Regional Housing Authority

March 22, 2016

Lizana Pierce, Program Manager

EERE Tribal Energy Program

US Department of Energy

RE: #DE-EE0005179 – Energy Efficiency Audit, Assessment, and Alternative Energy Study

Cover Letter for the Supplement to the Final Technical Report dated July 30, 2015

Dear Lizana,

Tlingit-Haida Regional Housing Authority (THRHA) received the DOE Tribal Energy Grant (Award #DE-EE0005179 – Energy Efficiency Audit, Assessment, and Alternative Energy Study) to assess 46 low-income multifamily residences owned and managed by THRHA in up to 14 southeast Alaska communities. The Objective of the grant was to identify efficiency measures to reduce energy costs by 30% for low-income multifamily housing by:

1. Decreasing energy demand by increasing multifamily housing energy efficiency
2. Reducing household energy consumption through energy conservation education and installation of energy upgrades
3. Projecting energy savings based on fossil fuel reduction to environmentally and economically benefit Tribal southeast communities

To accomplish the above Item #2, THRHA implemented the Energy Cents program to educate households on energy conservation behavior and ways to reduce energy costs. The Energy Cents program also provided homeowners with tools and materials to help seal, weatherize, and improve the efficiency of their homes. Data was collected and compiled to provide a useful baseline from which to estimate future energy savings. Information gathered from the Energy Cents program has been reported to DOE separately and is not included in this report.

To accomplish the above Items #1 and #3, energy audits were conducted on THRHA multifamily buildings to assess existing conditions and to model energy efficiency improvement options for future installation work. The methodology used trained professional energy assessors from THRHA's Weatherization Program as well as contracted energy auditors from the private sector

to conduct on-site inspections of each building, compile data, and where appropriate, input the data into an energy modeling software program developed by the Alaska Housing Finance Corporation called AkWarm. AkWarm is the recognized standard in Alaska for energy modeling of residential and commercial buildings.

The AkWarm energy modeling software is used to record building shell data, heating and hot water system data, ventilation and airtightness data, and other data to produce an Energy Efficiency Rating Report. The AkWarm software can also produce an Improvement Options Report (IOR) to estimate the Savings to Investment Ratio (SIR, a type of life-cycle cost analysis), and the amount of energy savings that could be realized if certain improvements were completed. In some cases AkWarms were not completed, and the energy auditor used his/her professional observations to make recommendations. Actual energy use, fuel use, and fuel costs were compiled and provided in the final report for the effort.

Upon completion of the overall assessment effort and Final Technical Report in July 2015, THRHA noted some discrepancies on certain buildings between the projected energy usage from the AkWarm models and the actual energy usage obtained from utility bills. THRHA subsequently asked for an extension of time on the #DE-EE0005179 grant to allow investigation of the reasons for this lack of agreement between the models and the actual fuel use, and to investigate some of the improvement options identified in the energy audits in greater detail. The extension allowed THRHA to complete the following additional tasks:

- Evaluate the reasons for discrepancies between AkWarm modeling and actual energy use
    - Update AkWarm files based on additional review of facilities
- Develop plans for monitoring key facilities where energy efficiency and/or renewable energy projects were being pursued
    - A summary discussing the value of monitoring efforts and presenting some examples of the monitoring from the Kake project are provided
- Development of Energy Calculations, a Concept Design (drawings and technical requirements), and a Project Investigation Report, and a Design-Build Request for Proposal for the Angoon Biomass District Heating Project
- Development of a Heating System Conversion Analysis for an Air-to-Water Heat Pump System and a Grant Preparation Report for the Saxman Low-Rent Multifamily Air Source Heat Pump System / Deep Energy Retrofit Project
- Development of a Monitoring Plan for the Hoonah Low-Rent Apartments
- Development of a comparison of wood pellet fuel to locally-produced wood briquette fuel for the Klawock Senior Center
- Development of a Heating System Conversion analysis of an Air-to-Water Heat Pump System, a Monitoring Plan, and a Grant Preparation Report for the Haines Low-Rent Multifamily Air Source Heat Pump System / Deep Energy Retrofit Project

The additional work completed during this time extension is being provided as a supplement to the #DE-EE0005179 – Energy Efficiency Audit, Assessment, and Alternative Energy Study report. The final deliverables include:

1. The #DE-EE0005179 – Energy Efficiency Audit, Assessment, and Alternative Energy Study Final Technical Report dated July 30, 2015 (as previously submitted);
2. This Supplemental Report, and
3. Electronic copies of all of the AkWarm files for the project.

During this entire effort, THRHA gathered very valuable information to assist us in moving ahead with implementing energy efficiency and alternative energy improvement options for our buildings in Southeast Alaska. With the time extension that was granted us, we were able to analyze and rectify data discrepancies and gain renewed confidence in the selection of recommended improvement options. We were also able to study in much greater detail some of the alternative energy options for some of our most inefficient buildings with high operating costs.

There was one important discovery we learned regarding renewable energy options that we wish to bring to DOE's attention. Southeast Alaska is in a temperate rainforest, meaning we have abundant rain and a temperate climate. Some of our island communities have locally-produced renewable hydroelectric power that offers the cleanest, most reliable and affordable energy source for the community. In these hydroelectric communities (where there is no natural gas fuel supply, and imported diesel fuel oil has been the predominate heating source) it makes both economic and environmental sense to switch heating loads from imported diesel fuel oil to modern air-source heat pump (ASHP) technology. These modern heat pumps with a high coefficient of performance (COP) are fast becoming the preferred renewable energy solution to fossil fuel heating in these SE Alaska communities with an abundant supply of locally generated hydroelectric power. While conversion to ASHP can have high upfront costs in multifamily buildings where low-temp hydronic distribution systems are used, such conversions can provide a drastic reduction in annual energy costs to heat the building, supports the local community by keeping energy dollars within the local economy, and drastically reduces greenhouse gas emissions. The problem we discovered, however, is that the current DOE Tribal Energy Program assumption for a site-source conversion factor of 3.14 for electricity does not allow ASHP technology in our SE Alaska hydro communities to compete with heating oil on DOE Tribal Energy renewable energy grants.

The Alaska Housing Finance Corporation (AHFC) has recognized this issue with DOE's blanket site-source conversion factor of 3.14 for electricity, and that it does not adequately reflect the efficiencies of the locally-produced non-grid-connected hydroelectric facilities in these small SE Alaska island communities. Accordingly, after much study of the issue, AHFC adopted a "Special Hydro" conversion factor of 1.5 that they use in their AkWarm energy modeling software for these SE Alaska communities with locally-produced hydroelectric generation. This reduces the penalty for converting to ASHP technology and makes it more than competitive against fossil fuels. THRHA believes these isolated SE Alaska island communities should not be

lumped into the same category as the grid-connected, coal-tainted electrical generation in the lower 48 states, and would like to partner with DOE to examine this issue and develop a way to promote clean, renewable ASHP technology as a viable alternative to fossil fuel heating in our remote, temperate island communities with locally-produced hydroelectric power.

Sincerely,



Craig Moore

VP Planning and Development

Tlingit-Haida Regional Housing Authority

DE-0005179 Energy Efficiency Audit, Assessment, and Alternative Energy Study

March 22, 2016

Tlingit Haida Regional Housing Authority

Supplemental Reports

Multifamily Residential Buildings in Southeast Alaska Communities



Regional Housing Authority

Principal Investigator:
Craig Moore

Consortium/Teaming Members :
THRHA Weatherization Staff, Alaska Energy Engineering, WES Energy & Environment, Marquam George, Lime Solar, BacGen Solar, Michael Reid

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THRHA – AKWARM ENERGY MODEL ANALYSIS

THRHA Regional Housing Authority
Juneau, Alaska

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
jim@alaskaenergy.us

Technical Memorandum

December 17, 2015

to: **Craig Moore, Tlingit-Haida Regional Housing Authority**

subject: **Final Report**

project: **AkWarm Energy Model Analysis**

EXECUTIVE SUMMARY

The Tlingit-Haida Regional Housing Authority has developed a Final Technical Report dated July 30, 2015 that includes an energy use assessment of their housing facilities. The energy use predictions in that report were based on AkWarm energy models of the buildings, which were also used to evaluate investments in energy efficiency measures.

Alaska Energy Engineering LLC compared the AkWarm predictions with actual energy use. Energy data was gathered directly from the suppliers and utilities for 42 THRHA apartment buildings. The actual energy use was compiled into a spreadsheet and then compared to AkWarm predictions for 18 of the buildings.

Discrepancies were found between the actual and predicted consumption. The models were reviewed and in many cases the discrepancies were due to incorrect modeling parameters. The program developer also provided insight into appropriate methods of modeling the buildings. The corrected models are more accurate in predicting energy use, validating the use of AkWarm energy models. The models also led to investigation into why a few buildings are using higher than predicted energy use.

ACTUAL ENERGY USE

The energy use for 42 THRHA apartment buildings is summarized in the Appendix. The energy use is normalized by the Energy Use Index (EUI) in kBtu/sqft and Energy Cost Index ($/sqft) to provide a metric for comparing the buildings. The following table shows the average EUI—the most valuable metric for comparing building energy use—and the breakdown between heating/DHW energy and non-heating electric loads.

Average Building Energy Use Index EUI), kBtu/sqft

Energy	EUI	Percent
Heat and Domestic Hot Water	47	78%
Electric Loads	14	22%
Total	61	100%

The data shows that 78% of the energy is used for heat and domestic hot water. The buildings consume nearly 15,000 MMBtu at an annual cost of $600,000 per year.

Heating and DHW Energy Use Index

A review of the energy data revealed that some of the buildings have relatively higher EUIs. The following buildings should be investigated to determine why they have heat/HW EUIs that are significantly above the average:

- Angoon Triplex 7A, 7B, & 7C
- Haines Senior Center
- Hoonah Senior Center
- Juneau Granite Drive 4063/4067
- Juneau Kanat'a Deyi (most buildings)
- Petersburg Housing

The Yakutat Senior Center has a low heat EUI because it is also heated with cordwood, which was not included in the total energy use. The Kasaan duplexes also have low EUI's, which is due to both a highly efficient envelope and the likely use of wood heat.

Non-heat EUI

Some of the buildings have higher non-heating EUIs. The following buildings should be evaluated to determine why they have non-heating EUIs that are significantly above the average:

- Hoonah Senior Center
- Juneau Granite Drive
- Juneau Kanat'a Deyi (4468-4470; 4480-4482)
- Kasaan Duplex 3A/3B

AKWARM COMPARISON

During development of the Final Technical Report, THRHA recognized that some buildings had significant discrepancies between the AkWarm energy predictions and actual energy use. A review of the AkWarm models was undertaken for the following buildings:

- Angoon Low Rent
- Haines Senior Center
- Hoonah Senior Center
- Juneau Fireweed Place
- Juneau Granite Drive
- Juneau Kanat'a Deyi
- Juneau Valley Boulevard
- Kasaan Duplexes
- Ketchikan Fairview
- Saxman Senior Center
- Yakutat Sunrise Apartments

Energy Modeling

The nature of an energy model is to predict energy use by inputting assumptions for building use and system efficiency. Since modeling the specific use of a building can be both difficult and tedious, an energy model is generally developed based on reasonable or average use of the building. This is effective when predicting differences in energy consumption for various options. It is less reliable as a predictor of actual energy use, which can vary widely with occupant use and system efficiency.

To account for these modeling realities, the total energy use of all the buildings was compared with the total energy use predicted by the AkWarm models. Reasonable adjustments were then made to bring the predicted and actual energy consumption in close agreement as a group.

Total Energy Use

The AkWarm models predicted total energy use for all of the buildings that was 35% higher than actual energy use. A single building (Juneau Fireweed Place) accounted for a majority of the error. However, a review of the AkWarm models revealed inaccurate inputs for occupancy, system efficiencies, load definitions, and tenant preferences. These were corrected as noted later in this report. The most common corrections were:

- Boiler seasonal efficiency (AFUE) was set at 70% for most of the buildings. Most models used a higher AFUE. A 70% value is more reasonable (it may even be lower) for boilers that are sized for a peak design load plus a peak domestic hot water load, effectively oversizing them significantly for average loads. Good information on boiler seasonal efficiency is not readily available. So, this inaccuracy is to be expected.
- Indirect hot water heater efficiency was set at 65% to account for the boiler efficiency and a 5% loss factor for the hot water tank.
- The ventilation rate was set to correspond to the size of the ventilation systems.
- Electric use was changed from medium to low use, which is appropriate for multi-family apartments of modest size (as opposed to single family houses), especially in communities with high electric rates.

After making the corrections to the models, the predicted total energy use came into close agreement at 0.4% higher than actual, a remarkable result. The following table compares total actual energy use for all buildings with the original AkWarm predictions and the corrected predictions.

Comparison of Actual Energy Use and AkWarm Predictions—All Bldgs, MMBtu

Energy	Actual	Original AkWarm	Corrected AkWarm
Heat/DHW Energy	3,930	3,400 (-13%)	3,870 (-2%)
Non-heat Energy	2,900	5,790 (+99%)	2,990 (+3%)
Total Energy	6,830	9,190 (+35%)	6,860 (+0.4%)

The results show that AkWarm is a highly accurate tool for predicting energy use. However, this is only true if the models are developed based on a thorough understanding of building use and system efficiency. Making experience-based changes to the models and then verifying the changes with the actual bills obtained this level of precision. Modelers may not have the benefit of such feedback.

Building Comparisons

After correcting the models so they accurately predict "typical use", the model predictions are a valuable tool for identifying energy use anomalies that may be related to tenant use or the energy systems.

A comparison of the individual building energy use with the corrected AkWarm models revealed that variations between actual and predicted use of +/-25% is reasonable. The following buildings have actual energy use that is more than 25% higher than the prediction:

- Angoon Bldg. 7 (triplex): The fuel oil use is 44% higher than the prediction.
- Juneau Granite Drive 4060-4064: The electric use is 70% higher than the prediction. The low electric use results in less heat gain, causing the fuel oil use to be 149% higher than the prediction.
- Juneau Granite Drive 4063-4067: The electric use is 41% higher than the prediction.
- Juneau Kanat'a Deyi 4481-4483: The fuel oil use is 32% higher than the prediction.
- Saxman Senior Center: The fuel oil use is 57% higher than the prediction.
- Yakutat Sunrise Apart. A: The actual fuel oil use is 269% lower than the prediction. This indicates that the supplier fuel oil records are not accurate.
- Hoonah Senior Center: The waste heat use is 52% higher than the prediction.
- Kasaan Duplexes: Electricity use is 23% and 68% higher than predicted.

These buildings should be evaluated for potential issues related to energy use.

SUMMARY

The Final Technical Report based its findings on energy savings predicted by AkWarm energy models. The models were found to contain inaccurate representations of building use and system efficiency. While the inaccuracies may lead to inaccurate energy use predictions, the inaccuracies tend to cancel when comparing energy use between two options, so any adjustments are likely to produce only slight changes in energy savings.

Actual energy use is also not a good metric for comparing energy efficiency measures because it is based on the current use, which may differ greatly from average use. For housing buildings, average use is a more valid metric since tenants come and go. Thus, an energy model, despite its potential limitations, is the better tool for energy savings predictions.

AkWarm was found to be a valid tool for predicting "typical" energy consumption, provided that reasonable accuracy is applied to modeling the building use and system operation and efficiencies. This is essentially the art of modeling which is to have an inherent understanding of energy systems and the important parameters that must be carefully determined.

AKWARM MODEL ADJUSTMENTS

Angoon Low Rent Housing

Description

- Eight buildings—four duplexes, two triplexes, two 4-plexes
- Heat: Fuel oil boiler for each apartment, except one of the 4-plexes, which has a single boiler; fuel oil consumption data from supplier.
- Electricity: Supplied by Inside Passage Electrical Cooperative; data from utility

Energy Use

Actual energy use varies for the buildings. There is no correlation with building size or number of apartments. The variations are the likely due to tenant lifestyle and equipment efficiency.

AkWarm Models

The AkWarm prediction of energy use varies widely from 67% to 120% of actual energy consumption. One consistent trend is that the models over predict electricity consumption by an average of 156%.

The models were reviewed and the following adjustments were deemed appropriate to more accurately model the buildings:

- Fuel Type: Changed from #1 to #2 fuel oil
- Boiler: The boiler was modeled with 82% seasonal efficiency and measured combustion efficiency. These were replaced with a seasonal AFUE efficiency of 70%. A 70% AFUE is appropriate for an oversized boiler supplying space heating and intermittent domestic hot water loads.
- HW Heater: The hot water heater was modeled without accounting for the boiler AFUE. An energy factor of 65% was added which takes into account the boiler AFUE and an additional 5% tank loss.
- Miscellaneous Electric Use: Reduced from medium to low. A reasonable adjustment given Angoon's high electric rates.

Results

The modeled electric use remains high at 119% of actual. This is likely because of high electric rates of 65¢ per kWh, which would cause occupants to use electricity more frugally. The model treats electric use as a heat gain, effectively reducing the heating load. This is not an equal trade-off in overall energy consumption because the boiler produces heat at 70% efficiency.

The adjustments to the model were beneficial to bringing the energy predictions into closer agreement with the actual. Modeled energy consumption is 99% of actual, which is well within the accuracy of the energy model.

		Annual Energy Consumption				AkWarm Comparison - Original Model					AkWarm Comparison - Corrected Model				
Building Name	Size	Fuel Oil	Electricity	Waste Heat	Propane	Fuel Oil		Electricity		Total	Fuel Oil		Electricity		Total
	sqft	gallons	kWh	MMBtu	gallons	gallons	% of actual	kWh	% of actual	kBtu	gallons	% of actual	kWh	% of actual	kBtu
Angoon Duplex 1A and 1B	2,688	1,148	10,848			940	82%	13,703	126%	90%	1,036	90%	10,276	95%	91%
Angoon Duplex 2A and 2B	2,688	933	14,195			940	101%	13,556	95%	99%	1,062	114%	10,432	73%	103%
Angoon Duplex 3A and 3B	2,250	738	9,621			848	115%	13,190	137%	120%	886	120%	9,650	100%	115%
Angoon Duplex 4A and 4B	2,250	851	7,042			848	100%	13,042	185%	114%	968	114%	10,007	142%	119%
Angoon 4-plex 5A 5B 5C 5D	3,680	1,325	14,702			988	75%	24,911	169%	95%	1,185	89%	18,993	129%	98%
Angoon 4-plex 6A 6B 6C 6D	3,680	1,294	13,486			1,048	81%	24,916	185%	102%	1,172	91%	18,997	141%	101%
Angoon Triplex 7A 7B 7C	1,794	1,171	9,463			521	44%	17,157	181%	67%	655	56%	13,324	141%	70%
Angoon Triplex 9A 9B 9C	2,250	728	8,689			615	84%	17,206	198%	110%	747	103%	13,311	153%	114%
Totals	21,280	8,188	88,046			6,748	82%	137,681	156%	98%	7,711	94%	104,990	119%	99%

Haines Low Rent Housing

Description

- Building: 12-unit multi-family housing
- Heat: Two fuel oil boilers; fuel oil consumption data from supplier.
- Electricity: Supplied by Alaska Power Company; data from utility

Energy Use

The building consumes 4,314 gallons of fuel oil and 22,480 kWh of electricity.

AkWarm Models

The AkWarm model predicts energy use of 2,277 gallons of fuel oil and 67,125 kWh. The high electric prediction is treated as heat gain by the model, which is contributing to the low fuel oil prediction. The model was reviewed and the following adjustments were made to more accurately model the buildings:

- Ventilation: Changed continuous ventilation airflow from 309 to 600 cfm.
- Boiler: Added 68% AFUE which is reasonable for an oversized boiler.
- HW Heater: Added 63% energy factor with accounts for the boiler AGUE of 68% and an additional 5% tank loss.
- Electric Loads: Changed from medium to low use and eliminated the electric range and eliminated the electric dryer and range

Results

The modeled electric use remains high at 137% of actual. This is likely because of high electric rates of 25¢ per kWh, which would cause occupants to use electricity more frugally. The model treats electric use as a heat gain, effectively reducing the heating load. This is not an equal trade-off in overall energy consumption because the boiler produces heat at 68% efficiency and electric loads produce heat at 100% efficiency.

The adjustments to the model were beneficial to bringing the energy predictions into closer agreement with the actual. Modeled energy consumption is 99% of actual, which is well within the accuracy of the energy model.

		Annual Energy Consumption				AkWarm Comparison - Original Model					AkWarm Comparison - Corrected Model				
Building Name	Size	Fuel Oil	Electricity	Waste Heat	Propane	Fuel Oil		Electricity		Total	Fuel Oil		Electricity		Total
	sqft	gallons	kWh	MMBtu	gallons	gallons	% of actual	kWh	% of actual	kBtu	gallons	% of actual	kWh	% of actual	kBtu
Haines Senior Center	4,824	4,314	22,480			2,277	-47%	67,125	299%	81%	4,056	94%	30,709	137%	99%

Hoonah Low Rent Housing

Description

- Building: 12-unit multi-family housing
- Heat: Two fuel oil boilers; fuel oil consumption data from supplier.
- Electricity: Supplied by Alaska Power Company; data from utility

Energy Use

The building consumes 639 MMBtu of waste heat and 55,000 kWh of electricity.

AkWarm Models

The AkWarm model predicts energy use of 258 MMBtu and 68,000 kWh. The high electric prediction is treated as heat gain by the model, which is contributing to the waste heat prediction. The model was reviewed and the following adjustments were made to more accurately model the buildings:

- Ventilation: Changed continuous ventilation airflow from 327 cfm, which is the code-required minimum.
- Heat: Changed to district heat with 95% efficiency to account for heat exchanger losses.
- HW Heater: The model would not accept a hot water heater connected to the district heat system. The hot water load was modeled as an electric hot water heater at 90% efficiency, which accounts for the heat exchanger efficiency of 95% and an additional 5% tank loss. The predicted how water energy was manually converted from electric energy to MMBtu.
- Electric Loads: Changed from medium to low use.

Results

The modeled electric use is appropriate at 96% of actual. The modeled heating load is 50% of actual. There is concern that the waste heat Btu meter is not properly calibrated. The calibration will be verified.

Modeled energy consumption is 82% of actual due to the low waste heat projection.

		Annual Energy Consumption				AkWarm Comparison - Original Model					AkWarm Comparison - Corrected Model				
Building Name	Size	Fuel Oil	Electricity	Waste Heat	Propane	Waste Heat		Electricity		Total	Waste Heat		Electricity		Total
	sqft	gallons	kWh	MMBtu	gallons	MMBtu	% of actual	kWh	% of actual	kBtu	MMBtu	% of actual	kWh	% of actual	kBtu
Hoonah Senior Center	7,650		54,520	639		258	40%	67,781	124%	59%	330	52%	52,595	96%	82%

Juneau Fireweed Place Senior Housing

Description

- Building: Residential apartment building; 65 units
- Heat: Electric baseboard
- Electricity: Supplied by Alaska Electric Light & Power; data from utility

Energy Use

The building has a house meter and individual apartment meters. Energy use and demand for the house meter has been reasonably consistent at 425,000 kWh per year and 79 kW demand per month. Use and demand increases in the winter months due to electric heating.

AkWarm Models

The AkWarm prediction of energy use is 1,140,000 kWh. The model was developed for the entire building. The model was modified to only capture the house loads and to more accurately model the building:

- Perimeter: Reduced the wall, roof, floor, and window areas to reflect the areas served by the house meter.
- Water Heaters: The apartment water heaters were removed from the model. Steady state efficiency was reduced from 100% to 95% to account for tank losses that are not being beneficial to heating the building.
- Ventilation: Reduced the air flow to 8,000 cfm; reduced fan power to 9500 watts
- Lighting: Removed the apartment lighting.

Results

The modeled electric use is 109% of actual. This is a reasonable result given the unknowns about ventilation flow rates, heat recovery effectiveness, and weather variations.

		Annual Energy Consumption				AkWarm Comparison - Original Model					AkWarm Comparison - Corrected Model				
Building Name	Size	Fuel Oil	Electricity	Waste Heat	Propane	Fuel Oil		Electricity		Total	Fuel Oil		Electricity		Total
	sqft	gallons	kWh	MMBtu	gallons	gallons	% of actual	kWh	% of actual	kBtu	gallons	% of actual	kWh	% of actual	kBtu
Juneau Fireweed Place	54,323		423,920					1,139,510	269%	269%			462,705	109%	109%

Juneau Granite Drive Housing

Description

- Duplex housing building
- Heat: Fuel oil boiler; fuel oil consumption data from supplier.
- Ventilation: Heat recovery ventilator
- Electricity: Supplied by Alaska Electric Light & Power; data from utility

Energy Use

The Granite Drive apartment buildings have high energy use when compared to other THRHA apartments. Actual energy use varies for each building due to tenant lifestyle and equipment efficiency. It is anticipated, however, that the modeled energy use will be in close agreement with average building energy use.

AkWarm Models

The AkWarm predictions of fuel oil and electricity energy use varies widely from the actual. The models were reviewed and the following adjustments were made to each model to more accurately model the buildings:

- Occupants: Changed occupancy of each 3-bedroom apartment form 6 to 4.
- Boiler: The boiler efficiency was reduced from 82% seasonal efficiency to 70%. A 70% AFUE is appropriate for a boiler oversized to meet high, intermittent domestic hot water loads.
- HW Heater: The hot water heater was modeled without accounting for the boiler AFUE. An energy factor of 65% was added which accounts for the boiler AFUE and the tank losses of 5%.
- Temperature: Turned off night setback control.
- Miscellaneous Electric Use: Reduced from medium to low.

Results

The 4060/4064 duplex has a much higher electricity use (kWh/sqft) than other THRHA apartments. This high use causes that building to use less heating energy because of heat gain form the electric appliances. Disregarding this anomaly, the AkWarm prediction is within 5% of overall actual use.

		Annual Energy Consumption				AkWarm Comparison - Original Model					AkWarm Comparison - Corrected Model				
Building Name	Size	Fuel Oil	Electricity	Waste Heat	Propane	Fuel Oil		Electricity		Total	Fuel Oil		Electricity		Total
	sqft	gallons	kWh	MMBtu	gallons	gallons	% of actual	kWh	% of actual	kBtu	gallons	% of actual	kWh	% of actual	kBtu
Juneau Granite Drive 4060-4064	2,120	681	35,677			1,378	202%	13,716	38%	110%	1,695	249%	10,582	30%	125%
Juneau Granite Drive 4063-4067	2,694	1,826	18,827			1,456	80%	14,634	78%	79%	1,797	98%	11,180	59%	91%
Totals	4,814	2,507	54,504			2,834	113%	28,350	52%	92%	3,492	139%	21,762	40%	105%

Juneau Kanat'a Deyi Housing 4481-4483

Description

- Duplex housing building
- Heat: Fuel oil boiler; fuel oil consumption data from supplier.
- Ventilation: Heat recovery ventilator
- Electricity: Supplied by Alaska Electric Light & Power; data from utility

Energy Use

The Kanat'a Deyi apartment buildings have relatively high energy use when compared to other THRHA apartments. Actual energy use varies for each building due to tenant lifestyle and equipment efficiency. It is anticipated, however, that the modeled energy use will be in close agreement with average building energy use.

AkWarm Models

The AkWarm prediction of fuel oil and electricity energy use is 51% and 127% of actual, respectively. The models were reviewed and the following adjustments were made to each model to more accurately model the buildings:

- Fuel Type: Changed from #1 to #2 fuel oil
- Boiler: The boiler efficiency was reduced from 82% seasonal efficiency to 70%. A 70% AFUE is appropriate for a boiler oversized to meet high, intermittent domestic hot water loads.
- HW Heater: The hot water heater was modeled without accounting for the boiler AFUE. An energy factor of 65% was added which accounts for the boiler AFUE and the tank losses of 5%.
- Temperature: Turned off night setback control.
- Miscellaneous Electric Use: Reduced from medium to low.

Results

The modeled fuel oil use is low at 68% of actual. The modeled electricity use is in close agreement at 108% of actual. The reason for the low fuel oil prediction cannot be explained. The other buildings show similar fuel oil use so life style does not appear to be the cause.

		Annual Energy Consumption				AkWarm Comparison - Original Model					AkWarm Comparison - Corrected Model				
Building Name	Size	Fuel Oil	Electricity	Waste Heat	Propane	Fuel Oil		Electricity		Total	Fuel Oil		Electricity		Total
	sqft	gallons	kWh	MMBtu	gallons	gallons	% of actual	kWh	% of actual	kBtu	gallons	% of actual	kWh	% of actual	kBtu
Juneau Kanat'a Deyi 4481-4483	2,266	1,381	10,185			707	51%	12,950	127%	63%	940	68%	10,961	108%	74%

Juneau Valley Blvd 8414, 8416, 8418, 8420

Description

- 4-plex apartment building
- Heat: Fuel oil boiler; fuel oil consumption data from supplier.
- Ventilation: Heat recovery ventilator
- Electricity: Supplied by Alaska Electric Light & Power; data from utility

Energy Use

The Valley Blvd apartments have relatively low energy use, when compared to other THRHA housing. However, modeled use is much higher than actual, ranging from 130% to 173%.

AkWarm Models

The AkWarm prediction of fuel oil and electricity energy use is 160% and 173% of actual, respectively. The models were reviewed and the following adjustments were made to each model to more accurately model the buildings:

- Fuel Type: Changed from #1 to #2 fuel oil
- Boiler: The boiler efficiency was reduced from 82% seasonal efficiency to 70%. A 70% AFUE is appropriate for a boiler oversized to meet high, intermittent domestic hot water loads.
- HW Heater: The hot water heater was modeled without accounting for the boiler AFUE. An energy factor of 65% was also which takes into account the boiler AFUE and the tank losses of 5%.
- Ventilation: The building has a 120 cfm HRV that serves the four apartments. The model showed 120 cfm being supplied to each apartment. The ventilation rate was lowered from 120 cfm to 30 cfm.
- Temperature: Turned off night setback control.
- Miscellaneous Electric Use: Reduced from medium to low.

Results

The modeled fuel oil use is low at 68% of actual. The modeled electricity use is in close agreement at 108% of actual. The reason for the low fuel oil prediction cannot be explained. The other buildings show similar fuel oil use so life style does not appear to be the cause.

		Annual Energy Consumption				AkWarm Comparison - Original Model					AkWarm Comparison - Corrected Model				
Building Name	Size	Fuel Oil	Electricity	Waste Heat	Propane	Fuel Oil		Electricity		Total	Fuel Oil		Electricity		Total
	sqft	gallons	kWh	MMBtu	gallons	gallons	% of actual	kWh	% of actual	kBtu	gallons	% of actual	kWh	% of actual	kBtu
Juneau Valley Boulevard 8414-8420	4,560	1,634	11,460			2,608	160%	28,372	248%	173%	2,157	132%	21,448	187%	140%

Kasaan Duplexes

Description

- Duplex apartment buildings
- Heat: Toyo Stove and wood stove; fuel oil data from supplier.
- Domestic Hot Water: Propane hot water heater; propane data from supplier.
- Ventilation: Heat recovery ventilator
- Electricity: Supplied by Alaska Power and Telephone; data from utility

Energy Use

The Kasaan Duplexes have relatively low energy use, when compared to other THRHA housing. However, building 3A/3B has much higher electricity use than the other two buildings.

AkWarm Models

The AkWarm prediction of energy use is 118% and 66% of actual for buildings 2A/2B and 3A/3B, respectively. The models were reviewed and the following adjustments were made to each model to more accurately model the buildings:

- Ventilation: Increased to 50 cfm per apartment
- Miscellaneous Electric Use: Reduced from medium to low.

Results

The modeled energy use is 116% of actual for apartments 2A/2B and 76% for apartments 3A/3B. The predominant discrepancy is that actual electricity use in 3A/3B is very high.

		Annual Energy		AkWarm Comparison - Original Model					AkWarm Comparison - Corrected Model						
Multifuel Buildings	Size	FO/Propane	Electricity	FO/Propane		Electricity		Total	FO/Propane		Electricity		Energy kBtu		
	sqft	kBtu	kWh	kBtu	% of actual	kWh	% of actual	kBtu	kBtu	% of actual	kWh	% of actual	Actual	Modeled	kBtu
Kasaan Duplex 2A and 2B	1,792	48,969	9,180	61,397	125%	9,736	106%	118%	69,430	142%	7,032	77%	80,291	93,423	116%
Kasaan Duplex 3A and 3B	1,792	60,956	21,966	59,106	97%	9,114	41%	66%	74,618	122%	6,930	32%	135,903	98,263	72%
Totals	3,584	109,925	31,146	120,503	110%	18,850	61%	85%	144,048	131%	13,962	45%	216,195	191,686	89%

Ketchikan Fairview Housing

Description

- 4-plex apartment building
- Heat: Electric baseboards
- Ventilation: Exhaust only ventilation
- Electricity: Supplied by Ketchikan Public Utilities; data from utility

Energy Use

The building has moderate energy use when compared to other THRHA apartments.

AkWarm Models

The AkWarm prediction of electricity energy use is 94% of actual. The models was reviewed and was found to be an accurate representation of the building.

Results

The modeled electricity use is within 6% of actual, which is acceptable.

		Annual Energy Consumption				AkWarm Comparison - Original Model					AkWarm Comparison - Corrected Model				
Building Name	Size	Fuel Oil	Electricity	Waste Heat	Propane	Fuel Oil		Electricity		Total	Fuel Oil		Electricity		Total
	sqft	gallons	kWh	MMBtu	gallons	gallons	% of actual	kWh	% of actual	kBtu	gallons	% of actual	kWh	% of actual	kBtu
Ketchikan Fairview	3,820		64,951					61,320	94%	94%			61,320	94%	94%

Saxman Low Rent Apartments

Description

- 12 unit apartment building
- Heat: Fuel oil boiler; fuel oil consumption data from supplier.
- Ventilation: Exhaust only
- Electricity: Supplied by Alaska Electric Light & Power; data from utility

Energy Use

The model is predicting fuel oil use that is 39% of actual and electricity use that is 106% of actual.

AkWarm Models

The models was reviewed and the following adjustments were made to more accurately model the buildings:

- Boiler: The boiler was modeled with 82% seasonal efficiency and measured combustion efficiency. These were replaced with a seasonal AFUE efficiency of 70%. A 70% AFUE is appropriate for a boiler oversized to meet high, intermittent domestic hot water loads.
- HW Heater: The hot water heater was modeled without accounting for the boiler AFUE. An energy factor of 65% was added which takes into account the boiler AFUE and the tank losses of 5%.

Results

The modeled fuel oil use increased to 43% of actual. The reason for the low fuel oil prediction is not apparent.

		Annual Energy Consumption				AkWarm Comparison - Original Model					AkWarm Comparison - Corrected Model				
Building Name	Size	Fuel Oil	Electricity	Waste Heat	Propane	Fuel Oil		Electricity		Total	Fuel Oil		Electricity		Total
	sqft	gallons	kWh	MMBtu	gallons	gallons	% of actual	kWh	% of actual	kBtu	gallons	% of actual	kWh	% of actual	kBtu
Saxman Senior Center	31,300	3,693	64,980			1,422	39%	69,009	106%	59%	1,589	43%	69,099	106%	62%

YAKUTAT SUNRISE APARTMENTS

Description

- 12 unit apartment building
- Heat: Fuel oil boiler; fuel oil consumption data from supplier.
- Ventilation: Exhaust only
- Electricity: Supplied by City of Yakutat; data from utility

Energy Use

The models are predicting fuel oil use that is 422% of actual and electricity use that is 270% of actual.

AkWarm Models

The models were reviewed and the following adjustments were made to more accurately model the buildings:

- Boiler: The boiler was modeled with 82% seasonal efficiency and measured combustion efficiency. These were replaced with a seasonal AFUE efficiency of 70%. A 70% AFUE is appropriate for a boiler oversized to meet high, intermittent domestic hot water loads.
- HW Heater: The hot water heater was modeled without accounting for the boiler AFUE. An energy factor of 65% was added which takes into account the boiler AFUE and the tank losses of 5%.
- The apartments are individually meters; their energy use is not included in this analysis. The model was modified to only include exterior lighting and laundry loads that are on the house meter.

Results

The modeled fuel oil use comes to 369% of actual use. A review of the supplier energy data shows no consistency over the past 3-years. It is apparent that the supplier data is not reliable.

The electric use is within 9% of actual, which is a reasonable estimate of use.

		Annual Energy Consumption				AkWarm Comparison - Original Model					AkWarm Comparison - Corrected Model				
Building Name	Size	Fuel Oil	Electricity	Waste Heat	Propane	Fuel Oil		Electricity		Total	Fuel Oil		Electricity		Total
	sqft	gallons	kWh	MMBtu	gallons	gallons	% of actual	kWh	% of actual	kBtu	gallons	% of actual	kWh	% of actual	kBtu
Yakutat Sunrise Apartments Bldg A	9,944	1,236	24,224			5,216	422%	65,517	270%	373%	4,566	369%	26,522	109%	285%

by: _____

Jim Rehfeldt, P.E.

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Building Energy Data

Tlingit-Haida Regional Housing Authority

Energy Cost ($/sqft) and Use (MMBtu/sqft) Indexes

THRHA Housing Buildings		Annual Energy Consumption				Current Energy Costs				Energy Cost Index (ECI) and Energy Use Indexes (EUI)					
Name	Size	Fuel Oil	Electricity	Waste Heat	Propane	Fuel Oil	Electricity	Waste Heat	Propane	ECI $ / sqft			EUI kBtu / sqft		
	sqft	gallons	kWh	MMBtu	gallons	$ / gal	$ / kWh	$ / MMBtu	$ / gal	Heat/HW	Electricity	Total	Heat/HW	Electricity	Total
Angoon Duplex 1A and 1B	2,968	1,148	10,848			$5.10	$0.633			$1.97	$2.31	$4.29	54	12	66
Angoon Duplex 2A and 2B	2,968	933	14,195			$5.10	$0.628			$1.60	$3.00	$4.61	44	16	60
Angoon Duplex 3A and 3B	2,250	738	9,621			$5.10	$0.648			$1.67	$2.77	$4.44	45	15	60
Angoon Duplex 4A and 4B	2,250	851	7,042			$5.10	$0.666			$1.93	$2.08	$4.01	52	11	63
Angoon 4-plex 5A 5B 5C 5D	3,680	1,325	14,702			$5.10	$0.633			$1.84	$2.53	$4.37	50	14	63
Angoon 4-plex 6A 6B 6C 6D	3,680	1,294	13,486			$5.10	$0.633			$1.79	$2.32	$4.11	49	13	61
Angoon Triplex 7A 7B 7C	2,250	1,171	9,463			$5.10	$0.633			$2.65	$2.66	$5.32	72	14	86
Angoon Triplex 9A 9B 9C	2,250	728	8,689			$5.10	$0.633			$1.65	$2.44	$4.09	45	13	58
Craig Senior Center	9,944	1,418	26,720			$3.86	$0.239			$0.55	$0.64	$1.19	20	9	29
Fireweed Place	54,323		423,920				$0.096				$0.75	$0.75	21	6	27
Haines Low Rent Housing	6,930	4,314	22,480			$3.84	$0.239			$2.39	$0.78	$3.17	86	11	97
Hoonah Senior Center	7,650		54,520	639			$0.589	$14.75		$1.23	$4.20	$4.20	84	24	24
Juneau Granite Drive 4060-4064	2,120	681	35,677			$4.27	$0.122			$1.37	$2.05	$3.42	44	57	102
Juneau Granite Drive 4063-4067	2,694	1,826	18,827			$3.81	$0.128			$2.58	$0.89	$3.48	94	24	118
Juneau Kanat'a Deyi 4428-4430	2,720	1,266	18,396			$3.75	$0.128			$1.75	$0.87	$2.61	64	23	88
Juneau Kanat'a Deyi 4449-4451	2,824	1,944	10,878			$3.75	$0.136			$2.58	$0.52	$3.11	95	13	108
Juneau Kanat'a Deyi 4461-4463	2,720	1,451	7,658			$3.75	$0.130			$2.00	$0.37	$2.37	74	10	83
Juneau Kanat'a Deyi 4468-4470	2,268	1,826	19,081			$3.75	$0.128			$3.02	$1.08	$4.10	112	29	140
Juneau Kanat'a Deyi 4480-4482	2,824	3,082	16,901			$3.75	$0.129			$4.09	$0.77	$4.86	151	20	172
Juneau Kanat'a Deyi 4481-4483	2,266	1,381	10,185			$3.75	$0.138			$2.29	$0.62	$2.91	84	15	100
Juneau Kanat'a Deyi 4492-4494	2,720	1,485	8,850			$3.75	$0.141			$2.05	$0.46	$2.51	76	11	87
Juneau Kanat'a Deyi 4503-4505	2,266	1,376	9,764			$3.75	$0.139			$2.28	$0.60	$2.88	84	15	99
Juneau Kanat'a Deyi 4530-4532	2,824	1,468	9,835			$3.75	$0.139			$1.95	$0.48	$2.43	72	12	84
Juneau Kanat'a Deyi 4543-4545	2,266	1,604	9,356			$3.75	$0.140			$2.65	$0.58	$3.23	98	14	112
Juneau Valley Boulevard 8414-8420	4,560	1,634	11,460			$3.75	$0.136			$1.34	$0.34	$1.69	50	9	58
Juneau Valley Boulevard 8422-8428	4,560	1,554	11,705			$3.75	$0.134			$1.28	$0.34	$1.62	47	9	56
Juneau Valley Boulevard 8430-8436	4,560	1,351	19,697			$3.75	$0.132			$1.11	$0.57	$1.68	41	15	56
Juneau Valley Boulevard 8438-8444	4,560	2,060	15,392			$3.75	$0.131			$1.69	$0.44	$2.14	63	12	74
Kake Senior Center	7,650	7,200	70,640			$5.09	$0.586			$4.79	$5.41	$10.20	25	7	162

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Building Energy Data

Tlingit-Haida Regional Housing Authority

Energy Cost ($/sqft) and Use (MMBtu/sqft) Indexes

THRHA Housing Buildings		Annual Energy Consumption				Current Energy Costs				Energy Cost Index (ECI) and Energy Use Indexes (EUI)					
Name	Size	Fuel Oil	Electricity	Waste Heat	Propane	Fuel Oil	Electricity	Waste Heat	Propane	ECI $ / sqft			EUI kBtu / sqft		
	sqft	gallons	kWh	MMBtu	gallons	$ / gal	$ / kWh	$ / MMBtu	$ / gal	Heat/HW	Electricity	Total	Heat/HW	Electricity	Total
Kasaan Duplex 1A/1B	1,792	123	330		375	$4.16	$0.274		$2.57	$0.29	$0.05	$0.87	10	1	29
Kasaan Duplex 2A/2B	1,792	123	9,180		349	$4.16	$0.246		$2.57	$0.29	$1.26	$2.05	10	17	45
Kasaan Duplex 3A/3B	1,792	123	21,906		480	$4.16	$0.210		$2.57	$0.29	$2.57	$3.54	10	42	76
Ketchikan Fairview	3,820		64,951				$0.099				$1.68	$1.68	45	13	58
Klawock Senior Center	24,946	2,161	126,080			$3.30	$0.233			$0.29	$1.18	$1.46	12	17	29
Petersbug 103 S 2nd Street	4,800	4,304	7,143			$3.27	$0.126			$2.93	$0.19	$3.12	124	5	129
Petersbug 104 S 3rd Street	4,800	4,833	7,897			$3.27	$0.122			$3.29	$0.20	$3.49	139	6	145
Saxman Senior Center	7,425	3,693	64,980			$2.91	$0.096			$1.45	$0.84	$2.29	69	30	99
Wrangell Case Avenue	4,160	2,068	8,948			$3.15	$0.126			$1.57	$0.27	$1.84	69	7	76
Wrangell Front Street	10,400	2,554	58,093			$3.15	$0.106			$0.77	$0.59	$1.37	34	19	53
Yakutat Senior Center	4,824	449	25,061			$4.33	$0.491			$0.40	$2.55	$2.95	13	18	31
Yakutat Sunrise Apartments Bldg A	9,944	1,236	24,224			$4.27	$0.491			$0.53	$1.20	$1.73	17	8	26
Yakutat Sunrise Apartments Bldg B	9,944	1,236	19,636			$4.27	$0.491			$0.53	$0.97	$1.50	17	7	24
Totals	**247,984**	**70,012**	**1,358,417**	**639**	**1,204**					**$1.31**	**$1.08**	**$2.39**	**47**	**13**	**60**

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Tlingit-Haida Regional Housing Authority

AkWarm Model Comparison

Fuel Oil or Electric Heat Buildings	Size	Annual Energy		AkWarm Comparison - Original Model					AkWarm Comparison - Corrected Model						
		Fuel Oil	Electricity	Fuel Oil		Electricity		Total	Fuel Oil		Electricity		Energy MMBtu		
	sqft	gallons	kWh	gallons	% of actual	kWh	% of actual	kBtu	gallons	% of actual	kWh	% of actual	Actual	Modeled	% of Actual
Angoon Duplex 1A and 1B	2,688	1,148	10,848	940	82%	13,703	126%	90%	1,036	90%	10,276	95%	196	179	91%
Angoon Duplex 2A and 2B	2,688	933	14,195	940	101%	13,556	95%	99%	1,062	114%	10,432	73%	178	183	103%
Angoon Duplex 3A and 3B	2,250	738	9,621	848	115%	13,190	137%	120%	886	120%	9,650	100%	135	156	115%
Angoon Duplex 4A and 4B	2,250	851	7,042	848	100%	13,042	185%	114%	968	114%	10,007	142%	142	168	119%
Angoon 4-plex 5A 5B 5C 5D	3,680	1,325	14,702	988	75%	24,911	169%	95%	1,185	89%	18,993	129%	234	229	98%
Angoon 4-plex 6A 6B 6C 6D	3,680	1,294	13,486	1,048	81%	24,916	185%	102%	1,172	91%	18,997	141%	225	227	101%
Angoon Triplex 7A 7B 7C	1,794	1,171	9,463	521	44%	17,157	181%	67%	655	56%	13,324	141%	194	136	70%
Angoon Triplex 9A 9B 9C	2,250	728	8,689	615	84%	17,206	198%	110%	747	103%	13,311	153%	130	149	114%
Haines Senior Center	6,930	4,314	22,480	2,277	-47%	67,125	299%	81%	4,056	94%	30,709	137%	674	667	99%
Juneau Fireweed Place	54,323		423,920			1,139,510	269%	269%			462,705	109%	1,446	1,579	109%
Juneau Granite Drive 4060-4064	2,120	681	35,677	1,378	202%	13,716	38%	110%	1,695	249%	10,582	30%	216	271	125%
Juneau Granite Drive 4063-4067	2,694	1,826	18,827	1,456	80%	14,634	78%	79%	1,797	98%	11,180	59%	317	287	91%
Juneau Kanat'a Deyi 4481-4483	2,266	1,381	10,185	707	51%	12,950	127%	63%	940	68%	10,961	108%	226	168	74%
Juneau Valley Boulevard 8414-8420	4,560	1,634	11,460	2,608	160%	28,372	248%	173%	2,157	132%	21,448	187%	265	372	140%
Ketchikan Fairview	3,820		64,951			61,320	94%	94%			61,320	94%	222	209	94%
Saxman Senior Center	31,300	3,693	64,980	1,422	39%	69,009	106%	59%	1,589	43%	69,099	106%	733	456	62%
Yakutat Sunrise Apartments Bldg A	9,944	1,236	24,224	5,216	422%	65,517	270%	373%	4,566	369%	26,522	109%	254	723	285%

Waste Heat Building	Size	Annual Energy		AkWarm Comparison - Original Model					AkWarm Comparison - Corrected Model						
		Waste Heat	Electricity	Waste Heat		Electricity		Total	Waste Heat		Electricity		Energy MMBtu		
	sqft	MMBtu	kWh	MMBtu	% of actual	kWh	% of actual	kBtu	MMBtu	% of actual	kWh	% of actual	Actual	Modeled	% of Actual
Hoonah Senior Center	7,650	639	54,520	258	40%	67,781	124%	59%	330	52%	52,595	96%	825	509	82%

Multi-fuel Buildings	Size	Annual Energy		AkWarm Comparison - Original Model					AkWarm Comparison - Corrected Model						
		FO/Propane	Electricity	FO/Propane		Electricity		Total	FO/Propane		Electricity		Energy MMBtu		
	sqft	kBtu	kWh	kBtu	% of actual	kWh	% of actual	kBtu	kBtu	% of actual	kWh	% of actual	Actual	Modeled	% of Actual
Kasaan Duplex 2A and 2B	1,792	48,969	9,180	61,397	125%	9,736	106%	118%	69,430	142%	7,032	77%	80	93	116%
Kasaan Duplex 3A and 3B	1,792	60,956	21,966	59,106	97%	9,114	41%	66%	74,618	122%	6,930	32%	136	98	72%

Total MMBtu - All Buildings		3,928	2,902	3,400	87%	5,788	199%	134.5%	3,869	98%	2,989	103%	6,830	6,858	100.4%

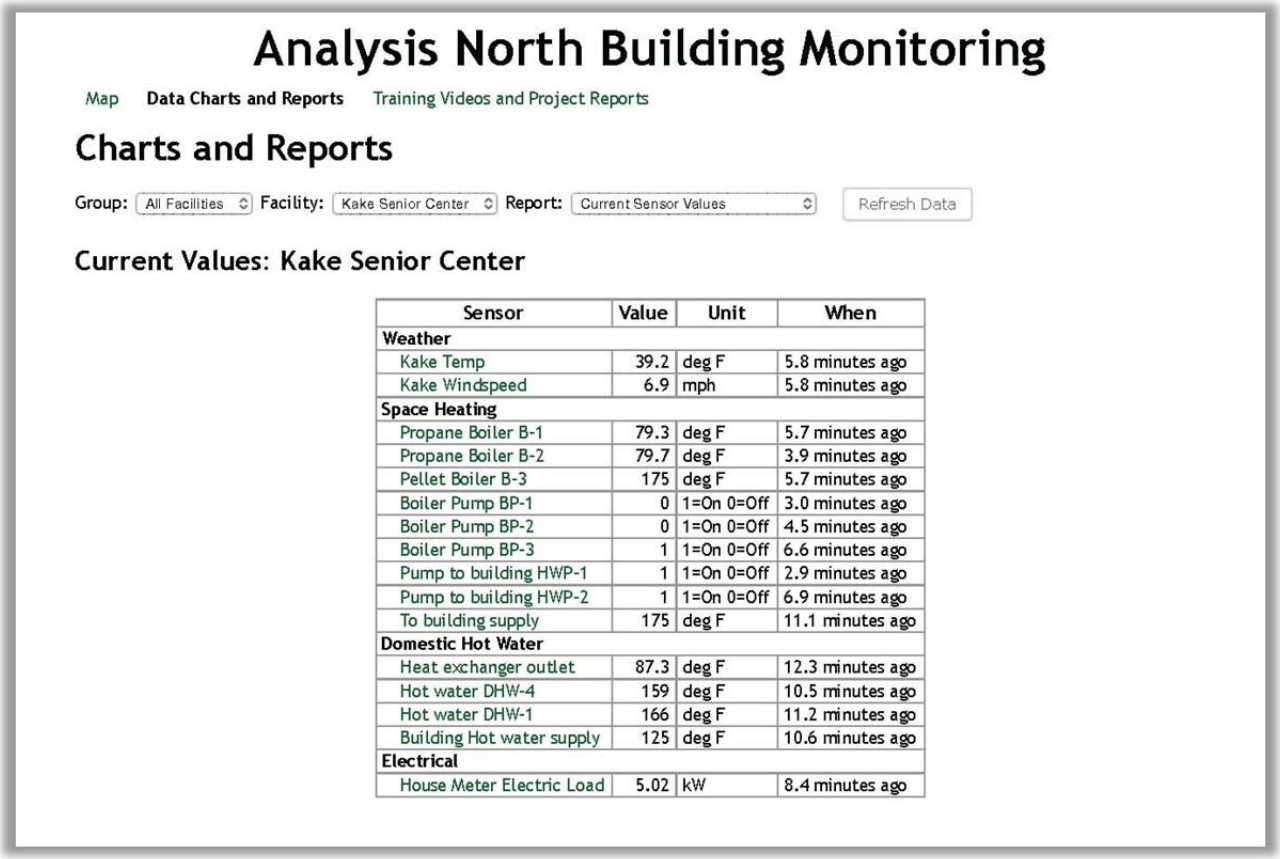
THRHA – MONITORING SYSTEM VALUE AND EXAMPLE OUTPUTS

THRHA Regional Housing Authority
Juneau, Alaska

Monitoring System Value and Example Outputs – Summary Report for DOE Grant

A key part of the work performed in the supplemental effort for the DOE project was to develop and implement remote monitoring plans for THRHA facilities and projects. This effort is seen by THRHA as extremely valuable. Now that these plans have been investigated further, THRHA is in a position to incorporate this technology and approach into its buildings and projects as the energy efficiency efforts identified as part of the DOE grant are implemented. This monitoring allows THRHA to track energy usage to identify when there are issues that need to be addressed, and to verify performance of equipment and energy saving measures. Importantly, this monitoring also allows THRHA to remotely see when equipment is down or not performing correctly, and this allows THRHA to dispatch its maintenance team in a cost effective manner to provide residents with the best service possible.

The following images are examples of screen shots from the recently implemented monitoring system at the Kake project where efficiency upgrades and a biomass renewable energy system were implemented. Figure 1 shows a summary screen that lists current key values. Figure 2 shows some of the trending options that are available from the system to view performance over time.



Analysis North Building Monitoring

Map Data Charts and Reports Training Videos and Project Reports

Charts and Reports

Group: All Facilities Facility: Kake Senior Center Report: Current Sensor Values Refresh Data

Current Values: Kake Senior Center

Sensor	Value	Unit	When
Weather			
Kake Temp	39.2	deg F	5.8 minutes ago
Kake Windspeed	6.9	mph	5.8 minutes ago
Space Heating			
Propane Boiler B-1	79.3	deg F	5.7 minutes ago
Propane Boiler B-2	79.7	deg F	3.9 minutes ago
Pellet Boiler B-3	175	deg F	5.7 minutes ago
Boiler Pump BP-1	0	1=On 0=Off	3.0 minutes ago
Boiler Pump BP-2	0	1=On 0=Off	4.5 minutes ago
Boiler Pump BP-3	1	1=On 0=Off	6.6 minutes ago
Pump to building HWP-1	1	1=On 0=Off	2.9 minutes ago
Pump to building HWP-2	1	1=On 0=Off	6.9 minutes ago
To building supply	175	deg F	11.1 minutes ago
Domestic Hot Water			
Heat exchanger outlet	87.3	deg F	12.3 minutes ago
Hot water DHW-4	159	deg F	10.5 minutes ago
Hot water DHW-1	166	deg F	11.2 minutes ago
Building Hot water supply	125	deg F	10.6 minutes ago
Electrical			
House Meter Electric Load	5.02	kW	8.4 minutes ago

Figure 1 – Summary Screen with Key System Values

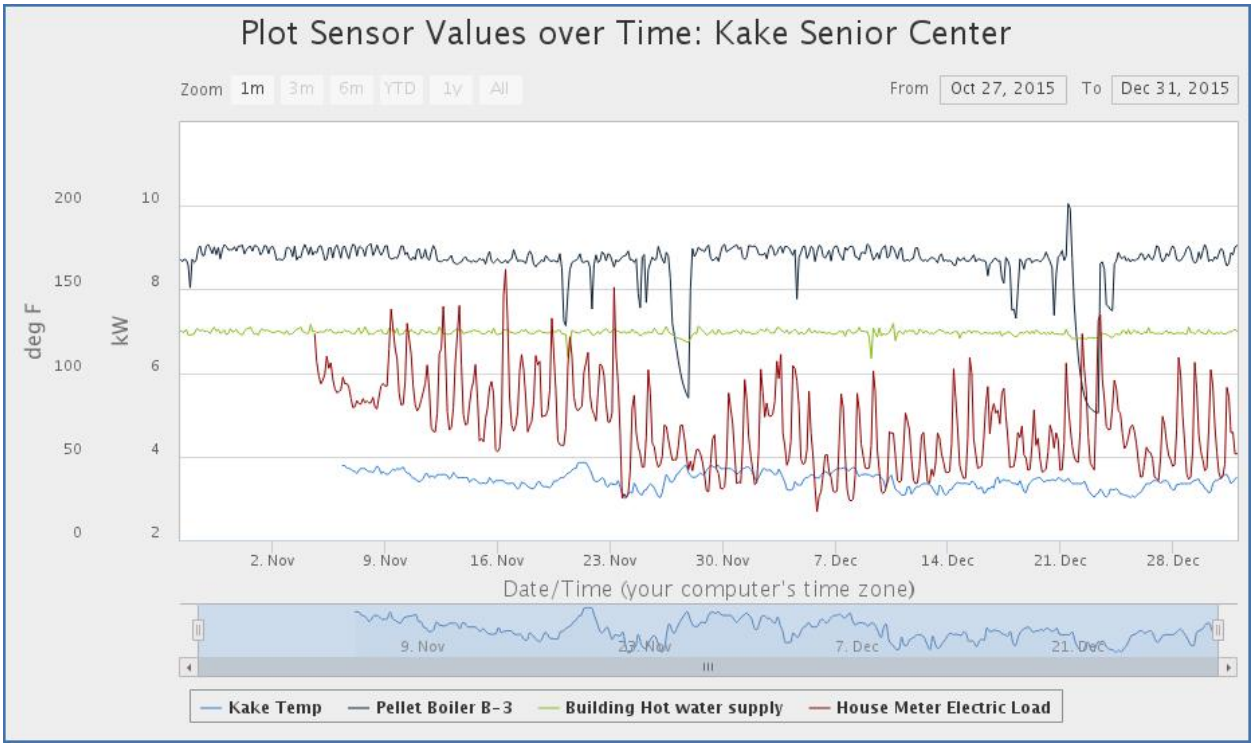


Figure 2 – Example of Trending of Key System Parameters

ANGOON – BIOMASS DISTRICT HEATING SYSTEM PROJECT INVESTIGATION REPORT

THRHA Regional Housing Authority
Juneau, Alaska

DE-0005179 Energy Efficiency Audit, Assessment, and Alternative Energy Study

December 21, 2015

Angoon Biomass District Heating System Project Investigation Report

Angoon, AK

Tlingit Haida Regional Housing Authority
PO Box 32237
Juneau, AK 99803
(907) 780-6868

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1.0 INTRODUCTION

THRHA has been awarded a grant from the Alaska Energy Authority (AEA) to install a new biomass district heating system connecting 9 buildings in Angoon, AK. These buildings include 8 multifamily housing buildings with 22 individual units, and a community center building. A preliminary feasibility study was completed for this project, and was the basis for the AEA grant application submittal. THRHA has since performed additional project investigations to focus the scope of the project, develop a preliminary system design, investigate fuel supply, establish a project budget, and analyze the life cycle costs associated with the project. This document summarizes the additional project investigations.

2.0 EXISTING ENERGY SYSTEMS AND USAGE

Table 2-1 lists the buildings, units, heating equipment in each, and the fuel usage for the 2013-2014 heating season. This heating season was the first full heating season after weatherization projects had been completed, and previous year fuel usages were higher due to less efficient buildings. For example, the fuel usage for 2012-2013 was 16,371 gallons. The 2013-2014 value is used in this document as the typical annual usage value. At current fuel oil pricing of approximately $4.65/gallon, this is an annual expenditure of $56,423.

Table 2-1 – Boiler Capacity & 2013-2014 Fuel Oil Usage for Each Building

Building	Unit	Installed Boiler Capacity, mmBtu/hr	2013-2014 Fuel Use, gal	2013-2014 Fuel Use, gal
1	A	0.089	771	1,373
	B	0.089	602	
2	A	0.089	664	1,377
	B	0.089	713	
3	A	0.089	507	962
	B	0.089	455	
4	A	0.089	577	1,228
	B	0.089	651	
5	A	0.175	284	1,723
	B		718	
	C		406	
	D		315	
6	A	0.089	407	1,607
	B	0.089	709	
	C	0.089	224	
	D	0.089	267	
7	A	0.089	420	1,548
	B	0.089	739	
	C	0.089	389	
8	-	0.124	1,149	1,149
9	A	0.089	343	1,167
	B	0.089	428	
	C	0.089	396	
Totals		**1.901**	**12,134**	**12,134**

Notes: Since 2013-2014, Building 5 has been converted to one single boiler serving all 4 units. The usage shown is for when there were individual boilers for each unit, and the installed capacity shown is for the single boiler that now serves these units.

The fuel oil pricing has ranged widely in the past several years. Table 2-2 lists the fuel oil costs for 2013, 2014, and 2015.

Table 2-2 – Oil Pricing in Past Years

Year	Oil Price Range, $/gallon
2013	5.15-5.33
2014	5.10-5.15
2015	4.65

Attachment A provides a district heating system sizing and energy analysis performed by Alaska Energy Engineering, LLC. This document provides an estimated annual electric usage by the existing boiler systems of 2,497 kWh. The current electric rate is $0.628/kWh for the first 500 kWh in the month, and $0.568/kWh after the first 500 kWh in the month. The boilers are assumed to have their own meters, and it is assumed they are not on the Power Cost Equalization (PCE) rate. The PCE rate is available to

provide economic assistance to customers in rural areas of Alaska where the kilowatt-hour charge for electricity can be three to five times higher than the charge in more urban areas of the state. The PCE rate is available to the residents of the multi-family units, but is not directly available to THRHA for operation of the boilers or central boiler plant.

3.0 WOOD PELLET DISTRICT HEATING SYSTEM OPTION CONSIDERATIONS

Using the preliminary feasibility study as a starting point, THRHA evaluated several options for the central plant, building interconnections, and wood pellet storage. This section discusses the various key factors considered for each of these, and identifies the direction selected.

3.1 Wood Pellet Boiler Type

THRHA considered two wood pellet boiler system approaches. These were to use multiple small commercial pellet boilers and thermal storage to meet the range of loads across the year, or to use one larger wood boiler and large thermal storage to meet the range of loads. The following is a list of key factors (pros and cons) considered for each system. As representative options, THRHA considered the Maine Energy Systems (MES) boiler line and the Viessmann boiler line. Both of these equipment vendors have successful installation examples in SE Alaska. After careful consideration of the options, two MES 191,000 Btu/hr output boilers were selected as the basis for the preliminary design of the project.

Small Commercial Pellet Boilers – 0.2 mmBtu and under (MES boiler line)

- Provides a wide band of boiler plant operation through modulation of the boilers firing rate as opposed to cycling (i.e. two boilers provide a modulating range of 0.057 – 0.383 Btu/hr).
- Smaller thermal storage requirement due to wider range of modulation, and lower firing rate.
- Single phase power is able to be used.
- THRHA already has several MES boilers, and has trained staff with experience running these boilers, as well as the ability to maintain a consistent stock of wear and replacement parts.
- The overall cost of the boilers needed to cover the vast majority of the heating demand is lower than the single Viessmann boiler.

Medium-Sized Commercial Pellet Boilers – 0.5 mmBtu and up (Viessmann ASME rated boiler line)

- Provides a robust combustion system able to handle a wider range of fuel qualities
    - Potential for future switch to refined chip fuel (under 30% MC wb and 1.25” minus).
- Requires 3-phase power
    - Initial estimate from utility of $50,000 to bring in 3-phase power.
- Lowest ASME rated option (0.512 mmBtu/hr) is larger than would be ideal for the range of loads seen as boiler plant would spend more time in cycling mode. This unit would modulate between approximately 0.128 mmBtu/hr and 0.512 mmBtu/hr.
- Larger thermal storage required to allow efficient coverage of summer loads and minimize cycling.

3.2 Central Plant Location

THRHA considered several central plant locations. These were the location identified in the preliminary feasibility study, at the end of Xoatz Road, and on a corner of the adjacent Angoon Assembly of God Church property. The first two locations were eliminated due to the impact to parking space and the location of future planned development tracks. The Church has been approached, and is looking favorably towards providing a lease of the land to THRHA for use for the central plant. Sheet M-1 in Attachment C shows the selected location for the central plant.

3.3 Heating Capacity Backup and Interconnections

THRHA considered several options for district heating system backup and interconnection to the individual buildings. The options for backup included keeping some or all of the existing boilers for backup of the wood pellet boiler, or locating the backup in the central plant and decommissioning the existing oil boilers. THRHA selected locating the backup in the central plant. The key reasons for this are to reduce long-term maintenance costs, and to remove the liability of the aging oil storage tanks. One of the key benefits of a district heating system is that the number of boilers and tanks to be maintained is drastically reduced, and using backup from the central plant allows THRHA to realize this benefit.

Both direct connection to building hydronic systems and indirect connection through a heat exchanger were considered by THRHA. Some key benefits of each are provided in the following list. In the end, indirect connection through a heat exchanger was selected due to the simplicity of the system's operation and ability to protect the expensive underground piping and central plant infrastructure.

Benefits of Direct Connection

- Direct connection allows a slightly lower district loop temperature (3-5^{o}F) since there isn't a heat exchanger between the district water and building water.
- Direction connection does not have the cost of a heat exchanger, however, there are potentially some offsetting valve and controls costs required depending on the exact method of direct connection.

Benefits of Indirect Connection

- Indirect connection results in a less complicated hydraulic system that is easier to commission and to troubleshoot. Changes in buildings will not impact district hydraulics.
- Indirect connection separates the district system water from that in the 9 buildings and 23 individual heating loops. This eliminates the potential for poor building water quality or contaminates from individual loops to impact the underground piping and central plant infrastructure.

Upon selecting the indirect connection method, THRHA considered the number of heat exchangers to use for each building. In the cases of the buildings with multiple boilers in the mechanical rooms or with adjacent mechanical rooms, a single heat exchanger was selected. For Buildings 1 and 2, where the mechanical rooms are relatively far apart, THRHA elected to use a heat exchanger in each mechanical

room. This avoided the electric cost associated with running a DHW circulation loop to reduce the time required for the hot water to reach the faucet.

3.4 District Heating Piping System

THRHA considered several types of piping systems for the district heating project. These included pre-insulated pex pipe, pre-insulated copper pipe, and pre-insulated steel pipe. The original feasibility study identified pre-insulated pex piping as the preferred material for this project. However, after consideration of the piping options, THRHA has selected copper pre-insulated piping with a minimum of 4" of insulation. The key factor in this decision is the need to reduce annual costs associated with the district energy system's operation. The heating loads of the buildings supported by the piping system are relatively small compared to the delivery capacity of the piping system, and thus district piping heat losses can comprise a large percentage of annual heating demand if high levels of insulation are not used.

The final piping route for the project would be determined by a design-build contractor. However, there are two likely routes as shown in the attached preliminary design. This document uses the completely buried district piping route. There is another potential route that would use crawlspaces under the buildings where possible. This route could potentially provide cost savings for the project, depending on the difficulty envisioned by the contractors in transitioning between the buried pipe and crawlspaces.

Table 3.4-1 shows how the average heat loss per foot of the district heating system over the course of the year impacts the annual operating costs of the system. The annual heating demand in the buildings themselves is approximately 1,176 mmBtu, and the cost for providing this heat using the existing fuel oil boilers is $56,423 (fuel oil at $4.65/gallon).

Table 3.4-1 – Impact of Varying Pipe Heat Loss Rates on Annual Energy Costs

Annual Average System Loss Per Foot of Trench, Btu/hr/ft	Approximate Annual Heat Loss (1,100 ft trench), mmBtu/yr	% of Annual Demand in Buildings (1,176 mmBtu/yr)	Cost of Heat Loss (Pellets at $465/ton)	% of Current Annual Heating Fuel Cost ($56,423)
8	77	7%	$2,705	5%
10	96	8%	$3,381	6%
15	145	12%	$5,072	9%
20	193	16%	$6,762	12%
25	241	20%	$8,453	15%
30	289	25%	$10,144	18%

There are many factors that impact the heat loss in the piping of the district system over the course of a year. The principle of these are, the ambient temperature, temperature of the supply and return water, insulation thickness and condition, soil conditions, and velocity of water in the pipe. Table 3.4-2 provides a comparison of a single run of nominal three-inch pipe with three different piping materials

and insulation thicknesses with 180°F water. Note that this is only comparing a single pipe to illustrate the impact of added insulation, and losses for supply and return configurations of either dual-line or two single-line pipes are higher than shown here.

Table 3.4-2 – Comparison of Heat Loss in Single Nominal 3" Pipe

Carrier Pipe Type, 3" Nominal	Outer Jacket Diameter, in	Insulation Thickness, in	Approximate Heat Loss per Foot, Btu/hr/ft
Pex	6.4	1.44	17.0
Steel A53B ERW	12	4.25	8.5
Copper "k"	12	4.44	7.8

Notes: Losses calculated using heat loss and Louden equations, 50°F ambient temperature, 180°F water temperature, 0.16 k factor for insulation, and 12 k factor for soil.

Given the low heating loads connected to the proposed central plant, and the high cost of wood pellets and oil (heat), the ability of the project to show annual savings requires that heat loss be minimized. Thus, THRHA has selected a minimum insulation thickness of 4" for the pre-insulated pipe. This does have a substantial impact on up front project costs. Table 3.4-3 provides a summary of straight pipe material costs for each of the piping types across the ~1,100 ft of trench for the project. Note that the pex piping as a significantly lower materials cost than the highly insulated steel or copper products. The pex piping also has significantly lower installation costs than either steel or copper. The copper product would be expected to have a lower installation cost than steel product.

3.4-3 – Comparison of Piping System Materials Costs for Project

Piping Material	Approximate Pipe Materials Cost
Pre-insulated pex	$29,000
Pre-insulated steel (min 4" insulation)	$50,000
Pre-insulated copper (min 4" insulation)	$65,000

Notes: The cost here is only intended to be the approximate straight pipe materials cost for the project. This does not include fittings or installation. The pex pipe would have the lowest installation costs, and steel would have the highest installation costs. Linear foot pricing based on piping quotes from Rovanco Piping Systems, Inc., (www.rovanco.com) which offers each of the piping systems discussed here.

3.5 Approach to Controls and Metering

The goal with the control of the central plant, district system, and building interconnections is to ensure simplicity of operations. The central plant boilers are controlled by a local boiler controller based on temperatures seen within the central plant. The district system distribution pumps are controlled by variable speed ECM motors that provide variable pressure differential control based on pressures seen at the central plant. The district system flows to the buildings are controlled by control valves that modulate district flow to meet building supply temperature set points. This is controlled by a local building-level controller. This control scheme eliminates the need for a complex and expensive DDC system connecting all the buildings and the central plant, while providing efficient operation of the system. Further eliminating the need for a complex DDC system with remote adjustment of system operating parameters is THRHA's onsite staff. THRHA has highly trained field staff located in Angoon able to respond quickly to any alarms and to routinely adjust system parameters and set points.

A monitoring plan for the district heating system developed by Alaska Energy Engineering, LLC is included in Attachment C. The monitoring will provide heating equipment status, system temperatures, and pump status for the central plant. This will allow remote viewing of system energy flows, and notification of alarms to personnel not immediately at the plant. The system will also provide energy metering that is remotely monitored and logged. The energy metering will include electric use of the central plant, and heat delivered by the central plant to the district heating system. The system will not provide BTU metering at each individual building. Energy metering at each individual building would add extensive cost and complexity to the system, without providing THRHA with major benefits.

3.6 Wood Pellet Supply Considerations and Storage Selection

THRHA sees reliable wood pellet supply as a major item to clearly understand for the Angoon project. This is in large part due to the logistics associated with transporting pellets to the site during the winter when the demand is the largest.

3.6.1 Water Access

Alaska Marine Highway System (AMHS) – Water access to the town is mainly provided by the AMHS. The ferry that serves the Angoon route is the LeConte, which has the following vehicle restrictions: 13.5 ft high, 9 ft wide (12 ft with 50% fee increase), 40 ft long (single unit) or 60 ft long (combined), and 25 tons. The AMHS charges by the length of the vehicle, and has charges to cover drivers and passengers. The size and type of vehicles that could be used to deliver pellets varies. For a bulk truck, this would be one vehicle. For a tractor and trailer with a container, this would be a combined vehicle. To provide an idea of the total cost for a trip, the cost for the longest vehicle is listed here. A one-way cost for a 60 ft long, 9ft wide combined unit is approximately $400 after accounting for a driver. Considering vehicle tare weight, the deliveries are likely limited to approximately 10-15 tons of wood pellets at a time in a bulk delivery. This limitation on delivery size is an issue that increases the cost of the delivered pellet fuel.

Other factors that drive up the cost of pellets when delivering by way of the AMHS are the logistics associated with delivery once the load is in the community, and the return trip. A delivery not only requires one arrival, but the delivery vehicle will not be able to make it back to the ferry before it leaves on that day. Thus, the delivery vehicle is in the community until the next time the ferry arrives. For much of the year, current schedules show a Thursday arrival and a Saturday arrival each week. Thus, the truck and a driver would need to remain in Angoon for approximately 2-3 days as part of the delivery, which drastically drives up costs. This can be partially mitigated by sending the vehicle with no driver, and having a licensed and insured driver from the community operate the vehicle while it is in Angoon.

Another major issue is that the schedule during the peak winter months is increasingly becoming limited. There are only three scheduled stops for the LeConte in Angoon in January 2016, and 4 in February 2016. There is over a month gap between the scheduled January 9th arrival, and the February 18th arrival. This drastically impacts the deliveries that can be made by a bulk vehicle during this time. A bulk provider will clearly not be able to tie their delivery vehicle up for over a month.

Pellets may also be brought in through supersacks in smaller vehicles which are more routinely delivering to the community on the AMHS ferry. The cost of this is approximately $100 per pallet for shipping alone, and a pallet will hold approximately 1 ton. This cost does not include unloading or handling of the super sack.

Barge – Beach landings are also possible in Angoon. This carries a charge of approximately $7,500 per barge run, and the capacity of a barge is typically approximately 130,000 lbs. This would allow for a larger bulk delivery (~up to 30 tons), but would typically be a more expensive option than use of the ferry, even with the ferry restrictions limiting the delivery size.

3.6.2 Delivery Types and Storage Configurations

The wood pellet central plant will require approximately 97 tons of wood pellets annually to offset 90% of the annual heating demand and cover losses in the district piping system. Efficient and flexible receiving of bulk deliveries is thus clearly important.

Delivery Types – Bulk deliveries are available from auger trucks, pneumatic systems, and in the form of super sacks. The mechanics of each of these delivery methods is identified in the following list.

- Auger truck
    - This option is able to provide approximately 10-30 tons per delivery depending on the vehicle size and water transport method limitations. SeaAlaska Corporation and Tongass Forest Enterprises stated that the approximate maximum reach of their augers would be 20 ft in elevation above where the truck sits. Tongass indicated that a 4 ft extension was being added to their delivery auger to increase this reach. The current least cost option is delivery using the AMHS ferry. In this case, the delivery vehicle carrying approximately 10 tons would be transported to the community via the LeConte, load the storage, and then wait until the next arrival of the LeConte to leave the

community. The use of a licensed and insured driver that is located in the Angoon community would keep costs down and avoid tie-up of an offsite driver.

- Pneumatic delivery
  - The pellets would come in a container and be unloaded with a separate blower, or come in a bulk truck with a pneumatic unloading system. Currently no known bulk trucks with pneumatic unloading systems are being used in SE Alaska, and the container transport would be expected. This method would be able to provide 10-25 tons per delivery depending on how the container is transported. The current least cost option is for delivery using the AMHS ferry, and containers with 10-15 tons could be shipped on the LeConte depending on the vehicle used. This delivery method is currently offered by Alaska Pellet Supply, LLC. A blower would also be shipped to Angoon and used to pneumatically load the pellets into the storage. The use of a licensed and insured driver that is trained to use the blower and located in the Angoon community would keep costs down and avoid tie-up of an offsite driver/operator.
- Super sack delivery
  - Super sacks can be delivered on pallets. Angoon Trading Company makes this type of delivery to the community using the ferry system. The pallets would need to be unloaded and handled by a forklift, and stored in a dry area onsite. Then they would need to be handled with a forklift, and the bottom would need to be untied or cut to allow placement in a storage bin. The design of a storage bin would need to provide safe access for a fork lift with a super sack suspended from the tines, while also allowing for an operator to safely untie the bottom of the bag for emptying into the storage. Angoon Trading Company also has a forklift that is able to be rented. The rental is approximately $50/hr, which includes the operator.

Storage Configurations – THRHA investigated several options for flexible bulk storage. One key consideration is the total storage volume required. An estimated distribution of the annual demand is provided in Attachment A – Sizing and Energy Analysis on Page3. During the highest three month demand (December through February), THRHA could use approximately 35 tons of wood pellets. During the highest four month demand (December through March) THRHA could use approximately 45 tons of wood pellets. The January and February time frame coincide with increasingly limited ferry access. A storage size of 40-50 tons was established for the storage volume to help span potential gaps in community access. This would also provide sufficient capacity for a 30-ton delivery while still having pellets in storage, which may be useful if a barge delivery is ever required and can accommodate a 30-ton bulk delivery vehicle.

The following list identifies each and discusses the advantages and disadvantages of the main storage options considered. The bulk hopper tank option (grain silo) was selected due to upfront costs, safety, and ease of access to moving components of the handling system.

- *Shed with Below-Grade Pellet Storage* – This configuration would include construction of an onsite building with below-grade pellet storage. The bin would have a sloped bottom and extraction auger or suction ports for removal of pellets from the storage. The structure would

have a set of fill/vent ports to allow pneumatic delivery, and large access doors and adequate clearance to allow use of a forklift to empty super sacks into the bin. This same access door would allow auger truck deliveries.

- This option allows use of any of the three delivery types. However, it has the following downsides:
  - Access to an extraction auger for jams and maintenance would be under the stored wood pellets.
  - Confined space entry considerations would be needed for access to certain portions of the handling equipment.
  - Costly construction in the remote Angoon community.

- *Bulk Hopper Tank* – This configuration would be a single bulk storage hopper tank (metal grain silo). This would accommodate the larger bulk deliveries, but would require a separate system to be configured if super sacks were to be blown or fed via auger into the hopper tank. Major benefits of this option are that all moving components are completely outside the storage, and can be isolated from the stored pellets using a slide gate. This allows for ease of service, and eliminates safety concerns regarding confined space entry. Additionally, this is a less costly option for storage volumes on the order of 40-50 tons. Figure 1 shows a picture of an example bulk hopper tank. A general cut sheet on the type of hopper tank envisioned is provided in Attachment B.
  - The system would include the following features:
    - Bin lid no higher than 20 ft from the elevation at which the delivery vehicle would sit, and a hopper bottom with an angle of 45^{o} or steeper.
    - A 4” line with a 4” camlock male end and vent line to allow pneumatic delivery. 4” camlock would be within 5 ft of grade where delivery person will stand to allow ease of connection.
    - Viewing ports to allow observation of the level of pellets in the storage bin.
    - Ladder with security door.
    - Spring lock lid type that allows lid to move out of way of delivery auger.
    - Boot with slide gate to accommodate fuel handling method for wood pellet system, and allow for isolation of the boot from the pellet storage for servicing of handling equipment.



Figure 1 – Example Bulk Hopper Bin Installation
Image from Froling Energy – www.frolingenergy.com

Delivery Truck Purchase – Due to the difficult logistics of supplying the Angoon project, and given the installation of several other pellet boilers across the THRHA building fleet, THRHA also considered the purchase of its own delivery vehicle. This could potentially allow for more flexibility and surety of supply. Two truck options were identified in order to develop an order of magnitude cost for delivery vehicle purchase. The first is purchase of an existing, used bulk delivery vehicle. Figure 2 shows a representative used vehicle option that was identified. This vehicle has a self-unloading, loose bulk commodity storage area, and a compartment for transport of other goods. The bulk commodity section has a volume of 792 ft^3, or approximately 16 tons of wood pellets. The vehicle fits inside the dimensions of the LeConte's requirements, with a width of 8.5 ft, total height of 12.5 ft, and a length of approximately 30 ft. The bulk area has a sloped floor at 45^o that feeds a 9" auger. This runs to a 12" vertical auger and then to a 20 ft long, 9" discharge auger that also has a 4 ft extension. With just the 20 ft discharge auger, the truck could deliver to a bin with an opening 20 ft above the elevation at which the truck would sit. The listed cost of this vehicle is ~$65,000. A cut sheet on this vehicle is provided in Attachment B.



Figure 2 – Example Used Delivery Vehicle Option
Vehicle for sale by CEI Equipment (www.CEIEquipment.net)

Another option that may be considered and would be cost effective is to purchase a new bulk commodity delivery trailer that could be matched to a tandem or tri-axle depending on the model selected. Figure 3 shows a picture of the finished product. The bulk trailer comes in a shipping container for assembly at its destination, and then would need to be set on a matching truck chassis. A new Model 12T20HOH version of this bulk trailer with a hard top would be approximately $45,000 in a container at the factory in Iowa. This model with the hard top can hold approximately 800 ft^3 of wood pellets, or ~16 tons, would meet the LeConte's vehicle dimensions, and would require a tandem axel truck. The discharge auger length can be selected to match the desired discharge height. With shipping, assembly, and purchase of a used truck, a complete package would be expected to be on the order of $90,000. A cut sheet on the bulk trailer is provided in attachment B.



Figure 3 – Image of Shippable Bulk Commodity Trailer Option
Image obtained from www.sudenga.com.

4.0 DISTRICT HEATING SYSTEM PRELIMINARY DESIGN

A preliminary design of the district heating system has been completed by Alaska Energy Engineering, LLC. This design along with performance specifications for the system is provided as Attachment C. This design was completed at the preliminary level to inform the decision making process for THRHA, and to inform development of a rough budget estimate of the project.

5.0 DISTRICT HEATING SYSTEM LIFE-CYCLE COST ANALYSIS

The economic goal of implementing the district heating system is to reduce annual operation and maintenance cost for THRHA associated with the 9 multifamily / community buildings located in Angoon. The district system provides the opportunity for annual energy savings, and savings on annual staffing and boiler maintenance costs. The existing heating systems include 20 boilers in 13 mechanical rooms. The oil tanks are at the end of their useful life, and are a liability. THRHA has seen other similar tanks recently fail, resulting in costly cleanup. Further, most of the key equipment in the boiler rooms is approximately 20 years old, and reaching the point at which plans for replacement are being made. THRHA is discussing plans to begin wholesale replacement of equipment in the next five years. The scope of this project not only includes connection of the existing mechanical rooms to one central plant, it also includes a complete overhaul of the pumps, piping, and domestic hot water equipment in each of the buildings. Table 5-1 provides a summary of the project capital cost estimate. Attachment D provides a breakdown of the line items summarized in Table 5-1.

Table 5-1 – Summary of Project Costs

Line Item	Cost	% of Total
Central Plant Boiler Systems, Structures, and Storage	$241,221	28%
Central Plant Site Work	$164,406	19%
Piping Distribution System (1,100 lf buried pre-insulated copper pipe)	$221,249	25%
District System Connection to 11 Mechanical Rooms (through HX only)	$56,425	6%
Boiler Room Demolition and Building Equipment Replacement in Mechanical Rooms	$187,296	22%
Total	**$870,596**	**100%**

By implementing the project, THRHA will avoid the future cost of demolition and removal of the aging oil boilers and storage tanks, and the cost of replacing the boilers / hydronic system equipment in the boiler rooms. This avoided cost is estimated at $372,644, and would be expected to occur within the next 5 years. Attachment D provides a breakdown of the avoided costs by building.

5.2 Annual Energy Cost Savings

Table 5-2 presents the annual energy costs associated with the existing heating system, and compares these to the projected energy costs with a wood pellet fueled district heating system.

Table 5-2 – Annual Energy Savings with Wood Pellet District Heating System

Existing System				Potential Wood Pellet District System						Annual Energy Cost Savings
Fuel Oil Use, gal	Fuel Oil Cost	Electric Use, kWh	Electric Cost	Fuel Oil Use, gal	Fuel Oil Cost	Electric Use, kWh	Electric Cost	Wood Pellet Use, ton	Wood Pellet Cost	
12,134	$56,423	2,497	$1,568	1,213	$5,642	8,270	$5,045	97	$45,200	$2,104

Notes: Attachment A includes a summary of the heating system analysis. Table 5-6 list the assumptions made in calculating energy savings.

It is important to note that fuel oil and wood pellet pricing are the major drivers of annual energy savings for the project, and these prices can vary. Table 5-5 demonstrates the sensitivity of the annual operational cost savings to fuel oil and wood pellet pricing.

5.3 Annual O&M Costs

One of the key advantages of a district heating system is reduction of annual operational costs through the reduction of the number of boilers that need to be maintained. Table 5-3 provides an estimate of the difference in annual operation and maintenance costs when comparing the district system to the existing operations. The table also provides an estimate of current and projected labor hours spent. Attachment A includes a breakdown of the O&M cost estimates. The table only focuses on the differences in annual maintenance between the two scenarios, and does not identify all of the existing or future maintenance costs associated with the remainder of the heating systems in the buildings.

Table 5-3 – Annual Operation and Maintenance Cost Savings

Item	Existing Boiler Systems	Potential District System	Difference (savings)
Annual O&M Cost	$12,800	$8,787	$4,013
Annual Labor Hours	220	148	72

Notes: The table only focuses on the differences in annual maintenance between the two scenarios, and does not identify all of the existing or future maintenance costs associated with the heating systems in the buildings. Attachment A provides a breakdown of existing and projected annual O&M costs identified.

5.4 Life Cycle Cost Analysis

Attachment E provides a 35-year cash flow analysis showing the life-cycle cash flows of the wood pellet district heating system when compared to existing operations. The cash flow analysis considers the energy savings at today's energy prices, annual operation and maintenance savings, and avoided cost of replacing the existing boiler systems and mechanical rooms. Also considered is the replacement of the wood pellet boilers at year 20 of the system's life. Table 5-4 summarizes the cash flow analysis. The project reaches the breakeven point at year 34, and provides a positive net present value of ~$25,000 over 35 years. It is critical to note that energy pricing and how it varies over time dramatically impacts the cash flow analysis. The cash flow analysis inflates fuel oil at 3.3% and wood pellets at 2.7%, while

using a discount rate of 3.0%. If the inflation rate of fuel oil were 4.0% and all other values were kept the same, the net present value would be approximately $240,000, and if the inflation rate of fuel oil were equal to pellets, the net present value would be negative. Similarly, if the cash flow analysis were run with a starting fuel oil price of $5.33/gallon (as seen in 2013), the net present value would be ~$290,000.

Table 5-4 – Summary of 35-year Cash Flow Analysis (Oil Price of $4.65/gallon)

Item	Value
A-Project Cost	$870,596
B-Present Value of Wood Boiler Replacement	$69,575
C-Present Value of Avoided Boiler Room Replacement Cost	($372,644)
D-Grants Received	($240,592)
E-Present Value of Investment (A+B+C+D)	$326,935
F-First Year Operating Savings	$6,117
Simple Payback (E/F), years	53
35-yr Net Present Value	$27,257

Given the first year operating savings, and the investment cost after accounting for future and avoided costs, the project provides a simple payback in the range of 53 years. Table 5-5 shows the sensitivity of annual operating savings to fuel oil and wood pellet prices. Fuel oil prices especially can be quite volatile. They are currently expected to drop over the next year or so, and, conversely were approximately $5.33/gallon two years ago. At $5.33/gallon, and keeping the other factors the same, the project would show a simple payback in the range of 24 years ($326,935/$13,543).

Table 5-5 – Sensitivity of Annual Operating Savings to Wood Pellet and Fuel Oil Prices

		Fuel Oil Price, $/gal				
		$4.00	**$4.65**	**$5.33**	**$5.50**	**$6.00**
Wood Pellet Price, $/ton	**$350**	$10,197	$17,296	$24,722	$26,578	$32,038
	$400	$5,337	$12,435	$19,861	$21,718	$27,178
	$465	($981)	$6,117	$13,543	$15,400	$20,860
	$500	($4,383)	$2,715	$10,141	$11,997	$17,458
	$550	($9,244)	($2,145)	$5,281	$7,137	$12,598

Notes: Table varies fuel prices as shown and keeps all other variables constant. The shaded value identifies current pricing that is used in this document. The price of fuel oil was $5.33/gallon, and this value is specifically shown to illustrate the impact of the fuel oil price change on annual operating savings.

Table 5-6 provides a list of key assumptions used in calculating the annual energy savings, and performing the life-cycle cost analysis.

Table 5-6 – List of Key Assumptions

Item	Value	Unit	Source
Annual fuel oil usage	12,134	gallons	2013-2014 Records
Fuel oil heating value	0.1385	mmBtu/gal	Assumption
Current fuel oil cost	4.65	$/gal	THRHA
Existing fuel oil boiler seasonal efficiency	0.7		Assumption
New oil boiler efficiency (accounts for district losses)	0.7		Assumption
Wood pellet cost	465	$/ton	Budgetary quote
Wood pellet energy content (HHV)	15.56	mmBtu/ton	Assumption
Wood pellet boiler efficiency (accounts for district losses)	0.7		Estimate
Electric cost (first 500 kWh)	0.628	$/kWh	IPEC
Electric cost (over 500 kWh)	0.568	$/kWh	IPEC
Wood pellet coverage of annual demand	0.9		Estimate
Portion of existing electric use for boilers at first 500 kWh rate	1.0		Assumption
Portion of central plant electric use at first 500 kWh rate	0.7		Assumption
Fossil fuel / electric inflation rate (apr)	3.3%	Percent	Assumption
Wood pellet inflation rate (apr)	2.7%	Percent	Assumption
General inflation rate (apr)	2.7%	Percent	Assumption
Discount rate	3.0%	Percent	Assumption

Attachment A

Sizing and Energy Analysis

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Conceptual Design Calculations

December 21, 2015

THRHA Angoon District Heating System
Sizing and Energy Analysis - w/o Church

CONCEPTUAL SIZING

Hot Water Heater Sizing (HUD Sizing per ASHRAE)

Building	Bedrooms	Baths	Storage	Recov, GPH, 120F	Recov, GPH, 140F	MBH	WM Aqua Plus
Building 1 (Typ of 2)	4	2	66	75	60	50	85
Building 2 (Typ of 2)	4	2	66	75	60	50	85
Building 3	6	3	82	75	60	50	85
Building 4	6	3	82	75	60	50	85
Building 5	8	4	132	150	120	100	85 (2)
Building 6	8	4	132	150	120	100	85 (2)
Building 7	3	3	66	66	53	44	85
Building 9	3	3	66	66	53	44	85
Building 8			66	91	73	61	85

Design Heating Loads

	Heat Loss	Existing DHW	Total Load	Existing	Plant Design Load, MBH		
Building	MBH	Load, MBH	MBH	Boiler, MBH	Heat Loss	DHW MBH	Total
Apartment 1A	18	61	79	89	18	50	68
Apartment 1B	18	61	79	89	18	50	68
Apartment 2A	18	61	79	89	18	50	68
Apartment 2B	18	61	79	89	18	50	68
Building 3	36	121	157	178	36	50	86
Building 4	36	121	157	178	36	50	86
Building 5	44	243	287	175	44	100	144
Building 6	44	243	287	356	44	100	144
Building 7	30	182	212	267	30	44	74
Building 8	61	61	121	124	61	61	121
Building 9	30	182	212	267	30	44	74
Totals	353	1,396	1,749	1,901	353	649	1,002
							53%

Distribution Losses

Length, Inft	Btuh/Inft	MBH
1,100	12	13

Heating Plant Design Load

Load	Peak MBH	Load Factor	Design MBH
Heating	353	100%	353
Distribution Losses	13	100%	13
Domestic Hot Water	649	50%	325
Totals	1,015		691

Sizing Analysis

Boilers	Boiler	Type	Design Load, MBH	Factor	Boiler MBH
	B-1	Pellet	691	28%	191
	B-2	Pellet	691	28%	191
	B-3	Fuel Oil	691	80%	551
				135%	934

Pumps	Service	Pump	GPM	Head	η, pump	Pump, BHP	η, motor
	B-1	P-1	19	20	50%	0.2	70%
	B-2	P-2	19	20	50%	0.2	70%
	B-3	P-3	55	20	60%	0.5	70%
	Distribution	P-4A	69	50	65%	1.3	80%
	Distribution	P-4B	69	50	65%	1.3	80%

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Conceptual Design Calculations

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THRHA Angoon District Heating System

Sizing and Energy Analysis - w/o Church

ENERGY USE

Historical Fuel Oil Consumption

Building	Gallons
Building 1	1,373
Building 2	1,377
Building 3	962
Building 4	1,228
Building 5	1,723
Building 6	1,607
Building 7	1,548
Senior Center	1,149
Building 9	1,167
Totals	12,134

ENERGY ANALYSIS

Existing Heating Systems

	Gallons	n, boiler	kBtu/gal	Net kBtu
Fuel Oil	12,134	70%	138.5	1,176,371

Boiler Burners	Building	Boilers	kW,ea	Oil, gal	Oil, GPH	Hours	kWh
	Building 1	2	0.2	1,373	0.75	1,831	410
	Building 2	2	0.2	1,377	0.75	1,836	411
	Building 3	2	0.2	962	0.75	1,283	287
	Building 4	2	0.2	1,228	0.75	1,637	366
	Building 5	1	0.2	1,723	1.45	1,188	266
	Building 6	4	0.2	1,607	0.75	2,143	480
	Building 7	3	0.2	1,548	0.75	2,064	462
	Senior Center	1	0.2	1,149	1.05	1,094	245
	Building 9	3	0.2	1,167	0.75	1,556	348
	Totals	20					3,275

District Heating System

	Net kBtu	Factor	n, boiler	Conversion	Fuel	
Pellets	1,176,371	90%	70%	15,560	97	tons
Fuel Oil	1,176,371	10%	70%	138.5	1,213	gallons
			inc dist losses			

Boiler Burner	Boiler, MBH	Net kBtu	Load factor	Load, kW	Hours	kWh
	191	1,176,371	70%	0.25	6,570	1,643

Pellet Handling				Hours	kW	kWh
				500	0.2	100

Pumps	Pump	Ave GPM	Head	Hours	kW	kWh
	P-1	19	20	7,500	0.3	2,074
	P-2	19	20	4,000	0.3	1,106
	P-3	55	20	500	0.7	332
	P-4A	25	30	8,760	0.4	3,194
				Average Demand, kW	1.8	6,706

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25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
jim@alaskaenergy.us

THRHA Angoon District Heating System

Sizing and Energy Analysis - w/o Church

Monthly Pellet Consumption

Month	Percent	MESys, tons
Jan	14%	14
Feb	12%	12
Mar	11%	10
Apr	8%	8
May	6%	6
Jun	4%	4
Jul	4%	4
Aug	4%	4
Sep	6%	5
Oct	8%	8
Nov	11%	10
Dec	13%	12
	100%	97

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
alaskaenergy@gci.net

Life Cycle Cost Analysis

December 21, 2015

THRHA Angoon District Heating System

Existing Heating Plants

Basis

35	Study Period (years)	2.8%	General Inflation
4.5%	Nominal Discount Rate	3.3%	Fuel Inflation
1.7%	Real Discount Rate	4.0%	Electricity Inflation
		2.7%	Wood Pellet Inflation

Annual Costs		Years	Qty	Unit	Base Cost	Life Cycle Cost	Annual Cost
Heating Plant							
Fuel Oil Boilers							
Fuel Oil Boiler Maintenance							
Parts Allowance, each		1 - 35	20	LS	$100.00	$51,528	$2,000
Monthly, each	0.5 hours/month	1 - 35	120	hrs	$40.00	$123,667	$4,800
Annual, each	4 hours/year	1 - 35	80	hrs	$40.00	$82,445	$3,200
Pumps							
Pump maintenance, cartridge		1 - 35	20	ea	$100.00	$51,528	$2,000
Domestic Hot Water							
Indirect HW heater		1 - 35	20	hrs	$40.00	$20,611	$800
					Total Annual Costs	**$330,000**	**$12,800**

Energy Costs	Years	Qty	Unit	Base Cost	Life Cycle Cost	Annual Cost
Fuel Oil	1 - 35	12,134	gallon	$4.73	$1,643,211	$57,407
Wood Pellets	1 - 35	0	ton	$472.42	$0	$0
Electricity	1 - 35	3,275	kWh	$0.661	$61,968	$2,165
				Total Energy Costs	**$1,705,000**	**$59,572**

	Life Cycle Cost	Annual Cost
Present Worth	**$2,035,000**	**$72,372**

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 alaskaenergy@gci.net

Life Cycle Cost Analysis

December 21, 2015

THRHA Angoon District Heating System

District Heat Plant

Basis

35	Study Period (years)	2.8%	General Inflation
4.5%	Nominal Discount Rate	3.3%	Fuel Inflation
1.7%	Real Discount Rate	3.3%	Electricity Inflation
		2.7%	Wood Pellet Inflation

Annual Costs		Years	Qty	Unit	Base Cost	Present Value	Annual Cost
Heating Plant							
Plant Observation							
Daily Heating Plant Observatic	5 min/day	1 - 35	30	hrs	$40.00	$31,346	$1,217
Wood / Fuel Oil Boilers							
Fuel Oil Boiler Maintenance							
Parts Allowance, each		1 - 35	1	LS	$200.00	$5,153	$200
Monthly, each	1.5 hours/month	1 - 35	18	hrs	$40.00	$18,550	$720
Annual, each	8 hours/year	1 - 35	8	hrs	$40.00	$8,244	$320
Pellet Boiler Maintenance - Small Capacity							
Parts Allowance, each		1 - 35	2	LS	$150.00	$7,729	$300
Monthly, each	2 hours/month	1 - 35	48	hrs	$40.00	$49,467	$1,920
2000 hour maintenance	8 hours/year	1 - 35	16	hrs	$40.00	$16,489	$640
Pellet Handling System							
Maintenance		1 - 35	16	hrs	$40.00	$16,489	$640
Equiipment Replacement							
Pellet boilers		20 - 20	1	LS	$70,000.00	$49,099	$2,000
Vacuum system		10 - 10	1	LS	$1,500.00	$1,246	$1,500
Vacuum system		30 - 30	1	LS	$1,500.00	$889	$1,500
Domestic Hot Water							
Indirect HW heater		1 - 35	12	hrs	$40.00	$12,367	$480
Pumps							
Pump maintenance, cartridge		1 - 35	11	ea	$100.00	$28,340	$1,100
Pump maintenance, pipe mounted		1 - 35	5	ea	$250.00	$32,205	$1,250
					Total Annual Costs	**$278,000**	**$13,787**

Energy Costs	Years	Qty	Unit	Base Cost	Present Value	Annual Cost
Fuel Oil	1 - 35	1,213	gallon	$4.73	$164,321	$5,741
Wood Pellets	1 - 35	97	ton	$472.42	$1,193,758	$45,921
Electricity	1 - 35	8,448	kWh	$0.630	$152,381	$5,324
				Total Energy Costs	**$1,510,000**	**$56,985**

	Life Cycle Cost	Annual Cost
Present Worth	**$1,788,000**	**$70,772**

Attachment B

Pellet Storage and Delivery Vehicle Cut Sheets

BROCK®

ON-FARM HOLDING BINS



STORAGE | HANDLING | CONDITIONING | STRUCTURES

BROCK®

GRAIN MANAGEMENT SYSTEMS

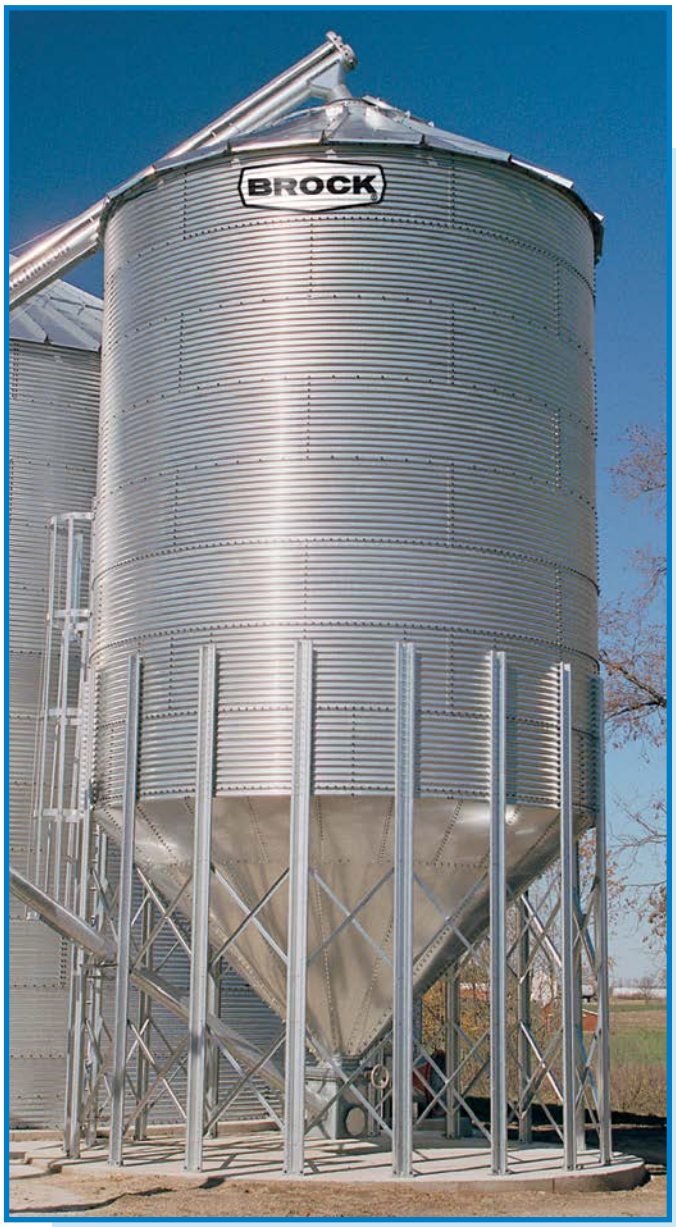
BROCK® 45° HOPPER BINS

BROCK QUALITY MEANS SECURE STORAGE, MORE FOR YOUR MONEY

MORE FEATURES PROVIDE YOU WITH ADDED VALUE

Whether your needs include wet holding bins, seed storage bins, overhead gravity-flow tanks, blending tanks or a bin for tempering your grain after drying, Brock's hopper-bottom bins are the bins of choice for today's modern grain producer. Some of the features you get with BROCK® Bins include:

- More models and choices – from 9 feet (2.7 meters) in diameter to a 21-foot (6.4-meter) diameter hopper-bottom holding bin with a maximum storage capacity of nearly 7,800 bushels (259 cubic meters).
- Sturdy gravity-flow hopper bottom aids the unloading of many types of wet or dry whole kernel grains.
- A wide variety of optional Brock components (sidewall ladders and ladder security doors, hopper access doors, roof vents, ventilation fans, and others) is available.
- Brock's one-year warranty for on-farm wet-holding bins – see Brock's full written warranty for complete warranty details.
- Grain system planning assistance.





Sturdy "X" bracing between legs gives additional bin strength. Bracing is simple to assemble and offers access to the boot.



Bin legs are formed from all-galvanized steel for superior fit, durability and strength.



Side ladders allow plenty of space between rungs and bin wall for a secure footing.



Brock's HYDROSHIELD® Weather Guard directs moisture to drip off the bin's sidewall and keeps it off the bin's hopper and boot.

FOR RELIABLE STORAGE

BROCK QUALITY ACCESSORIES

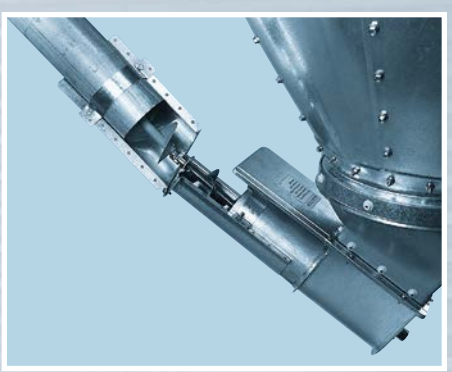


High strength Grade #8.2 bin assembly bolts are available with either the JS-1000™ rust-resistant coating or rust-proof polypropylene-encapsulated head.

JS-1000 is not owned or licensed by CTB and is the sole property of its respective owner.



A grain bin-style roof with a higher load rating is standard on larger diameter hopper bin models; economical hopper bin-style roof is standard for smaller models.



Available options include a variety of components for bin boots and auger systems.



Gravity roof ventilators provide free air movement into the bin. Elbow-style (shown) and round mushroom-style vents are available.



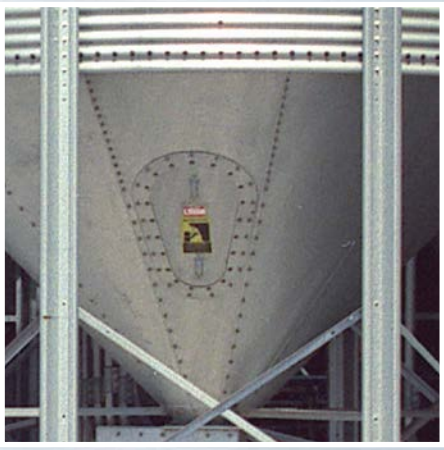
BROCK® field-proven GUARDIAN® Series Fans are designed for maximum in-bin aeration efficiency.



The hopper's discharge opening may be equipped with heavy-duty rack and pinion or roller-style unloading gates.



Patented BROCK® Eave-Vent System provides more total bin ventilation and eliminates the need for roof cuts.



Brock's ACCESS PLUS® Hopper Access Door gives easy access to the interior of the holding bin.



Optional Sidewall Ladders, as well as safety cages and rest platforms, are designed to meet or exceed relevant OSHA standards when installed properly.

UNMATCHED CHOICES

MORE MODELS TO MEET YOUR NEEDS

This is a sampling of the many holding bin sizes Brock offers.

DIAMETER FEET METERS	MODEL NUMBER	HOPPER ANGLE	MAXIMUM CAPACITY*		FILL HEIGHT	
			BUSHELS	M^3	FT. / IN.	METERS
9 FT. 2.7 M 45°	45-00931	45	259	9	11' - 10"	3.61
	45-00932	45	401	13	14' - 6"	4.42
	45-00933	45	543	18	17' - 2"	5.23
	45-00934	45	685	23	19' - 10"	6.05
	45-00935	45	828	28	22' - 6"	6.86
	45-00936	45	970	32	25' - 2"	7.67
	45-00937	45	1112	37	27' - 10"	8.48
	45-00938	45	1254	42	30' - 6"	9.30
	45-00939	45	1396	46	33' - 2"	10.11
	45-009310	45	1539	51	35' - 10"	10.92
	45-009311	45	1681	56	38' - 6"	11.74
12 FT. 3.7 M 45°	45-01231	45	532	18	14' - 2"	4.32
	45-01232	45	785	26	16' - 10"	5.13
	45-01233	45	1038	35	19' - 6"	5.94
	45-01234	45	1291	43	22' - 2"	6.76
	45-01235	45	1544	51	24' - 10"	7.57
	45-01236	45	1798	60	27' - 6"	8.38
	45-01237	45	2051	68	30' - 2"	9.19
	45-01238	45	2304	77	32' - 10"	10.01
	45-01239	45	2557	85	35' - 6"	10.82
	45-012310	45	2810	93	38' - 2"	11.63
	45-012311	45	3063	102	40' - 10"	12.45
12 FT. 3.7 M 60°	45-01201	60	674	22	19' - 5"	5.92
	45-01202	60	927	31	22' - 1"	6.73
	45-01203	60	1180	39	24' - 9"	7.54
	45-01204	60	1433	48	27' - 5"	8.36
	45-01205	60	1686	56	30' - 1"	9.17
	45-01206	60	1939	64	32' - 9"	9.98
	45-01207	60	2193	73	35' - 5"	10.80
	45-01208	60	2446	81	38' - 1"	11.61
	45-01209	60	2699	90	40' - 9"	12.42
	45-012010	60	2952	98	43' - 5"	13.23
	45-012011	60	3205	107	46' - 1"	14.05
15 FT. 4.6 M 45°	45-01532	45	1341	45	19' - 2"	5.84
	45-01533	45	1737	58	21' - 10"	6.65
	45-01534	45	2133	71	24' - 6"	7.47
	45-01535	45	2529	84	27' - 2"	8.28
	45-01536	45	2925	97	29' - 10"	9.09
	45-01537	45	3321	110	32' - 6"	9.91
	45-01538	45	3716	124	35' - 2"	10.72
	45-01539	45	4112	137	37' - 10"	11.53
15 FT. 4.6 M 60°	45-01502	60	1609	53	25' - 10"	7.87
	45-01503	60	2005	67	28' - 6"	8.69
	45-01504	60	2400	80	31' - 2"	9.50
	45-01505	60	2796	93	33' - 10"	10.31
	45-01506	60	3192	106	36' - 6"	11.13
	45-01507	60	3588	119	39' - 2"	11.94
	45-01508	60	3984	132	41' - 10"	12.75

DIAMETER FEET METERS	MODEL NUMBER	HOPPER ANGLE	MAXIMUM CAPACITY*		FILL HEIGHT	
			BUSHELS	M^3	FT. / IN.	METERS
18 FT. 5.5 M 45°	45-01832	45	2092	70	21' - 7"	6.58
	45-01833	45	2662	89	24' - 3"	7.39
	45-01834	45	3233	107	26' - 11"	8.20
	45-				- 7"	9.02
	45-				- 3"	9.83
	45-				- 11"	10.64
	45-				- 7"	11.46
	45-				- 3"	12.27
21 FT. 6.4 M 45°	45-02132	45	3072	102	24' - 0"	7.32
	45-02133	45	3849	128	26' - 8"	8.13
	45-02134	45	4625	154	29' - 4"	8.94
	45-02135	45	5402	180	32' - 0"	9.75
	45-02136	45	6179	205	34' - 8"	10.57
	45-02137	45	6955	231	37' - 4"	11.38
	45-02138	45	7732	257	40' - 0"	12.19

50-ton bin - sits 3.5 ft below truck pullout

***Maximum Capacity** for a bin allows for grain to be at the normal (28-degree) angle of repose, starting one inch (25 mm) below the eave. The grain capacities listed are based on ASAE Standard: ASAE S413, with a compaction factor of 6%. Standard and optional holding bin roof styles are available as follows:

On-Farm Holding Bin Roof Style	Roof Peak Capacity Rating	Standard Roof Style for Bin Diameters	Optional Roof Style for Bin Diameters
Feed Bin Roof	500 to 1,000 lbs (225-450 kg)	9 to 15 feet (2.7-4.6 m)	
3-Panel Ribbed Roof	1,000 lbs (450 kg)	18 to 21 feet (5.5-6.4 m)	12 to 15 feet (3.7-4.6 m)
4-Panel Ribbed Roof	4,000 lbs (1,800 kg)		15 to 21 feet (4.6-6.4 m)

Roof peak capacity ratings are based on ground snow loads of 40 pounds per square foot (195 kg per square meter). Bins are designed to meet code requirements for 90 mph (145 km/h) wind zones and seismic zone 1. In the pursuit of LEADERSHIP THROUGH INNOVATION®, we reserve the right to change specifications without prior notice.

NOTE: Hopper-bottom bins and silos are designed for the storage of free-flowing materials only. Soybean meal, meat scraps, and many other materials are NOT considered free-flowing and must use approved unloading equipment. Call Brock Grain Systems for approved unloading equipment. Any questions regarding the flowability of different materials should be directed to the material manufacturer. Because you will customize your grain storage system to your unique needs, not all potentially dangerous or harmful situations can be identified by Brock Grain Systems at the time the bin components and accessories are manufactured. Therefore, it is essential that you think safety first and pay close attention to all possible hazards within your storage systems.

Need More Capacity? Ask About Brock's Commercial Hopper-Bottom Bins In Diameters From 15 To 36 Feet (4.6 To 11 M).

BROCK®

BROCK GRAIN SYSTEMS
A Global Division of CTB, Inc.
Milford, IN • Kansas City, MO • Frankfort, IN
Phone: +1 574.658.4191 • Fax: +1 574.658.4133
Internet: www.BrockGrain.com
E-mail: Brock@BrockGrain.com

U# 2296 2001 PACER A65 & 2010 FREIGHTLINER M2-106

$ 64,950.00



Make:	Pacer
Model:	A65
Equipment Type:	truck-and-bag-bulk-feed-body
Mileage	225,500
Availability:	see description
Price:	$ 64,950.00
Description	**AVAILABLE MAR. 2016**
Mileage	225,500
Details:	

Body Details:

Body Width: 102"

Chassis:

C.A./C.T.: 190"
Engine: Cummins ISC 330 HP
Front Axle Rating: 20000
Front Rims/Hubs: Aluminum
Front Tire Condition: 25%
Front Tire Size: 385/65R 22.5
Fuel Tank: 2 - 80 Gal. Aluminum Tanks
Mileage: 225,500
Rear Axle Rating: 40000
Rear Rims/Hubs: Steel
Rear Tire Condition: 35%
Rear Tire Size: 11R 22.5
Suspension Design: Air Ride
Transmission: Eaton RTO 11908LL
Wheelbase: 254"

Augers & Hydraulics:

Auger Drives: Hydraulic Direct

Auger Material: Steel
Augers: 9"-12"-9"
Controls: Front Manual
Discharge Auger Length: 20' W 4' Bolt On Ext.
Floor Conveyor Type: Auger
Hydraulic Motors: Parker
Hydraulic Pump: Tandem
Hydraulic System: 3 Line
Oil Tank Location: Inside Front Of Body
Vertical Auger Postion: Front Straight

Body Design:

Body Length: 20
Compartment Length: 16"
Compartment Quantity: 15
Floor Crossmember Spacing: 16"
Gate Type: Drop
Height: 12' 6"
Top Door Type: Full Open Top

Sudenga INDUSTRIES, INC. SINCE 1888

"Big Boy" Feed Bodies





Our new narrow-width "Big Boy" Feed Bodies are designed to ship in sea containers - drastically reducing shipping costs, and giving you Sudenga quality at competitive prices. The first Sudenga feed body rolled out the gate 55 years ago in 1957. Time for another "first" from Sudenga.

"Big Boy" Feed Bodies

Body Features

- All-welded 12 ga. construction.
- Steel Top with manual crank.
- Wide fenders for bagged feed.
- Delrin spline coupler on the discharge auger.



Auger and Hydraulic System

- 8"-10"-10"-8" auger system.
- 2000 lb./minute unloading.
- 360° discharge rotation.
- Hydraulic raise and rotate on discharge auger with controls located at driver's door.
- Variable speed floor auger with rear pit discharge.
- Direct couple tandem hydraulic pumps.
- Orbit type auger motors.
- 29 gallon oil reservior with filter.

Options

- Manual rack & pinion compartment gates.
- Higher body sides.
- Discharge auger extensions - 4', 6', 8', and 10'.
- Extra body compartments.



Shipment

Body components are carefully labled and packed to assure that the customer receives a complete feed transport. Labeling is also done in a way that visually assists assembly by indicating how components are installed on the body.

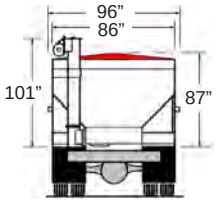


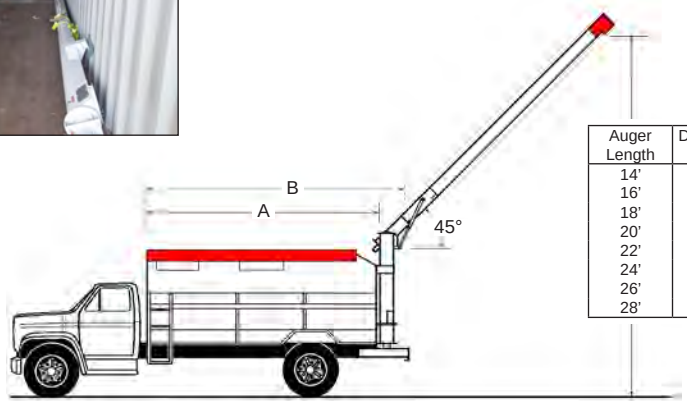




Truck frame ratings of 2,800K RBM per rail and18K front axles are recommended for Bodies with 15 ton capacity or larger.

Air ride suspension is recommended for all tandem, triple, and quad axle chassis. Bodies mounted on tractors must fit without stretching the frame.





Auger Length	Discharge Height
14'	19'
16'	20'-6"
18'	22'
20'	23'-6"
22'	25'
24'	26'-6"
26'	28'
28'	29'-6"

	8T12HOH	9T14HOH	10T16HOH	11T18HOH	12T20HOH	14T22HOH	15T24HOH	17T26HOH
A - Body Length	12'	14'	16'	18'	20'	22'	24'	26'
B - Overall Length	14'-5"	16'-5"	18'-5"	20'-8"	22'-8"	24'-8"	26'-8"	28'-8"
Body Weight[1]	4678	5068	5518	5821	6324	6691	7137	7853
Cab-to-Axle	108"	138"	138" (120")*	144"*	172"*	180"**	180"***	198"***
No. of Compartments	2	3	3	3	4	4	4	5
Capacity - cu. ft.	358	451	515	580	644	708	773	850
Capacity - ton	6.8	8.5	9.8	11	12.2	13.4	14.7	16.1

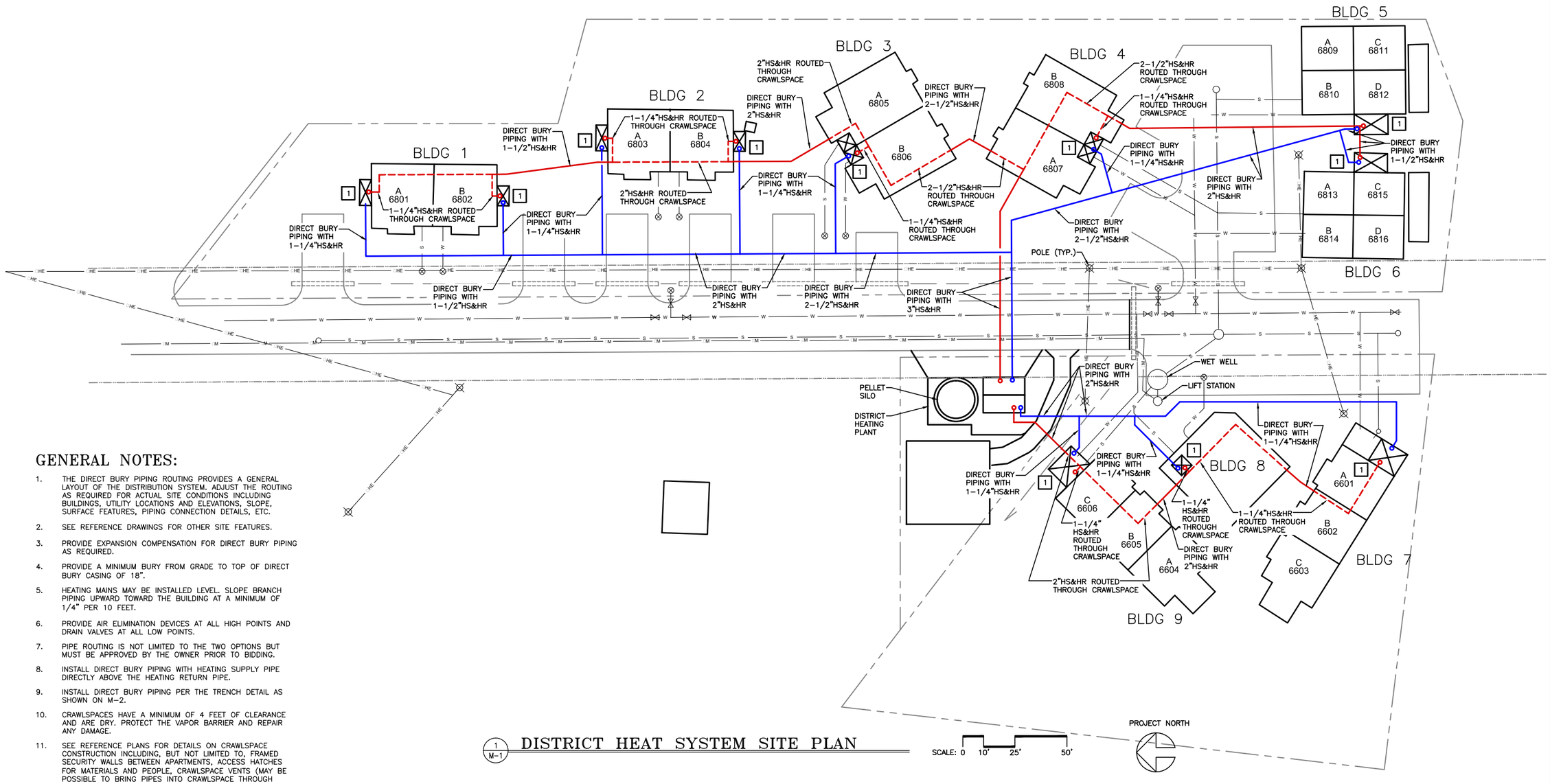
[1]Body weights are approximates and will vary with optional equipment. *Cab-to-center of tandem. **Cab-to-center of triple axles. ***Cab-to-center of quad axles. Cab-to-axle figures are only recommendations developed from trucks commonly used by our customers. We cannot guarantee their accuracy in all situations. Consult your truck dealer for chassis recommendations.

Box 8 • 2002 Kingbird Ave. • George, IA 51237 USA
1-888-SUDENGA (783-3642) • 1-712-475-3301 • Fax: 1-712-475-3320
E-mail: dtecken@sudenga.com • www.sudenga.com

SUDENGA INDUSTRIES, INC.

Attachment C

Preliminary Design



1 M-1 DISTRICT HEAT SYSTEM SITE PLAN

GENERAL NOTES:

1. THE DIRECT BURY PIPING ROUTING PROVIDES A GENERAL LAYOUT OF THE DISTRIBUTION SYSTEM. ADJUST THE ROUTING AS REQUIRED FOR ACTUAL SITE CONDITIONS INCLUDING BUILDINGS, UTILITY LOCATIONS AND ELEVATIONS, SLOPE, SURFACE FEATURES, PIPING CONNECTION DETAILS, ETC.
2. SEE REFERENCE DRAWINGS FOR OTHER SITE FEATURES.
3. PROVIDE EXPANSION COMPENSATION FOR DIRECT BURY PIPING AS REQUIRED.
4. PROVIDE A MINIMUM BURY FROM GRADE TO TOP OF DIRECT BURY CASING OF 18".
5. HEATING MAINS MAY BE INSTALLED LEVEL. SLOPE BRANCH PIPING UPWARD TOWARD THE BUILDING AT A MINIMUM OF 1/4" PER 10 FEET.
6. PROVIDE AIR ELIMINATION DEVICES AT ALL HIGH POINTS AND DRAIN VALVES AT ALL LOW POINTS.
7. PIPE ROUTING IS NOT LIMITED TO THE TWO OPTIONS BUT MUST BE APPROVED BY THE OWNER PRIOR TO BIDDING.
8. INSTALL DIRECT BURY PIPING WITH HEATING SUPPLY PIPE DIRECTLY ABOVE THE HEATING RETURN PIPE.
9. INSTALL DIRECT BURY PIPING PER THE TRENCH DETAIL AS SHOWN ON M-2.
10. CRAWLSPACES HAVE A MINIMUM OF 4 FEET OF CLEARANCE AND ARE DRY. PROTECT THE VAPOR BARRIER AND REPAIR ANY DAMAGE.
11. SEE REFERENCE PLANS FOR DETAILS ON CRAWLSPACE CONSTRUCTION INCLUDING, BUT NOT LIMITED TO, FRAMED SECURITY WALLS BETWEEN APARTMENTS, ACCESS HATCHES FOR MATERIALS AND PEOPLE, CRAWLSPACE VENTS (MAY BE POSSIBLE TO BRING PIPES INTO CRAWLSPACE THROUGH VENTS), ETC.
12. SEAL CONCRETE STEM WALL PENETRATIONS WITH APPROVED SEALANT.
13. SECURE ALL APARTMENT DIVIDER WALLS IN CRAWLSPACE WITH ESCUTCHEON SECURED TO EACH SIDE.
14. SIZE DISTRIBUTION PIPING FOR A PRESSURE DROP OF 1.5 FEET PER 100 FEET.

SPECIFIC NOTES:

[1] SEE TYPICAL HEATING PIPING DIAGRAM ON SHEET M-3 FOR BUILDING CONNECTION TO HEATING SYSTEM.

