Energy Plan Preparation

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APPENDICES

Additional appendices to be added containing annual community energy statistical updates.

STRATEGIC OBJECTIVES

The goal of the Strategic Energy Plan is improved regional energy security through strategic planning and an understanding of available energy options. This plan will address interim efforts to bridge the increasing burden of rising energy costs, and will detail future planning requirements to achieve regional long-term energy security and self-sufficiency. Strategic Objectives (SO) are:

- *SO 1* - Increased collaboration between Northwest Arctic stakeholders on energy policy, program, infrastructure, and increased capacity of tribal entities for the region.
- *SO2* - Improved understanding of energy options available to Northwest Arctic energy stakeholders for effective energy decision making.
- *SO3* - Increased awareness and understanding, on the part of external stakeholders, of the energy needs of the Northwest Arctic.

The purpose of this briefing is to address SO 3, the importance of educating policy makers and the donor community on the energy needs of the Northwest Arctic region. Energy security in Northwest Alaska will be achieved by a combination of infrastructure improvement and development of appropriate energy technologies in both traditional and renewable energy sectors. Finally, the approach is collaborative in nature and is supported by a variety of regional participants. This report represents and update for 2011.

ENERGY VISION

The vision of this plan is to be 75 percent reliant on regionally available energy resources for heating and generation purposes by the year 2030. It is our vision to decrease the need for transportation fuel imported into the region by 50% by the year 2020. As part of this plan, imported fossil fuels would remain available as emergency/back-up fuel only. Regionally available resources include renewables such as solar, wind, geothermal and biomass, as well as regionally available coal and natural gas resources. The focus of our energy vision is on regional resources. This regional reliance on local energy will be achieved incrementally:

- 25% decrease of imported fossil fuels by 2020
- 50% decrease of imported transportation fossil fuels by 2020
- 75% decrease of imported fossil fuels by 2030

PROCESS AND METHODOLOGY

The underlying premise of this energy plan is rooted in local Energy Options Analyses prepared by individual communities within the region. Through these analyses, all reasonable energy options available to a specific community were identified and assessed based on their technical and economic merits. The results of each community's energy options analyses are found in the appendices of this document.

The focus of this plan is on home heating and electric power generation options. While it is recognized that transportation fuels remain an substantial component of a household budget, the development of appropriate solutions for air travel and inter-community travel are beyond the scope of this analysis[1]. This plan is based upon the priorities identified with the energy options analyses. This information was supplemented through key informant interviews with steering committee members and others knowledgeable on the region's energy crisis.[2]

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[1] However, in places such as Kotzebue and perhaps taxi travel between the airport and community could be accomplished through electric vehicles.

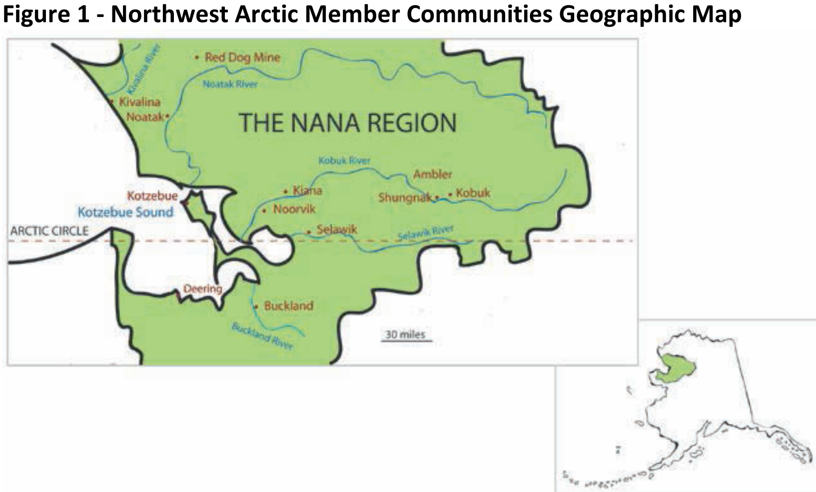
[2] See appendices for additional information and documentation.

Each of the following community initiatives includes a budget estimate. It is expected that these financial investments will be secured from a variety of public and private entities, including transportation infrastructure development, energy, policy, and social services funding programs. Furthermore, the timeframe is generalized to identify short, medium and long term initiatives. Finally, through regional coordination, including the NW Arctic Leadership Team, roles and responsibilities will be identified and assigned.

REGIONAL ENERGY "PROBLEM STATEMENT"

Straddling the Arctic Circle on the Chukchi Sea, the Northwest Alaska Native Association (NANA) region constitutes the boundaries of the Northwest Arctic Borough (NWAB). The region's total population is estimated to be roughly 7,600 people, of which 75% are of Inupiat Eskimo decent. Eleven (11) individual communities are located within the region and each is represented by an Indian Reorganization Act (IRA) federally recognized tribal council. Subsistence activities such as hunting caribou, moose and seals, as well as fishing, remain an integral part of the regional lifestyle.

Figure 1 - Northwest Arctic Member Communities Geographic Map



The regional Strategic Energy Plan (SEP) and its goals and desired outcomes will promote Inupiat Values, "knowledge sharing" methodology, responsibility to the tribe, energy efficiency, promotion of renewable energy, and self-determination through participatory planning. The high cost of energy in Northwest Alaska is one of the leading threats to the long term sustainability and well-being of the region.

The SEP will also assist individual member communities in achieving the long-term goals of utility solvency, energy efficiency and reduced energy related costs. Arguably one of the most remote regions in the U.S., NANA's villages have access to neither roads nor a power grid. Diesel fuel is the primary source of energy for heat and power generation in the region. Total annual (non-transportation) energy consumption by communities in Northwest Alaska is estimated to be 5.3 million gallons in diesel fuel or equivalent, not including the operations of the Red Dog Mine and port. The majority (53%) of this energy consumed in Northwest Alaska is in the form of heating fuel. For the purposes of this SEP, overall community energy use is assumed to remain relatively flat in the years ahead, with at most a 2% annual increase (largely due to population).

Diesel and Heating Fuel

An estimated 2.7 million gallons of heating oil (diesel) is used region-wide annually (Figure 2 and Table 1 below). In several communities located near forest land, wood heat is also used, equivalent to about 124,000 gallons of heating oil annually. . While fuel consumption rates have remained relatively stable, the escalating price of imported fuels has dramatically increased overall energy costs for Northwest Alaska communities.

Figure 2 - Annual Heating Fuel Consumption in Northwest Alaska

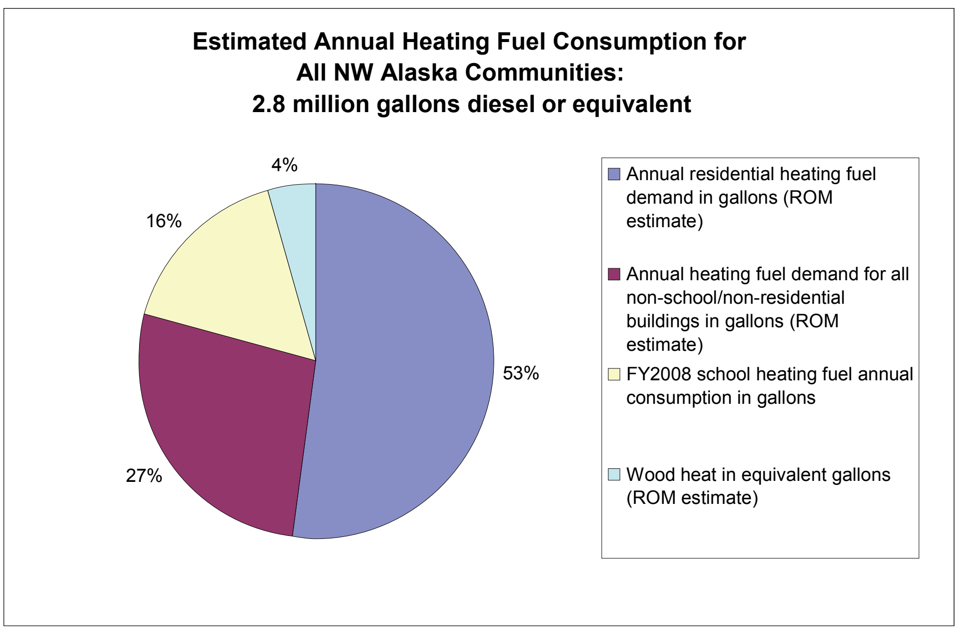


Table 1 - Estimated Annual Fuel Consumption by Community

Community:	FY2007 annual fuel consumption for power generation in gallons[3]	# of occupied households (2000 census)	Annual residential heating fuel demand in gallons (ROM estimate)[4]	Annual heating fuel demand for all non-school/non-residential buildings in gallons (ROM estimate)[5]	FY2008 school heating fuel annual consumption in gallons[6]	Wood heat in equivalent gallons (ROM estimate)[7]	Total heating fuel consumption by community in gallons or equivalent (ROM estimate)	Total fuel consumption by community in gallons or equivalent (ROM estimate)
Kotzebue	1,455,277	889	755,650	500,000	140,160		1,395,810	2,851,976
Ambler	100,053	79	55,300	22,000	26,604	40,000	143,904	244,036
Buckland	109,943	84	71,400	25,200	35,016		131,616	241,643
Deering	62,878	42	35,700	12,600	15,744		64,044	126,964
Kiana	103,820	97	67,900	29,100	46,464	35,000	178,464	282,381
Kivalina	93,795	78	66,300	23,400	28,872		118,572	212,445
Kobuk	-	26	18,200	10,000	8,736	14,000	50,936	50,962
Noatak	112,458	100	85,000	30,000	30,720		145,720	258,278
Noorvik	149,669	136	115,600	40,800	48,168		204,568	354,373
Selawik	209,058	172	146,200	51,600	58,584		256,384	465,614
Shungnak	109,965	56	39,200	17,000	22,140	35,000	113,340	223,361
Total:	2,506,916		1,456,450	761,700	461,208	124,000	2,803,358	5,310,274

[3] FY2007 PCE report (Alaska Energy Authority), Kotzebue Electric Association

[4] Rough Order of Magnitude (ROM) annual residential heating fuel demand is based on the multiplying the number of occupied households (according to 2000 U.S. Census) by 850 gallons/year, except for communities with wood heat: 700 gallons/year

[5] ROM annual public/commercial building heating demand estimated from Maniilaq Association figures on Ambler, Shungnak and Kobuk, extrapolated to other communities based on population

[6] Northwest Arctic Borough School District

[7] Wood heat in equivalent gallons based on 1981 *Shungnak, Kiana and Ambler Reconnaissance Study of Energy Requirements and Alternatives*, by Wind Systems, Inc. for the Alaska Power Authority.

Table 1 - Estimated Annual Fuel Consumption by Community

Community:	FY2009 annual fuel consumption for power generation in gallons[8]	# of occupied households (2010 Count) A indicate Grid connected as of 2009.	Annual residential heating fuel demand in gallons (ROM estimate)[9]	Annual heating fuel demand for all non-school/non-residential buildings in gallons (ROM estimate)[10]	FY2010 school heating fuel annual consumption in gallons[11]	Wood heat in equivalent gallons (ROM estimate)[12]	Total heating fuel consumption by community in gallons or equivalent (ROM estimate)	Total fuel consumption by community in gallons or equivalent (ROM estimate)
Kotzebue	1,430,483	975, 1350A,	755,650	500,000				
Ambler	90,941	69, 83A	55,300	22,000		40,000		
Buckland	109,943	90A	71,400	25,200				
Deering	55,145	42A	35,700	12,600				
Kiana	128,931	129A	67,900	29,100		35,000		
Kivalina	98,423	85A	66,300	23,400				
Kobuk	-	32, 31A	18,200	10,000		14,000		
Noatak	141,480	111A,	85,000	30,000				
Noorvik	176,711	155A,	115,600	40,800				
Selawik	229,070	194,184A,	146,200	51,600				
Shungnak	108,121	65, 59A	39,200	17,000		35,000		
Total:	2,506,916	1947,2319A	1,456,450	761,700		124,000		

8 FY2009 PCE report (Alaska Energy Authority), Kotzebue Electric Association

9 Rough Order of Magnitude (ROM) annual residential heating fuel demand is based on the multiplying the number of occupied households (according to 2000 U.S. Census) by 850 gallons/year, except for communities with wood heat: 700 gallons/year

10 ROM annual public/commercial building heating demand estimated from Maniilaq Association figures on Ambler, Shungnak and Kobuk, extrapolated to other communities based on population

11 Northwest Arctic Borough School District

12 Wood heat in equivalent gallons based on 1981 *Shungnak, Kiana and Ambler Reconnaissance Study of Energy Requirements and Alternatives*, by Wind Systems, Inc. for the Alaska Power Authority.

Energy Production: Ninety-seven percent of the total electricity production for all communities in Northwest Alaska comes from diesel fuel (See Table 2 and Figure 3, below).

Table 2 - Power Generation Comparison

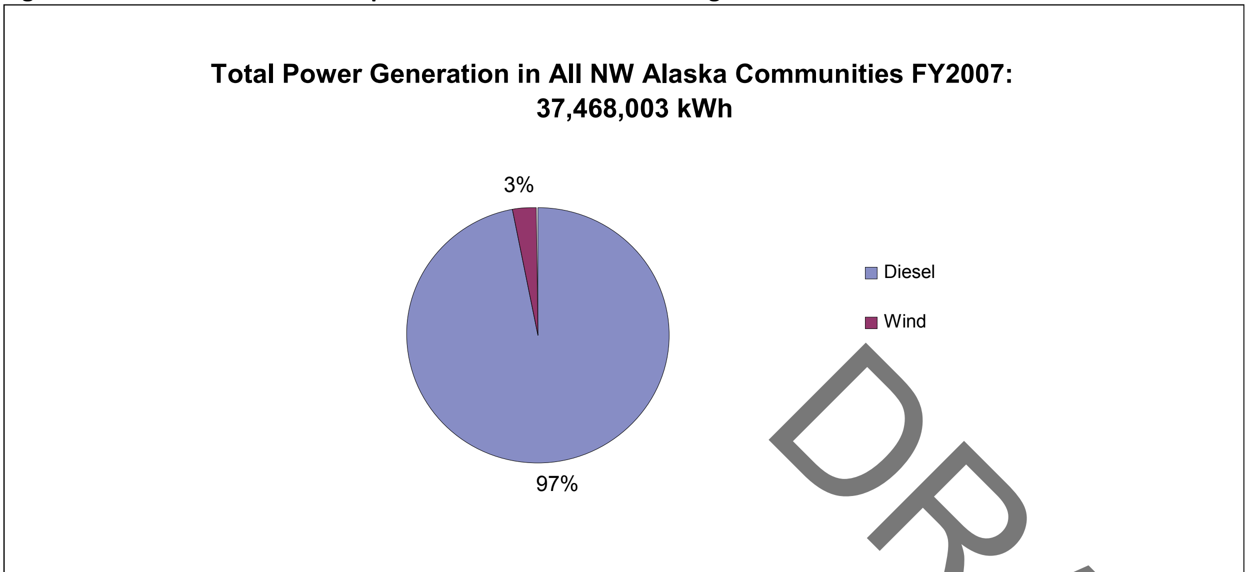
Community	FY 2006 Diesel (kWh)	FY 2007 Diesel (kWh)	FY 2006 Wind (kWh)	FY 2006 % Wind	FY 2007 Wind (kWh)	FY2007 % Wind	FY 2006 Total Generation	FY 2007 Total Generation
Kotzebue	22,524,973	21,807,319	787,794	3.38%	1,064,242	4.65%	23,330,767	22,871,561
Ambler	1,293,905	1,363,646					1,293,905	1,363,646
Buckland	1,497,970	1,518,027					1,497,970	1,518,027
Deering	661,760	709,559					661,760	709,559
Kiana	1,519,107	1,529,950					1,519,107	1,529,950
Kivalina	1,215,636	1,307,779					1,215,636	1,307,779
Noatak	1,488,500	1,492,730					1,488,500	1,492,730
Noorvik	1,951,017	1,991,566					1,951,017	1,991,566
Selawik	2,757,588	2,945,834	109,157	3.81%	184,918	5.91%	2,866.745	3,130,752
Shungnak-Kobuk	1,506,432	1,552,433					1,506,432	1,552,433
Total	36,434,888	36,218,843	896,951	2.40%	1,249,160	3.33%	37,331,839	37,468,003

Sources: FY2007 and FY2006 PCE report (Alaska Energy Authority), Kotzebue Electric Association

Community	FY 2008 Diesel (kWh)	FY 2009 Diesel (kWh)	FY 2008 Wind (kWh)	FY 2008 % Wind	FY 2009 Wind (kWh)	FY2009 % Wind	FY 2008 Total Generation	FY 2009 Total Generation
Kotzebue	20,915,914	20,962,858	874.900	4.18%	1,054,480	4.79%	21,790,814	22,017,338
Ambler	1,321,573	1,245,599					1,321,573	1,245,599
Buckland	1,545,961	1,518,027					1,545,961	1,518,027
Deering	668,630	711,319					668,630	711,319
Kiana	1,687,222	1,663,716					1,687,222	1,663,716
Kivalina	1,252,110	1,253,855					1,252,110	1,253,855
Noatak	1,771,796	1,948,974					1,771,796	1,948,974
Noorvik	2,031,037	2,067,727					2,031,037	2,067,727
Selawik	2,802,375	3,031,333	108,010	3.85%	263,116	7.99%	2,910,385	3,294,449
Shungnak-Kobuk	1,483,862	1,477,747					1,483,862	1,477,747
Total	36,736,894	35,881,155	983,851	2.68%	1,317,596	3.67%	36,463,390	37,198751

Sources: FY2008 and FY2009 PCE report (Alaska Energy Authority), Kotzebue Electric Association

Figure 3 - Power Generation Comparison in Northwest Arctic Region



Cost of Fuel

As a result of complex and lengthy logistics and the need for on-site fuel storage, retail fuel costs are exceedingly high. The region experiences some of the highest electricity prices in the nation, as shown below in Table 3. Recent increases in the price of oil have had a direct impact in the cost of heating and power generation with diesel fuel, especially in rural Alaska communities.

The impacts of increasing fuel costs within the region are magnified by unique regional conditions such as limited logistical options for bulk fuel shipping, the poor economies of scale in fuel transportation, power generation and distribution, and possible reduction and/or elimination of Alaska's Power Cost Equalization (PCE) program and the State-Municipal Sharing programs. Summer water levels along the Noatak River and the upper stretches of the Kobuk River have been insufficient to allow for annual delivery of fuel by barge. As a result, fuel is often shipped into the communities of Noatak, Ambler, Shungnak and Kobuk by airplane, greatly increasing energy delivery costs. As shown in Table 3 below, these four communities consequently have the highest fuel costs in the region.

Table 3 - Fuel and power costs in the Northwest Arctic Borough

Community	Reported June/July 2008 price of gasoline (per gallon)	Reported June/July 2008 price of diesel/#2 heating oil (per gallon)	Average FY2007 price of diesel for power generation (per gallon)[13]	Average FY2007 pre-PCE residential electric rate (per kWh)[14]
Kotzebue	$ 5.50	$ 4.28	$ 2.27	$ 0.3850
Ambler	8.18	5.78	3.96	0.5349
Buckland	5.71	9.77	2.51	0.4036
Deering	5.17	3.95	3.11	0.4900
Kiana	7.02	6.45	2.72	0.5103
Kivalina	5.29	4.85	2.48	0.5116
Kobuk	7.25	7.06	-	0.5300
Noatak	9.44	8.13	4.48	0.7118
Noorvik	4.90	5.00	2.46	0.5271
Selawik	5.19	4.61	2.48	0.5062
Shungnak	7.69	6.50	3.37	0.6113

[1] Statistical Report of the Power Cost Equalization Program for Fiscal Year 2007, Alaska Energy Authority
[1] Ibid.

Community	Reported June/July 2009 price of gasoline (per gallon)	Reported June/July 2009 price of diesel/#2 heating oil (per gallon)	Average FY2008 price of diesel for power generation (per gallon)[15]	Average FY2008 pre-PCE residential electric rate (per kWh) [16]
Kotzebue	$ 5.50	$ 4.28	$ 2.61	$ 0.3605
Ambler	8.95	9.50	6.27	0.8259
Buckland	7.00	7.00	3.09	0.4000
Deering	7.52	7.75	3.20	0.6215
Kiana	7.00	6.45	3.04	0.5413
Kivalina	7.00	6.45	3.13	0.5368
Kobuk	8.25	7.00	-	0.5300
Noatak	10.79	9.79	5.75	0.7572
Noorvik	7.30	7.22	2.98	0.5333
Selawik	6.10	6.60	3.14	0.5114
Shungnak	7.99	9.99	5.31	0.7364

[1] Statistical Report of the Power Cost Equalization Program for Fiscal Year 2008, Alaska Energy Authority
[1] Ibid.

Community	Reported June/July 2010 price of gasoline (per gallon)	Reported June/July 2010 price of diesel/#2 heating oil (per gallon)	Average FY2009 price of diesel for power generation (per gallon)[17]	Average FY2010 pre-PCE residential electric rate (per kWh) [18]
Kotzebue	$ 6.73	$ 6.75	3.60	
Ambler	8.95	9.50	4.29	
Buckland	6.55	6.75	6.99	
Deering	5.55	5.05	4.59	
Kiana	6.50	6.00	4.92	
Kivalina	5.49	5.49	4.76	
Kobuk	8.25	7.00	-	
Noatak	8.99	8.99	6.44	
Noorvik	7.55	6.27	4.90	
Selawik	6.10	6.60	4.94	
Shungnak	8.49	6.99	5.35	

[1] Statistical Report of the Power Cost Equalization Program for Fiscal Year 2009, Alaska Energy Authority
[1] Ibid.

Additional info 2010

ULSD (Ultra Low Sulfur Diesel) & Propane cost

Delivery by	ULSD Bulk	ULSD Drum/G @ 55G	Propane 100Lb		
Crowley FOB Kotzebue	--	7.66	163.63		
Brooks Fuel FOB Up River Kobuk	6.80	7.30	185.00		

Propane usage Region wide as of 2010

Approximately 350 households in the region currently use propane, primarily for cooking. According to Crowley and Brooks, the total amount of propane sold in 2010 was approximately 35,000 Gallons. In addition to the increasing cost of petroleum and other fossil fuels, the burning of these hydrocarbon fuels results in air pollution and an increased risk of fuel spills during transportation and storage. Community members are becoming increasingly aware of the effects of greenhouse gases on climate change and the resulting coastal erosion along the Chukchi Sea. The goal of reducing greenhouse gas emissions from the region's communities should be integrated into the regional energy planning process.

The Northwest Arctic Strategic Energy Plan

Since the mid-1990s, Northwest Alaska has been a leader in promoting and developing renewable energy resources with the Kotzebue wind/diesel hybrid system. There is much wind energy potential throughout the region, and other known energy resources include geothermal, small-scale hydropower, and a substantial biomass potential in the upper Kobuk River area. Finally, there are stranded natural gas sources, which could prove to be economically viable energy resources. Long-term strategies may include incremental reduction of diesel fuel shipments and gradual implementation of alternative energy sources. However, for the short to medium-term, efficient use of diesel fuel will remain an energy planning priority for the region.

Previous energy resource studies and energy planning efforts within the region have targeted specific resources (e.g. wind) or have been completed for privately funded projects. The need to coordinate energy work and synthesize findings is of paramount importance. The integration of multiple energy sources, combined with strategies to conserve energy and promote end-use energy efficiency, is essential for regional energy security and economic wellbeing. With proper planning, a synergy can be developed between different energy sources and uses, with the composition of the optimal 'energy-mix' custom-tailored for each community. The SEP will be used to guide energy decision making in the following manner:

- *Investment* - If a particular energy source is identified as economically viable, NRC and/or steering committee members could make capital investment decisions based upon the outcomes of the planning and analysis. Private industry and mining interests could be guided by the analysis and invest accordingly.
- *Planning* - Results of the SEP could be used for planning of critical power generation and heating infrastructure. There will be a prioritization process undertaken that identifies energy needs. Two

steering committee members have been actively involved in energy infrastructure development for the region.

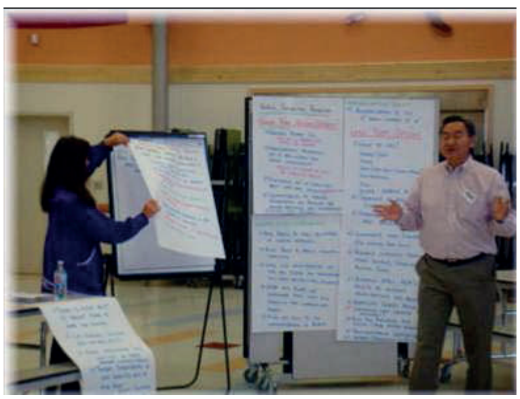
- *Advocacy* - NRC and the steering committee will also use the outcomes of the SEP to advocate various agencies for energy and energy efficiency investments in the region.

COMMUNITY SURVEYS

As part of the Energy Planning process, NRC coordinated a community-based survey of energy knowledge, attitudes, and practice (KAP Study). Results of the survey are described below.

Community Views of Energy Alternatives in Northwest Arctic Alaska

This section summarizes the results of community surveys designed to assess Northwest Arctic residents' opinions on energy options. The results of the survey were presented at the North West Arctic Regional Energy Summit on July 29, 2008. Since that presentation, additional communities have participated in the study.



The Purpose and Use of the Community Survey

The overall purpose of the survey was to assess Northwest Arctic residents' opinions of various regional energy options. Specifically, the survey was expected to:

- Explore short-term (immediate) and long-term (3 years or more) energy solutions.
- Document preferences among communities.
- Contribute to the Northwest Alaska Regional Energy Plan.
- Help support grant applications.
- Ensure consistency of public opinion data.
- Integrate perceptions of energy options for all NW Alaska communities at the Energy Summit.

Survey Development

This survey began with an examination of the common factors influencing energy decisions in other northern communities. A working paper was prepared by the survey team and submitted to NANA Development in December 2007. A draft survey was developed in January 2008, and pretested in Deering. The results of the pretest led to modifications in the survey.

The revised survey was reviewed with the NANA Resource Technicians in Kotzebue in February 2008. Additional revisions were made prior to distribution of the survey to participating communities.

Slow survey implementation resulted in the review and revision of the survey by the research team and advisory group in June 2008. The revised survey instrument had greater relevance to energy issues in the Northwest Arctic. The survey was administered to eight communities by July 2008. Following the presentation of results at the Northwest Arctic Regional Energy Summit, additional communities have participated in the study and this report includes all 10 communities in the Northwest Arctic Borough.

Survey Administration

The final survey instrument is provided in Attachment 1. The survey was administered by resource technicians under the supervision of the survey team. Participants were selected using a convenience sampling method between June and August, 2008. Survey data was entered by staff at the Northwest Arctic Borough, and then forwarded to the survey team for editing. Statistical analysis was completed using SPSS software.

Community Participation

Table 4 shows the participation of communities within the Northwest Arctic Borough. There were 166 surveys completed, representing 804 individuals. Forty Elders participated in the survey, representing 30.3% of all household surveys received.

Table 4 - Community Participation

Community	Households Responding	Percent of Surveys Completed
Ambler	20	12.0
Buckland	17	10.2
Deering	13.	7.8
Kiana	22	13.3
Kivalina	15	9.0
Kobuk	9	5.4
Noatak	28	16.2
Noorvik	10	6.0
Selawik	13	7.8
Shungnak	19	11.2
Total	166	

Short Term Energy Solutions

The survey first examined issues surrounding current energy use. The objective was to explore ways of providing immediate relief to communities. This section examined current home heating methods used by Northwest Arctic households, the use of electricity, options for improving home energy efficiency and the impact of increased fuel prices on transportation, including subsistence activities.

A Description of Respondent Housing

One of the principal objectives of the study was to find ways of providing efficient heating and lighting for people living in the region. Therefore, the first question that must be asked is "In what kind of houses do people in the Northwest Arctic Borough live?"

The survey found that the average family consisted of five people (4.99). The largest household participating in the survey had 15 people living in the same home. The average household had three bedrooms. On average, homes are approximately 25 years old and were built in 1983. The oldest home was built in 1930. Almost 63% (62.7%) are HUD homes, mostly built in the early 1980s.

Home Heating Sources

Figure 4 shows that almost half (47.8%) of all homes used more than one energy source for heating their homes. Figure 5 indicates that many households use wood to heat their homes, especially during the day throughout cold winters.

