BRISTOL BAY

Regional Energy Plan | Phase I

Preliminary Planning, Resource Inventory & Data Collection




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Prepared by

SWAMC
3300 Arctic Blvd., Ste. 203
Anchorage, Alaska 99503

Bristol Bay Native Assoc.
P.O. Box 310
Dillingham, Alaska 99576

Information Insights
212 Front Street, Ste. 100
Fairbanks, Alaska 99701

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EXECUTIVE SUMMARY

The Bristol Bay Regional Energy Plan is part of a statewide effort led by the Alaska Energy Authority to identify energy projects that will reduce the long-term cost of power and dependence on fossil fuels in Alaska.

This document represents the first step in a plan for the Bristol Bay region. The result of nearly a year of data collection, it provides an inventory of energy-related resources and projects in the region, including resource maps, community factsheets, funding options, and notes on energy technologies, project economics, key issues and data gaps.

While this inventory represents a snapshot in time in an ever changing energy landscape, it has been designed as a tool to focus conversations on the most technically feasible and economically realistic projects given the region's mix of energy resources and the current state of technology.

The next step is for community and regional leaders, residents, utilities, industry representatives, and other key stakeholders to engage in dialog about their priorities for addressing energy needs in the region. Phase II of the planning process will include opportunities for gathering that input from stakeholders both through a Regional Advisory Group and through presentations and discussions held in conjunction with regional meetings and events.

A preliminary analysis of potential energy projects is included at the end of the inventory. The project team encourages readers to tell us about additional projects that should be included. At the end of Phase II we will use the input we have gathered to identify broadly supported strategies and a list of fundable projects that can reduce energy costs in the region while developing local and regional energy resources.

KEY ISSUES

Bristol Bay faces many of the same issues at play elsewhere in rural Alaska and in the state as a whole, while other issues are more specific to the region.

- High and volatile fuel prices.
- High construction and maintenance costs for renewable energy projects due to remote location and the large distances between communities.
- High cost of building roads and transmission lines has resulted in few interconnections and preponderance of "island systems." Combined with small populations, this makes it difficult to achieve economies of scale or to create a truly "regional" plan.
- High space heating costs for homes, businesses and public facilities due to a cold climate.
- Heavy dependence on diesel fuel for electricity generation (96%). However, more renewable projects are under development or have recently come online.
- Declining population trends in some areas makes it difficult to plan for future demand.

- Uncertainty about potential new large industrial loads and "megaconceptual" projects.
- Uncertainty about future availability of natural gas.
- Patchwork of land ownership with federal, state, and tribal lands. Location of many renewable resources is on protected lands or too far from communities to develop economically.

Opportunities

Many of the renewable energy projects being considered in the region have the potential to attract private investment. While public financing through state and federal grant and loan programs is most common in Alaska, there is opportunity to expand into private financing in order to fund more projects. With the anticipated decline in public grant funding, this enables communities to advance projects that might otherwise go unfunded but which can reduce their cost of energy while producing a return on investment. Bundling similar projects, such as wind turbines, from many communities could create a more attractive investment package.

There is an opportunity to reduce fuel costs in the region through creation of a consolidated bulk fuel buying group. The larger utilities in the region already take advantage of such groups to get better prices and better terms on fuel orders, but we can increase the purchasing power of smaller utilities by coordinating bulk fuel orders.

Many opportunities exist to decrease the portion of personal and community budgets spent on fuel by increasing energy efficiency and conservation (EE&C), and state funding is still abundant in this area. Energy efficiency projects also create more jobs in the local economy than investments in some renewable generation projects do, and payback periods are typically shorter. This inventory calculates past savings from residential EE&C activities for each community and estimates the amount of additional energy savings available to the community through participation in existing energy efficiency programs. As a region, the potential exists to save another 75,000 MMBTU— nearly three times the amount of energy saved since 2008.

In addition to community-specific energy resources and projects, the inventory lists dozens of general resources available for enhancing training and technical assistance, energy efficiency, community sustainability, and project financing options. These are listed at the end of each section under Resources for Communities and in the Financing section.

Data Gaps

Data gaps are identified at the end of each section of the resource inventory. The most significant gaps are in data needed to assess total energy use in the region. While data is abundant on the electricity side, not enough is known to estimate heating and transportation energy demand on either a community or regional basis.

Fuel price data that includes the date fuel was delivered to the community would materially improve future price forecasts for rural Alaska and result in more accurate project evaluation.

Better information on issues with medium- to high-penetration wind-diesel systems as well as lessons learned from systems already in use in rural Alaska would help Bristol Bay communities make decisions on competing wind projects. This is especially true since higher penetration systems provide economies of scale that may look good on paper but be difficult to achieve.

More data on using excess electrical generation for space and hot water heating would improve benefit-cost modeling for renewable generation projects with excess capacity. In lieu of performance and cost data on specific technologies, a set of standard assumptions from AEA on modeling for thermal load conversion would be useful.

THE REGION

Land and People

The Bristol Bay region is comprised of 31 cities and census designated places with a total 2012 population estimated at 7,648. Dillingham is the largest community and serves as the regional hub. The region includes three census areas; two are organized boroughs (Bristol Bay Borough, Lake and Peninsula Borough) while the Dillingham Census Area is part of the state's large Unorganized Borough. Almost all communities have either a state-chartered city council or a village council which governs municipal affairs.

The majority of Bristol Bay residents live in small communities situated on the region's major rivers, bays and lakes. These bodies of water define the traditional subregions or community clusters useful in planning: Lake Iliamna, Kvichak Bay, Nushagak Bay, Nushagak River, Togiak Bay, and the Peninsula. Commercial, sport, and subsistence fishing play an important role in virtually every community in the region and represent a primary revenue source for local government.

Over 70 percent of Bristol Bay residents are Alaska Natives from the region's 31 federally recognized tribes. They include Yup'ik, Athabascan, and Alutiiq peoples. Major land owners include local, state and federal government, tribal organizations and Alaska Native corporations. The vast region includes five national parks, many wildlife refuges and designated federal wilderness areas, as well as a number of state wildlife protection areas and parks.

With few roads or transmission lines connecting communities, the region is served by 21 independent electric utilities. This resource inventory focuses on the 26 communities with year round populations that are served by an electric utility.

Population Change

Without infrastructure to connect most communities in the region, new energy projects will likely continue to serve small, discrete markets or "island systems." As a result, understanding where future populations will live is important to energy planning. While the region as whole has been growing gradually, despite small losses to out-migration, population trends for individual communities are more varied. About half have had net losses in population since 2000, while others have been stable or growing. The most significant declines have been in communities under 100.

Unfortunately, small sample sizes and large margins of error make census data unreliable for projecting population at the community level in rural Alaska. At the borough and census area level, state demographers project that the Dillingham Census Area will continue to grow by about 6% between 2010 and 2035 while the population of the Lake and Peninsula Borough is expected to decline by up to 9% and the Bristol Bay Borough by nearly 20%.

Figure 1: Map of the Bristol Bay Region

RENEWABLE ENERGY RESOURCES

Biomass

The use of biomass as an energy solution is limited in the Bristol Bay region by the lack of a significant timber resource or industry and the absence of Class I landfills. However, there is an opportunity for communities with modest timber resources to use relatively low-cost biomass boilers to heat some community buildings while providing local job benefits. Community-owned wood boilers have been installed in at least two Lakes area communities and feasibility work has been completed for all communities in the subregion. The use of biomass for heating is also being studied in Dillingham, Aleknagik and New Stuyahok.

Biopower projects such as Combined Heat and Power (CHP) and gasification systems may be feasible in larger hub communities, such as Dillingham, with high power demand and high diesel prices, but feasibility work is needed.

In other parts of Alaska, the byproducts of fishmeal plants are used to manufacture biodiesel engine fuels. Trident Seafoods has agreed to construct a fishmeal plant in Naknek to mitigate environmental risks from fish waste discharge. There is less biofuel potential from Bristol Bay's salmon and herring processors.

Geothermal

There are currently no geothermal energy projects in operation or under development in the region and no known geothermal sites close enough to Bristol Bay communities to develop economically. Even under optimistic assumptions, it would be hard for a geothermal project to be more cost effective than diesel given transmission and exploration costs unless a community is sitting on top of a geothermal resource. The most promising known resource not on federal lands is most likely the Mother Goose hot spring system, 27 miles from Ugashik. At 151°F, it is a low temperature resource insufficient for power generation. Low temperature resources can be used for space heating.

Ground source heat pumps (GSHP) represent another method of exploiting geothermal energy to heat homes and commercial buildings. The technology is fully commercial and already in use in Alaska in both residential and commercial settings. However GSHPs are most viable in regions with high heating costs and cheap electricity. If electrical rates in a community can be lowered significantly through a hydro or wind project, the use of GSHP to reduce space heating costs should be assessed.

Hydro Power

Though expensive to license and construct, hydropower installations have low operation and maintenance costs and long lifespans (50 to 100 years) that result in stable, relatively inexpensive electric rates. Hydropower is currently the largest and most important producer of renewable energy in Alaska. While only one project is currently producing power in the Bristol Bay region (the 824 kW Tazimina River project supplies 64% of the electricity for three communities in the Lakes region), construction is starting on a small-scale hydro project at Packer's Creek in Chignik Lagoon, and a 150 kW hydro project is entering final design and permitting at Knutson Creek in Pedro Bay. New feasibility work for several other conventional hydro projects is in progress or has recently been completed.

The economics of hydro projects in the region is challenged by the small size of populations to be served and the lack of a regional grid to distribute power to a larger market. Because of the remote location of many hydro resources, the cost of transmission lines between the generating site and the load may drive the delivered cost of energy above the current cost of diesel generation.

Unlike conventional hydro, the technology to harness hydrokinetic power from rivers, tides and waves is still largely pre-commercial, especially in cold climates, but it is developing rapidly. The Bristol Bay region's first hydrokinetic project is an in-river demonstration project on the Kvichak River in Igiugig. A tidal power pilot project is underway in Cook Inlet. Ocean wave energy is even further from commercial deployment, but Alaska is estimated to have 60% of the total U.S. potential, and the best wave resources in Alaska are believed to be on the southern side of the Alaska Peninsula, the coastlines of Kodiak and Southeast Alaska, and near Yakutat. Feasibility studies will be needed to verify the resource and prove the technology.

Solar

In Bristol Bay, as in the rest of the state, solar energy is most abundant in summer, when it is least needed, and minimally available during the winter when energy demand is greatest. That fact combined with the practical limitations of storing and disposing of battery banks makes solar systems unlikely to provide more than a minor amount of a community's total energy needs. However, residential-scale solar installations, including those used for space and hot water heating, can be used to reduce energy costs for individual homes, businesses and community buildings and may be capable of meeting essential electrical load demands during the summer months.

To date, there are very few community- or utility-operated solar power projects in operation in the region. The potential for using solar energy is greatest in communities with less precipitation and with southern exposure. While the installed cost of systems has been coming down rapidly, solar photovoltaic (PV) technology is still one of the more expensive electricity options for Alaska.

Wind Energy

Wind may be the best or only renewable resource currently available for power generation for some communities in the region. Feasibility studies to assess wind resources have been conducted in most communities, and at least six wind energy projects have been completed, including a high-penetration, utility-scale project in Kokhanok. Igiugig is currently testing an array of small "wind spires" (1.2 kW vertical axis wind turbines) that have not been deployed in the arctic before.

In general, areas with Class 3 winds or greater are considered to have a suitable resource for a wind project. For communities with good wind resources (class 4 or above) wind could become a bigger part of the total energy picture if technical solutions are found to improve integration of medium- to high-penetration wind projects into diesel systems and to take advantage of excess generation for heating buildings.

FOOD SECURITY

High fuel costs result in high food prices and cost of living when the majority of food consumed in a community is imported. Food security initiatives at the community level include community supported agriculture (CSA), farmers' markets, community gardens, farm-to-school initiatives, and food policy councils. Such initiatives lower the cost of food through reduced transportation and storage costs, while improving access to safe and healthy food and encouraging self-sufficiency. Food security projects promote community economic development by keeping money in the local economy and linking food production to workforce development and private enterprise. Some communities may be able to partner with the local electric utility or school to use waste heat for seasonal food production.

FOSSIL FUELS

Diesel Efficiency and Bulk Fuel Savings

Diesel generation accounts for 92% of the electricity produced by utilities in the region. Every community can benefit from diesel efficiency measures regardless of access to renewable resources. Considerable savings are possible from improving system efficiency through better maintenance and operator training, and through waste heat recovery. Communities with newer power plants can also take advantage of SCADA systems to identify issues through remote site monitoring. Remote monitoring can also be organized on a regional or subregional basis for greater savings.

The challenges of delivering and storing fuel in remote locations substantially increase energy costs in the region. Options exist to save on bulk fuel by reducing the cost of storing and transporting it. While the market price for bulk fuels is set globally, the transportation component of the price may be lowered by improving the safety and efficiency of transferring fuel at barge landings and by consolidating community fuel orders to reduce administrative costs for the fuel vendor and increase the vendor's incentive to offer competitive prices and terms. A 2012 survey of tank farm owners found that there is potential to pool orders for up to 1.4 million gallons of fuel across the region. Most of the interest in a bulk fuel purchasing group is from local governments, school districts, and village utilities that are not already part of a purchasing group.

Upgrading bulk fuel facilities reduces the cost of storing fuel by replacing leaking tanks and reducing the risk of future tank and equipment failure. Providing a centralized tank farm with the capacity for annual fuel storage could potentially lower costs for upper river villages that are difficult to access twice a year by barge.

For barge-accessible communities that purchase propane, an opportunity exists for significant savings by switching from 100 pound tanks to 1,100 gallon tanks as long as suitable landings and marine headers exist and local personnel become certified to handle propane.

Natural Gas

Compared with other fossil fuels, natural gas offers the prospect of clean, low cost energy for Alaska communities if affordable transportation, storage and distribution systems can be worked out. The Alaska Legislature passed two major pieces of legislation in 2013 supporting large-scale projects to bring natural gas from the North Slope to residents in the Railbelt with some consideration for Interior and coastal Alaska.

Other options being studied for bringing natural gas to Southwest Alaska include importing LNG from outside Alaska and using High-Voltage Direct Current (HVDC) transmission lines to deliver natural-gas generated electricity from the North Slope to rural Alaska communities.

In 2012 the Alaska Legislature passed a generalized tax credit bill with incentives for oil and gas production and storage in "Frontier Basins." Both the Egegik Basin in the Bristol Bay region and the Port Moller basin further south on the Alaska Peninsula are two potential locations for exploration. While years in the future, any commercial discovery may have the potential to supply affordable energy resources to nearby communities.

ENERGY EFFICIENCY AND CONSERVATION

Reducing energy demand through energy efficiency and conservation should be a community's first strategy in energy planning, since it provides both current savings through avoided fuel purchase, transportation and storage costs, and offers the potential for future savings by reducing or postponing the need for new capital investments in energy production.

EE&C improvements also provide one of the best ways to address total energy costs—not just the cost of electricity. Since space and hot water heating account for over 80% of home energy budgets in rural Alaska and around 50% of energy used in public and commercial building, this is a significant advantage.

Common home energy efficiency and weatherization measures typically save Bristol Bay households 27% to 29% on energy consumption, which translates into 300 to 450 gallons of fuel oil per home per year. EE&C improvements to public and commercial buildings average 30% statewide and typically pay for themselves within 4 years, returning $3 for every $1 invested.

Lighting retrofits have saved Bristol Bay communities $1,300 per building per year and typically pay for themselves within 2 years. LED street lighting is highly efficient compared to conventional street lights. With only two Bristol Bay communities receiving LED street lights as part of village energy audit and upgrade programs, there is potential here for additional savings.

Sanitation systems are one of the single largest energy uses in rural communities, accounting for 10% to 35% of a community's energy use. Alaska Native Tribal Health Consortium (ANTHC) estimates that rural communities can save $10,000 per year through an energy retrofit of its sanitation facilities, and substantially more if heat recovery is an option.

ENERGY INFRASTRUCTURE

Roads and Transportation Infrastructure

Few communities are currently connected by road in the region. More road and bridge connections and improvements to marine and aviation facilities would reduce fuel and freight costs, which would in turn reduce construction costs for interties and other energy infrastructure. Priority projects include improvements to the Williamsport-Pile Bay Road and the Chignik commercial dock, improvements to other port and harbor facilities especially in regional and subregional hubs, and improvements to roads providing intermodal access to air and ferry/barge terminals. Runway expansions are also a priority in order to reduce the cost of fuel to communities without barge service and to respond to anticipated changes in aircraft fleets.

Transmission Lines

The region currently has few transmission lines. Interties are limited to community pairs currently connected by road (Dillingham–Aleknagik, Naknek–King Salmon, and Iliamna–Newhalen) with tie ins to South Naknek (from Naknek-King Salmon) and Nondalton (from Iliamna-Newhalen). New utility connections are being pursued between Togiak and Twin Hills, and New Stuyahok and Ekwok.

In general, new conventional, alternating current (AC) transmission lines have not been found to be economic in rural Alaska, because the cost of transmission even over short distances exceeds the potential savings in power generation when capital costs, operations and maintenance, and utility margins are factored in. The concept of a regional transmission grid connecting communities in the Lake and Peninsula Borough to the Railbelt (via a submarine cable across Cook Inlet) or to a large in-region hydro project have been previously studied with mixed results. In general, larger loads (such as the addition on new industrial loads from fish processing, fish freezer facilities or a small mine) are needed to improve economies of scale. The construction of many small-scale local renewable energy projects may diminish the net benefits available from a large-scale hydro and regional grid approach.

The Denali Commission is supporting research into low-power HVDC transmission technology for use in rural Alaska. HVDC is typically used to transmit very large amounts of power over hundreds of miles. Any interconnection with the Railbelt grid that includes a submarine crossing of Cook Inlet will use HVDC technology since the distance is too long for AC transmission. At distances of more than 6 to 30 miles, HVDC interties promise better economics than AC systems. HVDC interties may also be more acceptable within refuges and other sensitive areas since they are either buried or have fewer wires and structures.

LARGE LOADS AND MEGACONCEPTUAL PROJECTS

The addition of large new energy loads in a region—whether from a mining operation, seafood plant, or other industrial energy use—can be a game changer, transforming both demand and supply and radically altering the economics of previously considered generation and transmission projects. The same is true for very large-scale generation projects, such as a new hydroelectric project with the potential to create a step change in the price of energy in a region. We call these "megaconceptual" projects because of their size and their long and uncertain time horizons, which make planning for or around them difficult. It is best to continue to monitor these efforts while pursing nearer-term local and regional solutions.

Pebble Mine

If developed, the proposed Pebble copper-gold-molybdenum deposit near Lake Iliamna would consume 450 MW of electricity, according to project developers—an amount more than a dozen times the current electric load of the Bristol Bay region. The mine's plans for meeting its huge energy needs currently focus on a 500 MW system fueled by a combination of wind and natural gas. If constructed, the system would likely create opportunities for communities to access cheaper fuel and electricity assuming new investments in energy infrastructure are made to distribute excess power to end users.

Chikuminuk Lake Hydro

The Chikuminuk Lake Hydroelectric Project is a 13 MW large reservoir project being proposed by Nuvista Light & Electric to provide most of the electrical power required by Bethel and surrounding communities. Longer-term plans include the opportunity for a second transmission line to Dillingham. At this point the project should be considered a long-term, megaconceptual project largely due to its size and the challenges of financing a project on that scale. Other challenges include high transmission costs and the possibility of land ownership and permitting issues. Funding to study the project's feasibility and to initiate the first steps towards preparing a Federal Energy Regulatory Commission (FERC) application has been provided by the state legislature.

PROJECT ECONOMICS AND FINANCING

Financing Options

There are four primary sources of project funding for energy projects: public funding, private equity, commercial debt, and third-party tax-equity investment. While public financing through state and federal grant and loan programs is most common in Alaska, there is opportunity to expand into private financing in order to fund more projects. Private financing options are being used successfully elsewhere and will become more important in Alaska if state and federal funding declines as anticipated. The Resource Inventory includes a nearly comprehensive list of state and federal funding sources for energy-related projects, including grant, loan, cash rebate and technical assistance programs.

Project Economics

In Phase I we conducted an economic analysis of proposed energy projects in the region that had a current champion and sufficiently detailed data available for use in modeling. Baseline assumptions for each project were based on information provided by project proponents. (See Appendix A.)

Projects were evaluated using three different methodologies or lenses, including criteria that prioritize state funding efficiency and community benefits while factoring in capital costs and oil price risk. The choice of methodologies results in different results, so it is critical to identify the most important values of project proponents and beneficiaries. No conclusions can be drawn about which projects would be best to pursue without the involvement of community and regional stakeholders.

Considering the lack of integration of energy systems in much of the region, the greatest value of the economic analysis may be in providing local decision makers with additional information they can use to evaluate the merits of local energy solutions and assess their potential for attracting public and private funding.

Public vs. Private Investment

It appears that several of the projects included in the preliminary project analysis may be candidates for private investment by virtue of charging rates that provide energy cost relief *and* allow recovery of the full costs of service. Table 1 shows those projects with a projected Cost of Service (COS) tariff lower than recent electric rates in the community. Tariffs shaded in green are lower than the per kWh cost even when subsidized through the State's Power Cost Equalization (PCE) program. Those shaded in yellow are more than the PCE rate but less than the average residential rate without the state subsidy.

Table 1: Private Investment Opportunities

Levelized COS, full project	Private Investment COS Tariff	Average Residential Rate per kWh	2011 PCE-subsidized Residential Rate
Port Alsworth Wind Project 1	$0.61	$0.69	$0.49
Knutson Creek Hydro Feasibility and Planning	$0.49	$0.91	$0.49
Port Alsworth Wind Project 2	$0.37	$0.69	$0.49
Port Heiden Wind & Power Distribution Upgrade	$0.32	$0.75	$0.20
Chignik Lagoon Wind Project 1	$0.16	$0.65	$0.40
Chignik Lagoon Wind Project 2	$0.11	$0.65	$0.40
Tazimina Hydro Project Capacity Increase	$0.05	$0.57	$0.26

The small customer base of many communities may present a key roadblock to private investment, however, since private investors typically want a 20-year power purchase agreement before they commit project capital. One approach would be for AIDEA to serve as a guarantor of local utility commitments, if necessary. Another would be for direct state investment (as opposed to grants).

Although charging the full cost of service runs counter to the goal of achieving the lowest possible energy cost, doing so could promote other social goals. Where energy costs can be reduced through private initiative it allows public funds to stretch further in support of energy cost relief.

Maximizing State Investment Efficiency

Benefit-cost (B/C) ratios for each project (equal to the present value of lifetime project benefits divided by the present cost of investment) were calculated using the same methodology employed by AEA. In a scenario in which government funds are unconstrained, the State should pursue all projects with a B/C ratio exceeding 1.0. However, if state funds are constrained then statewide net present value (NPV) will be maximized by ranking projects by B/C ratio and funding only those that fit within a set budget cap. This is AEA's current method of prioritizing projects for Renewable Energy Fund grants.

In Table 2, green rows highlight projects that should be funded if the State were to grant $60 million towards energy projects in the Bristol Bay region.[1] Yellow rows include additional projects that have a positive B/C ratio and should be funded if public funds were unconstrained. For a cost of $76 million, all energy projects with a B/C ratio over 1.0 could be developed.

Table 2: Project Benefit-Cost Ratios at $100 per Barrel Oil

	B/C Ratio	Project Cost	Cumulative Cost
Tazimina Hydro Project Capacity Increase	6.60	$ 2,308,628	$ 2,308,628
Chignik Lagoon Wind Project 2	3.44	$ 1,666,488	$ 3,975,116
Chignik Lagoon Wind Project 1	2.66	$ 1,198,915	
Port Alsworth Wind Project 2	1.87	$ 1,666,489	$ 5,641,605
Chignik Lake Wind Project 2	1.79	$ 1,540,334	$ 7,181,940
Knutson Creek Hydro Feasibility and Planning	1.36	$ 2,979,729	$ 10,161,668
Nushagak Area Hydro Project (NAHP) - Grant Lake	1.32	$ 45,667,660	$ 55,829,328
Nushagak Area Hydro Project (NAHP) - Lake Elva	1.20	$ 13,526,735	$ 69,356,063
Port Alsworth Wind Project 1	1.16	$ 1,549,391	
Port Heiden Wind & Power Distribution Upgrade	1.10	$ 2,220,280	$ 71,576,343
New Koliganek Wind & Heat Recovery Feasibility	1.09	$ 464,034	$ 72,040,377
Chignik (Indian Creek) Hydro Project	1.02	$ 3,856,572	$ 75,896,950
Chignik Lake Wind Project 1	0.85	$ 1,211,954	
Igiugig Wind Project	0.84	$ 1,391,654	$ 77,288,604
Pilot Point Wind-Diesel-CHP	0.83	$ 1,248,524	$ 78,537,128
Manokotak Wind & Heat Feasibility	0.78	$ 2,129,328	$ 80,666,455
Nushagak Community Wind Power Project	0.61	$ 3,384,396	$ 84,050,851
New Stuyahok Wind Feasibility & Concept Design	0.57	$ 4,245,171	$ 88,296,022
Bristol Bay School District Solar PV Project	0.36	$ 413,674	$ 88,709,696
Kvichak River RISEC Project	0.12	$ 5,905,072	$ 94,614,768

Notes: Assumes $100/Bbl flat real oil prices. Capital costs for alternative wind projects designed for the same community are only counted once since only one of the two projects would be developed. For this reason there is no entry in the Cumulative Cost column the second time a wind project appears in the list.

[1] The budget cap of $60 million has been chosen arbitrarily to demonstrate how B/C ratios can be used to prioritize funding. A different budget would result in a different cut-off point for funding, however there is no commitment from the State to invest any fixed sum per region. As part of the regional energy planning process, AEA will also be looking for evidence of local budget commitment to funding priority projects.

Community Sustainability and Capital Efficiency

This metric measures the effectiveness of a dollar in capital subsidy in delivering per-capita energy cost savings, thereby capturing potential benefits within the community that the project is located, while factoring in capital costs. It indicates the degree to which a project can foster community sustainability and independence from the need for ongoing state subsidy, and it shows the degree to which a project might affect household budgets and the business environment within the community. This metric presents a fairly dramatic reshuffling of projects.

Table 3: Per Capita Project Benefits per Capital Dollar Invested

	(PV Benefits/Person)/PC	Project Cost	Cumulative Cost
Chignik Lagoon Wind Project 2	0.04406	$ 1,666,488	$1,666,488
Chignik Lagoon Wind Project 1	0.03411	$ 1,198,915	
Knutson Creek Hydro Feasibility and Planning	0.03231	$ 2,979,729	$4,646,217
Chignik Lake Wind Project 2	0.02457	$ 1,540,334	$6,186,551
Igiugig Wind Project	0.01670	$ 1,391,654	$7,578,205
Tazimina Hydro Project Capacity Increase	0.01425	$ 2,308,628	$9,886,833
Pilot Point Wind-Diesel-CHP	0.01227	$ 1,248,524	$11,135,357
Port Alsworth Wind Project 2	0.01179	$ 1,666,489	$12,801,846
Chignik Lake Wind Project 1	0.01170	$ 1,211,954	
Chignik (Indian Creek) Hydro Project	0.01119	$ 3,856,572	$16,658,419
Port Heiden Wind & Power Distribution Upgrade	0.01080	$ 2,220,280	$18,878,698
Port Alsworth Wind Project 1	0.00728	$ 1,549,391	
New Koliganek Wind & Heat Recovery Feasibility	0.00523	$ 464,034	$19,342,733
Kvichak River RISEC Project	0.00250	$ 5,905,072	$25,247,805
Manokotak Wind & Heat Feasibility	0.00177	$ 2,129,328	$27,377,132
Nushagak Community Wind Power Project	0.00113	$ 3,384,396	$30,761,528
New Stuyahok Wind Feasibility & Concept Design	0.00111	$ 4,245,171	$35,006,699
Bristol Bay School District Solar PV Project	0.00067	$ 413,674	$35,420,373
Nushagak Area Hydro Project (NAHP) - Grant Lake	0.00051	$ 45,667,660	$81,088,033
Nushagak Area Hydro Project (NAHP) - Lake Elva	0.00046	$ 13,526,735	$94,614,768

Notes: Assumes $100/Bbl flat real oil prices. Capital costs for alternative wind projects designed for the same community are only counted once since only one of the two projects would be developed. For this reason there is no entry in the Cumulative Cost column the second time a wind project appears in the list.

Balancing Statewide Investment Efficiency and Community Benefits

The concepts of statewide investment efficiency and community impact can be combined in ways that might better reflect policy goals. Suppose, for example, that the State was willing to fund only projects that had benefit-cost ratios greater than unity, but also that have the potential to generate significant local benefits—e.g. per-capita benefits of more than $12,000 over the project's life. This might reflect a determination that funded projects should be "robust," and provide either statewide or material local benefits regardless of the PCE fund's fate.

Table 4 shows those projects that would be included if the State funded energy projects in the region with B/C ratios greater than 1.0, while providing per-capita benefits of more than $12,000 over the project's life. Cumulative state spending would be less than $17 million.

Table 4: Balancing Per Capita Benefits with State Investment Efficiency

	B/C ratio	(PV Benefits/ Person)/PC	Project Cost	Cumulative Cost
Chignik Lagoon Wind Project 2	3.44	0.04406	$ 1,666,488	$ 1,666,488
Chignik Lagoon Wind Project 1		0.03411	$ 1,198,915	
Knutson Creek Hydro Feasibility and Planning	1.36	0.03231	$ 2,979,729	$ 4,646,217
Chignik Lake Wind Project 2	1.79	0.02457	$ 1,540,334	$ 6,186,551
Tazimina Hydro Project Capacity Increase	6.60	0.01425	$ 2,308,628	$ 8,495,179
Port Alsworth Wind Project 2	1.87	0.01179	$ 1,666,489	$ 10,161,668
Chignik (Indian Creek) Hydro Project	1.02	0.01119	$ 3,856,572	$ 14,018,240
Port Heiden Wind & Power Distribution Upgrade	1.10	0.01080	$ 2,220,280	$ 16,238,520
Port Alsworth Wind Project 1	1.06	0.00728	$ 1,549,391	

Notes: Assumes $100/Bbl flat real oil prices. Capital costs for alternative wind projects designed for the same community are only counted once since only one of the two projects would be developed. For this reason there is no entry in the Cumulative Cost column the second time a wind project appears in the list.

The three different evaluative criteria can and do lead to different project rankings in a region given a budgetary constraint for the energy projects that can be funded within a region. In the context of regional energy plans there is a clear lack of alignment between potential state funding priorities and community desires. There is no non-messy way to bridge these perspectives. However, keeping them clearly in mind may help to clarify the goals and consequences of different funding approaches and lead to more transparent decisions.

INTRODUCTION

The goal of the Bristol Bay Regional Energy Plan is to identify local, subregional and regional energy projects that reduce the long-term cost of power and dependence on fossil fuels. The final report will feature a prioritized list of projects the State can support and an action plan designed to capitalize on the programs and funding sources available. The process will look at the total mix of energy needs in Bristol Bay communities, including electricity, heating and transportation, and consider all local and regional energy resources, including efficiency and conservation.

The project is part of a statewide effort led by the Alaska Energy Authority that builds off work begun with the Alaska Energy Pathway series. The regional planning process for Bristol Bay has been organized in two phases: Phase I includes preliminary planning, resource inventory and data collection. Phase II will include drafting the plan, community engagement and finalization.

The project is being funded by the Alaska Energy Authority and managed by the Bristol Bay Native Association and Southwest Alaska Municipal Conference. Information Insights has been contracted to provide data collection and project analysis, in association with Antony Scott of the University of Alaska Fairbanks. Blue Skies Solutions produced GIS maps for the project. Lamar Cotten serves as a technical advisor to the project.

The Phase I report is the result of nearly a year of data collection. In preparation for community and regional discussions, the report has been designed as a tool to focus conversations on technically feasible, economically realistic and ultimately fundable projects given the region's energy resource mix and the current state of technology.

While the report itself represents a snapshot in time of projects, resources and technologies with the potential to meet the region's energy needs, the plan that develops through community and regional engagement will continue to evolve.

Ultimately, this data collection effort is to determine what energy programs will be viable in the different communities, and what solutions communities would like for solving their energy needs. The most efficient, sustainable program will be the program most likely to gain support for funding.

- Deborah Vo, AEA Regional Planners Meeting, June 2012

1 | Renewable Energy

The U.S. Department of Energy (DOE), Office of Indian Energy, has produced a high level estimate of the technical potential for renewable energy resources on Native lands for each of the twelve Alaska Native Corporation (ANC) regions.[2] Using geospatial analysis (i.e. not boots on the ground), it looked only for *renewable resources* based on *commercially available technologies* on *developable Native lands*. It also focused solely on *electricity generation*; it does not address thermal potentials, such as biomass used for heating. Following those caveats, the results for Native lands within the Bristol Bay region are shown in Table 5.

Of course, not all resources with technical potential will be economically feasible to develop once technology and transportation costs are considered. Resources that are technically viable but not economically feasible to bring to market are considered "stranded." Even if not stranded, a variety of market considerations—including regulatory limits, competition with other energy resources, and investor interest—will also determine which of the region's potential resources are developed.

The purpose of Table 5 then is to show at the highest level the overall scale of the region's renewable energy potential, given current technology, and also to put this in context of the other regions of the state.

Table 5: Technical Potential for Renewable Resources on Native Lands in Bristol Bay Region

	Utility-Scale PV	Hydropower	Wind	Solid Biopower	Gaseous Biopower	Geothermal Hydrothermal
Potential (GWh)	1,335,744	552	17,552	1.8	0.1	-
Rank (out of 12)	3rd	6th	11th	7th	-	-

Source: (1). Notes: One gigawatt hour (GWh) is equal to 1 million killowatt hours (kWh).

In addition to its renewable resource potential, the Bristol Bay region may have developable offshore natural gas resources (see page 79). Like all other regions of the state, it also has considerable potential to reduce energy consumption—and thus costs—through energy efficiency and conservation, making both renewable and conventional energy sources go further (see page **Error! Bookmark not defined.**).

[2] DOE used the same methodology to estimate the technical potential for renewable energy resources in other states in 2012.

BIOMASS

Alaska's primary biomass fuels are wood, sawmill wastes, fish byproducts and municipal waste. Most biomass projects in the state have been in Southeast and Interior Alaska. In the Bristol Bay region, the use of biomass as an energy solution is limited by the lack of a significant timber resource or industry and the absence of Class I landfills.

While this may preclude the use of biomass for utility-scale Combined Heat and Power (CHP) and for complex gasification systems, communities with access to modest timber resources can still take advantage of efficient wood-fired boilers to significantly reduce heating costs in community buildings. In Tok, a chip-fired boiler installed at the school displaces approximately 65,000 gallons of fuel oil annually. Two cordwood boilers in Tanana heat the washeteria, adjacent buildings and a 280,000 gallon water tank, reducing the community's fuel oil consumption by 30%. A similar unit was recently installed in Kokhanok where it heats two community buildings.

Kotzebue, a community not too much larger than Dillingham, is currently studying the feasibility of a Waste-to-Energy project using municipal solid waste (MSW) to generate heat and/or power, because the community does not have much woody biomass and its landfill is reaching capacity. If the project goes forward, it will provide experience that could help determine whether a similar project is worth exploring in Dillingham. Both communities would need to augment municipal waste with other forms of biomass (2)

There is also untapped potential in the region for using oil from fish waste for biodiesel production. In other parts of Alaska, biofuels (vegetable oils, recycled cooking oil, fish oil and other animal fats) are being used to manufacture biodiesel engine fuels.[3] In Kodiak and the Aleutians, fishmeal plants produce approximately 8 million gallons of pollack oil annually as a byproduct. The oil is used as boiler fuel for drying fishmeal or exported to Pacific Rim markets for livestock and aquaculture feed supplements and other uses (3).

There is less biofuel potential from Bristol Bay's salmon and herring processors. However, Trident Seafoods has agreed to construct a fishmeal plant in Naknek to mitigate environmental risks from fish waste discharge, which will open up an opportunity for biodiesel production in the region while contributing to cleaner water.

Other types of biomass projects also provide benefits beyond reducing energy costs, including reduced wildfire risk and improvements to wildlife habitat, and landfill savings and extended lifespan. Because biomass projects often require more manpower than other energy technologies, they also have the ability to create local jobs and keep more money in the community and region.

[3] With assistance from the State of Alaska, fish processor UniSea Inc. conducted successful tests of raw fish oil/diesel blends in a 2.2 MW engine generator. Today UniSea uses about 1.5 million gallons of fish oil a year to operate their generators, boilers and fishmeal dryers.

Resource Inventory

FISH OIL

Fish oil is a potential biofuel resource for communities in the region that have at least one fish processing plant. Naknek has the greatest resource potential with seven land-based processors. Each of the land-based processors in Bristol Bay maintains and operates its own waste removal system. There are also several smaller, independent processors that also require a means to dispose of fish waste. According to Naknek Electric Association's Round 2 RE Fund application for a biofuel study, 30% of the whole fish is wasted on average during the fillet process. This waste is currently ground up and then pumped back into to the Naknek River as slurry and "grey water." In 2012, 126 million pounds of salmon were harvest in Bristol Bay, creating an estimated 37.8 million pounds of fish waste.

Table 6: Fish Oil Resource Potential by Community

Fish Processors (2011 permits)	Nearby Communities
1 to 3	Chignik, Ekuk, Egegik, Ekwok, King Salmon, Levelock, Togiak
4 or more	Dillingham, Naknek

Source: (4)

WOOD BIOMASS

According to the Alaska Division of Forestry, most of the Bristol Bay region has little timber value, with forests considered marginal in terms of both wood volumes and density. Woody biomass is most concentrated in the Lakes area and along rivers, and least available in coastal areas. Table 7 shows a crude ranking of biomass potential by community based on aerial photo and satellite imagery, but ground surveys are needed to verify that sustainable yields of suitable species exist. To continuously supply a small biomass project, such as a Garn boiler used to heat a school, a community should consider whether it has access to a nearby woodlot of at least 5 cords per acre that is not in direct competition with local residents who also use wood to heat their homes. Trees should be at least 7 inches in diameter for efficient harvest and transport (5).

Table 7: Potential Wood Biomass Resources by Community

Highest to Lowest	
	Chignik*, Chignik Lagoon*, Chignik Lake*, Clark's Point, Egegik, Naknek, Perryville*, Pilot Point*, Port Heiden, South Naknek
	Aleknagik*, Dillingham*, King Salmon, Koliganek*, Levelock*, Togiak, Twin Hills*
	Ekwok*, Igiugig*, Iliamna*, Manokotak*, New Stuyahok*, Newhalen*, Nondalton*, Port Alsworth*
	Kokhanok*, Pedro Bay*

Sources: (6) (7). Notes: *Wood included as a resource in the community's Alaska Energy Pathways profile.

A ground survey of timber volumes on Native allotments in the Bristol Bay region was conducted by Tanana Chiefs Conference (TCC) in 2006 at the request of BBNA (8). Because the study looked only at Native allotments, it does not provide a complete inventory of communities' available forest resources, but the stocking numbers may be useful in trying to assess overall biomass availability. TCC foresters looked at net timber volume by species and size class on 16% of Native allotment parcels, selected based on aerial photographs, in three areas: Dillingham subunit (Dillingham-Kanakanak-Aleknagik), Kokhanok subunit (Kokhanok) and Nushagak subunit (Ekwok-New Stuyahok-Koliganek).

