on the specific needs of the grid. Genset replacement to more efficient models could range from $200,000-$500,000 in smaller communities. Many communities could reduce line loss and improve reliability by adding and replacing aging, overloaded transformers. These cost $15-50k each, depending on size. Replacing manual or older switchgear with automated models can also improve energy efficiency of these systems. Upgrades and replacements of less efficient generation and distribution components have a simple payback time of just a few years, as improving generation and distribution efficiency by a few percent results in significant declines in diesel consumption and fuel costs.

An important component of energy efficiency is operator knowledge. The Lower Y-K region could improve its generation efficiency by funding training for local operators. A greater depth of knowledge for operators allows them to run the system more efficiently day-to-day and to do more preventative maintenance and inspection of regional power systems, saving not only fuel costs but equipment repair costs. Currently, communities need to fly in technical experts from outside the region or state, which is expensive and can take several days. During emergencies, this delay can cause hardship for the community as pipes may freeze, the airport lights may be dark (preventing landings), and medical equipment may not function. More local expertise in the region would reduce travel time for repairs during power emergencies.

Coalitions of nearby communities are encouraged for these applications, as shipping logistics of specialized equipment are a major challenge for rural Alaska construction. Communities collaborating on purchasing, shipping, and installation timelines may find their construction timelines and costs greatly reduced.

Table 3. Measure 1 overview: diesel generation and transmission upgrades

Implementing agency	Community and/or regional Tribal entities, the city government, and the utility operator
Implementation milestones	Upgrade plan approval, construction start, construction end.
Geographic location	Community electrical grid
Metrics tracking	Energy efficiency analysis before start, project overview published, quarterly status updates, final report with revised energy efficiency analysis.
Annual estimated GHG and criteria air pollutant reductions	22% reduction in CO_2 emissions, see Table 4.
Implementation authority milestones	Utility approval and where applicable, municipal approval

Benefits analysis

Benefits of diesel generation and transmission upgrades go far beyond the reduction of greenhouse gas emissions and fuel costs. Energy unreliability is a major threat to health, safety, and infrastructure, especially in the extreme environment of rural Alaska. Many communities experience regular brownouts, and some have scheduled blackouts, due to aging generation infrastructure. Better generators, switchgear, and transformers would allow communities to manage power generation in a way that maximizes generator and transmission efficiency (see Table 4). A more reliable grid means improved quality of life and less damage to plumbing and other infrastructure.

Diesel generation creates local air pollution, with particulates and hydrocarbons being particularly harmful to human health. Newer generators not only produce more power per gallon of fuel, but drastically diminish harmful co-pollutant emissions (Table 4).

Finally, future renewables projects would likely require grid improvements, including switchgear upgrades, in order to be successfully integrated into the diesel grid; these grid upgrades would lower the barrier to future renewables.

Authority to implement

Whether the project is led by the local Federally-recognized Tribe or a regional Tribal entity, these generation improvements will require the approval and cooperation of the local utility. A Memorandum of Agreement or Cooperative Project Agreement outlining roles and responsibilities of both entities should be completed prior to project implementation. Community projects in rural Alaska benefit from formalized support from each major entity, including the Federally-recognized Tribe, the municipal government, and the Alaska Native village corporation. This should include a signed resolution from the governing council of the implementing organization and letters of support from the other organizations.

Table 4. Benefits of diesel generation and distribution improvements for the Lower Yukon-Kuskokwim region.

	COMMUNITY AVERAGE	REGION TOTAL	% REDUCTION
GRID EFFICIENCY IMPROVEMENT POTENTIAL	1.9 kWh/gal	1.9 kWh/gal	>17%
FUEL COST SAVINGS PER YEAR	$180,000	$5,658,000	>17%
EMISSIONS REDUCTIONS (LB./YR.)			
CO_2	4,002,000	128,076,000	22%
N_2O	90,200	2,885,000	55%
PM2.5	190	6,100	94%
PM10	190	6,100	94%
BENZENE	9	295	79%

Funding landscape

The Alaska Energy Authority has a Rural Power System Upgrade (RPSU) program, funded in part by the Denali Commission and other partners. This program has a prioritized list of communities that are in need of power system upgrades and implements projects to increase generation efficiency and modernize rural power systems as funding is available.[15]

Tribal entities can also apply for grant funding available from the EPA's Diesel Emissions Reductions Act program, which has previously been successfully utilized for power system upgrades by communities in rural Alaska. The Alaska Energy Authority runs a Rural Power System Upgrade Program which is available for communities to apply for more efficient and reliable generators. The program provides a good model for a community wishing to improve its existing generation system, including operator training. However, the program can only fund half of the communities with identified need. The Denali Commission also works with federal agencies and communities to provide funding for power generation in rural Alaska, but funding is not sufficient to match need across the region.

Authority to implement

Whether the project is led by the local Federally-recognized Tribe or a regional Tribal entity, these generation improvements will require the approval and cooperation of the local utility. A Memorandum of Agreement or Cooperative Project Agreement outlining roles and responsibilities of both entities should be completed prior to project implementation. Community projects in rural Alaska benefit from formalized support from each major entity, including the Federally-recognized Tribe, the municipal government, and the Alaska Native village corporation. This should include a signed resolution from the governing council of the implementing organization and letters of support from the other organizations.