Figure 4 - Number of Heat Sources

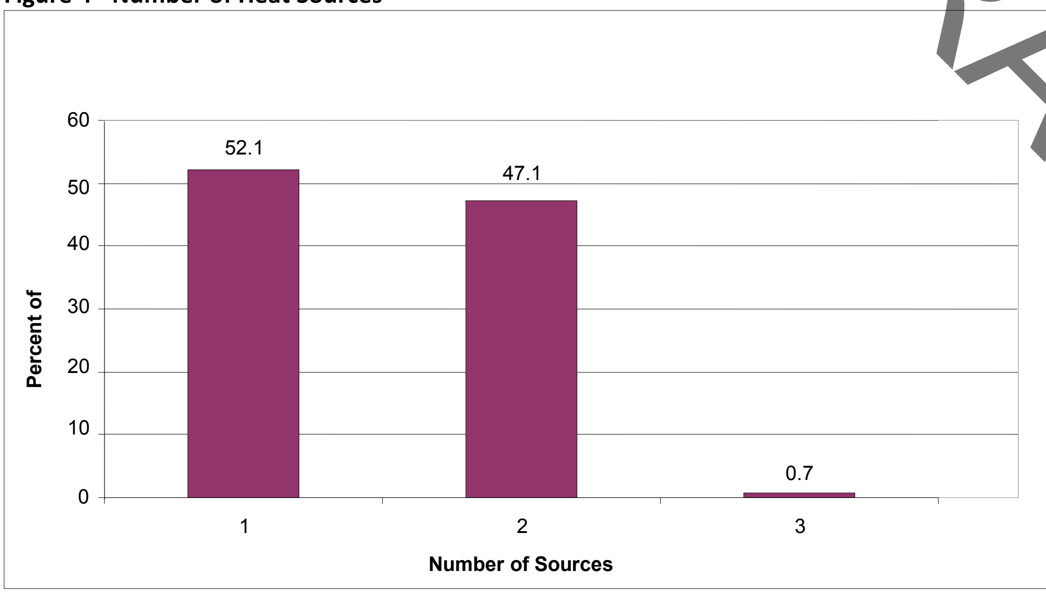
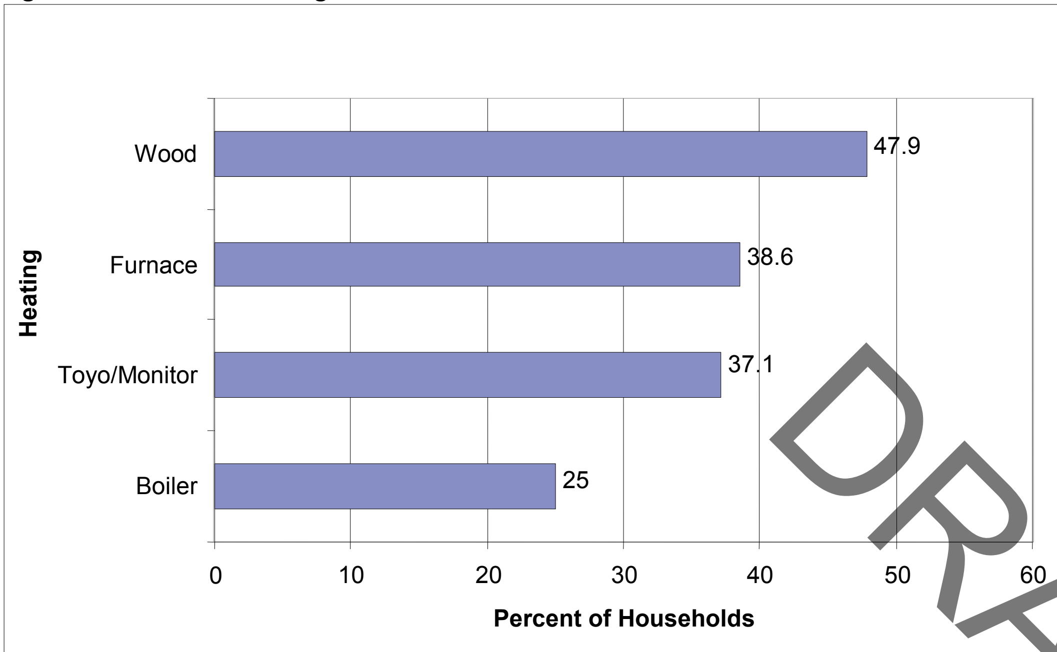


Figure 5 - Residential Heating Methods



Household Energy Expenditures

Table 5 shows the amount of money that households in the north Northwest Arctic spend on energy. The average amount, the middle (50^{th} percentile or median), and the highest cost are shown in the table below. The median cost of gasoline is seven dollars per gallon. Stove oil is approximately five dollars per gallon, for a median monthly expenditure of $530. The cost of wood as an energy source is extremely variable with a mean of $120 per month and a maximum of $500 per month. Electricity costs approximately $258 per month.

Table 5 - Monthly Household Energy Expenditures- 2008 data

Energy Source	Average	Middle	High
Gasoline (per gallon)	$6.69	$7.00	$9.97
Stove oil (per gallon)	$6.16	$5.00	$9.96
Stove oil used (gal/winter month)	129	106	600
Total stove oil cost ($/winter month)	$794.64	$530.00	$5,976
Wood (per month)	$137.04	$120	$500.00
Electricity (per month)	$298.06	$258.00	$900.00

Energy Costs by Community

Energy costs reported by survey respondents vary from community to community. The average cost per gallon of gasoline and stove oil, and the average monthly electric bill are shown in Table 6 below. Gasoline prices are highest in Noatak, while the price of stove oil is highest in Buckland. The cost of electricity appears to be highest in Noorvik. The energy costs shown below are based on data collected in June and

July of 2008. As prices continue to rise, the data below will be less useful in measuring energy costs in each community.

Table 6 - Energy Costs by Community (2008 data)

	Cost of gasoline per gallon		Cost of stove oil per gallon		Monthly electric bill	
Community	**Average**	**Middle**	**Average**	**Middle**	**Average**	**Middle**
Ambler	$8.18	$8.24	$5.78	$4.62	$347.85	$305.00
Buckland	$5.71	$5.75	$9.77	$9.79	$187.00	$200.00
Deering	$5.17	$5.15	$3.95	$3.86	$292.54	$230.00
Kiana	$7.02	$7.00	$6.45	$6.45	$264.77	$241.00
Kivalina	$5.29	$5.25	$4.85	$4.85	$291.54	$250.00
Kobuk	$7.25	$7.25	$7.06	$7.00	$215.00	$200.00
Noatak	$9.44	$9.29	$8.13	$7.95	$406.73	$430.00
Noorvik	$4.90	$4.90	$5.00	$5.00	$418.00	$310.00
Selawik	$5.19	$5.19	$4.61	$4.61	$209.75	$155.00
Shungnak	$	$	$5.23	$4.79	$	$

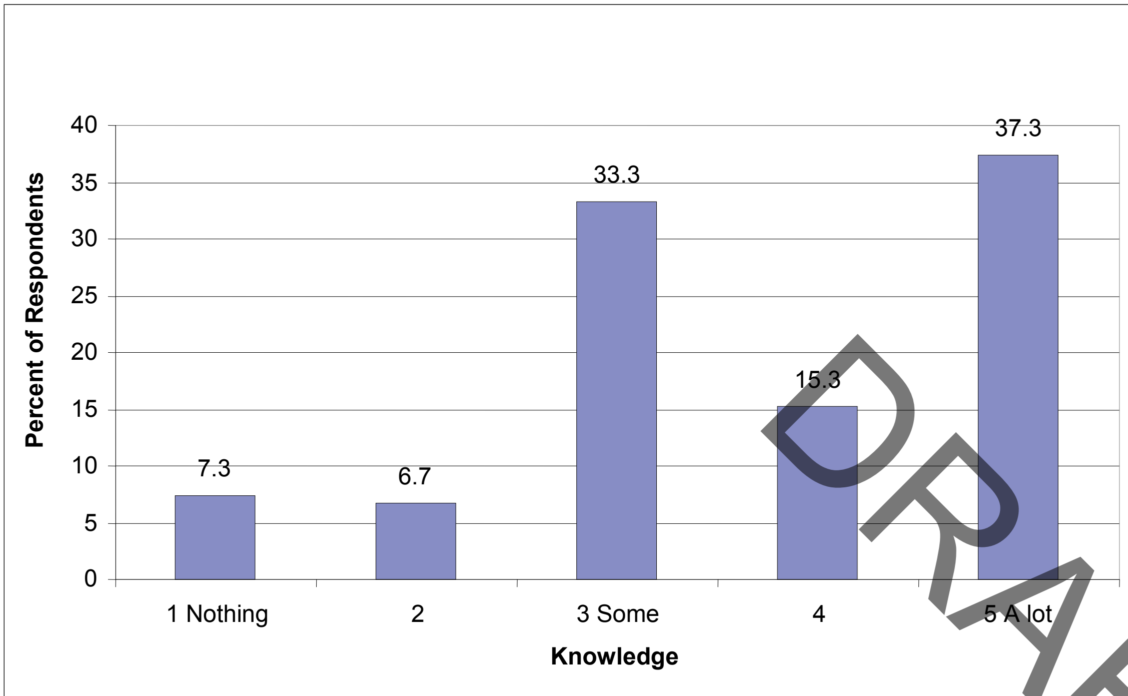
Improving Energy Efficiency

Respondents were asked how they could reduce the amount of energy used to heat and light their homes. Almost three quarters (73.8%) suggested that they could reduce electricity use by turning off or unplugging lights and appliances. Over 11% (11.5%) said they should just use less energy, while over half (50.9%) thought they could reduce energy by using more energy efficient appliances.

People were also asked about ways that they could reduce their use of stove oil. Almost 40% (39.4%) thought they could accomplish this by supplementing their stove oil home heating systems with wood heat. Over one quarter of the respondents (26.8%) suggested that they could reduce the amount of stove oil that they used by lowering the temperature of their homes.

Survey results indicate that Northwest Arctic households would benefit from additional information on energy efficient techniques. As illustrated by Figure 6, just over one half of the respondents knew “a lot” about energy efficiency. The remaining 47% of households had no knowledge or just some knowledge of energy efficiency. An expanded educational program may be valuable in helping households reduce energy costs.

Figure 6 - How much do you know about energy efficiency?



The Energy Requirements of Transportation

Almost all respondents (95%) were familiar with the impact of increased energy prices on transportation. Eight out of 10 respondents said that escalating fuel costs limited their subsistence activities and reduced travel to other communities. Almost three quarters of the respondents (73.6%) reported that rising fuel costs impacted the amount of time that they spent in camp.

Long-term Energy Solutions

As noted previously, the advisory group decided to separate discussions regarding short-term energy issues and long-term energy solutions. Long-term solutions were defined as those that could take three or more years to develop. The proposed long-term solutions are listed below together with a brief definition of each alternative energy source or distribution mechanism.

- *Combined Heat and Power System /Recovered Heat*- Waste heat recovery as a potential source of economic benefits for the community is a potential end-use for the heat for facilities in close proximity to the energy source. A potential use of the cogeneration heat is to keep washeterias warm and maintain hot water.
- *Wind Energy Systems* - Many parts of the Northwest Arctic Borough have enough wind to make wind power generation a feasible option. Communities would continue to use their diesel generators, but supplement them with wind-generated power from wind turbines.
- *Hydroelectric* - Some communities are located near rivers or coastal waters with hydroelectric generation potential. Typically, this requires the construction of dams or other means of harnessing water power. These structures take time to design and build. Minimal power would be generated from December through April,. Hydroelectric power would include certain inherent environmental constraints, such as the presence of whitefish and arctic grayling in the stream.

- *Solar* - While solar is not widely used in Alaska, it does remain an option for power generation and home heating. Solar power generation requires the installation of panels that collect the rays of the sun and turn it into electricity or heat that can be used in homes. Energy collected while the sun is bright must be stored for use during dark periods.
- *Geothermal* - The earth is a potential source of heat. In the Northwest Arctic Borough, the known sources of geothermal energy are hot springs.
- *Electric Interties / Transmission Lines* - Communities that are located within reasonable proximity of each other be able to share a common power source. These interties may also link mines and local communities.
- *District Heating Systems* - District heat is a distribution system in which buildings within a community share a common heat source. The heat can be produced in a variety of ways (diesel, geothermal, biomass, etc.).
- *Natural Gas* - There may be sources in the ground near communities that could be tapped and used as a fuel source. For example, in Barrow, the community taps into the local gas deposits and distributes the fuel to the community for heat and electricity.

Respondents were asked how much they knew about these systems, whether they would oppose or support the development of the systems, their impact on the environment, future economic development, the future of the community and the impact on traditional and subsistence activities. Of all of these variables, the strength of a respondent's opposition or support was most closely tied to their decision to pursue the alternative energy source or distribution system. Therefore an analysis of the support or opposition was used to assess regional opinions about alternative energy sources.

Regional Energy Sources and Distribution Systems Preferences

Table 7 shows the average score (1 = strongly opposed and 5 = strongly support) and regional rank of the proposed energy sources and distribution systems. Regional respondents preferred renewable nonpolluting wind and solar energy.

Table 7 - Regional Ranking of Energy Sources and Distribution Systems

Alternative Energy Source	Average Score	Rank
Combined heat and power systems	3.67	3
Wind energy systems	4.13	1
Hydroelectric energy	2.91	7
Solar energy	3.70	2
Geothermal energy	3.17	5
Interties and timelines	2.95	6
District energy distribution systems	2.94	8
Natural gas	3.27	4

Community Energy Sources and Distribution Systems Preferences

Community energy preferences were analyzed using the same method described above. In many cases, community preferences were markedly different than the regional preferences. For example, Kobuk rated interties as its first energy preference. This probably reflects extensive community discussions about interties with the community of Shugnak and an adjacent mine. The preference for geothermal power in Ambler, Buckland and Deering reflect a growing community awareness of the availability of nearby geothermal energy.

Table 8 - Community Energy and Distribution Systems Preferences

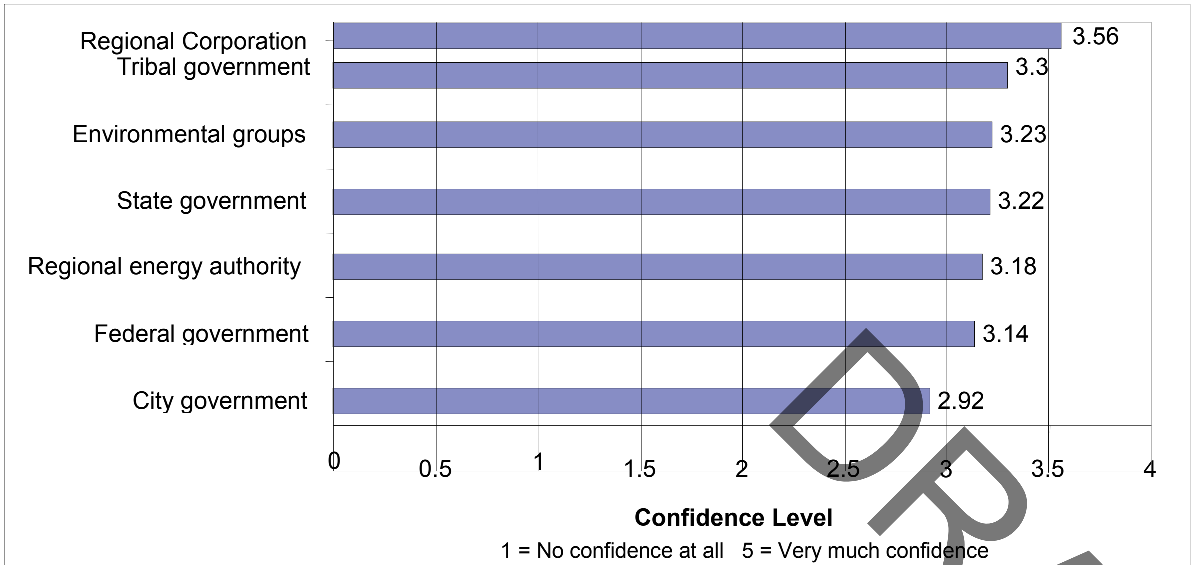
	Energy Preference		
Community	**First Choice**	**Second Choice**	**Third Choice**
Ambler	Wind	Combined heat and power/Natural gas	Geothermal
Buckland	Combined heat and power	Wind	Geothermal
Deering	Wind	Combined heat and power	Geothermal
Kiana	Wind	Combined heat and power	Solar
Kivalina	Wind	Natural gas/ Combined heat and power	Solar
Kobuk	Interties	Wind	Solar
Noatak	Wind	Combined heat and power	Interties/ Natural gas
Noorvik	Wind	Combined heat and power	Solar
Selawik	Wind/Natural gas	Hydroelectricity/ Combined heat and power	Hydroelectricity
Shungnak	Wind	Solar	Combined heat and power

THE MANAGEMENT OF ENERGY PROJECTS AND INITIATIVES

Short-term and long-term energy solutions require extensive management support. Short-term solutions, including the management of fuel supplies such as gasoline, stove oil and biofuel production, require the involvement of units of government, as do educational or weatherization programs aimed at improving household energy efficiency. Long-term solutions typically involve major publicly funded infrastructure development to locate and develop alternative fuel supplies or energy sources, and convert them to usable household energy.

A unit of government must be selected to help manage these complex projects. Figure 7 shows respondents' confidence in the ability of various entities to assume management or oversight responsibility for these projects. The data suggests that respondents would have the highest confidence in the regional Corporation. They appeared to have the least confidence in local city governments to manage these large and complex projects. The outcomes suggest that there is generally a positive rapport with the various regional organizations.

Figure 7 - Confidence in Various Regional Organizations



REGIONAL ENERGY PLAN-

In July of 2008, a regional energy summit was organized by NANA Regional Corporation in Kotzebue. This involved over 250 people from all communities in the region. A strong delegation from each community was present to discuss the regional energy concerns. Break-out sessions were organized by community and sub-region to discuss alternatives and identify. The communities' preferences have been highlighted in the report. A copy of this report is found in the document appendices.

ENERGY PLAN INITIATIVES

Regional Policy, Planning, & Program Management

The importance of continuity of planning, infrastructure development, and recognition that energy security and sustainability will be achieved by working across disciplines and programs cannot be understated. Furthermore, it is important to fully involve communities in the decision making process for energy initiatives and local policy development.

One of the policy initiatives is to ensure that the region participates in the various energy assistance programs currently available to the residents of Alaska to the greatest extent practical. Some of these state-administered programs include the Community Energy Assistance Program, the Power Cost Equalization (PCE) program, the Power Project Load Fund, the Bulk Fuel Revolving Loan Fund (BFRLF), the Bulk Fuel Bridge Loan Program (for communities which are ineligible for BFRLF), and the Low Income Home Energy Assistance Program (LIHEAP).

Table 9- Regional Policy Initiatives

Energy Initiative	Budget Need
Regional Policy, Planning, & Program Management (annual)	$250

There has been significant progress on this initiative. The NWAB has hired a full-time coordinator and has held quarterly energy steering committee meetings. The coordinator has conducted village by village meetings and assessments in all communities. This position and regional energy programming should be continued.

Energy Conservation & End-Use Energy Efficiency

Energy conservation and end-use energy efficiency initiatives are needed to more effectively utilize all forms of energy in Northwest Alaska, regardless of source. A leading initiative, and a project differentiator, is the promotion of energy conservation practices. NANA and the NWAB will continue to serve as leaders in the promotion of energy conservation initiatives in the region.

End-use efficiency measures for housing, commercial buildings and community-based water and sewer system are pragmatic investments. Cogeneration (combined heat and power) systems recover heat from power generation to be used for direct space and water heating. Power generation efficiency should also be aggressively pursued to maximize the kWh of electricity generated per gallon from diesel fuel. Community water and sewer systems which are warmed by an improperly installed heat-trace can waste large amounts of energy, and should be inspected and repaired if necessary. To ensure the highest level of energy efficiency, LEED-type standards[19] should be encouraged for all new construction and retro-fits of commercial and public buildings within Northwest Alaska.

The overall approach to conservation would include energy efficiency audits of local infrastructure (homes, schools, buildings, water and sewer facility, and power plant) using thermal sensing, blower door tests, and other appropriate assessment technologies. Once the energy audit is complete, mitigation and improvement efforts would be undertaken, such as weatherization and insulation, lighting and heating upgrades, co-generation (if feasible), and other improvement efforts as identified with the energy audits. The 2004 *Alaska Rural Energy Plan* estimated that a comprehensive end-use efficiency program (mostly lighting and heating upgrades) in rural Alaska communities would have an aggregate weighted average benefit/cost (b/c) ratio of 1.35.[20]

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[19] The Leadership in Energy and Environmental Design (LEED) standard is a national 'green building' rating system developed by the US Green Building Council (www.usgbc.org). The LEED system addresses five major aspects of building design: sustainable building sites, water consumption, energy use and emissions, materials and resource use, and indoor environmental quality. The first LEED-certified building constructed in Alaska was the National Weather Service's Tsunami Warning Center in Palmer, which opened in 2003.

[20] Alaska Rural Energy Plan: Initiatives for Improving Energy Efficiency and Reliability, by MAFA in collaboration with Northern Economics, Inc, April 2004; prepared for the Alaska Energy Authority with support from the Denali Commission and USDA Rural Dev.

Older, low-efficiency diesel generation units should be replaced with electronically controlled units. Also recommended is the installation of automatic demand level paralleling switchgear where appropriate, which allows a community power system to automatically switch between a larger generator (during peak demand) and a smaller generator (during low demand). This ensures that the size of generator provides the greatest fuel efficiency for a particular load, since a larger generator operates at a fraction of its capacity is much less fuel-efficient. Such systems also provide remote, continuous monitoring of the fuel efficiency of each generator. Automatic demand level paralleling switchgear is estimated to save a powerhouse with three or four generators an estimated 10% to 20% in fuel costs. According to the 2004 *Alaska Rural Energy Plan,* the installation of more efficient diesel generators in rural Alaska communities was estimated to have an aggregate weighted average b/c ratio of 1.06.[21]

In addition, alternatives for heat recovery from diesel generators should be explored as part of a cogeneration feasibility study. Since 2005, Kotzebue Electric Association has operated a heat recovery system in cooperation with the City of Kotzebue. This system now saves over 60,000 gallons of diesel fuel annually, and is the most important working example of this technology in the region. According to the 2004 Alaska Rural Energy Plan, the installation of diesel cogeneration/waste heat recovery systems in rural Alaska communities was estimated to have an aggregate weighted average b/c ratio of 1.13.[22]

CAP and NIHA are the weatherization agencies responsible for Western Alaska and have instated weatherization services in all communities of the region. Weatherization is an important intervention that can be immediately implemented. CAP is scheduled to work in Kiana in 2008 and Noatak in 2010. If possible, regional entities should cooperate with the Alaska Housing Finance Corporation's building weatherization program, and programs such as CAP's Weatherization and Energy Star-Energy Smart program (to disseminate energy efficiency information to the public), and the RurAL CAP VISTA energy volunteer program. Public education programs on home energy efficiency and conservation measures should also be developed. Recently, RURAL CAP, NRC, and the NWAB have planned for the deployment of Energy Wise- an innovative workforce development and energy efficiency program. The program was previously implemented statewide with a pilot effort in Selawik. This program should be deployed to all other communities.

Table 10 - Regional Energy Conservation and End-Use Energy Efficiency Budget

Energy Initiative	Budget Need
Energy Conservation and End-Use Energy Efficiency	$8 million

Home Heating Fuel

Oil will remain the dominant source of heating for homes in Northwest Alaska for the short term. However, because oil is a fossil fuel whose price is subject to the global economics of crude oil, additional energy source options for heating oil should be reviewed. Biomass fuels, in particular wood from local sources,

[21] Ibid.
[22] Alaska Rural Energy Plan: Initiatives for Improving Energy Efficiency and Reliability, by MAFA in collaboration with Northern Economics, Inc, April 2004; prepared for the Alaska Energy Authority with support from the Denali Commission and USDA Rural Development.

should be studied where appropriate. Another option worth exploring is district heating for homes and larger buildings, particularly in conjunction with a community-scale cogeneration system. District heating systems, which pipe hot water for heating alongside other utility lines, usually are most feasible for urban applications with large commercial, residential, and institutional buildings. However, centrally-located buildings in Kotzebue or other communities in Northwest Alaska may still benefit from the economy-of-scale savings of district heating systems.

There has been recent discussions with the Alaska Natural Gas Development Authority about the use of propane in the region. A pilot propane project for both home heating and cooking should be considered..
A survey of propane use in the region is currently being conducted.

Table 11- Energy Initiative

Energy Initiative	Budget Need
Home Heating Pilot Projects	$1,000,000

"Mini-Grids" and Electrical Intertie Lines

Inter-community electrical interties could be an important means of enhancing energy security in the region by encouraging economies of scale in both infrastructure development and generation. These "mini-grids" will make the development of renewable energy more feasible and economically viable at the locations listed below in Table 12. Due to the remoteness of the region, a cost of $350,000/mile is anticipated. The evolving development of small-scale DC transmission is an emerging technology that could potentially reduce the estimated cost.

An evaluation project led by "Polar Consult" and stakeholders in "DC-grid" technology is currently in progress to evaluate "SWER (Single wire earth return) technology for DC transmission lines in Alaska.
If successful, this project may have the potential to reduce transmission line cost to $ 50,000.00/mile for construction. A test set-up for 1Mw will be conducted during 2011-12.

Table 12 - NW Alaska Electric Interties

Mini-Grid	Distance
Red Dog Mine Port- Kivalina	16 miles
Ambler-Shungnak	25
Kiana-Noorvik	20
Noorvik-Selawik	30

Table 13 - Intertie Budget Needs

Energy Initiative	Budget Need
Mini-Grids and Electrical Interties	$15 million

AVEC, in conjunction with NANA Regional Corporation, has secured feasibility study funding from the Alaska Energy Authority to assess an electrical intertie between Kivalina and the Red Dog Mine Port. This will be implemented in 2011.

Transportation Infrastructure Development

Multi-modal transportation corridors and inter-connectivity between communities can promote energy security. Interconnecting Noatak with the Red Dog Mine Road[23] is one of the few options available to Noatak to help reduce the impact of air freighting fuel to the community. There are other multi-modal transportation corridors that could be developed in the region. A road from the potential deep port at Cape Blossom to Kotzebue can help reduce the cost of fuel and goods to the whole region by avoiding the lighterage expense over the shallow waters into Kotzebue.

Table 14 - Transportation Infrastructure Development

Energy Initiative	Budget Need
Noatak to Red Dog Mine Port	$50 million
Cape Blossom Port to Kotzebue Road	$40 million

There has been progress on both of these projects. Grant funding is being secured for the Noatak interconnection; design dollars are secured for the Cape Blossom Port to Kotzebue.

Bulk Fuel Storage Improvement and Development

An investment in the critical energy infrastructure of the region will ensure improved efficiencies of both traditional and renewable technologies. Potential use of aalternative fuels such as hydrogen, synthetic gas, propane, and regionally available natural gas should be a consideration in this design.

Hub Community Bulk Fuel Upgrades

Kotzebue remains a primary service center for the region's remote communities. Increases in tankage, suppliers, and regional efficiencies could have a positive impact on the energy prices in the region's communities. Improved infrastructure, such as dolphin tie up structures at Cape Blossom with tankage and a pipeline, to Nimiuk Point could service the upper Kobuk with spring deliveries. This could allow line haul fuel barges to offload fuel more efficiently. The proposed airport relocation for Kotzebue to Cape Blossom could lead to tankage and delivery solutions that could benefit the region.

Sub-Region Bulk Fuel Staging/Intermediate Area

There are a number of initiatives that could promote diesel fuel infrastructure transportation, logistics, and storage efficiencies. A leading concept of improved transportation of diesel fuel includes sub-regional staging areas for bulk fuel to expedite the transport fuel to the Upper Kobuk via surface transportation during winter months. Other technologies could include remote monitoring of bulk fuel, renewable energy, and rural power system critical infrastructure.

Table 15 - Sub-Region Bulk Fuel Staging/Intermediate Area

Energy Initiative	Budget Need
Improved Bulk Fuel Storage and Logistics	$15-20 million

[23] The closest straight-line distance between Noatak and Red Dog Mine Road is 18 miles.

Bulk Fuel and Rural Power Systems Upgrades

An important investment in the energy security of the region is continued investment in regional infrastructure. There are six communities in the region in need of bulk fuel and power system upgrades currently available through the Denali Commission.

Downstream fuel facilities such as 'day tanks' and individual residence fuel storage/piping, whilenot part of the Denali Commission's bulk fuel upgrade program, are nonetheless a key part of the energy infrastructure in Northwest Alaska communities. In many rural Alaska communities, these downstream day tanks and residential fuel tanks lack overfill protection and are subject to leaks. If possible, improvements to these downstream fuel facilities should be conducted in cooperation with initiatives such as the Low Income Home Energy Assistance Program (LIHEAP).

Rural power system upgrades include powerhouse (generation) upgrades or replacements, assessments and repairs of electrical distribution lines, demand-side energy efficiency improvements, and lines to new customers. Another type of rural power system upgrade is the development of mini-grids connecting communities, impacting the placement of bulk fuel, primary generation, emergency generation, and wind systems in the region. The communities in need of bulk fuel and power system upgrades are listed below.

Table 16 - NW Alaska Bulk Fuel and RPSU Upgrades

Communities	Amount Needed (million)
Shungnak/Kobuk/Ambler	$10-15
Noatak/ Kivalina	$10-15
Kiana/Noorvik	$10-15
TOTAL	$30-$45 million

Note: All communities are assumed to be interconnected.

These upgrades should be performed in close collaboration with AVEC, the NW Arctic Borough School District, the Alaska Energy Authority, local village organizations, and other significant bulk fuel owners and operators.

Table 17 - Regional Bulk Fuel Upgrades

Energy Initiative	Budget Need
Bulk Fuel Upgrades	$30-45 Million

WIND-DIESEL AND WIND SYSTEMS

Wind-diesel is a proven technology with demonstrable projects in Northwest Alaska. Both AVEC and KEA have real world experience in the development and operation of wind diesel and wind power plants. According to the 2004 Alaska Rural Energy Plan, the installation of wind-diesel hybrid systems in selected rural Alaska communities was estimated to have an aggregate weighted average b/c ratio of 1.10.[24] There remain a number of feasible village wind-diesel and larger public private partnership (PPP) opportunities available for improved wind development in the region, as shown below in tables 18 and 19.

