2012

Sustainable Energy Opportunities: Best Practices for Alaska Tribes

Background, case studies, and resources for sustainable energy project planning in Alaska Native communities

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*Some projects listed in this resource guide could potentially have impacts to aquatic resources or land management. There are specific permitting requirements (Federal/State/local) that Tribes would want to inquire about prior to any implementation (that could impact the total cost of the project or site selection).

Cover page photograph by Author: wind turbines in the village of Unalakleet, Alaska.

INTRODUCTION

"I like the idea of cultural sustainability, and focusing on the gifts, the strengths, the values, and the beliefs that we have and carrying those forward. Particularly in the Native community, our cultural beliefs and values support environmental consciousness."

~Nichole Maher (Tlingit)

The purpose of this document is to provide basic information on a range of cost effective renewable energy and efficiency practices with an emphasis on Alaska. This project was conceptualized as a resource for Tribes in Alaska and EPA Region 10, who are considering alternative energy sources as a way to lower their contributions to greenhouse gases and thus would be safeguarding the natural environment (air, water, and land upon which life depends) and protecting human health. There is also a need to provide cheaper energy in rural communities. These options reduce the need for diesel fuel and include; energy efficiency, biomass and waste-to-energy, wind, solar, geothermal, and hydrokinetic energy. The various options are organized in this guidebook by types of projects and technologies. Both the limitations and beneficial aspects of each option will be discussed and the regions within Alaska to which each is best suited will be indicated. Examples of projects, where they exist, are given as a framework for effective implementation. Each section includes contact information for further research for interested communities. The costs and energy productivity of each type of project are discussed as part of the description of the provided examples. Each type of project is followed by a "fast facts" reference to give a basic outline of project, its potential success, benefits, and costs or limitations. Through sharing of ideas and lessons-learned, these examples inspire renewable energy and efficiency ideas and provide resources and background information to make project planning easier. Though this guide includes technologies and project ideas that are applicable nationwide and would be beneficial in other regions, the resources, contacts, and issues in this document are specific to Alaska and its many uniquely challenging conditions.

Community Energy Project Planning

Laying out a community energy plan, regardless of what project looks best for your community, starts with gathering basic information about the community, such as the number of buildings and people, the amount of energy consumed overall, the average cost of energy bills in the community, the number of gallons of diesel consumed annually, etc. This basic information forms the foundation for more project-specific information such as the size and amount of insulation in buildings that would benefit most from weatherization improvements, information about current energy systems, such as diesel generators, and local, sustainable energy sources that appear possible based on the location and climate of the community.

Alongside information gathering, organizing community support for sustainable energy and efficiency projects is critical. Starting a community energy group to coordinate work, meeting with the main stakeholders in the community, such as Tribal council members, village corporation officials, and reaching out to the rest of the community to include them on the project are all important steps in building a community energy plan. Tribal coordinators in the Environmental Protection Agency's Tribal Trust and Assistance Unit (TTAU) can be great resources for this kind of planning and coordination (see the "Conclusions and Funding Resources" section for more information on the TTAU).

After information has been gathered and community coordination has taken place it is easier to identify areas for reducing dependence on diesel energy using local resources. After simple improvements have been accomplished, making contact with experts and officials for more complicated project planning will be a smoother process.

Background

Alaska Native communities, and Native Peoples of the world, have relied upon continuous natural cycles of energy throughout time immemorial. Indigenous communities understood where and how the natural world releases its stores of energy and how to use them as well as the limitations created by responsible use of those gifts.

As the world's stores of oil and gas have become limited and costly, the global discussion has turned to these ancient sustainable energy sources. To the Tribal communities of the world, and especially those of Alaska, stewardship and responsible consumption are not new energy guidelines, but foundational values. Adopting modern renewable energy technologies are an implementation of those traditional values.

Shifting to renewable energy sources has environmental, cultural and strong economic motivations. In the lower contiguous 48 States, consumers are faced with gas prices greater than $4 per gallon. In rural Alaska, those rates can be $10 per gallon for diesel and fuel oil that is relied upon for heat and electricity. In a region where winter temperatures register among the coldest in the world, access to energy for heat and transportation is a human rights concern as well as an economic one. Shifting to renewable energy sources also reduces contributions to greenhouse gases that cause global climate change, a process that has disproportionately negative effects on Alaska Native communities.

While the need for new energy sources other than oil is clear and the connection between reducing diesel use/emissions has a positive effect on public health, the path towards those sources is often complicated by technology and feasibility studies. Some modern renewable energy technologies, despite their increased efficiency and better design, are nonetheless the products of techniques that date back to a time long before the discovery of oil. Though renewable energy often appears complicated, at its core it remains a simple concept; the harnessing of energy sources that have been used to varying extents forever.

ENERGY EFFICIENCY

"Live a simple life and waste not, for what cannot be used today can be held for tomorrow."

~ Haida Legend of the Thunderbird[1]

Increased efficiency, or getting the most use out of each unit of energy, should be the starting point for any sustainability project. Improvements in efficiency are almost always the most cost effective method for reducing the use of electricity or heating energy. Unlike other options, efficiency is not limited by region or climate, it does not require studies, and energy conservation can be accomplished by individuals as well as at the community level.

The Alaska Energy Authority outlined a goal for the State to be 20 percent more efficient by 2020 and provide resources and detailed information on efficiency improvement possibilities for communities of all sizes.

- ✓ Efficiency information provided by the Alaska Energy Authority: http://akenergyefficiency.org

Housing Efficiency

Over the life of most houses, 50 to 80 percent of the total cost of the home goes towards energy to heat and power the building. In rural Alaska in particular, 79 percent of home heating is done by diesel at very high costs. Better heating and electrical efficiency in houses is the fastest and easiest way to reduce costs. This goal can be accomplished through the construction of a new house from the bottom up that is designed around high efficiency, through the weatherization of existing homes, or by simply changing light bulbs and practicing energy conservation habits (See list on page 10).

[1] "The Thunder Bird Tootooch Legends," W.L. Webber (1936).

Ventilation

Improving the efficiency of homes carries with it an increased emphasis on intentional ventilation. Low efficiency homes are, by their nature, well ventilated. While holding in heat is the end goal, too little air flow can result in trapping bad odors, harmful gases, or moisture that can result in mold and mildew. All of these can have negative health effects. The following case studies will note the importance of allowing fresh air flow and some of the negative effects of not allowing for ventilation. The following examples of high efficiency homes designed and built by the Cold Climate Housing Research Center (CCHRC) all emphasize proper ventilation as well as high efficiency.

Ventilating a home can be as simple as cutting a whole in the wall. To reduce drafts and too much cold air entering, a fresh air in-let or trickle vent helps control air flow. Letting in outside air may appear counterintuitive, but **permitting fresh air flow in a home and ensuring that wood stoves or oil and diesel heaters are properly maintained and appropriately vented are essential steps to preventing severe respiratory illness**.

- ✓ Positive Energy Conservation Products (search for possible resource for air in-let vents)

For a list of housing resources see page 43-45

High Efficiency Homes

The Cold Climate Housing Research Center (CCHRC) has been developing Alaska homes that are designed around the unique conditions of their environment, not only taking into account the intense winter cold, but the building limitations of each region. Two CCHRC projects, one in Anaktuvuk Pass in the Brooks Range, and another in Quinhagak in southwestern Alaska, exemplify efficient design for the arctic environment.

Anaktuvuk Pass is a Nunamiut community of 380 people located in the Brooks Range of northern Alaska and is only accessible by plane or over frozen tundra from Coldfoot during the winter, 80 miles away. Therefore, design considerations have to take into account not only the average winter temperature of -14 °F, but geographic limitations for bringing in building materials.

The prototype house is currently in its third year of monitoring. It was designed to be practical for the lifestyle of the residents, highly efficient, affordable, and capable of having the materials for its construction shipped in just one cargo plane trip. After several years of testing and modifications, the house consumed about 200 gallons of heating oil per year, over a 75 percent improvement from the average consumption in the town.

The construction design of the house is built low to the ground with dirt mounded up against the walls to reduce snow drift and pressure from high winds. This is unlike other houses that are built up on posts. The house is insulated with nine inches of spray on polyurethane foam (high density insulating foam) and heated with an oil heater and a wood stove backup. The final cost of construction came in at about $230,000. While this price estimate misses the goal set by CCHRC of $150,000, it is much less than the cost of building standard housing in Anaktuvuk Pass, which can reach $750,000.

To deal with the issue of ventilation and energy use, a heat recovery system (HRS) (which allows for air venting while reducing heat loss), was installed after the second year to provide fresh air in the home while reducing energy use. Providing fresh air is critical in any efficient house because moisture buildup can cause mold and mildew and trap gases such as carbon dioxide or carbon monoxide that can cause severe health problems and even, in extreme situations, death.

In addition to the high degree of heat efficiency, the house also uses a solar panel array that produces about seven percent of its yearly electricity, mostly during the summer months. This offsets the electricity that the house must pull from the village generator, and further reduces its energy costs.

The second project by CCHRC is located in the Yup'ik community of Quinhagak, south of Bethel. Due to its more southerly, coastal location, conditions are much different than in Anaktuvuk Pass. Instead of the relatively dry climate of the Brooks Range, Quinhagak is windy with more humidity, which, has caused rot and mildew in many homes. The mildewed conditions can contribute to serious respiratory diseases in young and elderly. While Quinhagak is accessible by barge, its remote location makes shipping large materials and using heavy machinery very challenging. The final housing design includes the same polyurethane envelope insulation as in Anaktuvuk, with an octagonal shaped building that is based on traditional Yup'ik designs which helps to shed snow in the winter.

The prototype house in Anaktuvuk Pass built by CCHRC cut heating fuel consumption by 75 to 80 percent.
Photo by the Author

Fifty-five homes in Quinhagak were found to have mold and mildew severe enough to be declared "disaster" sites and were recommended for reconstruction. In the shorter term, the houses were renovated to make them livable while homeowners wait for new housing, if they choose to build a new home.

