Feasibility Assessment for Biomass Heating Systems
Kiana, Alaska

FINAL REPORT – 8/23/2016

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Abbreviations

ACF	Accumulated Cash Flow
ASHRAE	American Society of Heating, Refrigeration, and Air-Conditioning Engineers
AEA	Alaska Energy Authority
AFUE	Annual Fuel Utilization Efficiency
B/C	Benefit / Cost Ratio
BTU	British Thermal Unit
BTUH	BTU per hour
CCF	One Hundred Cubic Feet
CEI	Coffman Engineers, Inc.
CFM	Cubic Feet per Minute
Eff	Efficiency
F	Fahrenheit
ft	Feet
GPM	Gallons Per Minute
HP	Horsepower
HVAC	Heating, Ventilating, and Air-Conditioning
in	Inch(es)
kWh	Kilowatt-Hour
lb(s)	Pound(s)
MBH	Thousand BTUs per Hour
O&M	Operations and Maintenance
MMBTU	One Million BTUs
PC	Project Cost
R	R-Value
SF	Square Feet, Supply Fan
TEMP	Temperature
V	Volts
W	Watts
WTP	Water Treatment Plant

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I. Executive Summary

A preliminary feasibility assessment was completed to determine the technical and economic viability of biomass heating systems for community buildings in Kiana, Alaska. The study evaluated a Garn style cordwood boiler system that would supply supplemental heat to the community buildings. The high price of heating oil is the main economic driver for the use of lower cost biomass heating.

Two biomass system options were evaluated. Biomass Option 1 will connect six community buildings (City Warm Storage Building, City Office, Community Center, Fire Hall, Youth Center and Clinic) with a district heat loop. A Garn cordwood boiler will be located in a new detached module located behind the City Warm Storage Building. Due to the large project cost associated with connecting the buildings and the relatively low heating oil savings, it was determined that Option 1 is not justified on a purely economic basis at this time.

Biomass Option 2 will connect three buildings (City Warm Storage Building, Clinic and School) with a district heat loop. To reduce costs, the Garn cordwood boiler is located inside the City Warm Storage Building. It was determined that Option 2 is economically justified at this time, due to the fact that the benefit to cost ratio of the project is greater than 1.0. An additional benefit is that the money used to purchase cordwood will stay in the local community, which can create local job opportunities.

Upgrading the Kiana Water Treatment Plant's heat recovery system was also evaluated in this study. It was found that upgrading the heat recovery system is economically justified at this time. Upgrading the heat recovery system has a larger benefit to cost ratio than the biomass options. The summary of the results of the economic evaluation are shown in the table below.

Table 1 – Executive Summary

Item	Biomass Option 1	Biomass Option 2	Water Treatment Plant Upgrades
Project Capital Cost	($872,000)	($552,000)	($391,000)
Present Value of Project Benefits (20-year life)	$1,012,598	$3,844,001	$1,225,437
Present Value of Operating Costs (20-year life)	($446,880)	($3,073,300)	($402,301)
Benefit / Cost Ratio of Project (20-year life)	0.65	1.40	2.11
Net Present Value (20-year life)	($306,283)	$218,701	$432,136
Year Cash Flow is Net Positive	First Year	First Year	First Year
Payback Period (Year Accumulated Cash Flow > Project Capital Cost)	>20 years	16 years	11 years

If Kiana wishes to further pursue the biomass project, the next step is to complete a schematic level engineering design and detailed cost estimate of the projects. An updated economic analysis can be completed and Kiana can then decide if it is in its best interest to pursue funding to continue with final design and construction.

II. Introduction

A preliminary feasibility assessment was completed to determine the technical and economic viability of a biomass heating system for selected community buildings of Kiana, Alaska. The biomass system is proposed to be located at the City Warm Storage Building and would heat community buildings with a district heating loop. The Kiana Water Treatment Plant was also evaluated for improvements to the existing heat recovery system.

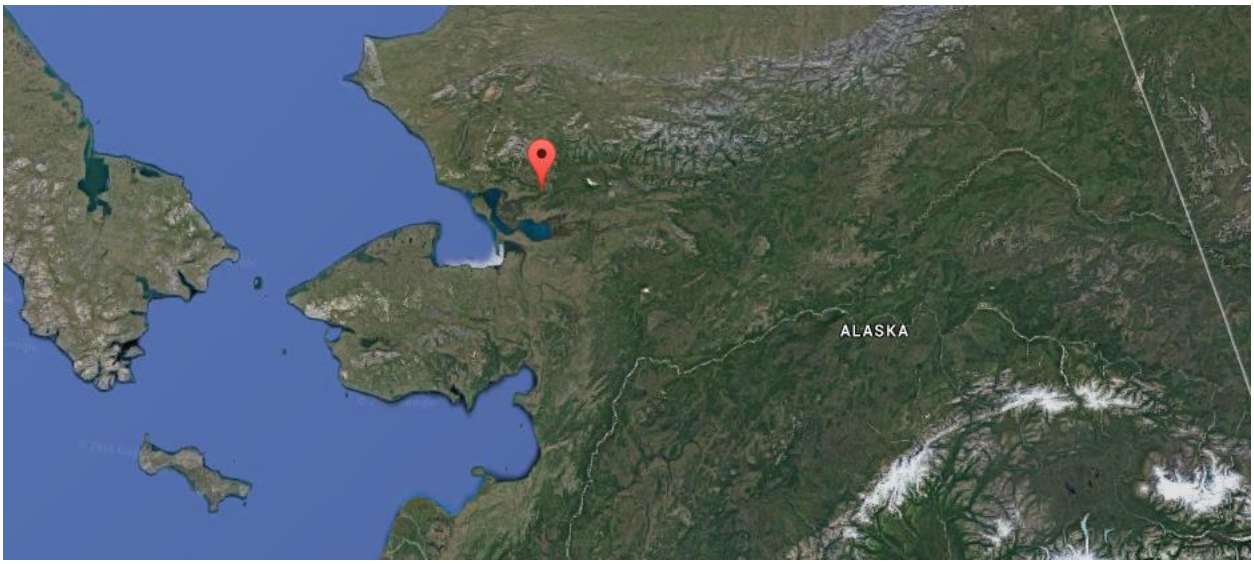


Figure 1 – Kiana, Alaska – Google Maps

Figure 2 – City Warm Storage Building

III. Preliminary Site Investigation

Previous Studies

There have been multiple biomass and heat recovery related studies completed for Kiana and the nearby region. These studies have looked at heat recovery improvements to the Water Treatment Plant, region wide biomass resource inventory, and region wide biomass feasibility. These past studies were used in developing this report and are listed below:

Table 2 – List of Previous Biomass Related Studies

Date	Report Title	Author
2010	Kiana Heat Recovery Study	Alaska Energy and Engineering (Prepared for ANTHC)
2013	NANA Region Native Allotment Forest Inventory	Tanana Chiefs Conference, Forestry Program (Prepared for Maniilaq)
2014	Biomass Project Feasibility and Design Report – Northwest Arctic Borough – Upper Kobuk Region	Tetra Tech

In general, the studies found that cordwood is a potentially viable energy resource in Kiana and that improvements to the Water Treatment Plant's heat recovery system are economically attractive.

Community Meeting

During the site visit, Coffman and a representative from the Alaska Energy Authority held a community meeting regarding the biomass and energy efficiency opportunities in the community. Twenty community members attended the meeting. Overall the community was very interested in biomass opportunities and very interested in developing local jobs for harvesting cordwood and operating biomass systems.

Building Description

The City Warm Storage Building is a 2,400 square foot metal framed shop that was originally built in 1980. In 2010 there was a major renovation that installed radiant floor heating, a new boiler and sheet rock to the walls and ceiling. The building is used about 40 hours per week by one to two people. Currently, there are no scheduled or planned renovations for the building.

Existing Heating System

The radiant floor of the City Warm Storage Building is heated by an Oil Miser boiler (OM-180, 124 MBH Output, direct vent) a primary/secondary glycol loop. The boiler is located at the ground level at the back of the building. A Modine Unit Heater (POR100B, 100 MBH Output) is mounted to the ceiling and provides supplemental heat to the air in the building. Both the boiler and unit heater were installed during the 2010 renovation. Each unit has its own wall mounted thermostat.

The combustion efficiency of the existing fuel oil boiler is approximately 87% and the unit heater is 80%. For this study, the Annual Fuel Utilization Efficiency of the oil fired equipment was estimated at 75% to account for typical oil boiler inefficiencies, including short cycling.

There is routine maintenance of the boiler by the City of Kiana maintenance. The boiler and unit heater appear to be in good shape and operating properly. No maintenance issues were reported to Coffman during the site visit.

One 500 gal heating oil tank serves the building and is located on the south side of the building. There is no additional spill containment present around the tank. Fuel oil in the tanks is only used for building heating and is not used by other buildings.

There is no domestic water heating or air handling systems at the CWS.

Building Envelope

The City Warm Storage Building is a typical 40ft by 60ft metal frame warehouse building. It is estimated to have R-13 wall and R-20 roof, made of foil faced fiberglass insulation. No design drawings of the building were available. Two large overhead doors face the street. No windows are present in the building.

Available Space

There is available space inside of the City Warm Storage Building for a biomass system. However, the City of Kiana would prefer a new detached building to house a biomass boiler system. There is adequate space located onsite behind the City Warm Storage Building for a new wood boiler building and a wood storage structure. The existing gravel pad will need to be expanded at the site in preparation for the new buildings.

Street Access and Fuel Storage

The City Warm Storage Building is located on a wide gravel road and can be easily accessed. Space for wood storage exists behind the building, which can be easily accessed by the existing gravel pad.

Building or Site constraints

There are no major building or site constraints that were found during the site visit. There are residential buildings on three sides of the City Warm Storage Building, which would make it difficult to expand the wood boiler system larger than the current lot size.

Proposed District Heating System

The City Warm Storage Building alone does not consume enough heating oil to make a viable biomass project. In order to offset a larger amount of heating oil, a district heating system is proposed. Two district loop options were investigated and are shown in the following table and figure. Both district loops will utilize buried, insulated piping to transfer heat from a biomass boiler system to the buildings connected to it.

Table 3 – District Heat Options

Map #	Building Name	Option 1 Connection	Option 2 Connection	Integration
23	City Warm Storage Building	Yes	Yes	Radiant Slab Return
27	Clinic	Yes	Yes	Boiler Return and New Unit Heater
28	Fire Hall	Yes	No	New Unit Heater
29	Community Center	Yes	No	New Unit Heater
30	City Office	Yes	No	New Unit Heater
35	Youth Center	Yes	No	New Unit Heater
21	Tribal Office	No	No	Potential Future Connection
24	School	No	Yes	Boiler Return and New Unit Heater

Option 1 will connect the City Warm Storage building, City Office, Community Center, Fire Hall, Youth Center and Clinic to a district heat loop. The biomass boiler will be located in a new module located behind the City Warm Storage Building.