Table 18 - NW AlaskaWind Initiatives

Community/Sub-Region	Type of Project	Amount (million)
Deering	Wind Diesel (Village Power)	$3
Buckland	Wind Diesel (Village Power)	$3
Kiana	Wind Diesel (Village Power)	$3
Noorvik	Wind Diesel (Village Power)	$3
Red Dog Mine Corridor / Kivalina (Tech Cominco)	PPP	$15
Upper Kobuk / NOVA Gold	PPP	$15
Kotzebue Wind Farm	Utility Scale	5 million[25]

Table 19 - Wind and Wind Diesel Systems

Energy Initiative	Budget Need
Wind-Diesel and Wind Systems	$50 million

NRC and the NWAB assisted with grant proposal funding from the Alaska Energy Authority for Deering, Buckland, and Noorvik. Deering in particular has advanced in their development efforts. Future initiatives should focus on advancing these projects to design and to construction.

FEASIBILITY STUDIES AND IMPROVED UNDERSTANDING OF REGIONAL RENEWABLE ENERGY RESOURCES

It is important to understand the potential impact of new technologies on known resources. Additionally, the introduction of new technologies requires the availability of a trained and capable local workforce able to service facilities. Existing energy facilities must be capable of promoting energy security in the region. A series of feasibility studies is needed for communities in Northwest Alaska, addressing potential renewable energy sources.

[24] Alaska Rural Energy Plan: Initiatives for Improving Energy Efficiency and Reliability, by MAFA in collaboration with Northern Economics, Inc, April 2004. Prepared for the Alaska Energy Authority with support from the Denali Commission and USDA Rural Development.

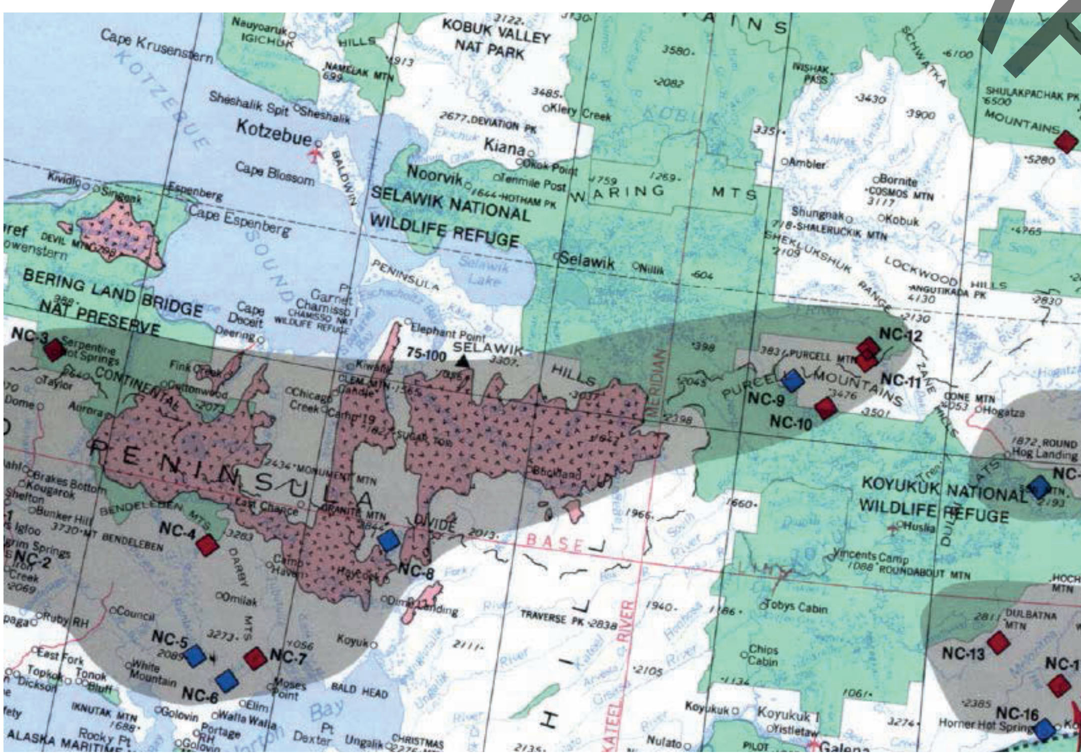
[25] Includes private sector investment

Geothermal

Regional partners have identified geothermal potential in the region for the Buckland and Upper Kobuk (Ambler, Kobuk and Shungnak) areas. There are important geo-scientific and drilling feasibility studies that could further define the potential of this resource. Figure 8 shows known hot springs in Northwest Alaska, as identified by the 1983 *Geothermal Resources of Alaska Map*.

NRC completed a geothermal feasibility study for the region. The key outcome is that the likely sources for geothermal energy are too far from communities to be developed in an economic manner. Furthermore, geothermal energy and power development in the Kotzebue area was also considered to be unfeasible. Greenhouse and other economic development initiatives appear to be the only economically feasible options at this time.

Figure 8 – Map of Hot Springs in NW Alaska[26]



[26] Hot springs in the NANA region, as identified by the 1983 Geothermal Resources of Alaska Map. Red diamonds = hot springs above 50°C; blue diamonds = hot springs below 50°C. Shaded areas indicate regions favorable for geothermal, but probably only small areas within the shaded region are viable for production.

Biomass

Through the region's energy options analysis, biomass was identified as one of the few viable options in the Upper Kobuk area. Wood-fired heat is already used in the upper Kobuk River area (Ambler, Kobuk and Shungnak), with most of the harvested wood coming from NANA land close to villages. Wood-fired combined heat and power (CHP) systems should be investigated for the upper Kobuk River area.

The boreal forest in the region consists of open woodland and small trees along the Kobuk River, interspersed with large expanses of arctic tundra. Spruce and balsam poplar grow in the lower and middle reaches of the valleys of the Kobuk River's tributaries that extend into the Baird and Waring mountains. Thickets of willow and alder trees, along with some isolated stands of cottonwood, grow up to the headwaters of the rivers and streams. In some areas, sparse stands of spruce, birch, and poplar grow above a thick ground cover of lichens. According to the Alaska Department of Natural Resources, very little forest inventory data exists for the upper Kobuk River area, but it is apparent that the current levels of harvest are well below a maximum "sustainable yield." Fast growing willows that are harvestable after a 3-4 year growing cycle are being evaluated for use in the generation of energy in other parts of the country.

The NW Inupiat Housing Authority is currently conducting a biomass feasibility study for the region, looking at both thermal heating and power generation. Preliminary findings suggest that increasing biomass thermal energy/heating deployment in Shungnak, Ambler, and Kobuk appears to be feasible. The feasibility report will be available in June of 2011.

Hydropower

Hydroelectric power has proven to be a reliable long term energy source; an evaluation of this technology for cold regions would be beneficial. Preliminary studies were conducted on small hydropower potential for villages in the region during the late 1970s and early 1980s. These older studies concluded that hydropower was not economically feasible due to very low flows during winter. More recently, the hydropower potential of the Upper Kobuk region was evaluated as part of an energy study for a proposed mining project. More up-to-date studies are needed to evaluate potential for new hydroelectric technologies to improve project economics. In-stream, or hydrokinetic, turbines are an emerging technology which could find applications in Northwest Alaska's rivers and streams. Figure 9 shows the Kogoluktuk River, a tributary of the Kobuk River, which has been identified as a possible hydroelectric site near the village of Kobuk.

Figure 9 – Kogoluktuk River

In 2010, AVEC initiated a feasibility study for small scale hydroelectric development in the Cosmos Hills area for the potential benefit of Shungnak, Ambler, and Kobuk. The most up to date information can be found at www.cosmoshills.org. Work done to date includes deployment of stream gauge monitoring. The feasibility study will be available by December of 2011.

Solar

Continued escalation of energy costs calls for a re-examination of solar energy. While solar electric generation and solar space heating were deemed expensive in the past, the rising cost of conventional fuels make solar an increasingly attractive and affordable alternative. Another use of solar energy that might have immediate benefits is the use of solar water heating to supplement electric or oil water heaters. Solar energy remains a viable resource for the region for up to 6 months out of the year.

SOLAR-PV

In 2009, the NW Arctic Borough initiated a Solar PV study for evaluation of the available resource. The test set-up consisted of a high efficiency Monocrystaline 200 watt solar array fixed at an angle of approximately 66 degrees in conjunction with a Microinverter type Enphase. The system produced 166 Kwh of electricity during one year of operation. This equated to approximately $90.00 of electricity for the building where it was installed. As the building was not equipped with PCE (power cost equalization), the project realized the full potential of the array, as the cost of electricity was $ 0.54/Kwh. Pay back is estimated at 10 to11 years. The recommendation for Solar PV usage would be to target buildings without PCE in the region and also ccommunity buildings where PCE is limited. Electricity is likely to rise in cost per KWh, as oil prices climb due to the use of ddiesel ggenerators in the Communities, making Solar PV a more attractive option.

Solar Heating

A test project is currently underway to determine the value of ssolar to supplement water or space heating. NIHA together with KEA have installed 10 small solar heating systems on selected households in Kotzebue. Two separate technologies are used in the evaluation, based ondata collected in 2011.

New Technology Initiatives Feasibility Analysis

It is imperative that the region remains at the forefront of technology development in the energy sector. Issues such as distribution, generation, and storage could profoundly improve the energy picture if commercial development is effectively monitored. Emerging technologies worthy of exploration include large-scale electric battery storage systems.

NANA Regional Corporation initiated a new technology screening study in 2010. The objective was to identify emerging or new technologies that could be deployed in the region. A copy of the summary presentation can be found on NANA Regional Corporation's web-site.

Transportation Feasibility Analysis

While we have developed some pragmatic logistics, transportation, and infrastructure concepts, there is more cost savings potential with more efficient transportation, logistics, and delivery improvements. Increasing transportation costs are one of the issues that will need to be addressed in order to reduce the cost of energy. An evaluation of current and potential future configurations of equipment or partnerships should be reviewed. Currently in Canada, there are efforts at evaluating the use of large payload airships to deliver fuel and supplies. An examination of the use of higher efficiency and electric transportation for personal equipment would be part of the study. We are requesting an additional $100,000 to undertake a transportation feasibility analysis. Furthermore, electric cars may be a consideration in Kotzebue.

Table 20 - Feasibility Study Budget Needs

Energy Initiative	Budget Need
Feasibility Studies	$5-10million

TRAINING AND WORKFORCE DEVELOPMENT

There remains the need to maintain and improve regional ability to maintain and develop the new energy infrastructure through training and workforce development. The training and workforce development objective will have three prongs; needs assessment; increasing awareness and collaboration; and training and development.

Region-wide Needs Assessment

The first step to a region-wide needs assessment is developing a firm understanding of regional needs as it relates to work-force development. There is anecdotal information that diesel power generation technician, utility management and training, and youth mentoring is needed. Review and confirm the workforce and training needs in the energy sector at all levels of the region is needed.

Increasing Awareness and Collaborations

It is important to increase interest and awareness of these new and emerging technologies in order to motivate residents to learn about more energy issues in the region. This could include education events in schools, stakeholder visits/youth mentoring, site visits where these new technologies are being used, curriculum development at the local schools and college, clubs, job shadowing and internships, regional and local conferences, and other training programs.

Energy Education & Classes

A College class was created in collaboration with Chukchi College & UAA by Dr. Andres Soria. The course instructed the student on the principles behind renewable energy systems, including solar, wind, hydro and biomass. Topics included available technologies, energy storage, applications for renewable energy systems, sizing and selection of system components, installation of successful systems, grid and off grid tied system and safety considerations. The course also included a hands-on exercise of building of an alternate energy system during springtime. The course was also broadcast via WEB to Ambler & Buckland. A similar class will be available in the spring of 2011.

Energy Awareness Project

In 2009 The Northwest Arctic Borough initiated the “Green Community Initiative” by launching an Energy awareness project using EECBG funding. The project consists of the installation of a “Smart Energy meter” in each household in the region. The equipment selected is type TED 1001 & TED 5000 by Energy Inc. and also ECO-meter by Landis+Gyr. The units will track household energy consumption by hourly, daily and monthly increments. The units will also alert the consumers when the PCE threshold has been reached. An ongoing collaboration with the school system will allow high school students to learn about energy efficiency using the meters in their homes. The project hopes to initially reduce average household energy consumption by 10-20 percent. Installation of Smart Meters in all households should be complete by the end of 2011.

Finally, Chukchi College has secured funding for a demonstration house in Buckland. The design concept closely follows the work completed by Anaktuvuk Pass and the Cold Climate Research Housing Center.

Meeting the Training and Workforce Development Needs

From the above exercises, stakeholders will better understand the region's workforce development needs and be able to identify appropriate technical schools and training programs that can promote energy security. This will involve collaborations with existing training providers and other entities who can add value to the region's workforce needs.

Table 21- Training and Workforce Development

Energy Initiative	Budget Need
Training and Workforce Development	$350,000/yr

OPERATIONS AND MAINTENANCE

It is important to maintain the integrity of existing infrastructure through operations and maintenance (O&M) business planning. In particular, bulk fuel O&M planning should be performed in cooperation with entities such as Rural Alaska Fuel Services (RAFS), a not-for-profit corporation organized to contract for the operation and maintenance of rural Alaskan bulk fuel storage facilities. RAFS also provides training services related to tank farm safety and O&M. The construction of renewable generation capacity, efficiency projects, and electrical inter-ties between communities, would also be a factor in O&M planning.

Table 22 - O&M Budget

Energy Initiative	Budget Need
Operations and Maintenance	$500,000/yr

HYDROCARBON RESOURCE DEVELOPMENT

Although the goal will be to displace as much fossil fuel as possible with renewable and other climate-friendly energy sources, it will also be necessary to look to traditional fuels that are or may be available in the region such as quantities of natural gas and coal. Energy costs, especially for village residents, are beyond the critical state.

Natural gas exploration is being conducted in the region and the results of that work and other drilling work in the region should be reviewed for potential gas extraction sites. Massive coal reserves exist north of the region in the Deadfall Syncline located near Point Lay. Coal quantities there are estimated to be approximately 25% of known U.S. reserves. This is a high thermal yield (12,500 BTU), low sulfur bituminous coal. In the past, coal was used for home heating in the region. A review of high efficiency heaters should be conducted. There are also projects currently underway to demonstrate carbon sequestration for the use of coal for electric generation. Also, the efforts for developing cleaner burning synfuels from coal should be monitored. Underground coal gasification (UCG) has been identified as a possible means of extracting the regions coal energy in an environmentally sensitive manner.

Table 23 - Hydrocarbon Resource Development

Energy Initiative	Budget Need
Hydrocarbon Resource Exploration and Development	$ 2 – 5 million

MINING AND ECONOMIC DEVELOPMENT

The development of natural resources in the region will also have a large impact in the development of an appropriate energy future for local communities. Mines are being proposed in the upper Kobuk, Seward Peninsula and Squirrel River regions that could assist in the planning and development of energy projects. The vision for the joint development of resources and the region's economic development will be a critical component for a successful energy future.

Table 24 - Mining and Economic Development

Energy Initiative	Budget Need
Energy Supply for Mining Development	$ 5 – 10 million

APPLICATIONS FOR SURPLUS ELECTRIC POWER

At the present time, none of the communities in Northwest Alaska have "excess electricity", or a surplus of power available above standard electric loads. However, if additional renewable generation capacity is constructed, such as a wind farm or hydroelectric installation, the amount of power generated could potentially exceed the village-level electric load. Applications for waste heat should also be explored. Possible uses include:

- Electric heat-trace lines installed in the pipes of community water systems.
- "Dump-load" electric space and water heaters. The main purpose of electric heating would be to displace hydrocarbon fuels.
- Battery charging for electric vehicles, including snow machines. Electric snow machines have been developed, and should be tested in Northwest Alaska.
- Other long-term uses of a community's surplus power, including heated greenhouses for agriculture/horticulture, aquaculture, and production of hydrogen with electrolysis.
- Demand-side management and 'smart grid' applications to manage excess power uses.

In the future, it is conceivable that with enough renewable power generation, and practical means of storing large amounts of electric energy, an "all electric village" to be completely powered by renewable energy. It should be noted that electric heating and other power-intensive applications may require an upgrade to a community's electric distribution system.

Table 25 - Budget

Energy Initiative	Budget Need
Surplus power applications	$ 2 – 5 million

METRICS AND MEASURING SUCCESS

We believe in "what gets measured gets achieved." Table 26 below is a list of process, impact, and proxy indicators that will indicate success of the program.

Table 26 - Metrics and Measuring Success

Indicator	Metric	How Measured/Who Responsible
Diesel fuel displacement	Gallons of diesel	AVEC, KEA, and NW Arctic Borough annual delivered fuel as a proxy indicator for the rest of the community.
Kobuk to Selawik interconnected via transmission interties by 2025	Intertie lines (capacity, number of electric consumers served)	Review of targeted areas.
Community support and willingness to engage	# of City and Tribal Resolutions	City and Tribal Council provided initiatives
New technologies adopted	Wind and/or other renewable energy technologies	Review of new technologies in community by NANA, AVEC, KEA, NAB, state and federal agencies, others
100% representation of youth and elders trained in energy planning in 5 years.	Number of people trained	NW Arctic Borough, Chuchi College
10% decrease of imported fossil fuels for generation and heating by 2015;	Gallons of diesel and other fuels	AVEC, KEA, and NW Arctic Borough annual delivered fuel.
25% decrease of imported fossil fuels by 2020;	Gallons of diesel and other fuels	AVEC, KEA, and NW Arctic Borough annual delivered fuel.
50% decrease of imported fossil fuels by 2030	Gallons of diesel and other fuels	AVEC, KEA, and NW Arctic Borough annual delivered fuel.
50% decrease the need for transportation fuel imported into the region by the year 2030.	Gallons of diesel and other fuels	AVEC, KEA, and NW Arctic Borough annual delivered fuel.
All new construction commercial buildings built to the LEED standard.	Number of buildings that are LEED certified	U.S. Green Building Council
All commercial building retrofitted to meet the LEED standard by 2025.	Number of buildings that are LEED certified	U.S. Green Building Council
100% of existing homes weatherized by 2015 under AHFC energy efficiency guidelines.	Number of buildings that are LEED certified	NIHA, AHFC
All new homes built in the region to reflect the AHFC 5-Star Plus rating.	Number of buildings that are LEED certified to have the AHFC 5-Star Plus rating	NIHA, AHFC, others
Reduction of greenhouse gas (GHG) emissions in the region	Tons of GHG emissions avoided due to energy efficiency/conservation, substitution of hydrocarbon energy with renewables.	TBD

ROLES AND RESPONSIBILITY

Table 27 below outlines to the potential roles and responsibilities of the various stakeholders for each energy initiative described in this SEP.

Table 27 - Potential Roles and Responsibilities of Regional Organizations

Energy Initiative	Who is responsible
Power generation and distribution	Utility, borough, city and tribal councils
Bulk fuel storage	Utility, school district, village corporations
Transportation infrastructure development	Borough, city and tribal councils
Home energy efficiency	Housing authority, city and tribal councils.
School energy efficiency	School district and borough
Commercial building energy efficiency	Private sector, city and tribal councils
Workforce development	University and school district

NEW ENERGY SOURCE OPTIONS FOR NORTHWEST ALASKA COMMUNITIES

Table 28 is a summary of the energy option analysis section found in the appendices, with a listing of the presently installed electric power generation capacity [diesel only] for each community.

Table 28 – Summary of Energy Options

Site	Electric Intertie	Infrastructure Development	Wind	Geothermal	Hydropower	Biomass
Ambler (982-kW)	The straight-line distance between Ambler and Shungnak is about 24 miles, An intertie is not likely to be economically feasible, but should be investigated.	Mines are being proposed in the upper Kobuk region that could assist in the planning and development of energy projects.	The wind resource for Ambler is predicted to be Class 1 or "Poor". Thus, wind energy appears unfeasible for the Ambler area.	The closest known geothermal sources are at Division Hot Springs, about 60 miles south-southeast of Ambler. The distance required for electric transmission does not make geothermal economically feasible for Ambler.	A 1981 study determined that a small hydroelectric plant on the East Fork of Jade Creek, located 9 miles northwest of Ambler, to be uneconomic. Hydropower resources are worth re-examining given new technology and economics.	The boreal forest in the Ambler area is open woodland of small trees along the Kobuk River, interspersed with large expanses of arctic tundra. Biomass energy resources for the upper Kobuk River are being investigated.
Buckland (650-kW)	The closed other community is Deering (about 50 miles away), thus an intertie is economically unfeasible.	Possible future road development could connect the Buckland area with communities in the Norton Sound region to the south.	Good wind resources (Class 4) are predicted to exist along the ridges about 5 miles west of Buckland, and are being investigated.	Granite Mountain Hot Springs is located approximately 40 miles south of Buckland. Exploration is recommended for possible sub-surface geothermal energy sources closer to Buckland.	A 1981 study determined that a small hydroelectric plant on Hunter Creek, located 23 miles southwest of Buckland, to be uneconomic. However, local hydropower resources are worth re-examining given new technology and economics.	No significant biomass resources are known to exist in the Buckland area.
Deering (453-kW)	The closed other community is Buckland (about 50 miles away), thus an intertie is economically unfeasible.	Possible future road development could connect the Deering area with communities in the Norton Sound region to the south.	Excellent wind resources (Class 5 and 6) are predicted to exist near Cape Deceit, 1.5 miles northwest of Deering, and are being investigated.	The closest known geothermal sources are at Lava Creek Hot Springs, located about 50 miles south of Deering. The distance would make this unfeasible as a power source for Deering.	No feasible hydroelectric sites are known to exist in the Deering area.	No significant biomass resources are known to exist in the Deering area.
Kiana (1163-kW)	The straight-line distance between Kiana and Noorvik is about 19 miles. An intertie is not likely to be economically feasible, but should be investigated.		The wind resource for Kiana is predicted to be Class 2 to 3 (or "Marginal" to "Fair"). However, much stronger wind resources (Class 5 to 7) are predicted to exist atop hills 6 miles to the east of Kiana, and should be investigated.	No significant geothermal energy resources are known to exist in the Kiana area.	A 1981 study determined that a small hydroelectric plant on Canyon Creek, located 8 miles northeast of Kiana, to be uneconomic. However, local hydropower resources are worth re-examining given new technology and economics.	The boreal forest in the Kiana area is open woodland of small trees along the Kobuk River, interspersed with large expanses of arctic tundra. Biomass energy resources for the Kiana are being investigated.
Kivalina (1040-kW)	At its present location, Kivalina is about 16 miles (straight line) from the Port of Red Dog Mine, although a new village location presumably would be closer. An electrical intertie line between the community and the port could be economically feasible, and is worth investigating.	Due to severe erosion and wind-driven ice damage, the City intends to relocate to a new site 7.5 miles away. The community needs a road to the proposed new town site near the Port of Red Dog Mine.	Good wind resources (Class 4) are predicted to exist both in Kivalina and the proposed new town site, and are worth investigating.	No significant geothermal energy resources are known to exist in the Kivalina area.	No feasible hydroelectric sites are known to exist in the Kivalina area.	No significant biomass resources are known to exist in the Kivalina area.

Table 29 – Summary of Energy Options (continued)

Site	Electric Intertie	Infrastructure Development	Wind	Geothermal	Hydropower	Biomass
Kotzebue (~12 MW)	It does not appear that electrical interties to Noorvik, Kiana, Selawik, or Buckland would be economically feasible.	Shore Avenue erosion protection project. Proposed Cape Blossom deep water port and road to Cape Blossom.	Kotzebue Electric Association presently has seventeen wind turbines integrated into the community power system. It would be feasible to augment the existing machines with additional wind turbines, or replace them with higher capacity models.	According to the Alaska Geothermal Resources Map and local knowledge, there are no known geothermal sources in close proximity to Kotzebue. However, drilling for hydrocarbon resources (see above) in the area could also yield information on whether a subsurface geothermal resource exists.	A 1979 study by the U.S. Department of Energy[27] concluded that there are no practical hydroelectric sites in close proximity to Kotzebue.	
Noatak (982-kW)	Noatak is about 30 miles (straight line) from the Port of Red Dog Mine, An intertie is not likely to be economically feasible, but should be investigated.	A new road is proposed to connect Noatak to the Red Dog Mine Road, and would enable easier fuel shipments to the community.	The wind resource for Noatak is predicted to be Class 1 or “Poor”. Thus, wind energy appears unfeasible for the Noatak area. However, better wind resources may exist along a new road connecting to the Red Dog Mine Road.	No significant geothermal energy resources are known to exist in the Noatak area.	No feasible hydroelectric sites are known to exist in the Noatak area.	Some biomass resources are known to exist in the Noatak area, and should be investigated.
Noorvik (1163-kW)	The straight-line distance between Noorvik and Kiana is about 19 miles. An intertie is not likely to be economically feasible, but should be investigated.		The wind resource for Noorvik is predicted to be Class 2 to 3 (or “Marginal” to “Fair”), and are being investigated.	No significant geothermal energy resources are known to exist in the Noorvik area.	No feasible hydroelectric sites are known to exist in the Noorvik area.	The boreal forest in the Noorvik area is open woodland of small trees along the Kobuk River, interspersed with large expanses of arctic tundra. Biomass energy resources for this area should be investigated.

[27] Small Hydroelectric Inventory of Villages Served by Alaska Village Electric Cooperative, U.S. Dept. of Energy, Alaska Power Administration. December 1979.

Site	Electric Intertie	Infrastructure Development	Wind	Geothermal	Hydropower	Biomass
Selawik (1686-kW)	Selawik is about 25 miles (straight-line distance) from Kiana, and about 32 miles from Noorvik. An intertie is not likely to be economically feasible, but should be investigated.		Selawik presently has four AOC 15/50 wind turbines integrated into the community power system. It would likely be feasible to augment the four existing AOC machines with additional wind turbines, or replace them with higher capacity models, and should be investigated.	No significant geothermal energy resources are known to exist in the Selawik area.	No feasible hydroelectric sites are known to exist in the Selawik area.	No significant biomass resources are known to exist in the Selawik area.
Shungnak-Kobuk (1248-kW)	There is an existing electric intertie between Shungnak and Kobuk. The straight-line distance between Shungnak and Ambler is about 24 miles, An intertie is not likely to be economically feasible, but should be investigated.	Mines are being proposed in the upper Kobuk region that could assist in the planning and development of energy projects.	The wind resource for the Shungnak and Kobuk is predicted to be Class 1, or Poor". However, much stronger wind resources (Class 5 to 7) are predicted to exist atop hills 5 miles north of Kobuk, and should be investigated.	The closest known geothermal sources are at Division Hot Springs, located about 40 miles south of the Shungnak-Kobuk area. Due to the distance required for electric transmission, geothermal does not appear to be economically feasible for Shungnak-Kobuk.	Several possible hydroelectric sites (small-scale: Dahl, Cosmos, and Camp creeks and large-scale: Shungnak and Kogoluktuk rivers) have been studied in the Shungnak-Kobuk area. Resources are investigating, especially if a gold mine is developed in the area.	The boreal forest in the Shungnak-Kobuk area is open woodland of small trees along the Kobuk River, interspersed with large expanses of arctic tundra. Biomass energy resources for the Shungnak-Kobuk area should be investigated.

FINANCING PLANS

The energy projects outlined by the SEP will likely require support from a variety of government agencies, foundations and corporate entities to secure the needed resources for such an undertaking. Possible funders, with contact information, are listed in Appendix XIII. Grant funds are the most obvious means of financing construction of such a facility, but there are other options to consider as well.

State of Alaska

The *Alaska Energy Authority* has assisted the Northwest Arctic region in the past with a variety of grant and loan programs such as the Alternative Energy and Energy Efficiency programs, Power Project Load Fund, Bulk Fuel Upgrade Program, Power System Upgrade Program, and community technical assistance and training programs. In 2008, the legislature's passage of HB152 created a Renewable Energy Fund, to which several regional stakeholders submitted applications for both pre-construction and construction funding for energy projects.

The *Alaska Department of Transportation and Public Facilities* prioritizes projects with the Statewide Transportation Improvements Program (STIP) and the Needs List programs, both of which could include new roads connecting communities in the NW Arctic Borough.

Federal Government

With a new administration in Washington, D.C., there are high expectations for both increased federal support of renewable energy development, and for federal infrastructure spending as part of an economic stimulus package. If federal taxation of greenhouse gas emissions becomes a reality, this would provide a great incentive for renewable development and mitigation funds for climate change impacts on infrastructure. Given that Northwest Alaska is already disproportionately affected by the impacts of climate change, most notably the village of Kivalina, the Northwest Arctic would be well-positioned to pursue these funds.

The *U.S. Department of Energy (DOE)* has a wide variety of grant programs for renewable energy development, energy efficiency programs, and projects involving tribal entities. In addition to the Tribal Energy Program, DOE funding may also be available through the Geothermal Technology Program, and the Wind and Hydropower Technologies Program.

The federal-state *Denali Commission* has funded bulk fuel upgrades in Northwest Alaska, in addition to a feasibility study of a wind-diesel system for Deering. The Denali Commission is involved in funding non-energy infrastructure projects as well.

The *USDA Rural Utilities Service's High Energy Cost Grant Program* provides financial assistance for the improvement of energy generation, transmission, and distribution facilities serving eligible rural communities with home energy costs that are over 275 percent of the national average.

The *U.S. Department of Housing and Urban Development's Community Development Block Grant Program* could be used by the Northwest Arctic Borough and the Indian Community Development Block Grant (ICDBG) for Tribal Entities, for energy efficiency and weatherization programs.

The federal government's *Production Tax Credit (PTC)* allows owners of qualifying renewable energy projects to take between one and 1.9 cents off their federal tax bill for every kWh of electricity generated for the first ten years of operation. The projects which qualify for the PTC tend to be for-profit, privately-owned facilities. In the NANA region, the Red Dog Mine's proposed wind generation would fall under this category. Other for-profit renewable generation options should be explored by NANA, perhaps in form of projects owned and operated by a NANA subsidiary. Under present legislation, the PTC will last the end of 2010, but hopefully will be extended. Federal tax deductions and credits are also available for energy efficiency investments for homes and commercial buildings.