A major complicating factor in designing the new prototypes was foundation design, which must accommodate a high degree of ground variability and moisture content of the surrounding soil. Construction of four more houses are planned to be built in summer of 2012. The new homes will be placed on adjustable elevated foundations to allow for leveling as the ground under the homes settles and shifts.

To address the original mold and mildew problems, the prototype house incorporates a heat recovery system to ensure maximum air ventilation and efficiency. To accommodate the short summer construction season, the entire house was built in seven weeks, by a six-person crew without heavy machinery. In the first year of operation, these homes consumed 80 to 90 percent less heating fuel in the first year than other houses in the community, a total of just 171 gallons.

Because of the severe health risks, as well as energy efficiency factors, involved with the old homes, making the new homes affordable was central to project planning. Initial estimates for replacing all 55 homes indicated that the project would cost $14 million, roughly $200,000 for each home. In response to the higher costs, the Native Village of Kwinhagak (NVK) implemented the "ENEKAQA" Housing Program to make the new homes as affordable as possible. The program combines various grant funds and a "Build-to-Own" (BTO) program to reduce the costs as much as possible. The principle cost of each new home is estimated to be $200,000. To offset this cost, the NVK offers to buy the old home for $30,000, making the adjusted total $170,000 and in addition, offers "sweat equity" through the Build-to-Own program. Homeowners are offered the chance to help build their home and have their working hours deducted from the cost of the home, further reducing its cost. The more family members involved with building, the more money is deducted from the cost.

Energy efficiency and CCHRC housing projects fast facts:

- Housing designs based on traditional housing styles
- Anaktuvuk Pass house improved heating efficiency by up to 80 percent (200 gallons of heating fuel compared to 880 gallons per year for other homes), Quinhagak improved efficiency by 90 percent
- Anaktuvuk Pass house built for about one-third the cost of other homes in the area due to using local labor and efficient material use (~$230,000 compared to $750,000)
- Complications: effective ventilation while maintaining high efficiency (Anaktuvuk), and foundation designs for building on the tundra (Quinhagak)

For a list of weatherization resources see page 43-45

Cellulose insulation added to the village store in Anaktuvuk Pass to improve heating efficiency.
Photo by the Author

Weatherization: Making Existing Homes More Efficient

For most existing homes, complete reconstruction for improved efficiency is not practical. For many buildings, additional insulation in the walls, roof, and floor, or by simply caulking cracks, combined with higher efficiency lighting and appliances can increase efficiency and cut energy expenditures by between 20 and 30 percent.

Efficiency improvements pay for themselves in savings in as little as three years. To cover the upfront costs however, many agencies, including local and state housing authorities offer these improvements through weatherization programs for free or reduced cost to qualified applicants (Programs that offer weatherization in conjunction with local housing authorities are listed in the sidebar below.).

The Rural Alaska Community Action Program, Inc. (RurAL CAP) provides a unique set of weatherization programs that operates throughout Alaska and does everything from energy efficiency education to weatherization retrofits. Educationally, RurAL CAP hosts volunteers in the AmeriCorps VISTA Energy Program (a national AmeriCorps program), where volunteers from rural Alaska are given training on energy efficiency to bring back knowledge to their home communities with information resources to start small scale energy efficiency and sustainability projects.

- ✓ Alaska Housing Finance Corporation (AHFC) weatherization homepage: http://www.ahfc.us/energy/weatherization_program.cfm

Projects by volunteers range from simple weatherization and efficiency improvements to community gardens and sustainable energy festivals. RurAL CAP also facilitates the Energy Wise program where community members are hired and trained by RurAL CAP as energy efficiency team leaders. The team leaders are then in charge of hiring local residents and hosting an efficiency fair for the community after which the team does door-to-door visits performing simple efficiency improvements at no cost to the residents. The key to the Energy Wise program is that it provides education about easy ways for residents to improve efficiency in their daily lives from changing light bulbs to unplugging appliances.

RurAL CAP's Energy Wise program functions alongside to its weatherization program. Services provided by the weatherization plan involve more labor intensive projects such as added insulation and installing higher efficiency windows and doors. In 2011, RurAL CAP, through its weatherization program, weatherized 810 homes (228 in 10 rural communities and 496 in Anchorage and 86 in Juneau) and hired and trained 263 local residents to do those projects in the process. Currently RurAL CAP is in the process of fully weatherizing 15 homes in Kotzebue. Also, the U.S. Department of Energy offers weatherization services similar to those of RurAL CAP for little to no cost.

Weatherization fast facts:

- Improves house energy on an average of 30 percent or more
- Weatherization programs available through RurAL CAP, local housing authorities, and the Department of Energy
- RurAL CAP also runs the VISTA Energy program and Energy Wise to promote and facilitate energy efficiency in local communities
- Many weatherization programs are available at free or reduced cost for homeowners
- Ideas for simple efficiency improvements can be found on pages nine and ten

Large scale lighting fixtures installed in the automotive garage in Anaktuvuk Pass cut energy consumption in that building by 60 percent.

Photo by the Author

Lighting Efficiency

One of the fastest and easiest ways to reduce electrical bills and usage is by switching to high efficiency lighting, particularly LED lights. LEDs, or light emitting diodes, are highly efficient light units first introduced in 1962, but have greatly improved and have become more widely available. The initial price of these lights tends to make them less attractive than typically purchased incandescent or fluorescent lights, but the benefits of LEDs are obvious when their efficiency and longevity are compared to other standard lighting options.

The industry standard for LED life expectancy is over 50,000 hours of use (over 11 years for lights that are operated 12 hours a day). The lifespan of LEDs is drastically longer than compact fluorescents (CFLs), which have a life expectancy of 8,000 to 10,000 hours. Incandescent lights, which have a life span of 1,000 to 1,200 hours, are being phased out by the government due to their inefficiency. For light equivalent to that produced by a 60 watt incandescent bulb – a standard household lighting unit – a CFL bulb consumes 13 to 18 watts, a good improvement, but an LED uses eight to twelve watts.[2] As a final benefit, LEDs are less sensitive to temperature extremes than either incandescent lights or CFLs; they are rated to temperatures as low as -40°F.

For more information on LED lighting purchase and information, see page 43-45

The prices for LED lights are significantly higher and vary depending on the distributor, but pay off quickly in energy savings and reduced need to replace light bulbs. For instance, the store in Anaktuvuk Pass Alaska invested $6,600 in LED lighting with the goal of making the store almost entirely lit by LEDs. In doing so, the diesel consumption for electricity was cut by 1,000 gallons per year and will pay itself off in less than one and half years. The village of Anaktuvuk Pass has installed LED streetlights and has switched several municipal buildings and the village automotive garage over to LED with potential diesel fuel conservation results of over 100 gallons per day.

Lighting Disposal

Another consideration is disposal of lighting. CFL bulbs in particular use mercury to create light, which is toxic to the health of people and the environment. Exposure to mercury from broken CFLs can cause brain damage and other serious long term side effects and, even in very small doses, can pollute large areas (0.035 ounces of mercury can contaminate a two acre pond). Incandescent lights also emit mercury into the environment during use at even greater levels than CFLs. When disposing of CFL or incandescent light bulbs, it is critical to avoid breaking the bulbs (especially CFLs) as this releases mercury into the air. The following link provides information on mercury gas, proper cleanup procedures, and methods of disposing of CFL bulbs. It is essential to assure these products do not end up in landfills (contact an expert to see about proper disposal in Alaska).

- ✓ EPA webpage on CFL bulbs, their use and disposal
  http://www.epa.gov/cfl/

LEDs on the other hand are solid state lights – meaning they contain no gases like CFLs – and can be disposed of just like any other recyclable material. Also, because they last over five times

[2] See LED information website for statistics.

longer than CFLs and 50 times longer than incandescent lights, LEDs contribute less to the volume of waste than CFLs or incandescent lights.

Lighting fast facts:			
	LED	**CFL**	**Incandescent**
Projected lifespan (hours)	50,000	10,000	1,200
Energy consumption (Watts)	8	14	60
Cost per bulb	$35.95	$3.95	$1.25
Equivalent 50,000 hours bulb expense	$35.95	$19.75	$52.50
Total cost of 50,000 hours of operation (Assuming $0.10/kWh)	$75.79*	$89.75	$352.50

*Note: LED bulbs continue to drop in price considerably as they become more common.

Simple Efficiency Improvements for Individuals

While the purpose of all energy efficiency improvements is to save money and energy, the initial investment price for many options can be too much for individuals. There are a number of actions that cost little to no money to implement and can, when consistently used, result in significant energy savings. Possibilities for cutting energy consumption include:

- Unplugging "phantom loads" such as computers, microwaves, coffee makers, stereos, television, and other electronics, which take constant energy even when not being used (It costs up to an estimated $50 per month to operate an electric coffeepot in rural Alaska.) – **This does not include ventilating fans or HVAC systems! These should not be unplugged!** They are essential for maintaining fresh air flow and reducing the risk of respiratory diseases associated with improperly ventilated living conditions.
- Use power strips to turn off many electronic appliances at once when they are not in use (More money is spent in Alaska on powering electronics when they are off than when they are being used.).
- Upgrading household lighting. Compact Fluorescent Lights (CLSs) or better yet, LED fixtures.
- Use natural light as much as possible. Take advantage of as much summertime daylight as possible to reduce or eliminate the need for electric lighting.
- When buying appliances, choose Energy Star certified appliances when possible. Energy Star appliances are those that are certified under federal guidelines to meet strict efficiency standards and can use as much as half the energy and/or water of normal appliances. Update freezers with Energy Star units.
- Set the water heater on a lower heat setting. Water heaters account for about 15 percent of the average rural Alaska household energy bill, so cutting energy use by the water heater can account for a large improvement in energy efficiency.