Table 8: Estimated Timber Volumes on Native Allotments

Subunit	Percent Forest	Sawtimber Board Feet per Acre of Forest	Poletimber Board Feet per Acre of Forest	All Timber Cubic Feet per Acre of Forest	All Timber Cubic Feet per Acre – All Land Cover Types
Dillingham	56.2%	1,259	1,391	714	401
Kokhanok	38.7%	2,004	1,964	676	262
Nushagak	48.6%	550	567	325	158

Source: (8). **Assumptions**: Sawtimber includes trees equal to or greater than 9 inches in diameter at breast height (DBH). Poletimber includes trees 4.5 to 8.9 inches DBH. A board foot is equivalent in volume to a board 1 inch thick, 12 inches wide, and 12 inches long. Because the board foot measure is based on actual boards that can be sawn from a log, it disregards all material wasted in the process such as slabs and sawdust. Cubic foot measurement includes all timber greater than 4.5 inches DBH.

Beetle-killed white spruce accounted for less than 4% of the sampled trees. Most of the beetle-killed spruce (63%) was in the Kokhanok subunit, with nearly all of the remainder (34%) found in the Dillingham subunit. Nearly 50% of the live birch sampled showing some sort of stem rot or decay.

TCC's lead forester concludes that there is a useable forest resource in the study areas that would probably be adequate for modestly proportioned thermal projects like a Garn boiler, but that Bristol Bay communities should pay somewhat more attention to sustainability issues than is required of communities in the Interior (9). In addition to the report, a GIS application and a relational database were provided to BBNA.

Table 9 lists current and recent community-sponsored wood biomass projects in the region.

Table 9: Community-sponsored Wood Biomass Projects in the Bristol Bay Region

Installed or Planned	**Igiugig**: Small wood boiler heats Tribal Council office and hangar.
	Kokhanok: Garn boiler heats Village Council and Community Building.
	Port Alsworth: Plans to add one or more boilers after their power plant upgrade.
Feasibility and Design	80% design completed for heating community buildings in Iliamna, Newhalen, Nondalton, Pedro Bay, Port Alsworth and one additional building in Kokhanok.
Pre-feasibility	New Stuyahok received a 2012 grant from the Alaska Wood Energy Development Task Group for a pre-feasibility study.

Sources: (2) (10) (11)

In addition to the community-scale projects listed above, there are many homeowners and private businesses throughout the region that heat with wood, and some are switching to high-efficiency wood boilers. In Port Alsworth, there are several private and at least one commercial unit installed.

The Bristol Bay Native Association and Aleknagik Traditional Council partnered to survey homeowners in Aleknagik and Dillingham on basic home information, as well as their primary and secondary heating systems, steam baths, smoke houses, and wood harvest practices in relationship to current use and practices. The final report is expected soon (12).

Technology Notes

Technology to generate electricity from biomass, whether through CHP systems or small, stand-alone biopower projects, is generally considered pre-commercial in the U.S. Most biomass to electrical generation systems are complex and have significant technical and economic challenges (3). This is especially true for small scale systems (less than 10 MW). Some companies are trying Organic Rankine Cycle and other new technologies around the 2 MW and less scale, but they are not yet proven to be commercially viable.

Biomass to Steam Turbine electrical generation technology less than 2 MW is proven technology, but requires a very large heat load and certified mechanics and operators. Large hospital complexes are good applications for steam to electrical generation because they have large steam/heat needs (13).

By comparison, high-efficiency, low-emissions (HELE) wood boilers used for space and hot water heating rely on simpler technology already in wide use in rural Alaska. Woody biomass can be used directly as cordwood, processed into woodchips, or densified into pellets or bricks to increase their BTU content. Buildings that can be heated with less fuel can be equipped with high efficiency cordwood boilers. Larger installations, requiring higher fuel consumption, need an automated boiler system that uses woodchips or pellets. The following information on the relative benefits of each for community-scale projects is from the Wood Heat Boiler Design & Permitting report prepared by RBA Engineers, Inc. (14).

CORDWOOD BOILERS

High-efficiency cordwood boilers are fairly simple systems. The GARN boiler, used in many Alaska communities, burns cordwood in a large combustion chamber to heat a large tank of water. When a thermostat calls for heat, a pump turns on and draws the hot water out of the tank into the heated space for distribution. The boiler can provide heat for domestic hot water by adding a water-to-water heat exchanger. Most cordwood boilers are manually operated. Cordwood needs to be “seasoned” or “dry” in order to burn cleanly and efficiently. Depending on the unit size and outside temperature, boilers need to be loaded one to three times a day. The ash needs to be removed after every complete burn. Solid residues are mostly non-toxic and useful as a soil amendment.

WOODCHIPS

Woodchips are a step up from using raw wood logs. A wood chipper ($30,000 to $100,000) needs to be purchased to process the trees. Compared with cordwood system, some of the wood supply cost, including labor, should be recovered as harvesting is faster and more automated, and no cordwood stacking is necessary. More usable wood is available, because all parts of a tree can be chipped, including small limbs and branches.

PELLETS

The advantage of manufactured wood pellets is higher heating output and virtually no dust. Pellet-fed systems also require less complex fuel handling since pellets can "flow" into the combustion chamber. However, pellets would have to be made or imported since there is no pellet mill in the region.

Project Economics

As a fuel, biomass is cost stable compared with fossil fuels and should be for the foreseeable future. However, the economics of specific projects will depend on the abundance and location of the biomass fuel source and on the scale, complexity and readiness of the chosen technology.

WASTE-TO-ENERGY

Biopower projects such as CHP and gasification systems are characterized by high capital and high projected O&M costs. They will likely be feasible only in larger communities with high power demand and high diesel prices. A 2007 study suggested that at then current fuel oil prices and technology costs, only larger rural hub communities (e.g. Aniak, Dillingham, Fort Yukon, Galena, Hoonah, Tok, and Yakutat) were likely candidates for CHP systems. Economics could improve in the future for smaller communities if fossil fuel prices increase and CHP technology evolves (3).

The City of Dillingham did an initial look at plasma conversion. It was determined that the City of Dillingham did not have enough waste to justify the investment. The fish processing plants had enough but their seasonal fluctuations and location posed logical problems. A plasma gasification process converts organic matter into a synthetic gas, which can then be used for heating or electricity generation. It uses a plasma torch powered to ionize and catalyze organic matter in the waste stream, requiring high inputs of energy. Only larger plants can produce enough electricity to be self-sufficient (15). Dillingham is currently pursuing the feasibility of an alternative gasification system available from Waste to Energy Canada (12).

WOOD BIOMASS BOILERS

With low capital and operating expenses, wood biomass heating projects have generally strong economics, while providing local jobs benefits. Potential savings are greatest for buildings that currently require a lot of fuel oil to heat. Schools and other buildings that already use waste heat from a power plant to reduce fuel consumption will not benefit as much from switching to wood-fired boilers for heating. Cost savings will also be highest when wood is available as a byproduct of commercial processing (lumber mill, wood product manufacturing). The cost of wood increases and savings decrease where wood fuel is from round wood and forest residue, which is more likely to be the case in the Bristol Bay region (3).

According to RBA Engineers, $250 to $300 per cord provides the same amount of heat as fuel oil at $3.50 per gallon, assuming the wood being burned is locally harvested spruce, including 10% dead trees, air dried to 20% moisture. In feasibility studies completed for the Lake and Peninsula Borough, estimates of the delivered cost per cord for wood in the Lakes area ranged from $250 to over $500. AEA's benefit-cost analysis for a wood boiler project in Iliamna assumed a price of $325 per cord, reflecting average costs in the Mat-Su and Kenai areas adjusted for less volume and less dense wood fiber.

Project Notes

BRISTOL BAY FISH WASTE

Naknek Electric was awarded $75,000 in RE Fund Round 2 to assess the feasibility of developing a stand-alone fish waste-processing facility in the Bristol Bay Borough to recover fish oil from the salmon waste stream in the Naknek-Kvichak fishery (including seven land-based processing facilities, three floating processing facilities and several smaller independent operators) to be used as a fuel blend in the NEA power system based on the findings of an earlier reconnaissance study. The study was never completed. In its proposal, NEA estimated annual energy savings at $200,000.

CITY OF DILLINGHAM WASTE-TO-ENERGY PROJECT

The city of Dillingham is pursuing a gasification project with Shearwater Systems, LLC, a subsidiary of Old Harbor Native Corporation. Work continues on financing and sizing for a modular waste-to-energy system deployed by Waste to Energy Canada (12).

FORESTRY MANAGEMENT PLAN

BBNA's forestry program is working in consultation with a forester to establish a regional forestry management plan. A draft version will be delivered in late 2013 for comments. The final version is due in 2015. The National Indian Forest Resources Management Act of 1990 (P.L. 101-630) mandates that all management activities on Indian trust forest lands be consistent with an approved forest management plan (12).

LAKE AND PENINSULA BOROUGH WOOD BOILERS

Wood biomass boilers have been installed in several Lakes area communities with a RE Fund grant. In addition to the units installed, designs were completed in 2010 for heating community buildings in five other Lakes communities with wood boilers similar to the one installed in Kokhanok (Table 9).

KANAKANAK HOSPITAL WASTEWATER TREATMENT SYSTEM

The Bristol Bay Area Health Corporation has contracted with DOWL HKM to study of several alternatives for wastewater treatment at Kanakanak Hospital in Dillingham. One of the alternatives being looked at is a plasma conversion waste-to-energy system. A 65% design document was completed in November 2012, and a 95% design document is pending (15).

Plasma conversion works best with feed stocks that are high in usable carbon. Since wastewater has a low ratio of organics to total volume, a large amount of energy would be required to evaporate what cannot be gasified. This alternative would require more energy than it would generate. Most likely the waste stream would have to include the hospital's solid waste as well as medical waste, saving costs on third party waste disposal but increasing O&M effort.

Although no recommendations are made in the 65% report, waste-to-energy plasma conversion performed poorly in the preliminary ranking of alternatives based on high risk (related to the newness of the technology), relatively high life-cycle and O&M costs, and moderate permitting requirements (possibly an air quality permit) compared with other options.

Issues

- Meeting the need for a continuous supply of fuel for wood biomass projects requires good fuel supply management and operator training.
- Successful deployment of biomass energy systems requires secure and sustainable wood supplies. Sustainability of forest resources is a sensitive issue involving the cooperation of many stakeholders. It is important that wood harvest operations be planned in the context of overall land use objectives to minimize conflicts with other users (3).
- The Alaska Energy Pathways report identified wood as a resource for a majority of Bristol Bay communities, including some communities in more sparsely wooded coastal areas. Long-term sustainability could be an issue even for smaller-scale projects if wood biomass projects are pursued simultaneously in multiple communities or by multiple users within the same community without adequate communication and planning.
- Pellet makers are available for small (residential) and large (industrial-size mills) application, but there is very little equipment and technology available for community-scale systems. A micro-mill would likely cost $250,000 while a large mill can cost up to $16 million (14).
- Efficient wood stoves and boilers required by EPA regulations are more expensive than some people can afford. The increased use of older, less efficient wood stoves and boilers in response to rising fuel oil costs can increase health risks related to air quality as has happened in the Fairbanks North Star Borough. Community- and industrial-scale systems are easier to regulate and present less of a health risk compared with domestic systems (3).

Data Gaps

- **Local timber inventories** to verify long-term sustainability for wood biomass projects and identify land ownership, access and potential user conflicts. BBNA's forthcoming forestry management plan for Tribal lands is expected to provide useful data and recommendations.
- **Feasibility of Bristol Bay fish waste potential for biofuel production**, as well as performance data and lessons learned from fish waste biofuel projects in other regions of the state and globally.
- **BBNA and Aleknagik Traditional Council survey results**, expected soon, on home heating systems and wood harvest practices in Dillingham and Aleknagik.

Resources for Communities

ALASKA WOOD ENERGY DEVELOPMENT TASK GROUP

The Alaska Wood Energy Development Task Group (AWEDTG) puts out a request for applications each year for communities interested in a wood energy pre-feasibility study. New Stuyahok was a successful applicant in 2012. The application is short, and although it is a competitive process, the group has been able to fund all applicants in recent years. More information: Karen Peterson UAF Cooperative Extension Service, phone (907) 828-3207, khpetersen@alaska.edu

ALASKA ENERGY AUTHORITY

AEA provides feasibility studies for heat recovery systems. Utilities should contact the AEA Heat Recovery Program Manager if they have opportunities to install or expand a heat recovery system (13).

GEOTHERMAL

There are currently no geothermal energy projects in operation or under development in the region. While the greatest geothermal potential is along the Alaska Peninsula, there are no known geothermal sites located close enough to Bristol Bay communities to make them economical to develop. The best geothermal resources are likely on federal lands within National Parks and Preserves.

The state is still developing its geothermal policy. In looking at feasibility and reconnaissance studies for potential geothermal projects statewide, AEA resource managers have found that it is hard to make the numbers work out given the expense of exploration and the relatively small populations served by remote projects. For this reason, AEA recommends a conservative approach when looking at potential geothermal resources (16).

For large-scale electrical power generation (measured in megawatts), temperatures in the neighborhood of 300 to 650°F are generally needed. While in Alaska it is possible to generate power from much lower geothermal temperatures because of the cold climate and abundant cold water, it is still true that, of the thousands of natural springs in the state, only a few have sufficient temperature and flow rates to produce electricity (3).

Geothermal resources with temperatures below 300°F are considered low temperature resources that are typically insufficient for power generation.[4] However, those of at least 150 °F may be appropriate for direct use, such as space heating or industrial drying (13). Of the two thermal springs in the Bristol Bay region that are not on federal lands, only Mother Goose has a discharge temperature over 100°F. However, distance to population centers is another limiting economic factor for developing potential geothermal resources for local energy use (17).

Resource Inventory

According to the geothermal energy survey recently completed by the Alaska Department of Natural Resources, geothermal gradients established by temperatures taken in deep oil and gas exploratory wells show a normal heat flow in most of the region, except in local areas near volcanic centers. The best geothermal prospects are located between Katmai National Park and Stepovak Bay, where two thermal springs are present (17).

The most promising is Mother Goose hot spring system, located at the northwest base of Mount Chiginagak. The largest Mother Goose spring discharges 151°F water at a rate of over 106 gallons per minute. The closest community is Ugashik, 27 miles northwest of the hot spring.

The other thermal spring has a discharge temperature of just 73°F. It emanates near an old volcanic vent and flows into Surprise Lake in the northeast part of Aniakchak caldera. There are also at least seven fumarole fields surrounding the site of the Valley of 10,000 Smokes in Katmai National Park, actively steaming at temperatures of up to 212°F. However, these are located on protected federal lands and not currently available for development.

[4] Chena Hot Springs Resort is able to generate around 200 kW of electricity, the amount of electricity used by a village of 300 residents, from 163°F water flowing at 500 gallons per minute. The combination of high flow rates of hot water and low surface water temperatures allow Chena to be the lowest temperature geothermal power plant in the world (3).

Project Economics

The 2008 Lake and Peninsula Regional Energy Plan offered a first order of magnitude estimate of the cost of geothermal energy in the borough under different scenarios related to distance from the geothermal site assuming a geothermal resource comparable to Chena Hot Springs. Using basic assumptions for geothermal power plant cost and performance in the Lower 48 (adjusted for rural Alaska), the study found that even under the most optimistic assumptions, it would be hard for a geothermal project to be more cost effective than diesel given transmission and exploration costs unless a community is sitting on top of a geothermal resource:

- If a community is currently sitting on top of a geothermal resource, the cost of electricity would be on the order of $0.32 per kWh without adding in any costs for exploration.
- Adding in the cost to build an electrical intertie from the geothermal resource to the local community (or to move the community to the resource), diesel appears to remain a lower cost alternative unless the geothermal resource is located within 10 miles of a community where fuel is flown in.
- In communities where fuel is barged in, diesel appears to remain a lower cost alternative unless the geothermal resource is located within four or five miles from the community.
- If one adds in the cost for prospecting, including drilling to determine the quality and quantity of the resource, geothermal is unlikely to be more cost effective than diesel for small remote rural communities that are not currently situated right on top of the resource (18).

Project Notes

SOUTHWEST ALASKA REGIONAL GEOTHERMAL ENERGY PROJECT

A geothermal energy project was being pursued by the Naknek Electric Association until 2011 when the cooperative was forced to file for reorganization under chapter 11 due to problems with the geothermal drilling program. The Southwest Alaska Regional Geothermal Energy Project was planned to bring cheaper, renewable energy to Naknek, King Salmon, South Naknek, NEA's large commercial customers and over 20 other communities that would have been tied into an expanded grid through new transmission lines if the project had been successful. To pursue the project, NEA bought a 120-acre drill site 17 miles outside King Salmon in 2008, and bought an oil and gas drilling rig in 2009. Project setbacks include unanticipated regulatory, financing and technical issues. As part of the reorganization, NEA plans to sell the drilling rig but keep the property (19).

According to AEA's 2007 Alaska Geothermal Development plan, a memorandum of understanding was being drafted at the time between the National Park Service and the U.S. Department of Energy to identify potential geothermal areas on NPS lands in the region. It is not known whether an MOU was ever signed (20).

IVANOF BAY REGION

A Reconnaissance Study of the Geothermal Potential for the Ivanof Bay Region was proposed by the Ivanof Bay Tribal Council in Round 5 of the RE Fund application process to investigate the geothermal potential of the area based on fumarole fields related to Kupreanof Volcano and the Big River deep oil and gas exploration well drilled in 1976-1977. The project was not recommended for funding by AEA due to concerns that the known geothermal resources referred to in the application—Port Moller, Kupreanof, and Aniakchak—are all at great distances from the communities of Perryville, Chignik, Chignik Lagoon, and Chignik Lake (between 28 and over 70 miles) and the low likelihood of finding an unknown resource.[5]

The agency was also concerned that the cost of developing a resource, if found, would be prohibitive. Cost estimates by HDL Engineering for developing a geothermal resource at Port Moller, for example, ranged between $47 and $92 million for a 1 MW plant. With total electricity generation for Perryville, Chignik, Chignik Lagoon, and Chignik Lake at approximately 1.6 million kWh per year, the levelized cost of energy would be $2 to $3.50 per kWh assuming no operation and maintenance costs, a 25-year life, and a 3% real discount rate. AEA's analysis also noted that, although the Big River well encountered good temperatures (~190°F), the depth was around 12,000 feet and the data suggest that a shallower, more accessible, hydrothermal system does not exist.

Heat Pumps

Heat pumps represent another method of exploiting geothermal energy that can be used to heat homes and commercial buildings.

TECHNOLOGY NOTES

Ground source heat pumps (GSHP) are electrically powered systems that take advantage of the relatively constant temperature of surrounding earth or water bodies for heating or cooling. It uses a traditional refrigeration cycle to transfer thermal energy from a low temperature source (the ground, a body of water, or the air) into a higher temperature target (a residence, building, or hot water supply). The technology is fully commercial and already in use in Alaska in both residential and commercial settings, although GSHPs are most viable in regions with an abundance of cheap electricity (3).

PROJECT ECONOMICS

Unfortunately, heat pumps are likely to be an economic option only in areas with low electric rates and high heating costs, and the presence of permafrost could be an issue. The economics of GSHP in rural Alaska is made more challenging by high installation and potentially high operating costs, though these costs are lower than for oil-heating appliances. A statewide GSHP assessment completed in 2011 by the Alaska Center for Energy and Power and Cold Climate Housing Research Center looked at the economics of heat pump systems in Juneau, Bethel, and three Railbelt cities. It found that operating costs for a GSHP were low enough to make it competitive with other heating systems in Fairbanks, Juneau, and Seward, while in Anchorage space heating costs were lower with natural gas unless a rebate were offered to reduce capital costs. In Bethel a GSHP was not economical due to high electricity costs even if a rebate were offered. The most economic heating system in Bethel in terms of both capital and operating costs was found to be a direct vent laser stove, such as a Toyostove® (21).

[5] A conceptual design report for a bulk fuel project in Perryville notes that there are volcanic vents 20 miles northwest of Perryville, and fumaroles at Kupreanoff 40 miles west, though there are no plans to pursue geothermal development for Perryville due to its small size and the prohibitive cost of transmission lines (23).

The study noted that, as the financial analysis is highly dependent on the cost of electricity, changes in electricity costs can dramatically impact the feasibility of a GSHP. If electrical rates in a community can be significantly lowered through a hydro or wind energy project, the use of GSHP to reduce space heating costs in the community could be reassessed.

HYDRO POWER

Hydropower is currently the largest and most important producer of renewable energy in Alaska. It provides almost one-quarter of the state's electricity and has the potential to provide more. According to the 2010 Alaska Energy Plan, Alaska has 40% of U.S. untapped hydropower. In 2010, 37 hydro projects provided power to utility customers in over 100 Alaska communities (3) (22). Only one of those projects is in the Bristol Bay region: the 824 kW Tazimina run-of-river project that supplies 64% of the electrical energy for three communities in the Lakes region. However, construction is starting on a second small-scale hydro project in Chignik Lagoon at Packer's Creek in 2013, and a 150 kW hydro project is entering final design and permitting at Knutson Creek in Pedro Bay. New feasibility work for several other conventional hydro projects is in progress or has recently been completed (See Table 11).

Though they can be expensive to license and construct, hydropower installations have low operation and maintenance costs and long lifespans (50 to 100 years) that result in stable, relatively inexpensive electric rates. Larger hydro projects have the capacity to generate enough renewable electricity to power a regional grid, displacing large amounts of diesel fuel, reducing greenhouse gas production from electricity generation, and optionally supplementing diesel space and water heating systems with cheaper electric energy on an interruptible basis. Hydropower also integrates well with wind power in community power systems. Careful design may be required to mitigate environmental risks especially to fisheries, and comprehensive, site-specific cost estimates are needed to reduce economic risks (3).

Unlike conventional hydro, the technology to harness hydrokinetic power from rivers, tides and waves is still largely pre-commercial, especially in arctic and cold climate conditions, but it is developing rapidly. A tidal power pilot project is underway in Cook Inlet, and several in-river test projects are in progress in the Interior. The Bristol Bay region's first hydrokinetic project will be an in-river demonstration project starting in 2013 on the Kvichak River in Igiugig, which is considered to have an ideal resource based on initial feasibility work. Ocean wave energy is even further from commercial deployment, but Alaska is estimated to have 60% of the total U.S. potential. If environmental and technical challenges are met, it could potentially meet the small-scale energy needs of remote communities near ice-free oceans in the future (3).

Resource Inventory

HYDROELECTRIC

Most developed hydropower projects in the state are in Southeast and Southcentral Alaska and the Alaska Peninsula—mountainous regions with moderate to high precipitation and relatively mild winters. While only one project is currently producing power in the Bristol Bay region, many communities have hydroelectric or hydrokinetic potential (see Table 10). A hydroelectric facility requires a dependable flow of water and a reasonable height of fall of water, called the head. The greater the head is, the greater the potential energy to drive turbines. More head or faster flowing water means more power (3).

Table 10: Hydroelectric and Hydrokinetic Resource Potential by Community

	Hydroelectric Resource (Proposed Project Capacity)	Ocean & River Resource (Potential Energy)
Aleknagik - Dillingham	Various (2 – 7,000 kW to > 50,000 kW)	
Chigniks	Various (2 – 7,000 kW)	Wave Power (40-50 kW/m)
Clark's Point - Ekuk		Tidal Power (1.3 - 25 MW)
Igiugig		In River Power (2.8 - 6.3 kW/m^2)
Iliamna - Newhalen - Nondalton	Various (2 – 7,000 kW to 25,000 – 50,000 kW)	
Naknek - King Salmon- South Naknek	Naknek L., Naknek R. (> 50,000 kW)	
Kokhanok	Kokhanok R. (2 – 25,000 kW)	
Pedro Bay	Knutson Creek (150 kW)	
Perryville	Kametolook R. (2 – 7,000 kW)	Wave Power (40-50 kW/m)
Pilot Point - Ugashik	Various (2 – 7,000 kW)	
Port Alsworth	Kontrashibuna L., Tanalian R. (7,000 – 25,000 kW)	
Port Heiden	Various (2 – 7,000 kW)	Wave Power (30 – 40 kW/m)
Togiak	Kartuk R. (2 – 7,000 kW)	

Sources: (22), AEA Renewable Energy Fund applications, Round VI

IN-STREAM HYDROKINETIC

In-stream hydrokinetic power is potentially available to communities in all regions of Alaska that are located near navigable rivers or tidal basins, excluding the North Slope (3). The University of Alaska is completing a statewide assessment of in-stream hydrokinetic potential in rural Alaska. In general, ideal locations provide significant water flow throughout the year and are not susceptible to serious flood events, turbulence, debris or extended periods of low water (22).

The Alaska Energy Plan published in 2009 noted that the Bristol Bay Campus of UAF was assessing resource potential for tidal energy in Nushagak Bay.

Ocean wave energy could be available in the future to communities located near unprotected waters of an ice-free ocean. Alaska is believed to have one of the best wave resources in the world, and the best resources in Alaska are believed to be on the southern side of the Alaska Peninsula, the coastlines of Kodiak and Southeast Alaska, and around Yakutat, but feasibility studies will be needed to verify the resource and prove the technology (22).

Table 11: Existing and Proposed Hydro Projects by Community

	Existing Project	Proposed Project	Energy Resource
Aleknagik-Dillingham (possible interties to Manokotak, Ekwok, New Stuyahok, Koliganek)		Nushagak Area Hydropower Project (NAHP) Proposed capacity: 1.5 MW Lake Elva 2.7 MW Grant Lake (Go/No-Go decision expected spring 2013)	Large reservoir Lake Elva: 280 ft net head; Grant Lake: 233 ft net head, 92cfs
Chignik	Antiquated 60 kW Indian Creek hydro plant conveyed to city by Trident Seafoods	520 kW Chignik (Indian Creek) Hydro Project (In feasibility)	Small reservoir 409 ft net head, 22 cfs flow
Chignik Lagoon		177 kW Packer's Creek Hydro Project (Construction 2013-14)	High head run of river
Igiugig		5-40 kW Kvichak River RISEC (Demonstration 2013-14)	In-river hydrokinetic 1.41 m/s avg. velocity 2.4 m avg. depth
Iliamna-Newhalen-Nondalton	Tazimina River 2 - 412 kW Offset 2,456 MWh in FY11 (64% of load)	1.5 MW Tazimina Hydro Project Capacity Increase (Feasibility 2013)	Run of river 100 ft natural head
Pedro Bay		150 kW Knutson Creek Hydro Project (Final Design and Permitting 2013-15)	Run of river 207 ft net head, 18 cfs flow
Port Alsworth		75-200 kW Port Alsworth (Tanalian River) Hydro	Run of river

Sources: (16) (23) (24) (25) (26), AEA Renewable Energy Fund applications and submitted feasibility studies; Emerging Energy Technology Fund Grant Program applications

Technology Notes

SMALL-SCALE HYDROELECTRIC

All projects being considered for Bristol Bay are considered small-scale hydro. Small hydro describes hydroelectric projects with a generating capacity of up to 10 MW. It can be further subdivided into mini hydro (less than 1,000 kW) and micro hydro (less than 100 kW).

DAMS & RESERVOIRS

The dams and reservoirs of larger hydroelectric projects provide for energy storage by holding water to be used to generate electricity when flows are lower. A strong attribute of these projects is the dispatchability that results from the ability to control the rate of power production through storage and release of water contained behind the dam (3).

RUN-OF-RIVER

A run-of-the-river power plant has little or no capacity for energy storage, and so cannot coordinate the output of electricity generation to match consumer demand. In Alaska, run-of-the-river generators also do not provide the seasonal consistency in electric supply that larger hydro projects can, because river flow rates are diminished in winter. Unfortunately, most Alaska electric loads are highest during the winter. This lowers the amount of run-of-the-river hydro capacity that can be installed without significant amounts of excess capacity in summer (3).

Compared with other renewable energy alternatives like wind and solar, run-of-the-river hydroelectric generators deliver a relatively consistent electric supply throughout the day. The variable nature of other renewable energy sources like wind and solar makes pairing with hydro energy storage an attractive option for integrated supply systems (3).

IN-STREAM HYDROKINETIC POWER

Tidal and river in-stream energy devices are placed directly in the river or tidal current and powered by the kinetic energy of the moving water. In-stream hydrokinetic devices typically use vertical or horizontal axis turbines similar to wind turbines, but because water is approximately 850 times denser than air, the amount of energy generated by a hydrokinetic device is much greater than that produced by the same-sized wind turbine. In addition, river and tidal flow do not fluctuate as dramatically as wind does. This is particularly true for tidal energy, which is not affected by weather and can be predicted years in advance (3).

Project Economics

HYDROELECTRIC POWER

The high capital cost of hydro (especially on a per kW basis for smaller projects) is the chief impediment to economic feasibility. This cost tends to decrease over time as original capital costs are paid down through electricity sales and the influence of low O&M costs is felt (27).

Hydro projects do not lend themselves to using unit cost factors to estimate capital cost because unit costs are variable and site specific. Turbine selection depends largely on site conditions, and site analysis is required to optimize power output and reduce capital costs (3). Since hydro sites are at fixed locations, an accurate assessment of required transmission must be made before a true determination of feasibility can be made (27).

Previous Studies. In an analysis by Crimp, Colt, and Foster Capital, capital costs for projects in Alaska’s 1996 hydroelectric project database were found to average $25,800 per kW and ranged from $1,500 to $250,000 per kW when updated to 2005 dollars using the wholesale price index for construction machinery manufacturing. In many but not all cases, relevant transmission costs were included in the capital cost estimate for a project. Annual O&M costs were generally equal to 3% of capital cost (27).

The analysis included five projects in the Bristol Bay region. Of these, projects in Chignik and Port Heiden showed positive but marginal economics (a benefit-cost ratio of 1.01) at high diesel prices and optimistic system cost assumptions (80% of base estimate). The Dillingham project showed positive economics (benefit-cost ration > 1.0) at high diesel prices and both mid-case and optimistic system cost assumptions. The Togiak and Twin Hills projects were among the 13 projects in the analysis that failed to show a benefit-cost ratio greater than 0 under any of the model scenarios.

The 2008 regional energy plan completed for the Lake and Peninsula Borough also rescreened previous estimates for hydro projects in that region. Starting with data from the 1982 Stone & Webster study, it filtered out projects that had rated poorly in prior studies then updated and verified individual project assumptions including capacity, capacity factor, stream flow and head, and capital cost. It found a levelized cost of energy (in 2008 dollars) ranging from $0.23 per kWh for the Indian Creek hydro project to $0.39 per kWh for a project that would tie hydropower from Kontrashibuna Lake and the Tanalian River near Port Alsworth into a regional grid, though it noted that that project had land issues related to its location in Lake Clark National Park & Preserve (18).

IN-STREAM HYDROKINETIC POWER

A 2008 Electric Power Research Institute (EPRI) study calculated simple payback periods in the 3-9 year range for three proposed in-stream hydrokinetic sites in Alaska, based on a conceptual design similar to the 40 kW system originally proposed for Igiugig. The single 5 kW Encurrent project at Ruby was installed for $16,000 per kW of generation capacity. The installed cost per kW was estimated at $7,500 for the 40 kW plant at Igiugig and $5,800 for the 60 kW plant at Eagle. EPRI says its project cost estimates contain a margin of error of up to 30%, and operating and maintenance costs (estimated at $12,000 per year for Igiugig) have a margin of error up to 80% (3).

There is minimal if any third party testing and verification of devices yet, and cost information is based largely on claims from manufacturers who typically underestimate project expenses in the early stages of development. In addition to capital costs, the economics of a project are also tied to other project costs (operation and maintenance, insurance costs, and permitting, design, and environmental monitoring costs) which could be substantial especially for early generation installations. These will likely vary from site to site and could dramatically impact the simple payback period (3).

Early estimates of the cost of energy for the first commercial-scale wave power facilities in the United States vary primarily with resource potential and O&M costs at different sites. While they do not compare favorably with some other forms of renewable energy such as hydropower, they are somewhat less than the costs for early commercial wind energy devices. Like those devices, the cost of wave energy facilities is expected to decrease with device improvement and operating experience (3).

Project Notes

CHIKUMINUK LAKE HYDRO

See page 100 for a description of the this 13 MW large reservoir project being studied by Nuvista Light & Electric and its future potential to provide energy in the Bristol Bay region.

INDIAN CREEK HYDRO

Trident Seafoods recently conveyed its antiquated 60-year-old Indian Creek hydroelectric facilities and FERC license to the City of Chignik. The city is using a Round 1 RE Fund grant to study the feasibility of restoring and upgrading the 60 kW micro-scale system, which also provides fresh water to the processing plant and community. The study being completed by Hatch Engineering will determine the actual potential of the resource and propose a project design to better match the community load. The preliminary design has a capacity of 520 kW, which would provide essentially all of the community's current electrical needs, displacing 50,000 gallons of diesel, and generating up to 2.4 MW amounts of excess energy (23).

While some of the extra power could be used for thermal loads, most of it would be available in the summer when heating demand is limited. The Lake and Peninsula Borough Regional Energy Plan noted that with the rain and wind profile in the Chignik area, it may be possible to optimize the size of hydro, wind, and diesel back-up systems to take advantage of each resource's availability to meet both winter and summer peak loads and overall energy production requirements. The screening study found that the Indian Creek hydro project appeared to be the most cost effective electric project in the area with a long-run levelized cost of electricity roughly 40% below the projected cost of electricity from diesel generator sets with secondary heat recover and about 25% less than a Chignik area wind project (18).

KVICHAK RIVER RISEC PROJECT

Through an early feasibility study that looked at the potential for River In-Stream Energy Conversion (RISEC) devices in several Alaska villages, the Kvichak River was identified as a nearly ideal location to test in-river hydrokinetic power in Alaska, because it is generally ice- and debris-free and there are sites near the village with suitable hydrology. A 40 kW project was originally designed based on village energy consumption and resource availability during summer months. That project was estimated to cost $300,000 in 2007 dollars with annual O&M at $12,000 per year. Total annual energy production was estimated at 200,000 kWh based on a 60% capacity factor (though actual generation would occur primarily over the summer months). Because the technology is still pre-commercial, two separate demonstration projects with funding from AEA's Emerging Energy Technology Fund will be conducted starting in 2013 to test the performance of devices from different manufacturers. Even if the technology proves feasible, Igiugig expects it take up to 10 years before the technology is ready for commercial deployment.

KNUTSON CREEK HYDRO PROJECT

Pedro Bay Village Council (PBVC) received a round 6 RE Fund grant for $290,000 for final design and permitting of a hydroelectric project on Knutson Creek. Construction costs for the 150 kW run-of-the-river project are estimated at $3 million. Construction could start as early as 2016 with completion in 2017.

The economics of the project rely largely on the community's ability to use excess energy for space and water heating by refitting its community buildings and 33 homes with interruptible electric heating systems. The existing electric utility load will only use 16% of the total hydro energy output to supply 94% of the current village electrical load, and interruptible electric heating services will use another 70% of the output to supply about two-thirds of the village's total building heating needs (including 85% of the annual space heating needs of seven community buildings). The remaining 14% of project output occurs during the summer months and is unused, available for future growth or new beneficial applications.

According to the AEA analysis, the recommended project was evaluated under several hypothetical load growth scenarios and maintains a benefit-cost ratio greater than 1 over a range from -75% to at least +400% of existing utility load. In modeling different load scenarios, the feasibility study authors kept total kW output relatively constant and assumed increasing amounts of interruptible energy would be dispatched to building heating loads if demand for prime loads declines. The study noted that "in small Alaska villages with extremely high electric rates demand often increases significantly in response to reduced electric rates. Reduced electric rates may also encourage an increase in population over time, which can also cause an increase in electrical demand" (28).

NEWHALEN RIVER HYDROELECTRIC PROJECT

The Newhalen River Diversion Project was identified in some previous studies as the most promising resource for developing a large scale (16 MW) hydroelectric project that could power a truly regional grid to share reliable, affordable energy throughout the Bristol Bay region. According to AEA resource managers, the project has been exhaustively studied over the years, and there are significant fisheries issues that would make it challenging to permit (24). The development of the Tazimina Hydro project and the three-village grid operated by INNEC has also reduced economies of scale for a larger project in the Lakes area (18). The project does not seem to have a current champion since no application has been submitted to the Renewable Energy Fund grant program in the first six rounds for a Newhalen River hydroelectric project.

NUSHAGAK AREA HYDROPOWER PROJECT

Two separate hydro projects are being pursued by Nushagak Electric and Telephone Cooperative (NETC) to add a stable-priced, renewable energy resource to the grid that currently serves Dillingham and Aleknagik. Grant Lake and Lake Elva are both located in Wood-Tikchik State Park north of Aleknagik. If one or both the projects are built, interties are possible to Manokotak, Ekwok, New Stuyahok and Koliganek. A transmission routing study was being conducted in 2012, along with continued field studies for fisheries and hydrology.

The project originally was found to be non-jurisdictional by the FERC. However, the licensing approach was changed voluntarily to provide for more certainty of process and timely responses from resource agencies. Nushagak Electric and Telephone Cooperative (NETC) received a preliminary permit from FERC for the project in April 2012 (29).

Preliminary feasibility work estimates capacity at 1.5 MW at Grant Lake and 2.7 MW at Lake Elva, although these could be reduced to mitigate impacts on fish and game or historic sites. A feasibility assessment report and Go/No-Go decision was expected in early 2013 to determine if one or both sites should be developed (30).

PACKER'S CREEK

The Packer's Creek Hydroelectric Project in Chignik Lagoon is expected to start construction in 2013 and be operational by 2015. The work is being completed by Polarconsult Alaska. The project received $1,993,496 in RE grant funds in Round 5 for construction and commissioning with local and in-kind matches totaling $523,000. The 177 kW project will generate about

520,300 kWh per year, offsetting 50,000 gallons of diesel currently used for electricity and up to 10,000 gallons for heating.

PORT ALSWORTH HYDRO PROJECT

Alaska Green Energy was awarded a Round 3 RE Fund grant of $150,000 for a reconnaissance study of a micro-hydro project on the Tanalian River in Lake Clark National Park and Preserve, but the study was never done and the grant was eventually pulled. The application had the support of the National Park Service, the Lake and Peninsula Borough, and local stakeholders including the local electric utility. The study was to include scoping meetings with the community and agencies as well as economic, engineering, and environmental determinations for a 75-200 kW project. While the Tanalian River is considered a promising hydro resource, a micro-hydro facility within National Park boundaries would face land use and permitting challenges. There are also potential environmental issues from large fish populations in the Tanalian River, although a falls below the proposed project site obstructs migration (24).

TAZIMINA RIVER HYDRO PROJECT CAPACITY INCREASE

The INN Electric Cooperative received a Round 6 RE Fund grant of $160,000 to study the feasibility of expanding the capacity of its existing Tazimina Hydroelectric Project up to 1.5 MW by replacing either one or two of the existing 412 kW turbine-generators. The original FERC license was issued for larger turbines and the plant throughput was built with this in mind, but the smaller turbine-generators were installed when the project was built in 1996. The study will evaluate existing energy use and future energy requirements for the region. Increased renewable capacity would limit diesel use during periods of low water and high demand, which is currently an issue. Markets for the increased energy may also include new dispatchable heating systems in private businesses and city governments at Newhalen, Iliamna and Nondalton. The feasibility work is being conducted by HDR Alaska in 2013. If favorable and if project financing is secured, procurement and installation would take place in 2014-15.