DIRECT BURY PIPING SCHEDULE:

HS & HR PIPE SIZE	CASING DIAMETER
3"	16"
2-1/2"	14"
1-1/2" AND 2"	12"

DISTRIBUTION PIPING OPTIONS:

OPTION	DESCRIPTION	LINE TYPE	
		DIRECT BURY	IN CRAWLSPACE
OPTION 1:	HEATING MAINS RUN PARALLEL TO THE STREET.	———	NA
OPTION 2:	HEATING MAINS ROUTE THROUGH CRAWLSPACES.	———	- - - -

PRELIMINARY NOT FOR CONSTRUCTION

Alaska Energy Engineering LLC
Phone and Fax: (907) 789-1726
E-mail: jim@alaskaenergy.us
25200 Amalga Harbor Road
Juneau, Alaska 99801

Angoon Housing District Heat System

Angoon Alaska

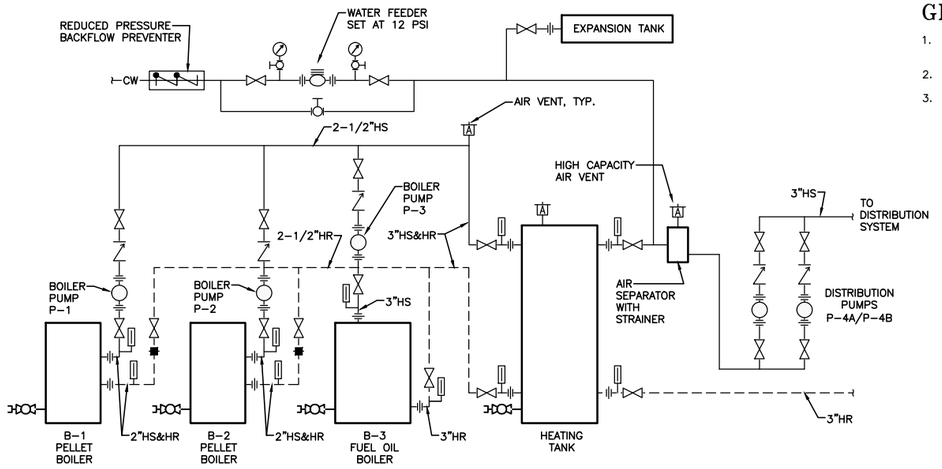
Tlingit-Haida Regional Housing Authority
Design-Build Procurement Package

SHEET TITLE:

DISTRICT HEAT SYSTEM SITE PLAN

Date: DECEMBER, 2015
Scale: As Noted
Drawn: KB
Checked: JR

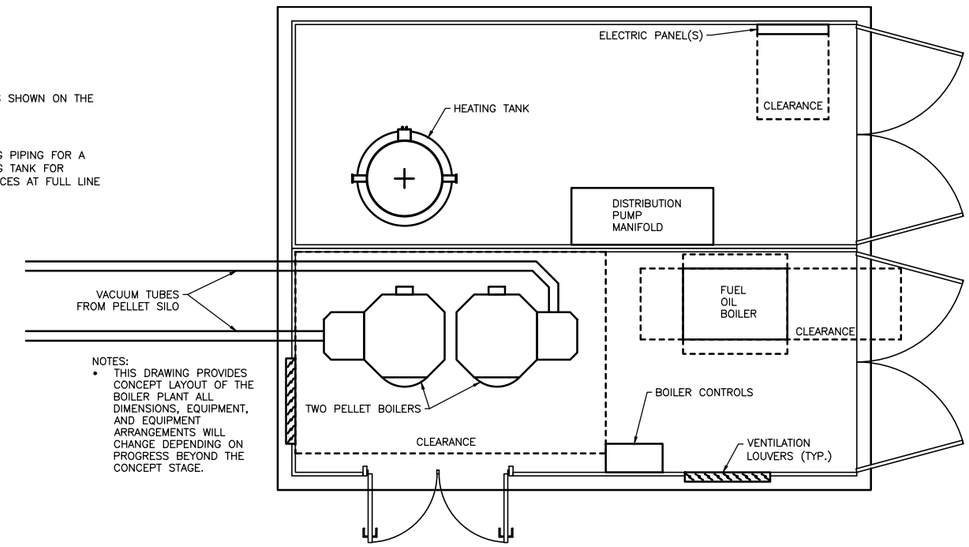
M-1



1 M-2 DISTRICT HEATING PLANT PIPING DIAGRAM

GENERAL NOTES:

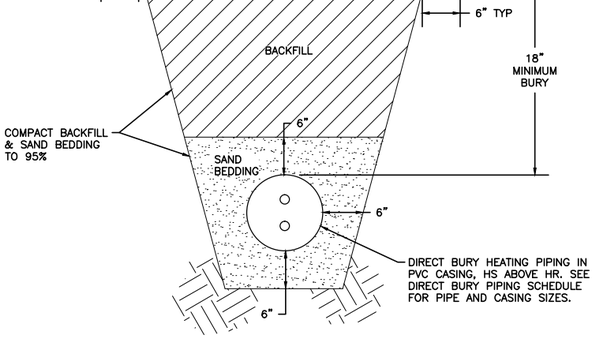
1. PROVIDE A PRIMARY/SECONDARY PIPING ARRANGEMENT AS SHOWN ON THE DISTRICT HEATING PLANT PIPING DIAGRAM.
2. PROVIDE A CHEMICAL FEEDER.
3. MINIMIZE HEATING SYSTEM PRESSURE DROP: SIZE HEATING PIPING FOR A MAXIMUM PRESSURE DROP OF 1.5'/100 FT; SIZE HEATING TANK FOR MAXIMUM 2' OF DROP. PROVIDE PIPING AND APPURTENANCES AT FULL LINE SIZE UP TO CONNECTION TO EQUIPMENT.



NOTES:
- THIS DRAWING PROVIDES CONCEPT LAYOUT OF THE BOILER PLANT ALL DIMENSIONS, EQUIPMENT, AND EQUIPMENT ARRANGEMENTS WILL CHANGE DEPENDING ON PROGRESS BEYOND THE CONCEPT STAGE.

2 M-2 DISTRICT HEATING PLANT PLAN

SCALE: 0 2' 4' 8'



3 M-2 TRENCH DETAIL

DISTRICT HEATING PLANT EQUIPMENT SCHEDULE

EQUIPMENT	CHARACTERISTICS
PELLET BOILER B-1	MANUFACTURER: MAINE ENERGY SYSTEMS MODEL PE56 CAPACITY: MODULATE FROM 57 MBH TO 191 MBH PROVIDE CHLORINE RESISTANT FLAME TUBE.
PELLET BOILER B-2	MANUFACTURER: MAINE ENERGY SYSTEMS MODEL PE56 CAPACITY: MODULATE FROM 57 MBH TO 191 MBH PROVIDE CHLORINE RESISTANT FLAME TUBE.
FUEL OIL BOILER B-3	MANUFACTURER: WEIL MCLAIN MODEL 680 CAPACITY: 551 MBH NET L=B=R WITH FULLY MODULATING BURNER
HEATING TANK	CAPACITY: 250 GALLON STORAGE; TANK AS TALL AS POSSIBLE TO FIT ROOM TO PROMOTE STRATIFICATION; 3" SUPPLY AND RETURN TAPPINGS FOR PLANT AND DISTRIBUTION ON OPPOSING SIDES WITHIN 6" OF TOP AND BOTTOM OF TANK.
BOILER PUMP P-1	CAPACITY: 19 GPM @ 20' HEAD; CONSTANT SPEED ECM MOTOR; MINIMUM 50% WATER-TO-WIRE EFFICIENCY; 120V/SINGLE PHASE.
BOILER PUMP P-2	CAPACITY: 19 GPM @ 20' HEAD; CONSTANT SPEED ECM MOTOR; MINIMUM 50% WATER-TO-WIRE EFFICIENCY; 120V/SINGLE PHASE.
BOILER PUMP P-3	CAPACITY: 55 GPM @ 20' HEAD; VARIABLE SPEED ECM MOTOR; MINIMUM 40% WATER-TO-WIRE EFFICIENCY; 240V/SINGLE PHASE.
DISTRIBUTION PUMP P-4A	CAPACITY: 69 GPM @ 50' HEAD; VARIABLE SPEED ECM MOTOR; 50% WATER-TO-WIRE EFFICIENCY; 240V/SINGLE PHASE. CONTROL: CONSTANT PRESSURE CONTROL, VARIABLE DIFFERENTIAL PRESSURE CONTROL, AND LEAD/STANDBY CONTROL.
DISTRIBUTION PUMP P-4B	CAPACITY: 69 GPM @ 50' HEAD; VARIABLE SPEED ECM MOTOR; 50% WATER-TO-WIRE EFFICIENCY; 240V/SINGLE PHASE. CONTROL: CONSTANT PRESSURE CONTROL, VARIABLE DIFFERENTIAL PRESSURE CONTROL, AND LEAD/STANDBY CONTROL.

ABBREVIATIONS

BLDG	BUILDING
CW	COLD WATER
FM	FORCED MAIN
HS	HEATING SUPPLY
HR	HEATING RETURN
HW	HOT WATER
HX	HEAT EXCHANGER
OHE	OVERHEAD ELECTRIC
S	SEWER
TYP	TYPICAL
W	WATER

GENERAL SYMBOLS

CONNECT TO EXISTING	
EXISTING TO REMAIN	(E)
GENERAL SHEET NOTE	1.
REFERENCED SHEET NOTE	2
DETAIL REFERENCE	1 / M3.1

PIPING SYMBOLS

CONTROL VALVE
GATE VALVE
BACKFLOW PREVENTION DEVICE
DRAIN VALVE WITH HOSE END CONNECTION
AIR VENT (A) AUTOMATIC, (M) MAINUAL
UNION
THERMOMETER
ELBOW, UP
ELBOW, DOWN
CONCENTRIC REDUCER
FLOWSETTER
WATER FEEDER
PRESSURE GAGE
CONNECTION POINT

SEQUENCE OF CONTROL DISTRICT HEATING PLANT

1. Pellet Boilers and Boiler Pumps: A integral control panel supplied with boiler B-1 will operate and modulate both boilers in a lead/lag configuration with weekly rotation of the lead boiler.
   a. Modulate and sequence the boilers to maintain the heating tank temperature setpoint per the heating tank temperature setpoint schedule.
   b. Enable the boilers when the heating tank temperature drops to the enable setpoint and disable the boilers when the heating tank temperature rises to the disable setpoint.
   c. Operate the respective boiler pump 2 minutes prior to enabling its respective boiler and for 5 minutes after the boiler has completed firing.
2. Fuel Oil Boiler: Provide a service switch mounted on the boiler to disconnect power to the burner for servicing.
   a. Sequence and modulate the boiler to maintain a manually selected heating tank temperature setpoint per the heating tank temperature setpoint schedule.
   b. Enable the boiler when the heating tank temperature drops to the enable setpoint and disable the boiler when the heating tank temperature rises to the disable setpoint.
   c. Operate the boiler pump for 2 minutes prior to enabling the boiler and for 5 minutes after the boiler has completed firing.
3. Heating Tank Temperature Setpoint: Set the boiler controls per the following table. The primary fuel source is selected by setting its respective boiler to be the lead boiler.

Heating Tank Temperature Setpoint Schedule

Boiler	Heating Tank SP	Boiler Enable SP	Boiler Disable SP
Winter Settings			
Lead Boiler	185°F	165°F	190°F
Lag Boiler	165°F	155°F	170°F
Summer Settings			
Lead Boiler	165°F	160°F	190°F
Lag Boiler	155°F	145°F	160°F

4. Distribution Pumps
   a. Operation: Operate the pumps in a lead/standby configuration. Modulate the lead pump to maintain a variable differential pressure setpoint. Determine the minimum and maximum flow differential pressure setpoints during balancing. Setpoints shall be as low as possible to provide the building flow rates.
   b. Sequencing: If the lead pump fails to operate, enable the standby pump and initiate an alarm.

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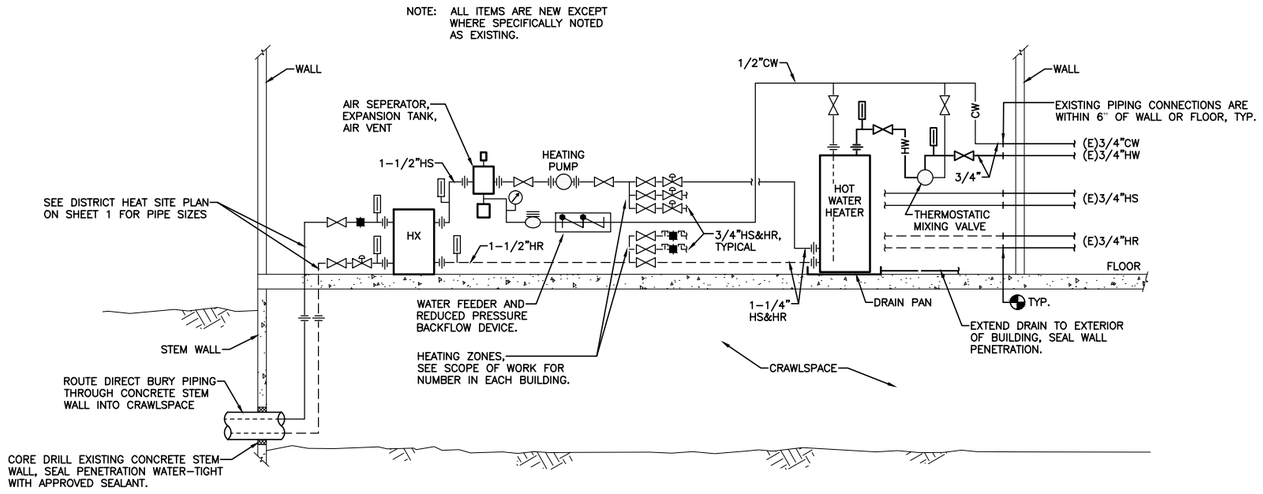
Alaska Energy Engineering LLC
25200 Amalga Harbor Road
Juneau, Alaska 99801
Phone and Fax: (907) 789-1726
E-mail: jim@alaskaenergy.us

Angoon Housing District Heat System
Angoon Alaska
Tlingit-Haida Regional Housing Authority
Design-Build Procurement Package

SHEET TITLE:
DISTRICT HEATING PLANT

Date: DECEMBER, 2015
Scale: As Noted
Drawn: KB
Checked: JR

M-2



1 / M-2 TYPICAL BUILDING PIPING DIAGRAM

SEQUENCE OF CONTROL BUILDING HEATING SYSTEM

1. Heating Supply Temperature: Modulate the heat exchanger automatic valve to maintain a building heating supply setpoint of 180°F.
2. Zone Control: Provide a zone control panel that opens the zone valve when a respective room thermostat or hot water tank temperature sensor calls for heat. Operate the heating pump on a call for heat and disable the pump when there is no call for heat.

BUILDING SCOPE OF WORK
Angoon Housing District Heat System

1.1 DEMOLITION

A. Each apartment has a separate heating system connected to a separate fuel oil tank, except in Building 5, which has one heating system and four fuel oil tanks. Building 8 has one heating system and oil tank.

B. The following apply to each heating system. See the reference drawings for specifics on each heating system.

C. Equipment: Remove the boiler, hot water heater, heating pump, air separator, and expansion tank. Remove the chimney and repair the roof penetration. Remove drain pans under the boilers and hot water heaters and connecting piping.

D. Piping and Appurtenances: Remove the piping within the boiler room including, but not limited to, insulation, valves, control valves, supports, etc.

1. Heating Piping: Remove the heating piping from the boiler to within 6" of the wall penetration.
2. Hot Water Piping: Remove the hot water piping from the hot water heater to within 6" of the wall penetration.
3. Cold Water Piping: Retain the cold water piping or replace in-kind if it hinders the new installation. Remove the branch serving the boiler feed including the isolation valve, water feeder, etc.
4. Seal all floor and wall penetrations.

E. Chimney: Remove the entire chimney, insulate the opening, and patch the inside and outside surfaces to match existing.

1. Building 5: Perform this work on four chimneys.

F. Combustion Air Openings: Remove the louver, insulate the opening, and patch the inside and outside surfaces to match existing.

G. Fuel Oil System: Remove the aboveground fuel tanks, steel and wood support frame, buried fuel oil piping, and all fuel oil piping and appurtenances within the boiler room including supports.

H. Electrical: For each heating system, there is a separate circuit supplying power to the burner, pump, and zone controls. Remove all raceways, conductors, control wiring and control transformer. Retain power circuits (as needed) and the room thermostat control wiring in the new work. Remove all other circuits through the floor and terminate in a new junction box under the floor. Seal floor penetrations.

1.2 NEW WORK

A. General Requirements

1. Scope: Provide new heating systems supplied by the district heating system except as modified in the Building Specific Requirements below. Install each system per the Typical Building Piping Diagram.
2. Layout equipment and piping to provide appropriate access to equipment for maintenance and repair.
3. Provide seismic restraints per code requirements.
4. Electrical: Utilize the existing power circuit for the pump and controls.

B. Building Specific Requirements

1. Building 1: Install a separate heating system for each apartment.
   a. Each heating system has two heating zones and one hot water heater.
   b. Provide a three-way control valve on the hot side of the heat exchanger to provide minimum pump flow for the district heat system. Provide a bypass balance valve, initially set at 2 gpm. Adjust as low as possible to maintain temperature in the distribution system and a reasonable pump speed when none of the heat exchangers are calling for heat.
   c. Apartment A: Provide a three-way control valve on the hot side of the heat exchanger to provide minimum pump flow for the district heat system. Provide a bypass balance valve, initially set at 2 gpm. Adjust as low as possible to maintain temperature in the distribution system and a reasonable pump speed when none of the heat exchangers are calling for heat.
2. Building 2: Install a separate heating system for each of two apartments.
   a. Each heating system has two heating zones and one hot water zone.
3. Building 3: Install one heating system serving two apartments. The building has two adjacent mechanical rooms.
   a. Locate the heating system in one of the mechanical rooms. If there is insufficient space, locate the heat exchanger in one room and the hot water heater in the other.
   b. The heating system has a heating zone for each apartment and one hot water heater.
4. Building 4: Install one heating system serving two apartments. The building has two adjacent mechanical rooms.
   a. Locate the heating system in one of the mechanical rooms. If there is insufficient space, locate the heat exchanger in one room and the hot water heater in the other.
   b. The heating system has a heating zone for each apartment and one hot water heater.
5. Building 5: Install one heating system serving four apartments.
   a. The heating system has a heating zone for each apartment and two hot water heaters.
   b. Provide a three-way control valve on the hot side of the heat exchanger to provide minimum pump flow for the district heat system. Provide a bypass balance valve, initially set at 2 gpm. Adjust as low as possible to maintain temperature in the distribution system and a reasonable pump speed when none of the heat exchangers are calling for heat.
6. Building 6: Install one heating system serving four apartments.
   a. The heating system has a heating zone for each apartment and two hot water heaters.
7. Building 7: Install one heating system serving three apartments.
   a. The heating system has a heating zone for each apartment and one hot water heater.
   b. Provide a three-way control valve on the hot side of the heat exchanger to provide minimum pump flow for the district heat system. Provide a bypass balance valve, initially set at 2 gpm. Adjust as low as possible to maintain temperature in the distribution system and a reasonable pump speed when none of the heat exchangers are calling for heat.
8. Building 8: Install one heating system serving the building
   a. The heating system has three heating zones and one hot water heater.
9. Building 9: Install one heating system serving three apartments.
   a. The heating system has a heating zone for each apartment and one hot water heater.
   b. Provide a three-way control valve on the hot side of the heat exchanger to provide minimum pump flow for the district heat system. Provide a bypass balance valve, initially set at 2 gpm. Adjust as low as possible to maintain temperature in the distribution system and a reasonable pump speed when none of the heat exchangers are calling for heat.

End of Section

PRELIMINARY NOT FOR CONSTRUCTION

Alaska Energy Engineering LLC
25200 Amalga Harbor Road
Juneau, Alaska 99801
Phone and Fax: (907) 789-1726
E-mail: jim@alaskaenergy.us

Angoon Housing District Heat System
Angoon Alaska
Tlingit-Haida Regional Housing Authority
Design-Build Procurement Package

SHEET TITLE:
BUILDING HEATING & DOMESTIC HOT WATER SYSTEMS

Date: DECEMBER, 2015
Scale: As Noted
Drawn: KB
Checked: JR

M-3

TECHNCIAL REQUIREMENTS

THRHA Angoon District Heating System

PART 1 - PERFORMANCE REQUIREMENTS

1.1 CONSTRUCTION ACTIVITIES ON-SITE

A. Daily Work Schedule: Work on the site is allowed daily from 8:00 am to 7:00 pm.

B. Work and Outage Plan: Submit a Work and Outage Plan that describes the work sequence and defines heating and domestic hot water outages.

1. Sequence of Work: Perform the work in accordance with the following sequence:

a. Construct the district heating plant and the distribution system including branches to each heat exchanger with isolation valves.

b. Startup the heating system and make fully operational to heat the buildings.

c. Connect each building to the system.

2. Buildings 1 and 2 (Duplexes):

a. Scope: Replace two separate heating and domestic hot water systems with two separate heating and domestic hot water systems connected to the district heat system.

1) Temporary Heat: Connect building to district heat system with a temporary heat exchanger or use a temporary boiler.

2) Temporary Domestic Hot Water: Connect a temporary hot water heater to the apartment piping and heat it from the temporary heating system.

3) Remove the existing heating and domestic hot water system prior to installing the new system.

b. Allowed Outages:

1) Heating: Two outages, each a maximum of 4 hours.

2) Domestic Hot Water: Two outages, each a maximum 8 hours

3. Buildings 3 and 4 (Duplexes):

a. Scope: Replace two separate heating and domestic hot water systems with two separate heating and domestic hot water systems connected to the district heat system.

1) Temporary Heat: Connect building to district heat system with a temporary heat exchanger or use a temporary boiler.

2) Domestic Hot Water: Connect a temporary hot water heater to the apartment piping and heat it from the temporary heating system.

3) Remove the existing heating and domestic hot water system prior to installing the new system.

b. Allowed Outages:

1) Heating: Two outages, each a maximum of four hours.

2) Domestic Hot Water: Two outages, each a maximum four hours

4. Building 5 (4-plex):
    a. Scope: Replace the heating and domestic hot water system serving all four apartments with a new heating and domestic hot water system connected to all four apartments.
        1) Install the new heating system in the mechanical room.
        2) Connect it to the building heating and domestic hot water distribution systems.
        3) Remove the existing heating system.
    b. Allowed Outages:
        1) Heating: One outage of a maximum 4 hours.
        2) Domestic Hot Water: One outage of a maximum 8 hours.
5. Building 6 (4-plex)
    a. Scope: Replace four separate heating and domestic hot water systems located in the mechanical room with one heating system supplying all four apartments.
        1) Temporarily combine the four heating and domestic hot water systems into two systems, each system serving two apartments. Remove the two heating and domestic hot water systems that were disconnected.
        2) Install the new heating and domestic hot water system.
        3) Connect the new heating and domestic hot water system to all four apartments.
    b. Allowed Outages:
        1) Heating: Two outages of a maximum 4 hours each.
        2) Domestic Hot Water: Two outages of a maximum 8 hours each.
6. Buildings 7 and 9 (Triplex)
    a. Scope: Replace three separate heating and domestic hot water systems located in the mechanical room with one heating system supplying all three apartments.
        1) Temporarily combine the one of the heating and domestic hot water systems with another system. Remove the heating and domestic hot water system that was disconnected.
        2) Install the new heating and domestic hot water system.
        3) Connect the new heating and domestic hot water system to all three apartments.
    b. Allowed Outages:
        1) Heating: Two outages of a maximum 4 hours each.
        2) Domestic Hot Water: Two outages of a maximum 8 hours each.
7. Building 8 (Senior Center):
    a. Scope: Replace the heating and domestic hot water system with a new heating and domestic hot water systems connected to the district heat system.
        1) Temporary Heat: Connect building to district heat system with a temporary heat exchanger or use a temporary boiler.

2) Temporary Domestic Hot Water: Connect a temporary hot water heater to the apartment piping and heat it from the temporary heating system.

3) Remove the existing heating and domestic hot water system prior to installing the new system.

b. Allowed Outages:

1) Heating: Two outages of a maximum 4 hours each.

2) Domestic Hot Water: Two outages, each a maximum 8 hours

1.2 SUBMITTAL REQUIREMENTS

A. Design Documents: Provide the following submittals in PDF format.

1. 50% Submittal

a. Manufacturers data for all equipment

b. Floor plans showing equipment layouts

c. Direct bury piping data, layout drawings, details, and calculations.

d. Control documentation

2. 100% Submittal: Completed design documents including incorporation of 50% comments.

3. Final Submittal: Signed design documents including incorporation of review comments.

B. Manufacturer's Data: Provide manufacturer's data for the following:

1. Pellet boiler and controls
2. Fuel oil boiler and controls
3. Heating tank
4. Heating and domestic hot water piping
5. Pumps
6. Heat exchangers
7. Domestic hot water tanks
8. Thermostatic mixing valve
9. Flow setters
10. Air vents
11. Thermometers
12. Insulation including thickness schedule for existing and new piping
13. Distribution pump controls
14. Building controls

C. Direct Bury Piping

1. Manufacturer's Catalog Data: All components of the piping system including Carrier Pipe; Carrier Pipe Insulation; Pipe Supports; Casing; Joint Kit; Shrink Wrap Sleeve.
2. Drawings: Complete drawings of the direct bury piping design and assembly of the system, materials of construction, and field installation instructions. Submittal shall include sufficient system details required to show that the specified minimum insulation thickness has been met. A detailed design layout of the system (plan and elevation views) showing size, type, elevations and location of each component to be used in the system, the design and location of anchors, pipe guides, pipe supports, expansion loops, Z-bends, L-bends, end seals, leak plates, joint locations, pipe and insulation thickness and sizes, types, and movements, connection to manhole and building wall penetrations, and including, if applicable, transition point design to aboveground or other type systems.
3. The piping layout design shall be prepared and approved by a registered Professional Engineer and certified by his/her stamp.
4. Data: Pipe stress and system expansion calculations: Submit pipe stress and system expansion calculations for each expansion compensation elbow using a finite element computer generated three-dimensional analysis. Calculations (including heat loss calculations) shall demonstrate that pipe stresses from temperature changes are within the allowable requirements in ASME B31.1 and the anchors and the guides will withstand the resultant forces. Layout shall also include all analysis node points. As a minimum, the computer analysis results include node stresses, forces, moments and displacements. Calculations shall be approved, certified, stamped and signed by a registered Professional Engineer in the employ of the manufacturer.
5. Certificates
    a. Manufacturer Certification: Certification that the manufacturer regularly and currently manufactures direct-buried systems, and that the designs of the system and equipment to be provided for this project conform to specification requirements. This certification shall be an original signed by a principal officer.
    b. Contractor Certification: The Manufacturer shall certify each contractor employee that is properly trained to install and test the system. Only certified personnel shall be allowed to install and test the system.
    c. Design: A Certificate of Satisfactory Operation certifying that at least 3 systems installed by the manufacturer within the previous 10 years have and are operating satisfactorily for not less than 5 years. The certificate shall indicate the location, type of system, size of system, point of contact (POC) including phone number, for information verification. This certificate of satisfactory operation shall be an original signed by a principal officer of the manufacturer.
    d. Certificate of Compliance: Upon completion of the work, and before final acceptance, a notarized statement signed by a principal officer of contractor, certifying that the system has been installed satisfactorily and in accordance with the contract drawings, specifications, UHDS manufacturer's detailed design layout drawings and with the UHDS manufacturer's recommendations.
    e. Hot-dip Galvanizing: Provide a statement certifying that the hot-dip galvanizing plant is capable of zinc coating steel components of the system in accordance with the specification requirements.

f. Certification of Contractor's Non-destruction Examination (NDE) personnel

D. As-built Drawings

1. Submit a complete set of as-built construction drawings in PDF and AutoCAD format.
2. Submit all design calculations.

E. O&M Manual

1. Submittals:
   a. Submit a draft O&M manual in PDF format for approval.
   b. Submit a final O&M manual in one 3-ring binder and one electronic copy.
2. Include approved submittal data, installation, operation, and maintenance instructions, parts list and service information for the following:
   a. Pellet boiler and controls
   b. Fuel oil boiler and controls
   c. Pumps
   d. Heating tank
   e. Heat exchangers
   f. Hot water heaters
   g. Thermostatic mixing valves
3. Include the approved direct bury piping submittal
4. Include control documentation for the distribution pumps and building controls.

PART 2 - REQUIREMENTS

2.1 GENERAL

A. See the Preliminary Drawings for additional information on project scope and equipment specifications.

B. Codes: Perform all work in accordance with applicable codes and industry standards.

1. Design Requirements
2. Minimize Electrical Energy: Minimize electrical energy use by the district heating system by minimizing equipment and piping pressure drop. Provide highly efficient ECM motors or NEMA Premium motors.
3. Substitutions: Equipment make and model substitutions shall be approved prior to submitting a bid.

C. Demolition: All items identified for removal become the property of the contractor, unless noted to be retained by the Owner, and shall be promptly removed from the Owner's property at the contractors expense.

D. Equipment and Piping Supports: Provide supports and seismic restraints for all equipment and piping.

E. Electrical: All equipment must be compatible with 120 volt or 240v single-phase service.

F. Insulation:

1. Where repairing insulation that is removed or damaged while performing the work, provide and install pipe and equipment insulation to match the original installation.
2. Insulate all new piping systems and equipment including:
    a. Insulation Blankets: Heat exchangers and flow setters
    b. Fiberglass Insulation: Heating and domestic piping, heating tank, valves, and all appurtenances except unions and pumps.

G. Expansion Compensation: Install all piping with appropriate expansion compensation.

H. Air Vents: Install 1/2" air vents with isolation ball valve at all heating piping high points. Run discharge line to appropriate drainage point outside the building that will preclude freezing.

I. Repairs: Repair all existing features that are damaged during construction to the original condition as found prior to performance of the work.

J. Equipment and Materials: Unless specified otherwise, furnish materials of similar quality and finishes to existing materials.

2.2 HEATING AND DOMESTIC PIPING

A. Copper Tube: ASTM B 88 (ASTM B 88M), Type L (B), drawn

B. Fittings and Joints

1. Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 430 to 535 degrees F.
2. Mechanical press fit joint with gasket equivalent to ProPress acceptable.

C. Pressure Test: All heating and domestic water piping tested hydrostatically at 125 psi for minimum of four hours. System shall remain tight for test period without leaks, displacement, or straining. Equipment, gages, and thermometer wells rated for a lesser pressure suitably protected during tests. Leaks developed during tests shall be corrected without caulking and test restarted until a perfectly tight system is obtained. Enclosed piping tested before concealing. Test performed in presence of Owner.

D. Disinfection of Domestic Water Piping

1. Prior to starting work, verify system is complete, flushed and clean.
2. Ensure pH of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda ash) or acid (hydrochloric).
3. Inject disinfectant, free chlorine in liquid, powder, tablet or gas form, throughout system to obtain 50 to 80 mg/L residual.
4. Bleed water from outlets to ensure distribution and test for disinfectant residual at minimum 15percent of outlets.
5. Maintain disinfectant in system for 24 hours.
6. If final disinfectant residual tests less than 25 mg/L, repeat treatment.
7. Flush disinfectant from system until residual equal to that of incoming water or 1.0 mg/L.
8. Take samples no sooner than 24 hours after flushing, from 10 percent of outlets and from water entry, and analyze in accordance with AWWA C651.

2.3 HEATING TANK

A. Tank: Welded steel, ASME labeled for working pressure of 125 psig, steel support saddles, tappings for accessories, threaded connections of stainless steel, access manhole. Tank shall be insulated with 4-inch thick rigid preformed insulation and jacketed.

B. Lining: 0.024 inches self-priming polymer epoxy continued into flanged connections.

C. Openings: Manway

D. Piping Connections: See drawings for heating piping connections. Include a temperature and pressure relief valve and air vent at the top of the tank. And a temperature sensor well and thermometer well on the front center of tank.

E. Accessories: Tank drain, thermometer range of 40 to 200 degrees F, ASME pressure relief valve suitable for maximum working pressure.

2.4 HEAT EXCHANGER

A. Brazed plate heat exchanger rated for a minimum of 50 psig.

B. The corrugated plate design consisting of stainless steel plates vacuum brazed together to form a durable, integral piece.

C. Channel Plates: Stainless Steel ASTM 316L

D. Brazing Material: Copper

E. Connections: Stainless Steel ASTM 304L

2.5 VALVES

A. Ball Valves: MSS SP-110, Class 150, 400 psi CWP, bronze body, chrome plated brass ball, full port, teflon seats and stuffing box ring, blow-out proof stem, lever handle, Propress, solder, or threaded ends.

B. Drain Valves: with vacuum breaker, threaded hose coupling, and cap with chain

2.6 EXPANSION TANKS

A. Replaceable Bladder type: Welded steel, tested and stamped in accordance with ASME SEC 8-D; rated for working pressure of 150 psig, with replaceable bladder. Steel stand support. Seismic bracing.

2.7 PIPING SPECIALTIES

A. Unions

1. Copper tube and pipe: Class 150 bronze unions with soldered joints.

2. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

B. Flow Setters: Angle or straight pattern, rising stem, inside screw globe valve for 125 psi working pressure, with bronze body and integral union for screwed connections, renewable composition disc, plastic wheel handle for shut-off service, and lockshield key cap and set screw memory bonnet for balancing service.

1. Manufacturers: Bell & Gossett

C. Pipe Markers: Plastic tape indicating flow direction arrow and identification of fluid being conveyed. Label the piping mains on the hot side of each heat exchanger and in the district heating plant.

D. Pipe Hangers: Provide hangers and supports that comply with MSS SP-58. Conform to ASME B31.9. Install hanger outside of pipe insulation and provide galvanized insulation shields.

1. Hanger: Hot dip galvanized steel, adjustable, clevis.
2. Overhead Supports: Individual galvanized steel rod hangers attached to structure or to trapeze hangers.
3. Trapeze Hangers: Welded steel channel

E. Air Vents: Brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.

F. Thermometers: Dial type bimetallic actuated; ASTM E1; stainless steel case, adjustable angle with front recalibration, silicone fluid damping, white with black markings and black pointer, hermetically sealed lens, stainless steel stem. Fill the well with thermo-conductive copper anti-seize paste

1. Size: 5 inch diameter dial
2. Lens: Clear Lexan
3. Accuracy: 1 percent
4. Calibration: Degrees F

G. Insulation

1. Piping: Glass fiber pipe insulation with vapor barrier jacket.
    a. Existing Piping: Match existing pipe insulation thickness.
    b. New Piping and Appurtenances
        1) 1-1/4” and larger: 3” insulation
        2) 1” and smaller: 2” insulation

2. Equipment: Insulate heat exchangers and balancing valves with removable insulating blankets. Equipment blankets shall be custom made to fit the equipment, capable of constant exposure to 200°F, and constructed of:
    a. Outer fabric: A silicone impregnated fiberglass fabric conforming to Mil-C-20079 G, Mil-C-24244, and ASTM E84. Fabric shall have a weight of 15.5 oz/square yard.
    b. Insulation: 1” layer of glass fiber insulation mat (density of 9 lb/ft3 and K-value of 0.4 Btu/in/hr/sqft/_F) sewn to a 2” layer of fiberglass insulation blanket (density of 2 lb/ft3 and K-value of 0.5 Btu/in/hr/sqft/_F). The insulation shall be non-combustible, asbestos free, and durable under moisture exposure.
    c. Attachments: Stainless steel wire and sewn grommets sealed with mastic shall be used to secure the jacket to the equipment.

2.8 CONTROLS

A. Distribution Pumps: Provide a distribution pump lead/standby control system capable of the sequence of control shown on the drawings.

B. Building Heating System: Provide a modulating control for the building heating supply temperature. Provide a zone control panel for the heating and domestic hot water zones capable of the sequence of control shown on the drawings.

2.9 TRENCHING MATERIALS

A. All existing materials that are excavated from the trench and not reused in the new work shall become the contractors property and shall be removed from the site as it is excavated.

B. Pipe Bedding: Bedding, Class A, shall be crushed rock material aggregate, free of muck, frozen material, lumps, organic material, trash, lumber or other debris, conforming to the following gradation:

SIEVE SIZE	% PASSING BY WEIGHT
1-Inch	100
3/8	60-100
No. 4	40-85
No. 10	25-70
No. 40	5-40
No. 200	0-6

1. Execution: Hand rake the bottom of the excavation ahead of placing bedding material to remove all stones, lumps and other protuberances. Place bedding material the full width of trenches in lifts no greater than 8 inches in thickness and compact. Beds shall be hand graded smooth to achieve proper elevation and slope before placement of utilities and/or pipe. Hand dig below bell-and-spigot joints to ensure that the length of the pipe bears on the bedding material and not the joint.

2. Covering Pipe: After the pipe has been laid and approved for covering, the bedding material shall be placed evenly on both sides of the pipe for the full width of the trench. Ensure that initially placed material is tamped firmly under pipe haunches. Bring up evenly on each side and along the full length of the pipe structure. Ensure that no damage is done to the utility or its protective coating. Approval for covering does not imply final acceptance of the pipe.

3. Bedding Material: Shall be thoroughly compacted to not less than 95% of maximum density.

C. Backfill: Use a locally available pit/river run material categorized as one of the following in accordance with ASTM D2487: GW (well-graded gravel), GP (poorly graded gravel), SW (well-graded sand), or SP (poorly graded sand).

1. Shall comply with gradation as shown in the table below when tested per ASTM C136. Submit a Certificate of Compliance verifying conformance to these requirements with a gradation table or graph attached.

Sieve Designation	Percent Passing by Weight
3”	100
1”	90-100
#4	30-70
#200	0-15

2. Compaction: Under gravel or seeded areas, compact succeeding layers of final backfill to 90 percent of maximum density. Under sidewalks, compact succeeding layers to 95 percent of maximum density.

D. Aggregate Base Course: Provide a non-frost-susceptible crushed stone or crushed gravel product meeting the requirements of ADOT Standard Specifications for Highway Construction section 703-2.03, type D-1, with gradation as shown in the following table when tested per ASTM C136. Thoroughly compact to not less than 97% of maximum density.

Sieve Designation	Percent Passing by Weight
1”	100
¾”	70-100
3/8”	50-80
#4	35-65
#8	20-50
#40	8-30
#200	0-6

2.10 DIRECT BURY PIPING

A. Scope: The work includes the design and fabrication, furnishing, installing, and testing of a direct buried underground insulated heating and domestic hot water system consisting of piping as indicated, together with all fittings, anchors, expansion compensation and appurtenances necessary for a complete and operable system.

1. Heating Piping: Jacket with two carrier pipes vertically separated by 1-1/2” of insulation.

B. Design: The direct bury piping manufacturer shall be responsible for the complete design of the piping layout, the product to be supplied, fabrication, and certifying the contractor for installation and testing of the system within the design parameters established by the contract drawings and specifications, and in compliance with the detailed design. The complete design of the direct bury piping system shall be sealed by a Professional Engineer in the employ of the manufacturer.

C. Operating Characteristics – Heating Supply and Return: Operating temperature of 200°F and an operating pressure of 50 psig.

D. Rated Characteristics: All thermal expansion calculations shall be computed using a design expansion length of 125% of the calculated pipe expansion. For calculation purposes the installation temperature (the ambient temperature at the site) shall be no higher than 10°F.

E. Materials

1. Carrier Pipe: Type K Hard Drawn Copper Tubing conforming to ASTM B-88 in 20 foot lengths.
2. Insulation: Polyurethane foam with the following minimum characteristics: K Factor of 0.14, Density 2 pcf, Closed Cell Content 90-95% in conformance with MIL-I-24172 and ASTM C-591 completely filling the annular space between carrier pipes and jacketing.
3. Jacketing Material: High impact, seamless Polyvinylchloride (PVC) Class 12454-B compound conforming to ASTM 1784, Type 1, Grade 1. No FRP jacketing will be allowed.
4. Joining Method: Join lengths of pipe by solder connection.
5. Fittings: All fittings wrought copper in conformance with job specifications and will be insulated and jacketed materials supplied by the system supplier and as per manufacturers standard procedures.
6. End Seals: Each length of pre-insulated pipe will be fitted with a watertight mastic end seal at jacket and pipe surfaces. All field cuts will be sealed with a field applied end seal.
7. Building Penetrations: Core drill concrete foundation walls in locations approved by the Owner. Seal penetrations watertight will sealant filling the entire annual space.
8. Anchors and Expansion Compensation: All pipes shall be anchored and expansion compensated per system supplier's design and recommendations.
9. Approved Vendors: Copper Pipe System by Rovanco, Joliet, Illinois or approved equal.

2.11 ELECTRICAL

A. Conduits: EMT with flexible connections to equipment.

B. Conductors: Copper conductors with THHN/THWN or XHHW insulation.

2.12 TESTING, ADJUSTING AND BALANCING

A. Distribution System: Balance the heating water flow through each boiler and to each building heat exchanger with all heating systems in full heating mode.

B. Buildings: Balance the heating water flow to each heating zone and each hot water heater.

2.13 COMMISSIONING

A. Commissioning the complete system in accordance with the commissioning plan provided by the Owner's Commissioning Authority (CxA).

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
jim@alaskaenergy.us

Memorandum

December 12, 2015

to: **Craig Moore, THRHA**

subject: **Monitoring Plan**

project: **Angoon District Heating System**

Introduction

This document describes the proposed monitoring plan for the proposed Angoon District Heating System. The monitoring plan is based on the preliminary schematic of the system. Any changes made during design may require changes to this plan.

The purpose of the monitoring system is to provide remote monitoring of system operation, measure energy flow, and provide alarms if equipment is not operating when expected.

The plan offers the following levels of monitoring:

- Temperature and Status Monitoring: Monitor equipment status, system temperatures and pump status.
- Energy Use: Measures plant electricity consumption and plant heating output to the buildings.

Monitoring Plan

The proposed monitoring system will display the status of the boilers and pumps, the system temperatures, and measure energy use.

Temperature and Status Monitoring System

- Fixed Costs for travel, per diem, and equipment
- Outside Temperature: Provides a temperature reference for assessing system operation
- Boiler Enable: Displays the status of each boiler
- Pump Enable
    - Displays the status of each pump.
    - Annunciates an alarm if the pump is not enabled when the boiler is enabled.
    - Annunciates an alarm if one of the distribution pumps is not operating.
- Temperatures
    - Monitors boiler supply and return temperature to the heating tank.
    - Monitors the supply temperature from each boiler
    - Monitors distribution system supply and return temperature to the buildings.
    - Annunciates an alarm if the distribution temperature is outside of expected range.

Energy Monitoring

- Measures plant electricity use
- Measures plant heat output to buildings. This allows a determination of seasonal efficiency by comparing the heat output with purchased energy.

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
jim@alaskaenergy.us

December 21, 2015

THRHA Energy Assessments

Angoon District Heat System Monitoring Plan

Angoon District Heat System Monitoring Plan

Item	Intent	Operationa	Energy
Fixed Cost			
Travel, per diem, equipment	Fixed costs	$5,352	
BMON site migration and set up	Moving THRHA to their own server	$800	
Unit Costs			
General			
Outdoor temperature	Outdoor temperature reference	$30	
Plant electric load, kW	Total energy use		$1,940
Heating Plant Status			
Boiler B-1 enable	Boiler status	$505	
Boiler B-2 enable	Boiler status	$505	
Boiler B-3 enable	Boiler status	$505	
Boiler pump P-1 enable	Boiler pump status	$337	
Boiler pump P-2 enable	Boiler pump status	$337	
Boiler pump P-3 enable	Boiler pump status	$337	
Distribution pump P-4A status	Distribution pump status	$337	
Distribution pump P-4B status	Distribution pump status	$337	
Heating Plant Temperatures			
Boiler B-1 Supply	Confirms boiler operation	$256	
Boiler B-2 Supply	Confirms boiler operation	$256	
Boiler B-3 Supply	Confirms boiler operation	$256	
Boiler plant supply to heating tank	Confirms boiler heat flow to heating tank	$256	
Boiler plant return from heating tank	Confirms boiler heat flow to heating tank	$256	
Distribution heating supply temperature	Confirms heat to buildings	$256	
Distribution heating return temperature	Confirms heat to buildings	$256	
Heating Plant Energy Output			
Distribution flow to buildings	Heating flow rate - 3" pipe		$4,365
Totals		$11,173	$6,305

Attachment D

Preliminary Cost Estimates

Conceptual Cost Estimate - Central Plant, Site Work, and Distribution System

Central Plant, Fuel Storage, and Boiler Systems

Line Item	Value	Units	$/Unit	Cost
191,000 Btu/hr MES Pellet Boilers with vacuum kit, ash removal, trim, circulators, and controls, freight	2	ls	$ 25,000	$ 50,000
Shipping containers modified to provide mechanical room openings, finishings, and stacks, freight	2	ls	$ 8,500	$ 17,000
250 gallon thermal storage tank with 4" insulation, freight	1	ls	$ 4,500	$ 4,500
Weil-Mclain 680 boiler, burner, trim, freight	1	ls	$ 12,000	$ 12,000
Stainless double-wall insulated stacks for the three boilers with connections	1	ls	$ 6,375	$ 6,375
Expansion tank	1	ls	$ 3,000	$ 3,000
District pumps and VFDs	2	ls	$ 4,500	$ 9,000
Build-out of containerized central plant by mechanical contractor offsite (electric service entrance, panels, wiring, piping, valves, etc.)	1	ls	$ 20,000	$ 20,000
50-ton pellet silo with 4" drop tube/vent/connections, ladder/cover, view ports, access, erection, freight	1	ls	$ 28,000	$ 28,000
Monitoring package	1	ls	$ 17,478	$ 17,478
Drop boot for silo with slide gate	1	ls	$ 1,500	$ 1,500
New oil tanks and above ground piping	1	ls	$ 4,500	$ 4,500
Sub-Total				$ 173,353
Contractor Profit	*10%*			*$ 17,335*
Sub-Total				*$ 190,688*
Contingency	*10%*			*$ 19,069*
Sub-Total				*$ 209,757*
Professional Services	*15%*			*$ 31,464*
Total				**$ 241,221**

Central Plant Site Work

Line Item	Value	Units	$/Unit	Cost
Unsuitable overburden removal	325	cy	$ 25	$ 8,125
Shot rock or other suitable material for gravel pads, in place	590	cy	$ 85	$ 50,150
Base course (gravel), in place	25	cy	$ 115	$ 2,875
Electric, water, sewer connections	1	ls	$ 15,000	$ 15,000
Concrete mat foundations, in place	24	cy	$ 500	$ 12,000
Three-foot high retaining walls (2 courses (25 each) 6'x2'x2' ECOblocks, suitable backfill, and drainage)	150	lf	$ 200	$ 30,000
Sub-Total				$ 118,150
Contractor Profit	*10%*			*$ 11,815*
Sub-Total				*$ 129,965*
Contingency	*15%*			*$ 19,495*
Sub-Total				*$ 149,460*
Professional Services	*10%*			*$ 14,946*
Total				**$ 164,406**

Piping Distribution System

Line Item	Value	Units	$/Unit	Cost
Copper preinsulated piping material costs (1,100 lf trench)	1	ls	$ 69,051	$ 69,051
Sand bedding material cost	200	cy	$ 125	$ 25,000
Equipment and labor package with consumables (mob and demob time included)	30	days	$ 3,800	$ 114,000
Existing conditions repairs, equipment transport	1	ls	$ 20,000	$ 20,000
Sub-Total				$ 159,000
Contractor Profit	*10%*			*$ 15,900*
Sub-Total				*$ 174,900*
Contingency	*15%*			*$ 26,235*
Sub-Total				*$ 201,135*
Professional Services	*10%*			*$ 20,114*
Total				**$ 221,249**

Summary of District System Building Connection and Mechanical Room Demo/Replacement Costs and Avoided Costs for Future Boiler/Mechanical Room Replacement

Building	Unit	Design Load, mmBtu/hr	District Heating System Mechanical Room Costs			Avoided Cost - Direct Replacement of Existing
			District Side Costs (through HX)	Building Side Demo and Heating System Work	Total Cost	
1	A	79	$4,035	$13,567	$17,602	$24,282
	B	79	$3,340	$13,567	$16,907	$24,282
2	A	79	$3,340	$13,567	$16,907	$24,282
	B	79	$3,340	$13,567	$16,907	$24,282
3	A	157	$5,357	$16,559	$21,916	$31,587
	B					
4	A	157	$5,357	$16,559	$21,916	$31,587
	B					
5	A	287	$7,305	$19,481	$26,786	$45,085
	B					
	C					
	D					
6	A	287	$6,888	$22,264	$29,152	$47,868
	B					
	C					
	D					
7	A	212	$6,192	$20,803	$26,995	$45,015
	B					
	C					
8		121	$5,079	$16,559	$21,638	$29,361
9	A	212	$6,192	$20,803	$26,995	$45,015
	B					
	C					
		1,749	**$56,425**	**$187,296**	**$243,721**	**$372,644**

Conceptual Cost Estimate - Building 1a District System and Mechanical Room Demolition and Replacement

Line Item	Value	Units	$/Unit	Cost
80,000 Btu/hr brazed plate HX	1	ls	$ 300	$ 300
District side control valve - three-way	1	ls	$ 600	$ 600
Remaining district side connection (circuit setter, shutoffs, bypass, piping, etc.) and install of district side equipment	1	ls	$ 2,000	$ 2,000
Circulator pump	1	ls	$ 750	$ 750
70,000 Btu/hr indirect hot water heater	1	ls	$ 1,500	$ 1,500
Piping, domestic water connection, expansion, valves, controls, installation of all building-side equipment	1	ls	$ 5,000	$ 5,000
Demolition, disposal, and weatherization	1	ls	$ 2,500	$ 2,500
Sub-Total				$ 12,650
Contractor Profit	*10%*			*$ 1,265*
Sub-Total				*$ 13,915*
Contingency	*10%*			*$ 1,392*
Sub-Total				*$ 15,307*
Professional Services	*15%*			*$ 2,296*
Total				**$ 17,602**

Notes:
Professional services are meant to include design, project management, balancing, and commissioning. Work intended to be completed as a package bid together with modifications for all 9 buildings at once.

Conceptual Cost Estimate - Building 1b, 2a, 2b District System and Mechanical Room Demolition and Replacement

Line Item	Value	Units	$/Unit	Cost
80,000 Btu/hr brazed plate HX	1	ls	$ 300	$ 300
District side control valve - two-way	1	ls	$ 400	$ 400
Remaining district side connection (circuit setter, shutoffs, piping, etc.) and install of district side equipment	1	ls	$ 1,700	$ 1,700
Circulator pump	1	ls	$ 750	$ 750
70,000 Btu/hr indirect hot water heater	1	ls	$ 1,500	$ 1,500
Piping, domestic water connection, expansion, valves, controls, installation of all building-side equipment	1	ls	$ 5,000	$ 5,000
Demolition, disposal, and weatherization	1	ls	$ 2,500	$ 2,500
Sub-Total				$ 12,150
Contractor Profit	*10%*			*$ 1,215*
Sub-Total				*$ 13,365*
Contingency	*10%*			*$ 1,337*
Sub-Total				*$ 14,702*
Professional Services	*15%*			*$ 2,205*
Total				**$ 16,907**

Notes:
Professional services are meant to include design, project management, balancing, and commissioning. Work intended to be completed as a package bid together with modifications for all 9 buildings at once.

Conceptual Cost Estimate - Buildings 3&4 District System and Mechanical Room Demolition and Replacement

Line Item	Value	Units	$/Unit	Cost
160,000 Btu/hr brazed plate HX	1	ls	$ 1,500	$ 1,500
District side control valve - two-way	1	ls	$ 450	$ 450
Remaining district side connection (circuit setter, shutoffs, piping, etc.) and install of district side equipment	1	ls	$ 1,900	$ 1,900
Circulator pump	1	ls	$ 900	$ 900
120,000 Btu/hr indirect hot water heater	1	ls	$ 2,500	$ 2,500
Piping, domestic water connection, expansion, valves, controls, installation of all building-side equipment	1	ls	$ 5,500	$ 5,500
Demolition, disposal, and weatherization	1	ls	$ 3,000	$ 3,000
Sub-Total				$ 15,750
Contractor Profit	*10%*			*$ 1,575*
Sub-Total				*$ 17,325*
Contingency	*10%*			*$ 1,733*
Sub-Total				*$ 19,058*
Professional Services	*15%*			*$ 2,859*
Total				**$ 21,916**

Notes:
Professional services are meant to include design, project management, balancing, and commissioning. Work intended to be completed as a package bid together with modifications for all 9 buildings at once.

Conceptual Cost Estimate - Building 5 District System and Mechanical Room Demolition and Replacement

Line Item	Value	Units	$/Unit	Cost
300,000 Btu/hr brazed plate HX	1	ls	$ 2,250	$ 2,250
District side control valve - three-way	1	ls	$ 750	$ 750
Remaining district side connection (circuit setter, by-pass, shutoffs, piping, etc.) and install of district side equipment	1	ls	$ 2,250	$ 2,250
Circulator pump	1	ls	$ 1,000	$ 1,000
120,000 Btu/hr indirect hot water heater	2	ls	$ 2,500	$ 5,000
Piping, domestic water connection, expansion, valves, controls, installation of all building-side equipment	1	ls	$ 6,000	$ 6,000
Demolition, disposal, and weatherization	1	ls	$ 2,000	$ 2,000
Sub-Total				$ 19,250
Contractor Profit	*10%*			*$ 1,925*
Sub-Total				*$ 21,175*
Contingency	*10%*			*$ 2,118*
Sub-Total				*$ 23,293*
Professional Services	*15%*			*$ 3,494*
Total				**$ 26,786**

Notes:
Professional services are meant to include design, project management, balancing, and commissioning. Work intended to be completed as a package bid together with modifications for all 9 buildings at once.

Conceptual Cost Estimate - Building 6 District System and Mechanical Room Demolition and Replacement

Line Item	Value	Units	$/Unit	Cost
300,000 Btu/hr brazed plate HX	1	ls	$ 2,250	$ 2,250
District side control valve - two-way	1	ls	$ 600	$ 600
Remaining district side connection (circuit setter, shutoffs, piping, etc.) and install of district side equipment	1	ls	$ 2,100	$ 2,100
Circulator pump	1	ls	$ 1,000	$ 1,000
120,000 Btu/hr indirect hot water heater	2	ls	$ 2,500	$ 5,000
Piping, domestic water connection, expansion, valves, controls, installation of all building-side equipment	1	ls	$ 6,000	$ 6,000
Demolition, disposal, and weatherization	1	ls	$ 4,000	$ 4,000
Sub-Total				$ 20,950
Contractor Profit	*10%*			*$ 2,095*
Sub-Total				*$ 23,045*
Contingency	*10%*			*$ 2,305*
Sub-Total				*$ 25,350*
Professional Services	*15%*			*$ 3,802*
Total				**$ 29,152**

Notes:
Professional services are meant to include design, project management, balancing, and commissioning. Work intended to be completed as a package bid together with modifications for all 9 buildings at once.

Conceptual Cost Estimate - Buildings 7&9 District System and Mechanical Room Demolition and Replacement

Line Item	Value	Units	$/Unit	Cost
225,000 Btu/hr brazed plate HX	1	ls	$ 1,800	$ 1,800
District side control valve - three-way	1	ls	$ 550	$ 550
Remaining district side connection (circuit setter, by-pass, shutoffs, piping, etc.) and install of district side equipment	1	ls	$ 2,100	$ 2,100
Circulator pump	1	ls	$ 950	$ 950
120,000 Btu/hr indirect hot water heater	2	ls	$ 2,500	$ 5,000
Piping, domestic water connection, expansion, valves, controls, installation of all building-side equipment	1	ls	$ 5,500	$ 5,500
Demolition, disposal, and weatherization	1	ls	$ 3,500	$ 3,500
Sub-Total				$ 19,400
Contractor Profit	*10%*			*$ 1,940*
Sub-Total				*$ 21,340*
Contingency	*10%*			*$ 2,134*
Sub-Total				*$ 23,474*
Professional Services	*15%*			*$ 3,521*
Total				**$ 26,995**

Notes:
Professional services are meant to include design, project management, balancing, and commissioning. Work intended to be completed as a package bid together with modifications for all 9 buildings at once.

Conceptual Cost Estimate - Building 8 District System and Mechanical Room Demolition and Replacement

Line Item	Value	Units	$/Unit	Cost
125,000 Btu/hr brazed plate HX	1	ls	$ 1,250	$ 1,250
District side control valve - two-way	1	ls	$ 500	$ 500
Remaining district side connection (circuit setter, shutoffs, piping, etc.) and install of district side equipment	1	ls	$ 1,900	$ 1,900
Circulator pump	1	ls	$ 900	$ 900
120,000 Btu/hr indirect hot water heater	1	ls	$ 2,500	$ 2,500
Piping, domestic water connection, expansion, valves, controls, installation of all building-side equipment	1	ls	$ 5,500	$ 5,500
Demolition, disposal, and weatherization	1	ls	$ 3,000	$ 3,000
Sub-Total				$ 15,550
Contractor Profit	*10%*			*$ 1,555*
Sub-Total				*$ 17,105*
Contingency	*10%*			*$ 1,711*
Sub-Total				*$ 18,816*
Professional Services	*15%*			*$ 2,822*
Total				**$ 21,638**

Notes:
Professional services are meant to include design, project management, balancing, and commissioning. Work intended to be completed as a package bid together with modifications for all 9 buildings at once.

Conceptual Cost Estimate - Buildings 1a-b & 2a-b Mechanical Room Demolition and Replacement of Boilers In-kind

Line Item	Value	Units	$/Unit	Cost
86,000 Btu/hr fuel oil boiler, burner, trim	1	ls	$ 5,000	$ 5,000
Boiler stack and connections	12	ls	$ 125	$ 1,500
275 gallon oil tank and new connection	1	ls	$ 1,200	$ 1,200
Circulator pump	1	ls	$ 750	$ 750
70,000 Btu/hr indirect hot water heater	1	ls	$ 1,500	$ 1,500
Piping, domestic water connection, expansion, valves, controls, installation of all building-side equipment	1	ls	$ 5,000	$ 5,000
Demolition, disposal, and weatherization	1	ls	$ 2,500	$ 2,500
Sub-Total				$ 17,450
Contractor Profit	*10%*			*$ 1,745*
Sub-Total				*$ 19,195*
Contingency	*10%*			*$ 1,920*
Sub-Total				*$ 21,115*
Professional Services	*15%*			*$ 3,167*
Total				**$ 24,282**

Notes:
Professional services are meant to include design, project management, balancing, and commissioning. Work intended to be completed as a package bid together with modifications for all 9 buildings at once.

Conceptual Cost Estimate - Buildings 3 & 4 Mechanical Room Demolition and Replacement of Boilers In-kind

Line Item	Value	Units	$/Unit	Cost
175,000 Btu/hr fuel oil boiler, burner, trim	1	ls	$ 7,500	$ 7,500
Boiler stack and connections	12	ls	$ 125	$ 1,500
Two 275 gallon oil tanks and new connection	1	ls	$ 1,800	$ 1,800
Circulator pump	1	ls	$ 900	$ 900
120,000 Btu/hr indirect hot water heater	1	ls	$ 2,500	$ 2,500
Piping, domestic water connection, expansion, valves, controls, installation of all building-side equipment	1	ls	$ 5,500	$ 5,500
Demolition, disposal, and weatherization	1	ls	$ 3,000	$ 3,000
Sub-Total				$ 22,700
Contractor Profit	*10%*			*$ 2,270*
Sub-Total				*$ 24,970*
Contingency	*10%*			*$ 2,497*
Sub-Total				*$ 27,467*
Professional Services	*15%*			*$ 4,120*
Total				**$ 31,587**

Notes:
Professional services are meant to include design, project management, balancing, and commissioning. Work intended to be completed as a package bid together with modifications for all 9 buildings at once.

Conceptual Cost Estimate - Building 5 Mechanical Room Demolition and Replacement of Boilers In-kind

Line Item	Value	Units	$/Unit	Cost
125,000 Btu/hr fuel oil boiler, burner, trim	2	ls	$ 6,500	$ 13,000
Boiler stack and connections	24	ls	$ 125	$ 3,000
275 gallon oil tank and new connection	2	ls	$ 1,200	$ 2,400
Circulator pump	1	ls	$ 1,000	$ 1,000
120,000 Btu/hr indirect hot water heater	2	ls	$ 2,500	$ 5,000
Piping, domestic water connection, expansion, valves, controls, installation of all building-side equipment	1	ls	$ 6,000	$ 6,000
Demolition, disposal, and weatherization	1	ls	$ 2,000	$ 2,000
Sub-Total				$ 32,400
Contractor Profit	*10%*			*$ 3,240*
Sub-Total				*$ 35,640*
Contingency	*10%*			*$ 3,564*
Sub-Total				*$ 39,204*
Professional Services	*15%*			*$ 5,881*
Total				**$ 45,085**

Notes:
Professional services are meant to include design, project management, balancing, and commissioning. Work intended to be completed as a package bid together with modifications for all 9 buildings at once.

Conceptual Cost Estimate - Building 6 Mechanical Room Demolition and Replacement of Boilers In-kind

Line Item	Value	Units	$/Unit	Cost
125,000 Btu/hr fuel oil boiler, burner, trim	2	ls	$ 6,500	$ 13,000
Boiler stack and connections	24	ls	$ 125	$ 3,000
275 gallon oil tank and new connection	2	ls	$ 1,200	$ 2,400
Circulator pump	1	ls	$ 1,000	$ 1,000
120,000 Btu/hr indirect hot water heater	2	ls	$ 2,500	$ 5,000
Piping, domestic water connection, expansion, valves, controls, installation of all building-side equipment	1	ls	$ 6,000	$ 6,000
Demolition, disposal, and weatherization	1	ls	$ 4,000	$ 4,000
Sub-Total				$ 34,400
Contractor Profit	*10%*			*$ 3,440*
Sub-Total				*$ 37,840*
Contingency	*10%*			*$ 3,784*
Sub-Total				*$ 41,624*
Professional Services	*15%*			*$ 6,244*
Total				**$ 47,868**

Notes:
Professional services are meant to include design, project management, balancing, and commissioning. Work intended to be completed as a package bid together with modifications for all 9 buildings at once.

Conceptual Cost Estimate - Buildings 7&9 Mechanical Room Demolition and Replacement of Boilers In-kind

Line Item	Value	Units	$/Unit	Cost
105,000 Btu/hr fuel oil boiler, burner, trim	2	ls	$ 6,000	$ 12,000
Boiler stack and connections	24	ls	$ 125	$ 3,000
275 gallon oil tank and new connection	2	ls	$ 1,200	$ 2,400
Circulator pump	1	ls	$ 950	$ 950
120,000 Btu/hr indirect hot water heater	2	ls	$ 2,500	$ 5,000
Piping, domestic water connection, expansion, valves, controls, installation of all building-side equipment	1	ls	$ 5,500	$ 5,500
Demolition, disposal, and weatherization	1	ls	$ 3,500	$ 3,500
Sub-Total				$ 32,350
Contractor Profit	*10%*			*$ 3,235*
Sub-Total				*$ 35,585*
Contingency	*10%*			*$ 3,559*
Sub-Total				*$ 39,144*
Professional Services	*15%*			*$ 5,872*
Total				**$ 45,015**

Notes:
Professional services are meant to include design, project management, balancing, and commissioning. Work intended to be completed as a package bid together with modifications for all 9 buildings at once.

Conceptual Cost Estimate - Building 8 District System and Mechanical Room Demolition and Replacement

Line Item	Value	Units	$/Unit	Cost
125,000 Btu/hr fuel oil boiler, burner, trim	1	ls	$ 6,500	$ 6,500
Boiler stack and connections	12	ls	$ 125	$ 1,500
275 gallon oil tank and new connection	1	ls	$ 1,200	$ 1,200
Circulator pump	1	ls	$ 900	$ 900
120,000 Btu/hr indirect hot water heater	1	ls	$ 2,500	$ 2,500
Piping, domestic water connection, expansion, valves, controls, installation of all building-side equipment	1	ls	$ 5,500	$ 5,500
Demolition, disposal, and weatherization	1	ls	$ 3,000	$ 3,000
Sub-Total				$ 21,100
Contractor Profit	*10%*			*$ 2,110*
Sub-Total				*$ 23,210*
Contingency	*10%*			*$ 2,321*
Sub-Total				*$ 25,531*
Professional Services	*15%*			*$ 3,830*
Total				**$ 29,361**

Notes:
Professional services are meant to include design, project management, balancing, and commissioning. Work intended to be completed as a package bid together with modifications for all 9 buildings at once.

Attachment E

Life-Cycle Cash Flow Analysis

Life-Cycle Cost Analysis
Cash Flow

Input Variables	Value	Units
Project Cost	870,596	$
Grants Received	(240,592)	$
Project Investment	630,004	$
Current #2 Fuel Oil Usage	12,134	gal
Year 1 #2 Fuel Oil Average Price	$4.65	$/gal
Wood Pellet Usage	97	tons/yr
Year 1 Wood Chip Purchase Price	$465	$/ton
Annual #1 Fuel Oil Usage w/ Wood System	1,213	gal/yr
Current Electric Usage for Boilers	2,497	kWh/yr
Electric Unit Price (under 500 kWh/mo)	$0.628	$/kWh
Projected Electric Usage w/ District System	8,270	kWh/yr
Electric Unit Price (over 500 kWh/mo)	$0.568	$/kWh
Portion of Projected Electric over 1st 500 kWh/mo	30%	Percent
Fossil Fuel / Electric Inflation Rate (apr)	3.3%	Percent
Wood Pellet Inflation Rate (apr)	2.7%	Percent
General Inflation Rate (apr)	2.7%	Percent
Discount Rate	3.0%	Percent
O&M Cost Savings with Central Plant	$ 4,013	$/yr

Year	Fossil Fuel Cost, Current System	Wood Pellet Cost	Fossil Fuel Cost, w/ Wood System	Increased Electric Cost	O&M Cost Reduction Compared to Distributed Boilers	Net Operating Savings / Cash Flow	Present Value of Avoided Costs or District System Equipment Replacement*	Present Value of Cash Flow
0								$ (630,004)
1	$ 56,423	$ (45,200)	$ (5,642)	$ (3,477)	$ 4,013	$ 6,117		$ 5,939
2	$ 58,285	$ (46,421)	$ (5,829)	$ (3,591)	$ 4,121	$ 6,566		$ 6,189
3	$ 60,208	$ (47,674)	$ (6,021)	$ (3,710)	$ 4,233	$ 7,037	$ 372,644	$ 379,083
4	$ 62,195	$ (48,961)	$ (6,220)	$ (3,832)	$ 4,347	$ 7,529		$ 6,690
5	$ 64,248	$ (50,283)	$ (6,425)	$ (3,959)	$ 4,464	$ 8,046		$ 6,940
6	$ 66,368	$ (51,641)	$ (6,637)	$ (4,089)	$ 4,585	$ 8,586		$ 7,191
7	$ 68,558	$ (53,035)	$ (6,856)	$ (4,224)	$ 4,709	$ 9,152		$ 7,441
8	$ 70,821	$ (54,467)	$ (7,082)	$ (4,364)	$ 4,836	$ 9,744		$ 7,692
9	$ 73,158	$ (55,938)	$ (7,316)	$ (4,508)	$ 4,966	$ 10,363		$ 7,942
10	$ 75,572	$ (57,448)	$ (7,557)	$ (4,656)	$ 5,100	$ 11,011	$ (1,500)	$ 6,693
11	$ 78,066	$ (58,999)	$ (7,807)	$ (4,810)	$ 5,238	$ 11,688		$ 8,444
12	$ 80,642	$ (60,592)	$ (8,064)	$ (4,969)	$ 5,380	$ 12,396		$ 8,695
13	$ 83,303	$ (62,228)	$ (8,330)	$ (5,133)	$ 5,525	$ 13,137		$ 8,946
14	$ 86,052	$ (63,908)	$ (8,605)	$ (5,302)	$ 5,674	$ 13,911		$ 9,197
15	$ 88,892	$ (65,634)	$ (8,889)	$ (5,477)	$ 5,827	$ 14,719		$ 9,448
16	$ 91,825	$ (67,406)	$ (9,183)	$ (5,658)	$ 5,984	$ 15,564		$ 9,699
17	$ 94,855	$ (69,226)	$ (9,486)	$ (5,845)	$ 6,146	$ 16,446		$ 9,950
18	$ 97,986	$ (71,095)	$ (9,799)	$ (6,038)	$ 6,312	$ 17,367		$ 10,201
19	$ 101,219	$ (73,014)	$ (10,122)	$ (6,237)	$ 6,482	$ 18,329		$ 10,453
20	$ 104,559	$ (74,986)	$ (10,456)	$ (6,443)	$ 6,657	$ 19,333	$ (69,575)	$ (58,871)
21	$ 108,010	$ (77,010)	$ (10,801)	$ (6,655)	$ 6,837	$ 20,381		$ 10,956
22	$ 111,574	$ (79,090)	$ (11,157)	$ (6,875)	$ 7,022	$ 21,474		$ 11,207
23	$ 115,256	$ (81,225)	$ (11,526)	$ (7,102)	$ 7,211	$ 22,615		$ 11,459
24	$ 119,060	$ (83,418)	$ (11,906)	$ (7,336)	$ 7,406	$ 23,806		$ 11,711
25	$ 122,989	$ (85,670)	$ (12,299)	$ (7,578)	$ 7,606	$ 25,047		$ 11,963
26	$ 127,047	$ (87,983)	$ (12,705)	$ (7,828)	$ 7,811	$ 26,342		$ 12,215
27	$ 131,240	$ (90,359)	$ (13,124)	$ (8,087)	$ 8,022	$ 27,693		$ 12,467
28	$ 135,571	$ (92,799)	$ (13,557)	$ (8,353)	$ 8,239	$ 29,101		$ 12,719
29	$ 140,044	$ (95,304)	$ (14,004)	$ (8,629)	$ 8,461	$ 30,568		$ 12,971
30	$ 144,666	$ (97,877)	$ (14,467)	$ (8,914)	$ 8,690	$ 32,098	$ (1,500)	$ 11,724
31	$ 149,440	$ (100,520)	$ (14,944)	$ (9,208)	$ 8,924	$ 33,692		$ 13,477
32	$ 154,371	$ (103,234)	$ (15,437)	$ (9,512)	$ 9,165	$ 35,354		$ 13,729
33	$ 159,466	$ (106,021)	$ (15,947)	$ (9,826)	$ 9,413	$ 37,085		$ 13,982
34	$ 164,728	$ (108,884)	$ (16,473)	$ (10,150)	$ 9,667	$ 38,888		$ 14,235
35	$ 170,164	$ (111,824)	$ (17,016)	$ (10,485)	$ 9,928	$ 40,767		$ 14,488
							Net Present Value	**$ 27,257**

*** Description of Avoided Costs or District System Equipment Replacement**

Year	Replacement of...
5	Boiler room equipment (boilers, circulation pumps, indirect DHW heaters, expansion tanks, piping, valves, fuel oil tanks, etc.) for each building - Avoided cost due to installation of all new mechanical room equipment with district system installation.
10 and 30	Pellet handing equipment replacement.
20	Wood pellet boilers - assumed cost with district system for replacing pellet boilers after 20 years

ANGOON – DISTRICT HEATING SYSTEM TECHNICAL REQUIREMENTS

THRHA Regional Housing Authority
Juneau, Alaska

TECHNCIAL REQUIREMENTS

THRHA Angoon District Heating System

PART 1 - PERFORMANCE REQUIREMENTS

1.1 CONSTRUCTION ACTIVITIES ON-SITE

A. Daily Work Schedule: Work on the site is allowed daily from 8:00 am to 7:00 pm.

B. Work and Outage Plan: Submit a Work and Outage Plan that describes the work sequence and defines heating and domestic hot water outages.

1. Sequence of Work: Perform the work in accordance with the following sequence:

a. Construct the district heating plant and the distribution system including branches to each heat exchanger with isolation valves.

b. Startup the heating system and make fully operational to heat the buildings.

c. Connect each building to the system.

2. Buildings 1 and 2 (Duplexes):

a. Scope: Replace two separate heating and domestic hot water systems with two separate heating and domestic hot water systems connected to the district heat system.

1) Temporary Heat: Connect building to district heat system with a temporary heat exchanger or use a temporary boiler.

2) Temporary Domestic Hot Water: Connect a temporary hot water heater to the apartment piping and heat it from the temporary heating system.

3) Remove the existing heating and domestic hot water system prior to installing the new system.

b. Allowed Outages:

1) Heating: Two outages, each a maximum of 4 hours.

2) Domestic Hot Water: Two outages, each a maximum 8 hours

3. Buildings 3 and 4 (Duplexes):

a. Scope: Replace two separate heating and domestic hot water systems with two separate heating and domestic hot water systems connected to the district heat system.

1) Temporary Heat: Connect building to district heat system with a temporary heat exchanger or use a temporary boiler.

2) Domestic Hot Water: Connect a temporary hot water heater to the apartment piping and heat it from the temporary heating system.

3) Remove the existing heating and domestic hot water system prior to installing the new system.

b. Allowed Outages:

1) Heating: Two outages, each a maximum of four hours.

2) Domestic Hot Water: Two outages, each a maximum four hours

4. Building 5 (4-plex):
    a. Scope: Replace the heating and domestic hot water system serving all four apartments with a new heating and domestic hot water system connected to all four apartments.
        1) Install the new heating system in the mechanical room.
        2) Connect it to the building heating and domestic hot water distribution systems.
        3) Remove the existing heating system.
    b. Allowed Outages:
        1) Heating: One outage of a maximum 4 hours.
        2) Domestic Hot Water: One outage of a maximum 8 hours.
5. Building 6 (4-plex)
    a. Scope: Replace four separate heating and domestic hot water systems located in the mechanical room with one heating system supplying all four apartments.
        1) Temporarily combine the four heating and domestic hot water systems into two systems, each system serving two apartments. Remove the two heating and domestic hot water systems that were disconnected.
        2) Install the new heating and domestic hot water system.
        3) Connect the new heating and domestic hot water system to all four apartments.
    b. Allowed Outages:
        1) Heating: Two outages of a maximum 4 hours each.
        2) Domestic Hot Water: Two outages of a maximum 8 hours each.
6. Buildings 7 and 9 (Triplex)
    a. Scope: Replace three separate heating and domestic hot water systems located in the mechanical room with one heating system supplying all three apartments.
        1) Temporarily combine the one of the heating and domestic hot water systems with another system. Remove the heating and domestic hot water system that was disconnected.
        2) Install the new heating and domestic hot water system.
        3) Connect the new heating and domestic hot water system to all three apartments.
    b. Allowed Outages:
        1) Heating: Two outages of a maximum 4 hours each.
        2) Domestic Hot Water: Two outages of a maximum 8 hours each.
7. Building 8 (Senior Center):
    a. Scope: Replace the heating and domestic hot water system with a new heating and domestic hot water systems connected to the district heat system.
        1) Temporary Heat: Connect building to district heat system with a temporary heat exchanger or use a temporary boiler.

2) Temporary Domestic Hot Water: Connect a temporary hot water heater to the apartment piping and heat it from the temporary heating system.

3) Remove the existing heating and domestic hot water system prior to installing the new system.

b. Allowed Outages:

1) Heating: Two outages of a maximum 4 hours each.

2) Domestic Hot Water: Two outages, each a maximum 8 hours

1.2 SUBMITTAL REQUIREMENTS

A. Design Documents: Provide the following submittals in PDF format.

1. 50% Submittal

a. Manufacturers data for all equipment

b. Floor plans showing equipment layouts

c. Direct bury piping data, layout drawings, details, and calculations.

d. Control documentation

2. 100% Submittal: Completed design documents including incorporation of 50% comments.

3. Final Submittal: Signed design documents including incorporation of review comments.

B. Manufacturer's Data: Provide manufacturer's data for the following:

1. Pellet boiler and controls
2. Fuel oil boiler and controls
3. Heating tank
4. Heating and domestic hot water piping
5. Pumps
6. Heat exchangers
7. Domestic hot water tanks
8. Thermostatic mixing valve
9. Flow setters
10. Air vents
11. Thermometers
12. Insulation including thickness schedule for existing and new piping
13. Distribution pump controls
14. Building controls

C. Direct Bury Piping

1. Manufacturer's Catalog Data: All components of the piping system including Carrier Pipe; Carrier Pipe Insulation; Pipe Supports; Casing; Joint Kit; Shrink Wrap Sleeve.
2. Drawings: Complete drawings of the direct bury piping design and assembly of the system, materials of construction, and field installation instructions. Submittal shall include sufficient system details required to show that the specified minimum insulation thickness has been met. A detailed design layout of the system (plan and elevation views) showing size, type, elevations and location of each component to be used in the system, the design and location of anchors, pipe guides, pipe supports, expansion loops, Z-bends, L-bends, end seals, leak plates, joint locations, pipe and insulation thickness and sizes, types, and movements, connection to manhole and building wall penetrations, and including, if applicable, transition point design to aboveground or other type systems.
3. The piping layout design shall be prepared and approved by a registered Professional Engineer and certified by his/her stamp.
4. Data: Pipe stress and system expansion calculations: Submit pipe stress and system expansion calculations for each expansion compensation elbow using a finite element computer generated three-dimensional analysis. Calculations (including heat loss calculations) shall demonstrate that pipe stresses from temperature changes are within the allowable requirements in ASME B31.1 and the anchors and the guides will withstand the resultant forces. Layout shall also include all analysis node points. As a minimum, the computer analysis results include node stresses, forces, moments and displacements. Calculations shall be approved, certified, stamped and signed by a registered Professional Engineer in the employ of the manufacturer.
5. Certificates
    a. Manufacturer Certification: Certification that the manufacturer regularly and currently manufactures direct-buried systems, and that the designs of the system and equipment to be provided for this project conform to specification requirements. This certification shall be an original signed by a principal officer.
    b. Contractor Certification: The Manufacturer shall certify each contractor employee that is properly trained to install and test the system. Only certified personnel shall be allowed to install and test the system.
    c. Design: A Certificate of Satisfactory Operation certifying that at least 3 systems installed by the manufacturer within the previous 10 years have and are operating satisfactorily for not less than 5 years. The certificate shall indicate the location, type of system, size of system, point of contact (POC) including phone number, for information verification. This certificate of satisfactory operation shall be an original signed by a principal officer of the manufacturer.
    d. Certificate of Compliance: Upon completion of the work, and before final acceptance, a notarized statement signed by a principal officer of contractor, certifying that the system has been installed satisfactorily and in accordance with the contract drawings, specifications, UHDS manufacturer's detailed design layout drawings and with the UHDS manufacturer's recommendations.
    e. Hot-dip Galvanizing: Provide a statement certifying that the hot-dip galvanizing plant is capable of zinc coating steel components of the system in accordance with the specification requirements.

f. Certification of Contractor's Non-destruction Examination (NDE) personnel

D. As-built Drawings

1. Submit a complete set of as-built construction drawings in PDF and AutoCAD format.
2. Submit all design calculations.

E. O&M Manual

1. Submittals:
   a. Submit a draft O&M manual in PDF format for approval.
   b. Submit a final O&M manual in one 3-ring binder and one electronic copy.
2. Include approved submittal data, installation, operation, and maintenance instructions, parts list and service information for the following:
   a. Pellet boiler and controls
   b. Fuel oil boiler and controls
   c. Pumps
   d. Heating tank
   e. Heat exchangers
   f. Hot water heaters
   g. Thermostatic mixing valves
3. Include the approved direct bury piping submittal
4. Include control documentation for the distribution pumps and building controls.

PART 2 - REQUIREMENTS

2.1 GENERAL

A. See the Preliminary Drawings for additional information on project scope and equipment specifications.

B. Codes: Perform all work in accordance with applicable codes and industry standards.

1. Design Requirements
2. Minimize Electrical Energy: Minimize electrical energy use by the district heating system by minimizing equipment and piping pressure drop. Provide highly efficient ECM motors or NEMA Premium motors.
3. Substitutions: Equipment make and model substitutions shall be approved prior to submitting a bid.

C. Demolition: All items identified for removal become the property of the contractor, unless noted to be retained by the Owner, and shall be promptly removed from the Owner's property at the contractors expense.

D. Equipment and Piping Supports: Provide supports and seismic restraints for all equipment and piping.

E. Electrical: All equipment must be compatible with 120 volt or 240v single-phase service.

F. Insulation:

1. Where repairing insulation that is removed or damaged while performing the work, provide and install pipe and equipment insulation to match the original installation.
2. Insulate all new piping systems and equipment including:
    a. Insulation Blankets: Heat exchangers and flow setters
    b. Fiberglass Insulation: Heating and domestic piping, heating tank, valves, and all appurtenances except unions and pumps.

G. Expansion Compensation: Install all piping with appropriate expansion compensation.

H. Air Vents: Install 1/2" air vents with isolation ball valve at all heating piping high points. Run discharge line to appropriate drainage point outside the building that will preclude freezing.

I. Repairs: Repair all existing features that are damaged during construction to the original condition as found prior to performance of the work.

J. Equipment and Materials: Unless specified otherwise, furnish materials of similar quality and finishes to existing materials.

2.2 HEATING AND DOMESTIC PIPING

A. Copper Tube: ASTM B 88 (ASTM B 88M), Type L (B), drawn

B. Fittings and Joints

1. Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 430 to 535 degrees F.
2. Mechanical press fit joint with gasket equivalent to ProPress acceptable.

C. Pressure Test: All heating and domestic water piping tested hydrostatically at 125 psi for minimum of four hours. System shall remain tight for test period without leaks, displacement, or straining. Equipment, gages, and thermometer wells rated for a lesser pressure suitably protected during tests. Leaks developed during tests shall be corrected without caulking and test restarted until a perfectly tight system is obtained. Enclosed piping tested before concealing. Test performed in presence of Owner.

D. Disinfection of Domestic Water Piping

1. Prior to starting work, verify system is complete, flushed and clean.
2. Ensure pH of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda ash) or acid (hydrochloric).
3. Inject disinfectant, free chlorine in liquid, powder, tablet or gas form, throughout system to obtain 50 to 80 mg/L residual.
4. Bleed water from outlets to ensure distribution and test for disinfectant residual at minimum 15percent of outlets.
5. Maintain disinfectant in system for 24 hours.
6. If final disinfectant residual tests less than 25 mg/L, repeat treatment.
7. Flush disinfectant from system until residual equal to that of incoming water or 1.0 mg/L.
8. Take samples no sooner than 24 hours after flushing, from 10 percent of outlets and from water entry, and analyze in accordance with AWWA C651.

2.3 HEATING TANK

A. Tank: Welded steel, ASME labeled for working pressure of 125 psig, steel support saddles, tappings for accessories, threaded connections of stainless steel, access manhole. Tank shall be insulated with 4-inch thick rigid preformed insulation and jacketed.

B. Lining: 0.024 inches self-priming polymer epoxy continued into flanged connections.

C. Openings: Manway

D. Piping Connections: See drawings for heating piping connections. Include a temperature and pressure relief valve and air vent at the top of the tank. And a temperature sensor well and thermometer well on the front center of tank.

E. Accessories: Tank drain, thermometer range of 40 to 200 degrees F, ASME pressure relief valve suitable for maximum working pressure.

2.4 HEAT EXCHANGER

A. Brazed plate heat exchanger rated for a minimum of 50 psig.

B. The corrugated plate design consisting of stainless steel plates vacuum brazed together to form a durable, integral piece.

C. Channel Plates: Stainless Steel ASTM 316L

D. Brazing Material: Copper

E. Connections: Stainless Steel ASTM 304L

2.5 VALVES

A. Ball Valves: MSS SP-110, Class 150, 400 psi CWP, bronze body, chrome plated brass ball, full port, teflon seats and stuffing box ring, blow-out proof stem, lever handle, Propress, solder, or threaded ends.

B. Drain Valves: with vacuum breaker, threaded hose coupling, and cap with chain

2.6 EXPANSION TANKS

A. Replaceable Bladder type: Welded steel, tested and stamped in accordance with ASME SEC 8-D; rated for working pressure of 150 psig, with replaceable bladder. Steel stand support. Seismic bracing.

2.7 PIPING SPECIALTIES

A. Unions

1. Copper tube and pipe: Class 150 bronze unions with soldered joints.

2. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

B. Flow Setters: Angle or straight pattern, rising stem, inside screw globe valve for 125 psi working pressure, with bronze body and integral union for screwed connections, renewable composition disc, plastic wheel handle for shut-off service, and lockshield key cap and set screw memory bonnet for balancing service.

1. Manufacturers: Bell & Gossett

C. Pipe Markers: Plastic tape indicating flow direction arrow and identification of fluid being conveyed. Label the piping mains on the hot side of each heat exchanger and in the district heating plant.

D. Pipe Hangers: Provide hangers and supports that comply with MSS SP-58. Conform to ASME B31.9. Install hanger outside of pipe insulation and provide galvanized insulation shields.

1. Hanger: Hot dip galvanized steel, adjustable, clevis.
2. Overhead Supports: Individual galvanized steel rod hangers attached to structure or to trapeze hangers.
3. Trapeze Hangers: Welded steel channel

E. Air Vents: Brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.

F. Thermometers: Dial type bimetallic actuated; ASTM E1; stainless steel case, adjustable angle with front recalibration, silicone fluid damping, white with black markings and black pointer, hermetically sealed lens, stainless steel stem. Fill the well with thermo-conductive copper anti-seize paste

1. Size: 5 inch diameter dial
2. Lens: Clear Lexan
3. Accuracy: 1 percent
4. Calibration: Degrees F

G. Insulation

1. Piping: Glass fiber pipe insulation with vapor barrier jacket.
    a. Existing Piping: Match existing pipe insulation thickness.
    b. New Piping and Appurtenances
        1) 1-1/4” and larger: 3” insulation
        2) 1” and smaller: 2” insulation

2. Equipment: Insulate heat exchangers and balancing valves with removable insulating blankets. Equipment blankets shall be custom made to fit the equipment, capable of constant exposure to 200°F, and constructed of:
    a. Outer fabric: A silicone impregnated fiberglass fabric conforming to Mil-C-20079 G, Mil-C-24244, and ASTM E84. Fabric shall have a weight of 15.5 oz/square yard.
    b. Insulation: 1” layer of glass fiber insulation mat (density of 9 lb/ft3 and K-value of 0.4 Btu/in/hr/sqft/_F) sewn to a 2” layer of fiberglass insulation blanket (density of 2 lb/ft3 and K-value of 0.5 Btu/in/hr/sqft/_F). The insulation shall be non-combustible, asbestos free, and durable under moisture exposure.
    c. Attachments: Stainless steel wire and sewn grommets sealed with mastic shall be used to secure the jacket to the equipment.

2.8 CONTROLS

A. Distribution Pumps: Provide a distribution pump lead/standby control system capable of the sequence of control shown on the drawings.

B. Building Heating System: Provide a modulating control for the building heating supply temperature. Provide a zone control panel for the heating and domestic hot water zones capable of the sequence of control shown on the drawings.

2.9 TRENCHING MATERIALS

A. All existing materials that are excavated from the trench and not reused in the new work shall become the contractors property and shall be removed from the site as it is excavated.

B. Pipe Bedding: Bedding, Class A, shall be crushed rock material aggregate, free of muck, frozen material, lumps, organic material, trash, lumber or other debris, conforming to the following gradation:

SIEVE SIZE	% PASSING BY WEIGHT
1-Inch	100
3/8	60-100
No. 4	40-85
No. 10	25-70
No. 40	5-40
No. 200	0-6

1. Execution: Hand rake the bottom of the excavation ahead of placing bedding material to remove all stones, lumps and other protuberances. Place bedding material the full width of trenches in lifts no greater than 8 inches in thickness and compact. Beds shall be hand graded smooth to achieve proper elevation and slope before placement of utilities and/or pipe. Hand dig below bell-and-spigot joints to ensure that the length of the pipe bears on the bedding material and not the joint.

2. Covering Pipe: After the pipe has been laid and approved for covering, the bedding material shall be placed evenly on both sides of the pipe for the full width of the trench. Ensure that initially placed material is tamped firmly under pipe haunches. Bring up evenly on each side and along the full length of the pipe structure. Ensure that no damage is done to the utility or its protective coating. Approval for covering does not imply final acceptance of the pipe.

3. Bedding Material: Shall be thoroughly compacted to not less than 95% of maximum density.

C. Backfill: Use a locally available pit/river run material categorized as one of the following in accordance with ASTM D2487: GW (well-graded gravel), GP (poorly graded gravel), SW (well-graded sand), or SP (poorly graded sand).

1. Shall comply with gradation as shown in the table below when tested per ASTM C136. Submit a Certificate of Compliance verifying conformance to these requirements with a gradation table or graph attached.

Sieve Designation	Percent Passing by Weight
3”	100
1”	90-100
#4	30-70
#200	0-15

2. Compaction: Under gravel or seeded areas, compact succeeding layers of final backfill to 90 percent of maximum density. Under sidewalks, compact succeeding layers to 95 percent of maximum density.

D. Aggregate Base Course: Provide a non-frost-susceptible crushed stone or crushed gravel product meeting the requirements of ADOT Standard Specifications for Highway Construction section 703-2.03, type D-1, with gradation as shown in the following table when tested per ASTM C136. Thoroughly compact to not less than 97% of maximum density.

Sieve Designation	Percent Passing by Weight
1”	100
¾”	70-100
3/8”	50-80
#4	35-65
#8	20-50
#40	8-30
#200	0-6

2.10 DIRECT BURY PIPING

A. Scope: The work includes the design and fabrication, furnishing, installing, and testing of a direct buried underground insulated heating and domestic hot water system consisting of piping as indicated, together with all fittings, anchors, expansion compensation and appurtenances necessary for a complete and operable system.

1. Heating Piping: Jacket with two carrier pipes vertically separated by 1-1/2” of insulation.

B. Design: The direct bury piping manufacturer shall be responsible for the complete design of the piping layout, the product to be supplied, fabrication, and certifying the contractor for installation and testing of the system within the design parameters established by the contract drawings and specifications, and in compliance with the detailed design. The complete design of the direct bury piping system shall be sealed by a Professional Engineer in the employ of the manufacturer.

C. Operating Characteristics – Heating Supply and Return: Operating temperature of 200°F and an operating pressure of 50 psig.

D. Rated Characteristics: All thermal expansion calculations shall be computed using a design expansion length of 125% of the calculated pipe expansion. For calculation purposes the installation temperature (the ambient temperature at the site) shall be no higher than 10°F.

E. Materials

1. Carrier Pipe: Type K Hard Drawn Copper Tubing conforming to ASTM B-88 in 20 foot lengths.
2. Insulation: Polyurethane foam with the following minimum characteristics: K Factor of 0.14, Density 2 pcf, Closed Cell Content 90-95% in conformance with MIL-I-24172 and ASTM C-591 completely filling the annular space between carrier pipes and jacketing.
3. Jacketing Material: High impact, seamless Polyvinylchloride (PVC) Class 12454-B compound conforming to ASTM 1784, Type 1, Grade 1. No FRP jacketing will be allowed.
4. Joining Method: Join lengths of pipe by solder connection.
5. Fittings: All fittings wrought copper in conformance with job specifications and will be insulated and jacketed materials supplied by the system supplier and as per manufacturers standard procedures.
6. End Seals: Each length of pre-insulated pipe will be fitted with a watertight mastic end seal at jacket and pipe surfaces. All field cuts will be sealed with a field applied end seal.
7. Building Penetrations: Core drill concrete foundation walls in locations approved by the Owner. Seal penetrations watertight will sealant filling the entire annual space.
8. Anchors and Expansion Compensation: All pipes shall be anchored and expansion compensated per system supplier's design and recommendations.
9. Approved Vendors: Copper Pipe System by Rovanco, Joliet, Illinois or approved equal.

2.11 ELECTRICAL

A. Conduits: EMT with flexible connections to equipment.

B. Conductors: Copper conductors with THHN/THWN or XHHW insulation.

2.12 TESTING, ADJUSTING AND BALANCING

A. Distribution System: Balance the heating water flow through each boiler and to each building heat exchanger with all heating systems in full heating mode.

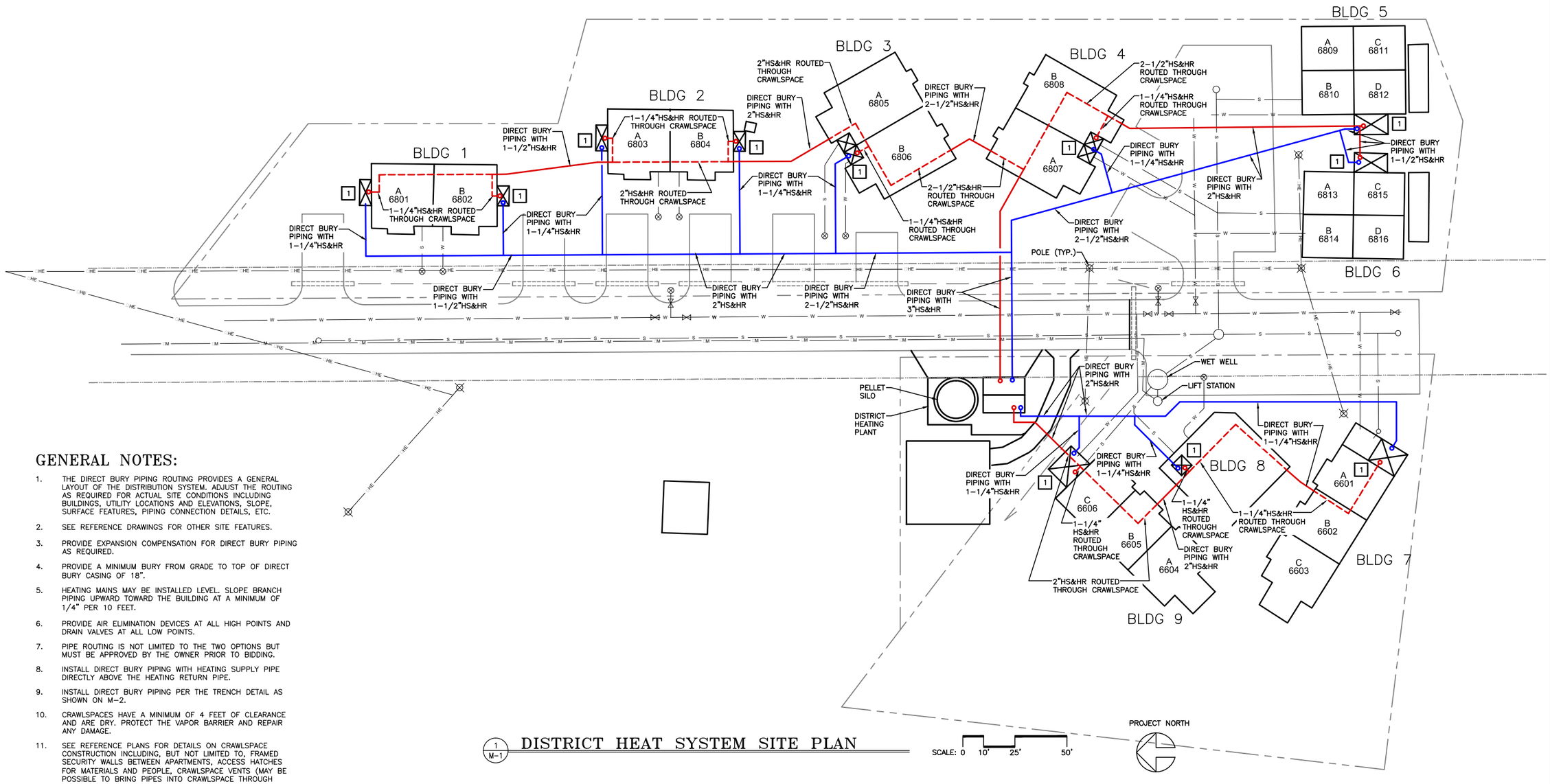
B. Buildings: Balance the heating water flow to each heating zone and each hot water heater.

2.13 COMMISSIONING

A. Commissioning the complete system in accordance with the commissioning plan provided by the Owner's Commissioning Authority (CxA).

ANGOON – DISTRICT HEAT SYSTEM CONCEPT DRAWINGS

THRHA Regional Housing Authority
Juneau, Alaska



1 M-1 DISTRICT HEAT SYSTEM SITE PLAN

GENERAL NOTES:

1. THE DIRECT BURY PIPING ROUTING PROVIDES A GENERAL LAYOUT OF THE DISTRIBUTION SYSTEM. ADJUST THE ROUTING AS REQUIRED FOR ACTUAL SITE CONDITIONS INCLUDING BUILDINGS, UTILITY LOCATIONS AND ELEVATIONS, SLOPE, SURFACE FEATURES, PIPING CONNECTION DETAILS, ETC.
2. SEE REFERENCE DRAWINGS FOR OTHER SITE FEATURES.
3. PROVIDE EXPANSION COMPENSATION FOR DIRECT BURY PIPING AS REQUIRED.
4. PROVIDE A MINIMUM BURY FROM GRADE TO TOP OF DIRECT BURY CASING OF 18".
5. HEATING MAINS MAY BE INSTALLED LEVEL. SLOPE BRANCH PIPING UPWARD TOWARD THE BUILDING AT A MINIMUM OF 1/4" PER 10 FEET.
6. PROVIDE AIR ELIMINATION DEVICES AT ALL HIGH POINTS AND DRAIN VALVES AT ALL LOW POINTS.
7. PIPE ROUTING IS NOT LIMITED TO THE TWO OPTIONS BUT MUST BE APPROVED BY THE OWNER PRIOR TO BIDDING.
8. INSTALL DIRECT BURY PIPING WITH HEATING SUPPLY PIPE DIRECTLY ABOVE THE HEATING RETURN PIPE.
9. INSTALL DIRECT BURY PIPING PER THE TRENCH DETAIL AS SHOWN ON M-2.
10. CRAWLSPACES HAVE A MINIMUM OF 4 FEET OF CLEARANCE AND ARE DRY. PROTECT THE VAPOR BARRIER AND REPAIR ANY DAMAGE.
11. SEE REFERENCE PLANS FOR DETAILS ON CRAWLSPACE CONSTRUCTION INCLUDING, BUT NOT LIMITED TO, FRAMED SECURITY WALLS BETWEEN APARTMENTS, ACCESS HATCHES FOR MATERIALS AND PEOPLE, CRAWLSPACE VENTS (MAY BE POSSIBLE TO BRING PIPES INTO CRAWLSPACE THROUGH VENTS), ETC.
12. SEAL CONCRETE STEM WALL PENETRATIONS WITH APPROVED SEALANT.
13. SECURE ALL APARTMENT DIVIDER WALLS IN CRAWLSPACE WITH ESCUTCHEON SECURED TO EACH SIDE.
14. SIZE DISTRIBUTION PIPING FOR A PRESSURE DROP OF 1.5 FEET PER 100 FEET.

SPECIFIC NOTES:

[1] SEE TYPICAL HEATING PIPING DIAGRAM ON SHEET M-3 FOR BUILDING CONNECTION TO HEATING SYSTEM.

DIRECT BURY PIPING SCHEDULE:

HS & HR PIPE SIZE	CASING DIAMETER
3"	16"
2-1/2"	14"
1-1/2" AND 2"	12"

DISTRIBUTION PIPING OPTIONS:

OPTION	DESCRIPTION	LINE TYPE	
		DIRECT BURY	IN CRAWLSPACE
OPTION 1:	HEATING MAINS RUN PARALLEL TO THE STREET.	———	NA
OPTION 2:	HEATING MAINS ROUTE THROUGH CRAWLSPACES.	———	- - - -

PRELIMINARY NOT FOR CONSTRUCTION

Alaska Energy Engineering LLC
Phone and Fax: (907) 789-1726
E-mail: jim@alaskaenergy.us
25200 Amalga Harbor Road
Juneau, Alaska 99801

Angoon Housing District Heat System

Angoon Alaska

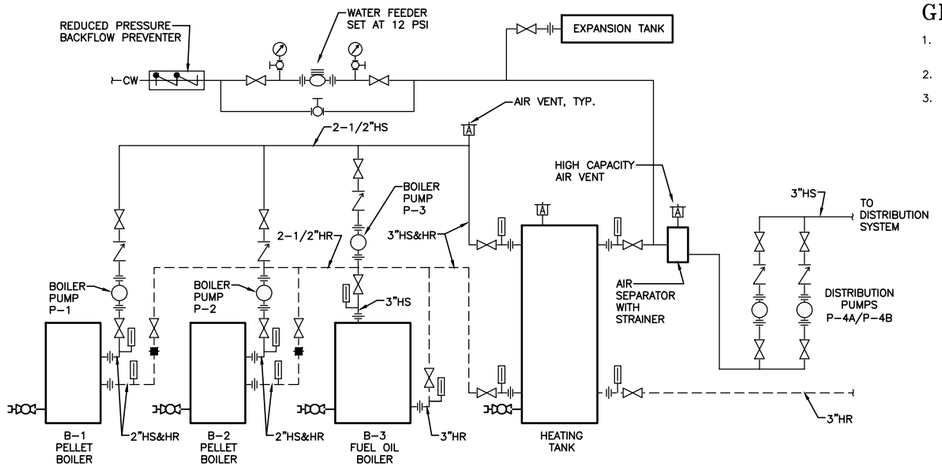
Tlingit-Haida Regional Housing Authority
Design-Build Procurement Package

SHEET TITLE:

DISTRICT HEAT SYSTEM SITE PLAN

Date: DECEMBER, 2015
Scale: As Noted
Drawn: KB
Checked: JR

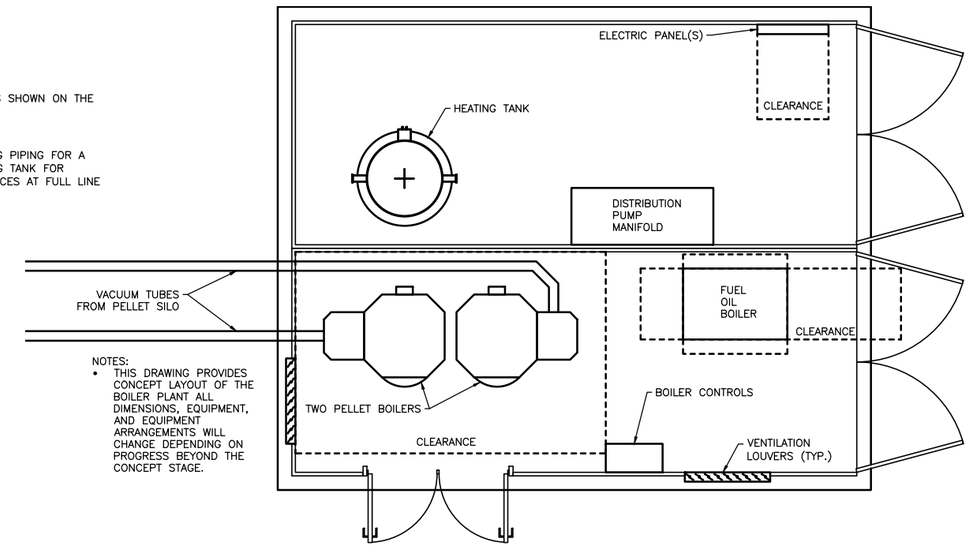
M-1



1 M-2 DISTRICT HEATING PLANT PIPING DIAGRAM

GENERAL NOTES:

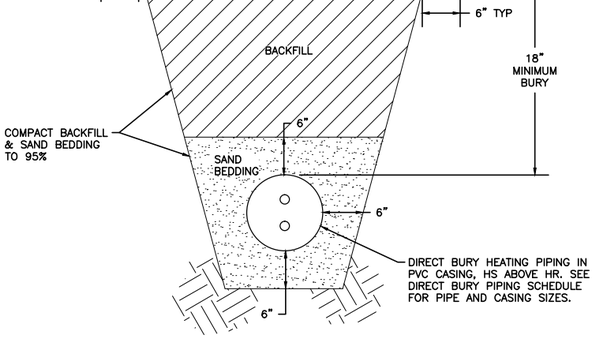
1. PROVIDE A PRIMARY/SECONDARY PIPING ARRANGEMENT AS SHOWN ON THE DISTRICT HEATING PLANT PIPING DIAGRAM.
2. PROVIDE A CHEMICAL FEEDER.
3. MINIMIZE HEATING SYSTEM PRESSURE DROP: SIZE HEATING PIPING FOR A MAXIMUM PRESSURE DROP OF 1.5'/100 FT; SIZE HEATING TANK FOR MAXIMUM 2' OF DROP. PROVIDE PIPING AND APPURTENANCES AT FULL LINE SIZE UP TO CONNECTION TO EQUIPMENT.



NOTES:
- THIS DRAWING PROVIDES CONCEPT LAYOUT OF THE BOILER PLANT ALL DIMENSIONS, EQUIPMENT, AND EQUIPMENT ARRANGEMENTS WILL CHANGE DEPENDING ON PROGRESS BEYOND THE CONCEPT STAGE.

2 M-2 DISTRICT HEATING PLANT PLAN

SCALE: 0 2' 4' 8'



3 M-2 TRENCH DETAIL

DISTRICT HEATING PLANT EQUIPMENT SCHEDULE

EQUIPMENT	CHARACTERISTICS
PELLET BOILER B-1	MANUFACTURER: MAINE ENERGY SYSTEMS MODEL PE56 CAPACITY: MODULATE FROM 57 MBH TO 191 MBH PROVIDE CHLORINE RESISTANT FLAME TUBE.
PELLET BOILER B-2	MANUFACTURER: MAINE ENERGY SYSTEMS MODEL PE56 CAPACITY: MODULATE FROM 57 MBH TO 191 MBH PROVIDE CHLORINE RESISTANT FLAME TUBE.
FUEL OIL BOILER B-3	MANUFACTURER: WEIL MCLAIN MODEL 680 CAPACITY: 551 MBH NET L=B=R WITH FULLY MODULATING BURNER
HEATING TANK	CAPACITY: 250 GALLON STORAGE; TANK AS TALL AS POSSIBLE TO FIT ROOM TO PROMOTE STRATIFICATION; 3" SUPPLY AND RETURN TAPPINGS FOR PLANT AND DISTRIBUTION ON OPPOSING SIDES WITHIN 6" OF TOP AND BOTTOM OF TANK.
BOILER PUMP P-1	CAPACITY: 19 GPM @ 20' HEAD; CONSTANT SPEED ECM MOTOR; MINIMUM 50% WATER-TO-WIRE EFFICIENCY; 120V/SINGLE PHASE.
BOILER PUMP P-2	CAPACITY: 19 GPM @ 20' HEAD; CONSTANT SPEED ECM MOTOR; MINIMUM 50% WATER-TO-WIRE EFFICIENCY; 120V/SINGLE PHASE.
BOILER PUMP P-3	CAPACITY: 55 GPM @ 20' HEAD; VARIABLE SPEED ECM MOTOR; MINIMUM 40% WATER-TO-WIRE EFFICIENCY; 240V/SINGLE PHASE.
DISTRIBUTION PUMP P-4A	CAPACITY: 69 GPM @ 50' HEAD; VARIABLE SPEED ECM MOTOR; 50% WATER-TO-WIRE EFFICIENCY; 240V/SINGLE PHASE. CONTROL: CONSTANT PRESSURE CONTROL, VARIABLE DIFFERENTIAL PRESSURE CONTROL, AND LEAD/STANDBY CONTROL.
DISTRIBUTION PUMP P-4B	CAPACITY: 69 GPM @ 50' HEAD; VARIABLE SPEED ECM MOTOR; 50% WATER-TO-WIRE EFFICIENCY; 240V/SINGLE PHASE. CONTROL: CONSTANT PRESSURE CONTROL, VARIABLE DIFFERENTIAL PRESSURE CONTROL, AND LEAD/STANDBY CONTROL.

ABBREVIATIONS

BLDG	BUILDING
CW	COLD WATER
FM	FORCED MAIN
HS	HEATING SUPPLY
HR	HEATING RETURN
HW	HOT WATER
HX	HEAT EXCHANGER
OHE	OVERHEAD ELECTRIC
S	SEWER
TYP	TYPICAL
W	WATER

GENERAL SYMBOLS

CONNECT TO EXISTING	
EXISTING TO REMAIN	(E)
GENERAL SHEET NOTE	1.
REFERENCED SHEET NOTE	2
DETAIL REFERENCE	1 / M3.1

PIPING SYMBOLS

CONTROL VALVE
GATE VALVE
BACKFLOW PREVENTION DEVICE
DRAIN VALVE WITH HOSE END CONNECTION
AIR VENT (A) AUTOMATIC, (M) MAINUAL
UNION
THERMOMETER
ELBOW, UP
ELBOW, DOWN
CONCENTRIC REDUCER
FLOWSETTER
WATER FEEDER
PRESSURE GAGE
CONNECTION POINT

SEQUENCE OF CONTROL DISTRICT HEATING PLANT

1. Pellet Boilers and Boiler Pumps: A integral control panel supplied with boiler B-1 will operate and modulate both boilers in a lead/lag configuration with weekly rotation of the lead boiler.
   a. Modulate and sequence the boilers to maintain the heating tank temperature setpoint per the heating tank temperature setpoint schedule.
   b. Enable the boilers when the heating tank temperature drops to the enable setpoint and disable the boilers when the heating tank temperature rises to the disable setpoint.
   c. Operate the respective boiler pump 2 minutes prior to enabling its respective boiler and for 5 minutes after the boiler has completed firing.
2. Fuel Oil Boiler: Provide a service switch mounted on the boiler to disconnect power to the burner for servicing.
   a. Sequence and modulate the boiler to maintain a manually selected heating tank temperature setpoint per the heating tank temperature setpoint schedule.
   b. Enable the boiler when the heating tank temperature drops to the enable setpoint and disable the boiler when the heating tank temperature rises to the disable setpoint.
   c. Operate the boiler pump for 2 minutes prior to enabling the boiler and for 5 minutes after the boiler has completed firing.
3. Heating Tank Temperature Setpoint: Set the boiler controls per the following table. The primary fuel source is selected by setting its respective boiler to be the lead boiler.

Heating Tank Temperature Setpoint Schedule

Boiler	Heating Tank SP	Boiler Enable SP	Boiler Disable SP
Winter Settings			
Lead Boiler	185°F	165°F	190°F
Lag Boiler	165°F	155°F	170°F
Summer Settings			
Lead Boiler	165°F	160°F	190°F
Lag Boiler	155°F	145°F	160°F

4. Distribution Pumps
   a. Operation: Operate the pumps in a lead/standby configuration. Modulate the lead pump to maintain a variable differential pressure setpoint. Determine the minimum and maximum flow differential pressure setpoints during balancing. Setpoints shall be as low as possible to provide the building flow rates.
   b. Sequencing: If the lead pump fails to operate, enable the standby pump and initiate an alarm.

PRELIMINARY NOT FOR CONSTRUCTION

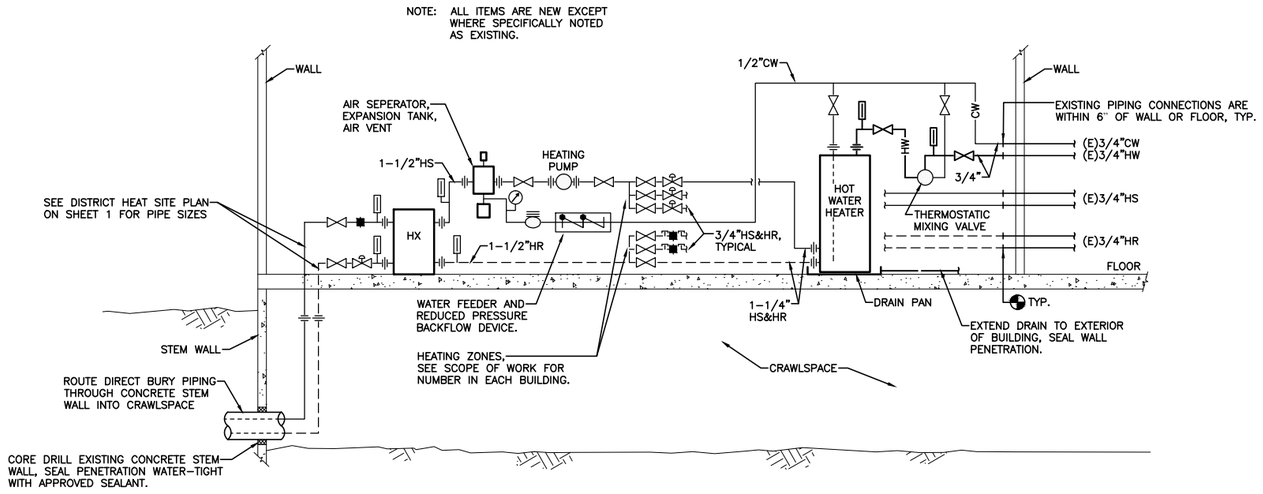
Alaska Energy Engineering LLC
25200 Amalga Harbor Road
Juneau, Alaska 99801
Phone and Fax: (907) 789-1726
E-mail: jim@alaskaenergy.us

Angoon Housing District Heat System
Angoon Alaska
Tlingit-Haida Regional Housing Authority
Design-Build Procurement Package

SHEET TITLE:
DISTRICT HEATING PLANT

Date: DECEMBER, 2015
Scale: As Noted
Drawn: KB
Checked: JR

M-2



1 / M-2 TYPICAL BUILDING PIPING DIAGRAM

SEQUENCE OF CONTROL BUILDING HEATING SYSTEM

1. Heating Supply Temperature: Modulate the heat exchanger automatic valve to maintain a building heating supply setpoint of 180°F.
2. Zone Control: Provide a zone control panel that opens the zone valve when a respective room thermostat or hot water tank temperature sensor calls for heat. Operate the heating pump on a call for heat and disable the pump when there is no call for heat.

BUILDING SCOPE OF WORK
Angoon Housing District Heat System

1.1 DEMOLITION

A. Each apartment has a separate heating system connected to a separate fuel oil tank, except in Building 5, which has one heating system and four fuel oil tanks. Building 8 has one heating system and oil tank.

B. The following apply to each heating system. See the reference drawings for specifics on each heating system.

C. Equipment: Remove the boiler, hot water heater, heating pump, air separator, and expansion tank. Remove the chimney and repair the roof penetration. Remove drain pans under the boilers and hot water heaters and connecting piping.

D. Piping and Appurtenances: Remove the piping within the boiler room including, but not limited to, insulation, valves, control valves, supports, etc.

1. Heating Piping: Remove the heating piping from the boiler to within 6" of the wall penetration.
2. Hot Water Piping: Remove the hot water piping from the hot water heater to within 6" of the wall penetration.
3. Cold Water Piping: Retain the cold water piping or replace in-kind if it hinders the new installation. Remove the branch serving the boiler feed including the isolation valve, water feeder, etc.
4. Seal all floor and wall penetrations.

E. Chimney: Remove the entire chimney, insulate the opening, and patch the inside and outside surfaces to match existing.

1. Building 5: Perform this work on four chimneys.

F. Combustion Air Openings: Remove the louver, insulate the opening, and patch the inside and outside surfaces to match existing.

G. Fuel Oil System: Remove the aboveground fuel tanks, steel and wood support frame, buried fuel oil piping, and all fuel oil piping and appurtenances within the boiler room including supports.

H. Electrical: For each heating system, there is a separate circuit supplying power to the burner, pump, and zone controls. Remove all raceways, conductors, control wiring and control transformer. Retain power circuits (as needed) and the room thermostat control wiring in the new work. Remove all other circuits through the floor and terminate in a new junction box under the floor. Seal floor penetrations.

1.2 NEW WORK

A. General Requirements

1. Scope: Provide new heating systems supplied by the district heating system except as modified in the Building Specific Requirements below. Install each system per the Typical Building Piping Diagram.
2. Layout equipment and piping to provide appropriate access to equipment for maintenance and repair.
3. Provide seismic restraints per code requirements.
4. Electrical: Utilize the existing power circuit for the pump and controls.

B. Building Specific Requirements

1. Building 1: Install a separate heating system for each apartment.
   a. Each heating system has two heating zones and one hot water heater.
   b. Provide a three-way control valve on the hot side of the heat exchanger to provide minimum pump flow for the district heat system. Provide a bypass balance valve, initially set at 2 gpm. Adjust as low as possible to maintain temperature in the distribution system and a reasonable pump speed when none of the heat exchangers are calling for heat.
   c. Apartment A: Provide a three-way control valve on the hot side of the heat exchanger to provide minimum pump flow for the district heat system. Provide a bypass balance valve, initially set at 2 gpm. Adjust as low as possible to maintain temperature in the distribution system and a reasonable pump speed when none of the heat exchangers are calling for heat.
2. Building 2: Install a separate heating system for each of two apartments.
   a. Each heating system has two heating zones and one hot water zone.
3. Building 3: Install one heating system serving two apartments. The building has two adjacent mechanical rooms.
   a. Locate the heating system in one of the mechanical rooms. If there is insufficient space, locate the heat exchanger in one room and the hot water heater in the other.
   b. The heating system has a heating zone for each apartment and one hot water heater.
4. Building 4: Install one heating system serving two apartments. The building has two adjacent mechanical rooms.
   a. Locate the heating system in one of the mechanical rooms. If there is insufficient space, locate the heat exchanger in one room and the hot water heater in the other.
   b. The heating system has a heating zone for each apartment and one hot water heater.
5. Building 5: Install one heating system serving four apartments.
   a. The heating system has a heating zone for each apartment and two hot water heaters.
   b. Provide a three-way control valve on the hot side of the heat exchanger to provide minimum pump flow for the district heat system. Provide a bypass balance valve, initially set at 2 gpm. Adjust as low as possible to maintain temperature in the distribution system and a reasonable pump speed when none of the heat exchangers are calling for heat.
6. Building 6: Install one heating system serving four apartments.
   a. The heating system has a heating zone for each apartment and two hot water heaters.
7. Building 7: Install one heating system serving three apartments.
   a. The heating system has a heating zone for each apartment and one hot water heater.
   b. Provide a three-way control valve on the hot side of the heat exchanger to provide minimum pump flow for the district heat system. Provide a bypass balance valve, initially set at 2 gpm. Adjust as low as possible to maintain temperature in the distribution system and a reasonable pump speed when none of the heat exchangers are calling for heat.
8. Building 8: Install one heating system serving the building
   a. The heating system has three heating zones and one hot water heater.
9. Building 9: Install one heating system serving three apartments.
   a. The heating system has a heating zone for each apartment and one hot water heater.
   b. Provide a three-way control valve on the hot side of the heat exchanger to provide minimum pump flow for the district heat system. Provide a bypass balance valve, initially set at 2 gpm. Adjust as low as possible to maintain temperature in the distribution system and a reasonable pump speed when none of the heat exchangers are calling for heat.

End of Section

PRELIMINARY NOT FOR CONSTRUCTION

Alaska Energy Engineering LLC
25200 Amalga Harbor Road
Juneau, Alaska 99801
Phone and Fax: (907) 789-1726
E-mail: jim@alaskaenergy.us

Angoon Housing District Heat System
Angoon Alaska
Tlingit-Haida Regional Housing Authority
Design-Build Procurement Package

SHEET TITLE:
BUILDING HEATING & DOMESTIC HOT WATER SYSTEMS

Date: DECEMBER, 2015
Scale: As Noted
Drawn: KB
Checked: JR

M-3

ANGOON – DISTRICT HEATING SYSTEM CONCEPTUAL DESIGN CALCULATIONS

THRHA Regional Housing Authority
Juneau, Alaska

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Conceptual Design Calculations

December 21, 2015

THRHA Angoon District Heating System
Sizing and Energy Analysis - w/o Church

CONCEPTUAL SIZING

Hot Water Heater Sizing (HUD Sizing per ASHRAE)

Building	Bedrooms	Baths	Storage	Recov, GPH, 120F	Recov, GPH, 140F	MBH	WM Aqua Plus
Building 1 (Typ of 2)	4	2	66	75	60	50	85
Building 2 (Typ of 2)	4	2	66	75	60	50	85
Building 3	6	3	82	75	60	50	85
Building 4	6	3	82	75	60	50	85
Building 5	8	4	132	150	120	100	85 (2)
Building 6	8	4	132	150	120	100	85 (2)
Building 7	3	3	66	66	53	44	85
Building 9	3	3	66	66	53	44	85
Building 8			66	91	73	61	85

Design Heating Loads

	Heat Loss	Existing DHW	Total Load	Existing	Plant Design Load, MBH		
Building	MBH	Load, MBH	MBH	Boiler, MBH	Heat Loss	DHW MBH	Total
Apartment 1A	18	61	79	89	18	50	68
Apartment 1B	18	61	79	89	18	50	68
Apartment 2A	18	61	79	89	18	50	68
Apartment 2B	18	61	79	89	18	50	68
Building 3	36	121	157	178	36	50	86
Building 4	36	121	157	178	36	50	86
Building 5	44	243	287	175	44	100	144
Building 6	44	243	287	356	44	100	144
Building 7	30	182	212	267	30	44	74
Building 8	61	61	121	124	61	61	121
Building 9	30	182	212	267	30	44	74
Totals	353	1,396	1,749	1,901	353	649	1,002
							53%

Distribution Losses

Length, Inft	Btuh/Inft	MBH
1,100	12	13

Heating Plant Design Load

Load	Peak MBH	Load Factor	Design MBH
Heating	353	100%	353
Distribution Losses	13	100%	13
Domestic Hot Water	649	50%	325
Totals	1,015		691

Sizing Analysis

Boilers	Boiler	Type	Design Load, MBH	Factor	Boiler MBH
	B-1	Pellet	691	28%	191
	B-2	Pellet	691	28%	191
	B-3	Fuel Oil	691	80%	551
				135%	934

Pumps	Service	Pump	GPM	Head	η, pump	Pump, BHP	η, motor
	B-1	P-1	19	20	50%	0.2	70%
	B-2	P-2	19	20	50%	0.2	70%
	B-3	P-3	55	20	60%	0.5	70%
	Distribution	P-4A	69	50	65%	1.3	80%
	Distribution	P-4B	69	50	65%	1.3	80%

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Conceptual Design Calculations

December 21, 2015

THRHA Angoon District Heating System

Sizing and Energy Analysis - w/o Church

ENERGY USE

Historical Fuel Oil Consumption

Building	Gallons
Building 1	1,373
Building 2	1,377
Building 3	962
Building 4	1,228
Building 5	1,723
Building 6	1,607
Building 7	1,548
Senior Center	1,149
Building 9	1,167
Totals	12,134

ENERGY ANALYSIS

Existing Heating Systems

	Gallons	n, boiler	kBtu/gal	Net kBtu
Fuel Oil	12,134	70%	138.5	1,176,371

Boiler Burners	Building	Boilers	kW,ea	Oil, gal	Oil, GPH	Hours	kWh
	Building 1	2	0.2	1,373	0.75	1,831	410
	Building 2	2	0.2	1,377	0.75	1,836	411
	Building 3	2	0.2	962	0.75	1,283	287
	Building 4	2	0.2	1,228	0.75	1,637	366
	Building 5	1	0.2	1,723	1.45	1,188	266
	Building 6	4	0.2	1,607	0.75	2,143	480
	Building 7	3	0.2	1,548	0.75	2,064	462
	Senior Center	1	0.2	1,149	1.05	1,094	245
	Building 9	3	0.2	1,167	0.75	1,556	348
	Totals	20					3,275

District Heating System

	Net kBtu	Factor	n, boiler	Conversion	Fuel	
Pellets	1,176,371	90%	70%	15,560	97	tons
Fuel Oil	1,176,371	10%	70%	138.5	1,213	gallons
			inc dist losses			

Boiler Burner	Boiler, MBH	Net kBtu	Load factor	Load, kW	Hours	kWh
	191	1,176,371	70%	0.25	6,570	1,643

Pellet Handling				Hours	kW	kWh
				500	0.2	100

Pumps	Pump	Ave GPM	Head	Hours	kW	kWh
	P-1	19	20	7,500	0.3	2,074
	P-2	19	20	4,000	0.3	1,106
	P-3	55	20	500	0.7	332
	P-4A	25	30	8,760	0.4	3,194
				Average Demand, kW	1.8	6,706

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Juneau, Alaska 99801

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THRHA Angoon District Heating System

Sizing and Energy Analysis - w/o Church

Monthly Pellet Consumption

Month	Percent	MESys, tons
Jan	14%	14
Feb	12%	12
Mar	11%	10
Apr	8%	8
May	6%	6
Jun	4%	4
Jul	4%	4
Aug	4%	4
Sep	6%	5
Oct	8%	8
Nov	11%	10
Dec	13%	12
	100%	97

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
alaskaenergy@gci.net

Life Cycle Cost Analysis

December 21, 2015

THRHA Angoon District Heating System

Existing Heating Plants

Basis

35	Study Period (years)	2.8%	General Inflation
4.5%	Nominal Discount Rate	3.3%	Fuel Inflation
1.7%	Real Discount Rate	4.0%	Electricity Inflation
		2.7%	Wood Pellet Inflation

Annual Costs		Years	Qty	Unit	Base Cost	Life Cycle Cost	Annual Cost
Heating Plant							
Fuel Oil Boilers							
Fuel Oil Boiler Maintenance							
Parts Allowance, each		1 - 35	20	LS	$100.00	$51,528	$2,000
Monthly, each	0.5 hours/month	1 - 35	120	hrs	$40.00	$123,667	$4,800
Annual, each	4 hours/year	1 - 35	80	hrs	$40.00	$82,445	$3,200
Pumps							
Pump maintenance, cartridge		1 - 35	20	ea	$100.00	$51,528	$2,000
Domestic Hot Water							
Indirect HW heater		1 - 35	20	hrs	$40.00	$20,611	$800
					Total Annual Costs	**$330,000**	**$12,800**

Energy Costs	Years	Qty	Unit	Base Cost	Life Cycle Cost	Annual Cost
Fuel Oil	1 - 35	12,134	gallon	$4.73	$1,643,211	$57,407
Wood Pellets	1 - 35	0	ton	$472.42	$0	$0
Electricity	1 - 35	3,275	kWh	$0.661	$61,968	$2,165
				Total Energy Costs	**$1,705,000**	**$59,572**

	Life Cycle Cost	Annual Cost
Present Worth	**$2,035,000**	**$72,372**

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 alaskaenergy@gci.net

Life Cycle Cost Analysis

December 21, 2015

THRHA Angoon District Heating System

District Heat Plant

Basis

35	Study Period (years)	2.8%	General Inflation
4.5%	Nominal Discount Rate	3.3%	Fuel Inflation
1.7%	Real Discount Rate	3.3%	Electricity Inflation
		2.7%	Wood Pellet Inflation

Annual Costs		Years	Qty	Unit	Base Cost	Present Value	Annual Cost
Heating Plant							
Plant Observation							
Daily Heating Plant Observatic	5 min/day	1 - 35	30	hrs	$40.00	$31,346	$1,217
Wood / Fuel Oil Boilers							
Fuel Oil Boiler Maintenance							
Parts Allowance, each		1 - 35	1	LS	$200.00	$5,153	$200
Monthly, each	1.5 hours/month	1 - 35	18	hrs	$40.00	$18,550	$720
Annual, each	8 hours/year	1 - 35	8	hrs	$40.00	$8,244	$320
Pellet Boiler Maintenance - Small Capacity							
Parts Allowance, each		1 - 35	2	LS	$150.00	$7,729	$300
Monthly, each	2 hours/month	1 - 35	48	hrs	$40.00	$49,467	$1,920
2000 hour maintenance	8 hours/year	1 - 35	16	hrs	$40.00	$16,489	$640
Pellet Handling System							
Maintenance		1 - 35	16	hrs	$40.00	$16,489	$640
Equiipment Replacement							
Pellet boilers		20 - 20	1	LS	$70,000.00	$49,099	$2,000
Vacuum system		10 - 10	1	LS	$1,500.00	$1,246	$1,500
Vacuum system		30 - 30	1	LS	$1,500.00	$889	$1,500
Domestic Hot Water							
Indirect HW heater		1 - 35	12	hrs	$40.00	$12,367	$480
Pumps							
Pump maintenance, cartridge		1 - 35	11	ea	$100.00	$28,340	$1,100
Pump maintenance, pipe mounted		1 - 35	5	ea	$250.00	$32,205	$1,250
					Total Annual Costs	**$278,000**	**$13,787**

Energy Costs	Years	Qty	Unit	Base Cost	Present Value	Annual Cost
Fuel Oil	1 - 35	1,213	gallon	$4.73	$164,321	$5,741
Wood Pellets	1 - 35	97	ton	$472.42	$1,193,758	$45,921
Electricity	1 - 35	8,448	kWh	$0.630	$152,381	$5,324
				Total Energy Costs	**$1,510,000**	**$56,985**

	Life Cycle Cost	Annual Cost
Present Worth	**$1,788,000**	**$70,772**

ANGOON – DISTRICT HEATING SYSTEM MONITORING PLAN

THRHA Regional Housing Authority
Juneau, Alaska

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
jim@alaskaenergy.us

Memorandum

December 12, 2015

to: **Craig Moore, THRHA**

subject: **Monitoring Plan**

project: **Angoon District Heating System**

Introduction

This document describes the proposed monitoring plan for the proposed Angoon District Heating System. The monitoring plan is based on the preliminary schematic of the system. Any changes made during design may require changes to this plan.