Private Equity and Corporate Giving

ConocoPhillips, BP, Alyeska Pipeline, Federal Express are all major corporations with a strong Alaskan presence that could be considered for a capital campaign. NANA Regional Corporation, as the regional corporation, is another entity to approach. Teck Cominco, due to its close proximity with the Red Dog Mine, is another viable option. Other mining projects in the region, such as Mantra Mining's proposed Ambler Project under exploration in the Upper Kobuk area, could offer similar opportunities. Shell, which is pursuing offshore oil and gas exploration near the Northwest Arctic region, is assisting with community energy efficiency programs as a direct result of company's participation in the July 2008 Northwest Arctic Regional Energy Summit.

On the national level, several large technology firms not previously involved with energy projects, most notably Google, are starting to invest large amounts in renewable energy ventures. Funding a renewable energy project in a rural Alaska community affected by climate change could be a noteworthy 'showcase' for such a company.

Appendix A
Reviewers and Contributors

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Appendix B
Kotzebue Energy Options Analysis

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KOTZEBUE OVERVIEW[28]

Kotzebue, population 3,100, is on the Baldwin Peninsula in Kotzebue Sound, on a 3-mile-long spit, which ranges in width from 1,100 to 3,600 feet. It is located near the discharges of the Kobuk, Noatak and Ssezawick Rivers, 549 air miles northwest of Anchorage and 26 miles above the Arctic Circle. This site has been occupied by Inupiat Eskimos for at least 600 years. "Kikiktagruk" was the hub of ancient arctic trading routes long before European contact, due to its coastal location near a number of rivers. The German Lt. Otto Von Kotzebue "discovered" Kotzebue Sound in 1818 for Russia. The community was named after the Kotzebue Sound in 1899 when a post office was established. The City was formed in 1958; an Air Force Base and White Alice Communications System were later constructed. The residents of Kotzebue are primarily Inupiat Eskimos, and subsistence activities are an integral part of the lifestyle. Each summer, the North Tent City fish camp is set up to dry and smoke the season's catch. Kotzebue is located in the transitional climate zone, which is characterized by long, cold winters and cool summers. Kotzebue Sound is ice-free from early July until early October.

Air is the primary means of transportation year-round. The State-owned Ralph Wien Memorial Airport supports daily jet service to Anchorage and several air taxis to the region's villages. It has a 5,900' long by 150' wide main paved runway and 3,800' long by 100' wide crosswind gravel runway. A seaplane base is also operated by the State. The shipping season lasts 100 days, from early July to early October, when the Sound is ice-free. Due to river sediments deposited by the Noatak River 4 miles above Kotzebue, the harbor is shallow. Deep draft vessels must anchor 15 miles out, and cargo is lightered to shore and warehoused. Crowley Marine Services operates shallow draft barges to deliver cargo to area communities. The City wants to examine the feasibility of developing a deep water port, since the cost of cargo delivery is high with the existing transportation systems. There are 26 miles of local gravel roads, used by cars, trucks and motorcycles during the summer. Snowmachines are preferred in winter for local transportation.

Kotzebue is the service and transportation center for all villages in the northwest region. It has a healthy cash economy, a growing private sector, and a stable public sector. Due to its location at the confluence of three river drainages, Kotzebue is the transfer point between ocean and inland shipping. It is also the air transport center for the region. Activities related to oil and minerals exploration and development have contributed to the economy. The majority of income is directly or indirectly related to government employment, such as the School District, Maniilaq Association, the City and Borough. The Red Dog Mine is a significant regional employer. Commercial fishing for chum salmon provides some seasonal employment. 128 residents hold commercial fishing permits. Most residents rely on subsistence to supplement income.
Water is supplied by the 150-million-gallon Vortac Reservoir, located one and a half miles from the City. Water is treated and stored in a 1.5-million-gallon tank. Funds have been requested to construct a second 1.5-million-gallon tank. Water is heated with a waste heat recovery system at the electric plant, and distributed in circulating mains. Piped sewage is treated in a 32-acre zero discharge facultative lagoon west of the airport. Around 80% of homes are fully plumbed, and 521 homes are served by the City system. A new transfer station and Class 2 permitted landfill with bale-fill has recently been completed.

CURRENT ENERGY CONDITIONS

Kotzebue Electric Association currently provides power to the city of Kotzebue, with a 11,520-kW (11.5 MW) diesel power plant as well as 1,165-kW (1.1 MW) of installed wind generation capacity for a total

[28] State of Alaska Department of Community and Economic Development Community website.

installed capacity of 12,675-kW (12.6 MW) . Kotzebue Electric Association generated 22,101,534 kWh total during fiscal year 2007, of which 95.2% (21,037,261 kWh) was from diesel and 4.8% (1,064,273 kWh) was from wind. During the same period of time, the community imported 1,490,063 gallons of fuel for power generation use, and consumed 1,420,457 gallons for the year. The average pre-PCE residential electric rate for fiscal year 2007 (based on monthly usage of 500 KWh) in Kotzebue was 38.50 cents per kWh. The average fiscal year 2007 price of diesel fuel purchased by Kotzebue Electric Association for power generation purposes was $2.6890 per gallon.

The primary source used for home heating for the community is home heating oil, which is shipped to Kotzebue on the spring and fall barges. It unlikely that biomass (i.e. wood) is viable as a primary source as a home heating fuel.[29] However, this should be confirmed.

The current usable bulk fuel storage capacity in Kotzebue by tank farm owner: Crowley Marine Services Tank Farm (6,200,000 gallons); Airport/Bering Air (20,000), Army National Guard (17,000); other bulk fuel storage listed (capacities unknown): Pacific Alaska Fuel Services, Baker's Fuel, Hanson's, Bison Street, Lee's Auto, K.I.C., NAPA Auto Parts.

KOTZEBUE ENERGY OPTIONS

A preliminary screening analysis of best available energy options was undertaken for Kotzebue. This included a high level review of reports, resource maps, and understanding of best available technology. Below is a list of energy options that require further analysis, followed by a discussion of each option. These options were identified through reports, resource maps, and the consultant's knowledge, but community members and other stakeholders may have additional source knowledge. As new information is brought forward, it will be incorporated into the analysis.

- *Combined Heat and Power Systems (Cogeneration)*. The preliminary screening analysis for Selawik suggested waste heat recovery as a potential source of economic benefits for the community if a potential end-use for the heat is located in close proximity to the power house. According to the Alaska Rural Energy Plan, a potential use of the cogeneration heat was to keep fuel storage tanks and distribution lines warm enough to use a more economical type of diesel fuel or to provide heat to an end-user.
- *End-Use Energy Efficiency*. End-Use Energy Efficiency (including electrical lighting, refrigerator/freezers, appliances, new space heating, and new water heating) has been identified as a potential source of economic benefits for Kotzebue. Types of interventions that could be considered for this initiative could include light bulb replacement program, upgrades to the thermal performance (insulation) of homes, the replacement of inefficient appliances, weatherization initiatives, and upgrades to the existing diesel generators. All end-use energy efficiency initiatives should be modeled/assessed in its impact on the diesel generation power and efficiency curves.
- *Wind-Diesel Hybrid System*. Kotzebue Electric Association presently has seventeen wind turbines integrated into the community power system. It would be feasible to augment the existing machines with additional wind turbines, or replace them with higher capacity models.
- *Home Heating Oil*. Home heating oil is and will likely remain a source of heating for Kotzebue homes future.. Since this is a fossil fuel, it will fluctuate with the global economics of crude oil. The potential for other home heating sources should be reviewed.

[29] A review of the Alaska Department of Natural Resources Biomass Map did not suggest significant potential for biomass.

- *Electrical Intertie*. The closest communities to Kotzebue are separated by the waters of Kotzebue Sound, and over 50 miles away. Therefore, it does not appear that electrical interties to Noorvik, Kiana, Selawik, or Buckland would be economically feasible.
- *Exploration for Natural Gas and other Hydrocarbon Fuels*. The area near Kotzebue may be explored for natural gas, and possibly oil, in the near future. The amount, if any, of these hydrocarbon resources in the Kotzebue Sound/Chukchi Sea area is presently unknown, and would require exploration drilling to determine.
- *Geothermal*. According to the Alaska Geothermal Resources Map and local knowledge, there are no known geothermal sources in close proximity to Kotzebue. However, drilling for hydrocarbon resources (see above) in the area could also yield information on whether a subsurface geothermal resource exists.
- *Hydroelectric*. A 1979 study by the U.S. Department of Energy[30] concluded that there are no practical hydroelectric sites in close proximity to Kotzebue.
- *Solar*. While solar is not widely used in Alaska, it does remain an option for power generation and home heating. A review of solar technology should be undertaken.

RECOMMENDED ENERGY OPTIONS FOR KOTZEBUE

The following recommendations are provided for the community of Kotzebue in order to frame energy policy for the region.

- *Wind Energy*. Kotzebue could expand its existing wind generation capacity, and the community should work with Kotzebue Electric Association in studying the feasibility of installing additional wind turbines. Also, performance data of the existing wind turbines should be analyzed to aid in the planning of future wind turbine installations. Electrical energy storage systems integrated with the Kotzebue Electric Association wind/diesel system could provide a means of capturing more wind energy and improving diesel generator efficiency.
- *Coordinate a Cogeneration (Combined Heat and Power) Feasibility Study*. Due to the potential economic benefit of cogeneration (combined heat and power) systems, it is recommended to implement a feasibility study of such systems for Kotzebue.
- *Coordinate an End-Use Energy Efficiency Study*. Kotzebue stakeholders should implement a study of end-use energy efficiency, with a particular focus on how energy efficiency could impact the efficiency of the existing generation sets.
- *Research Additional Home Heating Energy Options*. While home heating oil will remain as the mainstay for home heating, additional energy source options should be reviewed.
- *Coordinate Exploration Drilling/Geophysical Investigations for Hydrocarbon and Geothermal Resources*. The extent of natural gas, oil, or geothermal resources in the Kotzebue area is presently unknown, and would required exploratory drilling and geophysical work to assess the resource.

[30] Small Hydroelectric Inventory of Villages Served by Alaska Village Electric Cooperative, U.S. Dept. of Energy, Alaska Power Administration. December 1979.

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Appendix C
Ambler Energy Options Analysis

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AMBLER OVERVIEW[31]

Ambler, population 277, is located on the north bank of the Kobuk River, near the confluence of the Ambler and the Kobuk Rivers. It is 138 miles northeast of Kotzebue, 30 miles northwest of Kobuk and 30 miles downriver from Shungnak. Ambler is located in the continental climate zone, which is characterized by long, cold winters and mild summers. The Kobuk River is navigable from early July to mid-October. Crowley Marine Services barges fuel and goods from Kotzebue each summer. Small boats, ATVs and snow machines are used for local travel.

Ambler's economy is a mix of cash and subsistence activities. Chum salmon and caribou are the most important food sources. Freshwater fish, moose, bear, and berries are also harvested. Birch baskets, fur pelts, jade, quartz, bone, and ivory carvings are sold in gift shops throughout the state. The community is interested in developing a lapidary facility for local artisans.

The main source of water for the community is pumped from a 167' well near the Kobuk River to the treatment facility and stored in a 210,000-gallon insulated storage tank. An 80' standby well is also located at the water treatment plant. Sewage is collected via 6- and 8-inch arctic pipes and flows to a facultative lagoon through two lift stations, where it discharges to a natural watershed, then to the Kobuk River. A new water treatment plant, washeteria, and sewage lagoon have been funded. The landfill is not permitted.

CURRENT ENERGY CONDITIONS

The Alaska Village Electric Cooperative currently provides power to the community of Ambler with a 982-kW diesel power plant. The utility generated 1,363,646 kWh total in Ambler during fiscal year 2007 (PCE report for fiscal year 2007). During the same period, the community imported 100,053 gallons of fuel for power generation use. The average pre-PCE residential electric rate for fiscal year 2007 (based on 500 KWh monthly usages) was 53.49 cents per kWh.

According to AVEC's end-of-year 2006 generation statistics, the peak demand recorded to date at the Ambler AVEC power plant is 319 kW, with an overall average plant load in 2006 of 150 kW. The average 2006 price of diesel fuel purchased by AVEC in Ambler for power generation purposes was $2.66 per gallon. The average 2006 cost of generating a kWh of electricity was 19.55 cents per kWh.

The primary source for community home heating is heating oil, which is shipped to Ambler on the spring and fall barges. The current usable fuel storage capacity in Ambler by tank farm owner: Village Council (238,100 gallons); AVEC (98,550); Northwest Arctic Schools (29,000); Nunamiut (12,000); Ambler Air Service (2,153).

AMBLER ENERGY OPTIONS

A preliminary screening analysis of best available energy options for the Ambler community included a high level review of reports, resource maps, and understanding of best available technology. Below is a list of energy options that require further analysis, followed by a discussion of each option. These options were identified through reports, resource maps, and the consultant's knowledge, but community members and other stakeholders may have additional source knowledge. As new information is brought forward, it will be incorporated into the analysis.

[31] State of Alaska Department of Community and Economic Development Community website.

- *Combined Heat and Power Systems (Cogeneration)*. The preliminary screening analysis for Ambler suggested waste heat recovery as a potential source of economic benefits for the community if a potential end-use for the heat is located in close proximity to the power house. According to the Alaska Rural Energy Plan, a potential use of the cogeneration heat was to keep fuel storage tanks and distribution lines warm enough to use a more economical type of diesel fuel or to provide heat to an end-user.
- *End-Use Energy Efficiency*. End-Use Energy Efficiency (including electrical lighting, refrigerator/freezers, appliances, new space heating, and new water heating) has been identified as a potential source of economic benefits for Ambler. Types of interventions that could be considered for this initiative could include light bulb replacement program, upgrades to the thermal performance (insulation) of homes, the replacement of inefficient appliances, weatherization initiatives, and upgrades to the existing diesel generators. All end-use energy efficiency initiatives should be modeled/assessed in its impact on the diesel generation power and efficiency curves.
- *Wind-Diesel Hybrid Systems*. The NANA Region Wind Resource Status Report predicted for Ambler a low wind resource, Class 1 or "Poor." Potentially developable wind resources are predicted for hills about 10 miles to the northwest of Ambler.
- *Home Heating Oil*. Home heating oil will remain as a source of heating for Ambler homes and will likely remain as an option into the future. Since this is a fossil fuel, it will fluctuate with the global economics of crude oil. The potential for other home heating sources should be reviewed.
- *Electrical Intertie*. Two communities are within a reasonable distance from Ambler for an electrical intertie line: Shungnak and Kobuk, both of which are already connected by an existing electrical intertie that is about 7 miles long. Kobuk has very limited capacity for power generation, and purchases virtually all of its electricity from the Shungnak AVEC power plant via the intertie. The distance between Ambler and Shungnak is about 24 miles, and an intertie could be economically feasible.
- *Geothermal*. According to the Alaska Geothermal Resources Map and local knowledge, the closest known geothermal sources are at Division Hot Springs, located about 60 miles south of Ambler. The water temperatures of the Division Hot Springs are significantly below the necessary temperature of ~80º C for Chena-type power generation, although field investigations are needed to determine if hotter fluid exists below ground.
- *Hydroelectric*. Both a 1979 study by the U.S. Department of Energy[32] and a 1981 study commissioned by the U.S. Army Corps of Engineers[33] examined two potential hydroelectric sites on Jade Creek, located 9 miles northwest of Ambler. With a possible installed capacity ranging between 106 kW and 370 kW, a hydroelectric plant on Jade Creek was judged to be uneconomic. The 1981 study proposed a 106-kW installation on the East Fork of Jade Creek, with an estimated average annual plant factor of 0.27. Minimal power production would occur from December through April, and the environmental constraints listed were the presence of whitefish and arctic grayling in the stream.
- *Solar*. While solar is not widely used in Alaska, it does remain an option for power generation and home heating. A review of solar technology should be undertaken.
- *Biomass*. The biomass map in the Renewable Energy Atlas of Alaska identifies the Ambler area as "mixed forest and broadleaf." Wood from local trees is already used as a practical home heating source and should be investigated further.

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[32] Small Hydroelectric Inventory of Villages Served by Alaska Village Electric Cooperative, U.S. Dept. of Energy, Alaska Power Administration. December 1979.

[33] Regional Inventory and Reconnaissance Study for Small Hydropower Projects: Northwest Alaska. Ott Water Engineers, Inc., prepared for the U.S. Army Corps of Engineers, Alaska District. May 1981.

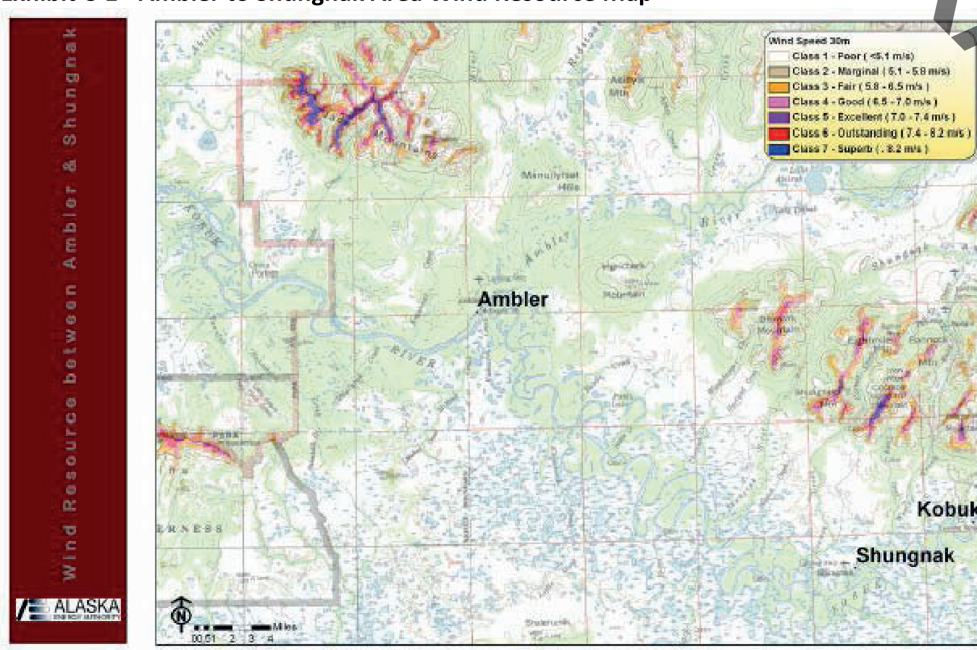
RECOMMENDED ENERGY OPTIONS FOR AMBLER

The following recommendations are provided for the community of Ambler in order to frame energy policy for the region.

- *Coordinate a Cogeneration (Combined Heat and Power) Feasibility Study*. Due to the potential economic benefit of cogeneration (combined heat and power) systems, it is recommended to implement a feasibility study of such systems for Ambler. This could be done at the time that the Bulk Fuel and Power System Upgrades are undertaken in Ambler. UCG of local coals sources may be a feasible option with further study.
- *Coordinate an End-Use Energy Efficiency Study*. Ambler stakeholders should implement a study of end-use energy efficiency, with a particular focus on how energy efficiency could impact the efficiency of the existing generation sets.
- *Research Additional Home Heating Energy Options*. While home heating oil will remain as the mainstay for home heating, additional energy source options should be reviewed. In particular, local biomass (wood) options should be studied.
- *Research Electrical Intertie with Shungnak*. The 25-mile distance between Ambler and Shungnak may be short enough to justify an electric intertie line.

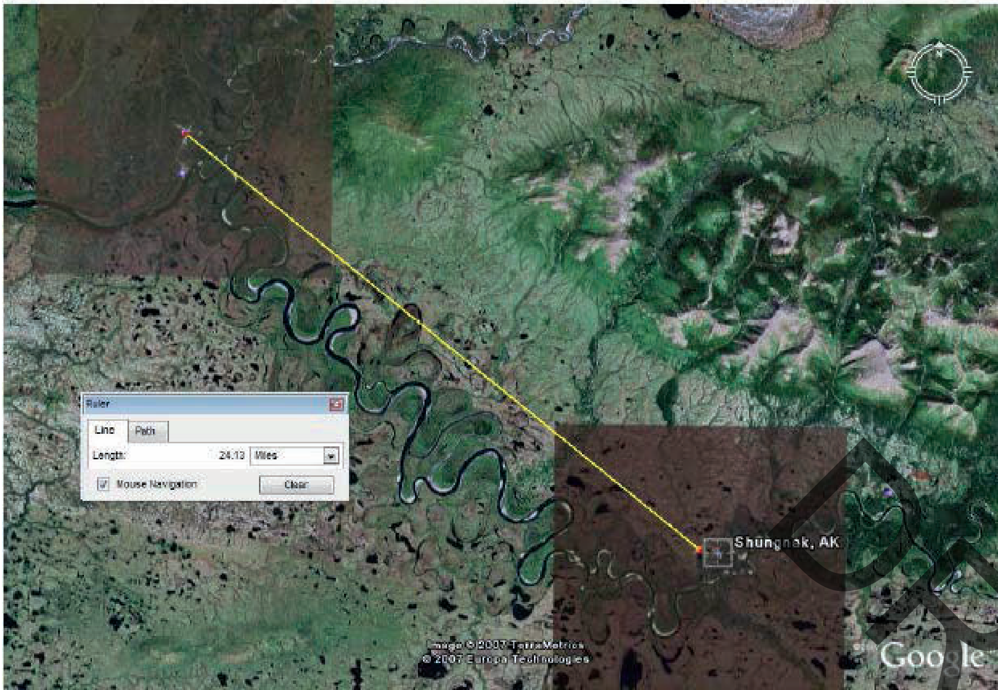
AMBLER EXHIBITS

Exhibit C-1 - Ambler to Shungnak Area Wind Resource Map



Source: NANA Region Wind Resource Status Report

Exhibit C-2 - Ambler to Shungnak Tie-line Distance Google Earth Image



Source: NANA Region Wind Resource Status Report

GEOTHERMAL PROSPECTS OF AMBLER AREA

Table C-1 – Division Hot Springs

Temp.	Flow (LPM)	TDS	SiO_2 geothermometer	Giggenbach geothermometer
68ºC / 154ºF	820	-	-	-
56ºC / 133ºF	2070	-	-	-

Source: NANA Geothermal Assessment Project (GAP) Draft Literature Review

Several hot springs comprise the Division Hot Springs, also called Shungnak Hot Springs or Selawik Hot Springs. They are approximately 40 miles from the Kobuk-Shungnak area and approximately 60 miles from Ambler. They are located on the north side of the Purcell Mountains, inside the Selawik National Wildlife Refuge. The lower springs are slightly cooler than the upper springs, so the source of the thermal water is probably topographically high. Like Hawk and South Hot Springs, the Division Hot Springs issue from within the Cretaceous-age, anomalously radioactive Wheeler Creek Pluton (Miller and Johnson, 1978; see description of Wheeler Creek Pluton above). Division Hot Springs are some of the hottest springs in the NANA region, but they are still significantly below the necessary temperature of ~80 ºC for Chena-type power generation. At this time, there are no geothermometer predictions of hotter fluid at depth – but is due to a lack of data. The flow rate of the upper spring is extremely high relative to other CAHSB Hot Springs, which would reduce the amount of pumping required for production. Hence, based on resource factors alone, these springs should be prospective for development; however their location inside of a National Wildlife Refuge could complicate development plans.

Appendix D
Buckland Energy Options Analysis

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BUCKLAND OVERVIEW[34]

Buckland, population 457, is located on the west bank of the Buckland River, about 75 miles southeast of Kotzebue. Buckland is located in the transitional climate zone which is characterized by long, cold winters and cool summers. Crowley Marine barges fuel in and various lighterage companies deliver cargo and supplies each summer. Small boats, ATVs and snow machines are used for local travel.

Buckland's economy is a mix of cash and subsistence activities. Residents depend on a subsistence lifestyle for most food sources. Chum salmon and caribou are the most important food sources. Freshwater fish, moose, bear, and berries are also harvested. A herd of more than 2,000 caribou are managed; workers are paid in meat. Cash employment is primarily with the school, city government, health clinic, stores, and some mining activities. The community is interested in developing a Native food products and crafts manufacturing facility to produce reindeer sausage, berry products, Labrador tea and ivory and wood carving.

Water is pumped from Buckland River, treated in the washeteria building, and stored in a 100,000-gallon tank. Some residents have water delivered to home tanks, but most haul their own water. The City of Buckland pumps flush/haul waste tanks or hauls honey buckets to the sewage lagoon. A flush/haul system has been problematic on the South side of town and freezes and fails during the winter. Only 8 homes and the school have functioning plumbing; 74 homes are not served. A new water treatment plant and sewage lagoon improvements are under construction. The landfill is not permitted.

CURRENT ENERGY CONDITIONS

The City of Buckland currently provides power to the community, with a 1,173-kW diesel power plant. The facility, operated by the city under contract to the Kotzebue Electric Association, generated 1,518,027 kWh total in Buckland during fiscal year 2007 (most recent PCE report). During the same period of time, the community imported 109,943 gallons of fuel for power generation use. The average fiscal year 2007 price of diesel fuel purchased by the City of Buckland for power generation purposes was $2.52 per gallon. The average pre-PCE residential electric rate for fiscal year 2007 (based on monthly usage of 500 KWh) in Buckland was 40.36 cents per kWh.

The primary source used for home heating for the community is home heating oil, which is shipped to Buckland on the spring and fall barges. It is unlikely that biomass (i.e. wood) is viable as a primary source as a home heating fuel.[35] However, this should be confirmed.

The current usable fuel storage capacity in Buckland by tank farm owner: Village Council Fuel Depot (151,800 gallons); Northwest Arctic Schools (62,500); City Power Plant (178,980 gallons); City Water/Washeteria (16,100); City Office/Clinic (14,800); Army National Guard (4,600); Alaska Dept. of Transportation and Public Facilities (2,700).

BUCKLAND ENERGY OPTIONS

A preliminary screening analysis of best available energy options for the Buckland community included a high level review of reports, resource maps, and understanding of best available technology. Below is a list of energy options that require further analysis, followed by a discussion of each option. These options were identified through reports, resource maps, and the consultant's knowledge, but community members and

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[34] State of Alaska Department of Community and Economic Development Community website.

[35] A review of the Alaska Department of Natural Resources Biomass Map did not suggest significant potential for biomass.

other stakeholders may have additional source knowledge. As new information is brought forward, it will be incorporated into the analysis.

- *Combined Heat and Power Systems (Cogeneration)*. The preliminary screening analysis for Buckland suggested waste heat recovery as a potential source of economic benefits for the community if a potential end-use for the heat is located in close proximity to the power house. According to the Alaska Rural Energy Plan, a potential use of the cogeneration heat was to keep fuel storage tanks and distribution lines warm enough to use a more economical type of diesel fuel or to provide heat to an end-user.
- *End-Use Energy Efficiency.* End-Use Energy Efficiency, including electrical lighting, refrigerator/freezers, appliances, new space heating, and new water heaters, has been identified as a potential source of economic benefits for Buckland. Types of interventions that could be considered for this initiative could include a light bulb replacement program, upgrades to thermal performance (insulation) of homes, replacement of inefficient appliances, weatherization initiatives, and upgrades to the existing diesel generators. All end-use energy efficiency initiatives should be modeled/assessed in its impact on the diesel generation power and efficiency curves.
- *Wind-Diesel Hybrid Systems.* The NANA Region Wind Resource Status Report predicted that good wind resources exist along the ridges several miles west of Buckland. The possible wind energy sites in this area are close to an existing road.
- *Home Heating Oil*. Home heating oil will remain as a source of heating for Buckland homes and will likely remain as an option into the future. Since this is a fossil fuel, it will fluctuate with the global economics of crude oil. The potential for other home heating sources should be reviewed.
- *Electrical Intertie*. The only community within a reasonable distance for an electrical intertie line is Deering. The distance between Buckland and Deering is about 50 miles, and could make an intertie economically unfeasible.
- *Geothermal*. According to the Alaska Geothermal Resources Map and local knowledge, there are known geothermal sources in close proximity. Villagers use these sources for recreational purposes during winter. Granite Mountain Hot Springs is located approximately 40 miles south of Buckland. Another possible geothermal site is the Inmachuk Springs, which are located approximately 30 miles equidistant from both Deering and Buckland. Little is currently known about the geothermal potential in the Deering/Buckland area aside from state maps and local knowledge. The water temperatures of the Division Hot Springs are significantly below the necessary temperature of ~80º C for Chena-type power generation, although field investigations are needed to determine if hotter fluid exists below ground.
- *Hydroelectric*. A 1981 study commissioned by the U.S. Army Corps of Engineers[36] examined a potential hydroelectric site on Hunter Creek, located 23 miles southwest of Buckland. The 1981 study proposed a 238-kW installation on Hunter Creek, with an estimated average annual plant factor of 0.27. Minimal power production would occur from December through April, and the environmental constraints listed were the presence of whitefish and arctic grayling in the stream. Partly due to the length of a needed transmission line, the project was judged to be economically unfeasible.
- *Solar*. While solar is not widely used in Alaska, it does remain an option for power generation and home heating. A review of solar technology should be undertaken.

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[36] Regional Inventory and Reconnaissance Study for Small Hydropower Projects: Northwest Alaska. Ott Water Engineers, Inc., prepared for the U.S. Army Corps of Engineers, Alaska District. May 1981.