Issues

HYDROELECTIC POWER

- Hydroelectric project costs are very site specific. AEA's experience has been that costs are often underestimated. Early studies tended to overlook costs for mobilizing construction equipment to remote locations and costs for transmission and switch gears back to the main diesel plant (24).
- Where excess hydropower is available, fuel switching to electric home heating is likely to occur in communities with low-cost hydropower. This impact will substantially increase the power sales. However, if enough customers convert to electric heating, the surplus electric capacity will dissipate and diesel generators will be needed to meet the load requirements. One method of addressing this issue is interruptible electric space and water heating when reservoir levels are low or electric use is high during the winter. During low water years in Sitka, the utility has had to ask people to heat with wood or diesel while it interrupts electric service to electric heaters (3).
- While many feasibility studies for hydro and wind projects count economic benefits from using excess electrical generation for thermal loads, few offer specifics about the systems

or technologies needed to achieve those benefits. Nor do they provide assumptions about costs for converting buildings to interruptible electric heating, who will pay those costs for commercial and residential buildings, or the percent of building owners that need to convert to achieve the assumed benefits.

- Almost every stream in the region has salmon habitat which necessarily restricts the potential for hydropower development, since salmon migration and habitat are well protected and fishery resources are highly valued for subsistence, sport and commercial use in the region (24). Careful design can mitigate some impacts to downstream aquatic life, water quality and recreational uses (3).
- Alaska's Hydro Technology Work Group recommended working toward the establishment of a fair, efficient and timely authorization permitting process for new hydropower projects, particularly for run-of-the-river hydro projects (3). FERC jurisdiction can add two years to the permitting process.
- There is a need for standardized plans for small hydro applications such as intakes, powerhouse, induction plants, and tailraces. The state's Hydro Technology Work Group also noted a number of research needs related to technical challenges in cold weather hydro applications, as well as design of Alaska-friendly fish passages, and methods for integrating small hydro in village settings (3).

HYDROKINETIC POWER

The Alaska Energy Plan outlines several issues that will need to be better understood before in-river and tidal hydrokinetic projects are ready for commercial deployment in Alaska (3):

- Environmental concerns, especially with regard to impacts on fish must be fully evaluated. Most communities with hydrokinetic resources are heavily dependent on local subsistence and commercial fisheries.
- Survivability and performance issues must be examined. Alaskan waters have many hazards for hydrokinetic devices, including high rates of sediment transfer in river beds, debris, and ice. These issues also complicate the design of anchoring and cabling systems.
- Many of the fast flowing rivers in Alaska with potential for hydrokinetic development are also major waterways for barge delivery of bulk materials to isolated communities. A major consideration is that these devices not impede river traffic.

Data Gaps

- **More rigorous modeling of thermal electric conversion costs**. Assumptions about the percent of utility customers likely to convert to interruptible electrical heating should be explicit and conservative for projects that assume significant benefits from dispatching electrical loads to meet thermal loads.
- **Resource mapping of river velocity and depth near Bristol Bay communities**, particularly in winter, is needed to assess the potential for in-river hydrokinetic projects; no data is currently available for the Bristol Bay region.
- **Results of hydrokinetic demonstration projects in other locations**, including project economics, survivability in cold climates, environmental impacts especially on marine mammals and fish, and lessons learned by early adopters.

Resources for Communities

HYDROKINETIC POWER

The statewide Alaska Energy Plan published by AEA and the Alaska Center for Energy and Power in 2009, has a large section on hydrokinetic technology with useful information for Alaska communities including case studies and manufacturer options.

The Alaska Energy Plan also noted that ACEP was seeking funding for the development of a Hydrokinetic Test Center in partnership with the University of Maine and Maine Maritime Academy. If developed, the proposed center would work with communities and industry to develop protocols, standards, and best practices in environmental and resource assessment of tidal and in-river sites through the permitting process. The center would also work on modeling and performance testing of devices. More current information about hydrokinetic devices and projects is posted on AEA's Ocean and River webpage at www.akenergyauthority.org/oreassessmentprojperm.html#Projects

SOLAR

In Bristol Bay, as in the rest of the state, solar energy is most abundant in summer, when it is least needed, and minimally available during the winter when energy demand is greatest. As a result, solar power does not have the potential to meet more than a fraction of a community's energy needs, at least given the current level of technology and prices.

While the installed cost of systems has been coming down rapidly, solar photovoltaic (PV) technology is still one of the more expensive electricity options for Alaska (31). A rigorous economic analysis should be done before any solar systems are considered economic (13).

Active solar systems include both solar PV systems, where solar energy generates electricity directly in a semiconductor solar cell, and solar thermal hot water systems, where water is heated and the heat stored in a reservoir. Solar thermal energy (STE) systems use solar-heated fluid to supply in-floor heating systems normally fueled by conventional boilers. The low level solar resource in Alaska precludes high temperature solar technologies, such as systems that generate steam to produce electricity (3).

Since the cost of space heating accounts for close to 90% of household energy use in small rural communities, solar hot water systems may hold greater potential than electricity-producing PV systems for reducing energy costs in the region (3) (32). A solar thermal project is underway in Perryville, and demonstration projects have been completed in Nome, Kotzebue and McKinley Village that are providing performance and economic data (6).

Where it can be used economically, solar energy has the advantage of low maintenance and minimal environmental impact, with small project footprints and no CO_2 emissions. It is also an attractive option for sites where the noise and emissions from diesel generators may not be acceptable on a continual basis (18).

Resource Inventory

The potential for using solar energy is greatest in communities with less precipitation and with southern exposure. Solar resource potential is measured by solar insolation—the amount of solar radiation that strikes a square meter of the earth's surface in a single day (kWh/m^2/day). Table 12 groups Bristol Bay communities by solar resource. According to National Renewable Energy Lab data, no place in Alaska has a solar resource greater 4.0 kWh/m^2/day.

Table 12: Photovoltaic Solar Resource by Community

kWh/m^2/day	Communities Grouped by Solar Energy Potential (Average Annual Solar Insolation)
2.5 to 3.0	Chignik Lagoon, Chignik Lake, Port Heiden
3.0 to 3.5	Aleknagik, Chignik, Chignik Lagoon, Dillingham, Igiugig, King Salmon, Nondalton, Pedro Bay, Perryville, Port Alsworth, Port Heiden, Togiak, Twin Hills
3.5 to 4.0	Clark's Point, Egegik, Ekwok, Iliamna, Kokhanok, Koliganek, Levelock, Manokotak, Naknek, New Stuyahok, Newhalen, Pilot Point, South Naknek

Source: (6). Note: Higher numbers are better.

Solar PV arrays have been installed on individual residential and non-residential buildings in the region. In Dillingham, these include some state and federal government buildings such as the

Bristol Bay Campus of the University of Alaska Fairbanks and the Alaska Department of Fish & Game offices (12). However, there are very few community- or utility-operated solar power projects in operation in the region. See Table 13 for a list of known projects. There may be others.

Table 13: Community- and Utility-operated Solar Projects

Community	Installed Projects
Perryville	A 3 kW grid-connected, solar PV system has been generating electricity in Perryville since March 2011. The village is working to resolve some issues with wind blowing the panels around. A solar thermal project is underway.
Ugashik	The small community of Ugashik installed a small-scale, wind-solar system with funding from EPA’s Indian Environmental General Assistance Program (IGAP), the Bristol Bay Economic Development Corporation (BBEDC), and the National Renewable Energy Laboratory (NREL) at DOE. The system includes a 2.2 kW solar PV array on a dual axis tracker, two 2.5 kW wind turbines, a 3.6 kW inverter, a battery bank, and a 12 kW diesel generator. A water heater and space heaters are used as remote control dump loads. The project has been used by the NREL to study the optimum mix between wind and solar and “useful” dump load controls to increase fuel savings (33) (34).

Sources: (6) (34) (35) (36), AEA Renewable Energy Fund application, Round III

Technology Notes

The typical solar energy system consists of multiple arrays of photovoltaic panels situated on top of buildings, towers or other relatively high structures. The fact that sunlight intensity varies from minute to minute due to changes in cloud cover, smoke from fires, blowing dust etc., requires that most solar-based systems have substantial battery storage (37).

Even though the longest day is in June, the greatest amount of solar energy that can be harnessed in Alaska is from March through May when panels receive snow-reflected light in addition to direct sunlight. Coupled with cool temperatures that reduce electrical resistance, PV systems may exceed their rated output at this time of year (6).

A study by the Cold Climate Housing Research Center in Fairbanks determined that dual axis tracking results in a 40% increase in capacity factor, all else being equal, compared with fixed systems. AEA has found that systems that use polycrystalline solar cells cost on average 20% less per watt than monocrystalline cells (34).

Project Economics

While project economics is dependent on fuel oil prices and local resource, generally speaking prices for solar electric and solar hot water systems make them more expensive than diesel systems. This is true in part because of the extreme seasonality of the resource in Alaska where technologies other than solar must carry the load for long months. For this reason, the addition of a solar auxiliary system does not reduce the capital cost of a primary heating or electrical system, which must be designed to operate without benefit of significant solar input.

For these reasons, solar PV energy may provide the best fit for stand-alone systems with relatively low power demand that are off the power grid and that operate only in summer, such as remote fish camps and lodges. That said, grid-connected PV systems still offer the most economical means of generating electricity with sunlight, because they avoid the expense of electrical storage. (3) (6).

In Dillingham, a 4 kW grid-connected system would generate about 3,368 kWh per year while displacing 260 gallons of fuel oil. Over a 30-year lifetime, it would generate just over 100,000 kWh and displace nearly 8,000 gallons of fuel.

Table 14: Energy savings in Dillingham with 4 kW solar PV

Month	Solar Radiation ($kWh/m^2/day$)	AC Energy (kWh)
January	1.22	121
February	2.68	247
March	3.87	382
April	4.50	416
May	4.32	390
June	4.08	344
July	4.05	345
August	3.53	304
September	3.30	289
October	2.92	270
November	1.86	169
December	0.91	89
Annual	**3.10**	**3,368**

Sources: (38). **Assumptions**: DC Rating: 4.0 kW, DC to AC Derate Factor: 0.77; AC Rating: 3.08 kW; Fixed tilt: 70 degrees.

The installed cost of a 4 kW system in Fairbanks is currently about $16,000 (39). The payback period in Dillingham will depend on transportation and local installation costs, but could be faster than in Fairbanks because of higher fuel and electricity costs in Dillingham, especially for commercial utility customers who pay the full, non-PCE subsidized cost of electricity.

The National Renewable Energy Laboratory's PVWatts model, which was used to estimate solar energy generation in the example above, does not take into account the effect of snow on solar panels. The Bristol Bay region has snow on the ground for approximately six months of the year. If a solar project is planned and includes snow removal, that cost should be included in the maintenance cost estimate (13).

Using solar PV or solar thermal energy technology to reduce space and hot water heating costs may be more economical than using solar energy to generate electricity.

The economics of solar projects will improve if the price of system components continues to drop as expected. The U.S. DOE's SunShot Initiative has set a goal of making PV cost competitive without government incentives by reducing the cost of PV-generated electricity by about 75% between 2010 and 2020. Installed prices of U.S. residential and commercial PV systems declined 5% to 7% per year, on average, from 1998–2011 depending on system size, and by 11% to 14% from 2010–2011. Market analysts expect continuing reductions in system costs (31).

Project Notes

BRISTOL BAY SCHOOL DISTRICT

The Bristol Bay School District submitted a Round 6 RE Fund grant application for design and construction of a 50 kW (DC) solar PV system and heat recovery system for the Naknek school that was not recommended for funding. Anticipated benefits of the $470,000 project included reducing the amount of electricity the school buys from the local utility, replacing fossil fuels with a cleaner burning renewable resource, and providing an opportunity for students and the wider community to learn about PV. While the project showed a benefit-cost ration greater than 1.0, AEA had concerns about the level of detail included in the application, the accuracy of cost estimates, and questions about net metering assumptions and support of the local utility.

IGIUGIG

Igiugig Village Council plans to install a solar hot water heater in one residence in summer 2013 and may install additional units if the first operates well (40).

PERRYVILLE

The Native Village of Perryville has installed solar heat tubes outside its multi-use building (34). It plans to connect the glycol-filled tubes to the building's boiler system to offset diesel fuel used for space heating. Capital costs are estimated at $12,000 to $15,000. The village currently uses 4,700 gallons of diesel per year to heat the 10,000 square foot building using radiant heating. The CDR for Perryville's new bulk fuel tank farm mentioned that potential heating fuel offset was expected to be minimal during the winter months (37).

Issues

Due to the dramatic fluctuations in solar radiation from summer to winter at high latitudes and the practical limitations of storing and disposing of battery banks, solar systems are unlikely to provide more than a minor amount of the total power necessary for a community. However, residential-scale solar installations, including those used for space and hot water heating, can be used to reduce energy costs for individual homes and community buildings and may be capable of meeting essential electrical load demands during the summer months (37).

As with other intermittent and unpredictable power sources, solar PV has the disadvantage of reducing heat recovery from diesels, introducing rapidly changing power generation onto a grid that must be compensated by remaining grid components (in some cases additional, new and expensive components), and potentially reducing diesel efficiency (13).

It is critically important for safety, legal and coordination reasons to discuss a solar PV project with the local utility before connecting. Most utilities in rural Alaska are not required to allow net metering or other forms of distributed generation according to RCA regulations (13).

Resources for Communities

ALASKANSUN.ORG

The alaskasun.org website has excellent information, including a number of publications related to solar installations in Alaska, and a list of contractors and suppliers.

PVWATTS VIEWER

PV Watts uses weather data from stations across the country to provide data on solar insolation. The PVWatts Viewer is a free, Web-based application that lets the user click on a map or input a U.S. zip code to assess the energy production and potential cost savings of grid-connected solar PV systems at that location. The resulting data can then be plugged into a solar calculator on the same site to calculate the potential for solar energy production and cost savings by month based on local electrical rates. The user can either see the results based on a default PV system or input a different type and size of array. Access the PVWatts Viewer at http://gisatnrel.nrel.gov/PVWatts_Viewer.

WIND ENERGY

Wind may be the best or only available renewable resource for power generation for many communities in the region. If technical challenges with integrating wind power into diesel systems and using excess generation for hot water and space heating can be resolved, wind could become a much bigger part of the energy picture for communities with good wind resources, though it will still not be an economical option for every community in the region. Wind energy economics depends on community size, the price of displaced fuel, as well as the quality and location of the wind resource.

Resource Inventory

Much of the best winds in Alaska are located in the western and coastal portions of the state. In the Chigniks as in other parts of Southwest Alaska, turbines may actually need to be sited away from some of the best winds to avoid extreme gusts and turbulence (41). Away from the coast, good wind resources are more likely to be found near lake shores, hills, or ridge tops. In general, areas with Class 3 winds or greater are considered to have a suitable wind resource for a wind project (42). This means good exposure to prevailing winds and annual average wind speeds around 4 meters per second (8.9 mph) or greater at a height of 30 meters if not obstructed by terrain features, vegetation, buildings, and atmospheric effects (43).

Feasibility studies to assess wind resources have been completed in most communities (see Table 15). At least six wind energy projects have been completed in the region, including a utility-scale project in Kokhanok with the potential to offset significant amounts of diesel generation as well as provide energy for secondary space heating loads. Several more projects are underway (See Table 16).

Project Economics

Three key variables drive the wind economics: wind resource, community size and the cost of fuel to be avoided. A large community with a high cost of delivered fuel and a Class 4 or great wind site appears to be the best candidate for wind energy under a range of future fuel price and capacity factor scenarios, according to a 2007 study by Crimp, Colt, and Foster. Large communities can take advantage of larger more efficient wind turbines, resulting in projects with a lower cost per kWh and shorter payback. The study found wind projects to be feasible in smaller communities if they have wind regimes of Class 5 or above and a high cost of delivered fuel, but as the size of the community drops below 350 people even the relatively small turbines (65 kW) become a relatively large electrical generator to efficiently integrate with an existing diesel system (27).

Earlier studies modeling wind project economics on a regional level have come to different conclusions about which Bristol Bay communities are the best candidates for wind energy systems. Crimp, Colt and Foster looked at five of the largest communities in the region and found positive project economics in Dillingham, Naknek, and New Stuyahok under scenarios with mid- to high diesel prices and high turbine efficiency (27).

Table 15: Wind Resource Assessment Data

Community	Wind Class Local Met Data[1]	Wind Class Model[2]	Mean Annual Wind Speed (at 30m)	Wind Quality	Wind Study	Study Findings/ Assessment
Aleknagik		7				
Chignik (Mud Hill Bay)	6	5	14.9 mph	Very high turbulence	2006	Look for alternate site (e.g. Chignik Head); Try VAWT
Chignik Lagoon (All sites tested are in proximity to runway)	1-7	5, 6		Turbulence	2011	High penetration level recommended
Chignik Lake (Tip of peninsula)	4-6	5, 6			2011	High penetration recommended
Clark's Point (High bluff)	4	5	15.5 mph	Fallow field, moderate wind shear, low turbulence	2007	Excellent. Superb exposure to onshore winds
Dillingham (AWOS)	2	3	11.2 mph		2006	Marginal
Dillingham (Kanakanak)	3	3	12.9 mph	High wind shear, moderate turbulence	2007	Sufficient. Try 50m tower further from forest margin
Dillingham (Wood River)	3	3	13.4 mph (33m)	High wind shear, moderate turbulence, forest	2007	Acceptable. Try 40-50m tower near test site
Egegik		4, 5				
Ekwok						
Igiugig (Lake shore)	3-4	4	13.0 mph (34 m)			
Iliamna		4, 6				
King Salmon (ASOS)	2	4	11.2 mph		2006	Marginal
Kokhanok	6	6, 7	17.5 mph	Smooth, low turbulence, very low wind shear	2007	Outstanding
Koliganek	4	4	12.8 mph	Many trees, high wind shear, low turbulence	2007	Very good. Old airstrip site best
Levelock		3				

Community	Wind Class Local Met Data[1]	Wind Class Model[2]	Mean Annual Wind Speed (at 30m)	Wind Quality	Wind Study	Study Findings/ Assessment
Manokotak	2	5	11.1 mph	Few trees, moderate wind shear, excellent turbulence	2009	Marginal
Naknek	4		14.0 mph		1999	Marginal. Sewage Lagoon best site
Naknek (Cape Suwarof)	4		15.0 mph	Fallow field, moderate wind shear, excellent turbulence	2007	Very good
New Stuyahok (Old Airport)	3-4	4	12.2 mph	Suburban, high wind shear, moderate to high turbulence	2007	Fair to Good. Old runway site recom-mended
Newhalen		4, 6				
Nondalton		4, 6				
Pedro Bay		3, 7				
Perryville	2	4	10.3 mph	Few trees, moderate wind shear	2007	Marginal. Not promising for village-scale project
Pilot Point	(2 at airport)	5	14.6 mph (38m)		2004-06	Inconsistent data. Need new study
Port Alsworth (Lake shore)	1-2	5			2010	Marginal
Port Heiden	4-6	5, 6	15.7 mph	Moderate turbulence	2005	Excellent
Port Heiden	5			Upper Class 5 with little variation	2010	Mid to high penetration level
South Naknek		4				
Togiak (Togiak Heights subdivision well down hillside)	3	3	12.7 mph	Fallow field, wind shear moderate, turbulence acceptable	2007	Fair. Try hill 55 about 2 miles west of town.
Twin Hills		3				

Sources: (22) (44), Wind feasibility studies by Knight Piésold & Co., AEA Renewable Energy Fund applications

Table 16: Current Wind Energy Projects in the Region

Community	Installation Completed	Under Construction	In Feasibility/Design
Aleknagik			Feasibility in progress
Dillingham			Feasibility in progress
Egegik			Feasibility to start summer 2013
Igiugig	3 – 2.4 kW Skystream (2 more planned for June 2013)	Multiple 1.2 kW vertical axis "wind spires" Summer 2013	Proposed in RE Fund Round 6. Not funded.
Iliamna-Newhalen	2 - 2.5 kW Proven		
Kokhanok	2 – 90 kW Vestas V-17 (installed 2010) Offset 32,679 kWh in FY11 (6.4% of load)		
Koliganek			Feasibility study due early 2013
Levelock			Feasibility to start summer 2013
Manokotak			Proposed in RE Fund Round 6. Not funded.
New Stuyahok			Feasibility in progress
Perryville	10 - 2.4 kW Skystream (installed 2009) Offset 13,361 kWh (4% of load)		
Pilot Point	2 – 10 kW Bergey (installed 2004) Offset 9,973 kWh in FY11 (2% of load)		Feasibility in progress
Port Heiden	1 – 10 kW Bergey (installed 2004)		Feasibility complete. Design on hold
Ugashik	2 - 2.5 kW Proven (84 ft. towers)		

Sources: (25) (33) (44)

The regional energy plan completed for the Lake and Peninsula Borough in 2008 looked at wind project economics across that borough and found the greatest energy savings per kWh tracked more closely with wind density rather than community size. Those communities assumed to have Class 7 winds (Pedro Bay and Kokhanok) showed the highest savings compared with existing diesel electric rates, followed by Iliamna-Newhalen-Nondalton (using a Class 6 assumption) and Igiugig (Class 4). Wind energy development was not recommended for Pilot Point, Port Alsworth, the Chigniks, Egegik, or Port Heiden unless other cost effective options were not available. Levelock, with a Class 3 resource, was not shown to have any cost savings (18).

Project Notes

ALEKNAGIK

At the time the 2010 Alaska Energy Pathways report was prepared, it was believed that met tower sites on Marsh ridge would produce up to Class 7 winds, and that the closest Class 4 resource would be the hill 250 to the northeast according to wind resource models. However, Nushagak Electric and Telephone Cooperative (NETC) is still looking for a Class 6 to 7 resource. Previous wind studies at Kanakanak, Wood River, Clark's Point, and Manokotak have been disappointing, finding wind densities of Class 3 or less. NETC plans to put up a met tower at Cinnabar Mountain near Aleknagik in spring 2013 (30).

CHIGNIKS

The wind resources around Chignik were assessed by IPPEC consulting in March 2006 and were found to be a Class 6 wind resource, but with turbulence outside of industry standards. The study recommended additional reconnaissance in areas with less obstruction. More recent assessments have been done for Chignik Lake (as part of a Chignik Lake Area Wind/Hydro Intertie project funded through a Round 1 Renewable Energy Fund grant) and Chignik Lagoon in 2011. A wind study was also funded for Chignik in FY10 as part of the airport master plan. The City of Chignik is currently focused on the transfer and repair of the Indian Creek hydroelectric facility from Trident Seafoods to the City.

DILLINGHAM

The Denali Commission is funding a study to integrate wind energy into the Nushagak Electric system (45). A 2007 study indicated a Class 2 to a fair Class 3 wind resource with high wind shear factors. NETC is continuing to study different locations in Dillingham and Aleknagik to find a Class 6 to 7 resource. If available, potential wind resources would prove more economical to interconnect with the Nushagak Area Hydro Project resource than with the existing diesel generation plant, according to an NETC grant application to the Renewable Energy Fund.

IGIUGIG

A wind study was completed in 2012 by Knight Piésold as part of the Lake and Peninsula Borough Wind Feasibility Study funded in Round 1 of the Renewable Energy Fund grant program. Igiugig's Round 6 application for a 100 kW wind system was not recommended for funding pending complete wind data, conceptual design and economic analysis. AEA also cited concerns that a Class 2 wind resource may not provide sufficient economics. (The feasibility study found a Class 3-4 resource, but the application used a capacity factor for a Class 2 project.)

PROFILE

High Penetration Wind-Diesel System in Kokhanok

A wind diesel project was completed and commissioned in 2010. Two 90 kW Vestas V-17 turbines supply 180 kW of wind to the existing 582 kW of diesel power in Kokhanok. One grid forming inverter stabilizes the grid with battery power and will allow the system to provide stable power with diesels off. The system includes 336 kWh of "nominal battery storage," one synchronous condenser which provides voltage excitation to the wind turbines when the diesel generators are off. The thermal electric heat recovery system and secondary load controls direct excess power from the wind to provide heat for the school complex. The school used 1,227 gallons less fuel for heat in 2011 than 2010. In future, the goal is to use excess generation for residential heating with electric heaters.

The project required a substantial power plant controls upgrade, and remote operations monitoring and control were added. Currently, the diesel generators run idle when the wind is blowing, which means they are using less diesel. When the generators were turned off in August 2012 as a test of the grid-forming inverter, the village was able to run off the wind and battery only for a few hours. The goal is to be able to run without the diesel generators at times (100).

Lake and Peninsula Borough required the contractor, Marsh Creek, to provide wind system operator training and a five-year O&M support package to ensure success of the project. Project Cost (without O&M): $1.94 million. According to the Tribal Administrator and Utility Manager, Nathan Hill, the wind turbines are performing better than predicted with capacity factors of 38.0% and 29.0%. As of February 2012, average power generation for the two turbines was 33.9 kW and 25.7 kW, and peak power of 115.5 kW and 117.2 kW from peak winds of 69 mph and 103 mph respectively. They have survived 13 events with winds over 100 mph and one event with gusting to 128 mph.

Challenges have included damage from high winds in December 2011 which destroyed the anemometer on one wind turbine and blew the cowling back on the other turbine. Clasps on cowling have now been modified to better withstand high winds. A problem with the American Semi-Conductor product has been addressed that caused delays to commissioning the battery bank, and operators have learned that hydraulic stations need more heat or need to be insulated. Both are being addressed (101).

Igiugig has funding through the Gordon and Betty Moore Foundation to install an array of 1.2 kW vertical axis wind turbines (VAWT) developed at the California Institute of Technology (see box on page 59). The small "wind spires" which can fit in the back of a pickup truck have not been deployed in the arctic before. A few will be installed in the community in summer 2013 to see how they do in arctic conditions. If the test is successful, the community could eventually install up to 60.

In working with the Community Partnership for Self-Reliance at UAF, Igiugig leaders were encouraged "not to put all eggs in one basket" by erecting one large 100 kW wind turbine. Having more than one smaller turbine provides redundancy. When a turbine is down for maintenance or repair, you are not back to relying only on diesel. Leaders are also trying to educate the community about wind power. UAF Bristol Bay Campus came out to offer a class that 10 people took. This summer the community is hosting a subregional training to install another 5 kW Skystream turbine. The emphasis is on educating themselves and making decisions for themselves. According to village council president, AlexAnna Salmon, they previously had grant applications put in by others on the community's behalf. They were always waiting to be told by others what to do, and sometimes that advice was conflicting (25).

KOLIGANEK

A feasibility study for a New Koliganek Wind Heat Recovery Project was funded in RE Fund Round 4 based on a wind resource analysis completed in 2006 (29). The final report from Marsh Creek was expected in early 2013. If the project is technically and economically feasible, the next stage will be the 65% design and to request funding for construction (46).

MANOKOTAK

A Wind and Heat Feasibility Study proposed by the local utility was recommended for funding in Round 6 of the AEA Renewable Energy Fund grants, but did not fall within the top tier of recommended projects (45). The utility proposed using Wind Atlas Analysis and Application Program (WAsP) from Denmark to further analyze current met tower data (which indicated a marginal Class 2 resource), investigate options for installing 3 to 4 more small met towers, and produce a conceptual design report in compliance with the Alaska Wind Program Guidelines.

NEW STUYAHOK

AVEC received an RE Fund Round 3 grant to complete a feasibility assessment for a 300 kW wind diesel project in New Stuyahok, including resolution of land and regulatory issues with the Alaska Department of Transportation and Public Facilities (ADOT&PF) over the proposed met tower site at the north end of the old runway. This land was expected to be a key area for the placement of wind turbines (29). AVEC is also planning to build an intertie to Ekwok which would enable the utility to tie in wind anywhere along the route. Site control is not expected to be a problem since land along the route is owned by the village corporations of New Stuyahok and Ekwok (47).

PILOT POINT

The City of Pilot Point received a RE Fund Round 3 grant for the feasibility, design, permitting, construction and startup of a wind farm and heat recovery boiler to be tied into the Pilot Point electrical grid. The wind farm is expected to have around a 100 kW capacity. Allocation of final design and construction funds are still to be awarded pending acceptance of the conceptual design report (CDR) by AEA. Problems with missing data and results inconsistent with previous studies have slowed the project. The grant was extended in Fall 2012 to allow assessment of other locations that show greater promise due to elevation and less distance from the ocean. Sites near the post office and the old wind farm appear to be promising based on three months of data. A third met tower will be installed in 2013 (29).

PORT ALSWORTH

A wind study was completed in 2011 by Knight Piésold as part of the Lake and Peninsula Borough Wind Feasibility Study funded in Round 1 of the RE Fund grant program. One site along the lake shore was selected as the only attractive site for a wind turbine in terms of both energy production and economics. From initial exploration, the community may be opposed to a turbine along the lake shore.

PORT HEIDEN

A wind study was completed in 2010 by Knight Piésold as part of the Lake and Peninsula Borough Wind Feasibility Study funded in Round 1 of the RE Fund grant program, and a Round 4 grant was received for a Port Heiden Wind Turbine Project & Power Distribution Upgrade. Currently the wind project is on hold at AEA pending conceptual design work for the diesel power plant and distribution system (45). According to the January 2013 Alaska Renewable Energy Fund Status Report, AEA has not accepted the findings in the Knight Piésold report, as the report does not address excess electricity generated from the wind-diesel system, and AEA believes the report significantly overestimates the benefits of a construction project (29).

TOGIAK

AVEC studied wind potential in Togiak through a RE Fund grant and determined that due to the number of Native allotments in the study area, site control would likely increase the timeline for developing a wind project. If an intertie is built to Twin Hills it would open up alternative energy such as wind along the route (48).

Issues

- There is a Catch 22 for rural Alaska communities wishing to develop wind energy. The wind projects recommended to be most economically feasible are not yet completely technologically feasible. While larger turbines appropriate for the Railbelt are fully commercial, integrated wind-diesel systems suitable for village microgrids range from commercial to early-commercial depending on level of wind penetration[6] (3).

  Many of the feasibility studies completed in the region recommend medium to high penetration systems as the most or the only economic option. Turbines in the 100 to 300 kW range provide lower cost power per kWh, displace more diesel, and generate excess energy when the wind is blowing that can be used for space and hot water heating.[7]

  However, the operational complexity of the system increases as the amount of wind energy increases compared with the load. Higher penetration systems require more sophisticated and expensive control systems to monitor and control power quality (49). Wind systems integrate more easily with hydro than diesel generation, as is being done in Kodiak.

  In island systems there is also no readily available market for excess power. In high wind locations it is a challenge to find cost effective ways to store or dispatch extra wind energy so that it can be put to use reducing diesel consumption rather than being dumped. Excess electrical energy can be stored (in batteries or high temperature bricks) or dispatched as a secondary load to an electric boiler or heat recovery loop, but these increase the cost and complexity of the system. Even in feasibility studies for projects that assume benefits from reducing thermal loads, cost estimates and technology recommendations are not well

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[6] The average annual penetration level is the amount of energy that will be produced by the wind turbine in a year divided by the annual load (the total amount of energy consumed by the community in a year). See Table 17.

[7] The 2007 study of wind project economics led by Peter Crimp found only a small incremental benefit for the additional cost and complexity of the medium and high penetration scenarios. Based on the results of HOMER model runs, the study concluded that the potential incremental benefit of medium or high penetration might be 2 cents per kWh for systems where the cost of electricity might be in the 22-32 cents per kWh range (54).

documented or are simply missing. There needs to be more information sharing on the solutions being tried in medium to high penetration wind-diesel systems elsewhere in rural Alaska.

Another difficulty in integrating wind into a diesel system lies in the fact that diesel generators generally have a narrow operating range for peak efficiency. Operating the generators at other than peak efficiency also results in higher operation and maintenance costs and generator wear. Unless a turbine generates enough power to allow the utility to shut down a diesel generator, savings resulting from diesel displacement will generally be low. The best option is to install the largest turbine possible so that adequate power is generated to displace a diesel turbine entirely (49). However, even in a high penetration system at least one diesel generator needs to be up all the time in order to keep the grid up (50).

Because of these issues, AEA recommends penetration levels no higher than 60%, and has found that with medium penetration levels (20 to 50%) a lot of performance issues can be avoided. This contrasts with the recommendations of feasibility studies completed by Dames and Moore[8], TDX Power[9], and Knight Piésold & Co.

- Because of the remoteness of many rural Alaska villages, most of the capital costs come from having to transport personnel, materials, components, and special construction equipment to the site. These factors and construction of transmission lines in remote areas result in a relatively high cost per installed kW for wind energy. There is an opportunity for cost savings if multiple wind turbines are to be installed in the region by combining shipment, mobilization, and construction activities (51).
- Most environmental concerns relate to potential impacts on birds. Often, coastal regions with good wind resources have strong bird populations, including the endangered Steller's Eider. Two general laws govern turbine impacts on birds, the Endangered Species Act and the Migratory Bird Treaty Act. At this point there is a limited amount data on the impacts of Alaska's current wind projects on local species and population (3).

Data Gaps

- **Medium and high penetration wind system performance and lessons learned.** In order to fully include thermal loads in benefic-cost models of wind projects, more details are needed on costs and performance of technologies already in use in diesel hybrid systems in rural Alaska, including the 500 kW high penetration systems operating on Saint Paul Island since 1999, the 90 kW system installed in Kokhanok in 2010, as well as the many hydro-diesel systems used to offset diesel for thermal loads in Southeast Alaska. This information should be readily accessible to contractors doing wind feasibility and design work in the

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[8] A 1999 Dames and Moore feasibility study for Naknek recommended installation of "the largest possible turbine for which capital funding can be obtained" and which can be installed using locally available equipment (88).

[9] The TDX power feasibility study prepared for Port Heiden in 2005 argued, "By sizing sufficient wind turbine generating capacity to have 'wind only' generation periods, as well as the simultaneous production of a beneficial thermal product, the high penetration design produces far greater total fuel avoidance, lower engine maintenance expense, and superior long-term total system operating efficiencies compared to the low and medium penetration system (88).

state. In lieu of cost estimates for specific technologies, a set of standard assumptions from AEA on modeling thermal loads would be useful.

Table 17: Wind Penetration Levels

Penetration Level	Operating Characteristics	Instantaneous	Average
LOW	Diesel runs full-time Wind power reduces net load on diesel All wind energy goes to primary load No supervisory control system	< 50%	< 20%
MEDIUM	Diesel runs full-time At high wind power levels, secondary loads are dispatched to insure sufficient diesel loading or wind generation is curtailed Requires relatively simple control system	50% – 100%	20% – 50%
HIGH	Diesels may be shut down during high wind availability Auxiliary components are required to regulate voltage and frequency Requires sophisticated control system	100% – 400%	50% – 150%

Source: (3)

Resources for Communities

ANEMOMETER LOAN PROGRAM

AEA's Anemometer Loan Program is aimed at communities with potential for utility-grade wind energy projects. This program supplies meteorological "met" towers, data logging equipment, and technical support to utilities and communities interested in wind power. After at least one year of data is collected the towers are then relocated to other communities. Such onsite met data allows for more precise modeling and feasibility studies and is often required by potential project funding sources. Funding for this program is from the Denali Commission and U.S. DOE (52). More information: www.akenergyauthority.org/programwindanemometerloan.html

Met towers are also available for loan from the Lake and Peninsula Borough to communities in the borough.

WIND FOR SCHOOLS

The Alaska Center for Energy and Power implements the national Wind for Schools program in Alaska. The program installs small wind turbines in rural elementary and secondary schools while developing Wind Application Centers (WAC) at higher education institutions. Teacher training and hands-on wind-related research tasks bring energy lessons into K-12 classrooms, while college students assist in the assessment, design, and installation of small wind systems in the host schools, preparing them for jobs in the energy sector. The program looks for participation from the host school, science teacher, school administration, community and local utility. The program is open to any school in the state who meets the success criteria (53). More information: www.uaf.edu/acep/alaska-wind-diesel-applic/wind-for-schools/

Emerging Technology

Vertical Axis Wind Turbines

The Wind Spires project being planned for Igiugig will seek to test whether small, vertical-axis wind turbines (VAWT) can produce more energy than conventional wind turbines and with less environmental impact. The main rotor shaft is set vertically and the main components are located at the base of the turbine. Among the advantages are that generators and gearboxes can be placed close to the ground, which makes components easier to service and repair, and that VAWTs do not need to be pointed into the wind.

While the turbines used in most standard wind farm projects can produce turbulence that decreases the output of the turbines downstream, the small, vertical-axis turbines are designed to create a wake that boosts the output of adjacent turbines if positioned strategically. In addition, the smaller turbines can be placed closer together without causing aerodynamic interference, are cheaper to produce, and are less likely to kill birds, according to John Dabiri, the California Institute of Technology professor who developed the turbines. He hopes the project in Igiugig, which could eventually grow to 70 turbines, can generate as much energy as the diesel generators currently used by the community (103).

SMALL SIZE AND EASY INSTALLATION

The rotor in this turbine system is 6 feet in diameter and 18 feet tall, with the airfoil blades arranged in three, 6-foot tall staggered vertical tiers. The small size makes shipping the system to many remote rural areas in Alaska easy and cheap. The small turbine size would also avoid many regulatory permitting restrictions due to zoning, environmental quality, visual impacts, public safety, etc., potentially increasing applications of these turbines. Some of these issues are particularly important in Alaska. For example, because of their small height and lower tip speed, vertical-axis wind turbines have less ice-throwing issues and have less impact on birds. They also interfere less with helicopter operations and radar making them attractive to the Department of Defense.

LOWER MAINTENANCE AND REPAIR COST

The system has a tier-rotor design with hierarchical modularity. Because the rotor can be configured with different numbers of rotor blades, the damage of a blade does not translate to loss of the entire wind energy system as in other wind energy systems. The system could be reconfigured on-site by simply removing or repositioning blades as needed to maintain the balance of rotational inertia.

OTHER CONSIDERATIONS

Vertical-axis wind turbines are not as efficient as conventional ones—half of the time the blades are actually moving against the wind, rather than generating the lift needed to spin a generator. And as the blades alternatively catch the wind and then move against it, they create more wear and tear.

While it might work well in isolated places where simpler construction and maintenance can offer big savings, the approach will require installing many more wind turbines to generate the same amount of power, and the wind industry has demonstrated that generally speaking making larger wind turbines lowers costs (102).

2 | Energy Efficiency & Conservation

Energy efficiency and conservation (EE&C) is a resource every community can take advantage of—one that offers significant savings on heating as well as electricity costs. Since space and hot water heating typically account for over 80% of home energy budgets (and around 50% of energy used in public and commercial buildings), EE&C improvements provide one of the best ways to address total energy costs—not just the cost of electricity which is already subsidized for rural Alaska residential customers and community facilities through the state PCE program.

Reducing energy demand through EE&C should be communities' first strategy in energy planning, since it provides both current savings through avoided fuel purchase, transportation and storage costs, and offers potential future savings by reducing or postponing the need for new capital investments in energy production.