[15] https://www.akenergyauthority.org/What-We-Do/Rural-Energy/Rural-Power-System-Upgrade-Program/Project-Status-Priority-Ranking

3.2.2 Measure 2 – Solar power and battery energy storage

Summary

Due to the size of the Lower Yukon-Kuskokwim region, and relative lack of transportation infrastructure, the communities therein are generally not electrically intertied. Instead, each community operates an isolated microgrid with a small power plant. While there are several existing wind installations, especially in the coastal communities, 90% of the region's power is supplied by small diesel generators. These smaller generators are relatively inefficient compared to larger utility-scale generators used in interconnected communities elsewhere. Further, the lack of roads requires that fuel is barged into the community in bulk. Between the inefficient generators and transportation requirements, electrical generation in this region has a high contribution to the total emission inventory.

To reduce emissions, keep money in the communities, and stimulate local economies, the proposed measure will provide funding to support the development of solar capacity. According to ANTHC models, optimized solar power systems with battery storage can replace about 33% of a community's annual diesel power production. Solar arrays with BESS systems for the community may cost from around $1.5M - $5.6M, depending on community size and system configuration. Because the communities are not interconnected, several smaller projects, rather than one large one, will be developed to ensure that the benefits of the program are equitably distributed. Preliminary estimates of a typical community's recommended solar and battery capacity are given in *Appendix B: Proposed solar and battery installations by community*.

Table 5. Measure 2 overview: solar power and battery energy storage

Implementing agency	Community and/or regional Tribal entities, the city government, and the utility operator
Implementation milestones	Project plan approval, materials procurement, construction start, construction end, tie-in to existing grid and system commissioning.
Geographic location	Appropriate siting within or near to community boundaries with necessary permissions for siting and transmission.
Funding sources	EPA CPRG and other funds as identified by the community
Metrics tracking	Quarterly progress reports, documented inspection, and energy production monitoring.
Cost	Approx. $1.6-6M per community for solar + BESS, more for larger BESS capacity
Annual estimated GHG and criteria air pollutant reductions	33% reduction in diesel generation in communities with community solar + BESS
Implementation authority milestones	Utility approval, landowner approval, and where applicable, municipal approval

Benefits analysis

Community solar arrays with a battery energy storage system can reduce community diesel fuel use by 33%. This measure also will have a transformative impact on the affordability of water and sewer in the region. As discussed previously, water and sewer utilities are heavily energy-intensive because of the need to heat supply and return lines. Any measure that will reduce diesel generation fuel costs will greatly reduce the cost of not just electrical utilities, but water and sewer utilities as well.

Table 6. Solar power + BESS benefits for an average community in the Lower Yukon-Kuskokwim.

	Annual metric
Additional solar production	468,000 kWh
Fuel cost savings per year	$198,000
Emissions reduction (lb./yr.)	
CO_2	1,670,000
CH_4	68
N_2O	18
PM2.5	1,100
PM10	1,100
Benzene	14

In addition to reducing water and sewer costs, the addition of solar and battery energy storage systems will serve as a source of backup power and increase the lifespan of the diesel gensets by reducing operating hours. Isolated microgrids currently have twice as many hours of outages annually as the national average and introducing back up solar power will reduce those service outages and increase energy resilience for rural Alaska Native communities.

Authority to implement

Whether the project is led by the local Federally-recognized Tribe or a regional Tribal entity, solar power will require the approval and cooperation of the local utility. A Memorandum of Agreement or Cooperative Project Agreement outlining roles and responsibilities of both entities should be completed prior to project implementation. Community projects in rural Alaska benefit from formalized support from each major entity, including the Federally-recognized Tribe, the municipal government, and the Alaska Native village corporation. This should include a signed resolution from the governing council of the implementing organization and letters of support from the other organizations.

3.2.3 Measure 3 – Wind, wind-to-heat, and wind energy storage

Summary

Many communities in Alaska have wind resources for viable community-scale wind generation. Existing wind projects across Alaska demonstrate that wind can be a major energy source, even in challenging environmental conditions. An advantage of wind power is that it is most abundant in winter, when community energy demand is highest. Currently 17 of the 34 communities in the region employ some form of wind power system, producing about 10% of the total regional power generation. A goal of expanding wind generation to 20% of total power production is well within reach.

Due to the exponential relationship between wind speed and power produced, many turbines in rural Alaska communities produce power exceeding electrical demand for periods of the year. This excess energy can be diverted into building heating to offset heating fuel use by implementing wind-to-heat systems and thermoelectric heaters, which can have huge impacts in reducing community fossil fuel use. Some wind-powered communities are implementing large energy storage systems to smooth wind power delivery, minimize energy waste through curtailment, and keep diesel generators offline as much as possible. Some western Alaska communities who were early adopters of wind turbines are prioritizing upgraded or replacement systems as the efficiency and reliability of these systems have improved. Grid upgrades are also needed in many communities for reliable integration of a wind power system. These upgrades would also improve transmission efficiency, further reducing diesel generation needs.