- More ideas for energy saving tips can be found in the Alaska Energy Authority's booklet on energy saving tips (below)

For more information about Waste Heat Capture, see page 43-45

- ✓ Alaska Energy Efficiency, complete list of home efficiency tips for rural Alaska residents: http://www.akenergyauthority.org/Efficiency/Energy_Savers_Tips_2011.pdf
- ✓ ENERGY STAR homepage: http://www.energystar.gov/

Waste Heat Capture

Diesel generators give off a lot of heat that generally goes unused. Waste heat capture uses the heat that would otherwise be lost during generation to use for heating water or providing space heating. The process works a little bit like the radiator on a car or ATV, liquid that is in pipes close to the hot engine is heated and then pumped elsewhere, taking the heat with it, to be used for another purpose. Improving the efficiency of diesel energy generators by using this heat can extend the use of a gallon of diesel fuel. Energy from diesel combustion systems has three, roughly equal paths out of a generator; about one-third is turned into electrical energy, another third exits as heat through the engine walls, and another third goes up the exhaust stack also as heat.

The Alaska Energy Authority, in association with the Denali Commission, helps to fund waste heat projects through the Energy Cost Reduction Program. Thus far, the $5.5 million value of the installed programs in 16 rural communities is estimated to save $10.2 million in diesel fuel costs over the life of the projects.

Kotzebue is one such example of a waste heat recovery project. As part of their goal to reduce diesel use by 25 percent from a current intake of 1.4 million gallons per year, the Kotzebue Electric Association implemented a heat recovery system.

The system provides energy to produce 10 tons of flake ice per day for fish preservation, heats one of the city's water loops, and provides heating for surrounding buildings through a district heating loop. All of this reduces the load on the service station and saves 273,306 gallons of diesel per year.

The Alaska Native Tribal Health Consortium (ANTHC) also plans, coordinates, and assists with funding heat recovery projects. Currently ANTHC is assisting 12 communities, which include Minto, Ambler, and Savoonga for an estimated total energy savings of over 81,843 gallons of fuel per year. In addition, ANTHC also conducts energy audits for tribal communities that help pinpoint the best energy saving options.

The Native Village of Kwinhagak (NVK) is in the process of working with Alaska Rural Utility Cooperative (ARUC), the organization that works with ANTHC to design energy systems, to design a heat recovery system for the village. Early estimates for the heat recovery system indicate that it will cost $700,000 and will reduce diesel fuel consumption by 15,000 gallons per year, a cost savings of $67,000. The waste heat will be used to heat the water and sewer systems, which currently must be heated electrically to keep them from freezing.

- ✓ Alaska Native Tribal Health Consortium heat recovery program: http://anthctoday.org/dehe/cbee/hr.html
- ✓ Alaska Energy Authority http://www.akenergyauthority.org/programsalternativediesel.html

Waste heat fast facts:

- Make existing diesel generators more efficient by using heat emitted from engine (up to 1/3 of energy from diesel combustion is escaped heat through engine walls)
- Provides heat for district heating or hot water
- Fuel savings vary depending on size of generator, larger systems produce more heat energy (Kotzebue saves over 273,000 gallons of diesel per year)

BIOMASS AND WASTE-TO-ENERGY

"Raven took some red cedar, and some white stones called neq! which are found on the beach, and he put fire into them so that it could be found ever afterward all over the world."

~Tlingit Creation Story

Biomass – energy from burning organic material such as wood – is one or our oldest energy sources. Biomass is a renewable and sustainable energy source when and if its fuel sources can be managed and grown in a relatively short time period. This can be accomplished through well managed, sustainably harvested forests. Additionally, biomass energy is better than diesel or other fossil fuels because it needs little to no processing and thus localizes the energy source and reduces the cost of its production. As an added benefit, spilling wood pellets poses less of an environmental risk than spilled diesel. The sources of energy are as varied as the types of communities that employ them, using anything from food and fish waste to wood chips, wood pellets, and logs or sawmill waste.

There are several factors to consider before planning a biomass energy project of any size. Projects can range from large scale burner and boiler systems, to residential fireplaces. The first consideration is fuel supply. Is there a large enough and consistent supply of material to be burned so that the furnace can be easily and reliably supplied? As well as what the distance is to accessing these resources? Are the resources close enough to be a valuable alternative? The burning of any material produces gases and smoke that can be harmful if confined in an enclosed space and when localized regionally. This is especially important when individuals are considering using wood fired stoves in their home. The smokestacks on wood fireplaces need to be cleaned and maintained at least once per year to make sure that no build up of soot blocks the flue. Soot clogged smoke stacks not only pose an air health risk by trapping smoke and gases inside, but also increase the risk of a house fire because material in the chimney can catch on fire. This factor is also important when siting larger scale facilities so that emissions are properly managed and do not contribute to local air quality deterioration.

For more information about Biomass evaluation and installation, see page 43-45

Wood Biomass

Wood has the greatest potential for biomass energy production, mostly in interior and coastal Alaska. Because of the comparatively widespread availability of wood as a fuel source and the simplicity of using it, wood has become a popular fuel source for many communities and in residential homes.

Wood Chip Boilers

Chip fired boilers utilize wood chips from sawmill waste, forest harvesting waste, manufacturers or wood chipped specially for the burner. A beneficial aspect of chip fired biomass systems is that they can accommodate a wide variation of chip composition, quality, and moisture content due to high incineration temperatures, producing upwards of 200,000 BTUs per hour, up to multi-millions of BTUs (For comparison, a kerosene lamp puts out 1,000 BTUs per hour.).[3]

[3] BTU stands for "British Thermal Unit" and is a standardized measure of heat energy.

Wood chip burner in Tok

Photo from Alaska Energy Authority 2011 Renewable Energy Atlas

Despite the low cost of the fuel resource, chip fired boiler systems tend to be large, best suited for large buildings or district heating. They require constant operational maintenance and more complex facilitates to accommodate an effective system, including an automatic chip feeding system.

In 2010, the Tok School installed a chip fired boiler with a waste heat system that replaces an oil powered system that previously consumed 65,000 gallons of fuel oil per year. The new system contributes to healthier air quality (producing only 14 ppm (parts per million) of Carbon monoxide (CO) compared to 200 ppm of CO from an oil fired furnace) and saves the community $486,450 per year in heating and electricity costs after installation, operation and maintenance.[4]

Cost of design and installation in Tok totaled $3.2 million, funded by Alaska's Renewable Energy Grant Fund (see funding resources on page 39), and operating costs from local wood harvesting and maintenance totaled $132,000 per year. That cost included a half time maintenance person to run the facility and $80,000 for fuel material, estimated at $40 per ton. Note that particular fuel costs for similar projects will vary depending on geographic location and available resources.

Cordwood Biomass Systems

Cordwood, or traditional log firewood, is the most common form of wood heating, used most commonly in residential stoves. Cordwood boilers operate very similarly to residential stoves, but on a much larger scale. These systems may operate at higher temperatures and with greater efficiency – as much as 87 percent efficiency.[5] Typical heat output is between 250,000 and 700,000 BTUs per hour. Though they produce less heat energy than chip boiler systems, they are much less complex to operate, requiring simple manual loading of firewood into the furnace up to four times per day. Additionally, cordwood boilers cost much less than chip boilers, ranging from $250,000 to $500,000 per unit depending on the scale of the project. Use of dry wood is very important for maintaining high efficiencies in these systems.

[4] Parts per million (ppm) is a measure of particle density, the number of particles that exist in one million particles of a larger sample, in this case, the number of molecules of carbon monoxide (CO) that are present in the air. CO levels of 200 ppm or greater inside building is when the building must be evacuated.

[5] Alaska Energy Authority, "Cordwood Boilers Factsheet," 2012.

Wood pellets

In 2010, the community of Gulkana installed two cordwood boilers that provide heat to a district heating loop for their community of 120, as well as to the water lines to prevent winter freezing. The total cost of the project was $500,000 and replaced 14,600 gallons of heating fuel annually with locally cut cordwood.

Cordwood is also the most common form of biomass for **residential scale fire places** and many communities are moving towards, or going back to using wood stoves for heating in place of oil or diesel heaters. When this is possible, wood can be a great residential heat source. Ensuring that the wood is properly dried and stored can improve efficiency and minimize air quality hazards. More information on residential wood stoves is available through the EPA's Burnwise program. Information on wood smoke hazards and how to burn wood cleaner and more efficiently can be found on the wood smoke factsheet (below).

- ✓ EPA Burnwise program (information on residential wood stoves) http://www.epa.gov/burnwise
- ✓ EPA wood smoke factsheet and recommendations for clean and safe wood burning http://www.epa.gov/region10/pdf/tribal/anv_wood_smoke_aug2010.pdf

Wood Pellet Biomass Systems

Wood pellet biomass systems offer the widest range of sizes, from residential pellet stoves costing $2,000 to commercial boiler systems costing $10,000 or more. Pellet systems utilize wood waste that has been refined into pencil eraser-sized pellets with extremely low moisture and ash content so they burn more efficiently than chips or cordwood. The pellets are loaded into an automatic feeder on the system and fed into the furnace using an electric auger.

Because of the refined nature of the pellets, pellet systems burn more efficiently and cleanly. As a result, these systems require very little maintenance and much less infrastructure is needed for installation. The downside of using pellets is that they do not create energy independence as pellets need to be imported. Pellets can be bought in bulk "supersacks" of 2,000 pounds for $300 or in residential 40 pound bags.

In 2010 in Juneau, the Sealaska Plaza replaced its fuel oil boiler with a pellet boiler. The total cost of the shift was $214,000 for a Wood Pellet Boiler put out 750,640 BTUs per hour, enough to heat the 58,000 square foot building. In one year, the system burned 251 tons of pellets at

$300 per ton for a savings of over $45,000 compared to the former oil boiler. It is estimated that the system will pay for itself in savings in 4.5 years.