Energy efficiency measures also act as an economic driver in Alaskan communities, while providing a quick payback on investment for building owners. Energy efficiency projects create more jobs in the economy than investments in some other energy projects do. There are approximately 7.8 jobs created for every $1 million spent on EE&C compared with only 2.6 jobs from the same investment in electrical power and 1.3 jobs from natural gas projects (54). Payback periods for EE&C investments can be as short as 4 months, while typical paybacks on new renewable energy generation are rarely shorter than 5 years (55).

Resource Inventory

The Alaska Statewide Housing Assessment estimated that there were roughly 4,500 housing units in the region in 2008. Compared to other rural areas of the state, the condition and availability of housing is above average (56).

Alaska has multiple programs to help individual homeowners, businesses, and local governments fund energy efficiency improvements. Total state funding for energy efficiency has grown from about $2 million in 2008 to over $300 million (54). Information on state and federal programs and eligibility requirements is included in the *Financing* section.

Past participation by Bristol Bay households and communities in residential and community energy audit programs is shown in Table 18. While AEA has a program to fund audits (but not retrofits) for commercial buildings, it is not commonly used in rural Alaska. AEA also provides audit assistance to fish processors. It is not known whether fish processors or other businesses in Bristol Bay businesses have taken advantage of these programs.

Project Economics

RESIDENTIAL ENERGY EFFICIENCY

Common home energy efficiency and weatherization measures typically save Bristol Bay households 27% to 29% on energy consumption, which translates into 300 to 450 gallons of fuel oil per home per year. Most of the energy savings is in home heating, although lighting efficiency upgrades result in some electrical savings. Statewide the average investment per home in the two programs is about $17,000. [10]

While there is no cost to the resident for participating in the Weatherization program, the average after-rebate investment by homeowners in the Home Energy Rebate program is $4,792. With annual cost savings averaging $1,464 statewide, the payback period for homeowners is 3.3 years (57).

[10] Total state cost is $30,000 per unit for weatherization services in rural Alaska when logistics, transportation, overhead, and health and safety measures are included. Home Energy Rebate costs are direct labor and materials.

Table 18: Participation by Community in Energy Audit Programs since 2008

	Residential Audits				Public Facilities Audits			
	HER "As-is" Audits (# Homes)	HER Rebates (# Homes)	HER Completion Rate	Weather-ization Program (# Homes)	VEEP (# Bldgs)	EECBG (# Bldgs)	AHFC Public Facility (# Bldgs)	ANTHC Water & Sewer[1] (# Bldgs)
Aleknagik				31		3	1	
Chignik					11			
Chignik Lagoon								
Chignik Lake				16			1	
Clark's Point						4		
Dillingham	45	16	37%	91		5		
Egegik						5	1	
Ekwok							1	
Igiugig				10				
Iliamna	1	1	100%	22				
King Salmon	12	5	45%	24				
Kokhanok				42	8			
Koliganek							1	
Levelock				20				
Manokotak[2]				58	3+		1	
Naknek	14	3	21%	36				
New Stuyahok				65				
Newhalen				37		4	1	
Nondalton				48			1	
Pedro Bay				13				
Perryville				33			1	
Pilot Point	1		0%					
Port Alsworth	9	3	33%				1	
Port Heiden	4	1	25%	21				
South Naknek				5				5
Togiak				20	8	7		5
Twin Hills							1	
Total	**86**	**29**	**35%**	**593**	**30+**	**28**	**11**	**10**

Sources: (58) (59) (60). Notes: 1/ ANTHC study funded building audits. Additional funding or local investment may be needed to finance recommended improvements. 2/ VEEP improvements in Manokotak included community-wide lighting upgrades.

Table 19: Average Residential EE&C Savings per Household in the Bristol Bay Region

	Pre "As-Is" Energy Audit (MMBTU)	Post Improvement Audit (MMBTU)	Annual Energy Savings (MMBTU/yr)	Estimated Fuel Oil Savings (gals/yr)	Estimated Cost Savings at $5.50/gal Fuel ($/yr)
Home Energy Rebates	223.1	162.3	60.8	437	$2,401
Weatherization	148.8	105.5	43.3	311	$1,710

Source: (58). Notes: Based on a sample of 37 homes. **BTU equivalents**: 1 MMBTU = 1,000,000 BTUs

Table 20: Average Residential EE&C Savings per Square Foot in the Bristol Bay Region

	Savings per Household All Bristol Bay Participants (MMBTU/yr)	Average Home Size Dillingham Participants (Square Feet)	Average Home Age Dillingham Participants (Year Built)	Estimated Energy Savings per Square Foot (kBTU/yr)	Cost Savings per Square Foot at $5.50/gal Fuel ($/yr)
Home Energy Rebates	60.8	2,195	1980	27.7	$1.07
Weatherization	43.3	1,583	1979	27.3	$1.08

Source: (58). Notes: Based on a sample of 37 homes. **BTU equivalents**: 1 MMBTU = 1,000 kBTU = 1,000,000 BTU

Average residential EE&C savings in the Bristol Bay region are shown in Table 19. The difference in energy use between homes in the HER and Weatherization programs (both before and after efficiency improvements) is largely due to house size (see Table 20).

House size comparisons are only available for Dillingham. In general, houses in the Home Energy Rebate program, which requires participants to be homeowners, are larger on average than houses served by the Weatherization program, which is open to both homeowners and renters with household incomes at or below median income. Once house size is accounted for, savings are nearly identical.

Based on the Dillingham sample, energy savings for both programs are 27 to 28 kBTU per square foot, for cost savings of $1.07 to $1.08 per square foot at $5.50 per gallon fuel oil. The average investment per home for the Bristol Bay region is not known, so the average payback period cannot be calculated Statewide the average EE&C investment per unit is $6 to $7 per square foot, but the number is likely higher in rural Alaska due to higher materials and labor costs.

NON-RESIDENTIAL ENERGY EFFICIENCY

The Village Energy Efficiency Program (VEEP) provides energy efficiency audit and upgrade services to Alaska communities with populations of 8,000 or less. Grants cover efficiency improvements in public and community buildings, including upgrades to the building envelope, domestic hot water, HVAC controls, heating, lighting, motors and pumps, and ventilation. The energy auditor assesses the best use of funding to achieve the highest energy savings. Bristol Bay participation by community in VEEP and the former Energy Efficiency and Conservation Block Grant Program (EECBG) program is included in Table 18. AEA has completed a few "whole village retrofits," but none in the Bristol Bay region so far.

Table 21: Benefits by Community of Village-wide Energy Audits

	VEEP/EECBG Annual Savings					
	Savings ($/yr)	Diesel (gals/yr)	Equivalent MMBTU/yr	Electricity (kWh/yr)	VEEP/EECBG Cost ($)	Simple Payback (yrs)
Aleknagik	$18,388	3,325	493	8,784	$21,748	1.2
Chignik	$24,463	3,256	561	31,591	$72,277	3.0
Clark's Point	$4,479	0	28	8,143	$11,460	2.6
Dillingham	$52,288	9,304	1,295	0	$148,590	2.8
Egegik	$6,790	0	29	8,595	$12,439	1.8
Iliamna						
King Salmon						
Kokhanok	$27,313	3,332	468	1,248	$53,865	2.0
Manokotak	$36,023	2,934	525	34,289	$87,983	2.4
Naknek						
Newhalen	$8,110	1,178	171	2,111	$20,029	2.5
Port Alsworth						
Port Heiden						
Togiak	$52,006	4,063	738	50,455	$135,572	2.6
Total	**$229,860**	**27,392**	**4,309**	**145,216**	**$563,963**	**2.5**

Source: (59)

Savings for efficiency improvements to non-residential buildings average 30% statewide, although there is some variation based on building type. The VEEP program has resulted in a $3 return for every $1 invested statewide, with a 3.8 year simple payback (57). Estimated savings from VEEP and EECBG investments in Bristol Bay communities are shown in Table 21.

ENERGY EFFICIENT LIGHTING

Electrical efficiency measures such as lighting retrofits generally have shorter payback periods than other building efficiency measures. After one whole village retrofit, AEA saw a total energy savings of 1% to 4% in the community just by looking at lighting improvements. Bristol Bay communities that received energy efficient lighting upgrades in multiple buildings through the VEEP and EECBG programs had average savings of around $1,300 per building at a cost of $2,500 per building.

Table 22: Savings from Energy Efficient Lighting Upgrades in Bristol Bay Region

Average Investment per Building	Average Savings per Building	Average Energy Savings per Building	Simple Payback Period
$2,521	$1,310/year	2,409 kWh/year	1.9 years

Notes: Means calculated from AEA data with highest and lowest data points discarded.

LED street lighting is highly efficient compared to conventional street lights. With only two communities receiving street lighting retrofits as part of VEEP and EECBG audits, there is potential for additional savings in this area.

Table 23: Savings from LED Street Lighting Retrofits by Community

	Total Investment	Annual Savings	Energy Savings	Simple Payback
Clark's Point	$4,600	$2,621/year	4,765 kWh/year	1.8 years
Manokotak	$24,280	$6,538/year	11,887 kWh/year	3.7 years

Notes: Means calculated from AEA data with highest and lowest data points discarded.

ANTHC WATER AND SEWER / PUBLIC FACILITIES

Sanitation systems are one of the single largest energy uses in rural communities, accounting for 10% to 35% of a community's energy use. Alaska Native Tribal Health Consortium (ANTHC) estimates that for every $1 spent on energy retrofits of rural sanitation facilities (including the cost of audits), there will be a 50 cent return each year to communities plus a 50 cent annual return to the State's operating budget through lower PCE payments.

ANTHC performed energy audits of public facilities in at least two Bristol Bay communities (Togiak and South Naknek) as part of its study of energy use in rural Alaska sanitation systems. Average savings to communities and the state based on audits in 40 rural communities are shown in Table 24. ANTHC estimates another 40 communities could benefit (61).

Table 24: Savings per Community from Water and Sewer Efficiency Measures

Cost of Audit	Estimated Investment[1]	Annual Savings[1] to Community	Annual Savings in PCE Costs to State[1]	Simple Payback
$17,500	$31,896	$9,847/year	$8,067/year	1.8 years

Source: (61). Notes: 1/ Does not include heat recovery.

Table 24 does not include potential savings from heat recovery, which will not be practical to install in every community. Because sanitation facilities can use low-quality recovered heat to warm large volumes of stored and circulation water, heat recovery systems offer even more efficiency for sanitation facilities than they do for other public facilities. While heat recovery projects require a substantial initial investment in material and labor, they result in significant savings to communities where they are appropriate.

Estimating Residential EE&C Savings and Potential

Estimates for regional energy savings from residential EE&C measures are shown in Table 25. HER and Weatherization measures already completed or planned for 2013 will account for over 27,000 MMBTU annually in energy savings, based on average savings for the Bristol Bay region (see Table 19). Additional potential for residential EE&C could save another 75,000 MMBTU per year, assuming all older, eligible homes participate in an EE&C program. If HER completion remains at 35%, only about 43,000 MMBTUs in additional energy savings would be achieved. The lack of data on public and commercial buildings (including number, type and square footage) in the region makes it difficult to estimate non-residential energy savings potential.

Table 25: Estimated Energy Savings and Potential from Residential EE&C

	Occupied Housing Units (2010 Census)	HER Rebates (2008-Apr 2013)	Weather-ization Projects (2008-13)	New BBHA Homes Completed or Planned (2008-14)	Estimated Additional EE&C Potential[1] (# Homes)	Estimated Energy Savings 2008-13 (MMBTU)	Additional Energy Savings Potential (MMBTU)
Aleknagik	71		31	6	32	1,342	1,341
Chignik	41		-	6	29	-	1,575
Chignik Lagoon	29		-	-	23	-	1,615
Chignik Lake	27		16	5	5	693	224
Clark's Point	24		-	-	22	-	1,184
Dillingham	855	16	91	3	516	4,913	29,934
Egegik	29		-	-	28	-	1,335
Ekwok	37		-	6	28	-	1,493
Igiugig	16		10	6	0	433	-
Iliamna	39	1	22	-	13	1,013	761
King Salmon	157	5	24	-	73	1,365	3,953
Kokhanok	52		42	3	7	1,819	155
Koliganek	55		-	-	44	-	2,651
Levelock	27		20	-	6	866	152
Manokotak	121		58	-	59	2,511	2,648
Naknek	231	3	36	-	142	1,743	8,295
New Stuyahok	114		65	10	36	2,815	1,344
Newhalen	50		37	-	11	1,602	313
Nondalton	57		48	-	9	2,078	173
Pedro Bay	19		13	-	5	563	123
Perryville	38		33	6	0	1,429	-
Pilot Point	27		-	-	24	-	1,246
Port Alsworth	44	3	-	-	26	182	1,562
Port Heiden	35	1	21	5	6	970	269
South Naknek	35		5	-	26	236	1,307
Togiak	231		20	-	192	866	9,821
Twin Hills	29		-	-	26	-	1,268
Total	**2,490**	**29**	**593**	**56**	**1,387**	**27,440**	**74,739**

Sources: Data from U.S. Census Bureau, AHFC, BBHA, and Alaska CDC. Notes: 1/ Based on low-moderate income (LMI) and home ownership rates. Assumes HER completion rate of 100%.

Issues

Estimating energy use and potential savings for heating and transportation is challenging due the lack of data on current fuel consumption. Most local governments operate multiple facilities and purchase fuel for a variety of buildings and vehicles. They do not usually account for individual building energy use, and fuel metering is rare. This limits the potential accuracy of the community-reported data used in many audits.

There is not a good mechanism for funding energy efficiency projects in high energy-consuming sanitation facilities, according to ANTHC. Many rural utilities have poor credit and lack the administrative capacity to acquire loans through AHFC Energy Efficiency Revolving Loan Fund. Communities that have completed retrofits have largely done so with nontraditional funding sources (61).

Data Gaps

- **Age, condition, and energy rating of the housing stock in the region**. American Survey Community data published by the U.S. Census Bureau on housing age and size is not accurate enough for planning purposes, given the huge margins of error for small rural Alaska communities. The Alaska Community Development Corporation and the Bristol Bay Housing Authority, which provide weatherization services in the region for AHFC's Weatherization Program, have this data on the homes they provide assistance to, but not for each community as a whole. An updated statewide housing stock assessment is due out in 2013 from the Cold Climate Housing Research Center, which will provide updated housing characteristic data on a regional basis, but is not expected to have community-level data.
- **Non-residential energy savings potential**. While there is not good data on the non-residential building stock in rural Alaska, there is data on how non-residential buildings behave in general that could be used to model non-residential energy consumption. There is potential in this area and existing programs to apply (13).
- **Energy use in community health clinics**. The region's three school districts track energy use in their buildings, and the Bristol Bay Area Health Corporation tracks energy consumption for the hospital at Kanakanak, but no one in the region is collecting energy used in village clinics from the individual tribes who own clinic buildings. Starting to track this data on a regional basis would facilitate energy planning. Clinics are important energy end users in each community, and at least one Tribal administrator believes energy efficiency has not been a high enough priority in the design of new clinics.
- **Saturation rates for specific energy efficiency technologies** like thermostats, water heaters, and lighting.
- **Street lighting inventory**. It would be useful for regional planning to know the type and approximate number of street lighting in each community. Some data may be available from the AEA End Use Study but it is not included in appendices published online.
- **Heat recovery inventory for water and sewer systems.** In order to identify on a regional basis the highest priorities for efficiency upgrades to community sanitation systems, it would be useful to know which communities already have heat recovery systems that serve sanitation facilities or have the potential to do so. It may be possible to compile this information by working with AEA staff to locate the data or by contacting building operators.

Resources for Communities

WWW.AKENERGYEFFICIENCY.ORG

The Alaska Energy Authority's energy efficiency website at www.akenergyefficiency.org has a wealth of information and online resources for communities, as well as educators, businesses, and households.

3 | Fossil Fuels

Bulk Fuel

Fuel oil and gasoline prices have been a point of considerable attention and contention in rural Alaska for many years. The challenges of delivering and storing fuel in remote locations are significant and substantially increase energy costs in the region. Fuel costs are tied closely to crude oil prices, which are set on a global market. While the market price (the price paid at the refinery) cannot be influenced by local, regional or state actions, two options exist to lower the cost of fuel oil and gasoline and thereby lower the cost of energy in Bristol Bay communities: lower storage and transportation costs.

Bulk Fuel Upgrade Program

Upgrading bulk fuel facilities reduces the cost of storing fuel by replacing leaking tanks and reducing the risk of future tank and equipment failure. Bringing these facilities into compliance with federal and state regulations also makes them safer and more reliable. With the help of federal funding from the Denali Commission, AEA has completed over 70 bulk fuel upgrade projects, at a cost of over $200 million, through the Bulk Fuel Upgrade program. The agency plans to complete projects in over 30 more communities. (Communities served by AVEC are not part of AEA's Bulk Fuel Upgrade Program.) See Table 30 on page 75 for the status of tank farm upgrade projects in the region.

Project Notes

IGIUGIG

Erosion at the Kvichak River adjacent to the Igiugig tank farm needs to be addressed (13).

PORT ALSWORTH

Bulk fuel tanks and infrastructure upgrade design and construction is at the top of AEA's list of projects to be addressed next.

NEWHALEN

INNEC Bulk Fuel Project. Fully funded for new gen-sets and bulk fuel tanks.

PERRYVILLE

Perryville Bulk Fuel Project: Fully funded for construction of bulk fuel tanks and infrastructure.

PORT HEIDEN

Port Heiden Bulk Fuel Project: Fully funded for construction of a small piping project. In the next few years, the Port Heiden tank farm will need to be re-located due to the severe shoreline erosion (30 to 50 ft. per year) (13).

SOUTH NAKNEK

Currently fuel is purchased from a private tank held by a fish processing company. A recent public facilities audit by ANTHC noted that the fuel tank has been deemed unfit for storage due to environmental concerns and the community will acquire its fuel from Naknek across the river, making fuel both more expensive and less convenient (62).

Bulk Fuel Purchasing Group

A second way to lower the cost of fuel purchased in the region is to form a bulk fuel purchasing group in order to consolidate community fuel orders and increase the incentive of fuel vendors to lower the transportation component of fuel prices. In 2012, Information Insights surveyed tank farm owners in the region on behalf of BBNA to evaluate the potential and interest in a regional or subregional purchasing group. Table 26 shows aggregate fuel requirements of communities who expressed interest in a bulk fuel purchasing group (63).

Table 26: Fuel Requirements of Interested Entities by Subregion

Subregion	#1 diesel (gals)	#2 diesel (gals)	ULSD (gals)	Avgas (gals)	Gasoline (gals)	Propane (gals)	Total (gals)
Kvichak Bay	215,025	54,000	86,005		58,525	2,000	415,555
Nushagak Bay	319,889				40,000		359,889
Togiak Bay	291,896						291,896
Peninsula	158,213						158,213
Iliamna Lake	111,106			10,000	16,300	300	137,706
Total	**1,096,129**	**54,000**	**86,005**	**10,000**	**114,825**	**2,300**	**1,363,259**

Source: (63)

Most of the interest in a bulk fuel purchasing group came from local governments, school districts, and village utilities who are not already part of a purchasing group. Of those who said they were not interested, some cited assumptions about a purchasing group that might not be accurate depending on the model chosen for a group. If specific details for a purchasing program are worked out, additional outreach may attract additional interest. A larger purchasing group should be able to negotiate lower transportation costs and better contract terms.

Table 27: Interest in Bulk Fuel Purchasing Group by Subregion

Subregion	Fuel Buyers Interested in the Concept of Pooling Bulk Fuel Purchases
Kvichak Bay	Levelock Village Council, City of Pilot Point, City of Port Heiden, Lake and Peninsula School District
Nushagak Bay	Aleknagik, City of Clark's Point, Koliganek Village Council, Southwest Region School District
Togiak Bay	Southwest Region School District, Togiak Natives Ltd.
Peninsula	Chignik Lake Village Council, Perryville Village Council, Lake and Peninsula School District,
Iliamna Lake	Kokhanok Utility, City of Newhalen, Pedro Bay Village Council, Lake and Peninsula School District, Alaska's Fishing Unlimited

Source: (63)

Project Economics

BULK FUEL PURCHASING GROUP

Due to the many factors that go into the transportation component of the delivered price of a gallon of fuel and the unwillingness of fuel suppliers to theorize about potential savings, it is very difficult to estimate how much savings might be realized by a Bristol Bay purchasing group. Based on the experience of other purchasing groups and the opinions of vendors, modest savings are available from consolidating purchases at either the regional or subregional level. Additional savings are likely to be achieved through reduced administration costs for buyers and vendors (63).

The volume of fuel purchased in 2011-12 by entities interested in a Bristol Bay purchasing group would be sufficient to save the group money even if the deliveries are spread across the region. Though fuel vendors generally calculate the delivered price of fuel on a case-by-case basis and do not publish price breaks, according to Delta Western, there are increased efficiencies at several volume thresholds from as low as 3,000 to over one million gallons.

A purchasing group operated by the Norton Sound Economic Development Corporation (NSEDC) CDQ group consolidated 1.05 million gallons of diesel and 500,000 gallons of gasoline on behalf of local communities in 2012. While it does not know how much it would have paid for fuel without consolidating, it believes the savings are significant. NSEDC cites the fact that 95% of those who need to buy bulk fuel in the Norton Sound region do it through NSEDC because they believe it provides the best possible price.

A 2007 study by Northern Economics put together an average volume discount schedule from interviews with a number of fuel suppliers. It shows savings ranging from 5 to 25 cents per gallon when you move up in quantity from under 5,000 gallons to over 100,000 gallons. While no higher volumes were listed in the schedule, the experience of purchasing groups and the comments of major fuel suppliers indicate that additional savings are available on orders exceeding one million gallons.

Because it is hard to say how large the savings for participants might be, it's important to keep the program costs and barriers to participation low and to follow the best practices established by other successful bulk fuel purchase programs.

Issues

As the region replaces diesel gen-sets, heavy equipment, and on-road diesel vehicles, it will increasingly have to use Ultra Low Sulfur Diesel (ULSD) instead of Low Sulfur Diesel. It is possible that fuel providers will switch entirely to ULSD, even though it is not required for heating purposes. Communities will need to address the issue of dedicated ULSD storage. (13)

Everts Air provides the only air delivery service for fuel. The service is both a resource and a risk for communities that receive it, since Everts' small DC-6 fleet is aging and expensive to maintain. Port Alsworth reports that Everts is increasingly less available to deliver fuel on a schedule that works for the community. Communities that rely on fuel delivery by air may be forced to change their fuel purchasing methods by ordering larger quantities for barge delivery in fall or spring, increasing tank farm capacity if needed, or finding other alternatives to air delivery (13).

Data Gaps

More information from regional fuel providers would help assess the need for dedicated ULSD storage. (13)

Resources for Communities

RURAL ALASKA FUEL SERVICES (RAFS)

Rural Alaska Fuel Services is a nonprofit organized to contract for the operation and maintenance of rural Alaskan bulk fuel storage facilities constructed by the Denali Commission. A condition of the Denali Commission grants is that the newly constructed tank farms be maintained and operated in accordance with all applicable state and federal regulations. RAFS offers a variety of financial service to its customers. Utility Accounting and Finance services include records retention, billing and collections, budgets and planning, and pricing analysis. RAFS' Power Cost Equalization Training and Assistance services include regular courses for utility clerks and managers, and assistance with reporting compliance. Find more information at www.rafs.net or contact Terri Harper at (907) 562-0285.

DIESEL EFFICIENCY & HEAT RECOVERY

Diesel generation accounts for 92% of the electricity produced by the region's utilities. Considerable energy savings are possible through improving system efficiency and waste heat recovery and thereby reducing the cost of buying, shipping and storing fuel. Every community can benefit from efficiency measures regardless of access to renewable resources.

Resource Inventory

RURAL POWER SYSTEMS UPGRADE (RPSU) STUDY

Selected data for Bristol Bay communities from the Community Survey conducted as part of the 2012 Rural Power Systems Upgrade (RPSU) Study are included in Table 28 and Table 29. Analysis and the recommendations have not yet been released.

Table 28: Diesel Efficiency Metrics by Community

Utility/Community	Diesel Efficiency (kWh/gal)	Generator Condition	Load Sizing/ Imbalance	Load Imbalance	Operator Proficiency
Naknek-King Salmon-South Naknek	15.53	n/a	n/a	n/a	n/a
Dillingham-Aleknagik	14.81	n/a	n/a	n/a	n/a
Togiak	13.58	C/C/C	Good	<10%	A/A/A/A/A
Chignik	13.56	C/A/A	Undersized	10-25%	A/C/A/C/B
New Stuyahok	13.29	C/C/C	Good	<10%	B/B/C/C/C
AEA Benchmark	*13.00*				
Perryville	12.79	C/C/C	Good	10-25%	C/C/C/C/C
Iliamna-Newhalen-Nondalton	12.78 (diesel kWh)	C/C/C/C	Good	<10%	C/B/B/C/C
Manokotak	12.73	C/C/C/C	Good	10-25%	B/B/B/B/B
Ekwok	12.37	C/C/C	Good	10-25%	A/A/B/B/B
Port Alsworth	12.20	C/C/C	Good	10-25%	B/C/C/C/C
Levelock	12.18	A/A/A	Good	10-25%	A/A/B/B/C
Igiugig	11.87	A/A/A	Good	10-25%	B/B/B/B/B
Pilot Point	11.38	A/A/A	Good	>25%	B/B/A/B/B
Kokhanok	11.24	A/A/A/A	Good	>25%	A/A/B/B/B
Pedro Bay	10.90	C/C/C	Good	<10%	B/C/C/C/C
Egegik	10.89	A/A	Good	10-25%	A/A/A/A/B
Chignik Lake	10.81	D/D/D/C	Good	>25%	D/B/A/C/D
Chignik Lagoon	10.01	C/C/C	Oversized	10-25%	B/A/B/C/D
Koliganek	9.96	C/D	Good	10-25%	B/B/B/C/C
Twin Hills	8.76	C/C	Good	10-25%	C/C/B/C/C
Clark's Point	n/a	C/C/C	Good	10-25%	C/C/C/C/C
Port Heiden	n/a	D/A	Good	>25%	A/C/C/C/B

Sources: (64) (65). Notes:
Diesel Efficiency: Port Heiden: Missing kWh reports 8 months. Twin Hills: Missing kWh reports two months.

Generator Condition: A=Good, like new, C=Fair, D=Poor, guards/covers missing for each generator installed

Operator Proficiency: A=Excellent, B=Good, C=Acceptable, D=Unacceptable for:
Meter Reading/Daily Logs/Routine Maintenance/Scheduled Maintenance/Maintenance Planning

Table 29: Waste Heat Recovery by Community

	Waste Heat Recovery Operational	BTU/hr Meter	Current Users	Additional Waste Heat Available	Potential New Users
Chignik	✓			Yes	
Chignik Lagoon	✓		School	No	
Chignik Lake	✓		School	No	
Clark's Point	✓			No	
Egegik				No	
Ekwok				n/a	
Igiugig	✓	✓	Pump house, clinic, store, rec house	No	
Iliamna-Newhalen-Nondalton	✓	✓	Office	Yes	School
Kokhanok	✓			No	
Koliganek	✓		Garage, Office	No	
Levelock	✓	✓	School	Yes	Community bldg.
Manokotak	✓	✓	Two shops	No	
New Stuyahok	✓		AVEC tool shack and bunkhouse	No	
Pedro Bay				n/a	
Perryville	✓	✓	School	No	
Pilot Point	✓	✓	School	Yes	City, tribal offices
Port Alsworth	✓		School	Yes	Port Alsworth Improvement Co.
Port Heiden	✓		Fire Dept., VPSO	No	
Togiak	✓		AVEC tool shack, bunkhouse, and Gen-set #4 module	No	
Twin Hills		n/a		Yes	

Source: (65) Notes: Data currently not available for communities served by Naknek Electrical Association (Naknek-King Salmon- South Naknek) and Nushagak Telephone and Electric Cooperative (Dillingham-Aleknagik).

Table 30: Energy Infrastructure Upgrades by Community

	Powerhouse Upgrades	Heat Recovery	Bulk Fuel Upgrade[1]	Docks/Landing[1]
Aleknagik	No Power Plant		2003	
Chignik	2008		2002	2004
Chignik Lagoon	*Pending*		Completed	
Chignik Lake	2004 Improvements		1999	
Clark's Point	*Pending*		2005	
Dillingham	2007	2013 Feasibility		
Egegik	2013 Construction		2003	
Ekwok[2,3]			2009	
Igiugig	2011		2003	2013
Iliamna	*Pending*		No Fuel Storage	*Pending*
Kokhanok	2004		2003	2013
Koliganek	2013 CDR	2013 Feasibility	2011	
Levelock	2010		2010	
Manokotak	2005		2001	
Naknek - King Salmon - South Naknek[2]			*Pending*	
New Stuyahok[2,3]	In Design (AVEC) Pending Wind & Intertie Studies	2013-14 Design & Construction	2012	?
Newhalen[2]	2012	2013 Feasibility	*Pending*	*Pending*
Nondalton[2]			*Pending*	
Pedro Bay	2005, 2013		2004	*Pending*
Perryville	2014 Construction		2014 Construction	2013
Pilot Point	2008		2008	
Port Alsworth	*Pending*		*Pending*	
Port Heiden	2013 Update CDR		Completed	
Togiak[2,3]	In Design (AVEC)	2013 Construction	?	
Twin Hills	2013 CDR (RPSU + intertie option)		2011	

Sources: (2) (66). Notes: 1/ Some dates are project close-out dates and may not reflect when upgrades were completed. 2/ Communities served by AVEC or connected by intertie are not part of AEA's RPSU Program. 3/ Communities served by AVEC or connected by roads are not part of AEA's Bulk Fuel Upgrade Program.

Project Notes

DILLINGHAM-ALEKNAGIK

A feasibility study is being discussed this year to access the opportunity of using waste heat during the summer to make ice for the fishing fleet. AEA is working with the Southwest Alaska Municipal Conference.

EGEGIK

Power plant upgrade is fully funded and will be installed in summer 2013.

EKWOK

The community of Ekwok joined AVEC in 2011, and modifications to the existing power plant have been done to meet AVEC and federal standards, though more work is needed for it to function as a standby plant once an intertie to New Stuyahok is constructed (67) (48).

ILIAMNA-NEWHALEN-NONDALTON

INNEC has been prioritized for a feasibility study in 2013 to access opportunities to use waste heat or excess energy for space heating.

KOLIGANEK

Conceptual design planning for a power plant upgrade is starting in 2013. AEA program managers will look at all energy resources available to the community and will assist the community in locating funding. A feasibility study to identify opportunities to use waste heat for space heating will be completed at the same time.

LAKE ILIAMNA COMMUNITY BARGE LANDING DESIGN

The Lake and Peninsula Borough received SAFETEA-LU funding through the Denali Commission for design and construction of barge landing infrastructure for multiple communities on Lake Iliamna. The goal was to create a construction template suitable for lake conditions at all community sites. Nondalton and Levelock needs will likely be met with the design templates developed for the lake communities.

NEW STUYAHOK

Work has been done on a concept design report for a proposed power plant upgrade for New Stuyahok. A new community tank farm and an AVEC tank farm were built in 2012. The AVEC tank farm containment has been sized to accommodate an additional tank to serve Ekwok after a tie line is constructed (67) (48).

A heat recovery feasibility study was completed in 2012, and the Southwest Regional School District received Round 6 RE grant funding for design and construction to provide recovered heat from the existing AVEC power plant for heating the adjacent New Stuyahok High School. The project is scheduled for 2013-2014.

PERRYVILLE

Perryville’s existing power generation infrastructure is aging, and in need of phase balancing and other repairs. The existing power plant building is in very poor condition and is not suitable to receive new gen-sets or controls. The community may be funded in 2014 for a power plant upgrade (37).

PORT ALSWORTH

Infrastructure plans including moving and upgrading the power house and adding at least one wood-fired boiler to the new “energy building” (10). The community is also slated for a bulk fuel tank farm upgrade.

PORT HEIDEN

The Port Heiden distribution network is in poor condition. AEA program managers are working with the community in 2013 on a conceptual design for a power plant distribution project that could include a wind power component if the wind resource looks good. Based on that work, they will revise the 2006 CDR, and could do final design in 2014 and construction in 2015.

TOGIAK

Design and construction funding was awarded to Southwest Region School District in RE Fund Round 5 to construct a heat recovery system to connect recovered heat from AVEC’s generating station to the water treatment plant, clinic, police station, City Office, and the “Old School” Community Activity Building. Construction is scheduled for 2013.

AVEC has also received funding for a CDR for a power plant upgrade in Togiak to include continued heat recovery and a new tank farm site to serve the plant. AVEC is also developing a business plan for a new community bulk fuel facility with proper containment and sufficient storage to serve community needs. The total costs for all projects is estimated to be $14.5 million (2013 dollars).

TWIN HILLS

Improvements to Twin Hills’ power plant and distribution system are pending through the RPSU program. AEA is also completing conceptual design work for a 3.8 mile intertie with Togiak to be completed in 2013. Preliminary results indicate an intertie would provide cheaper power and be more economically feasible (68). AVEC’s concept designs for its power plant upgrade in Togiak will include an option for a larger power plant that could serve both Togiak and the Twin Hills area if an intertie is deemed feasible (48). In that scenario, Twin Hill’s plant will serve as a standby unit.

Issues

AEA program managers offered the following observations and recommendations to increase system efficiency (68) (69):

- Maintenance is a key issue. The efficiency of a new generator or diesel power plant declines quickly if not maintained.
- SCADA software systems are included on all power plants installed since 2004 allowing remote monitoring to identify maintenance and performance issues. Remote site monitoring on a regional or subregional basis can save energy. The Bering Strait school district has one employee who watches all school systems and contacts schools when there is an issue.
- Education and training are very important, so turnover is a big issue. AEA educates local operators on the systems they have, but knowledge can be lost through operator turnover.

AEA operates a circuit rider program to assist local operators and keep education and training current.

- Energy savings and cost reductions are available by taking a more holistic approach to a community's energy needs and resources and combining projects, such as power house and tank farm upgrades, when possible. Heat recovery systems are included in every power plant upgrade project. AEA works with renewable resource managers when designing power and bulk fuel upgrade projects.
- There are a lot of fuel additives available but it is not clear whether they help with engine efficiency. It is up to a community if they want to try them. ACEP is looking into the efficiency of fuel additives.

Data Gaps

- **Load modeling data for communities**. AEA does extensive community load modeling when designing power plant upgrades and bulk fuel projects, including space heating loads at larger community buildings. It would be helpful if more raw data were available to regional energy planners. CDR reports include only brief summary tables.
- **Bulk fuel tank capacity for all communities**. There are gaps and inconsistencies in data available from the Denali Commission project reports and the DCRA community database online.
- **Rural Power Systems Upgrade survey analysis and recommendations**. This information is expected soon and will be useful to regional energy planners and local utilities.
- **The age of diesel generators**. Genset age influences diesel efficiency, but the profiles of generators included in the RPSU Community Survey data does not list the year individual generators came online. They do list hours of operation for each generator.

Resources for Communities

See *Financing* (page 60) for more information on the Rural Power System Upgrades Program and the Bulk Fuel Upgrades Program.

AEA CIRCUIT RIDER / EMERGENCY RESPONSE SERVICES

AEA's Circuit Rider/Emergency Response program provides on-site assistance and training to local operators in the daily operation and maintenance of their powerhouse, as well as on-call, as-needed emergency action response to mitigate extended power outages and electrical hazards that present imminent threat to life or property. It provides funding for procurement of manpower, materials and equipment for emergency response to electrical generation and distribution system emergencies and disasters in Alaska. Emergency response is provided on an as-needed basis only. Well-managed utilities with adequate technical and financial resources are not candidates for these services. More information: Contact: Kris Noonan at (907) 771-3061 or go to www.akenergyauthority.org/programsenergysystemupgrade.html (70)

AEA TRAINING

AEA trains local residents to manage and operate rural energy infrastructure. Training is available for bulk fuel operators, power plant operators, advanced power plant operators, and hydroelectric plant operators. More information: Contact Jessica Stolp at (907) 771-3026 or go to www.akenergyauthority.org/programtraining.html

Natural Gas

Natural Gas is currently one of the most important energy resources in Alaska, providing 57% of the state's total power requirements in 2010. The natural gas basin in Cook Inlet provides nearly all of the Southcentral Railbelt's energy needs, and the vast natural gas reserves on the North Slope are used locally to a limited extent.

While the ultimate resources available to Alaska are largely stranded, the vast quantity of North Slope known reserves, 35 trillion cubic feet (other forecasts range into the hundreds of trillions of cubic feet and even higher when accounting for shale gas, tight gas, and hydrates), will likely be accessed in the future.

In 2013 the Alaska Legislature passed two major pieces of legislation supporting large-scale natural gas projects: HB 4 and SB 23. The legislation provided organizational and financial structures for pursuing natural gas projects stemming from the North Slope to service residents in the Railbelt with some consideration for Interior and coastal Alaska.

Opportunities for developing natural gas reserves are also being explored at several other locations in the state. In 2012 the Alaska Legislature passed SB 23, a generalized tax credit bill with incentives for oil and gas production and storage in "Frontier Basins." Both the Egegik Basin in the Bristol Bay region and the Port Moller basin further south on the Alaska Peninsula are two potential locations for exploration (71).

Compared to other fossil fuels, natural gas and propane offer the prospect of clean, low cost energy for Alaska communities if affordable transportation, storage and distribution systems can be worked out. The City of Unalaska is considering options for importing LNG from outside Alaska. The All Alaska Energy Project envisions a statewide solution that uses High Voltage Direct Current (HVDC) transmissions lines to deliver electricity throughout the state from large-scale natural gas generation on the North Slope (72) (73).

There have been historical attempts exploring the feasibility of propane distribution throughout rural Alaska including the Alaska North Slope Propane Project led by the Alaska Natural Gas Development Authority and the Alaska Gasline Project led by the Alaska Gasline Port Authority. Propane is a byproduct of natural gas processing. Large-scale production of natural gas in Alaska would create more relatively cheap propane for in-state use.

The Southwest Alaska Municipal Conference has led discussions with its membership on taking a look at new natural gas and propane opportunities that may open up as Arctic shipping lanes expand.

Resource Inventory

The U.S. Geological Survey has estimated that the Alaska Peninsula has a 1-in-20 chance of containing 447 million barrels of oil and 1.4 trillion cubic feet of gas (74). The State of Alaska opened up waters in the Bristol Bay basin made up of both state- and Native-owned lands to oil and gas exploration in 2005. No wells have yet been drilled. Exploration licenses have a term of 10 years and can range from 10,000 to 500,000 acres.

CONVENTIONAL OIL & GAS RESOURCES

The North Aleutian sedimentary basin has the highest potential to host exploitable conventional petroleum resources in the Bristol Bay region. Although limited exploration has not resulted in a discovery, the basin is known to contain effective source rocks, reservoir rocks, and untested traps, especially in the federally managed Outer Continental Shelf acreage beneath Bristol Bay. Based on existing information, the most likely conventional hydrocarbon resource for local energy use would be gas derived from coaly Tertiary source rocks in offshore or nearshore areas of the eastern North Aleutian basin, particularly along the northwest side of the Alaska Peninsula, southwest of Port Heiden or between Ugashik and Egegik. Other parts of the North Aleutian basin are probably too shallow or dominated by volcanic rocks (17).