The temporal and geographic variability of wind resources in any particular community precludes a one-size-fits-all wind solution. In communities with high-quality studies demonstrating project viability, wind power is a priority measure. Where excess wind power is available, additive projects like wind-to-heat, thermoelectric heating, and energy storage systems could also provide additional significant GHG emissions reductions.

Table 7. Measure 3 overview: wind generation, wind-to-heat, and energy storage

Implementing agency	Community and/or regional Tribal entities, the city government, and the utility operator
Implementation milestones	Project plan approval, construction start, construction end, tie-in to existing grid.
Geographic location	Appropriate siting within or near to community boundaries with necessary permissions for siting and transmission.
Funding sources	EPA CPRG and other funds as identified by the community
Metrics tracking	Wind study, project overview published, quarterly construction updates, final tie-in and final report.
Cost	Approx. $5-10M per community for wind, more for wind-to-heat and energy storage systems.
Annual estimated GHG and criteria air pollutant reductions	10% reduction in diesel generation region-wide; communities with wind can expect 20-40% reduction in diesel generation.
Implementation authority milestones	Utility approval, landowner approval, and where applicable, municipal approval

Benefits analysis

Wind generation and energy storage provides many benefits to communities. Greenhouse gas emissions are reduced several ways through wind power systems. Wind generation directly offsets diesel generation. Excess power captured in energy storage improves grid reliability and further offsets diesel generation. Wind-to-heat systems and thermoelectric heaters offset heating fuel use and costs.

Many communities currently employ only diesel generation. Associated battery energy storage systems installed with wind turbines can further improve grid reliability. Any wind offset to diesel generation reduces wear and tear on diesel generators, reduces co-pollutants like particulate matter and hydrocarbons, and reduces community noise pollution.

Table 8. Benefits of switching 10% of the annual total power generation in the Lower Yukon-Kuskokwim region from diesel to wind power.

	Annual metric
Additional wind production goal	5,800,000 kWh
Fuel cost savings per year	$3,500,000
Emissions reduction (lb./yr.)	
CO_2	16,500,000
CH_4	700
NO_x	450,000
N_2O	260
PM2.5	10,400
PM10	10,400
Benzene	141

Authority to implement

Whether the project is led by the local Federally-recognized Tribe or a regional Tribal entity, wind power and associated infrastructure will require the approval and cooperation of the local utility. A Memorandum of Agreement or Cooperative Project Agreement outlining roles and responsibilities of both entities should be completed prior to project implementation. Community projects in rural Alaska benefit from formalized support from each major entity, including the Federally-recognized Tribe, the municipal government, and the Alaska Native village corporation. This should include a signed resolution from the governing council of the implementing organization and letters of support from the other organizations.

3.2.4 Measure 4 – Biomass heating

Summary

Heating for the region is generally provided by diesel heating fuel burned in boilers, furnaces, or monitor heaters. Because of the need to transport diesel fuel to remote communities, and often aging, inefficient equipment, the cost and emissions associated with these systems are among the highest in the nation. For communities with a local timber resource, supplementing diesel heating with biomass can reduce both cost and emissions. Biomass, derived from locally available organic materials such as cordwood or wood chips, holds significant promise for the region, and continues to gain acceptance as a heat source in rural Alaska thanks to a growing track record of positive performance. This measure specifically addresses non-residential heat users, such as water treatment plants, or schools. For biomass heating of that scale, the options are generally cordwood boilers, chip boiler, or pellet boilers.

Cordwood boilers are the most widely used in rural Alaska largely due to their simplicity and resilience. These boilers are essentially a tank of water with a firebox that is periodically loaded with cordwood by an operator. The wood is fired to heat the stored water, which is distributed to be used in hydronic heating systems. These boilers can be very effective, but require a large amount of hands on labor to operate. Chip boilers, on the other hand, require less day-to-day, hands-on operation, but are generally more complex, and have greater maintenance needs. Depending on the specific boiler, these systems can burn a large variety of woodchips, and can often make sense on communities that have sawmills because they can burn the resulting wood byproducts. Chip boilers are generally loaded with an automated auger system so they can be less labor intensive to operate. Because they are more complex than cordwood systems, chip boilers tend to be more expensive and are best applied to large heating loads. Another potential option is pellet boilers. While these can be very effective, there is not a reliable source of pellets in Alaska, and the operation of a pellet boiler may require the import of wood pellet fuel. As such, they are not recommended in this report.

Cost and funding

Based on previous projects, project costs generally should range from $1-3 million, depending on the size of the boiler system and the number of buildings provided with heat. Because the high cost of heating fuel, these project often have favorable economics, especially is they serve multiple buildings. Any CPRG funds could be used to leverage other funding sources, such as the Denali Commission, of the State of Alaska Renewable Energy Fund.

Benefits analysis

Biomass heating systems have several benefits for a community. Primarily, they reduce the amount of heating fuel burned, thereby reducing the cost and emissions associated with heating. Modern biomass boilers are extremely efficient and don't have the same issues with emissions that are common in residential wood stoves. Generally, emissions from these systems will fall below 2020 EPA Step 2 limits for wood stoves and pellet stoves. The cost per BTU for biomass is generally significantly less, often costing less than half of what an equivalent amount of fuel does. Further, biomass fuel is purchased from local harvesters, and stays in the community, unlike fuel which is purchased from outside entities. The exact benefits depend on the size of the biomass installation, however for a typical system that serves a clinic and a water plant could be expected to offset 8,000-15,000 gallons of fuel annually. For this report, the lower end is used to arrive at the following benefits.