Wood biomass fast facts:			
	Wood Chip	**Cordwood**	**Wood Pellets**
Capital cost	Approximately $1 million	$250,000 - $750,000 per unit	$2,000 (residential) $10,000+ (commercial)
Energy output range (BTU/hr)	200,000 – multi-million	250,000 – 700,000	35,000 – multi-million
Local energy independence	Yes	Yes	No (requires pellet processing)
Design considerations	Large installations that require full time operation and maintenance involvement	Requires a building or container to house the boiler system	Can be installed in place of standard fuel oil burners; comparable in size, operation, and maintenance

Biomass Briquettes

Briquettes are pressed logs, similar to wood pellets only larger, composed of wood chips, waste cardboard, paper, or other cellulose biomass. After pressing, the pressed logs can be used just like cordwood. Petersburg, in southeast Alaska, has been developing a briquette production system using a Biomass Briquette Press, costing $30,000 plus $45,000 per year for operating costs, which was funded by Alaska Marketplace. The project is beneficial to the community because it displaces 20,000 gallons of heating fuel per year, creates local jobs, and uses waste material that would otherwise have to be backhauled out of the community. The greatest benefit of pressing briquettes is that the process can use chipped wood, waste wood material, or any paper waste. The breadth of material that can be used makes finding a biomass source much easier and more reliable.

An important lesson learned from the project is that the waste material must be dried thoroughly before pressing in order for the logs to burn cleanly and efficiently. The Petersburg system uses a heat exchanger to air dry the biomass material from the floor.

- ✓ Petersburg biomass briquette fact sheet
  http://www.tongassfutures.net/docs/microsoft-word-petersburg-project.pdf

Biomass Briquette Fast Facts:

- About $30,000 capital cost of installation
- Combination of wood biomass and waste-to-energy (uses waste wood, paper and cardboard as well as chipped wood)
- Provides an easy means of disposing of waste material as well as producing locally produced heating fuel

WTEC mobile gasification system

From WTEC website

Waste-to-Energy

Waste-to-energy is the use of landfill waste as a fuel source to produce electricity and heat. It has the added benefit of eliminating or reducing the need to dispose of waste materials in landfills. However, the use of waste as fuel is often limited by insufficient supplies to maintain constant operations for a waste to energy facility.

Most rural Alaska landfills are Class III municipal waste landfills, meaning that they receive, on average, less than five tons of waste per day. However, effective waste-to-energy plants need much larger landfills in order to effectively deliver the required energy to the communities. For Instance, Anchorage regional landfill has installed a waste to energy power plant that produces 5.6 MW of electricity, but Anchorage processes over 200 tons of waste per day – over 40 times the volume of most rural landfills. While waste-to-energy is attractive and would be a good way to dispose of garbage, it is generally not feasible for the majority of rural Alaskan communities.

An important note concerning trash incineration is air quality control. Burning trash produces numerous toxins that are harmful to human health, especially the young and elderly. Avoiding open trash burning when possible is important to maintaining healthy air. The methods of using trash as waste mentioned here all use either controlled, oxygen free environments, which produces fewer air contaminants, or rely on harvesting gases and heat from decomposing waste. More information on the hazards of open air waste incineration is available on the EPA solid waste burning factsheet

- ✓ EPA solid waste burning factsheet
  http://www.epa.gov/region10/pdf/tribal/anv_waste_burning_aug2010.pdf

Plasma Gasification and Incineration

One possibility for energy production is to use ground up municipal waste as a fuel source to produce heat and electricity through a process called plasma gasification.

Landfill waste is ground up and added to a furnace that cooks the waste in an oxygen free environment. The byproducts of this process are ash (also called "slag") and a flammable gas called "synthesis gas" (or syngas) that is used to fire a burner and create electricity. The waste heat from the incineration process and gas burner can be used to heat nearby buildings in a district heating loop or to heat water. This method of waste disposal and energy generation has become popular in Europe, especially in Denmark, the Netherlands, and Germany. Because plasma gasification is more controlled, it produces fewer toxic gases and harmful air particles than simply burning trash.

Dillingham is investigating the possibility of implementing a plasma gasification plant, but has run into a common challenge of such facilities – not enough trash. Even in Dillingham with a population of over 2,300, not enough trash is produced to keep a small scale prototype waste-to-energy plant operating all day, every day.

Rather than a plasma gasification system, Chena Power installed a waste-to-energy incineration generator to power its headquarters in North Pole that simply uses cardboard and waste paper as a direct fuel source. This system produces 400 kW of power and utilizes 4,300 tons of paper and cardboard waste annually. However, like the Dillingham project, expansion of the Chena power generator is also limited by the availability of waste for fuel.

Waste-to-Energy Canada (WTEC) has developed a gasification unit specifically for isolated small rural communities in northern climates. The unit was designed for the community of Old Crow in Yukon, Canada that is only accessible by air. The two 40 foot container boxes that house the waste-to-energy system can be flown in, set up within hours, and require minimal operational training and very little startup energy. Each individual unit can accommodate up to 1.5 tons of waste per day. When municipal waste is not enough to fill the unit efficiently, other waste materials such as available biomass can be added to supplement the waste energy.

Municipal Waste Methane Capture

Another option for getting energy from waste is by capturing the gas that is emitted from landfills and using it as fuel. This method is often employed by large landfills. Currently in Alaska, only Class I landfills (those receiving greater than 20 tons of waste per day) in Anchorage, Kenai Peninsula, and Fairbanks are attempting methane capture projects. The Anchorage regional landfill is developing a 5.6 MW system powered by collected landfill gas. However, this method is nearly impossible for rural communities because of small landfill sizes.

Methane gas generators at the Anchorage Regional Landfill

Photo by the Author

- ✓ U.S. EPA Landfill Methane Outreach Program (LMOP) provides resources for using landfill methane for energy production: http://www.epa.gov/lmop/

Energy from Organic Waste

Another method for producing energy is using the heat and gas produced directly from composting organic material. This method has the added benefit of producing a leftover “waste” product after energy capture that is a nutrient rich fertilizer that can be used for growing local food.

In vessel composting systems, as opposed to simple compost piles, compost much more quickly (in as little as one month compared to up to six months) by operating in enclosed tubes, vats, or silos and including aerators. The enclosed environment creates the opportunity to harvest heat and gases from the composting process. When organic waste, such as food scraps, fish waste, animal manure, and plant matter decompose, the process releases substantial amounts of heat, part of which helps facilitate the composting process, but significant quantities can be used for other purposes such as space heating or warming water lines and tanks to prevent freezing.

Ideally, in vessel composting would be implemented as part of a greenhouse system, such as one that is being tested in Scotland, which cost an estimated $15,000 to design and construct.[6] The heat is piped off of the composter and used to heat the greenhouse while the compost provides the fertilizer necessary for plant growth. Using waste in composting systems could help contribute to local food growth that has further benefits for reduced energy consumption and better, more nutritious food.

Additionally, rural fishing communities in Greenland have experimented with using fish waste, which produces methane, "biogas," which, similar to landfill methane capture, can be used to create electricity. Adding other organic materials such as seaweed or organic food waste can increase methane production that occurs when organic materials decompose in an anaerobic, or oxygen free environment.

Fish oil that is produced from fish waste, is another method of employing waste materials for energy. In coastal fishing communities, fish oil is often used to supplement diesel fuel for burning in furnaces.

Waste-to-energy fast facts:			
	Plasma Gasification/Incineration	**Methane Capture**	**In Vessel Composting**
Energy type	Electricity and heat	Electricity and heat	Heat
Viable for rural AK	A strong possibility (depending on waste availability)	No (requires large Class I landfills)	Yes (depending on regional/seasonal organic waste output)
Capital cost	$690,000 to $890,000 per unit	Tens of millions	~$15,000 for in vessel composting and greenhouse system (based on model in Scotland, but varies depending on conditions and size)
Technical training needed	Installation and maintenance	High amount of training needed	Installation and Maintenance

[6] E.R. Lamont G. Irvine and B. Antizar-Ladislao, "Energy from Waste: Reuse of Compost Heat as a Source of Renewable Energy," International Journal of Chemical Engineering (2010).

WIND

"Looking up, the doll saw a hole in the sky wall, covered over with a piece of skin. The cover was bulging inwards, as if there was some powerful force on the other side. The doll was curious and, drawing his knife, he slashed the cords holding the cover in place and pulled it aside. At once a great wind rushed in, carrying birds and animals with it."

~ Aleut Story of the Origin of Wind

Wind is the most commonly used renewable energy sources in Alaska. Wind turbines turn the energy of the wind into electrical energy and are more efficient than they once were. The simplicity of the technology involved with wind power has also made the technology comparatively cheap to implement on a large scale. As an energy source based on the weather, its low price is accompanied by a degree of unpredictability, which makes balancing variable energy production with demand more difficult.

Wind energy benefits from a long history of use and technological development The technological advancements in wind energy generation have made wind turbines less expensive, more durable, reliable, and efficient. For all of these reasons, wind has become one of the most utilized renewable energy sources in windy rural locations in Alaska. When considering wind energy bear in mind the potential impacts to migratory birds.

Wind Potential: Measuring and Siting

Wind potential is measured by the average wind speed ranked on a scale of one to seven. Wind speeds of greater than 9.3 meters per second are considered "superb" (class 7) and wind speeds of zero to 5.3 meters per second are considered "poor" (class 1) wind resource areas. Increased height captures wind that is little impeded by friction with the ground and avoids uneven, less efficient winds that occur as a result of barriers closer to the ground. Measuring wind speeds and potential positioning is done with a meteorological ("met") tower, which records wind speeds, wind direction and temperature at frequent time intervals.