The purpose of the monitoring system is to provide remote monitoring of system operation, measure energy flow, and provide alarms if equipment is not operating when expected.

The plan offers the following levels of monitoring:

- Temperature and Status Monitoring: Monitor equipment status, system temperatures and pump status.
- Energy Use: Measures plant electricity consumption and plant heating output to the buildings.

Monitoring Plan

The proposed monitoring system will display the status of the boilers and pumps, the system temperatures, and measure energy use.

Temperature and Status Monitoring System

- Fixed Costs for travel, per diem, and equipment
- Outside Temperature: Provides a temperature reference for assessing system operation
- Boiler Enable: Displays the status of each boiler
- Pump Enable
    - Displays the status of each pump.
    - Annunciates an alarm if the pump is not enabled when the boiler is enabled.
    - Annunciates an alarm if one of the distribution pumps is not operating.
- Temperatures
    - Monitors boiler supply and return temperature to the heating tank.
    - Monitors the supply temperature from each boiler
    - Monitors distribution system supply and return temperature to the buildings.
    - Annunciates an alarm if the distribution temperature is outside of expected range.

Energy Monitoring

- Measures plant electricity use
- Measures plant heat output to buildings. This allows a determination of seasonal efficiency by comparing the heat output with purchased energy.

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
jim@alaskaenergy.us

December 21, 2015

THRHA Energy Assessments

Angoon District Heat System Monitoring Plan

Angoon District Heat System Monitoring Plan

Item	Intent	Operationa	Energy
Fixed Cost			
Travel, per diem, equipment	Fixed costs	$5,352	
BMON site migration and set up	Moving THRHA to their own server	$800	
Unit Costs			
General			
Outdoor temperature	Outdoor temperature reference	$30	
Plant electric load, kW	Total energy use		$1,940
Heating Plant Status			
Boiler B-1 enable	Boiler status	$505	
Boiler B-2 enable	Boiler status	$505	
Boiler B-3 enable	Boiler status	$505	
Boiler pump P-1 enable	Boiler pump status	$337	
Boiler pump P-2 enable	Boiler pump status	$337	
Boiler pump P-3 enable	Boiler pump status	$337	
Distribution pump P-4A status	Distribution pump status	$337	
Distribution pump P-4B status	Distribution pump status	$337	
Heating Plant Temperatures			
Boiler B-1 Supply	Confirms boiler operation	$256	
Boiler B-2 Supply	Confirms boiler operation	$256	
Boiler B-3 Supply	Confirms boiler operation	$256	
Boiler plant supply to heating tank	Confirms boiler heat flow to heating tank	$256	
Boiler plant return from heating tank	Confirms boiler heat flow to heating tank	$256	
Distribution heating supply temperature	Confirms heat to buildings	$256	
Distribution heating return temperature	Confirms heat to buildings	$256	
Heating Plant Energy Output			
Distribution flow to buildings	Heating flow rate - 3" pipe		$4,365
Totals		$11,173	$6,305

ANGOON – REQUEST FOR PROPOSALS: BIOMASS DISTRICT HEATING SYSTEM PROJECT

THRHA Regional Housing Authority
Juneau, Alaska

Regional Housing Authority

DRAFT

XXXXXXXXX DATE

REQUEST FOR PROPOSALS

For a Design-Build Contractor

For the Tlingit Haida Regional Housing Authority's Angoon Biomass District Heating System Project

Notice to Bidders: Tlingit Haida Regional Housing Authority (THRHA) seeks proposals from qualified entities to provide Design/Build services for a biomass district heating project serving 10 buildings in Angoon, AK. In this document the terms, "bidder" or "contractor" will refer to the design build contractor and the term, "Owner" will refer to THRHA.

Project Description: The project scope includes complete design, permitting, construction, installation, commissioning, and warranty of a new central plant and hot water district heating system to serve 10 buildings in Angoon, AK. The central plant will include a biomass boiler system with fuel oil backup. See Attachment B - Scope of Work for details of project.

Instructions: Submit two (2) paper copies and one (1) electronic copy of the Proposal in a sealed envelope marked "Angoon Biomass District Heating" to Mr. Craig Moore (PO Box 32237, Juneau, AK 99803). Along with the proposal include Attachment A – Bid Form. **Proposals should be received no later than 5:00 PM AKST, XXXXXXX date**. Submissions that are incomplete or in any other form or received after the deadline may be rejected at the discretion of THRHA.

Requests for Information (RFIs): All questions concerning bidding procedures, clarifications of information provided, or project scope and specifications should be submitted in writing and delivered by email to Mr. Craig Moore (cmoore@THRHA.org).

RFIs and responses to RFIs will be placed on the THRHA website at the following location for all bidders to view: Include web address, or other method for delivering responses. Bidders are responsible for checking the website for any new information. Deadline for submitting RFI's is 5:00 PM AKST, Date. All responses will be posted by 5:00 PM AKST, Date.

Addenda: Any addenda issued concerning the project specifications or bidding procedures will be posted on the previously listed website.

Mandatory Site Visit and Walk Through (do you want to require this?): A mandatory site visit will be held on Date. THRHA may choose to disqualify any bidder who does not attend. The meeting place for the site visit will be Address. The visit will include a project overview and then a follow-on walk through of each of the mechanical rooms for buildings to be connected to the new district system. (discuss duration estimate and logistics)

Proposal Content, Evaluation of Proposals, and Award: The exact format of the proposal is up to the bidder, and brevity and clarity are encouraged and appreciated. During evaluation of the proposals, weight will be placed on the bidder's response regarding the following key items, which must be discussed in the proposal:

- Past experience with design and installation of biomass and hot water district heating systems
- Bidder's approach to design of the hot water district heating distribution and interconnection system to balance initial costs with overall system efficiency and annual operating costs while meeting THRHA goals

THRHA retains the right to reject any and all bids. THRHA will review the proposals to determine best overall value. In addition to overall project cost, THRHA places high value on relevant experience, a sound approach to system design, and demonstrated ability of the bidder's team to work as a partner with the owner to ensure the job is completed in a timely and cost effective manner. THRHA requires that the resumes of the project manager and construction manager for the job be provided, and that the individuals presented will be the individuals working on the job on a day-to-day basis. THRHA reserves the right to request additional information from multiple firms as needed to ensure fair comparison and identify best value. THRHA will then negotiate with the vendor it deems to offer the best value. Should an acceptable contract agreement not be reached with this vendor, THRHA reserves the right to negotiate with another vendor of its choosing. Expected date of award is within 4 weeks after proposals are due.

Time of Completion: Bidders shall begin the Work on receipt of the Notice to Proceed and shall complete the Work within 180 (this may be pushing what is achievable, but would probably need to meet this to be complete this summer) calendar days of Notice to Proceed. Mention any time of work restrictions (required connection during summer, others). Liquidated damages or other suitable measures for ensuring timely project completion will be negotiated with the contractor.

Permits and Fees: The contractor shall secure and pay for building and other permits and governmental fees, licenses and inspections necessary for the proper execution and completion of the Work which are customarily secured after execution of the Design-Build Contract, and which were legally required on the date THRHA accepted the contractor's proposal.

Proposal Prices: Proposal prices are to remain firm and in effect for a period of sixty (60) days from the opening of the bids and may not be withdrawn after the submittal due date. All bids are to be submitted on Attachment A – Bid Form, with base price, breakdown of major components breakdown, and prices for all listed alternates.

Performance Clause: If the bidder is awarded the project, a performance bond and payment of obligations bond for the full amount of the award must be secured within 10 days of notification of award and must be in effect before the contract is signed.

Insurance: The Design Build Contractor and any subcontractor employed on the project must provide proof of the insurances listed below, that are to remain in effect at all times during the life of the contract. The insurance documents must name THRHA as co-insured and proof of insurance must be provided prior to signing of contract. THRHA will maintain a Builder's Risk policy for the duration of the project. The following insurances are required:

(insert THRHA requirements)

- **Workers Compensation Insurance:** Contractor shall carry Worker's Compensation Insurance as required by the State of Alaska.
- **Commercial General Liability Insurance:** Contractor shall maintain a broad form comprehensive insurance general liability insurance policy in an amount of not less than $1,000,000 combined single limit per occurrence, $2,000,000 aggregate.
- **Motor Vehicle Insurance:** The Contractor shall carry motor vehicle insurance to include bodily injury, property damage, uninsured motorist, and employer's non-ownership coverage in an amount of no less than $1,000,000 combined single limit per occurrence.
- **Employer's liability:** $1,000,000 per accident, injury or disease.
- **Professional liability:** $1,000,000 per occurrence, $2,000,000 aggregate.

Contract: The contractor will be expected to enter into a Design Build Contract. The contract is to be AIA Document A141-2004 or another document acceptable to both parties.

Bidder Qualifications: Bidders must be properly licensed under the laws of Alaska governing their respective trades and be able to obtain insurance and bonds required for the Work.

Warranties: Design Build Contractor is to provide a 1 year parts and labor warranty in the base bid for all equipment, material, workmanship, controls, and programming to begin upon project final completion and Owner acceptance. Any warranties provided by manufacturers over and above 1 year will transfer to the Owner upon Owner acceptance.

Included with this RFP are the following Attachments:

- Attachment A – Bid Form
- Attachment B – Scope of Work
    - Appendix 1: THRHA Angoon Housing District Heat System – Preliminary Drawings
    - Appendix 2: THRHA Angoon District Heating System – Technical Requirements
    - Appendix 3: Preliminary Sizing Calculations
    - Appendix 4: Angoon Low Rent Housing Contract Drawing Set 1996
    - Appendix 5: Geotechnical Report

Regional Housing Authority

DRAFT

ATTACHMENT A

BID FORM

REQUEST FOR PROPOSALS

For a Design-Build Contractor

For the Tlingit Haida Regional Housing Authority
Angoon Biomass District Heating System Project

Date

1. BIDDER AND PROJECT INFORMATION

Owner: Tlingit Haida Regional Housing Authority

Project: Angoon Biomass District Heating System

Project Location: Angoon, AK

Bidder: _____

2. CERTIFICATIONS AND BASE BID(Assumes fixed price design-build. Could also go with a Construction Management (cost plus) contract with a Guaranteed Maximum Price)

Base Bid for Single Prime (All Trades) Contract: Having carefully examined the Request for Proposal documents, Scope of Work, and all Addenda, and being familiar with all conditions and requirements of the work, bidder hereby agrees to furnish all material, labor, equipment and services, including all scheduled allowances, necessary to complete the construction of the above-named project, according to the requirements of the Request for Proposal documents, for the stipulated sum of:

_____ Dollars ($_____)

Please provide a breakdown of the base bid pricing into the following categories:

- Central plant site work, utilities, structures, and fuel storage $_____
- Boiler systems and balance of plant $_____
- Distribution piping $_____
- Building interconnections $_____
- Building mechanical room demo and replacement $_____

3. ALTERNATES AND UNIT PRICING

Having carefully examined the Request for Proposal documents, Scope of Work, and all Addenda, and being familiar with all conditions and requirements of the work, bidder hereby offers the following alternates and unit pricing:

Alternate #1 – Gravel Pad

ADD___ DEDUCT___ NO CHANGE___ NOT APPLICABLE___

_____ Dollars ($_____)

Unit Pricing #1 – Piping & Trenching 3” pre-insulated pipe _____($/LF)

Unit Pricing #2 – Piping & Trenching 1.25” pre-insulated pipe _____($/LF)

Unit Pricing #3 – Trench Rock Removal _____($/CY)

4. ACKNOWLEDGEMENT OF ADDENDA

The undersigned bidder acknowledges receipt of and use of the following Addenda in preparation of this Bid:

- Addendum #1, dated _____
- Addendum #2, dated _____
- Addendum #3, dated _____

5. CONTRACTOR’S LICENSE

The undersigned further states that it is a duly licensed contractor, for the type of work proposed, and that all fees, permits, etc. pursuant to submitting this proposal have been paid in full.

6. SUBMISSION OF BID

Respectfully submitted this _____ day of _____, 2016

Submitted by: _____
(name of bidding firm or corporation)

Authorized by: _____
(handwritten signature)

Signed by: _____
(type or print name)

Title: _____

Address: _____

Phone: _____

Email: _____

Regional Housing Authority

DRAFT

ATTACHMENT B

SCOPE OF WORK
REQUEST FOR PROPOSALS

For a Design-Build Contractor

For the Tlingit Haida Regional Housing Authority
Angoon Biomass District Heating System Project

Date

1. PROJECT / SCOPE OF WORK OVERVIEW AND GOALS

The intent of the project is to install a new hot water district heating system interconnecting 9 buildings in Angoon, AK. The new system will be fueled by a new central plant that includes a biomass system providing the vast majority of the heating with oil as the backup. In this document the terms, "bidder" or "contractor" will be synonymous with the design build contractor and the term "Owner" will be synonymous with THRHA.

The scope of work for this project includes the following key items:

Base Bid – Provide all materials, equipment, transportation, and labor to design and construct a District Heating System for the Angoon Low Rent Housing complex in Angoon, Alaska. The housing complex is owned by the Tlingit-Haida Regional Housing Authority and consists of 8 apartment buildings and a Senior Center. The work includes, but is not limited to:

1. Demolition of existing heating systems including:
    a. Heating systems consisting of fuel oil boilers, chimneys (to ceiling connector within mechanical room), combustion air openings, heating piping, pumps, controls, electrical circuits and appurtenances
    b. Fuel oil systems consisting of aboveground fuel oil tanks, buried fuel oil piping, and fuel appurtenances
    c. Plumbing systems consisting of heating and domestic hot water piping, domestic hot water tanks, and appurtenances.
2. Construction of a district heating plant consisting:
    a. Pellet boilers, pellet storage, and pellet conveying system
    b. Fuel oil boiler, fuel oil storage and fuel piping.
    c. Primary/secondary piping system consisting of
        i. Primary boiler pumps supplying heating water to a heating tank.
        ii. Distribution pumps supplying heating water to the buildings
        iii. Buried distribution piping connecting the plant to 8 apartment buildings and a Senior Center.
    d. Building heating and domestic hot water systems consisting of heat exchangers, pumps, zone valves, appurtenances and connection to the existing heating and domestic hot water piping system in each building.
    e. Automatic controls

Alternates – The following lists alternates for which pricing is requested. These are described in the Alternates and Unit Pricing section of this document.

1. Gravel Pad
2. Unit Pricing
    a. Piping & Trenching 3" pre-insulated pipe ($/LF)
    b. Piping & Trenching 1.25" pre-insulated pipe ($/LF)
    c. Trench Rock Removal ($/cy)

2. CONTRACTOR RESPONSIBILITY AND REFERENCE MATERIALS

The contractor is required to determine the required work and provide a complete and functional system. Bidders are encouraged to visit the site prior to issuing a bid. The RFP provides site visit details, and THRHA contact information.

Preliminary layouts, piping schematics, and equipment sizes are provided for the contractor's use in identifying the scope of the project. The contractor is responsible for the complete design and construction of the system. The Designer of Record shall determine the system loads, an operational heating system concept and layout, equipment selections and sizing, and installation details for a complete and operational system.

The following documents are provided for the contractors use. Contractor shall verify the accuracy of any existing conditions prior to bidding:

- Appendix 1: THRHA Angoon Housing District Heat System – Preliminary Drawings
- Appendix 2: THRHA Angoon District Heating System – Technical Requirements
- Appendix 3: Preliminary Sizing Calculations
- Appendix 4: Angoon Low Rent Housing Contract Drawing Set 1996
- Appendix 5: Geotechnical Report

2. PROJECT TIMELINE

Time is of the essence, and the project is to be completed within 180 days from an executed contract. THRHA seeks to partner with the selected design-build contractor in balancing the need to complete the project on time/budget (180 days from an executed contract), and the need to minimize disruptions to local residents. THRHA recognizes that there will be significant and invasive work that will occur as part of this project. The selected contractor, in turn, must recognize that the facilities are used year-round by residents, and impact to their daily lives must be minimized.

It is also important to note that all of the buildings will require domestic hot water continuously. Any potential interruption in service should be communicated in advance to determine if and what arrangements are necessary to cover any potential downtime. The contractor is responsible for any temporary heating or domestic hot water equipment and fuel that may be required.

3. COMMISSIONING, PROJECT CLOSEOUT, AND FINAL PAYMENT

THRHA sees the commissioning phase of the project as critical to the overall success of the new system. THRHA will employ an Owner's Commissioning Authority (CxA) to provide a commissioning plan and verify system performance against contract requirements. Final payment of retainage will not be made until satisfactory completion of all owner punch list items and signoff by the CxA that the system is functioning as contractually required.

4. BASE BID SCOPE OF WORK

The responsibility of the design-build contractor is to design, permit, construct, install, commission, and close out the project, which will provide a new central heating plant and hot water district system serving 9 buildings in Angoon. This section provides requirements for key portions of the project.

Preliminary layouts, piping schematics, and equipment sizes are provided in the Appendix to show THRHA's concept for the central plant, site layout, and building connections. This information is provided for reference only, and it is the design build contractor's responsibility to develop the project design.

3.1 CENTRAL PLANT

The purpose of the central plant is to move the heating equipment for the buildings to one central location. The central plant design is to be centered around the installation of a wood pellet boiler system with thermal storage and fuel oil backup.

Fuel Storage, Structures, Function, and Access – THRHA would like to ensure the central plant is cost efficient in design, and encourages the bidders to explore containerized systems. The following are requirements for the central plant.

- Structure housing biomass boiler equipment, oil boiler equipment, thermal storage, distribution pumps and controls, and balance of plant
    - A containerized system is acceptable.
    - The exact site layout and configuration will be designed in cooperation with THRHA, and must be approved by THRHA prior to the start of construction.
    - Doors are to be placed and sized as needed to allow ease of future servicing of biomass and oil boiler equipment.
    - Adequate space for system maintenance and ash removal must be provided.
- Wood pellet storage and fuel handling must designed in cooperation with the owner. A minimum of 40 tons of storage is to be provided. The owner's preferred storage method is a hopper bin. The bin(s) must have the following features.
    - The top height of the storage hopper bin opening must be no taller than 20 ft from the grade where the delivery truck will sit to allow delivery by auger trucks with a max reach of 20 ft in height.
    - A 4" line with a 4" camlock male end and vent line must be included to allow pneumatic delivery. 4" camlock is to be within 5 ft of grade where delivery person will stand to allow ease of connection.
    - Minimum of 3 viewing ports to allow observation of the level of pellets in the storage bin.
    - Proper grounding of the bin and components.
    - Hopper access door & appropriate labeling for confined space.
    - Ladder with security door.
    - Spring lock lid type that allows lid to move out of way of delivery auger.
    - Lockable valve kit in a convenient location to allow removal of small amounts of pellets from bin.
    - Boot with slide gate to accommodate fuel handling method for wood pellet system, and allow for isolation of the boot from the pellet storage for servicing of handling equipment.
    - A minimum 45^{o} slope to the hopper bin bottom (steeper acceptable).

- Fuel oil storage is to be a double-walled above-ground tank providing a minimum of 550 gallons of useful storage. Piping feeding the plant is to be above ground, fully-supported, above the tank level between the tank and the central plant, and designed for local codes and conditions.
- Access to be designed to allow delivery to the wood pellet and fuel oil storage while not blocking the roadway.

Central Plant Equipment – See the attached drawings and technical requirements. The contractor is also requited to provide 2" capped connections with shutoffs from the main distribution header to allow for future connection(s) from the central plant. Demolition and repair of openings for the existing boiler chimneys in each building is to stop at the ceiling connector within the mechanical space. These are to be temporarily capped, and THRHA will separately handle demolition and roof repair associated with these beyond the mechanical room.

Controls and Metering – See the attached drawings and technical requirements. A monitoring plan will be implemented by THRHA using a third-party contractor. The design-builder will be required to cooperate with the third-party contractor during system design and installation.

Utilities for Central Plant – THRHA will work with the local utility to provide single phase 120/240v service to the pole adjacent to the central plant location. The contractor will be responsible for providing underground service to the central plant from the Utility's transformer. THRHA will be responsible for all costs from the Utility for feeding this new service, and the contractor will be responsible for coordinating installation and connection with the Utility and all interconnection requirements. All water, sewer and electric services and interconnections are the responsibility of the Bidder. The existing site drawings show approximate locations for existing water and sewer infrastructure.

3.2 DISTRIBUTION SYSTEM AND INTERCONNECTION

The purpose of the project is to centralize the heat generating equipment and operation of heat distribution for the connected buildings. The contractor is responsible for ensuring that all operational capabilities provided by existing heating and domestic hot water equipment are maintained throughout the project. An acceptable plan for ensuring this, and allowable service outages are identified by building in the attached Technical Requirements. The following are key aspects of the distribution system and interconnection:

- Serve all of the heating and hot water demands in the buildings identified in this RFP. The contractor is responsible for developing an understanding of the interconnection requirements based on the information provided and onsite inspection of existing heating systems.
- Determining the exact method for interconnection for each building is the responsibility of the contractor. Example schematics developed by Alaska Energy Engineering, LLC are provided for contractor reference, and to illustrate THRHA's concept for the system. THRHA encourages the contractor to utilize approaches that will reliably deliver heat, maximize efficiency, minimize peak loads on the entire system, and provide the ability to optimize the temperature delta for

the district system. Interconnection shall ensure that heat does not migrate to the buildings when there is no call for heat.

- Curb stops outside each building, shutoffs and drains in the building prior to interconnection, and shutoffs allowing isolation of major sections of the district system are required.

Preliminary district system piping layout options have been developed based on knowledge of the site and the loads to be served. This has been provided in the Appendix for contractor reference. The information provided is for reference only, and the contractor is responsible for determining the piping routes. THRHA makes no warranties as to the accuracy of the information provided in the RFP, and verifying the locations and elevations of any buildings, utilities, or other features on the drawings/reports is the responsibility of the contractor. THRHA recognizes the potential risks associated pipeline routing, and wishes to partner with the winning bidder to minimize impact in overall project cost. In an effort to help identify the potential risk, THRHA is requesting unit pricing as part of the bid. Final risk sharing will be negotiated as part of the contract with the winning bidder.

4. ADDITIONAL CONTRACTOR RESPONSIBILITIES:

The Contractor is to provide a fully functioning biomass district heating system as described in the RFP documents and attachments. The Contractor's responsibilities include the following items, as well as any other work items required to provide a fully functioning system.

- Preliminary project design for THRHA approval.
- The Design Build Contractor shall furnish the services of geotechnical engineers or other consultants for subsoil, air and water conditions when such services are deemed reasonably necessary by the contractor to properly carry out the design services provided by the contractor. Such services may include, but are not limited to, test borings, test pits, determinations of soil bearing values, percolation tests, evaluations of hazardous materials, ground corrosion and resistivity tests, and necessary operations for anticipating subsoil conditions. The services of geotechnical engineer(s) or other consultants shall include preparation and submission of all appropriate reports and professional recommendations.
- The Design Build Contractor shall be responsible to provide surveys of the actual building site describing physical characteristics, and utility locations for the actual building and interconnecting distribution lines. The surveys and legal information shall include, as applicable, grades and lines of access driveways, pavements, drainage, and necessary data pertaining to existing buildings. All the information on the survey shall be referenced to a Project benchmark. THRHA will provide available existing survey and site information.
- Final project design (Construction Documents) to comply with local, state, and federal laws, regulations, and codes. Contractor is required to coordinate THRHA review of final design to ensure project meets THRHA's expectations prior to finalizing Construction Documents, and no construction is to occur prior to final approval of the Construction Documents by THRHA.
- Coordination of any required inspections with the appropriate Building Code Enforcement Officer.
- Acquiring all necessary permits and permissions including but not limited to:
    - Temporary Boiler Operating Permit
    - Boiler Operating Permit

  - National Environmental Policy Act Compliance, including State Historical Preservation Office approval
  - Storm Water Management Plan
  - NPDES Determination E & S Control Plan
  - Building and Construction Permits
  - All necessary operating and occupancy permits
  - Road crossings and coordination with locality and appropriate agencies
- Construction of central plant and fuel storage, installation of equipment, piping and interconnection of the biomass system to the distribution system.
  - Notify THRHA of the timing of all Special Observations and Inspections as required, including but not limited to:
    - Inspection of Fabricators
    - Inspection of steel construction
    - Inspection of concrete construction
    - Inspection of soil conditions
    - Inspection of cast in place concrete foundations
    - Structural observations
  - So a THRHA representative may observe, the contractor will notify THRHA of the timing of and coordinate, facilitate and document the following additional critical tasks:
    - Installation of all insulated buried district heating piping
    - Flushing and cleaning of all piping
    - Cleaning and flushing of the boilers and piping
    - Pressure testing of all installed lines
    - Covering and backfill of all buried piping
    - Installation and cover and backfill of all water and sewer lines
    - Installation and cover and backfill of all conduit for communication and electrical lines
    - Pouring of foundations
  - Coordinate, facilitate, and document all required factory representative inspections to maintain warranties of all piping, mechanical, electrical and building systems.
- Proper disposal of all construction or demolition waste, final grading and seeding of central plant site and restoration of all disturbed grounds and pavement affected by the project to their original condition.
- A final set of as-built plans and specifications and manuals for all components of the project. This is to include as-built piping and instrumentation diagram(s) with corresponding sequence of operations.
  - To include a detailed map showing piping dimensions and locations, shutoff and curb stop locations, and reference points
- Commissioning, testing, and balancing of all installed equipment. Final commissioning addressing any performance issues identified by performance verification efforts by the owner.
- Training of THRHA personnel on the operation and maintenance of all installed equipment and systems.
- Weekly construction progress meetings to provide project updates to THRHA, and shall include, but not be limited to:
  - Meeting minutes documenting items discussed during progress meetings.
  - Updated project schedule showing completed and remaining work tasks.

- The contractor shall secure and pay for building and other permits and governmental fees, licenses and inspections necessary for the proper execution and completion of the Work which are customarily secured after execution of the Design Build Contract and which were legally required on the date the Owner accepted the Design Builder Contractor's proposal.
- Design Build Contractor is to provide a 1 year parts and labor warranty in the base bid for all equipment, material, workmanship, controls, and programming to begin upon project final completion and Owner acceptance. Any warranties provided by manufacturers over and above 1 year will transfer to the Owner upon Owner acceptance.

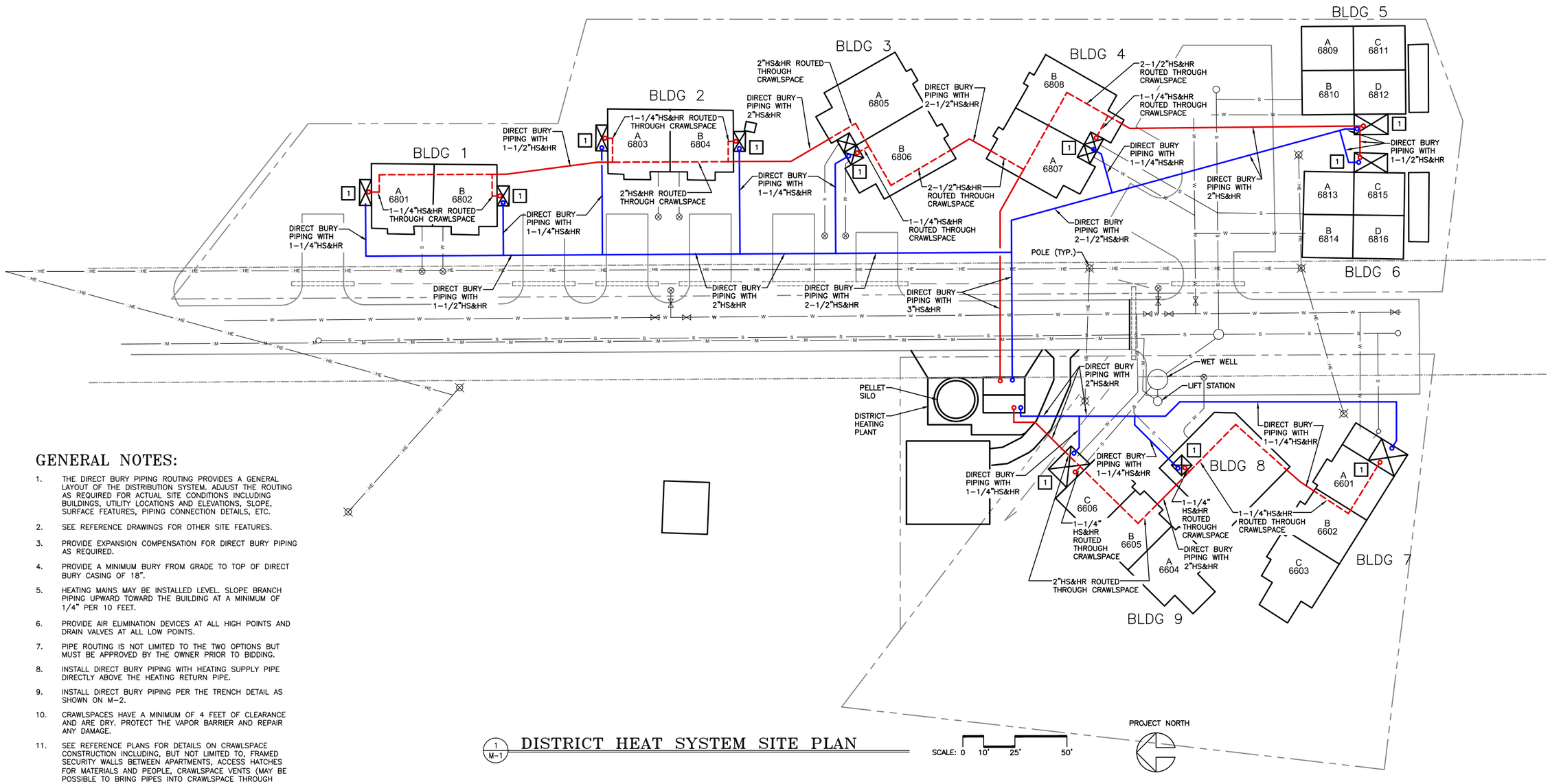
5. ALTERNATES AND UNIT PRICING:

The following describes the alternates listed on the Bid Form.

Alternate 1: (Gravel Pad) – This alternate is to include the construction of an extension of the gravel drive and a 40 ft by 40 ft gravel pad to the west of the area required for the central plant. This is shown on the attached drawings, and is not part of the base bid. This pad would be used at a later date to support containers, upon which a roof structure would be erected to create a covered shop area. The pad would need to be cleared with unsuitable foundations removed and replaced with suitable fill (shot rock with a 10" final layer of D-1 gravel).

Unit Pricing – The following pricing is being requested by THRHA to help assess risk associated with encountering rock and/or other obstacles in the field that have the potential to increase piping lengths or excavation costs. THRHA plans to partner with the winning bidder to ensure that the overall project cost is minimized by identifying and sharing risks. This will ultimately be accomplished through negotiation to develop the final contract.

- Piping & Trenching 3" pre-insulated pipe ($/LF) – to include all costs for procuring and installing supply and return piping of this diameter to include excavation and backfill
- Piping & Trenching 1.25" pre-insulated pipe ($/LF) – to include all costs for procuring and installing supply and return piping of this diameter to include excavation and backfill
- Trench Rock Removal ($/cy) – to include removal and disposal costs for rock within the trench cross-section



1 M-1 DISTRICT HEAT SYSTEM SITE PLAN

GENERAL NOTES:

1. THE DIRECT BURY PIPING ROUTING PROVIDES A GENERAL LAYOUT OF THE DISTRIBUTION SYSTEM. ADJUST THE ROUTING AS REQUIRED FOR ACTUAL SITE CONDITIONS INCLUDING BUILDINGS, UTILITY LOCATIONS AND ELEVATIONS, SLOPE, SURFACE FEATURES, PIPING CONNECTION DETAILS, ETC.
2. SEE REFERENCE DRAWINGS FOR OTHER SITE FEATURES.
3. PROVIDE EXPANSION COMPENSATION FOR DIRECT BURY PIPING AS REQUIRED.
4. PROVIDE A MINIMUM BURY FROM GRADE TO TOP OF DIRECT BURY CASING OF 18".
5. HEATING MAINS MAY BE INSTALLED LEVEL. SLOPE BRANCH PIPING UPWARD TOWARD THE BUILDING AT A MINIMUM OF 1/4" PER 10 FEET.
6. PROVIDE AIR ELIMINATION DEVICES AT ALL HIGH POINTS AND DRAIN VALVES AT ALL LOW POINTS.
7. PIPE ROUTING IS NOT LIMITED TO THE TWO OPTIONS BUT MUST BE APPROVED BY THE OWNER PRIOR TO BIDDING.
8. INSTALL DIRECT BURY PIPING WITH HEATING SUPPLY PIPE DIRECTLY ABOVE THE HEATING RETURN PIPE.
9. INSTALL DIRECT BURY PIPING PER THE TRENCH DETAIL AS SHOWN ON M-2.
10. CRAWLSPACES HAVE A MINIMUM OF 4 FEET OF CLEARANCE AND ARE DRY. PROTECT THE VAPOR BARRIER AND REPAIR ANY DAMAGE.
11. SEE REFERENCE PLANS FOR DETAILS ON CRAWLSPACE CONSTRUCTION INCLUDING, BUT NOT LIMITED TO, FRAMED SECURITY WALLS BETWEEN APARTMENTS, ACCESS HATCHES FOR MATERIALS AND PEOPLE, CRAWLSPACE VENTS (MAY BE POSSIBLE TO BRING PIPES INTO CRAWLSPACE THROUGH VENTS), ETC.
12. SEAL CONCRETE STEM WALL PENETRATIONS WITH APPROVED SEALANT.
13. SECURE ALL APARTMENT DIVIDER WALLS IN CRAWLSPACE WITH ESCUTCHEON SECURED TO EACH SIDE.
14. SIZE DISTRIBUTION PIPING FOR A PRESSURE DROP OF 1.5 FEET PER 100 FEET.

SPECIFIC NOTES:

[1] SEE TYPICAL HEATING PIPING DIAGRAM ON SHEET M-3 FOR BUILDING CONNECTION TO HEATING SYSTEM.

DIRECT BURY PIPING SCHEDULE:

HS & HR PIPE SIZE	CASING DIAMETER
3"	16"
2-1/2"	14"
1-1/2" AND 2"	12"

DISTRIBUTION PIPING OPTIONS:

OPTION	DESCRIPTION	LINE TYPE	
		DIRECT BURY	IN CRAWLSPACE
OPTION 1:	HEATING MAINS RUN PARALLEL TO THE STREET.	———	NA
OPTION 2:	HEATING MAINS ROUTE THROUGH CRAWLSPACES.	———	- - - -

PRELIMINARY NOT FOR CONSTRUCTION

Alaska Energy Engineering LLC
Phone and Fax: (907) 789-1726
E-mail: jim@alaskaenergy.us
25200 Amalga Harbor Road
Juneau, Alaska 99801

Angoon Housing District Heat System

Angoon Alaska

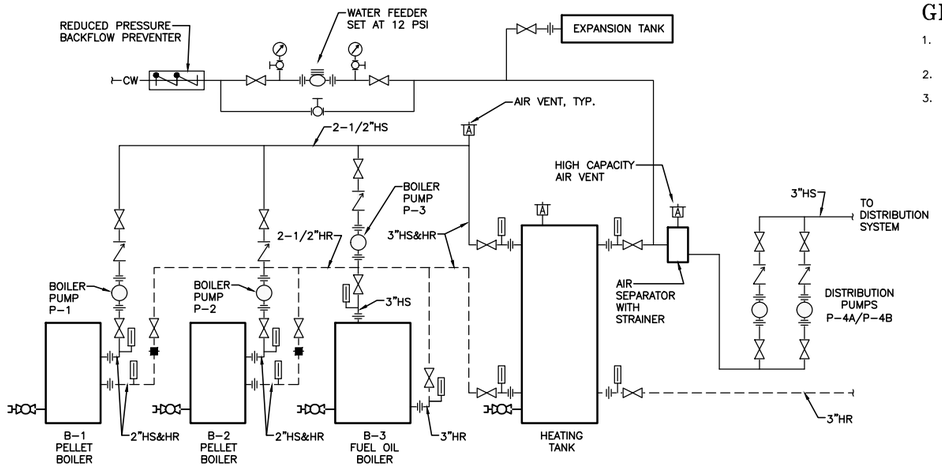
Tlingit-Haida Regional Housing Authority
Design-Build Procurement Package

SHEET TITLE:

DISTRICT HEAT SYSTEM SITE PLAN

Date: DECEMBER, 2015
Scale: As Noted
Drawn: KB
Checked: JR

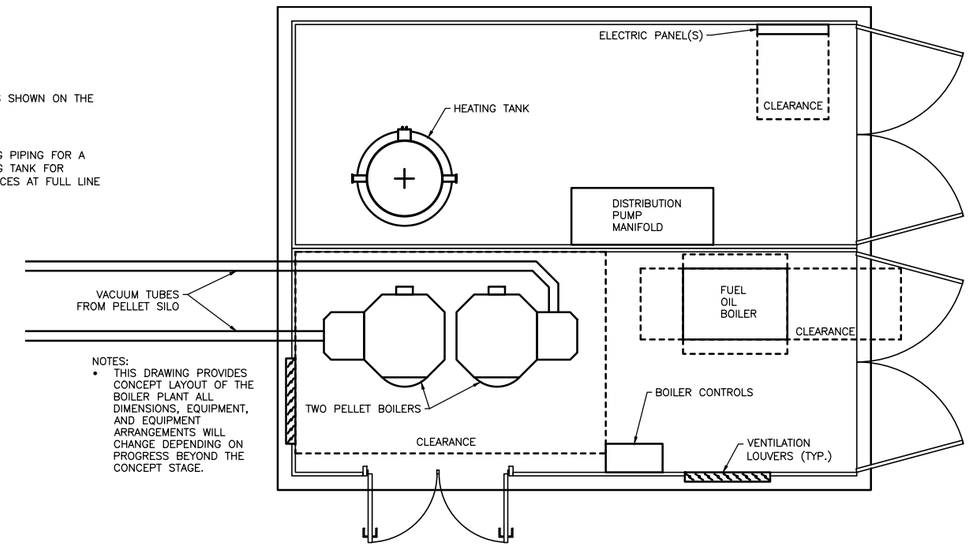
M-1



1 M-2 DISTRICT HEATING PLANT PIPING DIAGRAM

GENERAL NOTES:

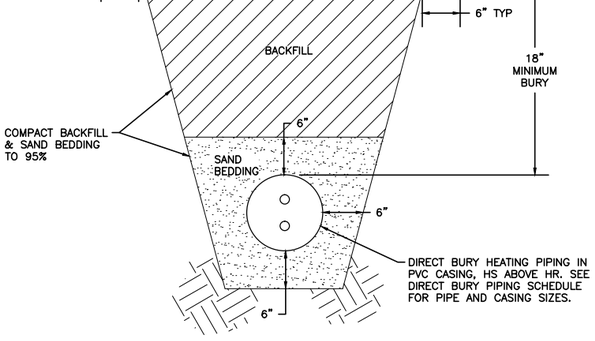
1. PROVIDE A PRIMARY/SECONDARY PIPING ARRANGEMENT AS SHOWN ON THE DISTRICT HEATING PLANT PIPING DIAGRAM.
2. PROVIDE A CHEMICAL FEEDER.
3. MINIMIZE HEATING SYSTEM PRESSURE DROP: SIZE HEATING PIPING FOR A MAXIMUM PRESSURE DROP OF 1.5'/100 FT; SIZE HEATING TANK FOR MAXIMUM 2' OF DROP. PROVIDE PIPING AND APPURTENANCES AT FULL LINE SIZE UP TO CONNECTION TO EQUIPMENT.



NOTES:
- THIS DRAWING PROVIDES CONCEPT LAYOUT OF THE BOILER PLANT ALL DIMENSIONS, EQUIPMENT, AND EQUIPMENT ARRANGEMENTS WILL CHANGE DEPENDING ON PROGRESS BEYOND THE CONCEPT STAGE.

2 M-2 DISTRICT HEATING PLANT PLAN

SCALE: 0 2' 4' 8'



3 M-2 TRENCH DETAIL

DISTRICT HEATING PLANT EQUIPMENT SCHEDULE

EQUIPMENT	CHARACTERISTICS
PELLET BOILER B-1	MANUFACTURER: MAINE ENERGY SYSTEMS MODEL PE56 CAPACITY: MODULATE FROM 57 MBH TO 191 MBH PROVIDE CHLORINE RESISTANT FLAME TUBE.
PELLET BOILER B-2	MANUFACTURER: MAINE ENERGY SYSTEMS MODEL PE56 CAPACITY: MODULATE FROM 57 MBH TO 191 MBH PROVIDE CHLORINE RESISTANT FLAME TUBE.
FUEL OIL BOILER B-3	MANUFACTURER: WEIL MCLAIN MODEL 680 CAPACITY: 551 MBH NET L=B=R WITH FULLY MODULATING BURNER
HEATING TANK	CAPACITY: 250 GALLON STORAGE; TANK AS TALL AS POSSIBLE TO FIT ROOM TO PROMOTE STRATIFICATION; 3" SUPPLY AND RETURN TAPPINGS FOR PLANT AND DISTRIBUTION ON OPPOSING SIDES WITHIN 6" OF TOP AND BOTTOM OF TANK.
BOILER PUMP P-1	CAPACITY: 19 GPM @ 20' HEAD; CONSTANT SPEED ECM MOTOR; MINIMUM 50% WATER-TO-WIRE EFFICIENCY; 120V/SINGLE PHASE.
BOILER PUMP P-2	CAPACITY: 19 GPM @ 20' HEAD; CONSTANT SPEED ECM MOTOR; MINIMUM 50% WATER-TO-WIRE EFFICIENCY; 120V/SINGLE PHASE.
BOILER PUMP P-3	CAPACITY: 55 GPM @ 20' HEAD; VARIABLE SPEED ECM MOTOR; MINIMUM 40% WATER-TO-WIRE EFFICIENCY; 240V/SINGLE PHASE.
DISTRIBUTION PUMP P-4A	CAPACITY: 69 GPM @ 50' HEAD; VARIABLE SPEED ECM MOTOR; 50% WATER-TO-WIRE EFFICIENCY; 240V/SINGLE PHASE. CONTROL: CONSTANT PRESSURE CONTROL, VARIABLE DIFFERENTIAL PRESSURE CONTROL, AND LEAD/STANDBY CONTROL.
DISTRIBUTION PUMP P-4B	CAPACITY: 69 GPM @ 50' HEAD; VARIABLE SPEED ECM MOTOR; 50% WATER-TO-WIRE EFFICIENCY; 240V/SINGLE PHASE. CONTROL: CONSTANT PRESSURE CONTROL, VARIABLE DIFFERENTIAL PRESSURE CONTROL, AND LEAD/STANDBY CONTROL.

ABBREVIATIONS

BLDG	BUILDING
CW	COLD WATER
FM	FORCED MAIN
HS	HEATING SUPPLY
HR	HEATING RETURN
HW	HOT WATER
HX	HEAT EXCHANGER
OHE	OVERHEAD ELECTRIC
S	SEWER
TYP	TYPICAL
W	WATER

GENERAL SYMBOLS

CONNECT TO EXISTING	
EXISTING TO REMAIN	(E)
GENERAL SHEET NOTE	1.
REFERENCED SHEET NOTE	2
DETAIL REFERENCE	1 / M3.1

PIPING SYMBOLS

CONTROL VALVE
GATE VALVE
BACKFLOW PREVENTION DEVICE
DRAIN VALVE WITH HOSE END CONNECTION
AIR VENT (A) AUTOMATIC, (M) MAINUAL
UNION
THERMOMETER
ELBOW, UP
ELBOW, DOWN
CONCENTRIC REDUCER
FLOWSETTER
WATER FEEDER
PRESSURE GAGE
CONNECTION POINT

SEQUENCE OF CONTROL DISTRICT HEATING PLANT

1. Pellet Boilers and Boiler Pumps: A integral control panel supplied with boiler B-1 will operate and modulate both boilers in a lead/lag configuration with weekly rotation of the lead boiler.
   a. Modulate and sequence the boilers to maintain the heating tank temperature setpoint per the heating tank temperature setpoint schedule.
   b. Enable the boilers when the heating tank temperature drops to the enable setpoint and disable the boilers when the heating tank temperature rises to the disable setpoint.
   c. Operate the respective boiler pump 2 minutes prior to enabling its respective boiler and for 5 minutes after the boiler has completed firing.
2. Fuel Oil Boiler: Provide a service switch mounted on the boiler to disconnect power to the burner for servicing.
   a. Sequence and modulate the boiler to maintain a manually selected heating tank temperature setpoint per the heating tank temperature setpoint schedule.
   b. Enable the boiler when the heating tank temperature drops to the enable setpoint and disable the boiler when the heating tank temperature rises to the disable setpoint.
   c. Operate the boiler pump for 2 minutes prior to enabling the boiler and for 5 minutes after the boiler has completed firing.
3. Heating Tank Temperature Setpoint: Set the boiler controls per the following table. The primary fuel source is selected by setting its respective boiler to be the lead boiler.

Heating Tank Temperature Setpoint Schedule

Boiler	Heating Tank SP	Boiler Enable SP	Boiler Disable SP
Winter Settings			
Lead Boiler	185°F	165°F	190°F
Lag Boiler	165°F	155°F	170°F
Summer Settings			
Lead Boiler	165°F	160°F	190°F
Lag Boiler	155°F	145°F	160°F

4. Distribution Pumps
   a. Operation: Operate the pumps in a lead/standby configuration. Modulate the lead pump to maintain a variable differential pressure setpoint. Determine the minimum and maximum flow differential pressure setpoints during balancing. Setpoints shall be as low as possible to provide the building flow rates.
   b. Sequencing: If the lead pump fails to operate, enable the standby pump and initiate an alarm.

PRELIMINARY NOT FOR CONSTRUCTION

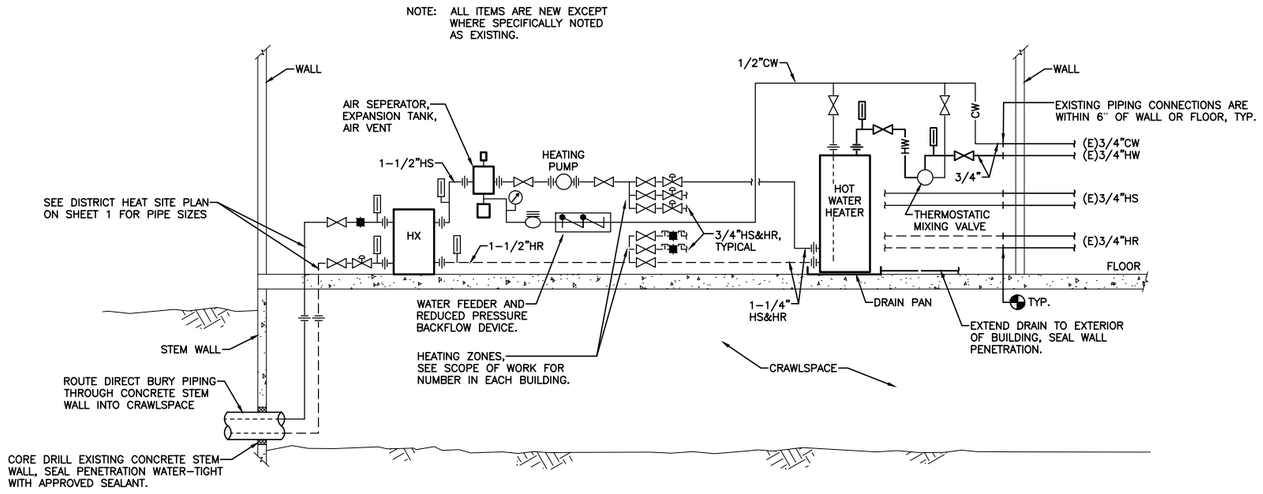
Alaska Energy Engineering LLC
25200 Amalga Harbor Road
Juneau, Alaska 99801
Phone and Fax: (907) 789-1726
E-mail: jim@alaskaenergy.us

Angoon Housing District Heat System
Angoon Alaska
Tlingit-Haida Regional Housing Authority
Design-Build Procurement Package

SHEET TITLE:
DISTRICT HEATING PLANT

Date: DECEMBER, 2015
Scale: As Noted
Drawn: KB
Checked: JR

M-2



1 / M-2 TYPICAL BUILDING PIPING DIAGRAM

SEQUENCE OF CONTROL BUILDING HEATING SYSTEM

1. Heating Supply Temperature: Modulate the heat exchanger automatic valve to maintain a building heating supply setpoint of 180°F.
2. Zone Control: Provide a zone control panel that opens the zone valve when a respective room thermostat or hot water tank temperature sensor calls for heat. Operate the heating pump on a call for heat and disable the pump when there is no call for heat.

BUILDING SCOPE OF WORK
Angoon Housing District Heat System

1.1 DEMOLITION

A. Each apartment has a separate heating system connected to a separate fuel oil tank, except in Building 5, which has one heating system and four fuel oil tanks. Building 8 has one heating system and oil tank.

B. The following apply to each heating system. See the reference drawings for specifics on each heating system.

C. Equipment: Remove the boiler, hot water heater, heating pump, air separator, and expansion tank. Remove the chimney and repair the roof penetration. Remove drain pans under the boilers and hot water heaters and connecting piping.

D. Piping and Appurtenances: Remove the piping within the boiler room including, but not limited to, insulation, valves, control valves, supports, etc.

1. Heating Piping: Remove the heating piping from the boiler to within 6" of the wall penetration.
2. Hot Water Piping: Remove the hot water piping from the hot water heater to within 6" of the wall penetration.
3. Cold Water Piping: Retain the cold water piping or replace in-kind if it hinders the new installation. Remove the branch serving the boiler feed including the isolation valve, water feeder, etc.
4. Seal all floor and wall penetrations.

E. Chimney: Remove the entire chimney, insulate the opening, and patch the inside and outside surfaces to match existing.

1. Building 5: Perform this work on four chimneys.

F. Combustion Air Openings: Remove the louver, insulate the opening, and patch the inside and outside surfaces to match existing.

G. Fuel Oil System: Remove the aboveground fuel tanks, steel and wood support frame, buried fuel oil piping, and all fuel oil piping and appurtenances within the boiler room including supports.

H. Electrical: For each heating system, there is a separate circuit supplying power to the burner, pump, and zone controls. Remove all raceways, conductors, control wiring and control transformer. Retain power circuits (as needed) and the room thermostat control wiring in the new work. Remove all other circuits through the floor and terminate in a new junction box under the floor. Seal floor penetrations.

1.2 NEW WORK

A. General Requirements

1. Scope: Provide new heating systems supplied by the district heating system except as modified in the Building Specific Requirements below. Install each system per the Typical Building Piping Diagram.
2. Layout equipment and piping to provide appropriate access to equipment for maintenance and repair.
3. Provide seismic restraints per code requirements.
4. Electrical: Utilize the existing power circuit for the pump and controls.

B. Building Specific Requirements

1. Building 1: Install a separate heating system for each apartment.
   a. Each heating system has two heating zones and one hot water heater.
   b. Provide a three-way control valve on the hot side of the heat exchanger to provide minimum pump flow for the district heat system. Provide a bypass balance valve, initially set at 2 gpm. Adjust as low as possible to maintain temperature in the distribution system and a reasonable pump speed when none of the heat exchangers are calling for heat.
   c. Apartment A: Provide a three-way control valve on the hot side of the heat exchanger to provide minimum pump flow for the district heat system. Provide a bypass balance valve, initially set at 2 gpm. Adjust as low as possible to maintain temperature in the distribution system and a reasonable pump speed when none of the heat exchangers are calling for heat.
2. Building 2: Install a separate heating system for each of two apartments.
   a. Each heating system has two heating zones and one hot water zone.
3. Building 3: Install one heating system serving two apartments. The building has two adjacent mechanical rooms.
   a. Locate the heating system in one of the mechanical rooms. If there is insufficient space, locate the heat exchanger in one room and the hot water heater in the other.
   b. The heating system has a heating zone for each apartment and one hot water heater.
4. Building 4: Install one heating system serving two apartments. The building has two adjacent mechanical rooms.
   a. Locate the heating system in one of the mechanical rooms. If there is insufficient space, locate the heat exchanger in one room and the hot water heater in the other.
   b. The heating system has a heating zone for each apartment and one hot water heater.
5. Building 5: Install one heating system serving four apartments.
   a. The heating system has a heating zone for each apartment and two hot water heaters.
   b. Provide a three-way control valve on the hot side of the heat exchanger to provide minimum pump flow for the district heat system. Provide a bypass balance valve, initially set at 2 gpm. Adjust as low as possible to maintain temperature in the distribution system and a reasonable pump speed when none of the heat exchangers are calling for heat.
6. Building 6: Install one heating system serving four apartments.
   a. The heating system has a heating zone for each apartment and two hot water heaters.
7. Building 7: Install one heating system serving three apartments.
   a. The heating system has a heating zone for each apartment and one hot water heater.
   b. Provide a three-way control valve on the hot side of the heat exchanger to provide minimum pump flow for the district heat system. Provide a bypass balance valve, initially set at 2 gpm. Adjust as low as possible to maintain temperature in the distribution system and a reasonable pump speed when none of the heat exchangers are calling for heat.
8. Building 8: Install one heating system serving the building
   a. The heating system has three heating zones and one hot water heater.
9. Building 9: Install one heating system serving three apartments.
   a. The heating system has a heating zone for each apartment and one hot water heater.
   b. Provide a three-way control valve on the hot side of the heat exchanger to provide minimum pump flow for the district heat system. Provide a bypass balance valve, initially set at 2 gpm. Adjust as low as possible to maintain temperature in the distribution system and a reasonable pump speed when none of the heat exchangers are calling for heat.

End of Section

PRELIMINARY NOT FOR CONSTRUCTION

Alaska Energy Engineering LLC
25200 Amalga Harbor Road
Juneau, Alaska 99801
Phone and Fax: (907) 789-1726
E-mail: jim@alaskaenergy.us

Angoon Housing District Heat System
Angoon Alaska
Tlingit-Haida Regional Housing Authority
Design-Build Procurement Package

SHEET TITLE:
BUILDING HEATING & DOMESTIC HOT WATER SYSTEMS

Date: DECEMBER, 2015
Scale: As Noted
Drawn: KB
Checked: JR

M-3

TECHNCIAL REQUIREMENTS

THRHA Angoon District Heating System

PART 1 - PERFORMANCE REQUIREMENTS

1.1 CONSTRUCTION ACTIVITIES ON-SITE

A. Daily Work Schedule: Work on the site is allowed daily from 8:00 am to 7:00 pm.

B. Work and Outage Plan: Submit a Work and Outage Plan that describes the work sequence and defines heating and domestic hot water outages.

1. Sequence of Work: Perform the work in accordance with the following sequence:

a. Construct the district heating plant and the distribution system including branches to each heat exchanger with isolation valves.

b. Startup the heating system and make fully operational to heat the buildings.

c. Connect each building to the system.

2. Buildings 1 and 2 (Duplexes):

a. Scope: Replace two separate heating and domestic hot water systems with two separate heating and domestic hot water systems connected to the district heat system.

1) Temporary Heat: Connect building to district heat system with a temporary heat exchanger or use a temporary boiler.

2) Temporary Domestic Hot Water: Connect a temporary hot water heater to the apartment piping and heat it from the temporary heating system.

3) Remove the existing heating and domestic hot water system prior to installing the new system.

b. Allowed Outages:

1) Heating: Two outages, each a maximum of 4 hours.

2) Domestic Hot Water: Two outages, each a maximum 8 hours

3. Buildings 3 and 4 (Duplexes):

a. Scope: Replace two separate heating and domestic hot water systems with two separate heating and domestic hot water systems connected to the district heat system.

1) Temporary Heat: Connect building to district heat system with a temporary heat exchanger or use a temporary boiler.

2) Domestic Hot Water: Connect a temporary hot water heater to the apartment piping and heat it from the temporary heating system.

3) Remove the existing heating and domestic hot water system prior to installing the new system.

b. Allowed Outages:

1) Heating: Two outages, each a maximum of four hours.

2) Domestic Hot Water: Two outages, each a maximum four hours

4. Building 5 (4-plex):
    a. Scope: Replace the heating and domestic hot water system serving all four apartments with a new heating and domestic hot water system connected to all four apartments.
        1) Install the new heating system in the mechanical room.
        2) Connect it to the building heating and domestic hot water distribution systems.
        3) Remove the existing heating system.
    b. Allowed Outages:
        1) Heating: One outage of a maximum 4 hours.
        2) Domestic Hot Water: One outage of a maximum 8 hours.
5. Building 6 (4-plex)
    a. Scope: Replace four separate heating and domestic hot water systems located in the mechanical room with one heating system supplying all four apartments.
        1) Temporarily combine the four heating and domestic hot water systems into two systems, each system serving two apartments. Remove the two heating and domestic hot water systems that were disconnected.
        2) Install the new heating and domestic hot water system.
        3) Connect the new heating and domestic hot water system to all four apartments.
    b. Allowed Outages:
        1) Heating: Two outages of a maximum 4 hours each.
        2) Domestic Hot Water: Two outages of a maximum 8 hours each.
6. Buildings 7 and 9 (Triplex)
    a. Scope: Replace three separate heating and domestic hot water systems located in the mechanical room with one heating system supplying all three apartments.
        1) Temporarily combine the one of the heating and domestic hot water systems with another system. Remove the heating and domestic hot water system that was disconnected.
        2) Install the new heating and domestic hot water system.
        3) Connect the new heating and domestic hot water system to all three apartments.
    b. Allowed Outages:
        1) Heating: Two outages of a maximum 4 hours each.
        2) Domestic Hot Water: Two outages of a maximum 8 hours each.
7. Building 8 (Senior Center):
    a. Scope: Replace the heating and domestic hot water system with a new heating and domestic hot water systems connected to the district heat system.
        1) Temporary Heat: Connect building to district heat system with a temporary heat exchanger or use a temporary boiler.

2) Temporary Domestic Hot Water: Connect a temporary hot water heater to the apartment piping and heat it from the temporary heating system.

3) Remove the existing heating and domestic hot water system prior to installing the new system.

b. Allowed Outages:

1) Heating: Two outages of a maximum 4 hours each.

2) Domestic Hot Water: Two outages, each a maximum 8 hours

1.2 SUBMITTAL REQUIREMENTS

A. Design Documents: Provide the following submittals in PDF format.

1. 50% Submittal

a. Manufacturers data for all equipment

b. Floor plans showing equipment layouts

c. Direct bury piping data, layout drawings, details, and calculations.

d. Control documentation

2. 100% Submittal: Completed design documents including incorporation of 50% comments.

3. Final Submittal: Signed design documents including incorporation of review comments.

B. Manufacturer's Data: Provide manufacturer's data for the following:

1. Pellet boiler and controls
2. Fuel oil boiler and controls
3. Heating tank
4. Heating and domestic hot water piping
5. Pumps
6. Heat exchangers
7. Domestic hot water tanks
8. Thermostatic mixing valve
9. Flow setters
10. Air vents
11. Thermometers
12. Insulation including thickness schedule for existing and new piping
13. Distribution pump controls
14. Building controls

C. Direct Bury Piping

1. Manufacturer's Catalog Data: All components of the piping system including Carrier Pipe; Carrier Pipe Insulation; Pipe Supports; Casing; Joint Kit; Shrink Wrap Sleeve.
2. Drawings: Complete drawings of the direct bury piping design and assembly of the system, materials of construction, and field installation instructions. Submittal shall include sufficient system details required to show that the specified minimum insulation thickness has been met. A detailed design layout of the system (plan and elevation views) showing size, type, elevations and location of each component to be used in the system, the design and location of anchors, pipe guides, pipe supports, expansion loops, Z-bends, L-bends, end seals, leak plates, joint locations, pipe and insulation thickness and sizes, types, and movements, connection to manhole and building wall penetrations, and including, if applicable, transition point design to aboveground or other type systems.
3. The piping layout design shall be prepared and approved by a registered Professional Engineer and certified by his/her stamp.
4. Data: Pipe stress and system expansion calculations: Submit pipe stress and system expansion calculations for each expansion compensation elbow using a finite element computer generated three-dimensional analysis. Calculations (including heat loss calculations) shall demonstrate that pipe stresses from temperature changes are within the allowable requirements in ASME B31.1 and the anchors and the guides will withstand the resultant forces. Layout shall also include all analysis node points. As a minimum, the computer analysis results include node stresses, forces, moments and displacements. Calculations shall be approved, certified, stamped and signed by a registered Professional Engineer in the employ of the manufacturer.
5. Certificates
    a. Manufacturer Certification: Certification that the manufacturer regularly and currently manufactures direct-buried systems, and that the designs of the system and equipment to be provided for this project conform to specification requirements. This certification shall be an original signed by a principal officer.
    b. Contractor Certification: The Manufacturer shall certify each contractor employee that is properly trained to install and test the system. Only certified personnel shall be allowed to install and test the system.
    c. Design: A Certificate of Satisfactory Operation certifying that at least 3 systems installed by the manufacturer within the previous 10 years have and are operating satisfactorily for not less than 5 years. The certificate shall indicate the location, type of system, size of system, point of contact (POC) including phone number, for information verification. This certificate of satisfactory operation shall be an original signed by a principal officer of the manufacturer.
    d. Certificate of Compliance: Upon completion of the work, and before final acceptance, a notarized statement signed by a principal officer of contractor, certifying that the system has been installed satisfactorily and in accordance with the contract drawings, specifications, UHDS manufacturer's detailed design layout drawings and with the UHDS manufacturer's recommendations.
    e. Hot-dip Galvanizing: Provide a statement certifying that the hot-dip galvanizing plant is capable of zinc coating steel components of the system in accordance with the specification requirements.

f. Certification of Contractor's Non-destruction Examination (NDE) personnel

D. As-built Drawings

1. Submit a complete set of as-built construction drawings in PDF and AutoCAD format.
2. Submit all design calculations.

E. O&M Manual

1. Submittals:
   a. Submit a draft O&M manual in PDF format for approval.
   b. Submit a final O&M manual in one 3-ring binder and one electronic copy.
2. Include approved submittal data, installation, operation, and maintenance instructions, parts list and service information for the following:
   a. Pellet boiler and controls
   b. Fuel oil boiler and controls
   c. Pumps
   d. Heating tank
   e. Heat exchangers
   f. Hot water heaters
   g. Thermostatic mixing valves
3. Include the approved direct bury piping submittal
4. Include control documentation for the distribution pumps and building controls.

PART 2 - REQUIREMENTS

2.1 GENERAL

A. See the Preliminary Drawings for additional information on project scope and equipment specifications.

B. Codes: Perform all work in accordance with applicable codes and industry standards.

1. Design Requirements
2. Minimize Electrical Energy: Minimize electrical energy use by the district heating system by minimizing equipment and piping pressure drop. Provide highly efficient ECM motors or NEMA Premium motors.
3. Substitutions: Equipment make and model substitutions shall be approved prior to submitting a bid.

C. Demolition: All items identified for removal become the property of the contractor, unless noted to be retained by the Owner, and shall be promptly removed from the Owner's property at the contractors expense.

D. Equipment and Piping Supports: Provide supports and seismic restraints for all equipment and piping.

E. Electrical: All equipment must be compatible with 120 volt or 240v single-phase service.

F. Insulation:

1. Where repairing insulation that is removed or damaged while performing the work, provide and install pipe and equipment insulation to match the original installation.
2. Insulate all new piping systems and equipment including:
    a. Insulation Blankets: Heat exchangers and flow setters
    b. Fiberglass Insulation: Heating and domestic piping, heating tank, valves, and all appurtenances except unions and pumps.

G. Expansion Compensation: Install all piping with appropriate expansion compensation.

H. Air Vents: Install 1/2" air vents with isolation ball valve at all heating piping high points. Run discharge line to appropriate drainage point outside the building that will preclude freezing.

I. Repairs: Repair all existing features that are damaged during construction to the original condition as found prior to performance of the work.

J. Equipment and Materials: Unless specified otherwise, furnish materials of similar quality and finishes to existing materials.

2.2 HEATING AND DOMESTIC PIPING

A. Copper Tube: ASTM B 88 (ASTM B 88M), Type L (B), drawn

B. Fittings and Joints

1. Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 430 to 535 degrees F.
2. Mechanical press fit joint with gasket equivalent to ProPress acceptable.

C. Pressure Test: All heating and domestic water piping tested hydrostatically at 125 psi for minimum of four hours. System shall remain tight for test period without leaks, displacement, or straining. Equipment, gages, and thermometer wells rated for a lesser pressure suitably protected during tests. Leaks developed during tests shall be corrected without caulking and test restarted until a perfectly tight system is obtained. Enclosed piping tested before concealing. Test performed in presence of Owner.

D. Disinfection of Domestic Water Piping

1. Prior to starting work, verify system is complete, flushed and clean.
2. Ensure pH of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda ash) or acid (hydrochloric).
3. Inject disinfectant, free chlorine in liquid, powder, tablet or gas form, throughout system to obtain 50 to 80 mg/L residual.
4. Bleed water from outlets to ensure distribution and test for disinfectant residual at minimum 15percent of outlets.
5. Maintain disinfectant in system for 24 hours.
6. If final disinfectant residual tests less than 25 mg/L, repeat treatment.
7. Flush disinfectant from system until residual equal to that of incoming water or 1.0 mg/L.
8. Take samples no sooner than 24 hours after flushing, from 10 percent of outlets and from water entry, and analyze in accordance with AWWA C651.

2.3 HEATING TANK

A. Tank: Welded steel, ASME labeled for working pressure of 125 psig, steel support saddles, tappings for accessories, threaded connections of stainless steel, access manhole. Tank shall be insulated with 4-inch thick rigid preformed insulation and jacketed.

B. Lining: 0.024 inches self-priming polymer epoxy continued into flanged connections.

C. Openings: Manway

D. Piping Connections: See drawings for heating piping connections. Include a temperature and pressure relief valve and air vent at the top of the tank. And a temperature sensor well and thermometer well on the front center of tank.

E. Accessories: Tank drain, thermometer range of 40 to 200 degrees F, ASME pressure relief valve suitable for maximum working pressure.

2.4 HEAT EXCHANGER

A. Brazed plate heat exchanger rated for a minimum of 50 psig.

B. The corrugated plate design consisting of stainless steel plates vacuum brazed together to form a durable, integral piece.

C. Channel Plates: Stainless Steel ASTM 316L

D. Brazing Material: Copper

E. Connections: Stainless Steel ASTM 304L

2.5 VALVES

A. Ball Valves: MSS SP-110, Class 150, 400 psi CWP, bronze body, chrome plated brass ball, full port, teflon seats and stuffing box ring, blow-out proof stem, lever handle, Propress, solder, or threaded ends.

B. Drain Valves: with vacuum breaker, threaded hose coupling, and cap with chain

2.6 EXPANSION TANKS

A. Replaceable Bladder type: Welded steel, tested and stamped in accordance with ASME SEC 8-D; rated for working pressure of 150 psig, with replaceable bladder. Steel stand support. Seismic bracing.

2.7 PIPING SPECIALTIES

A. Unions

1. Copper tube and pipe: Class 150 bronze unions with soldered joints.

2. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

B. Flow Setters: Angle or straight pattern, rising stem, inside screw globe valve for 125 psi working pressure, with bronze body and integral union for screwed connections, renewable composition disc, plastic wheel handle for shut-off service, and lockshield key cap and set screw memory bonnet for balancing service.

1. Manufacturers: Bell & Gossett

C. Pipe Markers: Plastic tape indicating flow direction arrow and identification of fluid being conveyed. Label the piping mains on the hot side of each heat exchanger and in the district heating plant.

D. Pipe Hangers: Provide hangers and supports that comply with MSS SP-58. Conform to ASME B31.9. Install hanger outside of pipe insulation and provide galvanized insulation shields.

1. Hanger: Hot dip galvanized steel, adjustable, clevis.
2. Overhead Supports: Individual galvanized steel rod hangers attached to structure or to trapeze hangers.
3. Trapeze Hangers: Welded steel channel

E. Air Vents: Brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.

F. Thermometers: Dial type bimetallic actuated; ASTM E1; stainless steel case, adjustable angle with front recalibration, silicone fluid damping, white with black markings and black pointer, hermetically sealed lens, stainless steel stem. Fill the well with thermo-conductive copper anti-seize paste

1. Size: 5 inch diameter dial
2. Lens: Clear Lexan
3. Accuracy: 1 percent
4. Calibration: Degrees F

G. Insulation

1. Piping: Glass fiber pipe insulation with vapor barrier jacket.
    a. Existing Piping: Match existing pipe insulation thickness.
    b. New Piping and Appurtenances
        1) 1-1/4” and larger: 3” insulation
        2) 1” and smaller: 2” insulation

2. Equipment: Insulate heat exchangers and balancing valves with removable insulating blankets. Equipment blankets shall be custom made to fit the equipment, capable of constant exposure to 200°F, and constructed of:
    a. Outer fabric: A silicone impregnated fiberglass fabric conforming to Mil-C-20079 G, Mil-C-24244, and ASTM E84. Fabric shall have a weight of 15.5 oz/square yard.
    b. Insulation: 1” layer of glass fiber insulation mat (density of 9 lb/ft3 and K-value of 0.4 Btu/in/hr/sqft/_F) sewn to a 2” layer of fiberglass insulation blanket (density of 2 lb/ft3 and K-value of 0.5 Btu/in/hr/sqft/_F). The insulation shall be non-combustible, asbestos free, and durable under moisture exposure.
    c. Attachments: Stainless steel wire and sewn grommets sealed with mastic shall be used to secure the jacket to the equipment.

2.8 CONTROLS

A. Distribution Pumps: Provide a distribution pump lead/standby control system capable of the sequence of control shown on the drawings.

B. Building Heating System: Provide a modulating control for the building heating supply temperature. Provide a zone control panel for the heating and domestic hot water zones capable of the sequence of control shown on the drawings.

2.9 TRENCHING MATERIALS

A. All existing materials that are excavated from the trench and not reused in the new work shall become the contractors property and shall be removed from the site as it is excavated.

B. Pipe Bedding: Bedding, Class A, shall be crushed rock material aggregate, free of muck, frozen material, lumps, organic material, trash, lumber or other debris, conforming to the following gradation:

SIEVE SIZE	% PASSING BY WEIGHT
1-Inch	100
3/8	60-100
No. 4	40-85
No. 10	25-70
No. 40	5-40
No. 200	0-6

1. Execution: Hand rake the bottom of the excavation ahead of placing bedding material to remove all stones, lumps and other protuberances. Place bedding material the full width of trenches in lifts no greater than 8 inches in thickness and compact. Beds shall be hand graded smooth to achieve proper elevation and slope before placement of utilities and/or pipe. Hand dig below bell-and-spigot joints to ensure that the length of the pipe bears on the bedding material and not the joint.

2. Covering Pipe: After the pipe has been laid and approved for covering, the bedding material shall be placed evenly on both sides of the pipe for the full width of the trench. Ensure that initially placed material is tamped firmly under pipe haunches. Bring up evenly on each side and along the full length of the pipe structure. Ensure that no damage is done to the utility or its protective coating. Approval for covering does not imply final acceptance of the pipe.

3. Bedding Material: Shall be thoroughly compacted to not less than 95% of maximum density.

C. Backfill: Use a locally available pit/river run material categorized as one of the following in accordance with ASTM D2487: GW (well-graded gravel), GP (poorly graded gravel), SW (well-graded sand), or SP (poorly graded sand).

1. Shall comply with gradation as shown in the table below when tested per ASTM C136. Submit a Certificate of Compliance verifying conformance to these requirements with a gradation table or graph attached.

Sieve Designation	Percent Passing by Weight
3”	100
1”	90-100
#4	30-70
#200	0-15

2. Compaction: Under gravel or seeded areas, compact succeeding layers of final backfill to 90 percent of maximum density. Under sidewalks, compact succeeding layers to 95 percent of maximum density.

D. Aggregate Base Course: Provide a non-frost-susceptible crushed stone or crushed gravel product meeting the requirements of ADOT Standard Specifications for Highway Construction section 703-2.03, type D-1, with gradation as shown in the following table when tested per ASTM C136. Thoroughly compact to not less than 97% of maximum density.

Sieve Designation	Percent Passing by Weight
1”	100
¾”	70-100
3/8”	50-80
#4	35-65
#8	20-50
#40	8-30
#200	0-6

2.10 DIRECT BURY PIPING

A. Scope: The work includes the design and fabrication, furnishing, installing, and testing of a direct buried underground insulated heating and domestic hot water system consisting of piping as indicated, together with all fittings, anchors, expansion compensation and appurtenances necessary for a complete and operable system.

1. Heating Piping: Jacket with two carrier pipes vertically separated by 1-1/2” of insulation.

B. Design: The direct bury piping manufacturer shall be responsible for the complete design of the piping layout, the product to be supplied, fabrication, and certifying the contractor for installation and testing of the system within the design parameters established by the contract drawings and specifications, and in compliance with the detailed design. The complete design of the direct bury piping system shall be sealed by a Professional Engineer in the employ of the manufacturer.

C. Operating Characteristics – Heating Supply and Return: Operating temperature of 200°F and an operating pressure of 50 psig.

D. Rated Characteristics: All thermal expansion calculations shall be computed using a design expansion length of 125% of the calculated pipe expansion. For calculation purposes the installation temperature (the ambient temperature at the site) shall be no higher than 10°F.

E. Materials

1. Carrier Pipe: Type K Hard Drawn Copper Tubing conforming to ASTM B-88 in 20 foot lengths.
2. Insulation: Polyurethane foam with the following minimum characteristics: K Factor of 0.14, Density 2 pcf, Closed Cell Content 90-95% in conformance with MIL-I-24172 and ASTM C-591 completely filling the annular space between carrier pipes and jacketing.
3. Jacketing Material: High impact, seamless Polyvinylchloride (PVC) Class 12454-B compound conforming to ASTM 1784, Type 1, Grade 1. No FRP jacketing will be allowed.
4. Joining Method: Join lengths of pipe by solder connection.
5. Fittings: All fittings wrought copper in conformance with job specifications and will be insulated and jacketed materials supplied by the system supplier and as per manufacturers standard procedures.
6. End Seals: Each length of pre-insulated pipe will be fitted with a watertight mastic end seal at jacket and pipe surfaces. All field cuts will be sealed with a field applied end seal.
7. Building Penetrations: Core drill concrete foundation walls in locations approved by the Owner. Seal penetrations watertight will sealant filling the entire annual space.
8. Anchors and Expansion Compensation: All pipes shall be anchored and expansion compensated per system supplier's design and recommendations.
9. Approved Vendors: Copper Pipe System by Rovanco, Joliet, Illinois or approved equal.

2.11 ELECTRICAL

A. Conduits: EMT with flexible connections to equipment.

B. Conductors: Copper conductors with THHN/THWN or XHHW insulation.

2.12 TESTING, ADJUSTING AND BALANCING

A. Distribution System: Balance the heating water flow through each boiler and to each building heat exchanger with all heating systems in full heating mode.

B. Buildings: Balance the heating water flow to each heating zone and each hot water heater.

2.13 COMMISSIONING

A. Commissioning the complete system in accordance with the commissioning plan provided by the Owner's Commissioning Authority (CxA).

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Conceptual Design Calculations

December 21, 2015

THRHA Angoon District Heating System
Sizing and Energy Analysis - w/o Church

CONCEPTUAL SIZING

Hot Water Heater Sizing (HUD Sizing per ASHRAE)

Building	Bedrooms	Baths	Storage	Recov, GPH, 120F	Recov, GPH, 140F	MBH	WM Aqua Plus
Building 1 (Typ of 2)	4	2	66	75	60	50	85
Building 2 (Typ of 2)	4	2	66	75	60	50	85
Building 3	6	3	82	75	60	50	85
Building 4	6	3	82	75	60	50	85
Building 5	8	4	132	150	120	100	85 (2)
Building 6	8	4	132	150	120	100	85 (2)
Building 7	3	3	66	66	53	44	85
Building 9	3	3	66	66	53	44	85
Building 8			66	91	73	61	85

Design Heating Loads

	Heat Loss	Existing DHW	Total Load	Existing	Plant Design Load, MBH		
Building	MBH	Load, MBH	MBH	Boiler, MBH	Heat Loss	DHW MBH	Total
Apartment 1A	18	61	79	89	18	50	68
Apartment 1B	18	61	79	89	18	50	68
Apartment 2A	18	61	79	89	18	50	68
Apartment 2B	18	61	79	89	18	50	68
Building 3	36	121	157	178	36	50	86
Building 4	36	121	157	178	36	50	86
Building 5	44	243	287	175	44	100	144
Building 6	44	243	287	356	44	100	144
Building 7	30	182	212	267	30	44	74
Building 8	61	61	121	124	61	61	121
Building 9	30	182	212	267	30	44	74
Totals	353	1,396	1,749	1,901	353	649	1,002
							53%

Distribution Losses

Length, Inft	Btuh/Inft	MBH
1,100	12	13

Heating Plant Design Load

Load	Peak MBH	Load Factor	Design MBH
Heating	353	100%	353
Distribution Losses	13	100%	13
Domestic Hot Water	649	50%	325
Totals	1,015		691

Sizing Analysis

Boilers	Boiler	Type	Design Load, MBH	Factor	Boiler MBH
	B-1	Pellet	691	28%	191
	B-2	Pellet	691	28%	191
	B-3	Fuel Oil	691	80%	551
				135%	934

Pumps	Service	Pump	GPM	Head	η, pump	Pump, BHP	η, motor
	B-1	P-1	19	20	50%	0.2	70%
	B-2	P-2	19	20	50%	0.2	70%
	B-3	P-3	55	20	60%	0.5	70%
	Distribution	P-4A	69	50	65%	1.3	80%
	Distribution	P-4B	69	50	65%	1.3	80%

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Conceptual Design Calculations

December 21, 2015

THRHA Angoon District Heating System

Sizing and Energy Analysis - w/o Church

ENERGY USE

Historical Fuel Oil Consumption

Building	Gallons
Building 1	1,373
Building 2	1,377
Building 3	962
Building 4	1,228
Building 5	1,723
Building 6	1,607
Building 7	1,548
Senior Center	1,149
Building 9	1,167
Totals	12,134

ENERGY ANALYSIS

Existing Heating Systems

	Gallons	n, boiler	kBtu/gal	Net kBtu
Fuel Oil	12,134	70%	138.5	1,176,371

Boiler Burners	Building	Boilers	kW,ea	Oil, gal	Oil, GPH	Hours	kWh
	Building 1	2	0.2	1,373	0.75	1,831	410
	Building 2	2	0.2	1,377	0.75	1,836	411
	Building 3	2	0.2	962	0.75	1,283	287
	Building 4	2	0.2	1,228	0.75	1,637	366
	Building 5	1	0.2	1,723	1.45	1,188	266
	Building 6	4	0.2	1,607	0.75	2,143	480
	Building 7	3	0.2	1,548	0.75	2,064	462
	Senior Center	1	0.2	1,149	1.05	1,094	245
	Building 9	3	0.2	1,167	0.75	1,556	348
	Totals	20					3,275

District Heating System

	Net kBtu	Factor	n, boiler	Conversion	Fuel	
Pellets	1,176,371	90%	70%	15,560	97	tons
Fuel Oil	1,176,371	10%	70%	138.5	1,213	gallons
			inc dist losses			

Boiler Burner	Boiler, MBH	Net kBtu	Load factor	Load, kW	Hours	kWh
	191	1,176,371	70%	0.25	6,570	1,643

Pellet Handling				Hours	kW	kWh
				500	0.2	100

Pumps	Pump	Ave GPM	Head	Hours	kW	kWh
	P-1	19	20	7,500	0.3	2,074
	P-2	19	20	4,000	0.3	1,106
	P-3	55	20	500	0.7	332
	P-4A	25	30	8,760	0.4	3,194
				Average Demand, kW	1.8	6,706

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Juneau, Alaska 99801

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jim@alaskaenergy.us

THRHA Angoon District Heating System

Sizing and Energy Analysis - w/o Church

Monthly Pellet Consumption

Month	Percent	MESys, tons
Jan	14%	14
Feb	12%	12
Mar	11%	10
Apr	8%	8
May	6%	6
Jun	4%	4
Jul	4%	4
Aug	4%	4
Sep	6%	5
Oct	8%	8
Nov	11%	10
Dec	13%	12
	100%	97

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
alaskaenergy@gci.net

Life Cycle Cost Analysis

December 21, 2015

THRHA Angoon District Heating System

Existing Heating Plants

Basis

35	Study Period (years)	2.8%	General Inflation
4.5%	Nominal Discount Rate	3.3%	Fuel Inflation
1.7%	Real Discount Rate	4.0%	Electricity Inflation
		2.7%	Wood Pellet Inflation

Annual Costs		Years	Qty	Unit	Base Cost	Life Cycle Cost	Annual Cost
Heating Plant							
Fuel Oil Boilers							
Fuel Oil Boiler Maintenance							
Parts Allowance, each		1 - 35	20	LS	$100.00	$51,528	$2,000
Monthly, each	0.5 hours/month	1 - 35	120	hrs	$40.00	$123,667	$4,800
Annual, each	4 hours/year	1 - 35	80	hrs	$40.00	$82,445	$3,200
Pumps							
Pump maintenance, cartridge		1 - 35	20	ea	$100.00	$51,528	$2,000
Domestic Hot Water							
Indirect HW heater		1 - 35	20	hrs	$40.00	$20,611	$800
					Total Annual Costs	**$330,000**	**$12,800**

Energy Costs	Years	Qty	Unit	Base Cost	Life Cycle Cost	Annual Cost
Fuel Oil	1 - 35	12,134	gallon	$4.73	$1,643,211	$57,407
Wood Pellets	1 - 35	0	ton	$472.42	$0	$0
Electricity	1 - 35	3,275	kWh	$0.661	$61,968	$2,165
				Total Energy Costs	**$1,705,000**	**$59,572**

	Life Cycle Cost	Annual Cost
Present Worth	**$2,035,000**	**$72,372**

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 alaskaenergy@gci.net

Life Cycle Cost Analysis

December 21, 2015

THRHA Angoon District Heating System

District Heat Plant

Basis

35	Study Period (years)	2.8%	General Inflation
4.5%	Nominal Discount Rate	3.3%	Fuel Inflation
1.7%	Real Discount Rate	3.3%	Electricity Inflation
		2.7%	Wood Pellet Inflation

Annual Costs		Years	Qty	Unit	Base Cost	Present Value	Annual Cost
Heating Plant							
Plant Observation							
Daily Heating Plant Observatic	5 min/day	1 - 35	30	hrs	$40.00	$31,346	$1,217
Wood / Fuel Oil Boilers							
Fuel Oil Boiler Maintenance							
Parts Allowance, each		1 - 35	1	LS	$200.00	$5,153	$200
Monthly, each	1.5 hours/month	1 - 35	18	hrs	$40.00	$18,550	$720
Annual, each	8 hours/year	1 - 35	8	hrs	$40.00	$8,244	$320
Pellet Boiler Maintenance - Small Capacity							
Parts Allowance, each		1 - 35	2	LS	$150.00	$7,729	$300
Monthly, each	2 hours/month	1 - 35	48	hrs	$40.00	$49,467	$1,920
2000 hour maintenance	8 hours/year	1 - 35	16	hrs	$40.00	$16,489	$640
Pellet Handling System							
Maintenance		1 - 35	16	hrs	$40.00	$16,489	$640
Equiipment Replacement							
Pellet boilers		20 - 20	1	LS	$70,000.00	$49,099	$2,000
Vacuum system		10 - 10	1	LS	$1,500.00	$1,246	$1,500
Vacuum system		30 - 30	1	LS	$1,500.00	$889	$1,500
Domestic Hot Water							
Indirect HW heater		1 - 35	12	hrs	$40.00	$12,367	$480
Pumps							
Pump maintenance, cartridge		1 - 35	11	ea	$100.00	$28,340	$1,100
Pump maintenance, pipe mounted		1 - 35	5	ea	$250.00	$32,205	$1,250
					Total Annual Costs	**$278,000**	**$13,787**

Energy Costs	Years	Qty	Unit	Base Cost	Present Value	Annual Cost
Fuel Oil	1 - 35	1,213	gallon	$4.73	$164,321	$5,741
Wood Pellets	1 - 35	97	ton	$472.42	$1,193,758	$45,921
Electricity	1 - 35	8,448	kWh	$0.630	$152,381	$5,324
				Total Energy Costs	**$1,510,000**	**$56,985**

	Life Cycle Cost	Annual Cost
Present Worth	**$1,788,000**	**$70,772**

HAINES – LOW-RENT HOUSING HEATING CONVERSION ANALYSIS

THRHA Regional Housing Authority
Juneau, Alaska

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
jim@alaskaenergy.us

Technical Memorandum

December 15, 2015

to: **Craig Moore, V.P. Planning and Development**
Tlingit-Haida Regional Housing Authority

subject: **Heating Conversion Analysis**

project: **Haines Low Rent Housing**

INTRODUCTION

This report presents a heating conversion analysis for the Haines Low Rent Apartment building. The purpose of the analysis is to compare the life cycle cost of retaining the fuel oil boiler heating system with converting to an air source heat pump heating system.

Jim Rehfeldt, P.E. of Alaska Energy Engineering LLC performed the analysis.

Background

The Tlingit-Haida Regional Housing Authority (THRHA) intends to convert the Haines Low Rent Apartment building in Haines, Alaska from fuel oil boiler heat to air source heat pump heat.

The existing heating system consists of two oil-fired boilers supplying an indirect hot water heater and a high-temperature distribution system consisting of baseboard units located in each apartment. The heating plant—fuel oil boilers, heating pumps, fuel oil tank—is 6 years old, in very good condition and has an expected service life of over 25 years. The distribution system is at the end of its service life.

The THRHA is interested in converting to a heat pump system by adding an air source heat pump, domestic hot water preheat tank heated by the heat pump and a low temperature distribution system and baseboard heaters.

Conversion to an air source heat pump system is aligned with THRHA energy goals to:

- Reduce long-term operating costs
- Increase use of sustainable energy sources: the majority of electricity in Haines is derived from hydroelectric generation
- Increase use of local energy sources, and
- Decrease the greenhouse gas footprint of their operations

ENERGY COSTS

Historic Energy Use and Cost

The Haines Low Rent Apartments is a 6,930-sqft facility that contains 12 apartments and a common hallway, laundry room, kitchen and dining room. Two fuel oil boilers supply heat to the spaces and heat domestic hot water. Historic energy use and cost is summarized in the following table:

Annual Energy Consumption and Cost

Source	Consumption	Cost	Energy, MMBtu	
Electricity	22,480 kWh	$5,474	77	12%
Fuel Oil	4,314 Gallons	$16,100	586	88%
Totals	-	$21,574	663	100%

The building has an energy use index (EUI) of 97, which is relatively high for THRHA facilities. Converting to an air source heat pump system will reduce energy costs.

Energy Costs and Inflation

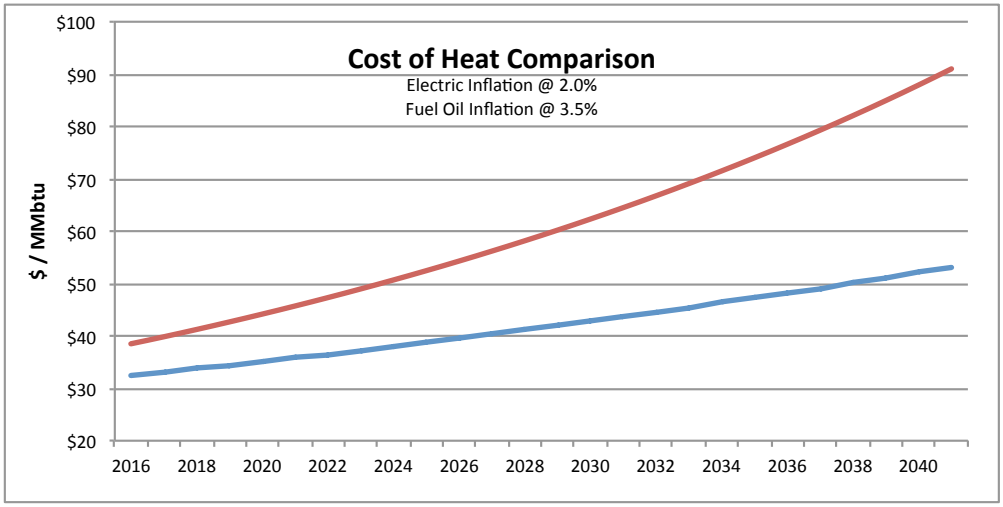
Energy costs and energy inflation used in the analysis are shown in the following table:

Summary of Economic and Energy Factors

Factor	Rate or Cost	Factor	Rate or Cost
Nominal Discount Rate	4.5%	General Inflation Rate	2.5%
Electricity (2016)	24.6¢ per kWh	Electricity Inflation	2.0%
Fuel Oil (2016)	$3.97 / gallon	Fuel Oil Inflation	3.5%

Cost of Heat Comparison

The cost of heat takes into account current energy prices, conversion efficiency, and energy inflation. The following chart shows projected energy prices over 25-years. On the left side of the chart is the cost of heat in 2016. Moving to right is how the cost changes with energy inflation.



An air source heat pump offers much lower heating costs over the life of the project because it extracts a majority of the supplied heat from the environment at no cost or energy inflation.

LIFE CYCLE COST COMPARISON

Description of Systems

The existing fuel oil boiler heating system requires investment to operate for the next 25-years. The plant—two boilers, pumps, fuel tank and appurtenances—are 6 years old and have over 25-years of remaining life. The distribution system and baseboard heating units are at the end of their service life and require replacement.

The analysis compares retaining the fuel oil boiler system with converting to an air source heat pump system. Conversion requires adding an air source heat pump and domestic hot water preheat tank and replacing the distribution system and baseboards with a low temperature system.

Attached to this report is a schematic diagram of the two systems.

Fuel Oil Boiler Option

A fuel oil boiler heating system will consist of:

- Retaining the two existing fuel oil boilers, each sized for 102% of the heating load and the two constant speed building pumps.
- Retaining the existing fuel oil tank and fuel oil system
- Retaining the indirect hot water heater
- Replacing the distribution system piping, baseboard heating units, and thermostats.

The fuel oil boilers are significantly oversized and have an estimated seasonal efficiency of 68%.

Air Source Heat Pump Option

An air source heat pump system will consist of:

- An air source heat pump located outdoors under an enclosure that protects it from wind-driven rain and snow and two indoor heat exchangers that transfer the heat to a low-temperature hydronic heating system.
- A buffer tank that adds thermal mass to the system.
- Two variable speed building pumps supplying low-temperature hydronic heat.
- Retaining one fuel oil boiler to provide supplemental heat during colder weather and to heat domestic hot water.
- An indirect hot water preheat tank heated by the heat pump to 115°F and an indirect hot water tank heated by the boiler to 125 °F.

The air source heat pump sized at 65% of the design load will supply 92% of the heating load. The fuel oil supplements the heating load during cold weather and will also supply supplemental heat to maintain the hot water supply temperature of 125°F.

Life Cycle Cost Comparison

Construction Costs

The fuel oil boiler system has lower construction costs because the heating plant is retained and only the distribution system is replaced. The heat pump represents an investment in higher efficiency so it has higher construction costs. The higher cost is primarily attributed to the following features of the ASHP system:

- Adding a heat pump, heat exchangers and a buffer tank to the building.
- The electrical service will be upgraded from 240v/1ϕ to 208v/3ϕ service.
- The ASHP system requires a low temperature distribution system with larger pumps and piping and higher cost baseboard heaters.

Maintenance Costs

The air source heat pump system has moderately higher maintenance costs associated with maintaining the outdoor units, including factory-trained maintenance every five-years. The outdoor units must also be replaced at the end of their expected service life of 15 years.

The fuel oil boilers require annual maintenance for the burner and to clean the combustion passages.

Energy Costs

The following table summarizes the energy analysis of the two heating options. The ASHP system offers a reduction in energy use and costs.

Energy Analysis

Item	Fuel Oil Boilers	Air Source Heat Pump
Heating Plant Sizing	Two exist @ 101% ea	ASHP @ 65% Fuel Boiler @ 101%
Seasonal Efficiency	68%	214%
Annual Energy Use	Oil: 4,314 gal Elec: 2,313 kWh	Elec: 52,848 kWh Oil: 335 gallons
Annual Energy Cost (2016)	$17,700	$14,300
Energy Use Index, kBtu/sqft	97	43
Energy Cost Index, $/sqft	$3.17	$2.70

Life Cycle Cost Comparison

The fuel oil boiler system has a lower life cycle cost, primarily because the heating plant requires no investment over the next 25-years. The air source heat pump has the lowest energy costs and the fuel oil boiler system has lower construction and maintenance costs.

Life Cycle Cost Comparison

Component	Fuel Oil Boiler	Air Source Heat Pump	% Difference
Construction Costs	$131,000	$515,000	+293%
Maintenance Costs	$29,000	$50,000	+72%
Energy Costs	$390,000	$269,000	-31%
Total Life Cycle Cost	$550,000	$834,000	+152%

The life cycle cost comparison is much closer if 50% of the construction cost is grant funded. The following table shows the cost comparison with 50% grant funding.

Life Cycle Cost Comparison – 50% Grant Funding

Component	Fuel Oil Boiler	Air Source Heat Pump	% Difference
Construction Costs	$131,000	$258,000	+97%
Maintenance Costs	$29,000	$50,000	+72%
Energy Costs	$390,000	$269,000	-31%
Total Life Cycle Cost	$550,000	$577,000	+5%

SUMMARY

For THRHA, this conversion offers several financial and operational benefits that promote conversion. The main benefit is a significant reduction in annual operating costs, helping to keep rents low. An ASHP conversion is also aligned with THRHA's goal to transition away from fuel oil toward sustainable, local energy sources. A high percentage of Haines's power is expected to be renewable hydroelectric power throughout the life of the system. As such, an ASHP system also has lower environmental impacts because it does not emit greenhouse gases.

This project can also benefit other building owners in Haines in the following ways:

- Hydroelectric communities are promoting heat pump heating as an efficient use of hydroelectric resources. The project demonstrates heat pump conversion of an existing building.
- Air source heat pump technology has improved greatly in the last five years to the point that they are viable systems in the relatively warmer climate of coastal Alaska. As the technology continues to gain efficiency, the lessons learned from this conversion will benefit more areas of Alaska.
- The recent drop in oil prices may lead to complacency in addressing future energy issues. By promoting heat pump technology and demonstrating its success now, the THRHA can make positive steps toward improving energy efficiency and lowering long-term energy costs.

This project will successfully demonstrate that heat pump technology is a viable option that offers long-term benefits to THRHA.

by: 

Jim Rehfeldt, P.E.

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Life Cycle Cost Analysis

December 15, 2015

THRHA Haines Low Rent Housing
Sizing and Energy Analysis

Building Loads

	Exist, MBH	ASHP Load, MBH	Energy, kBTU
Heat Loss	134	134	406,293
DHW	76	60	
Total	210	194	

Fuel Oil Boiler System

Sizing Analysis

Boilers	Boiler	Design Load, MBH	Factor	Boiler MBH
	B-1	210	101%	212
	B-2	210	101%	212
			202%	424

Pumps	Pump	GPM	Head	η, pump	Pump, BHP	η, motor	kW
	Building	21	32	50%	0.34	60%	0.422

Energy Analysis

Fuel Oil Boilers	Load, kBTU	% Load	Net, kBTU	Efficiency	kBTU/gal	Fuel, gals
	406,293	100%	406,293	68%	138.5	4,314

Heating Pumping	Pump	Ave GPM	Ave Head	kW	Hours	kWh
	Building	21	20	0.26	8,760	2,313

Air Source Heat Pump System

Sizing Analysis

Heating Equipment	Equip	Design MBH	Factor	Size, MBH	Effic	kW
	ASHP-1	194	65%	126	200%	18
	Fuel Oil Boiler	194	109%	212		
			174%	338		

Heat Exchangers	Equip	Design MBH	Factor	Size, MBH
	HEX-1	126	50%	63
	HEX-2	126	50%	63
			100%	126

Pumps	Pump	GPM	Head	η, pump	Pump, BHP	η, motor
	HEX Pump	13	10	50%	0.06	60%
	HEX Pump	13	10	50%	0.06	60%
	Fuel Oil Boiler	21	12	50%	0.13	70%
	Injection	21	12	50%	0.13	70%
	Building	21	20	50%	0.21	70%

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Juneau, Alaska 99801 jim@alaskaenergy.us

Life Cycle Cost Analysis

December 15, 2015

THRHA Haines Low Rent Housing
Sizing and Energy Analysis

Energy Analysis

	Load, kBTU	% Load	Net, kBTU
Heat Pumps	406,293	92%	373,789

Month	% Load	Load kBtu	Ave Temp	COP	Input kBtu	kWh
Jan	12%	44,855	24	1.7	27,030	7,922
Feb	10%	37,379	28	1.7	21,819	6,395
Mar	10%	37,379	33	1.9	20,050	5,876
Apr	8%	29,903	42	2.4	12,597	3,692
May	6%	22,427	50	3.0	7,533	2,208
Jun	5%	18,689	56	3.4	5,531	1,621
Jul	5%	18,689	59	3.5	5,320	1,559
Aug	6%	22,427	57	3.4	6,537	1,916
Sep	8%	29,903	51	3.1	9,799	2,872
Oct	9%	33,641	43	2.4	13,757	4,032
Nov	10%	37,379	31	1.8	20,859	6,113
Dec	11%	41,117	28	1.7	24,001	7,034
	100%	373,789		214%	174,832	51,240

Fuel Oil Boiler	Load, kBTU	% Load	Net, kBTU	Efficiency	kBTU/gal	Fuel, gals
	406,293	8%	32,503	70%	138.5	335

Pumps	Pump	Ave GPM	Ave Head	kW	Hours	kWh
	HEX Pump	13	10	0.1	7,500	594
	HEX Pump	13	10	0.1	4,000	317
	Fuel Oil Boiler	21	12	0.1	1,500	206
	Injection	21	12	0.1	750	103
	Building	8	12	0.1	7,500	388
						1,608

Electric Service Capacity

					Total kWh	52,848

Spare Capacity

Service Size: 240 volts / 400A	96 kVA
Capacity kVA (Assume 80%)	77 kVA
Capacity kW (Assume 90% PF)	69 kW
Peak Load	55 kW
Spare capacity	14 kW

Increased Electric Service	Qty	kW, ea	Total kW	kVA @ 90% PF	Volts	Amps
Existing Service	1	55	55	61	208	170
Heat Pump	1	18	18	21	208	57
			73	82	208	227

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
jim@alaskaenergy.us

Life Cycle Cost Analysis

December 15, 2015

THRHA Haines Low Rent Housing

Fuel Oil Boiler System

Basis

25	Study Period (years)	2.5%	General Inflation
4.5%	Nominal Discount Rate	3.5%	Fuel Inflation
2.0%	Real Discount Rate	2.0%	Electricity Inflation

Construction Costs		Year	Qty	Unit	Base Cost	Year 0 Cost
Hydronic Heating System						
Distribution System						
Building loop	1-1/4"	0	940	lnft	$35.00	$32,900
Finned pipe branches	3/4"	0	540	lnft	$25.00	$13,500
Finned pipe convectors		0	320	lnft	$75.00	$24,000
Thermostats and control valves		0	14	ea	$250.00	$3,500
Contingencies						
Estimating contingency		0			15%	$11,085
Overhead & profit		0			30%	$25,496
Design fees		0			10%	$11,048
Project management		0			8%	$9,722
					Total Construction Costs	**$131,000**

Annual Costs	Maintenance	$40.00	Years	Qty	Unit	Base Cost	Present Value
Heating Plant							
Plant Observation							
Daily Heating Plant Observation	30 min/mo		1 - 25	6	hrs	$40.00	$4,622
Fuel Oil Boilers							
Fuel Oil Boiler Maintenance							
Parts Allowance, each			1 - 25	2	LS	$200.00	$7,704
Annual, each	8 hours/year		1 - 25	16	hrs	$40.00	$12,326
Pumps							
Pump maintenance, cartridge			1 - 25	2	ea	$100.00	$3,852
Domestic Hot Water							
Indirect HW heater	1	1	1 - 25	1	hrs	$40.00	$770
						Total Annual Costs	**$29,000**

Energy Costs	Years	Qty	Unit	Base Cost	Present Value
Fuel Oil	1 - 25	4,314	gallon	$3.97	$379,182
Electricity	1 - 25	2,313	kWh	$0.245	$10,490
				Total Energy Costs	**$390,000**

Present Worth	$550,000

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Life Cycle Cost Analysis

December 15, 2015

THRHA Haines Low Rent Housing

Air Source Heat Pump System

Basis

25	Study Period (years)	2.5%	General Inflation
4.5%	Nominal Discount Rate	3.5%	Fuel Inflation
2.0%	Real Discount Rate	2.0%	Electricity Inflation

Construction Costs		Year	Qty	Unit	Base Cost	Year 0 Cost
Hydronic Heating System						
Crawlspace Mechanical Room						
Outdoor units		0	1	ea	$21,600.00	$21,600
Enclosure		0	1	ea	$3,000.00	$3,000
Refrigerant piping		0	2	ea	$1,200.00	$2,400
Indoor HEX units		0	2	ea	$9,000.00	$18,000
HEX pumps		0	2	ea	$1,200.00	$2,400
Buffer Tank	200 gallons	0	1	LS	$9,600.00	$9,600
Piping to building heating loop		0	2	ea	$1,800.00	$3,600
Boiler Room						
Demolition						
Remove fuel oil boiler, fuel piping, cap chimney		0	1	LS	$7,200.00	$7,200
Remove heating and domestic hot water piping		0	1	LS	$2,400.00	$2,400
Heating Plant						
Boiler Room						
Boiler piping and appurtenances	2"	0	1	LS	$2,400.00	$2,400
Injection pump and piping	1-1/2"	0	1	LS	$8,400.00	$8,400
Primary pump, pipe mounted	1/4 HP	0	1	LS	$1,200.00	$1,200
Secondary loop						
Secondary pumps	1/2 HP	0	2	ea	$2,100.00	$4,200
Secondary piping and appurtenances (boiler room)	2"	0	1	lot	$4,200.00	$4,200
Building loop	1-1/4"	0	940	lnft	$42.00	$39,480
Finned pipe branches	3/4"	0	540	ea	$30.00	$16,200
Finned pipe convectors		0	320	lnft	$108.00	$34,560
Thermostats and control valves		0	14	ea	$300.00	$4,200
Domestic Hot Water System						
Indirect HW heater, AV, piping, etc.	120 gallon	0	1	ea	$10,440.00	$10,440
Connect existing Indirect HW heater		0	1	LS	$1,800.00	$1,800
Domestic cold and hot water piping		0	1	ea	$6,000.00	$6,000
Miscellaneous						
Controls		0	1	LS	$7,200.00	$7,200
Test and balance		0	40	hrs	$180.00	$7,200
Commission heating system		0	1	lot	$6,000.00	$6,000
Electrical						
Three phase service		0	1	ea	$6,000.00	$6,000
Single phase service		0	7	ea	$1,800.00	$12,600
CT Enclosure		0	1	LS	$6,000.00	$6,000
208v/3-phase panel		0	1	LS	$8,400.00	$8,400
Connect existing panel		0	1	LS	$3,000.00	$3,000
Upgrade service from 240v/1-phase to 208v/3-phase		0	1	LS	$50,000.00	$50,000
Contingencies						
Estimating contingency		0			15%	$38,952
Overhead & profit		0			30%	$89,590
Design fees		0			10%	$38,822
Project management		0			8%	$38,163.50
					Total Construction Costs	**$515,000**

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
jim@alaskaenergy.us

Life Cycle Cost Analysis

December 15, 2015

THRHA Haines Low Rent Housing

Air Source Heat Pump System

Annual Costs	Maintenance	$40.00	Years	Qty	Unit	Base Cost	Present Value
Heating Plant							
Plant Observation							
Daily Heating Plant Observation	30	min/mo	1 - 25	6	hrs	$40.00	$4,622
Air-source Heat Pump Maintenance							
Parts Allowance			1 - 25	1	LS	$200.00	$3,852
Monthly	0.5	hours/month	1 - 25	6	hrs	$40.00	$4,622
Every Three Months	0.67	hours/3 months	1 - 25	3	hrs	$40.00	$2,054
Annual	8	hours/year	1 - 25	8	hrs	$40.00	$6,163
Five Year Maintenance	4	hours/year	5 - 5	4	hrs	$110.00	$392
Five Year Maintenance	4	hours/year	10 - 10	4	hrs	$110.00	$356
Five Year Maintenance	4	hours/year	20 - 20	4	hrs	$110.00	$293
Electric buffer tank			1 - 25	1	hrs	$40.00	$770
Air-source Heat Pump Replacement							
Replace outdoor units			15 - 15	1	LS	$16,200.00	$11,891
Pumps							
Pump maintenance, cartridge			1 - 25	4	ea	$100.00	$7,704
Pump maintenance, pipe mounted			1 - 25	2	ea	$150.00	$5,778
Domestic Hot Water							
Indirect HW heater			1 - 25	2	hrs	$40.00	$1,541
						Total Annual Costs	**$50,000**

Energy Costs	Years	Qty	Unit	Base Cost	Present Value
Fuel Oil	1 - 25	335	gallon	$3.97	$29,468
Electricity	1 - 25	52,848	kWh	$0.245	$239,703
				Total Energy Costs	**$269,000**

Present Worth	$834,000

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

THRHA Haines Low Rent Housing

Air Source Heat Pump System - 50% Grant Funding

Basis

25	Study Period (years)	2.5%	General Inflation
4.5%	Nominal Discount Rate	3.5%	Fuel Inflation
2.0%	Real Discount Rate	2.0%	Electricity Inflation

Construction Costs		Year	Qty	Unit	Base Cost	Year 0 Cost
Hydronic Heating System						
Crawlspace Mechanical Room						
Outdoor units		0	1	ea	$21,600.00	$21,600
Enclosure		0	1	ea	$3,000.00	$3,000
Refrigerant piping		0	2	ea	$1,200.00	$2,400
Indoor HEX units		0	2	ea	$9,000.00	$18,000
HEX pumps		0	2	ea	$1,200.00	$2,400
Buffer Tank	200 gallons	0	1	LS	$9,600.00	$9,600
Piping to building heating loop		0	2	ea	$1,800.00	$3,600
Boiler Room						
Demolition						
Remove fuel oil boiler, fuel piping, cap chimney		0	1	LS	$7,200.00	$7,200
Remove heating and domestic hot water piping		0	1	LS	$2,400.00	$2,400
Heating Plant						
Boiler Room						
Boiler piping and appurtenances	2"	0	1	LS	$2,400.00	$2,400
Injection pump and piping	1-1/2"	0	1	LS	$8,400.00	$8,400
Primary pump, pipe mounted	1/4 HP	0	1	LS	$1,200.00	$1,200
Secondary loop						
Secondary pumps	1/2 HP	0	2	ea	$2,100.00	$4,200
Secondary piping and appurtenances (boiler room)	2"	0	1	lot	$4,200.00	$4,200
Building loop	1-1/4"	0	940	lnft	$42.00	$39,480
Finned pipe branches	3/4"	0	540	ea	$30.00	$16,200
Finned pipe convectors		0	320	lnft	$108.00	$34,560
Thermostats and control valves		0	14	ea	$300.00	$4,200
Domestic Hot Water System						
Indirect HW heater, AV, piping, etc.	120 gallon	0	1	ea	$10,440.00	$10,440
Connect existing Indirect HW heater		0	1	LS	$1,800.00	$1,800
Domestic cold and hot water piping		0	1	ea	$6,000.00	$6,000
Miscellaneous						
Controls		0	1	LS	$7,200.00	$7,200
Test and balance		0	40	hrs	$180.00	$7,200
Commission heating system		0	1	lot	$6,000.00	$6,000
Electrical						
Three phase service		0	1	ea	$6,000.00	$6,000
Single phase service		0	7	ea	$1,800.00	$12,600
CT Enclosure		0	1	LS	$6,000.00	$6,000
208v/3-phase panel		0	1	LS	$8,400.00	$8,400
Connect existing panel		0	1	LS	$3,000.00	$3,000
Upgrade service from 240v/1-phase to 208v/3-phase		0	1	LS	$50,000.00	$50,000
Contingencies						
Estimating contingency		0			15%	$38,952
Overhead & profit		0			30%	$89,590
Design fees		0			10%	$38,822
Project management		0			8%	$38,163.50
					50% of Total Construction Costs	**$257,500**

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
jim@alaskaenergy.us

Life Cycle Cost Analysis

December 15, 2015

THRHA Haines Low Rent Housing

Air Source Heat Pump System - 50% Grant Funding

Annual Costs	Maintenance	$40.00	Years	Qty	Unit	Base Cost	Present Value
Heating Plant							
Plant Observation							
Daily Heating Plant Observation	30	min/mo	1 - 25	6	hrs	$40.00	$4,622
Air-source Heat Pump Maintenance							
Parts Allowance			1 - 25	1	LS	$200.00	$3,852
Monthly	0.5	hours/month	1 - 25	6	hrs	$40.00	$4,622
Every Three Months	0.67	hours/3 months	1 - 25	3	hrs	$40.00	$2,054
Annual	8	hours/year	1 - 25	8	hrs	$40.00	$6,163
Five Year Maintenance	4	hours/year	5 - 5	4	hrs	$110.00	$392
Five Year Maintenance	4	hours/year	10 - 10	4	hrs	$110.00	$356
Five Year Maintenance	4	hours/year	20 - 20	4	hrs	$110.00	$293
Electric buffer tank			1 - 25	1	hrs	$40.00	$770
Air-source Heat Pump Replacement							
Replace outdoor units			15 - 15	1	LS	$16,200.00	$11,891
Pumps							
Pump maintenance, cartridge			1 - 25	4	ea	$100.00	$7,704
Pump maintenance, pipe mounted			1 - 25	2	ea	$150.00	$5,778
Domestic Hot Water							
Indirect HW heater			1 - 25	2	hrs	$40.00	$1,541
						Total Annual Costs	**$50,000**

Energy Costs	Years	Qty	Unit	Base Cost	Present Value
Fuel Oil	1 - 25	335	gallon	$3.97	$29,468
Electricity	1 - 25	52,848	kWh	$0.245	$239,703
				Total Energy Costs	**$269,000**

Present Worth	$576,500

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

THRHA Haines Low Rent Housing

Cash Flow Analysis - No Grant Funding

Basis

25	Study Period (years)	2.5%	General Inflation
4.5%	Nominal Discount Rate	3.5%	Fuel Inflation
2.0%	Real Discount Rate	2.0%	Electricity Inflation

Energy Costs

Usage	Fuel Oil, gals	Electricity, kWh
Fuel Oil Boiler Option	4,314	2,313
ASHP Option	335	52,848
Cost, Year 0	$3.970	$0.245

Cash Flow - Air Source Heat Pump System

Year	Fuel Oil Boiler System			Air Source Heat Pump System			Total	
	Construction	Maintenance	Energy	Construction	Maintenance	Energy	Cash Flow	Present Worth
0	131,000			-515,000			-384,000	-384,000
1		1,520	18,304		-1,927	-14,583	3,314	3,171
2		1,558	18,936		-1,975	-14,896	3,624	3,318
3		1,597	19,590		-2,024	-15,215	3,948	3,459
4		1,637	20,267		-2,075	-15,541	4,287	3,595
5		1,678	20,967		-2,612	-15,875	4,157	3,336
6		1,720	21,691		-2,180	-16,216	5,015	3,851
7		1,763	22,441		-2,234	-16,565	5,404	3,971
8		1,807	23,216		-2,290	-16,922	5,811	4,086
9		1,852	24,019		-2,347	-17,286	6,237	4,197
10		1,898	24,850		-2,956	-17,659	6,133	3,949
11		1,946	25,709		-2,466	-18,041	7,148	4,404
12		1,994	26,598		-2,528	-18,431	7,634	4,502
13		2,044	27,518		-2,591	-18,829	8,142	4,594
14		2,095	28,470		-2,656	-19,237	8,673	4,683
15		2,148	29,456		-25,613	-19,654	-13,663	-7,060
16		2,201	30,475		-2,790	-20,081	9,806	4,849
17		2,256	31,530		-2,860	-20,517	10,410	4,926
18		2,313	32,622		-2,932	-20,963	11,040	4,999
19		2,371	33,751		-3,005	-21,419	11,698	5,069
20		2,430	34,920		-3,783	-21,886	11,681	4,843
21		2,491	36,130		-3,157	-22,363	13,100	5,198
22		2,553	37,382		-3,236	-22,852	13,847	5,258
23		2,617	38,677		-3,317	-23,351	14,625	5,314
24		2,682	40,017		-3,400	-23,862	15,437	5,368
25		2,749	41,404		-3,485	-24,385	16,283	5,418
							-190,209	-284,701

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Life Cycle Cost Analysis

December 15, 2015

THRHA Haines Low Rent Housing

Cash Flow Analysis - 50% Grant Funding

Basis

25	Study Period (years)	2.5%	General Inflation
4.5%	Nominal Discount Rate	3.5%	Fuel Inflation
2.0%	Real Discount Rate	2.0%	Electricity Inflation

Energy Costs

Usage	Fuel Oil, gals	Electricity, kWh
Fuel Oil Boiler Option	4,314	2,313
ASHP Option	335	52,848
Cost, Year 0	$3.970	$0.245

Cash Flow - Air Source Heat Pump System

Year	Fuel Oil Boiler System			Air Source Heat Pump System			Total	
	Construction	Maintenance	Energy	Construction	Maintenance	Energy	Cash Flow	Present Worth
0	131,000			-257,500			-126,500	-126,500
1		1,520	18,304		-1,927	-14,583	3,314	3,171
2		1,558	18,936		-1,975	-14,896	3,624	3,318
3		1,597	19,590		-2,024	-15,215	3,948	3,459
4		1,637	20,267		-2,075	-15,541	4,287	3,595
5		1,678	20,967		-2,612	-15,875	4,157	3,336
6		1,720	21,691		-2,180	-16,216	5,015	3,851
7		1,763	22,441		-2,234	-16,565	5,404	3,971
8		1,807	23,216		-2,290	-16,922	5,811	4,086
9		1,852	24,019		-2,347	-17,286	6,237	4,197
10		1,898	24,850		-2,956	-17,659	6,133	3,949
11		1,946	25,709		-2,466	-18,041	7,148	4,404
12		1,994	26,598		-2,528	-18,431	7,634	4,502
13		2,044	27,518		-2,591	-18,829	8,142	4,594
14		2,095	28,470		-2,656	-19,237	8,673	4,683
15		2,148	29,456		-25,613	-19,654	-13,663	-7,060
16		2,201	30,475		-2,790	-20,081	9,806	4,849
17		2,256	31,530		-2,860	-20,517	10,410	4,926
18		2,313	32,622		-2,932	-20,963	11,040	4,999
19		2,371	33,751		-3,005	-21,419	11,698	5,069
20		2,430	34,920		-3,783	-21,886	11,681	4,843
21		2,491	36,130		-3,157	-22,363	13,100	5,198
22		2,553	37,382		-3,236	-22,852	13,847	5,258
23		2,617	38,677		-3,317	-23,351	14,625	5,314
24		2,682	40,017		-3,400	-23,862	15,437	5,368
25		2,749	41,404		-3,485	-24,385	16,283	5,418
							67,291	-27,201

HAINES – LOW-RENT HOUSING MONITORING PLAN

THRHA Regional Housing Authority
Juneau, Alaska

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
jim@alaskaenergy.us

Memorandum

December 15, 2015

to: **Craig Moore, THRHA**

subject: **Monitoring Plan**

project: **Haines Low Rent Apartments**

Introduction

This document describes the proposed monitoring plan for the Haines Low Rent Apartments. The monitoring plan is based on converting the heating system to an air source heat pump system. Any changes made during design may require changes to this plan.

The plan offers the following levels of monitoring:

- Temperature and Status Monitoring: Monitor equipment status, system temperatures and pump status.
- Energy Use: Measures heat pump electricity consumption and heating output of the heat pump and boiler and heating load of the building and domestic hot water.

Monitoring Plan

The proposed monitoring system will display the status of the boilers and pumps, the system temperatures, and measure energy use.

Temperature and Status Monitoring System

- Fixed Costs for travel, per diem, and equipment
- Outside Temperature: Provides a temperature reference for assessing system operation
- Heat Pump Enable: Displays the status of the heat pump
- Boiler Enable: Displays the status of the boiler
- Pump Enable
  - Displays the status of each pump.
  - Annunciates an alarm if the pump is not enabled when the boiler is enabled.
  - Annunciates an alarm if one of the distribution pumps is not operating.
- Temperatures
  - Heat pump supply (2) and return temperature
  - Boiler supply and temperature from the boiler
  - Distribution supply and return temperature
  - Domestic hot water supply from the preheat tank
  - Domestic hot water supply from the hot water tank
  - Annunciates an alarm if the distribution temperature is outside of expected range.

Energy Monitoring

- Heat pump electricity use
- Heat pump output
- Boiler output
- Building heating load
- Domestic hot water heating load

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

THRHA Haines Low Rent Housing

Monitoring System Cost Estimate

Haines Low Rent Housing Monitoring Plan

Item	Intent	Operational	Energy
Fixed Cost			
Travel, per diem, equipment	Fixed costs	$5,400	
BMON site migration and set up	Moving THRHA to their own server	$800	
Unit Costs			
General			
Outdoor temperature	Outdoor temperature reference	$30	
Heat pump electric load, kW	Heat pump energy use		$1,940
Heating Plant Status			
Heat pump enable	Status	$505	
Boiler enable	Status	$505	
HX pump enable	Status	$337	
HX pump enable	Status	$337	
Boiler pump enable	Status	$337	
Injection pump enable	Status	$337	
Distribution pump enable	Status	$337	
Distribution pump enable	Status	$337	
Heating Plant Temperatures			
Heat pump supply	Heat pump operation	$256	
Heat pump return	Heat pump operation	$256	
Boiler supply	Boiler operation	$256	
Boiler return	Boiler operation	$256	
Buffer tank supply	Heat pump supply to building	$256	
Buffer tank return	Heat pump supply to building	$256	
Distribution heating supply temperature	Total supply to building	$256	
Distribution heating return temperature	Total supply to building	$256	
Heating Plant Energy Output			
Heat pump energy output	Heating flow rate		$4,365
Boiler energy output	Heating flow rate		$4,365
Energy to building	Heating flow rate		$4,365
Energy to DHW tank	Heating flow rate		$4,365
Totals		$11,310	$19,400

HAINES – LOW-RENT MULTIFAMILY DEEP ENERGY RETROFIT PROJECT

THRHA Regional Housing Authority
Juneau, Alaska

Report in Preparation for Seeking Grant Funding

Tlingit Haida Regional Housing Authority

(A Tribally Designated Housing Authority)

December 15, 2015

Haines Low-Rent Multifamily Deep Energy Retrofit Project

Location: 52 Deishu Drive, Haines, AK 99827

Technical Contact:
Craig Moore
VP Development & Construction Management
PO Box 32237
Juneau, AK 99803
Phone: 907-780-6868
Fax: 907-780-6895
Email: cmoore@thrha.org

Business Contact:
Irene Tupou
Finance Manager
PO Box 32237
Juneau, AK 99803
Phone: 907-780-6868
Fax: 907-780-6895
Email: itupou@thrha.org

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1.0 EXUCTIVE SUMMARY

1.1 Project Overview

Tlingit Haida Regional Housing Authority (THRHA) owns and manages the Haines Multifamily Low Rent Building in Haines, Alaska. The building is a ~7,000 ft^2 facility containing 12 apartments, a laundry room, storage room, day room, and mechanical room. Energy audits of this facility have generated a list of energy efficiency measures (EEM's) to reduce long term energy costs. THRHA is seeking grant funding to allow a deep energy retrofit of the facility. The energy efficiency measures included in this deep energy retrofit would include: air sealing to 4 ACH, upgrading ceiling insulation, insulating the floor cavity, upgrading windows and outside doors, installing Energy Star refrigerators, a new heat recovery ventilation unit for planned makeup air for the corridor and common spaces, and installation of a low-temperature hydronic heating system and an air source heat pump system (ASHP). These proposed steps would provide deep energy retrofit of the facility while improving indoor air quality and resident comfort.

Much of the annual energy savings from this effort will come from the installation of the low temperature hydronic heating system and the air-to-water heat pump system. Currently, two fuel oil boilers provide space heating and hot water. The boilers are relatively new, but the hydronic system is in need of replacement. While replacing the existing high temperature system in-kind is an option, THRHA is interested in replacing the system with an air source heat pump system to supply a new low temperature water distribution that feeds a central domestic hot water system and low temperature heat emitters. Converting to such a system would reduce long term energy costs, increase the use of local energy sources, and decrease the carbon footprint of the building. Conversion to an air source heat pump would allow the building to using a local, sustainable energy source, as Haines is a special hydro community in Alaska.

Table 1.1-1 shows a summary of the energy usage projections for the building with both the current heating system and with the deep energy retrofit completed. Converting the heating system for the building from fuel oil to a hydroelectricity fed air-to-water heat pump along with the other EEM's will reduce the energy used onsite by over 58% by using the heat available from the temperate climate of Southeast Alaska. Alaska Housing Finance Corporation has developed a Site-Source factor for use in Southeast Alaska's special hydro communities of 1.5. This is an appropriate factor for this community's renewable source of electricity, and using this factor shows that the total source energy is reduced by approximately 46%. DOE has prescribed a national Site-Source factor for electricity of 3.14. This factor is not appropriate for the Haines community, and results in showing that source energy use is only reduced by 18% with this deep energy retrofit.

Table 1.1-1 – Annual Energy Use Reduction Onsite and Converted to Source Energy

Heating System	A-Fuel Oil Usage, gallons	B-Electricity Usage (heating), kWh	C-Electricity Usage (non-heating), kWh	D-Total Energy Use (Site), kBtu	E-Total Energy Use (1.5 Site-Source), kBtu	F-Total Energy Use (3.14 Site-Source), kBtu
Projected Energy Usage, Fuel Oil Boiler	4,314	2,313	49,687	774,913	869,600	1,160,575
Projected Energy Usage, EEMs	140	39,028	48,134	316,776	465,670	953,405
			Annual Savings	***59%***	***46%***	***18%***

Note: Table presents the modeled annual heating demand after inclusion of the HRV unit to show the dramatic difference in the energy use onsite and when considering site to source factors. A site-to-source energy factor of 1.5 was used for electricity supplied by hydroelectric power. This factor is provided by the Alaska Housing Finance Corporation (AHFC). DOE conversion factors are used for all other energy sources, and the proposed DOE site-source factor is used in Column F for reference purposes. This factor is not appropriate for use in the Haines community.

1.2 Applicant Description

Tlingit Haida Regional Housing Authority (THRHA) is a tribally designated housing authority aimed at providing affordable housing opportunities for Southeast Alaskans. Since 1973, the THRHA has been working to meet the affordable housing needs of native and non-native individuals and families in Southeast Alaska. THRHA offers a variety of services, such as temporary emergency housing, senior independent living, down-payment assistance, home repair, and project and home construction. The authority also provides home ownership and rent-to-own opportunities. In addition, THRHA owns and operates Fireweed Place, which is a 67-unit apartment building for senior citizens who can live independently. The authority administers the Rural Owner Occupied Loan Program, which provides financing to construct, purchase or renovate owner-occupied single-family residences and duplexes. It has several departments, including administration, fiscal, housing management, mortgage loans, tribal services, and development, construction and maintenance. The Tlingit-Haida Regional Housing Authority is headquartered in Juneau, Alaska but services communities all over Southeast Alaska.

THRHA's Low Rent Program is a home and apartment rental program. Homes and apartments in this program consist of 1 to 4 bedroom units of various sizes and layouts. At a minimum, to be eligible for this program at least one household member must be able to provide proof that they belong to a federally recognized tribe. The Low Rent Program is currently offered in the following communities: Angoon, Craig, Haines, Hoonah, Juneau, Kasaan, Klukwan, Saxman, and Wrangell.