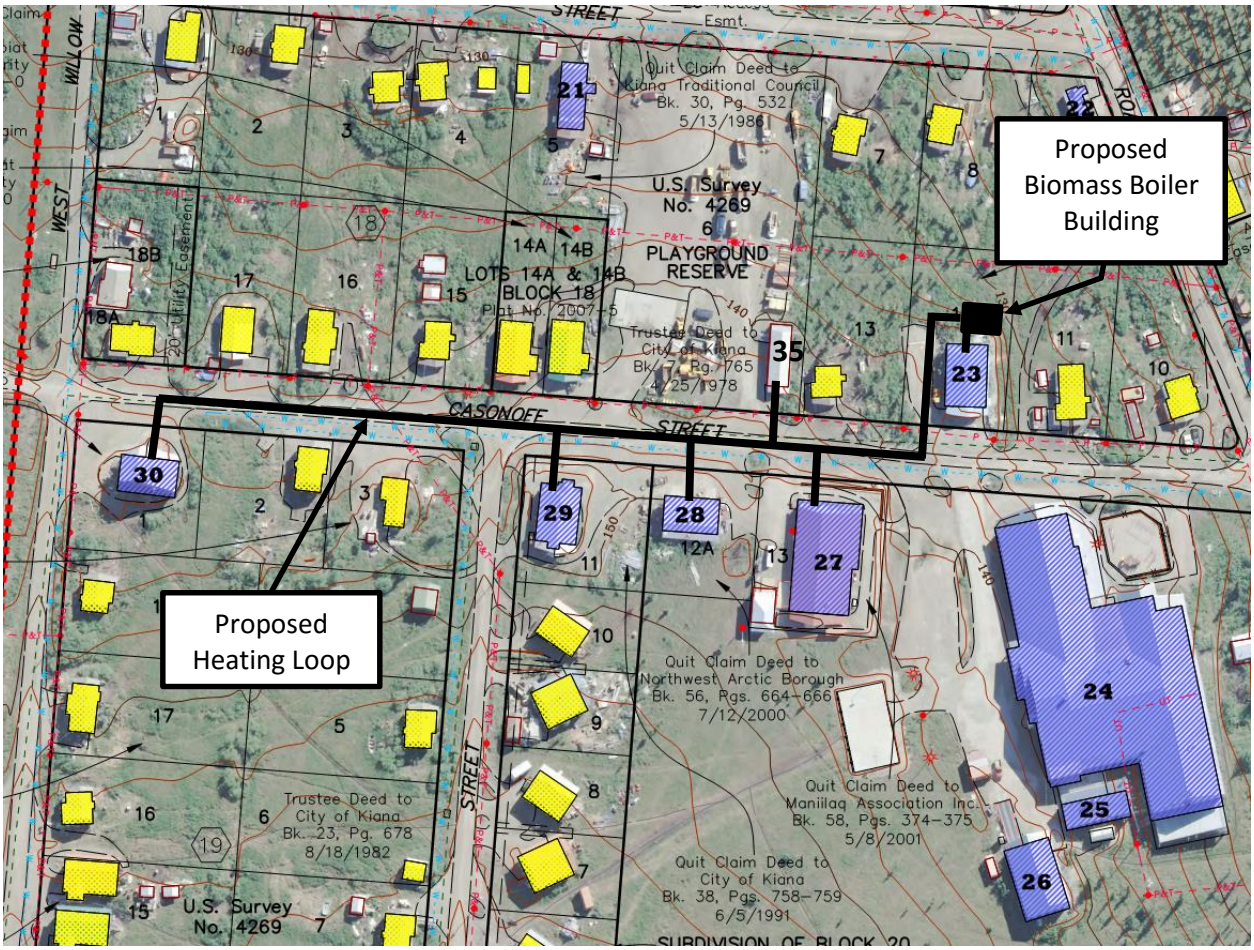


Figure 3 – Option 1 - Proposed Site Layout

In the 2014 Tetra Tech study of nearby communities of Ambler, Kobuk and Shungnak, it was determined that using biomass to offset each community's school heating oil consumption would have an adverse effect on wood availability for the rest of the community. This is because of the significant heating oil consumption of the schools, compared to the rest of the community. Also, funding for the school does not come from local resources, so the impact on the community would not be as great if heating oil offset go to the school. Due to these reasons the school was not included in the Option 1 district heating system.

Option 2 connects the City Warm Storage Building, Clinic and School, which are the largest heating oil consumers, to a district heat loop. To reduce costs, the biomass boiler will be located inside of the City Warm Storage Building.

The Option 2 district loop was investigated because the economic analysis of Option 1 show that it is not economically justified, at this time. In order to reduce installed costs, the number of buildings connected to the district loop was reduced in Option 2. The school was connected to the loop in order to increase heating oil offset by the biomass boiler. The goal is not to offset the majority of the school's heating oil, but rather provide supplemental heat to the school.

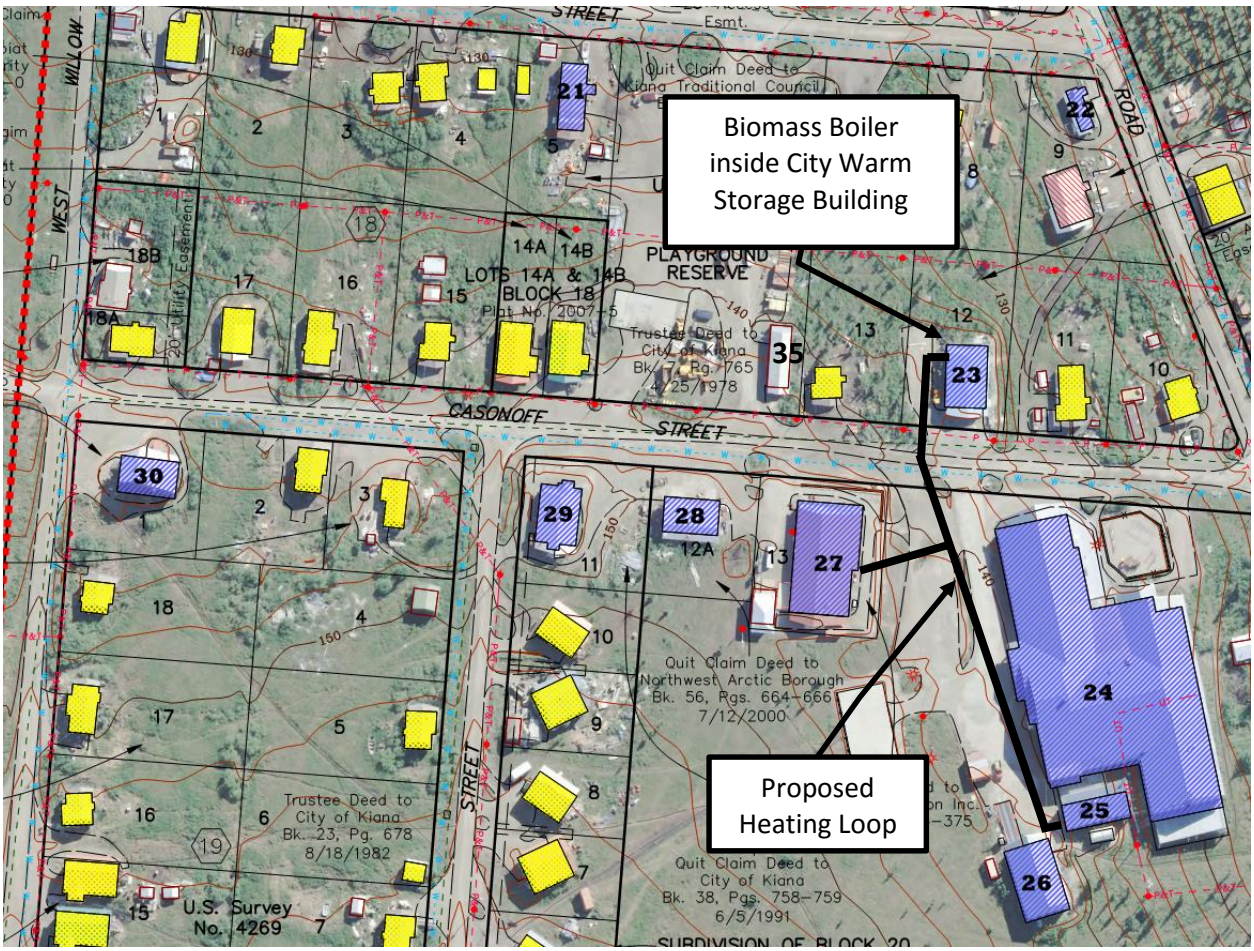


Figure 4 – Option 2 - Proposed Site Layout

The Tribal Office building was not included in either district heating loop for this analysis, but could be connected in the future.

Energy Agreement

For either biomass option, the Garn unit will deliver heat to multiple entities: City of Kiana, Maniilaq (Clinic), and/or Northwest Arctic Borough School District (School). An agreement between these entities will be needed in order allow the project to move forward.

For this economic analysis it is assumed that the entities would partner to fund, build and operate the biomass plant. BTU monitoring would be used to measure the amount of heat that each entity has used and each entity would be charged the BTU equivalent cord wood rate. This arrangement allows for the most cost savings for each entity.

Another option is for the City to fund, build and operate the biomass plant independently and sell heat to Maniilaq and/or the School District. The City would sell the heat to make a profit in order to pay for the cost of building and operating the plant. BTU monitoring will be used. In this arrangement the City will need to set a BTU price that makes the project attractive to the other entities, while still being able to make enough profit to pay for project expenses.

Biomass System Integration

Heat from the biomass system would be integrated into each building in several ways, as shown in Table 3. Each building will utilize their own heat exchanger and pumps to deliver heat from the district heat loop to either new unit heaters or tie into the existing boiler system.

In Option 1, new hydronic unit heaters will be installed in the City Office, Community Building, Fire Hall, and Youth Center. The new unit heaters will reduce installation costs and reduce control system complexity, compared with integrating into the existing boiler systems. Also, the new unit heaters can be designed to utilize lower temperature supply water. The Clinic will have both a new hydronic unit heater for the lobby area and a connection to the boiler return line. The biomass heat would tie into the City Warm Storage Building's radiant slab floor.

In Option 2, the connections for the Clinic and City Warm Storage Building will be the same as Option 1. The School will have both a new hydronic unit heater in the gym and a connection to the boiler return line.

It is assumed that an aggressive outdoor air supply water reset is added to the existing boiler systems of the Clinic and School. This will allow the existing hydronic systems to operate at lower supply water temperatures, which allows more heat to be extracted from the biomass boiler and reduces the amount of times the biomass boiler needs to be fired.

Biomass System Technology

Since cordwood is the local wood resource available in Kiana, the best biomass technology to implement is a Garn boiler type system. For this study, a single Garn WHS-3200 wood boiler was used as the basis of design. This unit has a 3,200-gallon water tank and is 7'4" wide x 7'8" high x 12' long.