Table 9. Benefits of a small biomass district heating system in a typical community.

	ANNUAL METRIC
FUEL SAVED ANNUALLY	8,000
FUEL COST SAVINGS PER YEAR	$40,000
EMISSIONS REDUCTION (LB./YR.)	
CO_2	179,600
CH_4	7
NO_X	4,830
N_2O	1.4
PM2.5	112
PM10	112
BENZENE	2

Authority to implement

Whether the project is led by the local Federally-recognized Tribe or a regional Tribal entity, a biomass heating system will require the cooperation of the owner of the buildings to be heated. A Memorandum of Agreement or Cooperative Project Agreement outlining roles and responsibilities of both entities should be completed prior to project implementation. Community projects in rural Alaska benefit from formalized support from each major entity, including the federally-recognized Tribe, the municipal government, and the Alaska Native village corporation. This should include a signed resolution from the governing council of the implementing organization and letters of support from the other organizations.

3.2.5 Measure 5 – River and ocean energy

Summary

Alaska is abundant in water resources. Many Alaska communities are sited on a river or coast (or both). Protecting salmon runs is a major concern in harnessing the renewable energy potential of these water resources, but many communities have been able to develop environmentally appropriate hydropower projects.

Run-of-river hydrokinetic development is of interest to many communities in Western Alaska, as large rivers are abundant, and impoundment dams are not feasible in the flat terrain. Hydropower is typically much less intermittent than other renewable resources such as wind or solar, which allows it to be used to provide baseload power and if appropriately sized meet the majority of the electric load in many communities. The community of Igiugig in the Bristol Bay region has been a leader in the region for demonstrating that in-river, non-diversion hydrokinetic power can be effectively utilized within an extremely sensitive and critical salmon fishery habitat, but production capacity remains small.

Communities in more mountainous regions potentially have options for impoundment dams and diversion hydropower. There are many successful examples in Southeast Alaska that also demonstrate minimal impacts on salmon habitat, and several communities in Southeast Alaska receive nearly all of their electricity from hydropower. In communities with appropriate hydropower resources and permitting, we recommend these projects as a high priority to meet community electrical demand. When year-round hydroelectric or hydrokinetic power is steadily available, communities can also convert their fuel oil heating systems to heat pumps and thermoelectric heating. These measures could reduce community non-transportation GHG emissions to nearly zero, if geography permits large projects. Transportation GHG emissions could also fall, as fuel transportation would be vastly reduced and electric vehicles would become viable.

Battery energy storage systems can amplify the benefits of hydro systems, where power production is inconsistent through time. These storage systems can smooth power delivery to the grid and provide communities with hours of power delivery after the hydro has diminished or ceased production. Where appropriate, BESS systems can enhance the benefits of hydropower and provide greater offsets to diesel generation.

Table 10. Measure 5 overview: water power - hydrokinetic run-of-river, impoundment dams, tidal, and wave energy

Implementing agency	Local or regional Tribal entity in partnership with local utility and/or municipality
Implementation milestones	Project approval by stakeholders state and/or federal permits secured within first year; construction; tie-in to grid by December 2029.
Geographic location	Rivers, streams, or ocean near the community
Metrics tracking	Project plan overview published; project updates every 6 mo.; completion and grid integration; percentage of community power converted to renewable energy
Implementation authority milestones	Confirm necessary permitting; obtain approval from all institutional stakeholders (tribe, utility, municipality if applicable).

Cost and funding

Hydropower projects of any kind are a relatively large up-front investment compared to most energy generation systems, with small in-river hydrokinetic projects carrying the least cost. However, the community benefits of hydropower are also very high and these facilities often have significantly longer expected design lives than other renewable energy systems. Hydropower is generally consistent, reliable, and predictable. In some cases, it can produce far above the existing diesel electric production of rural Alaskan communities, allowing other energy-saving and greenhouse-gas-saving projects to become viable, such as electrothermal heating, heat pumps, and electric vehicles. This measure would leverage existing funding sources and partnerships including State of Alaska matching funds, the Denali Commission, BIA and EPA grants, community matching funds, and DOE programs.

Benefits analysis

Hydro generation provides many co-benefits to communities. Greenhouse gas emissions are reduced several ways through water power systems. Hydro generation directly offsets diesel generation. Additional power can be sent to heat pump systems and thermoelectric heaters, offsetting heating fuel use and costs. Hydropower generation makes electric vehicle charging worthwhile as far as cost and emissions reductions. Once constructed, hydropower is significantly less expensive than diesel generation, and community members' utility bills have been greatly reduced in Alaska communities that utilize hydropower.

Many communities currently employ only diesel generation. Hydropower provides a secondary source of energy, buffering the community against power outages. Hydro energy storage systems, if utilized, further improve grid reliability. Any renewable offset to diesel generation reduces wear and tear on diesel generators, reduces co-pollutants like particulate matter and hydrocarbons, and reduces community noise pollution.