To support its mission of providing affordable housing, the THRHA has implemented its Energy Cents Program. This program has completed 400 home energy assessments in order to gather household data and identify potential solutions to energy costs for residents. The THRHA is working to reduce its energy costs and carbon footprint through the use of clean renewable energy as well as improved home weatherization.

1.3 Project Goals

With the Haines Low-Rent Multifamily Deep Energy Retrofit Project, THRHA plans to drastically reduce the energy usage at the facility, and to convert the heating system from non-renewable fuel oil to locally sourced renewable hydroelectricity. By implementing the deep energy retrofit, and extracting heat from the environment as opposed to burning fuel oil, this project will meet the following of THRHA's energy goals:

- Increasing the overall energy efficiency of the facility
- Reducing long term operating costs
- Protecting the facility against the volatility of the fossil fuel market
- Increasing the use of local sustainable energy sources
- Decreasing the greenhouse gas emissions of the facility

1.4 Project Benefits

THRHA's Haines Low-Rent Multifamily Deep Energy Retrofit Project will provide the following economic benefits:

- Reduce annual operating costs by $6,273 (~21%) even when assuming today's low fuel oil prices.
- Utilize local renewable energy source that has a history of stable pricing, which helps THRHA diversify away from volatile fuel oil. This provides annual heating budget certainty for THRHA.
- Switch from purchase of non-renewable fuel oil to locally sourced hydroelectricity for heating needs, keeping ~$9,600 dollars spent annually on heating within the local economy.

Along with the economic benefits of this project, replacing the fuel oil boilers would also provide the following environmental and social benefits:

- Reduce onsite emissions of greenhouse gases by 42 metric tonnes (GHGe) annually.
- Reduce onsite emissions of criteria pollutants including PM, NOx, and SOx by over 150 lbs annually.
- Eliminate the use of nearly 4,150 gallons of fuel oil annually, reducing the potential for spills in this fishing community.
- With electricity being supplied by local hydroelectric power generation in Haines, this facility would be heated by renewable, sustainable, and clean energy.
- Provide an example for future THRHA buildings, and other building owners within the SE Alaska region.

-

1.5 Impact of Funding

This $697,040 deep energy retrofit would provide THRHA with a simple payback of approximately 83 years without any grant assistance given the fuel oil pricing used in the analysis. This is beyond the investment horizon of what THRHA would be willing to accept. However, with a 50% grant the cash flow for the project looks promising for THRHA. Attachment G includes a 25-year cash flow analysis showing the impact a 50% grant for the total Deep Energy Retrofit. Table 1.5-1 provides a summary of the cash flow analysis.

Table 1.5-1 – Summary of Project Cash Flow Assuming 50% Grant Award

Project Cost with All EEMs	50% Grant Amount	25-year Net Present Value (4.5% Discount Rate)
$697,040	$348,520	$37,406

Notes: See Attachment G for detailed cash flow analysis.

2.0 PROJECT DESCRIPTION AND OUTCOMES

2.1 Detailed Project Description

THRHA plans to renovate and modernize the Haines Multifamily Low Rent Building on 52 Deishu Drive in Haines, Alaska. THRHA's mission is to provide affordable housing to Southeast Alaskans. In keeping with this mission, THRHA is actively seeking to reduce the high energy costs experienced in many of its Southeast communities through implementation of deep energy retrofits and renewable energy projects. In the special hydro communities like Haines, this effort includes converting heating systems from expensive fuel oil to affordable, locally sourced, renewable hydroelectricity.

The Multifamily Building in Haines is a ~7,000 ft^2 facility containing 12 one bedroom, one bathroom apartments, a laundry room, a common room, a storage room, and a mechanical room. This building was built in 1982. THRHA owns the property, and the building. Table 2.1-1 lists the current insulation levels and areas for the building.

Table 2.1-1: Haines Building Insulation Values and Area of Building Components

Building Address	Item	Living Area Floors	Walls	Door 1	Door 2	Door 3	South Windows	Remaining Windows	Ceiling
52 Deishu Dr.	R-Value	24.1	16.2	1.8	1.8	1.8	1.1	1.1	29.3
	Area, ft^2	6,930	3,188	22	22	22	305	343	6,930

The building is currently heated by two Weil McLain WGO-6 boilers firing #2 fuel oil. The boilers are each rated at 212,000 Btu/hr. Hot water circulation pumps distribute hot water for space heating and to an indirectly heated Amtrol domestic hot water tank. Baseboard heaters are located in each unit and common areas.

THRHA has had blower door tests and walkthrough assessments conducted for this facility by professional energy auditing companies. Based on the energy efficiency recommendations from these energy audits, THRHA would like to complete a deep energy retrofit for the building. The deep energy retrofit would capture the following opportunities for improved energy efficiency and resident comfort:

- Windows have double glazing, but many have broken seals or no longer close completely. They all need replacing with energy efficient windows with a minimum U-value of .28. The outside doors need to be replaced with doors that have better insulation.
- The building has a lot of air leakage. THRHA would like to tighten the building to no more than 4 ACH50.
- Thermal values of the building shell are low. THRHA would like to increase the R-values of the ceiling to R-60, the floor to R-38, and the walls to R-30. Outside insulation and new siding would be required to achieve R-30 walls.
- Refrigerators need to be replaced for aesthetic and efficiency reasons. THRHA would like to install energy star rated appliances during scheduled replacements.
- Conversion of heating for space heating and DHW to air-water heat pump using locally source, renewable hydroelectricity

The following previous efforts have been conducted to evaluate the potential of this deep energy retrofit project, and these are provided in Attachment E.

- DE-0005179 – Energy Efficiency Audit, Assessment, and Alternative Energy Study
    - Energy audit and assessment using AKWarm by Marquam George, LLC
    - Heating Conversion Analysis for Haines Low Rent Housing by Alaska Energy Engineering, LLC
    - Monitoring Plan for Haines Low Rent Housing by Alaska Energy Engineering, LLC

2.2 Technical Viability

The energy audit and subsequent system evaluations were funded by DOE under the DE-0005179 funding opportunity. These efforts identified the opportunity for the proposed project, and the report sections summarizing these efforts are provided in Attachment E. Table 2.2-1 provides a summary of the energy efficiency measures evaluated as part of this effort, and savings were updated from the report using the latest fuel oil and electric pricing. This table does not include the conversion of the heating system to low temperature hydronics and an air source heat pump. Each of the options listed in Table 2.2-1 are routine energy retrofit EEMs that are technically viable, and there are local contractors capable of completing this work. The materials and equipment for the EEMs are insulation as identified, weatherizing materials for air sealing, and energy efficient appliances.

Table 2.2-1 Energy Efficiency Measures

	Energy Efficiency Measure	Estimated Total Savings	Onsite Energy Use Offset, mmBtu	Estimated Total Cost	Simple Payback, Years	SIR
1	Replace 3 outside doors with U-0.16 insulation	$179	6.2	$1,467	8.2	2.9
2	Air sealing to 4 ACH	$1,207	42.1	$5,000	4.1	2.8
3	Insulate floors with R-30 dense pack insulation	$627	21.9	$10,380	16.6	1.4
4	Replace windows with U-0.26	$2,185	76.2	$34,650	15.9	1.1
5	Increase ceiling insulation to R-60	$572	20.0	$16,945	29.6	0.8
6	Energy Star refrigerators[2]	$382	5.3	$12,000	31.4	0.5
7	Outside wall insulation technique, rain screen, and concrete fiberboard siding	$345	12.0	$20,888	60.5	0.1
	Totals	**$5,497**	**184**	**$101,330**	**18.4**	

Notes:

1 – Costs and savings values for air sealing and insulation are estimated using the AkWarm software from the 3/30/2015 library. The savings have been updated to match the current energy costs for the facility, using $3.97/gallon and $0.246/kWh.

2 – Energy Star rated refrigerator savings generated from www.energystar.com savings calculator.

The full conversion of the heating system to a low-temperature hydronic system served by an air-to-water heat pump was identified as an opportunity and further analyzed through the DE-0005179 program. The attached Heating Conversion Analysis (in Attachment E) evaluates this option in detail. This option would allow for the provision the majority of space heating and DHW needs, by the air-water heat pump with backup by one of the existing fuel oil boilers.

As shown in the Heating Conversion Analysis, the facility is modeled to have a current annual heating fuel demand of approximately 4,314 gallons of fuel oil, or 597 mmBtu of input energy. EEMs 1-7 will reduce this annual heating energy demand by 178 mmBtu. An efficiency of 68% is estimated for the current fuel oil boilers, and thus the annual energy demand after EEMs 1-7 are implemented is 285 mmBtu. The Table 2.2-2 summarizes the estimated monthly average heating demands for the building after EEMs 1-7 are implemented, and Figure 2.2-1 shows the modeled daily average heating demand following EEM 1-7 implementation. Figure 2.2-2 shows the modeled annual coverage by the air source heat pump. Table 2.3-1 in the next section summarizes the annual energy use reduction, both onsite and at the source associated with EEMs 1-7 and the air-to-water heat pump and low temperature hydronic system.

Table 2.2-2 – Monthly Heating Demand for Facility after EEMs 1-7 Implemented

Month	Monthly Heating Demand, mmBtu	Average Heating Demand, Btu/hr
January	42.5	57,072
February	37.9	56,335
March	32.7	44,007
April	23.5	32,685
May	15.3	20,628
June	9.2	12,790
July	6.1	8,251
August	8.2	11,002
September	14.3	19,895
October	22.5	30,255
November	34.8	48,316
December	37.9	50,883

Air source heat pump technology has improved in the last five years to the point that they are an excellent match for the relatively temperate climate of Southeast Alaska where renewable hydroelectricity is available. Table 2.2-3 shows the coefficient of performance (COP) range for air source heat pumps at the monthly average temperatures for Haines, AK. The air source heat pump for this project will work in conjunction with water kit that includes two indoor heat exchangers. For the purpose of this effort, the Multi V IV Heat Pump, model no. ARUN072BTE4, and the Multi V Hydro Kit, model no. ARNH963K2A2, manufactured by LG have been selected. Attachment F includes the manuals for this equipment. Standard parts warranties for these products are 1 year from the installation or 24 months from the date of manufacture. An additional 5 year warranty applies to the compressor. The design contractor may choose a different manufacturer for the air source heat pump system.

Table 2.2-3: COP Range at Average Monthly Temperatures

Month	Average Temperature, °F	Air Source Heat Pump COP
Jan	24	1.7
Feb	28	1.7
Mar	33	1.9
Apr	42	2.4
May	50	3.0
Jun	56	3.4
Jul	59	3.5
Aug	57	3.4
Sep	51	3.1
Oct	43	2.4
Nov	31	1.8
Dec	28	1.7

Note: Average monthly temperatures and Air-to-Water Heat Pump performance data summarized from the attached Heating Conversion Analysis (Attachment E).

This low-temperature hydronic system and air-to-water heat pump system is a very technically viable option, and local designers and installers are available to complete the work. THRHA has installed a similar system for DHW heating for the Saxman Senior Center. The difference between these two systems is that this one would be coupled with a low temperature hydronic system to capture the building's space heating demand as well.

The design demand for peak loads is modeled at 134,000 Btu per hour for space heating and 60,000 Btu per hour for domestic hot water. The air source heat pump is sized at 65% of the design demand and is expected to supply 92% of the total annual heating demand. One fuel oil boiler will be kept as backup, to boost DHW temperatures, and to meet the total peak demand of 194,000 Btu per hour, however, it should be noted that these peak loads rarely occur simultaneously.

The project would be procured as a design-bid-build project, and this process would be managed and overseen by THRHA staff. There are several barriers/challenges to this deep energy retrofit that surround the largest energy savings option, which is the low-temperature hydronic system and the air-to-water heat pump. The following lists each, and how THRHA is addressing these.

- The heat pump needs access to three-phase power. THRHA has addressed this by obtaining a cost estimate from the local utility for bringing this into the site, and including planning for this utility change.
- There are few, local low-temperature hydronic systems installed by designers and mechanical contractors. These are not particularly difficult to design or install compared to conventional systems, but take a shift in focus from the routine practices in the industry. THRHA will ensure the designer is familiar with low temperature hydronic systems, that heat emitters are properly

sized, and that the operating temperatures allow for the system match the outputs of the heat pump.

- There are several locally installed air-to-water heat pumps for providing DHW needs, but no known local systems using air-to-water heat pumps for building heating. This is not particularly challenging, but THRHA will need to ensure the designer and installer have the experience needed to properly design and install the system.

THRHA onsite staff will maintain the equipment. THRHA onsite staff have experience with operating and maintaining the EEM's identified, including an air-to-water heat pump. The staff are also familiar with operating and maintaining hydronic heating systems. THRHA does not envision an outside service contract other than occasional servicing of the outdoor heat pump unit.

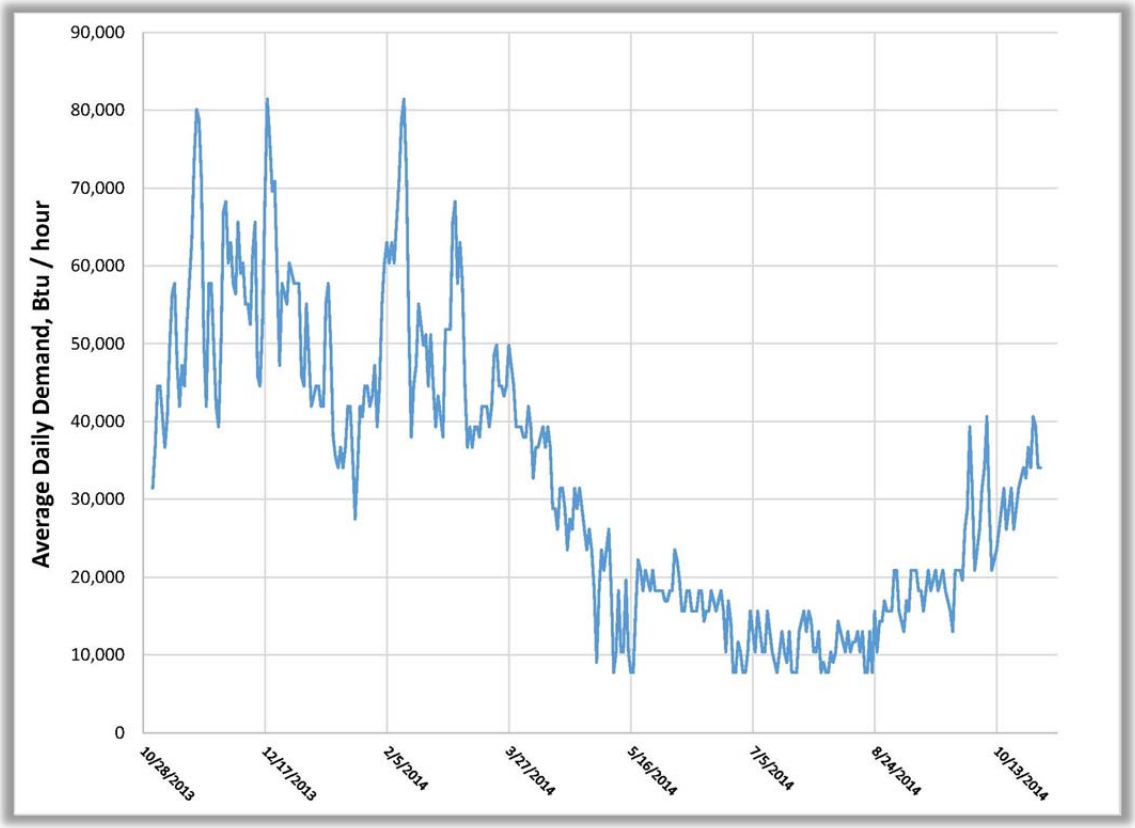


Figure2.2-1: Daily Average Heating Demand after EEMs 1-7 Implemented

Note: Values shown are daily average demand. During the course of 24 hours, actual demand will fluctuate above and below values shown in this figure.

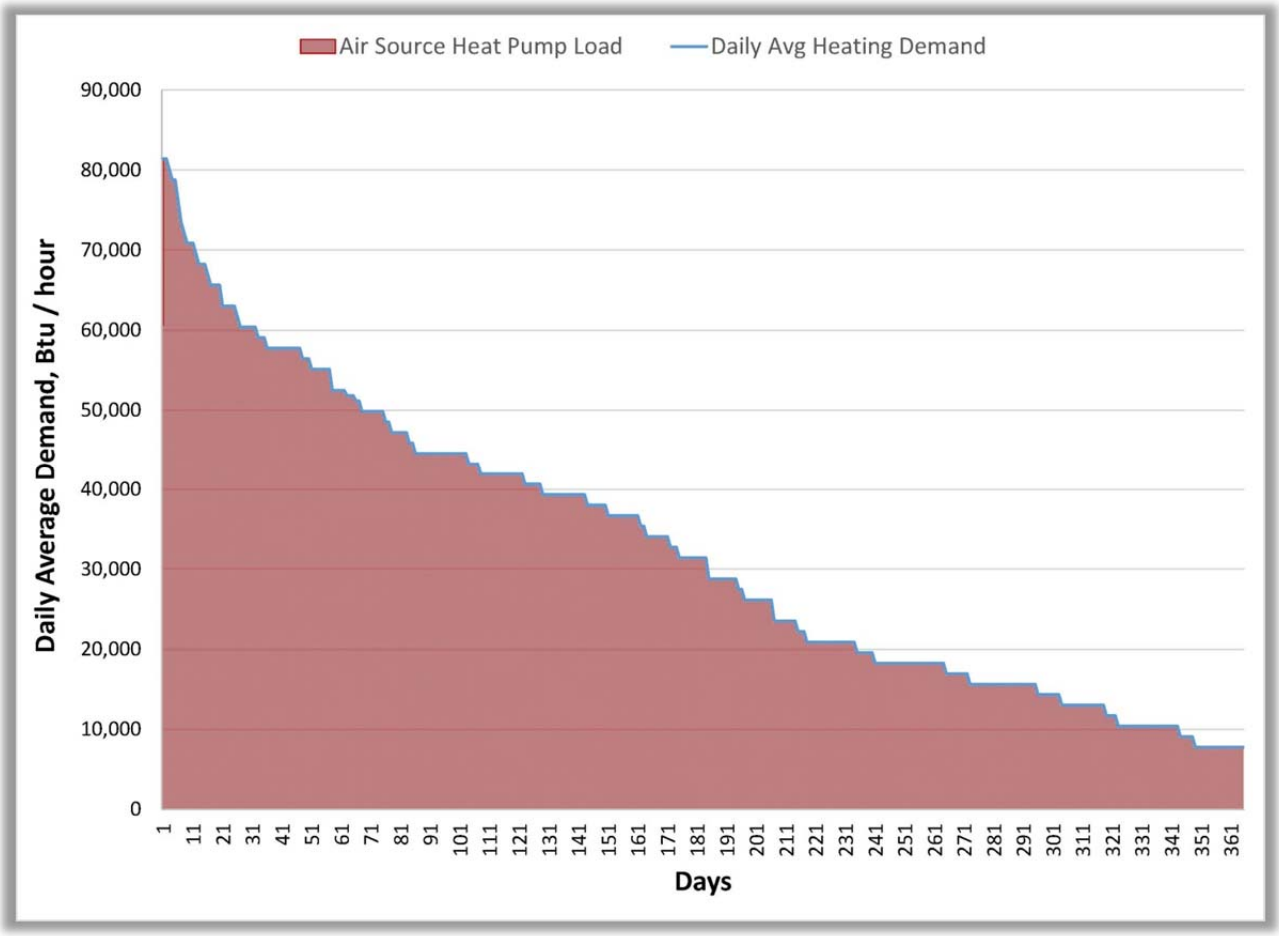


Figure 2.2-2: Daily Average Load Demand Curve (after Implementation of EEMs 1-7) and Potential for Coverage by ASHP

Note: Values shown are daily average demand. During the course of 24 hours, actual demand will fluctuate above and below values shown in this figure.

2.3 Economic Viability

2.3.1 Current Energy Costs - Table 2.3-1 provides a summary of the annual heating fuel and electric demands for 2014 (November 2013-October 2014). The full year of bills for oil and electricity for the facility are provided in Attachment D. The modeled annual average demand for oil is 4,314 gallons prior to implementation of any EEMs, and this is from the Heating Conversion Analysis (Attachment E). This is the annual heating demand for the existing building that is used a basis for energy use before the EEM's are implemented, and the 2014 (November 2013-October 2014) electric usage value of 52,000 kWh is assumed to be the baseline annual electric use.

Table 2.3-1 – Existing Building Energy Usage and Cost for 2014 (November 2013-October 2014)

Source	Consumption	Unit	Unit Cost	Annual Cost	Energy Use Onsite, mmBtu
Electricity	52,000	kWh	$0.214	$11,107	177
Fuel Oil	4,066	Gallons	$4.06	$16,506	563
Total	***-***	***-***	***-***	***$27,613***	***723***

Note: These usage and cost values are taken from THRHA records from a period of Nov 2013 to Oct 2014. Energy use values for onsite usage calculated using 0.003412 mmBtu/kWh and 0.1385 mmBtu/gallon.

Table 2.3-2 shows the modeled energy demand of the building with the current heating system versus the air source heat pump system and EEM's. The current fuel oil boilers are oversized and have an estimated seasonal efficiency of 68%. The current fuel oil and electric unit prices are used since they have changed significantly from 2014. These values are $3.97/gallon for fuel oil and $0.246/kWh for electricity.

Table 2.3-2 – Building Energy and Cost Savings with and without the ASHP & EEM's

Heating System	Fuel Oil Usage, gallons	Electricity Usage (heating), kWh	Electricity Usage (non-heating), kWh	Annual Cost	Annual Energy Use, mmBtu
Projected Energy Usage, Fuel Oil Boiler	4,314	2,313	49,687	$29,919	775
Projected Energy Usage, EEMs	140	39,028	48,134	$21,997	317
			Annual Savings	**$7,921**	**458**

Note: The fuel oil and electric costs are based on the latest values as presented in Attachment E (Heating Conversion Analysis), and are $3.97/gallon fuel oil and $0.264/kWh. Energy use values for onsite usage calculated using 0.003412 mmBtu/kWh and 0.1385 mmBtu/gallon.

2.3.2 Total Installed Cost - The total installed cost of the EEM's is provided in Table 2.3-3.

Table 2.3-3 – Estimate Cost of Energy Efficiency Measures and ASHP

#	Item	Cost	Source
1	Replace 3 outside doors with U-0.16 insulation	$1,467	DE-0005179 report
2	Air sealing to 4 ACH	$5,000	DE-0005179 report
3	Insulate floors with R-30 dense pack insulation	$10,380	DE-0005179 report
4	Replace windows with U-0.26	$34,650	DE-0005179 report
5	Increase ceiling insulation to R-60	$16,945	DE-0005179 report
6	Energy Star refrigerators	$12,000	DE-0005179 report
7	Outside wall insulation technique, rain screen, and concrete fiberboard siding	$20,888	DE-0005179 report
8	Low-temp hydronic system and ASHP	$515,000	AEE Haines Low Rent Housing memo
9	Heating System Monitoring	$30,710	AEE Haines Monitoring Plan memo
10	Ventilation System	$50,000	DE-0005179 report
	Total	**$697,040**	

2.3.3 Installed Cost Per Unit Energy Saved - Table 2.3-4 shows the energy savings using the DOE provided conversion factors with one exception. A value of 1.5 is used for electricity instead of the 3.14 value provided by DOE. The reason for this is that Haines is a special hydro community in Alaska. Thus, the energy is from renewable and local hydroelectricity, and the 3.14 factor does not make sense for this project. Using the Total Energy Use savings from Column E, the Installed Cost per kBtu saved is $1.73. For comparison purposes, the total source energy use change is identified in Column F when the DOE national site-source value of 3.14 is used for electricity for this project.

Table 2.3-4 – Annual Energy Savings Converted to Source Energy Savings

Heating System	A-Fuel Oil Usage, gallons	B-Electricity Usage (heating), kWh	C-Electricity Usage (non-heating), kWh	D-Total Energy Use (Site), kBtu	E-Total Energy Use (1.5 Site-Source), kBtu	F-Total Energy Use (3.14 Site-Source), kBtu
Projected Energy Usage, Fuel Oil Boiler	4,314	2,313	49,687	774,913	869,600	1,160,575
Projected Energy Usage, EEMs	140	39,028	48,134	316,776	465,670	953,405
			Annual Savings	***59%***	***46%***	***18%***

Notes: Energy use values in this table are calculated using the DOE default energy values and site to source conversion factors with one exception. Column E uses a site to source conversion factor of 1.5, which is a value developed by the Alaska Housing Finance Corporation for the Special Hydro Communities in Alaska. This is an appropriate value for this project. The impact of using the DOE site to source conversion factor of 3.14 is shown in Column F.

2.3.4 Life of EEM's - The life of the EEM's identified in this report is 25 years with the exception of the air source heat pump which is expected to be replaced by year 15 of operation or once within the first 25 years.

2.3.5 Payback Period and Cash Flow Analysis - The payback of the system is calculated using energy savings and avoided costs associated with the investments, and is presented in Table 2.3-5. With no grant funding, the total payback on the EEM's is approximately 83 years with the fuel oil pricing used for the analysis. This is beyond the investment horizon of what THRHA would be willing to accept. However, with a 50% grant the cash flow for the project looks promising for THRHA. Attachment G includes a 25-year cash flow analysis showing the impact a 50% grant for the total Deep Energy Retrofit Table 2.3-6 provides a summary of the cash flow analysis.

Table 2.3-5 – Simple Payback of project with NO GRANT ASSISTANCE

#	Item	Cost	Present Value of Avoided Cost	Avoided Cost Year	Annual Energy Savings	Increased O&M	Simple Payback
1	Replace 3 outside doors with U-0.16 insulation	$1,467	$0	-	$179	$0	8
2	Air sealing to 4 ACH	$5,000	$0	-	$1,207	$0	4
3	Insulate floors with R-30 dense pack insulation	$10,380	$0	-	$627	$0	17
4	Replace windows with U-0.26	$34,650	$0	-	$2,185	$0	16
5	Increase ceiling insulation to R-60	$16,945	$0	-	$572	$0	30
6	Energy Star refrigerators	$12,000	$0	-	$382	$0	31
7	Outside wall insulation technique, rain screen, and concrete fiberboard siding	$20,888	$0	-	$345	$0	60
8	Low-temp hydronic system and ASHP	$515,000	$131,000	2	$2,424	$1,648	495
9	Heating System Monitoring	$30,710	$0	-	$0	$0	-
10	Ventilation System	$50,000	$45,000	2	$0	$0	-
	Total	**$697,040**	**$176,000**		**$7,921**	**$1,648**	**83**

Notes: Simple payback assuming no grant funding is calculated by taking the total estimated project costs, subtracting out the present value of the avoided costs, and dividing this by the annual energy savings with increased annual O&M subtracted.

Table 2.3-6 – Summary of Project Cash Flow Assuming 50% Grant Award

Project Cost with All EEMs	50% Grant Amount	25-year Net Present Value (4.5% Discount Rate)
$697,040	$348,520	$37,406

With a 50% grant, the project has a net present value for THRHA of $37,406 using the assumptions as identified in the attached cash flow sheet (see Attachment G). This project would allow THRHA to reduce annual operating costs for the Multifamily Low Rent building at Haines, which helps secure THRHA's ability to provide continued services to Southeast Alaska's low income residents. This also helps diversify THRHA away from the volatile fuel oil market. The fuel oil price used for this analysis is $3.97/gallon. THRHA is dependent on fuel oil heating in many of its facilities, and swings in its annual budget from the volatility of fuel oil prices are difficult to absorb from year to year. Locally-sourced hydroelectricity has much more stable annual pricing than the fuel oil market. Further, diversifying the heating energy sources across THRHA's building fleet helps to ensure a more stable overall annual budget for heating.

2.3.6 Sources of Financing – The majority of THRHA's matching funds for this project would come from THRHA's IHBG NAHASDA funding allocation, and the remaining amount will come from THRHA's capital budget. THRHA has adequate funding available to complete this project with a grant award of 50% of the total project costs.

2.4 Outcomes

2.4.1 Amount of energy saved as a result of the proposed project - The direct onsite energy reduction would be approximately 59%, and the Total Source Energy Savings would be approximately 46% or 403,930 kBtu. Note that this value is calculated using the Site-to-Source factor of 1.5 as discussed in this section and in the notes for Table 2.4.1. Table 2.4-1 shows the energy savings using the DOE provided conversion factors with one exception. A value of 1.5 is used for electricity instead of the 3.14 value provided by DOE. The reason for this is that Haines is a special hydro community in Alaska. Thus, the energy is from renewable and local hydroelectricity, and the 3.14 factor does not make sense for this project.

Table 2.4-1 – Annual Energy Savings Converted to Source Energy Savings

Heating System	A-Fuel Oil Usage, gallons	B-Electricity Usage (heating), kWh	C-Electricity Usage (non-heating), kWh	D-Total Energy Use (Site), kBtu	E-Total Energy Use (1.5 Site-Source), kBtu	F-Total Energy Use (3.14 Site-Source), kBtu
Projected Energy Usage, Fuel Oil Boiler	4,314	2,313	49,687	774,913	869,600	1,160,575
Projected Energy Usage, EEMs	140	39,028	48,134	316,776	465,670	953,405
			Annual Savings	***59%***	***46%***	***18%***

Notes: Energy use values in this table are calculated using the DOE default energy values and site to source conversion factors with one exception. Column E uses a site to source conversion factor of 1.5, which is a value developed by the Alaska Housing Finance Corporation for the Special Hydro Communities in Alaska. This is an appropriate value for this project. The impact of using the DOE site to source conversion factor of 3.14 is shown in Column F.

2.4.2 Economic Benefits – Implementation of the EEM's at the Haines Low Rent Multifamily facility would provide first year operational savings of $6,273. Factoring in a 50% grant for upfront costs and avoided costs, the project will provide a projected 25-yr Net Present Value of $37,406. These values are calculated based on a current price of $3.97/gallon for fuel oil. The annual savings would allow THRHA to reduce annual operating costs for the Multifamily Low Rent building at Haines, which helps secure THRHA's ability to provide continued services to Southeast Alaska's low income residents. The project would also provide the following additional economic benefits:

- Decrease THRHA's building fleet's dependence on the volatile fuel oil market by nearly 4,150 gallons per year, providing diversity of heating energy sources and reducing budget fluctuations
- Provide temporary creation of ~7.6 FTEs during project construction ($92,000/FTE assumed)
- Support of the local economy and local jobs through the purchase of over $9,600 in locally produced hydroelectric power.

2.4.3 Environmental Benefits – Along with the economic benefits of this project, replacing the fuel oil boilers would also provide the following environmental benefits:

- Reduce onsite emissions of greenhouse gases by 42 metric tons (GHGe) annually.
- Reduce onsite emissions of criteria pollutants including PM, NOx, and SOx by over 150 lbs annually.
- Eliminate the use of nearly 4,150 gallons of fuel oil annually, reducing the potential for spills in this fishing community.
- With electricity being supplied by local hydroelectric power generation in Haines, this facility would be heated by renewable, sustainable, and clean energy.

2.4.4 Other Outcomes – The project could serve as a model for future THRHA building projects, as well as other building owners in Southeast Alaska. The project furthers THRHA's goal of investing in energy efficiency and renewable and sustainable energy technologies that will also reduce annual operating costs. This allows THRHA to be a good environmental steward while focusing annual budget dollars on its mission of providing affordable housing for Southeast Alaska residents. The largest savings from this project come from use of an air-to-water heat pump and low temperature hydronic heating system. The climate of coastal Alaska is very favorable to the use of air source heat pumps, and a successful installation and operation of an air-to-water heat pump at this facility would help promote this use of air source heat pump technology as a clean alternative to expensive fossil fuels in the region for building retrofits and new construction.

3.0 ROLES, RESPONSIBILITIES, CAPABILITIES, AND COMMITMENT

3.1 Business and Technical Contact

The Haines Low-Rent Multifamily Project will have a business contact and a technical contact. The business contact will be Joanne Wiita, Planning and Grants Administration. The technical contact will be Craig Moore, VP of Development and Construction Management.

Technical Contact:
Craig Moore
VP Development & Construction Management
PO Box 32237
Juneau, AK 99803
Phone: 907-780-6868
Fax: 907-780-6895
Email: cmoore@thrha.org

Business Contact:
Irene Tupou
Finance Manager
PO Box 32237
Juneau, AK 99803
Phone: 907-780-6868
Fax: 907-780-6895
Email: itupou@thrha.org

3.2 Project Management Approach

THRHA staff would be in charge of completing the project, and Craig Moore, VP of THRHA would be the manager of the project. Mr. Moore and his team have extensive experience in selecting and managing engineering and construction contractors for weatherization, energy efficiency, and energy system design and installation at a wide variety of housing facilities. This experience includes the similar Kake Low-Rent building, which recently underwent a similar renovation and deep energy retrofit while using a biomass renewable energy system to provide heating needs. THRHA also has experience managing the design, installation, and operation of air source heat pumps, including an installation at the Saxman Senior Center where an air-to-water heat pump is used for providing domestic hot water.

This project would be procured as a design-bid-build project. Mr. Moore's team has extensive experience in managing building system and energy projects in this manner. Mr. Moore's team would

scope out the project, and procure the design and construction team using THRHA's well established procurement procedures. Mr. Moore's team has the hands on experience to provide their own oversight/review of the design and construction oversight.

Mr. Moore and his team are also proficient in project communications, community outreach, and recording of project activities and progress. During the course of the project, regular update meetings or teleconferences will be held with contractors. Meeting notes will be recorded for the project file. THRHA will track and monitor the established budget versus actual expenditures by line item. The Team has a wealth of experience in working with contractors and the community. Before work begins Mr. Moore will conduct a coordination meeting to include all key partners and community. Forecasted meetings and reports will include; project coordination meeting, design review, notice of Intent to construct, teleconferences and reporting by the contractor, project commissioning and close out. Mr. Moore has demonstrated experience in meeting the reporting and communications requirements for a wide variety of grant funding agencies, including DOE.

The project roles, background, and expertise of the individuals who would be involved in managing and then operating and maintaining the project are discussed in the following paragraphs.

Mr. Moore is responsible for THRHA Development and Construction Management (resume attached), and will be the Project Manager for the design and construction. He works closely with Robert Reimer, THRHA's Maintenance Manager. Robert is responsible for operations and maintenance of 600 THRHA housing units including multi-family buildings throughout the southeast region of Alaska. Robert has been with THRHA for five years and prior he was with the Days Inn for six years as property manager where he was responsible for $24M of property assets. Robert manages THRHA's 20 onsite field representatives. THRHA field representatives are responsible for repairing and maintaining all THRHA properties which include: inspections, reports, estimating, purchasing, record-keeping, scheduling, computer data entry and all aspects of maintenance including plumbing, heating/ventilation, electrical, and carpentry. Field reps have received formal HVAC training and have advanced certifications.

THRHA manages an annual budget of $12 million and employs over 40 technical and administrative personnel. The VP of Administration, Joyce Niven, will lead fiscal management on this project. (resume attached) Ms. Niven has worked in the accounting field for over 20 years and for the past 12 years, she has been employed by THRHA. She has a Bachelor's of Science degree in business and finance from Western Washington University, Bellingham, Washington. Under the leadership of Ms. Niven, THRHA has successfully closed over five new construction project accounts and during the past three years. Two of these projects were closed with multiple funding sources.

Ms. Niven, will provide oversight to the project and grant accounting. She will supervise Finance Manager Irene Tupou who is responsible for all accounting functions including grant accounting that is performed by her staff. Ms. Tupou is a member of THRHA management, and she coordinates all aspects of project implementation with her senior colleagues at THRHA to ensure that THRHA complies, and maintains reporting on time and within budget. (resume attached)

Bookkeeping functions are performed in-house using Emphasys Systems Elite, to manage fund accounting that meets Federal requirements. Ms. Tupou is responsible for all accounting functions including grant accounting that is performed by her staff. Ms. Tupou has experience managing grant

funds from a variety of sources, including DOE, and ensures that no expenses that are unallowable will be requested for reimbursement.

THRHA financial management and internal controls provide assurance that project goals and objectives will be met and funds will be used efficiently. To provide checks and fiscal oversight, THRHA's internal financial controls and policy separate duties into three financial functions (authorizing transactions, keeping records, and handling funds). Program funds are tracked in separate grant accounts with a project code allocated to each. Upon award of funding THRHA conducts a grant implementation meeting and review newly established codes for associated expenses. Only allowable expenses are coded and paid out of grant funds, the expenses are approved by the Project Manager and monthly grant meetings are held among the finance staff, project manager, and grant administrator to ensure all expenses are allowable and coded properly according to the approved budget. THRHA also tracks grant in-kind and match including labor and expenses that are not allowable as grant reimbursement. In addition, THRHA conducts an annual external financial audit.

3.3 Level of Commitment to Project

The THRHA manages a suite of facilities in Southeastern Alaska that provide affordable housing opportunities for native and non-native residents and their families. Additionally, THRHA is involved in providing a wide variety of funding, construction, and technical services to low income residents and properties. This project provides the opportunity to demonstrate how buildings in Southeastern Alaska can utilize deep energy retrofits including air-to-water heat pumps for space heating as well as domestic hot water to offset the use of oil. This project utilizes the Southeastern Alaskan climate and new proven, but not widely adopted, technologies to reduce annual heating energy demands and costs by 1.5-3 times over typical fuel oil and electric resistance systems. These projects have the potential to dramatically reduce energy demand over time as building owners and local installers become familiar with them.

This project and THRHA's footprint in the building community in Southeastern Alaska provide the opportunity to showcase the real costs, energy performance, and benefits of this technology and application. This project also provides the opportunity to identify the challenges associated with implementing this type of project, such as needing/evaluating low-temperature hydronic heating systems, ensuring appropriate electrical service, and identifying the appropriate equipment and sizing of that equipment. THRHA hopes to show the benefits and challenges, and how the challenges can be addressed and overcome.

THRHA would hope to replicate this type of project at other buildings it owns in Southeastern Alaska, and would hope that others can use this same information to determine whether they are able to make the same move away from oil and to low temperature hydronic systems combined with air-to-water heat pumps for new construction or building renovations. The recent drop in oil prices may lead to complacency in addressing future energy issues. By promoting deep energy retrofits and heat pump technology and demonstrating success now, the THRHA can make positive steps toward improving energy efficiency and lowering long-term energy costs.

The THRHA is fully committed to its mission of providing sustainable housing options for Southeastern Alaskans. This project would reduce the annual cost to operate the facility at Haines, and would provide a demonstration that this type of deep energy retrofit project is viable in SE Alaska's hydro communities.

THRHA is fully committed to providing the matching funding required for this project to proceed, as is described in the letter of commitment provided. The full amount of $348,520 would come from THRHA's IHBG funding allocation and THRHA's capital budget.

4.0 ATTACHMENTS LIST

- Attachment A – Work Plan
- Attachment B – Site and Resource Maps and Graphics File
    - Location Map
    - Building Floor Plan
- Attachment C – Energy Savings Calculations
- Attachment D – Energy Use Data
    - 2014 Oil Deliveries (November 2013 – October 2014)
    - 2014 Electric Bills (November 2013 – October 2014)
- Attachment E – Energy Audits or Assessments for Deep Energy Retrofits
    - DE-0005179 – Energy Efficiency Audit, Assessment, and Alternative Energy Study
        - Excerpt from overall report summarizing Energy audit and assessment using AKWarm by Marquam George, LLC
        - Heating Conversion Analysis for Haines Multifamily Low Rent Housing by Alaska Energy Engineering, LLC
        - Monitoring Plan for Haines Multifamily Low Rent Housing by Alaska Energy Engineering, LLC
- Attachment F – Design and Engineering
    - Heat pump equipment and water kit cut sheets
    - Heat pump system warranty
- Attachment G – Economics
    - 25-yr cash flow analysis with key assumptions
- Attachment H – Statement of Commitment and Cost Sharing
    - Authorization for Application
- Attachment I – Subcontract Plan
- Attachment J – Resumes
    - Craig Moore – VP Development and Construction Management
    - Joyce Niven – VP Administration
    - Irene Tupou – Finance Manager

Attachment A

Work Plan

Regional Housing Authority

Work Plan

Haines Low-Rent Multifamily Deep Energy Retrofit Project

1.0 Project Objectives

With the Haines Low-Rent Multifamily Deep Energy Retrofit Project, THRHA plans to drastically reduce the energy usage at the facility through implementing multiple EEMs, the largest of which is a conversion of the heating system from non-renewable fuel oil and high temperature heat emitters to a low temperature hydronic system heated by an air-to-water heat pump fueled by locally sourced renewable hydroelectricity. The following are THRHA's objectives for the project:

- Increasing the overall energy efficiency of the facility
- Reducing long term operating costs
- Protecting the facility against the volatility of the fossil fuel market
- Increasing the use of local sustainable energy sources
- Decreasing the greenhouse gas emissions of the facility

2.0 Project Summary

Tlingit Haida Regional Housing Authority (THRHA) owns and manages the Haines Multifamily Low Rent Building in Haines, Alaska. The building is a ~7,000 ft^2 facility containing 12 apartments, a laundry room, storage room, day room, and mechanical room. Energy audits of this facility have generated a list of energy efficiency measures (EEM's) to reduce long term energy costs. THRHA is seeking grant funding to allow a deep energy retrofit of the facility. The energy efficiency measures included in this deep energy retrofit would include: air sealing to 4 ACH, upgrading ceiling insulation, insulating the floor cavity, upgrading windows and outside doors, installing Energy Star refrigerators, a new heat recovery ventilation unit for planned makeup air for the corridor and common spaces, and installation of a low-temperature hydronic heating system and an air source heat pump system (ASHP). These proposed steps would provide deep energy retrofit of the facility while improving indoor air quality and resident comfort.

3.0 Work Breakdown Structure (WBS) and Task Descriptions

The project is to be procured as a design-build project. THRHA is responsible for implementing the project, and will procure the services of a contractor to design and install the EEMs. The following table identifies the key milestones and tasks for the project.

Design and Permitting Phase			
Milestone	**Tasks**	**Start Date (Months from Project Start)**	**Responsible Party / Verification**
1-Project Scoping / Contractor Solicitation	Issue design RFP and select contractor	0.0	THRHA
2-Final System Design / Permitting	Final design / construction documents and submit application / obtain building permit	1.0	THRHA Contractor / THRHA Oversight
3-Final Cost Estimate / Updated Financials	Finalize construction cost estimate and financial analysis	2.0	THRHA Contractor / THRHA Oversight
4-Overall Review / Proceed to Construction	Review documents, approve, and move to Construction Phase	2.5	THRHA
Construction Phase			
Milestone	**Tasks**	**Start Date (Months from Project Start)**	**Responsible Party / Verification**
5-Develop Bid Documents	Use design documents, put together solicitation	3.0	THRHA
6-Vendor Selection and Award	Run bid process, select contractor(s), negotiate / sign contract	3.5	THRHA
7-Construction	Construction and construction management and oversight by THRHA	4.5	THRHA Contractor / THRHA Oversight
8-Integration and Testing	Testing and balancing, prepare for change over	9.5	THRHA Contractor / THRHA Oversight
9-Change Over / Decommissioning of Old System	Change over and remove extraneous equipment	10.0	THRHA Contractor / THRHA Oversight
10-Commissioning and Final Acceptance	Commissioning, final punch list, and acceptance of project as complete	10.5	THRHA Contractor / THRHA Oversight
11-Operations Monitoring and Reporting	Ongoing monitoring and reporting	11.0	THRHA

4.0 Project Management

THRHA staff would be in charge of completing the project, and Craig Moore, VP of THRHA would the manager of the project. Mr. Moore and his team have extensive experience in selecting and managing engineering and construction contractors for weatherization, energy efficiency, and energy system design and installation at a wide variety of housing facilities. This experience includes the similar Kake Low-Rent building, which recently underwent a similar renovation and deep energy retrofit while using a biomass renewable energy system to provide heating needs. The THRHA also has experience managing the design, installation, and operation of air source heat pumps, including an installation at the Saxman Senior Center where an air-to-water heat pump is used for providing domestic hot water.

This project would be procured as a design-bid-build project. Mr. Moore's team has extensive experience in managing building system and energy projects in this manner. Mr. Moore's team would scope out the project, and procure the design and construction team using THRHA's well established procurement procedures. Mr. Moore's team has the hands on experience to provide their own oversight/review of the design and construction oversight. Project risk will be managed through THRHA's oversight of the project contractors, deliverables, budget, construction and commissioning. Any necessary project changes will be managed through the design consultant's approval and the construction contract document requirements. It is anticipated that an AIA construction contract would be used.

Mr. Moore and his team are also proficient in project communications, community outreach, and recording of project activities and progress. During the course of the project, regular update meetings or teleconferences will be held with contractors. Meeting notes will be recorded for the project file. THRHA will track and monitor the established budget versus actual expenditures by line item. The Team has a wealth of experience in working with contractors and the community. Before work begins Mr. Moore will conduct a coordination meeting to include all key partners and community. Forecasted meetings and reports will include; project coordination meeting, design review, notice of Intent to construct, teleconferences and reporting by the contractor, project commissioning and close out. Mr. Moore has demonstrated experience in meeting the reporting and communications requirements for a wide variety of grant funding agencies, including DOE.

The project roles, background, and expertise of the individuals who would be involved in managing and then operating and maintaining the project are discussed in the following paragraphs.

Mr. Moore is responsible for THRHA Development and Construction Management, and will be the Project Manager for the design and construction. He works closely with Robert Reimer, THRHA's Maintenance Manager. Robert is responsible for operations and maintenance of 600 THRHA housing units including multi-family buildings throughout the southeast region of Alaska. Robert has been with THRHA for five years and prior he was with the Days Inn for six years as property manager where he was responsible for $24M of property assets. Robert manages THRHA's 20 onsite field representatives. THRHA field representatives are responsible for repairing and maintaining all THRHA properties which include: inspections, reports, estimating, purchasing, record-keeping, scheduling, computer data entry and all aspects of maintenance including plumbing, heating/ventilation, electrical, and carpentry. Field reps have received formal HVAC training and have advanced certifications.

THRHA manages an annual budget of $12 million and employs over 40 technical and administrative personnel. The VP of Administration, Joyce Niven, will lead fiscal management on this project. Ms. Niven has worked in the accounting field for over 20 years and for the past 12 years, she has been employed by THRHA. She has a Bachelor's of Science degree in business and finance from Western Washington University, Bellingham Washington. Under the leadership of Ms. Niven, THRHA has successfully closed over five new construction project accounts and during the past three years, two of these projects were closed with multiple funding sources

Ms. Niven, will provide oversight to the project and grant accounting. She will supervise Finance Manager Irene Tupou who is responsible for all accounting functions including grant accounting that is performed by her staff. Ms. Tupou is a member of THRHA management, and she coordinates all aspects

of project implementation with her senior colleagues at THRHA to ensure that THRHA complies, and maintains reporting on time and within budget.

Bookkeeping functions are performed in-house using Emphasys Systems Elite, to manage fund accounting that meets Federal requirements. Ms. Tupou is responsible for all accounting functions including grant accounting that is performed by her staff. Ms. Tupou has experience managing grant funds from a variety of sources, including DOE, and ensures that no expenses that are unallowable will be requested for reimbursement.

THRHA financial management and internal controls provide assurance that project goals and objectives will be met and funds will be used efficiently. To provide checks and fiscal oversight, THRHA's internal financial controls and policy separate duties into three financial functions (authorizing transactions; keeping records; and handling funds). Program funds are tracked in separate grant accounts with a project code allocated to each. Upon award of funding THRHA conducts a grant implementation meeting and review newly established codes for associated expenses. Only allowable expenses are coded and paid out of grant funds, the expenses are approved by the Project Manager and monthly grant meetings are held among the finance staff, project manager, and grant administrator to ensure all expenses are allowable and coded properly according to the approved budget. THRHA also tracks grant in-kind and match including labor and expenses that are not allowable as grant reimbursement. In addition, THRHA conducts an annual external financial audit.

5.0 Project Schedule

The following project schedule matches the table from the WBS section assuming a project start date of July 1, 2016.

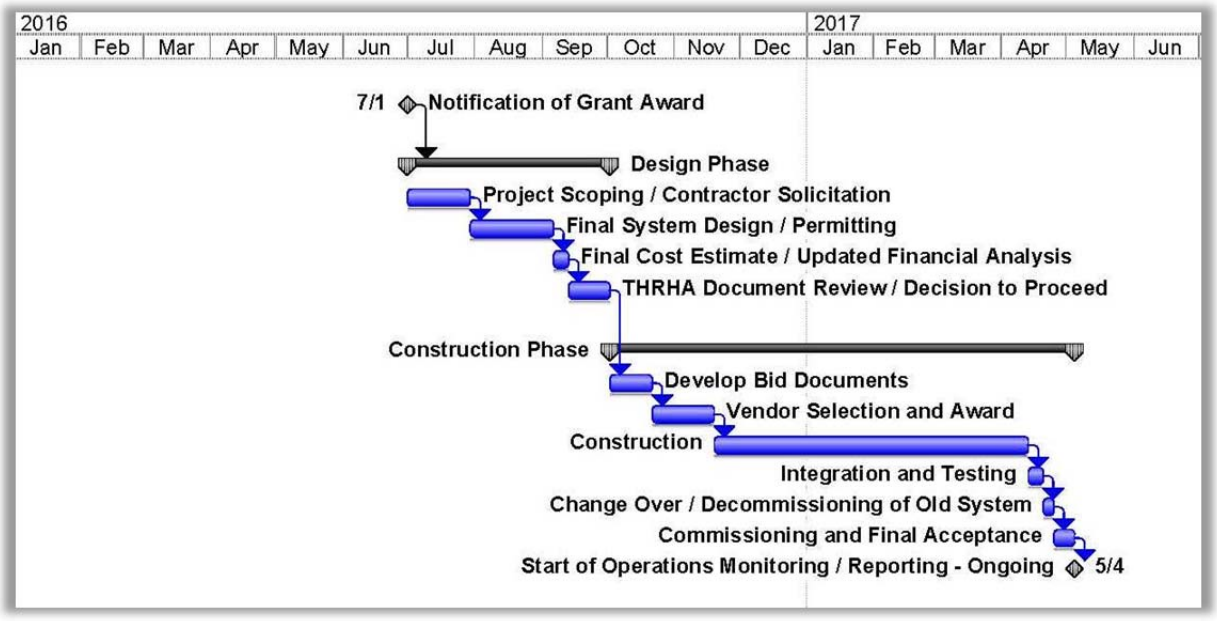


Figure 1 – Project Schedule

Attachment B

Site and Resource Maps and Graphics File

- Location Map
- Building Floor Plan



REVISIONS		
Date	Description	Approved

THRHA
Tlingit-Haida Regional Housing Authority

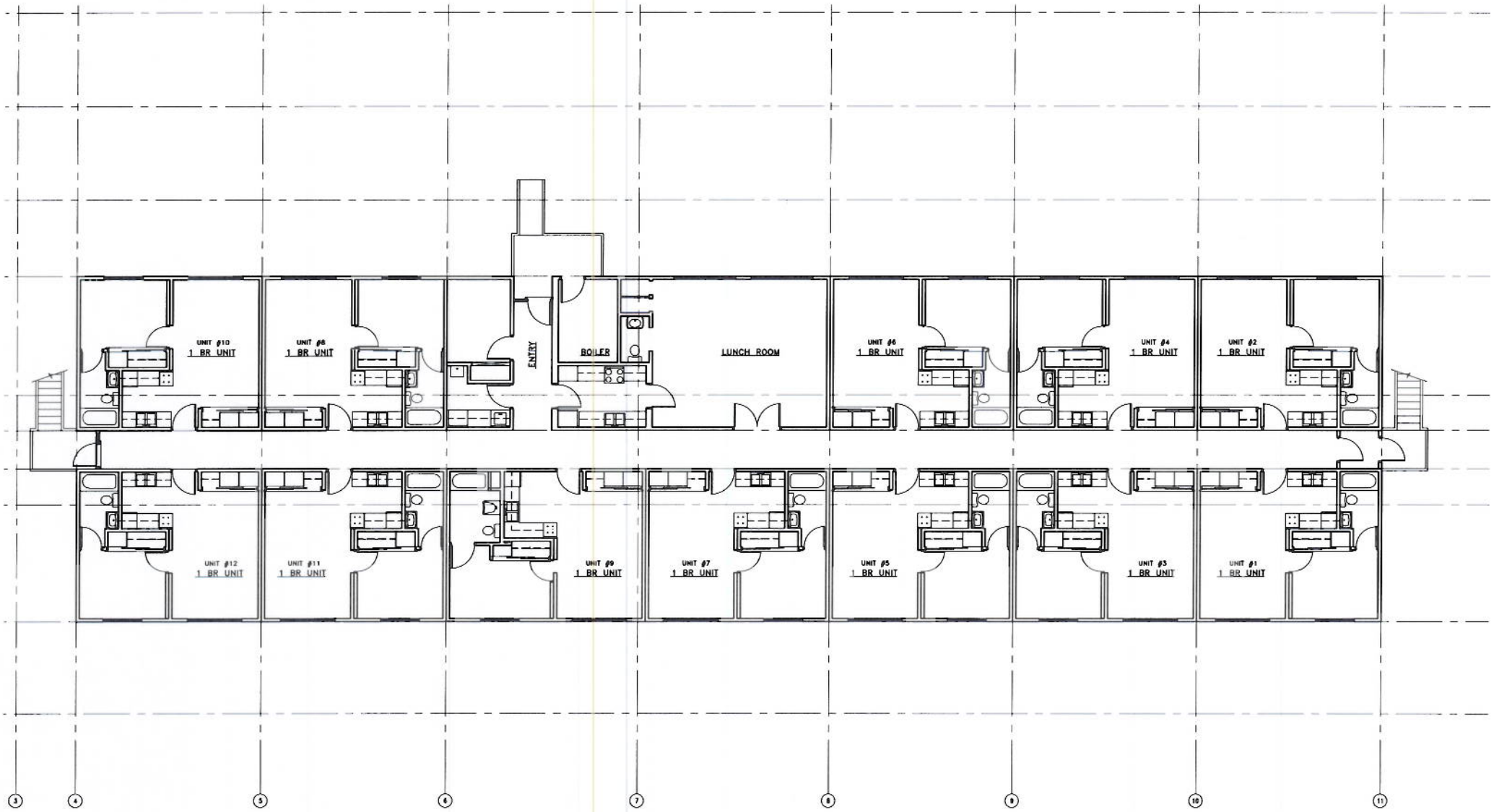
Haines Low-Rent Multifamily Retrofit

Haines, AK

Aerial View

Designed
Drawn
Checked

Approved _____ Date _____
Title _____ Job Class _____


UNIT #10
1 BR UNIT
UNIT #8
1 BR UNIT
ENTRY
BOILER
LUNCH ROOM
UNIT #6
1 BR UNIT
UNIT #4
1 BR UNIT
UNIT #2
1 BR UNIT
UNIT #12
1 BR UNIT
UNIT #11
1 BR UNIT
UNIT #9
1 BR UNIT
UNIT #7
1 BR UNIT
UNIT #5
1 BR UNIT
UNIT #3
1 BR UNIT
UNIT #1
1 BR UNIT
3
4
5
6
7
8
9
10
11

Attachment C

Energy Savings Calculations

Energy Savings Calculations

Heating System	A-Fuel Oil Usage, gallons	B-Electricity Usage (heating), kWh	C-Electricity Usage (non-heating), kWh	D-Total Energy Use (Site), kBtu	E-Total Energy Use (1.5 Site-Source), kBtu	F-Total Energy Use (3.14 Site-Source), kBtu
Projected Energy Usage, Fuel Oil Boiler	4,314	2,313	49,687	774,913	869,600	1,160,575
Projected Energy Usage, EEMs	140	39,028	48,134	316,776	465,670	953,405
			Annual Savings	***59%***	***46%***	***18%***

Dicussion of Calcluation: There are only two types of energy currently used at the facility. These are fuel oil for heating, and electricity for a wide variety of uses. Should all EEMs be implemented, including the low temperature hydronic heating system and air-to-water heat pump installation, the only form of energy used onsite will be electricity, with the heat pump using renewable heat from the surrounding air/climate. The source of electricity for this community is hydroelectricity, and Saxman is in one of Alaska's special hydro communities. The Alaska Housing Finance Corporation has developed a site-to-source factor of 1.5 for Alaska's special hydro communities. This factor is used when calculating the realistic source energy use for before and after all the EEMs are implemented. Column E totals the energy use onsite based on the energy usages listed here for the entire facility and the DOE conversion factors to kBtu. Column F shows the annual Source energy use for each scenario, and source values are calculated using the DOE conversion factors, with the exception of the one for electricty. In this case, the factor of 1.5 is used as it is more appropriate for this project than the blanket national value. Column G shows the source energy calculation if the national value were to be used in order to show the impact to the source savings calculation, but again, this is not an appropriate value for this project and is only shown for demonstration purposes.

Inputs to Calculations

Item	Value	Units	Source
#1 Fuel Oil HHV	0.138	mmBtu/gallon	DOE App C
Electricity	0.003412	mmBtu/kWh	DOE App C
#1 Fuel Oil Conversion to Source Energy	1.01		DOE App C
Electricity Conversion to Source Energy for Alaska Special Hydro Community	1.5		AHFC - Hydro
Electricity Conversion to Source Energy National Factor	3.14		DOE App C

Attachment D

Energy Use Data

- 2014 Oil Deliveries (November 2013 – October 2014)
- 2014 Electric Bills (November 2013 – October 2014)

Ship To: ELDE

T&H ELDERLY HOUSE - HAINES

Invoice #	Date	Ship To	Item #	Whse	Gallons	Price	Total
2223397	2/15/2013	ELDE	01	H12	543.3	4.189	2,275.88
2250843	8/2/2013	ELDE	01	H05	311.3	4.259	1,325.83
2251088	8/5/2013	ELDE	01	H12	92.0	4.259	391.83
2258058	9/9/2013	ELDE	01	H12	340.0	4.259	1,448.06
2294959	4/3/2014	ELDE	01	H14	130.8	3.980	520.58
2299850	5/2/2014	ELDE	01	H05	421.4	3.980	1,677.17
2305709	6/4/2014	ELDE	01	H12	151.5	3.980	602.97
2339130	11/20/2014	ELDE	01	H05	230.2	3.840	883.97
2343462	12/17/2014	ELDE	01	H12	639.9	3.940	2,521.21
2343704	12/18/2014	ELDE	01	H12	114.9	3.940	452.71
				Total for Ship to ELDE:	**2,975.3**		**12,100.20**

Ship To: ELDR

T&H - SENIOR ELDERLY - HAINES

Invoice #	Date	Ship To	Item #	Whse	Gallons	Price	Total
2218863	1/13/2013	ELDR	01	H12	201.3	4.289	863.38
2218880	1/14/2013	ELDR	01	H05	362.9	4.289	1,556.48
2228027	3/21/2013	ELDR	01	H14	501.3	4.259	2,135.04
2248313	7/22/2013	ELDR	01	H14	170.7	4.259	727.01
2264071	10/10/2013	ELDR	01	H12	350.0	4.259	1,490.65
2268718	11/8/2013	ELDR	01	H14	299.2	4.259	1,274.29
2273801	12/6/2013	ELDR	01	H12	652.6	4.119	2,688.06
2278712	1/6/2014	ELDR	01	H14	363.9	4.119	1,498.90
2283753	2/5/2014	ELDR	01	H12	751.4	4.119	3,095.02
2289549	3/6/2014	ELDR	01	H12	535.6	4.050	2,169.18
2305707	6/4/2014	ELDR	01	H12	160.0	3.980	636.80
2313765	7/9/2014	ELDR	01	H05	300.0	3.980	1,194.00
2313785	7/9/2014	ELDR	01	H12	106.1	3.980	422.28
2320899	8/12/2014	ELDR	01	H14	254.1	3.980	1,011.32
2328017	9/17/2014	ELDR	01	H12	321.5	3.980	1,279.57
2333455	10/17/2014	ELDR	01	H12	322.0	3.840	1,236.48
				Total for Ship to ELDR:	**5,652.6**		**23,278.45**

COMMUNITY: HN
ACCOUNT: HN0806

ALASKA POWER COMPANY
ACCOUNT ACTIVITY DETAIL
Power (arPWR) Billing

ACCT	NAME	CONNECT	DISCONNECT	CUR BAL	DEPOSIT	LVL	METER
HN0806	Tlingit & Haida Housing 52 Deishu Dr. Haines L R Bldg P.O. Box 32237 Juneau AK 99803-2237	08/01/1996		867.60		0.00	35686024

Period: 06-2015	Date	Code	Description		Amount	Deposit	Lvl.	Wire/Line	Note
MTREAD	06/18/2015	02	Energy Charge	3,600 KWH	328.32				
MTREAD	06/18/2015	13	Regulatory Cost Charge		2.71				
MTREAD	06/18/2015	14	A1 Customer Charge		13.85				
MTREAD	06/18/2015	20	A1 Electric Rate - Government		522.72				
HN209G	06/03/2015	90	Cash Payment Clearing		-810.68				
Totals: 3,600 KWH	**Last Read:**	**6200**	**Payments:**	**-810.68**	**56.92**				
			On Acct:	**867.60**					

Period: 05-2015	Date	Code	Description		Amount	Deposit	Lvl.	Wire/Line	Note
MTREAD	05/19/2015	02	Energy Charge	3,360 KWH	306.43				
MTREAD	05/19/2015	13	Regulatory Cost Charge		2.53				
MTREAD	05/19/2015	14	A1 Customer Charge		13.85				
MTREAD	05/19/2015	20	A1 Electric Rate - Government		487.87				
HN189G	05/06/2015	90	Cash Payment Clearing		-962.93				
Totals: 3,360 KWH	**Last Read:**	**6155**	**Payments:**	**-962.93**	**-152.25**				
			On Acct:	**810.68**					

Period: 04-2015	Date	Code	Description		Amount	Deposit	Lvl.	Wire/Line	Note
MTREAD	04/20/2015	02	Energy Charge	3,840 KWH	388.61				
MTREAD	04/20/2015	13	Regulatory Cost Charge		2.90				
MTREAD	04/20/2015	14	A1 Customer Charge		13.85				
MTREAD	04/20/2015	20	A1 Electric Rate - Government		557.57				
HN166G	04/03/2015	90	Cash Payment Clearing		-903.60				
Totals: 3,840 KWH	**Last Read:**	**6113**	**Payments:**	**-903.60**	**59.33**				
			On Acct:	**962.93**					

Period: 03-2015	Date	Code	Description		Amount	Deposit	Lvl.	Wire/Line	Note
MTREAD	03/19/2015	02	Energy Charge	3,600 KWH	364.32				
MTREAD	03/19/2015	13	Regulatory Cost Charge		2.71				
MTREAD	03/19/2015	14	A1 Customer Charge		13.85				
MTREAD	03/19/2015	20	A1 Electric Rate - Government		522.72				
HN146G	03/06/2015	90	Cash Payment Clearing		-941.93				
Totals: 3,600 KWH	**Last Read:**	**6065**	**Payments:**	**-941.93**	**-38.33**				
			On Acct:	**903.60**					

Period: 02-2015	Date	Code	Description		Amount	Deposit	Lvl.	Wire/Line	Note
MTREAD	02/18/2015	02	Energy Charge	3,920 KWH	355.94				
MTREAD	02/18/2015	13	Regulatory Cost Charge		2.96				
MTREAD	02/18/2015	14	A1 Customer Charge		13.85				
MTREAD	02/18/2015	20	A1 Electric Rate - Government		569.18				
HN124G	02/04/2015	90	Cash Payment Clearing		-998.75				
Totals: 3,920 KWH	**Last Read:**	**6020**	**Payments:**	**-998.75**	**-56.82**				
			On Acct:	**941.93**					

Period: 01-2015	Date	Code	Description		Amount	Deposit	Lvl.	Wire/Line	Note
MTREAD	01/20/2015	02	Energy Charge	4,160 KWH	377.73				
MTREAD	01/20/2015	13	Regulatory Cost Charge		3.14				
MTREAD	01/20/2015	14	A1 Customer Charge		13.85				
MTREAD	01/20/2015	20	A1 Electric Rate - Government		604.03				
HN101G	01/02/2015	90	Cash Payment Clearing		-933.03				
Totals: 4,160 KWH	**Last Read:**	**5971**	**Payments:**	**-933.03**	**65.72**				
			On Acct:	**998.75**					

COMMUNITY: HN
ACCOUNT: HN0806

ALASKA POWER COMPANY
ACCOUNT ACTIVITY DETAIL
Power (arPWR) Billing

ACCT	NAME	CONNECT	DISCONNECT	CUR BAL	DEPOSIT	LVL	METER

Period: 12-2014	Date	Code	Description	Amount	Deposit	Lvl.	Wire/Line	Note
MTREAD	12/18/2014	02	Energy Charge 4,000 KWH	363.20				
MTREAD	12/18/2014	13	Regulatory Cost Charge	3.02				
MTREAD	12/18/2014	14	A1 Customer Charge	13.21				
MTREAD	12/18/2014	20	A1 Electric Rate - Government	553.60				
HN640G	12/03/2014	90	Cash Payment Clearing	-859.43				
Totals: 4,000 KWH	**Last Read:**	**5919**	**Payments:**	**-859.43**	**73.60**			
			On Acct:	**933.03**				

Period: 11-2014	Date	Code	Description	Amount	Deposit	Lvl.	Wire/Line	Note
MTREAD	11/18/2014	02	Energy Charge 3,680 KWH	334.14				
MTREAD	11/18/2014	13	Regulatory Cost Charge	2.77				
MTREAD	11/18/2014	14	A1 Customer Charge	13.21				
MTREAD	11/18/2014	20	A1 Electric Rate - Government	509.31				
HN620G	11/05/2014	90	Cash Payment Clearing	-871.05				
Totals: 3,680 KWH	**Last Read:**	**5869**	**Payments:**	**-871.05**	**-11.62**			
			On Acct:	**859.43**				

Period: 10-2014	Date	Code	Description	Amount	Deposit	Lvl.	Wire/Line	Note
MTREAD	10/20/2014	02	Energy Charge 4,080 KWH	290.09				
MTREAD	10/20/2014	13	Regulatory Cost Charge	3.08				
MTREAD	10/20/2014	14	A1 Customer Charge	13.21				
MTREAD	10/20/2014	20	A1 Electric Rate - Government	564.67				
HN597G	10/03/2014	90	Cash Payment Clearing	-770.12				
Totals: 4,080 KWH	**Last Read:**	**5823**	**Payments:**	**-770.12**	**100.93**			
			On Acct:	**871.05**				

Period: 09-2014	Date	Code	Description	Amount	Deposit	Lvl.	Wire/Line	Note
MTREAD	09/18/2014	02	Energy Charge 3,600 KWH	255.96				
MTREAD	09/18/2014	13	Regulatory Cost Charge	2.71				
MTREAD	09/18/2014	14	A1 Customer Charge	13.21				
MTREAD	09/18/2014	20	A1 Electric Rate - Government	498.24				
HN575G	09/03/2014	90	Cash Payment Clearing	-837.41				
Totals: 3,600 KWH	**Last Read:**	**5772**	**Payments:**	**-837.41**	**-67.29**			
			On Acct:	**770.12**				

Period: 08-2014	Date	Code	Description	Amount	Deposit	Lvl.	Wire/Line	Note
MTREAD	08/19/2014	02	Energy Charge 3,920 KWH	278.71				
MTREAD	08/19/2014	13	Regulatory Cost Charge	2.96				
MTREAD	08/19/2014	14	A1 Customer Charge	13.21				
MTREAD	08/19/2014	20	A1 Electric Rate - Government	542.53				
HN553G	08/04/2014	90	Cash Payment Clearing	-786.94				
Totals: 3,920 KWH	**Last Read:**	**5727**	**Payments:**	**-786.94**	**50.47**			
			On Acct:	**837.41**				

Period: 07-2014	Date	Code	Description	Amount	Deposit	Lvl.	Wire/Line	Note
MTREAD	07/18/2014	02	Energy Charge 3,680 KWH	261.65				
MTREAD	07/18/2014	13	Regulatory Cost Charge	2.77				
MTREAD	07/18/2014	14	A1 Customer Charge	13.21				
MTREAD	07/18/2014	20	A1 Electric Rate - Government	509.31				
HN533G	07/07/2014	90	Cash Payment Clearing	-887.13				
Totals: 3,680 KWH	**Last Read:**	**5678**	**Payments:**	**-887.13**	**-100.19**			
			On Acct:	**786.94**				

Period: PRIOR BAL.	Date	Code	Description	Amount	Deposit	Lvl.	Wire/Line	Note
SUMM		00	Summary Record	887.13				
			Account HN0806 Report Totals:	**867.60**	**0.00**		**0.00**	**0.00**

AP&T

Customer Account #

HN0806

Bill Date 06/19/2014 | **Current Charges Due Date 07/14/2014** | **52 Deishu Dr. Haines L R Bldg**

Past Due	Current Charges Due	TOTAL DUE	AMOUNT PAID
0.00	887.13	887.13	**AUTOPAY**

TLINGIT & HAIDA HOUSING
PO BOX 32237
JUNEAU AK 99803-2237

Please send payment to:

Alaska Power Company
Attn: Billing Department
P O Box 3222
Port Townsend WA 98368

AutoPay Customers: Total due will be automatically withdrawn from the arranged source no sooner than 15 days after bill date.

TLINGIT & HAIDA HOUSING | **Account # HN0806** | **52 Deishu Dr. Haines L R Bldg**

Previous Balance	Applied to Prior	Past Due	Current Activity	TOTAL DUE	AMOUNT PAID
979.84	-979.84	0.00	887.13	887.13	**AUTOPAY**

Payments Applied Through 06/18/2014 **Bill Date 06/19/2014**

Route Nbr: 00000-00806	Present Reading:	5,632	06/16/2014	Multiplier:	80
Meter Nbr: 35686024	Previous Reading:	5,580	05/15/2014	KWH Used:	4,160
		52			

SUMMARY OF CHARGES

Electric Rate @ 13.84 cents per KWH
Energy Chrg @ 7.11 cents per KWH

Balance Forward		979.84
Cash Payment Clearing	6/4/2014	-979.84
A1 Electric Rate - Government		575.74
Energy Charge		295.78
Regulatory Cost Charge		2.40
A1 Customer Charge		13.21
Current Balance Due		887.13

ACCOUNT METER READING HISTORY

READ DATE	READING	USAGE
06/16/2014	5632	4,160
05/15/2014	5580	4,240
04/15/2014	5527	4,800
03/15/2014	5467	4,640
02/14/2014	5409	4,880
01/15/2014	5348	4,880
12/16/2013	5287	4,720
11/15/2013	5228	4,400
10/15/2013	5173	3,680
09/16/2013	5127	4,000
08/16/2013	5077	4,160
07/15/2013	5025	3,920
06/14/2013	4976	3,760

Accounts with past due balances are considered delinquent and are subject to disconnection 55 days after initial rendering.

Thank You For Letting Us Serve You
Our Local Number is 766-6500

RCA CONSUMER HOT LINE IS 1-800-390-2782

PAYMENTS RECEIVED AFTER 2:00 PM WILL BE POSTED THE FOLLOWING BUSINESS DAY

Attachment E

Energy Audits or Assessments for Deep Energy Retrofits

- DE-0005179 – Energy Efficiency Audit, Assessment, and Alternative Energy Study
  - Excerpt from overall report summarizing Energy audit and assessment using AKWarm by Marquam George, LLC
  - Heating Conversion Analysis for Haines Multifamily Low Rent Housing by Alaska Energy Engineering, LLC
  - Monitoring Plan for Haines Multifamily Low Rent Housing by Alaska Energy Engineering, LLC

2.3 HAINES

Haines, Alaska is a Census Designated Place (CDP) located on the western shore of Lynn Canal, between the Chilkoot and Chilkat Rivers. It is about 80 air miles northwest of Juneau, Alaska. The average annual high temperature is 46.8°F and the average annual low temperature is 35.3°F Annual Heating Degree Days (HDD) base 65F = 8,453 HDD.

Haines is accessible by road via the Haines Highway which is maintained year round and connects Haines to northern Alaskan communities. Air transportation is available with 2 regional carriers, Alaska Seaplane Service and Wings of Alaska. Both provide daily passenger service and some freight and cargo service. Haines is a part of the Alaska Marine Highway which provides the only water transportation of vehicles and passengers. Barge service is available for cargo and is offloaded at the 950 foot Lutak Dock.

The community has a population of 2,664 with the median age being 46.2 years old. There are 1,784 housing units in Haines. Owner occupied units number 882, while there are 348 renter occupied units. Haines' economy is classified as subsistence and relies heavily on tourism with 70% of the population employed in the private sector. Table 2.3-1 shows an energy cost comparison for heating fuels in the community.

Table 2.3-1 : Haines Cost of Energy Comparison

Technology, Unit	Input Btu/Unit	Cost/Unit	Assumed Efficiency	Output Btu/Unit	Cost/ mmBtu Output
#2 Fuel Oil, Gallon	138,800	$4.22	80%	111,040	$38.00
Propane, Gallon	91,300	$4.00	80%	73,040	$54.76
Electricity, kWh (Resistance)	3,412	$0.23	100%	3,412	$67.41
Electricity, kWh (Heat Pump)	3,412	$0.23	300%	10,236	$22.47
Wood Pellets, Ton	15,200,000	$350.00	80%	12,160,000	$28.78

Note: Fuel prices provided by AkWarm software based on the 3/30/2015 library. Biomass & propane prices obtained from local providers.

2.3.1 Haines 12 Unit Multifamily Building

THRHA operates a 7,000 ft^2 low rent multifamily building in the city of Haines that was constructed in 1982. The building is of modular construction and contains 12 one bedroom, one bath rental units and is 1 story, stick frame construction, vinyl sided, and has a steel roof. The foundation is creosote piles that support a raised floor with a skirted crawlspace.

A typical unit is 24' x 20' with all units exiting to a central corridor. The central corridor is 5' wide and has a utility chase above a drop ceiling for piping (heat and domestic hot and cold water) and electrical distribution to apartments. There are small common areas, including a small laundry room, storage locker room, day room, and the mechanical room. Figures 2.3-1 through 2.3-4 show the pictures of the Haines 12 Unit Multifamily Building.



Figure 2.3 – 1 : Haines Low Rent Apartment – Outside Shell



Figure 2.3 – 2 : Haines Low Rent Apartments – Under Floor



Figure 2.3 – 3 : Haines Low Rent Apartments – Attic Crawlspace

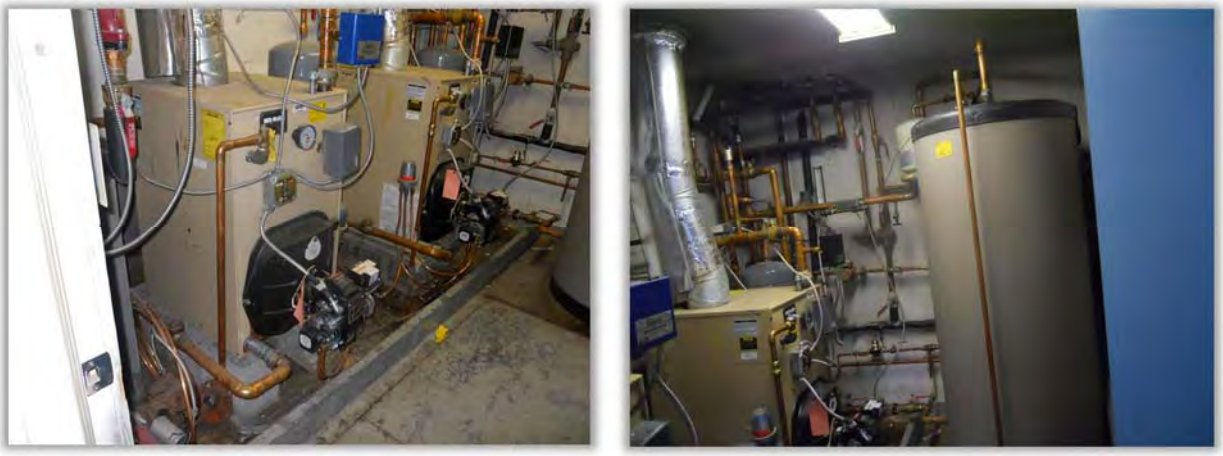


Figure 2.3 – 4 : Haines Low Rent Apartments – Boiler Room

Table 2.3-2 provides the building address, square footage, and insulation values of building components.

Table 2.3-2 : Haines 12 Unit Insulation Values and Area of Building Components

Building Address	Item	Living Area Floors	Walls	Door 1	Door 2	Door 3	South Windows	Remaining Windows	Ceiling
52 Deishu Dr.	R-Value	24.1	16.2	1.8	1.8	1.8	1.1	1.1	29.3
	Area, ft^2	6,930	3,188	22	22	22	305	343	6,930

Two Weil McLain WGO-6 hot water boilers firing on #2 fuel oil are used to heat the building and domestic hot water. The boilers are each rated at 212,000 Btu/hr. Hot water circulation pumps distribute hot water for space heating and to an indirect heated domestic hot water tank. Baseboard heat is located in each unit. Table 2.3-3 provides a breakdown of annual energy use and costs for the 12 unit building. Values are provided from AkWarm reports using the 3/30/2015 data library.

Table 2.3-3 : Haines Annual Energy Cost Breakdown

Space Heating #2 Oil Use, Gallons	Space Heating #2 Oil Cost	Water Heating #2 Oil Use, Gallons	Water Heating #2 Oil Cost	Appliances / Lights Electric Use, kWh	Appliances / Lights Electric Cost	Total Annual Costs
1,619	$6,832	658	$2,777	66,629	$15,965	$25,574

Note: Fuel use and cost information provided by AkWarm software based on the 3/30/2015 library

2.3.2 Improvement Option Recommendations

The energy audits of the facilities generated a list of energy efficiency recommendations. Blower door tests and walkthrough assessments were conducted by professional energy auditing companies. Energy efficiency measures considered for the Haines Low Rent Housing Building are as follows:

- **Windows** - Windows have double glazing, but many have broken seals or no longer close completely. They all need replacing with energy efficient new windows with a minimum U-value of .28.
- **Air Sealing** - The building has lots of air leakage. THRHA would like to tighten the building up to no more than 4 ACH50.
- **Insulation** - Thermal values of the building shell are low. THRHA would like to increase the R-values of the ceiling to R-60, the floor to R-38, and the walls to R-30. Outside insulation and new siding would be required to achieve R-30 walls.
- **Refrigerators** – Refrigerators need to be replaced for aesthetic and efficiency reasons. THRHA would like to install energy star rated appliances during scheduled replacements.

A summary of estimated costs and savings for recommended measures are provided in Table 2.3-4. Cost and savings values are a result of AkWarm calculations.

Table 2.3-4 : Haines Energy Conservation Measure Estimated Cost Benefit Summary

Energy Efficiency Measure	Estimated Total Savings	Estimated Total Cost	Simple Payback, Years	SIR Ratio
Replace 3 outside doors with U-0.16 insulation	$190	$1,467	7.7	3.0
Air sealing to 4 ACH	$1,283	$5,000	3.9	3.0
Insulate floors with R-30 dense pack insulation	$666	$10,380	15.6	1.5
Replace windows with U-0.26	$2,323	$34,650	14.9	1.2
Increase ceiling Insulation to R-60	$608	$16,945	27.9	0.9
Energy Star Refrigerators	$372	$12,000	32.3	0.5
Outside wall insulation technique, rain screen, and concrete fiberboard siding	$367	$95,640	260.6	0.1
Totals	**$5,809**	**$101,330**	**17.4**	

Notes:
1 – Costs and savings values for air sealing, windows, and insulation are estimated using the AkWarm software from the 3/30/2015 library.
2 – Energy Star rated refrigerator savings are generated from www.energystar.gov savings calculator.
3 – A detailed breakdown of lighting assumptions is provided in Section 4 Attachments.

THRHA also is considering upgrading portions of the building due to necessity that are not driven by energy savings. A summary of potential upgrades being considered are as follows:

- Install a new heat recovery ventilator system in the central corridor and common spaces.
- Replace room exhaust fans with high efficiency low sone exhaust fans with motion sensors and a programmable time delay.
- Install a wood pellet heating system.

Ventilation – The building does not currently have a central ventilation system. The central corridor is not ventilated and carries odors and apartment units have exhaust-only ventilation using a bath fan and a range hood. THRHA would like to install a heat recovery ventilator system for corridors and public spaces, and improve the exhaust-only ventilation system in each apartment with low-sone continuous duty rated exhaust fans on motion sensors with programmable time delays to meet ASHRAE 62.2-2012.

A heat recovery ventilator system is estimated to cost $50,000. This system will use additional energy but will improve indoor air quality and occupant comfort. Installing updated exhaust fans on motion sensors with programmable time delays are each estimated to cost $600 installed.

Wood Pellet Heating System - THRHA considered the feasibility of heating the building with a wood pellet fired hot water boiler located in a separate outbuilding. A propane on demand hot water heater will be installed for the non-heating season. The recommended system consists of a 70,000 Btu/hr wood pellet fired hot water boiler and 60 gallons of hot water thermal

storage. The financial summary of the wood pellet system is provided in Table 2.3-5. A cost breakdown is provided in Section 4.0 - Attachments.

Section Table 2.3-5 : Haines Wood Pellet Heating System Financial Summary

Current Oil Use, Gallons	Current Oil Cost	Estimated Wood Pellet Use, Tons	Estimated Wood Pellet Cost	Estimated O&M Costs	Estimated Propane Cost with Wood Pellet System	Estimated Savings	Estimated Capital Cost	Simple Payback
2,277	$9,609	16.6	$5,822	$1,500	$2,769	($482)	110,865	N/A

Note: Assumes 80% offset with wood pellet system. Remaining 20% is offset with an on demand propane fired system. Capital costs include the estimated cost for the propane fired system. Fuel prices used to generate economics are $4.22/gallon for #2 fuel oil, $4.00/gallon for propane, and $350/ton of wood pellets.

The savings for the wood pellet system are negative. This is mostly due to the low volume of oil currently used and the high price of propane. If the wood pellet system were operated throughout the summer using efficient loading of the thermal storage tank, coverage could approach 95% and savings could become positive due to increased propane offset. It is estimated that the savings would in the $500 a year range.

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
jim@alaskaenergy.us

Technical Memorandum

December 15, 2015

to: **Craig Moore, V.P. Planning and Development**
Tlingit-Haida Regional Housing Authority

subject: **Heating Conversion Analysis**

project: **Haines Low Rent Housing**

INTRODUCTION

This report presents a heating conversion analysis for the Haines Low Rent Apartment building. The purpose of the analysis is to compare the life cycle cost of retaining the fuel oil boiler heating system with converting to an air source heat pump heating system.

Jim Rehfeldt, P.E. of Alaska Energy Engineering LLC performed the analysis.

Background

The Tlingit-Haida Regional Housing Authority (THRHA) intends to convert the Haines Low Rent Apartment building in Haines, Alaska from fuel oil boiler heat to air source heat pump heat.

The existing heating system consists of two oil-fired boilers supplying an indirect hot water heater and a high-temperature distribution system consisting of baseboard units located in each apartment. The heating plant—fuel oil boilers, heating pumps, fuel oil tank—is 6 years old, in very good condition and has an expected service life of over 25 years. The distribution system is at the end of its service life.

The THRHA is interested in converting to a heat pump system by adding an air source heat pump, domestic hot water preheat tank heated by the heat pump and a low temperature distribution system and baseboard heaters.

Conversion to an air source heat pump system is aligned with THRHA energy goals to:

- Reduce long-term operating costs
- Increase use of sustainable energy sources: the majority of electricity in Haines is derived from hydroelectric generation
- Increase use of local energy sources, and
- Decrease the greenhouse gas footprint of their operations

ENERGY COSTS

Historic Energy Use and Cost

The Haines Low Rent Apartments is a 6,930-sqft facility that contains 12 apartments and a common hallway, laundry room, kitchen and dining room. Two fuel oil boilers supply heat to the spaces and heat domestic hot water. Historic energy use and cost is summarized in the following table:

Annual Energy Consumption and Cost

Source	Consumption	Cost	Energy, MMBtu	
Electricity	22,480 kWh	$5,474	77	12%
Fuel Oil	4,314 Gallons	$16,100	586	88%
Totals	-	$21,574	663	100%

The building has an energy use index (EUI) of 97, which is relatively high for THRHA facilities. Converting to an air source heat pump system will reduce energy costs.

Energy Costs and Inflation

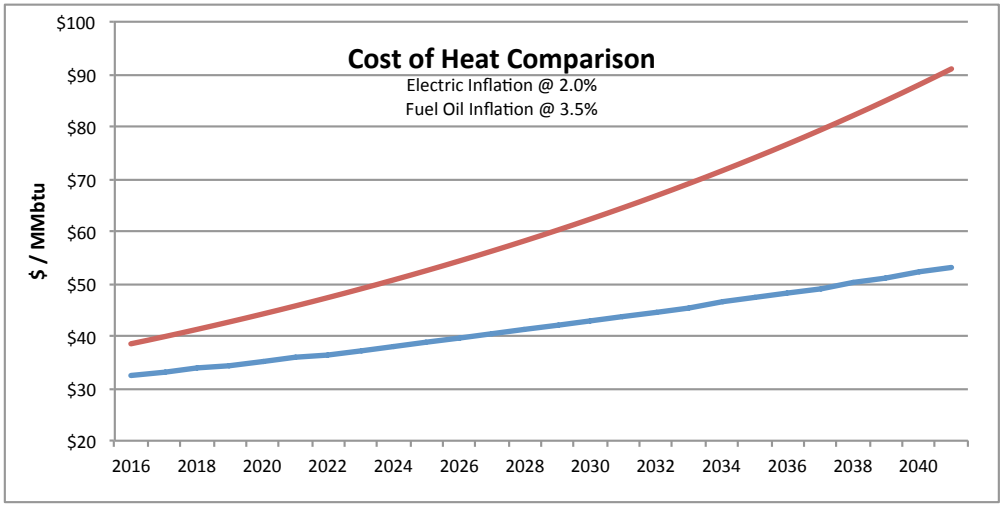
Energy costs and energy inflation used in the analysis are shown in the following table:

Summary of Economic and Energy Factors

Factor	Rate or Cost	Factor	Rate or Cost
Nominal Discount Rate	4.5%	General Inflation Rate	2.5%
Electricity (2016)	24.6¢ per kWh	Electricity Inflation	2.0%
Fuel Oil (2016)	$3.97 / gallon	Fuel Oil Inflation	3.5%

Cost of Heat Comparison

The cost of heat takes into account current energy prices, conversion efficiency, and energy inflation. The following chart shows projected energy prices over 25-years. On the left side of the chart is the cost of heat in 2016. Moving to right is how the cost changes with energy inflation.



An air source heat pump offers much lower heating costs over the life of the project because it extracts a majority of the supplied heat from the environment at no cost or energy inflation.

LIFE CYCLE COST COMPARISON

Description of Systems

The existing fuel oil boiler heating system requires investment to operate for the next 25-years. The plant—two boilers, pumps, fuel tank and appurtenances—are 6 years old and have over 25-years of remaining life. The distribution system and baseboard heating units are at the end of their service life and require replacement.

The analysis compares retaining the fuel oil boiler system with converting to an air source heat pump system. Conversion requires adding an air source heat pump and domestic hot water preheat tank and replacing the distribution system and baseboards with a low temperature system.

Attached to this report is a schematic diagram of the two systems.

Fuel Oil Boiler Option

A fuel oil boiler heating system will consist of:

- Retaining the two existing fuel oil boilers, each sized for 102% of the heating load and the two constant speed building pumps.
- Retaining the existing fuel oil tank and fuel oil system
- Retaining the indirect hot water heater
- Replacing the distribution system piping, baseboard heating units, and thermostats.

The fuel oil boilers are significantly oversized and have an estimated seasonal efficiency of 68%.

Air Source Heat Pump Option

An air source heat pump system will consist of:

- An air source heat pump located outdoors under an enclosure that protects it from wind-driven rain and snow and two indoor heat exchangers that transfer the heat to a low-temperature hydronic heating system.
- A buffer tank that adds thermal mass to the system.
- Two variable speed building pumps supplying low-temperature hydronic heat.
- Retaining one fuel oil boiler to provide supplemental heat during colder weather and to heat domestic hot water.
- An indirect hot water preheat tank heated by the heat pump to 115°F and an indirect hot water tank heated by the boiler to 125 °F.

The air source heat pump sized at 65% of the design load will supply 92% of the heating load. The fuel oil supplements the heating load during cold weather and will also supply supplemental heat to maintain the hot water supply temperature of 125°F.

Life Cycle Cost Comparison

Construction Costs

The fuel oil boiler system has lower construction costs because the heating plant is retained and only the distribution system is replaced. The heat pump represents an investment in higher efficiency so it has higher construction costs. The higher cost is primarily attributed to the following features of the ASHP system:

- Adding a heat pump, heat exchangers and a buffer tank to the building.
- The electrical service will be upgraded from 240v/1ϕ to 208v/3ϕ service.
- The ASHP system requires a low temperature distribution system with larger pumps and piping and higher cost baseboard heaters.

Maintenance Costs

The air source heat pump system has moderately higher maintenance costs associated with maintaining the outdoor units, including factory-trained maintenance every five-years. The outdoor units must also be replaced at the end of their expected service life of 15 years.

The fuel oil boilers require annual maintenance for the burner and to clean the combustion passages.

Energy Costs

The following table summarizes the energy analysis of the two heating options. The ASHP system offers a reduction in energy use and costs.

Energy Analysis

Item	Fuel Oil Boilers	Air Source Heat Pump
Heating Plant Sizing	Two exist @ 101% ea	ASHP @ 65% Fuel Boiler @ 101%
Seasonal Efficiency	68%	214%
Annual Energy Use	Oil: 4,314 gal Elec: 2,313 kWh	Elec: 52,848 kWh Oil: 335 gallons
Annual Energy Cost (2016)	$17,700	$14,300
Energy Use Index, kBtu/sqft	97	43
Energy Cost Index, $/sqft	$3.17	$2.70

Life Cycle Cost Comparison

The fuel oil boiler system has a lower life cycle cost, primarily because the heating plant requires no investment over the next 25-years. The air source heat pump has the lowest energy costs and the fuel oil boiler system has lower construction and maintenance costs.

Life Cycle Cost Comparison

Component	Fuel Oil Boiler	Air Source Heat Pump	% Difference
Construction Costs	$131,000	$515,000	+293%
Maintenance Costs	$29,000	$50,000	+72%
Energy Costs	$390,000	$269,000	-31%
Total Life Cycle Cost	$550,000	$834,000	+152%

The life cycle cost comparison is much closer if 50% of the construction cost is grant funded. The following table shows the cost comparison with 50% grant funding.

Life Cycle Cost Comparison – 50% Grant Funding

Component	Fuel Oil Boiler	Air Source Heat Pump	% Difference
Construction Costs	$131,000	$258,000	+97%
Maintenance Costs	$29,000	$50,000	+72%
Energy Costs	$390,000	$269,000	-31%
Total Life Cycle Cost	$550,000	$577,000	+5%

SUMMARY

For THRHA, this conversion offers several financial and operational benefits that promote conversion. The main benefit is a significant reduction in annual operating costs, helping to keep rents low. An ASHP conversion is also aligned with THRHA's goal to transition away from fuel oil toward sustainable, local energy sources. A high percentage of Haines's power is expected to be renewable hydroelectric power throughout the life of the system. As such, an ASHP system also has lower environmental impacts because it does not emit greenhouse gases.

This project can also benefit other building owners in Haines in the following ways:

- Hydroelectric communities are promoting heat pump heating as an efficient use of hydroelectric resources. The project demonstrates heat pump conversion of an existing building.
- Air source heat pump technology has improved greatly in the last five years to the point that they are viable systems in the relatively warmer climate of coastal Alaska. As the technology continues to gain efficiency, the lessons learned from this conversion will benefit more areas of Alaska.
- The recent drop in oil prices may lead to complacency in addressing future energy issues. By promoting heat pump technology and demonstrating its success now, the THRHA can make positive steps toward improving energy efficiency and lowering long-term energy costs.

This project will successfully demonstrate that heat pump technology is a viable option that offers long-term benefits to THRHA.

by: 

Jim Rehfeldt, P.E.

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Life Cycle Cost Analysis

December 15, 2015

THRHA Haines Low Rent Housing
Sizing and Energy Analysis

Building Loads

	Exist, MBH	ASHP Load, MBH	Energy, kBTU
Heat Loss	134	134	406,293
DHW	76	60	
Total	210	194	

Fuel Oil Boiler System

Sizing Analysis

Boilers	Boiler	Design Load, MBH	Factor	Boiler MBH
	B-1	210	101%	212
	B-2	210	101%	212
			202%	424

Pumps	Pump	GPM	Head	η, pump	Pump, BHP	η, motor	kW
	Building	21	32	50%	0.34	60%	0.422

Energy Analysis

Fuel Oil Boilers	Load, kBTU	% Load	Net, kBTU	Efficiency	kBTU/gal	Fuel, gals
	406,293	100%	406,293	68%	138.5	4,314

Heating Pumping	Pump	Ave GPM	Ave Head	kW	Hours	kWh
	Building	21	20	0.26	8,760	2,313

Air Source Heat Pump System

Sizing Analysis

Heating Equipment	Equip	Design MBH	Factor	Size, MBH	Effic	kW
	ASHP-1	194	65%	126	200%	18
	Fuel Oil Boiler	194	109%	212		
			174%	338		

Heat Exchangers	Equip	Design MBH	Factor	Size, MBH
	HEX-1	126	50%	63
	HEX-2	126	50%	63
			100%	126

Pumps	Pump	GPM	Head	η, pump	Pump, BHP	η, motor
	HEX Pump	13	10	50%	0.06	60%
	HEX Pump	13	10	50%	0.06	60%
	Fuel Oil Boiler	21	12	50%	0.13	70%
	Injection	21	12	50%	0.13	70%
	Building	21	20	50%	0.21	70%

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Life Cycle Cost Analysis

December 15, 2015

THRHA Haines Low Rent Housing
Sizing and Energy Analysis

Energy Analysis

	Load, kBTU	% Load	Net, kBTU
Heat Pumps	406,293	92%	373,789

Month	% Load	Load kBtu	Ave Temp	COP	Input kBtu	kWh
Jan	12%	44,855	24	1.7	27,030	7,922
Feb	10%	37,379	28	1.7	21,819	6,395
Mar	10%	37,379	33	1.9	20,050	5,876
Apr	8%	29,903	42	2.4	12,597	3,692
May	6%	22,427	50	3.0	7,533	2,208
Jun	5%	18,689	56	3.4	5,531	1,621
Jul	5%	18,689	59	3.5	5,320	1,559
Aug	6%	22,427	57	3.4	6,537	1,916
Sep	8%	29,903	51	3.1	9,799	2,872
Oct	9%	33,641	43	2.4	13,757	4,032
Nov	10%	37,379	31	1.8	20,859	6,113
Dec	11%	41,117	28	1.7	24,001	7,034
	100%	373,789		214%	174,832	51,240

Fuel Oil Boiler	Load, kBTU	% Load	Net, kBTU	Efficiency	kBTU/gal	Fuel, gals
	406,293	8%	32,503	70%	138.5	335

Pumps	Pump	Ave GPM	Ave Head	kW	Hours	kWh
	HEX Pump	13	10	0.1	7,500	594
	HEX Pump	13	10	0.1	4,000	317
	Fuel Oil Boiler	21	12	0.1	1,500	206
	Injection	21	12	0.1	750	103
	Building	8	12	0.1	7,500	388
						1,608

Electric Service Capacity

					Total kWh	52,848

Spare Capacity

Service Size: 240 volts / 400A	96 kVA
Capacity kVA (Assume 80%)	77 kVA
Capacity kW (Assume 90% PF)	69 kW
Peak Load	55 kW
Spare capacity	14 kW

Increased Electric Service	Qty	kW, ea	Total kW	kVA @ 90% PF	Volts	Amps
Existing Service	1	55	55	61	208	170
Heat Pump	1	18	18	21	208	57
			73	82	208	227

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
jim@alaskaenergy.us

Life Cycle Cost Analysis

December 15, 2015

THRHA Haines Low Rent Housing

Fuel Oil Boiler System

Basis

25	Study Period (years)	2.5%	General Inflation
4.5%	Nominal Discount Rate	3.5%	Fuel Inflation
2.0%	Real Discount Rate	2.0%	Electricity Inflation

Construction Costs		Year	Qty	Unit	Base Cost	Year 0 Cost
Hydronic Heating System						
Distribution System						
Building loop	1-1/4"	0	940	lnft	$35.00	$32,900
Finned pipe branches	3/4"	0	540	lnft	$25.00	$13,500
Finned pipe convectors		0	320	lnft	$75.00	$24,000
Thermostats and control valves		0	14	ea	$250.00	$3,500
Contingencies						
Estimating contingency		0			15%	$11,085
Overhead & profit		0			30%	$25,496
Design fees		0			10%	$11,048
Project management		0			8%	$9,722
					Total Construction Costs	**$131,000**

Annual Costs	Maintenance	$40.00	Years	Qty	Unit	Base Cost	Present Value
Heating Plant							
Plant Observation							
Daily Heating Plant Observation	30 min/mo		1 - 25	6	hrs	$40.00	$4,622
Fuel Oil Boilers							
Fuel Oil Boiler Maintenance							
Parts Allowance, each			1 - 25	2	LS	$200.00	$7,704
Annual, each	8 hours/year		1 - 25	16	hrs	$40.00	$12,326
Pumps							
Pump maintenance, cartridge			1 - 25	2	ea	$100.00	$3,852
Domestic Hot Water							
Indirect HW heater	1	1	1 - 25	1	hrs	$40.00	$770
						Total Annual Costs	**$29,000**

Energy Costs	Years	Qty	Unit	Base Cost	Present Value
Fuel Oil	1 - 25	4,314	gallon	$3.97	$379,182
Electricity	1 - 25	2,313	kWh	$0.245	$10,490
				Total Energy Costs	**$390,000**

Present Worth	$550,000

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Life Cycle Cost Analysis

December 15, 2015

THRHA Haines Low Rent Housing

Air Source Heat Pump System

Basis

25	Study Period (years)	2.5%	General Inflation
4.5%	Nominal Discount Rate	3.5%	Fuel Inflation
2.0%	Real Discount Rate	2.0%	Electricity Inflation

Construction Costs		Year	Qty	Unit	Base Cost	Year 0 Cost
Hydronic Heating System						
Crawlspace Mechanical Room						
Outdoor units		0	1	ea	$21,600.00	$21,600
Enclosure		0	1	ea	$3,000.00	$3,000
Refrigerant piping		0	2	ea	$1,200.00	$2,400
Indoor HEX units		0	2	ea	$9,000.00	$18,000
HEX pumps		0	2	ea	$1,200.00	$2,400
Buffer Tank	200 gallons	0	1	LS	$9,600.00	$9,600
Piping to building heating loop		0	2	ea	$1,800.00	$3,600
Boiler Room						
Demolition						
Remove fuel oil boiler, fuel piping, cap chimney		0	1	LS	$7,200.00	$7,200
Remove heating and domestic hot water piping		0	1	LS	$2,400.00	$2,400
Heating Plant						
Boiler Room						
Boiler piping and appurtenances	2"	0	1	LS	$2,400.00	$2,400
Injection pump and piping	1-1/2"	0	1	LS	$8,400.00	$8,400
Primary pump, pipe mounted	1/4 HP	0	1	LS	$1,200.00	$1,200
Secondary loop						
Secondary pumps	1/2 HP	0	2	ea	$2,100.00	$4,200
Secondary piping and appurtenances (boiler room)	2"	0	1	lot	$4,200.00	$4,200
Building loop	1-1/4"	0	940	lnft	$42.00	$39,480
Finned pipe branches	3/4"	0	540	ea	$30.00	$16,200
Finned pipe convectors		0	320	lnft	$108.00	$34,560
Thermostats and control valves		0	14	ea	$300.00	$4,200
Domestic Hot Water System						
Indirect HW heater, AV, piping, etc.	120 gallon	0	1	ea	$10,440.00	$10,440
Connect existing Indirect HW heater		0	1	LS	$1,800.00	$1,800
Domestic cold and hot water piping		0	1	ea	$6,000.00	$6,000
Miscellaneous						
Controls		0	1	LS	$7,200.00	$7,200
Test and balance		0	40	hrs	$180.00	$7,200
Commission heating system		0	1	lot	$6,000.00	$6,000
Electrical						
Three phase service		0	1	ea	$6,000.00	$6,000
Single phase service		0	7	ea	$1,800.00	$12,600
CT Enclosure		0	1	LS	$6,000.00	$6,000
208v/3-phase panel		0	1	LS	$8,400.00	$8,400
Connect existing panel		0	1	LS	$3,000.00	$3,000
Upgrade service from 240v/1-phase to 208v/3-phase		0	1	LS	$50,000.00	$50,000
Contingencies						
Estimating contingency		0			15%	$38,952
Overhead & profit		0			30%	$89,590
Design fees		0			10%	$38,822
Project management		0			8%	$38,163.50
					Total Construction Costs	**$515,000**

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Life Cycle Cost Analysis

December 15, 2015

THRHA Haines Low Rent Housing

Air Source Heat Pump System

Annual Costs	Maintenance	$40.00	Years	Qty	Unit	Base Cost	Present Value
Heating Plant							
Plant Observation							
Daily Heating Plant Observation	30	min/mo	1 - 25	6	hrs	$40.00	$4,622
Air-source Heat Pump Maintenance							
Parts Allowance			1 - 25	1	LS	$200.00	$3,852
Monthly	0.5	hours/month	1 - 25	6	hrs	$40.00	$4,622
Every Three Months	0.67	hours/3 months	1 - 25	3	hrs	$40.00	$2,054
Annual	8	hours/year	1 - 25	8	hrs	$40.00	$6,163
Five Year Maintenance	4	hours/year	5 - 5	4	hrs	$110.00	$392
Five Year Maintenance	4	hours/year	10 - 10	4	hrs	$110.00	$356
Five Year Maintenance	4	hours/year	20 - 20	4	hrs	$110.00	$293
Electric buffer tank			1 - 25	1	hrs	$40.00	$770
Air-source Heat Pump Replacement							
Replace outdoor units			15 - 15	1	LS	$16,200.00	$11,891
Pumps							
Pump maintenance, cartridge			1 - 25	4	ea	$100.00	$7,704
Pump maintenance, pipe mounted			1 - 25	2	ea	$150.00	$5,778
Domestic Hot Water							
Indirect HW heater			1 - 25	2	hrs	$40.00	$1,541
						Total Annual Costs	**$50,000**

Energy Costs	Years	Qty	Unit	Base Cost	Present Value
Fuel Oil	1 - 25	335	gallon	$3.97	$29,468
Electricity	1 - 25	52,848	kWh	$0.245	$239,703
				Total Energy Costs	**$269,000**

Present Worth	$834,000

Alaska Energy Engineering LLC

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THRHA Haines Low Rent Housing

Air Source Heat Pump System - 50% Grant Funding

Basis

25	Study Period (years)	2.5%	General Inflation
4.5%	Nominal Discount Rate	3.5%	Fuel Inflation
2.0%	Real Discount Rate	2.0%	Electricity Inflation

Construction Costs		Year	Qty	Unit	Base Cost	Year 0 Cost
Hydronic Heating System						
Crawlspace Mechanical Room						
Outdoor units		0	1	ea	$21,600.00	$21,600
Enclosure		0	1	ea	$3,000.00	$3,000
Refrigerant piping		0	2	ea	$1,200.00	$2,400
Indoor HEX units		0	2	ea	$9,000.00	$18,000
HEX pumps		0	2	ea	$1,200.00	$2,400
Buffer Tank	200 gallons	0	1	LS	$9,600.00	$9,600
Piping to building heating loop		0	2	ea	$1,800.00	$3,600
Boiler Room						
Demolition						
Remove fuel oil boiler, fuel piping, cap chimney		0	1	LS	$7,200.00	$7,200
Remove heating and domestic hot water piping		0	1	LS	$2,400.00	$2,400
Heating Plant						
Boiler Room						
Boiler piping and appurtenances	2"	0	1	LS	$2,400.00	$2,400
Injection pump and piping	1-1/2"	0	1	LS	$8,400.00	$8,400
Primary pump, pipe mounted	1/4 HP	0	1	LS	$1,200.00	$1,200
Secondary loop						
Secondary pumps	1/2 HP	0	2	ea	$2,100.00	$4,200
Secondary piping and appurtenances (boiler room)	2"	0	1	lot	$4,200.00	$4,200
Building loop	1-1/4"	0	940	lnft	$42.00	$39,480
Finned pipe branches	3/4"	0	540	ea	$30.00	$16,200
Finned pipe convectors		0	320	lnft	$108.00	$34,560
Thermostats and control valves		0	14	ea	$300.00	$4,200
Domestic Hot Water System						
Indirect HW heater, AV, piping, etc.	120 gallon	0	1	ea	$10,440.00	$10,440
Connect existing Indirect HW heater		0	1	LS	$1,800.00	$1,800
Domestic cold and hot water piping		0	1	ea	$6,000.00	$6,000
Miscellaneous						
Controls		0	1	LS	$7,200.00	$7,200
Test and balance		0	40	hrs	$180.00	$7,200
Commission heating system		0	1	lot	$6,000.00	$6,000
Electrical						
Three phase service		0	1	ea	$6,000.00	$6,000
Single phase service		0	7	ea	$1,800.00	$12,600
CT Enclosure		0	1	LS	$6,000.00	$6,000
208v/3-phase panel		0	1	LS	$8,400.00	$8,400
Connect existing panel		0	1	LS	$3,000.00	$3,000
Upgrade service from 240v/1-phase to 208v/3-phase		0	1	LS	$50,000.00	$50,000
Contingencies						
Estimating contingency		0			15%	$38,952
Overhead & profit		0			30%	$89,590
Design fees		0			10%	$38,822
Project management		0			8%	$38,163.50
					50% of Total Construction Costs	**$257,500**

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Life Cycle Cost Analysis

December 15, 2015

THRHA Haines Low Rent Housing

Air Source Heat Pump System - 50% Grant Funding

Annual Costs	Maintenance	$40.00	Years	Qty	Unit	Base Cost	Present Value
Heating Plant							
Plant Observation							
Daily Heating Plant Observation	30	min/mo	1 - 25	6	hrs	$40.00	$4,622
Air-source Heat Pump Maintenance							
Parts Allowance			1 - 25	1	LS	$200.00	$3,852
Monthly	0.5	hours/month	1 - 25	6	hrs	$40.00	$4,622
Every Three Months	0.67	hours/3 months	1 - 25	3	hrs	$40.00	$2,054
Annual	8	hours/year	1 - 25	8	hrs	$40.00	$6,163
Five Year Maintenance	4	hours/year	5 - 5	4	hrs	$110.00	$392
Five Year Maintenance	4	hours/year	10 - 10	4	hrs	$110.00	$356
Five Year Maintenance	4	hours/year	20 - 20	4	hrs	$110.00	$293
Electric buffer tank			1 - 25	1	hrs	$40.00	$770
Air-source Heat Pump Replacement							
Replace outdoor units			15 - 15	1	LS	$16,200.00	$11,891
Pumps							
Pump maintenance, cartridge			1 - 25	4	ea	$100.00	$7,704
Pump maintenance, pipe mounted			1 - 25	2	ea	$150.00	$5,778
Domestic Hot Water							
Indirect HW heater			1 - 25	2	hrs	$40.00	$1,541
						Total Annual Costs	**$50,000**

Energy Costs	Years	Qty	Unit	Base Cost	Present Value
Fuel Oil	1 - 25	335	gallon	$3.97	$29,468
Electricity	1 - 25	52,848	kWh	$0.245	$239,703
				Total Energy Costs	**$269,000**

Present Worth	$576,500

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THRHA Haines Low Rent Housing

Cash Flow Analysis - No Grant Funding

Basis

25	Study Period (years)	2.5%	General Inflation
4.5%	Nominal Discount Rate	3.5%	Fuel Inflation
2.0%	Real Discount Rate	2.0%	Electricity Inflation

Energy Costs

Usage	Fuel Oil, gals	Electricity, kWh
Fuel Oil Boiler Option	4,314	2,313
ASHP Option	335	52,848
Cost, Year 0	$3.970	$0.245

Cash Flow - Air Source Heat Pump System

Year	Fuel Oil Boiler System			Air Source Heat Pump System			Total	
	Construction	Maintenance	Energy	Construction	Maintenance	Energy	Cash Flow	Present Worth
0	131,000			-515,000			-384,000	-384,000
1		1,520	18,304		-1,927	-14,583	3,314	3,171
2		1,558	18,936		-1,975	-14,896	3,624	3,318
3		1,597	19,590		-2,024	-15,215	3,948	3,459
4		1,637	20,267		-2,075	-15,541	4,287	3,595
5		1,678	20,967		-2,612	-15,875	4,157	3,336
6		1,720	21,691		-2,180	-16,216	5,015	3,851
7		1,763	22,441		-2,234	-16,565	5,404	3,971
8		1,807	23,216		-2,290	-16,922	5,811	4,086
9		1,852	24,019		-2,347	-17,286	6,237	4,197
10		1,898	24,850		-2,956	-17,659	6,133	3,949
11		1,946	25,709		-2,466	-18,041	7,148	4,404
12		1,994	26,598		-2,528	-18,431	7,634	4,502
13		2,044	27,518		-2,591	-18,829	8,142	4,594
14		2,095	28,470		-2,656	-19,237	8,673	4,683
15		2,148	29,456		-25,613	-19,654	-13,663	-7,060
16		2,201	30,475		-2,790	-20,081	9,806	4,849
17		2,256	31,530		-2,860	-20,517	10,410	4,926
18		2,313	32,622		-2,932	-20,963	11,040	4,999
19		2,371	33,751		-3,005	-21,419	11,698	5,069
20		2,430	34,920		-3,783	-21,886	11,681	4,843
21		2,491	36,130		-3,157	-22,363	13,100	5,198
22		2,553	37,382		-3,236	-22,852	13,847	5,258
23		2,617	38,677		-3,317	-23,351	14,625	5,314
24		2,682	40,017		-3,400	-23,862	15,437	5,368
25		2,749	41,404		-3,485	-24,385	16,283	5,418
							-190,209	-284,701

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Life Cycle Cost Analysis

December 15, 2015

THRHA Haines Low Rent Housing

Cash Flow Analysis - 50% Grant Funding

Basis

25	Study Period (years)	2.5%	General Inflation
4.5%	Nominal Discount Rate	3.5%	Fuel Inflation
2.0%	Real Discount Rate	2.0%	Electricity Inflation

Energy Costs

Usage	Fuel Oil, gals	Electricity, kWh
Fuel Oil Boiler Option	4,314	2,313
ASHP Option	335	52,848
Cost, Year 0	$3.970	$0.245

Cash Flow - Air Source Heat Pump System

Year	Fuel Oil Boiler System			Air Source Heat Pump System			Total	
	Construction	Maintenance	Energy	Construction	Maintenance	Energy	Cash Flow	Present Worth
0	131,000			-257,500			-126,500	-126,500
1		1,520	18,304		-1,927	-14,583	3,314	3,171
2		1,558	18,936		-1,975	-14,896	3,624	3,318
3		1,597	19,590		-2,024	-15,215	3,948	3,459
4		1,637	20,267		-2,075	-15,541	4,287	3,595
5		1,678	20,967		-2,612	-15,875	4,157	3,336
6		1,720	21,691		-2,180	-16,216	5,015	3,851
7		1,763	22,441		-2,234	-16,565	5,404	3,971
8		1,807	23,216		-2,290	-16,922	5,811	4,086
9		1,852	24,019		-2,347	-17,286	6,237	4,197
10		1,898	24,850		-2,956	-17,659	6,133	3,949
11		1,946	25,709		-2,466	-18,041	7,148	4,404
12		1,994	26,598		-2,528	-18,431	7,634	4,502
13		2,044	27,518		-2,591	-18,829	8,142	4,594
14		2,095	28,470		-2,656	-19,237	8,673	4,683
15		2,148	29,456		-25,613	-19,654	-13,663	-7,060
16		2,201	30,475		-2,790	-20,081	9,806	4,849
17		2,256	31,530		-2,860	-20,517	10,410	4,926
18		2,313	32,622		-2,932	-20,963	11,040	4,999
19		2,371	33,751		-3,005	-21,419	11,698	5,069
20		2,430	34,920		-3,783	-21,886	11,681	4,843
21		2,491	36,130		-3,157	-22,363	13,100	5,198
22		2,553	37,382		-3,236	-22,852	13,847	5,258
23		2,617	38,677		-3,317	-23,351	14,625	5,314
24		2,682	40,017		-3,400	-23,862	15,437	5,368
25		2,749	41,404		-3,485	-24,385	16,283	5,418
							67,291	-27,201

Alaska Energy Engineering LLC

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Juneau, Alaska 99801

Tel/Fax: 907.789.1226
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Memorandum

December 15, 2015

to: **Craig Moore, THRHA**

subject: **Monitoring Plan**

project: **Haines Low Rent Apartments**

Introduction

This document describes the proposed monitoring plan for the Haines Low Rent Apartments. The monitoring plan is based on converting the heating system to an air source heat pump system. Any changes made during design may require changes to this plan.

The plan offers the following levels of monitoring:

- Temperature and Status Monitoring: Monitor equipment status, system temperatures and pump status.
- Energy Use: Measures heat pump electricity consumption and heating output of the heat pump and boiler and heating load of the building and domestic hot water.

Monitoring Plan

The proposed monitoring system will display the status of the boilers and pumps, the system temperatures, and measure energy use.

Temperature and Status Monitoring System

- Fixed Costs for travel, per diem, and equipment
- Outside Temperature: Provides a temperature reference for assessing system operation
- Heat Pump Enable: Displays the status of the heat pump
- Boiler Enable: Displays the status of the boiler
- Pump Enable
  - Displays the status of each pump.
  - Annunciates an alarm if the pump is not enabled when the boiler is enabled.
  - Annunciates an alarm if one of the distribution pumps is not operating.
- Temperatures
  - Heat pump supply (2) and return temperature
  - Boiler supply and temperature from the boiler
  - Distribution supply and return temperature
  - Domestic hot water supply from the preheat tank
  - Domestic hot water supply from the hot water tank
  - Annunciates an alarm if the distribution temperature is outside of expected range.

Energy Monitoring

- Heat pump electricity use
- Heat pump output
- Boiler output
- Building heating load
- Domestic hot water heating load

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THRHA Haines Low Rent Housing

Monitoring System Cost Estimate

Haines Low Rent Housing Monitoring Plan

Item	Intent	Operational	Energy
Fixed Cost			
Travel, per diem, equipment	Fixed costs	$5,400	
BMON site migration and set up	Moving THRHA to their own server	$800	
Unit Costs			
General			
Outdoor temperature	Outdoor temperature reference	$30	
Heat pump electric load, kW	Heat pump energy use		$1,940
Heating Plant Status			
Heat pump enable	Status	$505	
Boiler enable	Status	$505	
HX pump enable	Status	$337	
HX pump enable	Status	$337	
Boiler pump enable	Status	$337	
Injection pump enable	Status	$337	
Distribution pump enable	Status	$337	
Distribution pump enable	Status	$337	
Heating Plant Temperatures			
Heat pump supply	Heat pump operation	$256	
Heat pump return	Heat pump operation	$256	
Boiler supply	Boiler operation	$256	
Boiler return	Boiler operation	$256	
Buffer tank supply	Heat pump supply to building	$256	
Buffer tank return	Heat pump supply to building	$256	
Distribution heating supply temperature	Total supply to building	$256	
Distribution heating return temperature	Total supply to building	$256	
Heating Plant Energy Output			
Heat pump energy output	Heating flow rate		$4,365
Boiler energy output	Heating flow rate		$4,365
Energy to building	Heating flow rate		$4,365
Energy to DHW tank	Heating flow rate		$4,365
Totals		$11,310	$19,400

Attachment F

Design and Engineering

- Heat pump equipment and water kit cut sheets
- Heat pump system warranty

For more information and
customer assistance, please call
or visit our website.

Mailing Address
ATTN: B2B Air and Energy
201 James Record Road
Huntsville, Alabama 35824

LG Electronics, Inc.
www.lghvac.com

WARRANTY CARD 2/7
LG VARIABLE REFRIGERANT FLOW (VRF) SYSTEMS

Outdoor Units = ODUs, Indoor Units = IDUs
Applicable VRF Components
Multi V Air Cooled ODUs: ARUN***BTE4/DTE4, ARUB***BTE4/DTE4
Multi V Water Cooled Units: ARWN***BAS4/DAS4, ARWB***BAS4/DAS4
Multi V Space II Air Cooled Units: ARUN***GF2

Art Cool™ Mirror IDUs: ARNU***SER2/S8R2/SBR4/SCR4
Standard Wall Mount IDUs: ARNU***SEL2/S5L2/SBL4/SCL4

One-Way Ceiling Cassette IDUs: ARNU***TJC2/TUC4/TTC4
Two-Way Ceiling Cassette IDUs: ARNU*** TLC*
Four-Way (2' x 2') Ceiling Cassette IDUs: ARNU***TRC*/TQC*
Four-Way (3' x 3') Ceiling Cassette IDUs: ARNU***TPAA/TNAA/TNA*/TMAA/TMA*/TPC*/TNC*/TMC*

Ducted High Static IDUs: ARNU***BHA2/BGA*/BRA*/B8A*
Ducted Low Static IDUs: ARNU***B1G2/B2G2/L1G4/L2G4/L3G4
Ducted Low Static Built In IDUs: ARNU***B3G*/B4G*

Vertical/Horizontal AHU IDUs: ARNU***NJA*/NKA*

Ceiling Suspended IDUs: ARNU***VJA2

Convertible Surface Mount IDUs: ARNU***VEA2

Floor Standing IDUs: ARNU***CEA*/CFA*/CEU*/CFU*

Hydro Kit Units: ARNH***K2A2/K3B2
Dedicated Outdoor Air System Units: ARND***DAT2, ARND***DAR2
Energy Recovery Ventilator Units: ARVU***ZEA2

This limited warranty is valid in the United States and applies only in the country the product was purchased and installed, and only if the product was acquired from an authorized LG distributor, in the country in which the distributor was authorized to sell the product.

FOR A COPY OF THIS WARRANTY, VISIT WWW.LGHVAC.COM

LG MULTI V VRF SYSTEM LIMITED WARRANTY — USA

LG Electronics USA, Inc. ("LG") will replace defective internal functional parts ("Part[s]") of a qualified MULTI V VRF System ("System" as defined below) that fail during the warranty period if it proves to be defective in materials and/or factory workmanship under normal application, installation, use and service conditions. This Limited Warranty shall apply to the System sold by LG in the continental United States, Alaska and Hawaii and extend only to the original end use purchaser and subsequent owner(s) of location on which the System is originally installed (all such persons hereinafter referred to as "Customer"). A qualified system is defined as a System installed by an individual and/or company: (a) who holds a current government issued license that authorizes the individual and/or company to service and install heating, ventilation, and air conditioning equipment in the state where the System resides, if required; (b) where the system is installed, started, operated and service in compliance with (i) guidelines set forth in installation, operation, maintenance and engineering publications made available by LG, (ii) software based design programs made available by LG, (iii) local and state law and, (iv) applicable building, mechanical, plumbing and electrical codes and in accordance with best industry standards and practices.

LIMITED WARRANTY PERIOD

1. STANDARD ONE-YEAR PARTS WARRANTY FOR A QUALIFIED SYSTEM - The Part(s), including compressor are warranted for a period of one (1) year period beginning on the date of original installation or twenty four (24) months from the date of manufacture, whichever occurs first.
2. ADDITIONAL FIVE (5) YEAR COMPRESSOR PART WARRANTY - The Compressor is warranted for an additional five (5) year period from the second (2nd) through the sixth (6th) year after the date of original installation or twenty four (24) months from the date of manufacture, whichever occurs first.

EXTENDED WARRANTY

Standard one (1) year parts warranty is extended to two (2) years and six (6) year compressor warranty is extended to seven (7) years for a qualified system that has a completed commissioning report submitted to LG which includes two (2) hours of LGMV data. Extended parts and compressor warranty beginsfrom the date of the original installation or twenty four (24) months from the date of manufacture, whichever occurs first.

HOW DOES THIS LIMITED WARRANTY APPLY?

1. The remedies set forth in the Limited Warranty shall be the sole and exclusive remedies and the original warranty period in this Limited Warranty shall not extend beyond the period set forth therein, nor will a new warranty period begin, upon replacement of the Part(s) provided under this Limited Warranty.
2. Replacement Part(s) may be of like kind and quality and may be new or remanufactured Part(s) and warranted for the remaining portion of the original System's warranty period of ninety (90) days, whichever is longer.
3. Defective Part(s) must be made available to LG in exchange for the replacement Part(s) and become the property of LG. This Limited Warranty covers the transportation cost for reshipment of any replaced Part(s) to the Customer, but does not cover expedited shipping, risk including shipping damage or loss for return of the Part(s) to LG or its authorized agent and any other costs associated with installation, removal, or re-installation of the Part(s). If any Part(s) returned to LG are found not to be defective or this Limited Warranty has expired, the Customer is responsible to pay for return shipping cost.
4. This Limited Warranty does not cover charges for labor or other costs incurred in the trouble shooting, maintenance, repair, removing, replacing, installing, complying with local building and electric codes, handling, or replacement of Part(s) and the complete System.
5. LG will not be responsible or liable for any and all costs such as but not limited to any parts, labor, supplies, or refrigerant necessary to alter, rework, or modify the System to prepare the System for proper commissioning.
6. This Limited Warranty shall not be enlarged, extended, effected, and no obligation or liability shall be created by LG providing technical advice, information, service(s), applications suggestions, or equipment modifications to any person or entity associated with the installation of the System.

LIMITED WARRANTY EXCLUSIONS AND LIMITATIONS

1. A System sold and/or installed outside the continental United States, Alaska and Hawaii or removed from the location where it was originally installed.
2. A System sold AS IS or WITH ALL FAULTS or consumables.
3. A System that had a serial number or any Part(s) thereof altered, defaced or removed.
4. Charges related to the rental or purchase of temporary cooling, ventilating, and/or heating equipment.
5. Any and all freight charges, truck charges, trip charges, charges to pickup, transport, deliver and/or install the System, or any component or part of the System including costs to expedite shipments such as, but not limited to, air, overnight and/or courier charges.
6. Damage and/or failure caused by System misuse, neglect, or from a failure of the Customer to operate the System as specified by the manufacturer's instructions or perform necessary preventive and routine maintenance as defined in LG published documents. Routine maintenance includes such procedures including but not limited to cleaning the condensate drain system, evaporator, and condenser coils, cleaning and/or replacing of air filters or belts.
7. Damage and/or failure caused by any supplies or labor provided by any third party service provider that are beyond the terms of this Limited Warranty.
8. Damage and/or failure caused by a power surge (caused by lightning and fluctuations in or interruptions of electrical power), faulty power supply, fire, water, wind, impact damage from projectiles, earthquake, theft, riot, or any and all acts of God.
9. Damage and/or failure caused by improper wiring, installation, and handling of the System while in transit or in a storage facility or damage caused by force majeure.
10. Damage and/or failure caused by System exposure to corrosive chemical vapors and/or liquids.
11. Damage and/or failure caused by improper application of the System or any component of the System.
12. Damage and/or failure caused by modification and/or alteration of the System or any component of the System in order to meet government codes or regulations.
13. Maintenance or field provided part(s) other than those provided by LG such as filters, field installed components or accessories including but not limited to refrigerant piping, drain lines, control and electrical wiring, ductwork, etc.
14. Damage and/or failure caused by adjustments of user controls.
15. Acts, omissions, and conduct of any and all third parties including, but not limited to, the installing contractor.

LIMITATION OF WARRANTY SCOPE

EXCEPT TO THE EXTENT PROHIBITED BY APPLICABLE LAW, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE ON THE SYSTEM IS LIMITED IN DURATION OF THIS LIMITED WARRANTY. UNDER NO CIRCUMSTANCES SHALL LG BE LIABLE FOR ANY INCIDENTAL, SPECIAL OR CONSEQUENTIAL DAMAGES INCLUDING, WITHOUT LIMITATION, LOST GOODWILL, LOST REVENUE OR PROFITS, WORK, STOPPAGE, SYSTEM FAILURE, IMPAIRMENT OF OTHER GOODS, COST OF REMOVAL AND REINSTALLATION OF THE SYSTEM, LOSS OF USE, INJURY TO PERSONS OR PROPERTY ARISING OUT OF OR RELATED TO THE SYSTEM. LG'S TOTAL LIABILITY, IF ANY, DAMAGES OR OTHERWISE, SHALL NOT EXCEED THE INVOICE VALUE PAID BY THE CUSTOMER FOR THE SYSTEM FURNISHED, WHICH IS THE SUBJECT OF A CLAIM OR DISPUTE. SOME STATES DO NOT ALLOW THE EXCLUSION OR LIMITATION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES, OR ALLOW LIMITATIONS ON HOW LONG AN IMPLIED WARRANTY LAST, SO THE ABOVE LIMITATIONS OR EXCLUSIONS MAY NOT APPLY TO THE CUSTOMER. THIS LIMITED WARRANTY GIVES THE CUSTOMER SPECIFIC LEGAL RIGHTS. CUSTOMERS MAY ALSO HAVE OTHER RIGHTS THAT VARY FROM STATE TO STATE.