Figure 5 – Garn WHS-3200 Wood Boiler

In Option 1, the Garn boiler would be housed in a new 8' wide x 20' long insulated module located behind the City Warm Storage Building. The module would contain circulation pumps, heat exchanger and controls. The module and interior components could be pre-constructed offsite and shipped to Kiana for installation.

In Option 2, the Garn boiler would be located inside the City Warm Storage Building in order to reduce the costs of building a new module. The circulation pumps, heat exchanger and controls would also be located in the building.

The Garn boiler would deliver heat to a heat exchanger, which would transfer heat to a buried piping loop system with 50% propylene glycol. This loop would deliver heat through a direct buried, insulated pipe to a new heat exchanger at each building.

The biomass system should be designed to allow for additional garn boilers to be added in the future, if Kiana wishes to expand the project to offset further quantities of heating oil.

IV. Energy Consumption and Costs

Energy Costs

The table below shows the energy comparison of different fuel types. The system efficiency is used to calculate the delivered MMBTU's of energy to the building. The delivered cost of energy to the building, in $/MMBTU, is the most accurate way to compare costs of different energy types. As shown below, cordwood is cheaper than fuel oil on a $/MMBTU basis.

Table 4 – Energy Comparison

Fuel Type	Units	Gross BTU/unit	System Efficiency	$/unit	Delivered $/MMBTU
Cord Wood	cord	15,900,000	75%	$250	$20.96
Heating Oil #1	gal	134,000	75%	$5.50	$54.73
Electricity	kWh	3,413	99%	$0.60	$177.57

Wood Energy

The gross energy content of a cord of wood varies depending on tree species and moisture content. Wet or greenwood has higher moisture contents and require additional heat to evaporate moisture before the wood can burn. Thus, wood with higher moisture contents will have lower energy contents. Seasoned or dry wood will typically have 20% moisture content. According to the previous resource assessments in the Kiana area, the wood species is primarily White and Black spruce. The 2014 Tetra Tech Biomass Study estimates that the average heating value of Black spruce is 15.9 MMBTU/cord, which was used for the calculations in Coffman's analysis. To determine the delivered $/MMBTU of the biomass system, a 75% efficiency for batch burning systems was assumed. This is based on Garn manufacturer documentation and typical operational issues which do not allow firing 100% of the time.

Cordwood

Cord wood can be purchased by local wood cutters for approximately $300 to $350/cord. However, a new road is planned to be constructed next year to access a new gravel pit for the expansion of the Kiana airport. This new road will give access to a large area of forested land that could be used for harvest. The City of Kiana estimates that with this new road, cord wood will be easier to harvest and the price will drop to $250/cord. For this analysis it is assumed that the price for cord wood will be $250/cord. A sensitivity analysis is completed to show how changing cord wood prices will affect the projects benefit to cost ratio.

Wood Pellets

There is no local wood pellet manufacturer or distributer in Kiana, which means that wood pellets would have to be barged into the community. Wood pellets are typically sold in 40 pound bags and shipped by the pallet (where 50 bags are loaded on a pallet). Each pallet is one ton of pellets. Wood pellets are currently sold in Anchorage for $295/ton. The additional cost for shipping one ton of wood pellets by barge to Kiana would be significantly more expensive, making pellets cost-prohibitive compared to heating oil. Due to this factor, wood pellets were not considered as an economical fuel for this study.

Heating Oil

The high price of fuel oil is the main economic driver for the use of lower cost biomass heating. Fuel oil is shipped into Kiana by barge and currently costs approximately $5.50/gal. For this study, the energy content of fuel oil is based on 134,000 BTU/gal, according to the UAF Cooperative Extension.

Electricity

Electricity is provided by the local power utility, Alaska Village Electric Cooperative (AVEC). The City of Kiana receives a non-PCE rate of $0.60/kWh, which was used in this economic analysis.

Existing Heating Oil Consumption

Heating oil records for five city buildings were gathered for 2015 and are shown in the following table. The Clinic is operated by Maniilaq and heating oil records were not available, so annual heating oil consumption was estimated at 0.70 gallons per square foot. The heating oil consumption of the school was verbally reported by onsite maintenance during the site visit.

Table 5 – Existing Fuel Oil Consumption

Building	Fuel Type	Annual Consumption	Net MMBTU/yr	Avg. Annual Cost
City Office Building	Heating Oil #1	950 gal	95.5	$5,225
Community Building	Heating Oil #1	850 gal	85.4	$4,675
Fire Hall	Heating Oil #1	600 gal	60.3	$3,300
Youth Activity Center	Heating Oil #1	650 gal	65.3	$3,575
Warm Storage	Heating Oil #1	1,300 gal	130.7	$7,150
Clinic	Heating Oil #1	3,500 gal	351.8	$19,250
School	Heating Oil #1	25,000 gal	2512.5	$137,500

The existing heating oil consumption for each district heating option is shown below.

Table 6 – Existing Oil Consumption of Each Option Without Biomass

Option	Buildings Served	Annual Consumption	Net MMBTU/yr	Avg. Annual Cost
Option 1	City Warm Storage Building, Community Building, Fire Hall, Youth Center, Clinic, City Warm Storage Building	7,850 gal	788.9	**$43,175**
Option 2	Clinic, City Warm Storage Building, School	29,800 gal	2994.9	**$163,900**

Biomass System Consumption

For Option 1, it is estimated that the proposed biomass system will offset 85% of the heating energy for the connected community buildings. The remaining 15% of the heating energy will be provided by the existing oil boilers, Toyo stoves or unit heaters inside each building.

For Option 2, it is estimated that the proposed biomass system will offset 30% of the heating oil. The remaining 70% of the heat will be provided by the existing oil boilers in the Clinic, School and City Warm Storage Building.

The percentage of heating oil offsets is based on an analysis of the buildings' annual heating oil consumption, compared to temperature BIN data and the heat output of the Garn boiler. It is assumed that the Garn WHS-3200 is loaded every 12 hours, which will produce 150,000 BTU/hr with return water temperature of 125F per manufacturer documentation. More frequent loading is possible, which will increase BTU output and allow additional heating oil offset during colder times of the year. Overall, it is estimated that the Garn system will save approximately $22,160 and $30,094 in annual energy costs for Option 1 and Option 2, respectively.

Table 7 – Proposed Biomass System Fuel Consumption

Biomass Option	Fuel Type	% Heating Source	Net MMBTU/yr	Annual Consumption	Energy Cost	Total Energy Cost	Annual Energy Savings
Option 1	Cord Wood	85%	670.6	56 cords	$14,058	$21,015	**$22,160**
	Fuel Oil	15%	118.3	1,178 gal	$6,476		
	Additional Electricity	N/A	N/A	800 kWh	$480		
Option 2	Cord Wood	30%	898.5	75 cords	$18,836	$133,806	**$30,094**
	Fuel Oil	70%	2096.4	20,860 gal	$114,730		
	Additional Electricity	N/A	N/A	400 kWh	$240		

V. Preliminary Cost Estimating

An estimate of probable costs was completed for installing the Garn boiler system and district heating system for each option. The cost estimate is based upon equipment quotes and from previous cost estimates created for similar projects. A 15% remote factor was used to account for increased shipping and installation costs in Kiana. Project and Construction Management was estimated at 5%. Engineering design and permitting was estimated at 15% and a 25% contingency was used.

Table 8 – Estimate of Probable Cost – Biomass Option 1			
Category	**Description**		**Cost**
Site Work	Site Grading for Module	$	4,000
	Foundation (Timbers and Anchors)	$	5,000
	Buried Utilities	$	5,000
	Subtotal	**$**	**14,000**
Electrical Utilities	Service Entrance	$	4,000
	Conduit and Wiring	$	4,000
	Subtotal	**$**	**8,000**
Wood Boiler Building	Insulated Module 8 ft x 20 ft	$	15,000
	Garn Boiler WHS 3200	$	45,000
	Heat Exchanger	$	5,000
	Installation, Piping & Materials	$	70,000
	Fire Allowance	$	10,000
	Controls Allowance	$	20,000
	Electrical Allowance	$	10,000
	Shipping	$	30,000
	Subtotal	**$**	**205,000**
Heat Loop Distribution	Excavation (Using Local Labor)	$	30,000
	Insulated Arctic Pipe (With Supply and Return Lines)	$	90,000
	Sand Bedding	$	15,000
	Heat Exchangers for Each Building	$	24,000
	Circ Pumps for Each Building (2 each)	$	24,000
	Building Piping	$	30,000
	Unit Heaters	$	32,000
	Clinic Boiler Connection	$	10,000
	Shipping	$	20,000
	Subtotal	**$**	**275,000**
Subtotal Material and Installation Cost		**$**	**502,000**
Remote Factor	15%	$	75,300
	Subtotal	**$**	**577,300**
Project and Construction Management	5%	$	28,865
	Subtotal	**$**	**606,165**
Design Fees and Permitting	15%	$	90,925
	Subtotal	**$**	**697,090**
Contingency	25%	$	174,272
Total Project Cost		**$**	**871,362**
Budgetary Cost		**$**	**872,000**

Table 9 – Estimate of Probable Cost – Biomass Option 2			
Category	**Description**		**Cost**
Wood Boiler Install	Garn Boiler WHS 3200	$	45,000
	Heat Exchanger	$	5,000
	Installation, Piping & Materials	$	50,000
	Fire Allowance	$	10,000
	Controls Allowance	$	10,000
	Electrical Allowance	$	10,000
	Shipping	$	25,000
	Subtotal	**$**	**155,000**
Heat Loop Distribution	Excavation (Using Local Labor)	$	14,000
	Insulated Arctic Pipe (With Supply and Return Lines)	$	42,000
	Sand Bedding	$	7,000
	Heat Exchangers for Each Building	$	12,000
	Circ Pumps for Each Building (2 each)	$	12,000
	Building Piping	$	15,000
	Unit Heaters	$	16,000
	Clinic Boiler Connection	$	10,000
	School Boiler Connection	$	10,000
	Shipping	$	25,000
	Subtotal	**$**	**163,000**
Subtotal Material and Installation Cost		**$**	**318,000**
Remote Factor	15%	$	47,700
	Subtotal	**$**	**365,700**
Project and Construction Management	5%	$	18,285
	Subtotal	**$**	**383,985**
Design Fees and Permitting	15%	$	57,598
	Subtotal	**$**	**441,583**
Contingency	25%	$	110,396
Total Project Cost		$	551,978
Budgetary Cost		**$**	**552,000**

VI. Economic Analysis

The following assumptions were used to complete the economic analysis for this study.