Table 11. Benefits of switching 5% of the annual total power generation in the Lower Yukon-Kuskokwim region from diesel to hydro power. Base year 2022.

	ANNUAL METRIC
ADDITIONAL HYDRO PRODUCTION GOAL	2,750,000 kWh
FUEL COST SAVINGS PER YEAR	$1,800,000
EMISSIONS REDUCTIONS (LB./YR.)	
CO_2	8,300,000
CH_4	340
N_2O	90
PM2.5	5,300
PM10	5,300
BENZENE	71

Authority to implement

Whether the project is led by the local Federally-recognized Tribe or a regional Tribal entity, a hydropower project will require the approval and cooperation of the local utility. A Memorandum of Agreement or Cooperative Project Agreement outlining roles and responsibilities of both entities should be completed prior to project implementation. Community projects in rural Alaska benefit from formalized support from each major entity, including the Federally-recognized Tribe, the municipal government, and the Alaska Native village corporation. This should include a signed resolution from the governing council of the implementing organization and letters of support from the other organizations.

3.2.6 Measure 6 – Home weatherization and energy efficiency improvement

Summary

Home weatherization has been a longstanding priority for Alaska agencies and homeowners, beginning in 1976 with a cooperative effort between the state and federal government. The program has evolved over time, identifying the most energy efficient and cost-effective measures for the homes and climates of Alaska. Weatherization was identified as a high priority for every community in our EPA CPRG survey, not least because of its many co-benefits. Weatherization reduces energy use and costs, but also improves home comfort and safety, and reduces wear and tear on infrastructure.

In response to high oil prices and home utility costs in 2007-08, the state of Alaska undertook a $402 million effort to weatherize 20,900 homes, or 8% of Alaska residences. The state estimates that this program reduced household energy use by 30%, and saved 1.4 billion pounds of CO_2 emissions during the 2008-2018 period. The state also estimated that this program generated 5,500 annual jobs, with $860 million in economic impact and $320 million in health and safety impacts. It is a priority for rural Alaskan communities to build on the widespread success of this program. In the Lower Yukon-Kuskokwim region, 63% of homes are in need of weatherization, according to 2023 data from the Alaska Housing Finance Corporation. Because of the substantial impact of home weatherization on community fossil fuel use, household utility bills, health and safety, and quality of life, weatherization is the top priority energy project for many communities in the region.

Home weatherization consists of several major practices. Homes first receive a home energy audit to identify major sources of heat and energy loss. Air sealing is done on the exterior shell and within the interior to prevent advective loss of heat. Insulation is added to floors, ceilings, walls, and windows as appropriate. Appliances are upgraded or retrofitted as needed; for example, water heaters may receive efficiency upgrades and insulation. Heating systems are cleaned, tuned, and/or repaired. Heating systems might be replaced with more efficient models, or converted to more efficient systems like heat pumps. Other efficiencies are added, like LED lighting, motion-controlled lighting, waste heat recovery, and thermostats with programmable setbacks. And finally, health and safety measures are added to ensure good indoor air quality, such as improved exhaust and ventilation. It is essential that any home energy retrofit program be conducted by trained personnel and include safety evaluations of carbon monoxide and ventilation to ensure that homes have good indoor air quality.

Table 12. Measure 6 overview: home weatherization and energy efficiency improvements for 25% of homes needing weatherization in the Lower Yukon-Kuskokwim region.

Implementing agency	The regional housing authority, the Association of Village Council Presidents or the community Tribal housing authority, in cooperation with the local or regional Tribal association
Implementation milestones	Project approval by the village Tribe and homeowners
Geographic location	Homes in the community/region
Cost	$25,000,000 @ $36k per home
Metrics tracking	Project plan overview published; home energy audits take place; weatherization completed; home energy savings realized.
Implementation authority milestones	Approval from community Tribal council, approval from individual homeowners.

Cost and funding

AHFC budgeted $30k per home during its 2008-2018 home weatherization effort, which we have adjusted for inflation to $36,000 average cost per home today. Weatherizing all of the 2,791 unweatherized homes in the Lower Yukon-Kuskokwim region would cost upwards of $100M. Prioritizing the 25% of most needy homes, quantified by a combination of home condition and household income, would achieve significant benefits for fossil fuel emissions, household utility costs, and community health. These funds could be combined with state and federal funds to expand the program to include more homes.

Benefits analysis

Home weatherization is one of the most beneficial priority programs by cost and by co-benefits. The economics for home weatherization programs that have been implemented in Alaska are excellent, with a benefit-cost ratio of 1.5.[16] These economics are on par or better than community solar arrays and other large-scale renewables projects. Home heating fuel consumption is reduced by roughly a third, reducing fuel transportation logistics, fuel spillage, and wear on home heating systems. Reducing home heating fuel and electricity use by a third has direct effects on household emissions, reducing overall household fossil fuel emissions by approximately 25%.

[16] (Cold Climate Housing Research Center, 2019)

Table 13. Home weatherization annual fuel use and emissions reductions based on a) 25% of the local region and b) by household. Base year is 2018.