According to Alaska Department of Natural Resources, the petroleum industry has expressed clear interest in exploring federal waters of the southern North Aleutian basin, which is considered prospective for commercial-scale natural gas accumulations. A significant discovery could potentially make gas available to markets in the Bristol Bay region, although this cannot occur until offshore federal leasing is reinitiated. By contrast, industry has shown only moderate interest in exploring leasable state acreage onshore and beneath state waters, which have been available for leasing through the Alaska Peninsula area-wide lease sale since 2005. Acquisition of high-quality modern seismic data would be required to determine whether there are exploration prospects on currently accessible lands that would be worth evaluating by drilling. New industry-led exploration would improve knowledge of natural gas prospects on state lands. While years in the future, any commercial discovery may have the potential to supply affordable energy resources to nearby communities (17).

UNCONVENTIONAL OIL & GAS RESOURCES

Coalbed methane. The Chignik area possesses coal of sufficient rank to host coalbed methane. However, studies in 1999 and 2000 concluded the area was relatively unfavorable for exploration and development at the time, largely due to geologic complexity. Nevertheless, limited subsurface data from the area are promising, most notably significant gas shows in oil exploration wells where coal seams were encountered. Prior to any exploration drilling, it is recommended that substantial geologic fieldwork be conducted in the area, including detailed geologic mapping, structural studies, and analysis of lateral changes in sedimentary units (17).

Scattered thin coals are also present in the Ugashik district. While less is known about these occurrences, available data indicate that these coals are probably insufficient in thickness and extent to support coalbed methane development (17).

Tight gas sands. In terms of unconventional resources, tight gas sands have the highest likelihood of providing producible quantities of hydrocarbons for local use. The possibility exists for encountering fractured tight gas sands in the Mesozoic sandstones of the Bristol Bay region, in particular the Herendeen, Staniukovich, and Naknek Formation. However, available data suggest the probability of recovering commercial quantities of gas is low, and it would be difficult to entice commercial exploration given the remoteness of the region. Developing this type of unconventional resource typically involves significant drilling and stimulation costs that could challenge its economic viability as a local source of energy (17).

Shale gas. The likelihood of finding commercial quantities of shale gas in the region is low. Prior geologic investigations have not found the type of organic-rich source rock in the thermogenic gas window that is brittle enough to produce the natural fracture system necessary for efficient shale gas production. However, unconventional shale oil has never been evaluated in the region, and outcrop and well data indicate that high quality Mesozoic source rocks in southeastern coastal areas of the region are most likely oil prone. Recent advances in drilling technology have resulted in the production of oil directly from the hydrocarbons reservoired in this type of oil-prone source rock, termed shale oil. Although this resource type has never been considered in this region, the high quality of the source rocks may warrant further geologic study to determine their potential for shale oil production (17).

Gas hydrates. Due to the lack of extensive, continuous permafrost in most of southern Alaska, the likelihood of finding gas hydrates in the region is very low (17).

Project Economics

The current price of natural gas ranges from around $3 to $20 per MCF on the global market, while gasoline in rural Alaska can cost upwards of $8 per gallon. At a natural gas price of $9 per MCF and a gasoline price of $4 per gallon, natural gas holds an energy premium over three times that of gasoline; $4 per gallon gasoline is equal to $29 per MCF natural gas.

Without a defined project, including information on supply options, potential statewide distribution systems, price analysis, and local infrastructure requirements, there are too many variables to model the economics of a potential natural gas project.

Few communities in the region are currently using propane as a significant source of heating fuel, at least among those communities that responded to a bulk fuel purchasing survey in 2012 (63). For barge-accessible communities, cost savings are available by switching from small 100-pound tanks to 1,100 gallon tanks, saving about $1.50 per gallon in one estimate. However, barge delivery of large tanks requires suitable landings and marine headers which are missing in some villages. Fuel distributors also require local personnel to be certified in handling propane (75).

Issues

Projects in rural Alaska face more uncertainty than Railbelt projects that can benefit from greater economies of scale. Determining the project feasibility for a natural gas project in rural communities is complicated by the lack of demand-side data on total energy consumption, including transportation and heating loads, which could be converted to gas.

Electric generation is well understood, but fuel used for transportation, space and hot water heating has not been aggregated at the community or regional level; fuel sales data, where not required to be disclosed by a regulated utility, is generally proprietary. In addition, there will be unknown uses for cheaper power. While this can be overcome through modeling, it adds another layer of complexity and uncertainty.

The costs to convert energy systems to cheaper alternatives, such as natural gas, will be substantial and will require planning. Assuming a large portion of households would convert to the cheaper fuel source, if natural gas were available, communities would need to model demand and estimate the costs to build out local natural gas infrastructure for electricity, heating and transportation uses. A statewide study focused on needs and opportunities for natural gas in small, isolated communities would be useful to fill in the data gaps local communities do not have the resources to address.

In addition to help with financing critical infrastructure projects, small communities would also benefit from state support to lock in a long-term supply contracts at competitive prices.

Data Gaps

- **Supply options for natural gas distribution in Southwest Alaska** and the feasibility of a regional or statewide distribution network, including pricing and shipping assumptions.
- **High-quality modern seismic data** are needed to determine whether there are exploration prospects for natural gas on currently accessible lands that would be worth evaluating by drilling. Additional field mapping and stratigraphic studies would also improve the understanding of the region's petroleum potential, building on previous reconnaissance-scale fieldwork that has established the framework geology of the Alaska Peninsula (17).
- **An assessment of marine headers for ocean and riverside communities** to determine their suitability for large propane tank delivery.

4 | Food Security

The term "food security" is laden with a range of definitions, meanings, and controversies. Largely, governments tend to define the term around the concepts of access, safety and storage; while non-governments tend to define it more around the concepts of sustainability, local, home-grown and self-sufficiency. Examples of food security initiatives at the community level include community supported agriculture (CSA), farmers' markets, community gardens, farm-to-school initiatives, food policy councils, and community economic development linking food production to workforce development, private enterprise and the multiplier effect of keeping money circulating locally. Food security initiatives at the individual level include efforts to eat local foods, eat sustainable foods, home gardens, joining organizations and advocating on behalf of food issues.

In the context of energy planning, the discussion of food security is a means to make the connection between the price of fuel and food, and survey the region for opportunities. Recently there has been more discussion and awareness surrounding the concept of "food security" in Southwest Alaska and what it may mean.

Project Notes

SOUTHWEST ALASKA GARDENING INITIATIVE (SWAG)

The Southwest Alaska Gardening Initiative (SWAG) was formed to "promote food security and self-reliance in remote Alaska." The initiative is a collaborative effort between several entities:

- Bristol Bay Native Association
- UAF Bristol Bay Campus
- Marston Foundation (Muktuk Marston)
- UAF School of Natural Resources and Agricultural Sciences
- UAF Cooperative Extension Services
- Bristol Bay Area Health Consortium
- Alaska Sea Grant Marine Advisory Program
- Local Gardeners

When SWAG asked the question "Why Garden in Southwest Alaska," the responses included reasons such as "food security," "health and nutrition," "family and wellness," "adaptation to climate change," and a means to "manage the high cost of fresh produce due to increasing fuel prices" (76).

Rae Belle Whitcomb, Workforce Development Department Director at the Bristol Bay Native Association; and owner of Rae's – a local retail greenhouse in Dillingham - compiled data and compared costs of vegetables grown from seed versus store prices. She cautions, however, that "success depends on your individual determination to plan, maintain and harvest [a garden]." The table below illustrates the best case scenario between the price of a package of vegetable seeds, potential harvest yields and store prices.

Table 31: Vegetable Growth, Seed Prices versus Store Price

Vegetable	Package Price	10% Seeds	Harvest Yield	Store Price
Broccoli	$1.59	38 plants	38 heads	$170.62
Cabbage	$1.49	31 plants	31 heads	$185.07
Cauliflower	$1.49	21	21 heads	$144.27
Carrots	$2.99	157	157 carrots	$44.85
Green Onion	$1.59	110	110 onions	$15.55
Kale	$1.09	65	65 x 20 leaves	$216.66
Lettuce	$1.79	73	73 heads	$481.07
Potatoes	$1.75	5 pounds	3 eyes/potato x 5	$149.25
Radish	$1.59	46	46 radishes	$14.32
Rutabaga	$1.59	42	42 rutabaga	$62.58
Turnip	$1.49	105	105 turnips + greens	$207.90
Zucchini	$1.49	3 plants	10 per plant	$89.70

Source: (76)

The SWAG hosted garden symposiums in 2010, 2011 and 2012 with a focus on "bringing together local gardeners, gardening experts, and aspiring gardeners to exchange information and celebrate local food production for families and communities in Southwest Alaska in the spirit of self-reliance and sustainability" (76). The symposiums were held in Dillingham with students from Togiak, New Stuyahok, Manokotak, Twin Hills, Perryville, Naknek, King Salmon, Kokhanok and Iliamna.

The initiative continues to organize gardening classes and village visits throughout the year. Examples of classes offered include "Practical Gardening Basics," "Leaves of our Lives" and "Introduction to Composting." Village visits include trips to Togiak, Manokotak and New Stuyahok. The future for SWAG may include more village visits, collaboration with the Diabetes Prevention Program at the Bristol Bay Area Health Consortium, and exploring potential opportunities for private enterprise.

HIGH TUNNELS, BEYOND A GREENHOUSE

Bristol Bay retains a U.S. Department of Agriculture/National Resource Conservation Service (USDA/NRCS) agent in Dillingham who travels throughout the region and promotes natural resource conservation programs and opportunities. In 2010, the USDA through NRCS started the High Tunnel Initiative in an effort "to connect farmers and consumers, strengthen local and regional food production, increase the use of sustainable agricultural practices, and promote consumption of fresh, local food" (77). A high tunnel is not considered a greenhouse where plants usually grow in containers. A high tunnel should not be confused with a low tunnel or covered row. A high tunnel by definition is a polyethylene covered structure that raises the temperature inside to help extend the growing season, and plants usually grow directly in the soil or raised beds. A high tunnel is considered seasonal and therefore a temporary structure and must be at least six feet in height. A high tunnel cannot be self-made; it must be purchased from a qualified commercial supplier. There is an application process, eligibility qualifications, land and structural requirements to receive financial assistance.

Table 32: Food Security Participation by Community

	Southwest Alaska Gardening Initiative		High Tunnels	
	Participation	Village Visits	In Place	Planned
Aleknagik			✓	
Chignik Bay				
Chignik Lagoon				
Chignik Lake				
Clarks Point				
Dillingham	✓	✓	✓	✓
Egegik				
Ekwok				
Igiugig				✓
Iliamna	✓			
King Salmon	✓			
Kokhanok	✓			
Koliganek				
Levelock				
Manokotak	✓	✓		
Naknek	✓		✓	
Newhalen				
New Stuyahok	✓	✓		
Nondalton				✓
Pedro Bay				
Perryville	✓			
Pilot Point				
Port Alsworth				✓
Port Heiden				
South Naknek				
Togiak	✓	✓		
Twin Hills	✓			
Ugashik			✓	

Source: (12)

In Fiscal Year 2010, the NRCS received over 3,000 applications and obligated around $13 million for 2,422 seasonal high tunnels in 43 states. In Alaska, there were 125 applications with a fiscal obligation of $924,775.00 in financial assistance (78). In the Bristol Bay Region, there are 17 high tunnels located in the communities of Dillingham, Naknek, Ugashik and Aleknagik. High tunnels will soon be in the communities of Port Alsworth, Nondalton and Igiugig. The local

USDA/NRSC agent expects more applications for financial assistance with a spread to more communities in the region (79).

PROFILE

Pursuing Food Security at the Community Level in Igiugig

The village of Igiugig continues to develop a local food program. Today the Village Council hosts a chicken house, summer potato garden, portable greenhouse for early greens, four season greenhouse powered by wind, and a food bank. The Local Foods Program supports three main areas of interest:

- Providing fresh produce to the village
- Providing education to the school
- Advancing business opportunities and relationships with surrounding fishing lodges

The concept of a community food system began several years ago with the Egg Program, a program that started with a private coop and a few chickens, where locals could stop by and grab eggs at any time. The program now hosts a coop with 30 chickens. Locals and lodge owners separate food scraps to help feed the chickens. An honor fee of $3.50 for a dozen is now in place, but elders still get their eggs free. The program was so popular they expanded to growing potatoes with seeds provided from Port Alsworth. Igiugig now hosts a 24’ X 48’ greenhouse powered by three 2kW wind turbines confined within a solar powered electric bear fence. (The original 10’ X 10’ community greenhouse was made of plastic and metal and destroyed by several curious bears and high winds.) The greenhouse is outfitted with an in-floor heating element driven by a wood boiler to help extend the growing season. There are current plans to elevate and expand the raised boxes to maximize space and yield, and implement a pilot project to provide summer produce to a local fishing lodge. Future plans include the installation of two high tunnels adjacent to the current greenhouse.

The community continues to strive towards self-sufficiency, and look for ways to minimize importing supplies like seeds and fertilizer and implement automation systems. The community is small and depends on seasonal employment that takes residents away so automation is essential to help with shade and irrigation issues. The greenhouse has been an amazing addition to the community and a benefit to the area (78).

Project Economics

SOUTHWEST ALASKA MUNICIPAL CONFERENCE REPORT: “CONTROLLED ENVIRONMENT AGRICULTURE GREENHOUSES IN ALASKA”

The Southwest Alaska Municipal Conference (SWAMC) looked at the economic viability of controlled environmental agriculture (CEA) in the communities of Akutan, Dillingham, Kodiak and Saint Paul within the context of rising energy costs, pursuing and developing renewable energy resources at the community level. The study pulls empirical data from greenhouse production and research in North America, identifies the necessary inputs and outputs required, and explores enterprise budgets.

The SWAMC report points out the CEA industry in North American has grown substantially in recent years. The growth is mostly related to the desire to control the environment (temperature, lighting, soil nutrients, and CO_2) for ideal growth and production levels, and reduce the energy and expense associated with transporting perishable food items. Even for markets in the Lower 48, the greatest expense is linked to the supply chain and the energy required transporting fresh produce to markets. The association to Alaska markets is understandable:

> *This is magnified even further in regions of Southwest Alaska where product must be flown or shipped to market. The short growing season which exists in Alaska, and the costs associated with supplying a reliable crop are woefully uncompetitive for supping a reasonable food supply for the population. An important aspect for local communities is to note that the larger supply chain and middlemen activity drain direct value that could otherwise be retained by Alaskan communities. Produced locally, the complete value of the crop could include infrastructure development, jobs, education opportunities and the multiplying factor of money circulating through the economy. It is especially important to note the benefits will not exceed costs unless some local supply of energy is available to facilitate the growing season, either in natural heat, light or growing material and access to a reliable source of cheap power (80).*

The SWAMC report notes the University of Alaska Fairbanks is working with the Chena Hot Springs Resort to study the effects of a CEA in an arctic environment and transfer results to other parts of the state[11]. Using the "Chena Model" for start-up capital costs, SWAMC is able to include other inputs (demand, consumption, greenhouse size, enterprise accounting, temperature variations, heating and electrical requirements to name a few) and conclude a CEA greenhouse industry is feasible for Kodiak but not for Akutan, Dillingham and Saint Paul.

The SWAMC report is exhaustive, and continues to explore a variety of adjustments to the inputs in search of a viable solution for all communities. The adjustments are linked to demand, energy, efficiency and operating inputs. The conclusion:

> *The results of this study provide support that a CEA greenhouse industry could be profitable in Kodiak and that input cost need to be reduced in Dillingham, Akutan and Saint Paul before economically viable operations can be established. This study also identifies a lack of information needed to adequately produce a sound business plan that local communities would require prior to implementation. It is important to differentiate greenhouses between a structure which improves environmental factors of production and Controlled Environment Agriculture greenhouses referenced in this report. CEA greenhouses incorporate a high level of engineering and technology into a production facility capable of producing yields necessary to supply all of a community's vegetable needs. The result is that a great deal of planning and capital expenditure is required to ensure that failure is averted. This report is the first step necessary to expanding year-round growing potential in Alaska.*

Issues

There is a clear economic relationship between energy and food for families and communities, and there are ways to help offset or minimize the negative relationship.

- As communities plan and search for alternative sources of power, leaders should factor food production into the load for year round uses.

[11] The Chena Hot Springs Resort is known world-wide for its mineral hot springs and low temperature geothermal resource that provides power for district heating, an ice museum, and year-round hydroponic greenhouse production.

- Communities can also work in partnership with the local electric utility to plan for and use waste heat as a potential source of power for food production seasonally.
- Encourage more families to participate in education programs, follow state and federal programs to pursue family gardening as a means of greater self-sufficiency.
- Encourage more communities to participate in education programs, follow state and federal programs to pursue community gardening as a means of greater self-sufficiency.

Data Gaps

- **Estimate of energy loads associated with food production** to be factored in as alternative sources of power are being planned.
- **Heat recovery for seasonal food production**. A survey of utilities to determine local potential would be useful to community and regional planners.

5 | ENERGY INFRASTRUCTURE

TRANSPORTATION INFRASTRUCTURE

The only community pairs currently connected by road in the region are Dillingham-Aleknagik, Naknek-King Salmon, and Iliamna-Newhalen. More road connections in the region would reduce the cost to develop interties and could reduce transportation costs for fuel and freight.

While there has been little interest in proposals to connect communities by road historically, this appears to be changing. According to Julie Baltar of BBNA's Department of Transportation and Infrastructure Development, communities are now saying they want to be interconnected, due largely to high energy costs. Six member villages (Clark's Point, Ekuk, Ekwok, Pilot Point, Portage Creek and Twin Hills) recently expressed interest in new road connections (see Table 34). These same community pairs have historically been proposed for electric interties (81).

Road Projects

STIP FUNDING

Road and bridge projects for the region that are included in the 2013-2015 DOT&PF State Transportation Improvement Program (STIP) are shown in Table 33. The STIP is the state's four-year plan for transportation system improvements for which partial or full federal funding is approved. STIP projects that will upgrade or replace existing infrastructure are not listed.

Table 33: Bristol Bay Projects in 2013-15 STIP

Project Title	Funding FY13-FY15	Description
Iliamna-Nondalton Road Completion	$26.0 million	Construct a bridge across the Newhalen River with a connecting road link to Nondalton. (Funding not secured. Bridge is not supported by the Tribe.)
Williamsport-Pile Bay Road and Iliamna River Bridge Repair/Replacement	$5.5 million	Construct a permanent bridge and remove temporary bridge over the Iliamna river.
Wood River Bridge	$17.8 million	Two lane bridge between the North Shore of Aleknagik and the Dillingham-Aleknagik Road.

Sources: (82) (83)

WILLIAMSPORT-PILE BAY ROAD

The 2004 revised Southwest Alaska Transportation Plan (SWATP) recommended improvements to infrastructure and transfer facilities at both ends of the 15-mile-long Williamsport-Pile Bay Road. The project is also a priority in the Lake and Peninsula Comprehensive Plan, 2012 update.

The road is currently open for use only between June and November, and channel conditions limit barge delivery opportunities to a handful of days a month. Since 2009, it has been used by the Iliamna Development Corporation to ship fuel and freights from Homer to Lake Iliamna communities (84). Improvements to the state-owned road, the privately-owned barge landing at Williamsport, and the public dock at Pile Bay would make the route safer and more reliable for the movement of freight and fuel. Capital costs for the improvements were estimated at $27 million in 2004, with savings in freight costs calculated at $1 million annually (85).

CHIGNIK AREA ROAD AND DOCK PROJECTS

Improvement in transportation linkages in the Chigniks area, including a public dock in Chignik Bay, was the other primary intermodal recommendation in the revised 2004 SWATP. In support, the plan cited the communities' close proximity, low reliability of air service, and inadequate commercial dock. The dock is listed as a priority in the Lake and Peninsula Borough's Summer 2012 Comprehensive Plan Update (86).

SWATP UPDATE

Intermodal Access

The Phase I Report for the Southwest Alaska Transportation Plan was released for comments in May 2013 (83). While it does not recommend specific projects at this phase, it includes among its primary recommendations:

- Prioritize roads that provide access to hub communities. The state has completed a cluster study that has not yet been released.
- Examine the potential of port and harbor improvements at selected regional and sub-regional hubs to reduce regional costs of living (e.g., improving roads to ports, improving barge delivery facilities).
- Given the importance of air and sea transportation in Southwest Alaska, roads to aviation and marine facilities are of primary importance.

Table 34 lists road and bridge projects recommended in the 2004 Southwest Alaska Transportation Plan (SWATP), as well as those mentioned in comments for the SWATP Update that would improve intermodal access. Other projects have appeared in previous DOT&PF lists.

Runway Expansion

In the absence of Williamsport-Pile Bay Road improvements, another way to reduce fuel delivery costs in the Lakes area is by extending runways. Fuel delivery via air can run upwards of $2 per gallon per 100 one-way air miles from the fuel source for communities without the option of barge delivery if their runway is less than 4,000 feet. This includes Igiugig (3,000 ft.), Kokhanok (2,920 ft.), Nondalton (2,800 ft.), and Pedro Bay (3,000 ft).

Runways over roughly 4,000 feet in length are able to accommodate a Douglas DC-6 fuel cargo plane saving approximately $1per gallon per 100 air miles from the fuel source. An analysis for the Lake and Peninsula Regional Energy Plan estimated savings associated with runway extensions from $150,000 for Pedro Bay (50,000 gallons) to $403,200 in Kokhanok (112,000 gallons). Savings estimates were based on the number of gallons of fuel delivered annually to the community by air and air distance from fuel source (18).

Runway expansions are also listed as a priority in the Lake and Peninsula Borough's Comprehensive Plan 2012 update in order to lower fuel and freight costs in the region and open up new options for exporting fresh fish products (86).

The need to examine the costs and benefits of runway extensions for communities without barge service is a principal recommendation of the 2013 Southwest Alaska Transportation Plan Update Phase I Report. The plan also recommends an assessment of runway length needs in the region based on recent and potential changes to the aircraft fleet (83).

Table 34: Proposed Road Connections in Bristol Bay Region

Proposed Connection	Notes	Community Interest (BBNA)	DOT&PF STIP FY13-15	SWATP 2004 Revised	SWATP Update Phase I
Aleknagik-Ekwok					
Aleknagik-New Stuyahok					
Chigniks Area Road & Public Dock	35 miles			✓	✓
Chigniks-Perryville	62 miles				
Dillingham-Manokotak	22 miles	✓			
Ekuk-Clark's Point	2 to 5 miles	✓			✓
Ekwok-New Stuyahok	9 miles	✓			
Ekwok Landfill Road and Bridge to Klutuk Creek & Bluff	1 mile (potential access to resources)				✓
Igiugig High Ridge Subdivision Road	Potential access to resources				
Iliamna-Nondalton Road & Bridge			✓	✓	✓
Kaskanak Road: Kvichak-Lake Iliamna	N/A (in design)				✓
Naknek-South Naknek-King Salmon Road				✓	
Naknek-South Naknek					✓
New Stuyahok-Koliganek	19 miles	✓			
Pilot Point-Egegik		✓			
Pilot Point-Ugashik River Road	5 miles				
Pilot Point-Ugashik-Pacific Side/Wide Bay	~60 miles				
Port Alsworth Landfill Road & Tanalian River Bridge					
Portage Creek Landfill Road		✓			
South Naknek-Chigniks	200 miles				✓
Togiak-Hawaiian Island Road					
Togiak Tank Farm Bridge					
Togiak-Twin Hills	4 miles	✓			
Williamsport-Pile Bay Road & Bridge	15 miles		✓	✓	✓
Wood River Bridge to Aleknagik N.Shore	0.6 miles		✓	✓	✓

Sources: (12) (82) (83)

Harbors and Docks

The cost of barge-delivered fuel will be higher if a community has deficient moorings or marine headings due to the increased risk and extra time required for in offloading fuel. If a community is missing a marine fuel header, extensive fuel hose runs from the beach up to the tank farms are needed or the fuel must be trucked off the barge resulting in higher costs.

The Denali Commission partnered with the US Army Corps of Engineers, Alaska District (USACE) in 2007 to develop a Statewide Barge Landing Assessment, after three previous studies identified barge landing improvements as a critical need in rural Alaska (87). The study focused its first phase on the Alaska Peninsula, the Yukon, Kuskokwim and Kobuk Rivers, and the Bering, Chukchi and Beaufort Sea coasts.

New Stuyahok was the only site in the Bristol Bay region identified as a priority site for barge landing improvements in the study. Recommended improvements included a new dedicated barge landing site, near the downriver end of the community, a gravel or concrete plank ramp, a staging area, and access to the road system. Project cost was estimated at $2.7 million.

The report had the following general recommendations for improving the safety and efficiency of fuel transfers in waterfront communities:

- Consolidate marine fuel headers to a single landing site location at communities where multiple landings are currently required (e.g., electric utility, school, village corporation and stores all have separate tanks and headers). The header location is ideal if installed no more than 300 feet from the landing site, though 100 feet from the landing is preferred.
- Improve environmental concerns associated with floating fuel hose to shore by providing barge access to the shore. This effort could include removing navigation hazards and/or relocating the barge landing to a site where shore side receiving is practical.
- In some communities, a gravel causeway into the water may be a feasible approach to reaching sufficient water depth. In other cases, especially in areas of very shallow water, installing a new landing facility or dredging may not be practical. In these communities, relocating tanks and/or fuel headers may be the most feasible approach to improved delivery.
- It is often difficult to access the upper river villages and it would be ideal to go to these communities once a year instead of two times a year for fuel deliveries. Providing a centralized tank farm, capable of annual fuel storage, would facilitate this goal.

Issues

- Given current trends in Congress associated with the Highway Trust Fund, public development of long-distance roads in remote areas of Alaska is unlikely (83).
- Any cost-benefit analysis of runway expansions needs to look at alternatives to the DC-6 for fuel delivery, since Everts Air Cargo’s small DC-6 fleet is aging and expensive to maintain.

Data Gaps

- **Community interest in road linkages**, including priority resolutions from Tribes detailing their transportation desires under BIA’s Indian Reservation Roads (IRR) program

- **Updated analysis of costs and benefits of runway extensions** to accommodate larger aircraft service to communities that fly in fuel oil
- **Updated list of barge landing and marine header improvements** or consolidation that could lower fuel delivery costs in the region, including which communities still have long hose runs or require multiple stops at fuel tank farms in the community.

TRANSMISSION LINES

The Bristol Bay region currently has few transmission lines. Interties are limited to community pairs currently connected by road: Dillingham and Aleknagik, Naknek and King Salmon, and Iliamna and Newhalen, and also bring in South Naknek (to Naknek-King Salmon) and Nondalton (to Iliamna-Newhalen).

At present, these are the only true energy clusters or subregions in the Bristol Bay region. All other electric generation and distribution systems function as island systems serving single communities. This is due in part to economics and part to the historic interests of local communities. New utility connections are being pursued between Togiak and Twin Hills, and New Stuyahok and Ekwok.

Resource Inventory

Table 35: Current Transmission Lines in the Region

Operator	Communities Connected	Current Energy Sources
INN Electric Cooperative (INNEC)	Iliamna, Newhalen, Nondalton	River Hydro, Diesel backup
Naknek Electric Association (NEA)	Naknek, South Naknek, King Salmon	Diesel
Nushagak Cooperative	Dillingham, Kanakanak, Aleknagik	Diesel

Table 36: Proposed New Transmission Lines

Community A	Community B	Distance	Estimated Cost	Energy Source
New Stuyahok	Ekwok	10 mi.	$3.0 million	Diesel, Future wind potential
Togiak	Twin Hills	3.8 mi.	n/a	Diesel, Future wind potential

Sources: (68) (47)

In addition to the proposed interties above, another tie-in that might serve the energy needs of the region is connecting the existing grids in Dillingham and Naknek (68).

Project Economics

AEA TRANSMISSION LINE STUDY

AEA conducted a 2009 screening study that looked at all pairs of villages less than 25 miles apart to see if traditional AC transmission lines could reduce the cost of power to these communities with existing diesel plants. All village pairs not already connected by an intertie had transmission costs greater than the potential savings of the line when capital costs, operations and maintenance, and utility margins are factored in. Grant-funded projects enjoyed slightly better economics since the only cost requirement is to cover the operating cost of the line (88).

For remote power projects taking advantage of renewable resources (hydro, geothermal, and wind), the cost of transmission lines between the generating site and the load must also be considered in the overall economics of the project. The authors of the screening study noted that, in many cases, the cost of transmission alone drives the economics above the cost of current diesel fuel.

The study concluded that building transmission lines is technically possible in Alaska, but current costs make this option unattractive for delivering power to remote communities. It also found that developing a statewide transmission grid would likely not result in cost savings, as the O&M costs alone would be higher than current diesel fuel costs.

Table 37: Bristol Bay Village Pairs in the Transmission Screening Study

Community A	Community B	Distance in Miles	$/kWh Difference (2009)	Estimated Transmission Cost ($/kWh)
Iliamna	Newhalen	2.4	0.11	0.22
Togiak	Twin Hills	3.8	0.43	0.99
Chignik	Chignik Lagoon	5.1	0.13	0.51
New Stuyahok	Ekwok	9.1	0.04	1.16
Chignik Lake	Chignik Lagoon	9.6	0.17	0.97
Dillingham	Clark's Point	13.9	0.29	1.46
Chignik Lake	Chignik	14.1	0.04	1.29
New Stuyahok	Koliganek	19.1	0.32	2.56
Newhalen	Kokhanok	19.9	0.13	2.49
Manokotak	Clark's Point	20.4	0.15	2.14
Dillingham	Manokotak	21.7	0.14	0.85
Iliamna	Kokhanok	22.3	0.24	2.80
Nondalton	Port Alsworth	24.4	0.18	2.12

Source: (88)

The economics could change in the future if there were new large loads or new large-scale generation opportunities that create sufficient economies of scale to offset the high cost of building transmission lines in rural Alaska. New roads could also improve the economics by lowering the cost of constructing and maintaining transmission lines.

REGIONAL GRID STUDIES

Statewide Grid with Railbelt Intertie. The AEA transmission line screening study took a back of the envelope look at the feasibility of a transmission line network that integrated Railbelt power generation with every village in rural Alaska. Assuming the lines could be built for $400,000 per mile and that at least 10,000 miles of total lines would be needed, the cost was estimated to be in the range of $4 billion, or higher given the difficult terrain in much of the state. Maintenance costs were estimated at 3% per year or about $120 million—more than what was currently being spent on diesel fuel purchased for all remote communities in the state combined (88).

Railbelt Intertie to Regional Grid. Previous studies have looked at the potential for an intertie to the Railbelt to deliver lower-cost natural gas, hydro and coal power to a regional Bristol Bay grid. The 1982 Stone and Webster study found a large intertie from the Chugach Electric Beluga Power Plant on the west side of the Cook Inlet connected to a regional grid with local diesel back up would cost on the order of 35% more than a large, in-region hydro project providing the base load for the same regional grid.

More recent studies have modeled a 230 kV submarine cable from the Homer Electric Association (HEA) intertie on the Kenai Peninsula across Cook Inlet plus on overland transmission line to the proposed Pebble Mine site. The 2008 Lake and Peninsula Borough Regional Energy Plan updated costs estimates for one such study and estimated the delivered cost of power to the Lakes region from this approach to be on the order of $0.24 per kWh. While this was possibly 10-15% less than using that same regional grid to distribute power from a large in-region hydro project, the study's authors noted that their estimates were not sufficiently well developed to distinguish between alternatives that close).

The study concluded that a regional grid that distributes power from either a large scale in-region hydro project or imported power from the Railbelt might be competitive with individual island electric utility systems served with diesel-fired electrical generation, especially for communities that are not adjacent to a high-value renewable generation resource, like the Indian Creek hydro project (18).

Regional Grid with Large Renewable Resource. The 2008 Lake and Peninsula energy plan based its analysis of a large in-region hydro project on a 16 MW project on the Newhalen River (Alternative B-14 identified in the 1982 Stone and Webster study) and updated cost assumptions. The updated project cost totaled approximately $150 million for the hydro development and $140 million for a regional transmission grid. Assuming aggregate average long-run diesel prices across the region of $4.50 per gallon, the large-hydro-plus-regional-grid project yielded a benefit-cost ratio of less than 1.0—due in part to excess capacity in the early years combined with the "loss" (compared with the 1982 analysis) of roughly 2.2 million high-priced kWhs that have subsequently been replaced with lower-cost energy from the smaller Tazimina hydro project serving Iliamna, Newhalen and Nondalton. In other words, the construction of one small (824 kW) hydro renewable energy project in a region resulted in diminished economics for construction of a large-hydro-plus-regional-grid project, even though the rise in diesel costs would have made the original project economically viable.

The study noted that at $4.50 diesel the benefit-cost ratio could be enhanced enough to justify a large-hydro-plus-regional-grid project if either the new renewable energy project were scaled down to 8 MW or if additional industrial loads (such as fish processing, fish freezer facilities or a small mine) were available to connect to the grid in order to achieve greater economies of scale. The authors noted "what appears to be a continued preference for more expensive small-scale local projects rather than a large-scale project with a regional transmission grid." To the extent that additional renewable energy projects are built to meet more localized needs, they may diminish the net total benefits available from a larger scale hydro development and regional transmission grid (18).

Project Notes

NEW STUYAHOK TO EKWOK

AVEC recently received $2.52 million in federal rural utility funds for construction of a 10-mile electrical intertie between New Stuyahok and Ekwok. The cooperative estimates that it still needs an additional $250,000 for standby facilities in Ekwok (47). Additional project benefits from an intertie would include minimizing additional investment in upgrading older power plant and tank farm facilities in Ekwok and allowing consolidation of fuel storage for the two villages into the recently completed, code-compliant facility in New Stuyahok (67).

TOGIAK TO TWIN HILLS

AEA is studying the feasibility of an intertie between Togiak and Twin Hills as part of a comprehensive review of options for upgrading the Twin Hills power plant facilities. An intertie option will also be included in the concept design report being completed by AVEC for its new Togiak power plant and associated tank farm. While both communities have promising wind resources, there are site control issues that could make a Togiak wind project more challenging to develop. With a tie-line, wind could be harvested in either community or in a location along the route depending on where a project is most feasible (47).

Technology Notes

LOW POWER HVDC

For the past several years, the Denali Commission has supported a research and development project to develop a low-power high-voltage direct current (HVDC) transmission technology specifically tailored to rural Alaska interties. HVDC power transmission is a fundamentally different means of transporting power than more traditional alternating current (AC) power transmission (see box on page 97). According to Joel Groves, an engineer with Polarconsult Alaska, Inc., in Anchorage, the program seeks to commercialize a compact, modular 500 kW HVDC converter suitable for interconnecting Alaskan villages. The purpose of developing this technology is to help reduce the high cost of electricity in interconnected villages by lowering the cost of building and operating rural interties. The Denali Commission project successfully constructed and tested a prototype converter in 2012. Future efforts will focus on refining the hardware design and completing testing and demonstration efforts so the converter technology is available for commercial applications in the next three to five years.

Polarconsult Alaska prepared some very high level conceptual interties in the Bristol Bay region to illustrate the potential benefits of the HVDC technology compared with AC interties. The following narrative and the text in the box on page 97 is condensed from Polarconsult's May 2012 Phase II report, *HVDC Transmission Systems for Rural Alaska Applications: Prototyping and Testing* (89).

EMERGING TECHNOLOGY

Low Power HVDC

HVDC power transmission is a fundamentally different means of transporting power than more traditional alternating current (AC) power transmission. It is widely used around the world, usually for economic transmission of large amounts of power (1,000s of megawatts) over long distances (100s of miles), or for long-distance submarine cable interties. Because it is a very different technology than AC, HVDC presents a number of unique technical, economic, and regulatory considerations. Depending on the particular application, these unique considerations may result in significant advantages or disadvantages for an HVDC intertie compared with an AC intertie.

At this time, HVDC technology is readily available for transmission systems larger than approximately 100 MW, and may be available in limited circumstances for systems between approximately 20 to 100 MW. HVDC transmission technology is not currently commercially available for intertie applications below approximately 20 MW. Most rural Alaskan intertie needs are below 20 MW, so HVDC's role is very limited for near-term intertie applications in rural Alaska.

The following abbreviated comparison is presented to illustrate when an HVDC intertie is anticipated to be a good alternative to a comparable AC intertie in rural Alaska applications. Comparison of HVDC and AC transmission technologies for a specific project may include factors not listed below, and should be conducted by a qualified organization.

HVDC ADVANTAGES

Lower per-mile overhead transmission line cost than AC lines.

- Ability to use underground or submarine cables for long distances.
- Better compatibility with migratory bird flyways and aesthetically sensitive areas due to fewer overhead conductors (1 or 2 wires instead of 3 or 4 wires) and ability to use underground cables for long distances.
- Asynchronous connection – enhanced grid stability for weak grids.
- Lower per-mile conductor energy losses.

HVDC DISADVANTAGES

An HVDC converter is more expensive, requires more maintenance, and is less reliable than a comparable AC transformer.

Converter costs are a barrier to serving loads along the transmission line route.

Unconventional technology and limited equipment suppliers compared to AC.

HVDC converters generally have higher energy losses than a comparable AC transformer.

HVDC interties may have fewer funding opportunities than conventional AC lines because they are uncommon.

Implications for Rural Alaska Applications

- If an intertie must employ long-distance submarine or buried cables, HVDC offers a technically superior solution to AC cable interties, which are not technically feasible for long-distance transmission.
- Where both systems are technically feasible, the decision is largely economic. An HVDC intertie will have higher terminal costs and lower per-mile costs. Accordingly, an AC intertie is more cost effective for short interties, and HVDC is more cost effective for long interties. The longer the intertie, the greater the cost savings of an HVDC versus AC system. The economic crossover point is always project specific, but is estimated to occur at between 6 and 31 miles for low-power overhead interties in rural Alaska.
- Conceptual cost estimates for a 25-mile 1 MW intertie in rural Alaska indicate the capital cost of an HVDC intertie will be approximately 30% less than for a comparable AC intertie.
- Since the HVDC converters under development for rural Alaska applications are new technology, substantial savings will be a factor in encouraging utilities to adopt this technology in lieu of proven but more costly intertie solutions.
- Most AC interties are overhead and may not be environmentally acceptable in many parts of Alaska. HVDC interties are either buried or have fewer wires and structures and may be more acceptable within refuges and other sensitive areas.

Potential Applications in the Bristol Bay Region

If low-power HVDC transmission technology is commercially available, it could be applicable for many of the interties that have been proposed in the Bristol Bay region. In particular, the following transmission projects may be well-suited for HVDC:

- **Grant Lake / Elva Lake to Dillingham.** Use of HVDC for this intertie may offer several advantages, including lower cost and the ability to use underground cable, minimizing aesthetic and wildlife impacts within Wood-Tikchik State Park.
- **Chikuminuk Lake to Bethel.** Use of HVDC for this intertie may offer several advantages, including lower cost and the ability to use underground cable, minimizing aesthetic and wildlife impacts within Wood-Tikchik State Park and the Yukon Delta National Wildlife Refuge.
- **Other Regional Interties.** Many of the village-to-village interties, such as those included in the 25-village grid proposed in 2008 by Naknek Electric Cooperative, Inc., are long enough to realize the cost savings of HVDC.
- **Railbelt Intertie.** Any interconnection with the Railbelt electric grid that includes a submarine crossing of lower Cook Inlet will use HVDC technology, as the distance across lower Cook Inlet is too far for use of an AC submarine cable. Such an intertie would likely be large enough to use existing commercially available HVDC converter technology.