Table 10 – Inflation rates	
Discount Rate for Net Present Value Analysis	3%
Wood Fuel Escalation Rate	3%
Fossil Fuel Escalation Rate	5%
Electricity Escalation Rate	3%
O&M Escalation Rate	2%

The real discount rate, or minimum attractive rate of return, is 3.0% and is the current rate used for all Life Cycle Cost Analysis by the Alaska Department of Education and Early Development. This is a typical rate used for completing economic analysis for public entities in Alaska. The escalation rates used for the wood, heating oil, electricity and O&M rates are based on rates used in the Alaska Energy Authority funded 2013 and 2014 biomass pre-feasibility studies. These are typical rates used for this level of evaluation and were used so that results are consistent and comparable to the previous studies.

A net present value analysis was completed using real dollars (constant dollars) and the real discount rate, as required per the Alaska Department of Education and Early Development Life Cycle Cost Analysis Handbook.

O&M Costs

Non-fuel related operations and maintenance costs (O&M) were estimated at $700 per year. The estimate is based on annual maintenance time for the Garn boiler. For only the first two years of service, the maintenance cost is doubled to account for maintenance staff getting used to operating the new system. Labor costs for daily stoking of the boiler are not included, as this is typically completed by a maintenance person who is already hired by the organization that utilizes the boiler and stoking the boiler would become part of their daily duties.

Definitions

There are many different economic terms used in this study. A listing of all of the terms with their definition is provided below for reference.

Table 11 – Economic Definitions	
Economic Term	**Description**
Project Capital Cost	This is the opinion of probable cost for designing and constructing the project.
Present Value of Project Benefits (20-year life)	The present value of all of the heating oil that would have been consumed by the existing heating oil-fired heating system, over a 20-year period.
Present Value of Operating Costs (20-year life)	The present value of all of the proposed biomass systems operating costs over a 20-year period. This includes wood fuel, additional electricity, and O&M costs for the proposed biomass system and the heating oil required by the existing equipment to supply the remaining amount of heat to the building.
Benefit / Cost Ratio of Project (20-year life)	This is the benefit to cost ratio over the 20-year period. A project that has a benefit to cost ratio greater than 1.0 is economically justified. It is defined as follows: $$Benefit\ /\ Cost\ Ratio = \frac{PV(Project\ Benefits) - PV(Operating\ Costs)}{Project\ Capital\ Cost}$$ Where: PV = The present value over the 20-year period Reference Sullivan, Wicks and Koelling, "Engineering Economy", 14th ed., 2009, pg. 440, Modified B-C Ratio.
Net Present Value (20-year life)	This is the net present value of the project over a 20-year period. If the project has a net present value greater than zero, the project is economically justified. This quantity accounts for the project capital cost, project benefits and operating costs.
Payback Period (Year Accumulated Cash Flow > Project Capital Cost)	The Payback Period is the number of years it takes for the accumulated cash flow of the project to be greater than or equal to the project capital cost. This quantity includes escalating energy prices and O&M rates. This quantity is calculated as follows: $$Installed\ Cost \leq \sum_{k=0}^{J} R_k$$ Where: J = Year that the accumulated cash flow is greater than or equal to the Project Capital Cost. R_k = Project Cash flow for the kth year.

Results

An economic analysis was completed for each option in order to determine the payback, benefit to cost ratio, and net present value of the proposed Garn boiler system, as shown in the table below. Any project with a benefit to cost ratio above 1.0 is considered economically justified.

Option 1 has a benefit to cost ratio of 0.65 over the 20-year study period, which does not make the project justified on a purely economic basis. The main reasons for this low benefit to cost ratio is the high installation costs associated with connecting numerous community buildings and the relatively low amount of heating oil offset.

Option 2 has a benefit to cost ratio of 1.40 over the 20-year study period, which makes the project economically justified. Installing the Garn boiler inside the City Warm Storage Building and only connecting the three high heating oil consumers reduces the installation cost of the project while also maximizing heating oil offset.

The Alaska Energy Authority is now using a 25-year life span for the Garn Boiler for the Renewable Energy Fund applications. This means that the Garn will have five years of additional benefits after the 20-year study period.

A cordwood storage building was not included in either option. Please refer to Appendix B for the economic analysis spreadsheet for greater detail.

Table 12 – Economic Analysis Results

Item	Biomass Option 1	Biomass Option 2
Project Capital Cost	($872,000)	($552,000)
Present Value of Project Benefits (20-year life)	$1,012,598	$3,844,001
Present Value of Operating Costs (20-year life)	($446,880)	($3,073,300)
Benefit / Cost Ratio of Project (20-year life)	0.65	1.40
Net Present Value (20-year life)	($306,283)	$218,701
Year Cash Flow is Net Positive	First Year	First Year
Payback Period (Year Accumulated Cash Flow > Project Capital Cost)	>20 years	16 years

Sensitivity Analysis

A sensitivity analysis was completed to show how changing heating oil costs and wood costs affect the benefit to cost (B/C) ratios of each project. As heating oil costs increase and wood costs decrease, the projects becomes more economically viable. The B/C ratios greater than 1.0 are economically justified and are highlighted in green. B/C ratios less than 1.0 are not economically justified and are highlighted in red. The sensitivity analysis shows that Option 2 is economically justified over a much wider range in cordwood prices and heating oil prices than Option 1.

Table 13 – Sensitivity Analysis – Biomass Option 1

B/C Ratios		Cordwood Cost				
		$150/cord	$200/cord	$250/cord	$300/cord	$350/cord
Heating Oil Cost	$3.50/gal	0.41	0.35	0.29	0.23	0.17
	$4.00/gal	0.50	0.44	0.38	0.32	0.25
	$4.50/gal	0.59	0.53	0.47	0.41	0.34
	$5.00/gal	0.68	0.62	0.56	0.50	0.43
	$5.50/gal	0.77	0.71	0.65	0.59	0.52
	$6.00/gal	0.86	0.80	0.74	0.68	0.61
	$6.50/gal	0.95	0.89	0.83	0.77	0.70
	$7.00/gal	1.04	0.98	0.92	0.86	0.79
	$7.50/gal	1.13	1.07	1.01	0.95	0.88

Table 14 – Sensitivity Analysis – Biomass Option 2

B/C Ratios		Cordwood Cost				
		$150/cord	$200/cord	$250/cord	$300/cord	$350/cord
Heating Oil Cost	$3.50/gal	0.90	0.77	0.64	0.50	0.37
	$4.00/gal	1.09	0.96	0.83	0.69	0.56
	$4.50/gal	1.28	1.15	1.02	0.88	0.75
	$5.00/gal	1.47	1.34	1.21	1.07	0.94
	$5.50/gal	1.66	1.53	1.40	1.26	1.13
	$6.00/gal	1.85	1.72	1.59	1.45	1.32
	$6.50/gal	2.04	1.91	1.78	1.64	1.51
	$7.00/gal	2.23	2.10	1.97	1.83	1.70
	$7.50/gal	2.42	2.29	2.16	2.02	1.89

VII. Heat Recovery Modifications at Water Treatment Plant

During the site visit at Kiana, Coffman investigated the existing heat recovery system at the Water Treatment Plant (WTP) and evaluated ways to improve the system. The existing heat recovery system transfers heat from the nearby AVEC generator module through a buried, insulated arctic pipe. Heat is transferred through several heat exchangers to tank water and well line loop water. The heat recovery system is currently not connected to the WTP's boiler loop for building heat. The Alaska Native Tribal Health Consortium's (AHTHC) Alaska Rural Utility Collaborative (ARUC) is in charge of operating and maintaining the WTP. ANTHC was collaborated with to determine improvements and costs associated with upgrading the heat recovery system.

Figure 6 – Water Treatment Plant

Energy Consumption

Based on energy data from the Alaska Native Tribal Health Consortium (AHTHC) for fiscal years 2014 through 2016, the WTP consumes approximately 9,500 gallons of heating oil annually.

Table 15 – WTP Oil Consumption

Building Name	Fuel Type	Annual Consumption	Net MMBTU/yr	Avg. Annual Cost
Water Treatment Plant	Heating Oil #1	9,500 gal	954.8	$52,250

Heat Recovery Upgrades

Based on coordination with ANTHC and the site visit, the following upgrades to the heat recovery system are recommended:

1. Re-pipe and replace heat exchangers to allow for the utilization of heat by the entire heating system and not just the raw water heat exchanger and water storage tank. This will involve installing a new heat exchanger on the return side of the boiler loop. Heat exchanger size to be verified.
2. Replace above ground heat recovery piping with similar size piping with 3" of insulation to increase available energy and recharge the system with glycol. Sizing of piping to be verified.
3. Insulate exposed piping inside water plant to reduce heat loss and condensation buildup.
4. Modify the AVEC heat recovery module to increase available energy. This will involve adding marine jackets to the diesel generators and upgrading the thermostatic valve. Coordination with AVEC on appropriate upgrades will need to be completed.

Based on an analysis of AVEC's generator fuel consumption from 2013 to 2016, it is estimated that the modifications to the heat recovery system will allow a 90% offset of the WTP's heating oil. According to AVEC, the cost for heat recovery BTU's is approximately 30% of the cost of heating oil. It is unclear if AVEC is currently charging ARUC on heat recovery energy at this time. The savings associated with upgrading the heat recovery system is shown below.

Table 16 – WTP Energy Consumption with Upgrades

Fuel Type	% Heating Source	Net MMBTU/yr	Annual Consumption	Energy Cost	Total Energy Cost	Annual Energy Savings
Heat Recovery	90%	859.3	8,550 gal Equivalent	$14,108	$19,333	$32,918
Heating Oil	10%	95.5	950 gal	$5,225		

Preliminary Cost Estimate

An estimate of probable costs was completed for the WTP heat recovery upgrades. A 15% remote factor was used to account for increased shipping and installation costs in Kiana. Project and Construction Management was estimated at 5%. Engineering design and permitting was estimated at 15% and a 25% contingency was used.

Category	Description		Cost
WTP Work	Add New Heat Exchanger to Return Side of Boilers	$	50,000
	Replace Above Ground Heat Recover Piping with insulated Arctic Pipe	$	75,000
	Insulate Piping Inside Plant	$	50,000
	Modify Heat Recovery Module and Install Marine Jackets	$	50,000
Subtotal Material and Installation Cost		**$**	**225,000**
Remote Factor	15%	$	33,750
	Subtotal	**$**	**258,750**
Project and Construction Management	5%	$	12,938
	Subtotal	**$**	**271,688**
Design Fees and Permitting	15%	$	40,753
	Subtotal	**$**	**312,441**
Contingency	25%	$	78,110
Total Project Cost		**$**	**390,551**
Budgetary Cost		**$**	**391,000**

Economic Analysis

An economic analysis of the WTP upgrades was completed using the same escalation factors used in the biomass study. The benefit to cost ratio of the project is 2.11, which makes the project economically justified. Compared with the proposed biomass project, the WTP heat recovery upgrade project has a higher return on investment.