	REGIONAL ANNUAL SAVINGS	HOUSEHOLD ANNUAL SAVINGS
HOME HEATING FUEL	1,850,000 gal	255 gal
FUEL COST SAVINGS PER YEAR	$8,525,000	$1,913
EMISSIONS REDUCTION (LB/YR)		
CO_2	29,700,000	11,900
CH_4	548	0.11
N_2O	440	0.09
PM2.5	4,770	1.0
PM10	2,544	1.9
BENZENE	284	0.11

Home heating units, whether woodstoves or Toyostoves, produce local pollution that affects both indoor and outdoor air quality. Reducing fuel usage reduces co-pollutants that harm human health, like particulate matter and benzene. Weatherization overall makes homes healthier and more comfortable: they are less drafty and better-ventilated. Home weatherization is a priority measure because it not only reduces community fossil fuel emissions and household bills, but it improves the quality life for every resident in a weatherized home on a tangible, daily basis.

Authority to implement

Workforce planning analysis

According to a 2014 study by Alaska's Cold Climate Research Center:

> *"One of the strongest cases for energy efficiency is that it produces jobs. Money spent on energy efficiency retrofits involves a significant amount of labor, including construction, maintenance, and engineering. With a properly trained workforce, much of this labor can be provided locally, whereas typically money spent on fuels goes primarily to distant resource extraction companies. Additionally, reduced spending on energy can allow organizations to potentially spend more money on program staffing. Residential energy efficiency programs in Alaska are estimated to have already created 2,700 short-term jobs and 300 permanent jobs, with potential to create an additional 30,000 short-term jobs and 2,600 permanent jobs."*[17]

3.2.7 Measure 7 – Community building weatherization and energy efficiency improvement

Summary

Community buildings in rural Alaska communities typically include a school, a water treatment plant and washeteria (though some communities are without water treatment), athletic facilities, maintenance facilities, power plants, public service worker housing, and offices (public safety, Tribal governance, and municipal governance). Every community varies in the number and configuration of these facilities. Schools and water treatment plants are the greatest users of energy, of community buildings. Schools are usually the largest building in the community, and often have mechanical systems and controls that are in need of retro-commissioning. Water treatment plants and washeterias must keep water lines heated in the coldest months to prevent freezing. The cost of water treatment plant energy costs about $600 per community household, and retrofits would reduce that cost by 40%.[17]

Standard community building weatherization measures address a wide variety of energy losses[17]. The major improvement in most buildings would include improving air sealing, ventilation controls, and heating controls. Ventilation systems can be zoned and turned off when unoccupied. Heating systems, also, can be zoned and programed with temperature setbacks when unoccupied. Building shells tend to be under-insulated and leak air; building shell insulation and air tightening can be conducted in tandem. Heating systems may need cleaning and repairs, or it may be more effective to replace heating systems with more efficient models. In many communities, where it is feasible, waste heat from power generation is used to heat nearby power plants, schools, and/or other community buildings. Heat recovery projects, while expensive, have resulted in up to 80% heat energy savings for tied-in buildings.

After space heating, lighting is the second largest energy use in community buildings. Converting indoor and outdoor lighting, including street lighting, to LED bulbs is a high priority the region. While one of the simpler energy efficiency improvements, it remains a significant upfront cost that has been a barrier for many communities. The payback time for one school in the region was less than a year. Another community saved 1,800 man-hours by reducing the labor needed to replace lamps[17].

Table 14. Measure 7 overview: weatherization and energy efficiency improvements for 20% of community buildings needing weatherization in the Lower Yukon-Kuskokwim region.

Implementing agency	The lead Tribal entity, in cooperation with the organizations owning and operating the community buildings.
Implementation milestones	Project approval by the building owners
Geographic location	Community buildings in the in the region
Cost	$8,100,000 @ $108k per building
Metrics tracking	Project plan overview published; home energy audits take place; weatherization completed; home energy savings realized.
Implementation authority milestones	Approval from community Tribal council, approval from individual homeowners.

Benefits analysis

The goal is to weatherize 20% of the 374 community buildings[18] in the region. Adjusting the 2014 weatherization cost estimates to 2024, we estimate that each building would cost $108,000 to weatherize. With an estimated fuel savings of $23,000 per year (at an average regional cost of $4.61/gal in 2023), the simple payback time of weatherization is less than five years, making it a very cost-effective measure in reducing fossil fuel usage. For communities paying close to $10 per gallon of fuel, the fuel cost savings more than double.

Table 15. Benefits of weatherization of 20% of community buildings in the Lower Yukon-Kuskkwim region.