AEA Anemometer Wind Program Contact

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Wind Program Manager
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Wind energy has the most potential for use along coastal Alaska. Particularly the Aleutian Islands, along the North Slope coast, the coastal region north of Nome, west of Bethel and the southern

Meteorological tower in Togiak

Photo courtesy of V3 Energy LLC

Kenai Peninsula. These locations offer "good" (Class 4) to "superb" (Class 7) ratings on wind potential. Inland wind energy potential is usually much lower, but is still possible near Delta Junction and Healy. Regardless of regional location however, wind potential for villages is entirely dependent on local conditions. Therefore individual assessments should be conducted if wind appears to be a possible energy option both to check the practicality of wind installation and to gain funding assistance, as many project funding sources require such assessments. The Alaska Energy Authority offers technical and material assistance with wind feasibility studies through its anemometer (wind measurement) loan program. The Department of Energy also offers wind assessment assistance through the *Native American Anemometer Loan Program*.

Renewable Energy Alaska Project (REAP) offers a *Community Wind Toolkit* that provides step-by-step instructions on installing wind capacity. The guide explains the possible impacts, resources, and necessary considerations involving wind installations in small communities.

- ✓ Alaska Energy Authority's Anemometer Program page and project application forms: http://www.akenergyauthority.org/programwindanemometerloan.html
- ✓ Department of Energy *Anemometer Loan Program:* http://www.windpoweringamerica.gov/nativeamericans/anemometer_loan.asp
- ✓ Renewable Energy Science and Technology: Wind (Provides information on wind potential by location) http://www.renewableenergyst.org/wind.htm
- ✓ Community Wind Tookit: http://alaskarenewableenergy.org/wp-content/uploads/2009/04/WindToolkit_For-web_FINALMarch24_2011.pdf

Energy Storage Systems

One downside of wind, as with other renewable energy sources such as solar, is that it is dependent upon the natural elements to produce power. If there is no wind, there is no energy. Despite continued research on a variety of methods, battery storage – using large batteries to store energy from high production periods – remains a costly and relatively inefficient option.

Options for energy storage by other means have been practiced to varying success. The first method, pumped hydro, involves using wind power to pump water into a reservoir, which can then be released through hydroelectric turbines when needed for later energy use. This method has been used in Kodiak and the Columbia River Gorge between Oregon and Washington where large scale hydroelectric facilities and wind generation are found side-by-side. Pumped hydro systems, depending on design, operate at between 76 and 85 percent efficiency and have the greatest capacity storage because they are only limited by the amount of water that can be held by the reservoir.

For small scale pumped hydro systems, holding sufficient water for six to ten hours of operation, installation costs are $2,500 or more per kilowatt of energy produced. However, because of the cost of implementation, energy storage systems have not proven to be cost effective compared to simply using other renewable energy possibilities in combination with wind.

Wind-Diesel Hybrid Systems

The most common method to balance out the level of instability involved with wind power generation is to use it with existing diesel generators. Using wind energy as a "boost" on the generator reduces the amount of energy needed directly from the generator (called its "base load"), but still uses it to compensate for unsteady wind energy.

The degree to which wind energy is responsible for the total energy production is called its "penetration." Low penetration systems receive less than 20 percent of their output from wind, 50 percent of total energy coming from wind constitutes medium penetration, and high penetration systems are those where a majority of the electricity produced comes from wind generation.

Wind turbines in Quinhagak

Photo by the Author

Wind Use Examples

Among the most notable work in wind energy development in the world has been done by the Alaska Village Electric Cooperative (AVEC), which serves 54 villages in interior and western Alaska. In response to constantly rising fuel costs for its diesel generation plants, AVEC began developing wind-diesel generation facilities and now has wind turbines installed in 12 rural villages with interties to five more communities. Currently, AVEC owns and operates 34 wind turbines in these communities totaling 3,394 kW of capacity. Key to the development of wind infrastructure was AVEC's work on developing innovative foundation designs to adequately support the towers in the changing conditions of the permafrost. Additionally, AVEC has invested heavily in updating and improving diesel generator facilities in order to integrate them more effectively with the new wind generation facilities. As important as infrastructure development, AVEC's wind program also includes the development of a week-long training program conducted by Northern Power in Barre, Vermont. Training village residents in wind power maintenance has not only saved money for AVEC in transportation costs in and out of villages, but reduces down time of turbines that are in need of maintenance and provides a source of local income for village members.

AVEC villages with Installed wind capacity

- Chevak – 400 kW
- Emmonak – 400 kW
- Gambell – 300 kW
- Hooper Bay – 300 kW
- Kasigluk – 300 kW
- Mekoryuk – 200 kW
- Quinhagak – 300 kW
- Savoonga – 200 kW
- Selawik – 264 kW
- Shaktoolik – 200 kW
- Toksook Bay – 400 kW
- Wales – 130 kW

In Hooper Bay, AVEC's largest community, wind development was motivated by electricity prices that reached over $0.65 per kWh, about five times the price in urban areas of Alaska and the lower 48. Starting in 2001, AVEC, with funding from the U.S. Department of Agriculture High Energy Cost Grant Program and the Denali Commission, planned and implemented the installation of a medium penetration, wind-diesel hybrid system. The central feature of the project was three 100-kW capacity wind turbines that together displace 44,500 gallons of diesel annually.

Quinhagak, also in the Alaska Village Electric Cooperative (AVEC) service area, installed 300 kW of capacity. With help from AVEC engineers, community leaders in Quinhagak planned and executed the $4.3 million project, which started producing power in January of 2011. In 2011, the wind turbines produced 21.1 percent of the community's total electric needs, saving 28,877 gallons of diesel that (at $4.47 per gallon) resulted in a total fuel savings of $128,936 for the year. Energy costs for village residents dropped almost immediately, making Quinhagak the fifth least expensive village for energy out of the 54 villages in AVEC's service area, compared to its previous ranking of 18th.

- ✓ The National Renewable Energy Laboratory Wind Research Division:
  http://www.nrel.gov/wind/working_with.html
- ✓ Alaska Village Electric Cooperative (AVEC) Renewable Energy Projects
  http://www.avec.org/renewable-energy-projects
  4381 Eagle St.
  Anchorage, AK 99503
  (907)561-1818

Technical Training

For resources and contacts about wind generation, see page 43-45

Possibly the most important part of constructing a wind generation system is having the resources to repair, manage and operate the system effectively and independently. Having local staff on hand to take care of the day-to-day maintenance is critical to maintaining the cost effectiveness and continuing operation of wind turbines.

The Alaska Vocational Technical Center (AVTEC), which operates through the Alaska State Department of Labor and Workforce Development, in collaboration with AEA, the Denali Commission and others, offers several courses pertaining to wind energy maintenance. For those who are looking for more in depth study can take the 10 month Industrial Electricity Program, which covers a range of energy systems and their maintenance and operation, including wind and other renewable energy sources. However, AVTEC also offers an eight week Power Plant Program that includes an extra week for those students wanting to learn about wind generator maintenance. Both courses are held on AVTEC's Seward campus where students have the opportunity for hands on wind generation training on a 100 kW turbine.

- ✓ AVTEC Power Plant Program (8 weeks)
  http://www.avtec.edu/PowerPlt.htm
- ✓ AVTEC Industrial Electricity Program (10 months)
  http://www.avtec.edu/IE.htm

Residential Wind Turbines

Wind is also viable renewable energy to supplement the energy for individual homes. Even for areas where wind is not ideal for large scale wind installations, residential wind turbines can still be cost effective, especially when combined with a 30 percent tax credit for residential wind turbines with a capacity of less than 100 kW. Though costs vary greatly by location and size of the installed turbine, the American Wind Energy Association estimates that small residential wind energy systems cost between $3,000 and $5,000 to install per kW of generating capacity. The payback period varies according to average energy prices.

The Department of Energy has published a detailed manual on residential wind installation that provides information on deciding on the cost effectiveness of small wind installation and resources for design and construction.

- ✓ Alaska Consumer's Guide for Small Wind Electric Systems – Department of Energy http://www.windpoweringamerica.gov/pdfs/small_wind/small_wind_ak.pdf
- ✓ Federal tax credit webpage for residential wind turbines http://energystar.supportportal.com/link/portal/23002/23018/Article/33338/Is-there-a-tax-credit-for-residential-small-wind-turbines

Wind fast facts:

- Most well developed clean energy technology (benefit of many years of trial and technology improvements)
- Wind potential varies by region, but generally high along the coast
- Energy storage to stabilize energy output is not cost-effective
- Wind-diesel hybrid systems help stabilize variable output of wind
- Large scale projects that require more development and training
- Local wind technicians to maintain wind systems reduces operation costs

SOLAR

"The old man pointed his finger to the sun and to the moon. 'These two take care of the earth. The sun keeps the cold climate away from this land.'"

~ Inupiat Legend of Aungayoukuksuk[7]

Though solar energy is limited in Alaska by climate and geographic locations, the benefit is that the necessary technology or infrastructure is relatively low maintenance and requires little input after installation. Unfortunately, while energy storage methods have been attempted in the effort to reduce the energy output variation of solar energy and to extend use into less sunny months, few have shown to be efficient enough or cost effective to be worthwhile.[8]

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[7] From *People of Kauwerak: Legends of the Northern Eskimo*, by William A. Oquilluk.

[8] Energy storage methods that have been tested include a project in the United Kingdom using solar energy to spin a 275 ton flywheel, the momentum from which supplied electrical energy during the nonproductive periods. Other examples include using solar thermal energy to heat ground rocks that then provide heaenergy during the winter. However, these techniques remain in the early testing phases.

Solar energy is also an easy to implement renewable energy source for individuals because it is low maintenance and easy to install. There are a variety of companies who install or assist with installing solar energy systems, several of which are listed below. Like wind, residential solar installations are also eligible for Federal renewable energy tax credits.

- ✓ ABS Alaskan (information on a variety of residential renewable energy sources) http://www.absak.com
- ✓ Federal tax credit webpage for residential solar installations http://www.energystar.gov/index.cfm?c=tax_credits.tx_index

Regions of Best Implementation

In Alaska the best regions with solar potential are: the southwest, northwest and much of the eastern side of the state, centered largely in the north and interior. These regions provide solar energy best during the summer months, especially in April when sunlight, combined with reflection off of the remaining winter snow, intensify the light energy that can be collected.