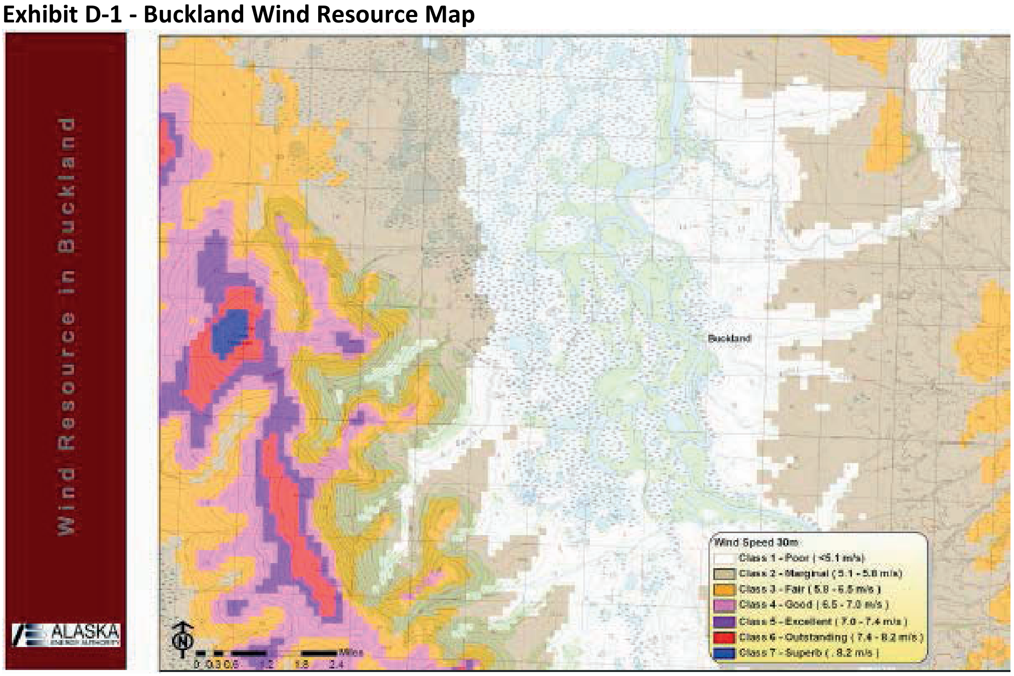
RECOMMENDED ENERGY OPTIONS FOR BUCKLAND

The following recommendations are provided for the community of Buckland in order to frame energy policy for the region.

- *Wind Resource Assessment Program*. The Buckland community is presently collecting wind data through the Alaska Energy Authority's wind resource assessment program. Data from an AEA met tower, installed in 2005 near the village, indicates Class 2 winds. In June 2008, this met tower was moved to a new location on a hill top several miles west of Buckland, where stronger winds are expected.
- *Coordinate a Geothermal Power Generation Feasibility Study.* The geothermal power potential should be reviewed for the community of Buckland by a qualified individual.
- *Coordinate a Cogeneration (Combined Heat and Power) Feasibility Study*. Due to the potential economic benefit of cogeneration (combined heat and power) systems, it is recommended to implement a feasibility study of such systems for Buckland. This could be done at the time that the Bulk Fuel and Power System Upgrades are undertaken for Buckland.
- *Coordinate an End-Use Energy Efficiency Study*. Buckland stakeholders should implement a study of end-use energy efficiency, with a particular focus on how energy efficiency could impact the efficiency of the existing generation sets.
- *Research Additional Home Heating Energy Options*. While home heating oil will remain as the mainstay for home heating, additional energy source options should be reviewed. In particular, local biomass (wood) options should be studied.

BUCKLAND EXHIBITS

Exhibit D-1 - Buckland Wind Resource Map



Source: NANA Region Wind Resource Status Report

GEOTHERMAL PROSPECTS IN BUCKLAND AREA

Table D-1 – Granite Mountain Hot Springs

Temp.	Flow (LPM)	TDS	SiO_2 geothermometer	Giggenbach geothermometer
49ºC / 120ºF	1630	260	121.7 ºC	100.7 ºC
			117.5 ºC	95.7 ºC

Source: NANA Geothermal Assessment Project (GAP) Draft Literature Review

Granite Mountain Hot Springs is located approximately 40 miles south of Buckland and 60 miles south of Deering. The springs issue from the contact between the anomalously radioactive Granite Mountain Pluton and the Cretaceous age volcanic rocks. The Granite Mountain Pluton is uranium-enriched, however not enough to be commercial (Gault and others, 1951). The springs are located on Spring Creek, a tributary of Sweepstakes Creek. The temperature of these hot springs is significantly below the temperature of the fluids utilized for power generation at Chena Hot Springs (~80 ºC) However, if the geothermometer predictions are correct and there is hotter fluid at depth, these springs could be suitable for development. The flow rate is fairly high relative to other CAHSB Hot Springs, meaning that less pumping may be required for production.

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Appendix E
Deering Energy Options Analysis

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ENERGY OPTIONS ANALYSIS

The objective of an energy options analysis is to provide preliminary screening analysis of energy options for a particular community. The energy sources described below are considered to be a first order, pre-feasibility screening. Additional analysis/study is needed to determine the feasibility of different energy sources for the community. This document will remain in draft until it is integrated into NW Alaska Regional Energy Plan.

DEERING OVERVIEW[37]

Deering, population 131, is located on Kotzebue Sound at the mouth of the Inmachuk River, 57 miles southwest of Kotzebue. It is built on a flat spit composed of sand and gravel, about 300 feet wide and a half-mile long. Deering is located in the transitional climate zone, which is characterized by long, cold winters and cool summers. Kotzebue Sound is ice-free from early July until mid-October. Crowley Marine Services barges fuel and goods from Kotzebue each summer. Small boats, ATVs and snow machines are used for local travel. Winter trails are available to Candle and Buckland.

Deering's economy is a mix of cash and subsistence activities. Moose, seal and beluga whale provide most meat sources; pink salmon, tom cod, herring, ptarmigan, rabbit and waterfowl are also utilized. The village wants to develop eco-tourism, including a 38-mile road to Inmachuk Springs for tourists.

Water is derived from the Inmachuk River, is treated and pumped to two raw water storage tanks, 400,000-gallon in capacity and one with a 425,000-gallon capacity. Major improvements are under construction for a water haul and vacuum sewer system. A new washeteria and water treatment plant are in operation. Archaeological remains were discovered while excavating for the new system. The City would like to purchase an incinerator with waste heat recovery to reduce the volume of refuse.

CURRENT ENERGY CONDITIONS

The Ipnatchiaq Electric Company currently provides power to the community of Deering, with a diesel power plant with a total generating capacity of 585-kW. The facility generated 709,559 kWh total in Deering during fiscal year 2007 (most recent PCE report). During the same period of time, the community imported 62,878 gallons of fuel for power generation use, and the price of diesel fuel purchased by the Ipnatchiaq Electric Company for power generation purposes was $3.11 per gallon. The average pre-PCE residential electric rate for fiscal year 2007 (based on monthly usage of 500 KWh) in Deering was 49.00 cents per kWh.

The primary source used for home heating for the community is home heating oil, which is shipped to Deering on the spring and fall barges. It unlikely that biomass (i.e. wood) would be a viable as a primary source as a home heating fuel.[38] However, this should be confirmed.

The current usable fuel storage capacity in Deering by tank farm owner: Village Council (88,600 gallons); City (84,500); Northwest Arctic Schools (36,800).

DEERING ENERGY OPTIONS

A preliminary screening analysis of best available energy options for the Derring community included a high level review of reports, resource maps, and understanding of best available technology. Below is a list of energy options that require further analysis, followed by a discussion of each option. These options were identified through reports, resource maps, and the consultant’s knowledge, but community members and

[37] State of Alaska Department of Community and Economic Development Community website.

[38] A review of the Alaska Department of Natural Resources Biomass Map did not suggest significant potential for biomass.

other stakeholders may have additional source knowledge. As new information is brought forward, it will be incorporated into the analysis.

- *Combined Heat and Power Systems (Cogeneration)*. The preliminary screening analysis for Deering suggested waste heat recovery as a potential source of economic benefits for the community if a potential end-use for the heat is located in close proximity to the power house. According to the Alaska Rural Energy Plan, a potential use of the cogeneration heat was to keep fuel storage tanks and distribution lines warm enough to use a more economical type of diesel fuel or to provide heat to an end-user. Finally, the City of Deering would like to purchase an incinerator with waste heat recovery to reduce the volume of refuse and to provide a source of heat to a potential end-user.
- *End-Use Energy Efficiency*. End-Use Energy Efficiency (including electrical lighting, refrigerator/freezers, appliances, new space heating, and new water heating) has been identified as a potential source of economic benefits for Deering. Types of interventions that could be considered for this initiative could include light bulb replacement program, upgrades to the thermal performance (insulation) of homes, the replacement of inefficient appliances, weatherization initiatives, and upgrades to the existing diesel generators. All end-use energy efficiency initiatives should be modeled/assessed in its impact on the diesel generation power and efficiency curves.
- *Wind-Diesel Hybrid Systems*. According to the Alaska Rural Energy Plan, Deering has been identified as an attractive opportunity for wind-diesel hybrid development with a benefit cost ratio of 1.55. To be considered for development, the B/C ratio should be greater than 1; Deering has been identified as the fifth most attractive community for wind power development according to the Alaska Rural Energy Plan. Additional efficiencies could result if improved switchgear, SCADA systems, and remote monitoring systems are incorporated into the wind/diesel design.
- *Home Heating Oil*. Home heating oil will remain as a source of heating for Deering homes and will likely remain as an option into the future. Since this is a fossil fuel, it will fluctuate with the global economics of crude oil. The potential for other home heating sources should be reviewed, such as coal deposits or other resources which could exist in the region.
- *Electrical Intertie*. The only community within reasonable distance for a tie-line/inter-tie is Buckland. The distance between Buckland and Deering is about 50 miles, and could make an intertie economically unfeasible.
- *Geothermal*. According to the Alaska Geothermal Resources Map and local knowledge, there are known geothermal sources in close proximity. Villagers use these sources for recreational purposes during the winter. Granite Mountain Hot Springs is located approximately 60 miles southeast of Deering. Another possible geothermal sites are Inmachuk Springs, which are located approximately 30 miles equidistant from both Deering and Buckland; Lava Creek Hot Springs, located about 50 miles south of Deering; and Serpentine Hot Springs, located about 60 miles west of Deering. Little is currently known about the geothermal potential in the Deering/Buckland area aside from state maps and local knowledge. The water temperatures of Division Hot Springs are significantly below the necessary temperature of ~80º C for Chena-type power generation, although field investigations are needed to determine if hotter fluid exists below the ground.
- *Hydroelectric*. Both a 1979 study by the U.S. Department of Energy[39] concluded that there are no potential hydroelectric sites in close proximity to Deering.
- Solar. While solar is not widely used in Alaska, it does remain an option for power generation and home heating. A review of solar technology should be undertaken.

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[39] Small Hydroelectric Inventory of Villages Served by Alaska Village Electric Cooperative, U.S. Dept. of Energy, Alaska Power Administration. December 1979.

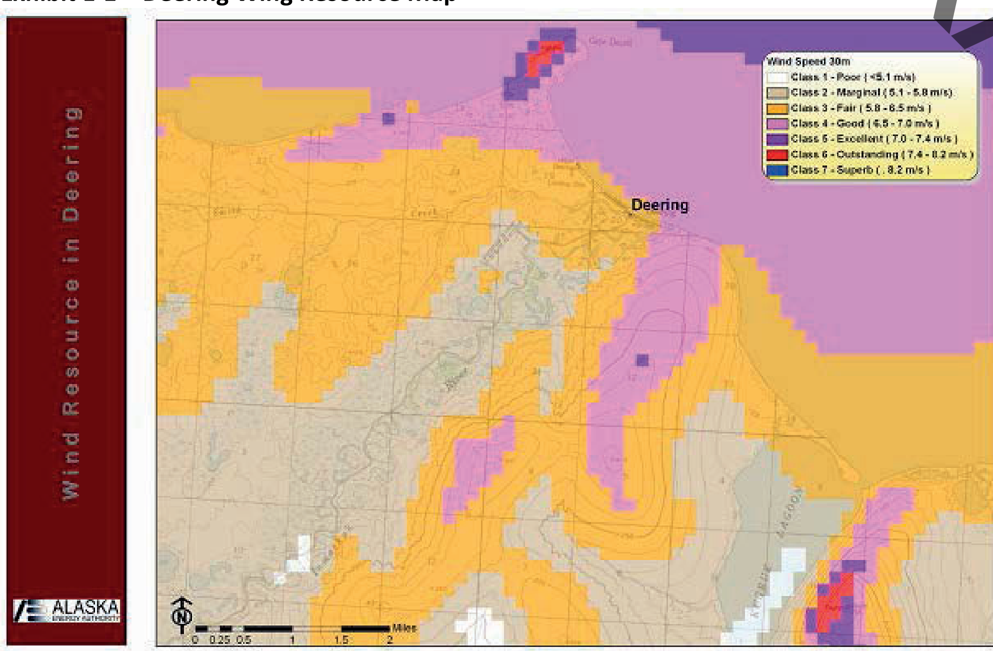
RECOMMENDED ENERGY OPTIONS FOR DEERING

The following recommendations are provided for the community of Deering in order to frame energy policy for the region.

- *Wind Resource Assessment Program*. The Deering Community is currently collecting wind data with a met tower, installed in August 2008, borrowed through the Alaska Energy Authority's wind resource assessment program.
- *Coordinate a Geothermal Power Generation Feasibility Study*. The geothermal power potential should be reviewed for the community of Deering by a qualified individual.
- *Coordinate a Cogeneration (Combined Heat and Power) Feasibility Study*. Due to the potential economic benefit of cogeneration (combined heat and power) systems, it is recommended to implement a feasibility study of such systems for Deering. UCG with local coal resources may be feasible for CHP with further study.
- *Coordinate an End-Use Energy Efficiency Study*. Deering stakeholders should implement a study of end-use energy efficiency, with a particular focus on how energy efficiency could impact the efficiency of the existing generation sets.
- *Research Additional Home Heating Energy Options*. While home heating oil will remain as the mainstay for home heating, additional energy source options should be reviewed.

DEERING EXHIBITS

Exhibit E-1 – Deering Wing Resource Map



Source: NANA Region Wind Resource Status Report

GEOTHERMAL PROSPECTS OF DERRING AREA

Table E-1 – Serpentine Hot Springs

Temp.	Flow (LPM)	TDS	SiO_2 geothermometer	Giggenbach geothermometer
75ºC / 167ºF	520	3290	137.10 ºC	119.0 ºC
60ºC / 140ºF	137 GPM	2472.7	130.8 ºC	111.4 ºC

Serpentine Hot Springs, located approximately 60 miles west of Deering in the Bering Land Bridge National Preserve, is the hottest of all the springs in the CAHSB. It is also anomalously saline relative to other CAHSB springs, containing elevated concentrations of total dissolved solids (TDS), mostly Cl, Na, Ca, K, Li , Br, and B

(Miller, 1973). The hot springs issue out of the Serpentine Hot Springs granite, which is actually a composite body of several different granites emplaced at different times. The composite body is cut by several sets of steep faults. An intricate network of faults southeast of the granite is associated with major geochemical anomalies and mineralized areas lying along a NW-trending fault zone (Sainsbury and others, 1980). The Serpentine Hot Springs granite contains small amounts of radioactive material disseminated throughout; however not in large enough quantities to be commercially interesting (Moxham and West, 1953). Based on temperature data alone, these springs appear be suitable for Chena-type power generation, though the salinity of the fluids could be an issue in terms of scaling in wells and pipes.

Table E-2 – Lava Creek Hot Springs

Temp.	Flow (LPM)	TDS	SiO2 geothermometer	Giggenbach geothermometer
53ºC / 127ºF	360	330	118.2 ºC	96.6 ºC
50ºC / 122ºF	360	295.5	-	-

Lava Creek Hot Springs is located approximately 50 miles south of Deering and 70 miles southwest of Buckland. The hot springs are about 15 miles south of the Lost Jim lava flow and the Imuruk Lake volcanic field, some of the youngest lava flows in western Alaska. The Imuruk Lake volcanic field is a vast geologic feature consisting of flows and ~75 vents (cones) that covers nearly 2,300 km2 of area. The largest and most recent cone is the Lost Jim vent, which erupted 1,655 years ago; but the bulk of the volcanic deposits are much older (5.7 to 2.2 million years old). This suggests that this part of the Seward Peninsula may still be a volcanically "active" region. The hot spring, however, issues from within granitic rocks of the Bendeleben Mountains, not the volcanic deposits. It is so named because the spring is located approximately 3 miles from the probable source area for the basalt that flowed down Lava Creek in the Bendeleben Mountains (Miller and others, 1973). The Imuruk Lake area lies in a poorly defined graben (Hopkins, 1959) with giant scarps as high as 30 m and as long as 5 km (Wood and Kienle, 1990). Several faults in the Bendeleben Mountains continue this trend, but it is not clear whether the Lava Creek Hot Springs are situated on or near such faults. The hot springs are also about 10 miles northeast of the Death Valley / Boulder Creek uranium deposit, which follows a northwest-trending linear strike. If the geothermometer predictions are correct and hotter fluid exists at depth, then depending on the depth of the reservoir these springs could be suitable for Chena-type power generation. One concern is that the flow rate is somewhat low so substantial pumping may be required.

Table E-3 – Granite Mountain Hot Springs

Temp.	Flow (LPM)	TDS	SiO_2 geothermometer	Giggenbach geothermometer
49ºC / 120ºF	1630	260	121.7 ºC	100.7 ºC
			117.5 ºC	95.7 ºC

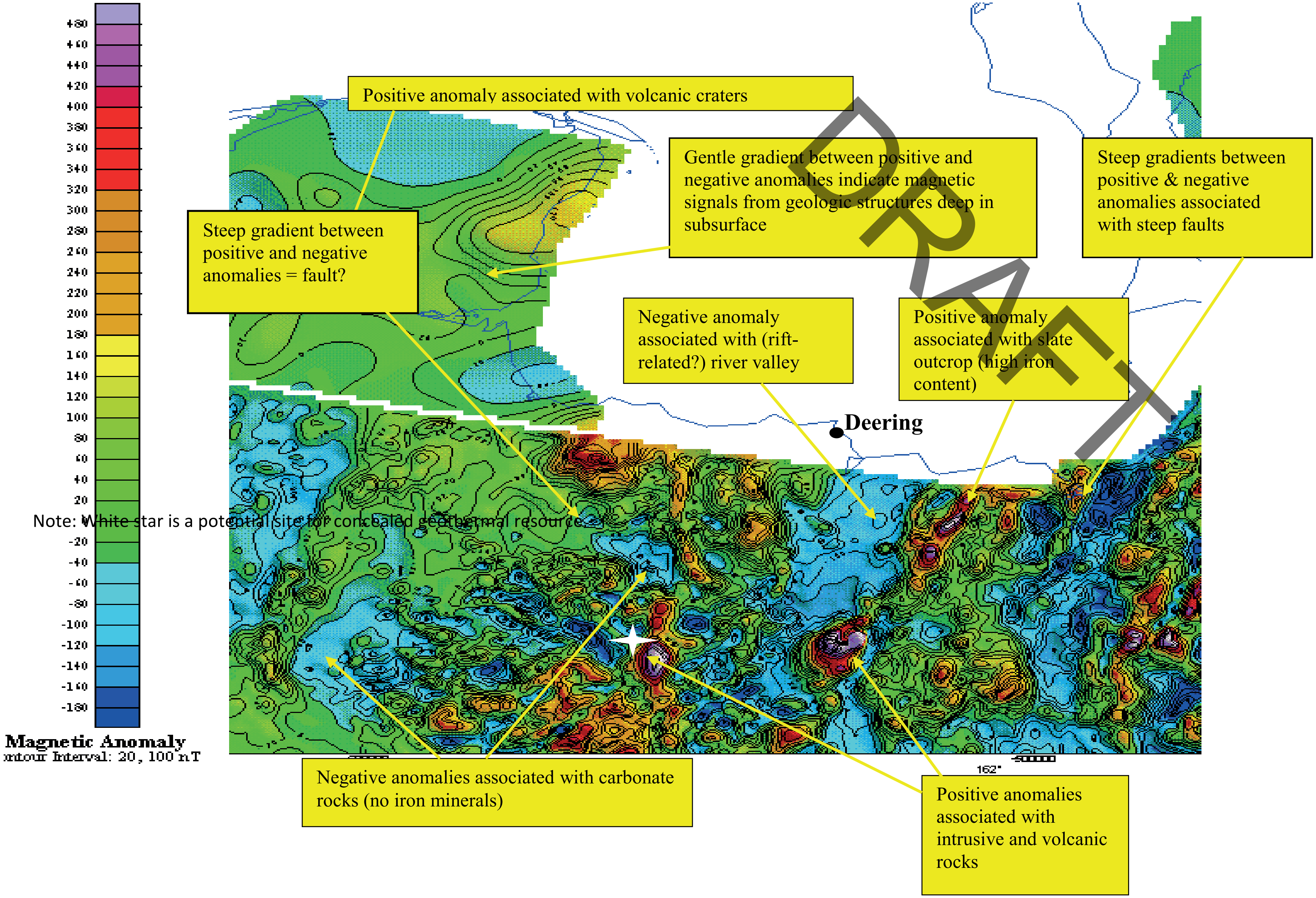
Granite Mountain Hot Springs is located approximately 40 miles south of Buckland and 60 miles south of Deering. The springs issue from the contact between the anomalously radioactive Granite Mountain Pluton and the Cretaceous age volcanic rocks. The Granite Mountain Pluton is uranium-enriched, however not enough to be commercial (Gault and others, 1951). The springs are located on Spring Creek, a tributary of Sweepstakes Creek. The temperature of these hot springs is significantly below the temperature of the fluids utilized for power generation at Chena Hot Springs (~80 ºC) However, if the geothermometer predictions are correct and there is hotter fluid at depth, these springs could be suitable for development. The flow rate is fairly high relative to other CAHSB Hot Springs, meaning that less pumping may be required for production.

AEROMAGNETIC MAPS

Six aeromagnetic maps were obtained from the USGS Alaska Digital Aeromagnetic Database that cover the NANA region. Details on the aeromagnetic data can be found at http://pubs.usgs.gov/of/1999/ofr-99-0503/. Aeromagnetic maps show the spatial distribution and relative abundance of magnetic minerals (iron oxides) in the upper levels of the crust. Because different rock types differ in their content of magnetic minerals, the magnetic map allows a visualization of the geologic structure of the upper subsurface (www.wikipedia.org). For example, the iron mineral magnetite is abundant in volcanic and some plutonic rocks, distinguishing them from sedimentary rocks that tend to have low to zero iron content.

It is important to note that aeromagnetic maps cannot be used to "see" geothermal resources; but they can aid in geologic interpretations and thus aid in predicting the occurrences of subsurface thermal reservoirs. An example of an aeromagnetic map is shown in Fig. 5. This map, considered in the context of other geologic and geophysical data, can be utilized to target certain locations that satisfy the seemingly requisite conditions for geothermal resources in the NANA region. Based on what we know about almost all hot springs in the CAHSB, geothermal resources are likely to occur at the pluton margins; or if it is a composite pluton, at the contact between different plutonic phases (see Sainsbury and others, 1980; and Kolker and others, 2007). Fig. 5 shows the location of one possible intersection between fault(s) and a pluton (indicated by a white star). In the case of known hot springs, careful examination of aeromagnetic maps can also aid in understanding subsurface structures and therefore speculating on the geometry of the feeder hydrothermal reservoir.

Figure E-1 - Aeromagnetic map of the Deering area, with geologic interpretations



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Appendix F
Kiana Energy Options Analysis

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KIANA OVERVIEW[40]

Kiana, population 401, is located on the north bank of the Kobuk River, 57 air miles east of Kotzebue. The Kobuk River is navigable from the end of May to early October. Kiana is located in the transitional climate zone, which is characterized by long, cold winters and mild summers. Crowley Marine Services barges fuel and goods from Kotzebue each summer and local store owners have large boats to bring supplies upriver. Small boats, ATVs and snow machines are used for local travel. A road extends along the river to Kobuk Camp, and a network of old trading trails exists.

Kiana's economy is a mix of cash and subsistence activities. Chum salmon, freshwater fish, moose, caribou, waterfowl and berries are harvested. The school, City, Maniilaq Association and three general stores provide the majority of year-round jobs. The Red Dog Mine also provides some jobs, and seasonal employment also includes work on river barges, BLM fire-fighting and jade mining. There is local interest in constructing a whitefish and turbot value-added processing plant. The City is also interested in developing eco-tourism, primarily guided river trips to the Great Kobuk Sand Dunes.

A 200,000-gallon steel tank is intermittently filled from two wells near the Kobuk River. Water is chlorinated prior to distribution through buried water mains. Piped water and sewer are provided to 73 homes, a clinic, school, and community hall. Kiana maintains a 6-inch buried gravity sewer system, which drains to a lift station and is pumped through a buried force main to the sewage treatment lagoon northeast of the village. In addition, 19 households haul water and use honey buckets or septic tanks. The landfill is located west of the sewage disposal lagoon, and needs to be relocated. A water and sewer master plan, new water treatment, and additional service connections have been funded.

CURRENT ENERGY CONDITIONS

The Alaska Village Electric Cooperative currently provides power to the community of Kiana, with a 1163-kW diesel power plant. The utility generated 1,529,950 kWh total in Kiana during fiscal year 2007 (most recent PCE report). During the same period of time, the community imported 103,820 gallons of fuel for power generation use. The average pre-PCE residential electric rate for fiscal year 2007 (based on monthly usage of 500 KWh) in Kiana was 51.03 cents per kWh.

According to AVEC's end-of-year 2006 generation statistics, the peak demand recorded to date at the Kiana AVEC power plant is 365 kW, with an overall average plant load in 2006 of 172 kW. The average 2006 price of diesel fuel purchased by AVEC in Kiana was $2.45 per gallon. The average 2006 fuel-only cost of generating a kWh of electricity in Kiana was 18.78 cents per kWh.

The primary source used for home heating for the community is home heating oil, which is shipped to Kiana on the spring and fall barges.

The current usable fuel storage capacity in Kiana by tank farm owner: AVEC (136,621 gallons); Northwest Arctic Schools (107,700); City (94,300); Kiana Trading Post (51,400); Blankenship Trading Post (7,100); Alaska Dept. of Transportation and Public Facilities (2,900); City Firehouse (2,200).

KIANA ENERGY OPTIONS

A preliminary screening analysis of best available energy options was undertaken for Kiana. This included a high level review of reports, resource maps, and understanding of best available technology. Below is a list

[40] State of Alaska Department of Community and Economic Development Community website.

of energy options that require further analysis, followed by a discussion of each option. These options were identified through reports, resource maps, and the consultant's knowledge, but community members and other stakeholders may have additional source knowledge. As new information is brought forward, it will be incorporated into the analysis.

- *Combined Heat and Power Systems (Cogeneration)*. The preliminary screening analysis for Kiana suggested waste heat recovery as a potential source of economic benefits for the community if a potential end-use for the heat is located in close proximity to the power house. According to the Alaska Rural Energy Plan, a potential use of the cogeneration heat was to keep fuel storage tanks and distribution lines warm enough to use a more economical type of diesel fuel or to provide heat to an end-user.
- *End-Use Energy Efficiency*. End-Use Energy Efficiency (including electrical lighting, refrigerator/freezers, appliances, new space heating, and new water heating) has been identified as a potential source of economic benefits for Kiana. Types of interventions that could be considered for this initiative could include light bulb replacement program, upgrade to thermal performance (insulation) of homes, the replacement of inefficient appliances, weatherization initiatives, and upgrades to the existing diesel generators. All end-use energy efficiency initiatives should be modeled/assessed in its impact on the diesel generation power and efficiency curves.
- *Wind-Diesel Hybrid Systems*. The NANA Region Wind Resource Status Report predicted for Kiana a wind resource of Class 2 to 3 (or "Marginal" to "Fair"). However, wind resources of Class 5 to 7 (or "Excellent" to "Superb") are predicted for hills about 6 miles to the east-northeast of Kiana.
- *Home Heating Oil*. Home heating oil will remain as a source of heating for Kiana homes and will likely remain as an option into the future. Since this is a fossil fuel, it will fluctuate with the global economics of crude oil. The potential for other home heating sources should be reviewed.
- *Electrical Intertie*. The closest community within a reasonable distance for an electrical intertie line is Noorvik. The straight-line distance between Kiana and Noovik is about 19 miles, and could make an intertie economically feasible.
- *Geothermal*. According to the Alaska Geothermal Resources Map and local knowledge, there are no known geothermal sources in close proximity to Kiana.
- *Hydroelectric*. Both a 1979 study by the U.S. Department of Energy[41] and a 1981 study commissioned by the U.S. Army Corps of Engineers[42] examined a potential hydroelectric site on Canyon Creek, located 8 miles northeast of Kiana. The 1979 study also identified a second possible hydroelectric site at Portage Creek, located 7 miles south of Kiana. The 1981 study proposed a 205-kW installation on Canyon Creek, with an estimated average annual plant factor of 0.22. Minimal power production would occur from December through April, and the environmental constraints listed were the presence of whitefish and arctic grayling in the stream, as well as potential peregrine falcon nesting habitat.
- *Solar*. While solar is not widely used in Alaska, it does remain an option for power generation and home heating. A review of solar technology should be undertaken.
- *Biomass*. The biomass map in the Renewable Energy Atlas of Alaska identifies the Kiana area as "mixed forest and broadleaf."

[41] Small Hydroelectric Inventory of Villages Served by Alaska Village Electric Cooperative, U.S. Dept. of Energy, Alaska Power Administration. December 1979.
[42] Regional Inventory and Reconnaissance Study for Small Hydropower Projects: Northwest Alaska. Ott Water Engineers, Inc., prepared for the U.S. Army Corps of Engineers, Alaska District. May 1981.