ASSERTION OF CLAIMS

The assertion of claims under this Limited Warranty presupposes that the Customer has: (i) informed the authorized reseller/distributor of the System in writing of the alleged claim, or that; (ii) this written notification has been sent directly to the address stated below in the event that the authorized reseller/distributor no longer exists (e.g. due to discontinuance of business or bankruptcy). Any such assertion of claims must be accompanied by the original sales receipt as the proof of purchase and time of installation of the System. The assertion of the claim must occur within thirty (30) days from the date that the claim is identified. The return of Part(s) may only occur after the written authorization of LG has been given.

OBTAINING WARRANTY PARTS AND ADDITIONAL INFORMATION

Customers who believe they have a justified claim covered by this Limited Warranty must immediately notify the authorized LG representative, or contact directly by calling to 1-888-865-3026, or by writing to:

LG ELECTRONICS USA, INC.
B2B AIR AND ENERGY
201 JAMES RECORD ROAD
HUNTSVILLE, AL 35824

DISPUTE

Except to the extent prohibited by applicable law, the Customer agrees she/he will not bring any action, regardless of form, arising out of or in any way connected with this Limited Warranty, more than one (1) year after the cause of action has occurred.

ARBITRATION

The laws of the state of Georgia govern this Limited Warranty and all of its terms and conditions, without giving effect to any principles of conflicts of laws. All actions at law or in equity arising out of or relating to these terms and conditions shall be submitted to confidential arbitration in Atlanta, Georgia. Arbitration under this Limited Warranty shall be conducted under the rules then prevailing of the American Arbitration Association. The arbitrator's award shall be binding and may be entered as a judgment in any court of competent jurisdiction. To the fullest extent permitted by applicable law, no arbitration under this Limited Warranty shall be joined to an arbitration involving any other party subject to this Limited Warranty, whether through class arbitration proceedings or otherwise.

SEVERABILITY

If a part, provision or section of this Limited Warranty, or its application to any person or circumstance is held invalid, void or unenforceable, such holding shall not affect this Limited Warranty and all other parts, provisions, clauses or applications shall remain, and, to this end, such other parts, provisions, clauses or applications of the Limited Warranty shall be treated as severable.

VALIDITY

This Limited Warranty shall be valid from October 1, 2013 and shall apply to all commercial MULTI V VRF Systems sold to specified Customers on or after this date. LG holds the right to amend the provisions, clauses or applications of this Limited Warranty from time to time without notice, however such changes would not be retrospective.

WD_MV_VRF_Warranty_2-7_Terms-07-15
Supersedes: WD_MV_VRF_Warranty_2-7_Terms-05-15

LG
Life's Good

Job Name/Location: **Tag #:**

Date:

PO No.:

For: ☑ File ☑ Resubmit ☑ Approval ☐ Other

Architect: GC:

Engr: Mech:

Rep:
(Company) (Project Manager)



ARUN072BTE4
Multi V™ IV Heat Pump
6.0 Ton Outdoor Unit

LG Life's Good

Performance:

Cooling Mode:

Nominal Capacity (Btu/h)	72,000
Power Input[1] (kW)	4.37

Heating Mode:

Nominal Capacity (Btu/h)	81,000
Power Input[1] (kW)	5.02

Nominal Capacity is outside the scope of AHRI Standard 1230 and based on the following conditions:

Indoor: 80°F DB / 67°F WB
Outdoor 95°F DB

Indoor: 70°F DB
Outdoor 47°F DB / 43°F WB

Electrical:

Power Supply (V/Hz/Ø)	208-230/60/3
MOP (A)	40
MCA (A)	25.3
Rated Amps (A)	21.0
Compressor A (A)	17.0
Compressor B (A)	-
Fan (A)	4.0

Piping:

Refrigerant Charge (lbs)	16.9
Liquid Line (in, OD)	3/8
Vapor Line (in, OD)	3/4

Standard Features:

- HiPOR (high pressure oil return)
- Smart Oil Control
- Split Coil Defrost
- Night Quiet Operation
- Fault Detection and Diagnosis

Optional Accessories:

☐ Air Guide - PRAGX2S0

☐ Low Ambient Baffle Kit - ZLABKA01A (1), Control Kit - PRVC2 (1 per system)

****(-9.9°F achieved only when all IDU's are operating in cooling mode.)**

Operating Range:

Cooling (˚F WB)**	14-122
Heating (˚F DB)	-13 - 61

Unit Data:

Refrigerant Type	R410A
Refrigerant Control	EEV
Max Number of Indoor Units[2]	13
Sound Pressure[3] dB(A)	58.5
Net Unit Weight (lbs)	430
Shipping Weight (lbs)	452
Communication Cable[4] (No x AWG)	2 x 18
Heat Exchanger Coating	GoldFin™

Compressor:

Type	HSS SC Scroll
Quantity	1
Oil/Type	PVE/FVC68D

Fan:

Type	Propeller
Quantity	1
Motor/Drive	Brushless Digitally Controlled/Direct
Air Flow Rate (CFM)	7,400

Notes:

1.For AHRI ratings, refer to the AHRI website http://www.ahridirectory.org.
2.The combination ratio must be between 50 – 130%.
3.Sound Pressure levels are tested in an anechoic chamber under ISO Standard 3745.
4.All communication cable to be minimum 18 AWG, 2-conductor, stranded, shielded and must comply with applicable local and national code.
5.Nominal data is rated 0 ft above sea level, with 25 ft of refrigerant line per indoor unit and a 0 ft level difference between outdoor and indoor units. All capacities are net with a combination ratio between 95-105%.
6.Power wiring cable size must comply with the applicable local and national
7.The voltage tolerance is ± 10%.

Inverter

Intertek

AHRI CERTIFIED™ www.ahridirectory.org
Variable Refrigerant Flow (VRF) Multi-Split AC and HP AHRI Standard 1230

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Job Name/Location:

ARUN072BTE4

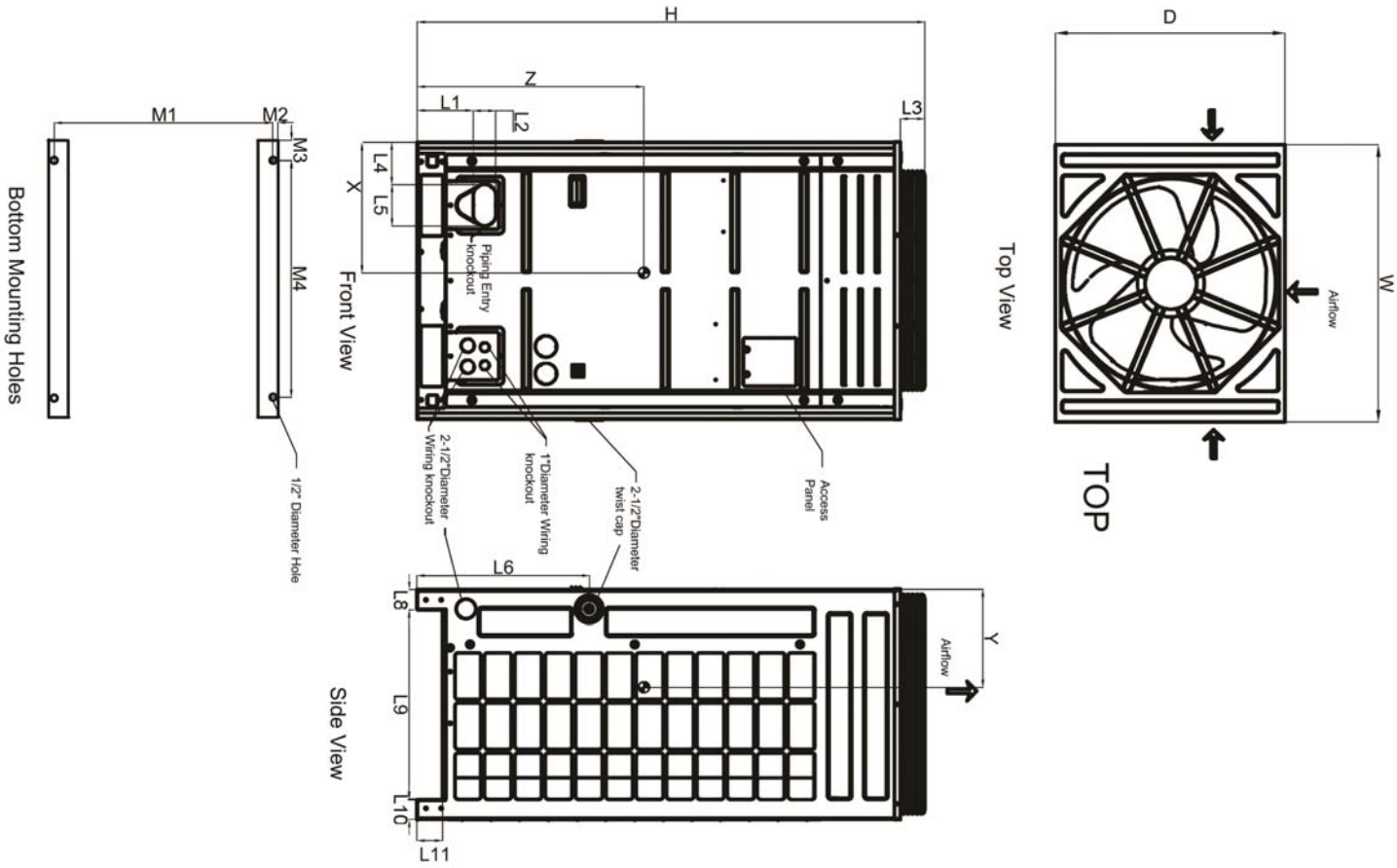
Multi V™ IV Heat Pump

6.0 Ton Outdoor Unit

Tag #:

Date:

PO No.:



W	36-1/4"
D	29-15/16"
H	66-1/8"
L1	7-1/4"
L2	2-15/16"
L3	3-1/8"
L4	5-1/2"
L5	5-3/8"
L6	22-7/16"
L7	2-9/16"
L8	2-9/16"
L9	24-3/16"
L10	2-9/16"
L11	3-5/16"
M1	29-1/16"
M2	7/16"
M3	2-5/8"
M4	31-3/16"

Center of Gravity

X	17-5/8"
Y	13-1/2"
Z	29-5/8"

Note - All dimensions have a tolerance of ± 0.25 in.

⊕ = Center of Gravity

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Job Name/Location: **Tag #:**

Date:

For: ☑ File ☑ Resubmit ☑ Approval ☐ Other

PO No.:

Architect: GC:

Engr: Mech:

Rep:

(Company) (Project Manager)



ARNH963K2A2

Hydro Kit Medium Temperature 96 MBh Indoor Unit

LG Life's Good

Performance:

Cooling Mode:

Rated Capacity (Btu/h)	95,900
Entering Water Temperature Range (°F)	50-86
Leaving Water Temperature Range (°F)	42-77

Heating Mode:

Rated Capacity (Btu/h)	107,500
Entering Water Temperature Range (°F)	59-113
Leaving Water Temperature Range (°F)	68-122

Air Source Outdoor Unit

Cooling Rated Test Conditions: Heating Rated Test Conditions:
Bldg Water: 95°F DB/75°F WB Bldg Water: 47°F DB/43°F WB
Water Temp. Inlet/Outlet: 73.4°F/65.5°F Water Inlet/Outlet: 86°F/94.8°F
Interconnected refrigerant pipe length is 25 ft at 0 elevation change.

Water Source Unit:

Cooling RatedTest Conditions: Heating Rated Test Conditions:
Bldg Water: 95°F Bldg Water: 47°F
Water Temp. Inlet/Outlet: 73.4°F/65.5°F Water Temp. Inlet/Outlet: 86°F/94.8°F
Interconnected refrigerant pipe length is 25 ft at 0 elevation change.

Electrical:

Power Supply[1] (V/Hz/Ø)	208-230/60/1
Power Input (kW) Cooling/Heating	0.01
Rated Amps (A)	0.05
MCA (A)	0.06
MOP (A)	15

MCA - Minimum Circuit Ampacity MOP – Maximum Overcurrent Protection

Piping:

Liquid Line (in, OD)	3/8 Braze
Vapor Line (in, OD)	7/8 Braze
Water Inlet/Outlet (in, OD)	1-MPT
Condensate Outlet (in, OD)	1-MPT

MPT - Male Pipe Thread

Included Accessories

- Hot Water Tank Temp Sensor with 32 ft communication cable [2,3]
- 1/2" MPT Hot Water Tank Sensor Well[2]
- Remote Wall Mounted Hydro Kit Controller with 32 ft communication cable [2, 3A]
- Standby Power Module [2,4]
- 1" Female Pipe Thread (FPT) #50 mesh inlet strainer[2]

Optional Accessories (sold seperately)

- ☐ Dry Contact – PQDSB1
- ☐ Remote Temperature Sensor – PQRSTA0
- ☐ Wired Remote Group Control Cable Assembly – PZWRCG3 [2,5]
- ☐ Solar Heating System Interface Kit - PHLLA

Unit Data:

Refrigerant Type	R410A
Refrigerant Control	EEV
Sound Pressure[6] dB(A) Heating/Cooling	26/26
Net Weight (lbs)	77
Shipping Weight (lbs)	89
Heat Rejected to Equipment Room (Btu/h)	Negligible
Factory Charge	Dry Nitrogen

Heat Exchanger:

Heat Exchanger	Refrigerant to Water
Heat Exchanger Type	316 Stainless Brazed Plate
Rated Water Flow (GPM)	24.3
Nominal Pressure Drop[7] (ft-wg)	23.1
Range of Flow (GPM)	8-24.3
Water Side Volume (US Gallons)	0.58
Water Side Design Pressure (psig)	464

Water Flow Control Options:

- Water Pump On/Off Interlock
- 208V 3-Way Diverting Valve [8,9,10]
- 208V 2-Way Heating Circuit Isolation Valve [8,10,11]

Standard Features:

- Water cooling and medium temperature heating
- Domestic water heating[12]
- Cold surface insulation
- Factory mounted inlet/outlet water temperature sensors
- Factory mounted internal flow switch
- Third party thermostat interface [10,13]
- Group control[14]
- Remote on/off site monitoring capability via the internet[15]

Notes:

1.Voltage fluctuation tolerance is ±10%.
2.Field mounted.
3.Cannot field splice.
3A. To extend cable length, use Group Control Extension Cable (PZCWRC1), sold separately.
4.On power outage, closes EEV valve(s) to prevent heat exchanger freezing.
5.Requires the installation of the Hydro Kit controller. Does not apply when used in conjunction with 3rd party thermostat.
6.Sound pressure levels tested in an anechoic chamber in accordance with ISO Standard 3475.
7.Water only (no antifreeze).
8.Not required on dedicated domestic water heating applications.
9.Alternates flow between comfort cooling/heating equipment and water heating tank.
10.Field provided and mounted.
11.Shut-off flow to in-floor heating circuit while operating in cooling mode.
12.Requires the use of an indirect water storage tank.
13.Field provided thermostat must be a 208V, 24V or mechanical type. Must be field adjustable heating only or cooling/heating with a manual changeover. Cooling and heating setpoint, deadband, and manual restart functions provided by Hydro Kit Controller are not available with use of a 3rd party thermostat. Cannot be used in conjunction with remote temperature sensor.
14.Wired Remote Group Control Cable Assembly (PZWRCG3) required and sold separately.
15.Monitoring capability available using LG's AC Smart Premium or a BMS system integration gateway (sold separately). Requires a field provided LAN/internet connection or BMS system provided by others.

Intertek Inverter

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Job Name/Location:

ARNH963K2A2

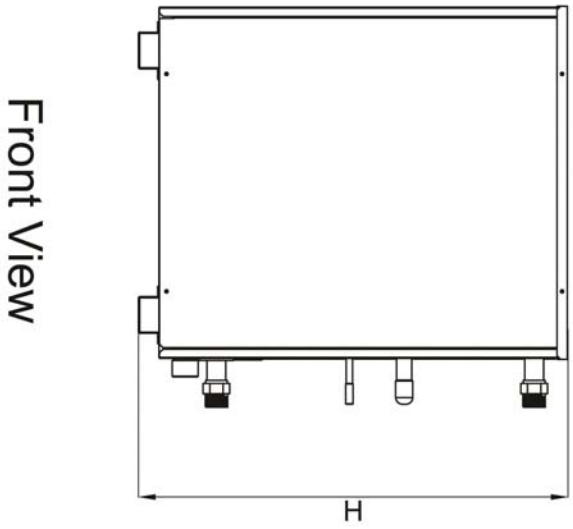
Hydro Kit Medium Temperature

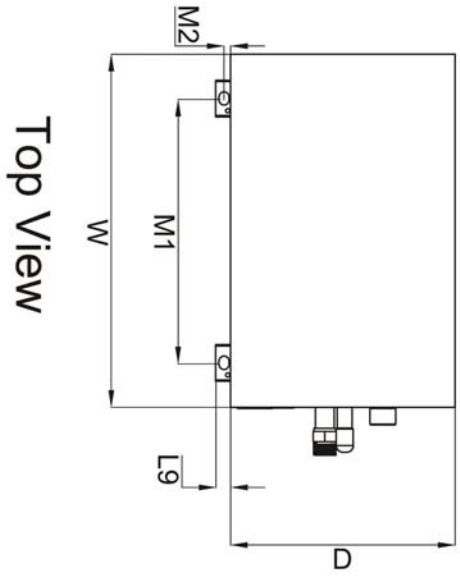
96 MBh Combination Water Heater and Cooler

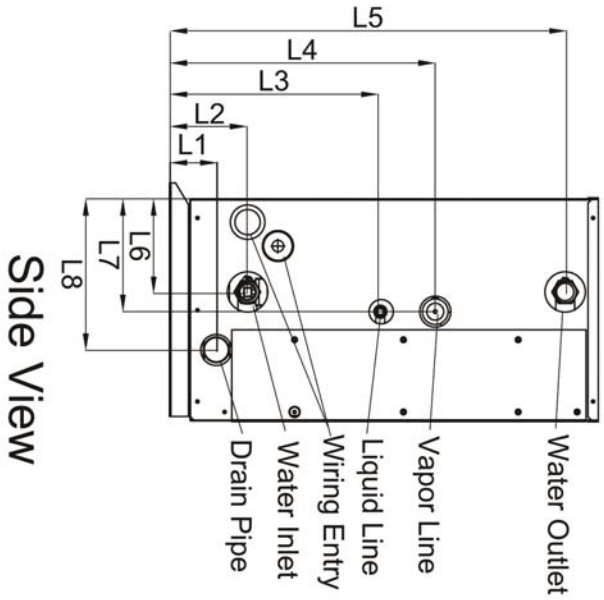
Tag #:

Date:

PO No.:







W	D	H	L1	L2	L3	L4	L5	L6	L7	L8	L9	M1	M2
20-5/8"	13-1/8"	24-3/4"	2-3/4"	4-9/16"	12-7/16"	15-9/16"	22-7/8"	5-7/16"	6-9/16"	8-3/4"	7/8"	15-7/16"	7/16"

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Attachment G

Economics

- 25-yr cash flow analysis with key assumptions

Input Variables	Value	Units
Project Cost after 50% Grant	348,520	$
Yr 2 Cost Planned Air Exchange for Common Space	45,000	
Yr 2 Cost Hydronic System Replacement	131,000	$
Projected Energy Costs with Fuel Oil System	29,919	$
Projected Energy Costs with ASHP & EEM's	21,997	$
Fossil Fuel Inflation Rate (apr)	3.5%	Percent
Electricity Inflation Rate (apr)	2.0%	Percent
General Inflation Rate (apr)	2.5%	Percent
Discount Rate (apr)	4.5%	Percent
Year 1 Increased O&M Cost	1,648	$/yr

Year	Energy Costs with Fuel Oil System	Energy Costs with ASHP & EEM's	Added O&M Cost	Net Operating Savings	Net Cash Flow	Present Value of Cash Flow
0	$ -	$ -	$ -	$ -	$ (348,520)	$ (348,520)
1	$ 29,919	$ (21,997)	$ (1,648)	$ 6,273	$ 6,273	$ 6,273
2	$ 30,966	$ (22,437)	$ (1,689)	$ 6,839	$ 182,839	$ 174,966
3	$ 32,050	$ (22,886)	$ (1,731)	$ 7,432	$ 7,432	$ 6,806
4	$ 33,171	$ (23,344)	$ (1,775)	$ 8,053	$ 8,053	$ 7,057
5	$ 34,332	$ (23,811)	$ (1,819)	$ 8,702	$ 8,702	$ 7,298
6	$ 35,534	$ (24,287)	$ (1,865)	$ 9,382	$ 9,382	$ 7,529
7	$ 36,778	$ (24,773)	$ (1,911)	$ 10,094	$ 10,094	$ 7,751
8	$ 38,065	$ (25,268)	$ (1,959)	$ 10,838	$ 10,838	$ 7,964
9	$ 39,397	$ (25,774)	$ (2,008)	$ 11,616	$ 11,616	$ 8,168
10	$ 40,776	$ (26,289)	$ (2,058)	$ 12,429	$ 12,429	$ 8,363
11	$ 42,203	$ (26,815)	$ (2,110)	$ 13,279	$ 13,279	$ 8,551
12	$ 43,680	$ (27,351)	$ (2,162)	$ 14,167	$ 14,167	$ 8,730
13	$ 45,209	$ (27,898)	$ (2,216)	$ 15,095	$ 15,095	$ 8,901
14	$ 46,791	$ (28,456)	$ (2,272)	$ 16,063	$ 16,063	$ 9,064
15	$ 48,429	$ (29,025)	$ (2,329)	$ 17,075	$ 17,075	$ 9,220
16	$ 50,124	$ (29,606)	$ (2,387)	$ 18,132	$ 18,132	$ 9,369
17	$ 51,878	$ (30,198)	$ (2,446)	$ 19,234	$ 19,234	$ 9,511
18	$ 53,694	$ (30,802)	$ (2,508)	$ 20,385	$ 20,385	$ 9,646
19	$ 55,573	$ (31,418)	$ (2,570)	$ 21,585	$ 21,585	$ 9,774
20	$ 57,519	$ (32,046)	$ (2,635)	$ 22,838	$ 22,838	$ 9,896
21	$ 59,532	$ (32,687)	$ (2,700)	$ 24,144	$ 24,144	$ 10,011
22	$ 61,615	$ (33,341)	$ (2,768)	$ 25,506	$ 25,506	$ 10,121
23	$ 63,772	$ (34,008)	$ (2,837)	$ 26,927	$ 26,927	$ 10,224
24	$ 66,004	$ (34,688)	$ (2,908)	$ 28,408	$ 28,408	$ 10,322
25	$ 68,314	$ (35,382)	$ (2,981)	$ 29,952	$ 29,952	$ 10,414
					Net Present Value	$ 37,406

Attachment H

Statement of Commitment and Cost Sharing

- Authorization for Application

Regional Housing Authority

Tlingit-Haida Regional Housing Authority
RES 14-06
September 5, 2014

ENTITLED: AUTHORIZATION TO APPLY FOR GRANT PROGRAM FUNDS FOR TLINGIT-HAIDA REGIONAL HOUSING AUTHORITY

WHEREAS, Tlingit-Haida Regional Housing Authority (T-HRHA), in its efforts to develop additional affordable housing and economic development opportunities and programs; and

WHEREAS, the Board of Commissioner's authorization is required to apply for certain grant funding opportunities, and

WHEREAS, T-HRHA may apply for the following grant programs through 2015 where Board of Commissioner authorization is required:

1. Community Development Financial Institution (CDFI) Grant
2. HUD Indian Community Development Block Grant (ICDBG)
3. HUD Community Development Block Grant (CDBG)
4. HUD Rural Housing & Economic Development Grant (RHED)
5. HUD Rural Opportunities for Self-Sufficiency (ROSS)
6. AHFC HOME Grant
7. AHFC CHODO
8. Low Income Housing Tax Credit
9. Section 184 or Title VI Loan Guarantee Program
10. USDA Rural Community Development and Rural Utility Service Grants
11. Department of Energy and Tribal Department of Energy
12. Federal Home Loan Bank/AHP
13. Other federal, state, city, foundation or financial institution grant or loan opportunities that are housing- related that T-HRHA may be eligible to apply.

NOW, THEREFORE, BE IT RESOLVED that the Board of Commissioners of the Tlingit-Haida Regional Housing Authority does hereby support the preparation and submission of the above mentioned grant programs and authorizes the President/CEO to sign the appropriate grant applications and execute any related contract documents.

PASSED, ADOPTED AND APPROVED by the Board of Commissioners of the Tlingit-Haida Regional Housing Authority this 5th day of September, 2014 by a vote of 4 Yeas, 0 Nays and 1 Absent.

CERTIFY:

Joe Williams, Chairman
Board of Commissioner

ATTEST:

Virginia Lawnicki, Secretary
Board of Commissioner

Attachment I

Subcontract Plan

Regional Housing Authority

Subcontracting Plan

Haines Low-Rent Multifamily Deep Energy Retrofit Project

THRHA will be responsible for the implementation and administration of this project, and it is anticipated that this project would be procured as a design-build project, or possibly a design-bid-build project. THRHA has selected the contractors for this project at this point, and is thus submitting this subcontracting plan. Mr. Moore's team has extensive experience in managing building system and energy projects in this manner. Mr. Moore's team would scope out the project, and procure the design and construction team using THRHA's well established procurement procedures. Mr. Moore's team has the hands on experience to provide their own oversight/review of the design and construction oversight.

THRHA has a Procurement Policy in place which will be applied to the procurement of all contract labor and materials secured for this project. The THRHA Board of Commissioners, by resolution has adopted this Policy for implementation of all THRHA projects. THRHA Policy outlines the process for both procurement of identified goods and services required by established thresholds of the purchases (small purchase $0-$100,000); Sealed Bids/invitation for Bids (IFB), when applicable over $100,000; Competitive Proposals/Request for Proposals (RFP), when applicable over $100,000; and Non Competitive (Sole Source) Proposals, as well as the methods used for purchase (request for price quotes, request for proposals, and invitation for bids) that controls the method of procurement.

Attachment J

Resumes

- Craig Moore – VP Development and Construction Management
- Joyce Niven – VP Administration
- Irene Tupou – Finance Manager

Staff Background
Craig Moore, VP Planning and Development

Academic

Construction Technology	Portland Community College
Business Administration	Portland State College
Building Construction Technology	University of Alaska Southeast

Training in Advanced Cold Climate Homebuilding techniques; Lead-Based Paint Risk Assessments; OSHA regulations; HUD HQS inspections; Mold and Mildew assessments, Energy Efficiency and Indoor Air Quality.

Professional Licenses and Affiliations

- ICBO Combination Dwelling Inspector #1060428-55
- Professional Member #0393365 International Conference of Building Officials
- Certified AkWarm Energy Rater #65 - Alaska Housing Finance Corporation
- HUD 203(K) fee consultant #S0134 – rehab loans
- Charter Member Ketchikan Home Builders Association
- Board of Directors - Alaska Building Science Network
- Member, Alaska State Homebuilders Association
- Advisory Board Member, SE Region, Cold Climate Housing Research Center

Professional

DCM Manager	Tlingit-Haida Regional Housing Authority December 2003 to Present
Construction Coordinator	Tlingit-Haida Regional Housing Authority 1997 – 2003
Project Inspector	Ketchikan Gateway Borough
General Contractor ICBO Home Inspector Energy Rater	Owner First City Builders Ketchikan 1986 - 1997

Irene D Tupou

Professional Experience

Tlingit & Haida Regional Housing Authority (THRHA),

May 2009 - Present

Finance Manager

Responsible for oversight of all accounting and reporting activities lead all day-to-day finance operations of a budget of $20 million and supervise a team of 8 staff members including functional responsibility over accounting, accounts payable, accounts receivable, payroll, and grants administration. Oversee cash flow planning and ensure availability of funds as needed. Ensure THRHA has the systems and procedures in place to support effective program implementation and comply with audit standards. Work closely with program managers and their staffs, not only to educate them regarding finance and accounting procedures but also to explore how the finance function can support program operations.

Accounting Supervisor

Responsible for the day to day operations of fiscal department. Supervise staff engaged in payroll, accounts payable, travel, and accounts receivable. Also reconcile general ledger accounts, post adjusting journals to general ledger, and review daily cash receipts. Assist Controller in annual audit and special projects as assigned. Supervise 4 staff.

Central Council Tlingit & Haida Indian Tribes of Alaska (CCTHITA),

March 2000 – May 2009

Deputy Manager, Tribal Child Support

Assist in planning, directing, coordinating all program activities. Develop and implement department policies, procedures, and protocols conform to Tribal codes, policies and the Code of Federal Regulations. Ensure program components were developed with a focus on organizational mission, and goals identified in the Child Support Program's strategic plan. Develop, implement, and provide continuous training on data system to assist users in processing and/or accessing information needed. Responsible for case management which includes, assigning and reviewing cases and ensuring cases are in compliance with program requirements. Assist caseworkers in resolving issues with their assigned cases. Visit communities to promote program and answer questions regarding their cases. Generate financial and statistical reports, and file federal quarterly and annual reports for program. Perform Paternity tests for families. Act on behalf of the Manager during his/her absence. Assist in developing the department budget. In the absence of attorney presented cases in tribal court. Supervise 3 Child Support Specialists.

Supervisory Accountant

Responsible for the day to day operations of the CCTHITA's finance department. Supervise staff engaged in payroll, accounts payable, travel, cash deposits, benefits programs, budgets, and grants. Assist CFO with annual audit, indirect cost proposal, insurance, and special projects. Supervise 5 accounting support staff.

Accounting Technician

Process transactions for retirement plan. Post general ledger entries for investment transactions. Install upgrades or fixes for accounting system. Implement cash receipts and electronic timesheet modules. Develop procedures and training materials for employees. Assist department with accounting and computer software problems. Process payroll when Payroll Technician was not available.

LABYRINTH TECHNOLOGY, January 1999 – March 2000

Bookkeeper

Responsible for processing payrolls for affiliated companies. Complete federal and state reports. Ensure sufficient funds are in company bank accounts for all affiliated companies and process cash transfers when necessary. Responsible for accounts payable and accounts receivable. Reconcile bank statements and post entries in general ledger.

KLUKWAN, INC. May 1993 – January 1999

Pension/Insurance\Shareholder Specialist

Pension Plan - Verify eligibility and process of transactions involving cash transfers in or out of the trust. Reconcile trust statements. Communicate with participants to facilitate transactions for pension plan. Resolve participant questions and problems regarding benefits. Ensure corporate compliance with ERISA Act and Department Labor. Review and process retirement forms (i.e. beneficiary designations, salary deferrals, loans, hardships, and distributions) for 401k plan. Audit payroll reports to ensure accuracy regarding eligible wages and contributions. Enroll new participants and inform payroll offices of new or changed information. Maintain participants' files.

Cash Management – Daily processing of cash data and funding of subsidiary accounts as needed. Download daily cash transactions that affect all company checking accounts, estimate check clearing and cash needs for each subsidiary company and consolidate the Line of Credit from Bank. Prepare daily cash reports for management. Data entry of monthly transactions and reconcile cash accounts.

Insurance – Reporting, monitoring and administering the corporate property, casualty and liability insurance programs. Allocating and coding insurance invoices to proper subsidiary. Data entry of monthly insurance expenses and reconciles prepaid insurance accounts. Assist in the annual insurance renewal process.

Shareholder Services – Process monthly shareholder distribution checks and annual 1099's for shareholders. This included auditing reports and verifying calculations were accurate based on the dollar per share authorized. Process payments to shareholders for emergency loan program. Track repayments before issuing distributions and new loans. Ensure policies set by Board of Directors were followed. Resolve shareholders' questions. Reconcile shareholder expense accounts and post journals to general ledger. Assist shareholders in completing beneficiary forms. Maintain strict confidentiality of records and corporate information.

UNIVERSITY OF ALASKA SOUTHEAST, September 1987 – September 1992

Personnel Technician II

Resolve employee concerns on benefits and wages. Provide technical information and training to cost center clerks and outlying locations on personnel, payroll, benefits and the Human Resource Information Systems (HRIS) procedures. This position required extensive knowledge of policies, payroll practices, state and federal requirements, and benefits plans. Conduct orientations and exit interviews individually or in-group settings. Assist employees and departments in completing personnel and payroll forms. Reviewed payroll reports for discrepancies and made corrective actions when necessary. Calculate adjustments on pay, taxes, deductions, benefits and leave. Back up for Recruitment Technician which involved reviewing applications and screening documents to ensure compliance to EEO requirements; prepare job descriptions and advertisements.

Personnel Technician (Benefits)

Coordinate Annual Benefits Fair for employees. Compile HR statistics for reports from personnel records, verifying and determining placement of data. Re-design personnel and payroll forms for the University of Alaska statewide. Enroll employees in PERS, TRS, and Tax Shelter Annuities. Research records for years of service and report to State of Alaska retirement plans the number of years vested for employees. During the statewide implementation of HRIS (integrated data system) participated on payroll and forms committees. During this time developed forms for payroll and human resource which were used by all the University of Alaska's campuses.

Personnel Technician (Payroll)

Review payroll reports for discrepancies and made corrective action when necessary. Calculate payroll adjustments on leave, labor accounts, voids, retros, and overpayments. Process employee initiated actions such as taxes, benefits and deductions. Perform special projects that required researching personnel and payroll records and producing reports.

EDUCATION

B.S., Travel Management, Brigham Young University – Hawaii Campus, 1986
A.A., Business Information, Brigham Young University – Hawaii Campus, 1986

Staff Background

Joyce M. Niven, Vice President of Administration

Academic

Bachelor of Arts	1987 Business, Finance Concentration, Western Washington University, Bellingham Washington

Professional

VP of Administration	Tlingit-Haida Regional Housing Authority January 2014 to present
Fiscal Officer	Tlingit-Haida Regional Housing Authority December 2004 to January 2014
Senior Accountant	Tlingit-Haida Regional Housing Authority November 2000 to December 2004
General Manager	Capital Office Supply 1995 – November 2000
Finance Manager	Capital Office Supply February 1990 to 1995
Accounting Supervisor	Fluor Daniel Inc. 1988 – December 1989

Community Involvement

Event Co-Chair	American Cancer Society Relay for Life of Juneau
Volunteer	Juneau Women of the Moose

HOONAH – LOW-RENT APARTMENTS MONITORING PLAN

THRHA Regional Housing Authority
Juneau, Alaska

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
jim@alaskaenergy.us

Memorandum

December 15, 2015

to: **Craig Moore, THRHA**

subject: **Monitoring Plan**

project: **Hoonah Low Rent Apartments**

Introduction

This document describes the proposed monitoring plan for the Hoonah Low Rent Apartment building. The monitoring plan is for the heating system, which consists of two fuel oil boilers, and waste heat received from the local utility.

The plan offers the following levels of monitoring:

- Temperature and Status Monitoring: Monitor equipment status, system temperatures and pump status.
- Energy Use: Measures heat pump electricity consumption and heating output of the heat pump and boiler and heating load of the building and domestic hot water.

Monitoring Plan

The proposed monitoring system will display the status of the boilers and pumps, the system temperatures, and measure energy use.

Temperature and Status Monitoring System

- Outside Temperature: Provides a temperature reference for assessing system operation
- Boiler Enable: Displays the status of each boiler
- Pump Enable
  - Displays the status of each pump.
  - Annunciates an alarm if the pump is not enabled when the boiler is enabled.
  - Annunciates an alarm if one of the distribution pumps is not operating.
- Temperatures
  - Waste heat supply and return temperature
  - Boiler supply temperature for each boiler
  - Distribution supply and return temperature
  - Domestic hot water supply from the hot water tank
  - Annunciates an alarm if the distribution temperature is outside of expected range.

Energy Monitoring

- Waste heat output
- Boiler output
- Building heating load
- Domestic hot water heating load

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

THRHA Hoonah Low Rent Housing

Monitoring System Cost Estimate

Item	Intent	Operational	Energy
Fixed Cost			
Travel, per diem, equipment	Fixed costs	$5,400	
BMON site migration and set up	Moving THRHA to their own server	$800	
Unit Costs			
General			
Outdoor temperature	Outdoor temperature reference	$30	
Heating Plant Status			
Boiler B-1 enable	Status	$505	
Boiler B-2 enable	Status	$729	
Boiler pump P-1 enable	Status	$337	
Boiler pump P-2 enable	Status	$609	
Distribution pump P-3A enable	Status	$337	
Distribution pump P-3B enable	Status	$337	
Heating Plant Temperatures			
Waste heat supply	Heat pump operation	$256	
Boiler B-1 supply	Boiler operation	$256	
Boiler B-2 supply	Boiler operation	$256	
Distribution supply	Total supply to building	$256	
Distribution return	Total supply to building	$256	
Heating Plant Energy Output			
Waste heat output	Heating flow rate		$4,365
Boiler B-1 energy output	Heating flow rate		$4,365
Boiler B-2 energy output	Heating flow rate		$4,365
Heat to building	Heating flow rate		$4,365
Heat to domestic HW tank	Heating flow rate		$4,365
Totals		$10,364	$21,825

KLAWOCK – SENIOR CENTER WOOD BRIQUETTE / WOOD PELLET OPTION COMPARISON

THRHA Regional Housing Authority
Juneau, Alaska

DE-0005179 Energy Efficiency Audit, Assessment, and Alternative Energy Study

December 15, 2015

Klawock Senior Center Wood Briquette / Wood Pellet Option Comparison

Klawock, AK

Tlingit-Haida Regional Housing Authority
PO Box 32237
Juneau, AK 99803
(907) 780-6868

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1.0 EXECUTIVE SUMMARY

This document compares options for the Tlingit-Haida Regional Housing Authority to utilize high efficiency, low emission wood fired technologies the Klawock Senior Center located on Prince of Wales Island, Alaska. Installation of a wood fired heating system would present the Tlingit-Haida Regional Housing Authority with the opportunity to utilize a renewable fuel for heating, and keep fuel expenditures within the regional economy. Figure 1 shows an aerial picture of the Klawock Senior Center located in Klawock, Alaska.



Figure 1 – Aerial View of the Klawock Senior Center

Image source: Bing Maps

The building uses #1 fuel oil fired boilers for space heating and domestic hot water heating. Two biomass boiler technologies are considered for integration into the facility. These are a wood pellet boiler system and a wood briquette boiler system. A summary of the costs and economic impacts for each option are listed in Table ES1. Note that the current low cost of fuel oil, $3.00/gallon, results in project options that either do not provide annual savings, or show low savings compared to investment costs. It is important to note that annual savings are

directly dependent on volatile fuel oil pricing. If 2014 fuel oil pricing of $4.13/gallon were used, this would drastically change the financial performance of the options. The wood pellet option would show positive savings of approximately $1,200, but still a very long payback period. The wood briquette option would show substantive annual savings of approximately $5,500 and provide a payback of ~20 years assuming no grant incentives.

Table ES1 – Cost and Benefit Summary

Option	Estimated Capital Cost	1st Year Net Annual Operating Savings	Simple Payback, Years	Present Value of Annual Cash Flows, 20 yrs	20 Year B/C Ratio
1 – Wood Pellet System	$116,380	-$4,140	NA	($205,999)	(0.62)
2 – Wood Briquette System	$113,471	$992	114.3	($101,339)	0.23

Notes:

1 – Net Annual Operating Savings include costs for wood fuel, supplemental fossil fuel, and operation & maintenance (O&M) costs.

2 – 20 Year Benefit/Cost (B/C) Ratio is calculated by dividing the present value of net annual operating savings over a 20 year period with a discount rate of 3.0% by the Estimated Capital Cost. A value greater than 1 means the benefits exceed the costs over a 20 year period.

The clean and efficient use of wood fuel at the facility would provide the following environmental and social benefits:

- Purchase of wood briquettes would immediately impact the local economy since the fuel is produced by a local mill
- Purchase of wood pellets would impact the regional economy, with wood pellet production from one provider currently operational in Ketchikan, AK
- Decreased dependence on fuel oil by replacing up to 4,750 gallons of oil with renewable biomass fuel
- Net reduction of up to 48 metric tonnes of CO2 equivalent emissions annually
- Reduction of up to 65 lbs of sulfur dioxide annually
- A hedge against the volatility of the fossil fuel market

2.0 EXISTING FUEL USAGE & HEATING SYSTEM

The Klawock Senior Center is a 24,980 ft^2 facility housing approximately 30 residents and staff. THRHA provided an annual facility usage number of 5,000 gallons of #1 fuel oil annually for space heating and domestic hot water heating. Annual expenditures are approximately $15,000 at the current fuel price of $3.00 per gallon. An above ground 1,100 gallon fuel oil tank is used for onsite storage.

The boiler room contains two model WTGO-7 Weil McLain hot water boilers firing on #1 fuel oil and rated at 210,000 Btu/hr output and 50 psig. The boilers were installed in 2008 and are in excellent condition. The hot water heating distribution system is a primary-secondary piping system with individual zone pumps distributing water throughout the building. Baseboard fin tube radiant heaters provide space heating for rooms. A makeup air handling unit with a hot water coil is used for the kitchen and common area. A digital control system is installed by Delta Controls, however there is no way to interface with the control system without bringing in a service technician with a laptop and appropriate software. Domestic hot water is heated indirectly using the heating boilers and stored in two 120 gallon HTP Superstor tanks. There is potential room in the existing boiler room to locate a hot water thermal storage tank and one wood-fired boiler.

THRHA reported usage for calendar year (CY) 2013 as 5,000 gallons. The heating degree days for CY 2013 were fairly close to the 30-year average for the region. Thus, CY 2013 weather data from Klawock, Alaska is used with the 5,000 gallon annual fuel oil use for the purposes of load modeling in this report. Figure 2 shows how the daily average heating demand for the Klawock Senior Center would be expected to vary over the course of a year. During a 24-hr period, the actual load will vary above and below this average value. Actual demand would fluctuate above and below the average heating demand values shown over a 24-hr period.

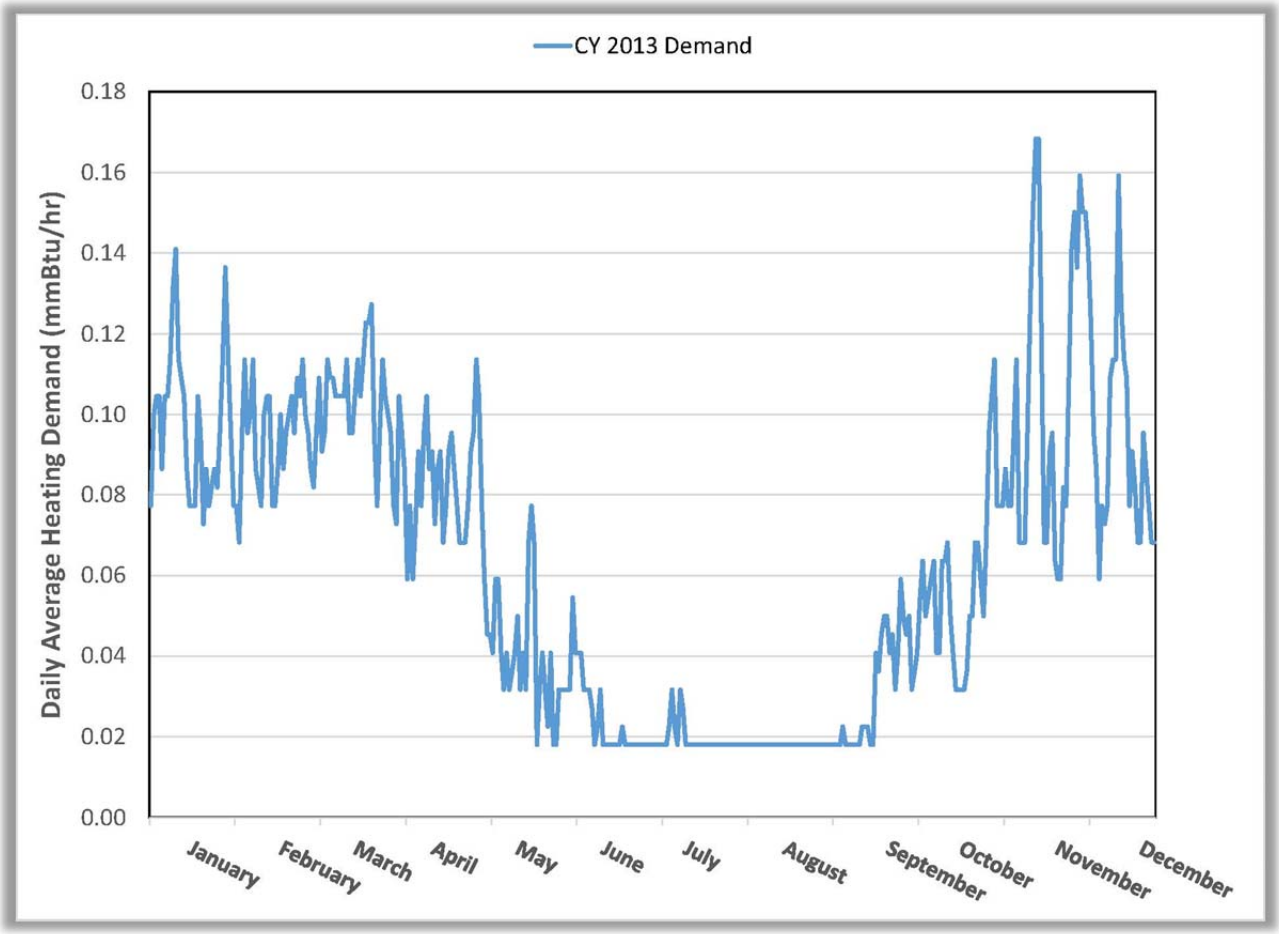


Figure 2 – Klawock Senior Center Estimated Average Daily Heating Demand for CY 2013

Note: The daily average heating demand model is based on local weather data and annual fuel usage provided by the Tlingit-Haida Regional Housing Authority. The model assumes that each person uses 20 gallons of domestic hot water per day for bathing, cooking, laundry, and hand washing. Actual demand would fluctuate above and below the average heating demand values shown over a 24-hr period.

A load duration curve was developed using the daily average heating demand curves. Load duration curves sort the daily average heating demand over the course of a year from highest to lowest and plot it over the number of days to show the annual range of facility heating demand. Figure 3 shows the estimated load duration curve for CY 2013.

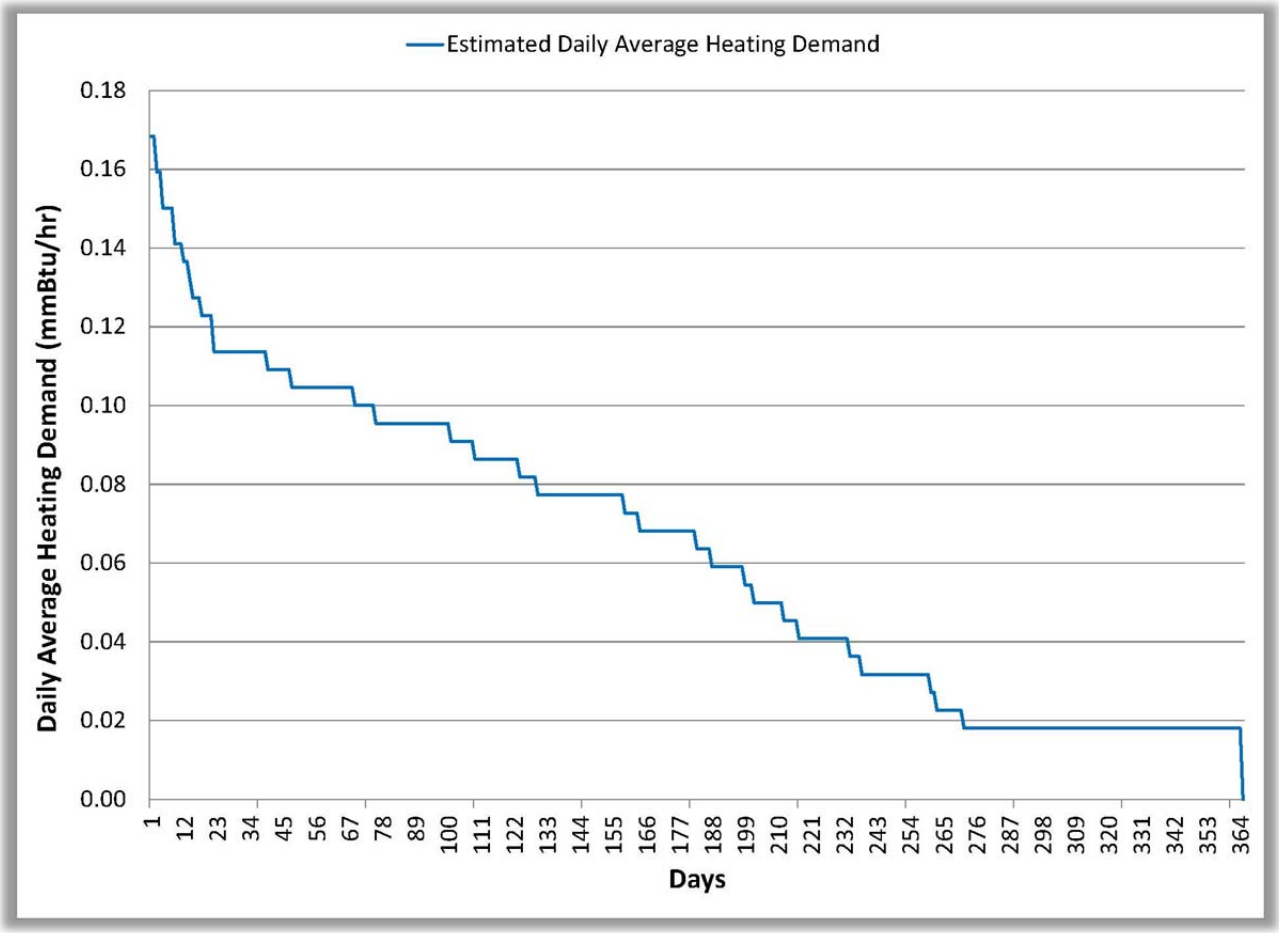


Figure 3 – Klawock Senior Center Estimated Load Duration Curve for CY 2013

Note: The daily average heating demand model is based on local weather data and annual fuel usage provided by the Tlingit-Haida Regional Housing Authority. The model assumes that each person uses 20 gallons per day of domestic hot water. Actual demand would fluctuate above and below the daily average heating demand values shown over a 24-hr period.

3.0 BIOMASS FUEL AVAILABILITY AND COST

The biomass fuels considered for evaluation in this report are wood pellets and wood briquettes. The following is a discussion of the fuels and logistics for the delivery of the fuels.

Wood Pellets – There are several wood pellet fuel vendors providing bulk fuel delivery for the SE Alaska region. These providers either produce their own pellets or import them from mills in the lower 48 or Canada. The fuel is then delivered via the ferry system. Klawock is accessed from the Inter-Island Ferry Authority (IFA) dock at Hollis. This ferry has significant capacity and operates daily between Hollis and Ketchikan. The general standard for pellet fuel in the US is published by the Pellet Fuels Institute (PFI). Not all pellet manufacturers are certified to provide PFI standard pellets, and exact product specifications can vary. Regardless, PFI standards are generally accepted as targeted in the US, and the PFI standards for wood pellet

fuel are provided in Appendix D. For the purposes of this report, the higher heating value of the wood pellet fuel is assumed to be 15.2 mmBtu/ton.

Providers are able to deliver fuels into the onsite storage in one of two ways. These are pneumatically or through an auger. The IFA ferry allows vehicle dimensions of up to 14.5' high, 9' wide (or potentially 12' with call ahead), and 55' long for a double unit. The total weight allowed is 60,000 lbs. The available capacity for a delivery is on the order of 15 tons, but will vary based on the tare weight of the vehicle used. Alaska Pellet Supply, LLC provided a budgetary quote of approximately $375/ton delivered into a storage bin that can accept a full 15 ton delivery. Once pellets are delivered into the onsite storage bin, they are automatically delivered to the pellet boiler through either an auger system or pneumatically.

Wood Briquettes – Viking Lumber Company, Inc. is located approximately 3 miles from the Center, and manufactures wood briquettes at its facility in Klawock. The briquettes have the following characteristics, and an advertisement sheet is provided in Appendix D.

- ~8% moisture content
- For the purposes of this report it is assumed that the higher heating value of the briquettes is 15.2 mmBtu/ton, but this value will vary some depending on moisture and species (the cut sheet lists a range of 15-18 mmBtu/ton)
- ~3 lbs/brick, and each brick is approximately 2"x 3" x 9"
    - This is approximately 23,000 Btu/brick based on the assumed heating value of 15.2 mmBtu/ton
- Palletized dimensions are 40"H x 40"W x 48"D for unboxed pallet (~1 ton) – ~672 briquettes

Viking Lumber maintains an inventory of the briquettes, and can potentially provide storage of capacity onsite for purchasers if requested. The stated cost per ton of pellets is $200. Delivery could be made through truck and forklift rental. It is assumed that two 10-pallet flat deliveries could be completed in a day, and an assumed day rental rate of a truck and towed forklift is $720. The total delivered cost per ton would be approximately $236. It is recommended that onsite storage be sized to allow just over 20 tons (20 pallets) to be stored to allow for delivery costs to be minimized. Once the pallets were onsite, they would be handled by a hand pallet truck from the storage through the two double doors and into the boiler room. It is envisioned a whole or partial pallet load could be handled over the door threshold(s) with fabrication of a small shallow sloped ramp. A pallet truck can be purchased for approximately $400.

Table 1 summarizes the cost per mmBtu of output for wood fuels evaluated and for fuel oil.

Table 1 – Fuel Pricing and Cost per mmBtu

Fuel, Unit	Cost per Unit	Input Heating Value, mmBtu per Unit	Estimated Boiler Efficiency	Boiler Output Heating Cost, $/mmBtu
Wood Briquettes	$236.00	15.2	75%	$20.70
Wood Pellets, Ton	$375.00	15.2	80%	$30.84
#1 Fuel Oil, Gallon	$3.00	0.138	80%	$27.17

Note:

1 - Input heating value assumes 8% moisture content wet basis for wood pellets with an average High Heating Value of 8,255 Btu/lb of bone dry wood based on a mixture of Sitka Spruce (8,100 Btu/lb) and Western Hemlock (8,410 Btu/lb)[1].

4.0 PROPOSED BIOMASS SYSTEM OPTIONS

Two options for using high efficiency, low emission biomass systems are evaluated for heating the Klawock Senior Center. The Center has space to fit one boiler firing on wood pellets or wood briquettes and hot water thermal storage in the existing boiler room. Option 1 considers a boiler system that would fire on wood pellets. Option 2 considers a boiler system that would fire on wood briquettes.

4.1.1 Option 1: 190,000 Btu/hr Wood Pellet System

One advanced wood pellet boiler sized at approximately 0.19 mmBtu/hr of heat output would be combined with approximately 200 gallons of thermal storage to efficiently meet the range of heating needs. The wood pellet system's most efficient range of operation would be from ~0.04 to ~0.19 mmBtu/hr. In this range the boiler would be modulating to meet the heating demand. Below this range, the boiler would be expected to cycle to meet the demand. The hot water thermal storage would be heated to a preset temperature (typically 195°F) that is higher than the temperature distributed for building heat. A 3-way mixing valve would be used to blend hot water in the tank with cooler return water from the Center to maintain a range of supply water temperatures (160°F – 190°F) determined by an outside air temperature or seasonal reset schedule.

The storage would also allow the boiler to operate efficiently to provide summer domestic hot water heating. The storage could hold up to approximately 88,000 Btu for domestic water heating. This allows the pellet boiler to fire for a period of approximately 30 minutes within its efficient firing range to charge the storage during the periods where there is no other demand. The heat in the storage is then used to provide domestic hot water needs, until the temperature drops to ~140^{O}F and the system has to fire to charge it once more.

[1] Avery, Robert B., Funck, James W., & Wilson, Pamela L. (2010). *Fuelwood Characteristics of Northwestern Conifers and Hardwoods (updated)*. Portland, Or.: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

The wood pellet boiler, metering bin, thermal storage tank, valves, fittings, and boiler pump would be installed in the existing boiler room. A fuel storage bin capable of holding ~30 tons of wood pellets would be located next to the building to accept bulk deliveries of wood pellets pneumatically or with an auger truck. It is envision that a specially constructed bin would be constructed for this application instead of using a silo. This would be needed to keep from obstructing the views from the windows of the Senior Center. Wood pellets would be automatically transferred using a flexible auger or pneumatic hose from the storage bin to a metering bin that feeds the wood pellet boiler. The wood pellet boiler will heat the hot water thermal storage system located in the existing boiler room. The hot water thermal storage will tie in with the existing heating distribution pipes. The existing fuel oil fired heating boilers would remain to supplement the biomass system during periods of maintenance and if the heating demand is outside the operating range of the biomass system. Biomass system heat output metering would be accomplished through a BTU meter package that includes a calculating unit, temperature sensor pair, and flow meter. The calculating unit would provide display of total energy and flow as well as instantaneous values. The unit would also be capable of providing analog or serial output to the monitoring system as discussed in the June 2015 Klawock Senior Center Energy Assessment Technical Memorandum by Alaska Energy Engineers. Appendix A contains a conceptual plan and schematic for the biomass system. Figure 4 shows the estimated wood pellet system coverage of the FY 2013 load duration curve.

THRHA has experience installing the type of wood pellet boiler discussed in this report. The vendor THRHA is experienced with is Maine Energy Systems, and a cut sheet on their boiler is attached.

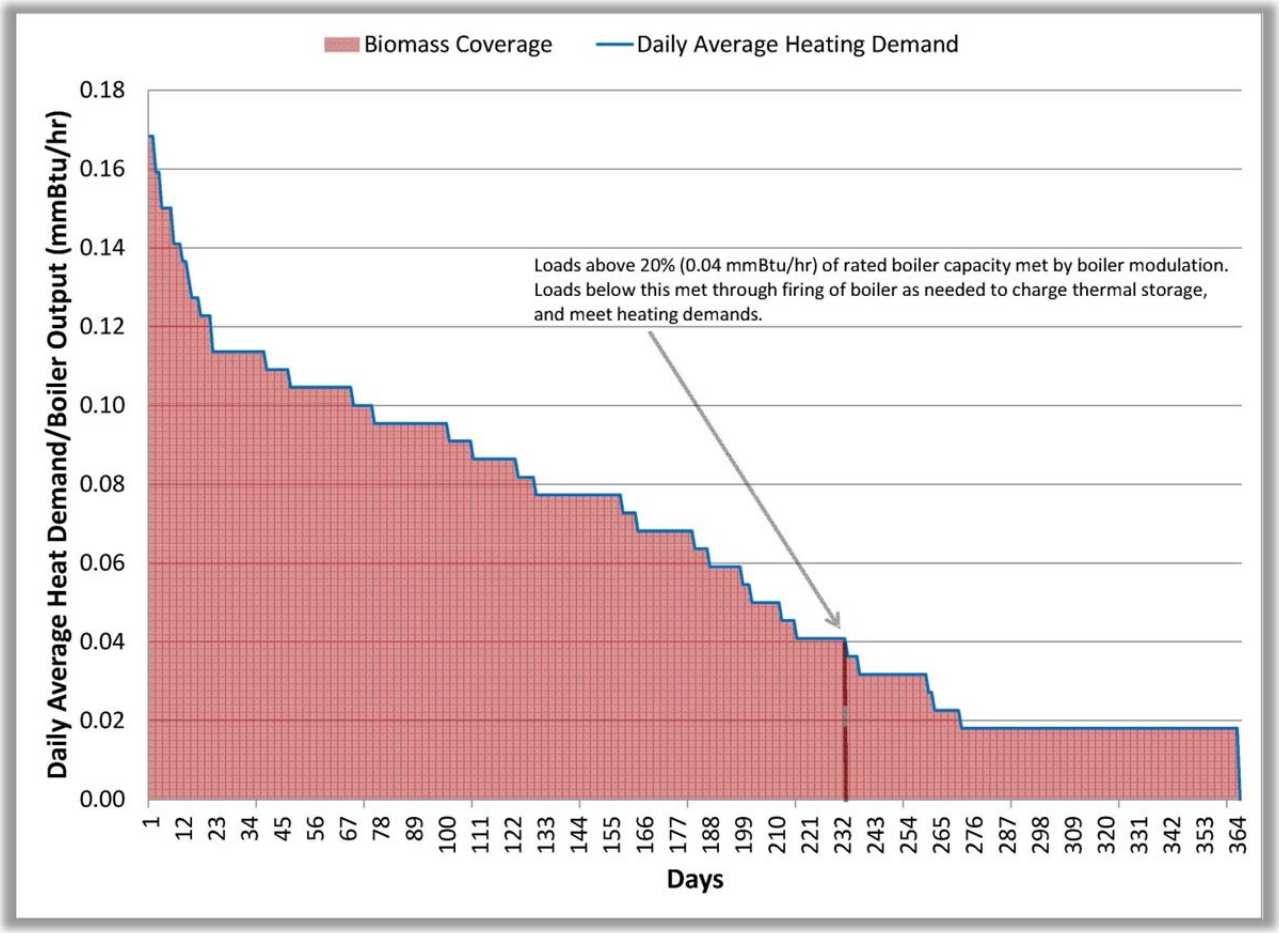


Figure 4 – Estimated Wood Pellet System Coverage of Load Duration Curve

Note: The load duration curve model is based on local weather data and annual fuel delivery volumes provided by Tlingit-Haida Regional Housing Authority. Potential coverage of ~99% is shown. Actual coverage will depend on management of loads, down time for maintenance, and the use of thermal storage.

Figure 4 shows potential for ~99% biomass coverage of the FY 2013 load duration curve. Actual coverage will vary depending on weather conditions, peak demands, equipment operation schedules, and periods when the boilers are shut down for maintenance. This report assumes 95% coverage of fuel oil usage for estimating the potential fuel use and savings for this document.

4.1.2 Option 2: 170,000 Btu/hr Wood Briquette System

An advanced combustion unit and hot water boiler capable of firing on wood briquettes sized at approximately 170,000 Btu/hr of heat output is evaluated. The exact size would depend on the manufacturer/equipment line selected. The boiler would be combined with approximately 800 gallons of thermal storage to efficiently meet the Center's range of heating needs. Note that this system would have the flexibility to use seasoned cord wood if that were a more cost effective fuel. The existing oil boilers would remain in place as backup, and to provide coverage of demands outside the operating range of the wood system.

Note that there are several manufactures of manually-fed solid wood boilers that will accommodate wood briquettes or bio-bricks in their equipment. Some key options for the equipment to optimize efficiency and the range of loads that can be met are lambda control of the combustion process, and the ability to modulate the firing rate down to 50% of the boiler's rated output. Options that provide for automated feeding of wood briquettes that are widely commercially available were not able to be identified, and the boilers identified would need to be loaded manually.

The wood boiler, thermal storage tank, valves, fittings, and boiler pump would be installed in the existing boiler room. A fuel storage building bin capable of holding ~20 tons (20 pallets) of wood briquettes would be constructed. This is anticipated to be a simple stick framed building of about 500 ft^2. Once the pallets were onsite, they would be handled by a hand pallet truck from the storage through the two sets of double doors and into the boiler room. It is envisioned a whole or partial pallet load could be handled over the door threshold(s) with fabrication of a small shallow sloped ramp. Wood briquettes would staged in or adjacent to the boiler room to allow ease of daily loading. The wood boiler will heat the hot water thermal storage system located in the existing boiler room. The hot water thermal storage will tie in with the existing heating distribution pipes. The existing fuel oil fired heating boilers would remain to supplement the biomass system during periods of maintenance and if the heating demand is outside the operating range of the biomass system. Biomass system heat output metering would be accomplished through a BTU meter package that includes a calculating unit, temperature sensor pair, and flow meter. The calculating unit would provide display of total energy and flow as well as instantaneous values. The unit would also be capable of providing analog or serial output to the monitoring system as discussed in the June 2015 Klawock Senior Center Energy Assessment Technical Memorandum by Alaska Energy Engineers. Appendix A contains a conceptual plan and schematic for the biomass system.

Discussion of Boiler Loading and Operations – Manually loaded systems operate efficiently when they convert all of the energy stored in the wood loaded into the firebox in one continuous firing at over 50% of the boilers rated capacity. Some systems have the ability to modulate the firing rate, which is beneficial for matching lower loads, but it is not recommended that firing be modulated to below 50% of the boiler's rated capacity. The hot water thermal storage will provide a place to store the heat from the rapid and efficient firing cycle when the building's demand does not match the boiler's output. The heat stored in the tank will then be used on demand for building needs. It is important for the operator to gauge how much wood fuel to charge the fire box with based on expected heat load and available capacity in the storage tank.

As an example, summer usage when there is no space heating demand is estimated to require approximately 0.45 mmBtu/day. The 800 gallon thermal storage tank(s) could hold approximately 0.35 mmBtu, and the Superstore tanks can hold up to 0.125 mmBtu. Thus, between the two tank sets, there is approximately enough storage for one day's worth of domestic hot water demand. The full day's demand would require an input of approximately 0.6 mmBtu of wood assuming a conversion efficiency of 0.75. The firebox of the boiler models in the size range evaluated are on the order of 7-8 ft^3. One wood briquette is approximately

0.03 ft^3, weighs 3 lbs, and provides 23,000 Btu (HHV) of input energy. With a loading pattern that provides adequate air space, it would be possible to load almost 3.0 mmBtu of energy into the firebox.

Comparing the firebox capacity to the daily summer demand and the heat storage capacity shows that fully loading the firebox would result in a situation where demand would be fully satisfied, while there was still the equivalent of 4 more days of energy in the firebox. This would result in smoldering, and inefficient combustion. The recommended approach would be for the operator to check the temperature of the thermal storage, and input the number of bricks needed to match the thermal storage capacity plus some recharge of the superstore tanks matching ongoing demand. A total of ~25 bricks would match the estimated total DHW demand for an average day. It is anticipated that 1 to 2 small loadings matching the storage availability during the day would be required during the summer.

During the higher demand periods of the year, a fully-loaded fire box would provide on the order of 50-80% of the daily heating demand. This means that 2-3 loadings per day would be required. Depending on staff availability for loadings, it may be difficult to cover the day's full demand, and the existing oil boilers would kick in to provide heating as necessary.

Figure 5 shows the potential coverage of the daily average demand as nearly all of the annual demand. However, given the requirements for loading, it is assumed that 80% of the annual demand will be met by the wood briquettes. The existing fuel oil system will supplement the wood boiler during peak loads, low loads, and during periods of maintenance. Actual coverage will vary depending on weather conditions, peak demands, equipment operation schedules, and periods when the boilers are shut down for maintenance.

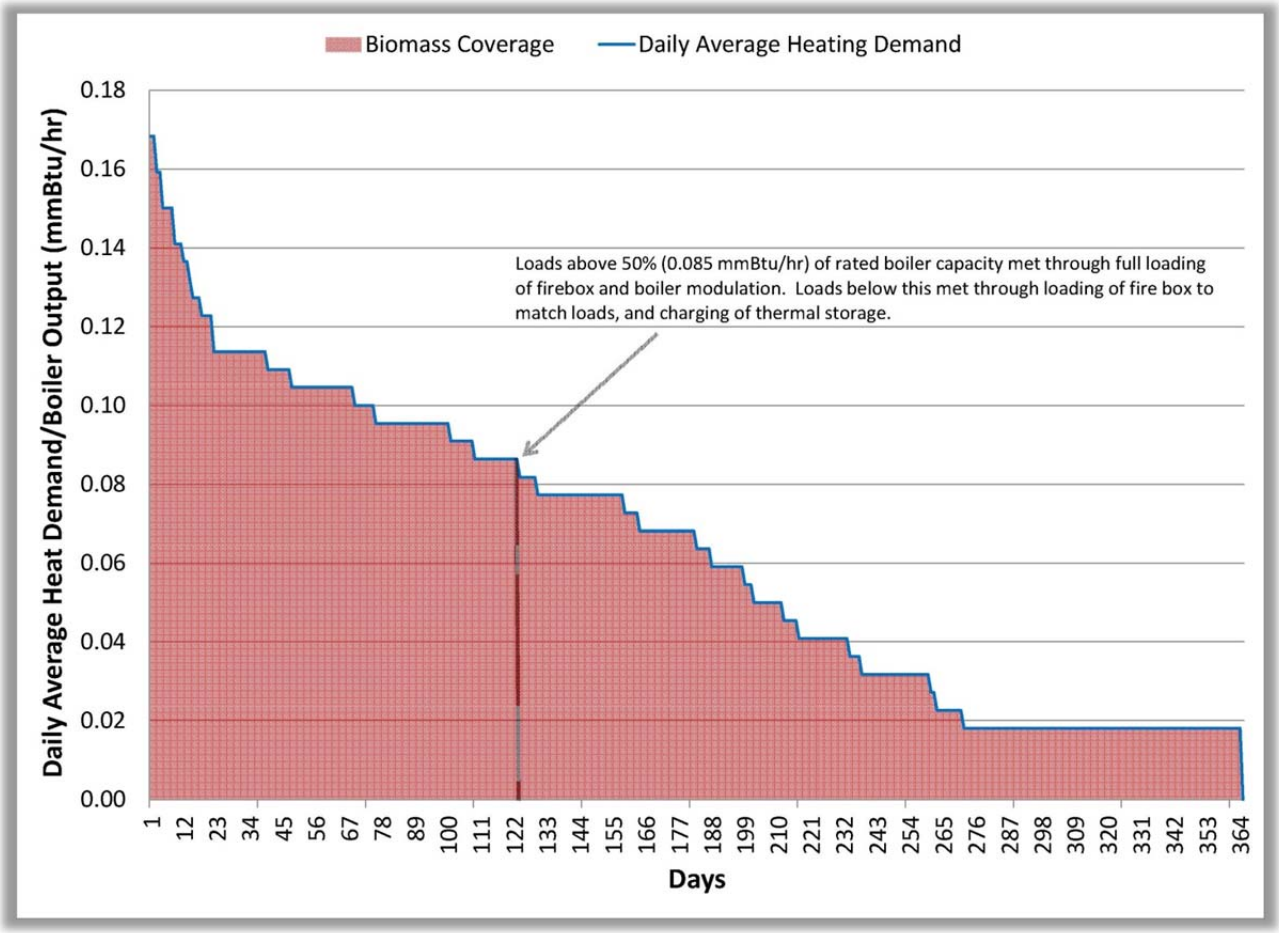


Figure 5 – Estimated Wood Briquette System Coverage of Load Duration Curve

Note: The load duration curve model is based on local weather data and annual fuel delivery volumes provided by Tlingit-Haida Regional Housing Authority. Potential coverage of the vast majority of the demand is shown. Actual coverage will depend on management of loads and the use of thermal storage, and 80% coverage is assumed given the manual loading requirements of the boiler.

There are currently a limited number of manufacturers who offer an ASME rated manually-fed boiler with the ability to modulate based on lambda control or stack temperature. Further, new EPA rules for emissions of hydronic heaters in this size range have resulted in manufactures discontinuing certain lines/sizes of equipment due to added testing costs required to certify the equipment. For some manufacturers, this has resulted in discontinuing smaller (~0.1 mmBtu/hr) ASME rated options than shown here, which used to be available. An open non pressurized system could be utilized with a non-ASME rated boiler to heat the system with piping and control modifications, and this approach would increase the number of vendors available. The non-ASME rated boiler transfers heat to the existing pressurized system via a heat exchanger, and there are some key considerations on the hydronics and building permit side when using the non-ASME rated options. These include:

- Cost effective heat exchanger design will reduce the temperature that can be delivered on the pressure side of the system by about 5 °F, and there are upfront and

maintenance cost considerations for adding the heat exchanger and an additional circulation pump.

- An open vent tank is required, and water levels and water quality needs to be monitored closely with an open system.
- Some imported boilers also do not have a UL listing, and local code officials would need to be comfortable accepting European certifications on the electronics.
    - Note that some imported models require 50 hz, and care should be taken to understand the electrical requirements for the boilers.

Appendix D provides cut sheets on an ASME-rated option (Econoburn) and a non-ASME rated option (Froiling) for this boiler system. The vendors of each system identified have experience with utilizing wood briquettes with similar specifications in their equipment. These vendors offered to run a test-burn of the specific product if it is shipped to their facilities. This is not a complete list of potential vendors, and those identified here are selected to provide examples of both ASME and non-ASME options.

5.0 BENEFIT/COST ANALYSIS

Capital Costs – Capital costs are estimated for each option based on recent quotations and bids provided by boiler manufacturers and recent bids for similar projects. These costs include the fuel storage and handling system, biomass combustion unit, boiler, accessory equipment, installation, integration with the existing heating and domestic hot water systems, professional fees, and contingency. The estimated capital costs for each Option are listed in Table 2. Tables showing the cost breakdowns are found in Appendix B.

Table 2 – Estimated Project Capital Costs

Option	Estimated Capital Cost
1 – Wood Pellet System	$116,380
2 – Wood Briquette System	$113,471

O&M Costs – Since it is assumed the existing fuel oil boilers would be retained and continue to be maintained, most of the costs for O&M of the wood boilers would be additional. One cost that would not be directly additional is electric use since the oil boilers would not fire as often. For the purposes of this report, this is ignored given that it is a small cost and this results in a measure of conservatism when comparing the wood options to the existing fuel oil system .

It is assumed that existing staff would coordinate fuel deliveries, empty ash bins, check on the system, and in the case of the briquette option, load the boiler. Ash removal costs have been estimated at $70 per ton of ash and $220 per container delivery. Wood ash can be used as a direct replacement for lime and costs for removal could be reduced if it is used as a soil amendment on facility grounds or other locations.

An increase in electricity use would occur from the circulation pumps, combustion fans, and fuel handling system (wood pellet only). Electricity costs using a price of $0.22/ kWh have been estimated considering motors for pumps, augers, and fans for the wood pellet system and motors for pumps and fans for the wood briquette system. Annual operation and maintenance (O&M) costs are estimated for each option and are listed in Table 3.

Table 3 – Estimated Annual O&M Costs

Task/Item	Option 1	Option 2
Electricity	$650	$570
Ash Removal	$240	$234
Annual Service	$1,000	$1,000
Additional Labor Hours (no staff increase/cost assumed)	109	531
Totals	**$1,890**	**$1,804**

Note:

1 – Electricity costs are estimated at $0.22/kW.

2 – Ash removal costs are estimated at $70/ton and $220 per container delivery. Ash generation is estimated at 0.5% by weight for wood pellets and briquettes. Ash is a valuable product that can be used a soil amendment and costs for removal could be mitigated if used as such.

3 – Annual service is assumed to include burner plate and combustion area cleanings, boiler tunings, and wear part replacement. This service may be performed by THRHA staff or by outside service technicians as appropriate.

Even though it is not anticipated that additional staff would not be hired, there would be significant additional staff time for system operation, particularly in the case of the wood briquette option, and there is a cost associated with this. Table 4 provides an estimate of the weekly and annual man-hours for operation of each system. If a value of $20/hr is used for additional staff time, the added staff time would cost $2,260 for the wood pellet option and $10,620 for the wood briquette option.

Table 4 – Estimated Weekly and Annual Labor Hours for Each Option

Task		Wood Pellets		Wood Briquettes	
		Weekly Man-Hours	Annual Man-Hours	Weekly Man-Hours	Annual Man-Hours
Heating Season (assume 40 weeks)					
	Ash removal	1	40	1	40
	Periodic observation	1	40	1	40
	Delivery coordination	NA	10	NA	15
	Fuel handling/loading	-	-	8.75	350
	Total	-	*90*	-	*445*
Summer Season (assume 12 weeks)					
	Ash removal	0.5	6	0.5	6
	Periodic observation	1	12	1	12
	Delivery coordination	NA	5	NA	5
	Fuel handling/loading	-	-	5.25	63
	Total	-	*23*	-	*86*
Totals			**113**		**531**

Notes: The assumed time per week over and above current fuel oil boiler plant tasks is listed along with the annual value. For delivery coordination, it is assumed there would be 3 deliveries of wood pellets annually (~15 tons each), and 4 deliveries of wood briquettes annually (~10 tons each). The wood pellet option has automated fuel handling and loading once the pellets are onsite. The largest share of hours for either option is associated with onsite handling and loading of the wood briquette boiler. The assumed duration is 0.5 hrs per loading, and it is assumed there would be 2.5 loadings per day 7 days per week in the heating season, and 1.5 loadings per day 7 days per week in the summer season. It is anticipated that pallets would be staged adjacent to the wood boilers using a hand pallet truck to move them from the outside storage to the staging area.

Annual operating savings are estimated considering fuel costs and O&M costs. Table 5 shows the estimated annual operating savings for each option. Note that these annual savings are driven by volatile oil prices. As recently as 2014, the fuel oil price was $4.13/gallon. This is ~38% higher than the current price of $3.00/gallon. Tables 6 and 7 present a sensitivity analysis of the annual operating savings for each option to fuel prices.

Table 5 – Estimated Annual Operating Savings

Option	Current Annual Fuel Oil Cost	Estimated Annual Biomass Cost	Estimated Annual Fuel Oil Cost with Biomass System	Estimated Additional Annual O&M Costs	Estimated Annual Savings
1 – Wood Pellet System	$15,000	$16,500	$750	$1,890	-$4,140
2 – Wood Briquette System	$15,000	$9,204	$3,000	$1,804	$992

Notes: Estimated additional O&M costs do not include increased labor hours for existing THRHA staff since it is assumed that no new staff would be hired with the addition of the above options. Table 4 presents the estimated annual increase in labor hours for each system, and the labor hours are particularly substantial for the wood briquette option.

Table 5 – Sensitivity of Option 1 to Wood Pellet and Fuel Oil Pricing

		Price of Fuel Oil per Gallon							
		$2.50	**$3.00**	**$3.50**	**$4.00**	**$4.13**	**$5.00**	**$5.50**	**$6.00**
Price of Wood Pellets per Ton	**$300**	($3,215)	($840)	$1,535	$3,910	$4,528	$8,660	$11,035	$13,410
	$325	($4,315)	($1,940)	$435	$2,810	$3,428	$7,560	$9,935	$12,310
	$350	($5,415)	($3,040)	($665)	$1,710	$2,328	$6,460	$8,835	$11,210
	$375	($6,515)	($4,140)	($1,765)	$610	$1,228	$5,360	$7,735	$10,110
	$400	($7,615)	($5,240)	($2,865)	($490)	$128	$4,260	$6,635	$9,010
	$425	($8,715)	($6,340)	($3,965)	($1,590)	($973)	$3,160	$5,535	$7,910
	$450	($9,815)	($7,440)	($5,065)	($2,690)	($2,073)	$2,060	$4,435	$6,810

Notes: The shaded value shows the result from the values assumed in this document. All other variables are kept static as these fuel prices are varied when developing the table. The 2014 cost of fuel oil was $4.13/gallon, and this value is specifically shown to allow comparison to current (December 2015) pricing.

Table 6 – Sensitivity of Option 2 to Wood Briquette and Fuel Oil Pricing

		Price of Fuel Oil per Gallon							
		$2.50	**$3.00**	**$3.50**	**$4.13**	**$4.50**	**$5.00**	**$5.50**	**$6.00**
Price of Wood Briquettes per Ton	**$150**	$2,346	$4,346	$6,346	$8,866	$10,346	$12,346	$14,346	$16,346
	$175	$1,371	$3,371	$5,371	$7,891	$9,371	$11,371	$13,371	$15,371
	$200	$396	$2,396	$4,396	$6,916	$8,396	$10,396	$12,396	$14,396
	$236	($1,008)	$992	$2,992	$5,512	$6,992	$8,992	$10,992	$12,992
	$250	($1,554)	$446	$2,446	$4,966	$6,446	$8,446	$10,446	$12,446
	$275	($2,529)	($529)	$1,471	$3,991	$5,471	$7,471	$9,471	$11,471
	$300	($3,504)	($1,504)	$496	$3,016	$4,496	$6,496	$8,496	$10,496

Notes: The shaded value shows the result from the values assumed in this document. All other variables are kept static as these fuel prices are varied when developing the table. The 2014 cost of fuel oil was $4.13/gallon, and this value is specifically shown to allow comparison to current (December 2015) pricing.

A benefits summary is listed in Table 6 showing the estimated capital cost, 1st year net operating savings, simple payback, 20-year sum of annual cash flow present values, and 20 Year Benefits to Cost (B/C) ratio.

Table 6 – Cost and Benefit Summary

Option	Estimated Capital Cost	1st Year Net Annual Operating Savings	Simple Payback, Years	Present Value of Annual Cash Flows, 20 yrs	20 Year B/C Ratio
1 – Wood Pellet System	$116,380	-$4,140	NA	($205,999)	(0.62)
2 – Wood Briquette System	$113,471	$992	114.3	($101,339)	0.23

Notes:

1 – Net Annual Operating Savings include costs for wood fuel, supplemental fossil fuel, and operation & maintenance (O&M) costs.

2 – 20 Year Benefit/Cost (B/C) Ratio is calculated by dividing the present value of net annual operating savings over a 20 year period with a discount rate of 3.0% by the Estimated Capital Cost. A value greater than 1 means the benefits exceed the costs over a 20 year period.

A cash flow analysis was completed for financing the projects assuming a 20 year financing term at a 4.0% interest rate. Neither of the Options had a positive first year cash flow after annual payments. The detailed analyses are shown in Appendix C.

Table 7 lists the assumptions and values used to develop costs and savings in this report.

Table 7 – Assumptions and Values Used in the Report

Item	Value	Unit	Source
Klawock Senior Center annual #1 fuel oil use	5,000	gallons	THRHA
Option 1 portion of fuel oil replaced	95%		Estimated
Option 2 portion of fuel oil replaced	80%		Estimated
#1 Fuel oil heat content	0.138	mmBtu/gal	Assumption
Wood pellet energy content (HHV)	15.2	mmBtu/ton	Assumption
Wood briquette energy content (HHV)	15.2	mmBtu/ton	Assumption
#1 Fuel oil boiler efficiency (HHV)	80%		Assumption
Wood pellet boiler efficiency (HHV)	80%		Assumption
Wood briquette boiler efficiency (HHV)	75%		Assumption
#1 Fuel oil price	$3.00	$/gallon	THRHA Dec 2015
Electricity price	$0.22	$/kWh	THRHA
Wood pellet price	$375.00	$/ton	Budget quote
Wood briquette price	$236.00	$/ton	Budget quote - handling added
Discount rate	3.0%		NISTIR 85-3273-28
#1 Fuel oil inflation rate	3.3%		Assumption
Wood pellet inflation rate	3.0%		Assumption
O&M inflation rate	3.0%		Assumption
Wood briquette inflation rate	3.0%		Assumption
Financing term	20	yrs	Assumption
Financing rate	4.0%		Assumption

6.0 SUMMARY

This report compares two high efficiency, low emission wood energy options for replacing fuel oil use for space heating and domestic hot water heating at the Klawock Senior Center. The first option would use wood pellets provided through bulk deliveries from mills either located in Southeast Alaska, the lower 48, or Canada. The second option would use wood briquettes produced at Viking Lumber Company which is approximately 3 miles away and also in Klawock. Note that the second option could also use locally sourced seasoned cord wood if wood briquettes become unavailable at some point in the life of the project.

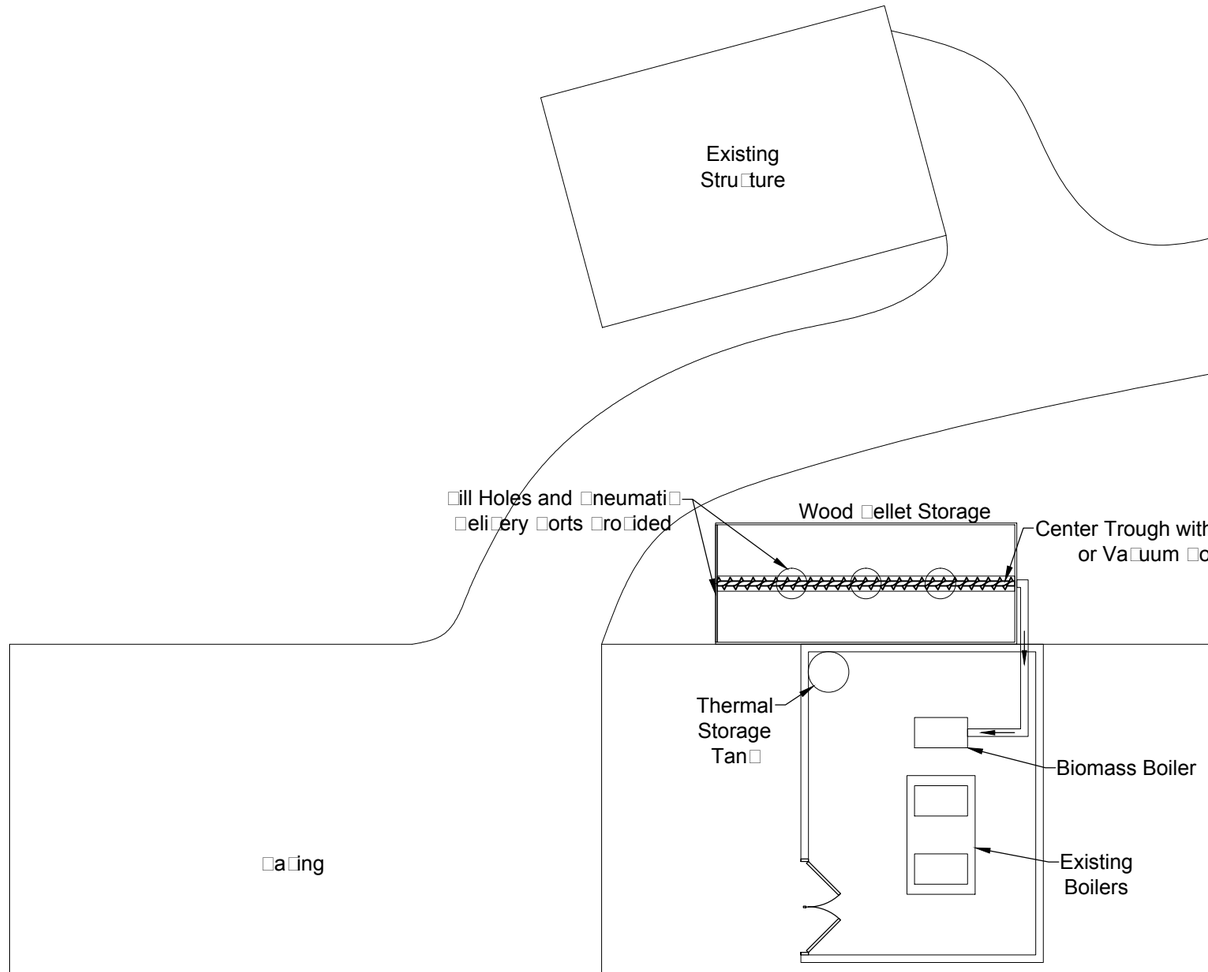
The wood pellet option does not provide annual energy or operating savings based on the current low price of oil at $3.00 per gallon. Wood pellet prices would need to be below $300/ton before annual operating savings would be seen at this fuel oil price. The wood briquette option does provide annual energy savings of approximately $1,000 at the current oil pricing. However, with a project cost of approximately $115,000, the payback of a system is very long at current energy pricing. Using 2014 oil pricing, the payback of the system assuming no grant funding would drop to approximately 20 years and provide a slightly positive cash flow with 20-yr financing.

The clean and efficient use of wood fuel at the facility would provide the following environmental and social benefits:

- Purchase of wood briquettes would immediately impact the local economy since the fuel is produced by a local mill
- Purchase of wood pellets would impact the regional economy, with wood pellet production from one provider currently operational in Ketchikan, AK
- Decreased dependence on fuel oil by replacing up to 4,750 gallons of oil with renewable biomass fuel
- Net reduction of up to 48 metric tonnes of CO2 equivalent emissions annually
- Reduction of up to 65 lbs of sulfur dioxide annually
- A hedge against the volatility of the fossil fuel market

Appendix A

Conceptual Drawings



SCALE

□0' 0' 5' □0'

NORTH

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Approved
Date
Title
Job Class

Klawo□□ Senior Center
Klawo□□, AK

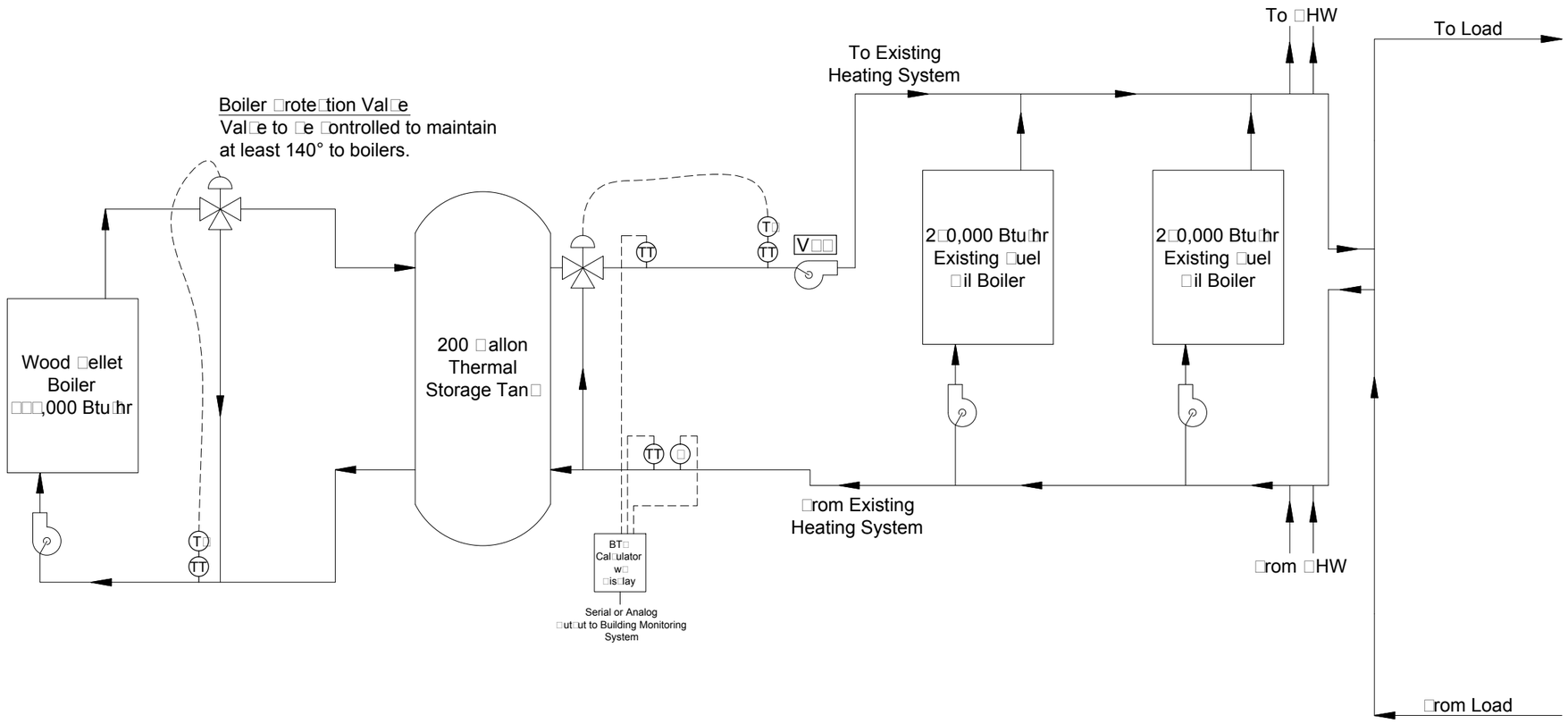
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Date	Description	Approved

A.2



Legend

- Three Way Mixing Val□e
- □um□
- Tem□erature □ndi□ator
- Tem□erature Transmitter
- Varia□le □re□uen□y □ri□e
- □low Meter

□ote□This drawing is a □on□e□tual s□hemati□ for the □ur□oses of showing a general □iomass system arrangement□ E□ui□ment, final si□ing, and □ressures will □ary de□ending on the engineer, manufa□turer and □ontra□tor installing the □iomass system□

Klawo□□ Senior Center
Klawo□□, AK

□□tion □ S□hemati□

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Date
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Job Class

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WES Energy and Environment
wesEnergyAndEnvironment.com

REVISIONS
Date | Description | Approved

A.3

Existing
Stru□ture

Wood Bri□uette
Storage 25'x20'

□a□ing

Thermal
Storage
Tan□

Biomass Boiler

Existing
Boilers

Exisitng Building

SCALE

□0' 0' 5' □0'

NORTH

Klawo□□ Senior Center

Klawo□, AK

□□tion 2 □lan View

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Date

Title

Job Class

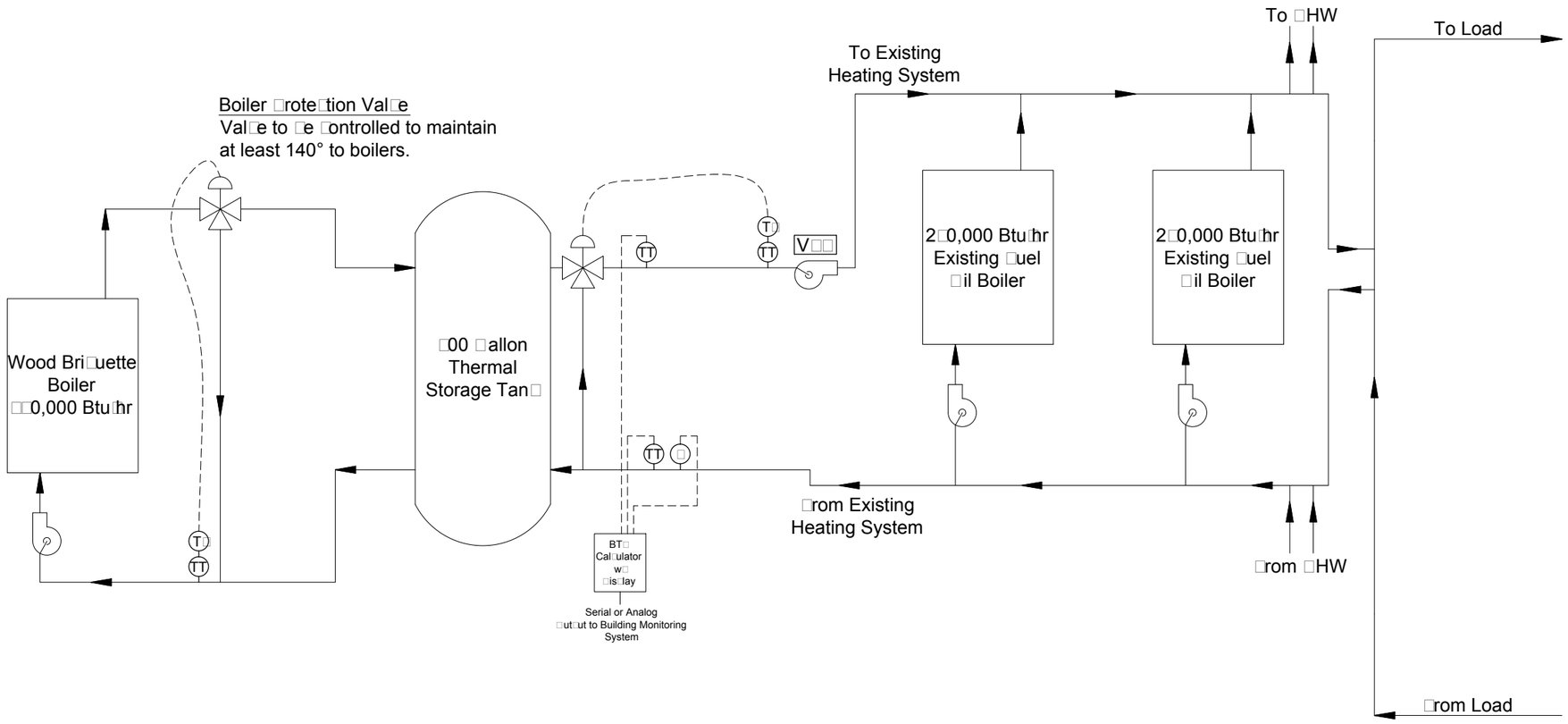
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A.4



Legend

- Three Way Mixing Val□e
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- Tem□erature □ndi□ator
- Tem□erature Transmitter
- Varia□le □re□uen□y □ri□e
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Title
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Klawo□□ Senior Center
Klawo□□, AK

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Date	Description	Approved

Appendix B

Preliminary Capital Cost Estimates

- Option 1 – Wood Pellet Boiler
- Option 2 – Wood Briquette Boiler

Appendix B

Option 1 - Conceptual Cost Estimate - Klawock Senior Center
Wood Pellet Boiler System

Line Item			Cost
One (1) - 190,000 Btu/hr wood pellet hot water boiler package, freight		$	27,500
~30 ton storage bin with bottom extraction		$	25,500
Thermal storage 200 gal with insulation, freight		$	4,000
Interconnection with existing boiler room, pumps, installation		$	7,500
BTU metering		$	6,500
Electrical		$	4,500
Mechanical		$	4,500
Sub-Total		$	80,000
Contractor Profit	*10%*	*$*	*8,000*
Sub-Total		*$*	*88,000*
Contingency	*15%*	*$*	*13,200*
Sub-Total		*$*	*101,200*
Professional Services	*15%*	*$*	*15,180*
Total		**$**	**116,380**

Notes:
1 - The boiler system is to be installed in the existing boiler room. Pricing is based on a one-boiler solution. There are multiple manufacturers that can provide varying boiler sizes. Other boiler sizing combinations to

2 - Integration of the boiler itself with the DDC system is not envisioned to ensure simplicity of system operation unless the existing DDC system is overhauled to allow daily use by onsite staff. Integration of the injection from the thermal storage may be done independently of the DDC system as well, but it will be critical that existing fuel oil boiler setpoints/calls for firing are able to be adjusted, and this will likely require interface with the DDC system. Integration of the biomass system with the DDC system may increase project costs.

3 - Metering line item covers the cost of a BTU meter package that provides display of total energy and flow values as well as instantaneous values. The meter package would also be capable of providing either analog or serial outputs to an overall building energy metering package or DDC system. This would allow integration with the monitoring package as detailed in the June 2015 Technical Memorandum by Alaska Energy Engineering.

4 - Professional Services includes permitting, legal, engineering, & project management.
5 - Estimate is based on competitive bidding.

Appendix B

Option 2 - Conceptual Cost Estimate - Klawock Senior Center
Wood Briquette Boiler System

Line Item				Cost
One (1) - 170,000 Btu/hr ASME rated cord wood boiler package, freight			$	19,000
Stick frame storage building with poured concrete floor, 500 ft^2 @ \$50/ft^2			$	25,000
Thermal storage - 800 gal with insulation and shipping			$	10,000
Interconnection with existing boiler room, pumps, installation			$	7,500
BTU metering			$	6,500
Electrical			$	5,000
Mechanical			$	5,000
Sub-Total			$	78,000
	Contractor Profit	*10%*	*$*	*7,800*
Sub-Total			*$*	*85,800*
	Contingency	*15%*	*$*	*12,870*
Sub-Total			*$*	*98,670*
	Professional Services	*15%*	*$*	*14,801*
Total			**$**	**113,471**

Notes:

1 - The boiler system is to be installed in the existing boiler room. Pricing is based on a one-boiler solution. There are multiple manufacturers that can provide varying boiler sizes. Other boiler sizing combinations to meet a similar output range may also be selected.

2 - Integration of the boiler itself with the DDC system is not envisioned to ensure simplicity of system operation unless the existing DDC system is overhauled to allow daily use by onsite staff. Integration of the injection from the thermal storage may be done independently of the DDC system as well, but it will be critical that existing fuel oil boiler setpoints/calls for firing are able to be adjusted, and this will likely require interface with the DDC system. Integration of the biomass system with the DDC system may increase project costs.

3 - Metering line item covers the cost of a BTU meter package that provides display of total energy and flow values as well as instantaneous values. The meter package would also be capable of providing either analog or serial outputs to an overall building energy metering package or DDC system. This would allow integration with the monitoring package as detailed in the June 2015 Technical Memorandum by Alaska Energy Engineering.

4 - Professional Services includes permitting, legal, engineering, & project management.

5 - Estimate is based on competitive bidding.

Appendix C

20 Year Financing at 4% APR Cash Flow Analysis

- Option 1 – Wood Pellet Boiler
- Option 2 – Wood Briquette Boiler

Appendix C

Option 1 - Klawock Senior Center Wood Pellet Boiler System
20 Year, 4% Financing

Input Variables	Value	Units
Project Costs Financed	116,380	$
Financing Term	20	# years
Financing Rate (apr)	4.0%	Percent
Current #1 Fuel Oil Usage	5,000	gal
Year 1 #1 Fuel Oil Average Price	$3.00	$/gal
Proposed Annual Wood Pellet Usage	44	tons/yr
Year 1 Wood Pellet Purchase Price	$375	$/ton
Annual #1 Fuel Oil Usage w/ Wood System	250	gal/yr
Fossil Fuel Inflation Rate (apr)	3.3%	Percent
Wood Pellet Inflation Rate (apr)	3.0%	Percent
O&M Inflation Rate	3.0%	Percent
Discount Rate (apr)	3.0%	Percent
Added Annual O&M Costs for Biomass Plant	$ 1,890	$/yr

Year	#1 Fuel Oil Cost, Current System	Wood Pellet Cost	#1 Fuel Oil Cost, w/ Wood System	Added O&M Cost	Net Operating Savings	Annual Financing Payment	Net Cash Flow	Present Value of Cash Flow
1	$ 15,000	$ (16,500)	$ (750)	$ (1,890)	$ (4,140)	$ (8,563)	$ (12,703)	$ (12,703)
2	$ 15,495	$ (16,995)	$ (775)	$ (1,947)	$ (4,221)	$ (8,563)	$ (12,785)	$ (12,413)
3	$ 16,006	$ (17,505)	$ (800)	$ (2,005)	$ (4,304)	$ (8,563)	$ (12,867)	$ (12,129)
4	$ 16,535	$ (18,030)	$ (827)	$ (2,065)	$ (4,387)	$ (8,563)	$ (12,951)	$ (11,852)
5	$ 17,080	$ (18,571)	$ (854)	$ (2,127)	$ (4,472)	$ (8,563)	$ (13,035)	$ (11,582)
6	$ 17,644	$ (19,128)	$ (882)	$ (2,191)	$ (4,557)	$ (8,563)	$ (13,121)	$ (11,318)
7	$ 18,226	$ (19,702)	$ (911)	$ (2,257)	$ (4,644)	$ (8,563)	$ (13,207)	$ (11,061)
8	$ 18,828	$ (20,293)	$ (941)	$ (2,324)	$ (4,731)	$ (8,563)	$ (13,295)	$ (10,810)
9	$ 19,449	$ (20,902)	$ (972)	$ (2,394)	$ (4,819)	$ (8,563)	$ (13,383)	$ (10,565)
10	$ 20,091	$ (21,529)	$ (1,005)	$ (2,466)	$ (4,909)	$ (8,563)	$ (13,472)	$ (10,325)
11	$ 20,754	$ (22,175)	$ (1,038)	$ (2,540)	$ (4,999)	$ (8,563)	$ (13,562)	$ (10,091)
12	$ 21,439	$ (22,840)	$ (1,072)	$ (2,616)	$ (5,089)	$ (8,563)	$ (13,653)	$ (9,863)
13	$ 22,146	$ (23,525)	$ (1,107)	$ (2,695)	$ (5,181)	$ (8,563)	$ (13,744)	$ (9,640)
14	$ 22,877	$ (24,231)	$ (1,144)	$ (2,776)	$ (5,273)	$ (8,563)	$ (13,837)	$ (9,422)
15	$ 23,632	$ (24,958)	$ (1,182)	$ (2,859)	$ (5,366)	$ (8,563)	$ (13,930)	$ (9,209)
16	$ 24,412	$ (25,706)	$ (1,221)	$ (2,945)	$ (5,460)	$ (8,563)	$ (14,023)	$ (9,001)
17	$ 25,217	$ (26,478)	$ (1,261)	$ (3,033)	$ (5,554)	$ (8,563)	$ (14,118)	$ (8,798)
18	$ 26,049	$ (27,272)	$ (1,302)	$ (3,124)	$ (5,649)	$ (8,563)	$ (14,212)	$ (8,599)
19	$ 26,909	$ (28,090)	$ (1,345)	$ (3,218)	$ (5,744)	$ (8,563)	$ (14,308)	$ (8,404)
20	$ 27,797	$ (28,933)	$ (1,390)	$ (3,314)	$ (5,840)	$ (8,563)	$ (14,403)	$ (8,214)
						Sum of Present Values		**$ (205,999)**

Appendix C

Option 2 - Klawock Senior Center - Wood Briquette Boiler System
20 Year, 4% Financing

Input Variables	Value	Units
Project Costs Financed	113,471	$
Financing Term	20	# years
Financing Rate (apr)	4.0%	Percent
Current #1 Fuel Oil Usage	5,000	gal
Year 1 #1 Fuel Oil Average Price	$3.00	$/gal
Proposed Annual Wood Briquette Usage	39	tons/yr
Year 1 Wood Briquette Purchase Price	$236	$/ton
Annual #1 Fuel Oil Usage w/ Wood System	1,000	gal/yr
Fossil Fuel Inflation Rate (apr)	3.3%	Percent
Cord Wood Inflation Rate (apr)	3.0%	Percent
O&M Inflation Rate	3.0%	Percent
Discount Rate (apr)	3.0%	Percent
Added Annual O&M Costs for Biomass Plant	$ 1,804	$/yr

Year	#1 Fuel Oil Cost, Current System	Wood Briquette Cost	#1 Fuel Oil Cost, w/ Wood System	Added O&M Cost	Net Operating Savings	Annual Financing Payment	Net Cash Flow	Present Value of Cash Flow
1	$ 15,000	$ (9,204)	$ (3,000)	$ (1,804)	$ 992	$ (8,349)	$ (7,357)	$ (7,357)
2	$ 15,495	$ (9,480)	$ (3,099)	$ (1,858)	$ 1,058	$ (8,349)	$ (7,291)	$ (7,079)
3	$ 16,006	$ (9,765)	$ (3,201)	$ (1,913)	$ 1,127	$ (8,349)	$ (7,222)	$ (6,808)
4	$ 16,535	$ (10,057)	$ (3,307)	$ (1,971)	$ 1,199	$ (8,349)	$ (7,150)	$ (6,543)
5	$ 17,080	$ (10,359)	$ (3,416)	$ (2,030)	$ 1,275	$ (8,349)	$ (7,074)	$ (6,286)
6	$ 17,644	$ (10,670)	$ (3,529)	$ (2,091)	$ 1,354	$ (8,349)	$ (6,995)	$ (6,034)
7	$ 18,226	$ (10,990)	$ (3,645)	$ (2,154)	$ 1,437	$ (8,349)	$ (6,912)	$ (5,789)
8	$ 18,828	$ (11,320)	$ (3,766)	$ (2,218)	$ 1,524	$ (8,349)	$ (6,825)	$ (5,550)
9	$ 19,449	$ (11,659)	$ (3,890)	$ (2,285)	$ 1,615	$ (8,349)	$ (6,734)	$ (5,316)
10	$ 20,091	$ (12,009)	$ (4,018)	$ (2,353)	$ 1,710	$ (8,349)	$ (6,639)	$ (5,088)
11	$ 20,754	$ (12,369)	$ (4,151)	$ (2,424)	$ 1,810	$ (8,349)	$ (6,540)	$ (4,866)
12	$ 21,439	$ (12,740)	$ (4,288)	$ (2,497)	$ 1,914	$ (8,349)	$ (6,436)	$ (4,649)
13	$ 22,146	$ (13,123)	$ (4,429)	$ (2,572)	$ 2,023	$ (8,349)	$ (6,327)	$ (4,438)
14	$ 22,877	$ (13,516)	$ (4,575)	$ (2,649)	$ 2,136	$ (8,349)	$ (6,213)	$ (4,231)
15	$ 23,632	$ (13,922)	$ (4,726)	$ (2,728)	$ 2,255	$ (8,349)	$ (6,094)	$ (4,029)
16	$ 24,412	$ (14,340)	$ (4,882)	$ (2,810)	$ 2,380	$ (8,349)	$ (5,970)	$ (3,832)
17	$ 25,217	$ (14,770)	$ (5,043)	$ (2,894)	$ 2,510	$ (8,349)	$ (5,840)	$ (3,639)
18	$ 26,049	$ (15,213)	$ (5,210)	$ (2,981)	$ 2,646	$ (8,349)	$ (5,704)	$ (3,451)
19	$ 26,909	$ (15,669)	$ (5,382)	$ (3,071)	$ 2,787	$ (8,349)	$ (5,562)	$ (3,267)
20	$ 27,797	$ (16,139)	$ (5,559)	$ (3,163)	$ 2,936	$ (8,349)	$ (5,414)	$ (3,087)
						Sum of Present Values		**$ (101,339)**

Appendix D

Wood Fuel Specifications

- Pellet Fuels Institute wood pellet standards
- Viking Lumber Company's wood briquette spec sheet

	Residential/Commercial Densified Fuel Standards See notes 1-6		
Fuel Property	PFI Premium	PFI Standard	PFI Utility
Normative Information - Mandatory			
Bulk Density, lb./cubic foot	40.0 - 48.0	38.0 - 48.0	38.0 - 48.0
Diameter, inches	0.230 - 0.285	0.230 - 0.285	0.230 - 0.285
Diameter, mm	5.84 - 7.25	5.84 - 7.25	5.84 - 7.25
Pellet Durability Index	≥ 96.5	≥ 95.0	≥ 95.0
Fines, % (at the mill gate)	≤ 0.50	≤ 1.0	≤ 1.0
Inorganic Ash, %	≤ 1.0	≤ 2.0	≤ 6.0
Length, % greater than 1.50 inches	≤ 1.0	≤ 1.0	≤ 1.0
Moisture, %	≤ 8.0	≤ 10.0	≤ 10.0
Chloride, ppm	≤ 300	≤ 300	≤ 300
Heating Value	N/A	N/A	N/A
Informative Only - Not Mandatory			
Ash Fusion	N/A	N/A	N/A

VIKING LUMBER COMPANY, INC

Mile 6 Craig-Klawock Hwy, P.O. Box 670

Craig, Alaska 99921

P (907) 755-8880 - F (907) 755-8888

ATTN: DAN

Wood Briquettes

Caution:

- **BURNS HOT! DO NOT OVERLOAD WOOD BURNING STOVES!**
  - **Start with 2-4 Briquettes**
- Keep dry, store off the ground and away from damp surfaces

Advantages:

- Burns clean, burns long, low ash, low emission
- Drier than seasoned firewood (~ 8% moisture content)
- Easier to handle (each briquette 3lbs)
- Easier to start
- Clean and free of bugs
- No need to split and season
- Stacks neatly and takes up less room than firewood

Information:

- 100% Compressed sawdust and wood chips
- Burns hotter than firewood (start with 2-4 briquettes to avoid overheating stove)
- Approved for use in catalytic stoves (check with your manufacturer)
- 8 briquettes per box
- 672 briquettes per pallet unboxed; 84 boxes per pallet 672 briquettes
- ½ pallet 336 briquettes per pallet; 42 boxes per pallet 336 briquettes

Palletized information:

- Unboxed 40" Height x 40" Width x 48" Depth
- Boxed 47" Height x 40" Width x 48" Depth
- Weight ~ 1 ton (2,000 lbs.)

Pricing: (Subject to change)

- **$200.00 per palletized unboxed; ½ pallet $100.00**
- **$250.00 per palletized boxed; ½ pallet $125.00**

Comparisons:

- 1 cord of split and stacked hemlock firewood = ~ 128 cu ft.
- 1 pallet (ton) of unboxed briquettes = ~ 45 cu ft.
- 1 cord dry Hemlock is ~ 2,800 lbs., ~ 20% moisture content ~ 15-18 Million BTUs
- 1 ton of wood briquettes, ~ 8% moisture content ~ 15-18 Million BTUs

Appendix E

Advanced Wood Boiler Cut Sheets

- Maine Energy Systems wood pellet boiler
- Econoburn ASME rated wood briquette / cord wood boiler
- Froling wood briquette / cord wood boiler

AutoPellet Boiler System

Central heating using renewable wood pellet fuel

- **Self-feeding**
  high capacity pellet storage
- **Continous**
  burner adjustment for optimum performance
- **Automatic**
  ash removal
- **Reduced**
  heating costs and freedom from fossil fuels
- **Greatly**
  reduced carbon footprints
- **Integration**
  with existing systems possible
- **Efficient**
  output from advanced technology



MESYS
MAINE ENERGY SYSTEMS

licenced by

ÖkoFEN
PELLET HEATING

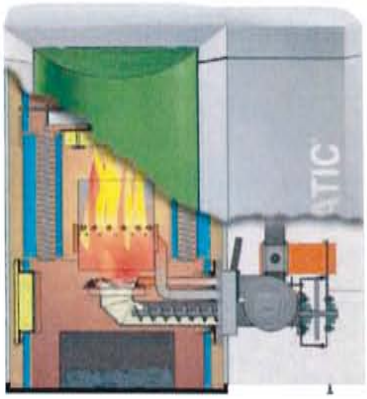
Europe's specialist in pellet heating

www.oekofen-usa.com

AutoPellet Boiler System



The AutoPellet boiler systems are UL approved for use with premium grade pellets. Suitable for direct replacement of an existing oil/gas boiler, or as the main heat source while maintaining the existing oil/gas boiler. An AutoPellet system is the ideal solution for decreasing our dependence on fossil fuels in times of unpredictable energy prices without reducing the level of convenience.
Each AutoPellet boiler system comes standard with either an auger or vacuum pellet feed system and automatic ash removal equipment.



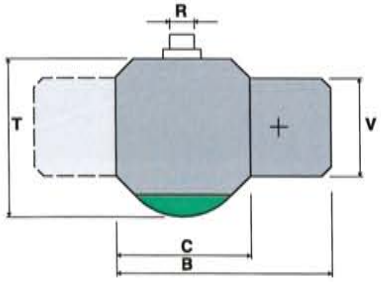
Venting and Installation Requirements:

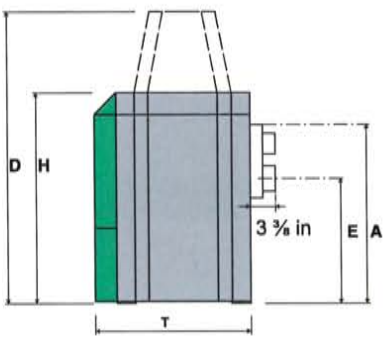
The boiler must have its own chimney/flue chase approved for solid fuel firing. Use a black smoke pipe for boiler breeching to the chimney. Install a furnished barometric in vertical direction. Slope flue pipe to chimney at least 1/4" per foot upward to the chimney. Ensure adequate combustion air at all times. Extend chimney at least 3 ft above roof penetration and at least 2 ft above any part of the roof within a radius of 10 ft. Follow Table below for minimum chimney heights. Maintain at least 4 ft lateral clearance between pellet boiler and pellet fuel storage.

Boiler – Type			PE(S)12	PE(S)15	PE(S)20	PE(S)25	PE(S)32	PES36	PES48	PES56
Boiler-rated power		BTU/hr	41,000	51,000	68,300	85,300	109,500	123,000	164,000	191,000
Width - total	B	Inch	44 ½	44 ½	44 ½	46 ¾	46 ¾	51	51	51
Width - boiler	C	Inch	27 ½	27 ½	27 ½	29 ¾	29 ¾	34	34	34
Height - boiler	H	Inch	43	43	43	50 ¾	50 ¾	61 ¼	61 ¼	61 ¼
Height - vacuum suction system	D	Inch	60	60	60	67 ¼	67 ¼	73	73	73
Depth - boiler	T	Inch	32	32	32	34 ¼	34 ¼	39	39	39
Depth - casing	V	Inch	20	20	20	20	20	20	20	20
Water supply/return - dimensions		Inch	1	1	1	5/4	5/4	2	2	2
Water supply/return - height of connection	A	Inch	35 ¾	35 ¾	35 ¾	43 ¾	43 ¾	52	52	52
Flue size - diameter	R	Inch	5	5	5	6	6	7	7	7
Flue - height of connection	E	Inch	25 ½	25 ½	25 ½	33 ¼	33 ¼	41	41	41
Overall Weight		Lb	534	542	551	697	705	1,327	1,336	1,345
Water capacity		Gal	15.0	15.0	15.0	23.6	23.6	30.6	30.6	30.6

Chimney Size	Min. Height
6" x 6"	17 ft
7" x 7"	16 ft
8" x 8"	16 ft
6" round	19 ft
7" round	17 ft

The AutoPellet system must be installed by a trained service technician. The boiler will require cleaning and brushing of the boiler heating surfaces **once a year.**





MESys Certified Contractor

Maine Energy Systems, LLC (MESys) 8 Airport Road P.O. Box 547 Bethel, Maine 04217
207.824.NRGY (6749) info@maineenergysystems.com

Econoburn Technical Datasheet



Models

EBW-100

EBW-150

EBW-200

EBW-300

EBW-500

EBW-150-0

EBW-200-0

Econoburn Highlights

- Saves homeowners money... burns HALF the wood!
- Integrates seamlessly with any existing hot water boiler or furnace.
- Achieves an amazing 87% thermal effiiciency!
- Burns cleanly with minimal residual smoke, creosote, or ash.
- Constructed with double-welded 1/4" ASME grade 36 carbon steel.
- Available in sizes from 100,000 to 500,000 BTU.
- Covered by the industry's best 25-year warranty!

Econoburn
High-Efficiency Wood-Fired Boilers

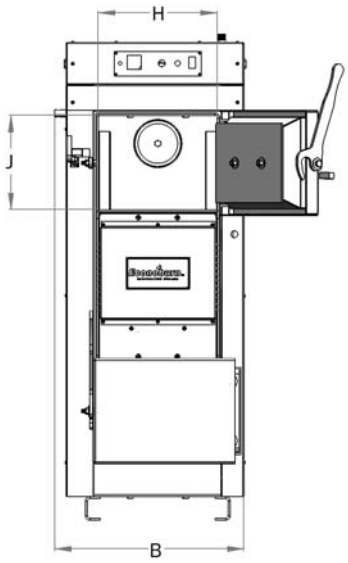
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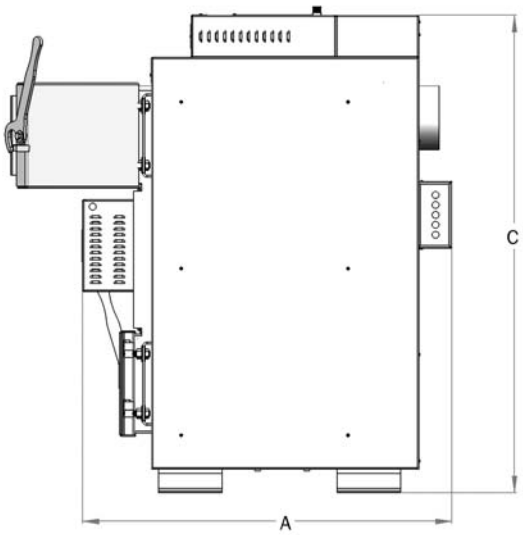
Boiler Cut-Away

Indoor Boiler

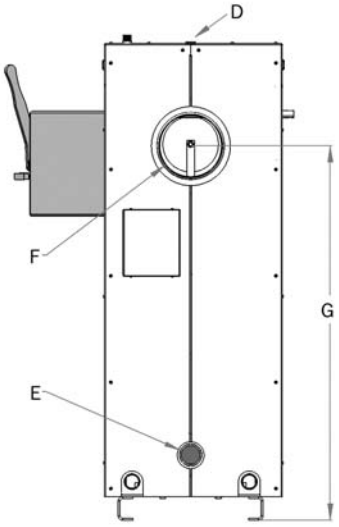
Front



Side

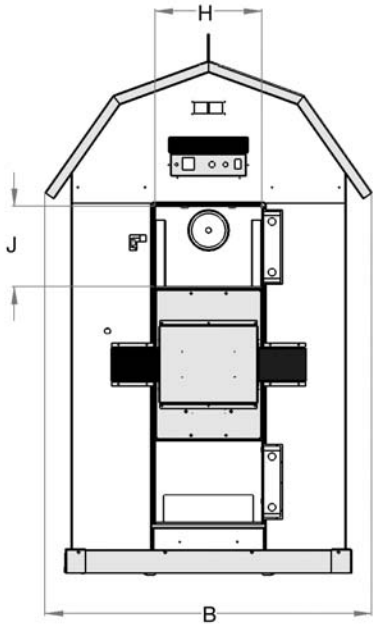


Rear

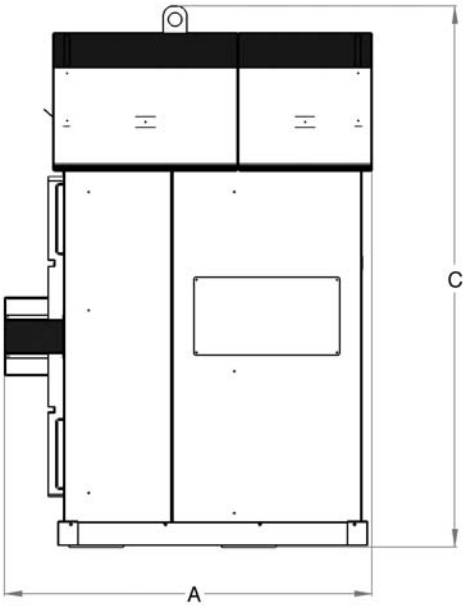


Outdoor Boiler

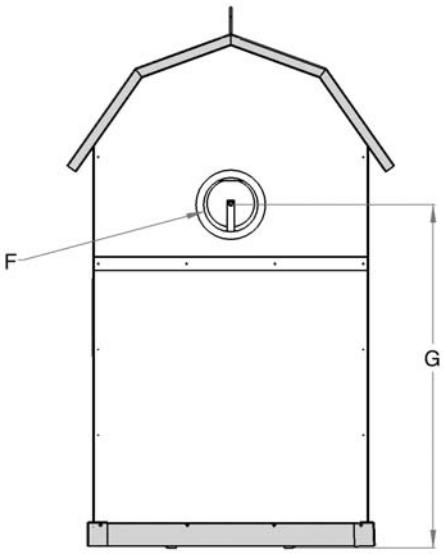
Front



Side



Rear



ph: 1-866-818-5162 fax: 1-716-792-2098 e-mail: info@econoburn.com

Models: EBW-100, EBW-150, EBW-200, EBW -300, EBW-500, EBW-150-0, EBW-200-0

Specifications

Boiler Model	Key	EBW-100	EBW-150	EBW-200	EBW-300	EBW-500	EBW-150-0	EBW-200-0
Design Application		Indoor	Indoor	Indoor	Indoor	Indoor	Outdoor	Outdoor
BTU Output		100,000	150,000	200,000	300,000	500,000	150,000	200,000
Boiler Dimensions								
Depth	A	47" / 119.4cm	47" / 119.4cm	47" / 119.4cm	50" / 127cm	63" / 160cm	54.25" / 137.8cm	54.25" / 137.8cm
Width	B	26" / 66cm	26" / 66cm	30" / 76.2cm	36" / 91.4cm	41" / 104.1cm	48.4" / 122.9cm	48.4" / 122.9cm
Height	C	63.75" / 161.9cm	63.75" / 161.9cm	64.25" / 163.2cm	70" / 177.8cm	76" / 193cm	80" / 203.2cm	80.5" / 204.5cm
Weight Empty		1,670 Lbs / 708 kg	1,670 Lbs / 708kg	1,980 Lbs / 898 kg	2,515 Lbs / 1,141 kg	3,405 Lbs / 1,544 kg	~1,800 Lbs / 816 kg	~2,100 Lbs / 953 kg
Firebox Dimensions								
Depth		23" / 58.4cm	23" / 58.4cm	23" / 58.4cm	26" / 66cm	32" / 81.3cm	23" / 58.4cm	23" / 58.4cm
Width		16" / 38.1cm	16" / 38.1cm	21" / 53.3cm	24" / 61cm	27" / 68.6cm	16" / 40.6cm	21" / 53.3cm
Height		28" / 71.1cm	28" / 71.1cm	29" / 73.7cm	32" / 83.8cm	39" / 99. 1cm	28" / 71.1cm	29" / 73.7cm
Maximum Log length		21" / 53.3cm	21" / 53.3cm	21" / 53.3cm	24" / 83.8cm	33" / 83.8cm	21" / 53.3cm	21" / 53.3cm
Firebox Door Height	J	12" / 30.5cm	12" / 30.5cm	12" / 30.5cm	12" / 30.5cm	12" / 30.5cm	12" / 30.5cm	12" / 30.5cm
Firebox Door Length	H	15.75" / 38.1cm	15.75" / 38.1cm	20.5" / 52.1cm	23.5" / 59.7cm	27.5" / 69.9cm	15.75" / 40cm	20.5" / 52.1cm
Piping Data								
Water Volume		37 Gal / 140 L	37 Gal / 140 L	42 Gal / 159 L	79 Gal / 299 L	95 Gal / 360 L	37 Gal / 140 L	42 Gal / 159 L
Supply Pipe (female connection)	D	2"	2"	2"	2.5"	4"	2"	2"
Return Pipe (female connection)	E	2"	2"	2"	2.5"	4"	2"	2"
Min Boiler Loop Size		1-¼"	1-¼"	1-½"	2"	3"	1-¼"	1-½"
Fill / Drain Valve Size		1-¼"	1-¼"	1-½"	1-½"	1-½"	1-¼"	1-½"
Flue Dimensions								
Flue Outlet Diameter	F	8"	8"	8"	8"	12"	8"	8"
Height to Center of Flue	G	50.75"	50.75"	51.25"	57"	61.5"	50.75"	51.25"
Operating Data								
Max Operating Temperature		210°F / 99°C						
Max Operating Pressure		30 PSI / 207 kPa						
Output Temperature (range)		170°F - 200°F / 77°C - 93°C						
Specified Fuel		Wood (recommended moisture content: 15-22%)						
Minimum Draft Required		-0.02 to -0.06 inch WC / -0.005 kPa to -0.015 kPa						
Flue Gas Temperature		280°F - 400°F / 138°C - 204°C						
Electrical Data								
Boiler Power Requirement		110 volt, 15 amp						
Electrical Consumption (watts)		100	175	175	175	200	175	175
Aquastat Overheat Setting		220°F / 104°C						
Electrical Consumption		< 5 amps						

Rev 01.20.10

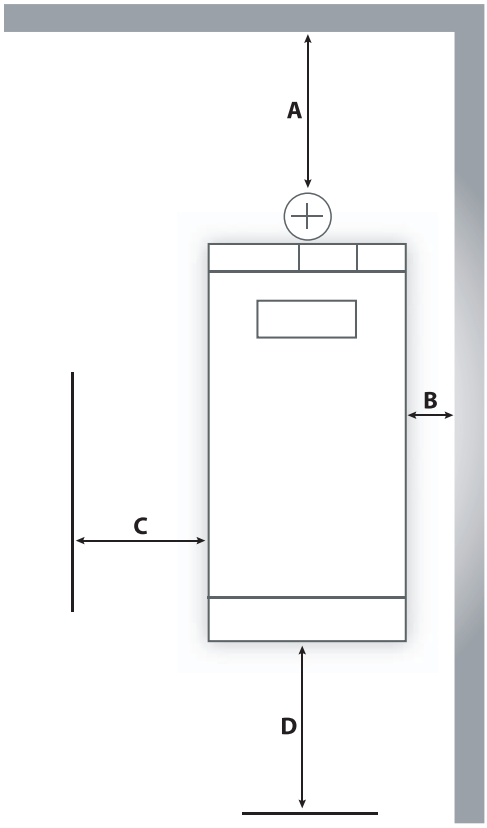
Specifications subject to change without notice.