For resources about solar energy project installation, see page 43-45

Trackers, or devices that employ a small amount of electrical power to turn solar panel arrays to follow the sun, can also improve the efficiency of solar collecting systems, but at a small electrical cost. Tracker systems tend to be most beneficial in the north, where the sun's energy is constant or nearly constant for several months out of the year, but also involves a wide range of motion across the sky. However, it is not entirely clear that, even with the added efficiency of a tracker system, that their installation is cost effective.

The collection of solar energy can be done in a variety of ways, ranging from electrical production to simple heat capture, and are widely used. However, both heat and electricity systems are not generally cost effective for large scale utility, but offer great opportunities for small scale and individual users to reduce electrical energy consumption from other sources.

Photovoltaic Systems

Photovoltaic (PV) arrays, or sets of PV panels installed together, are possibly the most recognizable of the solar energy collection systems and work by converting light energy directly into electrical energy within each "cell", the smallest unit of a PV light collecting system measuring 10 cm to 15 cm square. The technology behind the functioning of PV systems is relatively complex and constantly improving. Within each cell, sunlight striking the PV material, usually silicone, creates an electrical current that can then be used directly for an energy source. PV modules, a unit composed of multiple PV cells, have no moving parts therefore suffer little wear and tear thus making operation and maintenance very low cost and providing life expectancies of 20 years or more. Power inverters, mechanisms that convert electricity from the panels into usable electricity in the home, are typically the only pieces of equipment that need replacing over the life of the PV system.

Photovoltaic panels on top of the Nenana teen recreational center

Photo courtesy of Yukon River Inter-Tribal Watershed Council

Within the area of PV technology, there are three main categories; monocrystalline, polycrystalline, and thin film. The differences between the three types are relatively minor, except that monocrystalline and polycrystalline panels are as much as twice as efficient as thin film PV. Monocrystalline and polycrystalline will be more expensive, but because they are more efficient, the price per kilowatt produced will be similar between all three types. In areas where space is a constraint, monocrystalline and polycrystalline panels are preferable because they require less space per kW of output, whereas in situations where space is not a factor, thin film can be used.

Lime Village, several hundred miles west of Anchorage, installed a 12kW PV array as part of a diesel-solar hybrid system, a donation by British Petroleum (BP). The array offsets 5,800 gallons of diesel per year, 28 percent of the village's annual use. Currently, with the help of a grant from the Alaska Energy Authority, the AVEC is conducting an assessment of the performance of possible solar-hybrid projects in rural Alaska villages.

The community of Nenana, outside of Fairbanks, installed a 4.4 kW PV system on the teen recreational center that has produced over eight MW of electricity since it was installed in early 2011.

- ✓ Real time information on the Nenana PV solar system: https://enlighten.enphaseenergy.com/public/systems/BTcD7969

Solar Thermal Energy

Solar thermal energy involves using the sun's energy to heat conveying fluids that are then used for space heating, hot water heating, or any uses of a similar type. The technology is not unlike that used by wood fired boilers or waste heat recovery systems. The only difference between solar thermal systems and fuel fired boilers is that rather than piping the fluid within the immediate area of a fuel heated source like a burner or diesel generator, the fluid is heated by the sun in large panels before being piped to its point of use and distributed through a heat exchanger. Several types of solar thermal panels can be used; the two most common types are glazed flat plate panels and evacuated tube panels. Though the configurations of the panels differ, they operate on the same principle of absorbing and transporting thermal energy.

Solar Thermal panels in Nenana

Photo courtesy of Yukon River Inter-Tribal Watershed Council

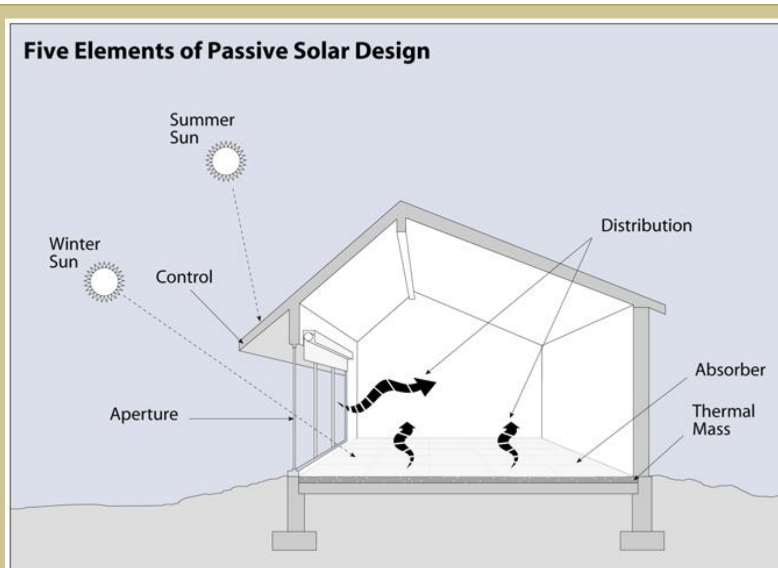
In addition to PV panels for electricity, Nenana installed two glazed flat solar thermal panels that heat water in the recreational center before entering the hot water heater.

Solar thermal energy can be used for heating hot water during the summer, thereby reducing summer energy costs. One consideration for solar thermal systems in Alaska is the result of fluid freezing within the panels and pipes, which can cause the system to rupture. Using conveying fluids with as low a freezing point as possible and shutting down the system during some seasons can help avoid freezing.

One method of extending the seasonal use of solar thermal seasons is being investigated in Alberta, Canada and involves using solar thermal panels to heat the ground. In the winter, when solar energy is limited, the stored heat energy that was pumped into the ground during the summer is extracted using a ground source heat pump (see page 36) and used for space heating in surrounding homes (see "Ground Source Heat Pumps" on page 36 for further information).

Passive Solar

Passive solar energy is more of a housing design concept to utilize the position and design of a building to absorb the sun's warmth to heat it without mechanical assistance. For instance, the Cold Climate Housing Research Center prototype home built in Anaktuvuk Pass has soil built up against the walls on all sides except the south facing wall. The south facing wall has high efficiency windows to collect as much sunlight as possible to warm the building while releasing as little heat from the structure as possible.



The five elements of a passively heated home can be used to heat and cool the building.

Passive solar building design incorporates **five main elements** that help to make the most of the sun's energy in the winter, while shedding as much heat as possible during the summer.

1. The first element is **aperture**, or the window openings that face sunlight and capture the most sunlight during the winter. This involves the position of the building, which should be within 30 degrees of true south and free of shade from other buildings or trees.
2. The second element is to have an "**absorber**," a hard, dark surface used to absorb the maximum amount of the sun's energy as heat.
3. Third is a **thermal mass**, which is a dense material, stone, concrete, masonry, etc., which holds the thermal energy absorbed by the surface.

4. Fourth is **heat distribution**, either by strictly passive modes of transfer, conduction, convection, and radiation, or via fans, ducts and blowers.
5. Fifth is a **method of controlling thermal collection** including roof overhangs and awnings that can be used to shade south facing windows.

It is difficult to quantify the benefit of such construction design. Employing passive solar elements to an existing home can be as simple as installing more windows on a south facing wall, or painting a wall near south facing windows a dark color to absorb more of the sun's warmth.

Solar fast facts:			
	Photovoltaic (PV)	**Solar Thermal**	**Passive Solar**
Type of energy	Electrical	Heat (space or water)	Heat (space) and natural lighting
Technology	PV panels (high tech)	Solar thermal panels (low tech)	Proper building materials and design
Viability	Low - Small scale supplemental, not a good primary electricity source for communities	Good - lower cost systems, reduce heating load for water	High - no technology needed and little additional material investment if considered during building design process

GEOTHERMAL

"The man took the mud out of the muskrat's hands into his palm. He let it dry and then crumbled it to dust. Then he blew the dust out of his palm all over the waters. This made the world."

~Athabascan Creation Story

Earth contains a large quantity of its own heat. Around the Earth, the average temperature rises by 1°F for every 70 feet of depth (this varies by location). In other areas, especially in volcanically active regions like the *Ring of Fire* that runs along southern coastal Alaska, the interior temperatures rise much higher. In either case, geothermal energy, or the energy from this interior heat, can be a useful energy source because the temperature of the Earth remains fairly constant and thus provides a constant and stable source of energy, unlike sources such as wind or solar which have a high degree of variability.

Types of Geothermal Uses

There are two distinct types of geothermal energy that can be used depending on the specific conditions of the region. The ground temperatures that are available in a certain geographic region dictate how they can be used.

Geothermal Electrical Generation

Producing Electricity from geothermal sources requires high heat sources, like those found in the hot springs regions of Alaska. The lowest temperature hot spring source that has been utilized for electricity production is at Chena Hot Springs outside of Fairbanks, which operates at ground temperatures of 165°F.

Geothermal generators at Chena Hot Springs

Photo courtesy of Chena Hot Springs Geothermal Project

Produced by United Technologies Corporation (UTC) and owned by Chena Hot Springs Resort, the $2.1 million system generates 680kW of electricity, displaces 224,000 gallons of diesel and reduces energy costs to as low as $0.05 per kWhr. The geothermal heat is also used for space, greenhouse, and hot water heating, and to run a 16 ton absorption chiller that keeps an outdoor ice museum frozen year round.

The pump and generator unit for the Chena Hot Springs geothermal power plant

Photo from the Chena Power Report to AEA (2007)

Other areas that have undergone testing for geothermal energy sources include Mt. Spurr near Anchorage, the City of Akutan in the Aleutians and areas around Mt. Makushin. However, while testing of these sites have indicated great potential for geothermal, no production has taken place as of yet.