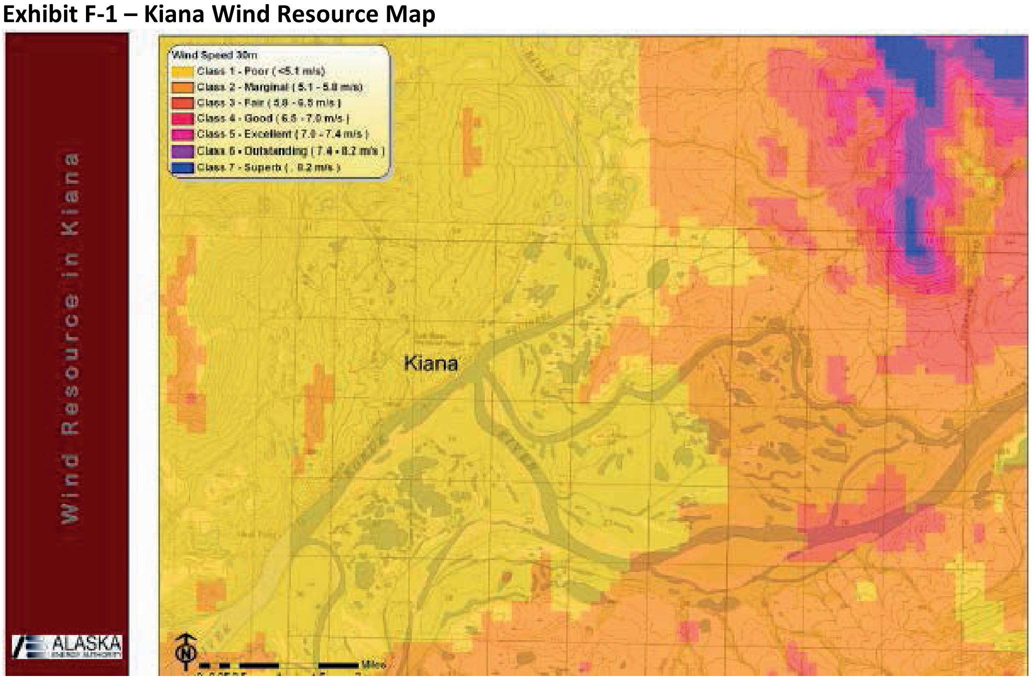
RECOMMENDED ENERGY OPTIONS FOR KIANA

The following recommendations are provided for the community of Kiana in order to frame energy policy for the region.

- *Coordinate a Cogeneration (Combined Heat and Power) Feasibility Study*. Due to the potential economic benefit of cogeneration (combined heat and power) systems, it is recommended to implement a feasibility study of such systems for Kiana. This could be done at the time that the Bulk Fuel and Power System Upgrades are undertaken in Kiana. UCG with local coal resources for CHP may be feasible based on further study.
- *Coordinate an End-Use Energy Efficiency Study*. Kiana stakeholders should implement a study of end-use energy efficiency, with a particular focus on how energy efficiency could impact the efficiency of the existing generation sets.
- *Wind Resource Assessment Program*. Unless an inexpensive way to access the wind resources on the hills outside Kiana can be found, the community should combine a wind resource assessment program with Noorvik (in case an intertie is built between the two communities).
- *Research Additional Home Heating Energy Options*. While home heating oil will remain as the mainstay for home heating, additional energy source options should be reviewed. In particular, local biomass (wood) options should be studied.
- *Research Electrical Intertie with Noorvik*. The 19-mile distance between Kiana and Noorvik may be short enough to justify an electric intertie line.
- *Research Local Hydroelectric Options*. Although small-scale hydropower could only provide significant power for Kiana from May through November, the Canyon Creek site (located 8 miles from town) warrants further investigation.

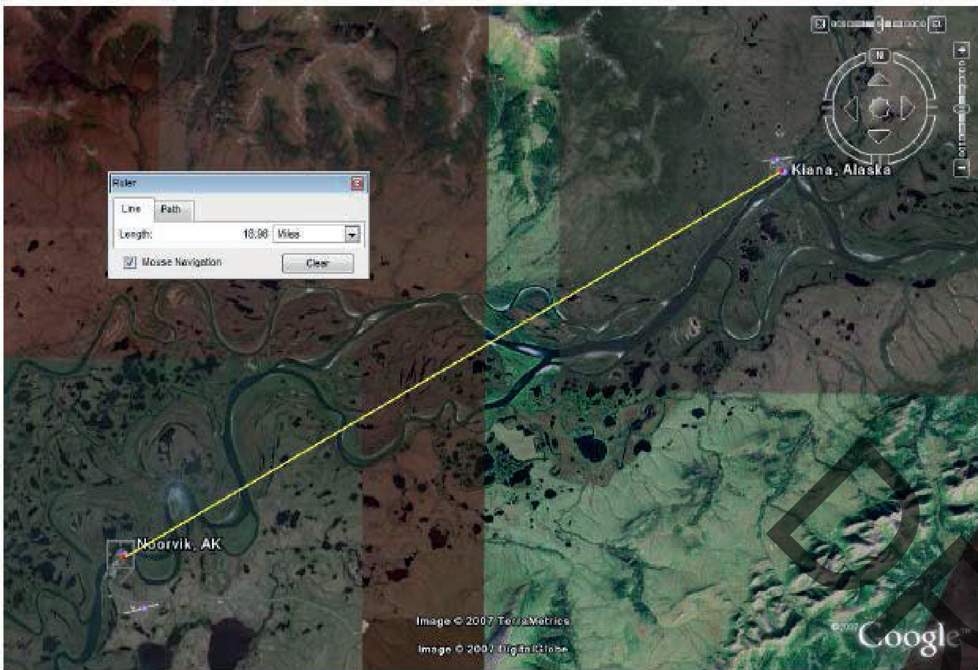
KIANA EXHIBITS

Exhibit F-1 – Kiana Wind Resource Map



Source: NANA Region Wind Resource Status Report

Exhibit F-2 – Kiana Wind Resource Map



Source: NANA Region Wind Resource Status Report

Appendix G
Kivalina Energy Options Analysis

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KIVALINA OVERVIEW[43]

Kivalina, population 391, lies about 80 air miles northwest of Kotzebue at the tip of an 8-mile barrier reef in between the Chukchi Sea and Kivalina River. Kivalina is located in the transitional climate zone which is characterized by long, cold winters and cool summers. The Chukchi Sea is ice-free and open to boat traffic from mid-June to the first of November. The major means of transportation into the community are plane and barge. Crowley Marine Services barges goods from Kotzebue during July and August. Small boats, ATVs and snow machines are used for local travel. Two main hunting trails follow the Kivalina and Wulik Rivers.

Due to severe erosion and wind-driven ice damage, the City intends to relocate to a new site 7.5 miles away. Relocation alternatives have been studied and a new site has been designed and engineered. The relocation is estimated to cost $102 million. The community needs a road to the proposed new town site.

Kivalina's economy is a mix of cash and subsistence activities. Residents depend on a subsistence lifestyle for most food sources. Seal, walrus, whale, salmon, whitefish and caribou are utilized. Cash employment is primarily with the school, city government, Maniilaq Association, village council, airlines and local stores. The nearby Red Dog Mine also offers some employment. Native carvings and jewelry are produced from ivory and caribou hooves. The community is interested in developing an Arts and Crafts Center that could be readily moved to the new city site.

Wells have proven unsuccessful in Kivalina. Water is drawn from the Wulik River via a 3-mile surface transmission line, and is stored in a 700,000-gallon raw water tank. It is then treated and stored in a 500,000-gallon steel tank. Water is hauled by residents from this tank. One-third of residents have tanks which provide running water for the kitchen, but homes are not fully plumbed. The school and clinic have individual water and sewer systems. Residents haul their own honey buckets to bunkers. A new landfill and honey bucket disposal site were recently completed. A Master Plan is underway to examine sanitation alternatives at the new community site.

CURRENT ENERGY CONDITIONS

The Alaska Village Electric Cooperative currently provides power to the community of Kivalina, with a 1040-kW diesel power plant. The utility generated 1,307,779 kWh total in Kivalina during fiscal year 2007 (most recent PCE report). During the same period of time, the community imported 93,795 gallons of fuel for power generation use. The average pre-PCE residential electric rate for fiscal year 2007 (based on monthly usage of 500 KWh) in Kivalina was 51.16 cents per kWh.

According to AVEC's end-of-year 2006 generation statistics, the peak demand recorded to date at the Kivalina AVEC power plant is 267 kW, with an overall average plant load in 2006 of 144 kW. The average 2006 price of diesel fuel purchased by AVEC in Kivalina for power generation purposes was $2.39. The average 2006 fuel-only cost of generating a kWh of electricity in Kivalina was 17.18 cents per kWh.

The primary source used for home heating for the community is home heating oil, which is shipped to Kivalina on the spring and fall barges. It is unlikely that biomass (i.e. wood) is viable as a primary source as a home heating fuel[44]. However, this should be confirmed.

The current usable fuel storage capacity in Kivalina by tank farm owner: Native Store (135,800); AVEC (101,037 gallons); Northwest Arctic Schools (49,600); Army National Guard (10,000); City Washeteria (7,800); Alaska Dept. of Transportation and Public Facilities (2,700).

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[43] State of Alaska Department of Community and Economic Development Community website.

[44] A review of the Alaska Department of Natural Resources Biomass Map did not suggest significant potential for biomass.

KIVALINA ENERGY OPTIONS

A preliminary screening analysis of best available energy options was undertaken for Kivalina. This included a high level review of reports, resource maps, and understanding of best available technology. Below is a list of energy options that require further analysis, followed by a discussion of each option. These options were identified through reports, resource maps, and the consultant's knowledge, but community members and other stakeholders may have additional source knowledge. As new information is brought forward, it will be incorporated into the analysis.

- *Combined Heat and Power Systems (Cogeneration)*. The preliminary screening analysis for Kivalina suggested waste heat recovery as a potential source of economic benefits for the community if a potential source is located in close proximity to the power house. According to the Alaska Rural Energy Plan, a potential use of the cogeneration heat was to keep fuel storage tanks and distribution lines warm enough to use a more economical type of diesel fuel or to provide heat to an end-user.
- *End-Use Energy Efficiency*. End-Use Energy Efficiency (including electrical lighting, refrigerator/freezers, appliances, new space heating, and new water heating) has been identified as a potential source of economic benefits for Kivalina. Types of interventions that could be considered for this initiative could include light bulb replacement program, upgrades to the thermal performance (insulation) of homes, the replacement of inefficient appliances, weatherization initiatives, and upgrades to the existing diesel generators. All end-use energy efficiency initiatives should be modeled/assessed in its impact on the diesel generation power and efficiency curves.
- *Wind-Diesel Hybrid Systems*. The NANA Region Wind Resource Status Report predicted that good wind resources exist in Kivalina (Class 4). However, if the community decides to move to a new location, a met tower could be erected on-site, or at the nearby Port of Red Dog Mine, to collect the data needed to support wind power development.
- *Home Heating Oil*. Home heating oil will remain as a source of heating for Kivalina homes and will likely remain as an option into the future. Since this is a fossil fuel, it will fluctuate with the global economics of crude oil. The potential for other home heating sources should be reviewed.
- *Electrical Intertie and Road Connection*. At its present location, Kivalina is about 16 miles (straight line) from the Port of Red Dog Mine, although a new village location presumably would be closer. The relatively short distance between the community and the port could make both an electrical intertie line and new road economically feasible.
- *Geothermal*. According to the Alaska Geothermal Resources Map and local knowledge, there are no known geothermal sources in close proximity to Kivalina.
- *Hydroelectric*. A 1979 study by the U.S. Department of Energy[45] concluded that there are no potential hydroelectric sites in close proximity to Kivalina.
- *Solar*. While solar is not widely used in Alaska, it does remain an option for power generation and home heating. A review of solar technology should be undertaken.

RECOMMENDED ENERGY OPTIONS FOR KIVALINA

The following recommendations are provided for the community of Kivalina in order to frame energy policy for the region.

- *Wind Resource Assessment Program*. The Kivalina community should commence with a wind resource assessment program through the Alaska Energy Authority. A met tower should be

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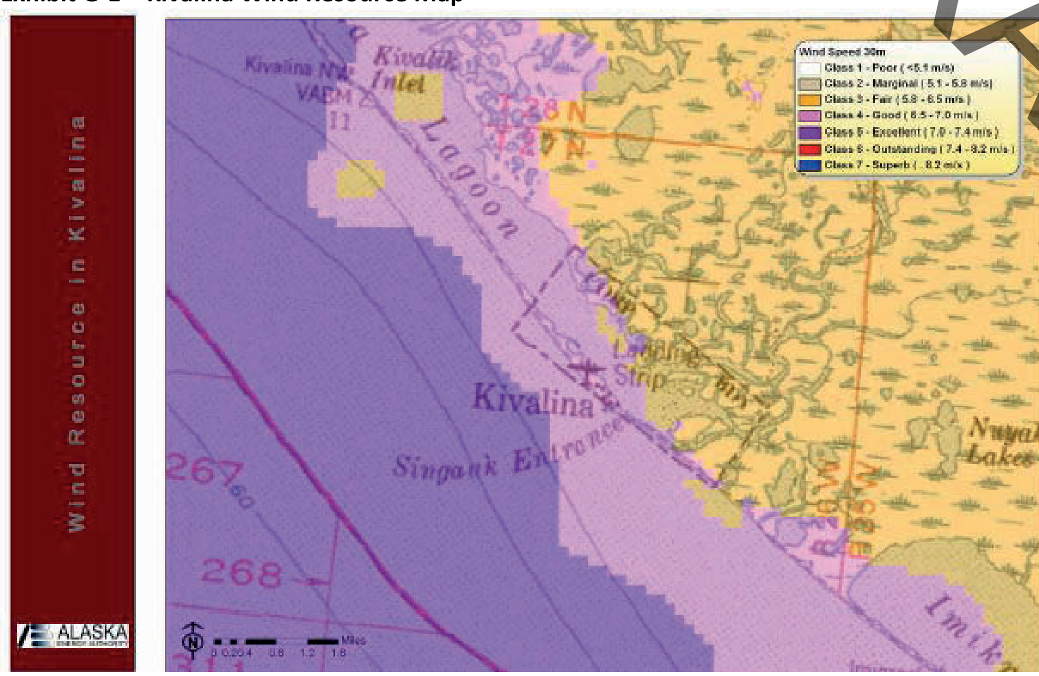
[45] Small Hydroelectric Inventory of Villages Served by Alaska Village Electric Cooperative, U.S. Dept. of Energy, Alaska Power Administration. December 1979.

installed at the Port of Red Dog Mine, and the possibility of building an intertie between the port and the village investigated.

- *Coordinate a Cogeneration (Combined Heat and Power) Feasibility Study*. Due to the potential economic benefit of cogeneration (combined heat and power) systems, it is recommended to implement a feasibility study of such systems for Kivalina. This could be done at the time that the Bulk Fuel and Power System Upgrades are undertaken for Kivalina.
- *Coordinate an End-Use Energy Efficiency Study*. Kivalina stakeholders should implement a study of end-use energy efficiency, with a particular focus on how energy efficiency could impact the efficiency of the existing generation sets.
- *Research Additional Home Heating Energy Options*. While home heating oil will remain as the mainstay for home heating, additional energy source options should be reviewed.
- *Research Electrical Intertie and Road Connection with Red Dog Mine Port*. The 16-mile distance between the present site of Kivalina and the Port of Red Dog Mine may be short enough to justify an electric intertie line. If the community of Kivalina is moved, it is expected that the new town site would be even closer to the port area and could then also justify the construction of a new road. An intertie would also provide access to locations for wind power generation away from Kivalina where FAA airspace and erosion conditions exist.

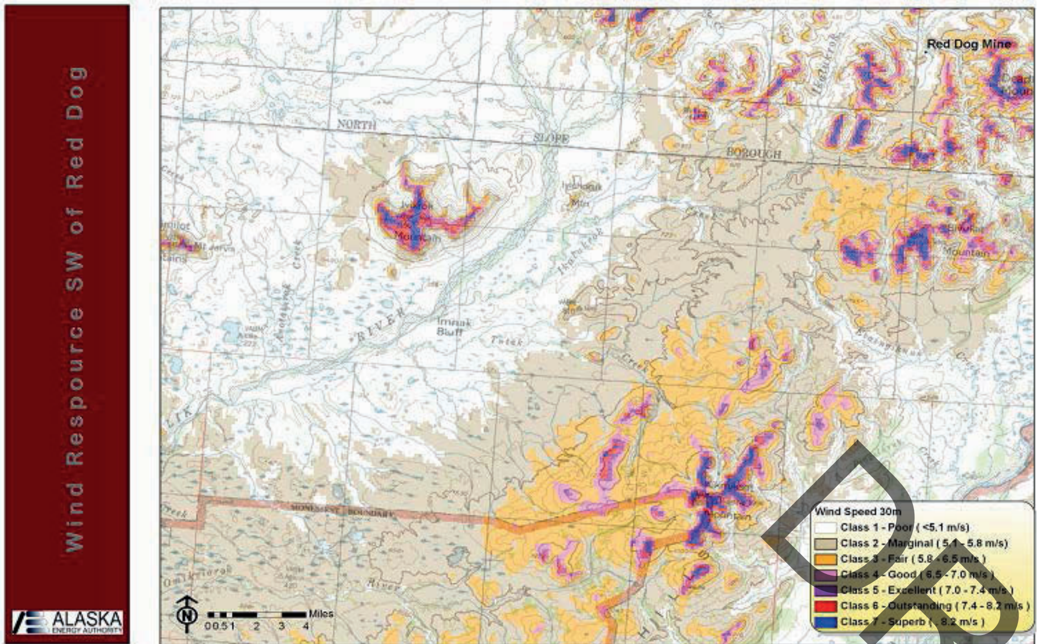
KIVALINA EXHIBITS

Exhibit G-1 – Kivalina Wind Resource Map



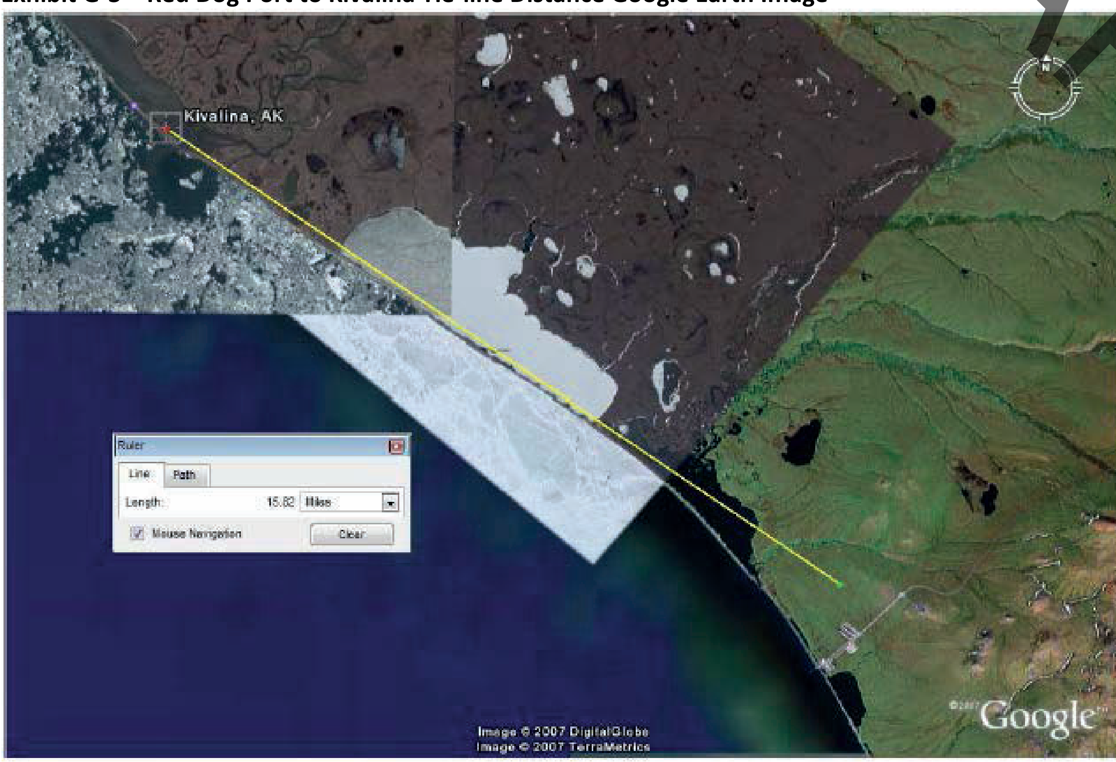
Source: NANA Region Wind Resource Status Report

Exhibit G-2 – Red Dog Mine Wind Resource Map



Source: NANA Region Wind Resource Status Report

Exhibit G-3 – Red Dog Port to Kivalina Tie-line Distance Google Earth Image



Source: NANA Region Wind Resource Status Report

Appendix H
Noatak Energy Options Analysis

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NOATAK OVERVIEW[46]

Noatak, population 500, is located on the west bank of the Noatak River, 55 miles north of Kotzebue and 70 miles north of the Arctic Circle. This is the only settlement on the 396 mile-long Noatak River, just west of the 66-million acre Noatak National Preserve.

Noatak is located in the transitional climate zone which is characterized by long, cold winters and mild summers. The Noatak River is navigable by shallow-draft boats from early June to early October. Noatak is primarily accessed by air; there are currently no barge services to Noatak. Small boats, ATVs and snow machines are used for local travel. Many historic trails along the Noatak River are important today for inter-village travel and subsistence uses.

Noatak's economy is a mix of cash and subsistence activities. Residents depend on a subsistence lifestyle for most food sources. Chum salmon, whitefish, caribou, moose and waterfowl are harvested. Cash employment is primarily with the school, local government, Maniilaq Association, and local stores. During the summer, many families travel to seasonal fish camps at Sheshalik, and others find seasonal work in Kotzebue or fire-fighting.

Water is derived from the Noatak River and is treated. The primary well occasionally runs dry -- groundwater wells have been unsuccessful in the area. A piped, re-circulating water and sewer distribution system serves over 150 homes, the school and businesses in Noatak. The village has recently upgraded the water supply, expanded the piped system, and constructed a washeteria. The landfill has recently been relocated west of the airport.

CURRENT ENERGY CONDITIONS

The Alaska Village Electric Cooperative currently provides power to the community of Noatak, with a 982-kW diesel power plant. The utility generated 1,492,730 kWh total during fiscal year 2007 (most recent PCE report). During the same period of time, the community imported 112,458 gallons of fuel for power generation use. The average pre-PCE residential electric rate for fiscal year 2007 (based on monthly usage of 500 KWh) in Kivalina was 71.18 cents per kWh.

According to AVEC's end-of-year 2006 generation statistics, the peak demand recorded to date at the Noatak AVEC power plant is 349 kW, with an overall average plant load in 2006 of 170 kW. The average 2006 price of diesel fuel purchased by AVEC in Noatak for power generation purposes was $3.98. The average 2006 fuel-only cost of generating a kWh of electricity in Noatak, 31.32 cents per kWh, was the highest of all the NANA communities.

The primary source used for home heating for the community is home heating oil, which is shipped to Noatak by air. It is unlikely that biomass (i.e. wood) would be viable as a primary source as a home heating fuel.[47] However, this should be confirmed.

The current usable fuel storage capacity in Noatak by tank farm owner: AVEC (91,922 gallons); Northwest Arctic Schools (89,500); IRA Native Store (65,300); Village Council (26,500); Army National Guard (7,400); Alaska Dept. of Transportation and Public Facilities (3,100).

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[46] State of Alaska Department of Community and Economic Development Community Web-site.

[47] A review of the Alaska Department of Natural Resources Biomass Map did not suggest significant potential for biomass.

NOATAK ENERGY OPTIONS

A preliminary screening analysis of best available energy options was undertaken for Noatak. This included a high level review of reports, resource maps, and understanding of best available technology. Below is a list of energy options that require further analysis, followed by a discussion of each option. These options were identified through reports, resource maps, and the consultant's knowledge, but community members and other stakeholders may have additional source knowledge. As new information is brought forward, it will be incorporated into the analysis.

- *Combined Heat and Power Systems (Cogeneration)*. The preliminary screening analysis for Noatak suggested waste heat recovery as a potential source of economic benefits for the community if a potential use for the heat energy is located in close proximity to the power house. According to the Alaska Rural Energy Plan, a potential use of the cogeneration heat was to keep fuel storage tanks and distribution lines warm enough to use a more economical type of diesel fuel or to provide heat to an end-user.
- *End-Use Energy Efficiency*. End-Use Energy Efficiency (including electrical lighting, refrigerator/freezers, appliances, new space heating, and new water heating) has been identified as a potential source of economic benefits for Noatak. Types of interventions that could be considered for this initiative could include light bulb replacement program, upgrades to the thermal performance (insulation) of homes, the replacement of inefficient appliances, weatherization initiatives, and upgrades to the existing diesel generators. All end-use energy efficiency initiatives should be modeled/assessed in its impact on the diesel generation power and efficiency curves.
- *Road Connection*. A road could be built to connect Noatak to the Red Dog Mine Road, which at its closest point to the community is about 18 miles (straight line) away. Trucks could use such a road to transport fuel from the Port of Red Dog Mine to Noatak, in order to eliminate the need of shipping fuel to Noatak by air, and thus reduce fuel costs in the community.
- *Wind-Diesel Hybrid Systems*. The NANA Region Wind Resource Status Report predicted that poor wind resources exist in Noatak (Class 1). The report also states that a met tower was installed in Noatak around 2003; but no known data has been collected from the site.
- *Home Heating Oil*. Home heating oil will remain as a source of heating for Noatak homes and will likely remain as an option into the future. Since this is a fossil fuel, it will fluctuate with the global economics of crude oil. The potential for other home heating sources should be reviewed.
- *Electrical Intertie*. Noatak is about 40 miles (straight line) from Kivalina, the next closest community, and is about 30 miles (straight line) from the Port of Red Dog Mine. The distances involved would likely make an electrical intertie line economically unfeasible.
- *Geothermal*. According to the Alaska Geothermal Resources Map and local knowledge, there are no known geothermal sources in close proximity to Noatak.
- *Hydroelectric*. A 1979 study by the U.S. Department of Energy[48] concluded that there are no potential hydroelectric sites in close proximity to Noatak.
- *Solar*. While solar is not widely used in Alaska, it does remain an option for power generation and home heating. A review of solar technology should be undertaken.

RECOMMENDED ENERGY OPTIONS FOR NOATAK

The following recommendations are provided for the community of Noatak in order to frame energy policy for the region.

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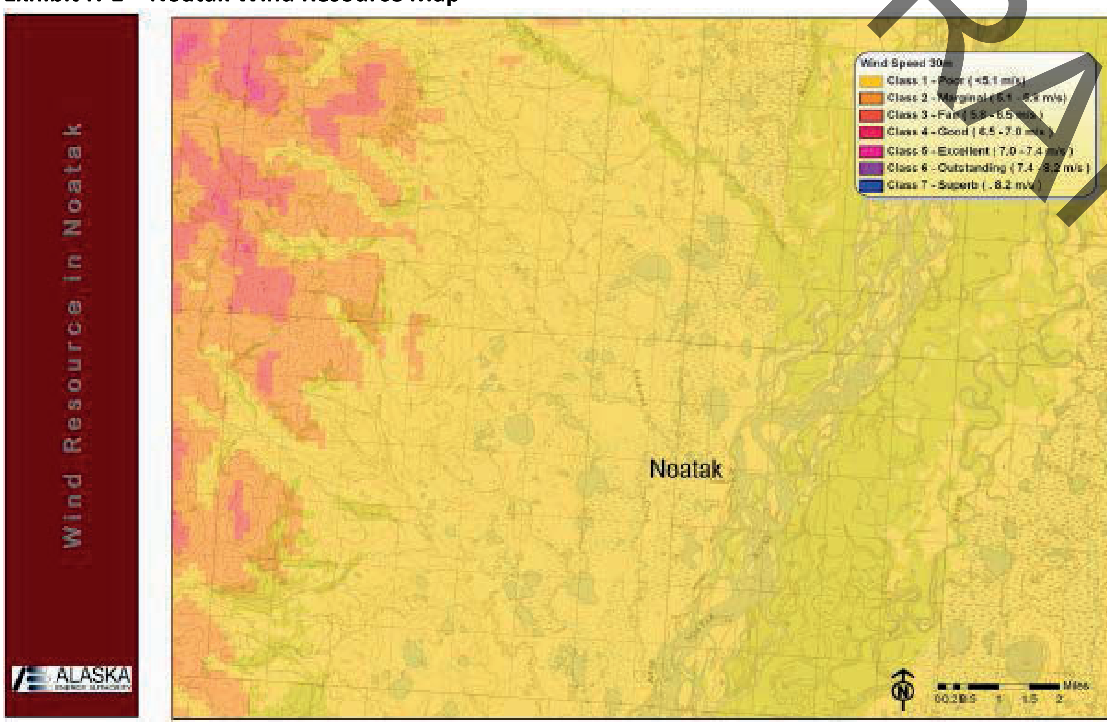
[48] Small Hydroelectric Inventory of Villages Served by Alaska Village Electric Cooperative, U.S. Dept. of Energy, Alaska Power Administration. December 1979.