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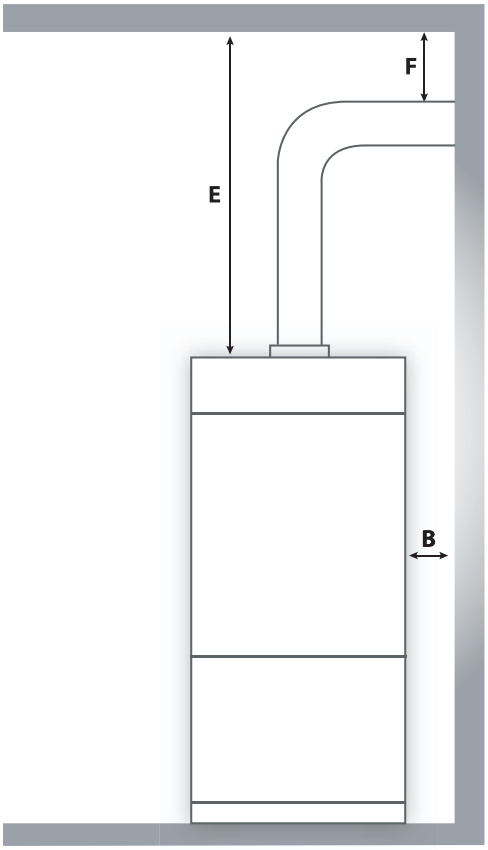
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Clearance to Combustibles

Top Down View



Side View



Clearances to Combustibles

Measurement	Key	Recommend Service	Safety	Notes
Backwall to Appliance	A	24"	18"	Minimum distance to allow clearance for the flue pipe
Sidewall to Appliance (R)	B	18"	0"	Minimum distance
Sidewall to Appliance (L)	C	24"	0"	Minimum distance on left side to allow clearance for the turbulator arm
Front of Appliance	D	48"	16"	Required distance for cleaning the boiler
Ceiling to Appliance	E	28"	16"	Required distance for cleaning the boiler
Combustibles to Pipe	F	18"	18"	Minimum distance

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Choose the Boiler Size

We recommend performing a detailed heat load calculation to use in calculation to determine boiler size. It is also useful to calculate the capacity of the heat supply system (commonly forced air ducts or baseboard) to ensure adequate distribution. Important note: square foot-based load calculations are often not as accurate as a structure's heat load and can vary widely depending on the building's age and construction.

Connect to the Chimney

It is critical to provide the Econoburn boiler with a properly functioning chimney. Indeed, a good chimney ensures that the boiler will benefit from a continuous draft and will prevent combustion products from spilling into the building. The boiler must be connected to either a tile-lined masonry chimney or a Type UL 103 HT (ULC S629 in Canada) all-fuel chimney with a height conforming to local codes. The minimum flue diameter is equal to the flue collar size (or 6" for the EBW-100). For maximum boiler performance, we recommend a draft of -0.02 to -0.05 inches of water column.

Ensure Appropriate Access to Combustion Air

Like any combustion appliance, the Econoburn boiler consumes a small amount of air as it operates. Accordingly, for every 100,000 BTU input of all combustion appliances found within a connected space, provide for combustion air equal to any combination of the following: 1) 50 sq inches of free area opening to the outside and/or 2) 6,667 cubic feet of continuous interior space. For the indoor model, provide combustion air that is at least 30 degrees (do not connect the boiler directly to outside air). The outdoor model comes standard with an air intake system designed to pre-heat its combustion air. Do not store flammable liquids or materials (including gasoline, propane, paint, bleach, etc.) in the same room as the boiler .

Place the Boiler

The Econoburn indoor boiler must be protected from the weather. Install the boiler in a weather-tight, protected space on a non-combustible floor base. Although the boiler is approved for 0"clearance to combustibles on the sides and 18" on the back, it is best to allow for a service area equal to 18" on the right side, 24" on the left side, and 24" in the back. To allow room for loading and servicing, allow for 48" free space in front of the boiler.

Install the Power Supply

The Econoburn requires a 120 VAC, 60 hertz power supply. The electrical connection should come from a 15 amp dedicated circuit breaker. Install an emergency switch within easy reach of the boiler. Please follow all electrical codes.

pH and Anti-Freeze Concerns

System pH should be between 8.0-8.6. Anti-freeze may be utilized, but may impact the heat transfer efficiency. Use only anti-freeze approved for heating systems.

Design and System Plumbing

Since Econoburn boilers operate as pressurized systems (closed loop), they do not require a plate heat exchanger. Copper, iron, or oxygen-barrier plastic tubing are all acceptable piping materials. Insulation is a must for any piping exposed to unconditioned spaces (outdoors or indoors). The boiler output and the length of piping will determine the required piping size.

Econoburn
High-Efficiency Wood-Fired Boilers

2 Central Avenue
Brocton, NY 14716
phone: **1-866-818-5162**
e-mail: **info@econoburn.com**
fax: **1-716-792-2098**
web: **www.econoburn.com**

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FHG-L

Models 20, 30, 40, and 50

Technical Datasheet



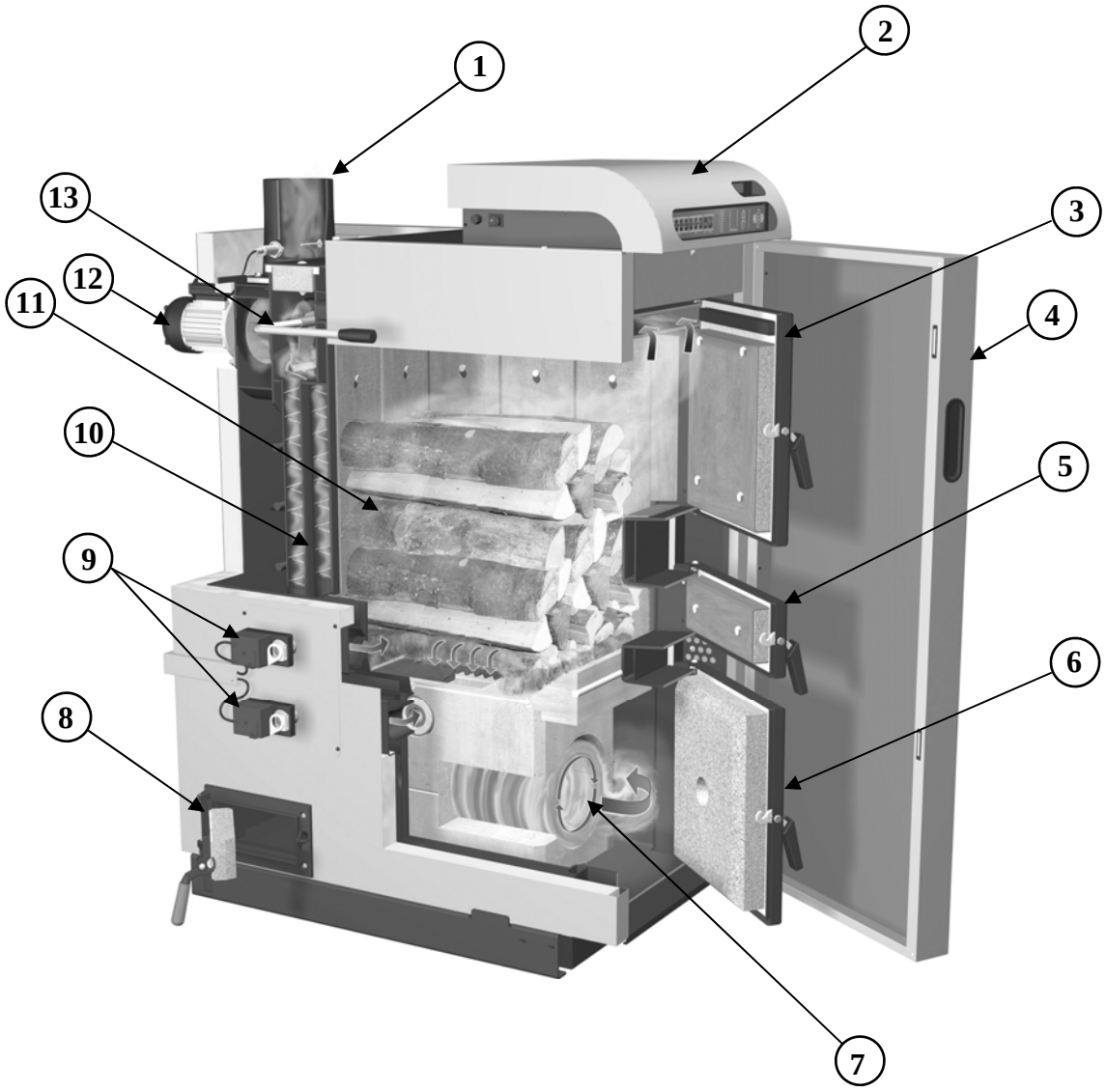
Fröling FHG-L

The FHG-L is a patented, wood-fired gasification boiler available in two sizes with outputs from 70,000-170,700 Btu/hr.

Benefits at a Glance:

- Add on to your existing fossil-fuel-fired or electric heating system
- Can be used with hot water baseboard, radiant floor, or hot air systems.
- Overall efficiencies of over 80%.
- Clean burn with virtually no smoke or creosote.
- Large easily accessible firebox.
- Smoke-free loading.
- Easy to clean manual; turbulators for heat exchanger tubes.
- Covered by a 20-year limited warranty.

Boiler Information
Boiler Overview

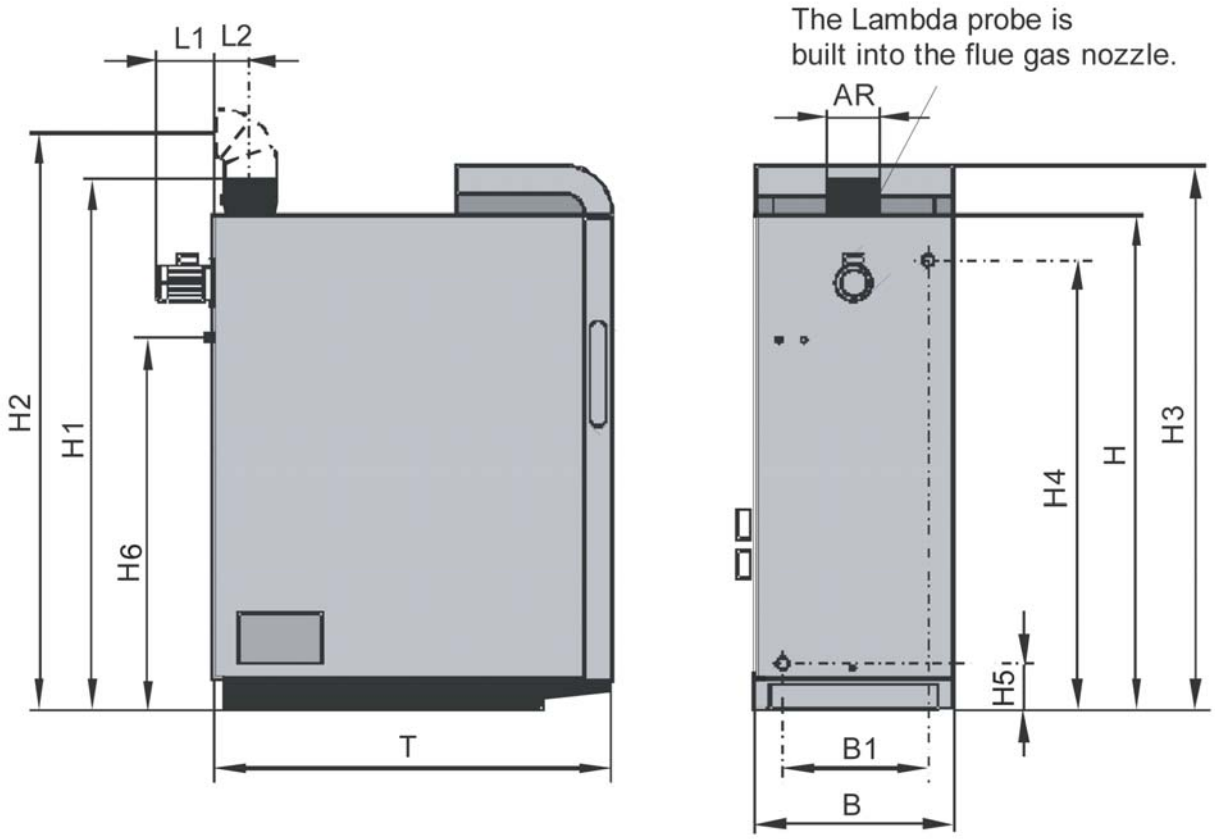


1. Exhaust Stack
2. Lambdatronic S 3200 control
3. Fuel loading door
4. Insulating door for reduced heat radiation
5. Pre-heating chamber
6. Combustion chamber door
7. Combustion chamber
8. Side cleaning port door
9. Server-controlled primary and secondary air dampers
10. Heat Exchangers
11. Firebox
12. Draft Fan
13. Lever for heat exchanger cleaning system

Specification Data

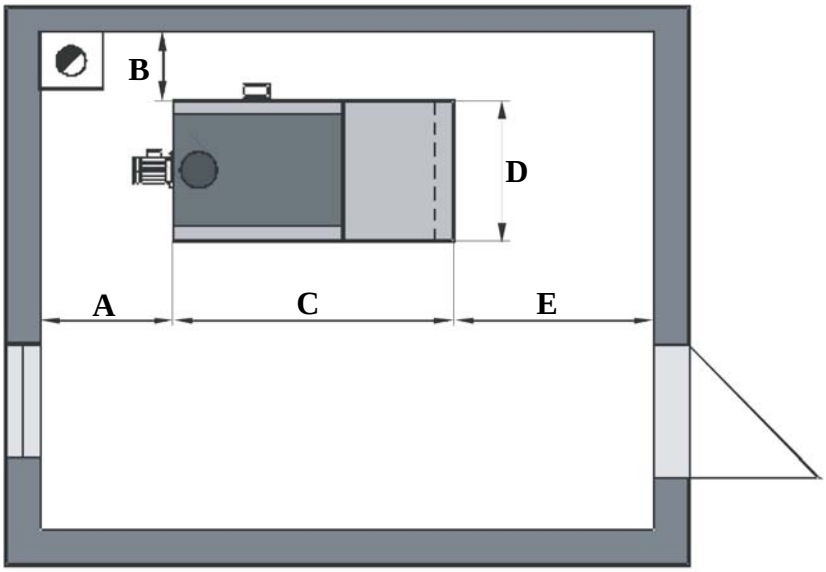
Component	Units	FHG 20	FHG 30	FHG 40	FHG 50
Depth-Boiler-Total	inches	45.25	45.5	49.5	49.5
Width-Boiler-Total	inches	22.75	22.75	22.75	22.75
Height-Boiler-Total	inches	61.75	62	65.75	65.75
Flue Collar Diameter	inches	6	6	6	6
Rated Heat Output	Btu/Hr	70,000	102,500	136,560	170,700
Heating Efficiency Range	Btu/Hr	35,000-70,000	51,250-102,000	68,280-136,560	85,350-170,700
Electrical Connection	V/Hz	240/60	240/60	240/60	240/60
Electrical Consumption	W	180	180	180	180
Output Temperature Range	ºF	158-194	158-194	158-194	159-194
Boiler Weight	Pounds	1150	1150	1345	1345
Loading Door	inches	13 X 14½	13 X 14½	13 X 14½	13 X 14½
Firebox Volume	Cu Ft	5	5	7.4	7.4
Wood Length	inches	21	21	21	21
Water Contents	Gallons	32	32	50	50
Upstream Resistance	Psi	.042	.094	.157	.245
Minimum Return Feed Temperature	ºF	131	131	131	131
Maximum Operating Temperature	ºF	203	203	203	203
Maximum Operating Pressure	Psi	43.5	43.5	43.5	43.5
Permitted Fuel		Firewood	Firewood/Coarse Waste-Wood	Firewood/Coarse Waste-Wood	Firewood/Coarse Waste-Wood
Boiler Test Pressure	Psi	65	65	65	65
Flue Gas Temperature Rated Load/Partial Load	ºF	303/203	329/212	311/214	253/223
Minimum Draft Required Rated Load/Partial Load	Inch WC	-0.060/-0.028	-0.060/-0.040	-0.072/-0.040	-0.072/-0.040

Specification Data



Description	Units	FHG20/30	FHG40/50
H- Total Height of Boiler	inches	56	60
H1-Height of Flue Gas Pipe Connection	inches	60¼	64
H2-Height of Flue Gas Pipe Connection Including an Elbow	inches	69	72¾
H3-Total Height of the Boiler Including the Controller	inches	61¾	65¾
H4-Height of Supply Feed Connection	inches	50¼	54
H5-Height of Return Feed Connection	inches	5	5
B-Total Width of Boiler	inches	22¾	26¾
B1-Width Between Supply and Return Feed Connections	inches	14	18
T-Boiler Total Depth	inches	45½	50¼
L1-Length of Induced Draft Fan	inches	7	7
L2-Distance between center of Flue Pipe and Back of Boiler	inches	4¼	4¼

Boiler Clearances



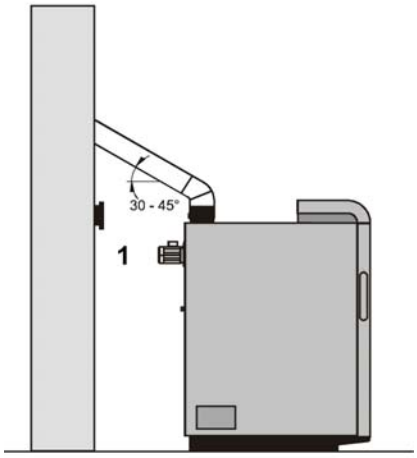
Clearances to Combustibles			
Measurement	Units	FHG 20/30	FHG 40/50
A-Backwall to Appliance	inches	21	21
B-Sidewall to Appliance	inches	12-20	12-20
C-Boiler Depth	inches	45½	50¼
D-Boiler Width	inches	22½	27
E-Distance in Front of Boiler	inches	32	32
Combustibles to Flue Pipe	inches	18	18

System Design Considerations

Sizing

It is critical to size the boiler properly. A proper, up to date heat load calculation is advised. An accurate history of building fuel usage over several years can help to calculate the proper size boiler. Be wary of using simple techniques based only on square footage. The heat load of a home can vary widely depending on age and type of heating system and location of the home. Boiler sizing is the responsibility of the installer. Tarm Biomass bears no responsibility for boiler sizing, but can provide sizing input.

Chimney



The chimney is the most critical factors in the successful operation of any solid fuel heater, including the FHG-L boiler. A good chimney will provide a continuous and dependable draft to pull the exhaust gasses out of the building. The boiler must be connected to a tile-lined masonry chimney or to a Factory-Built Type UL 103 HT (ULC S629 in Canada) approved chimney. The chimney must be in good condition. If the boiler is connected to a dirty or inadequate chimney, it can present a serious fire hazard. All chimney connections must conform to NFPA standard #211. No other appliance should be connected to this flue unless allowed by the local code authority. Consult your local inspector for chimney requirements and install the boiler in accordance with all applicable codes.

The installation of a barometric damper (1) is recommended. The barometric damper should be mounted under the mouth of the flue gas pipe, since an under-pressure condition can always be found there.

Outside Combustion Air

Provision for outside combustion air may be necessary to ensure that fuel-burning appliances do not discharge products of combustion into the house. Guidelines to determine the need for additional combustion air may not be adequate for every situation. If in doubt, it is advisable to provide additional air.

The FHG-L boiler is not suitable for direct connection to outside air. Outside air should be ducted to no closer than 12” from the boiler.

The boiler must not be installed in an area or room where there are flammable liquids or combustibles. Examples include, refrigerants, paint, thinner, bleach, etc.

Boiler Location

The boiler is not suitable for outdoor installation. It must be located in a weather-tight, protected space. The boiler must be placed on a level, non-combustible floor, such as a concrete slab on earth. If the boiler is placed near inhabited rooms, so that the flue gas can easily penetrate into these rooms, a carbon monoxide alarm must be installed that can give a warning regarding possible escapes of carbon monoxide into the inhabited rooms.

Electrical

For the FHG-L boiler a 240 VAC, 60 hertz, 4 wire power supply is required. This electrical connection should be from a dedicated 15 amp, circuit breaker. A master service switch for the boiler, mounted on the wall in the proximity of the boiler, is recommended. Locally enforced electrical codes must be followed.

Water Quality

If water quality is poor, water treatment should be considered. Boiler system pH should be 8.0-8.6.

An anti-freeze can be utilized in areas where freezing could occur. Automotive or silicate-based anti-freeze cannot be used. Use only anti -freeze approved for heating systems. Using anti-freeze can cause a loss in heating efficiency and some heating components within the system could be negatively impacted.

System Plumbing

For the heating system piping, it is possible to use either copper or iron piping materials. The supply and return pipe should be insulated to avoid heat loss.

In systems where plastic tubing is used, it must have an oxygen diffuser barrier. If non-oxygen barrier tubing is used, the boiler must be separated from the tubing by a heat exchanger.

A thermostatic mixing valve, set to open at 140 ºF (60 ºC), is required to temper return water to prevent cold return water from reaching the boiler. This valve helps prevent boiler corrosion.

Boiler Accessories

- **Termovar Mixing Valve**
- **Termovar Loading Unit**
- **Aquastats**
- **Thermal Storage Systems**

SAXMAN – MULTIFAMILY LOW-RENT HOUSING HEATING CONVERSION ANALYSIS

THRHA Regional Housing Authority
Juneau, Alaska

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
jim@alaskaenergy.us

Technical Memorandum

September 14, 2015

to: **Craig Moore, V.P. Planning and Development**
Tlingit-Haida Regional Housing Authority

subject: **Heating Conversion Analysis**

project: **Saxman Multifamily Low Rent Housing**

INTRODUCTION

This report presents a heating conversion analysis for the Saxman Multifamily Low Rent Housing building. The purpose of the analysis is to compare the life cycle cost of a fuel oil boiler heating system with an air source heat pump heating system.

Jim Rehfeldt, P.E. of Alaska Energy Engineering LLC performed the analysis.

Background

The Tlingit-Haida Regional Housing Authority (THRHA) plans to renovate, modernize, and expand the Saxman Multifamily Low Rent building in Saxman, Alaska. The project will include a complete replacement of the heating system because it has reached the end of its service life.

The existing heating system consists of an oil-fired boiler and high-temperature distribution system supplying a central indirect hot water heater and baseboard units located in each apartment. Replacing the heating system in-kind is a common, status quo option for heating system replacement. The THRHA is interested in replacing the boiler system with an air source heat pump system that employs low temperature distribution to supply a central domestic hot water system and low-temperature baseboard heaters.

Conversion to an air source heat pump system is aligned with THRHA energy goals to:

- Reduce long-term operating costs
- Increase use of sustainable energy sources: electricity in Saxman is derived from hydroelectric generation
- Increase use of local energy sources, and
- Decrease the greenhouse gas footprint of their operations

ENERGY COSTS

Historic Energy Use

The Saxman Multifamily low rent housing is a 7,600-sqft facility that contains 12 apartments and a common hallway, laundry room, kitchen and dining room. Two fuel oil boilers supply heat for the spaces and for heating domestic hot water. Historic energy use and cost is summarized in the following table:

Annual Energy Consumption and Cost

Source	Consumption	Cost	Energy, MMBtu	
Electricity	64,980 kWh	$6,300	222	31%
Fuel Oil	3,693 Gallons	$10,700	502	69%
Totals	-	$17,000	723	100%

The building has an energy use index (EUI) of 95, which is relatively high for THRHA facilities. To improve the energy performance of the facility, the proposed project will increase the wall and window insulation and install LED lighting. Converting to an air source heat pump system will also reduce energy costs.

Energy Costs and Inflation

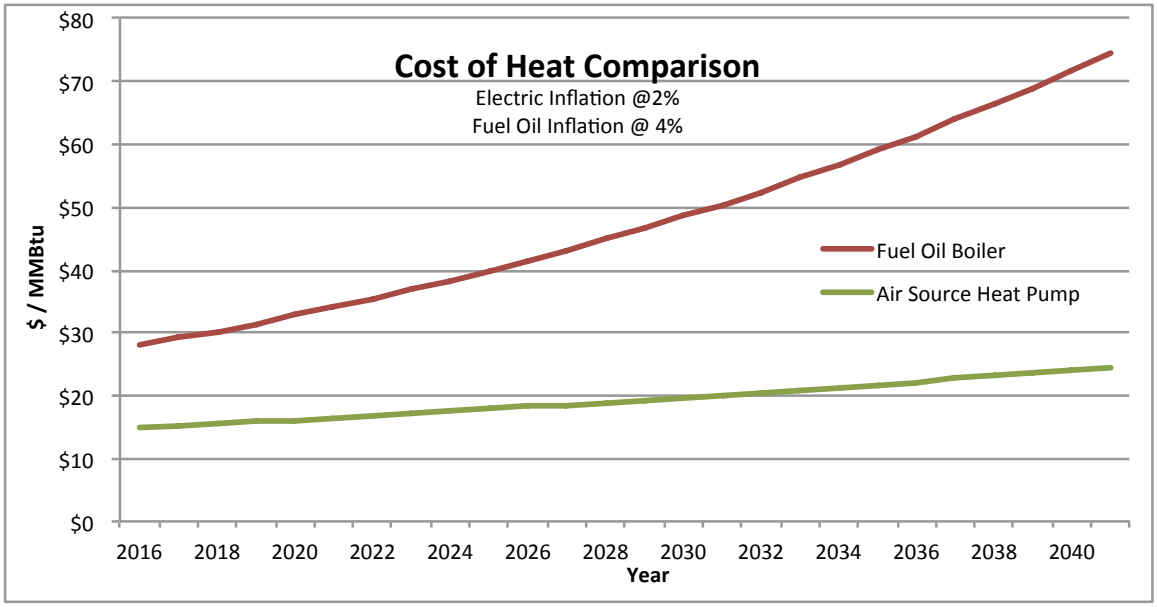
Energy costs and energy inflation used in the analysis are shown in the following table:

Summary of Economic and Energy Factors

Factor	Rate or Cost	Factor	Rate or Cost
Nominal Discount Rate	4.5%	General Inflation Rate	2.5%
Electricity (2016)	11.2¢ per kWh	Electricity Inflation	2.0%
Fuel Oil (2016)	$3.03 / gallon	Fuel Oil Inflation	4.0%

Cost of Heat Comparison

The cost of heat takes into account current energy prices, conversion efficiency, and energy inflation. The following charts shows projected energy prices over 25-years. On the left side of the chart is the cost of heat in 2016. Moving to right is how the costs change with energy inflation.



An air source heat pump offers much lower heating costs over the life of the project because it extracts a majority of the supplied heat from the environment at no cost or energy inflation.

LIFE CYCLE COST COMPARISON

Description of Systems

The existing fuel oil boiler heating system has reached the end of its service life and will be replaced in entirety. The analysis compares an in-kind replacement of a fuel oil boiler system with converting to an air source heat pump system. Attached to this report is a schematic diagram of the two systems.

Fuel Oil Boiler Option

A fuel oil boiler heating system will consist of:

- Two fuel oil boilers sized for 70% of the heating load, each with a constant speed boiler pump.
- Two variable speed building pumps supplying high-temperature hydronic heat to apartment baseboard heaters and to two indirect domestic hot water heaters.

The fuel oil boiler plant will have a seasonal efficiency of 75% when operated in a lead/lag configuration.

Air Source Heat Pump Option

An air source heat pump system will consist of:

- An air source heat pump located outdoors under an enclosure that protects it from wind-driven rain and snow and two indoor heat exchangers that transfer the heat to a low-temperature hydronic heating system.
- A buffer tank with electric heating elements that both adds thermal mass to the system and also provides backup heating when the heat pump requires maintenance or repair.

- Two variable speed building pumps supplying low-temperature hydronic heat to apartment baseboard heaters and to an indirect domestic hot water preheat tank
- An electric hot water heater that increases the hot water temperature to 125°F for distribution to the fixtures.

The air source heat pump sized at 80% of the design heating load will supply 95% of the heating load. The backup electric buffer tank supplement during cold weather and the electric hot water heater will also supply supplemental heat to maintain a hot water supply temperature of 125°F.

Life Cycle Cost Comparison

Construction Costs

As expected for a system with higher efficiency, the ASHP system has higher construction costs than the fuel oil boiler system. The higher cost is primarily attributed to the following features of the ASHP system:

- The heat pump costs more than a fuel oil boiler per Btu of delivered heat.
- The electrical service will be upgraded from 240v/1ϕ to 208v/3ϕ service. This will also require a rate schedule change from residential service to commercial service.
- The ASHP system requires a low temperature distribution system with larger pumps and piping and higher cost baseboard heaters.

Maintenance Costs

The air source heat pump system has moderately higher maintenance costs associated with maintaining the outdoor units, including factory-trained maintenance every five-years. The outdoor units must also be replaced at the end of their expected service life of 15 years.

The fuel oil boilers require annual maintenance for the burner and to clean the combustion passages.

Energy Costs

The following table summarizes the energy analysis of the two heating options. The ASHP system offers a significant reduction in energy use and costs.

Energy Analysis

Item	Fuel Oil Boilers	Air Source Heat Pump
Heating Plant Sizing	Two at 70% each	ASHP: 80% Electric Tank: 100%
Seasonal Efficiency	72%	233%
Annual Energy Use	Oil: 4,058 gal Elec: 1,690 kWh	Elec: 57,703 kWh
Annual Energy Cost (2016)	$12,500	$7,300 [1]
Energy Use Index, kBtu/sqft	94	51
Energy Cost Index, $/sqft	$2.22	$1.65

1. Includes a cost of 1.2¢ per kWh for non-heating electricity as a result of changing the building electric service from residential to commercial rates.

Life Cycle Cost Comparison

Both options have essentially equal life cycle cost. The air source heat pump has the lowest energy costs and the fuel oil boiler system has lower construction and maintenance costs.

Life Cycle Cost Comparison

Component	Fuel Oil Boiler	Air Source Heat Pump	% Difference
Construction Costs	$239,000	$385,000	+61%
Maintenance Costs	$34,000	$47,000	+38%
Energy Costs	$292,000	$136,000	-53%
Total Life Cycle Cost	$565,000	$568,000	+1% [1]

1. Within the accuracy of the analysis, the two projects have essentially equal life cycle costs.

SUMMARY

Building Owners typically require a reasonable savings on their investment—typically in the range of 5-10%—as incentive to undertake the effort and risk of a heating system conversion. In this project, the heating system is failing and must be replaced; THRHA must endure a level of effort and risk regardless of which heating option they choose, lowering their needed return on investment.

For THRHA, this conversion offers several financial and operational benefits that promote conversion. The main benefit is a significant reduction in annual operating costs, helping to keep rents low. An ASHP conversion is also aligned with THRHA's goal to transition away from fuel oil toward sustainable, local energy sources. A high percentage of Saxman's power is expected to be renewable hydroelectric power throughout the life of the system. As such, an ASHP system also has lower environmental impacts because it does not emit greenhouse gases.

This project can also benefit other building owners in Saxman and other Alaska communities in the following ways:

- Hydroelectric communities are promoting heat pump heating as an efficient use of hydroelectric resources. The project demonstrates heat pump conversion of an existing building.
- Air source heat pump technology has improved greatly in the last five years to the point that they are viable systems in the relatively warmer climate of coastal Alaska. As the technology continues to gain efficiency, the lessons learned from this conversion will benefit more areas of Alaska.
- The recent drop in oil prices may lead to complacency in addressing future energy issues. By promoting heat pump technology and demonstrating its success now, the THRHA can make positive steps toward improving energy efficiency and lowering long-term energy costs.

Replacing a heating system in-kind is the often chosen path for building owners, especially for similar buildings with relatively modest heating loads. This project will successfully demonstrate that heat pump technology is a viable option that offers long-term benefits to THRHA.

by: 

Jim Rehfeldt, P.E.

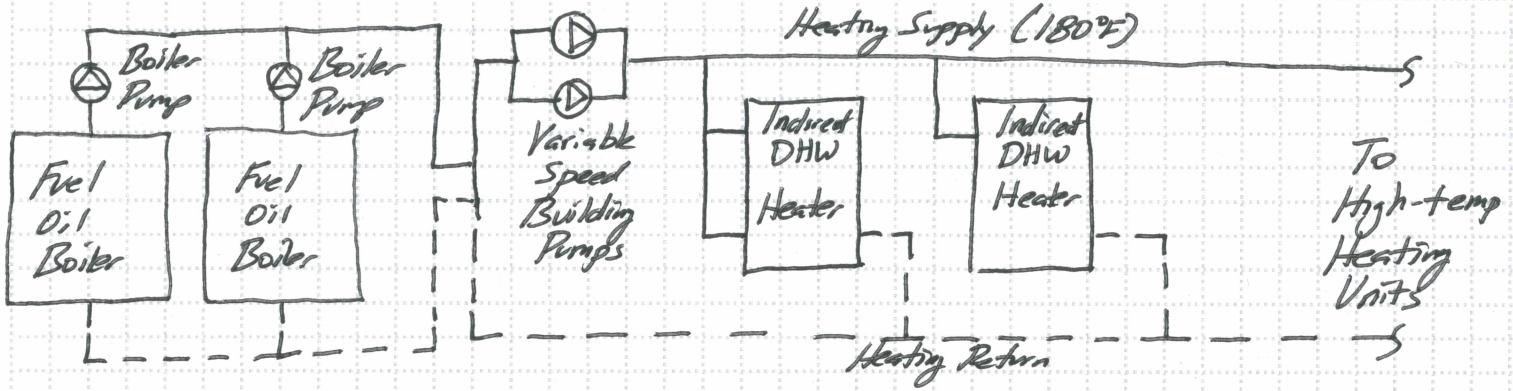
Alaska Energy Engineering LLC

Subject: Heating System Schematic

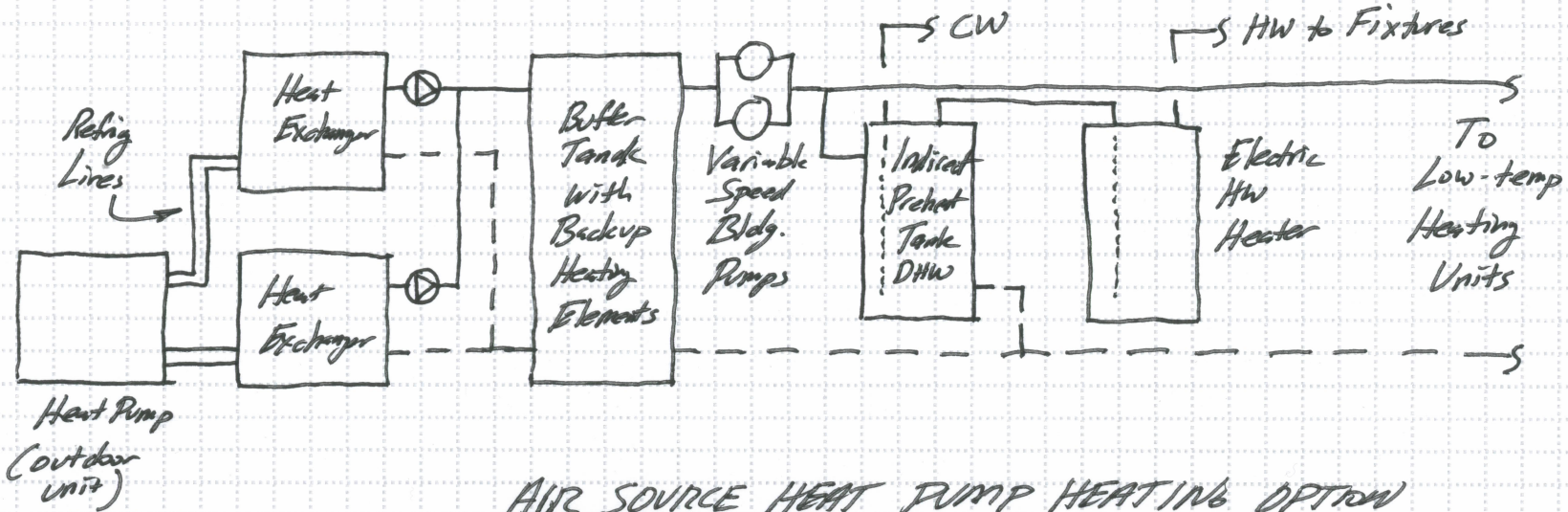
Project: Sexsmith

Date: 5-21-16

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FUEL OIL BOILER HEATING OPTION



AIR SOURCE HEAT PUMP HEATING OPTION

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Life Cycle Cost Analysis

September 14, 2015

THRHA Saxman Low Rent Housing
Sizing and Energy Analysis

Building Loads

Heating	Design Load, MBH	Energy, kBTU
	150	404,678

Fuel Oil Boiler System

Sizing Analysis

Boilers	Boiler	Design Load, MBH	Factor	Boiler MBH
	B-1	150	70%	105
	B-2	150	70%	105
			140%	210

Pumps	Pump	GPM	Head	η, pump	Pump, BHP	η, motor
	Boiler	11	12	50%	0.06	70%
	Building	15	20	50%	0.15	70%

Energy Analysis

Fuel Oil Boilers	Load, kBTU	% Load	Net, kBTU	Efficiency	kBTU/gal	Fuel, gals
	404,678	100%	404,678	72%	138.5	4,058

Heating Pumping	Pump	Ave GPM	Ave Head	kW	Hours	kWh
	Boiler	11	12	0.07	3,854	274
	Building	15	20	0.16	8,760	1,416
						1,690

Air Source Heat Pump System

Sizing Analysis

Heating Equipment	Equip	Design MBH	Factor	Size, MBH	Effic	kW
	ASHP-1	100	78%	78	200%	11
	Elec Boiler	150	102%	154	100%	45
			Total	232		

Heat Exchangers	Equip	Design MBH	Factor	Size, MBH
	HEX-1	78	60%	47
	HEX-2	78	60%	47
				94

Pumps	Pump	GPM	Head	η, pump	Pump, BHP	η, motor
	HEX Pump	9	10	50%	0.05	70%
	HEX Pump	9	10	50%	0.05	70%
	Elec Boiler	31	12	50%	0.19	70%
	Building	31	20	50%	0.31	70%

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

THRHA Saxman Low Rent Housing
Sizing and Energy Analysis

Energy Analysis

	Load, kBTU	% Load	Net, kBTU
Heat Pumps	404,678	95%	384,444

Month	% Load	Load kBtu	Ave Temp	COP	Input kBtu	kWh
Jan	12%	46,133	34	1.9	24,198	7,092
Feb	10%	38,444	36	2.0	19,198	5,627
Mar	10%	38,444	38	2.1	18,191	5,331
Apr	8%	30,756	41	2.3	13,346	3,911
May	6%	23,067	47	2.7	8,396	2,461
Jun	5%	19,222	50	3.0	6,456	1,892
Jul	5%	19,222	55	3.3	5,786	1,696
Aug	6%	23,067	56	3.4	6,826	2,001
Sep	8%	30,756	53	3.2	9,630	2,822
Oct	9%	34,600	45	2.6	13,338	3,909
Nov	10%	38,444	40	2.2	17,180	5,035
Dec	11%	42,289	33	1.9	22,683	6,648
	100%	384,444		233%	165,229	48,426

Electric Boiler	Load, kBTU	% Load	Net, kBTU	Efficiency	kBTU/kWh	kWh
	404,678	5%	20,234	95%	3.4	6,242

Pumps	Pump	Ave GPM	Ave Head	kW	Hours	kWh
	HEX Pump	9	10	0.1	7,500	378
	HEX Pump	9	10	0.1	1,500	76
	Elec Boiler	31	12	0.2	500	99
	Building	31	20	0.3	7,500	2,482
						3,035

Electric Service Capacity

Spare Capacity

Service Size: 240 volts / 400A	96 kVA
Capacity kVA (Assume 80%)	77 kVA
Capacity kW (Assume 90% PF)	69 kW
Peak Load	55 kW
Spare capacity	14 kW

Increased Electric Service	Qty	kW, ea	Total kW	kVA @ 90% PF	Volts	Amps
Existing Service	1	86	86	96	208	265
Heat Pump	1	11	11	13	208	35
Electric Buffer Tank	1	30	30	33	208	93
Electric HW Tank	1	21	21	23	208	65
			148	165	208	458

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
alaskaenergy@gci.net

THRHA Saxman Low Rent Housing

Fuel Oil Boiler System

Basis

25	Study Period (years)	2.5%	General Inflation
4.5%	Nominal Discount Rate	4.0%	Fuel Inflation
2.0%	Real Discount Rate	2.0%	Electricity Inflation

Construction Costs		Year	Qty	Unit	Base Cost	Year 0 Cost
Hydronic Heating System						
Heating Plant						
Fuel Oil System						
Boiler fuel oil piping		0	2	LS	$500.00	$1,000
Primary Loop						
Fuel oil boilers	105 MBH	0	2	LS	$6,500.00	$13,000
Boiler stack		0	30	lnft	150.00	$4,500
Primary piping and appurtenances for each boiler	1-1/4"	0	2	LS	$1,500.00	$3,000
Primary supply and return header	1-1/2"	0	10	lnft	$35.00	$350
Primary pump, pipe mounted	1/10 HP	0	2	LS	$750.00	$1,500
Secondary loop						
Secondary pumps	1/4 HP	0	2	ea	1,500.00	$3,000
Secondary piping and appurtenances (boiler room)	1-1/2"	0	1	lot	3,000.00	$3,000
Building loop	1"	0	900	lnft	30.00	$27,000
Finned pipe branches	3/4"	0	520	lnft	25.00	$13,000
Finned pipe convectors		0	300	lnft	75.00	$22,500
Thermostats and control valves		0	13	ea	250.00	$3,250
Domestic Hot Water System						
Indirect HW heater, AV, piping, etc.	120 gallon	0	2	ea	8,700.00	$17,400
Miscellaneous						
Test and balance		0	40	hrs	150.00	$6,000
Commission heating system		0	1	lot	4,000.00	$4,000
Electrical						
Three phase service		0	0	ea	5,000.00	$0
Single phase service		0	8	ea	1,500.00	$12,000
Contingencies						
Estimating contingency		0			15%	$20,175
Overhead & profit		0			30%	$46,403
Design fees		0			10%	$20,108
Project management		0			8%	$17,695
					Total Construction Costs	**$239,000**

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
alaskaenergy@gci.net

THRHA Saxman Low Rent Housing

Fuel Oil Boiler System

Annual Costs	Maintenance	$40.00		Years	Qty	Unit	Base Cost	Present Value
Heating Plant								
Plant Observation								
Daily Heating Plant Observation		30	min/mo	1 - 25	6	hrs	$40.00	$4,622
Fuel Oil Boilers								
Fuel Oil Boiler Maintenance								
Parts Allowance, each				1 - 25	2	LS	$200.00	$7,704
Annual, each		8	hours/year	1 - 25	16	hrs	$40.00	$12,326
Pumps								
Pump maintenance, cartridge				1 - 25	4	ea	$100.00	$7,704
Domestic Hot Water								
Indirect HW heater		2	1	1 - 25	2	hrs	$40.00	$1,541
							Total Annual Costs	**$34,000**

Energy Costs	Years	Qty	Unit	Base Cost	Present Value
Fuel Oil	1 - 25	4,058	gallon	$3.03	$288,652
Electricity	1 - 25	1,690	kWh	$0.099	$3,098
				Total Energy Costs	**$292,000**

Present Worth	$565,000

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
alaskaenergy@gci.net

Life Cycle Cost Analysis

September 14, 2015

THRHA Saxman Low Rent Housing

Air Source Heat Pump System

Basis

25	Study Period (years)	2.5%	General Inflation
4.5%	Nominal Discount Rate	4.0%	Fuel Inflation
2.0%	Real Discount Rate	2.0%	Electricity Inflation

Construction Costs		Year	Qty	Unit	Base Cost	Year 0 Cost
Air Source Heat Pumps						
Outdoor units		0	1	ea	$18,000.00	$18,000
Enclosure		0	1	ea	$2,500.00	$2,500
Refrigerant piping		0	2	ea	$1,000.00	$2,000
Indoor HEX units		0	2	ea	$7,500.00	$15,000
Piping to building heating loop		0	2	ea	$1,500.00	$3,000
HEX pumps		0	2	ea	$1,000.00	$2,000
Hydronic Heating System						
Heating Plant						
Primary Loop						
Buffer Tank, Electric backup	200 gallons, 30 kW	0	1	LS	$12,000.00	$12,000
Boiler piping and appurtenances	2"	0	1	LS	$2,000.00	$2,000
Primary supply and return header	2"	0	10	lnft	$42.00	$420
Primary pump, pipe mounted	1/4 HP	0	1	LS	$1,000.00	$1,000
Secondary loop						
Secondary pumps	1/2 HP	0	2	ea	1,750.00	$3,500
Secondary piping and appurtenances (boiler room)	2"	0	1	lot	3,500.00	$3,500
Building loop	1-1/4"	0	900	lnft	35.00	$31,500
Finned pipe branches	3/4"	0	520	ea	25.00	$13,000
Finned pipe convectors		0	300	lnft	90.00	$27,000
Thermostats and control valves		0	13	ea	250.00	$3,250
Domestic Hot Water System						
Indirect HW heater, AV, piping, etc.	120 gallon	0	1	ea	8,700.00	$8,700
Electric hot water heater	120 gallon, 21kW	0	1	ea	7,000.00	$7,000
Miscellaneous						
Test and balance		0	40	hrs	150.00	$6,000
Commission heating system		0	1	lot	5,000.00	$5,000
Electrical						
Three phase service		0	3	ea	5,000.00	$15,000
Single phase service		0	6	ea	1,500.00	$9,000
CT Enclosure		0	1	LS	5,000.00	$5,000
208v/3-phase panel		0	1	LS	7,000.00	$7,000
Connect existing panel		0	1	LS	2,500.00	$2,500
Upgrade service from 240v/1-phase to 208v/3-phase		0	1	LS	20,000.00	$20,000
Contingencies						
Estimating contingency		0			15%	$30,731
Overhead & profit		0			30%	$70,680
Design fees		0			10%	$30,628
Project management		0			8%	$28,553
					Total Construction Costs	**$385,000**

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
alaskaenergy@gci.net

Life Cycle Cost Analysis

September 14, 2015

THRHA Saxman Low Rent Housing

Air Source Heat Pump System

Annual Costs	Maintenance $40.00	Years	Qty	Unit	Base Cost	Present Value
Heating Plant						
Plant Observation						
Daily Heating Plant Observation	30 min/mo	1 - 25	6	hrs	$40.00	$4,622
Air-source Heat Pump Maintenance						
Parts Allowance		1 - 25	1	LS	$200.00	$3,852
Monthly	0.5 hours/month	1 - 25	6	hrs	$40.00	$4,622
Every Three Months	0.67 hours/3 months	1 - 25	3	hrs	$40.00	$2,054
Annual	8 hours/year	1 - 25	8	hrs	$40.00	$6,163
Five Year Maintenance	4 hours/year	5 - 5	4	hrs	$110.00	$392
Five Year Maintenance	4 hours/year	10 - 10	4	hrs	$110.00	$356
Five Year Maintenance	4 hours/year	15 - 15	4	hrs	$110.00	$323
Five Year Maintenance	4 hours/year	20 - 20	4	hrs	$110.00	$293
Electric buffer tank		1 - 25	1	hrs	$40.00	$770
Air-source Heat Pump Replacement						
Replace outdoor units		15 - 15	1	LS	$13,500.00	$9,910
Pumps						
Pump maintenance, cartridge		1 - 25	2	ea	$100.00	$3,852
Pump maintenance, pipe mounted		1 - 25	3	ea	$150.00	$8,667
Domestic Hot Water						
Indirect HW heater		1 - 25	1	hrs	$40.00	$770
Electric HW Heater		1 - 25	1	hrs	$40.00	$770
					Total Annual Costs	**$47,000**

Energy Costs	Years	Qty	Unit	Base Cost	Present Value
Fuel Oil	1 - 25	0	gallon	$3.03	$0
Electricity (Non-HVAC cost increase due to rate change)	1 - 25	69,000	kWh	$0.012	$15,597
Electricity (Heating System)	1 - 25	57,703	kWh	$0.112	$119,956
				Total Energy Costs	**$136,000**

Present Worth	$568,000

SAXMAN – LOW-RENT MULTIFAMILY DEEP ENERGY RETROFIT PROJECT

THRHA Regional Housing Authority
Juneau, Alaska

Regional Housing Authority

Technical Report in Preparation for Seeking Grant Funding

Tlingit Haida Regional Housing Authority

(A Tribally Designated Housing Authority)

December 15, 2015

Saxman Low-Rent Multifamily Deep Energy Retrofit Project

Location: 2708 Halibut Street, Ketchikan, AK 99901

Technical Contact:
Craig Moore
VP Development & Construction Management
PO Box 32237
Juneau, AK 99803
Phone: 907-780-6868
Fax: 907-780-6895
Email: cmoore@thrha.org

Business Contact:
Irene Tupou
Finance Manager
PO Box 32237
Juneau, AK 99803
Phone: 907-780-6868
Fax: 907-780-6895
Email: itupou@thrha.org

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1.0 EXUCTIVE SUMMARY

1.1 Project Overview

Tlingit Haida Regional Housing Authority (THRHA) plans to renovate and expand the Saxman Multifamily Low Rent Building in Saxman, Alaska. The building is a 7,600 sf facility containing 12 apartments, a laundry room, kitchen, and dining room. THRHA plans to add approximately 1,020 ft^2 to the building for storage space, a new entrance, and a new ADA bathroom. As part of this renovation, THRHA is seeking grant funding to allow a deep energy retrofit of the facility. The energy efficiency measures (EEMs) included in this deep energy retrofit would include: air sealing to 4 ACH, insulation of rim joist, floor cavity, and adding insulation to ceiling, a new heat recovery ventilation unit for planned makeup air for the corridor and common spaces, and installation of a low-temperature hydronic heating system and an air-to-water heat pump system. The facility underwent a weatherization in 2010, and these proposed steps would provide deep energy retrofit of the facility while improving indoor air quality and resident comfort.

The majority of the annual energy savings from this effort will come from the installation of the low temperature hydronic heating system and the air-to-water heat pump system. Currently, two fuel oil boilers provide space heating and hot water. While replacing the fuel oil boiler system in-kind is an option, THRHA is interested in replacing the system with an air source heat pump system that uses low temperature water distribution to supply a central domestic hot water system and low temperature heat emitters. Converting to such a system would reduce long term energy costs, increase the use of local energy sources, and decrease the carbon footprint of the building. Conversion to an air source heat pump would also convert the building to using a local, sustainable energy source, as Saxman is a special hydro community in Alaska.

Table 1.1-1 shows a summary of the energy usage projections for the renovated building with both heating options after considering the other energy efficiency upgrades. Converting the heating system for the renovated building from fuel oil to a hydroelectricity fed air-to-water heat pump will reduce the energy used onsite by over 45% by using the heat available from the temperate climate of Southeast Alaska. Alaska Housing Finance Corporation has developed a Site-Source factor for use in Southeast Alaska's special hydro communities of 1.5. This is an appropriate factor for this community's renewable source of electricity, and using this factor shows that the total source energy is reduced by 30%. DOE has prescribed a national Site-Source factor for electricity of 3.14. This factor is not appropriate for the Saxman community, and results in showing an increase in source energy used.

Table 1.1-1 – Annual Energy Use Reduction Onsite and Converted to Source Energy

Heating System	A-Fuel Oil Usage, gallons	B-Electricity Usage (heating), kWh	C-Electricity Usage (non-heating), kWh	D-Total Energy Use (Site), kBtu	E-Total Energy Use (1.5 Site-Source), kBtu	F-Total Energy Use (3.14 Site-Source), kBtu
Projected Energy Usage, Fuel Oil Boiler	4,058	1,690	68,200	802,527	927,400	1,318,482
Projected Energy Usage, ASHP	0	57,703	68,200	429,581	644,372	1,348,884
			Annual Savings	***46%***	***31%***	***-2%***

Note: Table presents the modeled annual heating demand after inclusion of the HRV unit to show the dramatic difference in the energy use onsite and when considering site to source factors. A site-to-source energy factor of 1.5 was used for electricity supplied by hydroelectric power. This factor is provided by the Alaska Housing Finance Corporation (AHFC). DOE conversion factors are used for all other energy sources, and the proposed DOE site-source factor is used in Column F for reference purposes. This factor is not appropriate for use in the Saxman community.

1.2 Applicant Description

Tlingit Haida Regional Housing Authority (THRHA) is a tribally designated housing authority aimed at providing affordable housing opportunities for Southeast Alaskans. Since 1973, the THRHA has been working to meet the affordable housing needs of native and non-native individuals and families in Southeast Alaska. THRHA offers a variety of services, such as temporary emergency housing, senior independent living, down-payment assistance, home repair, and project and home construction. The authority also provides home ownership and rent-to-own opportunities. In addition, THRHA owns and operates Fireweed Place, which is a 67-unit apartment building for senior citizens who can live independently. The authority administers the Rural Owner Occupied Loan Program, which provides financing to construct, purchase or renovate owner-occupied single-family residences and duplexes. It has several departments, including administration, fiscal, housing management, mortgage loans, tribal services, and development, construction and maintenance. The Tlingit-Haida Regional Housing Authority is headquartered in Juneau, Alaska but services communities all over Southeast Alaska.

THRHA's Low Rent Program is a home and apartment rental program. Homes and apartments in this program consist of 1 to 4 bedroom units of various sizes and layouts. At a minimum, to be eligible for this program at least one household member must be able to provide proof that they belong to a federally recognized tribe. The Low Rent Program is currently offered in the following communities: Angoon, Craig, Haines, Hoonah, Juneau, Kasaan, Klukwan, Saxman, and Wrangell.

To support its mission of providing affordable housing, the THRHA has implemented its Energy Cents Program. This program has completed 400 home energy assessments in order to gather household data and identify potential solutions to energy costs for residents. The THRHA is working to reduce its energy costs and carbon footprint through the use of clean renewable energy as well as improved home weatherization.

1.3 Project Goals

With the Saxman Low-Rent Multifamily Deep Energy Retrofit Project, THRHA plans to drastically reduce the energy usage at the facility, and to convert the heating system from non-renewable fuel oil to locally

sourced renewable hydroelectricity. By extracting heat from the environment as opposed to burning fuel oil, this project will meet the following of THRHA's energy goals:

- Increasing the overall energy efficiency of the facility
- Reducing long term operating costs
- Protecting the facility against the volatility of the fossil fuel market
- Increasing the use of local sustainable energy sources
- Decreasing the greenhouse gas emissions of the facility

1.4 Project Benefits

THRHA's Saxman Low-Rent Multifamily Deep Energy Retrofit Project will provide the following economic benefits:

- Reduce annual operating costs by $4,627 (~22%) even when assuming today's low fuel oil prices.
- Utilize local renewable energy source that has a history of stable pricing, which helps THRHA diversify away from volatile fuel oil. This provides annual heating budget certainty for THRHA.
- Switch from purchase of non-renewable fuel oil to locally sourced hydroelectricity for heating needs, keeping ~$6,000 dollars spent annually on heating within the local economy.
- Decrease the annual onsite GHG emissions of the heating system by 41 metric tons.

Along with the economic benefits of this project, replacing the fuel oil boilers would also provide the following environmental and social benefits:

- Reduce onsite emissions of greenhouse gases by 41 metric tons (GHGe) annually.
- Reduce onsite emissions of criteria pollutants including PM, NOx, and SOx by over 145 lbs annually.
- Eliminate the use of over 4,000 gallons of fuel oil annually, reducing the potential for spills in this fishing community.
- With electricity being supplied by local hydroelectric power generation in Saxman, this facility would be heated by renewable, sustainable, and clean energy.
- Provide an example for future THRHA buildings, and other building owners within the SE Alaska region.

1.5 Impact of Funding

This $448,049 deep energy retrofit would provide THRHA with a simple payback of approximately 35 years without any grant assistance given the current low fuel oil pricing used in the analysis. This is beyond the investment horizon of what THRHA would be willing to accept. However, with a 50% grant the cash flow for the project looks promising for THRHA. Attachment G includes a 25-year cash flow analysis showing the impact a 50% grant for the total Deep Energy Retrofit Table 1.5-1 provides a summary of the cash flow analysis.

Table 1.5-1 – Summary of Project Cash Flow Assuming 50% Grant Award

Project Cost with All EEMs	50% Grant Amount	25-year Net Present Value (4.5% Discount Rate)
$448,049	$224,025	$120,911

Notes: See Attachment G for detailed cash flow analysis.

2.0 PROJECT DESCRIPTION AND OUTCOMES

2.1 Detailed Project Description

THRHA plans to renovate, modernize, and expand the Saxman Multifamily Low Rent Building in Saxman, Alaska. THRHA's mission is to provide affordable housing to Southeast Alaskans. In keeping with this mission, THRHA is actively seeking to reduce the high energy costs experienced in many of its Southeast communities through implementation of deep energy retrofits and renewable energy projects. In the special hydro communities like Saxman, this effort includes converting heating systems from expensive fuel oil to affordable, locally sourced, renewable hydroelectricity.

The Multifamily Building in Saxman is a 7,600 sf facility containing 12 apartments, a laundry room, kitchen, and dining room. This building was built in 1982. THRHA has had a long-term lease for the land on which the building sits with the City of Saxman since 1977 (see Attachment I), and THRHA owns the building. Weatherization and insulation projects were completed in 2010, and Table 2-1 lists the current insulation levels and areas for the building.

Table 2.1-1: Saxman Building Insulation Values and Area of Building Components

Building Address	Item	Living Area Floors	Wall Section 1 House	Wall Section 2 Rim Joist	Exterior Doors	Windows	Ceiling
2708 Halibut Street	R-Value	48.3	11.3	18.4	5.0	2.0	54.4
	Area, ft^2	7,425	3,360	7,425	80	688	7,425

The building is currently heated by two Weil McLain WGO-6 oil boilers (212,000 Btu/hr rated output each). These boilers are coupled with a high temperature (180°F) hydronic distribution system, finned tube hydronic baseboard in each of the 12 residences and the common lunch room, and hydronic panel heaters in the main corridor. Domestic hot water is provided by an Amtrol indirect hot water heater fed from the oil boilers.

THRHA is planning the addition of 1,020 sf of space for a new vestibule, laundry room, and storage space for the residents. While this renovation is ongoing, THRHA would like to complete a deep energy retrofit for the building. THRHA recently identified energy efficiency opportunities through an energy audit, assessment, and alternative energy study completed through DOE's funding opportunity DE-0005179. This effort identified the following opportunities for improved energy efficiency and resident comfort:

- Air sealing to 4 ACH
- Insulation of Rim Joist on above grade walls
- Add more insulation to ceiling and floor
- Heat Recovery Ventilation Unit for common spaces
- Conversion of heating for DHW to air-water heat pump using locally source, renewable hydroelectricity
- Conversion of heating for space heating to air-water heat pump using locally source, renewable hydroelectricity

The following previous efforts have been conducted to evaluate the potential of this deep energy retrofit project, and these are provided in Attachment E.

- DE-0005179 – Energy Efficiency Audit, Assessment, and Alternative Energy Study
  - Energy audit and assessment using AKWarm by Marquam George, LLC
  - Heating Conversion Analysis for Saxman Multifamily Low Rent Housing by Alaska Energy Engineers, LLC

2.2 Technical Viability

The energy audit and subsequent system evaluations were funded by DOE under the DE-0005179 funding opportunity. These efforts identified the opportunity for the proposed project, and the report summarizing these efforts is provided in Attachment E. Table 2.2-1 provides a summary of the energy efficiency measures evaluated as part of this effort. This table includes consideration of an air-water heat pump for providing DHW for the facility. This study identified the addition of a Heat Recovery Ventilation Unit to provide planned air exchange for the common spaces within the building to improve indoor air quality and occupant comfort. Each of the options listed in Table 2.2-1 are typical energy retrofit EEMs that are technically viable, and there are local contractors capable of completing this work. The materials and equipment for EEMs 1,3,4, and 5 are insulation as identified, and weatherizing materials for air sealing.

Table 2.2-1 Energy Efficiency Measures

Energy Efficiency Measure	Estimated Total Savings	Estimated Total Cost	Simple Payback, Years	SIR
1-Air Sealing to 4 ACH	$207	$500	2.4	3.8
2-Air to Water Heat Pump (for DHW only)	$1,333	$10,000	7.5	2
3-Insulate Rim Joist with R-14 on Above Grade Wall	$32	$699	21.8	1.1
4-Add R-19 Blown in Insulation to Exposed Floor 2x12 Cavity	$174	$7,128	41.0	0.6
5-Add R-12 Insulation to Attic Space	$100	$4,722	47.2	0.5
Totals	**$1,846**	**$23,049**	**12.5**	

Notes: *1 – Costs and savings values for air sealing and insulation are estimated using the AkWarm software from the 3/30/2015 library.*
2 – Costs and savings for an air to water heat pump are estimated by WES Energy & Environment and assume 90% offset of fuel oil use for domestic hot water.

The full conversion of the heating system to a low-temperature hydronic system served by an air-to-water heat pump was identified as an opportunity and further analyzed through the DE-0005179 program. The attached Heating Conversion Analysis (in Attachment E) evaluates this option in detail. This option includes not only covering the building's DHW needs as shown EEM 2, but also the space heating needs. The analysis for that option modeled the building's energy usage with the planned renovation and including the Energy Efficiency Measures 1, 3, 4, 5, and the added Heat Recovery Ventilation Unit.

Table 2.2-2 summarizes the monthly average demands from this model, and Figure 2.2-1 shows the modeled daily average heating demand. Figure 2.2-2 shows the modeled annual coverage by the air source heat pump. Table 2.3-1 in the next section summarizes the annual energy use reduction, both onsite and at the source associated with the air-to-water heat pump and low temperature hydronic system.

Table 2.2-2 – Modeled Monthly Heating Demand for Facility with EEMs 1,3,4,5

Month	Monthly Heating Demand, kBtu	Average Heating Demand, Btu/hr
January	59,035	79,348
February	44,746	66,586
March	41,822	56,212
April	29,320	40,722
May	22,060	29,651
June	18,821	26,140
July	18,667	25,090
August	18,559	24,945
September	22,284	30,950
October	34,116	45,855
November	41,903	58,199
December	53,345	71,700

Air source heat pump technology has improved in the last five years to the point that they are an excellent match for the relatively temperate climate of Southeast Alaska where renewable hydroelectricity is available. Table 2.2-3 shows the coefficient of performance (COP) range for air source heat pumps at the monthly average temperatures for Ketchikan, AK, which is immediately adjacent to Saxman, AK. The air source heat pump for this project will work in conjunction with water kit that includes two indoor heat exchangers. For the purpose of this effort, the Multi V IV Heat Pump, model no. ARUN072BTE4, and the Multi V Hydro Kit, model no. ARNH963K2A2, manufactured by LG have been selected. Attachment F includes the manuals for this equipment. Standard parts warranties for these products are 1 year from the installation or 24 months from the date of manufacture. An additional 5 year warranty applies to the compressor. The design contractor may choose a different manufacturer for the air source heat pump system.

Table 2.2-3: COP Range at Average Monthly Temperatures

Month	Average Temperature, °F	Air Source Heat Pump COP
Jan	34	1.9
Feb	36	2.0
Mar	38	2.1
Apr	41	2.3
May	47	2.7
Jun	50	3.0
Jul	55	3.3
Aug	56	3.4
Sep	53	3.2
Oct	45	2.6
Nov	40	2.2
Dec	33	1.9
		2.33

Note: Average monthly temperatures for Ketchikan, AK are obtained from USClimateData.com for the 30-yr period spanning 1981-2010. COP data is taken from LG ThermaV Air-to-Water Heat Pump performance data, and will vary by manufacturer and model.

This low-temperature hydronic system and air-to-water heat pump system is a very technically viable option, and local designers and installers are available to complete the work. THRHA has installed a similar system for DHW heating for the Saxman Senior Center. The difference between these two systems is that this one would be coupled with a low temperature hydronic system to capture the building's space heating demand as well.

This portion of the deep energy retrofit provides the vast majority of the cost and energy savings for the facility. The design demand for peak loads is modeled at 100,000 Btu per hour for space heating and 50,000 Btu per hour for domestic hot water. The air source heat pump and electric buffer tank system is designed to meet this total peak demand of 150,000 Btu per hour. It should be noted that these peak loads rarely occur simultaneously and demand for hot water can be mitigated by the hot water tank. The air source heat pump is sized at 78% of the space heating design demand and is expected to supply 95% of the total annual heating demand. The electric heated buffer tank will serve as a backup heating source and also cover peak loads when necessary.

The project would be procured as a design-bid-build project, and this process would be managed and overseen by THRHA staff. There are several barriers/challenges to this deep energy retrofit that surround the largest energy savings option, which is the low-temperature hydronic system and the air-to-water heat pump. The following lists each, and how THRHA is addressing these.

- The heat pump needs access to three-phase power, and THRHA has obtained a cost estimate from the local utility for bringing this into the site. This also puts the facility into a new rate

class, which slightly increases the cost of electricity for all use at the facility, and thus this needed to be accounted for in the annual savings estimates.

- There are few low-temperature hydronic systems installed by designers and mechanical contractors. These are not difficult to design or install, but take a shift in focus from the routine practices in the industry. THRHA will ensure the designer is familiar with low temperature hydronic systems, that heat emitters are properly sized, and that the operating temperatures allow for the system match the outputs of the heat pump.
- There are several locally installed air-to-water heat pumps for providing DHW needs, but no known local systems using air-to-water heat pumps for building heating. This is not particularly challenging, but THRHA will need to ensure the designer and installer have the experience needed to properly design and install the system.

THRHA onsite staff will maintain the equipment. THRHA onsite staff have experience with operating and maintaining the EEMs identified, including an air-to-water heat pump for DHW production at the nearby Saxman Senior Center. The staff are also familiar with operating and maintaining hydronic heating systems. THRHA does not envision an outside service contract other than occasional servicing of the outdoor heat pump unit.

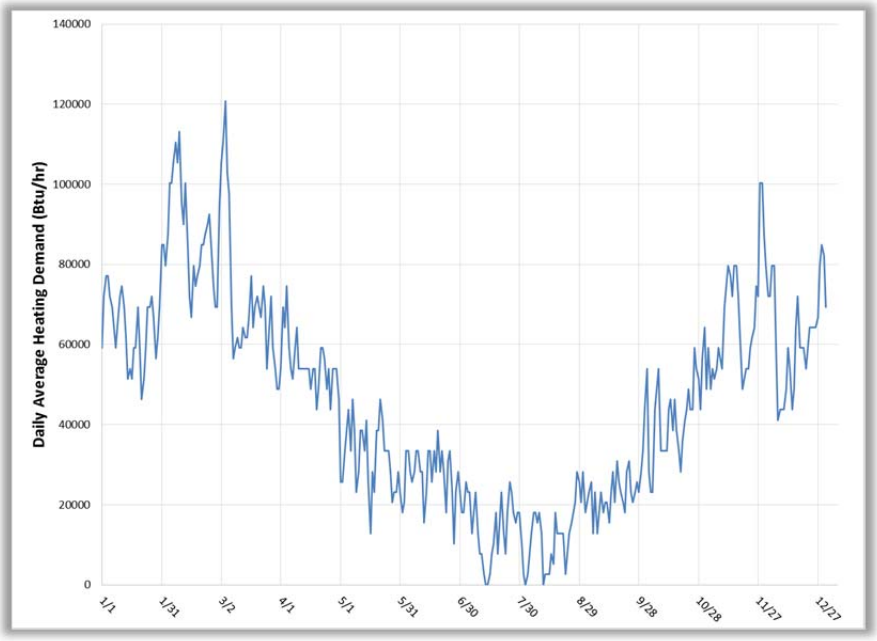


Figure2.2-1: Daily Average Heating Demand

Note: Values shown are daily average demand. During the course of 24 hours, actual demand will fluctuate above and below values shown in this figure.

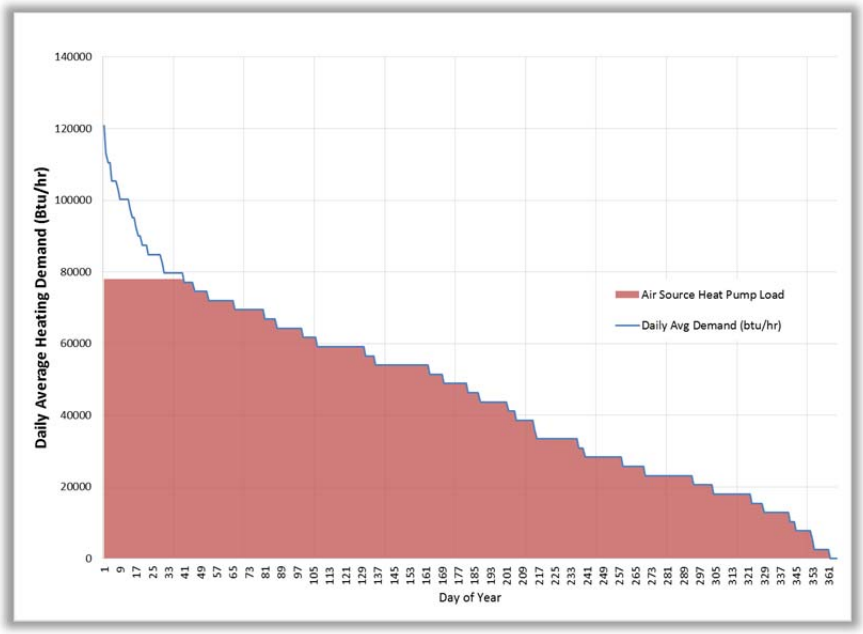


Figure 2.2-2: Load Demand Curve

Note: Values shown are daily average demand. During the course of 24 hours, actual demand will fluctuate above and below values shown in this figure.

2.3 Economic Viability

2.3.1 Current Energy Costs - Table 2.3-1 provides a summary of the annual heating fuel and electric demands for 2014. The full year of bills for oil and electricity for the facility are provided in Attachment D. These demands are for the existing building, and are not representative of the annual demands for the renovated building. These are included for reference by the reviewers to see current building costs. Table 2.3-2 shows the modeled energy demand of the expanded and renovated building, including implementation of EEM's 1,3,4,5 and addition of the Heat Recovery Ventilation Unit. This table then shows the annual energy costs with implementation of the low temperature hydronic system and air-to-water heat pump.

Table 2.3-1 – Existing Building Energy Usage and Cost for in 2014

Source	Consumption	Unit	Unit Cost	Annual Cost	Energy Use Onsite, mmBtu
Electricity	68,200	kWh	$0.091	$6,227	233
Fuel Oil	3,698	Gallons	$3.74	$13,829	512
Total	**-**	**-**	**-**	***$20,056***	***723***

Note: These usage and cost values are taken from THRHA records from calendar year 2014. These values are provided for reference. Annual savings are based on Table 2.3-2 and 2.3-5. Energy use values are onsite usage calculated using 0.003412 mmBtu/kWh and 0.1385 mmBtu/gallon.

Table 2.3-2 – Renovated Building (with EEMs) Energy and Cost Savings with and without ASHP EEM

Heating System	Fuel Oil Usage, gallons	Electricity Usage (heating), kWh	Electricity Usage (non-heating), kWh	Annual Cost	Annual Energy Use Onsite, mmBtu
Projected Energy Usage, Fuel Oil Boiler	4,058	1,690	68,200	$19,285	800
Projected Energy Usage, ASHP	0	57,703	68,200	$14,101	430
			Annual Savings	**$5,184**	**371**

Note: These usage and values are from the model of the building energy usage based on the renovation and implementation of EEMs 1,3,4,5 and the Heat Recovery Ventilation Unit. The fuel oil and electric costs are based on the latest bills for 2015, and are 3.03/gallon fuel oil and $0.10/kWh. A cost of $0.112/kWh for electricity is used for the ASHP option since there will be an increase of $0.012/kWh when the whole building is shifted to 3-phase. Energy use values are onsite usage calculated using 0.003412 mmBtu/kWh and 0.1385 mmBtu/gallon.

2.3.2 Total Installed Cost - The total installed cost of the EEMs is provided in Table 2.3-3.

Table 2.3-3 – Estimate Cost of Energy Efficiency Measures

Item	Cost	Source
1-Air Sealing to 4 ACH	$500	DE-0005179 report
3-Insulate Rim Joist with R-14 on Above Grade Wall	$699	DE-0005179 report
4-Add R-19 Blown in Insulation to Exposed Floor 2x12 Cavity	$7,128	DE-0005179 report
5-Add R-12 Insulation to Attic Space	$4,722	DE-0005179 report
Heat Recovery Ventilation Unit	$50,000	DE-0005179 report
Low-temp hydronic system and ASHP	$385,000	DE-0005179 Heating Conversion Analysis
Total	**$448,049**	

2.3.3 Installed Cost Per Unit Energy Saved - Table 2.3-4 shows the energy savings using the DOE provided conversion factors with one exception. A value of 1.5 is used for electricity instead of the 3.14 value provided by DOE. The reason for this is that Saxman is a special hydro community in Alaska. Thus, the energy is from renewable and local hydroelectricity, and the 3.14 factor does not make sense for this project. Using the Total Energy Use savings from Column E, the Installed Cost per kBtu saved is $1.58. For comparison purposes, the total source energy use change is identified in Column F when the DOE national site-source value of 3.14 is used for electricity for this project.

Table 2.3-4 – Annual Energy Savings Converted to Source Energy Savings

Heating System	A-Fuel Oil Usage, gallons	B-Electricity Usage (heating), kWh	C-Electricity Usage (non-heating), kWh	D-Total Energy Use (Site), kBtu	E-Total Energy Use (1.5 Site-Source), kBtu	F-Total Energy Use (3.14 Site-Source), kBtu
Projected Energy Usage, Fuel Oil Boiler	4,058	1,690	68,200	802,527	927,400	1,318,482
Projected Energy Usage, ASHP	0	57,703	68,200	429,581	644,372	1,348,884
			Annual Savings	***46%***	***31%***	***-2%***

Notes: Energy use values in this table are calculated using the DOE default energy values and site to source conversion factors with one exception. Column E uses a site to source conversion factor of 1.5, which is a value developed by the Alaska Housing Finance Corporation for the Special Hydro Communities in Alaska. This is an appropriate value for this project. The impact of using the DOE site to source conversion factor of 3.14 is shown in Column F.

2.3.4 Life of EEMs - The life of the EEMs identified in this report is 25 years with the exception of two of them. The Heat Recovery Ventilation Unit and the outdoor unit for the air source heat pump are expected to be replaced by year 15 of operation or once within the first 25 years.

2.3.5 Payback Period and Cash Flow Analysis - The payback of the system is calculated using energy savings and avoided costs associated with the investments, and is presented in Table 2.3-5. With no grant funding, the total payback on the EEMs is approximately 35 years with the temporarily low fuel oil pricing used for the analysis. This is beyond the investment horizon of what THRHA would be willing to accept. However, with a 50% grant the cash flow for the project looks promising for THRHA. Attachment G includes a 25-year cash flow analysis showing the impact a 50% grant for the total Deep Energy Retrofit Table 2.3-6 provides a summary of the cash flow analysis.

Table 2.3-5 – Simple Payback of EEMs with NO GRANT ASSISTANCE

Item	Cost	Present Value of Avoided Cost	Avoided Cost Year	Annual Energy Savings	Increased O&M	Simple Payback Assuming No Grant Assistance
1-Air Sealing to 4 ACH	$500	$0	-	$207	$0	2
3-Insulate Rim Joist with R-14 on Above Grade Wall	$699	$0	-	$32	$0	22
4-Add R-19 Blown in Insulation to Exposed Floor 2x12 Cavity	$7,128	$0	-	$174	$0	41
5-Add R-12 Insulation to Attic Space	$4,722	$0	-	$100	$0	47
Heat Recovery Ventilation Unit	$50,000	$45,000	0	$500	$100	13
Low-temp hydronic system and ASHP	$385,000	$239,000	5	$5,184	$1,470	39
Total	**$448,049**	**$284,000**		**$6,197**	**$1,570**	**35**

Notes: Simple payback assuming no grant funding is calculated by taking the total estimated project costs, subtracting out the present value of the avoided costs, and dividing this by the annual energy savings with increased annual O&M subtracted.

Table 2.3-6 – Summary of Project Cash Flow Assuming 50% Grant Award

Project Cost with All EEMs	50% Grant Amount	25-year Net Present Value (4.5% Discount Rate)
$448,049	$224,025	$120,911

With a 50% grant, the project has an attractive net present value for THRHA of $120,911 using the assumptions as identified in the attached cash flow sheet (see Attachment G). Further, the project would allow THRHA to reduce annual operating costs for the Multifamily Low Rent building at Saxman, which helps secure THRHA's ability to provide continued services to Southeast Alaska's low income residents. This also helps diversify THRHA away from the volatile fuel oil market. The fuel oil price used for this analysis is $3.03/gallon. Just 1 year ago, this price averaged $3.74/gallon. This would show an annual savings that is 24% higher for this project. THRHA is dependent on fuel oil heating in many of its facilities, and these swings in annual budget are difficult to absorb from year to year. Locally-sourced hyrdorelectricity has much more stable annual pricing that the fuel oil market. Further, diversifying the heating energy sources across THRHA's building fleet helps to ensure a more stable overall annual budget for heating.

2.3.6 Sources of Financing – The majority of THRHA's matching funds for this project would come from THRHA's IHBG NAHASDA funding allocation, and the remaining amount will come from THRHA's capital budget. THRHA has adequate funding available to complete this project with a grant award of 50% of the total project costs.

2.4 Outcomes

2.4.1 Amount of energy saved as a result of the proposed project - The direct onsite energy reduction would be approximately 46%, and the Total Source Energy Savings would be approximately 31% or 283,028 kBtu. Note that this value is calculated using a the Site-to-Source factor of 1.5 as discussed in this section and in the notes for Table 2.4.1. Table 2.4-1 shows the energy savings using the DOE provided conversion factors with one exception. A value of 1.5 is used for electricity instead of the 3.14 value provided by DOE. The reason for this is that Saxman is a special hydro community in Alaska. Thus, the energy is from renewable and local hydroelectricity, and the 3.14 factor does not make sense for this project.

Table 2.4-1 – Annual Energy Savings Converted to Source Energy Savings

Heating System	A-Fuel Oil Usage, gallons	B-Electricity Usage (heating), kWh	C-Electricity Usage (non-heating), kWh	D-Total Energy Use (Site), kBtu	E-Total Energy Use (1.5 Site-Source), kBtu	F-Total Energy Use (3.14 Site-Source), kBtu
Projected Energy Usage, Fuel Oil Boiler	4,058	1,690	68,200	802,527	927,400	1,318,482
Projected Energy Usage, ASHP	0	57,703	68,200	429,581	644,372	1,348,884
			Annual Savings	***46%***	***31%***	***-2%***

Notes: Energy use values in this table are calculated using the DOE default energy values and site to source conversion factors with one exception. Column E uses a site to source conversion factor of 1.5, which is a value developed by the Alaska Housing Finance Corporation for the Special Hydro Communities in Alaska. This is an appropriate value for this project. The impact of using the DOE site to source conversion factor of 3.14 is shown in Column F.

2.4.2 Economic Benefits – Implementation of the EEMs at the Saxman Low Rent Multifamily facility would provide projected operational savings of $172,296 over a 25-year period, and this is equivalent to $99,520 in present value savings using discount rate of 4.5%. Factoring in a 50% grant for upfront costs and avoided costs, the project will provide a projected 25-yr Net Present Value of $120,911. These savings are calculated based on a current price of $3.03/gallon for fuel oil, and assuming that local hydroelectric energy and fuel oil increase in cost at the same rate. Just one year ago, 2014, the average fuel oil price was $3.74, which would showing an increase in project savings of approximately 24% over what is shown in this analysis. The annual savings would allow THRHA to reduce annual operating costs for the Multifamily Low Rent building at Saxman, which helps secure THRHA's ability to provide continued services to Southeast Alaska's low income residents. The project would also provide the following additional economic benefits:

- Decrease THRHA's building fleet's dependence on the volatile fuel oil market by over 4,000 gallons per year, providing diversity of heating energy sources and reducing budget fluctuations
- Provide temporary creation of ~4.9 FTEs during project construction ($92,000/FTE assumed)
- Support of the local economy and local jobs through the purchase of over $6,000 in locally produced hydroelectric power.

2.4.3 Environmental Benefits – Along with the economic benefits of this project, replacing the fuel oil boilers would also provide the following environmental benefits:

- Reduce onsite emissions of greenhouse gases by 41 metric tons (GHGe) annually.

- Reduce onsite emissions of criteria pollutants including PM, NOx, and SOx by over 145 lbs annually.
- Eliminate the use of over 4,000 gallons of fuel oil annually, reducing the potential for spills in this fishing community.
- With electricity being supplied by local hydroelectric power generation in Saxman, this facility would be heated by renewable, sustainable, and clean energy.

2.4.4 Other Outcomes – The project could serve as a model for future THRHA building projects, as well as other building owners in Southeast Alaska. The project furthers THRHA's goal of investing in energy efficiency and renewable and sustainable energy technologies that will also reduce annual operating costs. This allows THRHA to be a good environmental steward while focusing annual budget dollars on its mission of providing affordable housing for Southeast Alaska residents. The largest savings from this project come from use of an air-to-water heat pump and low temperature hydronic heating system. The climate of coastal Alaska is very favorable to the use of air source heat pumps, and a successful installation and operation of an air-to-water heat pump at this facility would help promote this use of air source heat pump technology as a clean alternative to expensive fossil fuels in the region for building retrofits and new construction.

3.0 ROLES, RESPONSIBILITIES, CAPABILITIES, AND COMMITMENT

3.1 Business and Technical Contact

The Saxman Low-Rent Multifamily Project will have a business contact and a technical contact. The business contact will be Joanne Wiita, Planning and Grants Administration. The technical contact will be Craig Moore, VP of Development and Construction Management.

Technical Contact:
Craig Moore
VP Development & Construction Management
PO Box 32237
Juneau, AK 99803
Phone: 907-780-6868
Fax: 907-780-6895
Email: cmoore@thrha.org

Business Contact:
Irene Tupou
Finance Manager
PO Box 32237
Juneau, AK 99803
Phone: 907-780-6868
Fax: 907-780-6895
Email: itupou@thrha.org

3.2 Project Management Approach

THRHA staff would be in charge of completing the project, and Craig Moore, VP of THRHA would be the manager of the project. Mr. Moore and his team have extensive experience in selecting and managing engineering and construction contractors for weatherization, energy efficiency, and energy system design and installation at a wide variety of housing facilities. This experience includes the similar Kake Low-Rent building, which recently underwent a similar renovation and deep energy retrofit while using a biomass renewable energy system to provide heating needs. THRHA also has experience managing the design, installation, and operation of air source heat pumps, including an installation at the nearby Saxman Senior Center where an air-to-water heat pump is used for providing domestic hot water.

This project would be procured as a design-bid-build project. Mr. Moore's team has extensive experience in managing building system and energy projects in this manner. Mr. Moore's team would scope out the project, and procure the design and construction team using THRHA's well established

procurement procedures. Mr. Moore's team has the hands on experience to provide their own oversight/review of the design and construction oversight.

Mr. Moore and his team are also proficient in project communications, community outreach, and recording of project activities and progress. During the course of the project, regular update meetings or teleconferences will be held with contractors. Meeting notes will be recorded for the project file. THRHA will track and monitor the established budget versus actual expenditures by line item. The Team has a wealth of experience in working with contractors and the community. Before work begins Mr. Moore will conduct a coordination meeting to include all key partners and community. Forecasted meetings and reports will include; project coordination meeting, design review, notice of Intent to construct, teleconferences and reporting by the contractor, project commissioning and close out. Mr. Moore has demonstrated experience in meeting the reporting and communications requirements for a wide variety of grant funding agencies, including DOE.

The project roles, background, and expertise of the individuals who would be involved in managing and then operating and maintaining the project are discussed in the following paragraphs.

Mr. Moore is responsible for THRHA Development and Construction Management (resume attached), and will be the Project Manager for the design and construction. He works closely with Robert Reimer, THRHA's Maintenance Manager. Robert is responsible for operations and maintenance of 600 THRHA housing units including multi-family buildings throughout the southeast region of Alaska. Robert has been with THRHA for five years and prior he was with the Days Inn for six years as property manager where he was responsible for $24M of property assets. Robert manages THRHA's 20 onsite field representatives. THRHA field representatives are responsible for repairing and maintaining all THRHA properties which include: inspections, reports, estimating, purchasing, record-keeping, scheduling, computer data entry and all aspects of maintenance including plumbing, heating/ventilation, electrical, and carpentry. Field reps have received formal HVAC training and have advanced certifications.

Local field representative Eric Trout has extensive facility operation experience, including for the air-to-water heat pump at Saxman Senior Center, and the existing hydronic heating system at the Saxman Low-Rent building.

THRHA manages an annual budget of $12 million and employs over 40 technical and administrative personnel. The VP of Administration, Joyce Niven, will lead fiscal management on this project. (resume attached) Ms. Niven has worked in the accounting field for over 20 years and for the past 12 years, she has been employed by THRHA. She has a Bachelor's of Science degree in business and finance from Western Washington University, Bellingham, Washington. Under the leadership of Ms. Niven, THRHA has successfully closed over five new construction project accounts and during the past three years. Two of these projects were closed with multiple funding sources.

Ms. Niven, will provide oversight to the project and grant accounting. She will supervise Finance Manager Irene Tupou who is responsible for all accounting functions including grant accounting that is performed by her staff. Ms. Tupou is a member of THRHA management, and she coordinates all aspects of project implementation with her senior colleagues at THRHA to ensure that THRHA complies, and maintains reporting on time and within budget. (resume attached)

Bookkeeping functions are performed in-house using Emphasys Systems Elite, to manage fund accounting that meets Federal requirements. Ms. Tupou is responsible for all accounting functions including grant accounting that is performed by her staff. Ms. Tupou has experience managing grant funds from a variety of sources, including DOE, and ensures that no expenses that are unallowable will be requested for reimbursement.

THRHA financial management and internal controls provide assurance that project goals and objectives will be met and funds will be used efficiently. To provide checks and fiscal oversight, THRHA's internal financial controls and policy separate duties into three financial functions (authorizing transactions, keeping records, and handling funds). Program funds are tracked in separate grant accounts with a project code allocated to each. Upon award of funding THRHA conducts a grant implementation meeting and review newly established codes for associated expenses. Only allowable expenses are coded and paid out of grant funds, the expenses are approved by the Project Manager and monthly grant meetings are held among the finance staff, project manager, and grant administrator to ensure all expenses are allowable and coded properly according to the approved budget. THRHA also tracks grant in-kind and match including labor and expenses that are not allowable as grant reimbursement. In addition, THRHA conducts an annual external financial audit.

3.3 Level of Commitment to Project

The THRHA manages a suite of facilities in Southeastern Alaska that provide affordable housing opportunities for native and non-native residents and their families. Additionally, THRHA is involved in providing a wide variety of funding, construction, and technical services to low income residents and properties. This project provides the opportunity to demonstrate how buildings in Southeastern Alaska can utilize deep energy retrofits including air-to-water heat pumps for space heating as well as domestic hot water to offset the use of oil. This project utilizes the Southeastern Alaskan climate and new proven, but not widely adopted, technologies to reduce annual heating energy demands and costs by 1.5-3 times over typical fuel oil and electric resistance systems. These projects have the potential to dramatically reduce energy demand over time as building owners and local installers become familiar with them.

This project and THRHA's footprint in the building community in Southeastern Alaska provide the opportunity to showcase the real costs, energy performance, and benefits of this technology and application. This project also provides the opportunity to identify the challenges associated with implementing this type of project, such as needing/evaluating low-temperature hydronic heating systems, ensuring appropriate electrical service, and identifying the appropriate equipment and sizing of that equipment. THRHA hopes to show the benefits and challenges, and how the challenges can be addressed and overcome.

THRHA would hope to replicate this type of project at other buildings it owns in Southeastern Alaska, and would hope that others can use this same information to determine whether they are able to make the same move away from oil and to low temperature hydronic systems combined with air-to-water heat pumps for new construction or building renovations. The recent drop in oil prices may lead to complacency in addressing future energy issues. By promoting deep energy retrofits and heat pump technology and demonstrating success now, the THRHA can make positive steps toward improving energy efficiency and lowering long-term energy costs.

The THRHA is fully committed to its mission of providing sustainable housing options for Southeastern Alaskans. This project would reduce the annual cost to operate the facility at Saxman, and would provide a demonstration that this type of deep energy retrofit project is viable in SE Alaska's hydro communities. THRHA is fully committed to providing the matching funding required for this project to proceed, as is described in the letter of commitment provided. The full amount of $224,025 would come from THRHA's IHBG funding allocation and THRHA's capital budget.

The Central Council Tlingit Haida Indian Tribes of Alaska is the Federally recognized tribe for SE Alaska, representing over 26,000 enrolled tribal members. The CCTHITA supports this project, stating "This is the right thing to do in a hydroelectric community like Saxman. It will help assure that THRHA can continue to provide affordable housing in Saxman, and will demonstrate that clean, renewable, "green" energy solutions are available and a viable alternative to fossil fuels in our region." It should also be noted that the City of Saxman, the Organized Villiage of Saxman, and Ketchikan Public Utilities are all supportive of this project.

4.0 ATTACHMENTS LIST

- Attachment A – Work Plan
- Attachment B – Site and Resource Maps and Graphics File
    - Location Map
    - Building Floor Plan
- Attachment C – Energy Savings Calculations
- Attachment D – Energy Use Data
    - 2014 Oil Deliveries
    - 2014 Electric Bills
- Attachment E – Energy Audits or Assessments for Deep Energy Retrofits
    - DE-0005179 – Energy Efficiency Audit, Assessment, and Alternative Energy Study
        - Excerpt from overall report summarizing Energy audit and assessment using AKWarm by Marquam George, LLC
        - Heating Conversion Analysis for Saxman Multifamily Low Rent Housing by Alaska Energy Engineers, LLC
- Attachment F – Design and Engineering
    - Heat pump equipment and water kit cut sheets
    - Heat pump system warranty
- Attachment G – Economics
    - 25-yr cash flow analysis with key assumptions
- Attachment H – Statement of Commitment and Cost Sharing
    - Central Council Tlingit Haida Indian Tribes of Alaska Project Support
    - Authorization for Application
    - Statement of Commitment and Cost Sharing
- Attachment I – Agreements
    - Long-term lease from Saxman for building land
- Attachment J – Subcontract Plan
- Attachment K – Resumes
    - Craig Moore – VP Development and Construction Management

- Joyce Niven – VP Administration
- Irene Tupou – Finance Manager

Attachment A

Work Plan

Regional Housing Authority

Work Plan

Saxman Low-Rent Multifamily Deep Energy Retrofit Project

1.0 Project Objectives

With the Saxman Low-Rent Multifamily Deep Energy Retrofit Project, THRHA plans to drastically reduce the energy usage at the facility through implementing multiple EEMs, the largest of which is a conversion of the heating system from non-renewable fuel oil and high temperature heat emitters to a low temperature hydronic system heated by an air-to-water heat pump fueled by locally sourced renewable hydroelectricity. The following are THRHA's objectives for the project:

- Increasing the overall energy efficiency of the facility
- Reducing long term operating costs
- Protecting the facility against the volatility of the fossil fuel market
- Increasing the use of local sustainable energy sources
- Decreasing the greenhouse gas emissions of the facility

2.0 Project Summary

Tlingit Haida Regional Housing Authority (THRHA) plans to renovate and expand the Saxman Multifamily Low Rent Building in Saxman, Alaska. The building is a 7,600 sf facility containing 12 apartments, a laundry room, kitchen, and dining room, and THRHA plans to add approximately 1,020 ft^2 to the building for storage space, a new entrance, and a new ADA bathroom. As part of this renovation, THRHA is seeking grant funding to allow a deep energy retrofit of the facility. The energy efficiency measures (EEMs) included in this deep energy retrofit would include: air sealing to 4 ACH, insulate rim joist, floor cavity, and adding insulation to ceiling, a new heat recovery ventilation unit for planned makeup air for the corridor and common spaces, and installation of a low-temperature hydronic heating system and an air-to-water heat pump system. The facility underwent a weatherization in 2010, and these proposed steps would provide deep energy retrofit of the facility while improving indoor air quality and resident comfort.

3.0 Work Breakdown Structure (WBS) and Task Descriptions

The project is to be procured as a design-build project. THRHA is responsible for implementing the project, and will procure the services of a contractor to design and install the EEMs. The following table identifies the key milestones and tasks for the project.

Design and Permitting Phase			
Milestone	**Tasks**	**Start Date (Months from Project Start)**	**Responsible Party / Verification**
1-Project Scoping / Contractor Solicitation	Issue design RFP and select contractor	0.0	THRHA
2-Final System Design / Permitting	Final design / construction documents and submit application / obtain building permit	1.0	THRHA Contractor / THRHA Oversight
3-Final Cost Estimate / Updated Financials	Finalize construction cost estimate and financial analysis	2.0	THRHA Contractor / THRHA Oversight
4-Overall Review / Proceed to Construction	Review documents, approve, and move to Construction Phase	2.5	THRHA
Construction Phase			
Milestone	**Tasks**	**Start Date (Months from Project Start)**	**Responsible Party / Verification**
5-Develop Bid Documents	Use design documents, put together solicitation	3.0	THRHA
6-Vendor Selection and Award	Run bid process, select contractor(s), negotiate / sign contract	3.5	THRHA
7-Construction	Construction and construction management and oversight by THRHA	4.5	THRHA Contractor / THRHA Oversight
8-Integration and Testing	Testing and balancing, prepare for change over	9.5	THRHA Contractor / THRHA Oversight
9-Change Over / Decommissioning of Old System	Change over and remove extraneous equipment	10.0	THRHA Contractor / THRHA Oversight
10-Commissioning and Final Acceptance	Commissioning, final punch list, and acceptance of project as complete	10.5	THRHA Contractor / THRHA Oversight
11-Operations Monitoring and Reporting	Ongoing monitoring and reporting	11.0	THRHA

4.0 Project Management

THRHA staff would be in charge of completing the project, and Craig Moore, VP of THRHA would the manager of the project. Mr. Moore and his team have extensive experience in selecting and managing engineering and construction contractors for weatherization, energy efficiency, and energy system design and installation at a wide variety of housing facilities. This experience includes the similar Kake Low-Rent building, which recently underwent a similar renovation and deep energy retrofit while using a biomass renewable energy system to provide heating needs. The THRHA also has experience managing the design, installation, and operation of air source heat pumps, including an installation at the nearby Saxman Senior Center where an air-to-water heat pump is used for providing domestic hot water.

This project would be procured as a design-bid-build project. Mr. Moore's team has extensive experience in managing building system and energy projects in this manner. Mr. Moore's team would scope out the project, and procure the design and construction team using THRHA's well established procurement procedures. Mr. Moore's team has the hands on experience to provide their own oversight/review of the design and construction oversight. Project risk will be managed through THRHA's oversight of the project contractors, deliverables, budget, construction and commissioning. Any necessary project changes will be managed through the design consultant's approval and the construction contract document requirements. It is anticipated that an AIA construction contract would be used.

Mr. Moore and his team are also proficient in project communications, community outreach, and recording of project activities and progress. During the course of the project, regular update meetings or teleconferences will be held with contractors. Meeting notes will be recorded for the project file. THRHA will track and monitor the established budget versus actual expenditures by line item. The Team has a wealth of experience in working with contractors and the community. Before work begins Mr. Moore will conduct a coordination meeting to include all key partners and community. Forecasted meetings and reports will include; project coordination meeting, design review, notice of Intent to construct, teleconferences and reporting by the contractor, project commissioning and close out. Mr. Moore has demonstrated experience in meeting the reporting and communications requirements for a wide variety of grant funding agencies, including DOE.

The project roles, background, and expertise of the individuals who would be involved in managing and then operating and maintaining the project are discussed in the following paragraphs.

Mr. Moore is responsible for THRHA Development and Construction Management, and will be the Project Manager for the design and construction. He works closely with Robert Reimer, THRHA's Maintenance Manager. Robert is responsible for operations and maintenance of 600 THRHA housing units including multi-family buildings throughout the southeast region of Alaska. Robert has been with THRHA for five years and prior he was with the Days Inn for six years as property manager where he was responsible for $24M of property assets. Robert manages THRHA's 20 onsite field representatives. THRHA field representatives are responsible for repairing and maintaining all THRHA properties which include: inspections, reports, estimating, purchasing, record-keeping, scheduling, computer data entry and all aspects of maintenance including plumbing, heating/ventilation, electrical, and carpentry. Field reps have received formal HVAC training and have advanced certifications.

Local field representative Eric Trout has extensive facility operation experience, including for the air-to-water heat pump at Saxman Senior Center, and the existing hydronic heating system at the Saxman Low-Rent building.

THRHA manages an annual budget of $12 million and employs over 40 technical and administrative personnel. The VP of Administration, Joyce Niven, will lead fiscal management on this project. Ms. Niven has worked in the accounting field for over 20 years and for the past 12 years, she has been employed by THRHA. She has a Bachelor's of Science degree in business and finance from Western Washington University, Bellingham Washington. Under the leadership of Ms. Niven, THRHA has successfully closed over five new construction project accounts and during the past three years, two of these projects were closed with multiple funding sources

Ms. Niven, will provide oversight to the project and grant accounting. She will supervise Finance Manager Irene Tupou who is responsible for all accounting functions including grant accounting that is performed by her staff. Ms. Tupou is a member of THRHA management, and she coordinates all aspects of project implementation with her senior colleagues at THRHA to ensure that THRHA complies, and maintains reporting on time and within budget.

Bookkeeping functions are performed in-house using Emphasys Systems Elite, to manage fund accounting that meets Federal requirements. Ms. Tupou is responsible for all accounting functions including grant accounting that is performed by her staff. Ms. Tupou has experience managing grant funds from a variety of sources, including DOE, and ensures that no expenses that are unallowable will be requested for reimbursement.

THRHA financial management and internal controls provide assurance that project goals and objectives will be met and funds will be used efficiently. To provide checks and fiscal oversight, THRHA's internal financial controls and policy separate duties into three financial functions (authorizing transactions; keeping records; and handling funds). Program funds are tracked in separate grant accounts with a project code allocated to each. Upon award of funding THRHA conducts a grant implementation meeting and review newly established codes for associated expenses. Only allowable expenses are coded and paid out of grant funds, the expenses are approved by the Project Manager and monthly grant meetings are held among the finance staff, project manager, and grant administrator to ensure all expenses are allowable and coded properly according to the approved budget. THRHA also tracks grant in-kind and match including labor and expenses that are not allowable as grant reimbursement. In addition, THRHA conducts an annual external financial audit.

5.0 Project Schedule

The following project schedule matches the table from the WBS section assuming a project start date of July 1, 2016.

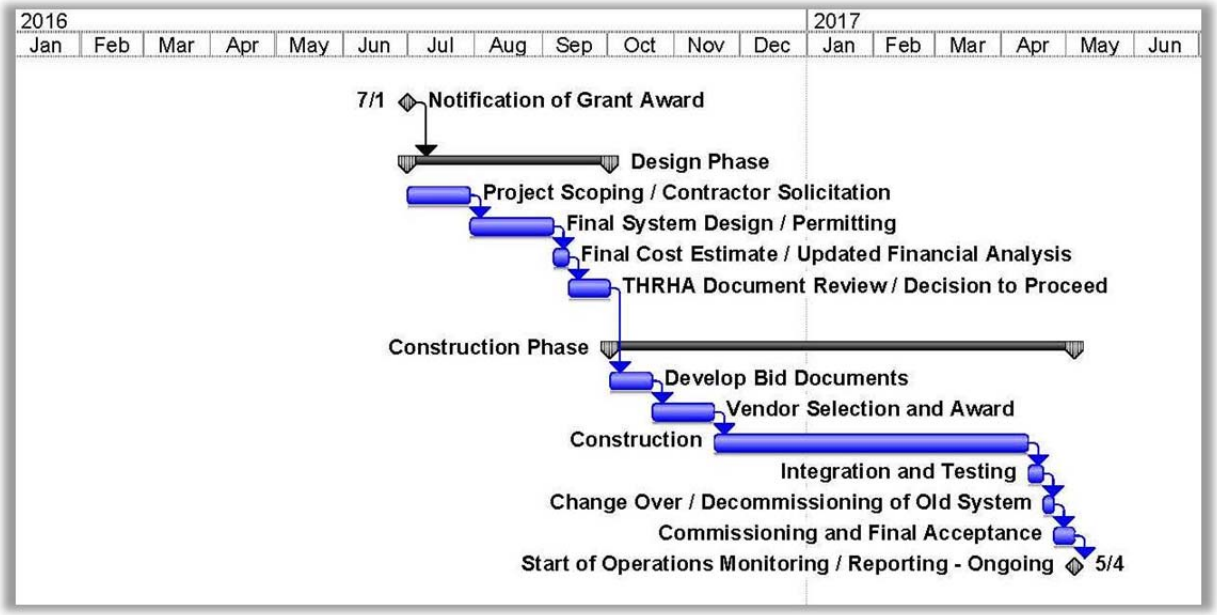


Figure 1 – Project Schedule

Attachment B

Site and Resource Maps and Graphics File

- Location Map
- Building Floor Plan



REVISIONS		
Date	Description	Approved

THRHA

Tlingit-Haida Regional Housing Authority

Saxman Low-Rent Multifamily Building

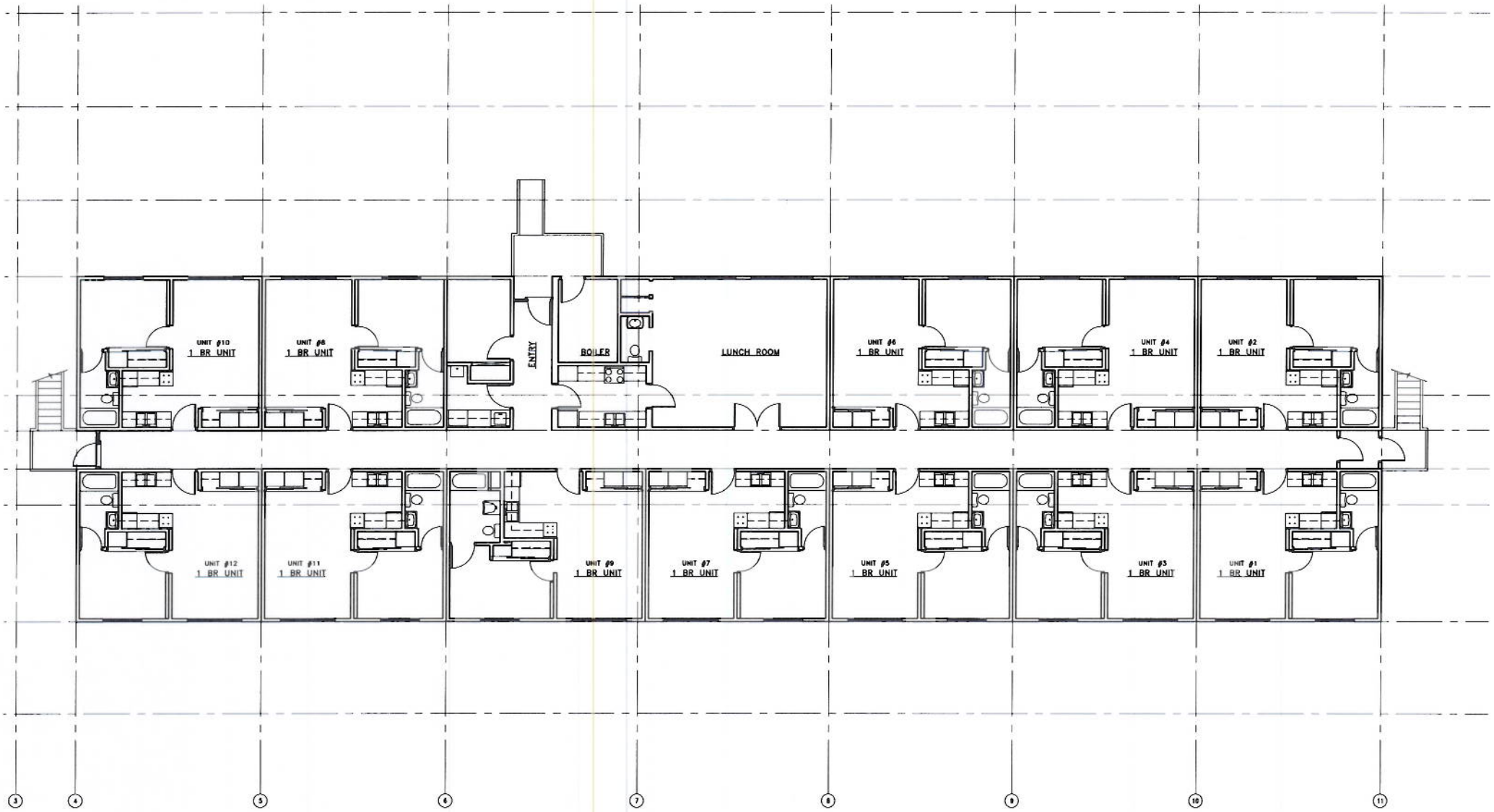
Saxman, AK

Aerial View

Designed	
Drawn	
Checked	

Approved _____ Date _____

Title _____ Job Class _____


UNIT #10
1 BR UNIT
UNIT #8
1 BR UNIT
ENTRY
BOILER
LUNCH ROOM
UNIT #6
1 BR UNIT
UNIT #4
1 BR UNIT
UNIT #2
1 BR UNIT
UNIT #12
1 BR UNIT
UNIT #11
1 BR UNIT
UNIT #9
1 BR UNIT
UNIT #7
1 BR UNIT
UNIT #5
1 BR UNIT
UNIT #3
1 BR UNIT
UNIT #1
1 BR UNIT
3
4
5
6
7
8
9
10
11

Attachment C

Energy Savings Calculations

Energy Savings Calculations

A-Heating System	B-Fuel Oil Usage, gallons	C-Electricity Usage (heating), kWh	D-Electricity Usage (non-heating), kWh	E-Total Energy Use (Site), kBtu	F-Total Energy Use (1.5 Site-Source), kBtu	G-Total Energy Use (3.14 Site-Source), kBtu
Projected Energy Usage after Renovation	4,058	1,690	68,200	802,527	927,400	1,318,482
Projected Energy Usage with All EEMs	0	57,703	68,200	429,581	644,372	1,348,884
			Annual Savings	***46%***	***31%***	***-2%***

Dicussion of Calcluation: There are only two types of energy currently used at the facility. These are fuel oil for heating, and electricity for a wide variety of uses. Should all EEMs be implemented, including the low temperature hydronic heating system and air-to-water heat pump installation, the only form of energy used onsite will be electricity, with the heat pump using renewable heat from the surrounding air/climate. The source of electricity for this community is hydroelectricity, and Saxman is in one of Alaska's special hydro communities. The Alaska Housing Finance Corporation has developed a site-to-source factor of 1.5 for Alaska's special hydro communities. This factor is used when calculating the realistic source energy use for before and after all the EEMs are implemented. Column E totals the energy use onsite based on the energy usages listed here for the entire facility and the DOE conversion factors to kBtu. Column F shows the annual Source energy use for each scenario, and source values are calculated using the DOE conversion factors, with the exception of the one for electricty. In this case, the factor of 1.5 is used as it is more appropriate for this project than the blanket national value. Column G shows the source energy calculation if the national value were to be used in order to show the impact to the source savings calculation, but again, this is not an appropriate value for this project and is only shown for demonstration purposes.

Inputs to Calculations

Item	Value	Units	Source
#1 Fuel Oil HHV	0.138	mmBtu/gallon	DOE App C
Electricity	0.003412	mmBtu/kWh	DOE App C
#1 Fuel Oil Conversion to Source Energy	1.01		DOE App C
Electricity Conversion to Source Energy for Alaska Special Hydro Community	1.5		AHFC - Hydro
Electricity Conversion to Source Energy National Factor	3.14		DOE App C

Attachment D

Energy Use Data

- 2014 Oil Deliveries
- 2014 Electric Bills

Sales Alias / Order Number	Source / Vehicle	Unit Price	Product / Container / Invoice Qty	Net Qty	Gross Qty	Shipped Qty	Salesperson	Total Sale Excluding Taxes	Total Sale
20, CPD Alaska LLC									
ShipTo: 002, 2708 Halibut St. FO									
Invoice No: 167279		Invoice Date: 01/02/2014 11:00:00 PM			Account: 119099, THRHA		Ship To: 002		
30-155300/Gallon	K4110		155000/Gallon				Ketchikan		
167279	D164	$3.72900	263.20	263.20	263.20	263.20		$981.47	$981.73
Invoice 167279 Totals:			263.20	263.20	263.20	263.20		$981.47	$981.73
Invoice No: 178936		Invoice Date: 01/23/2014 11:00:00 PM			Account: 119099, THRHA		Ship To: 002		
30-155300/Gallon	K4110		155000/Gallon				Ketchikan		
178936	D162	$3.72900	273.60	273.60	273.60	273.60		$1,020.25	$1,020.52
Invoice 178936 Totals:			273.60	273.60	273.60	273.60		$1,020.25	$1,020.52
Invoice No: 193753		Invoice Date: 02/13/2014 11:00:00 PM			Account: 119099, THRHA		Ship To: 002		
30-155300/Gallon	K4110		155000/Gallon				Ketchikan		
193753	D164	$3.72900	343.30	343.30	343.30	343.30		$1,280.17	$1,280.51
Invoice 193753 Totals:			343.30	343.30	343.30	343.30		$1,280.17	$1,280.51
Invoice No: 209229		Invoice Date: 03/12/2014 11:00:00 PM			Account: 119099, THRHA		Ship To: 002		
30-155300/Gallon	K4110		155000/Gallon				Ketchikan		
209229	D164	$3.72900	271.60	271.60	271.60	271.60		$1,012.80	$1,013.07
Invoice 209229 Totals:			271.60	271.60	271.60	271.60		$1,012.80	$1,013.07
Invoice No: 218503		Invoice Date: 04/02/2014 11:00:00 PM			Account: 119099, THRHA		Ship To: 002		
30-155300/Gallon	K4110		155000/Gallon				Ketchikan		
218503	D164	$3.72900	403.40	403.40	403.40	403.40		$1,504.28	$1,504.68
Invoice 218503 Totals:			403.40	403.40	403.40	403.40		$1,504.28	$1,504.68
Invoice No: 229883		Invoice Date: 04/23/2014 11:00:00 PM			Account: 119099, THRHA		Ship To: 002		
30-155300/Gallon	K4110		155000/Gallon				Ketchikan		
229883	D164	$3.72900	214.50	214.50	214.50	214.50		$799.87	$800.08
Invoice 229883 Totals:			214.50	214.50	214.50	214.50		$799.87	$800.08
Invoice No: 241913		Invoice Date: 05/14/2014 11:00:00 PM			Account: 119099, THRHA		Ship To: 002		
30-155300/Gallon	K4110		155000/Gallon				Ketchikan		
241913	D164	$3.82900	193.50	193.50	193.50	193.50		$740.91	$741.10
Invoice 241913 Totals:			193.50	193.50	193.50	193.50		$740.91	$741.10
Invoice No: 249250		Invoice Date: 06/05/2014 11:00:00 PM			Account: 119099, THRHA		Ship To: 002		
30-155300/Gallon	K4110		155000/Gallon				Ketchikan		
249250	D162	$3.82900	55.90	55.90	55.90	55.90		$214.04	$214.10
Invoice 249250 Totals:			55.90	55.90	55.90	55.90		$214.04	$214.10
Invoice No: 298805		Invoice Date: 09/02/2014 11:00:00 PM			Account: 119099, THRHA		Ship To: 002		
30-155300/Gallon	K4110		155000/Gallon				Ketchikan		
298805	D164	$3.87900	643.30	643.30	643.30	643.30		$2,495.36	$2,496.00
Invoice 298805 Totals:			643.30	643.30	643.30	643.30		$2,495.36	$2,496.00

Sales Alias / Order Number	Source / Vehicle	Unit Price	Product / Container: Invoice Qty	Net Qty	Gross Qty	Shipped Qty	Salesperson	Total Sale Excluding Taxes	Total Sale
Invoice No: 311487	Invoice Date: 09/23/2014 11:00:00 PM						Account: 119099, THRHA	Ship To: 002	
30-155300/Gallon	K4110		155000/Gallon				Ketchikan		
311487	D164	$3.83900	152.70	152.70	152.70	152.70		$586.22	$586.37
Invoice 311487 Totals:			152.70	152.70	152.70	152.70		$586.22	$586.37
Invoice No: 328901	Invoice Date: 10/14/2014 11:00:00 PM						Account: 119099, THRHA	Ship To: 002	
30-155300/Gallon	K4110		155000/Gallon				Ketchikan		
328901	D164	$3.83900	170.80	170.80	170.80	170.80		$655.70	$655.87
Invoice 328901 Totals:			170.80	170.80	170.80	170.80		$655.70	$655.87
Invoice No: 341866	Invoice Date: 11/05/2014 11:00:00 PM						Account: 119099, THRHA	Ship To: 002	
30-155300/Gallon	K4110		155000/Gallon				Ketchikan		
341866	D164	$3.69900	186.60	186.60	186.60	186.60		$690.23	$690.42
Invoice 341866 Totals:			186.60	186.60	186.60	186.60		$690.23	$690.42
Invoice No: 353071	Invoice Date: 11/26/2014 11:00:00 PM						Account: 119099, THRHA	Ship To: 002	
30-155300/Gallon	K4110		155000/Gallon				Ketchikan		
353071	D164	$3.64900	238.80	238.80	238.80	238.80		$871.38	$871.62
Invoice 353071 Totals:			238.80	238.80	238.80	238.80		$871.38	$871.62
Invoice No: 365830	Invoice Date: 12/18/2014 11:00:00 PM						Account: 119099, THRHA	Ship To: 002	
30-155300/Gallon	K4110		155000/Gallon				Ketchikan		
365830	D163	$3.64900	281.90	281.90	281.90	281.90		$1,028.65	$1,028.93
Invoice 365830 Totals:			281.90	281.90	281.90	281.90		$1,028.65	$1,028.93
Invoice No: 375786	Invoice Date: 01/08/2015 11:00:00 PM						Account: 119099, THRHA	Ship To: 002	
30-155300/Gallon	K4110		155000/Gallon				Ketchikan		
375786	D164	$3.44900	268.30	268.30	268.30	268.30		$925.37	$925.64
Invoice 375786 Totals:			268.30	268.30	268.30	268.30		$925.37	$925.64
Invoice No: 386621	Invoice Date: 01/29/2015 11:00:00 PM						Account: 119099, THRHA	Ship To: 002	
30-155300/Gallon	K4110		155000/Gallon				Ketchikan		
386621	D164	$3.30900	232.10	232.10	232.10	232.10		$768.02	$768.25
Invoice 386621 Totals:			232.10	232.10	232.10	232.10		$768.02	$768.25
Invoice No: 398601	Invoice Date: 02/18/2015 11:00:00 PM						Account: 119099, THRHA	Ship To: 002	
30-155300/Gallon	K4110		155000/Gallon				Ketchikan		
398601	D164	$3.05900	260.10	260.10	260.10	260.10		$795.65	$795.91
Invoice 398601 Totals:			260.10	260.10	260.10	260.10		$795.65	$795.91
Invoice No: 411905	Invoice Date: 03/11/2015 11:00:00 PM						Account: 119099, THRHA	Ship To: 002	
30-155300/Gallon	K4110		155000/Gallon				Ketchikan		
411905	D164	$3.05900	250.10	250.10	250.10	250.10		$765.06	$765.31
Invoice 411905 Totals:			250.10	250.10	250.10	250.10		$765.06	$765.31
Invoice No: 420162	Invoice Date: 04/01/2015 11:00:00 PM						Account: 119099, THRHA	Ship To: 002	

Sales Alias / Order Number	Source / Vehicle	Unit Price	Product / Container: Invoice Qty	Net Qty	Gross Qty	Shipped Qty	Salesperson		Total Sale Excluding Taxes	Total Sale
30-155300/Gallon	K4110		155000/Gallon				Ketchikan			
420162	D164	$2.90900	217.80	217.80	217.80	217.80			$633.58	$633.80
Invoice 420162 Totals:			217.80	217.80	217.80	217.80			$633.58	$633.80
Invoice No: 429943	Invoice Date: 04/21/2015 11:00:00 PM						Account: 119099, THRHA	Ship To: 002		
30-155300/Gallon	K4110		155000/Gallon				Ketchikan			
429943	D164	$2.90900	218.30	218.30	218.30	218.30			$635.03	$635.25
Invoice 429943 Totals:			218.30	218.30	218.30	218.30			$635.03	$635.25
Invoice No: 444259	Invoice Date: 05/20/2015 11:00:00 PM						Account: 119099, THRHA	Ship To: 002		
30-155300/Gallon	K4110		155000/Gallon				Ketchikan			
444259	D164	$2.90900	231.00	231.00	231.00	231.00			$671.98	$672.21
Invoice 444259 Totals:			231.00	231.00	231.00	231.00			$671.98	$672.21
Invoice No: 458346	Invoice Date: 06/17/2015 11:00:00 PM						Account: 119099, THRHA	Ship To: 002		
30-155300/Gallon	K4110		155000/Gallon				Ketchikan			
458346	D164	$2.90900	200.70	200.70	200.70	200.70			$583.84	$584.04
Invoice 458346 Totals:			200.70	200.70	200.70	200.70			$583.84	$584.04
ShipTo 002, 2708 Halibut St. FO Totals:			5,571.50	5,571.50	5,571.50	5,571.50			$19,659.86	$19,665.41
Company 20, CPD Alaska LLC Totals:			5,571.50	5,571.50	5,571.50	5,571.50			$19,659.86	$19,665.41
Report Totals:			5,571.50	5,571.50	5,571.50	5,571.50			$19,659.86	$19,665.41

Consumption Trend Report: 1/1/2012 - 12/31/2014

Account #

107207-001

Service Address

2708 Halibut St
Ketchikan, AK 99901

Mailing Address

Tlingit & Haida Regional Housing Authority
Lrph
PO Box 32237
Juneau, AK 998032237

Consumption Information	Electric Usage			
	KW	Charge Amount	KWH	Charge Amount
12/08/2014	22	$563.58	6,200	$563.58
11/05/2014	22	$483.58	5,320	$483.58
10/06/2014	22	$476.32	5,240	$476.32
09/05/2014	22	$447.22	4,920	$447.22
08/05/2014	22	$410.86	4,520	$410.86
07/07/2014	22	$561.72	6,040	$561.72
06/05/2014	22	$364.56	3,920	$364.56
05/12/2014	22	$472.44	5,080	$472.44
04/18/2014	22	$799.80	8,600	$799.80
03/10/2014	6,120	$548.96	55	$548.96
02/05/2014	5,720	$513.08	55	$513.08
01/06/2014	6,520	$584.84	55	$584.84
12/06/2013	4,760	$426.97	55	$426.97
11/05/2013	6,000	$538.20	55	$538.20
10/07/2013	4,600	$412.62	55	$412.62
09/05/2013	4,200	$413.04	55	$413.04
08/05/2013	5,280	$509.92	55	$509.92
07/08/2013	4,680	$456.10	55	$456.10
06/05/2013	4,640	$452.51	55	$452.51
05/06/2013	5,960	$570.91	55	$570.91

Consumption Trend Report

Consumption Information	Electric Usage			
	KW	Charge Amount	KWH	Charge Amount
04/05/2013	4,880	$474.04	55	$474.04
03/08/2013	4,600	$412.62	55	$412.62
02/05/2013	6,720	$602.78	55	$602.78
01/07/2013	5,440	$487.97	55	$487.97
12/06/2012	4,840	$434.15	55	$434.15
11/05/2012	5,240	$470.03	55	$470.03
10/08/2012	4,560	$409.03	55	$409.03
09/05/2012	5,240	$506.33	55	$506.33
08/06/2012	4,720	$459.68	55	$459.68
07/06/2012	4,760	$463.27	55	$463.27
06/05/2012	4,720	$459.68	55	$459.68
05/07/2012	7,160	$678.55	55	$678.55
04/05/2012	6,200	$592.44	55	$592.44
03/07/2012	7,440	$667.37	55	$667.37
02/06/2012	7,480	$670.96	55	$670.96
01/05/2012	7,360	$660.19	54	$660.19
Total	150,038	$18456.32	51,324	$18456.32

Attachment E

Energy Audits or Assessments for Deep Energy Retrofits

- DE-0005179 – Energy Efficiency Audit, Assessment, and Alternative Energy Study
  - Excerpt from overall report summarizing Energy audit and assessment using AKWarm by Marquam George, LLC
  - Heating Conversion Analysis for Saxman Multifamily Low Rent Housing by Alaska Energy Engineers, LLC

2.11 SAXMAN

The city of Saxman, Alaska is located on the west side of Revillagigedo Island, about 2 miles south of Ketchikan on the South Tongass Highway. The average annual high temperature is 50.9°F and the average annual low temperature is 39.3°F. Annual Heating Degree Days (HDD) base 65F = 7,081 HDD.

As an island community, there is no direct road access to Saxman from the main land. Saxman relies on Ketchikan for its boat moorage, air travel, & state ferry services. Saxman is connected to Ketchikan by the South Tongass Highway. The Saxman Seaport has a dock and commercial barge off-loading facilities for propane, construction materials, equipment and supplies.

The population of Saxman is 447 and the median age is 35.2 years old. Saxman relies heavily on tourism and the Southeast Arts Economy. The average household income is $76,352. There are 136 housing units available in the area with 86 owner occupied and 45 renter occupied. Table 2.11-1 shows an energy cost comparison for heating fuels in the community.

Table 2.11-1 : Saxman Cost of Energy Comparison

Technology, Unit	Input Btu/Unit	Cost/Unit	Assumed Efficiency	Output Btu/Unit	Cost/ mmBtu Output
#2 Fuel Oil, Gallon	138,800	$3.95	80%	111,040	$35.57
Propane, Gallon	91,300	$2.64	80%	73,040	$36.14
Electricity, kWh (Resistance)	3,412	$0.10	100%	3,412	$29.31
Electricity, kWh (Heat Pump)	3,412	$0.10	300%	10,236	$9.77
Wood Pellets, Ton	15,200,000	$330.00	80%	12,160,000	$27.14

Note: Fuel prices provided by AkWarm software based on the 3/30/2015 library. Biomass prices obtained from local providers.

2.11.1 Saxman 12-Unit Multifamily Housing Building

THRHA operates a low rent multifamily building in the city of Saxman built in 1978. The building is of modular construction and contains 12 one bedroom, one bath rental units and is 1 story, stick frame construction, vinyl sided, and has a steel roof. The foundation is creosote piles that support a raised floor with a skirted crawlspace.

A typical unit is 24' x 20' with all units exiting to a central corridor. The central corridor is 5' wide and has a utility chase above the drop ceiling for heat, domestic hot and cold water piping, and electrical distribution to apartments. The building was weatherized in 2010. Figures 2.11-1 through 2.11-4 show the pictures of the Saxman 12 Unit Multifamily Building.



Figure 2.11-1 Saxman 12-Unit Low Rent Apartment Building Outside Shell



Figure 2.11-2 Saxman 12-Unit Low Rent Apartment Building Back



Figure 2.11-3 Saxman Outbuilding



Figure 2.11-4 Saxman 12-Unit Low Rent Apartment Building Entrance & Corridor

Table 2.11-2 provides the square footage and insulation values of building components for the Saxman Low Rent Apartment Building.

Table 2.11-2 : Saxman Building Insulation Values and Area of Building Components

Building Address	Item	Living Area Floors	Wall Section 1 House	Wall Section 2 Rim Joist	Exterior Doors	Windows	Ceiling
2708 Halibut Street	R-Value	48.3	11.3	18.4	5.0	2.0	54.4
	Area, ft^2	7,425	3,360	7,425	80	688	7,425

Two Weil McLain hot water boilers firing on #2 fuel oil are used to heat the building and domestic hot water. Hot water circulation pumps distribute hot water for space heating and to the indirect heated domestic hot water tank. Baseboard heat is located in each unit. The boilers are failing and are scheduled for replacement or removal in the near future. Table 2.11-3 provides a breakdown of annual energy use and costs for the 12 unit building. Values are provided from AkWarm reports using the 3/30/2015 data library.