Operationally, electrical generation from high heat geothermal sources works exactly like any other boiler system electrical generation. The ground heat is used to boil water that produces steam to turn a turbine generator, exactly like a wood, coal, or natural gas fired electrical power plant, except that the heat source is free and without CO_2 emissions. However, as will be discussed later, the availability of high heat geothermal sources is limited by geographic locations.

- ✓ More information on the Chena power plant: http://www.yourownpower.com/Power/
- ✓ Final report on the Chena Hot Springs power plant: http://www.akenergyauthority.org/Reports%20and%20Presentations/FinalProjectReport_ChenaPowerGeothermalPlant.pdf

Ground Source Heat Pumps (GSHP)

For low heat geothermal sources, anything other than hot springs, geothermal energy can be used directly for district heating, hot water heating, or greenhouses. In these cases, even relatively low ground temperatures can be used to warm water tanks or space heating.

Ground source heat pumps (GSHP) operate by using the constant ground temperature as a heat source during the winter when the ground temperature is warmer than ambient air temperatures, and as a heat sink in the summer, when ground temperatures are cooler than ambient temperatures. By pumping a liquid medium through pipes in the ground and then through a compressor and a heat exchanger in the building, GSHP systems use the ground's warmth to heat buildings, but can also act as cooling systems by taking heat from the house and injecting it back into the ground. The installation of such systems can cut residential energy use by as much as 40 percent of total use. Even when ground temperatures are not warm enough to provide all of the heat for the building, ground source heat can raise the room temperature and reduce the base load on supplementary heating systems. GSHP systems require an electrical input to run the pumps that circulate the fluids, so while they provide cheap heat, they do it at an electrical cost. When designed and installed correctly, systems have a payback period of five to ten years and system life for in-home components is 25 years while ground loop life expectancy is over 50 years.

Ground source heat pumps melt snow and ice on sidewalks and runways at the Juneau Airport

Photo courtesy of JuneauEmpire.com

Of the types of geothermal energy available in Alaska, GSHP systems are the most easily implemented and over one million systems have been installed worldwide, including dozens of such systems in Alaska. Juneau has implemented several systems, one to heat the runways at the airport to melt ice, which displaces 29,500 gallons of fuel per year, and another to help heat the Dimond Park Aquatic Center.

Another method of employing GSHP systems combines them with solar thermal systems (see page 32). The GSHP system is used to pump solar thermal energy into the ground during the summer where it is stored. During the winter, when solar energy is not as available, the GSHP system is used to extract the stored heat for use as space heating. This method is being tested in the Alberta, Canada community of Drake Landing where ninety percent of home heating comes from stored solar thermal energy.

- ✓ Drake Landing Solar Community
  http://www.dlsc.ca

However, GSHP systems are limited in feasibility by the type of ground. Areas with permafrost, or where removing heat from the ground may cause permafrost heaving or growing, may not be appropriate for GSHP systems. Additionally, because installing heat pumps requires installing either vertical or horizontal pipe, which requires heavy machinery, communities without access to machine equipment may not find these systems financially feasible. Because heat pumps use electricity, the availability of low cost electricity makes them more feasible.

- ✓ For resources about GSHP, including suppliers and installers, see page 43-45

Regions of Best Implementation

Currently, geothermal electrical energy is not widely used in Alaska because of the limitations of the remote locations of the most notable "hot spots". There are four distinct regions that have great potential for high heat geothermal electricity production; 1) the interior regions running from east to west across the state starting in the Yukon Territory, 2) southeast Alaska, 3) the Wrangell Mountains northeast of Anchorage, and 4) the Ring of Fire chain of volcanoes starting at Mt. Spur and following the Aleutian Island chain. Throughout the rest of the state, low heat geothermal energy for GSHP systems, which uses only the constant temperature of the interior, is available, but may be complicated by the effect that ground heat pumping has on the permafrost layer.

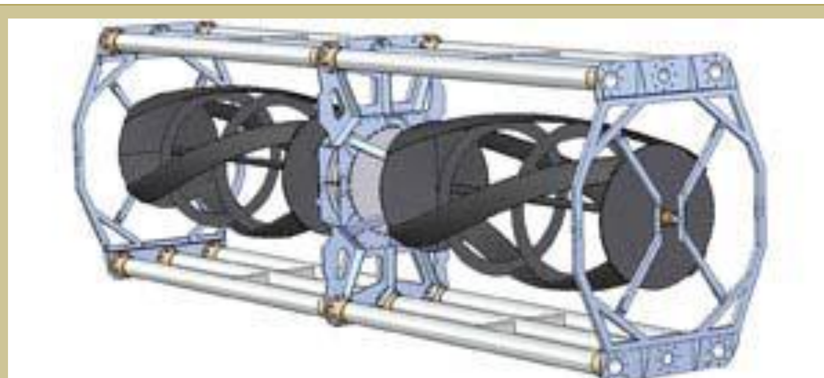
Geothermal fast facts:		
	Geothermal Electricity	**Ground Source Heat Pumps (GSHP)**
Viability	Region dependent	High – good way to reduce heating costs/fuel use
Type of energy	Electrical and heat	Heat
System size	Medium to large (industrial production to municipality)	Small to medium (for residential to industrial size projects)

HYDROKINETIC ENERGY: RIVERS AND TIDES

"First [Raven] let some water fall from his mouth and made the Nass. By and by he spit more out and made the Stikine. Next he spit out Taku River, then Chilkat, then Alsek, and all the other large rivers. The small drops that came out of his mouth made the small salmon creeks."

~Tlingit Creation Story

Hydrokinetic energy refers to any energy source that uses the movement of water to turn a turbine and produce electricity. Hydrokinetic energy can also include what it generally referred to as hydroelectric energy from medium to large scale dams, but because of the prohibitively high costs associated with implementing and operating large scale hydroelectric power plants for small scale community use, hydrokinetic will refer only to small scale in-stream turbines and tidal energy. With over 90 percent of the tidal hydrokinetic energy potential and 40 percent of in-stream hydrokinetic potential for the entire United States, energy from water is possibly the largest, mostly untapped, renewable energy source in Alaska.



Prototype hydrokinetic turbine design

Photo from the Alaska Center for Energy and Power report, "River, Tidal, and Ocean Current Hydrokinetic Energy Technologies: Status and Future Opportunities in Alaska".

Despite the enormous potential of hydrokinetic energy, primary limitations on immediate implementation of hydrokinetic turbines involve seasonal operating complications and insufficient design and technology to deal with them. Examples of operational complications include freezing and thawing ice that slows current speeds, reducing the energy output of a submerged turbine, and can freeze directly on turbines inhibiting their ability to produce electricity. Current research is also focused on designs that minimize negative impacts of floating and submerged debris in rivers that jam around turbines also impeding their efficiency or damaging the turbine.

Hydrokinetic energy shows a great deal of future promise as an energy source, similar to where wind technology was 15 years ago. If development continues at its current pace, hydrokinetic technology will approach a similar feasibility level as wind is now within the next 10 to 15 years.[9] Wind energy prices have dropped by as much as 80 percent in the last thirty years as technology, industry standardization, and design innovations improved efficiency. While still a pre commercial technology, hydrokinetic is a worthy option for potential future use as it undergoes further improvements.

- ✓ 2010 report by Alaska Center for Energy and Power on hydrokinetic technology and potential: http://www.uaf.edu/files/acep/2010_11_1_State_of_the_Art_Hydrokinetic_Final.pdf

Types of Hydrokinetic Projects

Hydrokinetic energy can be gained from any water source with sufficient water speed and volume to spin a turbine. Currently, the minimum speed for electrical generation is two to four knots (one to two meters per second), but optimal conditions for much of the available technology are those with current speeds of five to seven knots (1.5 to 3.5 meters per second). Though pilot projects for both in stream and tidal hydrokinetic energy have been implemented or assessed in several sites in Alaska, none are productively operating as of yet. An older type of river hydrokinetic technology involves diverting water through a pipe or channel and through a turbine and has been implemented for electricity production.

[9] Jerome B. Johnson and Dominique J. Pride, "River, Tidal, and Ocean Current Hydrokinetic Energy Technologies: Status and Future Opportunities in Alaska," Alaska Center for Energy and Power, November 1, 2010.

In-Stream Hydrokinetic

The first U.S. installed hydrokinetic project was a 5 kW device deployed in Ruby, Alaska in 2008 and again in 2009 and 2010. A similar 25 kW turbine was installed in the Yukon River in Eagle in 2010. However, both projects faced serious difficulties with debris carried by the river. Determining possible operation costs of hydrokinetic is difficult to assess due to the early stage of the technology. Statistics for three possible Alaska installations were estimated by the Electric Power Research Institute (EPRI) for Igiugig, Eagle, and Whitestone. The kWh price estimates for these projects ranged from $0.19 per kWh to $0.68 per kWh with the projected 590 kW installation at Whitestone, the largest of the three, being the cheapest per kWh.

Prototype in stream turbine deployed in the Yukon River

Photo from the Alaska Center for Energy and Power report, "River, Tidal, and Ocean Current Hydrokinetic Energy Technologies: Status and Future Opportunities in Alaska".

Different from in-stream turbines, run-of-the-river diverted water stream turbines have been employed for many years. They function by using the natural flow of a river or stream through a constructed channel to turn a turbine and produce electricity. Diverted water hydro systems are larger than in-stream systems requiring more infrastructure, which makes them more costly than in-stream turbines, but without requiring large dams as with traditional hydroelectric. The Gustavus Electric Company installed a diverted hydro system in 2006 for $10 million that provides the majority of their electrical needs and displaces approximately 126,000 gallons of fuel.

Tidal Flow Hydrokinetic

Similar to in-stream hydrokinetic, tidal energy technology is also still in the developmental phase, but with its own unique challenges.