Table 17 – Economic Analysis Results – WTP Upgrades	
Project Capital Cost	($391,000)
Present Value of Project Benefits (20-year life)	$1,225,437
Present Value of Operating Costs (20-year life)	($402,301)
Benefit / Cost Ratio of Project (20-year life)	2.11
Net Present Value (20-year life)	$432,136
Year Cash Flow is Net Positive	First Year
Payback Period (Year Accumulated Cash Flow > Project Capital Cost)	11 years

A sensitivity analysis was completed to show how changing heating oil costs and total project costs affect the benefit to cost (B/C) ratios of the heat recovery project. The B/C ratios greater than 1.0 are economically justified and are highlighted in green. B/C ratios less than 1.0 are not economically justified and are highlighted in red. The sensitivity analysis shows that the heat recovery project is economically justified over a wide range of project costs and heating oil costs.

Table 18 – Sensitivity Analysis – WTP Heat Recovery Upgrades						
B/C Ratios		Project Cost				
		($200,000)	($300,000)	($391,000)	($500,000)	($600,000)
Heating Oil Cost	$3.50/gal	2.23	1.49	1.14	0.89	0.74
	$4.00/gal	2.61	1.74	1.33	1.04	0.87
	$4.50/gal	2.99	1.99	1.53	1.19	1.00
	$5.00/gal	3.36	2.24	1.72	1.34	1.12
	$5.50/gal	3.74	2.49	1.91	1.50	1.25
	$6.00/gal	4.12	2.74	2.11	1.65	1.37
	$6.50/gal	4.49	2.99	2.30	1.80	1.50
	$7.00/gal	4.87	3.25	2.49	1.95	1.62
	$7.50/gal	5.25	3.50	2.68	2.10	1.75

VIII. Forest Resource and Fuel Availability Assessments

Forest Resource Assessments

Several Forest Resource Assessments have been completed in the Kiana area. Refer to Table 2 for a list of the resource assessments.

It is recommended that a local biomass resource study be completed for both Kiana and the nearby community of Noorvik, similar to the Tetra Tech report. A 25-mile radius around each community should be studied to determine actual biomass resources available and what a sustainable harvest of wood will be.

Air Quality Permitting

Currently, air quality permitting is regulated according to the Alaska Department of Environmental Conservation Section 18 AAC 50 Air Quality Control regulations. Per these regulations, a minor air quality permit is required if a new wood boiler or wood stove produces one of the following conditions per Section 18 AAC 50.502 (C)(1): 40 tons per year (TPY) of carbon dioxide (CO2), 15 TPY of particulate matter greater than 10 microns (PM-10), 40 TPY of sulfur dioxide, 0.6 TPY of lead, 100 TPY of carbon monoxide within 10 kilometers of a carbon monoxide nonattainment area, or 10 TPY of direct PM-2.5 emissions. These regulations assume that the device will operate 24 hours per day, 365 days per year and that no fuel burning equipment is used. If a new wood boiler or wood stove is installed in addition to a fuel burning heating device, the increase in air pollutants cannot exceed the following per AAC 50.502 (C)(3): 10 TPY of PM-10, 10 TPY of sulfur dioxide, 10 TPY of nitrogen oxides, 100 TPY of carbon monoxide within 10 kilometers of a carbon monoxide nonattainment area, or 10 TPY of direct PM-2.5 emissions. Per the Wood-fired Heating Device Visible Emission Standards (Section 18 AAC 50.075), a person may not operate a wood-fired heating device in a manner that causes black smoke or visible emissions that exceed 50 percent opacity for more than 15 minutes in any hour in an area where an air quality advisory is in effect.

From Coffman's discussions with Patrick Dunn at the Alaska Department of Environmental Conservation, these regulations are focused on permitting industrial applications of wood burning equipment. In his opinion, it would be unlikely that an individual wood boiler would require an air quality permit unless several boilers were to be installed and operated at the same site. If several boilers were installed and operated together, the emissions produced could be greater than 40 tons of CO2 per year. This would require permitting per AAC 50.502 (C)(1) or (C)(3). Permitting would not be required on the residential wood fired stoves unless they violated the Wood-fired Heating Device Visible Emission Standards (Section 18 AAC 50.075). Recent Garn boiler systems installed in Alaska have not required air quality permits.

IX. General Biomass Technology Information

Heating with Wood Fuel

Wood fuels are among the most cost-effective and reliable sources of heating fuel for communities adjacent to forestland when the wood fuels are processed, handled, and combusted appropriately. Compared to other heating energy fuels, such as oil and propane, wood fuels typically have lower energy density and higher associated transportation and handling costs. Due to this low bulk density, wood fuels have a shorter viable haul distance when compared to fossil fuels. This short haul distance also creates an advantage for local communities to utilize locally-sourced wood fuels, while simultaneously retaining local energy dollars.

Most communities in rural Alaska are particularly vulnerable to high energy prices due to the large number of heating degree days and expensive shipping costs. For many communities, wood-fueled heating can lower fuel costs. For example, cordwood sourced at $250 per cord is just 25% of the cost per MMBTU as #1 fuel oil sourced at $7 per gallon. In addition to the financial savings, the local communities also benefit from the multiplier effect of circulating energy dollars within the community longer, more stable energy prices, job creation, and more active forest management.

The local cordwood market is influenced by land ownership, existing forest management and ecological conditions, local demand and supply, and the State of Alaska Energy Assistance program.

Types of Wood Fuel

Wood fuels are specified by energy density, moisture content, ash content, and granulometry. Each of these characteristics affects the wood fuel's handling characteristics, storage requirements, and combustion process. Higher quality fuels have lower moisture, ash, dirt, and rock contents, consistent granulometry, and higher energy density. Different types of fuel quality can be used in wood heating projects as long as the infrastructure specifications match the fuel content characteristics. Typically, lower quality fuel will be the lowest cost fuel, but it will require more expensive storage, handling, and combustion infrastructure, as well as additional maintenance.

Projects in rural Alaska must be designed around the availability of wood fuels. Some fuels can be harvested and manufactured on site, such as cordwood, woodchips, and briquettes. Wood pellets can also be used, but typically require a larger scale pellet manufacturer to make them. The economic feasibility of manufacturing on site is determined by a financial assessment of the project. Typically, larger projects offer more flexibility in terms of owning and operating the wood harvesting and manufacturing equipment, such as a wood chipper, splitter, or equipment to haul wood out of forest, than smaller projects.

High Efficiency Wood Pellet Boilers

High efficiency pellet boilers are designed to burn wood pellets cleanly and efficiently. These boilers utilize pellet storage bins or silos that hold a large percentage of the building's annual pellet supply. Augers or vacuums transfer pellets from the silos to a pellet hopper adjacent to the pellet boiler, where pellets can be fed into the boiler for burning. Pellets are automatically loaded into the pellet boiler and do not require manual loading such as in a Garn cordwood boiler. The pellet boilers typically have a 3 to 1 turn down ratio, which allows the firing rate to modulate from 100% down to 33% fire. This allows the boiler to properly match building heat demand, increasing boiler efficiency. The efficiencies of these boilers can range from 85% to 92% efficiency depending on firing rate.

High Efficiency Cordwood Boilers

High Efficiency Low Emission (HELE) cordwood boilers are designed to burn cordwood fuel cleanly and efficiently. The boilers use cordwood that is typically seasoned to 25% moisture content (MC) or less and meet the dimensions required for loading and firing. The amount of cordwood burned by the boiler will depend on the heat load profile of the building and the utilization of the fuel oil system as back up. Two HELE cordwood boiler suppliers include Garn (www.garn.com) and TarmUSA (www.woodboilers.com). Both of these suppliers have units operating in Alaska. TarmUSA has a number of residential units operating in Alaska and has models that range between 100,000 to 300,000 BTU/hr. Garn boilers, manufactured by Dectra Corporation, are used in Tanana, Kasilof, Dot Lake, Thorne Bay, Coffman Cove and other locations to heat homes, washaterias, schools, and community buildings.

The Garn boiler has a unique construction, which is basically a wood boiler housed in a large water tank. Garn boilers come in several sizes and are appropriate for facilities using 100,000 to 1,000,000 BTUs per hour. The jacket of water surrounding the fire box absorbs heat and is piped into buildings via a heat exchanger, and then transferred to an existing building heating system, in-floor radiant tubing, unit heaters, or baseboard heaters. In installations where the Garn boiler is in a detached building, there are additional heat exchangers, pumps and a glycol circulation loop that are necessary to transfer heat to the building while allowing for freeze protection. Radiant floor heating is the most efficient heating method when using wood boilers such as Garns, because they can operate using lower supply water temperatures compared to baseboards.

Garn boilers are approximately 87% efficient and store a large quantity of water. For example, the Garn WHS-2000 holds approximately 1,825 gallons of heated water. Garns also produce virtually no smoke when at full burn, because of a primary and secondary gasification (2,000 ^{o}F) burning process. Garns are manually stocked with cordwood and can be loaded multiple times a day during periods of high heating demand. Garns are simple to operate with only three moving parts: a handle, door and blower. Garns produce very little ash and require minimal maintenance. Removing ash and inspecting fans are typical maintenance requirements. Fans are used to produce a draft that increases combustion temperatures and boiler efficiency. In cold climates, Garns can be equipped with exterior insulated storage tanks for extra hot water circulating capacity. Most facilities using cordwood boilers keep existing oil-fired systems operational to provide heating backup during biomass boiler downtimes and to provide additional heat for peak heating demand periods.

Low Efficiency Cordwood Boilers

Outdoor boilers are categorized as low-efficiency, high emission (LEHE) systems. These boiler systems are not recommended as they produce significant emission issues and do not combust wood fuels efficiently

or completely, resulting in significant energy waste and pollution. These systems require significantly more wood to be purchased, handled and combusted to heat a facility as compared to a HELE system. Additionally, several states have placed a moratorium on installing LEHE boilers because of air quality issues (Washington). These LEHE systems can have combustion efficiencies as low as 25% percent and produce more than nine times the emission rate of standard industrial boilers. In comparison, HELEs can operate around 87% efficiency.

High Efficiency Wood Stoves

Newer high efficiency wood stoves are available on the market that produce minimal smoke, minimal ash and require less firewood. New EPA-certified wood stoves produce significantly less smoke than older uncertified wood stoves. High efficiency wood stoves are easy to operate with minimal maintenance compared to other biomass systems. The Blaze King Classic high efficiency wood stove (www.blazeking.com) is a recommended model, due to its built-in thermostats that monitor the heat output of the stove. This stove automatically adjusts the air required for combustion. This unique technology, combined with the efficiencies of a catalytic combustor with a built-in thermostat, provides the longest burn times of any wood stove. The Blaze King stove allows for optimal combustion and less frequent loading and firing times.