- *Coordinate a Cogeneration Feasibility Study for Generation*. Due to the potential economic benefit of cogeneration systems, it is recommended to implement a feasibility study to ascertain the potential of cogeneration. This could be done at the time that the Bulk Fuel and Power System Upgrades are undertaken for Noatak.
- *Coordinate an End-Use Energy Efficiency Study*. Noatak stakeholders should implement a study of end-use energy efficiency, with a particular focus on how energy efficiency could impact the efficiency of the existing generation sets.
- *Research the Feasibility of a Road to Noatak*. A new road connecting Noatak to the Red Dog Mine Road should be studied, in order to possibly eliminate the costly shipping of fuel to Noatak by air.
- *Research Additional Home Heating Energy Options*. While home heating oil will remain as the mainstay for home heating, additional energy source options should be reviewed such as biomass and solar.
- *Wind Resource Assessment Program*. The Noatak Community should recommence with a wind energy feasibility study through the Alaska Energy Authority's wind resource assessment program. The met tower installed in Noatak should be investigated to see if it could be re-used.

NOATAK EXHIBITS

Exhibit H-1 – Noatak Wind Resource Map



Source: NANA Region Wind Resource Status Report

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Appendix I
Noorvik Energy Options Analysis

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NOORVIK OVERVIEW[49]

Noorvik, population 636, is located on the right bank of the Nazuruk Channel of the Kobuk River, 33 miles northwest of Selawik and 45 miles east of Kotzebue. The village is downriver from the 1.7-million acre Kobuk Valley National Park. The Kobuk River is navigable from the end of May to mid-October. Noorvik is located in the transitional climate zone, which is characterized by long, cold winters and mild summers. Crowley Marine Services barges fuel and goods from Kotzebue each summer. Small boats, ATVs and snowmachines are used for local travel. There is no road linking Noorvik to any other communities.

Noorvik's economy is a mix of cash and subsistence activities. Chum salmon, freshwater fish, moose, caribou, waterfowl and berries are harvested. The school, City, Maniilaq Association and two stores provide the majority of year-round jobs. The Red Dog Mine also provides some jobs, and seasonal employment also includes work on river barges and BLM fire-fighting.

Water is pumped from the Kobuk River to the water treatment/utility building and stored in a tank. From there, a pressurized circulating system distributes water in utilidors. Groundwater wells have proven unsuccessful. Noorvik has a vacuum sewer system in which waste is carried by air instead of water. Vacuum pressure pumps the sewage to the 60,000-gallon tank at the collection and treatment plant. The system requires special toilets and water valves which collect wastewater from the sinks, toilets and showers. Over 100 homes, the schools and businesses are served. Funds have been requested to connect and plumb the remaining 16 unserved homes on the south side of town and along River Road. A new landfill and access road are under development. Funds have also been requested to construct a multi-purpose facility, including a new washeteria, recreation center, Head Start, day care center, a restaurant, Native Crafts production and a food processing plant.

CURRENT ENERGY CONDITIONS

The Alaska Village Electric Cooperative currently provides power to the community of Noorvik, with a 1163-kW diesel power plant. The utility generated 1,991,566 kWh total in Noorvik during fiscal year 2007 (most recent PCE report). During the same period of time, the community imported 149,669 gallons of fuel for power generation use. The average pre-PCE residential electric rate for fiscal year 2007 (based on monthly usage of 500 KWh) in Noorvik was 52.71 cents per kWh.

According to AVEC's end-of-year 2006 generation statistics, the peak demand recorded to date at the Noorvik AVEC power plant is 474 kW, with an overall average plant load in 2006 of 226 kW. The average 2006 price of diesel fuel purchased by AVEC in Noorvik for power generation purposes was $2.42 per gallon. The average 2006 fuel-only cost of generating a kWh of electricity in Noorvik was 17.24 cents per kWh.

The primary source used for home heating for the community is home heating oil, which is shipped to Noorvik on the spring and fall barges.

The current usable fuel storage capacity in Noorvik by tank farm owner: AVEC (202,944 gallons); Native Store (130,500); Northwest Arctic Schools (94,900); Morris Trading Post (59,000); City (30,900).

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[49] State of Alaska Department of Community and Economic Development Community website.

NOORVIK ENERGY OPTIONS

A preliminary screening analysis of best available energy options was undertaken for Noorvik. This included a high level review of reports, resource maps, and understanding of best available technology. Below is a list of energy options that require further analysis, followed by a discussion of each option. These options were identified through reports, resource maps, and the consultant's knowledge, but community members and other stakeholders may have additional source knowledge. As new information is brought forward, it will be incorporated into the analysis.

- *Combined Heat and Power Systems (Cogeneration)*. The preliminary screening analysis for Noorvik suggested waste heat recovery as a potential source of economic benefits for the community if a potential end-use for the heat is located in close proximity to the power house. According to the Alaska Rural Energy Plan, a potential use of the cogeneration heat was to keep fuel storage tanks and distribution lines warm enough to use a more economical type of diesel fuel or to provide heat to an end-user.
- *End-Use Energy Efficiency*. End-Use Energy Efficiency (including electrical lighting, refrigerator/freezers, appliances, new space heating, and new water heating) has been identified as a potential source of economic benefits for Noorvik. Types of interventions that could be considered for this initiative could include light bulb replacement program, upgrades to the thermal performance (insulation) of homes, the replacement of inefficient appliances, weatherization initiatives, and upgrades to the existing diesel generators. All end-use energy efficiency initiatives should be modeled/assessed in its impact on the diesel generation power and efficiency curves.
- *Wind-Diesel Hybrid Systems*. It is understood that a met tower was installed about four miles east of Noorvik for a one-year period from September 2001 to September 2002. The NANA Region Wind Resource Status Report says that the preliminary results of the data collected during the 2001-2002 period indicates a Class 3 (fair) wind resource.
- *Home Heating Oil*. Home heating oil will remain as a source of heating for Noorvik homes and will likely remain as an option into the future. Since this is a fossil fuel, it will fluctuate with the global economics of crude oil. The potential for other home heating sources should be reviewed.
- *Electrical Intertie*. The closest community within a reasonable distance for an electrical intertie line is Kiana. The straight-line distance between Kiana and Noorvik is about 19 miles, and could make an intertie economically feasible.
- *Geothermal*. According to the Alaska Geothermal Resources Map and local knowledge, there are no known geothermal sources in close proximity to Noorvik.
- *Hydroelectric*. A 1979 study by the U.S. Department of Energy[50] concluded that there are no potential hydroelectric sites in close proximity to Noorvik.
- *Solar*. While solar is not widely used in Alaska, it does remain an option for power generation and home heating. A review of solar technology should be undertaken.
- *Biomass*. The biomass map in the Renewable Energy Atlas of Alaska identifies the Noorvik area as "mixed forest and broadleaf".

RECOMMENDED ENERGY OPTIONS FOR NOORVIK

The following recommendations are provided for the community of Noorvik in order to frame energy policy for the region.

- *Coordinate a Cogeneration (Combined Heat and Power) Feasibility Study*. Due to the potential economic benefit of cogeneration (combined heat and power) systems, it is recommended to

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[50] Small Hydroelectric Inventory of Villages Served by Alaska Village Electric Cooperative, U.S. Dept. of Energy, Alaska Power Administration. December 1979.

implement a feasibility study of such systems for Noorvik. This could be done at the time that the Bulk Fuel and Power System Upgrades are undertaken for Noorvik.

- *Coordinate an End-Use Energy Efficiency Study*. Noorvik stakeholders should implement a study of end-use energy efficiency, with a particular focus on how energy efficiency could impact the efficiency of the existing generation sets.
- *Wind Resource Assessment Program*. The Noorvik community should commence with a wind energy feasibility study through the Alaska Energy Authority. Noorvik had an installed met tower for a one-year period from September 2001 to September 2002, which produced enough data sufficient to characterize Noorvik as a Class 3 resource, and to plan a wind power project.
- *Research Additional Home Heating Energy Options*. While home heating oil will remain as the mainstay for home heating, additional energy source options should be reviewed. In particular, local biomass (wood) options should be studied.
- *Research Electrical Intertie with Noorvik*. The 19-mile distance between Kiana and Noorvik may be short enough to justify an electric intertie line.

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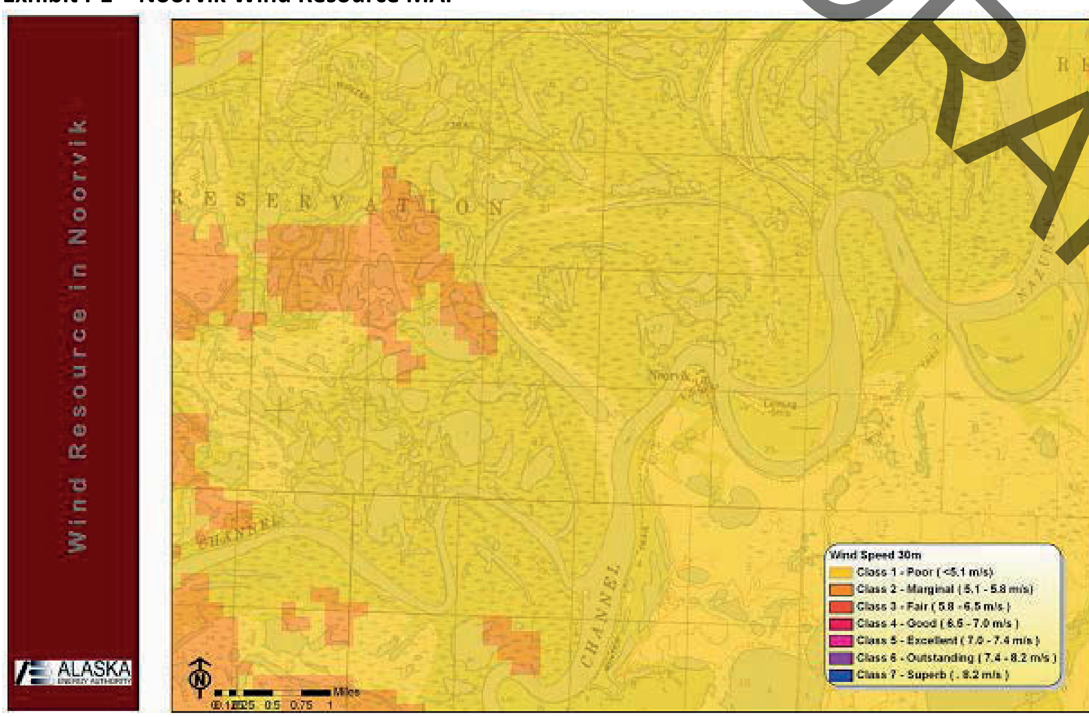
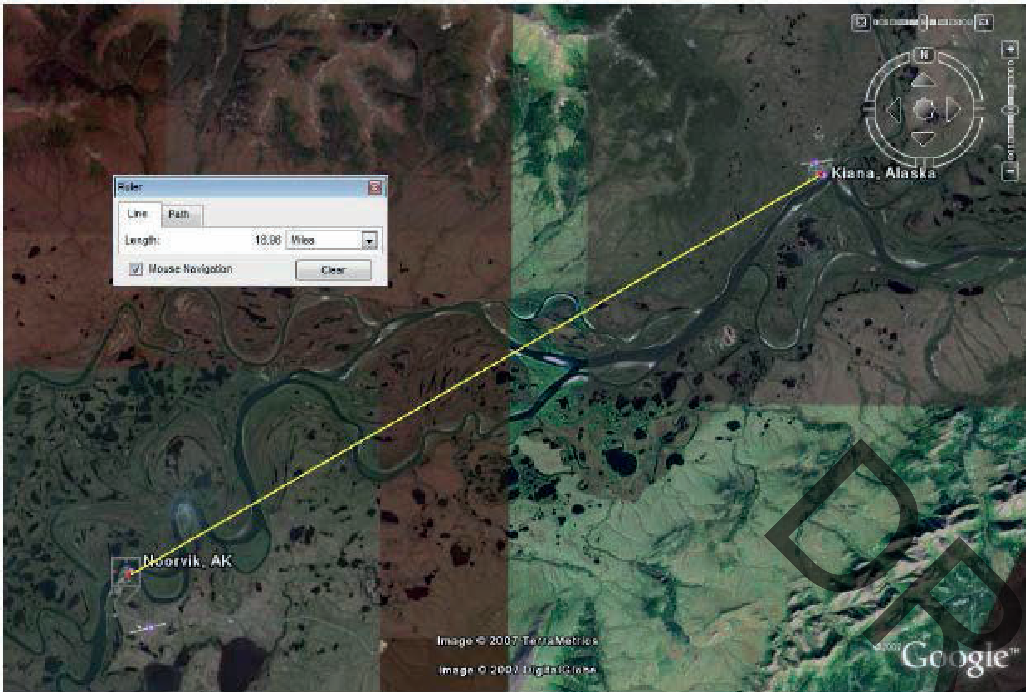
NOORVIK EXHIBITS

Exhibit I-1 – Noorvik Wind Resource MAP



Source: NANA Region Wind Resource Status Report

Exhibit I-2 Noorvik to Kiana Tie-line Distance Google Earth Image



Source: NANA Region Wind Resource Status Report

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Appendix J
Selawik Energy Options Analysis

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SELAWIK OVERVIEW[51]

Selawik, population 841, is located at the mouth of the Selawik River where it empties into Selawik Lake, about 90 miles east of Kotzebue. The community is near the Selawik National Wildlife Refuge, a key breeding and resting spot for migratory waterfowl. Selawik is located in the transitional climate zone, which is characterized by long, cold winters and mild summers. The Selawik River is navigable from early June to mid-October. Crowley Marine Services barges fuel and goods from Kotzebue each summer. Small boats, ATVs and snow machines are used for local travel. Boardwalks have been constructed within the village. There is no road linking Selawik to any other communities.

Selawik's economy is a mix of cash and subsistence activities. Whitefish, sheefish, moose, caribou, waterfowl and berries are harvested. Occasionally, bartered seal and beluga whale supplement the diet. The primary employers in the community include the school, the City, the IRA, Maniilaq and three grocery stores. Handicrafts are made and sold locally and at gift shops in larger cities. Seasonal work is also found outside of Selawik at the Red Dog Mine, BLM firefighting or on river barges.

A circulating water and vacuum sewer system was recently completed. A central treatment facility pumps water from the Selawik River, providing up to 8,000 gallons a day. Groundwater wells have been unsuccessful. 53 homes in the West II area of town and 20 new HUD homes have been plumbed and connected. About 30 homes are now connected on the island and near the airport. A new permitted landfill is needed.

CURRENT ENERGY CONDITIONS

The Alaska Village Electric Cooperative currently provides power to the community of Selawik, with a 1,686-kW diesel power plant as well as 200-kW of installed wind generation capacity (for a total of 1,886-kW total installed capacity). The utility generated 3,130,752 kWh total in Selawik during fiscal year 2007 (most recent PCE report), of which 94.1% (2,945,834 kWh) was from diesel and 5.9% (184,918 kWh) was from wind. During the same period of time, the community imported 209,058 gallons of fuel for power generation use. The average pre-PCE residential electric rate for fiscal year 2007 (based on monthly usage of 500 KWh) in Selawik was 50.62 cents per kWh.

According to AVEC's end-of-year 2006 generation statistics, the peak demand recorded to date at the Selawik AVEC power plant (both diesel and wind combined) is 669 kW, with an overall average plant load in 2006 of 308 kW. The average 2006 price of diesel fuel purchased by AVEC in Selawik for power generation purposes was $2.44 per gallon. The average 2006 fuel-only cost of generating a kWh of electricity with diesel in Selawik was 18.69 cents per kWh.

The primary source used for home heating for the community is home heating oil, which is shipped to Selawik on the spring and fall barges. It unlikely that biomass (i.e. wood) is viable as a primary source as a home heating fuel.[52] However, this should be confirmed.

The current usable fuel storage capacity in Selawik by tank farm owner: AVEC (272,834 gallons); IRA Store (258,100); Northwest Arctic Schools (92,900); HUD Housing (26,000); Rotman Stores (9,800), Army National Guard (8,500); Alaska Dept. of Transportation and Public Facilities (2,500).

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[51] State of Alaska Department of Community and Economic Development Community website.

[52] A review of the Alaska Department of Natural Resources Biomass Map did not suggest significant potential for biomass.

SELAWIK ENERGY OPTIONS

A preliminary screening analysis of best available energy options was undertaken for Selawik. This included a high level review of reports, resource maps, and understanding of best available technology. Below is a list of energy options that require further analysis, followed by a discussion of each option. These options were identified through reports, resource maps, and the consultant's knowledge, but community members and other stakeholders may have additional source knowledge. As new information is brought forward, it will be incorporated into the analysis.

- *Combined Heat and Power Systems (Cogeneration)*. The preliminary screening analysis for Selawik suggested waste heat recovery as a potential source of economic benefits for the community if a potential end-use for the heat is located in close proximity to the power house. According to the Alaska Rural Energy Plan, a potential use of the cogeneration heat was to keep fuel storage tanks and distribution lines warm enough to use a more economical type of diesel fuel or to provide heat to an end-user.
- *End-Use Energy Efficiency*. End-Use Energy Efficiency (including electrical lighting, refrigerator/freezers, appliances, new space heating, and new water heating) has been identified as a potential source of economic benefits for Selawik. Types of interventions that could be considered for this initiative could include light bulb replacement program, upgrades to the thermal performance (insulation) of homes, the replacement of inefficient appliances, weatherization initiatives, and upgrades to the existing diesel generators. All end-use energy efficiency initiatives should be modeled/assessed in its impact on the diesel generation power and efficiency curves.
- *Wind-Diesel Hybrid Systems*. Selawik presently has four AOC 15/50 wind turbines integrated into the AVEC power system. It would likely be feasible to augment the four existing AOC machines with additional wind turbines, or replace them with higher capacity models.
- *Home Heating Oil*. Home heating oil is and will likely remain a source of heating for Selawik homes future.. Since this is a fossil fuel, it will fluctuate with the global economics of crude oil. The potential for other home heating sources should be reviewed.
- *Electrical Intertie*. The closest communites within a reasonable distance for an electrical intertie are Kiana and Noorvik. Selawik is about 25 miles (straight-line distance) from Kiana, and about 32 miles from Noorvik. These distances could make an intertie economically unfeasible, but should be studied further.
- *Geothermal*. According to the Alaska Geothermal Resources Map and local knowledge, there are no known geothermal sources in close proximity to Selawik.
- *Hydroelectric*. A 1979 study by the U.S. Department of Energy[53] concluded that there are no potential hydroelectric sites in close proximity to Selawik.
- *Solar*. While solar is not widely used in Alaska, it does remain an option for power generation and home heating. A review of solar technology should be undertaken.

RECOMMENDED ENERGY OPTIONS FOR SELAWIK

The following recommendations are provided for the community of Selawik in order to frame energy policy for the region.

- *Wind Energy*. Selawik could expand its existing wind generation capacity, and the community should work with AVEC in studying the feasibility of installing additional wind turbines. Also, performance data of the existing wind turbines should be provided by AVEC to aid in the planning of future wind turbine installations.

[53] Small Hydroelectric Inventory of Villages Served by Alaska Village Electric Cooperative, U.S. Dept. of Energy, Alaska Power Administration. December 1979.

- *Coordinate a Cogeneration (Combined Heat and Power) Feasibility Study*. Due to the potential economic benefit of cogeneration (combined heat and power) systems, it is recommended to implement a feasibility study of such systems for Selawik.
- *Coordinate an End-Use Energy Efficiency Study*. Selawik stakeholders should implement a study of end-use energy efficiency, with a particular focus on how energy efficiency could impact the efficiency of the existing generation sets.
- *Research Additional Home Heating Energy Options*. While home heating oil will remain as the mainstay for home heating, additional energy source options should be reviewed.
- R*esearch Electrical Intertie with Kiana*. The 25-mile distance between Kiana and Selawik may be short enough to justify an electric intertie line.

Appendix K
Shungnak-Kobuk Energy Options Analysis

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SHUNGNAK AND KOBUK OVERVIEW[54]

Shungnak, population 260, is located on the west bank of the Kobuk River about 150 miles east of Kotzebue. Kobuk, population 135, is located on the right bank of the Kobuk River, about 7 miles northeast of Shungnak and 128 miles northeast of Kotzebue. It is the smallest village in the Northwest Arctic Borough. The two communities are located in the continental climate zone, which is characterized by long, cold winters and mild summers. The Kobuk River is navigable from the end of May through October. Crowley Marine Services barges fuel and goods from Kotzebue each summer. Small boats, ATVs, snow machines and dog sleds are used for local travel. There are many trails along the river for year-round inter-village travel and subsistence activities, including a 7-mile trail connecting Shungnak and Kobuk.

Shungnak's economy is a mix of cash and subsistence activities. Subsistence food sources include sheefish, whitefish, caribou, moose, ducks and berries. Cash employment is limited to the school district, local government, and the Maniilaq Association's seasonal construction. BLM's fire fighting also provides some income. In Shungnak, there is also employment at two stores and a lodge. Shungnak also has a strong arts and crafts industry; residents make and sell finely-crafted baskets, masks, mukluks, parkas, hats and mittens. The community wants to develop a visitor center, mini-mall, post office and clinic complex at Dahl Creek.

The main source of water for Shungnak is the Kobuk River, via a portable pump that fills a 200,000-gallon steel storage tank through 1,110' of buried arctic pipe. Groundwater wells have proven unsuccessful in Shungnak. Piped water and sewer are provided to 53 homes (those at the top of the bluff,) the clinic, school and community building. Shungnak has a 6-inch buried gravity sewage main, which drains into a small diked lake one-half mile northwest of the city. In Kobuk, a piped water and sewer system, including household plumbing, was recently completed. A 30-foot well provides water, which is treated and stored by the washeteria. The washeteria has its own septic tank. Waste is disposed of at Dahl Creek. New landfills have also been recently completed in both Shungnak and Kobuk.

CURRENT ENERGY CONDITIONS

The Alaska Village Electric Cooperative (AVEC) currently provides power to the community of Shungnak, with a 1,248-kW diesel power plant. The Kobuk Valley Electric Cooperative purchases power from AVEC over the Kobuk-Shungnak intertie. The AVEC utility generated 1,522,433 kWh total in Shungnak during fiscal year 2007 (most recent PCE report), using 109,965 gallons of diesel, to power both Kobuk and Shungnak. During the same period, AVEC sold the Kobuk Valley Electric Cooperative 573,266 kWh of electricity over the Kobuk-Shungnak intertie. The Kobuk Valley Electric Company also has its own 75-kW back-up diesel power plant. The average pre-PCE residential electric rate for fiscal year 2007 (based on monthly usage of 500 KWh) in Shungnak was 61.13 cents per kWh, while in Kobuk during the same time period it was 53.00 cents per kWh.

According to AVEC's end-of-year 2006 generation statistics, the peak demand recorded to date at the Shungnak AVEC power plant is 336 kW, with an overall average plant load in 2006 of 178 kW. The average 2006 price of diesel fuel purchased by AVEC in Shungnak was $3.34 per gallon. The average 2006 fuel-only cost of generating a kWh of electricity in Shungnak was 24.72 cents per kWh.
The primary source used for home heating for the community is home heating oil, which is shipped to Shungnak and Kobuk on the spring and fall barges.

[54] State of Alaska Department of Community and Economic Development Community website

The current usable fuel storage capacity in Shungank by tank farm owner: AVEC (113,368 gallons); IRA Store (74,300); Northwest Arctic Schools (41,700); City (16,400); Commack Lodge (8,100); Army National Guard (6,900); Alaska Dept. of Transportation and Public Facilities (2,800).
The current usable fuel storage capacity in Kobuk by tank farm owner: City (16,900 gallons); Northwest Arctic Schools (11,700); IRA Store (8,700).

SHUNGNAK-KOBUK ENERGY OPTIONS

A preliminary screening analysis of best available energy options was undertaken for the Shungnak-Kobuk area. This included a high level review of reports, resource maps, and understanding of best available technology. Below is a list of energy options that require further analysis, followed by a discussion of each option. These options were identified through reports, resource maps, and the consultant's knowledge, but community members and other stakeholders may have additional source knowledge. As new information is brought forward, it will be incorporated into the analysis.

- *Combined Heat and Power Systems (Cogeneration)*. The preliminary screening analysis for Shungnak and Kobuk suggested waste heat recovery as a potential source of economic benefits for the community if a potential end-use for the heat is located in close proximity to the power house. According to the Alaska Rural Energy Plan, a potential use of the cogeneration heat was to keep fuel storage tanks and distribution lines warm enough to use a more economical type of diesel fuel or to provide heat to an end-user.
- *End-Use Energy Efficiency*. End-Use Energy Efficiency (including electrical lighting, refrigerator/freezers, appliances, new space heating, and new water heating) has been identified as a potential source of economic benefits for Shungnak and Kobuk. Types of interventions that could be considered for this initiative could include light bulb replacement program, upgrades to the thermal performance (insulation) of homes, the replacement of inefficient appliances, weatherization initiatives, and upgrades to the existing diesel generators. All end-use energy efficiency initiatives should be modeled/assessed in its impact on the diesel generation power and efficiency curves.
- *Wind-Diesel Hybrid Systems*. The NANA Region Wind Resource Status Report predicted for Shungnak and Kobuk a low wind resource, Class 1 or "Poor". Potentially developable wind resources are predicted for the hills about 5 miles north of Kobuk.
- *Home Heating Oil*. Home heating oil will remain as a source of heating for Shungnak and Kobuk homes and will likely remain as an option into the future. Since this is a fossil fuel, it will fluctuate with the global economics of crude oil. The potential for other home heating sources should be reviewed.
- *Electrical Intertie*. There is an existing electrical intertie between Shungnak and Kobuk. The distance between Shungnak and Ambler is about 24 miles, and an intertie could be economically feasible. Also, interties between the Shungnak-Kobuk system and any future gold mining activities in the area could also prove feasible.
- *Geothermal*. According to the Alaska Geothermal Resources Map and local knowledge, the closest known geothermal sources are at Division Hot Springs, located about 40 miles south-southwest of the Shungnak-Kobuk area. The water temperatures of the Division Hot Springs are significantly below the necessary temperature of ~80º C for Chena-type power generation, although field investigations are needed to determine if hotter fluid exists below ground.
- *Hydroelectric*. Both a 1979 study by the U.S. Department of Energy (DOE)[55] and a 1981 study commissioned by the U.S. Army Corps of Engineers[56] examined potential small hydroelectric sites

[55] Small Hydroelectric Inventory of Villages Served by Alaska Village Electric Cooperative, U.S. Dept. of Energy, Alaska Power Administration. December 1979.

[56] Regional Inventory and Reconnaissance Study for Small Hydropower Projects: Northwest Alaska. Ott Water Engineers, Inc., prepared for the U.S. Army Corps of Engineers, Alaska District. May 1981.

in the Shungnak-Kobuk area. A 2006 study conducted by Shaw Stone & Webster[57] examined potential large-scale hydroelectric sites involving dams on the Shungnak and Kogoluktuk rivers as a possible power source for a gold mine proposed in the area about 10 miles north of Kobuk. The 2006 study also included preliminary investigations of run-of-river hydroelectric potentials of the Shungnak and Kogoluktuk rivers and smaller streams in the area.

- *Dahl Creek*. The 1981 Army Corps study proposed a 140-kW hydroelectric installation on Dahl Creek to serve both Kobuk and Shungnak, at a site located about 3 miles north of Kobuk. The average annual plant factor of this site was estimated to be only 0.28, with minimal power production occurring from December through April. The environmental constraints listed were whitefish and grayling in the stream.
- *Cosmos and Camp Creeks*. The 1979 DOE study describes a power potential of over 1,200-kW (during summer flow) on a site on Cosmos Creek, roughly 7 miles north of Shungnak. Nearby Camp Creek was also identified as having power potential. The 1981 Army Corps study proposed a 144-kW installation on Cosmos Creek, with an estimated average annual plant factor of only 0.26. Like Dahl Creek, minimal power production would occur from December through April, and the environmental constraints listed were the presence of whitefish and arctic grayling in the stream.
- *Shungnak River*. The 2006 study by Stone & Webster proposed a 13 MW 'full-scale' (with a 195' high dam) or a 10.6 MW 'limited' (with a 135' high dam) hydroelectric development on the Shungnak River. In either case, the installation would produce no power from January through April. A 5.8 MW run-of-river (with no dam) hydroelectric plant was also proposed for the Shungnak River, but was judged to not be as economical as a dam-storage facility.
- *Kogoluktuk River*. The 1979 DOE study references a 1966 statewide inventory of hydropower sites conducted by the Alaska Power Administration, which proposed a 8,400-kW (8.4 MW) hydroelectric plant on the Kogoluktuk River, which a 205-foot high concrete arch dam to provide 100% stream flow regulation. However, the 1979 study also describes the possibility of a much smaller installation where the Kogoluktuk River flows through a narrow canyon about 7 miles northeast of Kobuk. The 2006 study by Stone & Webster proposed an 11.7 MW 'full-scale' (with a 175' high dam) or a 7 MW 'limited' (with a 90' high dam) hydroelectric development on the Kogoluktuk River. In either case, the installation would produce no power from January through April. A 3.2 MW run-of-river (with no dam) hydroelectric plant was also proposed for the Kogoluktuk River, but was judged to not be as economical as a dam-storage facility.
- *Solar*. While solar is not widely used in Alaska, it does remain an option for power generation and home heating. A review of solar technology should be undertaken.
- *Biomass*. The biomass map in the Renewable Energy Atlas of Alaska identifies the Shungnak-Kobuk area as "mixed forest and broadleaf". Wood from local trees is already used as a practical home heating source, and should be further investigated.

RECOMMENDED ENERGY OPTIONS FOR SHUNGNAK-KOBUK

The following recommendations are provided for the communities of Shungnak and Kobuk in order to frame energy policy for the region.