Issues

- The economies of scale needed for a large-scale renewable project that could connect communities in a regional transmission grid will be diminished by construction of numerous more expensive (on a per kW basis) small-scale renewable projects built to meet localized needs (18).

- Connecting nearby communities with independent diesel power generators does not appear to be an effective cost saving measure, even when the villages are relatively close (88). The biggest savings from an intertie are for commercial customers. PCE customers do not see as large a benefit (42).
- One downside of connecting villages with interties is the loss of a heat recovery system to serve local heating loads in the community at the receiving end of the transmission line. The recipient community may also lose part of an FTE (full-time equivalent) job in power plant operations. While a back-up diesel power plant would still be maintained in the community, it would be operated on a standby basis and would require significantly less labor for operations and maintenance.
- Communities have also chosen not to be connected to an adjacent community by a transmission line for issues other than economic ones. Maintaining independence was one of the reasons Manokotak residents cited in rejecting a proposal to build a transmission line to Dillingham in the past. With the increase in fuel and transportation costs there now seems to be more interest in seeking both transmission and road connections between some communities (68).

Data Gaps

- **Results of Denali Commission research on low power HVDC** transmission and its applicability for rural Alaska
- **Updated study of technical and economic feasibility of regional grid alternatives**: diesel only, diesel hybrid, natural gas and propane imports

6 | Energy Demand

Large Loads & Megaconceptual Projects

The addition of large new energy loads in a region—whether from a mining operation, seafood processing plant, or other industrial energy customer—can be a game changer, transforming both demand and supply and radically altering the economics of previously considered generation and transmission projects. The same is true for very large-scale energy generation projects, such as a new hydroelectric project with the potential to create a step change in the price of energy in a region. We call these "megaconceptual" projects because of their size and their long and uncertain time horizons, which make planning for or around them difficult. It is best to continue to monitor these efforts while pursing local and regional solutions. Proposed projects with the potential to change the energy landscape in the region include, but are not limited to, the following development efforts.

Chikuminuk Lake Hydroelectric Project

The Chikuminuk Lake Hydroelectric Project is a 13 MW large reservoir project being proposed by Nuvista Light & Electric to provide most of the electrical power required by Bethel and 13 surrounding communities (90). The communities anticipated to be serviced by the proposed project include Akiachak, Akiak, Kwethluk, Tuluksak, Bethel, Oscarville, Napakiak, Napaskiak, Atmautluak, Kasigluk, Nunapitchuk, Tuntutuliak, Eek and Quinhagak. Longer-term plans include the opportunity for a multi-region intertie by building a second transmission line to Dillingham.

At this point the project should be considered a long-term, megaconceptual project largely due to its size and the challenges of financing a project on that scale. Other challenges include high transmission costs and the possibility of land ownership and permitting issues. Chikuminuk Lake is entirely within the Wood Tikchik State Park. The majority of the transmission line would be located within the Yukon Delta National Wildlife Refuge. Nuvista is currently engaging the land owners in early consultation regarding permits and other authorizations that would be required to conduct studies within the Park and the Refuge.

Earlier studies found that the Chikuminuk Lake project was not economically viable; however the 2011 study found that the current price of oil increased the likelihood that the Chikuminuk Lake Project may be feasible. Funding to study the feasibility of developing the Chikuminuk Lake resource and to initiate the first steps towards preparing a Federal Energy Regulatory Commission (FERC) application was provided by the state legislature.

Pebble Mine

The proposed Pebble copper-gold-molybdenum deposit near Lake Iliamna would consume 450 MW of electricity, according to the project developers (91). At this stage of development, it is not certain whether the multi-billion-dollar project will be permitted. If constructed, it would radically alter energy supply and demand in the region, especially in the Lakes area. The estimated power consumption would be more than a dozen times the current electrical load of the entire region and require a power plant big enough to serve the entire Anchorage area.

The Pebble Partnership has considered several options for meeting its large-scale energy needs as well as generating excess power that could be made available to Lake and Peninsula Borough communities and potentially others in the region at the mine's cost of production. This is dependent upon necessary investments in transportation and energy infrastructure to distribute power to end users throughout the subregion or region.

Over the years the Pebble Partnership has investigated multiple scenarios to develop a 500 MW power system, with the most recent being a combination of wind (125 MW) and natural gas (91). This could include an LNG pipeline and gasification plant (12). Previous concepts for importing energy to the mine site have included a submarine cable across Cook Inlet connecting Homer's electrical power grid to overhead transmission lines and substations on the Bristol Bay side (18).

The Pebble Partnership initially proposed paying for capital improvements to the Williamsport-Pile Bay Road to make it suitable for hauling ore to tidewater. Later plans have looked at construction of a new deep water port on Iniskin Bay, down the coast from Williamsport, and a new private road from the mine to the port that covers just part of the Pile Bay route. Pipelines along the new road would carry fuel and a slurry of metal concentrate between the port and mine. Issues include land ownership (some of the land at Iniskin Bay is owned by Native corporations or is eligible for selection by village corporations) and potential impacts on Cook Inlet Beluga whales (92).

The Lake and Peninsula Borough's 2008 Regional Energy Plan listed other potential impacts of the proposed mine (18):

- Larger, better maintained roads that lead to more efficient delivery of fuels. However, the Pile Bay Road construction could occur with or without the mine.
- More extensive road construction could also reduce the cost to develop electrical interties along the transportation corridor, opening up the possibility of lower cost energy from regional hydroelectric or wind resources being shared over a wider area.
- To the extent that a local work force is hired, higher household incomes are likely to lead to higher energy consumption, but could also lead to households making different choices as to where to live year round or seasonally. Some believe that employment at the Red Dog Mine has led to more households living in urban Alaska as well as outside the state.

Construction of any new energy or transportation infrastructure related to the proposed mine is years away. Project developers have yet to file a final mine plan, and over 60 state and federal permits will be required before development can go forward (93). While the Pebble Partnership says it anticipates permitting to begin in late 2013, controversy surrounding the mine and its potential impact on Bristol Bay's salmon fishery creates additional uncertainty on top of the already long timelines that govern the permitting process.[12]

[12] A ruling is expected in December 2013 on the legality of the Lake and Peninsula Borough's ordinance requiring a borough permit be obtained for mining operations larger than 640 acres before applying for state and federal permits (62). A coalition of Alaska Native tribes, Native corporations, and commercial fishermen has petitioned the

Other Mining Prospects

While the Pebble Mine would be the biggest energy producer and consumer in the region if developed, there are smaller mining prospects in the region that would also impact energy demand and supply. Mining companies have staked many other claims in the Lakes area, and the Bristol Bay Native Corporation signed an agreement in 2013 with Millrock Resources Inc. to explore known porphyry copper-gold prospects in the Chigniks (94). As preliminary prospects, not enough detail is known about these potential developments to inform energy planning.

CURRENT LOADS

The ability to estimate total energy use and to project future demand is a necessary step in energy planning. While demand-side data is readily available for electricity thanks to state utility regulation and the PCE program, not enough data exists on heating and transportation energy use to easily quantify it for planning purposes on either a community or regional scale.

Electric Energy Demand

Total installed capacity for electric generation in the Bristol Bay region was 27.6 MW in 2010 (32). In 2012, the total amount of electricity generated in the region was 56,000 MWh, of which 53,000 MWh was sold, as shown in Table 38. Diesel generation accounted for 92% of all power produced, requiring 3.6 million gallons of diesel fuel. Hydroelectric generation by INNEC in the Lakes area accounted for most of the remaining 8%. Residential sales accounted for 29% of kWh sold, 7% for commercial sales, 62% other sales, while 3% of kWh were used for generation at the powerhouse.

U.S. Environmental Protection Agency to use its authority under Section 404(c) of the Clean Water Act to preemptively restrict or deny discharge of mine wastes into Bristol Bay waters or wetlands if they would create an unacceptable adverse impact on fisheries, wildlife, municipal water supplies or recreational areas (61).

Table 38: Current Electricity Generation and Sales in the Bristol Bay Region, 2012

	Generated (kWh)			Sold (kWh)					Fuel Used (Gallons)
Utilities	**Diesel**	**Renewable**	**Total**	**Residential**	**Commercial**	**Other**	**Utility Use**	**Total**	
Chignik	961,922	-	961,922	214,879	101,713	542,925	27,710	887,227	70,955
Chignik Lagoon	476,564	-	476,564	253,925	49,040	177,147	17,413	497,525	47,619
Chignik Lake	407,978		407,978	153,478	52,171	166,989	13,644	386,282	27,736
Egegik	618,450	-	618,450	154,433	124,100	285,875	1,781	566,189	56,795
Ekwok	512,688	-	512,688	179,830	28,398	231,771	41,607	481,606	41,457
Igiugig	326,338	-	326,338	91,626	71,128	110,493	15,417	288,664	27,482
INNEC	81,578	4,221,973	4,303,551	999,434	205,630	1,927,217	473,426	3,605,707	6,382
Kokhanok	386,060	97,783	483,843	181,975	63,451	168,992	29,611	444,029	34,353
Koliganek	697,078	-	697,078	260,683	90,720	271,873	21,099	644,375	69,955
Levelock	482,532	-	482,532	155,794	39,056	156,855	31,628	383,333	39,620
Manokotak	1,436,297	-	1,436,297	565,241	95,333	679,479	39,269	1,379,322	112,829
Naknek Electric	20,056,950	-	20,056,950	3,433,397	1,168,598	13,524,737	586,065	18,712,797	1,291,844
New Stuyahok	1,509,656	-	1,509,656	627,899	100,994	689,363	47,249	1,465,505	113,593
Nushagak Electric	19,277,850	-	19,277,850	5,779,980	1,002,484	11,523,843	90,675	18,396,982	1,301,711
Pedro Bay	213,746	-	213,746	62,360	19,595	103,769	11,190	196,914	19,609
Perryville	401,110	30,676	431,786	121,616	79,264	181,389	7,763	390,032	31,364
Pilot Point	477,704	288	477,992	167,485	66,532	173,347	21,296	428,660	41,993
Port Alsworth	729,600	-	729,600	276,508	-	388,877	17,878	683,263	59,781
Port Heiden	183,800	-	183,800	214,622	57,161	370,976	26,218	668,977	62,668
Togiak	3,067,898	-	3,067,898	1,316,657	289,979	1,333,763	34,924	2,975,323	225,894
Twin Hills	269,363	-	269,363	106,235	43,843	61,506	27,875	239,459	30,754
Total	**51,613,240**	**4,350,720**	**55,963,960**	**15,103,178**	**3,647,477**	**32,528,261**	**1,556,028**	**52,834,944**	**3,643,439**
Total (MWh)	**51,613**	**4,351**	**55,964**	**15,103**	**3,647**	**32,528**	**1,556**	**52,835**	

Source: (64)

Heating Energy Use

The best numbers for estimating home heating energy demand in rural Alaska come from the 2012 AEA End Use Study conducted by WH Pacific (32). New Stuyahok was one of three small rural Alaska villages included in the study. Results for Bethel are also included in Table 39the Table 39 as an example of a larger rural hub community. Due to the low number of non-residential buildings in remote villages, non-residential data has been aggregated for three small rural communities (including New Stuyahok) in Table 39. Average non-residential energy use is also shown for the regional hub community of Bethel.

Table 39: Average Residential Energy Use in New Stuyahok and Bethel, 2012

	New Stuyahok			Bethel	
By Use	kBTU/sq ft/yr	Average MMBTU/yr	% of Total Residential Energy Use	Average MMBTU/yr	% of Total Residential Energy Use
Space Heating	87.84	86.79	85%	139.22	72%
Hot Water	2.68	2.65	3%	33.79	18%
Electrical	12.51	12.35	12%	20.24	10%
Total	**103.03**	**101.79**	**100%**	**193.25**	**100%**

Source: (32)

Table 40: Average Non-residential Energy Use in Bethel and 3 Small Rural Communities, 2012

	3 Small Rural Communities			Bethel		
By Use	Average MMBTU/yr	kMBTU /sq ft/yr	% of Non-residential Energy Use	Average MMBTU/yr	kMBTU /sq ft/yr	% of Non-Residential Energy Use
HVAC	539.73	96.48	76%	847.87	166.1	72%
Hot Water	17.53	3.17	2%	137.59	8.47	12%
Lighting	64.6	11.6		133.25	22.21	
Other Electrical	85.26	21.39		59.48	12.93	
Total Electrical	149.86	32.99	21%	192.73	35.14	16%
Total Energy	**707.12**	**132.64**	**100%**	**1178.19**	**209.71**	**100%**

Source: (32)

Using available census data and making some assumptions about average house sizes in the region, we can extrapolate from the end use data to estimate residential heating loads for Bristol Bay communities, as shown in Table 41. Unfortunately, this gives us only half the picture, since there is not a good inventory of non-residential buildings (including building use and square footage) for the region. Energy use in commercial buildings and public facilities can vary widely depending on building type and use, with warehouses using much less energy per square foot than schools or offices. For this reason, we have not estimated non-residential heating demand.

Table 41: Estimated Annual Residential Energy Use in Bristol Bay

	Space Heating Energy Use (MMBTU/yr)	Hot Water Energy Use (MMBTU/yr)	Electrical Energy Use (MMBTU/yr)	Total Residential Energy Use (MMBTU/yr)
Aleknagik	6,162	188	877	**7,227**
Chignik	3,558	109	506	**4,173**
Chignik Lagoon	2,517	77	358	**2,952**
Chignik Lake	2,343	72	333	**2,748**
Clark's Point	2,083	64	296	**2,443**
Dillingham	74,205	2,266	10,559	**87,030**
Egegik	2,517	77	358	**2,952**
Ekwok	3,211	98	457	**3,766**
Igiugig	1,389	42	198	**1,629**
Iliamna	3,385	103	482	**3,970**
King Salmon	13,626	416	1,939	**15,981**
Kokhanok	4,513	138	642	**5,293**
Koliganek	4,773	146	679	**5,598**
Levelock	2,343	72	333	**2,748**
Manokotak	10,502	321	1,494	**12,317**
Naknek	20,048	612	2,853	**23,513**
New Stuyahok	9,894	302	1,408	**11,604**
Newhalen	4,340	133	618	**5,090**
Nondalton	4,947	151	704	**5,802**
Pedro Bay	1,649	50	235	**1,934**
Perryville	3,298	101	469	**3,868**
Pilot Point	2,343	72	333	**2,748**
Port Alsworth	3,819	117	543	**4,479**
Port Heiden	3,038	93	432	**3,563**
South Naknek	3,038	93	432	**3,563**
Togiak	20,048	612	2,853	**23,513**
Twin Hills	2,517	77	358	**2,952**
Total	**216,107**	**6,599**	**30,752**	**253,457**

Transportation Energy Use

Little data is available to estimate the energy used for transportation in the Bristol Bay region, including aviation, on-road, off-road and marine uses. The AEA 2010 Alaska Energy Pathway report estimated the amount of diesel used annually by Bristol Bay households for transportation at around 500 gallons, for a total of 1.3 million gallons for the region (95). This is significantly less than the annual purchases of unleaded and diesel gasoline reported by communities in the 2012 Bulk Fuel Purchasing Group Study, which are shown in Table 42. It is also less than the household transportation fuel use recently reported by Norton Sound residents in another study.

Table 42: Average Annual Unleaded and Diesel Gasoline Purchases by Community

	#2 Diesel (gals)	Unleaded Gasoline (gals)	Total Gallons per Capita	Total Gallons per Household
High	70,000	90,000	962	3,125
Low	30,000	4,500	40	118
Average	48,333	24,181	349	1,092

Source: (63). Based on data from 12 Bristol Bay communities. Survey participants were asked to report bulk fuel purchases for the past year based on fuel invoices and were asked to estimate average annual community fuel use.

ENERGY USE FOR SUBSISTENCE TRANSPORTATION IN NORTON SOUND AND INTERIOR ALASKA

In a 2010 study of household energy use for subsistence transportation, residents of four Norton Sound communities (Golovin, Koyuk, Shaktoolik, White Mountain) were asked about the number, age, and type of vehicles owned per household, as well as how vehicles were used, fuel consumption and potential for energy efficiency (96). The findings were compared with an ADF&G subsistence survey of 207 households in Interior Alaska in 2011. Reported fuel consumption in the Norton Sound communities was slightly higher than for remote Interior communities and significantly higher than in road-accessible Interior locations.

Table 43: Average Annual Household Gasoline Consumption by Vehicle Type in Norton Sound, 2010

	Norton Sound (Remote)		Interior (Remote)		Interior (Road accessible)	
Type of Vehicle	Gallons	% of Total	Gallons	% of Total	Gallons	% of Total
ATV	229	23%	249	22%	53	7%
Boat	327	25%	665	52%	171	21%
Snowmachine	665	52%	478	41%	129	16%
Car					449	56%
Total	**1,291**	**100%**	**1,162**	**100%**	**802**	**100%**

Source: (96)

Other findings:

- Subsistence harvest accounts for about a third of total transportation energy use. Most households only use a little gasoline for subsistence-related transportation; a few use a lot.
- Most households own just one ATV, but more than one snowmachine and more than one boat. Snowmachines and ATVs are newest; boat engines are oldest. ATVs are most suitable for integration with renewables.
- Two-stroke engines have lower up-front costs, but are less efficient (i.e. fewer miles per gallon). Four-stroke engines have more expensive parts, but need many fewer oil changes and do not need a gas mixture

It is likely that here would be considerable variation in subsistence transportation patterns between Norton Sound and the Bristol Bay regions, as well as between different t subregions within the Bristol Bay region. More needs to be known about transportation energy use throughout rural Alaska.

POPULATION CHANGE

Population size directly impacts the demand for energy and thus the economics of any energy project being considered. Calculating the return on investment or benefit-cost ratio of a 20- to 50-year energy project requires assumptions about future energy consumption including the number of energy customers.

While the region as whole has been growing gradually, population trends for individual communities are more varied. Without infrastructure to connect most communities in the region, new energy projects will likely continue to serve small, discrete markets or “island systems.” As a result, understanding where future populations will live is important to energy planning.

Current Population

The majority of Bristol Bay residents live in small communities of less than 500 people. Of the region’s 31 cities and census designated places (CDPs), only Dillingham has more than 1,000 residents and only three others (Togiak, Naknek and New Stuyahok) have more than 500. Ten communities have populations of less than 100 residents, according to the July 2012 population estimates from the Alaska Department of Labor and Workforce Development (ADOLWD).

Six communities in the region are largely seasonal villages or have year-round populations under 25. They are Ekuk, Ivanof Bay, Kanatak, Pope-Vannoy Landing, Portage Creek and Ugashik. None have local electric utilities. While these communities have not been actively included in data collection, they appear in the resource inventory when a known renewable energy resource exists or when they have a notable residential or community-scale energy projects.

Population Trends

The region as whole has been growing gradually through natural increase (more births than deaths) since 2010 despite small losses to out-migration, as shown in Table 44. An exception is the Bristol Bay Borough where net losses from migration have not been offset by new births.

Table 44: Components of Population Change by Census Area, 2010-2012

Borough or Census Area	Census Apr 2010	Estimate Jul 2012	Natural Increase 2010-12	Net Migration 2010-12	Population Change 2010-12	Average Annual Growth 2010-12
Bristol Bay Borough	997	987	8	-18	-10	-0.45 %
Dillingham Census Area	4,847	4,988	155	-14	141	1.27 %
Lake and Peninsula Borough	1,631	1,673	39	3	42	1.13 %
Total Region	**7,475**	**7,648**	**202**	**-29**	**173**	**1.01 %**

Sources: (97)

Table 45: Population Trends by Community, 2000-2012

Population	2000 Census	2012 Est.	Avg. Annual Growth	Trend Since 2000
Over 1,000				
Dillingham	2,466	2,406	-0.20%	Stable
501 to 1,000				
Togiak	809	871	0.64%	Slight Growth
Naknek	678	550	-1.57%	Declining
New Stuyahok	471	507	0.64%	Slight Growth
201 to 500				
Manokotak	399	449	1.04%	Growing
King Salmon	442	357	-1.60%	Declining
Koliganek	182	223	1.88%	Growing
Aleknagik	223	204	-0.71%	Slight Decline
101 to 200				
Newhalen	160	178	0.94%	Slight Growth
Kokhanok	174	170	-0.19%	Stable
Nondalton	221	169	-1.96%	Declining
Port Alsworth	104	167	5.05%	Growing
Port Heiden	119	123	0.28%	Stable
Ekwok	130	118	-0.77%	Slight Decline
Perryville	112	112	0.00%	Stable
Iliamna	102	111	0.74%	Slight Growth
Egegik	116	106	-0.72%	Slight Decline
100 or less				
Chignik	79	91	1.27%	Growing
Levelock	122	88	-2.32%	Declining
Twin Hills	69	83	1.69%	Growing
Chignik Lagoon	145	70	-4.31%	Declining
South Naknek	137	80	-3.47%	Declining
Chignik Lake	103	82	-1.70%	Declining
Pilot Point	100	68	-2.67%	Declining
Clark's Point	75	59	-1.78%	Declining
Igiugig	53	52	-0.16%	Stable
Pedro Bay	50	42	-1.33%	Declining

Population trends for individual communities are more varied. About half have had net losses in population since 2000, while others have been stable or growing. Looking at Table 45, it is apparent that the most significant declines have been in communities under 100, where seven out of 10 have lost population.

Population Projections

Looking forward, ADOLWD demographers project that Southwest Alaska will continue to grow slowly through high fertility rates, despite somewhat strong net losses from migration. An exception is again the Bristol Bay Borough where birth rates are lower than average for the state (10.4 births per 1,000 people compared with 16.3 statewide). Population growth in the Borough is also expected to be slower than other areas in the region due to higher mortality (8.1 deaths per 1,000 people compared with 5.2 for the state as a whole).

ADOLWD does not expect relative birth or death rates to change much at a regional level over the projection period (2010-2035), though as Alaska's population ages over the period, there will likely be increases in crude death rates for all boroughs and census areas. Birth and death rates are projected by analyzing gender and age cohorts for each population.

Table 46: Population Projections by Census Area, 2010-2035

	Estimate	Projection				
	2010	2015	2020	2025	2030	2035
Bristol Bay Borough	1,002	968	936	897	851	806
Dillingham Census Area	4,874	4,930	5,016	5,085	5,126	5,180
Lake and Peninsula Borough	1,647	1,622	1,601	1,575	1,540	1,503

Source: (98)

Table 47: Birth Rates by Census Area, 2007-2011

	Women 15 to 50	Margin of Error	Women with Births in Past 12 Mos.	Margin of Error	Birth Rate / 1,000 women	Margin of Error
Bristol Bay Borough	219	+/-40	5	+/-8	23	+/-35
Dillingham Census Area	1,121	+/-17	113	+/-33	101	+/-30
Lake and Peninsula Borough	396	+/-50	32	+/-17	81	+/-44

Source: (99)

Issues

The low population density in rural Alaska creates challenges for energy planners as it does for other policymakers. It is difficult to estimate future energy needs for very small communities, particularly those where population has been declining. For very small communities, policymakers should consider whether some form of energy price relief makes more sense than long-term capital investment.

With few roads or transmission lines, energy projects will continue to serve small, discrete markets. Yet the small sample sizes and large margins of error in much of rural Alaska for both the decennial Census and American Community Survey makes sex by age data unreliable for projecting population growth at the community level (100). For this reason, the state only projects population growth at the borough or census area level. This is less than useful for analyzing the economics of "island systems" that will provide energy to isolated markets.

Data Gaps

- **Accurate population counts**, especially for communities with populations under 100, including sex by age data.

Resources for Communities

COMMUNITY PARTNERSHIP FOR SELF-RELIANCE

Community Partnership for Self-Reliance (CPS) is a collaboration between the Alaska Native Science Commission (ANSC) and the University of Alaska (UA) to partner with selected rural communities to refine and implement their visions of self-reliance in the face of major challenges from rising fuel costs, climate warming, declining state and federal budgets, and many social and cultural changes. CPS creates liaison teams that match the needs of communities with the research expertise at the University of Alaska.

7 | Project Economics & Financing

Project Economics

In Phase I we conducted an economic analysis of proposed energy projects in the region that have a current champion and sufficiently detailed data available for use in modeling. Because the regional planning process is focused on projects considered economically and technically feasible and which could be developed in the near- to mid-term (3 to 5 years), the analysis included only projects that have been previously defined. The scope of the project precluded engineering hypothetical projects for inclusion in the analysis.

Projects were evaluated using three different methodologies or lenses, including criteria that prioritize state funding efficiency and community benefits while factoring in capital costs and oil price risk. The choice of methodologies results in different results, so it is critical to identify the most important values of project proponents and beneficiaries. No conclusions can be drawn about which projects would be best to pursue without the involvement of community and regional stakeholders.

Considering the lack of integration of energy systems in much of the region, the greatest value of the economic analysis may be in providing local decision makers with additional information they can use to evaluate the merits of local energy solutions and assess their potential for attracting public and private funding.

Project Identification

We started by looking at all known energy projects that have been proposed but not built in the region—a list of 50—including all projects submitted to the Renewable Energy Fund in Rounds 1 to 6 that have not had construction funds allocated. Then we talked with project sponsors, including the larger utilities, to find out their current priorities and if there were any older projects on the list they no longer considered viable. We also talked with AEA program managers in most resource areas for their input on where resource potential exists. The result was a continued narrowing of the list of projects to analyze. Several additional projects dropped off not because they are not viable or supported, but because we were not able to get sufficiently detailed project cost and other information to enable analysis.

With exception of Kvichak River RISEC, the final list does not include any projects based on emerging technologies that may become technically feasible in a mid-term timeframe (5 to 10 years). While the other projects are all based on widely deployed technologies, some of the high penetration wind projects may also have to wait until the technology is fully mature for integrating into isolated diesel micro-grid systems.

Through our conversations, we found that the Renewable Energy Fund has done a good job in flushing out the most viable renewable energy projects with the greatest local support, while the

State's active RPSU and Bulk Fuel programs, with support from the Denali Commission, have resulted in major upgrades to diesel energy infrastructure and efficiency throughout the region.

The final list of projects analyzed includes 20 projects in 14 communities.[13] Reflecting the mix of resources in the region, the final list includes 13 wind projects, five conventional hydro projects, one hydrokinetic project, and one solar PV project. Descriptions of individual projects are included in the respective sections of the resource inventory (e.g. Hydro, Solar, Wind). While all projects generate electricity, and quite a few would generate excess capacity that could be dispatched to thermal loads, none directly addresses transportation energy. There are also no energy efficiency projects in the mix.

Because of the lack of existing roads and transmission lines in the region, few of the projects would serve more than their local communities. The projects are located in 14 communities, but would serve 18 communities through existing or already funded interties in the region. The two Nushagak Area Hydro Projects would have the capacity to serve additional communities if new interties were built.

Obviously, there are some communities for which no project is included. Considering that energy costs are high throughout the region and nearly all communities are heavily dependent on non-renewable fossil fuels for heat, electricity and transportation, this is a significant gap that needs to be addressed in the next phase of the regional planning process. We anticipate that in the next phase of the project community members and regional stakeholders will identify additional projects they are interested in developing, so that more projects will be added to the analysis.

Ranking Methodologies

Projects have been ranked using three different evaluative criteria, which prioritize state funding efficiency and community benefits while factoring in capital costs and oil price risk. We start by looking at which projects offer opportunities for private investment based on levelized Cost of Service tariffs.

The choice of methodologies results in different project rankings, so it is critical to identify the most important values of local project proponents and beneficiaries in such areas as preferred time horizon, appetite for risk, economic development goals, interest in regional linkages, and priorities for addressing the total mix of energy needs including heating and transportation energy. Selecting or refining a ranking methodology will also require discussion with AEA and regional energy stakeholders.

Ideally, being clear about the assumptions and results behind different ranking methodologies will clarify the goals and consequences of different funding approaches and lead to more transparent decisions.

Baseline assumptions for each project, including capacity, capital and O&M costs, energy output, etc., are included in Appendix A. Assumptions are based on information provided by project proponents, either in grant applications or feasibility and conceptual design reports. Some effort has been made to update and verify project specifications with project sponsors and engineers. In

[13] Because three of the high-penetration wind projects represent alternative approaches to the same project, the actual number of distinct projects is 17.

the case of projects submitted to the Renewable Energy Fund, numbers from the AEA analysis have been use. For a details on model inputs, differences and methodologies, see Appendix C.

Ranking by Cost of Service Tariffs

PUBLIC VS. PRIVATE INVESTMENT

Unlike cost-benefit metrics, calculated tariffs show what must be charged to final consumers to capture the fully-loaded costs of providing service. Rates include the return on and of capital, as well as all applicable taxes and operating expenses. If tariffs associated with privately owned projects appear to be lower than current unsubsidized or PCE-subsidized electricity rates, then there may be room for private entities to contribute to local energy solutions even absent state involvement.

Table 48 shows those projects with a projected Cost of Service (COS) tariff lower than recent electric rates in the community. Tariffs shaded in green are lower than the per kWh cost even when subsidized through the state's PCE program. Those shaded in yellow are more than the PCE rate but less than the average residential rate without the state subsidy.

It appears that several of the projects may, all else equal, be candidates for private investment by virtue of charging rates that provide energy cost relief *and* allow recovery of the full costs of service. Although charging the full cost of service runs counter to the goal of achieving the lowest possible energy cost, doing so could promote other social goals. Where energy costs can be reduced through private initiative it allows public funds to stretch further in support of energy cost relief.

ISSUES AND POLICY OPTIONS

The small customer base of many communities may present a key roadblock to private investment, however. Private investors commonly want a 20-year power purchase agreement before they commit project capital. If they are unsure about the economic sustainability of the local community's customer base then even assuming a contract can be secured they may have reasonable doubts about the security of their investment. This is, potentially, an area where AIDEA might be able to help.

One approach would be for AIDEA to serve, if necessary, as a guarantor of local utility commitments. Another would be for direct state investment (as opposed to grants). This would further reduce project energy costs (compare state and private COS tariffs in Table 48). It could also further promote community sustainability. If tariffs include the costs of capital recovery (depreciation) and debt service, then consumers can finance the replacement of project assets at the end of their useful life. Were something like separate capital fund accounts established then communities would reduce their vulnerability to the state's possible future inability to provide the subsidy needed to replace those assets.

Table 48: Levelized Nominal-Dollar Cost of Service Tariffs, State vs. Private Investment

Levelized COS, full project	(A) Private Investment COS Tariff	(B) State Funding COS Tariff	Average Residential Rate per kWh	2011 PCE-subsidized Residential Rate
Knutson Creek Hydro Feasibility and Planning	$0.49	$0.34	$0.91	$0.49
Kvichak River RISEC Project	$6.36	$4.68	$0.80	$0.41
Igiugig Wind Project	$0.83	$0.68	$0.80	$0.41
Port Heiden Wind & Power Distribution Upgrade	$0.32	$0.27	$0.75	$0.20
Port Alsworth Wind Project 1	$0.61	$0.50	$0.69	$0.49
Port Alsworth Wind Project 2	$0.37	$0.31	$0.69	$0.49
Chignik Lagoon Wind Project 1	$0.16	$0.13	$0.65	$0.40
Chignik Lagoon Wind Project 2	$0.11	$0.09	$0.65	$0.40
New Stuyahok Wind Feasibility & Concept Design	$1.02	$0.80	$0.62	$0.41
Tazimina Hydro Project Capacity Increase	$0.05	$0.04	$0.57	$0.26
Manokotak Wind & Heat Feasibility	$0.65	$0.54	$0.55	$0.27
Bristol Bay School District Solar PV Project	$1.16	$0.85	$0.52	$0.24
Nushagak Community Wind Power Project	$0.57	$0.45	$0.52	$0.24
New Koliganek Wind & Heat Recovery Feasibility	$0.62	$0.51	$0.50	$0.36
Pilot Point Wind-Diesel-CHP	$0.76	$0.60	$0.50	$0.37
Nushagak Area Hydro Project (NAHP) - Grant Lake	$0.62	$0.42	$0.39	$0.20
Nushagak Area Hydro Project (NAHP) - Lake Elva	$1.12	$0.90	$0.39	$0.20
Chignik (Indian Creek) Hydro Project	$0.70	$0.36	NA	NA
Chignik Lake Wind Project 1	$0.46	$0.38	NA	NA
Chignik Lake Wind Project 2	$0.19	$0.15	NA	NA

Notes: Cost of service tariffs shaded in green are less than or equal to a community's 2011 PCE-subsidized residential rate; those in yellow are higher than the PCE rate but less than the average unsubsidized residential rate. Projects with tariffs shaded either color may be candidates for private investment, though the energy cost relief is slightly greater with state funding. Those with tariffs shaded orange make economic sense only in the case of state funding.

Ranking by Benefit-Cost Ratio

MAXIMIZING STATE INVESTMENT EFFICIENCY

If the social goal is to maximize the State's net present value (NPV), then only those projects with a benefit-cost (B/C) ratio exceeding unity (1.0) should be funded. Following AEA, we calculate benefit-cost ratios for each project (i.e., the present value of benefits divided by the present cost of investment). If government funds are unconstrained then the state should pursue all projects with a B/C ratio greater than 1.0.[14]

If government funds are constrained then statewide NPV will be maximized by rank-ordering projects by benefit-cost ratios and funding only those that fit within the budget cap. For example, if the State had $60 million to invest in the Bristol Bay region, only those shaded green in Table 49 would receive funding. Yellow highlights additional projects that have a positive B/C ratio and should be funded if public funds were unconstrained. For a cost of $76 million, all energy projects with a B/C ratio over 1.0 could be developed.

Table 49: Project Benefit-Cost Ratios at $100 per Barrel Oil

	B/C Ratio	Project Cost	Cumulative Cost
Tazimina Hydro Project Capacity Increase	6.60	$ 2,308,628	$ 2,308,628
Chignik Lagoon Wind Project 2	3.44	$ 1,666,488	$ 3,975,116
Chignik Lagoon Wind Project 1	2.66	$ 1,198,915	
Port Alsworth Wind Project 2	1.87	$ 1,666,489	$ 5,641,605
Chignik Lake Wind Project 2	1.79	$ 1,540,334	$ 7,181,940
Knutson Creek Hydro Feasibility and Planning	1.36	$ 2,979,729	$ 10,161,668
Nushagak Area Hydro Project (NAHP) - Grant Lake	1.32	$ 45,667,660	$ 55,829,328
Nushagak Area Hydro Project (NAHP) - Lake Elva	1.20	$ 13,526,735	$ 69,356,063
Port Alsworth Wind Project 1	1.16	$ 1,549,391	
Port Heiden Wind & Power Distribution Upgrade	1.10	$ 2,220,280	$ 71,576,343
New Koliganek Wind & Heat Recovery Feasibility	1.09	$ 464,034	$ 72,040,377
Chignik (Indian Creek) Hydro Project	1.02	$ 3,856,572	$ 75,896,950
Chignik Lake Wind Project 1	0.85	$ 1,211,954	
Igiugig Wind Project	0.84	$ 1,391,654	$ 77,288,604
Pilot Point Wind-Diesel-CHP	0.83	$ 1,248,524	$ 78,537,128
Manokotak Wind & Heat Feasibility	0.78	$ 2,129,328	$ 80,666,455
Nushagak Community Wind Power Project	0.61	$ 3,384,396	$ 84,050,851
New Stuyahok Wind Feasibility & Concept Design	0.57	$ 4,245,171	$ 88,296,022
Bristol Bay School District Solar PV Project	0.36	$ 413,674	$ 88,709,696
Kvichak River RISEC Project	0.12	$ 5,905,072	$ 94,614,768

Notes: Assumes $100/Bbl flat real oil prices. Capital costs for alternative wind projects designed for the same community are only counted once since only one of the two projects would be developed. For this reason there is no entry in the Cumulative Cost column the second time a wind project appears in the list.

[14] If the discount rate used in the analysis reflects the cost of state borrowing, then government funds should substantially be treated as unconstrained.

Note that the budget cap of $60 million has been chosen arbitrarily to demonstrate how B/C ratios can be used to prioritize state funding. A different budget amount would result in a different cut-off point. More to the point, there is no commitment from the State to invest any fixed sum per region. As part of the regional energy planning process, AEA will also be looking for evidence of local budget commitment to funding priority projects.

FACTORING IN OIL PRICE RISK

It is important to understand, though, that the level of future oil prices affects how many projects are deemed funding worthy under this approach. This is because benefit-cost ratios are sensitive to assumed oil price.

Future price scenarios include both flat, real oil price decks and US EIA base case, high, and low price projections. Benefit-cost ratios are affected by the dynamic interaction of the project spend profile, project start date, and the EIA projection's real price growth rate. This causes the US EIA base case price projection to equilibrate different projects' benefit-cost ratios at different flat real oil prices (see boxed entries, Table 50). Meanwhile, benefit-cost ratios increase essentially linearly with increases in fixed real oil prices. *The upshot is that projects' benefit-cost ratio ordinal rankings are sensitive to which EIA price projection is used, but are unaffected by flat real oil price differences*.

Table 50: Project Benefit-Cost Ratios as a Function of Future Oil Price Scenarios

ANS WC Crude Oil Price per Bbl (real 2013$)	$60	$70	$80	$90	$100	$110	$120	$130	$140	EIA Mid	EIA High	EIA Low
Tazimina Hydroelectric Project Capacity Increase	4.87	5.30	5.73	6.17	6.60	7.03	7.47	7.9	8.33	8.33	11.15	5.47
Chignik Lagoon Wind Project 2	2.34	2.62	2.89	3.16	3.44	3.71	3.98	4.26	4.53	3.85	5.3	2.7
Chignik Lagoon Wind Project 1	1.80	2.02	2.23	2.45	2.66	2.88	3.09	3.30	3.52	2.99	4.13	2.08
Port Alsworth Wind Project 2	1.45	1.56	1.66	1.77	1.87	1.98	2.09	2.19	2.30	2.04	2.60	1.59
Chignik Lake Wind Project 2	1.22	1.37	1.51	1.65	1.79	1.94	2.08	2.22	2.36	2.01	2.77	1.41
Knutson Creek Hydro Feasibility and Planning	1.05	1.13	1.20	1.28	1.36	1.43	1.51	1.59	1.66	1.68	2.18	1.16
Nushagak Area Hydro Project (NAHP) - Grant Lake	0.96	1.05	1.14	1.23	1.32	1.41	1.50	1.59	1.68	1.69	2.28	1.09
Nushagak Area Hydro Project (NAHP) - Lake Elva	0.87	0.95	1.03	1.11	1.20	1.28	1.36	1.44	1.52	1.55	2.09	0.98
Port Alsworth Wind Project 1	0.89	0.96	1.03	1.09	1.16	1.22	1.29	1.35	1.42	1.26	1.61	0.98
Port Heiden Wind & Power Distribution Upgrade	0.84	0.91	0.97	1.04	1.10	1.17	1.23	1.30	1.36	1.19	1.53	0.93
New Koliganek Wind & Heat Recovery Feasibility	0.8	0.88	0.95	1.02	1.09	1.17	1.24	1.31	1.38	1.19	1.56	0.90
Chignik (Indian Creek) Hydro Project	0.68	0.76	0.85	0.93	1.02	1.10	1.19	1.27	1.36	1.35	1.90	0.80
Chignik Lake Wind Project 1	0.57	0.64	0.71	0.78	0.85	0.92	0.99	1.07	1.14	0.96	1.34	0.66
Igiugig Wind Project	0.65	0.69	0.74	0.79	0.84	0.88	0.93	0.98	1.02	0.91	1.16	0.71
Pilot Point Wind-Diesel-CHP	0.62	0.67	0.73	0.78	0.83	0.89	0.94	0.99	1.05	0.93	1.22	0.69
Manokotak Wind & Heat Feasibility	0.58	0.63	0.68	0.73	0.78	0.83	0.89	0.94	0.99	0.88	1.16	0.64
Nushagak Community Wind Power Project	0.41	0.46	0.51	0.56	0.61	0.67	0.72	0.77	0.82	0.71	1.00	0.47
New Stuyahok Wind Feasibility & Concept Design	0.42	0.45	0.49	0.53	0.57	0.61	0.64	0.68	0.72	0.63	0.84	0.46
Bristol Bay School District Solar PV Project	0.24	0.27	0.30	0.33	0.36	0.39	0.42	0.46	0.49	0.45	0.63	0.28
Kvichak River RISEC Project	0.10	0.10	0.11	0.12	0.12	0.13	0.14	0.15	0.15	0.14	0.18	0.10

Notes: Benefit-cost ratios outlined in red show which flat oil prices produce roughly the same ratio as the EIA base case. Green-shaded cells indicate flat prices required to generate a B/C ratio of unity (1.0). If the social goal is to maximize state net present value (NPV), then only those projects with a B/C ratio greater than 1.0 should be funded. Projects low on the list require higher oil prices to generate a break-even B/C ratio and thus engender more oil price risk.