Cost estimates for tidal energy are incomplete, but the Electric Power Research Institute (EPRI) conducted initial estimates for large scale implementations for the Knik Arm in Cook Inlet and in Yakutat. Installation estimates for these sites were significantly larger than those for in-stream hydrokinetic, ranging from 5,200 kW to 17,000 kW of installed capacity. These would cost between $48 million and $123 million to implement. Due to increased capacities, per kWh prices were much lower than in stream project estimates, ranging from $0.11 to $0.28.

Pelamis wave energy buoy off of Hawaii

Photo courtesy of theirEarth.com

Wave Energy

Separate from tidal energy, wave energy comes from capturing the movement of waves, caused by wind, across the surface of the ocean. The technology for capturing wave energy employs buoys that rise and fall with the waves and generate electricity from the movement. This technology has seen very little development in the United States. One 40 kW buoy has been installed in Hawaii for use by the Navy, but overall, wave energy is still in the early stages of design.

Regions of Best Implementation

Areas of best implementation are those with consistently high current speeds and adequate depth. The University of Alaska Anchorage (UAA) conducted a two year feasibility study, funded by the Alaska Energy Authority (AEA), of hydrokinetic turbines in 27 sites along the Yukon, Kuskokwim, Susitna, and Copper Rivers. Sites included Bethel, Lower Kalskag, Upper Kalskag, Aniak, Chuathbaluk, Napaimute, Galena, Koyukuk, Nulato, Kaltag, Grayling, Anvik, Holy Cross, Marshall, Pilot Station, St. Mary's, Mountain Village, Whitestone, Tanacross, Gakona, Copper Center, Chitina, Teller, Stony River, Sleetmute, Red Devil, and Crooked Creek. The study found that nearly all of the sites have sufficient current velocity for hydrokinetic installation, with the best sites furthest upstream because current is more rapid in those locations.

Hydrokinetic fast facts:

	Run-of-the-river diverted flow turbines	**In Stream Hydrokinetic**	**Tidal Flow and Wave Energy**
Viability	Region dependent (needs enough fall over the course of the channel to create the necessary current speed)	Not viable – more technological development needed (will be effective in approximately 10 to 15 years)	
Infrastructure Scale	Medium to large (primary energy source for city of Gustavus)	Small to medium (when research is complete)	small to Large

CONCLUSIONS AND FUNDING RESOURCES

"The Power of Wisdom will be with you and you will be amazed at the things you will see every step you make. You will become an expert person about the changed way of living. You will find different and new resources to bring to your people that they will use."

~Aungayoukuksuk (Inupiat Legend)

The planning of renewable energy and energy efficiency projects can be made smoother through sharing of ideas and lessons learned. Planning is only part of the process. Finding resources to fund renewable energy projects is equally as important. While identifying sources of funding is not the focus of this document, the following resources provide useful starting points.

The Indian Environmental General Assistance Program (GAP), through the Environmental Protection Agency (EPA), Tribal Trust and Assistance Unit (TTAU), is a resource for doing the planning, legal, administrative, and technical capacity development of a sustainable energy project. The GAP program can be a starting point for identifying resources, program planning and researching prospective funders. A list of funding opportunities is also available in the *Tribal Climate Change Funding Guide* developed by the TTAU in association with the University of Oregon.

- ✓ U.S. EPA Indian Environmental General Assistance Program
  http://yosemite.epa.gov/r10/tribal.nsf/grants/igap
- ✓ University of Oregon and EPA Tribal Climate Change Funding Guide
  http://tribalclimate.uoregon.edu/publications

The Alaska Energy Authority also plays a role in funding renewable energy projects through their *Emerging Energy Technology Fund*, *Renewable Energy Grant Fund*, *Power Project Loan Fund*, and the *Alaska Wood Energy Development Task Group* (AWEDTG) programs. Additionally, AEA offers training courses for power plant operators.

- ✓ AEA Emerging Energy Technology Fund
  http://www.akenergyauthority.org/EETFundGrantProgram.html
  Contact: Shawn Calfa – Grant Manager
  (907)771-3031
  scalfa@aidea.org
- ✓ AEA Renewable Energy Grant Fund
  http://www.akenergyauthority.org/RE_Fund-6.html
  Deadline: September 24, 2012
  Contact: Shawn Calfa
- ✓ AEA Power Project Loan Fund
  http://www.akenergyauthority.org/programsloan.html
  Contact: Mike Catsi – Business Development Officer
  (907)771-3060
  mcatsi@aidea.org
- ✓ AEA Alaska Wood Energy Development Task Group
  http://www.akenergyauthority.org/biomasswoodenergygrants.html
  Contact: Devany Plentovich – Biomass Project Manager
  (907)771-3068
  dplentovich@aidea.org
- ✓ AEA Training Programs
  http://www.akenergyauthority.org/programtraining.html
  Contact: Jessica Stolp – Training Programs Manager
  (907)771-3026
  jstolp@aidea.org

The Alaska Conservation Foundation (ACF) supports sustainability projects of many forms through the *Alaska Native Fund*, in association with the Alaska Native Steering Committee. Also, the Alaska Federation of Natives offers energy grants to support village projects. Finally, the U.S. Department of Energy offers the chance to apply for technical assistance from the National Renewable Energy Laboratory or Sandia National Laboratories staff.

- ✓ Alaska Conservation Foundation (ACF) Alaska Native Fund Webpage
  http://alaskaconservation.org/grant-opportunities/alaska-native-fund/
- ✓ Alaska Federation of Natives Energy Grants
  http://www.nativefederation.org/energy.php
- ✓ DOE Technical Assistance Application page
  http://apps1.eere.energy.gov/tribalenergy/tech_assistance.cfm

In addition to grant funding, tax credits and incentives are available for residential renewable energy and efficiency projects through the Federal ENERGY STAR Program for projects installed before December 31, 2016.

- ✓ Federal Energy Efficiency and Renewable Energy Tax Credits
  http://www.energystar.gov/index.cfm?c=tax_credits.tx_index

This is not a complete list, but it can at least offer a starting place for finding financial resources for renewable energy and efficiency projects. Finding where to start is one of the most difficult steps, and hopefully these resources can provide the first stepping stone in developing a successful project that will benefit your community.

RENEWABLE ENERGY RESOURCES

EPA disclaimers:

*The viewpoints presented in this document are those of a Greater Research Opportunity (GRO) Intern, Aiden Irish, during the summer of 2012 as he compiled and prioritized this information and do not reflect EPA recommendations or endorsements of any specific product or provider mentioned.

*Some projects listed in this resource guide could potentially have impacts to aquatic resources or land management. There are specific permitting requirements (Federal/State/local) that Tribes would want to inquire about prior to any implementation (that could impact the total cost of the project or site selection).

If other organizations are interested in being included on the resources list below please contact Adrienne Fleek, EPA Project Officer, at 907-271-6558 or fleek.adrienne@epa.gov

- ✓ Presentation version of this document http://prezi.com/tk2vfoht2taq/sustainable-energy-opportunities-best-practices-for-alaska-tribes
- ✓ The 7th Annual Chena Hot Springs Renewable Energy Fair
  August 26, 2012
  http://www.chenahotsprings.com/renewable-energy-fair/
- ✓ The Alaska Center for Energy and Power (ACEP)
  http://www.uaf.edu/acep/

- ✓ Alaska Conservation Foundation (ACF)
  http://alaskaconservation.org
- ✓ Alaska Energy Network
  http://www.akenergynetwork.com
- ✓ Alaska Federation of Natives (AFN)
  http://www.nativefederation.org
- ✓ Alaska Energy Authority Alternative Energy and Efficiency Programs
  http://www.akenergyauthority.org/programsalternative(2).html
- ✓ Alaska Energy Wiki (by the Alaska Center for Energy and Power):
  http://energy-alaska.wikidot.com/
- ✓ Alaska Housing Finance Corporation: Energy information
  http://www.ahfc.us/energy/energy.cfm
- ✓ Alaska's Institute of Technology (AVTEC)
  http://www.avtec.edu/
- ✓ Alaska Native Tribal Health Consortium (ANTHC)
  http://anthctoday.org/
- ✓ Alaska Village Electric Cooperative (AVEC)
  http://www.avec.org/
- ✓ Cold Climate Housing Research Center (CCHRC)
  http://www.cchrc.org/
- ✓ Department of Energy Free Tribal Webinar Series on Energy Self-Sufficiency
  http://www.repartners.org/ (for past webinars and to register for future courses)
- ✓ Department of Energy: Guide to Tribal Energy Development
  http://www1.eere.energy.gov/tribalenergy/guide/about.html
- ✓ Department of Energy – Office of Indian Energy (DOE-IE)
  http://energy.gov/indianenergy/resources/energy-resource-library
- ✓ GeoExchange GSHP supplier and installation
  http://www.geoexchange.org/findapro/index.php?option=com_content&Itemid=4&catid=5&id=223&view=article
- ✓ National Renewable Energy Laboratory (NREL)
  http://www.nrel.gov
- ✓ Renewable Energy Alaska Project (REAP)
  http://alaskarenewableenergy.org/
- ✓ Rural Alaska Community Action Program Inc. (RurAL CAP)
  http://www.ruralcap.com/
- ✓ Renewable Energy Science and Technology
  http://www.renewableenergyst.org/REST_Home.php

- ✓ Renewable Energy Science and Technology: Solar (provides site specific information on solar energy potential)
  http://www.renewableenergyst.org/solar.htm
- ✓ Sustainable Energy Courses: University of Alaska Fairbanks Bristol Bay Campus
  Contact: Chet Chambers
  cochambers@alaska.edu
  (907)842-5109
- ✓ U.S. Department of Energy (DOE)
  http://www.eere.energy.gov/
- ✓ Waste to Energy Canada (WTEC)
  wtecanada.com
- ✓ Yukon River Inter-Tribal Watershed Council
  http://www.yritwc.org

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"There's an intelligence inherent in us, that if we allow it, and we don't function simply from the head, will bring us more into alignment with creation."

~Larry Merculieff (Aleut)

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