[17] (Cold Climate Housing Research Center, 2014)
[18] (Alaska Energy Authority, 2022)

	REGIONAL ANNUAL SAVINGS	BUILDING ANNUAL SAVINGS
BUILDING FUEL (HEAT & ELEC.)	370,000 gal	4,950 gal
FUEL COST SAVINGS PER YEAR	$1,700,000	$22,900
EMISSIONS REDUCTION (LB/YR)		
CO_2	8,300,000	2,800
CH_4	140	1.9
N_2O	65	0.9
PM2.5	1,700	23
PM10	2,200	30
BENZENE	77	1.0

Workforce planning analysis

According to a 2014 study by Alaska's Cold Climate Research Center:

> *"One of the strongest cases for energy efficiency is that it produces jobs. Money spent on energy efficiency retrofits involves a significant amount of labor, including construction, maintenance, and engineering. With a properly trained workforce, much of this labor can be provided locally, whereas typically money spent on fuels goes primarily to distant resource extraction companies. Additionally, reduced spending on energy can allow organizations to potentially spend more money on program staffing. Residential energy efficiency programs in Alaska are estimated to have already created 2,700 short-term jobs and 300 permanent jobs, with potential to create an additional 30,000 short-term jobs and 2,600 permanent jobs".*[17]

Authority to implement

Whether the project is led by the local Federally-recognized Tribe or a regional Tribal entity, building improvements will require the approval and cooperation of building owners. A Memorandum of Agreement or Cooperative Project Agreement outlining roles and responsibilities of both entities should be completed prior to project implementation. Community projects in rural Alaska benefit from formalized support from each major entity, including the Federally-recognized Tribe, the municipal government, and the Alaska Native village corporation. This should include a signed resolution from the governing council of the implementing organization and letters of support from the other organizations.

3.2.8 Measure 8 – Independent Power Producer

Summary and benefits

Tribal entities can use the Independent Power Producer (IPP) model to implement and manage renewable energy projects, such as the proposed renewable energy measures in this document. The Tribal entity builds and owns the renewable energy system as an IPP, and can enter into a power purchase agreement (PPA) with local electrical utilities if they are interested in purchasing the renewable electricity generated by the system. . This model allows a Tribal entity to generate revenue which can be used to pay for operations and maintenance costs for the system as well as using the net revenue to provide value to the community.

ANTHC recommends using the net revenue to reduce the cost burden of residential water and sewer bills, allowing affordable access to an essential health service, and providing direct economic benefit to community members. Under Alaska's Power Cost Equalization (PCE) program, utilities are disincentivized from developing renewables, as reductions in utility costs can reduce PCE subsidy amounts. The IPP model does not alter the PCE cost subsidy, and keeps diesel generation more affordable while substituting renewables generation into the energy production mix. This model has been implemented in about a dozen communities in western Alaska, and has proven to be very successful in promoting renewables project implementation and bringing residents' utility costs down drastically. In communities where utility-managed renewables implementation is faced with financial barriers, the IPP model allows Tribes to add renewable energy, improve grid reliability, and bring down costs of electricity, water, and sewer to residents.

3.2.9 Measure 9 – Electric vehicles

Summary and benefits

Electric vehicles eliminate fossil fuel emissions and fossil fuel costs when they are powered by electricity from renewable sources. Electric vehicles have not been widely adopted in the Lower Yukon-Kuskokwim for several major reasons. The first is that a large portion of vehicle travel is by small plane, small boat, four-wheeler, and snow machine, and there are not many EV options in these non-auto transportation categories. The second is that battery reliability and charge falls drastically in cold temperatures. Range and reliability are serious safety concerns in cold weather. Third, diesel fuel generation for EV charging is not substantially less expensive nor more efficient than gas-powered vehicle fuel costs. And finally significant adoption of EVs would likely require infrastructure upgrades in these small, isolated microgrids to be able to meet the additional power demands for charging. Many communities operate near their existing generation capacity, and so EVs could lead to a need for additional diesel generators, transformer upgrades, etc. Electric vehicles are popular choices in rural Alaska communities like Juneau, where energy comes from hydropower, there is an extensive local paved road system, and the climate is mild year-round.

Communities across Alaska have expressed interest in adopting EV technologies as they become available and reliable in their local context. In larger communities, Tribal organizations, schools, and other entities operate shuttles and buses for community members. Communities would like to convert these vehicles to EVs to reduce fuel costs and local pollution. These larger hubs tend to have robust electrical grids and some alternative energies that could charge vehicles with lower fossil fuel emissions than gas-powered vehicles. Some communities are prioritizing electric watercraft as part of their emissions reductions plans. In any community with a significant renewable energy sources, EVs can reduce vehicle GHG emissions accordingly. Electric vehicle implementation would require both vehicles and charging infrastructure, necessitating cooperation between the Tribal entity, the vehicle owners, and the local utility.

Authority to implement

Whether the project is led by the local Federally-recognized Tribe or a regional Tribal entity, the local utility should be engaged in reviewing and approving any vehicle charging infrastructure. A Memorandum of Agreement or Cooperative Project Agreement outlining roles and responsibilities of both entities should be completed prior to project implementation. Community projects in rural Alaska benefit from formalized support from each major entity, including the Federally-recognized Tribe, the municipal government, and the Alaska Native village corporation. This should include a signed resolution from the governing council of the implementing organization and letters of support from the other organizations.