Table 2.11-3 : Saxman Low Rent Apartment Building Annual Fuel Use and Cost Breakdown

Space Heating #2 Oil Use, Gallons	Space Heating #2 Oil Cost	Water Heating #2 Oil Use, Gallons	Water Heating #2 Oil Cost	Appliances & Lights Electric Use, kWh	Appliances & Lights Electric Cost	Total Annual Costs
470	$1,857	517	$2,042	67,421	$6,742	$10,641

Note: Fuel use and cost information provided by AkWarm software based on the 3/30/2015 library

2.11.2 Improvement Option Recommendations

The energy audit and blower door tests of the building generated a list of energy efficiency recommendations. Energy efficiency measures considered for the Saxman Low Rent Housing Building are as follows:

- **Air Sealing** - THRHA would like to tighten building up to no more than 4 ACH50.
- **Insulation** - THRHA considered insulating the rim joist, floor cavity, and adding insulation to the attic.
- **Air to Water Heat Pumps** - THRHA considered installing water to air heat pumps and leaving the oil fired boilers for backup. The heat pumps are limited to 130°F leaving water temperature, so the system would be limited to domestic hot water heating or require conversion to low temperature heating.

A summary of estimated costs and savings for recommended measures are provided in Table 2.11-4.

Table 2.11-4 : Saxman 12 Unit – Energy Efficiency Measure Cost Benefit Summary

Energy Efficiency Measure	Estimated Total Savings	Estimated Total Cost	Simple Payback, Years	SIR
Air Sealing to 4 ACH	$207	$500	2.4	3.8
Air to Water Heat Pumps	$1,333	$10,000	7.5	2.0
Insulate Rim Joist with R-14 on Above Grade Wall	$32	$699	21.8	1.1
Add R-19 Blown in Insulation to Exposed Floor 2x12 Cavity	$174	$7,128	41.0	0.6
Add R-12 Insulation to Attic Space	$100	$4,722	47.2	0.5
Totals	**$1,846**	**$23,049**	**12.5**	

Notes:

1 – Costs and savings values for air sealing and insulation are estimated using the AkWarm software from the 3/30/2015 library.

2 – Costs and savings for an air to water heat pump are estimated by WES Energy & Environment and assume 90% offset of fuel oil use for domestic hot water.

THRHA also is considering upgrading portions of the building due to necessity that are not necessarily driven by energy savings. A summary of potential upgrades being considered are as follows:

- Install a new heat recovery ventilator system in the central corridor and common spaces.
- Replace old Type M copper piping in corridor ceiling with new PEX
- Install individual electrical meters and service panels in each apartment.
- Installing a wood pellet fired hot water boiler system

Ventilation – The building does not currently have a central ventilation system. The central corridor is not ventilated and carries odors and apartments units have exhaust-only ventilation using a bath fan and a range hood. THRHA would like to install a heat recovery ventilator system for corridors and public spaces. A heat recovery ventilator system is estimated to cost $50,000. This system will use additional energy but will improve indoor air quality and occupant comfort.

Copper Pipe Replacement – Copper heating pipes are run above the ceiling to individual baseboard heaters in each unit. The pipes are leaking and zone valves are likely failed in place. THRHA is considering replacing the piping with new insulated PEX piping. Replacement costs are estimated at $150 per linear foot of supply and return pipe.

Individual Electric Meters – There is currently one electric meter on the building and electricity is billed as a commercial rate. THRHA would like to install individual meters for each unit to encourage a reduction in electricity use. Estimated installed costs for individual electric meter sockets and service panels are $1,100 per unit for a total cost of $13,200.

Wood Pellet Heating System - THRHA considered the feasibility of heating the building with a wood pellet fired biomass boiler located in a separate outbuilding. The recommended system

consists of a 40,000 Btu/hr wood pellet fired hot water boiler and 60 gallons of hot water thermal storage. The financial summary of the wood pellet system is provided in Table 2.11-5. A cost breakdown is provided in Section 4.0 – Attachments.

Table 2.11-5 : Saxman Wood Pellet Heating System Financial Summary

Current #2 Oil Use, Gallons	Current #2 Oil Cost	Estimated Wood Pellet Use, Tons	Estimated Wood Pellet Cost	Estimated O&M Costs	Estimated #2 Oil Cost with Wood Pellet System	Estimated Savings	Estimated Capital Cost	Simple Payback, Years
987	$3,899	7.2	$2,379	$1,500	$780	($760)	104,843	N/A

Note: Assumes 80% offset of the heating fuel use with wood pellets. Fuel price values used to estimate savings are provided in Table 2.11-1.

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
jim@alaskaenergy.us

Technical Memorandum

September 14, 2015

to: **Craig Moore, V.P. Planning and Development**
Tlingit-Haida Regional Housing Authority

subject: **Heating Conversion Analysis**

project: **Saxman Multifamily Low Rent Housing**

INTRODUCTION

This report presents a heating conversion analysis for the Saxman Multifamily Low Rent Housing building. The purpose of the analysis is to compare the life cycle cost of a fuel oil boiler heating system with an air source heat pump heating system.

Jim Rehfeldt, P.E. of Alaska Energy Engineering LLC performed the analysis.

Background

The Tlingit-Haida Regional Housing Authority (THRHA) plans to renovate, modernize, and expand the Saxman Multifamily Low Rent building in Saxman, Alaska. The project will include a complete replacement of the heating system because it has reached the end of its service life.

The existing heating system consists of an oil-fired boiler and high-temperature distribution system supplying a central indirect hot water heater and baseboard units located in each apartment. Replacing the heating system in-kind is a common, status quo option for heating system replacement. The THRHA is interested in replacing the boiler system with an air source heat pump system that employs low temperature distribution to supply a central domestic hot water system and low-temperature baseboard heaters.

Conversion to an air source heat pump system is aligned with THRHA energy goals to:

- Reduce long-term operating costs
- Increase use of sustainable energy sources: electricity in Saxman is derived from hydroelectric generation
- Increase use of local energy sources, and
- Decrease the greenhouse gas footprint of their operations

ENERGY COSTS

Historic Energy Use

The Saxman Multifamily low rent housing is a 7,600-sqft facility that contains 12 apartments and a common hallway, laundry room, kitchen and dining room. Two fuel oil boilers supply heat for the spaces and for heating domestic hot water. Historic energy use and cost is summarized in the following table:

Annual Energy Consumption and Cost

Source	Consumption	Cost	Energy, MMBtu	
Electricity	64,980 kWh	$6,300	222	31%
Fuel Oil	3,693 Gallons	$10,700	502	69%
Totals	-	$17,000	723	100%

The building has an energy use index (EUI) of 95, which is relatively high for THRHA facilities. To improve the energy performance of the facility, the proposed project will increase the wall and window insulation and install LED lighting. Converting to an air source heat pump system will also reduce energy costs.

Energy Costs and Inflation

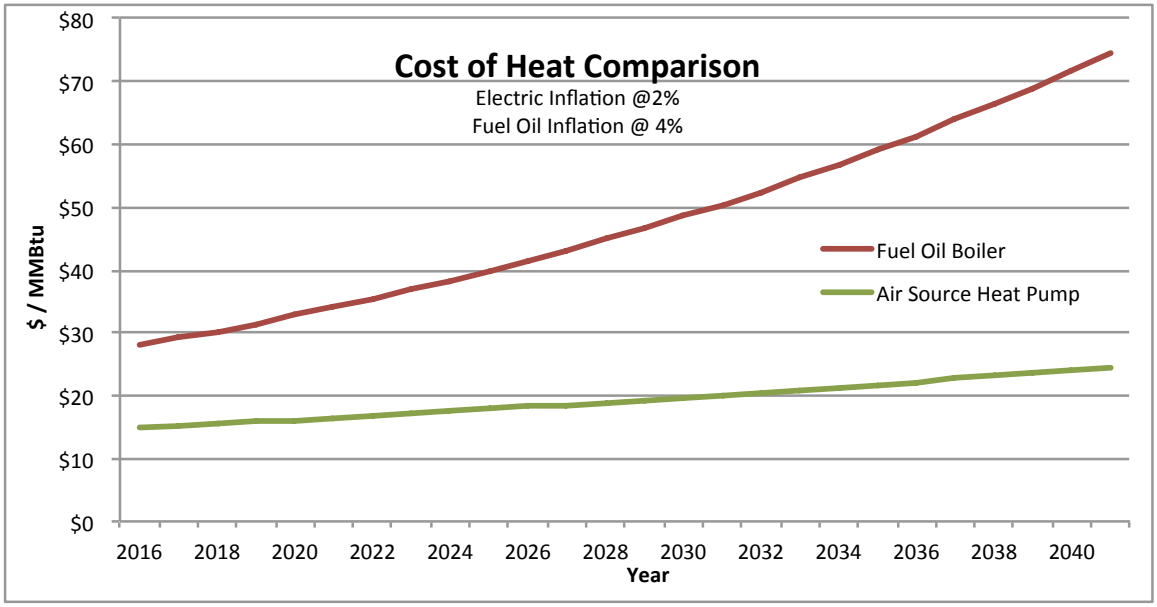
Energy costs and energy inflation used in the analysis are shown in the following table:

Summary of Economic and Energy Factors

Factor	Rate or Cost	Factor	Rate or Cost
Nominal Discount Rate	4.5%	General Inflation Rate	2.5%
Electricity (2016)	11.2¢ per kWh	Electricity Inflation	2.0%
Fuel Oil (2016)	$3.03 / gallon	Fuel Oil Inflation	4.0%

Cost of Heat Comparison

The cost of heat takes into account current energy prices, conversion efficiency, and energy inflation. The following charts shows projected energy prices over 25-years. On the left side of the chart is the cost of heat in 2016. Moving to right is how the costs change with energy inflation.



An air source heat pump offers much lower heating costs over the life of the project because it extracts a majority of the supplied heat from the environment at no cost or energy inflation.

LIFE CYCLE COST COMPARISON

Description of Systems

The existing fuel oil boiler heating system has reached the end of its service life and will be replaced in entirety. The analysis compares an in-kind replacement of a fuel oil boiler system with converting to an air source heat pump system. Attached to this report is a schematic diagram of the two systems.

Fuel Oil Boiler Option

A fuel oil boiler heating system will consist of:

- Two fuel oil boilers sized for 70% of the heating load, each with a constant speed boiler pump.
- Two variable speed building pumps supplying high-temperature hydronic heat to apartment baseboard heaters and to two indirect domestic hot water heaters.

The fuel oil boiler plant will have a seasonal efficiency of 75% when operated in a lead/lag configuration.

Air Source Heat Pump Option

An air source heat pump system will consist of:

- An air source heat pump located outdoors under an enclosure that protects it from wind-driven rain and snow and two indoor heat exchangers that transfer the heat to a low-temperature hydronic heating system.
- A buffer tank with electric heating elements that both adds thermal mass to the system and also provides backup heating when the heat pump requires maintenance or repair.

- Two variable speed building pumps supplying low-temperature hydronic heat to apartment baseboard heaters and to an indirect domestic hot water preheat tank
- An electric hot water heater that increases the hot water temperature to 125°F for distribution to the fixtures.

The air source heat pump sized at 80% of the design heating load will supply 95% of the heating load. The backup electric buffer tank supplement during cold weather and the electric hot water heater will also supply supplemental heat to maintain a hot water supply temperature of 125°F.

Life Cycle Cost Comparison

Construction Costs

As expected for a system with higher efficiency, the ASHP system has higher construction costs than the fuel oil boiler system. The higher cost is primarily attributed to the following features of the ASHP system:

- The heat pump costs more than a fuel oil boiler per Btu of delivered heat.
- The electrical service will be upgraded from 240v/1ϕ to 208v/3ϕ service. This will also require a rate schedule change from residential service to commercial service.
- The ASHP system requires a low temperature distribution system with larger pumps and piping and higher cost baseboard heaters.

Maintenance Costs

The air source heat pump system has moderately higher maintenance costs associated with maintaining the outdoor units, including factory-trained maintenance every five-years. The outdoor units must also be replaced at the end of their expected service life of 15 years.

The fuel oil boilers require annual maintenance for the burner and to clean the combustion passages.

Energy Costs

The following table summarizes the energy analysis of the two heating options. The ASHP system offers a significant reduction in energy use and costs.

Energy Analysis

Item	Fuel Oil Boilers	Air Source Heat Pump
Heating Plant Sizing	Two at 70% each	ASHP: 80% Electric Tank: 100%
Seasonal Efficiency	72%	233%
Annual Energy Use	Oil: 4,058 gal Elec: 1,690 kWh	Elec: 57,703 kWh
Annual Energy Cost (2016)	$12,500	$7,300 [1]
Energy Use Index, kBtu/sqft	94	51
Energy Cost Index, $/sqft	$2.22	$1.65

1. Includes a cost of 1.2¢ per kWh for non-heating electricity as a result of changing the building electric service from residential to commercial rates.

Life Cycle Cost Comparison

Both options have essentially equal life cycle cost. The air source heat pump has the lowest energy costs and the fuel oil boiler system has lower construction and maintenance costs.

Life Cycle Cost Comparison

Component	Fuel Oil Boiler	Air Source Heat Pump	% Difference
Construction Costs	$239,000	$385,000	+61%
Maintenance Costs	$34,000	$47,000	+38%
Energy Costs	$292,000	$136,000	-53%
Total Life Cycle Cost	$565,000	$568,000	+1% [1]

1. Within the accuracy of the analysis, the two projects have essentially equal life cycle costs.

SUMMARY

Building Owners typically require a reasonable savings on their investment—typically in the range of 5-10%—as incentive to undertake the effort and risk of a heating system conversion. In this project, the heating system is failing and must be replaced; THRHA must endure a level of effort and risk regardless of which heating option they choose, lowering their needed return on investment.

For THRHA, this conversion offers several financial and operational benefits that promote conversion. The main benefit is a significant reduction in annual operating costs, helping to keep rents low. An ASHP conversion is also aligned with THRHA's goal to transition away from fuel oil toward sustainable, local energy sources. A high percentage of Saxman's power is expected to be renewable hydroelectric power throughout the life of the system. As such, an ASHP system also has lower environmental impacts because it does not emit greenhouse gases.

This project can also benefit other building owners in Saxman and other Alaska communities in the following ways:

- Hydroelectric communities are promoting heat pump heating as an efficient use of hydroelectric resources. The project demonstrates heat pump conversion of an existing building.
- Air source heat pump technology has improved greatly in the last five years to the point that they are viable systems in the relatively warmer climate of coastal Alaska. As the technology continues to gain efficiency, the lessons learned from this conversion will benefit more areas of Alaska.
- The recent drop in oil prices may lead to complacency in addressing future energy issues. By promoting heat pump technology and demonstrating its success now, the THRHA can make positive steps toward improving energy efficiency and lowering long-term energy costs.

Replacing a heating system in-kind is the often chosen path for building owners, especially for similar buildings with relatively modest heating loads. This project will successfully demonstrate that heat pump technology is a viable option that offers long-term benefits to THRHA.

by: 

Jim Rehfeldt, P.E.

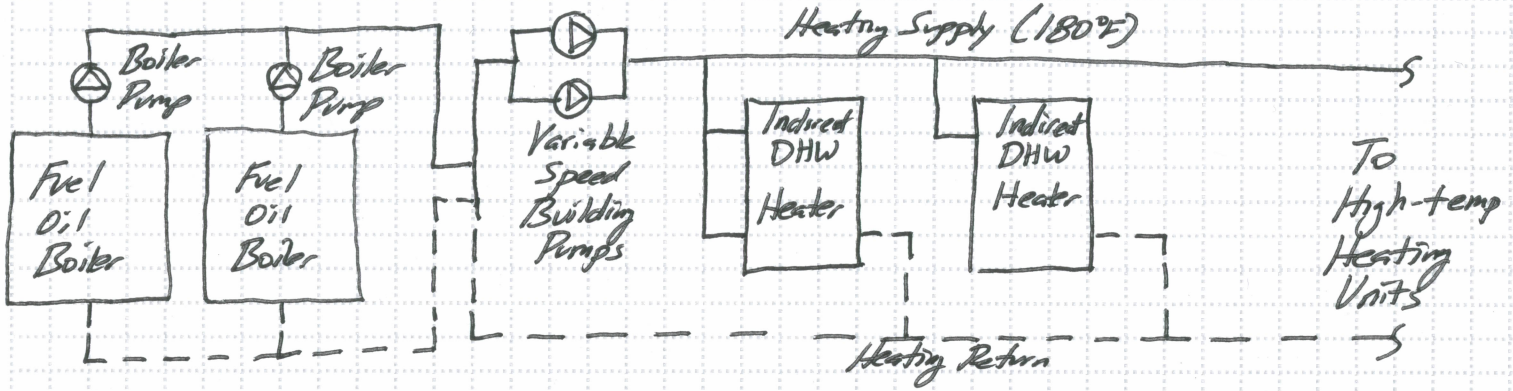
Alaska Energy Engineering LLC

Subject: Heating System Schematic

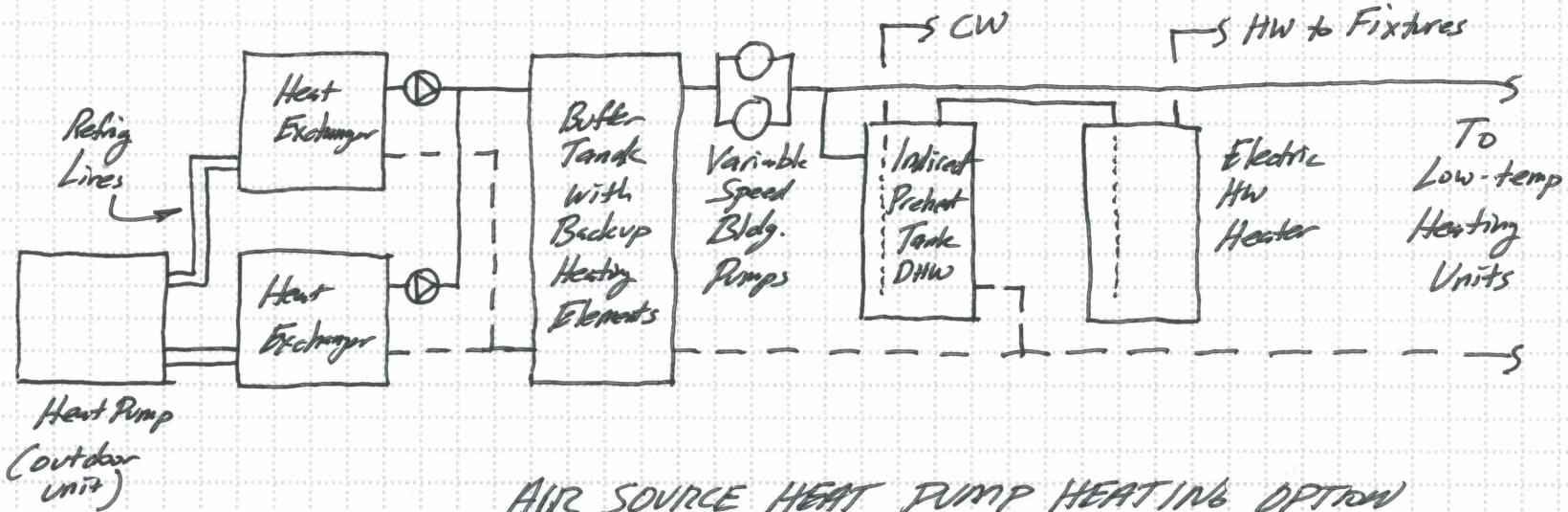
Project: Sexsmith

Date: 5-21-16

Page: 1 of 1



FUEL OIL BOILER HEATING OPTION



AIR SOURCE HEAT PUMP HEATING OPTION

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Life Cycle Cost Analysis

September 14, 2015

THRHA Saxman Low Rent Housing
Sizing and Energy Analysis

Building Loads

Heating	Design Load, MBH	Energy, kBTU
	150	404,678

Fuel Oil Boiler System

Sizing Analysis

Boilers	Boiler	Design Load, MBH	Factor	Boiler MBH
	B-1	150	70%	105
	B-2	150	70%	105
			140%	210

Pumps	Pump	GPM	Head	η, pump	Pump, BHP	η, motor
	Boiler	11	12	50%	0.06	70%
	Building	15	20	50%	0.15	70%

Energy Analysis

Fuel Oil Boilers	Load, kBTU	% Load	Net, kBTU	Efficiency	kBTU/gal	Fuel, gals
	404,678	100%	404,678	72%	138.5	4,058

Heating Pumping	Pump	Ave GPM	Ave Head	kW	Hours	kWh
	Boiler	11	12	0.07	3,854	274
	Building	15	20	0.16	8,760	1,416
						1,690

Air Source Heat Pump System

Sizing Analysis

Heating Equipment	Equip	Design MBH	Factor	Size, MBH	Effic	kW
	ASHP-1	100	78%	78	200%	11
	Elec Boiler	150	102%	154	100%	45
			Total	232		

Heat Exchangers	Equip	Design MBH	Factor	Size, MBH
	HEX-1	78	60%	47
	HEX-2	78	60%	47
				94

Pumps	Pump	GPM	Head	η, pump	Pump, BHP	η, motor
	HEX Pump	9	10	50%	0.05	70%
	HEX Pump	9	10	50%	0.05	70%
	Elec Boiler	31	12	50%	0.19	70%
	Building	31	20	50%	0.31	70%

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

THRHA Saxman Low Rent Housing
Sizing and Energy Analysis

Energy Analysis

	Load, kBTU	% Load	Net, kBTU
Heat Pumps	404,678	95%	384,444

Month	% Load	Load kBtu	Ave Temp	COP	Input kBtu	kWh
Jan	12%	46,133	34	1.9	24,198	7,092
Feb	10%	38,444	36	2.0	19,198	5,627
Mar	10%	38,444	38	2.1	18,191	5,331
Apr	8%	30,756	41	2.3	13,346	3,911
May	6%	23,067	47	2.7	8,396	2,461
Jun	5%	19,222	50	3.0	6,456	1,892
Jul	5%	19,222	55	3.3	5,786	1,696
Aug	6%	23,067	56	3.4	6,826	2,001
Sep	8%	30,756	53	3.2	9,630	2,822
Oct	9%	34,600	45	2.6	13,338	3,909
Nov	10%	38,444	40	2.2	17,180	5,035
Dec	11%	42,289	33	1.9	22,683	6,648
	100%	384,444		233%	165,229	48,426

Electric Boiler	Load, kBTU	% Load	Net, kBTU	Efficiency	kBTU/kWh	kWh
	404,678	5%	20,234	95%	3.4	6,242

Pumps	Pump	Ave GPM	Ave Head	kW	Hours	kWh
	HEX Pump	9	10	0.1	7,500	378
	HEX Pump	9	10	0.1	1,500	76
	Elec Boiler	31	12	0.2	500	99
	Building	31	20	0.3	7,500	2,482
						3,035

Electric Service Capacity

Spare Capacity

Service Size: 240 volts / 400A	96 kVA
Capacity kVA (Assume 80%)	77 kVA
Capacity kW (Assume 90% PF)	69 kW
Peak Load	55 kW
Spare capacity	14 kW

Increased Electric Service	Qty	kW, ea	Total kW	kVA @ 90% PF	Volts	Amps
Existing Service	1	86	86	96	208	265
Heat Pump	1	11	11	13	208	35
Electric Buffer Tank	1	30	30	33	208	93
Electric HW Tank	1	21	21	23	208	65
			148	165	208	458

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
alaskaenergy@gci.net

THRHA Saxman Low Rent Housing

Fuel Oil Boiler System

Basis

25	Study Period (years)	2.5%	General Inflation
4.5%	Nominal Discount Rate	4.0%	Fuel Inflation
2.0%	Real Discount Rate	2.0%	Electricity Inflation

Construction Costs		Year	Qty	Unit	Base Cost	Year 0 Cost
Hydronic Heating System						
Heating Plant						
Fuel Oil System						
Boiler fuel oil piping		0	2	LS	$500.00	$1,000
Primary Loop						
Fuel oil boilers	105 MBH	0	2	LS	$6,500.00	$13,000
Boiler stack		0	30	lnft	150.00	$4,500
Primary piping and appurtenances for each boiler	1-1/4"	0	2	LS	$1,500.00	$3,000
Primary supply and return header	1-1/2"	0	10	lnft	$35.00	$350
Primary pump, pipe mounted	1/10 HP	0	2	LS	$750.00	$1,500
Secondary loop						
Secondary pumps	1/4 HP	0	2	ea	1,500.00	$3,000
Secondary piping and appurtenances (boiler room)	1-1/2"	0	1	lot	3,000.00	$3,000
Building loop	1"	0	900	lnft	30.00	$27,000
Finned pipe branches	3/4"	0	520	lnft	25.00	$13,000
Finned pipe convectors		0	300	lnft	75.00	$22,500
Thermostats and control valves		0	13	ea	250.00	$3,250
Domestic Hot Water System						
Indirect HW heater, AV, piping, etc.	120 gallon	0	2	ea	8,700.00	$17,400
Miscellaneous						
Test and balance		0	40	hrs	150.00	$6,000
Commission heating system		0	1	lot	4,000.00	$4,000
Electrical						
Three phase service		0	0	ea	5,000.00	$0
Single phase service		0	8	ea	1,500.00	$12,000
Contingencies						
Estimating contingency		0			15%	$20,175
Overhead & profit		0			30%	$46,403
Design fees		0			10%	$20,108
Project management		0			8%	$17,695
					Total Construction Costs	**$239,000**

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
alaskaenergy@gci.net

THRHA Saxman Low Rent Housing

Fuel Oil Boiler System

Annual Costs	Maintenance	$40.00		Years	Qty	Unit	Base Cost	Present Value
Heating Plant								
Plant Observation								
Daily Heating Plant Observation		30	min/mo	1 - 25	6	hrs	$40.00	$4,622
Fuel Oil Boilers								
Fuel Oil Boiler Maintenance								
Parts Allowance, each				1 - 25	2	LS	$200.00	$7,704
Annual, each		8	hours/year	1 - 25	16	hrs	$40.00	$12,326
Pumps								
Pump maintenance, cartridge				1 - 25	4	ea	$100.00	$7,704
Domestic Hot Water								
Indirect HW heater		2	1	1 - 25	2	hrs	$40.00	$1,541
							Total Annual Costs	**$34,000**

Energy Costs	Years	Qty	Unit	Base Cost	Present Value
Fuel Oil	1 - 25	4,058	gallon	$3.03	$288,652
Electricity	1 - 25	1,690	kWh	$0.099	$3,098
				Total Energy Costs	**$292,000**

Present Worth	$565,000

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
alaskaenergy@gci.net

Life Cycle Cost Analysis

September 14, 2015

THRHA Saxman Low Rent Housing

Air Source Heat Pump System

Basis

25	Study Period (years)	2.5%	General Inflation
4.5%	Nominal Discount Rate	4.0%	Fuel Inflation
2.0%	Real Discount Rate	2.0%	Electricity Inflation

Construction Costs		Year	Qty	Unit	Base Cost	Year 0 Cost
Air Source Heat Pumps						
Outdoor units		0	1	ea	$18,000.00	$18,000
Enclosure		0	1	ea	$2,500.00	$2,500
Refrigerant piping		0	2	ea	$1,000.00	$2,000
Indoor HEX units		0	2	ea	$7,500.00	$15,000
Piping to building heating loop		0	2	ea	$1,500.00	$3,000
HEX pumps		0	2	ea	$1,000.00	$2,000
Hydronic Heating System						
Heating Plant						
Primary Loop						
Buffer Tank, Electric backup	200 gallons, 30 kW	0	1	LS	$12,000.00	$12,000
Boiler piping and appurtenances	2"	0	1	LS	$2,000.00	$2,000
Primary supply and return header	2"	0	10	lnft	$42.00	$420
Primary pump, pipe mounted	1/4 HP	0	1	LS	$1,000.00	$1,000
Secondary loop						
Secondary pumps	1/2 HP	0	2	ea	1,750.00	$3,500
Secondary piping and appurtenances (boiler room)	2"	0	1	lot	3,500.00	$3,500
Building loop	1-1/4"	0	900	lnft	35.00	$31,500
Finned pipe branches	3/4"	0	520	ea	25.00	$13,000
Finned pipe convectors		0	300	lnft	90.00	$27,000
Thermostats and control valves		0	13	ea	250.00	$3,250
Domestic Hot Water System						
Indirect HW heater, AV, piping, etc.	120 gallon	0	1	ea	8,700.00	$8,700
Electric hot water heater	120 gallon, 21kW	0	1	ea	7,000.00	$7,000
Miscellaneous						
Test and balance		0	40	hrs	150.00	$6,000
Commission heating system		0	1	lot	5,000.00	$5,000
Electrical						
Three phase service		0	3	ea	5,000.00	$15,000
Single phase service		0	6	ea	1,500.00	$9,000
CT Enclosure		0	1	LS	5,000.00	$5,000
208v/3-phase panel		0	1	LS	7,000.00	$7,000
Connect existing panel		0	1	LS	2,500.00	$2,500
Upgrade service from 240v/1-phase to 208v/3-phase		0	1	LS	20,000.00	$20,000
Contingencies						
Estimating contingency		0			15%	$30,731
Overhead & profit		0			30%	$70,680
Design fees		0			10%	$30,628
Project management		0			8%	$28,553
					Total Construction Costs	**$385,000**

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
alaskaenergy@gci.net

Life Cycle Cost Analysis

September 14, 2015

THRHA Saxman Low Rent Housing

Air Source Heat Pump System

Annual Costs	Maintenance $40.00	Years	Qty	Unit	Base Cost	Present Value
Heating Plant						
Plant Observation						
Daily Heating Plant Observation	30 min/mo	1 - 25	6	hrs	$40.00	$4,622
Air-source Heat Pump Maintenance						
Parts Allowance		1 - 25	1	LS	$200.00	$3,852
Monthly	0.5 hours/month	1 - 25	6	hrs	$40.00	$4,622
Every Three Months	0.67 hours/3 months	1 - 25	3	hrs	$40.00	$2,054
Annual	8 hours/year	1 - 25	8	hrs	$40.00	$6,163
Five Year Maintenance	4 hours/year	5 - 5	4	hrs	$110.00	$392
Five Year Maintenance	4 hours/year	10 - 10	4	hrs	$110.00	$356
Five Year Maintenance	4 hours/year	15 - 15	4	hrs	$110.00	$323
Five Year Maintenance	4 hours/year	20 - 20	4	hrs	$110.00	$293
Electric buffer tank		1 - 25	1	hrs	$40.00	$770
Air-source Heat Pump Replacement						
Replace outdoor units		15 - 15	1	LS	$13,500.00	$9,910
Pumps						
Pump maintenance, cartridge		1 - 25	2	ea	$100.00	$3,852
Pump maintenance, pipe mounted		1 - 25	3	ea	$150.00	$8,667
Domestic Hot Water						
Indirect HW heater		1 - 25	1	hrs	$40.00	$770
Electric HW Heater		1 - 25	1	hrs	$40.00	$770
					Total Annual Costs	**$47,000**

Energy Costs	Years	Qty	Unit	Base Cost	Present Value
Fuel Oil	1 - 25	0	gallon	$3.03	$0
Electricity (Non-HVAC cost increase due to rate change)	1 - 25	69,000	kWh	$0.012	$15,597
Electricity (Heating System)	1 - 25	57,703	kWh	$0.112	$119,956
				Total Energy Costs	**$136,000**

Present Worth	$568,000

Attachment F

Design and Engineering

- Heat pump equipment and water kit cut sheets
- Heat pump system warranty

Job Name/Location: **Tag #:**

Date:

PO No.:

For: ☑ File ☑ Resubmit ☑ Approval ☐ Other

Architect: GC:

Engr: Mech:

Rep:
(Company) (Project Manager)



ARUN072BTE4
Multi V™ IV Heat Pump
6.0 Ton Outdoor Unit

LG Life's Good

Performance:

Cooling Mode:

Nominal Capacity (Btu/h)	72,000
Power Input[1] (kW)	4.37

Heating Mode:

Nominal Capacity (Btu/h)	81,000
Power Input[1] (kW)	5.02

Nominal Capacity is outside the scope of AHRI Standard 1230 and based on the following conditions:

Indoor: 80°F DB / 67°F WB
Outdoor 95°F DB

Indoor: 70°F DB
Outdoor 47°F DB / 43°F WB

Electrical:

Power Supply (V/Hz/Ø)	208-230/60/3
MOP (A)	40
MCA (A)	25.3
Rated Amps (A)	21.0
Compressor A (A)	17.0
Compressor B (A)	-
Fan (A)	4.0

Piping:

Refrigerant Charge (lbs)	16.9
Liquid Line (in, OD)	3/8
Vapor Line (in, OD)	3/4

Standard Features:

- HiPOR (high pressure oil return)
- Smart Oil Control
- Split Coil Defrost
- Night Quiet Operation
- Fault Detection and Diagnosis

Optional Accessories:

☐ Air Guide - PRAGX2S0

☐ Low Ambient Baffle Kit - ZLABKA01A (1), Control Kit - PRVC2 (1 per system)

****(-9.9°F achieved only when all IDU's are operating in cooling mode.)**

Operating Range:

Cooling (˚F WB)**	14-122
Heating (˚F DB)	-13 - 61

Unit Data:

Refrigerant Type	R410A
Refrigerant Control	EEV
Max Number of Indoor Units[2]	13
Sound Pressure[3] dB(A)	58.5
Net Unit Weight (lbs)	430
Shipping Weight (lbs)	452
Communication Cable[4] (No x AWG)	2 x 18
Heat Exchanger Coating	GoldFin™

Compressor:

Type	HSS SC Scroll
Quantity	1
Oil/Type	PVE/FVC68D

Fan:

Type	Propeller
Quantity	1
Motor/Drive	Brushless Digitally Controlled/Direct
Air Flow Rate (CFM)	7,400

Notes:

1.For AHRI ratings, refer to the AHRI website http://www.ahridirectory.org.
2.The combination ratio must be between 50 – 130%.
3.Sound Pressure levels are tested in an anechoic chamber under ISO Standard 3745.
4.All communication cable to be minimum 18 AWG, 2-conductor, stranded, shielded and must comply with applicable local and national code.
5.Nominal data is rated 0 ft above sea level, with 25 ft of refrigerant line per indoor unit and a 0 ft level difference between outdoor and indoor units. All capacities are net with a combination ratio between 95-105%.
6.Power wiring cable size must comply with the applicable local and national
7.The voltage tolerance is ± 10%.

Inverter

Intertek

AHRI CERTIFIED™ www.ahridirectory.org
Variable Refrigerant Flow (VRF) Multi-Split AC and HP AHRI Standard 1230

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Job Name/Location:

ARUN072BTE4

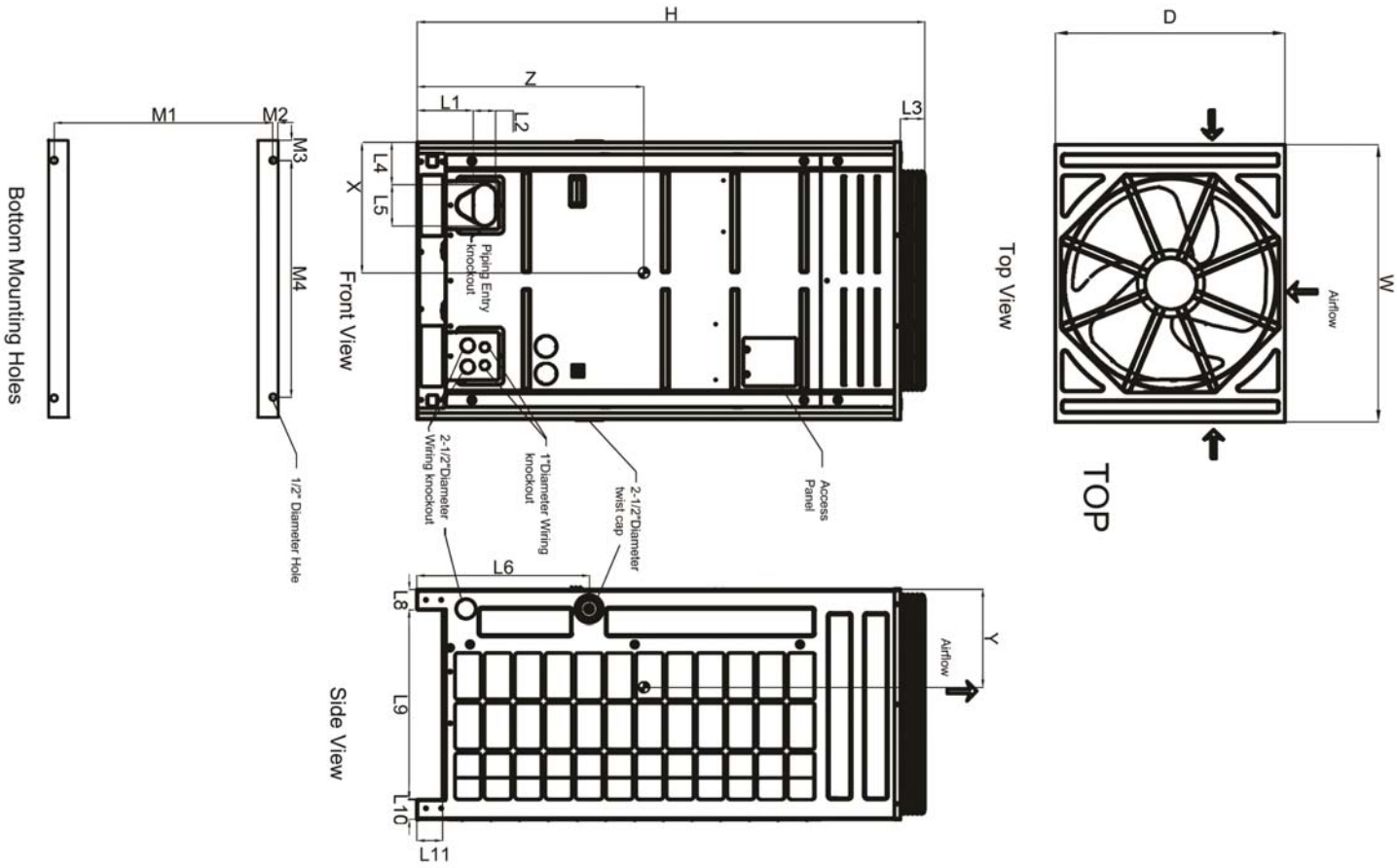
Multi V™ IV Heat Pump

6.0 Ton Outdoor Unit

Tag #:

Date:

PO No.:



W	36-1/4"
D	29-15/16"
H	66-1/8"
L1	7-1/4"
L2	2-15/16"
L3	3-1/8"
L4	5-1/2"
L5	5-3/8"
L6	22-7/16"
L7	2-9/16"
L8	2-9/16"
L9	24-3/16"
L10	2-9/16"
L11	3-5/16"
M1	29-1/16"
M2	7/16"
M3	2-5/8"
M4	31-3/16"

Center of Gravity

X	17-5/8"
Y	13-1/2"
Z	29-5/8"

Note - All dimensions have a tolerance of ± 0.25 in.

⊕ = Center of Gravity

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Job Name/Location: **Tag #:**

Date:

For: ☑ File ☑ Resubmit ☑ Approval ☐ Other

PO No.:

Architect: GC:

Engr: Mech:

Rep:

(Company) (Project Manager)



ARNH963K2A2

Hydro Kit Medium Temperature 96 MBh Indoor Unit

LG Life's Good

Performance:

Cooling Mode:

Rated Capacity (Btu/h)	95,900
Entering Water Temperature Range (°F)	50-86
Leaving Water Temperature Range (°F)	42-77

Heating Mode:

Rated Capacity (Btu/h)	107,500
Entering Water Temperature Range (°F)	59-113
Leaving Water Temperature Range (°F)	68-122

Air Source Outdoor Unit

Cooling Rated Test Conditions: Heating Rated Test Conditions:
Bldg Water: 95°F DB/75°F WB Bldg Water: 47°F DB/43°F WB
Water Temp. Inlet/Outlet: 73.4°F/65.5°F Water Inlet/Outlet: 86°F/94.8°F
Interconnected refrigerant pipe length is 25 ft at 0 elevation change.

Water Source Unit:

Cooling RatedTest Conditions: Heating Rated Test Conditions:
Bldg Water: 95°F Bldg Water: 47°F
Water Temp. Inlet/Outlet: 73.4°F/65.5°F Water Temp. Inlet/Outlet: 86°F/94.8°F
Interconnected refrigerant pipe length is 25 ft at 0 elevation change.

Electrical:

Power Supply[1] (V/Hz/Ø)	208-230/60/1
Power Input (kW) Cooling/Heating	0.01
Rated Amps (A)	0.05
MCA (A)	0.06
MOP (A)	15

MCA - Minimum Circuit Ampacity MOP – Maximum Overcurrent Protection

Piping:

Liquid Line (in, OD)	3/8 Braze
Vapor Line (in, OD)	7/8 Braze
Water Inlet/Outlet (in, OD)	1-MPT
Condensate Outlet (in, OD)	1-MPT

MPT - Male Pipe Thread

Included Accessories

- Hot Water Tank Temp Sensor with 32 ft communication cable [2,3]
- 1/2" MPT Hot Water Tank Sensor Well[2]
- Remote Wall Mounted Hydro Kit Controller with 32 ft communication cable [2, 3A]
- Standby Power Module [2,4]
- 1" Female Pipe Thread (FPT) #50 mesh inlet strainer[2]

Optional Accessories (sold seperately)

- ☐ Dry Contact – PQDSB1
- ☐ Remote Temperature Sensor – PQRSTA0
- ☐ Wired Remote Group Control Cable Assembly – PZWRCG3 [2,5]
- ☐ Solar Heating System Interface Kit - PHLLA

Unit Data:

Refrigerant Type	R410A
Refrigerant Control	EEV
Sound Pressure[6] dB(A) Heating/Cooling	26/26
Net Weight (lbs)	77
Shipping Weight (lbs)	89
Heat Rejected to Equipment Room (Btu/h)	Negligible
Factory Charge	Dry Nitrogen

Heat Exchanger:

Heat Exchanger	Refrigerant to Water
Heat Exchanger Type	316 Stainless Brazed Plate
Rated Water Flow (GPM)	24.3
Nominal Pressure Drop[7] (ft-wg)	23.1
Range of Flow (GPM)	8-24.3
Water Side Volume (US Gallons)	0.58
Water Side Design Pressure (psig)	464

Water Flow Control Options:

- Water Pump On/Off Interlock
- 208V 3-Way Diverting Valve [8,9,10]
- 208V 2-Way Heating Circuit Isolation Valve [8,10,11]

Standard Features:

- Water cooling and medium temperature heating
- Domestic water heating[12]
- Cold surface insulation
- Factory mounted inlet/outlet water temperature sensors
- Factory mounted internal flow switch
- Third party thermostat interface [10,13]
- Group control[14]
- Remote on/off site monitoring capability via the internet[15]

Notes:

1.Voltage fluctuation tolerance is ±10%.
2.Field mounted.
3.Cannot field splice.
3A. To extend cable length, use Group Control Extension Cable (PZCWRC1), sold separately.
4.On power outage, closes EEV valve(s) to prevent heat exchanger freezing.
5.Requires the installation of the Hydro Kit controller. Does not apply when used in conjunction with 3rd party thermostat.
6.Sound pressure levels tested in an anechoic chamber in accordance with ISO Standard 3475.
7.Water only (no antifreeze).
8.Not required on dedicated domestic water heating applications.
9.Alternates flow between comfort cooling/heating equipment and water heating tank.
10.Field provided and mounted.
11.Shut-off flow to in-floor heating circuit while operating in cooling mode.
12.Requires the use of an indirect water storage tank.
13.Field provided thermostat must be a 208V, 24V or mechanical type. Must be field adjustable heating only or cooling/heating with a manual changeover. Cooling and heating setpoint, deadband, and manual restart functions provided by Hydro Kit Controller are not available with use of a 3rd party thermostat. Cannot be used in conjunction with remote temperature sensor.
14.Wired Remote Group Control Cable Assembly (PZWRCG3) required and sold separately.
15.Monitoring capability available using LG's AC Smart Premium or a BMS system integration gateway (sold separately). Requires a field provided LAN/internet connection or BMS system provided by others.

Intertek Inverter

For continual product development, LG reserves the right to change specifications without notice.
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Job Name/Location:

ARNH963K2A2

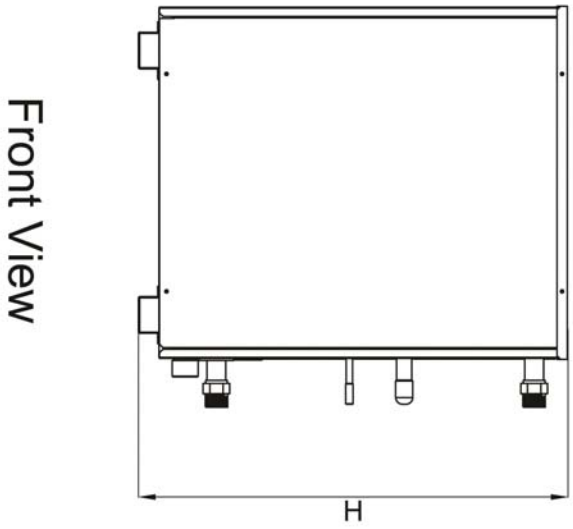
Hydro Kit Medium Temperature

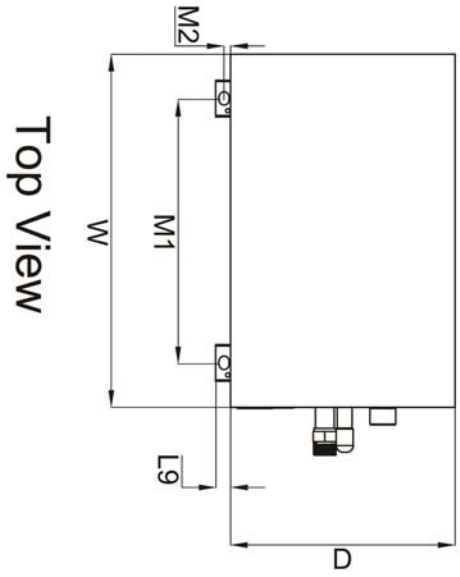
96 MBh Combination Water Heater and Cooler

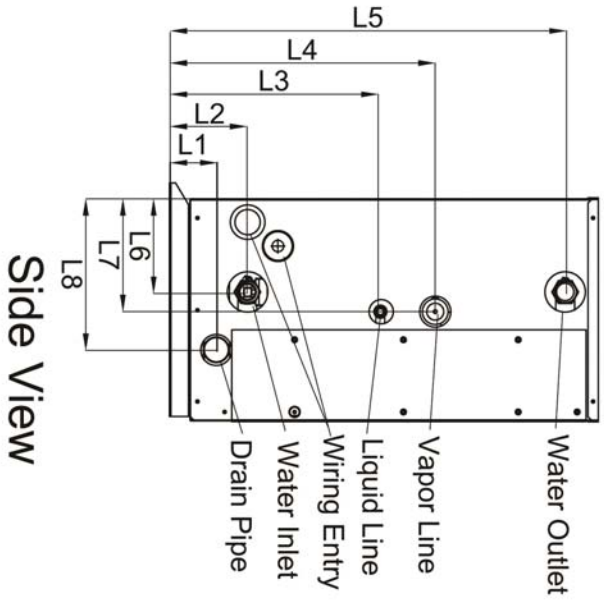
Tag #:

Date:

PO No.:







W	D	H	L1	L2	L3	L4	L5	L6	L7	L8	L9	M1	M2
20-5/8"	13-1/8"	24-3/4"	2-3/4"	4-9/16"	12-7/16"	15-9/16"	22-7/8"	5-7/16"	6-9/16"	8-3/4"	7/8"	15-7/16"	7/16"

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For more information and
customer assistance, please call
or visit our website.

Mailing Address
ATTN: B2B Air and Energy
201 James Record Road
Huntsville, Alabama 35824

LG Electronics, Inc.
www.lghvac.com

WARRANTY CARD 2/7
LG VARIABLE REFRIGERANT FLOW (VRF) SYSTEMS

Outdoor Units = ODUs, Indoor Units = IDUs
Applicable VRF Components
Multi V Air Cooled ODUs: ARUN***BTE4/DTE4, ARUB***BTE4/DTE4
Multi V Water Cooled Units: ARWN***BAS4/DAS4, ARWB***BAS4/DAS4
Multi V Space II Air Cooled Units: ARUN***GF2

Art Cool™ Mirror IDUs: ARNU***SER2/S8R2/SBR4/SCR4
Standard Wall Mount IDUs: ARNU***SEL2/S5L2/SBL4/SCL4

One-Way Ceiling Cassette IDUs: ARNU***TJC2/TUC4/TTC4
Two-Way Ceiling Cassette IDUs: ARNU*** TLC*
Four-Way (2' x 2') Ceiling Cassette IDUs: ARNU***TRC*/TQC*
Four-Way (3' x 3') Ceiling Cassette IDUs: ARNU***TPAA/TNAA/TNA*/TMAA/TMA*/TPC*/TNC*/TMC*

Ducted High Static IDUs: ARNU***BHA2/BGA*/BRA*/B8A*
Ducted Low Static IDUs: ARNU***B1G2/B2G2/L1G4/L2G4/L3G4
Ducted Low Static Built In IDUs: ARNU***B3G*/B4G*

Vertical/Horizontal AHU IDUs: ARNU***NJA*/NKA*

Ceiling Suspended IDUs: ARNU***VJA2

Convertible Surface Mount IDUs: ARNU***VEA2

Floor Standing IDUs: ARNU***CEA*/CFA*/CEU*/CFU*

Hydro Kit Units: ARNH***K2A2/K3B2
Dedicated Outdoor Air System Units: ARND***DAT2, ARND***DAR2
Energy Recovery Ventilator Units: ARVU***ZEA2

This limited warranty is valid in the United States and applies only in the country the product was purchased and installed, and only if the product was acquired from an authorized LG distributor, in the country in which the distributor was authorized to sell the product.

FOR A COPY OF THIS WARRANTY, VISIT WWW.LGHVAC.COM

LG MULTI V VRF SYSTEM LIMITED WARRANTY — USA

LG Electronics USA, Inc. ("LG") will replace defective internal functional parts ("Part[s]") of a qualified MULTI V VRF System ("System" as defined below) that fail during the warranty period if it proves to be defective in materials and/or factory workmanship under normal application, installation, use and service conditions. This Limited Warranty shall apply to the System sold by LG in the continental United States, Alaska and Hawaii and extend only to the original end use purchaser and subsequent owner(s) of location on which the System is originally installed (all such persons hereinafter referred to as "Customer"). A qualified system is defined as a System installed by an individual and/or company: (a) who holds a current government issued license that authorizes the individual and/or company to service and install heating, ventilation, and air conditioning equipment in the state where the System resides, if required; (b) where the system is installed, started, operated and service in compliance with (i) guidelines set forth in installation, operation, maintenance and engineering publications made available by LG, (ii) software based design programs made available by LG, (iii) local and state law and, (iv) applicable building, mechanical, plumbing and electrical codes and in accordance with best industry standards and practices.

LIMITED WARRANTY PERIOD

1. STANDARD ONE-YEAR PARTS WARRANTY FOR A QUALIFIED SYSTEM - The Part(s), including compressor are warranted for a period of one (1) year period beginning on the date of original installation or twenty four (24) months from the date of manufacture, whichever occurs first.
2. ADDITIONAL FIVE (5) YEAR COMPRESSOR PART WARRANTY - The Compressor is warranted for an additional five (5) year period from the second (2nd) through the sixth (6th) year after the date of original installation or twenty four (24) months from the date of manufacture, whichever occurs first.

EXTENDED WARRANTY

Standard one (1) year parts warranty is extended to two (2) years and six (6) year compressor warranty is extended to seven (7) years for a qualified system that has a completed commissioning report submitted to LG which includes two (2) hours of LGMV data. Extended parts and compressor warranty beginsfrom the date of the original installation or twenty four (24) months from the date of manufacture, whichever occurs first.

HOW DOES THIS LIMITED WARRANTY APPLY?

1. The remedies set forth in the Limited Warranty shall be the sole and exclusive remedies and the original warranty period in this Limited Warranty shall not extend beyond the period set forth therein, nor will a new warranty period begin, upon replacement of the Part(s) provided under this Limited Warranty.
2. Replacement Part(s) may be of like kind and quality and may be new or remanufactured Part(s) and warranted for the remaining portion of the original System's warranty period of ninety (90) days, whichever is longer.
3. Defective Part(s) must be made available to LG in exchange for the replacement Part(s) and become the property of LG. This Limited Warranty covers the transportation cost for reshipment of any replaced Part(s) to the Customer, but does not cover expedited shipping, risk including shipping damage or loss for return of the Part(s) to LG or its authorized agent and any other costs associated with installation, removal, or re-installation of the Part(s). If any Part(s) returned to LG are found not to be defective or this Limited Warranty has expired, the Customer is responsible to pay for return shipping cost.
4. This Limited Warranty does not cover charges for labor or other costs incurred in the trouble shooting, maintenance, repair, removing, replacing, installing, complying with local building and electric codes, handling, or replacement of Part(s) and the complete System.
5. LG will not be responsible or liable for any and all costs such as but not limited to any parts, labor, supplies, or refrigerant necessary to alter, rework, or modify the System to prepare the System for proper commissioning.
6. This Limited Warranty shall not be enlarged, extended, effected, and no obligation or liability shall be created by LG providing technical advice, information, service(s), applications suggestions, or equipment modifications to any person or entity associated with the installation of the System.

LIMITED WARRANTY EXCLUSIONS AND LIMITATIONS

1. A System sold and/or installed outside the continental United States, Alaska and Hawaii or removed from the location where it was originally installed.
2. A System sold AS IS or WITH ALL FAULTS or consumables.
3. A System that had a serial number or any Part(s) thereof altered, defaced or removed.
4. Charges related to the rental or purchase of temporary cooling, ventilating, and/or heating equipment.
5. Any and all freight charges, truck charges, trip charges, charges to pickup, transport, deliver and/or install the System, or any component or part of the System including costs to expedite shipments such as, but not limited to, air, overnight and/or courier charges.
6. Damage and/or failure caused by System misuse, neglect, or from a failure of the Customer to operate the System as specified by the manufacturer's instructions or perform necessary preventive and routine maintenance as defined in LG published documents. Routine maintenance includes such procedures including but not limited to cleaning the condensate drain system, evaporator, and condenser coils, cleaning and/or replacing of air filters or belts.
7. Damage and/or failure caused by any supplies or labor provided by any third party service provider that are beyond the terms of this Limited Warranty.
8. Damage and/or failure caused by a power surge (caused by lightning and fluctuations in or interruptions of electrical power), faulty power supply, fire, water, wind, impact damage from projectiles, earthquake, theft, riot, or any and all acts of God.
9. Damage and/or failure caused by improper wiring, installation, and handling of the System while in transit or in a storage facility or damage caused by force majeure.
10. Damage and/or failure caused by System exposure to corrosive chemical vapors and/or liquids.
11. Damage and/or failure caused by improper application of the System or any component of the System.
12. Damage and/or failure caused by modification and/or alteration of the System or any component of the System in order to meet government codes or regulations.
13. Maintenance or field provided part(s) other than those provided by LG such as filters, field installed components or accessories including but not limited to refrigerant piping, drain lines, control and electrical wiring, ductwork, etc.
14. Damage and/or failure caused by adjustments of user controls.
15. Acts, omissions, and conduct of any and all third parties including, but not limited to, the installing contractor.

LIMITATION OF WARRANTY SCOPE

EXCEPT TO THE EXTENT PROHIBITED BY APPLICABLE LAW, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE ON THE SYSTEM IS LIMITED IN DURATION OF THIS LIMITED WARRANTY. UNDER NO CIRCUMSTANCES SHALL LG BE LIABLE FOR ANY INCIDENTAL, SPECIAL OR CONSEQUENTIAL DAMAGES INCLUDING, WITHOUT LIMITATION, LOST GOODWILL, LOST REVENUE OR PROFITS, WORK, STOPPAGE, SYSTEM FAILURE, IMPAIRMENT OF OTHER GOODS, COST OF REMOVAL AND REINSTALLATION OF THE SYSTEM, LOSS OF USE, INJURY TO PERSONS OR PROPERTY ARISING OUT OF OR RELATED TO THE SYSTEM. LG'S TOTAL LIABILITY, IF ANY, DAMAGES OR OTHERWISE, SHALL NOT EXCEED THE INVOICE VALUE PAID BY THE CUSTOMER FOR THE SYSTEM FURNISHED, WHICH IS THE SUBJECT OF A CLAIM OR DISPUTE. SOME STATES DO NOT ALLOW THE EXCLUSION OR LIMITATION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES, OR ALLOW LIMITATIONS ON HOW LONG AN IMPLIED WARRANTY LAST, SO THE ABOVE LIMITATIONS OR EXCLUSIONS MAY NOT APPLY TO THE CUSTOMER. THIS LIMITED WARRANTY GIVES THE CUSTOMER SPECIFIC LEGAL RIGHTS. CUSTOMERS MAY ALSO HAVE OTHER RIGHTS THAT VARY FROM STATE TO STATE.

ASSERTION OF CLAIMS

The assertion of claims under this Limited Warranty presupposes that the Customer has: (i) informed the authorized reseller/distributor of the System in writing of the alleged claim, or that; (ii) this written notification has been sent directly to the address stated below in the event that the authorized reseller/distributor no longer exists (e.g. due to discontinuance of business or bankruptcy). Any such assertion of claims must be accompanied by the original sales receipt as the proof of purchase and time of installation of the System. The assertion of the claim must occur within thirty (30) days from the date that the claim is identified. The return of Part(s) may only occur after the written authorization of LG has been given.

OBTAINING WARRANTY PARTS AND ADDITIONAL INFORMATION

Customers who believe they have a justified claim covered by this Limited Warranty must immediately notify the authorized LG representative, or contact directly by calling to 1-888-865-3026, or by writing to:

LG ELECTRONICS USA, INC.
B2B AIR AND ENERGY
201 JAMES RECORD ROAD
HUNTSVILLE, AL 35824

DISPUTE

Except to the extent prohibited by applicable law, the Customer agrees she/he will not bring any action, regardless of form, arising out of or in any way connected with this Limited Warranty, more than one (1) year after the cause of action has occurred.

ARBITRATION

The laws of the state of Georgia govern this Limited Warranty and all of its terms and conditions, without giving effect to any principles of conflicts of laws. All actions at law or in equity arising out of or relating to these terms and conditions shall be submitted to confidential arbitration in Atlanta, Georgia. Arbitration under this Limited Warranty shall be conducted under the rules then prevailing of the American Arbitration Association. The arbitrator's award shall be binding and may be entered as a judgment in any court of competent jurisdiction. To the fullest extent permitted by applicable law, no arbitration under this Limited Warranty shall be joined to an arbitration involving any other party subject to this Limited Warranty, whether through class arbitration proceedings or otherwise.

SEVERABILITY

If a part, provision or section of this Limited Warranty, or its application to any person or circumstance is held invalid, void or unenforceable, such holding shall not affect this Limited Warranty and all other parts, provisions, clauses or applications shall remain, and, to this end, such other parts, provisions, clauses or applications of the Limited Warranty shall be treated as severable.

VALIDITY

This Limited Warranty shall be valid from October 1, 2013 and shall apply to all commercial MULTI V VRF Systems sold to specified Customers on or after this date. LG holds the right to amend the provisions, clauses or applications of this Limited Warranty from time to time without notice, however such changes would not be retrospective.

WD_MV_VRF_Warranty_2-7_Terms-07-15
Supersedes: WD_MV_VRF_Warranty_2-7_Terms-05-15

LG
Life's Good

Attachment G

Economics

- 25-yr cash flow analysis with key assumptions

Input Variables	Value	Units
Project Cost after 50% Grant	224,025	$
Yr 1 Cost Planned Air Exchange for Common Space	45,000	
Yr 5 Cost Fossil Fuel System Replacement	239,000	$
Projected 2016 Energy Costs with no EEMs	20,298	$
Projected 2016 Energy Costs with EEMs	14,101	$
Fossil Fuel Inflation Rate (apr)	3.0%	Percent
Electricity Inflation Rate (apr)	3.0%	Percent
General Inflation Rate (apr)	2.5%	Percent
Discount Rate (apr)	4.5%	Percent
Year 1 Increased O&M Cost	1,570	$/yr

Year	Energy Costs with Fuel Oil System	Energy Costs with EEMS Implemented	Added O&M Cost	Net Operating Savings	Present Value of Avoided Costs*	Net Cash Flow	Present Value of Cash Flow
0	$ -	$ -	$ -	$ -	$ 45,000	$ (179,025)	$ (179,025)
1	$ 20,298	$ (14,101)	$ (1,570)	$ 4,627		$ 4,627	$ 4,627
2	$ 20,907	$ (14,524)	$ (1,609)	$ 4,773		$ 4,773	$ 4,568
3	$ 21,534	$ (14,960)	$ (1,649)	$ 4,924		$ 4,924	$ 4,510
4	$ 22,180	$ (15,409)	$ (1,691)	$ 5,080		$ 5,080	$ 4,452
5	$ 22,845	$ (15,871)	$ (1,733)	$ 5,241	$ 239,000	$ 244,241	$ 204,811
6	$ 23,531	$ (16,347)	$ (1,776)	$ 5,407		$ 5,407	$ 4,339
7	$ 24,237	$ (16,837)	$ (1,821)	$ 5,578		$ 5,578	$ 4,284
8	$ 24,964	$ (17,343)	$ (1,866)	$ 5,755		$ 5,755	$ 4,229
9	$ 25,713	$ (17,863)	$ (1,913)	$ 5,937		$ 5,937	$ 4,175
10	$ 26,484	$ (18,399)	$ (1,961)	$ 6,124		$ 6,124	$ 4,121
11	$ 27,278	$ (18,951)	$ (2,010)	$ 6,318		$ 6,318	$ 4,068
12	$ 28,097	$ (19,519)	$ (2,060)	$ 6,518		$ 6,518	$ 4,016
13	$ 28,940	$ (20,105)	$ (2,111)	$ 6,723		$ 6,723	$ 3,965
14	$ 29,808	$ (20,708)	$ (2,164)	$ 6,936		$ 6,936	$ 3,914
15	$ 30,702	$ (21,329)	$ (2,218)	$ 7,155		$ 7,155	$ 3,863
16	$ 31,623	$ (21,969)	$ (2,274)	$ 7,380		$ 7,380	$ 3,814
17	$ 32,572	$ (22,628)	$ (2,331)	$ 7,613		$ 7,613	$ 3,764
18	$ 33,549	$ (23,307)	$ (2,389)	$ 7,853		$ 7,853	$ 3,716
19	$ 34,556	$ (24,006)	$ (2,449)	$ 8,101		$ 8,101	$ 3,668
20	$ 35,592	$ (24,726)	$ (2,510)	$ 8,356		$ 8,356	$ 3,621
21	$ 36,660	$ (25,468)	$ (2,573)	$ 8,619		$ 8,619	$ 3,574
22	$ 37,760	$ (26,232)	$ (2,637)	$ 8,891		$ 8,891	$ 3,528
23	$ 38,893	$ (27,019)	$ (2,703)	$ 9,170		$ 9,170	$ 3,482
24	$ 40,059	$ (27,830)	$ (2,770)	$ 9,459		$ 9,459	$ 3,437
25	$ 41,261	$ (28,665)	$ (2,840)	$ 9,757		$ 9,757	$ 3,392
						Net Present Value	$ 120,911

See table 2.3-5 in the report for listing of avoided costs.

Attachment H

Statement of Commitment and Cost Sharing

- Central Council Tlingit Haida Indian Tribes of Alaska Project Support
- Authorization for Application
- Statement of Commitment and Cost Sharing

CENTRAL COUNCIL
Tlingit and Haida Indian Tribes of Alaska
Edward K. Thomas Building
9097 Glacier Highway • Juneau, Alaska 99801

Date: September 14, 2015

RE: Letter of Support for THRHA's grant application to AEA for heat pumps in Saxman

Dear Alaska Energy Authority,

The Central Council Tlingit Haida Indian Tribes of Alaska (CCTHITA) is the federally-recognized tribe for SE Alaska, representing over 26,000 enrolled tribal members. We provide many services to our members throughout our region, and strongly support any programs that provide for the well-being of our members while protecting our resources.

We strongly support the Tlingit-Haida Regional Housing Authority's efforts to provide energy efficient and affordable housing in our region, and to reduce their usage of fossil fuels by converting to local clean and renewable energy sources. We strongly support THRHA's application to the Alaska Energy Authority for funding to convert their Saxman 12-unit low rent multifamily apartment building from oil heat to air source heat pumps.

This is the right thing to do in a hydroelectric community like Saxman. It will help assure that THRHA can continue to provide affordable housing in Saxman, and will demonstrate to all that clean, renewable, "green" energy solutions are available and a viable alternative to fossil fuels in our region.

We thank you kindly for considering this project for funding.

Sincerely

Richard J. Peterson
President

Regional Housing Authority

Tlingit-Haida Regional Housing Authority
RES 14-06
September 5, 2014

ENTITLED: AUTHORIZATION TO APPLY FOR GRANT PROGRAM FUNDS FOR TLINGIT-HAIDA REGIONAL HOUSING AUTHORITY

WHEREAS, Tlingit-Haida Regional Housing Authority (T-HRHA), in its efforts to develop additional affordable housing and economic development opportunities and programs; and

WHEREAS, the Board of Commissioner's authorization is required to apply for certain grant funding opportunities, and

WHEREAS, T-HRHA may apply for the following grant programs through 2015 where Board of Commissioner authorization is required:

1. Community Development Financial Institution (CDFI) Grant
2. HUD Indian Community Development Block Grant (ICDBG)
3. HUD Community Development Block Grant (CDBG)
4. HUD Rural Housing & Economic Development Grant (RHED)
5. HUD Rural Opportunities for Self-Sufficiency (ROSS)
6. AHFC HOME Grant
7. AHFC CHODO
8. Low Income Housing Tax Credit
9. Section 184 or Title VI Loan Guarantee Program
10. USDA Rural Community Development and Rural Utility Service Grants
11. Department of Energy and Tribal Department of Energy
12. Federal Home Loan Bank/AHP
13. Other federal, state, city, foundation or financial institution grant or loan opportunities that are housing- related that T-HRHA may be eligible to apply.

NOW, THEREFORE, BE IT RESOLVED that the Board of Commissioners of the Tlingit-Haida Regional Housing Authority does hereby support the preparation and submission of the above mentioned grant programs and authorizes the President/CEO to sign the appropriate grant applications and execute any related contract documents.

PASSED, ADOPTED AND APPROVED by the Board of Commissioners of the Tlingit-Haida Regional Housing Authority this 5th day of September, 2014 by a vote of 4 Yeas, 0 Nays and 1 Absent.

CERTIFY:

Joe Williams, Chairman
Board of Commissioner

ATTEST:

Virginia Lawnicki, Secretary
Board of Commissioner

Regional Housing Authority

September 15, 2015

Shawn M. Calfa
Grant Administrator
Alaska Energy Authority
813 West Northern Lights Blvd.
Anchorage, Alaska 99503

Re: Authorization to apply - Saxman, Alaska

Dear Mr. Calfa,

Tlingit-Haida Regional Housing Authority (THRHA) serves as the Tribally Designated Housing Entity for the community of Saxman, Alaska. In 2016 THRHA will be modernizing and improving the Saxman 12-unit low-rent multi-family building that is owned and operated by THRHA.

Whereas the THRHA desires to install heat pump technology where appropriate to provide reliable energy savings and reduce the use of non-renewable fossil fuels in THRHA buildings, and whereas AEA is offering funding through the Renewable Energy Fund for heating projects, as the President and CEO of THRHA, I affirm and support the submission of an AEA Renewable Energy Fund Grant Application for the design and construction of an air source heat pump project at the Saxman 12-unit low rent multifamily building, and I authorize Craig Moore to commit THRHA to the obligations as per the grant application and AEA requirements. Craig Moore, Joanne Wiita, and Joyce Niven will serve as AEA's main points of contact.

I certify that THRHA is in compliance with applicable federal, state, and local, laws including existing credit and federal tax obligations. The attached resolution RES 14-06 (13) September 5, 2014 demonstrates authorization to apply.

THRHA firmly commits match in the amount of $213,193 toward the AEA Saxman project and as indicated in the grant application.

The management body of THRHA supports the submission of the AEA grant application and authorizes Craig Moore, Vice President of Planning and Development to sign the grant application and execute any related contract documents.

Sincerely,

Ricardo Worl
President and CEO

P.O. Box 32237 Juneau, AK 99803 www.thrha.org (p) 907.780.6868 (f) 907.780.6895

Attachment I

Agreements

- Long-term lease from Saxman for building land

BOOK 70 PAGE 418
Petersburg Recording District

KETCHIKAN GATEWAY BOROUGH

PLANNING COMMISSION

RESOLUTION NO. 753

A RESOLUTION OF THE KETCHIKAN GATEWAY BOROUGH PLATTING BOARD APPROVING THE REQUEST OF THE CITY OF SAXMAN AND THE KLINGIT-HAIDA HOUSING DEVELOPMENT CORPORATION TO VACATE A PORTION OF UNDEVELOPED TOTEM AVENUE RIGHT-OF-WAY, LOCATED BETWEEN LOT 8, BLOCK 30, U.S. SURVEY 1652A AND UNSURVEYED U.S. SURVEY 1652 , LOCATED WITHIN THE CITY OF SAXMAN.

WHEREAS THE PLATTING BOARD OF THE KETCHIKAN GATEWAY BOROUGH, ALASKA RESOLVES as follows:

Section 1: In considering this request, the Platting Board is following the procedure set forth in KGB Code, 56.10.005.

Section 2: The Platting Board held a public hearing on this request on Tuesday, December 13, 1977.

Section 3: The Platting Board hereby approves the request of the City of Saxman and the Tlingit-Haida Housing Development Corporation to vacate the following portion of Totem Avenue:

> Beginning at the most northerly corner of Lot 8, Block 30, as shown on aforementioned plat of U.S. Survey No. 1652A, the true point of beginning of the portion herein described, thence N 53° 48' E, a distance of 30.00 feet; thence S 36° 12' E, a distance of 100.00 feet; thence S 53° 48' W, a distance of 30.00 feet; thence N 36° 12' W, a distance of 100.00 feet, back to the true point of beginning, containing an area of 3,000 square feet more or less.

PASSED AND APPROVED THIS 13th day of December, 1977.

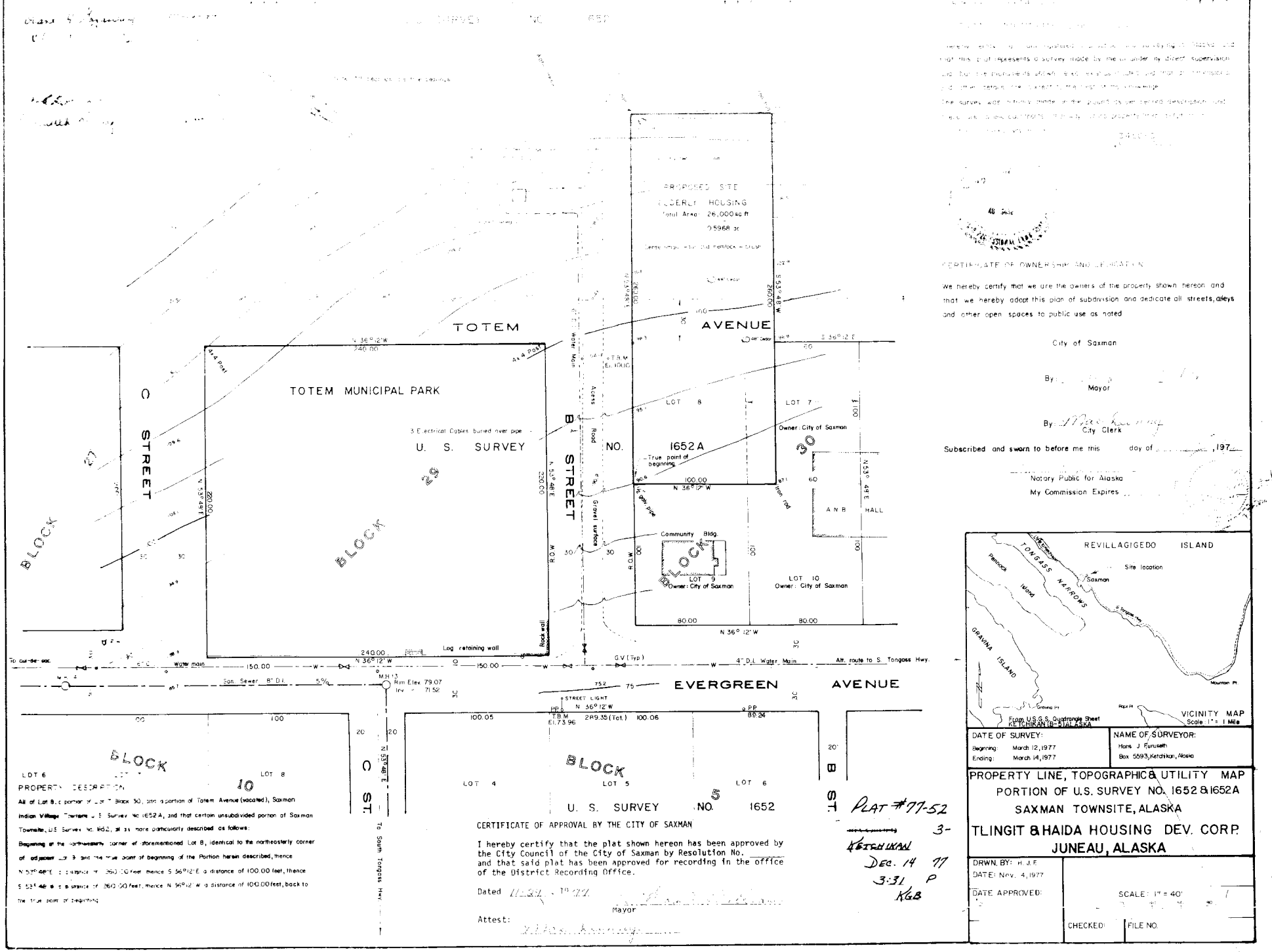
Gary Ward
Planning Commission Chairman

ATTEST:

Norma Dalton
Planning Commission Secretary

77-5264

RECORDED - PETERSBURG REC. DISTRICT
Dec 14 3 30 PM 77
REQUESTED BY KGB



PROPERTY DESCRIPTION

All of Lot 8, a portion of Lot 7, Block 30, and a portion of Totem Avenue (vacated), Saxman Indian Village Townsite, U.S. Survey No. 1652A, and that certain unsubdivided portion of Saxman Townsite, U.S. Survey No. 1652, all as more particularly described as follows:

Beginning at the northeasterly corner of aforementioned Lot 8, identical to the northeasterly corner of adjacent Lot 9 and the true point of beginning of the Portion herein described, thence N 53° 48' E a distance of 260.00 feet, thence S 36° 12' E a distance of 100.00 feet, thence S 53° 48' W a distance of 260.00 feet, thence N 36° 12' W a distance of 100.00 feet, back to the true point of beginning.

CERTIFICATE OF APPROVAL BY THE CITY OF SAXMAN

I hereby certify that the plat shown hereon has been approved by the City Council of the City of Saxman by Resolution No. _____ and that said plat has been approved for recording in the office of the District Recording Office.

Dated 11-30-77

Mayor

Attest:

CERTIFICATE OF OWNERSHIP AND DEDICATION

We hereby certify that we are the owners of the property shown hereon and that we hereby adopt this plan of subdivision and dedicate all streets, alleys and other open spaces to public use as noted.

City of Saxman

By _____ Mayor

By _____ City Clerk

Subscribed and sworn to before me this _____ day of _____, 197__

_____ Notary Public for Alaska

My Commission Expires _____

DATE OF SURVEY:	NAME OF SURVEYOR:
Beginning: March 12, 1977	Hans J. Furuseth
Ending: March 14, 1977	Box 5593, Ketchikan, Alaska

PROPERTY LINE, TOPOGRAPHIC & UTILITY MAP
PORTION OF U.S. SURVEY NO. 1652 & 1652A
SAXMAN TOWNSITE, ALASKA
TLINGIT & HAIDA HOUSING DEV. CORP.
JUNEAU, ALASKA

DRWN. BY: H. J. F.	
DATE: Nov. 4, 1977	
DATE APPROVED:	SCALE: 1" = 40'
	CHECKED: FILE NO.

PLAT #77-52
3-
KETCHIKAN
DEC. 14 77
3:31 P
KGB

BOOK 10 PAGE 19
Ketchikan Recording District

LEASE

This Lease, made and entered into this ___ day of _____, 1977, by and between the City of Saxman, Alaska, a municipal corporation, with its mailing address, Box 379, Ketchikan, Alaska, Lessor and Tlingit-Haida Housing Development Corporation, a non-profit corporation organized under the laws of the State of Alaska, its address being 811 West 12th Street, Juneau, Alaska, Lessee,

WITNESSETH:

1. Premises: Lessor, for and in consideration fo the rents and covenants hereinafter specified to be paid, performed and obeserved by the lessee, does hereby let, lease and demise unto the Lessee a fraction of U. S. Survey No. 1652A, described more particularly as follows:

> All of Lot 8, a portion of Lot 7, Block 30, also a portion of Totem Avenue, Saxman Indian Village Townsite, U. S. Survey No. 1652A, and that certain unsubdivided portion of Saxman Townsite, U. S. Survey No. 1652, all as more particularly described as follows:
>
> Beginning at the northwesterly corner of aforementioned Lot 8, identical to the northeasterly corner of adjacent Lot 9, and the true point of beginning of the portion herein described, thence N 53°48'E a distance of 260.00 feet, thence S 36°12'E a distance of 100.00 feet, thence S 53°48'W a distance of 260.00 feet, thence N 36°12'W a distance of 100.00 feet, back to the true point of beginning.

2. Purpose of Lease and Special Termination Provision: Said leased premises will be used by Lessee to construct an Elderly Housing Project. Should Lessee, within eighteen (18) months from the date hereto fail to enter into a mortgage contract and construction contract for the development of elderly housing to be constructed on the leasehold property, then said lease shall terminate and the remainder of the leasehold term shall revert to Lessor; provided that not more than sixty nor less than thirty days prior to the end of said eighteen month period, Lessor shall give written notice to Lessee at its address in Juneau, Alaska, of Lessor's intention to exercise said right of termination. Failure to give such notice during said time period, time being of the essence, shall constitute a waiver of Lessor's termination right under this paragraph.

3. Easements: The Lessor agrees that the orderly development of the leased property for the Elderly Housing Project may require creation of temporary and permanent easements for roads and utilities and hereby agrees to permit such easements. All expenses of creation and dedication of these easements shall be borne by the Lessee.

The described premises are leased, subject to patent restrictions and governmental regulations now in effect or hereafter adopted by any governmental authority.

4. Term: The term of this lease shall be for seventy-six (76) years, commencing on the date first above written, and terminating upon the 7 day of _____, 2053.

5. Rent: No rental shall be charged for the granting of this leasehold estate. Said leasehold estate is a grant to Lessee for the purpose of constructing elderly housing.

6. Taxes and Other Charges: Lessee agrees to pay to the public authorities charged with collection thereof, promptly as the same become due and payable, all taxes, assessments, general and special, permit, inspection and license fees and other public charges, whether of a like or different nature, levied upon or assessed against the leased premises and any buildings, structures, fixtures or improvements now or hereafter located thereon, or arising in respect of the occupancy, use of possession of the leased premises, and which are assessed and are, or become, a lien during the term of this lease. Lessee shall also pay all charges for water, gas, electricity, sewer, or other public utility services rendered during the term of this lease as such charges become due.

7. Compliance with Law: Lessee shall comply with all applicable laws, ordinances and regulations of duly constituted public authorities now or hereafter in any manner affecting the leased premises or the sidewalks, alleys, streets, and ways adjacent thereto or any buildings, structures, fixtures or improvements or the use thereof.

8. Quiet Possession: Provided Lessee is not in default hereunder, Lessor covenants that Lessee shall have peaceful and quiet enjoyment of the leased premises without let or hinderance on the part of Lessor, and the Lessor shall warrant and defend Lessee in the peaceful and quiet enjoyment of the leased premises.

9. Care of Premises: During the term of this lease, Lessee shall maintain or cause to be maintained in a reasonable state of repair the premises hereby leased, together with any and all buildings, structures, improvements, fixtures, or appurtenances thereto, whether now on the premises, or hereafter built, erected, affixed, or otherwise placed on or under the property hereby leased. Failure to so maintain in accordance with the foregoing shall constitute a default of the terms and conditions of this lease.

10. Destruction of Premises: If, at any time during the term of this lease, a substantial portion of the Elderly Housing Project shall be destroyed by wind, fire, earthquake or other casualty, and are not repaired or restored within one calendar year from the date of such casualty, such delay in repair and restoration shall constitute a default of the terms and conditions of this lease.

11. Default: If Lessee, at any time during the term of this lease, shall fail to observe or perform any of the covenants, agreements or obligations hereunder, and if such default shall not be cured within six months after Lessor shall have given to Lessee written notice specifying such default or defaults, Lessor shall have the right at his election, then or at any time thereafter, and while such default shall continue, to give Lessee notice of Lessor's intention to terminate this lease and all Lessee's rights hereunder, on a date specified in such notice, which date shall not be less than thirty (30) days after the date of giving of such notice, and on the date specified in such notice, the term of this lease and all rights granted Lessee hereunder shall come to an end, and Lessee hereby covenants peaceably and quietly to yield up and surrender to Lessor said leased premises and all structures, buildings, improvements and equipment located thereon, and to execute and deliver such instrument or instruments as shall be required by Lessor, as will properly evidence termination of Lessee's rights hereunder of the transfer of its interests therein.

12. Mortgage by Lessee: Lessee, its sublessees and assigns may at any time mortgage or convey deed of trust in the nature of a mortgage, its estate in the premises and any buildings or improvements thereon, provided it shall not be in default in any agreement herein contained to be kept, observed and performed by Lessee; and provided further no mortgagee or trustee or other person shall claim any greater rights in the premises and any building or improvement thereon than Lessee has under this lease, and futher provided that such mortgage or deed of trust shall be subject to all of the terms and conditions of this lease.

Should this lease be cancelled or forfeited for cause, the holder or owner of a properly recorded mortgage, conditional assignment, collateral assignment or other interest will have a sixty (60) day option from date of cancellation or forfeiture to cure the default and to acquire the lease for the unexpired term, subject to the same terms and conditions herein contained.

13. Successors in Interest: This lease shall be binding upon and shall inure to the benefit of the respective heirs, successors and assigns of the parties hereto. This lease may be sublet or assigned without permission of Lessor in order to accomplish the purpose of this lease; To provide elderly housing on the demised premises.

14. Federal Government Provisions: Notwithstanding any other provisions of this lease, if and so long as this leasehold is subject to a mortgage insured, reinsured, or held by the United States Federal Housing Commissioner or given to the Commissioner in connection with a resale, or the demised premises are acquired and held by him because of a default under said mortgage:

(a) The Lessee is authorized to obtain a loan, the repayment of which is to be insured by the Federal Housing Commissioner and secured by a mortgage on this leasehold estate. Lessee is further authorized to execute a mortgage on this leasehold and otherwise to comply with the requirements of the Federal Housing Commissioner for obtaining such an insured mortgage loan.

(b) The Federal Housing Commissioner, or his successors in office, shall have the option, in the event that he or his successors in office, through the operation of his contract of mortgage insurance, shall acquire title to the leasehold interest, to purchase good and marketable fee title to the demised premises, free of all liens and encumbrances except such as may be waived or accepted by him or his successors in office, within twelve (12) months after so acquiring the leasehold interest, for the sum of THREE THOUSAND SEVEN HUNDRED FIFTY AND NO/100 ($3,750.00), payable in cash, or by Treasury check, provided all rents are paid to date of transfer of title, upon first giving sixty (60) days written notice to the Lessor or other person or corporation who may then be the owner of the fee, and the owner of the fee shall thereupon execute and deliver to the Federal Housing Commissioner, or his successor in office, a deed of conveyance to the said demised premises, containing a covenant against the grantor's acts, but excepting therefrom such acts of the Lessee and those claiming by, through, or under the Lessee of the leasehold interest. Nothing in this option shall require the Lessor to pay any taxes or assessments which were due and payable by the Lessee.

(c) If approved by the Federal Housing Commissioner, Lessee may assign, transfer or sell his interest in the demised premises.

(d) (1) Insurance policies shall be in an amount, and in such company or companies and in such form, and against such risks and hazards, as shall be approved by such mortgagee and/or the Federal Housing Commissioner.

(2) The Lessor shall not take out separate insurance concurrent in form or contributing in the event of loss with that specifically required to be furnished by the Lessee to the mortgagee. The Lessor may, at its own expense, however, take out separate insurance which is not concurrent in form or not contributing in the event of loss with that specifically required to be furnished by the Lessee.

(e) (1) If all or any part of the demised premises shall be taken by condemnation, that portion of any award attributable to the improvements or damage to the improvements shall be paid to the mortgagee or otherwise disposed of as may be provided in the insured mortgage. Any portion of the award attributable solely to the taking of land shall be paide to the Lessor. After the date of taking, the annual ground rent shall be reduced ratably by the proportion which the award paid the Lessor bears to the total value of the land as established by the amount the Federal Housing Commissioner would be required to pay upon acquisition of the fee as set out in subparagraph 14 (b) of this addendum.

(2) In the event of a negotiated sale of all or a portion of demised premises in lieu of condemnation, the proceeds shall be distributed and ground rents reduced as provided in cases of condemnation, but the approval of the Commissioner and the mortgagee shall be required as to the amount and division of the payment to be received.

(f) The Lessor agrees that, within ten (10) days after receipt of written request from Lessee, it will join in any and all applications for permits, licenses or other authorizations required by any governmental or other body claiming jurisdiction in connection with any work which the Lessee may do hereunder, and will also join in any grants for easements for electric, telephone, gas, water, sewer and such other public utilities and facilities as may be reasonably necessary in the operation of the demised premises or of any improvements that may be erected thereon, and if, at the expiration of such ten (10) days' period, the Lessor shall not have joined in any such application, or grant of easements, the Lessee shall have the right to execute such application and grants in the name of the Lessor, and, for that purpose, the Lessor hereby irrevocably appoints the Lessee as its attorney-in-fact to execute such papers on behalf of the Lessor.

(g) Nothing in this lease contained shall require the Lessee to pay any transfer, estate, inheritance, succession, capital levy or transfer tax of the Lessor, or any income, excess profits or revenue tax, or any other tax, assessment,

charge or levy upon the rent payable by the Lessee under this lease.

(h) Upon any default under this lease which authorizes the cancellation thereof by the Lessor, Lessor shall give notice to the mortgagee and the Federal Housing Commissioner, and the mortgagee and the Federal Housing Commissioner, their successors and assigns, shall have the right within any time within six (6) months from the date of such notice to correct the default and reinstate the lease unless Lessor has first terminated the lease as provided herein.

At any time after two (2) months from the date a notice of default is given to the mortgagee and the Commissioner, the Lessor may elect to terminate the lease and acquire possession of the demised premises. Upon acquiring possession of the demised premises Lessor shall notify the Commissioner and mortgagee. Mortgagee and Commissioner shall have six (6) months from the date of such notice of acquisition to elect to take a new lease on the demised premises. Such new lease shall have a term equal to the unexpired portion of the term of this lease and shall be on the same terms and conditions as contained in this lease, except that the mortgagee's and Commissioner's liability for ground rent shall not extend beyond their occupancy under such lease. The Lessor shall tender such new lease to the mortgagee or Commissioner within thirty (30) days after a request for such lease and shall deliver possession of the demised premises immediately upon execution of the new lease. Upon executing a new lease the mortgagee or Commissioner shall pay to Lessor any unpaid ground rentals due or that would have become due under this lease to the date of the execution of the new lease, including any taxes which were liens on demised premises and which were paid by Lessor, less any net rentals or other income which Lessor may have received on account of this property since the date of default under this lease.

(i) All notices, demands and requests which are required to be given by the Lessor, the Lessee, the mortgagee or the Commissioner shall be in writing and shall be sent by registered or certified mail, postage prepaid, and addressed to the address of the party as given in the instrument unless a request for a change in this address has been sent to the party giving the notice by registered or certified mail prior to the time when such notice is given.

(j) This lease shall not be modified without the consent of the Federal Housing Commissioner.

IN WITNESS WHEREOF, the parties hereto have caused this instrument to be executed the day and year first above mentioned.

LESSOR: City of Saxman, Alaska

By: _____
Mayor

_____
City Clerk

LESSEE: Tlingit-Haida Housing Development Corporation

By: _____
Executive Director

STATE OF ALASKA)
) ss.
FIRST JUDICIAL DISTRICT)

On this ___ day of _____, 1977, before me, the undersigned, a Notary Public residing in _____, Alaska, in such state and city, personally appeared _____, known to me to be the Mayor of the City of Saxman, Alaska, and _____, known to me to be City Clerk of said Saxman, Alaska, and they severally acknowledged to me that they knew the contents of the foregoing instrument and that they knew the contents of the foregoing instrument and that they are such Mayor and City Clerk of said City and

BOOK 70 PAGE 423

in their official capacities aforesaid executed the foregoing instrument as a free act and deed of said municipality for the consideration and purposes therein mentioned.

WITNESS my hand and seal the day and year in the certificate first above written.

Notary Public for the State of Alaska
My Commission Expires: [illegible]

STATE OF ALASKA)
)ss
FIRST JUDICIAL DISTRICT)

THIS IS TO CERTIFY that on the 7 day of December, 1977, at Juneau, Alaska, Robert W. Loescher, Executive Director of Tlingit-Haida Housing Development Corporation, whom I know, appeared before me and acknowledged that he executed the foregoing instrument, was authorized so to do, knew the contents thereof and the same was his free act and deed for the purposes therein specified.

IN WITNESS WHEREOF, I hereto set my hand and seal the day and year in this certificate first above written.

Notary Public in and for Alaska
My Commission Expires: 9-17-78

IN WITNESS WHEREOF, the parties hereto have caused this Agreement to Cancel Lease and Amendments to be executed on the day, month, and year first above written.

LESSOR: City of Sitka, Alaska

By: _____
Mayor

_____
City Clerk

LESSEE: Tlingit-Haida Housing Development Corporation

By: _____
Executive Director

STATE OF ALASKA)
)ss
FIRST JUDICIAL DISTRICT)

On this 2 day of _____, 1977, before me, the undersigned, a notary public in and for Alaska, personally appeared _____, known to me to be the Mayor of the City of Sitka, Alaska, and _____, known to me to be the City Clerk if said Sitka, Alaska, and they severally acknowledged to me that they knew the contents of the foregoing instrument and that they are such Mayor and City Clerk of said City, that they are authorized to execute the same, and in their official capacities a foresaid executed the foregoing instrument as their free act and deed of said municipality for the uses and purposes therein mentioned.

WITNESS, my hand and seal the day and year in this certificate first above written.

_____
Notary Public for the State of Alaska
My Commission expires: _____

STATE OF ALASKA)
)
FIRST JUDICIAL DISTRICT)

THIS IS TO CERTIFY that on the 1 day of December, 1977, at Juneau, Alaska, Robert W. Loescher, Executive Director of Tlingit-Haida Housing Development Corporation, whom I know, appeared before me and acknowledged that he executed the foregoing instrument, was authorized so to do, knew the contents thereof and the same was his free act and deed for the purposes therein specified.

IN WITNESS WHEREOF, I hereto set my hand and seal the day and year this certificate first above written.

Charlotte M. Wilson
Notary Public in and for Alaska
My Commission Expires: 9-17-78

AGREEMENT TO CANCEL LEASE AND AMENDMENTS

THIS AGREEMENT, made and entered into this 7 day of December, 1977, by and between the City of Saxman, Alaska, a municipal corporation, with its mailing address being Box 379, Ketchikan, Alaska, hereinafter referred to as Lessor, and Tlingit-Haida Housing Development Corporation, a non-profit corporation organized under the laws of the State of Alaska, its address being 811 West 12th Street, Juneau, Alaska, hereinafter referred to as Lessee.

WITNESSETH:

WHEREAS, Lessor and Lessee entered into a certain Lease of Real Property dated October 19, 1977, and recorded the same date in Book 80, Pages 618-624, in the Ketchikan Recording District, First Judicial District, State of Alaska; and

WHEREAS, it has subsequently been determined that the legal discription of the subject real property contained in said Lease is erroneous, and the parties desire to correct the same and enter into a new agreement correctly describing the subject real property and embodying the terms and conditions of the instrument herein described,

NOW THEREFORE, the parties mutually agree that the Lease of Real Property dated October 19, 1977, shall be and is hereby terminated and declared to be null and void.

77-5766

19-

FILED
KETCHIKAN REC.
DISTRICT

Dec 14 3 40 PM '77

REQUESTED BY Tlingit-Haida
ADDRESS 811 West 12th St.
Juneau, Alaska

Attachment J

Subcontract Plan

Regional Housing Authority

Subcontracting Plan

Saxman Low-Rent Multifamily Deep Energy Retrofit Project

THRHA will be responsible for the implementation and administration of this project, and it is anticipated that this project would be procured as a design-build project, or possibly a design-bid-build project. THRHA has selected the contractors for this project at this point, and is thus submitting this subcontracting plan. Mr. Moore's team has extensive experience in managing building system and energy projects in this manner. Mr. Moore's team would scope out the project, and procure the design and construction team using THRHA's well established procurement procedures. Mr. Moore's team has the hands on experience to provide their own oversight/review of the design and construction oversight.

THRHA has a Procurement Policy in place which will be applied to the procurement of all contract labor and materials secured for this project. The THRHA Board of Commissioners, by resolution has adopted this Policy for implementation of all THRHA projects. THRHA Policy outlines the process for both procurement of identified goods and services required by established thresholds of the purchases (small purchase $0-$100,000); Sealed Bids/invitation for Bids (IFB), when applicable over $100,000; Competitive Proposals/Request for Proposals (RFP), when applicable over $100,000; and Non Competitive (Sole Source) Proposals, as well as the methods used for purchase (request for price quotes, request for proposals, and invitation for bids) that controls the method of procurement.

Attachment K

Resumes

- Craig Moore – VP Development and Construction Management
- Joyce Niven – VP Administration
- Irene Tupou – Finance Manager

Staff Background

Joyce M. Niven, Vice President of Administration

Academic

Bachelor of Arts	1987 Business, Finance Concentration, Western Washington University, Bellingham Washington

Professional

VP of Administration	Tlingit-Haida Regional Housing Authority January 2014 to present
Fiscal Officer	Tlingit-Haida Regional Housing Authority December 2004 to January 2014
Senior Accountant	Tlingit-Haida Regional Housing Authority November 2000 to December 2004
General Manager	Capital Office Supply 1995 – November 2000
Finance Manager	Capital Office Supply February 1990 to 1995
Accounting Supervisor	Fluor Daniel Inc. 1988 – December 1989

Community Involvement

Event Co-Chair	American Cancer Society Relay for Life of Juneau
Volunteer	Juneau Women of the Moose

Staff Background
Craig Moore, VP Planning and Development

Academic

Construction Technology	Portland Community College
Business Administration	Portland State College
Building Construction Technology	University of Alaska Southeast

Training in Advanced Cold Climate Homebuilding techniques; Lead-Based Paint Risk Assessments; OSHA regulations; HUD HQS inspections; Mold and Mildew assessments, Energy Efficiency and Indoor Air Quality.

Professional Licenses and Affiliations

- ICBO Combination Dwelling Inspector #1060428-55
- Professional Member #0393365 International Conference of Building Officials
- Certified AkWarm Energy Rater #65 - Alaska Housing Finance Corporation
- HUD 203(K) fee consultant #S0134 – rehab loans
- Charter Member Ketchikan Home Builders Association
- Board of Directors - Alaska Building Science Network
- Member, Alaska State Homebuilders Association
- Advisory Board Member, SE Region, Cold Climate Housing Research Center

Professional

DCM Manager	Tlingit-Haida Regional Housing Authority December 2003 to Present
Construction Coordinator	Tlingit-Haida Regional Housing Authority 1997 – 2003
Project Inspector	Ketchikan Gateway Borough
General Contractor ICBO Home Inspector Energy Rater	Owner First City Builders Ketchikan 1986 - 1997

Irene D Tupou

Professional Experience

Tlingit & Haida Regional Housing Authority (THRHA),

May 2009 - Present

Finance Manager

Responsible for oversight of all accounting and reporting activities lead all day-to-day finance operations of a budget of $20 million and supervise a team of 8 staff members including functional responsibility over accounting, accounts payable, accounts receivable, payroll, and grants administration. Oversee cash flow planning and ensure availability of funds as needed. Ensure THRHA has the systems and procedures in place to support effective program implementation and comply with audit standards. Work closely with program managers and their staffs, not only to educate them regarding finance and accounting procedures but also to explore how the finance function can support program operations.

Accounting Supervisor

Responsible for the day to day operations of fiscal department. Supervise staff engaged in payroll, accounts payable, travel, and accounts receivable. Also reconcile general ledger accounts, post adjusting journals to general ledger, and review daily cash receipts. Assist Controller in annual audit and special projects as assigned. Supervise 4 staff.

Central Council Tlingit & Haida Indian Tribes of Alaska (CCTHITA),

March 2000 – May 2009

Deputy Manager, Tribal Child Support

Assist in planning, directing, coordinating all program activities. Develop and implement department policies, procedures, and protocols conform to Tribal codes, policies and the Code of Federal Regulations. Ensure program components were developed with a focus on organizational mission, and goals identified in the Child Support Program's strategic plan. Develop, implement, and provide continuous training on data system to assist users in processing and/or accessing information needed. Responsible for case management which includes, assigning and reviewing cases and ensuring cases are in compliance with program requirements. Assist caseworkers in resolving issues with their assigned cases. Visit communities to promote program and answer questions regarding their cases. Generate financial and statistical reports, and file federal quarterly and annual reports for program. Perform Paternity tests for families. Act on behalf of the Manager during his/her absence. Assist in developing the department budget. In the absence of attorney presented cases in tribal court. Supervise 3 Child Support Specialists.

Supervisory Accountant

Responsible for the day to day operations of the CCTHITA's finance department. Supervise staff engaged in payroll, accounts payable, travel, cash deposits, benefits programs, budgets, and grants. Assist CFO with annual audit, indirect cost proposal, insurance, and special projects. Supervise 5 accounting support staff.

Accounting Technician

Process transactions for retirement plan. Post general ledger entries for investment transactions. Install upgrades or fixes for accounting system. Implement cash receipts and electronic timesheet modules. Develop procedures and training materials for employees. Assist department with accounting and computer software problems. Process payroll when Payroll Technician was not available.

LABYRINTH TECHNOLOGY, January 1999 – March 2000

Bookkeeper

Responsible for processing payrolls for affiliated companies. Complete federal and state reports. Ensure sufficient funds are in company bank accounts for all affiliated companies and process cash transfers when necessary. Responsible for accounts payable and accounts receivable. Reconcile bank statements and post entries in general ledger.

KLUKWAN, INC. May 1993 – January 1999

Pension/Insurance\Shareholder Specialist

Pension Plan - Verify eligibility and process of transactions involving cash transfers in or out of the trust. Reconcile trust statements. Communicate with participants to facilitate transactions for pension plan. Resolve participant questions and problems regarding benefits. Ensure corporate compliance with ERISA Act and Department Labor. Review and process retirement forms (i.e. beneficiary designations, salary deferrals, loans, hardships, and distributions) for 401k plan. Audit payroll reports to ensure accuracy regarding eligible wages and contributions. Enroll new participants and inform payroll offices of new or changed information. Maintain participants' files.

Cash Management – Daily processing of cash data and funding of subsidiary accounts as needed. Download daily cash transactions that affect all company checking accounts, estimate check clearing and cash needs for each subsidiary company and consolidate the Line of Credit from Bank. Prepare daily cash reports for management. Data entry of monthly transactions and reconcile cash accounts.

Insurance – Reporting, monitoring and administering the corporate property, casualty and liability insurance programs. Allocating and coding insurance invoices to proper subsidiary. Data entry of monthly insurance expenses and reconciles prepaid insurance accounts. Assist in the annual insurance renewal process.

Shareholder Services – Process monthly shareholder distribution checks and annual 1099's for shareholders. This included auditing reports and verifying calculations were accurate based on the dollar per share authorized. Process payments to shareholders for emergency loan program. Track repayments before issuing distributions and new loans. Ensure policies set by Board of Directors were followed. Resolve shareholders' questions. Reconcile shareholder expense accounts and post journals to general ledger. Assist shareholders in completing beneficiary forms. Maintain strict confidentiality of records and corporate information.

UNIVERSITY OF ALASKA SOUTHEAST, September 1987 – September 1992

Personnel Technician II

Resolve employee concerns on benefits and wages. Provide technical information and training to cost center clerks and outlying locations on personnel, payroll, benefits and the Human Resource Information Systems (HRIS) procedures. This position required extensive knowledge of policies, payroll practices, state and federal requirements, and benefits plans. Conduct orientations and exit interviews individually or in-group settings. Assist employees and departments in completing personnel and payroll forms. Reviewed payroll reports for discrepancies and made corrective actions when necessary. Calculate adjustments on pay, taxes, deductions, benefits and leave. Back up for Recruitment Technician which involved reviewing applications and screening documents to ensure compliance to EEO requirements; prepare job descriptions and advertisements.

Personnel Technician (Benefits)

Coordinate Annual Benefits Fair for employees. Compile HR statistics for reports from personnel records, verifying and determining placement of data. Re-design personnel and payroll forms for the University of Alaska statewide. Enroll employees in PERS, TRS, and Tax Shelter Annuities. Research records for years of service and report to State of Alaska retirement plans the number of years vested for employees. During the statewide implementation of HRIS (integrated data system) participated on payroll and forms committees. During this time developed forms for payroll and human resource which were used by all the University of Alaska's campuses.

Personnel Technician (Payroll)

Review payroll reports for discrepancies and made corrective action when necessary. Calculate payroll adjustments on leave, labor accounts, voids, retros, and overpayments. Process employee initiated actions such as taxes, benefits and deductions. Perform special projects that required researching personnel and payroll records and producing reports.

EDUCATION

B.S., Travel Management, Brigham Young University – Hawaii Campus, 1986
A.A., Business Information, Brigham Young University – Hawaii Campus, 1986

DE-0005179 Energy Efficiency Audit, Assessment, and Alternative Energy Study

July 30, 2015

Tlingit Haida Regional Housing Authority

Final Technical Report

Energy Efficiency Audits, Energy Usage Assessments, and Alternative Energy Studies for Low-Income, Multifamily Residences in Southeast Alaska Communities

Principal Investigator:
Craig Moore

Consortium/Teaming Members :
THRHA Weatherization Staff, WES Energy & Environment, Alaska Energy Engineering, Marquam George, Lime Solar, BacGen Solar, Michael Reid

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1.0 EXECUTIVE SUMMARY

Tlingit-Haida Regional Housing Authority (THRHA) received a DOE Tribal Energy Grant (Award #DE-EE0005179 – Energy Efficiency Audit, Assessment, and Alternative Energy Study) to assess 46 low-income multifamily residences owned and managed by THRHA in up to 14 southeast Alaska communities. The Objective of the grant was to identify efficiency measures to reduce energy costs by 30% for low-income multifamily housing by:

1. Decreasing energy demand by increasing multifamily housing energy efficiency
2. Reducing household energy consumption through energy conservation education and installation of energy upgrades
3. Projecting energy savings based on fossil fuel reduction to environmentally and economically benefit Tribal southeast communities

To accomplish the above **Item #2**, THRHA implemented the Energy Cents program to educate households on energy conservation behavior and ways to reduce energy costs. The Energy Cents program also provided homeowners with tools and materials to help seal, weatherize, and improve the efficiency of their homes. Data was collected and compiled to provide a useful baseline from which to estimate future energy savings. Information gathered from the Energy Cents program is being reported separately and is not included in this report.

To accomplish the above **Items #1 and #3**, energy audits were conducted on THRHA multifamily buildings to assess existing conditions and to model energy efficiency improvement options for future installation work. The methodology used trained professional energy assessors from THRHA's Weatherization Program as well as contracted energy auditors from the private sector to conduct on-site inspections of each building, compile data, and where appropriate, input the data into an energy modeling software program developed by the Alaska Housing Finance Corporation called AkWarm.

The AkWarm energy modeling software is used to record building shell data, heating and hot water system data, ventilation and airtightness data, and other data to produce an Energy Efficiency Rating Report. The AkWarm software can also produce an Improvement Options Report (IOR) to estimate the Savings to Investment Ratio (SIR, a type of life-cycle cost analysis), and the amount of energy savings that could be realized if certain improvements were completed. In some cases AkWarms were not completed, and the energy auditor used his/her professional observations to make recommendations. Actual energy use, fuel use, and fuel costs were compiled and provided in Section 4 Attachments for reference.

This report provides a final summary of the findings of the Energy Efficiency Audits, Assessments, and Alternative Energy Studies completed for the 13 communities and 48 buildings as a result of this grant award. The results of the studies add to the understanding of building energy use, potential for energy conservation, and corresponding economic feasibility for implementing identified projects. The research completed directly benefits the local communities since implementing cost savings projects allows THRHA to keep housing costs affordable for occupants.

2.0 THRHA COMMUNITIES EVALUATED WITH THE DOE K11 GRANT

THRHA manages buildings in 13 communities in Southeast Alaska that received funding from the DOE Tribal Energy Grant to complete Energy Efficiency Audits, Assessments, and Alternative Energy Studies. The communities evaluated under the DOE Tribal Energy Grant include:

- Angoon
- Craig
- Haines
- Hoonah
- Juneau
- Kake
- Kasaan
- Ketchikan
- Klawock
- Petersburg
- Saxman
- Wrangell
- Yakutat

The communities are spread out geographically across Southeast Alaska. Many are accessible exclusively by air or ferry. The communities of Craig, Klawock, and Kasaan are all located on Prince of Wales Island and are connected to each other by the extensive road system within the island. The community of Hydaburg was originally considered for evaluation, however THRHA sold the multifamily building to the local tribe and is not included in the report.

There are a wide range of utility prices between the communities due to differing fuel sources for electricity generation and accessibility for heating fuel deliveries. Angoon, Hoonah, and Yakutat are all high-cost diesel electric communities paying in excess of $0.50/kWh. The remaining communities have access to hydroelectric generation and pay $0.25/kWh or less. This section provides a summary of the Energy Efficiency Measures identified and Assessments of Alternative Energy Sources evaluated for the communities under the DOE Tribal Energy Grant. Each community is listed alphabetically.

2.1 ANGOON

The City of Angoon, Alaska is located on Admiralty Island approximately 60 miles southwest of Juneau. The average annual high temperature is 47.6°F and the average annual low temperature is 36.9°F. Annual Heating Degree Days (HDD) base 65F = 8,284 HDD. The community has a population of 456 with an average household income of approximately $64,869 per year. Many jobs are seasonal or temporary

Transportation of goods and people to and from Angoon is primarily by water and air. As an island community, Angoon is not road-connected to other Alaskan communities. Air transport is by float plane only since there is no airport. Angoon is served by the AMHS ferry system and the schedule varies by month and season. The ferries serving Angoon have a limited carrying capacity and can only accommodate containers on chassis of 20 feet or less. Angoon does not have regularly scheduled barge service and all materials transported by AMHS must yield to their regulations and the limited carrying capacity. No fuel oils may be transported on an AMHS ferry. Chartered barges and landing craft may be used for transporting goods and materials, but may require a beach landing since there is no barge dock or container transfer facility. However, The Angoon Trading Company (Angoon Oil and Gas) has made arrangements with AMHS to use the ferry dock and ramp to offload oil and fuel that is transported by Alaska Marine Lines barge service.

Angoon is a high cost energy community that endures extremely high utility costs. Residential homes in Angoon predominantly use fuel oil heat and electricity is provided by Inside Passage Electric Cooperative (IPEC), generated by fuel oil fired generators. IPEC has the ability to recover heat, and is currently supplying waste heat to the nearby elementary school and high school. It's unlikely there is enough excess heat to economically supply additional buildings. A small percentage of residential homes heat with locally sourced wood. It is typically cost effective to implement energy efficiency upgrades in Angoon due to the high cost of energy.

Angoon Fuel has heating oil and LPG available for purchase in Angoon. They also make fuel deliveries to residences. There is no supplier in Angoon for bulk wood pellets or 40# bags of wood pellets. There are no warehouses to store wood pellets. There are no commercial suppliers of cord wood. Angoon has no general contractors, or electrical or heating contractors.

Current utility prices are $0.62/kWh for electricity and $5.36/gallon for #1 fuel oil. The electric price is subsidized for residential customers at $0.2447/kWh for the first 500 kWh by the Alaska Energy Authority through the Power Cost Equalization (PCE) program. Additionally, wood pellets can be purchased from fuel suppliers located in Ketchikan, Alaska. Anticipated costs per ton including shipping will range from $400 to $450 per ton. No wood pellet systems are currently utilized in Angoon. Table 2.1-1 shows an energy cost comparison for heating fuels.

Table 2.1-1 : Angoon Cost of Energy Comparison

Technology, Unit	Input Btu/Unit	Cost/Unit	Assumed Efficiency	Output Btu/Unit	Cost/ mmBtu Output
#1 Fuel Oil, Gallon	134,000	$5.36	80%	107,200	$50.00
Propane, Gallon	91,300	$6.26	80%	73,040	$85.71
Electricity, kWh (Resistance)	3,412	$0.62	100%	3,412	$181.71
Electricity, kWh (Heat Pump)	3,412	$0.62	300%	10,236	$60.57
Wood Pellets, Ton	15,200,000	$400.00	80%	12,160,000	$32.89

Note: Fossil fuel prices provided by AkWarm software based on the 3/30/2015 library. Biomass & propane prices obtained from local providers.

2.1.1 Angoon Multi-Family Dwellings

THRHA owns and operates a community center and 22 residential low-income housing units within 8 multiplex buildings located in Angoon, Alaska. Four duplex, two triplex, two fourplex and a community building consist of 21,772 ft^2 of conditioned floor space. The buildings utilize hot water boilers manufactured by Burnham that fire on #1 fuel oil. Circulating pumps distribute heating water through baseboard radiators for space heating. Domestic hot water is generated with the heating boilers using indirect hot water storage tanks.

The boilers have been in operation for 18 years and are scheduled to be replaced in the near future. Fuel use for space heating and domestic hot water totaled 11,400 gallons of #1 fuel oil. Current fuel oil prices are $5.36/gallon which results in a total annual cost of $61,104 for space heating and domestic hot water. THRHA has weatherized the buildings under a State weatherization program to ensure energy efficiency as the first measure of energy conservation.

Duplex Units: Style #1

Two Duplex Style #1 buildings located in Angoon are operated by THRHA. They are two story, 4 bedrooms each, stick frame construction, vinyl sided, and have steel roofs. Figures 2.1-1 and 2.1-2 show the typical outside and mechanical room of a Duplex Style #1 building.



Figure 2.1 – 1 : Typical Angoon Duplex Style #1



Figure 2.1 – 2 : Typical Angoon Duplex Style #1 Mechanical Room

The addresses associated with the four units in this style are provided in Table 2.1-2.

Table 2.1-2 : Angoon Duplex Style #1 Building Addresses

Building Address	Layout Style
801 Xootz Road 1A	Duplex Style #1
803 Xootz Road 1B	
805 Xootz Road 2A	
807 Xootz Road 2B	

Square footages and insulation values of building components are listed in Table 2.1-3.

Table 2.1-3 : Angoon Duplex Style #1 Insulation Values and Area of Building Components

Item	Floors	Walls	Entry Door	Mechanical Door	Windows	House Attic	Mechanical Attic
R-Value	37.2	16.7	2.6	5.0	3.6	55.2	40.4
Area, ft^2	829	1,440	20	20	111	784	45

Two Burnham hot water boilers firing on #1 fuel oil are used for each duplex building, with one dedicated boiler per housing unit. The boilers are each rated at 84,000 Btu/hr and have an efficiency of 78% as determined by a stack test. Hot water circulation pumps distribute hot water for space heating. Table 2.1-4 provides a breakdown of annual energy costs for two units in the Duplex Style #1 buildings. Values are provided from AkWarm reports using the 3/30/2015 data library.

Table 2.1-4 : Annual Duplex Style #1 Energy Cost Breakdown

Unit	Space Heating #1 Oil Use, Gallons	Space Heating #1 Oil Cost	Water Heating #1 Oil Use, Gallons	Water Heating #1 Oil Cost	Appliances / Lights Electric Use, kWh	Appliances / Lights Electric Cost	Total Annual Costs
1	251	$1,345	217	$1,163	6,778	$1,627	$4,135
2	255	$1,367	217	$1,163	6,778	$1,627	$4,157
Totals	**506**	**$2,712**	**434**	**$2,326**	**13,556**	**$3,253**	**$8,292**

Note: Fuel use and cost information provided by AkWarm software based on the 3/30/2015 library

Duplex Units: Style #2

Two Duplex Style #2 buildings located in Angoon are operated by THRHA. They are one story, 3 bedrooms each, stick frame construction, vinyl sided, and have steel roofs. Figure 2.1-3 shows the typical outside of a Duplex Style #2 building.



Figure 2.1 – 3 : Typical Angoon Duplex Style #2

The addresses associated with the four units in this style are provided in Table 2.1-5.

Table 2.1-5 : Angoon Duplex Style #2 Building Addresses

Building Address	Layout Style
809 Xootz Road 3A	Duplex Style #2
811 Xootz Road 3B	
813 Xootz Road 4A	
815 Xootz Road 4B	

Square footages and insulation values of building components are listed in Table 2.1-6.

Table 2.1-6 : Angoon Duplex Style #2 Insulation Values and Area of Building Components

Item	Floors	Walls	Front Entry Door	Rear Entry Door	Windows	House Attic
R-Value	37.2	16.2	2.6	5.0	3.6	61.5
Area, ft^2	1,125	784	20	20	74	1,125

Two Burnham hot water boilers firing on #1 fuel oil are used for each duplex building, with one dedicated boiler per housing unit. The boilers are each rated at 84,000 Btu/hr and have an efficiency of 79% as determined by a stack test. Hot water circulation pumps distribute hot water for space heating Table 2.1-7 provides a breakdown of annual energy costs for two units in the Duplex Style #2 buildings. Values are provided from AkWarm reports using the 3/30/2015 data library.

Table 2.1-7 : Annual Duplex Style #2 Energy Cost Breakdown

Unit	Space Heating #1 Oil Use, Gallons	Space Heating #1 Oil Cost	Water Heating #1 Oil Use, Gallons	Water Heating #1 Oil Cost	Appliances / Lights Electric Use, kWh	Appliances / Lights Electric Cost	Total Annual Costs
1	168	$900	179	$959	6,428	$1,543	$3,403
2	249	$1,335	179	$959	6,428	$1,543	$3,837
Totals	**417**	**$2,235**	**358**	**$1,919**	**12,856**	**$3,085**	**$7,239**

Note: Fuel use and cost information provided by AkWarm software based on the 3/30/2015 library

Triplex Units

Two Triplex buildings located in Angoon are operated by THRHA. They are one story, 1 bedroom each, stick frame construction, vinyl sided, and have steel roofs. Figure 2.1-4 shows the typical outside and mechanical room of a Triplex building.



Figure 2.1 – 4 : Typical Angoon Triplex

The addresses associated with the six housing units are provided in Table 2.1-8.

Table 2.1-8 : Angoon Triplex Building Addresses

Building Address	Layout Style
806 Xootz Road 7A	Triplex
808 Xootz Road 7B	
810 Xootz Road 7C	
814 Xootz Road 9A	
816 Xootz Road 9B	
818 Xootz Road 9C	

Square footages and insulation values of building components are listed in Table 2.1-9.

Table 2.1-9 : Triplex Insulation Values and Area of Building Components

Item	Floor	Walls	Entry Door	South Atrium Door Windows	Windows	House Attic
R-Value	37.2	16.7	2.6	2.0	3.6	73.4
Area, ft^2	598	368	20	40	17	598

Three Burnham hot water boilers firing on #1 fuel oil are used for each Triplex building, with one dedicated boiler per housing unit. The boilers are each rated at 84,000 Btu/hr and have an efficiency of 76% as determined by stack test. Hot water circulation pumps distribute hot water for space heating. Table 2.1-10 provides a breakdown of annual energy costs for three units in each triplex building. Values are provided from AkWarm reports using the 3/30/2015 data library.

Table 2.1-10 : Annual Triplex Energy Cost Breakdown

Unit	Space Heating #1 Oil Use, Gallons	Space Heating #1 Oil Cost	Water Heating #1 Oil Use, Gallons	Water Heating #1 Oil Cost	Appliances / Lights Electric Use, kWh	Appliances / Lights Electric Cost	Total Annual Costs
1	63	$338	62	$332	5,585	$1,340	$2,010
2	65	$348	62	$332	5,585	$1,340	$2,021
3	88	$472	62	$332	5,586	$1,341	$2,145
Totals	**216**	**$1,158**	**186**	**$997**	**16,756**	**$4,021**	**$6,176**

Note: Fuel use and cost information provided by AkWarm software based on the 3/30/2015 library

Fourplex Units

Two Fourplex buildings located in Angoon are operated by THRHA. They are two story, 2 bedrooms each, stick frame construction, vinyl sided, and have steel roofs. Figure 2.1-5 shows the typical outside and mechanical room of a Fourplex building.



Figure 2.1 – 5 : Typical Angoon Fourplex

The addresses associated with the eight housing units provided in Table 2.1-11.

Table 2.1-11 : Angoon Fourplex Building Addresses

Building Address	Layout Style
817 Xootz Road 5A	Fourplex
819 Xootz Road 5B	
821 Xootz Road 5C	
823 Xootz Road 5D	
825 Xootz Road 6A	
827 Xootz Road 6B	
829 Xootz Road 6C	
831 Xootz Road 6D	

Square footages and insulation values of the building components are listed in Table 2.1-12.

Table 2.1-12 : Fourplex Insulation Values and Area of Building Components

Item	Living Area Floors	Mechanical Area Floors	Walls	Entry Door 1	Entry Door 2	Windows	House Attic Apartment C	Mechanical Attic	House Attic Apartment D
R-Value	36.3	8.3	16.2	2.6	5.0	3.6	57.6	40.4	66.0
Area, ft^2	1,772	140	2,924	20	80	444	886	140	886

The Fourplex buildings have recently been converted from using 4 boilers with each serving a unit to one central oil boiler for all 4 units. The new hot water boilers are manufactured by Weil

McLain and are rated at 170,000 Btu/hr with #1 fuel oil. Hot water circulation pumps distribute hot water for space heating. An indirect domestic hot water storage tank is heated using water from the hydronic heating system to charge the tank. Table 2.1-13 provides a breakdown of annual energy costs for four units in each Fourplex building. Values are provided from AkWarm reports using the 3/30/2015 data library.

Table 2.1-13 : Annual Fourplex Energy Cost Breakdown

Unit	Space Heating #1 Oil Use, Gallons	Space Heating #1 Oil Cost	Water Heating #1 Oil Use, Gallons	Water Heating #1 Oil Cost	Appliances / Lights Electric Use, kWh	Appliances / Lights Electric Cost	Total Annual Costs
1	428	$2,294	450	$2,412	24,407	$5,857	$10,563
2	428	$2,294	450	$2,412	24,407	$5,857	$10,563
3	428	$2,294	450	$2,412	24,407	$5,857	$10,563
4	428	$2,294	450	$2,412	24,407	$5,857	$10,563
Totals	**1,712**	**$9,176**	**1,800**	**$9,648**	**97,628**	**$23,428**	**$42,252**

Note: Fuel use and cost information provided by AkWarm software based on the 3/30/2015 library

2.1.2 Improvement Option Recommendations

The energy audits of the facilities generated a list of energy efficiency recommendations. THRHA has weatherized the buildings under a State weatherization program to ensure energy efficiency as the first measure of energy conservation. Blower door tests and walkthrough assessments were conducted by professional energy auditing companies. Energy efficiency measures considered for the Angoon multiplex buildings are as follows:

- Air sealing and insulation.
- Energy efficient lighting
- Replace refrigerators with Energy Star rated refrigerators

A summary of energy conservation measures are provided in Tables 2.1-14 through 2.1-17 for each building type.

Table 2.1-14: Duplex 1 Energy Efficiency Measure Cost Benefit Summary

Energy Efficiency Measure	Duplex 1 Savings	Estimated Total Cost	Simple Payback, Years	SIR
Caulk and Seal so that Home Air Leakage is Reduced by 200 CFM at 50 Pascals.	$374	$400	1.1	8.6
Lighting Upgrade	$554	$2,860	5.2	1.5
Energy Star Refrigerator	$220	$2,000	9.1	1.8
Totals	**$1,148**	**$5,260**	**4.6**	

Notes:
1 – Costs and savings values for air sealing are estimated using the AkWarm software.
2 – Energy Star rated refrigerator savings are generated from www.energystar.gov savings calculator.
3 – A detailed breakdown of lighting assumptions is provided in Section 4 Attachments.

Table 2.1-15: Duplex 2 Energy Efficiency Measure Cost Benefit Summary

Energy Efficiency Measure	Duplex 2 Savings	Estimated Total Cost	Simple Payback, Years	SIR
Caulk and Seal so that Home Air Leakage is Reduced by 500 CFM at 50 Pascals.	$571	$1,000	1.8	5.3
Lighting Upgrade	$519	$2,460	4.7	1.7
Energy Star Refrigerator	$220	$2,000	9.1	1.8
Totals	**$1,310**	**$5,460**	**4.2**	

Notes:
1 – Costs and savings values for air sealing are estimated using the AkWarm software.
2 – Energy Star rated refrigerator savings are generated from www.energystar.gov savings calculator.
3 – A detailed breakdown of lighting assumptions is provided in Section 4 Attachments.

Table 2.1-16: Triplex Energy Efficiency Measure Cost Benefit Summary

Energy Efficiency Measure	Triplex Savings	Estimated Total Cost	Simple Payback, Years	SIR
Caulk and Seal so that Home Air Leakage is Reduced by 300 CFM at 50 Pascals.	$141	$900	6.4	1.2
Lighting Upgrade	$676	$2,490	3.7	2.2
Energy Star Refrigerator	$330	$3,000	9.1	1.8
Totals	**$1,147**	**$6,390**	**5.6**	

Notes:
1 – Costs and savings values for air sealing are estimated using the AkWarm software.
2 – Energy Star rated refrigerator savings are generated from www.energystar.gov savings calculator.
3 – A detailed breakdown of lighting assumptions is provided in Section 4 Attachments.

Table 2.1-17: Fourplex Energy Efficiency Measure Cost Benefit Summary

Energy Efficiency Measure	Fourplex Savings	Estimated Total Cost	Simple Payback, Years	SIR
Caulk and Seal so that Home Air Leakage is Reduced by 800 CFM at 50 Pascals.	$2,120	$3,200	1.5	6.2
Lighting Upgrade	$970	$4,120	4.2	1.9
Energy Star Refrigerator	$440	$4,000	9.1	1.8
Totals	**$3,530**	**$11,320**	**3.2**	

Notes:
1 – Costs and savings values for air sealing are estimated using the AkWarm software.
2 – Energy Star rated refrigerator savings are generated from www.energystar.gov savings calculator.
3 – A detailed breakdown of lighting assumptions is provided in Section 4 Attachments.

THRHA is also considering upgrading portions of the building due to necessity that are not driven by energy savings. A summary of potential upgrades being considered are as follows:

- Install new heat recovery ventilator system in the central corridor and common spaces.
- Install a wood pellet heating system.

Ventilation – The buildings currently have old and mostly inoperable heat recovery ventilation (HRV) systems for whole house ventilation. They also have bathroom exhaust fans with motion sensors. THRHA would like to replace the old HRV systems with new energy efficient heat recovery ventilator systems for whole house ventilation to improve indoor air quality and meet the ventilation standards for ASHRAE 62.2-2012. The estimated installed cost for a heat recovery ventilator is $50,000.

Wood Pellet Boiler System - A district heating system utilizing wood pellet fired hot water boilers is under consideration for installation. The system would include: a central wood pellet fired boiler plant, buried pre-insulated distribution piping, and interconnection with each building for space heating and domestic hot water heating. One new fuel oil boiler would be installed in each building for backup and supplemental heat during peak heating conditions. Table 2.1-18 shows a summary of costs and savings for the wood pellet system serving all of the THRHA buildings in Angoon. All values are from the August 22, 2014 version of *"Angoon Multifamily Apartments Biomass Pre-Feasibility Report"* created by Alaska Wood Energy Associates.

Table 2.1-18 : Wood Pellet District Heating System Economic Summary

Current Oil Use, Gallons	Current Oil Cost	Estimated Wood Pellet Use, Tons	Estimated Wood Pellet Cost	Estimated O&M Costs	Estimated Oil Cost with Wood Pellet System	Estimated Savings	Estimated Capital Cost	Simple Payback, Years
11,400	$61,104	103	$30,900	$2,178	$25	$28,001	$323,898	11.6

Note: Based on $5.36/gallon of #1 fuel oil and $300/ton of wood pellets. Annual oil use, wood pellet use, fuel costs, and O&M values are from the August 22, 2014 report titled "Angoon Multifamily Apartments Biomass Pre-Feasibility Report" created by Alaska Wood Energy Associates.