- *Coordinate a Cogeneration (Combined Heat and Power) Feasibility Study*. Due to the potential economic benefit of cogeneration (combined heat and power) systems, it is recommended to implement a feasibility study of such systems for Shungnak and Kobuk. This could be done at the

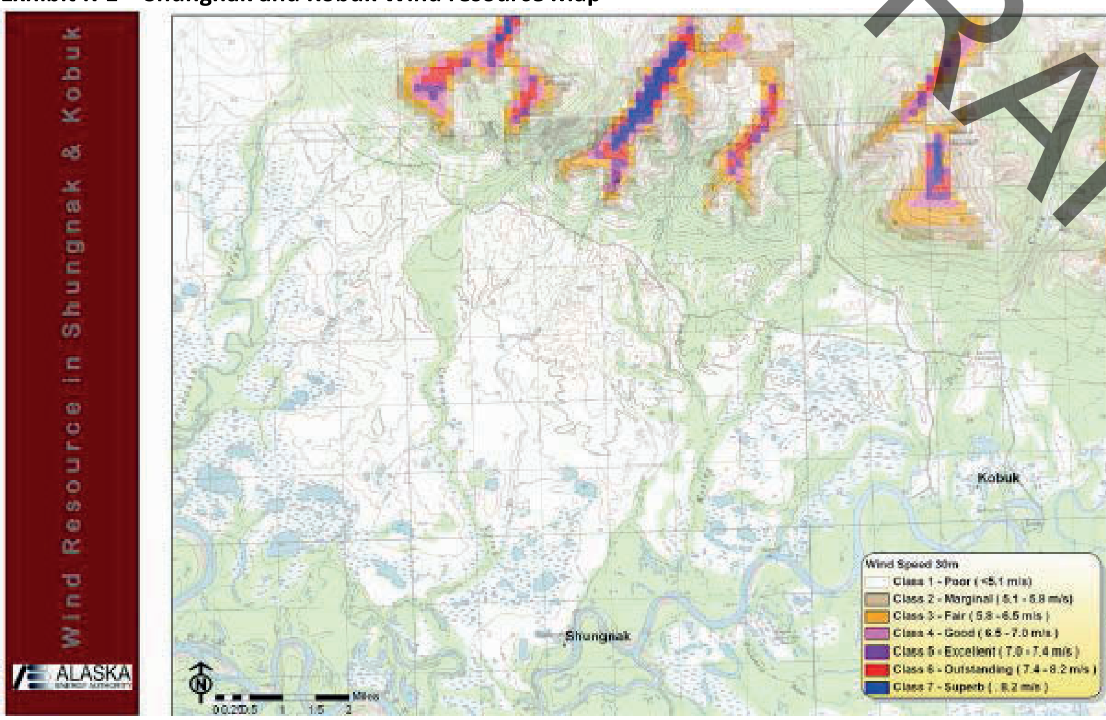
[57] Mine Power Study: Arctic Project – Ambler Mining District Alaska. Shaw Stone & Webster Management Consultants, Inc. February 2006.

time that the Bulk Fuel and Power System Upgrades are undertaken for both communities. A local woody-biomass supply may be suitable for CHP based on further study.

- *Coordinate an End-Use Energy Efficiency Study*. Shungnak stakeholders should implement a study of end-use energy efficiency, with a particular focus on how energy efficiency could impact the efficiency of the existing generation sets.
- *Research Additional Home Heating Energy Options*. While home heating oil will remain as the mainstay for home heating, additional energy source options should be reviewed. In particular, local biomass (wood) options should be studied.
- *Research Electrical Intertie with Proposed Mine*. The power needs of the polymetallic mine proposed in the area would be greater than the combined demand of Shungnak and Kobuk. Therefore, any large-scale power generation serving the mine could justify an electric intertie line between the mine and the two communities.
- *Research Local Hydroelectric Options*. Although small-scale hydropower could only provide significant power for Shungnak-Kobuk from May through November, several potential sites in the area warrant further investigation if the gold mine north of Kobuk is constructed.

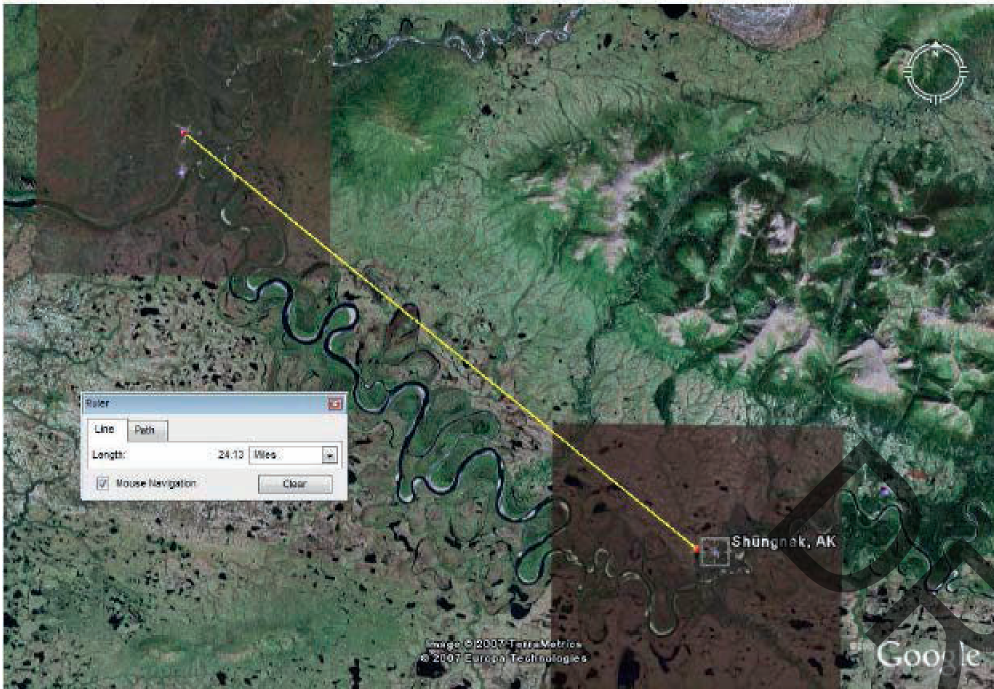
SHUNGNAK-KOBUK EXHIBITS

Exhibit K-1 – Shungnak and Kobuk Wind resource Map



Source: NANA Region Wind Resource Status Report

Exhibit K-2 – Ambler to Shungnak Tie-line Distnace Google Earth Image



Source: NANA Region Wind Resource Status Report

HYDROELECTRIC PROSPECTS OF SHUNGNAK-KOBUK AREA[58]

Ambler Mining District -Mine Power Study

Table 5-8 Comparative Summary of Kogoluktuk and Shungnak Sites

	FULL DEVELOPMENT		REDUCED DEVELOPMENT	
	Kogoluktuk	Shungnak	Kogoluktuk	Shungnak
Reservoir full WL, ft	400	550	315	490
Installed capacity, MW	11.7	13	7	10.6
PH tailwater level, ft	165	200	165	200
Assumed head loss, ft	25	40	25	37
Assumed net head, ft	210	310	125	253
Drainage area, sq mi	290	200	290	200
Avg annual inflow volume, cfs-days	146,094	100,754	146,094	100,754
Avg annual flow, cfs	400	276	400	276
PH hydraulic capacity, cfs	800	600	800	600
Dam type	Concrete faced rockfill	Concrete faced rockfill	Concrete faced rockfill	Concrete faced rockfill
Dam height at max section, ft	175	195	90	135
Dam crest length, ft	3200	800	1800	750
Dam volume, cy	3,500,000	1,200,000	610,000	550,000
Power tunnel length, ft	12,600	11,700	12,600	11,700
Power tunnel diameter, ft	12	10.5	12	10.5
Bridge across reservoir, L, ft	n/a	1200	n/a	n/a
Reservoir full surface area, sq mi	32	13		
Reservoir full volume, AF	1,228,000	428,000	40,000	99,000
Time for filling of reservoir, yrs	4.2	2.1	0.1	0.5
Avg annual energy, MWH	51,500	52,400	30,600	42,700
Cost per installed kW, $/kW	13,500	6,900	11,400	5,850

Of the two sites, the Shungnak scheme appears more attractive and potentially at a cost level that might be more viable for remote Alaska.

Mainly because of the larger dam structure, the Kogoluktuk scheme appears more costly. Also, higher costs are included for the longer power tunnel as well as turbine and hydraulic equipment passing larger flow at a lower head.

[58] Source: Mine Power Study: Arctic Project – Ambler Mining District Alaska. Shaw Stone & Webster Management Consultants, Inc., 2006

Table 5-7 Comparative Summary of Run of River Hydro Sites

Site	Drainage area, sq mi	Installed capacity, kW	Hydraulic capacity, cfs	Estimated net head, ft	Est annual energy, MWH
Shungnak River	200	5,800	600	138	19,900
Kogoluktuk River (1)	290	3,200	800	57	12,000
Comos Creek	13	1,000	50	293	2,900
Ryan Creek (1)	12	600	45	200	1,800
Dahl Creek (1)	9	500	35	222	1,500
Kollioksak Lake (2)	10	400	40	145	1,300
Ruby Creek	5	200	20	133	500

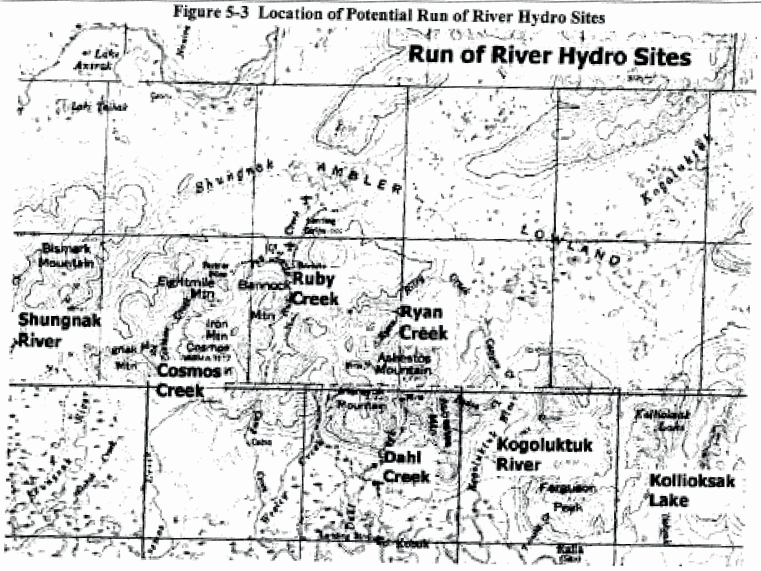
(1) Located at Asbestos Mountain area.

(2) Powerhouse is about 15 miles from camp area.

Capital and operating costs for these installations will be much higher on a $/kW basis than for the larger hydro power applications at Shungnak and Kogoluktuk, and the costs become much more sensitive to project development and permitting costs and the risks of completion. These projects could be evaluated further if higher cost options become appropriate.

Ambler Mining District -Mine Power Study

Figure 5-3 Location of Potential Run of River Hydro Sites



Run of river developments are possible at both the Shungnak and Kogoluktuk sites. These schemes include the same power tunnel and powerhouse location as for other larger schemes discussed above. Shungnak run of river scheme has available head of 138 feet and an installed capacity of 5,800 kW. Kogoluktuk run of river scheme has available head of 57 feet and an installed capacity of 3,200 kW.

Run of river installations on smaller side drainages in the area were also evaluated. These schemes include an intake and pressure pipe delivering water to a downstream powerhouse to develop available head. Sites on Cosmos Creek, Ryan Creek, Dahl Creek, Kollioksak Lake, and Ruby Creek were considered. The available output from each of these schemes is very limited (1 MW or less) because each of these drainage areas is small (about 10 to 12 square miles) and correspondingly available streamflow is very limited.

Initial parameters of potential run of river schemes are comparatively summarized below in Table 5-7.

Table K-1 – Division Hot Springs

Temp.	Flow (LPM)	TDS	SiO_2 geothermometer	Giggenbach geothermometer
68ºC / 154ºF	820	-	-	-
56ºC / 133ºF	2070	-	-	-

GEOTHERMAL PROSPECTS OF DIVISION HOT SPRINGS[59]

Several hot springs comprise the Division Hot Springs, also called Shungnak Hot Springs or Selawik Hot Springs. They are approximately 40 miles from the Kobuk-Shungnak area and approximately 60 miles from Ambler. They are located on the north side of the Purcell Mountains, inside the Selawik National Wildlife Refuge. The lower springs are slightly cooler than the upper springs, so the source of the thermal water is probably topographically high. Like Hawk and South Hot Springs, the Division Hot Springs issue from within the Cretaceous-age, anomalously radioactive Wheeler Creek Pluton (Miller and Johnson, 1978; see description of Wheeler Creek Pluton above). Division Hot Springs are some of the hottest springs in the NANA region, but they are still significantly below the necessary temperature of ~80 ºC for Chena-type power generation. At this time, there are no geothermometer predictions of hotter fluid at depth – but is due to a lack of data. The flow rate of the upper spring is extremely high relative to other CAHSB Hot Springs, which would reduce the amount of pumping required for production. Hence, based on resource factors alone, these springs should be prospective for development; however their location inside of a National Wildlife Refuge could complicate development plans.

[59] Source: NANA Geothermal Assessment Project (GAP) Draft Literature Review

Appendix L
Financial Analysis of Selected Energy Proposals

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BENEFIT-COST RATIOS

B/C ratios calculated using the RETScreen software[60], which defines the benefit/cost (B/C) ratio as the ratio of net benefits to costs of the project. Net benefits represent the present value of annual reserves (or savings) less annual costs, while the cost is defined as the project equity. Other energy options for the region (solar, hydroelectric, electrical interties) have not yet been analyzed with the RETScreen software.

WIND ENERGY FINANCIAL ANALYSIS: DEERING, BUCKLAND, AND NOORVIK

Based on the assumptions listed below, a pre-feasibility financial analysis of a small wind farm installation for the communities of Deering, Buckland and Noorvik was conducted using the software program RETScreen. The results of this analysis are shown in Table L-1 below. Assumptions for wind turbine installations are:

Characteristics

Wind turbines used are 100-kW Northwind100 machines with a 30 m hub-height
Two turbines installed in Deering (200-kW total wind capacity)
Three turbines installed in Buckland and Noorvik (300-kW total wind capacity)

Installation cost assumptions (for all three communities)

Feasibility, development and engineering costs	$300,000
Wind turbines	$250,000/turbine
Substation	$150,000
Installation labor costs	$150,000
Foundation	$200,000
Misc./contingencies	$338,000 to $524,000
Transmission line cost	$350,000/mile
Annual operations and maintenance (O&M) costs	$ 22,000
Drive train replacement	$ 30,000 every 10 years
Blade replacement	$ 80,000 every 15 years

Financial assumptions

Electricity avoided cost (compared to diesel)	$0.20/kWh
Annual electricity cost escalation rate	10%
Inflation rate	2.5%
Discount rate	7%
Project life	25 years

Table L-1: Financial analysis of wind farm installation for Deering, Buckland, and Noorvik

	Deering	Buckland	Noorvik
Average annual wind speed	7.2 m/s	6.8 m/s	5.5 m/s
Wind plant capacity factor	29.1%	25.9%	15.7%
Total installed wind capacity	200-kW	300-kW	300-kW
Annual wind energy generated	510 MWh	682 MWh	413 MWh
Total generated in FY2006[61]	662 MWh	1498 MWh	1951 MWh
Transmission line length	1.5 miles	5 miles	1 mile
Transmission line cost	$525,000	$1,750,000	$350,000
Total installation cost	$2,152,700	$3,823,875	$2,237,675

[60] RetScreen software is used to at the pre-feasibility or feasibility stage to evaluate the financial performance of energy.
[61] Statistical Report of the Power Cost Equalization (PCE) Program, Fiscal Year 2006, Alaska Energy Authority

Benefit-cost (B-C) ratio	1.54	1.20	1.17

Geothermal

Based the assumptions listed below, a pre-feasibility financial analysis of a 400-kW geothermal power plant at Granite Mountain Hot Springs, and points closer to Buckland, was conducted using the software program RETScreen. The economic model is based on the 400-kW Chena Hot Springs geothermal power plant near Fairbanks, which at the end of 2006 had a total installation cost of about $2,000,000. This figure included the cost of the geothermal power generation equipment, as well as the feasibility study, development and engineering costs.

Assuming three-fold increase in cost of developing an unknown resource in a remote area as compared to Chena Hot Springs, the total installation cost of a 400-kW geothermal power plant at Granite Mountain Hot Springs is estimated to be $6,000,000. This figure includes the cost of the power plant as well as feasibility, development and engineering costs, but does not include the cost of a transmission line to Buckland, or a substation connecting to the City of Buckland's electrical distribution system.

According to the FY2006 PCE report, City of Buckland's 650-kW capacity diesel power plant generates about 1500 MWh annually. Assuming this level of power demand does not increase, a 400-kW geothermal power plant with an annual electricity production of 1507 MWh of electricity would serve Buckland's needs at an annual capacity factor of 43%.

With a benefit-cost (B-C) ratio of only 0.46, as calculated by the RETScreen software, a geothermal power plant located at Granite Mountain Hot Springs appears to be an un-economic source of electricity for Buckland. The majority of the project's cost is the 40-mile long a transmission line needed to connect the site at Granite Mountain Hot Springs to the community of Buckland. The length of the transmission line is chief reason why the project would not be economical, although the project's economic feasibility could be improved somewhat if Buckland's annual electricity demand increased significantly compared to 1500 MWh (the 2006 level). According to the RETScreen financial analysis, if the Granite Mountain Hot Springs geothermal power plant produced 3189 MWh of electricity annually (increasing the plant's capacity factor to 91%), the B-C ratio would increase to 1.00. The economics of a geothermal project at Granite Mountain Hot Springs may also improve if communities in addition to Buckland connected to the system, but due to the great distances of electric transmission lines needed this is not likely.

However, if a previously unknown sub-surface geothermal energy resource is discovered a much closer distance to Buckland, the economics improve significantly (all other costs remaining the same), as can be seen below in Table L-2. At a distance of 9 miles, RETScreen calculates a B/C ratio of 1.00.

Table L-2 - B/C Ratio of 400-kW Chena-Type Geothermal Power Plant for Buckland

Transmission Line Length	Transmission Line Cost	Total Installation Cost	B/C Ratio
40 miles	$14,000,000	$22,937,585	0.46
30	10,500,000	18,972,085	0.56
20	7,000,000	15,006,585	0.71
15	5,250,000	13,023,835	0.82
10	3,500,000	11.041,085	0.96
5	1,750,000	9,058,335	1.18

Assumptions for Granite Mountain Hot Springs/Buckland geothermal plant are:

Characteristics

400-kW power generation plant (Chena-type)
Annual electricity generated: 1507 MWh (43% capacity factor)

Installation cost assumptions (based on Chena Hot Springs geothermal plant)

Feasibility, development and engineering costs	$2,000,000
Geothermal power plant (400 kW)	4,000,000
Transmission line (per mile)	350,000
Substation	200,000
Contingencies	10% of installation cost
Interest during construction	6% over 12 months
Spare parts	15,000
Transportation	240,000

Financial assumptions

Electricity avoided cost (compared to diesel)	$0.20/kWh
Annual electricity cost escalation rate	10%
Inflation rate	2.5%
Discount rate	7%
Project life	25 years
Annual operations and maintenance (O&M) costs:	$110,000

GEOTHERMAL ELECTRICITY FINANCIAL ANALYSIS FOR KOTZEBUE

It is not known if a geothermal energy resource exists in Kotzebue or nearby, or if a resource did exist, that it would be hot enough for the generation of electricity. However, if a geothermal resource of sufficient temperature is discovered by exploration drilling in Kotzebue, it would be an energy source worth investigating.

Based on the assumptions listed below, a pre-feasibility financial analysis of a *hypothetical* 1200-kW geothermal power plant in or near Kotzebue was conducted using the software program RETScreen. In 2007, Kotzebue Electric Association generates about 21,807 MWh annually from diesel and 1,064 MWh from wind. Assuming that Kotzebue's electric power demand does not increase, a 1200-kW base-load geothermal power plant with an annual electricity production of 10,092 MWh of electricity (or an annual capacity factor of 96%) could provide slightly less than half of Kotzebue's electricity needs. It must be emphasized that this hypothetical scenario only takes into account electricity production and not utilization of the geothermal for district heating applications as part of a combined heat-and-power, or co-generation, facility.

The economic model is based on the 400-kW Chena Hot Springs geothermal power plant near Fairbanks, which at the end of 2006 had a total installation cost of about $2,000,000, or $5000 per kW of capacity. This figure included the cost of the geothermal power generation equipment, as well as the feasibility study, development and engineering costs. Assuming a 13% annual increase in construction costs between 2006 and 2008, and a construction cost increase factor of 1.27 (comparing the NW Arctic Borough and the Railbelt), the installation cost of a 400-kW "Chena-clone" geothermal power plant in Kotzebue would be $8000 per kW of capacity. This figure includes the cost of the power plant as well as feasibility, development and engineering costs, but does not include the cost of a transmission line or other electrical infrastructure. A Kotzebue geothermal power plant with a capacity of 1200-kW, significantly greater than 400-kW, is assumed to have an overall installation cost of $6000 per kW of capacity due to economy of scale. So a 1200-kW geothermal power plant in Kotzebue has an assumed installation cost of $7,200,000. This figure does not include development costs, which would include an estimated $5 million for exploratory drilling.

With a benefit-cost (B-C) ratio of 3.26, as calculated by the RETScreen software, a hypothetical 1200-kW geothermal power plant located in Kotzebue appears to be a very economic source of electricity for the community. However, such figures are highly speculative since this model assumes an unknown geothermal resource, as high-quality as Chena Hot Springs, exists underground very close to Kotzebue. Further, geophysical exploration is needed to determine what, if any, geothermal resource exists in the Kotzebue area. Assumptions for Kotzebue geothermal plant are:

Characteristics

1200-kW power generation plant (Chena-type)
Annual electricity generated: 10,092 MWh (96% capacity factor)

Installation cost assumptions (based on Chena Hot Springs geothermal plant)

Feasibility, development and engineering costs	$5,000,000
Geothermal power plant (1200 kW)	7,200,000
Transmission line (2 miles)	700,000
Substation	200,000
Misc./contingencies	2,325,795
Approximate Total Installation Cost	$15,425,795 ($12,854.83 per kW)

Financial Assumptions

Electricity avoided cost (compared to diesel)	$0.15/kWh
Annual electricity cost escalation rate	10%
Inflation rate	2.5%
Discount rate	7%
Project life	25 years
Annual operations and maintenance (O&M) costs	$330,000
Benefit-Cost (B/C Ratio)	3.26

Biomass

Wood-fired heating is a very cost-effective option for many communities in rural Alaska. Assuming a wood-to-heat energy conversion efficiency of 75%, 1 cord of wood (assumed heating value: 8,890 BTU/lb.) will replace 80 gallons of #2 heating oil. A cord of wood has a volume of 128 cubic feet. Table L-3 below, compares the price of heat (per million BTU) of wood and heating oil.

Table L-3: Cost per Million BTU by Heat Source

Fuel Oil #2 (110,400 net BTU/gal)		Wood (8,833,500 net BTU/cord)	
Price per gallon	$ per million BTU	Price per cord	$ per million BTU
5.50	49.82	200	22.64
7.00	63.41	250	28.30
8.50	76.99	300	33.96

Biomass-fired Power Generation and Combined Heat and Power

The PureCycle200 can provide up to 200 kW of electrical power from a low temperature heat source (200º F or less) using the Organic Rankine Cycle (ORC). Manufactured by United Technologies Corporation (UTC) since 2004, the PureCycle 200 power generation module was originally designed to operate using industrial waste heat. However, the system has proven viable for generating electricity from other low-temperature

heat sources. For example, two PureCycle 200 units were installed in 2006 as part of Alaska's first geothermal power plant at Chena Hot Springs, which has a maximum water temperature of only 165º F.
The PureCycle 200 system is mostly comprised of components and hardware from Carrier Refrigeration (also a division of UTC), and employs a 'working fluid' (R134a) commonly used in air conditioning equipment. For biomass electricity production with a PureCycle 200 unit, water is first heated by burning wood. The hot water enters the evaporator to heat the system working fluid until it is vaporized. This hot, vaporized working fluid then enters the PureCycle power module where it drives a turbine to produce electrical power. After passing through the turbine, the vapor cycles through a condenser to be cooled and re-liquefied. The liquid working fluid is then sent through a pump back in to the evaporator.

Aside from ORC, other technology options for small-scale, wood-fired, combined heat and power (CHP), as identified in the paper "Renewable Power in Rural Alaska: Improved Opportunities for Economic Deployment" (2008), by Peter M. Crimp, Steve Colt and Mark A. Foster are:

- Gasifier-fed reciprocating engine generators
- Conventional Rankine cycle fed by steam from a woodchip-fed pile burner
- Fluidized bed combustor

The 2008 paper modeled the economics of wood-biomass CHP in rural Alaska, using the fluidized bed combustor technology as the "pessimistic" scenario and ORC as the "optimistic" scenario. The "optimistic" scenario also assumes a wood cost of \$21/m^3 (\$50/cord) and a higher heating value of 7.98 GJ/m^3 (18 MMBtu/cord), and that the CHP system has an overall efficiency of 35% of converting wood fuel into useful energy (both electricity and heat). The results for the upper Kobuk River communities of Ambler and Shungnak, indicating positive economics for biomass CHP under an "optimistic" scenario, can be seen in Table L-4 below:

Table L-4 – Biomass CHP System Cost and Benefit/Cost Ratio[62]

	Pessimistic				Mid-Case				Optimistic			
		Diesel Price				Diesel Price				Diesel Price		
	Installed Cost (1000$)	Low	Medium	High	Installed Cost (1000$)	Low	Medium	High	Installed Cost (1000$)	Low	Medium	High
Location		B/C Ratio				B/C Ratio				B/C Ratio		
Ambler	2,750	(1.95)	(1.67)	(1.42)	2,292	(0.22)	0.23	0.63	1,834	2.36	3.07	3.70
Shungnak	2,886	(2.00)	(1.42)	(0.65)	2,405	(0.12)	0.81	2.07	1,924	2.68	4.16	6.14

[62] Source: Renewable Power in Rural Alaska: Improved Opportunities for Economic Deployment (2008, Crimp, et al.

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Appendix M
Potential Funding Sources for SEP

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Table M-1 - Potential Funding Sources for SEP

Agency	Contact	Description
Alaska Energy Authority	**Peter Crimp** Project Manager P: 907-771-3039 E: pcrimp@aidea.org	Alternative Energy and Energy Efficiency programs, Power Project Load Fund, Bulk Fuel Upgrade Program, Power System Upgrade Program, community technical assistance and training programs.
U.S. Department of Energy, Golden Field Office (National Renewable Energy Laboratory)	Lizana Pierce Tribal Energy Program Project Manager E: lizana.piece@go.doe.gov	In addition to the Tribal Energy Program, DOE funding may also be available through the Geothermal Technology Program, and the Wind and Hydropower Technologies Program.
Denali Commission	Kathy Prentki Energy Program Manager E: kprentki@denali.gov	For FY2008, funding for the Denali Commission's energy program is $10 million for legacy bulk fuel and power upgrades (from the statewide deficiency lists), up to $9 million for renewable energy projects, about $4 million from the TAPL funds which can only be spent on bulk fuel, and an undetermined amount from USDA Rural Utility Service high energy cost grant funds.
U.S. Department of Agriculture- Rural Utilities Service	**Eric A. Marchegiani, P.E**. USDA Rural Development-Electrical PO Box 771876 Eagle River, AK 99577 P: (907) 688-8732 / F: 1-888-655-3357 E: Eric.Marchegiani@wdc.usda.gov	The High Energy Cost Grant Program provides financial assistance for the improvement of energy generation, transmission, and distribution facilities serving eligible rural communities with home energy costs that are over 275 percent of the national average.
Alaska Housing Finance Corporation	Scott Waterman Energy Specialist I Phone: (907) 330-8195	Alaska Housing Finance Corporation offers a variety of nationally recognized, award winning & innovative energy programs to serve the needs of Alaskans. The Research and Rural Development Department (R2D2) is the Alaska State Energy Office. It is the primary recipient of federal funds for Renewable Energy and Energy Efficiency to Alaska. R2D2 provides funding to weatherization service providers; the Alaska Energy Authority for geothermal, wind and other renewable energy projects; and energy-efficiency programs for schools and community buildings.
RurAL CAP	Mark Lyman Weatherization Program Manager P: 907-865-7375 E: mlyman@ruralcap.com	In addition to the home weatherization program, RurAL CAP also offers a VISTA energy program and education about energy conservation.
Alaska Department of Transportation and Public Facilities	Donna Gardino Northern Area Planner Northwest Arctic Borough P: (907) 451-2375 E: donna.gardino@alaska.gov	Statewide Transportation Improvements Program (STIP) and Needs List, which could include new roads connecting communities in the NW Arctic Borough.
U.S. Department of Housing and Urban Development	Colleen Bickford Alaska Office Director P: (907) 677-9800 E: AK_Webmanager@hud.gov	A Community Development Block Grant could be used by the Northwest Arctic Borough, and the Indian Community Development Block Grant (ICDBG) for Tribal Entities, for energy efficiency and weatherization programs.
Corporate Giving	N/A	ConocoPhillips, BP, Alyeska Pipeline, Federal Express are all major corporations with a strong Alaskan presence that could be considered for a capital campaign. NANA Regional Corporation, as the regional corporation, is another entity. Tech Cominco, due to its close proximity is another viable option. On the national level, several large technology firms not previously involved with energy projects, most notably Google, are starting to invest large amounts in renewable energy ventures. Funding a renewable energy project in rural Alaska community affected by climate change could be a noteworthy 'showcase' for such a company.