Bulk Fuel Boilers

Bulk fuel boilers usually burn wood chips, sawdust, bark or pellets and are designed around the wood resources that are available from the local forests or local industry. Several large facilities in Tok, Craig, and Delta Junction (Delta Greely High School) are using bulk fuel biomass systems. Tok uses a commercial grinder to process woodchips. The chips are then dumped into a bin and are carried by a conveyor belt to the boiler. The wood fuel comes from timber scraps, local sawmills and forest thinning projects. The Delta Greely High School has a woodchip bulk fuel boiler that heats the 77,000 square foot facility. The Delta Greely system, designed by Coffman engineers, includes a completely separate boiler building which includes a chip storage bunker and space for storage of tractor trailers full of chips (so handling of frozen chips could be avoided). Woodchips are stored in the concrete bunker and augers move the material on a conveyor belt to the boilers.

Grants

There are state, federal, and local grant opportunities for biomass work for feasibility studies, design and construction. If a project is pursued, a thorough search of websites and discussions with the AEA Biomass group is recommended to make sure no possible funding opportunities are missed. Below are some funding opportunities and existing past grants that have been awarded.

Currently, there is a funding opportunity for tribal communities that develop clean and renewable energy resources through the U.S. Department of Energy. The Energy Department's Tribal Energy Program, in cooperation with the Office of Indian Energy, will help Native American communities, tribal energy resource development organizations, and tribal consortia to install community or facility scale clean energy projects.

http://apps1.eere.energy.gov/tribalenergy/

The U.S. Department of Agriculture Rural Development has over fifty financial assistance programs for a variety of rural applications. This includes energy efficiency and renewable energy programs.

http://www.rd.usda.gov/programs-services

The Department of Energy (DOE), Alaska Native programs, focus on energy efficiency and add ocean energy into the mix. In addition, the communities are eligible for up to $250,000 in energy-efficiency aid. The Native village of Kongiganak will get help strengthening its wind-energy infrastructure, increasing energy efficiency and developing "smart grid technology". Koyukuk will get help upgrading its energy infrastructure, improving energy efficiency and exploring biomass options. The village of Minto will explore all the above options as well as look for solar-energy ideas. Shishmaref, an Alaska Native village faced climate-change-induced relocation, will receive help with increasing energy sustainability and building capacity as it relocates.

http://energy.gov/articles/alaska-native-communities-receive-technical-assistance-local-clean-energy-development

The city of Nulato was awarded a $40,420 grant for engineering services for a wood energy project by the United States Department of Agriculture (USDA) and the United States Forest Service. Links regarding the award of the Woody Biomass Utilization Project recipients are shown below:

http://www.fs.fed.us/news/2012/releases/07/renewablewoods.shtml

http://www.usda.gov/wps/portal/usda/usdahome?contentid=2009/08/0403.xml

Delta Junction was awarded a grant for engineering from the Alaska Energy Authority from the Renewable Energy Fund for $831,203. This fund provides assistance to utilities, independent power producers, local governments, and tribal governments for feasibility studies, reconnaissance studies, energy resource monitoring, and work related to the design and construction of eligible facilities.

http://www.akenergyauthority.org/re-fund-6/4_Program_Update/FinalREFStatusAppendix2013.pdf

http://www.akenergyauthority.org/PDF%20files/PFS-BiomassProgramFactSheet.pdf

http://www.akenergyauthority.org/RenewableEnergyFund/RFA_Project_Locations_20Oct08.pdf

The Alaska Wood Energy Development Task Group (AWEDTG) consists of a coalition of federal and state agencies and not-for-profit organizations that have signed a Memorandum of Understanding (MOU) to explore opportunities to increase the utilization of wood for energy and biofuels production in Alaska. A pre-feasibility study for Aleknagik was conducted in 2012 for the AWEDTG. The preliminary costs for the biomass system(s) are $346,257 for the city hall and health center system and $439,096 for the city hall, health center, and future washateria system.

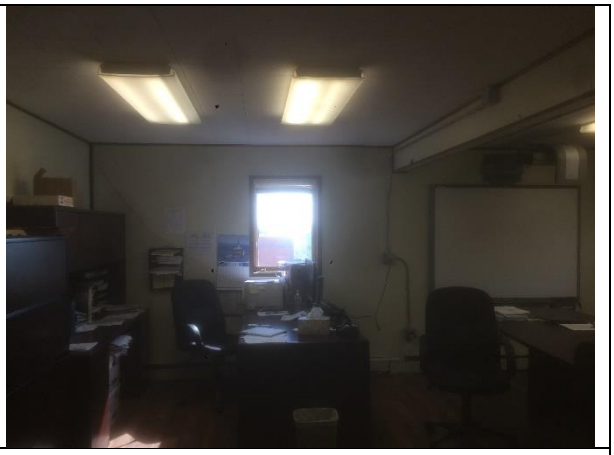
http://www.akenergyauthority.org/biomasswoodenergygrants.html

http://www.akenergyauthority.org/BiomassWoodEnergy/Aleknagik%20Final%20Report.pdf

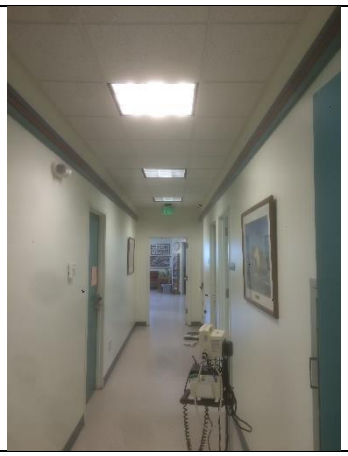
The Emerging Energy Technology Fund grand program provides funds to eligible applicants for demonstrations projects of technologies that have a reasonable expectation to be commercially viable within five years and that are designed to: test emerging energy technologies or methods of conserving energy, improve an existing energy technology, or deploy an existing technology that has not previously been demonstrated in Alaska.

http://www.akenergyauthority.org/EETFundGrantProgram.html

Appendix A
Site Photos

	
1. City Office Building	2. City Office Building - Interior
3. Community Building	4. Community Building - Interior
5. Fire Hall	6. Fire Hall – Interior

7. Clinic



8. Clinic - Hallway

9. City Warm Storage Building

10. City Warm Storage Building - Interior

11. School

12. School – Typical Classroom

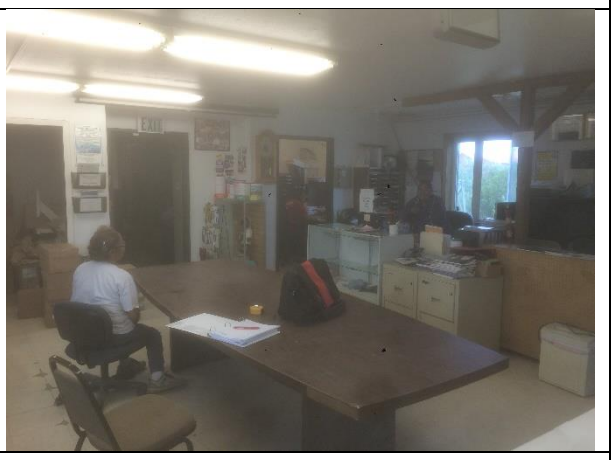
13. School – Boiler Plant

14. School – Industrial Arts Classroom

15. Youth Center

16. Youth Center - Interior

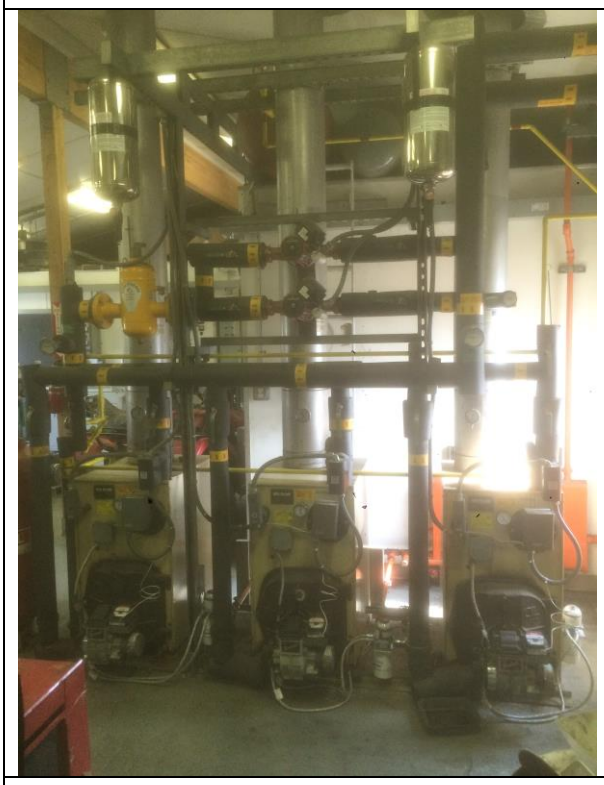
17. Tribal Office



18. Tribal Office - Interior

19. Water Treatment Plant

20. Above Ground Well Loop Piping connecting to Water Treatment Plant



21. Water Treatment Plant Boilers

22. Heat Recovery Lines Connecting to Water Treatment Plant

Appendix B
Economic Analysis Spreadsheet

Kiana Garn System - Option 1
Kiana, Alaska

Economic Analysis Results	
Project Capital Cost	($872,000)
Present Value of Project Benefits (20 year life)	$1,012,598
Present Value of Operating Costs (20 year life)	($446,880)
Benefit / Cost Ratio of Project (20 year life)	0.65
Net Present Value (20 year life)	($306,283)
Year Accumulated Cash Flow is Net Positive	First Year
Year Accumulated Cash Flow > Project Capital Cost	>20 years

Inflation Rates	
Discount Rate for Net Present Value Analysis	3%
Wood Fuel Escalation Rate	3%
Fossil Fuel Escalation Rate	5%
Electricity Escalation Rate	3%
O&M Escalation Rate	2%