This insight should affect how price projections are used in project evaluation. If one believes the EIA base case price projections to be a reliable indicator of the future oil price path, then it would make sense to report project rankings against that benchmark. However, if one views the EIA as providing *projections* rather than *predictions*—a logically structured "what if" rather than a best-guess of future events—then rankings using the EIA price deck should hold no special status in deciding which projects to fund. Because they isolate one of the pieces that otherwise is moving in the EIA projections, flat price projections may better highlight relative project differences. *Projects requiring higher oil prices to generate a break-even benefit-cost ratio engender more risk. Project-relative price risk can be assessed by "solving" for the oil price differential that equilibrates their benefit-cost ratios.*

Ranking by Distribution of Project Benefits

FACTORING IN COMMUNITY SUSTAINABILITY AND INDEPENDENCE

The state's objective function is not clearly defined as seeking to maximize overall state NPV. Things other than "investment efficiency" may matter. In particular, the potential future *distribution* of project benefits may matter. From the perspective of a regional energy plan, an energy project's impact on household budgets in the community, or the ability of a project to wean a community off ongoing PCE subsidies, may be salient.

At present, the PCE program causes renewable energy project benefits to materially flow to the state general fund. A reduction in the cost of power generation at the community level serves, substantially, to reduce PCE subsidy payments made by the state. *Accordingly, projects targeted primarily or exclusively towards displacing diesel generation may fail to provide material community-level benefits in years when the PCE is fully funded.*

However, there is no telling whether the PCE will be fully funded in perpetuity. Alternatively, there is no telling that the PCE program will always be structured to divert funding away from communities that have reduced their energy bills through innovative projects. And finally, in some instances, the cost of state-grant-funded project power may be below levels that qualify for PCE subsidies. That is, some—and in future potentially all—of the benefits of a renewable energy project might stay within the community.

To illustrate potential community project benefits we also report per-capita potential project benefits. In other words:

(Present value of project benefits)/(Community population)

Abstracting from commercial sales, this metric captures potential benefits within the community that the project is located. Benefits become fully "actual," rather than "potential," under a number of circumstances—the most obvious of which are the disappearance of PCE funding or modification of the PCE program. This metric therefore indicates the degree to which a project can foster community sustainability and independence from the need for ongoing state subsidy. It shows the degree to which a project might affect household budgets and the business environment within the community.

Table 51: Present Value of Per Capita Project Benefits over a Project's Economic Life

	B/C ratio	PV Benefits/ Person	Project Cost	Cumulative Cost
Knutson Creek Hydro Feasibility and Planning	1.36	$96,286	$ 2,979,729	$ 2,979,729
Chignik Lagoon Wind Project 2	3.44	$73,423	$ 1,666,488	$ 4,646,217
Chignik (Indian Creek) Hydro Project	1.02	$43,145	$ 3,856,572	$ 8,502,789
Chignik Lagoon Wind Project 1	2.66	$40,894	$ 1,198,915	
Chignik Lake Wind Project 2	1.76	$37,841	$ 1,540,334	$ 10,043,124
Tazimina Hydro Project Capacity Increase	6.60	$32,905	$ 2,308,628	$ 12,351,752
Port Heiden Wind & Power Distribution Upgrade	1.10	$23,977	$ 2,220,280	$ 14,572,031
Igiugig Wind Project	0.84	$23,243	$ 1,391,654	$ 15,963,685
Nushagak Area Hydro Project (NAHP) - Grant Lake	1.32	$23,102	$ 45,667,660	$ 61,631,345
Port Alsworth Wind Project 2	1.87	$19,646	$ 1,666,489	$ 63,297,834
Pilot Point Wind-Diesel-CHP	0.83	$15,319	$ 1,248,524	$ 64,546,358
Kvichak River RISEC Project	0.12	$14,760	$ 5,905,072	$ 70,451,430
Chignik Lake Wind Project 1	0.85	$14,177	$ 1,211,954	
Port Alsworth Wind Project 1	1.16	$11,279	$ 1,549,391	
Nushagak Area Hydro Project (NAHP) - Lake Elva	1.20	$6,191	$ 13,526,735	$ 83,978,165
New Stuyahok Wind-Feasibility & Concept Design	0.57	$4,730	$ 4,245,171	$ 88,223,336
Nushagak Community Wind Power Project	0.61	$3,826	$ 3,384,396	$ 91,607,732
Manokotak Wind & Heat Feasibility	0.78	$3,771	$ 2,129,328	$ 93,737,060
New Koliganek Wind & Heat Recovery Feasibility	1.09	$2,429	$ 464,034	$ 94,201,094
Bristol Bay School District Solar PV Project	0.36	$276	$ 413,674	$ 94,614,768

Note: Assumes $100/Bbl flat real oil prices. The red line demarcates those projects that should be funded if the State were to grant money towards regional energy projects that provide a minimum level ($100/month) of per-capita benefits. The green and yellow shading indicate the 12 projects with positive B /C rations shown in Table 49. Once again, there is no entry in the Cumulative Cost column the second time a project appears in the list.

Not surprisingly, the new metric reshuffles projects. For a given level of total state spending different projects would be funded (compare Table 49 and Table 51). Indeed, if the funding goal was to make a step-change in community viability, one can imagine choosing to fund only those projects that provide a minimum level of per-capita project benefits (e.g. present-value benefits of greater than $100/month per capita over the project's economic life—or $24,000 per capita for a 20 year-project) rather than projects that generate B/C ratios greater than 1.0.

FACTORING IN CAPITAL COSTS

The downside to per capita project benefits is that it essentially treats the capital costs of a project as irrelevant, yet of course state capital is limited. One way to bridge the twin goals of capital efficiency and potential household impacts is to assess the per capita present value of project benefits per investment dollar. In other words:

[(Present value of benefits)/(Community population)]/(Present value of capital costs)

This ratio measures the effectiveness of a dollar in capital subsidy in delivering per-capita energy cost savings. For a given regional capital expenditure budget, funding projects in rank order would—under the conditions discussed—maximize community household impacts (Table 52).

Table 52: Per Capita Project Benefits per Capital Dollar Invested

	(PV Benefits/Person)/PC	Project Cost	Cumulative Cost
Chignik Lagoon Wind Project 2	0.04406	$ 1,666,488	$1,666,488
Chignik Lagoon Wind Project 1	0.03411	$ 1,198,915	
Knutson Creek Hydro Feasibility and Planning	0.03231	$ 2,979,729	$4,646,217
Chignik Lake Wind Project 2	0.02457	$ 1,540,334	$6,186,551
Igiugig Wind Project	0.01670	$ 1,391,654	$7,578,205
Tazimina Hydro Project Capacity Increase	0.01425	$ 2,308,628	$9,886,833
Pilot Point Wind-Diesel-CHP (High Penetration)	0.01227	$ 1,248,524	$11,135,357
Port Alsworth Wind Project 2	0.01179	$ 1,666,489	$12,801,846
Chignik Lake Wind Project 1	0.01170	$ 1,211,954	
Chignik (Indian Creek) Hydro Project	0.01119	$ 3,856,572	$16,658,419
Port Heiden Wind & Power Distribution Upgrade	0.01080	$ 2,220,280	$18,878,698
Port Alsworth Wind Project 1	0.00728	$ 1,549,391	
New Koliganek Wind & Heat Recovery Feasibility	0.00523	$ 464,034	$19,342,733
Kvichak River RISEC Project	0.00250	$ 5,905,072	$25,247,805
Manokotak Wind & Heat Feasibility	0.00177	$ 2,129,328	$27,377,132
Nushagak Community Wind Power Project	0.00113	$ 3,384,396	$30,761,528
New Stuyahok Wind Feasibility & Concept Design	0.00111	$ 4,245,171	$35,006,699
Bristol Bay School District Solar PV Project	0.00067	$ 413,674	$35,420,373
Nushagak Area Hydro Project (NAHP) - Grant Lake	0.00051	$ 45,667,660	$81,088,033
Nushagak Area Hydro Project (NAHP) - Lake Elva	0.00046	$ 13,526,735	$94,614,768

Notes: Assumes $100/Bbl flat real oil prices. Capital costs for alternative wind projects designed for the same community are only counted once since only one of the two projects would be developed. For this reason there is no entry in the Cumulative Cost column the second time a wind project appears in the list.

This metric presents a fairly dramatic reshuffling of projects. In particular, the two Nushagak hydropower projects drop to the bottom of the funding priority list. The reason is that they matter relatively little to community household budgets (assuming project savings were to stay in community) given their costs to the state. Surprisingly, with a regional investment budget of roughly $35 million essentially all other projects would be funded. Even projects with low B/C ratios, and that generate relatively small per-capita project benefits, would be candidates for funding.

Ranking to Balance Statewide Investment Efficiency and Community Benefits

The concepts of statewide investment efficiency (captured by the benefit-cost ratios in Table 49) and community impact (captured by the per capita benefits in Table 51) can be combined in other sensible ways that might better reflect policy goals. Suppose, for example, that the state was willing to fund only projects that had benefit-cost ratios greater than unity, but also that have the potential to generate significant local benefits—e.g. per-capita benefits of more than $12,000 over the project's life. This might reflect a determination that funded projects should be "robust," and provide either statewide or material local benefits regardless of the PCE fund's fate. The result would be to "kick out" a number of projects shown in Table 52 either due to the benefit-cost constraint (orange-shaded projects in Table 53) or the community benefit constraint (yellow-shaded project). Cumulative state spending on projects passing through both screens would come to less than $17 million.

Table 53: Balancing Per Capita Benefits with State Investment Efficiency

	B/C ratio	(PV Benefits/ Person)/PC	Project Cost	Cumulative Cost
Chignik Lagoon Wind Project 2	3.44	0.04406	$ 1,666,488	$ 1,666,488
Chignik Lagoon Wind Project 1	2.66	0.03411	$ 1,198,915	
Knutson Creek Hydro Feasibility and Planning	1.36	0.03231	$ 2,979,729	$ 4,646,217
Chignik Lake Wind Project 2	1.79	0.02457	$ 1,540,334	$ 6,186,551
Tazimina Hydro Project Capacity Increase	6.60	0.01425	$ 2,308,628	$ 8,495,179
Port Alsworth Wind Project 2	1.87	0.01179	$ 1,666,489	$ 10,161,668
Chignik (Indian Creek) Hydro Project	1.02	0.01119	$ 3,856,572	$ 14,018,240
Port Heiden Wind & Power Distribution Upgrade	1.10	0.01080	$ 2,220,280	$ 16,238,520
Port Alsworth Wind Project 1	1.06	0.00728	$ 1,549,391	
New Koliganek Wind & Heat Recovery Feasibility	1.09	0.00523	$ 464,034	$ 16,702,554
Igiugig Wind Project	0.84	0.01670	$ 1,391,654	$ 18,094,208
Pilot Point Wind-Diesel-CHP (High Penetration)	0.83	0.01227	$ 1,248,524	$ 19,342,732
Chignik Lake Wind Project 1	0.85	0.01170	$ 1,211,954	
Kvichak River RISEC Project	0.12	0.00250	$ 5,905,072	$ 25,247,804
Manokotak Wind & Heat Feasibility	0.78	0.00177	$ 2,129,328	$ 27,377,132
Nushagak Community Wind Power Project	0.61	0.00113	$ 3,384,396	$ 30,761,528
New Stuyahok Wind Feasibility & Concept Design	0.57	0.00111	$ 4,245,171	$ 35,006,699
Bristol Bay School District Solar PV Project	0.36	0.00067	$ 413,674	$ 35,420,373
Nushagak Area Hydro Project (NAHP) - Grant Lake	1.32	0.00051	$ 45,667,660	$ 81,088,033
Nushagak Area Hydro Project (NAHP) - Lake Elva	1.20	0.00046	$13,526,735	$ 94,614,768

Notes: Assumes $100/Bbl flat real oil prices. Green shading indicates projects that would be funded if the State funded energy projects in the region with benefit-cost ratios greater than 1.0 while providing per-capita benefits of more than $12,000 over the project's life. Once again, there is no entry in the Cumulative Cost column the second time a project appears in the list.

The three different evaluative criteria can and do lead to different project rankings in a region given a budgetary constraint for the energy projects that can be funded within a region. In the context of regional energy plans there is a clear lack of alignment between potential state funding priorities and community desires. There is no non-messy way to bridge these perspectives. However, keeping them clearly in mind may help to clarify the goals and consequences of different funding approaches and lead to more transparent decisions.

FINANCING

There are four primary sources of project funding for energy projects: public funding, private equity, commercial debt, and third-party tax-equity investment. While public financing through state and federal grant and loan programs is most common in Alaska, there is opportunity to expand into private financing in order to capture more project potential. Private financing options are being used successfully elsewhere and will become more important in Alaska if state and federal funding declines. While most programs are available to both taxable and tax-exempt organizations, it is important to consider tax status, project terms, and ownership interest when considering financing options (1).

State and Federal Funding Options

Table 54: State Funding Options for Energy Projects

AEA	Bulk Fuel Upgrades (BFU)	Grants
Dave Lockard (907) 771-3062 www.akenergyauthority.org/programsenergysystemupgrade.html	AEA also operates the Bulk Fuel Upgrades program, which replaces older bulk fuel tanks and infrastructure to bring them into compliance with state and federal regulations and reduces the risk of leaks and equipment failure. With significant funding from the Denali Commission, Bulk Fuel Upgrades have been completed in over 70 communities at a combined cost of over $200 million. AEA has another 30 projects on its list.	**Eligibility**: Communities that are served by AVEC, the North Slope Borough, Alaska Power and Telephone Co, or connected by roads are not part of the Bulk Fuel Upgrades program.
AEA	**Commercial Building Energy Audit (CBEA)**	**Grants**
Cady Lister (907) 771-3039 www.akenergyauthority.org/EfficiencyAudits.html	The CBEA program provides grants that cover up to 100% of the cost of an energy audit for privately owned commercial buildings. Grant amount is based on the size and complexity of the building. A stipend is available for the auditor to travel to locations with one. The maximum reimbursement ranges from $1,800 for buildings under 2,500 square feet up to $7,000 for buildings from 60,000 to 160,000 square feet.	**Eligibility**: Private owners of non-residential buildings up to 160,000 square feet. Both for-profit and nonprofit businesses are eligible.
AEA	**Emerging Energy Technology Fund (EETF)**	**Grants**
Shawn Calfa (907) 771-3031 www.akenergyauthority.org/eetfundgrantprogram.html	The Emerging Energy Technology Fund was created by the Alaska Legislature to fund demonstration projects that test emerging energy technologies or methods that have a reasonable expectation to be commercially viable within five years. EETF funds can also be used to improve an existing technology or deploy one that has not previously been demonstrated in Alaska. Sixteen out of 70 applications were approved for funding in 2012.	**Eligibility**: The Renewable Energy Fund accepts applications from utilities, independent power producers, and local and tribal governments for the purpose of developing renewable energy projects. It does not provide funding for energy efficiency improvements.

AEA	Industrial Energy Audits of Seafood Processing Plants	Service
Cady Lister (907) 771-3039 www.akenergyauthority.org/eec-industrialenergyaudit.html	AEA launched an industrial energy audit program in 2010 to assist the seafood industry to better understand energy use in their plants in order to lower their carbon footprint and operating costs. The program has three parts: An energy audit kit (to measure power consumption of equipment and provide data to small and medium sized processors); an energy audit service for larger processors; an energy efficiency section on the Marine Advisory Program website to anonymously publish results of efficiency audits.	No subsidies currently available
AEA	**Power Cost Equalization (PCE) Program**	**Subsidy**
Jeff Williams (907) 771-3046 www.akenergyauthority.org/programspce.html	Alaska's Power Cost Equalization program provides economic assistance to residential customers and qualifying community facilities in rural areas of Alaska to offset the high cost of electricity compared with urban areas of the state. PCE pays a portion of approximately 30% of all kWh's sold by participating utilities. Participating utilities are required to reduce each eligible customer's bill by the amount that the State pays for PCE.	**Eligibility**: The Regulatory Commission of Alaska (RCA) determines if a utility is eligible and calculates the amount of PCE payable to the utility. AEA determines eligibility of community facilities and residential customers. Commercial customers are not eligible to receive PCE credit.
AEA	**Power Project Fund (PPF)**	**Loans**
Mike Catsi (907) 771-3060 www.akenergyauthority.org/programsloan.html	The Power Project Fund provides loans to local utilities, local governments or independent power producers for the development or upgrade of small-scale electric power production. The loan term is related to the life of the project. Interest rates vary between zero, at the low end, and tax-exempt rates at the high end.	**Eligibility**: Small-scale (<10 MW) electric power production, including conservation, bulk fuel storage and waste energy conservation.
AEA	**Renewable Energy Fund (RE Fund)**	**Grants**
Shawn Calfa (907) 771-3031 www.akenergyauthority.org	The Renewable Energy Fund was created by the Alaska Legislature in 2008 with the intent to appropriate $50 million annually for five years. Actual appropriations have been around $25 million in recent years, and the program has since been extended through 2023. In Round VI, 23 out of 85 projects were recommended for funding. Individual awards ranged from $10,000 for a wind feasibility study to $6.7 million for hydroelectric project construction.	**Eligibility**: The Renewable Energy Fund accepts applications from utilities, independent power producers, and local and tribal governments for the purpose of developing renewable energy projects. It does not provide funding for energy efficiency improvements.

AEA	Rural Power System Upgrades (RPSU)	Grants
Kris Noonan (907) 771-3061 www.akenergyauthority.org/programsenergysystemupgrade.html	With significant funding from the Denali Commission, AEA operates the RPSU program, which replaces outdated, inefficient village powerhouse and electrical distribution systems, adds or upgrades heat recovery and remote monitoring systems, and improves overall diesel efficiency through other upgrades including electronic fuel injectors, switchgears and controls. RPSU projects have been completed in over 50 communities, and AEA plans to complete projects in over 50 more.	**Eligibility:** Communities that are served by AVEC, the North Slope Borough, Alaska Power and Telephone Co. or connected by intertie are not part of the RPSU program.
AEA	**Village Energy Efficiency Program (VEEP)**	**Grants**
Rebecca Garrett (907) 771-3042 www.akenergyauthority.org/programsalternativeVEEP.html	AEA provides energy efficiency audits and improvements to community buildings primarily in rural Alaska through the Village Energy Efficiency Program.	**Eligibility:** Communities with no more than 8,000 residents. Priority is given to communities with the highest energy costs and fuel use.
AEA	**Whole Village Retrofit**	**Grants**
Rebecca Garrett (907) 771-3042 www.akenergyauthority.org/programsalternativeVEEP.html	A subprogram of VEEP, AEA has provided deeper energy efficiency retrofits in certain communities to demonstrate the impact energy efficiency can create when conducted thoroughly throughout a community. In recent years, recipients have included Nightmute, Fort Yukon, Emmonak and Alakanuk.	
AHFC	**5-Star Plus New Home Energy Rebate**	**Cash Rebate**
(877) 257-3228 www.akrebate.com	A cash rebate of $7,500 is available for the purchase of a newly constructed 5-Star Plus home.	**Eligibility**: Must be original owner, not more than one year from time of completion. Individuals may not participate in a Home Energy Rebate and the Weatherization Program.
AHFC	**Energy Efficiency Revolving Loan Fund (AEERLP)**	**Loans**
Eric A. Havelock (907) 330-8245 www.ahfc.us/efficiency/energy-programs/energy-efficiency-revolving-loan-fund-aeerlp	AEERLP provides financing for permanent energy-efficient improvements to government-owned facilities. Financed improvements must be from the list of energy efficiency measures identified in an Investment Grade Audit. All improvements must be completed within one year of loan closing. Guaranteed savings from energy efficiency improvements are used to repay the loan. There is no maximum loan amount. The maximum loan term is 15 years.	**Eligibility**: Buildings must be owned by a government entity, such as the schools, local municipalities, state agencies, and University of Alaska buildings. Only improvements identified during an Investment Grade audit are eligible

AHFC	**Energy Efficiency Interest Rate Reduction (EEIRR)**	**Interest Rate Reduction**
www.ahfc.us/efficiency /energy-programs /interest-rate-reduction	AHFC offers an energy efficiency interest rate reduction (EEIRR) when financing new or existing 5-Star or 5-Star Plus rated homes or when borrowers purchase and make energy improvements to an existing home. Interest rate reductions apply to the first $200,000 of the loan amount. A loan over $200,000 receives a blended interest rate. The percentage rate reduction depends on the property's energy rating and whether there is access to natural gas.	**Eligibility:** Any property that can be energy rated and is otherwise eligible for AHFC financing may qualify for this program.
AHFC	**Home Energy Rebate (HER) program**	**Cash Rebate**
(877) 257-3228 www.akrebate.com	Homeowners receive rebates up to $10,000 after making energy-efficient improvements through AHFC's Home Energy Rebate program. Before ("As-Is") and after ("Post-Improvement") energy ratings are required. In January 2013, the program was changed to allow homeowners who previously used the HER or 5-Star Plus New Home Rebate programs to receive second rebates up to $10,000 for making recommended improvements.	**Eligibility**: The program is open to all owner-occupied, year-round Alaskan homeowners. There are no income requirements. Only one rebate per dwelling. Individuals may not participate in both AHFC's Weatherization and Home Energy Rebate Program.
AHFC	**Second Mortgage for Energy Conservation**	**Loans**
Alaska USA Federal Credit Union (888) 425-9813 www.ahfc.us/efficiency /energy-programs /second-mortgage-energy-conservation	Borrowers may obtain financing to make energy improvements on owner-occupied properties. All improvements must be completed within 365 days of loan closing (improvements not listed may not be included in the loan). For borrowers participating in the Home Energy Rebate Program, the rebate received will be applied toward the outstanding balance of loan. The maximum loan amount is $30,000. The maximum loan term is 15 years.	**Eligibility**: Homes must be owner-occupied, and only improvements on the list of energy upgrades included with an energy audit by an AKWarm™ Certified Energy Rater are eligible.
AHFC	**Weatherization Program**	**Cash Rebate**
(800) 478-808 www.ahfc.us/efficiency /energy-programs /weatherization/	Individuals who meet income guidelines may apply for the Weatherization Program through one of two weatherization service providers that serve specific communities in region. The weatherization provider will provide program services at no cost to qualified applicants. Every home receives health and safety measures, efficiency improvements and client education.	**Eligibility**: Homeowners and renters with household income equal to 100% of median income. Priority to households with people over 55 and under 6. Individuals may not participate in both Weatherization and Home Energy Rebate Program.
ADOT&PF	**STIP Community Transportation Program**	**Grants**
Irene Gallion (888) 752-6329 www.dot.state.ak.us /stwdplng/cip_stip	Community partners can take advantage of federal surface transportation improvement funding through a competitive process that generally runs on a 2-year cycle. Sponsors have to provide the required match, which generally runs approximately 10% of project costs.	**Eligibility**: Anyone can nominate a project, but it must have the support of the community that will eventually own the asset.

AIDEA	**Sustainable Energy Transmission and Supply (SETS) Development Fund**	**Loans & Loan Guarantees**
www.aidea.org /programs/specialtyfinancing/sets.aspx	The SETS fund was created with Senate Bill 25 as part of the Alaska Sustainable Strategy for Energy Transmission and Supply (ASSETS). The bill gave the Alaska Industrial Development Export Authority (AIDEA) the ability to directly finance energy infrastructure projects by issuing loans or to partner with banks or credit unions. AIDEA can also offer loan or bond guarantees, defer principal payments, and capitalize interest on project financing. Terms of 30 or 50 years are available to qualified hydropower or transmission line projects. Legislative approval is required if AIDEA finances more than one-third of the capital cost of an energy project or provides loan guarantees that exceed $20 million.	**Eligibility**: Qualified energy projects include: Transmission, generation, conservation, storage, or distribution of heat or electricity; Liquefaction, regasification, distribution, storage, or use of natural gas (except a natural gas pipeline project) for transporting natural gas from the North Slope or Cook Inlet to market; Distribution or storage of refined petroleum products.
ALASKA DCCED DCRA	**Bulk Fuel Revolving Loan Fund**	**Loans**
Jane Sullivan (907) 269-4614 commerce.alaska.gov/ dnn/dcra/ BulkFuelLoanProgram .aspx	The DCCED Division of Community and Regional Affairs (DCRA) now administers the state's single bulk fuel loan program. All loans must be paid within one year. The loan amount, added to the principle of all other bulk fuel revolving loans to the same borrower may not exceed $750,000. A cooperative organization representing more than one community may qualify for a loan amount not to exceed $1.8 million.	**Eligibility**: Loans may be made to a municipality or unincorporated village with a population under 2,000, or a private individual or company retailing fuel or electricity in such a community.
Alaska DCCED DED	**Commercial Alternative Energy Conservation Loan Fund**	**Loans**
Jim Andersen (907) 465-2510 commerce.alaska.gov /ded/fin/ae.cfml	DCCED provides loans up to $50,000 to finance alternative energy systems or conservation in commercial buildings. Interest rates are fixed at time of loan approval. Maximum loan term is 20 years. Loan requests over $30,000 require a letter of denial from a financial institution.	**Eligibility**: Loans must be for the purchase, construction, and installation of alternative energy systems or energy conservation improvement in commercial buildings.
Alaska DEED	**Capital Improvement Projects (CIP)**	**Grants**
www.eed.state.ak.us /facilities /FacilitiesCIP.html	School districts can use CIP funds to address energy efficiency measures. Securing additional energy efficiency funds from another source may increase a CIP application's competitiveness.	**Eligibility**: Alaska school districts
Alaska DHSS	**Low Income Home Energy Assistance**	**Subsidy**
Susan Marshall (907) 465-3099 dhss.alaska.gov/dpa /Pages/hap/	This federally funded program helps eligible families pay home heating bills and can assist with weatherization and energy-related minor home repairs. The federal Low Income Home Energy Assistance Program (LIHEAP) program is administered in Alaska by the Alaska Department of Health and Social Services (DHSS) through its Heating Assistance Program (HAP).	**Eligibility**: Families with incomes less than 225% of the federal poverty guidelines for Alaska may be eligible. Other factors that affect eligibility and final benefit amount include the family's community, type of dwelling and home heating system.

Table 55: Federal Funding Options for Energy Projects

BIA	**Energy and Mineral Development Program (EMDP)**	**Grants**
Dawn Chargin (720) 407-0652 www.bia.gov /WhoWeAre/AS-IA /IEED/DEMD/TT/TF	The Bureau of Indian Affairs (BIA) provides grants through an annual solicitation to help with the evaluation of conventional and renewable energy and mineral resources on Tribal lands. In return, the program provides Tribes and allottees with the information they need to promote their lands, negotiate the best agreements with partners or investors, and eventually develop their resources.	**Eligibility**: Activities can include initial exploration; market analyses; outreach and education to Tribes concerning energy or mineral development issues; economic evaluation and analyses; and promotion of completed projects at industry conferences and to prospective partners or investors.
BIA	**Indian Affairs Loan Guaranty, Insurance, and Interest Subsidy Program**	**Loan Guarantees and Interest Subsidies**
www.bia.gov /WhoWeAre /AS-IA/IEED /LoanProgram	The purpose of the BIA Guaranteed Loan program is to encourage eligible borrowers to develop viable Indian businesses through conventional lender financing. The direct function of the program is to help lenders reduce excessive risks on loans they make. That function in turn helps borrowers secure conventional financing that might otherwise be unavailable. BIA will guarantee a loan up to 90%. The interest subsidy covers the difference between the lender's rate and the Indian Financing Act rate.	**Eligibility**: Borrower must have 20% tangible equity in the project.
Denali Commission	**Energy Program**	**Grants**
Jodi Fondy (907) 271-3011 www.denali.gov	The Denali Commission is an independent federal agency with the authority to procure federal funding from Congress and a variety of federal agencies, such as the USDA. The commission has made energy its primary infrastructure theme since 1999. It primarily works with the AEA and AVEC to meet rural communities' energy infrastructure needs.	**Eligibility**: Projects include design and construction of replacement bulk fuel storage facilities, upgrades to community power generation, transmission and distribution systems, energy efficiency measures and alternative energy projects.
Denali Commission	**Transportation Program**	**Grants**
Tessa Axelson (907) 271-1624 | www.denali.gov	Denali Commission's Transportation Program assists rural roads and waterfront development. The waterfront portion of the program addresses planning, design and construction of port, harbor and other rural waterfront needs. Congress did not extend funding for the Transportation Program beyond 2012, but commission staff continues to administer the program in coordination with the Transportation Advisory Committee (TAC). The TAC is the body who, recommends projects and advises on rural surface transportation needs in Alaska.	**Eligibility**: Eligible road projects include, but are not limited to, ATV board roads, local community road and street improvements, and roads and board roads to subsistence use sites. Waterfront project types include, but are not limited to, regional ports, barge landings and docking facilities.

HUD	Indian Community Development Block Grant (ICDBG)	Grants
portal.hud.gov /hudportal/HUD?src= /program_offices /public_indian_housing /ih/grants/icdbg	The ICDBG Program provides direct grants for use in community and economic development, including housing rehabilitation, roads, water and sewer facilities, single or multipurpose community buildings, and a wide variety of commercial, industrial, and agricultural projects which may be recipient-owned and operated or which may be owned or operated by a third party.	**Eligibility**: Eligible applicants include any Tribe or Alaska Native village which has established a relationship to the Federal government as defined in the program regulations. In some instances, Tribal organizations may be eligible.
SBA	**7(a) Loan Program**	**Loans and Loan Guarantees**
www.sba.gov/category /navigation-structure /loans-grants /small-business-loans /sba-loan-programs /7a-loan-program	Congress established the 7(a) Loan Program under the Small Business Act to facilitate lending to small businesses. The program provides loan guarantees to for-profit businesses that are otherwise unable to secure funds through traditional lending. If the business is eligible, the Small Business Administration (SBA) will guarantee a maximum of 85% of the loan amount on loans up to $5 million, and repayment periods may extend up to 25 years.	**Eligibility**: A business must meet industry-specific size limitations. Loans guaranteed through the program may be used for a wide variety of business purposes.
USDA-NRCS	**EQUIP Seasonal High Tunnel Initiative**	**Grants and Technical Assistance**
www.nrcs.usda.gov/wps /portal/nrcs/detailfull /national/programs /?&cid=stelprdb1046250	The Seasonal High Tunnel Initiative provides financial and technical assistance to agricultural producers. Goals include extending the growing season and providing consumers with a local source of fresh produce. Maximum practice payment shall be for five percent of an acre and can be a single or multiple structures.	**Eligibility**: Individuals, legal entities, Tribes, or joint operations engaged in agricultural production.
USDA-RD	**Energy Programs**	**Grants, Loans and Loan Guarantees**
Energy Programs: www.rurdev.usda.gov /energy.html **Grants**: www.rurdev.usda.gov /RD_Grants.html **Loans**: www.rurdev.usda.gov /RD_Loans.html	USDA-RD has a $181.1 billion loan portfolio and expects to administer $38 billion in loans, guarantees, and grants in FY2013 (1). Several programs exist to promote the expanded use of biofuels and development of commercial-scale biorefineries.	**Eligibility**: Borrower must be rural small business or agricultural producer. Projects include feasibility, construction and energy efficiency improvements.

USDA-RD	**High Energy Cost Grant**	**Grants**
Kristi Kubista-Hovis (202) 720-9545 | www.rurdev.usda.gov/UEP_Our_Grant_Programs.html	USDA High Energy Cost Grants are available for improving and providing energy generation, transmission and distribution facilities serving communities with average home energy costs exceeding 275% of the national average. Grant funds may be used for on-grid and off-grid renewable energy projects, energy efficiency and energy conservation projects serving eligible communities. In Alaska, High Energy Cost Grants are made through the Denali Commission for energy generation, transmission, and distribution facilities serving rural communities with average home costs exceeding 275% of the national average. Grants range $75,000 to $5 million.	**Eligibility:** Communities in which average home energy expenditures exceed 275% of the national average.
USDA-RD	**Rural Energy for America Program (REAP)**	**Grants**
www.rurdev.usda.gov/BCP_Reap.html	The Rural Energy for America Program offers several grant opportunities, including: 1) the Energy Audit and Renewable Energy Development Assistance Grant; 2) the Renewable Energy System and Energy Efficiency Improvement Guaranteed Loan and Grant Program; and 3) the Feasibility Studies Grant. Grants grange from $2,500 to $500,000 or 25% of project costs, whichever is less.	**Eligibility**: Borrower must be rural small business or agricultural producer. Technologies include: biomass, solar, wind, hydro, hydrogen, geothermal. Applications include equipment, construction, permitting, professional service fees, feasibility studies, business plans, and land acquisition.
USDA-RD	**Rural Utility Service (RUS)**	**Loans and Loan Guarantees**
www.rurdev.usda.gov/UEP_About_Electric.html	The Rural Utility Service makes direct loans and loan guarantees to help finance the construction, improvement and replacement of rural electric utility infrastructure. RUS offers very low interest rate federal loans (~1%) with longer terms than banks, and they are willing to work with communities (101).	**Eligibility:** Borrowers must be electric utilities that serve customers in rural areas. Projects include electric distribution, transmission, and generation facilities.
US DOE	**Section 1703 Loan Guarantee Program**	**Loan Guarantees**
https://lpo.energy.gov/programs/1703-2	Section 1703 of Title XVII of the Energy Policy Act of 2005 authorizes the U.S. Department of Energy to support innovative clean energy technologies that are typically unable to obtain conventional private financing due to high technology risks. In addition, the technologies must avoid, reduce, or sequester air pollutants or anthropogenic emissions of greenhouse gases.	**Eligibility**: Must be pre-commercial technology. Technologies with more than three installations that have been active for more than five years are excluded.

US DOE-EERE	**Energy Efficiency & Renewable Energy (EERE)**	**Various**
www.eere.energy.gov **Funding Opportunity Exchange**: https://eere-exchange.energy.gov/ **Financial Opportunities by Audience**: www1.eere.energy.gov/financing/audience.html	The U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in clean energy technologies that strengthen the economy, protect the environment, and reduce dependence on foreign oil. The EERE website includes a database of funding opportunities and links to financial opportunities by audience (business, industry, universities, consumers, states and tribes, etc.)	
US DOE-IE	**START Alaska Program (START)**	**Technical Assistance / Grants**
Tracey LeBeau (202) 586-1272 | www.energy.gov/indianenergy/resources/start-program	The DOE Office of Indian Energy Policy and Programs (DOE-IE) partners with the Denali Commission to provide on-the-ground technical assistance (TA) and financial support to help participating tribes with renewable energy project development. Alaska Tribal governments, selected through a competitive application process, are paired with DOE, NREL, and other experts with experience relevant to the Tribe's clean energy technology and project development stage, including help conducting community-based planning and training. In the current round, each community can apply for $250,000 for a specific energy-related activity projects, including energy storage infrastructure, renewable energy deployment, and energy efficiency.	**Eligibility:** Tribal governments in Alaska.
US DOE-IE	**Tribal Energy Program**	**Technical Assistance / Grants**
apps1.eere.energy.gov/tribalenergy/about.cfm	The U.S. Department of Energy's Tribal Energy Program provides financial and technical assistance that enables tribes to evaluate and develop their renewable energy resources and reduce their energy consumption through efficiency and weatherization. The program also offers education and training opportunities designed to foster clean energy technology adoption, promote green jobs and growth, and strengthen Native communities.	**Eligibility:** Renewable energy and energy efficiency projects on tribal lands.

Private Equity and Commercial Debt

Private financing is typically used for the development of large-scale renewable energy projects that exhibit sufficient rates of return to offset perceived risk and high transaction costs. While private financing often requires a relatively large project scale for economic viability, many regional Native corporations have sufficient land holdings, earnings, and project development expertise to take advantage of private financing for renewable energy development. Although larger Native corporations may be best suited for private financing arrangements, smaller village corporations have potential to use private financing to fund portions of larger projects or group several projects together to attract capital (1).

Private equity can be used in conjunction with grants and federal and state tax credits to meet project funding requirements and bolster lender and investor confidence in overall project viability (1).

PRIVATE EQUITY INVESTMENT

The preconstruction phase of a large-scale project is typically funded with development equity, while capital for project construction is often provided through a combination of private investment and commercial debt (e.g., banks). Equity investors receive an ownership share in the project and are entitled to a portion of the distributable profits of the partnership (1).

Potential equity partners include Alaska Native corporations, village corporations, Tribal governments, federal and state government, local utilities and electric cooperatives, third-party developers, individual community members and nonprofit organizations.

DEBT FINANCING

In Alaska, debt financing for large projects can be sourced through entities such as commercial banks, credit unions, the U.S. Department of the Treasury (via its lending arm, the Federal Financing Bank), USDA, and now AIDEA (after passage of Senate Bill 25 in 2012).

While sources of bank debt do not have an ownership share in the project like equity investors, they do retain collateral claims on a project and may be required to approve major decisions in day-to- day management and operations. Still, if maintaining project ownership is a priority to a developer, it is preferable to structure the project's financing such that bank debt comprises a greater share of the capital structure than equity (1).

ENERGY SAVINGS PERFORMANCE CONTRACTING (ESPC)

Energy Savings Performance Contracting can be used to finance energy efficiency improvements through partnership with an Energy Savings Company or ESCO. ESCOs are often used by local governments and state and federal agencies to make improvements in government-owned buildings without up-front capital costs or budget appropriations. Typically, the ESCO conducts a comprehensive energy audit for the facility and identifies improvements. The ESCO designs and constructs a project that meets the agency's needs and arranges the necessary funding. The ESCO guarantees that the improvements will generate energy cost savings sufficient to pay for the project over the term of the contract. After the contract ends, all additional cost savings accrue to the agency. Contract terms up to 25 years are allowed (102).