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5 Appendix A: Funding historically available to rural Alaska energy projects

Table 16. Federal energy funding opportunities with historical success in rural Alaska

Funding Agency	Grant opportunity	Eligible applicants	Eligible project types	Max funding request	Match requirement
USDA	High Energy Cost Grant	Tribes, municipalities, utilities, States, non-profits, ANCs	Energy efficiency & renewable energy	\$3M	None
EPA	Community Change Grants	Community Based Organization (CBO) in partnership with a City, Tribe, or another CBO	Low and zero emissions technologies to reduce GHG emissions, climate resiliency, reducing pollution	\$25M	None
DOE-OIE	Clean Energy Technology Deployment on Tribal Lands	Tribes, intertribal orgs, TEDOs on Tribal lands	Renewable energy, energy storage, efficiency for Tribal buildings	\$4M	20%, may be reduced to 10% if requested and applicant falls below socioeconomic thresholds
EPA	Diesel Emissions Reductions Act (Tribal & State)	States, Tribal governments, intertribal consortia	Diesel emissions reducing projects: diesel generator upgrades, marine manifold upgrades, upgraded switchgear		
DOE OCED	Energy Improvements in Rural and Remote Areas	Universities, Non-profit entities, For-profit entities, Tribal Nations, State and local governmental entities, Incorporated Consortia, Unincorporated Consortia	Projects that lower energy costs, improve energy access/resilience, and reduce environmental harm. Projects must demonstrate new models or technologies	Area 1: \$5-\$10M Area 2: \$10M - \$100M Single community: \$500k - \$5M	20% for universities, non-profits, State/local/tribal gov'ts & ANCs, 50% others
DOE	401010d	Set-asides for Federally-recognized Tribes	Grid resilience, preparing electric systems for renewable integration	\$84k - \$5M	15% Tribal match plus 33% utility sub-recipient match
BIA	Energy and Mineral Development Program	Federally recognized Tribes & TEDOs	Pre-development work necessary to develop energy resources: feasibility for solar, hydro, wind, etc.	\$10k - \$2.5M	None

Table 17. State, regional, and match funding opportunities in Alaska

Funding Agency	Grant opportunity	Eligible applicants	Eligible project types	Max funding request	Match requirement
Denali Commission	Program Grants	Tribes, municipalities, utilities, States, non-profits, ANCs	Renewable energy: gap funding, match, rehabilitation	$750k for Energy, $2M for infrastructure	20% (Distressed), 50% (non-Distressed)
AEA	Renewable Energy Fund	Electric utilities, IPPs, municipal or Tribal governments, housing authorities	Renewable energy feasibility/ design/ construction	$4M	None mandatory; improves score
NWAB	Village Improvement Funds	Tribes/municipalities in the Northwest Arctic Borough	Infrastructure improvement projects located in NWAB communities	Varies based on Village Improvement Commission approval	None
NSEDC	Community Energy Funds	Tribes/municipalities in the Norton Sound region	Energy projects located in Norton Sound communities	$1M allocated per community	None
AHFC / DOE	Low income Weatherization Assistance Program	Individual households that meet criteria	Home energy efficiency retrofits	Allocation based on DOE funds / State of Alaska funds	None
AEA	Village Energy Efficiency Program	City and borough governments	Building-scale renewable energy, energy efficiency, and conservation projects in public buildings and facilities located in rural Alaska	~$200k	None
AEA	Rural Power System Upgrades program	Rural electric utilities	Power system upgrades, including generators, switchgear, cooling systems, etc.	Varies by funding allocations & needs	None
State of Alaska	Community Development Block Program	Cities and municipal governments (can partner with utilities and Tribes), must meet HUD low-income requirements	Planning and design, financial resources for public facilities (switchgear upgrades, generator replacements, gap funding)	$850,000	25%

6 Appendix B: Proposed solar and battery installations by community

COMMUNITY	SOLAR ARRAY (KW)	BESS (KWH)	AVOIDED ANNUAL FUEL COST PER HOUSEHOLD	AVOIDED ANNUAL CO_2 EMISSIONS (TONS)
AKIACHAK	540	700	$1,219	610
AKIAK	360	700	$1,368	347
ALAKANUK	675	700	$2,996	1,387
ATMAUTLUAK	292.5	350	$2,587	305
CHEFORNAK	382.5	700	$1,702	383
CHEVAK	517.5	700	$1,112	679
EEK	360	700	$1,236	373
EMMONAK	742.5	700	$1,999	1,398
HOOPER BAY	765	700	$886	726
KASIGLUK	337.5	700	$854	350
KIPNUK	360	700	$537	369
KONGIGANAK	225	350	$534	256
KOTLIK	585	700	$1,536	568
KWETHLUK	495	700	$1,453	701
KWIGILLINGOK	337.5	700	$1,847	529
LIME VILLAGE	112.5	140	$9,362	124
MARSHALL	405	700	$1,165	386
MEKORYUK	247.5	350	$743	221
MOUNTAIN VILLAGE	675	700	$1,025	544
NAPASKIAK	292.5	350	$966	315
NEWTOK	180	210	$2,921	771
NUNAM IQUA	247.5	350	$1,679	265
NUNAPITCHUK	315	700	$928	327
PILOT STATION	517.5	700	$1,650	620
QUINHAGAK	472.5	700	$832	473
RUSSIAN MISSION	270	350	$1,218	295

SAINT MARY'S	765	700	$940	558
SCAMMON BAY	472.5	700	$1,331	492
TOKSOOK BAY	765	700	$1,742	794
TULUKSAK	135	210	$0[19]	138
TUNTUTULIAK	315	700	$801	340

[19] Tuluksak has limited energy cost savings because of existing renewables production.