Description	Unit Cost	Heating Source Proportion	Annual Energy Units	Energy Units	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Existing Heating System Operating Costs																								
Existing Heating Oil Consumption	$5.50		7,850	gal	**$43,175**	**$45,334**	**$47,600**	**$49,980**	**$52,479**	**$55,103**	**$57,859**	**$60,752**	**$63,789**	**$66,979**	**$70,328**	**$73,844**	**$77,536**	**$81,413**	**$85,484**	**$89,758**	**$94,246**	**$98,958**	**$103,906**	**$109,101**
Biomass System Operating Costs																								
Cord Wood (Delivered to site)	$250.00	85%	56.0	cords	($14,000)	($14,420)	($14,853)	($15,298)	($15,757)	($16,230)	($16,717)	($17,218)	($17,735)	($18,267)	($18,815)	($19,379)	($19,961)	($20,559)	($21,176)	($21,812)	($22,466)	($23,140)	($23,834)	($24,549)
Fossil Fuel	$5.50	15%	1,178	gal	($6,479)	($6,803)	($7,143)	($7,500)	($7,875)	($8,269)	($8,682)	($9,117)	($9,572)	($10,051)	($10,554)	($11,081)	($11,635)	($12,217)	($12,828)	($13,469)	($14,143)	($14,850)	($15,592)	($16,372)
Additional Electricity	$0.60		800	kWh	($480)	($494)	($509)	($525)	($540)	($556)	($573)	($590)	($608)	($626)	($645)	($664)	($684)	($705)	($726)	($748)	($770)	($793)	($817)	($842)
Operation and Maintenance Costs					($700)	($714)	($728)	($743)	($758)	($773)	($788)	($804)	($820)	($837)	($853)	($870)	($888)	($906)	($924)	($942)	($961)	($980)	($1,000)	($1,020)
Additional Operation and Maintenance Costs for first 2 years					($700)	($714)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Operating Costs					**($22,359)**	**($23,145)**	**($23,233)**	**($24,066)**	**($24,930)**	**($25,828)**	**($26,761)**	**($27,729)**	**($28,735)**	**($29,781)**	**($30,867)**	**($31,995)**	**($33,168)**	**($34,387)**	**($35,654)**	**($36,971)**	**($38,340)**	**($39,763)**	**($41,243)**	**($42,783)**
Annual Operating Cost Savings					$20,816	$22,188	$24,367	$25,915	$27,549	$29,275	$31,098	$33,022	$35,054	$37,198	$39,461	$41,849	$44,368	$47,026	$49,830	$52,787	$55,906	$59,195	$62,662	$66,318
Accumulated Cash Flow					$20,816	$43,004	$67,372	$93,286	$120,835	$150,111	$181,209	$214,231	$249,285	$286,483	$325,943	$367,792	$412,160	$459,186	$509,015	$561,802	$617,708	$676,902	$739,565	$805,883
Net Present Value					**($851,790)**	**($830,876)**	**($808,576)**	**($785,551)**	**($761,787)**	**($737,270)**	**($711,984)**	**($685,916)**	**($659,050)**	**($631,372)**	**($602,864)**	**($573,513)**	**($543,300)**	**($512,210)**	**($480,227)**	**($447,332)**	**($413,508)**	**($378,737)**	**($343,002)**	**($306,283)**

Kiana Garn System - Option 2
Kiana, Alaska

Economic Analysis Results	
Project Capital Cost	($552,000)
Present Value of Project Benefits (20 year life)	$3,844,001
Present Value of Operating Costs (20 year life)	($3,073,300)
Benefit / Cost Ratio of Project (20 year life)	1.40
Net Present Value (20 year life)	$218,701
Year Accumulated Cash Flow is Net Positive	First Year
Year Accumulated Cash Flow > Project Capital Cost	16 years

Inflation Rates	
Discount Rate for Net Present Value Analysis	3%
Wood Fuel Escalation Rate	3%
Fossil Fuel Escalation Rate	5%
Electricity Escalation Rate	3%
O&M Escalation Rate	2%

Description	Unit Cost	Heating Source Proportion	Annual Energy Units	Energy Units	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Existing Heating System Operating Costs																								
Existing Heating Oil Consumption	$5.50		29,800	gal	**$163,900**	**$172,095**	**$180,700**	**$189,735**	**$199,221**	**$209,183**	**$219,642**	**$230,624**	**$242,155**	**$254,263**	**$266,976**	**$280,325**	**$294,341**	**$309,058**	**$324,511**	**$340,736**	**$357,773**	**$375,662**	**$394,445**	**$414,167**
Biomass System Operating Costs																								
Cord Wood (Delivered to site)	$250.00	30%	75.0	cords	($18,750)	($19,313)	($19,892)	($20,489)	($21,103)	($21,736)	($22,388)	($23,060)	($23,752)	($24,464)	($25,198)	($25,954)	($26,733)	($27,535)	($28,361)	($29,212)	($30,088)	($30,991)	($31,921)	($32,878)
Fossil Fuel	$5.50	70%	20,860	gal	($114,730)	($120,467)	($126,490)	($132,814)	($139,455)	($146,428)	($153,749)	($161,437)	($169,508)	($177,984)	($186,883)	($196,227)	($206,039)	($216,341)	($227,158)	($238,515)	($250,441)	($262,963)	($276,111)	($289,917)
Additional Electricity	$0.60		400	kWh	($240)	($247)	($255)	($262)	($270)	($278)	($287)	($295)	($304)	($313)	($323)	($332)	($342)	($352)	($363)	($374)	($385)	($397)	($409)	($421)
Operation and Maintenance Costs					($700)	($714)	($728)	($743)	($758)	($773)	($788)	($804)	($820)	($837)	($853)	($870)	($888)	($906)	($924)	($942)	($961)	($980)	($1,000)	($1,020)
Additional Operation and Maintenance Costs for first 2 years					($700)	($714)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Operating Costs					**($135,120)**	**($141,454)**	**($147,365)**	**($154,308)**	**($161,586)**	**($169,215)**	**($177,213)**	**($185,596)**	**($194,385)**	**($203,598)**	**($213,257)**	**($223,384)**	**($234,002)**	**($245,134)**	**($256,805)**	**($269,043)**	**($281,876)**	**($295,331)**	**($309,440)**	**($324,236)**
Annual Operating Cost Savings					$28,780	$30,641	$33,335	$35,427	$37,635	$39,967	$42,429	$45,028	$47,770	$50,665	$53,718	$56,940	$60,339	$63,924	$67,706	$71,693	$75,898	$80,331	$85,004	$89,931
Accumulated Cash Flow					$28,780	$59,421	$92,756	$128,183	$165,818	$205,785	$248,214	$293,242	$341,013	$391,677	$445,396	$502,336	$562,675	$626,600	$694,305	$765,998	$841,896	$922,227	$1,007,231	$1,097,162
Net Present Value					**($524,058)**	**($495,176)**	**($464,670)**	**($433,194)**	**($400,729)**	**($367,257)**	**($332,759)**	**($297,213)**	**($260,601)**	**($222,902)**	**($184,095)**	**($144,158)**	**($103,070)**	**($60,808)**	**($17,350)**	**$27,326**	**$73,246**	**$120,431**	**$168,908**	**$218,701**

Kiana WTP Heat Recovery Upgrades
Kiana, Alaska

Economic Analysis Results	
Project Capital Cost	($391,000)
Present Value of Project Benefits (20 year life)	$1,225,437
Present Value of Operating Costs (20 year life)	($402,301)
Benefit / Cost Ratio of Project (20 year life)	2.11
Net Present Value (20 year life)	$432,136
Year Accumulated Cash Flow is Net Positive	First Year
Payback Period (Year Accumulated Cash Flow > Project Capital Cost)	11 years

Inflation Rates	
Discount Rate for Net Present Value Analysis	3%
Wood Fuel Escalation Rate	3%
Fossil Fuel Escalation Rate	5%
Electricity Escalation Rate	3%
O&M Escalation Rate	2%

Description	Unit Cost	Heating Source Proportion	Annual Energy Units	Energy Units	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Existing Heating System Operating Costs																								
Existing Heating Oil Consumption	$5.50		9,500	gal	**$52,250**	**$54,863**	**$57,606**	**$60,486**	**$63,510**	**$66,686**	**$70,020**	**$73,521**	**$77,197**	**$81,057**	**$85,110**	**$89,365**	**$93,833**	**$98,525**	**$103,451**	**$108,624**	**$114,055**	**$119,758**	**$125,746**	**$132,033**
Operating Costs with Upgraded Heat Recovery System																								
Heat Recovery	$1.65	90%	8,550	gal	($14,108)	($14,531)	($14,967)	($15,416)	($15,878)	($16,354)	($16,845)	($17,350)	($17,871)	($18,407)	($18,959)	($19,528)	($20,114)	($20,717)	($21,339)	($21,979)	($22,638)	($23,318)	($24,017)	($24,738)
Heating Oil	$5.50	10%	950	gal	($5,225)	($5,486)	($5,761)	($6,049)	($6,351)	($6,669)	($7,002)	($7,352)	($7,720)	($8,106)	($8,511)	($8,937)	($9,383)	($9,853)	($10,345)	($10,862)	($11,406)	($11,976)	($12,575)	($13,203)
Additional Electricity	$0.60		500	kWh	($300)	($309)	($318)	($328)	($338)	($348)	($358)	($369)	($380)	($391)	($403)	($415)	($428)	($441)	($454)	($467)	($481)	($496)	($511)	($526)
Operation and Maintenance Costs					$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Additional Operation and Maintenance Costs for first 2 years					$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Operating Costs					**($19,633)**	**($20,326)**	**($21,045)**	**($21,792)**	**($22,567)**	**($23,371)**	**($24,205)**	**($25,072)**	**($25,971)**	**($26,904)**	**($27,873)**	**($28,880)**	**($29,925)**	**($31,010)**	**($32,138)**	**($33,309)**	**($34,525)**	**($35,789)**	**($37,102)**	**($38,467)**
Annual Operating Cost Savings					$32,618	$34,537	$36,560	$38,694	$40,943	$43,315	$45,815	$48,449	$51,226	$54,153	$57,236	$60,485	$63,908	$67,515	$71,314	$75,315	$79,530	$83,969	$88,643	$93,566
Accumulated Cash Flow					$32,618	$67,154	$103,714	$142,408	$183,351	$226,666	$272,481	$320,931	$372,157	$426,310	$483,546	$544,031	$607,940	$675,454	$746,768	$822,083	$901,613	$985,582	$1,074,225	$1,167,792
Net Present Value					**($359,333)**	**($326,779)**	**($293,321)**	**($258,942)**	**($223,624)**	**($187,348)**	**($150,097)**	**($111,850)**	**($72,589)**	**($32,295)**	**$9,054**	**$51,477**	**$94,996**	**$139,631**	**$185,405**	**$232,338**	**$280,455**	**$329,778**	**$380,330**	**$432,136**

Appendix C
AWEDTG Field Data Sheet

ALASKA WOOD ENERGY DEVELOPMENT TASK GROUP (AWEDTG)

PRE-FEASIBILITY ASSESSMENT **FIELD DATA SHEET**

APPLICANT:	City of Kiana
Eligibility: (check one)	☒ Local government ☐ State agency ☐ Federal agency ☐ School/School District ☐ Federally Recognized Tribe ☐ Regional ANCSA Corp. ☐ Village ANCSA Corp. ☐ Not-for-profit organization ☐ Private Entity that can demonstrate a Public Benefit ☐ Other (describe):
Contact Name:	Brad Reich (Mayor)
Mailing Address:	PO Box 150
City:	Kiana
State:	AK **Zip Code:** 99749
Office phone:	(907) 475-2136 **Cell phone:** ( )
Fax:	(907) 475-2174
Email:	cityclerk@cityofkiana.org

Facility Identification/Name:	City Warm Storage
Facility Contact Person:	Nelson Walker (City Administrator)
Facility Contact Telephone:	(907) 475-5018 ( )
Facility Contact Email:	administrator@cityofkiana.org

SCHOOL/FACILITY INFORMATION (complete separate Field Data Sheet for each building)

SCHOOL FACILITY (Name: NA **)**

School Type: (check all that apply)	[ ] Pre-School [ ] Elementary [ ] Middle School	[ ] Junior High [ ] High School [ ] Campus	[ ] Student Housing [ ] Pool [ ] Gymnasium	[ ] Other (describe):

Size of facility (sq. ft. heated):		Year built/age:		
Number of floors:		Year(s) renovated:		
Number of bldgs.:		Next renovation:		
# of Students:		Has en energy audit been conducted?:		If Yes, when? *

OTHER FACILITY (Name: City Warm Storage **)**

Type:	[ ] Health Clinic [ ] Public Safety Bldg. [ ] Community Center	[ ] Water Plant [ ] Washeteria [ ] Public Housing	[ ] Multi-Purpose Bldg [ ] District Energy System ☒ Other (list): SHOP

Size of Facility (sq. ft. heated)	2400 SF	Year built/age:	1980
Number of floors:	1	Year(s) renovated:	2010 installed radiant floor & heat work
Number of bldgs.:	1 bldg	Next renovation:	none
Frequency of Usage:	8 hrs/day	# of Occupants	1-2
Has an energy audit been conducted?	NO	If Yes, when? *	NO.