Tax-Exempt Bonds

Local, state and Tribal governments also have the option of issuing tax-exempt bonds, which have the effect of lowering investment costs (compared with traditional borrowing), thereby lowering the cost of capital and the long-term cost of energy.

CLEAN RENEWABLE ENERGY BONDS (CREBS)

Clean Renewable Energy Bonds may be used by primarily public sector entities to finance a wide range of renewable energy projects. CREBs may be issued by rural electric cooperatives, municipal utilities, schools, and local, state and Tribal governments. The bondholder receives federal tax credits in lieu of a portion of the traditional bond interest, resulting in a lower effective interest rate for the borrower. The issuer remains responsible for repaying the principal on the bond. Congress has made over $1 billion available for CREBS. More information is available at www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US45F&ee=0

QUALIFIED ENERGY CONSERVATION BONDS (QECBS)

Congress authorized $800 million in tax-exempt Qualified Energy Conservation Bonds (QECBs) in 2008 to finance qualified energy conservation projects. Allocations were made state by state based on population. In Alaska, $7.1 million was allocated, but no bonds have been issued yet. When surveyed, many states indicated that they had not used the program due to high transaction costs associated with small allocations, debt aversion, and lack of awareness. More information is available at www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US51F

Tax Credits

Tax credits can lower capital costs by 40% to 50%. There are several federal tax credits currently available for qualified investments in renewable energy technologies, in addition to accelerated depreciation, which improves the economic viability of a project by reducing tax liability in the initial years of production. Current tax benefits are shown in Table 56. Note: Tax credits that expire in 2013 are not shown.

A 30% tax credit reduces the capital cost of a project by 30%. The federal government essentially pays for a third of the project. However, only taxable entities, such as Alaska Native corporations and third-party developers, can take advantage of these benefits. This provides an incentive for tax-exempt utilities and local governments to find ways to partner with taxable entities when developing renewable energy projects (101).

Table 56: Federal Tax Incentives for Renewable Energy

Tax Credit	Amount	Eligible Projects	Details
Investment Tax Credits (ITC)	30%	Solar, fuel cells (≤0.5 kW), small wind (≤100 kW), geothermal, microturbines (≤2 MW), and combined heat and power (≤50 MW)	Available when the project is placed in service. Expires 12/31/2016
New Market Tax Credit (NMTC)	39%	Investments in qualified community development entities (CDEs). Most Alaska villages qualify.	Claimed over a 7-year period. Starting in the year the investment is made
Modified Accelerated Cost Recovery System (MACRS)	NA	Accelerated depreciation is available to qualified investments in wind, geothermal, and solar technologies	Enables investment to be recovered over a 5-year schedule in lieu of the standard life of the asset.

Source: (1)

TAX-EQUITY PARTNERSHIPS

Tax-equity partnerships are financing arrangements that enable tax-exempt entities and taxable entities with insufficient tax liabilities, to take advantage of tax credits to lower a project's capital costs. While there are several variations on tax-equity partnerships, all require assigning project ownership to an investor with sufficient tax liability to fully capture available tax benefits. This is typically a large U.S. bank or insurance companies. Google has also made such investments. The taxable entity must retain ownership of the project until the tax credits have been fully captured, after which ownership can be transferred to the public utility or other tax-exempt entity (1).

Financing through tax-equity partnerships typically requires more complex transactions than other options in order to allocate risk and return among the parties involved. There are several ways to structure a tax-equity partnership: partnership flip, sale-leaseback, and pass-through lease. For more information, see *Financing Opportunities for Renewable Energy Development* listed under Resources for Communities at the end of this section.

Power Purchase Agreements and Net Metering

Net metering and third-party power purchase agreements provide additional mechanisms for project developers to capitalize on renewable energy deployment.

POWER PURCHASE AGREEMENTS (PPA)

A Power Purchase Agreement (PPA) is a legal contract between an electricity generator (seller) and a power purchaser (buyer). The seller is typically an independent power producer (IPP).The buyer is often a utility or large power user, such as a business, municipality, university, school, or hospital. The buyer enters into a long-term contract to pay a predetermined rate for the kilowatt hours delivered from the renewable energy asset. The length of the contract can range from 5 to 20 years. The PPA rate is typically fixed or pegged to a floating index on par with or below the current electricity rate being charged by the local utility company.

The renewable energy developer uses the contract to attract private investors who are comfortable with the customer's ability to make payments over the term of the agreement. If the energy payments over the life of the contract plus any other incentives produce a desirable return on investment, then investors will provide the up-front capital to finance the project. Such agreements play a key role in financing independently owned electricity generating assets.

The PPA financing structure is most appropriately utilized for a planned major renewable energy installation, where speed is less critical, since it requires coordination from all stakeholders. They may also be appropriate where projected revenues are uncertain and so some guarantees as to quantities purchased and price paid are required to make the project viable, or where there is one or a few major customers who will be taking the bulk of the product and who want price certainty and security of supply (103) (104).

NET METERING

Alaska's net metering regulations require that all utilities with retail sales of at least 5 GWh (5 million kWh) offer net metering to their customers for renewable energy systems up to 25 kW in capacity. Net excess generation (NEG) is reconciled each month, with the utility issuing the customer a credit for NEG. The state's interconnection guidelines mandate that all utilities that are required to offer net metering must also issue tariffs incorporating interconnection (1). In the

Bristol Bay region, net metering and interconnection policies apply only Nushagak Telephone and Electric Cooperative and Naknek Electric Association based on FY2012 sales volumes.

Freeing the Grid, an annual scorecard rating state-level net-metering and interconnection standards, gives Alaska's net-metering regulations a "C," citing the arbitrary system size limits not based on on-site load, monthly NEG reconciliation instead of indefinite NEG carryover, and ambiguity regarding renewable energy credit (REC) ownership as areas that reduce the impact of this policy on driving investments in renewable energy generation (1).

Resources for Communities

FINANCING OPPORTUNITIES FOR RENEWABLE ENERGY DEVELOPMENT IN ALASKA

The DOE Office of Indian Energy and NREL have put together a handbook on financing renewable energy development in Alaska. It provides an overview of existing and potential financing structures with a focus on four primary sources of project funding: government financed or supported, developer equity capital, commercial debt, and third-party tax-equity investment. It is available electronically at www.osti.gov/bridge.

More information on private financing is available in *Renewable Energy Development in Indian Country: A Handbook for Tribes*, published by the U.S. DOE Tribal Energy Program and available at apps1.eere.energy.gov/tribalenergy/pdfs/indian_energy_legal_handbook.pdf

8 | Project Advisors & Stakeholders

Phase I calls for the identification of an advisory group and stakeholders at-large. The Bristol Bay region formed a Technical Team in an attempt to honor energy projects in motion, manage expectations, and stay on budget. The team reports to the Bristol Bay Partnership serving as the advisory group.

Technical Team

The Technical Team focused on Phase I – Preliminary Planning, Resource Inventory & Data Collection. The Technical Team is a combination of contractors, consultants and advisers with strong connections to energy issues, energy projects and the Bristol Bay region.

The principal team members include:

Table 57: Bristol Bay Regional Energy Planning Technical Team

Name	Title	Organization
Melody Nibeck	Tribal Energy Program Manager	Bristol Bay Native Association
Andy Varner	Executive Director	Southwest Alaska Municipal Conference
Jana Peirce	Senior Consultant	Information Insights, Inc.
Antony Scott	Senior Economist and Policy Analyst	University of Alaska Fairbanks
Lamar Cotten	Consultant (former borough manager)	Lake and Peninsula Borough
Michael Knapp	GIS Consultant	Blue Skies Solutions, LLC

The team focused on activities linked to the broad categories listed below:

- Identification of technical and advisory teams
- Identification of stakeholders
- Data collection and analysis
- Identification of data gaps
- Validation of capital
- Operating and fuel cost projections
- Technology performance parameters
- GIS mapping of resources
- Regional energy modeling and methodology

- Website development
- General communications
- Presentation of findings to Advisory Group

The team met various times via teleconference, and held one face-to-face meeting in Anchorage. The team also met with various resource managers with the Alaska Energy Authority.

Table 58: Technical Team Meetings and Activities

Date	Topic(s)
July, August, September 2012	Contract Issues Scope of Work Contract Authorizations & Signatures
September, October 2012	Web Site Development Project Communications
November, December 2012	Data Collection Bulk Fuel Fuel Types
January 16, 2013	Project Modeling Project Methodology
January 23, 2013	Diesel Efficiency Resources Rural Power Systems & Resources Transmission and Distribution Resources
January 23, 2013	Hydroelectric Resources
January 24, 2013	Energy Efficiency & Conservation Resources
January 25, 2013	Geothermal Resources Ocean & River Resources Bulk Fuel Resources
February 7, 2013	Project Modeling Project Methodology
February 13, 2013	SWAMC Energy Workshop Regional Break Out Discussion
February 20, 2013	SWAMC Energy Workshop Regional Break Out Discussion
March 20, 2013	Review of Deliverables Preliminary Analysis of Energy Projects Data Gaps Discussion on Framework Discussion on Methodology Next Steps

Advisory Group

The Advisory Group is the Bristol Bay Partnership, a collaborative effort of the major regional service organizations. The partnership met at the Bristol Bay Regional Vision Summit with the Alaska Energy Authority and designated the Bristol Bay Native Association as the project leader. The partnership operates under a memorandum of understanding regarding communication, collaboration and points of agreement.

The principal partners include:

Table 59: Bristol Bay Regional Energy Planning Advisory Group

Name	Title	Organization
Ralph Andersen	President and CEO	Bristol Bay Native Association
Jason Metrokin	President and CEO	Bristol Bay Native Corporation
Robert J. Clark	President and CEO	Bristol Bay Area Health Corporation
H. Robin Samuelsen	President and CEO	Bristol Bay Economic Development Corporation
Dave McClure	Executive Director	Bristol Bay Housing Authority

The associate partners include:

- Bristol Bay Borough
- Lake and Peninsula Borough
- Southwest Alaska Municipal Conference
- Southwest Alaska Vocational and Education Center
- University of Alaska Fairbanks, Bristol Bay Campus

The points of agreement include:

Bottom Up Approach. The Partnership agrees to respect the local concerns and priorities of constituency villages and work together to provide resources and programs that support their needs using a "bottom-to-top" approach or village to region approach.

Sustainability. The Partnership recognizes the importance of utilizing sustainable principles when designing and developing projects and providing services.

Community Plans. The Partnership recognizes the importance of a single community comprehensive plan as a central tool to identify and establish the values, priorities and development goals; and develop independent and collaborative approaches to assist village initiatives.

Regional Forum. The Partnership recognizes systematic planning and coordination on a local, regional and statewide level is necessary to achieve effective results from investments in infrastructure, economic development and training.

Sharing Information. The Partnership recognizes sharing information increases efficiencies and decreases duplication of services.

Workforce Development. The Partnership recognizes education, vocation, and technical training is critical to a local and regional workforce development.

Coordination of Procurement and Local Hire. The Partnership works together to gain economies of scale when purchasing and delivering goods and services; and utilizes local hire and locally-owned businesses available at the community, subregional and regional levels.

Stakeholder Identification

Stakeholders were identified and a database created to help facilitate communications. Identification was centered on tribes, cities, boroughs, school districts, utilities, regional organizations, state and federal partners, and strategic entities familiar and interested in the Bristol Bay region.

The list was cross-referenced with Information Insights who identified stakeholders for the Bristol Bay Regional Vision project, and the Southwest Alaska Municipal Conference, and determined to be exhaustive. The list will serve as a basis to facilitate communication and disseminate information about the project for both phases.

Table 60: Bristol Bay Region Energy Stakeholders

Organization	Type of Entity
Bristol Bay Borough (Manager)	Borough
Bristol Bay Borough (Mayor)	Borough
Lake and Peninsula Borough (Manager)	Borough
Lake and Peninsula Borough (Mayor)	Borough
City of Aleknagik	City
City of Clark's Point, Electric	City
City of Dillingham (Manager)	City
City of Dillingham (Mayor)	City
City of Egegik	City
City of Ekwok	City
City of Manokotak	City
City of New Stuyahok	City
City of Newhalen	City
City of Nondalton	City
City of Togiak	City
City of Chignik	City / Utility
City of Clark's Point	City / Utility
City of Pilot Point & Pilot Point Electric	City / Utility
City of Port Heiden	City / Utility
Denali Commission	Federal Partner
National Renewable Energy Laboratory (Alaska)	Federal Partner
U.S. Department of Energy, Golden Field Office	Federal Partner
Tribal Environmental Program Coordinators	IGAP Environmental Partners
Alaska Conservation Foundation	Non-Profit Partner
Renewable Energy Alaska Project	Non-Profit Partner
Rural Alaska Community Action Program	Non-Profit Partner
Wild Salmon Ecosystems Imitative	Non-Profit Partner

Organization	Type of Entity
Bristol Bay Area Health Corporation	Regional Organization
Bristol Bay Native Corporation (In-Region Investments)	Regional Organization
Southwest Alaska Municipal Conference	Regional Organization
Southwest Alaska Vocational and Education Center	Regional Organization
University of Alaska Fairbanks, Bristol Bay Campus	Regional Organization
Bristol Bay Economic Development Corporation	Regional Organization
Bristol Bay Housing Authority	Regional Organization
Bristol Bay Native Corporation	Regional Organization
Bristol Bay Borough School District	School District
Dillingham City School District	School District
Lake and Peninsula School District	School District
Southwest Region School District	School District
Alaska Center for Energy and Power	State Partner
Alaska Legislature (Representative)	State Partner
Alaska Legislature (Representative)	State Partner
Alaska Legislature (Senator)	State Partner
Alaska Legislature (Senator)	State Partner
Local Government Assistance/Rural Utility Business Adviser	State Partner
Local Government Assistance/Rural Utility Business Adviser	State Partner
State of Alaska, Division of Community & Regional Affairs	State Partner
Aleknagik Traditional Council	Tribe
Chignik Bay Tribal Council	Tribe
Chignik Lake Traditional Council	Tribe
Clark's Point Village Council	Tribe
Curyung Tribal Council	Tribe
Egegik Village Council	Tribe
Ekuk Village Council	Tribe
Ekwok Natives Limited	Tribe
Ekwok Village Council	Tribe
Iliamna Village Council	Tribe
Ivanof Bay Village Council	Tribe
Kanatak Tribal Council	Tribe
King Salmon Tribe	Tribe
Koliganek Natives Limited	Tribe
Levelock Village Council	Tribe
Manokotak Village Council	Tribe
Naknek Village Council	Tribe
New Stuyahok Traditional Council	Tribe
Newhalen Tribal Council	Tribe
Nondalton Tribal Council	Tribe
Pilot Point Tribal Council	Tribe
Port Heiden Village Council	Tribe

Organization	Type of Entity
Portage Creek Village Council	Tribe
South Naknek Village Council	Tribe
Togiak Traditional Council	Tribe
Ugashik Traditional Village Council	Tribe
Chignik Lagoon Village Council	Tribe / Utility
Igiugig Village Council	Tribe / Utility
Kokhanok Village Council	Tribe / Utility
Native Village of Perryville	Tribe / Utility
New Koliganek Village Council	Tribe / Utility
Pedro Bay Village Council	Tribe / Utility
Twin Hills Village Council	Tribe / Utility
Alaska Village Electric Cooperative	Utility
Chignik Lake Electric Utility	Utility
Egegik Light and Power	Utility
I-N-N Electric Cooperative, Inc.	Utility
Levelock Electric Cooperative	Utility
Naknek Electric Association	Utility
Nushagak Electric and Cooperative	Utility
Nuvista Light and Electric Cooperative	Utility
Aleknagik Natives Limited	Village Corporation
Chignik Lagoon Native Corporation	Village Corporation
Choggiung Limited	Village Corporation
Igiugig Native Corporation	Village Corporation
Levelock Natives Limited	Village Corporation
Pedro Bay Native Corporation	Village Corporation
Saguyak, Incorporated	Village Corporation
Stuyahok, Limited	Village Corporation
Tanalian Incorporated (Port Alsworth)	Village Corporation
Togiak Natives Limited	Village Corporation
Twin Hills Native Corporation	Village Corporation
Manokotak Natives Limited/Manokotak Power Company	Village Corporation / Utility

Stakeholder Outreach

WEBSITE

A website was developed to facilitate communications and assist with the dissemination of information to stakeholders and the public at-large. The universal resource locator is www.bristolbayenergy.org. The site contains basic information about the project including tabs for “about the project,” advisory group, technical team, timeline, resources and contact information. The website is referred to in all types of communications.

PROJECT INFORMATION FLYER

A project information flyer was created to accompany verbal and written communications about the project with stakeholders and the public at-large. The flyer contains basic information about the project including project description, goal, management, timeline, website universal resource locator, links of related interest and contact information. The project information flyer accompanies all types of communications.

LETTER OF INTRODUCTION

A letter of introduction was written by Ralph Andersen of the Bristol Bay Native Association and mailed to stakeholders on October 8, 2012 outlining the project. Attached to the letter was the project information flyer.

POWERPOINT PRESENTATION

A PowerPoint presentation was written and designed containing basic information about the project including project description, goal, management, phases, timelines, technical team, a status report and key takeaway facts.

SWAMC ANNUAL ECONOMIC SUMMIT & ENERGY WORKSHOP

The energy workshop at the SWAMC Annual Economic Summit highlighted the regional energy planning process where regions broke out to discuss philosophy and outcomes of the plans. The Bristol Bay region had participation from the communities of Pilot Point, Dillingham, King Salmon and Manokotak. The discussion centered on the need and concept of a central resource for energy-related information.

9 | Community Profiles

DILLINGHAM CENSUS AREA

Nushagak Bay
Pop. 2,669

- Aleknagik
- Clark's Point
- Dillingham

Nushagak River
Pop. 848

- Ekwok
- Kokiganek
- New Stuyahok

Togiak Bay
Pop. 1,403

- Manokotak
- Togiak
- Twin Hills

LAKES & PENINSULA BOROUGH

Lakes
Pop. 977

- Igiugig
- Iliamna
- Kokhanok
- Levelock
- Newhalen
- Nondalton
- Pedro Bay
- Port Alsworth

Peninsula
Pop. 355

- Chignik Bay
- Chignik Lagoon
- Chignik Lake
- Perryville

LAKE & PEN BOROUGH
BRISTOL BAY BOROUGH

Kvichak Bay
Pop. 1,284

- Egegik
- Pilot Point
- Port Heiden
- King Salmon
- Naknek
- South Naknek

APPENDIX A

ENERGY PROJECTS ANALYZED

APPENDIX B

RESOURCE MAPS

Most of the resource maps were created for this project by Blue Skies Solutions, LLC, using GIS datasets from the *Renewable Energy Atlas of Alaska*, 2011 edition, in order to better highlight renewable energy resource potential in the Bristol Bay region.

The map of wood biomass pre-feasibility studies comes from the Alaska Wood Energy Development Task Force.

The map of Bristol Bay canneries and seafood processors was created by the Alaska Department of Environmental Conservation, and includes processors permitted for 2011.

The map of frontier oil and gas basins was provided by the Alaska State Legislature.

APPENDIX C

ECONOMIC MODELING & METHODOLOGIES

Project economics were modeled in two different ways, reflecting different perspectives on who might execute various aspects of an eventual Regional Energy Plan. As well, the different modeling approaches reveal different potential policy directions and innovations that the state might pursue. We begin by noting some particularly important approaches that we have taken to adopting or modifying model inputs. Subsequently, each of the primary modeling methodologies is discussed. Differences between our and AEA's approach to cash flow modeling are explained. Finally, different cash flow metrics, reflecting different policy priorities are motivated and reported.

Data Sources for Modeled Project Economics

In general we have adopted the project proponent's, or (if corrected) AEA's, assessment of capital costs, operating expenses, and estimate of total annual kWh generation. There are a couple of exceptions.

For purposes of modeling tariffs and calculating benefit-cost ratios and the like, all historical capital and operating cost estimates were first updated to 2013 dollars using IHS/CERA Power Plant Construction and Operating Cost Indexes (respectively). Power plant construction costs have no necessary relationship to the broader CPI index, and in fact often significantly differ.

Second, in the case of Knudson Creek hydro project at Pedro Bay, the project proponent assumed a very high (82%) capacity factor. We have somewhat arbitrarily reduced this to 68%—still a high capacity factor for a hydropower project. Because even at this level the total generation—900,000 kWh/year—significantly exceeds Pedro Bay's diesel generation in 2011 (as reported in PCE statistics), we have assumed that the remaining generation is used to heat the village "by wire." The amount of project energy modeled as being used for heat is about 2.5 times the amount that would be used for electricity. Work by ISER suggests that space heating needs in rural Alaska generally are roughly three to four times the energy used for electricity. This suggests that the modeled output for space heating may be within a reasonable range.

Finally, all project economics have been calculated on a "going forward" basis only. If the purpose of the analysis were to address comparative life-cycle economics of technologies in various places in Alaska, then historical expenditures might be relevant. However, the Bristol Bay Energy Plan is intended to help allocate scarce investment dollars to relieve energy costs in the region. Historical expenditures to date are not relevant to decisions as to whether future capital investment should be made.

Additional limitations affect the results, aside from reliance on project proponents' assessments of project costs and generation capacity factors. Several projects are modeled assuming that a significant share of project electricity will be used to “heat by wire.” As with integrating a new project into an existing electricity generation system, economic evaluation is here incomplete and partial. The true potential of using electricity for space heating requires on-the-ground assessment of the geographic extent and capacity of local electricity distribution infrastructure. Distribution infrastructure upgrade costs were not included in proponents’ project cost assessments, but would need to be included to comprehensively evaluate potential project benefits. As well, end-user savings would need to be sufficient to induce significant individual expenditures of installing electricity-based heating systems. No such assessment has been performed in this phase, yet it is critical to the business case for projects that would “heat by wire”.

Because the project tariffs would be charged in nominal (rather than real) dollars, project costs are projected in money of the day. For this purpose an annual inflation rate of 2% is assumed, as applied against operating, maintenance, and capital costs. In keeping with this the cost of capital, described below, is in nominal rather than real terms.

Cost of Service Modeling

Levelized cost of service “tariffs” were developed. Tariffs were calculated as if the cost of power being generated were regulated by the Regulatory Commission of Alaska using standard (if somewhat simplified) discounted original cost rate-making procedures. Schematically, tariffs are calculated as:

$$\text{Electricity Rate (\$/kWh)} = \{O\&M + t + d + r(V\text{-}D)\}/\{\text{kWh generated}\}$$

where

$O\&M$	=	**operations and maintenance** costs, including any property taxes
t	=	Federal and State income **taxes** (if any)
d	=	annual “book” **depreciation** (or *recovery of* capital)
r	=	weighted average **rate of return** *on* capital, consisting of both the cost of debt and a regulated (allowed) return on equity
V	=	**value** of the project’s original capital cost, including the cost of compound interest on debt and equity during the period prior to operation
D	=	**accumulated depreciation**, or the sum of all prior years’ d.

Both traditional (straight line) and levelized tariffs were generated. Levelized tariffs adjust the depreciation schedule so that: a) tariffs are equal in every year of the project’s economic life; b) the net present value of levelized tariff payments is equal to that of the traditional tariffs. Only levelized tariffs are reported here, as they facilitate comparisons across projects with different economic lives.

Tariffs are modeled under two scenarios, representing stylized polar cases that span a reasonable range of possible project financing. In the first a private developer is assumed. The developer might be an independent power producer, or a local privately-owned utility. Here the cost of debt is assumed to be 6%, and the after-tax regulated return on equity is assumed to be 12%. The debt-to-equity ratio is assumed to be 70/30%. In the second, the developer is a state entity. Here all of the capital is assumed to be debt-financed, with a cost of 3%; property taxes are not included in rates, given the state ownership model.

Cash Flow Modeling: Model Structure and Inputs

We model project cash flows using different Excel code but essentially the same parameter choices and implicit assumptions (i.e., that the State will be providing grant funding for energy projects) as AEA's project evaluation template. Project benefits are the sum of avoided fuel costs and avoided O&M costs associated with existing diesel generation assets (the ability to avoid costs associated with potential future carbon legislation is real but considered too remote to affect expected benefits). Project costs are the sum of project capital and operating costs. Below, we note two relatively minor structural model differences between our model and the AEA evaluation template, explain our approach to modeling future fuel oil prices, and describe our approach to modeling the timing of capital expenditures.

Unlike the AEA project evaluation template, which analyzes projects using real dollars, our cash flow model converts all expenditures to money of the day. (Again, we use money of the day figures to allow meaningful infrastructure cost of service "tariffs" to be developed.) The ordinal ranking of projects should be largely unaffected, however. We adjust AEA's recommended real 3% discount rate to a nominal 5% discount rate, given an assumed 2% annual inflation.

Structurally, where possible we also model O&M costs differently than the AEA project evaluation template. The template assumes that project O&M costs vary in direct proportion to the number of kWh generated. In essence, all operating costs are variable, and all projects of a given technology receive the same $/kWh allowance. Though parsimonious this approach does not incorporate the known and substantial O&M economies of scale that renewable energy projects can enjoy. It also does not "penalize" projects that fail to produce as much electricity as expected, nor does it "reward" projects that generate more. Our model takes the polar opposite approach, where possible. That is, we treat O&M costs as fixed, or invariant to the number of kWh generated, whenever we could elicit annual O&M expenditure information. In the other circumstance we follow the AEA approach and indicated per kWh parameter values.

Perhaps the most important potential difference between the AEA template and our own model results lies in how avoided fuel oil value is determined. Differences exist in both the projected quantity and pricing of displaced fuel oil. These are described, below.

Fuel oil consumption is avoided by displacing fuel used in electricity generation or space heating. We generally calculate avoided generation fuel with reference to the target community's latest available PCE data on the diesel generation efficiency (kWh/gallon) and the proponent's forecast of project generation.[15] Community-specific efficiency data, rather than average Alaska efficiency benchmarks, are used in recognition that different communities achieve different levels of performance from their diesel generation systems. The avoided heating fuel calculation adopts the US EPA's assumptions of 98% efficiency in converting electricity to heat, and 78% efficiency in converting heating oil to heat.

[15] Displaced fuel for projects serving Illiamna, Newhalen and Nondalton was calculated using PCE data from 2010 rather than 2011 as the 2011 data appear unrealistic. Similarly, because recent PCE-data efficiency figures for Igiugig are unrealistic, we rely on the efficiency figure provided by Igiugig Power Company in their November, 2011 Renewable Energy Fund application (12.1 kWh/gallon).

Fuel oil prices are calculated using a methodology that has the same conceptual underpinnings as AEA's but differs with regard to details.[16] The key question lies in how to correlate fuel oil prices with crude oil prices. AEA's fuel oil pricing template regresses each community's annual average, CPI-deflated PCE fuel oil cost against the prior year's average CPI-deflated crude oil value. In essence, the approach assumes that there are over 180 different price processes for fuel oil in Alaska.

For purposes of project screening we believe that this approach sacrifices accuracy for precision. For a large number of communities, the regressions have relatively low R^2 values. At the same time, regression coefficients predicted by the AEA approach can materially differ for communities that would appear, notionally, to be in the same market; that is, pricing should generally be similar across communities of similar size and served by the same mode of fuel transport. This suggests that differences between the regression coefficients may in many circumstances be substantially spurious.

Consider, for example, the communities of Pilot Point and Port Heiden. The two communities are less than 60 miles apart on the same side of the Peninsula; both are directly served by ocean-going barge. According to the US Census, the population of Pilot Point was 68 in 2010; Port Heiden's was 102. Absent reason to the contrary, logic suggests that the two communities should be in the "same market", with access to the same fuel oil prices. The estimated AEA regressions suggest, however, that the markets are not only different but different in counterintuitive ways:

Pilot Point Fuel oil \$/gal = 0.857 + 0.0406*(crude oil, \$/Bbl)

Port Heiden Fuel oil \$/gal = 1.005 + 0.0322*(crude oil, \$/Bbl)

At \$120/Bbl crude oil – roughly the EIA's "base case" forecast in the most recent AEO Outlook – the predicted fuel oil price for Pilot Point is \$5.73, while the predicted fuel oil price for Port Heiden is \$4.87. This difference is material. Meanwhile, to the extent that Pilot Point is slightly further away from refineries than is Port Heiden one might imagine that the *y*-intercept in its fuel price equation should be larger, but the opposite is the case.

Are the statistically estimated differences in fuel oil markets real, or spurious? We believe it is the latter. Other fuel oil markets generate very tight correlations – R^2 values in excess of .95 – for the same simple ordinary least squares regression specification.[17] Here the regressions' relatively low overall "goodness of fit"(R^2 for Pilot Point and Port Heiden are .666 and .489, respectively) supports that parameter differences are perhaps spurious.

We believe that the AEA community fuel oil regressions often do not tightly fit the data because at root they are "mis-specified". The "logic" behind the regression's functional form is that crude oil prices drive fuel oil prices because they figure essentially in the fuel oil cost function. The intercept term captures community differences in fixed costs per gallon of delivery, while the slope term captures differences that vary with the cost of crude oil. However, in the AEA specification for each community average *annual* crude oil prices are being regressed against the average price associated what are often only a small handful of fuel oil deliveries. Crude oil price

[16] AEA's suggested approach to fuel oil pricing is outlined in Fay et al (2012).

[17] Regressions of Fairbanks heating oil against appropriate crude oil prices, or regional lower-48 heating oil against corresponding WTI crude oil prices (Scott, 2012).

volatility undermines any causal relationship between average *annual* crude oil values and the fuel oil prices charged on specific days of delivery.

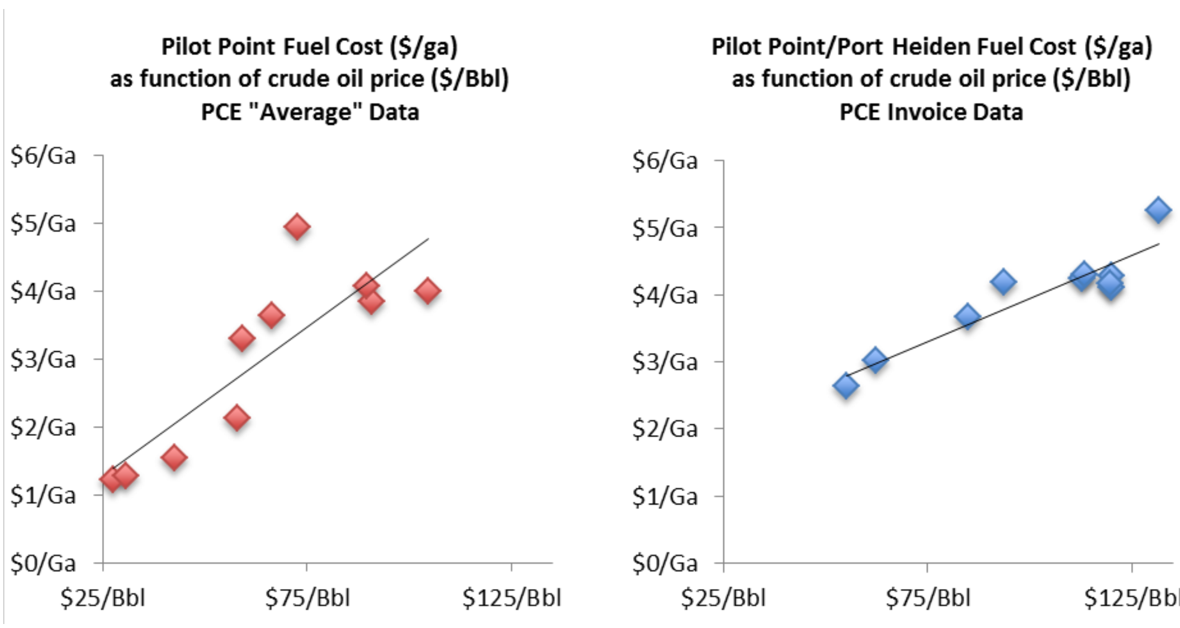
Another approach would be to try to pinpoint the "right" crude oil prices – in essence, the prices on the appropriate days – that correlate to the days and prices on which the fuel oil is delivered. Crowley Maritime indicates that they typically price fuel oil based on the date that the cargo was "lifted" from the refinery (105). Attending to the date of community fuel oil delivery, as recorded in PCE fuel oil invoices filed with the RCA, allows lifting dates to be reasonably approximated given transport time from refinery to community. This allows better targeting of the appropriate daily crude oil price. Regional market-specific regression parameters, based on this more painstaking approach to data collection, could in future be used to capture cross-market differences in aggregate distribution costs and markups.

Digging up PCE fuel invoices is time intensive. We have done so for only two communities, Port Heiden and Pilot Point. Representatives from Crowley Maritime provided exact lifting dates that correspond to fuel oil delivery dates (and prices) on the invoices. We pooled these limited data for #1 diesel fuel deliveries (there are only 11 observations available from the RCA's on-line document library). Bloomberg Daily ANS WC crude oil prices for the day of lift were regressed against the delivered fuel oil prices. The result:

Pilot Point/Port Heiden Fuel oil \$/ga = 1.377 + 0.0257*(crude oil, \$/Bbl)

The regression's R^2 is .856; *p*-values on the estimated coefficients indicate statistical significance at better than the 1% level. Comparing the AEA approach as applied to only the 11 observations (the most recent 11 years of data) for Pilot Point visually demonstrates the benefits of more carefully choosing transactions (i.e. price) rather than average value data. (See Figure 2.)

Figure 2: Data and Regression Plots Comparing PCE "Average" and PCE Invoice Data



Notes: On left: Average annual PCE-reported fuel oil costs and lagged prior-year annual average crude oil values. On right: PCE-reported fuel oil prices on approximate day of lifting and corresponding daily crude oil prices.

Visual inspection alone shows the materially better fit provided by invoice-level data. This is not surprising given that a distributer prices fuel oil with reference to their costs, which are a function of the prices of the product lifted, which are themselves materially affected by crude oil prices at the time of lift.

The invoiced-based Pilot Point and Port Heiden regression was used as a basis for projecting fuel prices in other communities in the region. We do so by assuming that the slope coefficient estimated by the PCE-invoice data is invariant across all of the communities in the region, and that differences in fuel prices across communities can be reasonably captured by differences in a community's *y*-intercept. In essence, fuel price differences are assumed to be substantially driven by fixed $/gallon factors associated with transportation distance and mode, rather than credit risk concerns (for example) that might affect the slope coefficient.

Differences in *y*-intercepts were developed in a multi-step process. Projected results are neither theoretically nor empirically fully grounded, but hopefully adequate in light of existing data limitations. In the first step energy project host communities were roughly grouped by geographic proximity, mode of fuel oil transport, and population. AEA-predicted fuel prices served as rough check on groupings. Grouping and derivation of differences in community *y*-intercept parameters for modeling purposes are shown in Table 61.

The AEA community fuel price regression results were used to calculate community-group average predicted fuel prices, assuming $100/Bbl crude oil.[18] The difference between a community-group average price and the Pilot Point/Port Heiden average price was used to adjust the *y*-intercept for projecting a community's fuel price at different crude oil prices.

The resulting diesel price correlations were used, as applicable, to develop heating oil price correlations for electricity projects expected to directly displace home heating oil. Heating and diesel oil prices are modeled on a fixed dollar-per-gallon differential. Price differences were adopted from consistent with the AEA's project evaluation spreadsheet.

The correlations between fuel oil and crude oil were used to model fuel oil price scenarios. Following AEA's guidance we use the US EIA's Annual Energy Outlook crude oil price scenarios to generate corresponding fuel oil prices. We also model cash flow metrics at flat real prices, from $60 to $140 per barrel in $10 increments. Flat real prices provide a less conceptually complex lens through which to understand a project's sensitivity to oil price.

Cash-flow results address only "going forward" capital costs. Generally, project developers do not specify capital cost spend profiles, but are reasonably able to articulate spend durations. Using this information capital cost spend profiles were developed as follows.

[18] AEA-reported regression parameters and statistics taken from file "2012-07-Fuel_price_projection_2012-2035.xlsx" accompanying Fay et al (2012); currently available online at: http://www.iser.uaa.alaska.edu/publications.php?id=1518 (98)

Table 61: Community-Group Average Predicted Fuel Prices

Community	Geographical group	Population	AEA-reported parameters R^2	Intercept	Slope (per Bbl)	Predicted Price @ $100/Bbl
Chignik	Eastern side of peninsula, on ocean	91	0.758	0.566	0.0282	$ 3.39
Chignik Lagoon		78	0.469	1.285	0.0254	$ 3.82
Chignik Lake		73				
Perryville		113	0.681	1.470	0.0183	$ 3.30
					Average	**$ 3.50**
					Difference from reference	**$ (1.07)**
Igiugig	Western side of peninsula, substantial secondary transport required	50	0.689	0.716	0.0505	$ 5.77
Iliamna/Newhalen/Nondalton		463	0.694	0.774	0.0401	$ 4.78
Pedro Bay		42	0.677	1.177	0.0427	$ 5.45
Port Alsworth		159	0.463	1.184	0.0371	$ 4.90
					Average	**$ 5.22**
					Difference from reference	**$ 0.65**
Manokotak	Western side of peninsula, modest secondary transport required	442	0.055	1.731	0.0073	$ 2.46
New Stuyahok		510	0.808	0.771	0.0339	$ 4.16
Koliganek		209	0.432	1.307	0.0336	$ 4.67
					Average	**$ 4.42**
					Difference from reference	**$ (0.16)**
Dillingham	Western side of peninsula, on ocean, "large" populations	2392	0.819	0.263	0.0317	$ 3.43
Naknek		544	0.794	0.309	0.0305	$ 3.36
					Average	**$ 3.39**
					Difference from reference	**$ (1.18)**
Pilot Point	Western side of peninsula, on ocean, "small" populations	68	0.666	0.857	0.0406	$ 4.92
Port Heiden		102	0.489	1.005	0.0322	$ 4.23
					Average	**$ 4.57**
					Difference from reference	**$ -**

Sources: All regression parameters from Excel worksheet accompanying Alaska Fuel Price Projections 2012-2035, ISER, University of Alaska Anchorage, 2012.

We divide capital costs between project “development” and “execution” phases. The development phase consists of all work and expenditures prior to “project sanction,” and generally includes engineering, design, and permitting and regulatory work. The execution stage generally consists of land clearing, construction, and project commissioning. Project execution was modeled as beginning only at the conclusion of the project development phase. Project phase durations, measured in months, and the proportion of overall capital expenditures required for each phase, were taken from project proponent materials, or elicited in interviews from proponents or AEA staff. This information was then converted to overall project capital spend profiles using the “dimensionless” (percent spend per percent time) development and execution spend schedules developed in the AGIA Finding (106).

The analysis follows AEA’s template and assumes that each project kWh that saves 2 cents (2013 real dollars) in existing diesel generator operation and maintenance costs. In any given instance savings could be greater, smaller, or even negative. The issue hinges, critically, on the details of how the new project would be integrated into existing energy systems. Such a technical assessment has generally not been performed by project proponents, and is beyond the scope of this effort.

Appendix D

Past Reports and Studies

Appendix E

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