*** If an Energy Audit has been conducted, please provide a copy.**

HEATING SYSTEM INFORMATION

CONFIGURATION (check all that apply)

- ☐ Heat plant in one location: ☒ on ground level ☐ below ground level ☒ mezzanine ☐ roof ☐ at least 1 exterior wall
- ☒ Different heating plants in different locations: How many? 2 What level(s)? Unit heater on ceiling. Oil boiler on ground level feeds radiant floor.
- ☐ Individual room-by-room heating systems (space heaters)
- ☐ Is boiler room accessible to delivery trucks? ☐ Yes ☒ No

HEAT DELIVERY (check all that apply)

- ☒ Hot water: ☐ baseboard ☒ radiant heat floor ☐ cabinet heaters ☐ air handlers ☐ radiators ☐ other: _____
- ☐ Steam: _____
- ☒ Forced/ducted air
- ☐ Electric heat: ☐ resistance ☐ boiler ☐ heat pump(s)
- ☐ Space heaters

$6.00/gal in 2015

HEAT GENERATION (check all that apply)

							Heating capacity (Btuh / kWh)	Annual Fuel Consumption	Annual Fuel Cost
☒ Hot water boiler:	☐ natural gas	☐ propane	☐ electric	☒ #1 fuel oil	☐ #2 fuel oil		180,000 BTU/hr	1,300 gal combined	$5.50/gal
☐ Steam boiler:	☐ natural gas	☐ propane	☐ electric	☐ #1 fuel oil	☐ #2 fuel oil				
☒ Warm air furnace:	☐ natural gas	☐ propane	☐ electric	☒ #1 fuel oil	☐ #2 fuel oil		100,000 BTU/hr		
☐ Electric resistance:	☐ baseboard	☐ duct coils							
☐ Heat pumps:	☐ air source	☐ ground source	☐ sea water						
☐ Space heaters:	☐ woodstove	☐ Toyo/Monitor	☐ other: _____						

TEMPERATURE CONTROLS (type of system; check all that apply)

- ☒ Thermostats on individual devices/appliances; no central control system → Non-Programmable.
- ☐ Pneumatic control system Manufacturer: _____ Approx. Age: _____
- ☐ Direct digital control system Manufacturer: _____ Approx. Age: _____

Record Name Plate data for boilers (use separate sheet if necessary): Oil Miser OM-180 Boiler. Direct vent. MODINE PDR100B, 100,000 BTU/hr. Unit heater.

Describe locations of different parts of the heating system and what building areas are served: Boiler serves radiant floor in primary/secondary loop. Unit heater is to directly heat air.

Describe age and general condition of existing equipment: Installed 2010 during renovation. Units look in good shape.

Who performs boiler maintenance? City of Kiana Describe any current maintenance issues: None.

Where is piping or ducting routed through the building? (tunnels, utilidors, crawlspace, above false ceiling, attic, etc.): Inside building. Accessible.

Describe on-site fuel storage: Number of tanks, size of tanks, location(s) of tanks, condition, spill containment, etc.: 500 gal oil tank. No spill containment.

If this fuel is also used for other purposes, please describe: No.

DOMESTIC HOT WATER — No Water or Sewer connected to building.

USES OF DOMESTIC HOT WATER
Check all that apply:

- ☐ Lavatories
- ☐ Kitchen
- ☐ Showers
- ☐ Laundry
- ☐ Water treatment
- ☐ Other: _____

TYPE OF SYSTEM
Check all that apply:

- ☐ Direct-fired, single tank
- ☐ Direct fired, multiple tanks
- ☐ Indirect , using heating boiler with separate storage tank
- ☐ Hot water generator with separate storage tank
- ☐ Other: _____

What fuels are used to generate hot water? (Check all that apply): ☐ natural gas ☐ propane ☐ electric ☐ #1 fuel oil ☐ #2 fuel oil

Describe location of water heater(s): None.

Describe on-site fuel storage: number of tanks, size of tanks, location(s) of tanks, condition, spill containment, etc.:
None for DHW.

BUILDING ENVELOPE

Wall type (stick frame, masonry, SIP, etc.): Metal frame Bldg. Insulation Value: R-13 estimated

Roof type: Vented cold roof. Insulation Value: R-20 estimated

Windows: ☐ single pane ☐ double pane ☐ other: No windows

Arctic entry(s): ☒ none ☐ at main entrance only ☐ at multiple entrances ☐ at all entrances

Drawings available: ☐ architectural ☐ mechanical ☐ electrical NO Dwgs.

Outside Air/Air Exchange: ☐ HRV ☐ CO_2 Sensor None

ELECTRICAL

Utility company that serves the building or community: AVEC (PCE community)

Type of grid: ☐ building stand-alone ☒ village/community power ☐ railbelt grid

Energy source: ☐ hydropower ☒ diesel generator(s) ☐ Other: _____

Electricity rate per kWh: $0.64 Demand charge: No ← City Building Receive NON-PCE RATE of $0.64/kWh.

Electrical energy phase(s) available: ☒ single phase ☐ 3-phase

Back-up generator on site: ☐ Yes ☒ No If Yes, provide output capacity: _____

Are there spare circuits in MDP and/or electrical panel?: ☒ Yes ☐ No

Record MDP and electrical panel name plate information: Yes.

WOOD FUEL INFORMATION

- Wood pellet cost delivered to facility $ — /ton Viable fuel source? Yes (No) } No Processor. Too Remote.
- Wood chip cost delivered to facility $ — /ton Viable fuel source? Yes (No)
- Cord wood cost delivered to facility $ SEE BELOW /cord Viable fuel source? (Yes) No
- Distance to nearest wood pellet and wood chip suppliers? Anchorage + Fairbanks.

Can logs or wood fuel be stockpiled on site or at a nearby facility? Space at City Warm Storage.

Who manages local forests? Village Native Corp, Regional Native Corp, State of Alaska, Forest Service, BLM, USF&WS, Other:

New road planned to access new gravel (2.5 miles long + 1.5 from town = 4 miles from town.) If this goes in cord wood cost would be less ($200-$250). Currently prices are around $300-$350/cord. NANA owns land.

FACILITY SITE CONSIDERATIONS — City Warm Storage

Are there good access to site for delivery vehicles (trucks, chip vans, etc)? Yes.

Are there any significant site constraints? (Playgrounds, other buildings, wetlands, underground utilities, etc.)?
Close to school + clinic.

What are local soil conditions? Permafrost issues? Permafrost exists 4 ft down.
Gravel + Clay.

Is the building in proximity to other buildings with biomass potential? If so, Which ones and How close?
It could feed many city bldgs + clinic + school.

Can building accommodate a biomass boiler inside, or would an addition for a new boiler be necessary? Where would addition go?
No Space inside City Shop. Locate unit in new module. Room onsite.

Where would potential boiler plant or addition utilities (water/sewer/power/etc.) come from?
Already has electricity. Water + Sewer can be provided if needed.

If necessary, can piping be run underground from a central plant to the building? Where would piping enter boiler room?
Piping already runs underground. They already have excavator, loader to do work.

OTHER INFORMATION

Provide any other information that will help describe the space heating and domestic hot water systems, such as

Is heat distribution system looping or branching? Primary/secondary loops to radiant floor.
For baseboard hydronic heat, what is the diameter of the copper tubing? Size of fins? Number of fins per lineal foot? No Baseboard
Any other energy using systems (kitchen equipment, lab equipment, pool etc)? Fuel or energy source? No.
Any systems that could be added to the boiler system? Not needed.
Are heating fuel records available? Yes.

PICTURE / VIDEO CHECKLIST

Exterior
Main entry ✓
Building elevations ✓
Several near boiler room and where potential addition/wood storage and/or exterior piping may enter the building ✓
Access road to building and to boiler room ✓
Power poles serving building ✓
Electrical service entry ✓
Emergency generator None

Interior
Boilers, pumps, domestic water heaters, heat exchangers – all mechanical equipment in boiler room and in other parts of the building. ✓
Boiler room piping at boiler and around boiler room ✓
Piping around domestic water heater None
MDP and/or electrical panels in or around boiler room ✓
Pictures of available circuits in MDP or electrical panel (open door). ✓
Picture of circuit card of electrical panel ✓
Picture of equipment used to heat room in the building (i.e. baseboard fin tube, unit heaters, unit ventilators, air handler, fan coil) ✓
Pictures of any other major mechanical equipment ✓
Pictures of equipment using fuel not part of heating or domestic hot water system (kitchen equip., lab equip., pool, etc.) ✓
Pictures of building plans (site plan, architectural floor plan, mechanical plan, boiler room plan, electrical power plan) none.

Wood

How much local wood availability is there? → See resource assessment.

Will additional wood demand cause issues? → Nelson doesn't believe it will. People want work.

Where would wood storage and wood drying occur: → City Warm Storage

Typical Wind Direction at Storage Area: → East.

Local Wood Species (~~Birch, Spruce~~): Black Spruce

Moisture Content of Wood (Wet, dry, MC%): MC%. depends. cutters usually get dry wood.

Domestic Hot Water

Avg DHW Usage (ASHRAE Daily Avg for Office Bldg is 1.0 gal/day): None.

Logistics

Drake Construction has Barge (out of Kotz.) | Vitus & Crowley Barge in fall. (Fuel) vitus & crowley can barge in spring. } Dependent on water levels.

How are construction materials shipped to Village (barge company):

Here (Lynden Air Cargo). And Barge.

Can't do full load. ($42K to ANC Kiana)

Is there local gravel or fill? How far away?

Current gravel pit is 1.5 mile away at sewer lagoon.

State will extend runway. Funds here (50 M), 3-year project. They will build one-lane road to new gravel pit (2.5 miles away). Goes out to Bid in 2017. Gravel pit has good quality spruce (large trees) for biomass use. It also is a good access point for future biomass resource expansion.