2.2 CRAIG

The city of Craig, Alaska is located on the west coast of Prince of Wales Island and is 55 air miles northwest of Ketchikan, Alaska. The average annual high temperature is 51.0°F and the average annual low temperature is 40.0°F. Annual Heating Degree Days (HDD) base 65F = 7,124 HDD.

The community has a population of 1,232 with the median age being 36.6 years old. There are 520 housing units in Craig. Owner occupied units number 329, while there are 163 renter occupied units. The community is classified as subsistence and relies on fishing and related support businesses as well as logging support, sawmill operations, and tourism as the economic base.

Craig is not directly accessible from the main land. Travel to Craig is through Ketchikan, Alaska by either flying Alaska Airlines or using the Alaska Marine Highway Ferry (AMHF). From Ketchikan, service to Craig is through small commuter airlines or The Inter-Island Ferry Authority (IFA) which has daily service between Ketchikan and Hollis on Prince of Wales Island. The IFA terminal on Prince of Wales Island is 30 miles from Craig over paved roads. The Port of Craig is comprised of 3 harbors and 2 docks. Alaska Marine Lines provides weekly barge service for cargo.

Current utility prices are $0.23/kWh for electricity and $4.10/gallon for #1 fuel oil. Additionally, wood pellets can be purchased from fuel suppliers located in Ketchikan, Alaska. Anticipated costs per ton including shipping will range from $330 to $400 per ton. No wood pellet systems are currently utilized in Craig. Bio-Bricks are now being produced and are available in palletized form. Costs ranges from $200 to $250 per ton depending on packaging. Table 2.2-1 shows an energy cost comparison for heating fuels.

Table 2.2-1 : Craig Cost of Energy Comparison

Technology, Unit	Input Btu/Unit	Cost/Unit	Assumed Efficiency	Output Btu/Unit	Cost/ mmBtu Output
#1 Fuel Oil, Gallon	134,000	$4.10	80%	107,200	$38.25
Propane	91,300	$2.42	80%	73,040	$33.13
Electricity, kWh (Resistance)	3,412	$0.23	100%	3,412	$67.41
Electricity, kWh (Heat Pump)	3,412	$0.23	300%	10,236	$22.47
Wood Pellets, Ton	15,200,000	$330.00	80%	12,160,000	$27.14
Bio Bricks, Ton (Palletized Unboxed)	15,200,000	$200.00	75%	11,400,000	$17.54
Bio Bricks, Ton (Palletized Boxed)	15,200,000	$250.00	75%	11,400,000	$21.93
Seasoned Hemlock, Full Cord	18,100,000	$250.00	70%	12,670,000	$19.73

Note: Fossil fuel prices provided by AkWarm software based on the 3/30/2015 library. Biomass prices obtained from local providers.

2.2.1 Craig 9 Unit Multifamily Building

THRHA operates a 5,400 ft^2 low rent multifamily building in the city of Craig. The building contains 9 rental units and is 1 story, stick frame construction, vinyl sided, and has a steel roof.

The foundation is creosote piles that support a raised floor. Figures 2.2-1 through 2.2-4 show the pictures of the Craig Low Rent Apartment Building.



Figure 2.2 – 1 : Craig Low Rent Multifamily Apartments – Street Front



Figure 2.2 – 2 : Craig Low Rent Multifamily Apartments – Back Side



Figure 2.2 – 3 : Craig Low Rent Multifamily Apartments – Under Floor



Figure 2.2 – 4 : Craig Low Rent Multifamily Apartments – Boiler Room

Table 2.2-2 provides the building address, square footage, and insulation values of building components.

Table 2.2-2 : Craig Low Rent Housing Insulation Values and Area of Building Components

Building Address	Item	Living Area Floors	Wall Section 1	Wall Section 2	North Door	South Door	Windows	Ceiling
500 East Hamilton Dr Units 1-9	R-Value	42.7	15.3	11.3	5.0	5.0	2.0	46.3
	Area, ft^2	4,440	314	2,355	20	20	396	4440

Two Weil McLain hot water boilers firing on #1 fuel oil are used to heat the building and domestic hot water. The boilers are each rated at 184,000 Btu/hr and have an efficiency of 84.5% as determined by a stack test. Hot water circulation pumps distribute hot water for space heating and to the indirect heated domestic hot water tank. A 1,100 gallon above ground oil storage tank is used to store oil for heating. Figure 2.2-5 shows the oil storage tank.



Figure 2.2 – 5 : Craig Low Rent Apartments – Oil Tank

Table 2.2-3 provides a breakdown of annual energy use and costs for the 9 unit building. Values are provided from AkWarm reports using the 3/30/2015 data library.

Table 2.2-3 : Craig Annual Energy Cost Breakdown

Space Heating Oil Use, Gallons	Space Heating #1 Oil Cost	Water Heating Oil Use, Gallons	Water Heating #1 Oil Cost	Appliances / Lights Electric Use, kWh	Appliances / Lights Cost	Total Annual Costs
2,484	$10,184	516	$2,116	50,296	$11,065	$23,365

Notes:

1 – Total oil use is 3,000 gallons per year as provided by THRHA. Space heating fuel use was estimated based on subtracting the AkWarm calculated water heating oil use from the 3,000 gallon total.

2 – Water heating, appliance, and light energy use and cost information provided by AkWarm software based on the 3/30/2015 library

2.2.2 Improvement Option Recommendations

The energy audits of the facilities generated a list of energy efficiency recommendations. THRHA has weatherized the buildings under a State weatherization program to ensure energy efficiency as the first measure of energy conservation. Blower door tests and walkthrough assessments

were conducted by professional energy auditing companies. Energy efficiency measures considered for the Craig Low Rent Multifamily Apartments are as follows:

- Air sealing and attic insulation
- Outside insulation and rain-screen siding
- Energy efficient lighting
- Replace refrigerators with Energy Star rated refrigerators

A summary of recommended measures are provided in Table 2.2-4.

Table 2.2-4 : Craig Energy Conservation Measure Estimated Cost Benefit Summary

Energy Efficiency Measure	Estimated Total Savings	Estimated Total Cost	Simple Payback, Years	SIR
Above-Grade Wall: Add R-14 rigid insulation to rim joist of above grade wall.	$40	$723	18.1	1.3
Caulk and Seal so that Home Air Leakage is Reduced by 700 CFM at 50 Pascals.	$39	$700	17.9	0.5
Above-Grade Wall: House: Install R-10 rigid foam board to exterior and cover with T1-11 siding or equivalent.	$418	$19,710	47.2	0.5
Exterior Door: North door: Remove existing door and install standard pre-hung U-0.16 insulated door.	$3	$506	168.7	0.2
Exterior Door: South Door: Remove existing door and install standard pre-hung U-0.16 insulated door.	$3	$506	168.7	0.2
Lighting Upgrade	$747	$11,940	16.0	0.5
Energy Star Refrigerator	$252	$9,000	35.7	0.4
Totals	**$1,502**	**$43,085**	**28.7**	

Notes:

1 – Costs and savings values for air sealing and insulation are estimated using the AkWarm software from the 3/30/2015 library.

2 – Energy Star rated refrigerator savings are generated from www.energystar.gov savings calculator.

3 – A detailed breakdown of lighting assumptions is provided in Section 4 Attachments.

THRHA also is considering upgrading portions of the building due to necessity that are not driven by energy savings. A summary of potential upgrades being considered are as follows:

- Install new heat recovery ventilator system in the central corridor and common spaces.
- Install a wood pellet heating system.
- Install a biobrick heating system.
- Move building back from roadway an additional 12 feet onto new foundation to create more parking in front of building and room for expansion for a common

community room. This will require excavation and concrete "eco-block" retaining wall behind building.

- Replace old Type M copper piping in corridor ceiling with new PEX.
- Install individual electrical meters and service panels in each apartment so they can take advantage of the Power Cost Equalization (PCE) rates for personal residential usage rather than the current commercial rates.

Ventilation – The building does not currently have a central ventilation system. The central corridor is not ventilated and carries odors. THRHA would like to install a heat recovery ventilator system for corridors and public spaces to improve indoor air quality and meet the ventilation standards for ASHRAE 62.2-2012. The estimated installed cost for a heat recovery ventilator is $50,000.

Copper Pipe Replacement – Copper heating pipes are run above the ceiling to individual baseboard heaters in each unit. The pipes are leaking and zone valves are likely failed in place. THRHA is considering replacing the piping with new insulated PEX piping. Replacement installed costs are estimated at $150 per linear foot of supply and return pipe.

Create Additional Parking – Parking is limited at the building due to the landscape and location of the building. Move building back from roadway an additional 12 feet onto new foundation would create more room for parking in front of the building. This would also create room for expansion for a common community room. This will require excavation and concrete "eco-block" retaining wall behind building.

Individual Electric Meters – There is currently one electric meter on the building and electricity is billed as a commercial rate. Renters could utilize the PCE rate if individual meters were installed for each unit. This would reduce the electric price from $0.23/kWh to $0.17 per kWh for the first 500 kWh of electricity use. Estimated installed costs for individual electric meters and service panels are $1,100 per unit for a total cost of $9,900.

Wood Pellet Boiler System - Installation of wood pellet fired boiler system was evaluated in a pre-feasibility study from September 2, 2014 titled *"High Efficiency Low Emission Wood Fired Heating System Pre-Feasibility Report"* created by WES Energy & Environment. The recommended system consists of a 110,000 Btu/hr wood pellet fired hot water boiler and 200 gallons of hot water thermal storage. The financial summary of the wood pellet system is provided in Table 2.2-5.

Table 2.2-5 : Craig Wood Pellet Heating System Financial Summary

Current #1 Fuel Oil Use, Gallons	Current Oil Cost	Estimated Wood Pellet Use, Tons	Estimated Wood Pellet Cost	Estimated O&M Costs	Estimated Oil Cost with Wood Pellet System	Estimated Savings	Estimated Capital Cost	Simple Payback
3,000	$12,300	26	$8,580	$1,590	$615	$1,515	131,497	86.8

Note: Based on $4.10/gallon of #1 fuel oil and $330/ton of wood pellets. Annual oil use and wood pellet use values are from the September 2, 2014 report titled "High Efficiency Low Emission Wood Fired Heating System Pre-Feasibility Report" created by WES Energy & Environment.

Biobrick Boiler System - Installation of cord wood fired boiler system was evaluated in a pre-feasibility study from September 2, 2014 titled *"High Efficiency Low Emission Wood Fired Heating System Pre-Feasibility Report"* created by WES Energy & Environment. The equipment recommended for use with the cord wood system would also be used for biobricks. The recommended system consists of a 100,000 Btu/hr cord wood style hot water boiler firing on biobricks and 500 gallons of hot water thermal storage. The financial summary of the biobrick system is provided in Table 2.2-6.

Table 2.2-6 : Craig Biobrick Heating System Financial Summary

Current Oil Use, Gallons	Current Oil Cost	Estimated Biobrick Use, Tons	Estimated Biobrick Cost	Estimated O&M Costs	Estimated Oil Cost with Biobrick System	Estimated Savings	Estimated Capital Cost	Simple Payback
3,000	$12,300	23.0	$5,750	$1,480	$2,460	$2,610	103,667	39.7

Note: Based on $4.10/gallon of #1 fuel oil and $250/ton for boxed biobricks. Assumes 80% offset of oil use with the biobrick system. Capital costs and O&M costs are from the September 2, 2014 report titled "High Efficiency Low Emission Wood Fired Heating System Pre-Feasibility Report" created by WES Energy & Environment.

2.3 HAINES

Haines, Alaska is a Census Designated Place (CDP) located on the western shore of Lynn Canal, between the Chilkoot and Chilkat Rivers. It is about 80 air miles northwest of Juneau, Alaska. The average annual high temperature is 46.8°F and the average annual low temperature is 35.3°F Annual Heating Degree Days (HDD) base 65F = 8,453 HDD.

Haines is accessible by road via the Haines Highway which is maintained year round and connects Haines to northern Alaskan communities. Air transportation is available with 2 regional carriers, Alaska Seaplane Service and Wings of Alaska. Both provide daily passenger service and some freight and cargo service. Haines is a part of the Alaska Marine Highway which provides the only water transportation of vehicles and passengers. Barge service is available for cargo and is offloaded at the 950 foot Lutak Dock.

The community has a population of 2,664 with the median age being 46.2 years old. There are 1,784 housing units in Haines. Owner occupied units number 882, while there are 348 renter occupied units. Haines' economy is classified as subsistence and relies heavily on tourism with 70% of the population employed in the private sector. Table 2.3-1 shows an energy cost comparison for heating fuels in the community.

Table 2.3-1 : Haines Cost of Energy Comparison

Technology, Unit	Input Btu/Unit	Cost/Unit	Assumed Efficiency	Output Btu/Unit	Cost/ mmBtu Output
#2 Fuel Oil, Gallon	138,800	$4.22	80%	111,040	$38.00
Propane, Gallon	91,300	$4.00	80%	73,040	$54.76
Electricity, kWh (Resistance)	3,412	$0.23	100%	3,412	$67.41
Electricity, kWh (Heat Pump)	3,412	$0.23	300%	10,236	$22.47
Wood Pellets, Ton	15,200,000	$350.00	80%	12,160,000	$28.78

Note: Fuel prices provided by AkWarm software based on the 3/30/2015 library. Biomass & propane prices obtained from local providers.

2.3.1 Haines 12 Unit Multifamily Building

THRHA operates a 7,000 ft^2 low rent multifamily building in the city of Haines that was constructed in 1982. The building is of modular construction and contains 12 one bedroom, one bath rental units and is 1 story, stick frame construction, vinyl sided, and has a steel roof. The foundation is creosote piles that support a raised floor with a skirted crawlspace.

A typical unit is 24' x 20' with all units exiting to a central corridor. The central corridor is 5' wide and has a utility chase above a drop ceiling for piping (heat and domestic hot and cold water) and electrical distribution to apartments. There are small common areas, including a small laundry room, storage locker room, day room, and the mechanical room. Figures 2.3-1 through 2.3-4 show the pictures of the Haines 12 Unit Multifamily Building.



Figure 2.3 – 1 : Haines Low Rent Apartment – Outside Shell



Figure 2.3 – 2 : Haines Low Rent Apartments – Under Floor

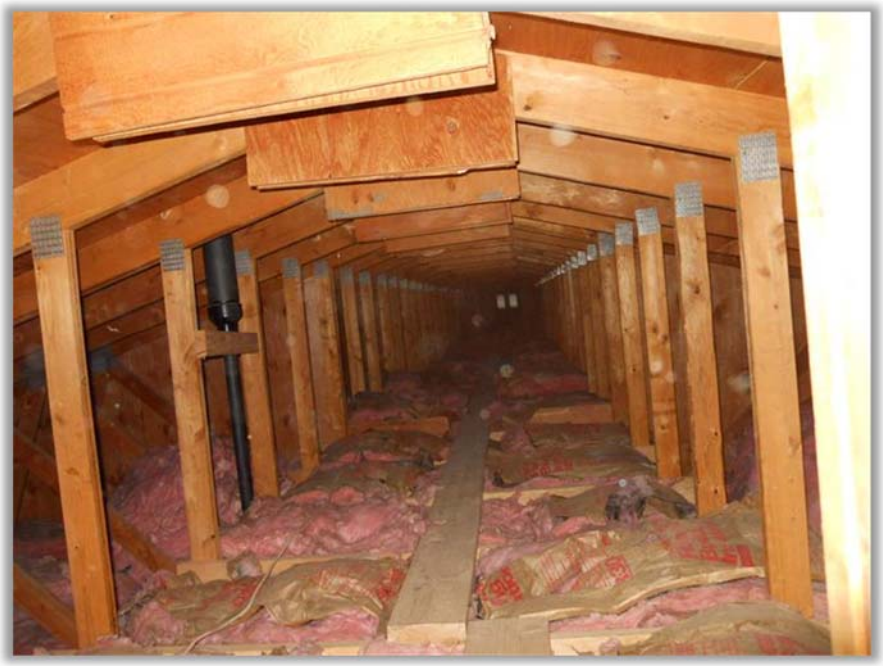


Figure 2.3 – 3 : Haines Low Rent Apartments – Attic Crawlspace



Figure 2.3 – 4 : Haines Low Rent Apartments – Boiler Room

Table 2.3-2 provides the building address, square footage, and insulation values of building components.

Table 2.3-2 : Haines 12 Unit Insulation Values and Area of Building Components

Building Address	Item	Living Area Floors	Walls	Door 1	Door 2	Door 3	South Windows	Remaining Windows	Ceiling
52 Deishu Dr.	R-Value	24.1	16.2	1.8	1.8	1.8	1.1	1.1	29.3
	Area, ft^2	6,930	3,188	22	22	22	305	343	6,930

Two Weil McLain WGO-6 hot water boilers firing on #2 fuel oil are used to heat the building and domestic hot water. The boilers are each rated at 212,000 Btu/hr. Hot water circulation pumps distribute hot water for space heating and to an indirect heated domestic hot water tank. Baseboard heat is located in each unit. Table 2.3-3 provides a breakdown of annual energy use and costs for the 12 unit building. Values are provided from AkWarm reports using the 3/30/2015 data library.

Table 2.3-3 : Haines Annual Energy Cost Breakdown

Space Heating #2 Oil Use, Gallons	Space Heating #2 Oil Cost	Water Heating #2 Oil Use, Gallons	Water Heating #2 Oil Cost	Appliances / Lights Electric Use, kWh	Appliances / Lights Electric Cost	Total Annual Costs
1,619	$6,832	658	$2,777	66,629	$15,965	$25,574

Note: Fuel use and cost information provided by AkWarm software based on the 3/30/2015 library

2.3.2 Improvement Option Recommendations

The energy audits of the facilities generated a list of energy efficiency recommendations. Blower door tests and walkthrough assessments were conducted by professional energy auditing companies. Energy efficiency measures considered for the Haines Low Rent Housing Building are as follows:

- **Windows** - Windows have double glazing, but many have broken seals or no longer close completely. They all need replacing with energy efficient new windows with a minimum U-value of .28.
- **Air Sealing** - The building has lots of air leakage. THRHA would like to tighten the building up to no more than 4 ACH50.
- **Insulation** - Thermal values of the building shell are low. THRHA would like to increase the R-values of the ceiling to R-60, the floor to R-38, and the walls to R-30. Outside insulation and new siding would be required to achieve R-30 walls.
- **Refrigerators** – Refrigerators need to be replaced for aesthetic and efficiency reasons. THRHA would like to install energy star rated appliances during scheduled replacements.

A summary of estimated costs and savings for recommended measures are provided in Table 2.3-4. Cost and savings values are a result of AkWarm calculations.

Table 2.3-4 : Haines Energy Conservation Measure Estimated Cost Benefit Summary

Energy Efficiency Measure	Estimated Total Savings	Estimated Total Cost	Simple Payback, Years	SIR Ratio
Replace 3 outside doors with U-0.16 insulation	$190	$1,467	7.7	3.0
Air sealing to 4 ACH	$1,283	$5,000	3.9	3.0
Insulate floors with R-30 dense pack insulation	$666	$10,380	15.6	1.5
Replace windows with U-0.26	$2,323	$34,650	14.9	1.2
Increase ceiling Insulation to R-60	$608	$16,945	27.9	0.9
Energy Star Refrigerators	$372	$12,000	32.3	0.5
Outside wall insulation technique, rain screen, and concrete fiberboard siding	$367	$20,888	56.9	0.4
Totals	**$5,809**	**$101,330**	**17.4**	

Notes:
1 – Costs and savings values for air sealing, windows, and insulation are estimated using the AkWarm software from the 3/30/2015 library.
2 – Energy Star rated refrigerator savings are generated from www.energystar.gov savings calculator.
3 – A detailed breakdown of lighting assumptions is provided in Section 4 Attachments.

THRHA also is considering upgrading portions of the building due to necessity that are not driven by energy savings. A summary of potential upgrades being considered are as follows:

- Install a new heat recovery ventilator system in the central corridor and common spaces.
- Replace room exhaust fans with high efficiency low sone exhaust fans with motion sensors and a programmable time delay.
- Install a wood pellet heating system.

Ventilation – The building does not currently have a central ventilation system. The central corridor is not ventilated and carries odors and apartment units have exhaust-only ventilation using a bath fan and a range hood. THRHA would like to install a heat recovery ventilator system for corridors and public spaces, and improve the exhaust-only ventilation system in each apartment with low-sone continuous duty rated exhaust fans on motion sensors with programmable time delays to meet ASHRAE 62.2-2012.

A heat recovery ventilator system is estimated to cost $50,000. This system will use additional energy but will improve indoor air quality and occupant comfort. Installing updated exhaust fans on motion sensors with programmable time delays are each estimated to cost $600 installed.

Wood Pellet Heating System - THRHA considered the feasibility of heating the building with a wood pellet fired hot water boiler located in a separate outbuilding. A propane on demand hot water heater will be installed for the non-heating season. The recommended system consists of a 70,000 Btu/hr wood pellet fired hot water boiler and 60 gallons of hot water thermal storage.

The financial summary of the wood pellet system is provided in Table 2.3-5. A cost breakdown is provided in Section 4.0 - Attachments.

Section Table 2.3-5 : Haines Wood Pellet Heating System Financial Summary

Current Oil Use, Gallons	Current Oil Cost	Estimated Wood Pellet Use, Tons	Estimated Wood Pellet Cost	Estimated O&M Costs	Estimated Propane Cost with Wood Pellet System	Estimated Savings	Estimated Capital Cost	Simple Payback
2,277	$9,609	16.6	$5,822	$1,500	$2,769	($482)	110,865	N/A

Note: Assumes 80% offset with wood pellet system. Remaining 20% is offset with an on demand propane fired system. Capital costs include the estimated cost for the propane fired system. Fuel prices used to generate economics are $4.22/gallon for #2 fuel oil, $4.00/gallon for propane, and $350/ton of wood pellets.

The savings for the wood pellet system are negative. This is mostly due to the low volume of oil currently used and the high price of propane. If the wood pellet system were operated throughout the summer using efficient loading of the thermal storage tank, coverage could approach 95% and savings could become positive due to increased propane offset. It is estimated that the savings would in the $500 a year range.

2.4 HOONAH

Hoonah, Alaska is the largest Tlingit village in the state and is located on the northeast shore of Chichagof Island, about 40 air miles west of Juneau, Alaska. The average annual high temperature is 49.9°F and the average annual low temperature is 40.6°F. Annual Heating Degree Days (HDD) base 65F = 8,225 HDD.

As an island community there is no direct road access to Hoonah. Transportation of goods and people is by plane or boat only. The Alaska Marine Highway provides year round ferry service for vehicles and people. The Hoonah Airport has a 3,000 ft paved runway for small aircraft that provide daily flights from Juneau and surrounding communities. Flights are serviced by Wings of Alaska and Air Excursions. The Port of Hoonah can accommodate barge service for cargo shipments.

The community has a population of 764 with the median age being 44.6 years old. There are 399 housing units in Hoonah. Owner occupied units number 181, while there are 127 renter occupied units. The Hoonah economy is classified as subsistence and is seasonally reliant on tourism. There is a small impact from commercial fishing and logging. Table 2.4-1 shows an energy cost comparison for heating fuels in the community.

Table 2.4-1 : Hoonah Cost of Energy Comparison

Technology, Unit	Input Btu/Unit	Cost/Unit	Assumed Efficiency	Output Btu/Unit	Cost/ mmBtu Output
#2 Fuel Oil, Gallon	138,800	$4.02	80%	111,040	$36.20
Propane, Gallon	91,300	$4.70	80%	73,040	$64.35
Electricity, kWh (Resistance)	3,412	$0.62	100%	3,412	$181.71
Electricity, kWh (Heat Pump)	3,412	$0.62	300%	10,236	$60.57
Wood Pellets, Ton	15,200,000	$400.00	80%	12,160,000	$32.89
IPEC Waste Heat, 1 mmBtu	1,000,000	$14.75	100%	1,000,000	$14.75

Note: Fuel prices provided by AkWarm software based on the 3/30/2015 library. Biomass & propane prices obtained from local providers. IPEC Waste Heat cost is based on the May 2015 bill and divides the billed amount by the quantity of metered energy in million Btu's listed on the billing statement.

2.4.1 Hoonah 12 Unit Multifamily Building

THRHA operates a 7,650 ft^2 low rent multifamily building in the city of Hoonah that was constructed in 1982. The building is of modular construction and contains 12 one bedroom, one bath rental units and is 1 story, stick frame construction, vinyl sided, and has a steel roof. The foundation is creosote piles that support a raised floor with a skirted crawlspace.

A typical unit is 24' x 20' with all units exiting to a central corridor. The central corridor is 5' wide and has a utility chase above drop ceiling for piping and electrical distribution to apartments. Figures 2.4-1 through 2.4-3 show the pictures of the Hoonah 12 Unit Multifamily Building.



Figure 2.4 – 1 : Hoonah 12 Unit Multifamily Building Front





Figure 2.4 – 2 : Hoonah 12 Unit Multifamily Building Back



Figure 2.4 – 3 : Hoonah 12 Unit Multifamily Building Boiler Room

Table 2.4-2 provides the building address, square footage, and insulation values of building components.

Table 2.4-2 : Hoonah 12 Unit Insulation Values and Area of Building Components

Building Address	Item	Living Area Floors	Walls House-Rim	Walls House	Walls House Crawlspace	Doors	Windows	Ceiling
566 Hemlock	R-Value	42.8	41.5	15.5	3.0	3.3	2.0	46.3
Street #'s 1-12	Area, ft^2	7,650	430	3,189	3,010	60	662	7650

The building is heated using two Weil McClain Gold Boilers with Amtrol indirect "sidearm" water heaters. Circulator pumps distribute hot water to hydronic baseboard heaters. There is no central ventilation system and apartments have their own exhaust-only ventilation.

In early 2014 THRHA entered into a waste heat purchase agreement with local utility IPEC, and waste heat piping from local diesel-electric generation plant was plumbed into boiler room. Existing oil boilers are still used as secondary. Table 2.4-3 provides a breakdown of annual energy costs for the building. Values are provided from AkWarm reports using the 3/30/2015 data library.

Table 2.4-3 : Hoonah Annual Fuel Use and Cost Breakdown

Space Heating #2 Oil Use, Gallons	Space Heating #2 Oil Cost	Water Heating #2 Oil Use, Gallons	Water Heating #2 Oil Cost	Appliances / Lights Electric Use, kWh	Appliances / Lights Electric Cost	Total Annual Costs
1,590	$6,392	560	$2,777	67,781	$38,906	$48,075

Note: Fuel use and cost information provided by AkWarm software based on the 3/30/2015 library

2.4.2 Improvement Option Recommendations

The energy audit of the building generated a list of energy efficiency recommendations. Blower door tests and walkthrough assessments were conducted by professional energy auditing companies. Energy efficiency measures considered for the Hoonah Multifamily Building are as follows:

- New energy efficient windows
- Outside insulation and new rain-screen siding
- Air tightening and increased attic insulation
- Lighting retrofit to remove old lighting and install new energy efficient lighting
- Install new Energy Star refrigerators

A summary of recommended measures are provided in Table 2.4-4.

Table 2.4-4 : Hoonah Energy Conservation Measure Estimated Cost Benefit Summary

Energy Efficiency Measure	Estimated Total Savings	Estimated Total Cost	Simple Payback, Years	SIR
Caulk and Seal so that Home Air Leakage is Reduced by 1000 CFM at 50 Pascals.	$309	$1,000	3.2	2.9
Remove existing vinyl siding and install rain screen, 2" rigid XPS insulation and new concrete siding	$994	$182,000	183.1	0.1
Energy Star Refrigerators	$888	$12,000	13.5	1.2
Remove old windows and install new energy rated vinyl windows	$1,002	$45,000	44.9	0.4
Ceiling w/ Attic: House: Add R-12 blown cellulose insulation to attic with Standard Truss.	$200	$12,000	60.0	0.4
Lighting Upgrade	$2,688	$24,310	9.0	0.9
Totals	**$6,081**	**$276,310**	**45.4**	

Notes:
1 – Costs and savings values for air sealing, windows, and insulation are estimated using the AkWarm software from the 3/30/2015 library and are compared to reducing Fuel Oil use.
2 – Savings values will be 50% of the values listed when compared to reducing IPEC waste heat use.
3 – Energy Star rated refrigerator savings are generated from www.energystar.gov savings calculator.
4 – A detailed breakdown of lighting assumptions is provided in Section 4 Attachments.

THRHA is also considering upgrading portions of the building due to necessity that are not driven by energy savings. A summary of potential upgrades being considered are as follows:

- Install a new heat recovery ventilator system in the central corridor and common spaces.
- Replace old Type M copper piping in the corridor ceiling with new PEX.
- Install individual electrical meters and service panels in each apartment so residents can take advantage of the Power Cost Equalization (PCE) rates for personal residential usage rather than the current commercial rates.
- Installing a wood pellet fired hot water boiler system.

Ventilation – The building does not currently have a central ventilation system. The central corridor is not ventilated and carries odors. THRHA would like to install a heat recovery ventilator system for corridors and public spaces to improve indoor air quality and to meet ASHRAE 62.2-2012. A heat recovery ventilator system is estimated to cost $44,000. This system will use additional energy but will improve indoor air quality and occupant comfort.

Copper Pipe Replacement – Copper heating pipes are run above the ceiling to individual baseboard heaters in each unit. The pipes are leaking and zone valves are likely failed in place. THRHA is considering replacing the piping with new insulated PEX piping and installing new zone valves. Replacement costs are estimated at $9,500.

Individual Electric Meters – There is currently one electric meter on the building and electricity is billed as a commercial rate. Renters could utilize the PCE rate if individual meters were installed for each unit. This would reduce the electric price from $0.62/kWh to $0.22 per kWh for the first 500 kWh of electricity use. Estimated installed costs for individual electric meter sockets and service panels are $1,100 per unit for a total cost of $13,200.

Crawlspace Vapor Barrier – Install 10 mil p mil poly vapor barrier on the crawlspace dirt floor and place pressure treated plywood on top of the poly in the immediate area around the entrance to the crawlspace. Estimated installed costs are $3,500.

Wood Pellet Heating System - THRHA evaluated the feasibility of heating the building with a wood pellet boiler in a separate outbuilding. The recommended system consists of a 40,000 Btu/hr wood pellet fired hot water boiler and 60 gallons of hot water thermal storage. The financial summary of the wood pellet system is provided in Table 2.4-5. A cost breakdown is provided in Section 4 - Attachments.

Table 2.4-5 : Hoonah Wood Pellet Heating System Financial Summary

Current Oil Use, Gallons	Current Oil Cost	Estimated Wood Pellet Use, Tons	Estimated Wood Pellet Cost	Estimated O&M Costs	Estimated Oil Cost with Wood Pellet System	Estimated Savings	Estimated Capital Cost	Simple Payback
2,150	$8,643	15.7	$6,283	$1,500	$1,729	($868)	109,802	N/A

Note: Assumes 80% offset with wood pellet system. Remaining 20% is covered with the existing oil fired system. Fuel prices used to generate economics are $4.02/gallon for #2 fuel oil and $400/ton of wood pellets.

The savings for the wood pellet system are negative. This is mostly due to the low volume of oil currently used, the cost of wood pellets, and the estimated O&M costs. Even if the wood pellet system covered 100% of the heating demand, the O&M costs would outweigh the savings.

2.5 JUNEAU

Juneau, the third largest community in Alaska, is a united home rule municipality located on the mainland of Southeast Alaska. Meterological information for Juneau includes two distinct areas, downtown Juneau, and the Mendenhall Valley, (near the airport and Mendenhall glacier) where most THRHA homes are situated. The Mendenhall Valley is generally a little colder and dryer than downtown. For the Mendenhall Valley, the average annual high temperature is 47.3°F and the average annual low temperature is 34.6°F Annual Heating Degree Days (HDD) base 65F = 8,763 HDD.

There is no direct road access to Juneau. Travel to Juneau is by air or water. There is daily jet service to Juneau and the Alaska Marine Highway System is available for vehicle transportation. There are two commercial loading facilities for cargo. Heavy equipment and building supplies are handled separately at the Port of Juneau's Auke Bay Loading Facility.

The population in Juneau is 33,119 with the median age being 38.1 years old. There are 13,920 housing units located in Juneau with 8,010 owner occupied units and 5,043 renter occupied units. The three largest drivers of Juneau's economy are tourism, commercial fishing, and Government positions. State and Federal government jobs are responsible for 39% of local employment and the private sector accounts for 60%. Table 2.5-1 shows an energy cost comparison for heating fuels in the community.

Table 2.5-1 : Juneau Cost of Energy Comparison

Technology, Unit	Input Btu/Unit	Cost/Unit	Assumed Efficiency	Output Btu/Unit	Cost/ mmBtu Output
#1 Fuel Oil, Gallon	134,000	$4.05	80%	107,200	$37.78
#2 Fuel Oil, Gallon	138,800	$4.05	80%	111,040	$36.47
Propane, Gallon	91,300	$2.42	80%	73,040	$33.13
Electricity, kWh (Resistance)	3,412	$0.11	100%	3,412	$32.24
Electricity, kWh (Air Source Heat Pump)	3,412	$0.11	300%	10,236	$10.75
Electricity, kWh (Ground Source Heat Pump)	3,412	$0.11	500%	17,060	$6.45
Wood Pellets, Ton	15,200,000	$375.00	80%	12,160,000	$30.84

Note: Fuel prices provided by AkWarm software based on the 3/30/2015 library. Biomass & propane prices obtained from local providers.

2.5.1 Juneau Multifamily Dwellings

THRHA owns and operates 18 buildings in Juneau that consist of the Fireweed Place 65 unit senior apartment building, 13 duplexes, and 4 four-plex buildings. The buildings utilize a mix of electric heat and boilers firing on #2 and #1 fuel oil. Current fuel oil prices are $4.05/gallon for #1 and #2 fuel oil and electricity prices range from $0.10 – 0.13/kWh.

Fireweed Place 65 Unit Senior Housing Building

The Fireweed Place is a 5 story Senior Housing Building located in Juneau containing 65 housing units. The building has a concrete foundation, wood framed walls with vinyl siding, and an asphalt shingle roof. The ground floor contains office spaces and floors 2 – 5 contain apartments. The building was constructed in 1994 and is an all-electric building. Individual electric meters serve each apartment unit and all non-apartment electricity use is served by one separate master electric meter. Figures 2.5-1 through 2.5-5 show the construction of the building.



Figure 2.5 – 1 : Fireweed Place 65 Unit Senior Housing Building – Front



Figure 2.5 – 2 : Fireweed Place 65 Unit Senior Housing Building – Side



Figure 2.5 – 3 : Fireweed Place 65 Unit Senior Housing Building – Exterior Wall Construction



Figure 2.5 – 4 : Fireweed Place 65 Unit Senior Housing Building – Attic Insulation



Figure 2.5 – 5 : Fireweed Place 65 Unit Senior Housing Building – Roof

Table 2.5-2 and 2.5-3 provides the building address, square footage, and insulation values of the wall and shell and the windows and doors respectively.

Table 2.5-2 : Fireweed Place Wall and Shell Insulation Values and Areas

Building Address	Item	1st Floor Perimeter	1st Floor Center	2nd Floor	Wall House	House Ceiling	Elevator Ceiling
415 Willoughby Avenue	R-Value	6.7	35.5	6.6	18.2	38.5	21.3
	Area, ft^2	584	1,000	12,155	26,022	13,448	80

Table 2.5-3 : Fireweed Place Window and Door Insulation Values and Areas

Building Address	Item	Patio Doors	Emergency Doors	Parking Doors	Windows	Entry Door Window	Entry Window	Office Window
415 Willoughby Avenue	R-Value	2.9	1.8	1.7	2.6	1.2	2.6	2.4
	Area, ft^2	60	60	27	4,930	27	47	54

The apartments and support spaces are heated by electric resistance heaters. They are controlled by wall thermostats or integral thermostats. None of the thermostats are programmable for night temperature setback.

Most of the common area lighting is fluorescent with T12 lamps. Most of the exterior lighting has been converted to LED lamps. There are five T12 fixtures over the main entrance door that are not efficient. The lighting in the parking garage has been recently converted to LED lamps.

The building has two heat recovery ventilating (HRV) units that supply the apartments and common spaces. The energy consumption of these units, fans to circulate the air and heating coils to temper the air, are on the house meter. The units are nearing the end of their service life.

There is a laundry room on each floor of the building with a total of 5 washing machines and 5 dryers. The washing machines consist of three top load machines and two front load machines. The top load machines use more water and electricity than front loading models.

The building has four 50 gallon electric hot water heaters supplying laundry rooms, janitor rooms, toilets, and sinks. In addition, there is a 119 gallon HW heater that serves the 2nd floor laundry room, spa, sink, and toilet rooms. Each apartment has an electric hot water heater connected to the apartment utility meter. Table 2.5-4 provides a breakdown of annual energy costs for the building. Values are provided from AkWarm reports using the 3/30/2015 data library.

Table 2.5-4 : Fireweed Place Annual Electricity Cost Breakdown

Space Heating	Water Heating	Cooling	Ventilation Fans	Cooking	Clothes Drying	Lighting	Refrigeration	Service Fees	Totals
$68,682	$31,148	$0	$15,453	$0	$1,152	$47,663	$8,711	$326	$173,135

Note: Energy summary provided from the AkWarm library dated 3/30/2015.

Granite Street 3 Bedroom Duplexes Style 1

Three Duplex Style 1 buildings located on Granite Street are operated by THRHA. They are one story, stick frame construction, vinyl sided, and have asphalt shingled roofs. Figures 2.5-6 through 2.5-8 show the typical construction and mechanical room of a Duplex Style #1 building.



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Figure 2.5 – 6 : Granite St. Style 1 Duplex - Front



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Figure 2.5 – 7 : Granite St. Style 1 Duplex – Attic




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Figure 2.5 – 8 : Granite St. Style 1 Duplex – Boiler, Indirect Storage, & Inline Fan w/ Filter Box

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The addresses associated with the six units in this style are provided in Table 2.5-5.

Table 2.5-5 : Granite Street Duplex Style #1 Building Addresses

Building Address	Layout Style
4063 Granite Street	Duplex Style #1
4067 Granite Street	
4060 Granite Street	
4064 Granite Street	
4047 Granite Street	
4051 Granite Street	

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Tables 2.5-6 and 2.5-7 provide the square footage and insulation values of the wall and shell and the windows and doors respectively.

Table 2.5-6 : Granite St Duplex Style 1 - Wall and Shell Insulation Values and Areas

Item	Perimeter Floor Below Living-Dining	Center Floor Below Living-Dining Room	Perimeter Floor House	Center Floor House	Wall Rim Joist	Wall Common	Wall House	Rake Walls	Interior Mechanical Wall	Ceiling
R-Value	23.1	40.9	23.1	40.9	135.0	21.7	19.2	19.3	18.5	40.4
Area, ft^2	176	160	192	600	117	208	840	48	128	1,143

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Table 2.5-7 : Granite St Duplex Style 1 – Window and Door Insulation Values and Areas

Item	ICF Wall	Entry	Doors	Windows	Sliding Door
R-Value	19.7	5.0	2.6	2.6	2.0
Area, ft^2	370	20	20	138	40

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Two Weil McLain WGO-2 hot water boilers firing on #2 fuel oil are used to heat the building and domestic hot water. The boilers are each rated at 86,000 Btu/hr and have an efficiency of 84.1% as determined by a stack test. Hot water circulation pumps distribute hot water for space heating and to an indirect heated domestic hot water tank. Baseboard heat is located in each unit. Table 2.5-8 provides a breakdown of annual energy use and costs for a typical Granite Street Style 1 Duplex Building. Values are provided from AkWarm reports using the 3/30/2015 data library.

Table 2.5-8 : Granite St Duplex Style 1 – Annual Energy Use and Cost Summary

Space Heating #2 Oil Use, Gallons	Space Heating #2 Oil Cost	Water Heating #2 Oil Use, Gallons	Water Heating #2 Oil Cost	Appliances & Lights Electric Use, kWh	Appliances & Lights Electric Cost	Total Annual Costs
1,132	$4,585	342	$1,385	14,634	$1,902	$7,872

Note: Energy summary provided from the AkWarm library dated 3/30/2015.

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Granite Street 3 Bedroom Duplex Style 2

THRHA owns and operates one Style 2 Duplex Building on Granite Street. It is a two story building with stick frame construction, vinyl siding, and an asphalt shingled roof. Figures 2.5-9 through 2.5-12 show the construction and mechanical room of the Duplex Style #2 building.



Figure 2.5 – 9 : Granite St. Style 2 Duplex – Front and Side



Figure 2.5 – 10 : Granite St. Style 2 Duplex – Back and Oil Tank



Figure 2.5 – 11 : Granite St. Style 2 Duplex – Boiler/Hot Water Storage & Crawlspace



Figure 2.5 – 12 : Granite St. Style 2 Duplex – Living room

The addresses associated with the two units in this style are provided in Table 2.5-9.

Table 2.5-9 : Granite Street Duplex Style #1 Building Addresses

Building Addresses	Layout Style
4039 Granite Street	Duplex Style #2
4043 Granite Street	

Tables 2.5-10 and 2.5-11 provide the square footage and insulation values of the wall and shell and the windows and doors respectively.

Table 2.5-10 : Granite St Duplex Style 2 - Wall and Shell Insulation Values and Areas

Item	Center Floor Dining Room	Perimeter Floor	Center Floor House	Wall Rim Joist	Wall Common	Wall House	Rake Walls	Interior Mechanical Wall	ICF Wall	Ceiling
R-Value	40.9	23.1	40.9	13.5	21.7	19.2	19.3	18.5	19.7	40.4
Area, ft^2	300	320	345	130	550	1,297	64	135	325	961

Table 2.5-11 : Granite St Duplex Style 2 – Window and Door Insulation Values and Areas

Item	Entry	Doors	Windows	Sliding Door
R-Value	5.0	2.6	2.6	2.0
Area, ft^2	20	20	138	40

Two Weil McLain WGO-2 hot water boilers firing on #2 fuel oil are used to heat the building and domestic hot water. The boilers are each rated at 86,000 Btu/hr and have an efficiency of 81.9% as determined by a stack test. Hot water circulation pumps distribute hot water for space heating and to an indirect heated domestic hot water tank. Baseboard heat is located in each unit. Table 2.5-12 provides a breakdown of annual energy use and costs for the Granite Street Style 2 Duplex Building. Values are provided from AkWarm reports using the 3/30/2015 data library.

Table 2.5-12 : Granite St Duplex Style 2 – Annual Energy Use and Cost Summary

Space Heating #2 Oil Use, Gallons	Space Heating #2 Oil Cost	Water Heating #2 Oil Use, Gallons	Water Heating #2 Oil Cost	Appliances & Lights Electric Use, kWh	Appliances & Lights Electric Cost	Total Annual Costs
1,170	$4,739	268	$1,085	14,634	$1,902	$7,726

Note: Energy summary provided from the AkWarm library dated 3/30/2015.

Valley Fourplex Apartment Buildings

THRHA owns and operates 4 identical fourplex units on Valley Boulevard. Each building has 2 - one story 2 bedroom units and 2 - two story 3 bedroom units. The buildings are stick frame construction, vinyl sided, and have metal roofs. Figures 2.5-13 through 2.5-16 show the typical construction of a fourplex building.



Figure 2.5 – 13 : Valley Blvd Fourplex – Street Front



Figure 2.5 – 14 : Valley Blvd Fourplex – South Walls



Figure 2.5 – 15 : Valley Blvd Fourplex – Attic Insulation and Crawlspace



Figure 2.5 – 16 : Valley Blvd Fourplex – Living room

The addresses associated with the 16 units in this style are provided in Table 2.5-13.

Table 2.5-13 : Valley Blvd Fourplex Building Addresses

Building Address	Layout Style
8414 Valley Blvd	Fourplex
8416 Valley Blvd	
8418 Valley Blvd	
8420 Valley Blvd	
8422 Valley Blvd	
8424 Valley Blvd	
8426 Valley Blvd	
8428 Valley Blvd	
8430 Valley Blvd	
8432 Valley Blvd	
8434 Valley Blvd	
8436 Valley Blvd	
8438 Valley Blvd	
8440 Valley Blvd	
8442 Valley Blvd	
8444 Valley Blvd	

Tables 2.5-14 and 2.5-15 provide the square footage and insulation values of building components for the 1 story and 2 story units respectively.

Table 2.5-14 : Valley Fourplex 1 Story Unit Insulation Values and Area of Building Components

Item	Floor House/Crawl Space	Floor House	House Wall	Vault Wall	Door	Windows	Window Door	Ceiling
R-Value	14.6	42.0	20.1	20.0	4.0	2.6	1.7	40.4
Area, ft^2	312	528	258	1,256	20	157	20	861

Table 2.5-15 : Valley Fourplex 2 Story Unit Insulation Values and Area of Building Components

Item	Floor House/Crawl Space	Floor House/Crawl Space	Wall ICF	Wall Exterior	Door	Windows	Window South Door	Ceiling
R-Value	15.7	43.1	20.1	20.0	4.0	2.6	1.7	40.4
Area, ft^2	192	528	174	1,131	20	205	20	759

One Weil McLain UO-4 hot water condensing boiler firing on #1 fuel oil is used to heat all four units. Domestic hot water is generated using a sidearm heater off of the same boiler and indirectly heats four domestic hot water storage tanks individually serving each unit. The boiler is rated at 146,000 Btu/hr and has an efficiency of 84.9% as determined by a stack test. Hot water circulation pumps distribute hot water for space heating. A whole house ventilation unit provides ventilation air to the units. Table 2.5-16 provides a breakdown of annual energy use and costs for a typical Valley Blvd Fourplex Building. Values are provided from AkWarm reports using the 3/30/2015 data library.

Table 2.5-16 : Valley Fourplex – Annual Energy Use and Cost Summary

Unit	Description	Space Heating #1 Oil Use, Gallons	Space Heating #1 Oil Cost	Water Heating #1 Oil Use, Gallons	Water Heating #1 Oil Cost	Appliances & Lights Electric Use, kWh	Appliances & Lights Electric Cost	Total Annual Costs
1	1 Story, 2 BR	542	$2,195	101	$409	6,613	$860	$3,464
2	1 Story, 2 BR	542	$2,195	101	$409	6,613	$860	$3,464
3	2 Story, 3 BR	554	$2,244	62	$251	6,613	$860	$3,354
4	2 Story, 3 BR	554	$2,244	62	$251	6,613	$860	$3,354
	Totals	**2,192**	**$8,878**	**326**	**$1,320**	**26,452**	**$3,439**	**$13,637**

Note: Energy summary provided from the AkWarm library dated 3/30/2015.

Kanat'a Dey'i 1 Story Duplex

THRHA owns and operates 4 identical 1 story 3 bedroom duplex units on Kanat'a Dey'i Street. They are one story, stick frame construction, vinyl sided, and have asphalt shingled roofs. Figures 2.5-17 through 2.5-19 show the typical construction and mechanical room of a Kanat'a Dey'i 1 story duplex building.



Figure 2.5 – 17 : Kanat'a Dey'i 1 Story Duplex – Street Front



Figure 2.5 – 18 : Kanat'a Dey'i 1 Story Duplex – Crawlspace



Figure 2.5 – 19 : Kanat'a Dey'i 1 Story Duplex – Mechanical Room & HRV

The addresses associated with the four buildings in this style are provided in Table 2.5-17.

Table 2.5-17 : Kanat'a Dey'i 1 Story Duplex Building Addresses

Building Address	Layout Style
4503 Kanat'a Dey'i	1 Story Duplex
4505 Kanat'a Dey'i	
4543 Kanat'a Dey'i	
4545 Kanat'a Dey'i	
4468 Kanat'a Dey'i	
4470 Kanat'a Dey'i	
4481 Kanat'a Dey'i	
4483 Kanat'a Dey'i	

Table 2.5-18 provides the square footage and insulation values of building components for a typical 1 story duplex.

Table 2.5-18: Kanat'a Dey'i 1 Story Duplex Insulation Values and Area of Building Components

Item	Floor House	Wall House	Door House	Windows	Ceiling
R-Value	37.2	19.2	5.0	2.6	40.4
Area, ft^2	1,133	720	40	115	1,210

One Weil McLain WTGO-3 hot water boiler firing on #2 fuel oil is used to heat each building. Domestic hot water is generated using a tankless coil in the heating boiler. The boiler is rated at 115,000 Btu/hr and has an efficiency of 85.8% as determined by a stack test. Hot water

circulation pumps distribute hot water for space heating. A heat recovery ventilating unit provides ventilation air to the building. Table 2.5-19 provides a breakdown of annual energy use and costs for a typical Kanat'a Dey'i 1 story duplex building. Values are provided from AkWarm reports using the 3/30/2015 data library.

Table 2.5-19 : Kanat'a Dey'i 1 Story Duplex – Annual Energy Use and Cost Summary

Unit	Space Heating #2 Oil Use, Gallons	Space Heating #2 Oil Cost	Water Heating #2 Oil Use, Gallons	Water Heating #2 Oil Cost	Appliances & Lights Electric Use, kWh	Appliances & Lights Electric Cost	Total Annual Costs
1	141	$571	193	$782	6,477	$842	$2,195
2	143	$579	230	$932	6,473	$841	$2,352
Totals	**284**	**$1,150**	**423**	**$1,713**	**12,950**	**$1,684**	**$4,547**

Note: Energy summary provided from the AkWarm library dated 3/30/2015.

Kanat'a Dey'i 4C Duplex

THRHA owns and operates 3 identical 4 bedroom duplex units on Kanat'a Dey'i Street referred to as the 4C Duplexes. They are two story, stick frame construction, and vinyl sided. Figure 2.5-20 shows three elevation drawings from the building plans that represent the typical construction of the 4C duplex building.

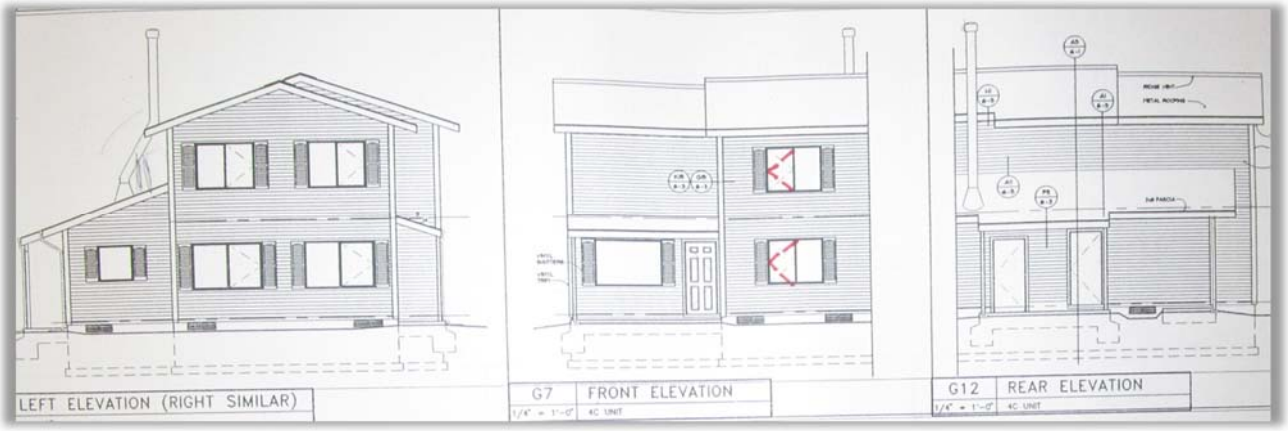


Figure 2.5 – 20 : Kanat'a Dey'i 4C Duplex – Typical Construction Details

The addresses associated with the three buildings in this style are provided in Table 2.5-20.

Table 2.5-20 : Kanat'a Dey'i 4C Duplex Building Addresses

Building Address	Layout Style
4530 Kanat'a Dey'i	4C Duplex
4532 Kanat'a Dey'i	
4480 Kanat'a Dey'i	
4482 Kanat'a Dey'i	
4551 Kanat'a Dey'i	
4549 Kanat'a Dey'i	

Table 2.5-21 provides the square footage and insulation values of building components for a typical 2 story 4C Duplex building.

Table 2.5-21 : Kanat'a Dey'i 4C Duplex Insulation Values and Area of Building Components

Item	Floor House	Wall House	Door House	Windows	Ceiling 1st Floor	Ceiling 2nd Floor
R-Value	36.3	19.2	5.0	2.6	40.4	51.5
Area, ft^2	760	1,340	38	135	160	600

One Burnham LE hot water boiler firing on #2 fuel oil is used to heat each building. Domestic hot water is generated using the heating boiler and a Superstor Ultra domestic hot water storage tank. The boiler has an efficiency of 78.1% as determined by a stack test. Hot water circulation pumps distribute hot water for space heating. A Vanee 1000 Solo heat recovery ventilating unit provides ventilation air to the building. Table 2.5-22 provides a breakdown of annual energy use and costs for a typical 4C Duplex Building. Values are provided from AkWarm reports using the 3/30/2015 data library.

Table 2.5-22 : Kanat'a Dey'i 4C Duplex – Annual Energy Use and Cost Summary

Unit	Space Heating #2 Oil Use, Gallons	Space Heating #2 Oil Cost	Water Heating #2 Oil Use, Gallons	Water Heating #2 Oil Cost	Appliances & Lights Electric Use, kWh	Appliances & Lights Electric Cost	Total Annual Costs
1	211	$855	208	$842	6,804	$885	$2,581
2	209	$846	230	$932	6,805	$885	$2,663
Totals	**420**	**$1,701**	**438**	**$1,774**	**13,609**	**$1,769**	**$5,244**

Note: Energy summary provided from the AkWarm library dated 3/30/2015.

Kanat'a Dey'i 3D Duplex

THRHA owns and operates 3 identical 3 bedroom duplex units on Kanat'a Dey'i Street referred to as the 3D Duplexes. They are two story, stick frame construction, and vinyl sided. Figure 2.5-21 shows elevation drawings from the building plans that represent the typical construction of a typical 3D duplex building.

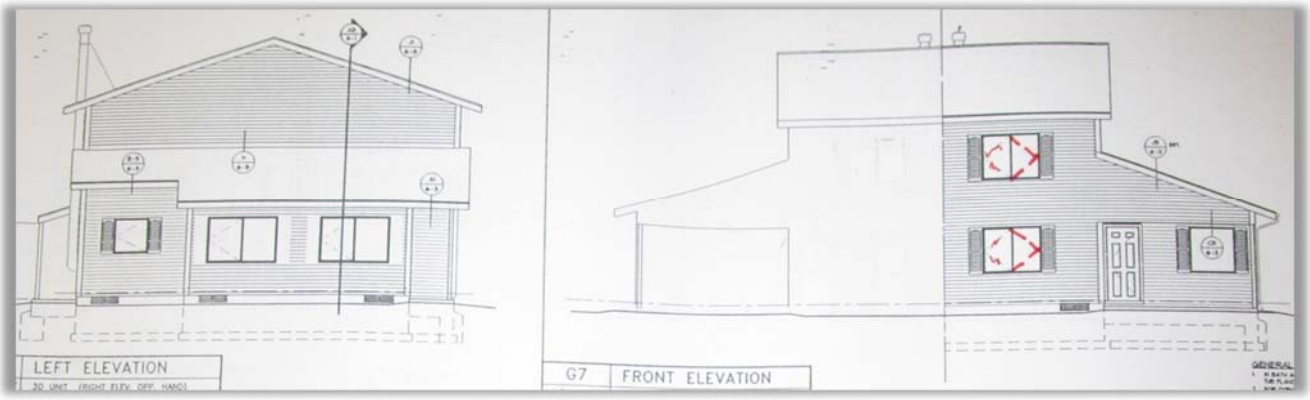


Figure 2.5 – 21 : Kanat'a Dey'i 3D Duplex – Typical Construction Details

The addresses associated with the three buildings in this style are provided in Table 2.5-23.

Table 2.5-23 : Kanat'a Dey'i 3D Duplex Building Addresses

Building Address	Layout Style
4492 Kanat'a Dey'i	3D Duplex
4494 Kanat'a Dey'i	
4430 Kanat'a Dey'i	
4428 Kanat'a Dey'i	
4461 Kanat'a Dey'i	
4463 Kanat'a Dey'i	

Table 2.5-24 provides the square footage and insulation values of building components for a typical 3D Duplex building.

Table 2.5-24 : Kanat'a Dey'i 3D Duplex Insulation Values and Area of Building Components

Item	Floor House	Wall House	Door House	Windows	Ceiling 1st Floor	Ceiling 2nd Floor
R-Value	36.3	19.2	5	2.6	40.4	40.4
Area, ft^2	936	1,206	38	133	460	476

One Burnham LE hot water boiler firing on #2 fuel oil is used to heat each building. Domestic hot water is generated using the heating boiler and a Superstor Ultra domestic hot water storage tank. Hot water circulation pumps distribute hot water for space heating. A Vanee 1000 Solo heat recovery ventilating unit provides ventilation air to the building. Table 2.5-25 provides a breakdown of annual energy use and costs for a typical 3D Duplex Building. Values are provided from AkWarm reports using the 3/30/2015 data library.

Table 2.5-25 : Kanat'a Dey'i 3D Duplex – Annual Energy Use and Cost Summary

Unit	Space Heating #2 Oil Use, Gallons	Space Heating #2 Oil Cost	Water Heating #2 Oil Use, Gallons	Water Heating #2 Oil Cost	Appliances & Lights Electric Use, kWh	Appliances & Lights Electric Cost	Total Annual Costs
1	206	$834	171	$693	6,890	$896	$2,423
2	225	$911	171	$693	6,890	$896	$2,500
Totals	**431**	**$1,746**	**342**	**$1,385**	**13,780**	**$1,791**	**$4,922**

Note: Fuel use and cost information provided by AkWarm software based on the 3/30/2015 library

2.5.2 Improvement Option Recommendations

Energy Audits were performed by professional auditing firms for the buildings in Juneau. This section provides recommended improvements identified during the audits for each building.

Fireweed Place Recommended Improvement Summary

Energy Audits and energy efficiency measures for the Fireweed Place Building were split up between the building shell and building systems. The building shell energy audit was completed by the contractor Marquam George, LLC and the building systems energy audit was completed by Alaska Energy Engineering, LLC. A summary of the building shell Energy Efficiency Measures are shown in Table 2.5-26.

Table 2.5-26: Fireweed Place Building Shell Energy Efficiency Measure Cost Benefit Summary

Location		Existing Configuration	Improvement	Installed Cost	Savings	SIR
Building Shell – Above Floor	Exposed Floor: Second Floor	Framing Type: 2 x Lumber Insulating Sheathing: None Top Insulation Layer: None Bottom Insulation Layer: R-4 Batt: FG or RW, 1.25 inches Insulation Quality: Very Damaged Modeled R-Value: 6.6	Install R-14 rigid board insulation to floor.	$18,719	$14,804	15.2
Building Shell – Ceiling Attic	Ceiling w/ Attic: House/Elevator	Framing Type: Energy Truss Framing Spacing: 24 inches Insulated Sheathing: None Bottom Insulation Layer: R-19 Batt: FG or RW, 6 inches Top Insulation Layer: None Modeled R-Value: 21.3	Add R-33 blown cellulose insulation to attic space with Energy Truss.	$166	$26	3
Building Shell – Ceiling Attic	Ceiling w/ Attic: House	Framing Type: Energy Truss Framing Spacing: 24 inches Insulated Sheathing: None Bottom Insulation Layer: R-38 Batt: FG or RW, 12 inches Top Insulation Layer: None Insulation Quality: Damaged Modeled R-Value: 38.5	Add R-21 blown cellulose insulation to attic space with Energy Truss.	$19,634	$1,390	1.36
Air Tightening	Building	Air Tightness from Blower Door Test: 18539 cfm at 50 Pascals	Perform air sealing to reduce air leakage by 4,635 cfm at 50 Pascals.	$4,635	$6,213	11.3
			Totals	**$43,154**	**$22,433**	

Note: Savings summary values obtained from the Energy Audit and AkWarm Analysis performed by Marquam George, LLC dated November, 2014.

Table 2.5-27 shows a summary of the Energy Efficiency Measures identified by the Buildings Systems Auditor.

Table 2.5-27: Fireweed Place Building Systems Energy Efficiency Measure Cost Benefit Summary

Energy Efficiency Measures	Annual			Life Cycle Costs				
	O&M	Energy	Total	Investment	O&M	Energy	Total	SIR
Reduce Hot Water Heater Capacity	$0	($900)	($900)	$500	$0	($16,800)	($16,800)	33.6
Air Seal Shafts	$0	($3,520)	($3,520)	$8,900	$0	($65,300)	($65,300)	7.3
Insulate Hot Water Heaters and Piping	$0	($180)	($180)	$800	$0	($3,300)	($3,300)	4.1
Combine Electric Meters	$0	($230)	($230)	$2,000	$0	($4,200)	($4,200)	2.1
Replace Heat Recovery Ventilators	$0	($15,290)	($15,290)	$163,400	$0	($283,600)	($283,600)	1.7
Upgrade Exterior Lighting	($60)	($30)	($90)	$1,000	($1,000)	($600)	($1,600)	1.6
Increase Attic Insulation	$0	($3,360)	($3,360)	$57,800	$0	($62,400)	($62,400)	1.1
Install Air Source Heat Pumps for HRVs	$960	($4,530)	($3,570)	$111,900	$16,300	($84,000)	($67,700)	0.6
Totals	**$900**	**($28,040)**	**($27,140)**	**$346,300**	**$15,300**	**($520,200)**	**($504,900)**	

Notes:
1 – Savings summary values obtained from the Energy Audit performed by Alaska Energy Engineering, LLC dated February 2015.
2 – Negative values denote savings.

Descriptions of the EEM's identified during the audit as well as shown in Table 2.5-27 including the purpose, scope, and analysis completed to develop the recommendations are as follows:

Reduce Hot Water Heater Capacity

- Purpose: The recovery rate of the 2nd floor hot water heater serving the laundry and spa area appears to be much higher than is needed to serve the load. Disconnecting one of the heating elements will reduce demand charges while maintaining an adequate HW supply for the fixtures.
- Scope: Disconnect one of three 6 kW heating elements to reduce demand charges by 6 kW per month.

Air Seal Shafts

- Purpose: Energy will be saved if the plumbing and duct shafts that extend through all floors of the building are sealed to preclude upward air flow into the attic due to stack effect.
- Scope: Seal the duct and plumbing shafts at the opening into the attic.

Insulate Hot Water Heaters and Piping

- Purpose: Energy will be saved if additional insulation is added to the hot water tanks and the hot water piping is insulated. While the hot water tanks and piping provide some beneficial heat, they are located in interior spaces with little heating load.

- Scope: Install an insulating blanket on each hot water tank and insulate the hot water piping.

Combine Electric Meters

- Purpose: The building has a separate electric meter for the kitchen that creates an additional monthly service charge. Combining the kitchen service with the house service will eliminate the service charge.
- Scope: Remove the kitchen meter and feed the kitchen service from the main panel MH.

Replace Heat Recovery Ventilators

- Purpose: Energy will be saved if the heat recovery ventilators HRV-1 and HRV-2 are replaced with smaller units sized for the code ventilation requirement.
- Scope: Replace HRV-1 and HRV-2 with 2,000 cfm units and balance the air system for the smaller air flows.

Upgrade Exterior Lighting

- Purpose: Energy will be saved if the fluorescent exterior lighting above the front entrance is upgraded to LED lighting.
- Scope: Replace five fluorescent T12 light fixtures with LED fixtures.

Increase Attic Insulation

- Purpose: Energy will be saved by installing additional insulation in the attic.
- Scope: Add additional blown-in cellulose insulation to increase the attic R-value from R-38 to R-58.

Replace Clothes Washers with Front-loading Model

- Purpose: Three of the clothes washers are top-loading models that use more water and energy than front-loading models.
- Scope: Replace top-loading washers with front-loading models when they require replacement.

Reduce Heat Recovery Ventilator Supply Air Setpoint

- Purpose: The supply air setpoint for the heat recovery ventilators is manually set at 60°F during summer and 70°F during winter. Reducing the setpoint will shift the ventilation load from the house meter to the tenant meters."
- Scope: Investigate if the supply air temperature setpoint can be reduced without adversely affecting the tenant's thermal comfort.

Install Air Source Heat Pump for Heat Recovery Ventilator Units

- Purpose: Energy will be saved if the ventilation air is heated with an air-to-water heat pump instead of with an electric heating coil.
- Scope: Install two 25 MBH air source heat pumps and hydronic piping connected to the HRVs in the attic. The heat pumps will operate when outside temperature is below 65°F to heat the ventilation air.

Granite Street Duplexes Recommended Improvement Summary

Energy Audits were completed and energy efficiency measures were identified for the Granite Street Duplexes were completed by the contractor Marquam George, LLC. A summary of the identified Energy Efficiency Measures for the Style 1 Duplexes are shown in Table 2.5-28.

Table 2.5-28: Granite Street Style 1 Energy Efficiency Measure Cost Benefit Summary

Energy Efficiency Measure	Savings	Installed Cost	Simple Payback, Years	SIR
Above-Grade Wall: House/Rim: Add R-14 rigid (or same as above grade wall recommendation) to rim joist of above grade wall.	$38	$272	7.2	3.33
Ceiling w/ Attic: House: Add R-21 blown cellulose insulation to attic space with Energy Truss.	$40	$825	20.6	1.16
On- or Below-Grade Floor, Perimeter: House: Install 2' of R-15 rigid board insulation on perimeter of Crawl Space Floor.	$5	$104	20.8	1.12
On- or Below-Grade Floor, Perimeter: House/Below Living-Dining: Install 2' of R-15 rigid board insulation on perimeter of Crawl Space Floor.	$12	$259	21.6	1.12
Ceiling w/ Attic: House/Living-Dining Vault: Install R-19 loose-fill insulation in attic with Energy Truss.	$26	$626	24.1	1
Window/Skylight: House/North: Replace existing window with triple pane, 2 low-E, argon window.	$12	$961	80.1	0.21
Window/Skylight: House/West: Replace existing window with triple pane, 2 low-E, argon window.	$26	$2,124	81.7	0.21
Window/Skylight: House/South/Shaded Bay: Replace existing window with triple pane, 2 low-E, argon window.	$19	$1,972	103.8	0.17
Window/Skylight: House/South: Replace existing window with triple pane, 2 low-E, argon window.	$12	$1,922	160.2	0.11
Totals	**$190**	**$9,065**	**47.7**	

Note: Savings summary values obtained from the Energy Audit and AkWarm Analysis performed by Marquam George, LLC.

A summary of the identified Energy Efficiency Measures for the Style 2 Duplexes are shown in Table 2.5-29.

Table 2.5-29: Granite Street Style 2 Energy Efficiency Measure Cost Benefit Summary

Energy Efficiency Measure	Savings	Installed Cost	Simple Payback, Years	SIR
Above-Grade Wall: House/Rim: Add R-14 rigid (or same as above grade wall recommendation) to rim joist of above grade wall.	$40	$272	3.5	3.33
Ceiling w/ Attic: House: Add R-21 blown cellulose insulation to attic space with Energy Truss.	$42	$825	1.2	1.16
On- or Below-Grade Floor, Perimeter: House: Install 2' of R-15 rigid board insulation on perimeter of Crawl Space Floor.	$5	$104	1.2	1.12
On- or Below-Grade Floor, Perimeter: House/Below Living-Dining: Install 2' of R-15 rigid board insulation on perimeter of Crawl Space Floor.	$13	$259	1.2	1.12
Ceiling w/ Attic: House/Living-Dining Vault: Install R-21 loose-fill insulation in attic with Energy Truss.	$30	$669	1.0	1
Window/Skylight: House/North: Replace existing window with triple pane, 2 low-E, argon window.	$12	$961	0.2	0.21
Window/Skylight: House/West: Replace existing window with triple pane, 2 low-E, argon window.	$27	$2,124	0.2	0.21
Window/Skylight: House/South/Shaded Bay: Replace existing window with triple pane, 2 low-E, argon window.	$20	$1,972	0.2	0.17
Window/Skylight: House/South: Replace existing window with triple pane, 2 low-E, argon window.	$12	$1,922	0.1	0.11
Totals	**$201**	**$9,108**	**45.3**	

Note: Savings summary values obtained from the Energy Audit and AkWarm Analysis performed by Marquam George, LLC.

The walkthrough inspection identified a failed whole house ventilation fan for the crawlspace. This unit is recommended for replacement due to necessity. THRHA also considered installing air source heat pumps for the Granite Duplexes. It was assumed that each housing unit had an indoor heating only unit installed in the living room and an air to water domestic hot water heater installed for each unit. Fossil fuel offset was assumed to be 90% of the current fuel oil use. Table 2.5-30 shows the estimated costs and savings for installing heat pumps in a typical granite street duplex.

Table 2.5-30: Granite Street Duplex Estimated Heat Pump Cost and Savings Summary

No. of Mini Split Air to Air Systems Installed	No. of Mini Split Air to DHW Systems Installed	Estimated Installed Cost	Estimated Offset of Oil Use Heating and DHW	Potential Heating Savings	Potential DHW Savings	Total Potential Savings	Simple Payback, Years	SIR Ratio
2	2	$20,000	90%	$2,910	$879	$3,790	5.3	2.8

Note: Cost and Savings Summary estimated by WES Energy & Environment and assumes 90% offset of the existing fuel oil use for space heating and domestic hot water and energy cost values listed in Table 2.5-1. A service life of 15 years was used to determine the SIR for each building.

Valley Boulevard Fourplex Recommended Improvement Summary

Energy Audits were completed and energy efficiency measures were identified for the Valley Boulevard Fourplex Units by the contractor Marquam George, LLC. A summary of the identified Energy Efficiency Measures for the Valley Boulevard Fourplex Units are shown in Table 2.5-31.

Table 2.5-31: Valley Blvd Fourplex Energy Efficiency Measure Cost Benefit Summary

Description	Savings	Estimated Cost	Simple Payback, Years	SIR
Caulk and Seal so that Home Air Leakage is Reduced by 300 CFM at 50 Pascals.	$353	$300	0.8	5.46
Above-Grade Wall: House/+ East & West Vault: Add R-19 dense-pack insulation, at 3.5 lb./cu. Ft., to empty 2x6 stud cavity.	$358	$899	2.5	4.7
On- or Below-Grade Floor, Perimeter: House/Crawlspace: Install 2' of R-30 rigid board insulation on perimeter of Crawl Space Floor.	$176	$630	3.6	3.3
Ceiling w/ Attic: House/Vault: Add R-21 blown cellulose insulation to attic space with Energy Truss.	$60	$591	9.9	1.19
Ceiling w/ Attic: House: Add R-21 blown cellulose insulation to attic space with Energy Truss.	$67	$666	9.9	1.19
Window/Skylight: House/Door: Remove existing glass and install triple, 2 low-E, argon glass.	$74	$573	7.7	1.11
Above-Grade Wall: House/East & West Vault: Add R-15 rigid foam to interior or exterior of existing wall. (Estimated cost does not include siding or wall coverings.)	$58	$709	12.2	0.96
Exterior Door: House: Add insulated storm door.	$18	$286	15.9	0.55
Window/Skylight: House/North: Replace existing window with triple pane, 2 low-E, argon window.	$52	$2,073	39.9	0.22
Window/Skylight: House/East & West: Replace existing window with triple pane, 2 low-E, argon window.	$98	$4,298	43.9	0.2
Window/Skylight: House/South Shaded: Replace existing window with triple pane, 2 low-E, argon window.	$16	$708	44.3	0.18
Window/Skylight: House/South: Replace existing window with triple pane, 2 low-E, argon window.	$12	$860	71.7	0.12
Totals	**$1,342**	**$12,593**	**9.4**	

Note: Savings summary values obtained from the Energy Audit and AkWarm Analysis performed by Marquam George, LLC.

THRHA also considered installing air source heat pumps for the Valley Boulevard Fourplex Buildings. It was assumed that each housing unit had an indoor heating only unit installed in the living room and an air to water domestic hot water heater installed for each unit. Fossil fuel offset was assumed to be 90% of the current fuel oil use. Table 2.5-32 shows the estimated costs and savings for installing heat pumps in the Valley Blvd Fourplex.

Table 2.5-32: Valley Blvd Fourplex Estimated Heat Pump Cost and Savings Summary

No. of Mini Split Air to Air Systems Installed	No. of Mini Split Air to DHW Systems Installed	Estimated Installed Cost	Estimated Offset of Oil Use Heating and DHW	Potential Heating Savings	Potential DHW Savings	Total Potential Savings	Simple Payback, Years	SIR Ratio
2	2	$20,000	90%	$2,910	$879	$3,790	5.3	2.8

Note: Cost and Savings Summary estimated by WES Energy & Environment and assumes 90% offset of the existing fuel oil use for space heating and domestic hot water and energy cost values listed in Table 2.5-1. A service life of 15 years was used to determine the SIR for each building.

Kanat'a Dey'i Duplexes Recommended Improvement Summary

Energy Audits were completed and energy efficiency measures were identified for the Kanat'a Dey'i Duplexes by the contractor Marquam George, LLC. A summary of the identified Energy Efficiency Measures for a typical Kanat'a Dey'i 1 Story Duplex are shown in Table 2.5-33.

Table 2.5-33: Kanat'a Dey'i 1 Story Duplex Energy Efficiency Measure Cost Benefit Summary

Description	Savings	Estimated Cost	Simple Payback, Years	SIR
Caulk and Seal so that Home Air Leakage is Reduced by 400 CFM at 50 Pascals.	$194	$800	4.1	2.3
Ceiling w/ Attic: House: Add R-21 blown cellulose insulation to attic space with Energy Truss.	$95	$2,522	26.5	0.9
Exposed Floor: House: Install R-7 rigid board insulation to floor.	$61	$2,220	36.4	0.7
Window/Skylight: House: Replace existing window with triple pane, 2 low-E, argon window.	$35	$3,894	111.3	0.2
Window/Skylight: House/East: Replace existing window with triple pane, 2 low-E, argon window.	$32	$3,692	115.4	0.2
Window/Skylight: House/South: Replace existing window with triple pane, 2 low-E, argon window.	$29	$4,046	139.5	0.1
Totals	**$446**	**$17,174**	**38.5**	

Note: Savings summary values obtained from the Energy Audit and AkWarm Analysis performed by Marquam George, LLC.

Table 2.5-34 shows a summary of the identified Energy Efficiency Measures for a typical Kanat'a Dey'i 4C Duplex building.

Table 2.5-34: Kanat'a Dey'i 4C Duplex Energy Efficiency Measure Cost Benefit Summary

Description	Savings	Estimated Cost	Simple Payback, Years	SIR
Caulk and Seal so that Home Air Leakage is Reduced by 500 CFM at 50 Pascals.	$460	$1,000	2.2	4.6
Ceiling w/ Attic: House: Add R-21 blown cellulose insulation to attic space with Energy Truss.	$19	$468	24.6	1.0
Exposed Floor: House: Install R-14 rigid board insulation to floor.	$73	$2,097	28.7	0.9
Ceiling w/ Attic: House/Second Floor: Add R-12 blown cellulose insulation to attic space with Energy Truss.	$30	$1,272	42.4	0.6
Window/Skylight: House: Replace existing window with triple pane, 2 low-E, argon window.	$69	$6,827	98.9	0.2
Window/Skylight: House/South: Replace existing window with triple pane, 2 low-E, argon window.	$59	$6,827	115.7	0.2
Totals	**$710**	**$18,491**	**26.0**	

Note: Savings summary values obtained from the Energy Audit and AkWarm Analysis performed by Marquam George, LLC.

Table 2.5-35 shows a summary of the identified Energy Efficiency Measures for a typical Kanat'a Dey'i 3D Duplex building.

Table 2.5-35: Kanat'a Dey'i 3D Duplex Energy Efficiency Measure Cost Benefit Summary

Description	Savings	Estimated Cost	Simple Payback, Years	SIR
Caulk and Seal so that Home Air Leakage is Reduced by 400 CFM at 50 Pascals.	$358	$800	2.2	4.12
Ceiling w/ Attic: House: Add R-21 blown cellulose insulation to attic space with Energy Truss.	$55	$1,344	24.4	0.94
Ceiling w/ Attic: House/Second Floor: Add R-21 blown cellulose insulation to attic space with Energy Truss.	$56	$1,390	24.8	0.93
Exposed Floor: House: Install R-14 rigid board insulation to floor.	$90	$2,583	28.7	0.78
Window/Skylight: House/East: Replace existing window with triple pane, 2 low-E, argon window.	$21	$2,022	96.3	0.18
Window/Skylight: House/West: Replace existing window with triple pane, 2 low-E, argon window.	$55	$5,664	103.0	0.17
Window/Skylight: House/South: Replace existing window with triple pane, 2 low-E, argon window.	$20	$2,882	144.1	0.12
Window/Skylight: House/North: Replace existing window with triple pane, 2 low-E, argon window.	$30	$2,882	96.1	0.18
Totals	**$685**	**$19,567**	**28.6**	

Note: Savings summary values obtained from the Energy Audit and AkWarm Analysis performed by Marquam George, LLC.

THRHA also is considering upgrading portions of the building due to necessity that are not driven by energy savings but driven by necessity or energy cost savings. A summary of potential upgrades being considered are as follows:

- Install Air Source Heat Pumps for space heating and DHW
- Clean existing heat recovery ventilator units to improve efficiency of operation.
- Adding R-10 rigid insulation below floor joists for passively vented foundations.

Heat Pumps – Air source heat pumps were evaluated for Kanat'a Dey'i Duplexes by the contractor WES Energy & Environment. It was assumed that each housing unit had an indoor heating only unit installed in the living room and an air to water domestic hot water heater installed for each unit. Fossil fuel offset was assumed to be 90% of the current fuel oil use. Tables 2.5-36 through 2.5-38 show the estimated costs and savings for installing heat pumps in typical Kanat'a Dey'i Duplexes.

Table 2.5-36: Kanat'a Dey'i 1 Story Duplex Estimated Heat Pump Cost and Savings Summary

No. of Mini Split Air to Air Systems Installed	No. of Mini Split Air to DHW Systems Installed	Estimated Installed Cost	Estimated Offset of Oil Use Heating & DHW	Potential Heating Savings	Potential DHW Savings	Total Potential Savings	Simple Payback, Years	SIR Ratio
2	2	$20,000	90%	$730	$1,088	$1,818	11	1.4

Note: Cost and Savings Summary estimated by WES Energy & Environment and assumes 90% offset of the existing fuel oil use for space heating and domestic hot water and energy cost values listed in Table 2.5-1.

Table 2.5-37: Kanat'a Dey'i 4C Duplex Estimated Heat Pump Cost and Savings Summary

No. of Mini Split Air to Air Systems Installed	No. of Mini Split Air to DHW Systems Installed	Estimated Installed Cost	Estimated Offset of Oil Use Heating and DHW	Potential Heating Savings	Potential DHW Savings	Total Potential Savings	Simple Payback, Years	SIR Ratio
2	2	$20,000	90%	$1,080	$1,126	$2,206	9.1	1.7

Note: Cost and Savings Summary estimated by WES Energy & Environment and assumes 90% offset of the existing fuel oil use for space heating and domestic hot water and energy cost values listed in Table 2.5-1.

Table 2.5-38: Kanat'a Dey'i 3D Duplex Estimated Heat Pump Cost and Savings Summary

No. of Mini Split Air to Air Systems Installed	No. of Mini Split Air to DHW Systems Installed	Estimated Installed Cost	Estimated Offset of Oil Use Heating and DHW	Potential Heating Savings	Potential DHW Savings	Total Potential Savings	Simple Payback, Years	SIR Ratio
2	2	$20,000	90%	$1,108	$879	$1,987	10.1	1.5

Note: Cost and Savings Summary estimated by WES Energy & Environment and assumes 90% offset of the existing fuel oil use for space heating and domestic hot water and energy cost values listed in Table 2.5-1.

2.6 KAKE

Kake, Alaska is located on Kupreanof Island in the Southeast Alaskan panhandle, 95 air miles southwest of Juneau. The average annual high temperature is 49.9°F and the average annual low temperature is 40.6°F. Annual Heating Degree Days (HDD) base 65F = 7,988 HDD

As an island community there is no direct road access to Kake. Transportation of goods and people is by plane or boat only. There is a small boat harbor, boat launch, deep water dock, & state owned/operated ferry terminal. The Alaska Marine Highway provides year round ferry and barge service. There is a state owned, lighted, paved runway and 2 seaplane bases. Flights are serviced by Alaska Seaplanes.

The community has a population of 626 with the median age being 42.5 years old. There are 421 housing units in Kake of which 178 are owner occupied and 62 are renter occupied units. The Kake economy is classified as subsistence and is reliant on local government and seasonal tourism. The island is a high energy cost community paying prices of $5.67/gallon for #1 fuel oil and $0.62/kWh for electricity. The Alaska Power Cost Equalization (PCE) program subsidizes the first 500 kWh for residential use to $0.22/kWh. Table 2.6-1 shows an energy cost comparison for heating fuels in the community.

Table 2.6-1 : Kake Cost of Energy Comparison

Technology, Unit	Input Btu/Unit	Cost/Unit	Assumed Efficiency	Output Btu/Unit	Cost / mmBtu Output
#1 Fuel Oil, Gallon	134,000	$5.67	80%	107,200	$52.89
Propane	91,300	$2.95	80%	73,040	$40.39
Electricity, kWh (Resistance)	3,412	$0.62	100%	3,412	$181.71
Electricity, kWh (Heat Pump)	3,412	$0.62	300%	10,236	$60.57
Wood Pellets, Ton	15,200,000	$400.00	80%	12,160,000	$32.89

Note:
1 - Fossil fuel prices provided by AkWarm software based on the 3/30/2015 library and local providers.
2 - Biomass prices obtained from local providers.
3 – Fuel oil has to be unloaded from the barge and delivered to Kake buildings using a flatbed pickup truck.

2.6.1 Kake Senior Center (Formerly Kake Elderly Low Rent Building)

THRHA manages a senior center and 17 single family apartments on the island community of Kake. The Kake Senior Center is undergoing a Modernization Project that includes an expansion, building shell improvements, new mechanical room and equipment, and incorporation of renewable fuels. A list of the modernization improvements are as follows:

- 7,000 ft^2 expansion including a new dining room, commercial kitchen, and ADA compliant bathrooms
- Apartment interior renovations
- Upgrading from T-12 to T-5 overhead lighting

- Adding R-10 exterior insulation, building wrap, and new fiber cement board siding
- Fire sprinkler system
- New mechanical room containing a wood pellet hot water boiler and propane backup boilers
- Domestic hot and cold water piping
- Hydronic distribution piping
- Baseboard heaters
- Energy star refrigerators
- Under road pipe installation for potential connection to a future district heating system
- Metal roof replacement
- New maintenance office
- Expanded parking lot
- Energy efficient windows

Figures 2.6-1 through 2.6-5 show the progress of the renovation.



Figure 2.6-1 – Kake Senior Center Addition



Figure 2.6-2 – Kake Senior Center Paving, Roof, and Exterior

The vinyl siding was removed from the walls and R-10 insulation is being added to the outside of the exterior walls and covered with building wrap. New vinyl siding is then installed over the building wrap as the new exterior surface. Figure 2.6-3 shows the installation of the exterior insulation and building wrap on the south side of the Senior Center.



Figure 2.6-3 – Kake Senior Center Exterior Insulation and Building Wrap

A new mechanical room has been constructed which contains a new wood pellet fired hot water boiler and backup propane boilers. Hot water thermal storage is used to reduce boiler cycling and improve operating efficiency of the wood pellet boiler. THRHA has worked through issues with securing bulk deliveries of wood pellets to Kake. Wood pellets are sourced from a pellet mill near Ketchikan and delivered by barge in 1 ton super sacks. The super sacks are then unloaded from the barge and transported into the community for storage. A fork lift dumps the wood pellets from the super sacks into a storage bin to maintain a full stockpile for the boiler. Figure 2.6-4 shows the boiler room, wood pellet boiler, hot water thermal storage tank, and boiler room piping.



Figure 2.6-4 – Kake Senior Center Wood Pellet Boiler and Hot Water Thermal Storage

THRHA is also planning for future applications to reduce operating costs at the Kake Senior Center. There have been discussions in the community for the possibility of a district heating system that will be installed in the future. THRHA installed a conduit under the road while installing other utilities to allow future connection to a district heating system. Figure 2.6-5 shows the capped conduit that will allow for connection to a district heating system.



Figure 2.6-5 – Kake Senior Center Future District Heating Connection

Additionally, THRHA is investigating the feasibility for installing solar panels on the facility to offset electricity costs. Since electricity prices can exceed $0.62/kWh, a small installation could yield significant savings. THRHA is using the Kake Senior Center as a model for what they would like to achieve at the remaining communities using the results from the energy audits completed under the DOE funding program. Pre expansion fuel use and costs are shown in Table 2.6-2.

Table 2.6-2 – CY 2014 Fuel Use and Costs

Annual #1 Oil Use, Gallons	Annual #1 Oil Cost	Annual Electric Use, kWh	Annual Electric Cost	Total Annual Costs
7,200	$40,824	70,640	$43,797	$84,621

2.6.2 Improvement Option Recommendations

THRHA commissioned studies for the Kake Senior Center including an Energy Assessment completed by Alaska Energy Engineering and solar PV studies completed by BacGen and Lime Solar. Each study evaluated grid connected and battery connected PV systems. A summary of the potential PV costs and savings are listed in Table 2.6.2-1. The studies are provided for reference in Section 4.0 - Attachments.

Table 2.6.1 – Solar PV Feasibility Study Summary

Item	BacGen Study		Lime Solar Study	
	6 kW Grid Tied	12 kW Battery	12 kW Grid Tied	12 kW Battery
Budget Cost	$41,000	$72,000	$61,715	$75,061
Annual Production, kWh	5,747	10,675	10,795	10,795
Annual Savings	$3,276	$6,085	$6,153	$6,153
Simple Payback, Years	14.0	13.0	10.0	12.2

The energy assessment completed by Alaska Energy Engineering recommended one energy conservation measure and installation of a building monitoring system. Table 2.6.2 shows the savings and costs estimated for the energy conservation measure identified. The energy assessment is provided in Section 4.0 - Attachments.

Table 2.6.2 – ECM Summary

ECM	Installed Cost	Annual Savings	Simple Payback	SIR
Refrigeration Room Heat Recovery	$1,950	$305	6.4	4.5

Refrigeration Room Heat Recovery – The dry storage room has a reach in refrigerator and freezer. The freezer and refrigerator will reject heat into the room and there is no ventilation in the room to remove the heat. The recommendation is to install a ceiling exhaust fan, duct, and grilles to transfer warm air into the dining room. The dining room has a heating load for most of the year. For periods that it is too warm in the dining room, the windows can be opened to allow heat to be removed from the space. Estimated installed costs are $1,950 which result in estimate annual heating offset of $305 per year.

2.7 KASAAN

The city of Kasaan, Alaska is located on the east side of Prince of Wales Island on Kasaan Bay, about 30 miles northwest of Ketchikan. The average annual high temperature of the area is 50.9°F and the average annual low temperature of the area is 39.3°F. Annual Heating Degree Days (HDD) base 65F = 7,124 HDD based on Craig location.

Kasaan is not directly accessible from the main land. Travel to Kasaan is through Ketchikan, Alaska by either flying Alaska Airlines or using the Alaska Marine Highway Ferry (AMHF). From Ketchikan, service to Kasaan is through small commuter airlines or The Inter-Island Ferry Authority (IFA) which has daily service between Ketchikan, on Revillagigedo Island to Hollis, on Prince of Wales Island. The IFA terminal on Prince of Wales Island is 64 miles from Kasaan using State Highway 924 and Thorne Bay road. There is a state owned seaplane base in Kasaan and small wheeled aircraft service is located in the neighboring community of Klawock. There are daily scheduled flights from Ketchikan to Klawock provided by Island Air Express. Cargo shipments to Kasaan must be offloaded at another port since the Kasaan Harbor is too small to accommodate large vessels and only has one city owned dock.

The population of Kasaan is 50 and the median age is 46.8 years old. There are 46 housing units in Kasaan of which 18 are owner occupied units and 7 are rented. Kasaan is listed as a subsistence community with 50% of the employed population involved in business and management and 23% involved in farming, fishing, and forestry. Table 3.7-1 shows an energy cost comparison for heating fuels.

Table 3.7-1 : Kasaan Cost of Energy Comparison

Technology, Unit	Input Btu/Unit	Cost/Unit	Assumed Efficiency	Output Btu/Unit	Cost/ mmBtu Output
#1 Fuel Oil, Gallon	134,000	$3.86	80%	107,200	$36.01
Propane	91,300	$2.82	80%	73,040	$38.61
Electricity, kWh (Resistance)	3,412	$0.22	100%	3,412	$65.06
Electricity, kWh (Heat Pump)	3,412	$0.22	300%	10,236	$21.69
Wood Pellets, Ton	15,200,000	$400.00	80%	12,160,000	$32.89

Note: Fuel prices provided by AkWarm software based on the 3/30/2015 library. Biomass & propane prices obtained from local providers.

3.7.1 Kasaan Multifamily Dwellings

THRHA operates three duplexes in Kasaan. There is one 3 bedroom, 2 bathroom duplex and two 2 bedroom, one bath duplexes. Each was built in 2007 and has a 5 Star Plus energy rating. The buildings have concrete foundations and all-weather wood foundation (AWW) stem walls. The AWW stem walls are 3/4" treated plywood which are sealed with Blueskin WP200 self-adhering membrane water protector and insulated on the outside with 1" rigid extruded polystyrene. They are covered with drain fabric and backfilled with drain rock. Crawlspaces are dry and sealed with two layers of 6 mil poly vapor barrier. Crawlspace ventilation has closeable foundation vents and a 4" diameter PVC passive stack vent from the crawlspace through the roof.

The roof is framed with raised heel scissor trusses and flat 8' ceilings furred down over hallway and bathrooms. A conditioned storage space is provided over the ceiling. The ceiling of this storage space has a vapor barrier and is covered with sheetrock and fire tape to isolate it from the cold attic and attic insulation. The storage space also acts as a warm air plenum for distribution of warm air from the living room to the back bedrooms via a low sone fan controlled by a switch in hallway. All windows are Certainteed Insulate with low e argon glazing and NFRC U-value of 0.32. Figures 3.7-1 and 3.7-2 show a typical Kasaan Duplex building.



Figures 3.7 – 1 : Kasaan Duplexes: Outside Shell



Figure 2.7 – 2 : Kasaan Duplexes: Kitchen

The addresses associated with the three buildings in this style are provided in Table 2.7-2.

Table 2.7-2 : Kasaan Duplex Building Addresses

Address	Bedroom
College Street 1A	3 Bedroom Duplex
College Street 1B	
College Street 2A	2 Bedroom Duplex
College Street 2B	
College Street 3A	
College Street 3B	

Table 2.7-3 provides the typical square footage and insulation values of building components for the Kasaan Duplex Buildings.

Table 2.7-3 : Kasaan Duplex Building Insulation Values and Area of Building Components

Building	Item	Living Area Floors	Walls	Door 1	Door 2	South Windows	Remaining Windows	Ceiling
3 Unit Duplex	R-Value	41.0	19.2	5.0	3.3	3.1	3.1	51.5
	Area, ft^2	1,408	1,016	20	20	59	77	1428
2 Unit Duplex	R-Value	41.0	19.0	5.0	3.3	3.1	3.1	51.5
	Area, ft^2	896	852	20	20	64	60	924

Heating is provided using a Monitor 2200 space heater in the living room. Cadet Softheat glycol-filled electric baseboard heaters are used for backup heating in all sleeping rooms and bathrooms, and an airtight Quadrafire wood stove in living room, with combustion air drawn from the crawlspace.

Heat from the living room can be distributed to sleeping rooms by switching on an 80 CFM Panasonic fan (24 watts) in the conditioned storage space above the flat ceiling. This heat is ducted to each sleeping room in 4" round metal duct, all inside the conditioned space.

Domestic hot water is heated with a Rinnai R53 LPG water heater in the laundry room. The hot water heater pulls water from a standard 50 gallon electric hot water tank that is set for storage of water only (not electrically heated). The storage tank is intended to provide room temperature water for the Rinnai, thus lowering the temperature rise for the Rinnai to heat hot water. The Gas Appliance Manufacturers Association (GAMA) energy factor is 0.84. The kitchen range and clothes dryer use propane. Table 2.7-4 and 2.7-5 provide a breakdown of annual energy use and costs for the Kasaan Duplex Buildings. Values are provided from AkWarm reports using the 3/30/2015 data library.

Table 2.7-4: Kasaan 3 Bedroom Duplex – Annual Energy Use and Cost Summary

Space Heating Oil Use, Gallons	Space Heating Cost	Water Heating Propane Use, Gallons	Water Heating Cost	Lights Electric Use, kWh	Lights Electric Cost	Stove / Dryer Propane Use	Stove / Dryer Propane Cost	Total Annual Costs
130	$502	214	$625	5,034	$1,118	112	$316	$2,563

Note: Fuel use and cost information provided by AkWarm software based on the 3/30/2015 library

Table 2.7-5: Kasaan 2 Bedroom Duplex – Annual Energy Use and Cost Summary

Space Heating Oil Use, Gallons	Space Heating Cost	Water Heating Propane Use, Gallons	Water Heating Cost	Lights Electric Use, kWh	Lights Electric Cost	Stove / Dryer Propane Use	Stove / Dryer Propane Cost	Total Annual Costs
86	$332	165	$482	4,215	$936	112	$316	$2,066

Note: Fuel use and cost information provided by AkWarm software based on the 3/30/2015 library

2.7.2 Improvement Option Recommendations

The energy audits of the facilities generated a list of energy efficiency recommendations. The buildings are constructed efficiently and require minimal upgrades. Energy efficiency measures considered for the Kasaan Low Rent Housing Building are as follows:

- **Air Sealing** – The building is very tight, however THRHA considered improving the air sealing by 10%.
- **Insulation** – Insulation values in the building are high. THRHA considered adding R-12 blown cellulose to the attic space.
- **LED Exterior Lighting** – THRHA considered replacing exterior lighting with high efficiency LED lighting.

A summary of estimated costs and savings for recommended measures are provided in Table 2.7-6. Cost and savings values are a result of AkWarm calculations.

Table 2.7-6: Kasaan Duplexes – Energy Efficiency Measure Cost Benefit Summary

Energy Efficiency Measure	3 Bedroom Duplex			2 Bedroom Duplex		
	Annual Savings	Costs	Simple Payback, Years	Annual Savings	Costs	Simple Payback, Years
Caulk and seal so that air leakage is reduced by 75 CFM (10%) at 50 pascals.	Negligible	$500	N/A	$25	$500	20.0
Add R-12 blown cellulose insulation to attic space.	$35	$1,988	56.8	$20	$1,287	64.4
LED outside lighting	$123	$460	3.7	$123	$460	3.7
Totals	**$158**	**$2,948**	**18.7**	**$168**	**$2,247**	**13.4**

Notes:
1 – Costs and savings values for air sealing, windows, and insulation are estimated using the AkWarm software from the 3/30/2015 library.

2 – LED outside lighting savings are estimated. A summary of assumptions and savings are listed in Section 4.0 – Attachments.

THRHA also is considering upgrading portions of the building due to necessity that are not driven by energy savings. A summary of potential upgrades being considered are as follows:

- Replacing Rinnai water heating when required
- Replace Monitor space heaters with newer Toyo space heaters.
- Replace wood stoves with newer models when needed.
- Replace oil fired space heaters with mini-split heat pumps when hydroelectric rates become available.

2.8 KETCHIKAN

Ketchikan is located close to the southern boundary of Alaska. It is a home rule city that is located on the southwestern coast of Revillagigedo Island, opposite Gravina Island. The average annual high temperature of the area is 50.9°F and the average annual low temperature of the area is 39.3°F. Annual Heating Degree Days (HDD) base 65F = 7,081 HDD.

Ketchikan is accessible by major airlines, the Alaska Marine Highway System, and small air and water craft. The Ketchikan International Airport serves Ketchikan. There are 4 seaplane/floatplane landing facilities and a deep draft dock for cargo shipments that can accommodate vessels up to 71 feet long.

The population of Ketchikan is 8,009 and the median age is 38.3 years old. The average household income is $64,415. As a major port of entry into southeast Alaska, Ketchikan's economy is diverse. It is composed primarily of a large fishing fleet, fish processing, tourism, and timber. There are 3,794 housing units available in Ketchikan of which 1,610 are owner occupied and 1,641 are renter occupied. Table 2.8-1 shows an energy cost comparison for heating fuels in Ketchikan.

Table 2.8-1 : Ketchikan Cost of Energy Comparison

Technology, Unit	Input Btu/Unit	Cost/Unit	Assumed Efficiency	Output Btu/Unit	Cost/ mmBtu Output
#1 Fuel Oil, Gallon	134,000	$3.95	80%	107,200	$36.85
Propane, Gallon	91,300	$2.64	80%	73,040	$36.14
Electricity, kWh (Resistance)	3,412	$0.10	100%	3,412	$29.31
Electricity, kWh (Heat Pump)	3,412	$0.10	300%	10,236	$9.77

Note: Fuel prices provided by AkWarm software based on the 3/30/2015 library. Propane price is provided by local suppliers.

2.8.1 Ketchikan Fourplex Multifamily Building

THRHA operates a 1,531 ft^2 fourplex multifamily building in the city of Ketchikan. This building was constructed in 2005 using the outside-insulation technique, where 2 staggered layers of rigid extruded polystyrene foam board are installed on the outside of the walls. There is an insulated concrete foundation and conditioned crawlspace with mechanical crawlspace ventilation. It has two 2-bedroom fully accessible apartments on the ground level and two 3-bedroom apartments on the top floor above the carport. Figure 2.8-1 shows the typical outside of the Fourplex building.



Figure 2.8 – 1 : Ketchikan Fourplex

Tables 2.8-2 and 2.8-3 provide the square footage and insulation values of building components for the 2 bedroom and 3 bedroom units respectively.

Table 2.8-2 : Ketchikan 2 Bedroom Unit Insulation Values and Area of Building Components

Item	Living Area Floors	ICF Stem Wall	House Below Grade	Wall Section 1	Wall Section 2	House Entry Door	Carport Door	Windows	Ceiling w/Attic	Cathedral Ceiling
R-Value	12.1	21.0	42.0	19.6	24.4	5.0	5.3	3.1	51.5	40.0
Area, ft^2	1	455	465	1,152	383	20	20	161	269	1

Table 2.8-3 : Ketchikan 3 Bedroom Unit Insulation Values and Area of Building Components

Item	Living Area Floors	Wall Section 1	House Entry Door	House Fixed Window	House South Patio	House Patio not South	Ceiling w/Attic
R-Value	38.4	19.6	5.0	3.1	2.8	2.8	51.5
Area, ft^2	609	1,345	20	128	40	40	1,238

The building is all-electric for space heating and domestic hot water. The electric heating is provided by oil-filled SoftHeat electric baseboard heaters in all rooms. Oil fired Toyo space heaters are provided for backup heating in the living rooms, though they are not needed to keep the units warm. Table 2.8-4 provides a breakdown of annual energy use and costs for the Ketchikan Fourplex Building. Values are provided from AkWarm reports using the 3/30/2015 data library.

Table 2.8-4 : Ketchikan Fourplex Annual Fuel Use and Cost Breakdown

Address	Unit	Space Heating #1 Oil Use, Gallons	Space Heating #1 Oil Cost	Space Heating Electric Use, kWh	Space Heating Electric Cost	Water Heating Electric Use, kWh	Water Heating Electric Cost	Lights / Appliance Electric Use, kWh	Lights / Appliance Electric Cost	Total Annual Costs
3245 Fairview Avenue	1	14	$55	4,047	$405	5,129	$513	6,550	$655	$1,628
	2									
	3	14	$55	4,305	$431	3,884	$388	6,090	$609	$1,483
	4									
		28	**$111**	**8,352**	**$835**	**9,013**	**$901**	**12,640**	**$1,264**	**$3,111**

Note: Fuel use and cost information provided by AkWarm software based on the 3/30/2015 library

2.8.2 Improvement Option Recommendations

The energy audits of the Ketchikan Fourplex generated a list of energy efficiency recommendations. Energy efficiency measures considered for the Ketchikan Fourplex are as follows:

- **Air Sealing** – The building is very tight, however THRHA considered improving the air sealing by 10%.
- **Insulation** – Insulation values in the building are high. THRHA considered adding R-12 blown cellulose to the attic space.
- **LED Exterior Lighting** – THRHA considered replacing exterior lighting with high efficiency LED lighting.

A summary of estimated costs and savings for recommended measures are provided in Table 2.8-5. Cost and savings values are a result of AkWarm calculations.

Table 2.8-5 : Ketchikan 4-Plex – Energy Efficiency Measure Cost Benefit Summary

Energy Efficiency Measure	Annual Savings	Costs	Simple Payback, Years
Caulk and Seal so that Air Leakage is Reduced by 75 CFM (10%) at 50 Pascals.	Negligible	$1,000	N/A
Add R-12 blown cellulose insulation to attic space.	$26	$1,598	61.5
LED Outside Lighting	$123	$920	7.5
Totals	**$149**	**$3,518**	**23.6**

Notes:

1 – Costs and savings values for air sealing, windows, and insulation are estimated using the AkWarm software from the 3/30/2015 library.

2 – LED outside lighting savings are estimated. A summary of assumptions and savings are listed in Section 4.0 – Attachments.

THRHA also is considering upgrading portions of the building to improve the function of the building and not necessarily justified by energy savings. A summary of potential upgrades being considered are as follows:

- Replace the Toyo oil fired space heaters with mini-split heat pumps.
- Replace the electric hot water heaters with air source heat pump water heaters.
- Replace the crawlspace exhaust fan with a humidity controlled DC fan.

Heat Pump Space Heaters – The space heaters currently use minimal fuel since the building is primarily heated using the electric baseboard heaters. Estimated fuel costs are $110 per year in the space heaters. Electric mini-split heat pump units would be less expensive to operate than baseboard heaters and space heaters, however savings potential is minimal. The estimated cost to install a mini split heat pump is $4,500. Even if the heat pumps were sized to heat a larger portion of the building and offset electric heat, savings values would be difficult to justify the expense. Capital avoidance costs could be considered to improve economics as existing equipment requires replacement.

Heat Pump Water Heaters – Heat pump water heaters have the potential to heat domestic hot water for the building. Efficiencies can be in the 300% range. The estimated installed cost for each heat pump system ducted to the outdoors is $3,000 to replace an indirect hot water tank. Table 2.8-6 shows the estimated cost benefit summary for installing heat pumps.

Table 2.8-6 : Ketchikan 4-Plex – Estimated Heat Pump DHW Cost Benefit Summary

No. of Mini Split Air to DHW Systems Installed	Estimated Installed Cost	Estimated Offset of Electric Use for DHW	Potential DHW Savings	Simple Payback, Years	SIR Ratio
4	$12,000	95%	$571	21.0	0.7

Geothermal Heat Pump – Geothermal heat pumps can be in the 500% range. Drawbacks to these systems are the high installed cost of wells or trenches to be used as a heat sink and heat supply for the system. Capital costs vary greatly by location, soil structure, and size. Economics for geothermal heat pump installations are not considered in this report.

2.9 KLAWOCK

Klawock, Alaska is located on the west coast of Prince of Wales Island on Klawock Inlet. It is about 7 miles north of Craig by road and 55 air miles west of Ketchikan. The average annual high temperature of the area is 50.9°F and the average annual low temperature of the area is 39.3°F. Annual Heating Degree Days (HDD) base 65F = 7,124 HDD. The community is classified as subsistence and relies on fishing and related support businesses as well as logging support, sawmill operations, and tourism as the economic base.

There is no direct road access from the main land to Klawock. Travel to Klawock is through Ketchikan, Alaska by either flying Alaska Airlines or using the Alaska Marine Highway Ferry (AMHF). From Ketchikan, service to Klawock is through small commuter airlines or The Inter-Island Ferry Authority (IFA) which has daily service between Ketchikan and Hollis. The IFA terminal at Hollis is 22 miles from Klawock using Hollis Road. The Port of Klawock has 1 float plane dock and 1 airport for small wheeled aircraft. There are daily scheduled flights from Ketchikan to Klawock provided by Island Air Express. Cargo may shipped using Alaska Marine Lines.

The population of Klawock is 774 with the median age being 41.4 years old. The average household income is $53,091. There are 380 housing units available in the area of which 197 are owner occupied and 114 are renter occupied. Table 2.9-1 shows an energy cost comparison for heating fuels in Klawock.

Table 2.9-1 : Klawock Cost of Energy Comparison

Technology, Unit	Input Btu/Unit	Cost/Unit	Assumed Efficiency	Output Btu/Unit	Cost/ mmBtu Output
#1 Fuel Oil, Gallon	134,000	$4.13	80%	107,200	$38.53
Propane, Gallon	91,300	$2.57	80%	73,040	$35.19
Electricity, kWh (Resistance)	3,412	$0.22	100%	3,412	$64.48
Electricity, kWh (Heat Pump)	3,412	$0.22	300%	10,236	$21.49
Wood Pellets, Ton	15,200,000	$330.00	80%	12,160,000	$27.14

Note: Fuel prices provided by AkWarm software based on the 3/30/2015 library. Biomass prices obtained from local providers.

2.9.1 Klawock 18-Unit Senior Housing Building

The Klawock Senior Center is a 24,980 ft^2 facility housing approximately 30 residents and staff. It was originally constructed as a 10 unit building. An 8 unit expansion and rehab of the existing units occurred in 2008. The floors are 12" I-joists that are 16" o.c, walls are 2 x 6 studs 24" o.c. with insulated headers, and the ceiling is 24" o.c truss construction with baffles at the eaves. The basement slab has 2 foot of 2" XPS insulation underneath the perimeter and down the inside of the stem wall to the footing. Windows are CertainTeed Low E Argon vinyl sliders with a U- value of 0.32. Figure 2.9-1 shows an aerial view of the Klawock Senior Center.



Figure 2.9-1 Klawock Senior Center

Table 2.9-2 provides the square footage and insulation values of building components for the Klawock Senior Center.

Table 2.9-2 Klawock Senior Center Insulation Values and Area of Building Components

Building Address	Item	Living Area Floors	Floor Over Crawl Space	Floor Over Carport	Conditioned Stairwell	Conditioned Basement	Basement, Stairwell, & Main Living Walls	Ceiling
465 Summit Street	R-Value	38	38	38	38	10	21	38
	Area, ft^2	8,675	1,949	816	120	1,333	6,082	4,383

The boiler room contains two Weil McLain model WTGO-7 hot water boilers firing on #1 fuel oil and rated at 210,000 Btu/hr output and 50 psig. The boilers were installed in 2008 and are in excellent condition. The hot water heating distribution system is a primary-secondary piping system with individual zone pumps distributing water throughout the building. Baseboard fin tube radiant heaters provide space heating for rooms. A makeup air handling unit with a hot water coil is used for the kitchen and common area.

Domestic hot water is heated indirectly using the heating boilers and stored in two 120 gallon HTP Superstor tanks. There is potential room in the existing boiler room to locate hot water thermal storage tanks and one wood fired boiler.

The facility used approximately 5,000 gallons of #1 fuel oil annually for space heating and domestic hot water heating. Annual expenditures are approximately $20,650 at the current fuel price of $4.13 per gallon. An above ground 1,100 gallon fuel oil tank is used for onsite storage.

2.9.2 Improvement Option Recommendations

The results of the Energy Audit suggest that Klawock Senior Center is very efficient in construction. Installation of a wood pellet fired boiler system was evaluated in a pre-feasibility study from September 2, 2014 titled *"High Efficiency Low Emission Wood Fired Heating System Pre-Feasibility Report"* created by WES Energy & Environment. The recommended system consists of a 160,000 Btu/hr wood pellet fired hot water boiler and 200 gallons of hot water thermal storage. The financial summary of the wood pellet system is provided in Table 2.9-3. A cost breakdown is provided in Section 4.0 - Attachments.

Table 2.9-3 : Klawock Wood Pellet Heating System Financial Summary

Current #1 Fuel Oil Use, Gallons	Current Oil Cost	Estimated Wood Pellet Use, Tons	Estimated Wood Pellet Cost	Estimated O&M Costs	Estimated Oil Cost with Wood Pellet System	Estimated Savings	Estimated Capital Cost	Simple Payback, Years
5,000	$20,650	42	$13,860	$1,590	$1,033	$4,168	102,275	24.5

Note: Assumes 95% offset with wood pellet system. Remaining 5% is offset with existing oil fired system. Fuel prices used to generate economics are $4.13/gallon for #1 fuel oil and $330/ton of wood pellets. Annual oil use and wood pellet use values are from the September 2, 2014 report titled "High Efficiency Low Emission Wood Fired Heating System Pre-Feasibility Report" created by WES Energy & Environment.

2.10 PETERSBURG

The Borough of Petersburg, Alaska is located on the northwest end of Mitkof Island, about 120 miles between Juneau and Ketchikan. The average annual high temperature in the area is 49.3°F and the average annual low temperature in the area is 36.7°F. Annual Heating Degree Days (HDD) base 65F = 8,485 HDD.

Petersburg is not accessible by direct road access. It can only be reached by air or water. There is twice daily jet service provided by Alaska Airlines. The Alaska Marine Highway System provides ferry access. Alaska Marine Lines provides twice weekly barge service. Charter aircraft and boats are also available. The community has 2 barge terminals, 3 harbors, and 3 docks. The maximum vessel length that can be accommodated is 140 ft. The state owned James A Johnson Airport is located there and also the Lloyd R. Roundtree Seaplane Base.

The population of Petersburg is 2,823 and the median age is 41.4 years old. Petersburg's economy relies heavily on commercial fishing, fish processing, and seasonal tourism and is designated as a subsistence community. 72% of the population is employed in the private sector, while 22% is in local government. The average household income is $84,408. There are 1,356 housing units available in the area, of which 821 are owner occupied and 402 are renter occupied. Table 2.10-1 shows an energy cost comparison for heating fuels in the community.

Table 2.10-1 : Petersburg Cost of Energy Comparison

Technology, Unit	Input Btu/Unit	Cost/Unit	Assumed Efficiency	Output Btu/Unit	Cost/ mmBtu Output
#2 Fuel Oil, Gallon	138,800	$4.03	80%	111,040	$36.29
Propane, Gallon	91,300	$2.65	80%	73,040	$36.28
Electricity, kWh (Resistance)	3,412	$0.08	100%	3,412	$23.45
Electricity, kWh (Heat Pump)	3,412	$0.08	300%	10,236	$7.82
Wood Pellets, Ton	15,200,000	$450.00	80%	12,160,000	$37.01

Note: Fuel prices provided by AkWarm software based on the 3/30/2015 library. Biomass & propane prices obtained from local providers.

2.10.1 Eagle-Raven Apartments

The Eagle-Raven Apartments are an apartment complex formerly owned and operated by AHFC. They are now owned by Petersburg Indian Association and are managed using a collaborative effort with THRHA. They were constructed around 1974. There are 2 buildings with 6-three bedroom apartments each. The apartments are 2 floors, with the kitchen, living room, and laundry on the main floor and the bedrooms and bathroom on the second floor. The layouts are the same in all of the units, however, each pair is mirrored of the adjacent unit. The exterior is aluminum siding over plywood and 2x4 walls. The foundation is creosote piles that support a raised floor with an insulated skirted crawlspace. Figures 2.10-1 through 2.10-4 show the pictures of the Eagle-Raven Apartments.



Figure 2.10-1 Eagle-Raven Apartments Typical 6-Unit Building



Figure 2.10-2 Eagle-Raven Apartments Typical Insulated Crawlspace



Figure 2.10-3 Eagle-Raven Apartments Typical Attic



Figure 2.10-4 Eagle-Raven Apartments Typical Electric Meters

Table 2.10-2 provides the square footage and insulation values of building components for a typical Eagle-Raven 6 unit apartment building.

Table 2.10-2 : Eagle Raven Building Insulation Values and Area of Building Components

Building Address	Item	Perimeter Living Area Floors	Center Living Area Floors	Crawlspace Skirting	Rim Joist	House	Doors	Windows	Ceiling
104 3rd Street	R-Value	6.7	35.5	11.7	11.9	11.3	5.3	2.6	10.6
	Area, ft^2	1,056	1,344	1,232	308	5,236	80	599	2,400

A System 2000 Energy Kinetics hot water boiler firing on #2 fuel oil is used to heat each 6 unit building. The size of the boiler is approximately 200,000 Btu/hr. Hot water circulation pumps distribute hot water for space heating to baseboard fin tube heaters. An 80 gallon electric hot water tank with a 4.5 kW electric heater generates domestic hot water for the building. Table 2.10-3 provides a breakdown of annual energy use and costs for each 6 unit building. Values are provided from AkWarm reports using the 3/30/2015 data library.

Table 2.10-3 : Typical Eagle-Raven Apartment Building Annual Fuel Use and Cost Breakdown

Unit	Space Heating #2 Oil Use, Gallons	Space Heating #2 Oil Cost	Water Heating Electricity Use, kWh	Water Heating Electricity Cost	Appliances & Lights Electricity Use, kWh	Appliances & Lights Electricity Cost	Total Annual Costs
1	1,652	$6,658	32,520	$2,602	50,296	$4,024	$13,283

Note: Fuel use and cost information provided by AkWarm software based on the 3/30/2015 library

2.10.2 Improvement Option Recommendations

The energy audit and blower door tests of the building generated a list of energy efficiency recommendations. Energy efficiency measures considered for the Eagle Raven Apartments are as follows:

- **Air Sealing** - THRHA would like to reduce air leakage by 150 CFM at 50 Pascal's.
- **Insulation** - THRHA considered insulating the ceiling joist cavities, crawlspace walls, and adding insulation to the attic.
- **Boiler Replacement** – THRHA considered replacing the oil fired boiler with an electric boiler.
- **Heat Pump DHW Heater –** Replace the existing electric hot water heater with an air source heat pump hot water heater.
- **Energy efficient lighting -** Replace T-12 fixtures with T-8 fixtures and incandescent bulbs with CFLs.

- **Energy Star Refrigerators** - Replace fridges with Energy Star appliance.

A summary of estimated costs and savings for recommended measures are provided in Table 2.10-4.

Table 2.10-4 : Eagle-Raven Apartment – Energy Efficiency Measure Cost Benefit Summary

Energy Efficiency Measure	Estimated Total Savings	Estimated Total Cost	Simple Payback, Years	SIR
On- or Below-Grade Floor, Perimeter: House: Install 4' of R-30 rigid board insulation on perimeter of Crawl Space Floor.	$1,012	$5,072	5.0	4.7
Cathedral Ceiling: House: Fill empty 2x12 cavity with 12" dense-pack blown-in cellulose insulation, density at least 3.5 lb/ft3.	$1,345	$8,565	6.4	3.7
Caulk and Seal so that Home Air Leakage is Reduced by 150 CFM at 50 Pascals.	$76	$250	3.3	2.8
Above-Grade Wall: Crawlspace Skirting: Install R-20 rigid foam board to interior of wall.	$436	$7,334	16.8	1.4
Primary Heating System: Replace Heating System with a Boiler having an AFUE of 94%, <130 F distribution.	$477	$11,361	23.8	0.7
Exterior Door: Door to Main Body: Remove existing door and install U-0.16 fiberglass door with polyurethane core.	$13	$1,779	136.8	0.1
Lighting Upgrade	$201	$5,220	26.0	0.3
Totals	**$3,360**	**$39,581**	**11.1**	

1 – Costs and savings values for air sealing, windows, and insulation are estimated using the AkWarm software from the 3/30/2015 library.

2 – Lighting savings are estimated. A summary of assumptions and savings are listed in Section 4.0 – Attachments.

Am air source heat pump was considered for domestic hot water heating. Table 2.10-5 shows the estimated cost benefit summary for installing heat pumps.

Table 2.10-5 : Eagle-Raven Apartment Estimated Heat Pump DHW Cost Benefit Summary

No. of Mini Split Air to DHW Systems Installed	Estimated Installed Cost	Estimated Offset of Electric Use for DHW	Potential DHW Savings	Simple Payback, Years	SIR Ratio
1	$3,000	95%	$824	3.6	4.1

THRHA also is considering upgrading portions of the building due to necessity that are not driven by energy savings. A summary of potential upgrades being considered are as follows:

- Provide new bath fans with motion sensor and vent them to the exterior.

- Provide new 3 speed 150 cfm kitchen range hoods and vent them to the exterior.
- Provide 110 CFM fan in crawlspace on moisture control and vent to exterior.
- Provide makeup air vents in bedrooms and living room.

Bathroom Ventilation – THRHA would like to install low-sone continuous duty rated exhaust fans on motion sensors with programmable time delays to meet ASHRAE 62.2-2012 for each bathroom. Installed costs are estimated at $750 per fan.

Kitchen Ventilation – THRHA would like to install new 3 speed 150 cfm kitchen range hoods that are vented to the exterior to replace the existing recirculating hoods. The estimated installed cost for each system is $1,500.

Crawlspace Ventilation – THRHA would like to install a 110 cfm exhaust fan to remove moisture from the crawlspace. The estimated installed cost for each system is $750.

Makeup Air Vents - THRHA would like to install fresh air makeup vents in the bedrooms and living room. The estimated installed cost for each room is $200.

2.11 SAXMAN

The city of Saxman, Alaska is located on the west side of Revillagigedo Island, about 2 miles south of Ketchikan on the South Tongass Highway. The average annual high temperature is 50.9°F and the average annual low temperature is 39.3°F. Annual Heating Degree Days (HDD) base 65F = 7,081 HDD.

As an island community, there is no direct road access to Saxman from the main land. Saxman relies on Ketchikan for its boat moorage, air travel, & state ferry services. Saxman is connected to Ketchikan by the South Tongass Highway. The Saxman Seaport has a dock and commercial barge off-loading facilities for propane, construction materials, equipment and supplies.

The population of Saxman is 447 and the median age is 35.2 years old. Saxman relies heavily on tourism and the Southeast Arts Economy. The average household income is $76,352. There are 136 housing units available in the area with 86 owner occupied and 45 renter occupied. Table 2.11-1 shows an energy cost comparison for heating fuels in the community.

Table 2.11-1 : Saxman Cost of Energy Comparison

Technology, Unit	Input Btu/Unit	Cost/Unit	Assumed Efficiency	Output Btu/Unit	Cost/ mmBtu Output
#2 Fuel Oil, Gallon	138,800	$3.95	80%	111,040	$35.57
Propane, Gallon	91,300	$2.64	80%	73,040	$36.14
Electricity, kWh (Resistance)	3,412	$0.10	100%	3,412	$29.31
Electricity, kWh (Heat Pump)	3,412	$0.10	300%	10,236	$9.77
Wood Pellets, Ton	15,200,000	$330.00	80%	12,160,000	$27.14

Note: Fuel prices provided by AkWarm software based on the 3/30/2015 library. Biomass prices obtained from local providers.

2.11.1 Saxman 12-Unit Multifamily Housing Building

THRHA operates a low rent multifamily building in the city of Saxman built in 1978. The building is of modular construction and contains 12 one bedroom, one bath rental units and is 1 story, stick frame construction, vinyl sided, and has a steel roof. The foundation is creosote piles that support a raised floor with a skirted crawlspace.

A typical unit is 24' x 20' with all units exiting to a central corridor. The central corridor is 5' wide and has a utility chase above the drop ceiling for heat, domestic hot and cold water piping, and electrical distribution to apartments. The building was weatherized in 2010. Figures 2.11-1 through 2.11-4 show the pictures of the Saxman 12 Unit Multifamily Building.



Figure 2.11-1 Saxman 12-Unit Low Rent Apartment Building Outside Shell



Figure 2.11-2 Saxman 12-Unit Low Rent Apartment Building Back



Figure 2.11-3 Saxman Outbuilding



Figure 2.11-4 Saxman 12-Unit Low Rent Apartment Building Entrance & Corridor

Table 2.11-2 provides the square footage and insulation values of building components for the Saxman Low Rent Apartment Building.

Table 2.11-2 : Saxman Building Insulation Values and Area of Building Components

Building Address	Item	Living Area Floors	Wall Section 1 House	Wall Section 2 Rim Joist	Exterior Doors	Windows	Ceiling
2708 Halibut Street	R-Value	48.3	11.3	18.4	5.0	2.0	54.4
	Area, ft^2	7,425	3,360	7,425	80	688	7,425

Two Weil McLain hot water boilers firing on #2 fuel oil are used to heat the building and domestic hot water. Hot water circulation pumps distribute hot water for space heating and to the indirect heated domestic hot water tank. Baseboard heat is located in each unit. The boilers are failing and are scheduled for replacement or removal in the near future. Table 2.11-3 provides a breakdown of annual energy use and costs for the 12 unit building. Values are provided from AkWarm reports using the 3/30/2015 data library.

Table 2.11-3 : Saxman Low Rent Apartment Building Annual Fuel Use and Cost Breakdown

Space Heating #2 Oil Use, Gallons	Space Heating #2 Oil Cost	Water Heating #2 Oil Use, Gallons	Water Heating #2 Oil Cost	Appliances & Lights Electric Use, kWh	Appliances & Lights Electric Cost	Total Annual Costs
470	$1,857	517	$2,042	67,421	$6,742	$10,641

Note: Fuel use and cost information provided by AkWarm software based on the 3/30/2015 library

2.11.2 Improvement Option Recommendations

The energy audit and blower door tests of the building generated a list of energy efficiency recommendations. Energy efficiency measures considered for the Saxman Low Rent Housing Building are as follows:

- **Air Sealing** - THRHA would like to tighten building up to no more than 4 ACH50.
- **Insulation** - THRHA considered insulating the rim joist, floor cavity, and adding insulation to the attic.
- **Air to Water Heat Pumps** - THRHA considered installing water to air heat pumps and leaving the oil fired boilers for backup. The heat pumps are limited to 130°F leaving water temperature, so the system would be limited to domestic hot water heating or require conversion to low temperature heating.

A summary of estimated costs and savings for recommended measures are provided in Table 2.11-4.

Table 2.11-4 : Saxman 12 Unit – Energy Efficiency Measure Cost Benefit Summary

Energy Efficiency Measure	Estimated Total Savings	Estimated Total Cost	Simple Payback, Years	SIR
Air Sealing to 4 ACH	$207	$500	2.4	3.8
Air to Water Heat Pumps	$1,333	$10,000	7.5	2.0
Insulate Rim Joist with R-14 on Above Grade Wall	$32	$699	21.8	1.1
Add R-19 Blown in Insulation to Exposed Floor 2x12 Cavity	$174	$7,128	41.0	0.6
Add R-12 Insulation to Attic Space	$100	$4,722	47.2	0.5
Totals	**$1,846**	**$23,049**	**12.5**	

Notes:

1 – Costs and savings values for air sealing and insulation are estimated using the AkWarm software from the 3/30/2015 library.

2 – Costs and savings for an air to water heat pump are estimated by WES Energy & Environment and assume 90% offset of fuel oil use for domestic hot water.

THRHA also is considering upgrading portions of the building due to necessity that are not necessarily driven by energy savings. A summary of potential upgrades being considered are as follows:

- Install a new heat recovery ventilator system in the central corridor and common spaces.
- Replace old Type M copper piping in corridor ceiling with new PEX
- Install individual electrical meters and service panels in each apartment.
- Installing a wood pellet fired hot water boiler system

Ventilation – The building does not currently have a central ventilation system. The central corridor is not ventilated and carries odors and apartments units have exhaust-only ventilation using a bath fan and a range hood. THRHA would like to install a heat recovery ventilator system for corridors and public spaces. A heat recovery ventilator system is estimated to cost $50,000. This system will use additional energy but will improve indoor air quality and occupant comfort.

Copper Pipe Replacement – Copper heating pipes are run above the ceiling to individual baseboard heaters in each unit. The pipes are leaking and zone valves are likely failed in place. THRHA is considering replacing the piping with new insulated PEX piping. Replacement costs are estimated at $150 per linear foot of supply and return pipe.

Individual Electric Meters – There is currently one electric meter on the building and electricity is billed as a commercial rate. THRHA would like to install individual meters for each unit to encourage a reduction in electricity use. Estimated installed costs for individual electric meter sockets and service panels are $1,100 per unit for a total cost of $13,200.

Wood Pellet Heating System - THRHA considered the feasibility of heating the building with a wood pellet fired biomass boiler located in a separate outbuilding. The recommended system consists of a 40,000 Btu/hr wood pellet fired hot water boiler and 60 gallons of hot water thermal

storage. The financial summary of the wood pellet system is provided in Table 2.11-5. A cost breakdown is provided in Section 4.0 – Attachments.

Table 2.11-5 : Saxman Wood Pellet Heating System Financial Summary

Current #2 Oil Use, Gallons	Current #2 Oil Cost	Estimated Wood Pellet Use, Tons	Estimated Wood Pellet Cost	Estimated O&M Costs	Estimated #2 Oil Cost with Wood Pellet System	Estimated Savings	Estimated Capital Cost	Simple Payback, Years
987	$3,899	7.2	$2,379	$1,500	$780	($760)	104,843	N/A

Note: Assumes 80% offset of the heating fuel use with wood pellets. Fuel price values used to estimate savings are provided in Table 2.11-1.

2.12 WRANGELL

The city of Wrangell is located on the northwest tip of Wrangell Island, about 155 miles south of Juneau and 90 miles northwest of Ketchikan. The average annual high temperature is 49.9°F and the average annual low temperature is 37.9°F. Annual Heating Degree Days (HDD) base 65F = 7,849 HDD.

As an island community, there is no direct road access to Wrangell from the main land. Commercial jet service to Wrangell is provided by Alaska Airlines. There is a seaplane base adjacent to the runway. The Port of Wrangell is a deep water port with barge facility, 2 marine travel lifts and work yard, and three boat harbors. In addition to the local airport, state operated facilities include a ferry dock. It is served by the Alaska Marine Highway, with ferry service out of Bellingham, Washington or Prince Rupert, British Columbia. Regular barge service from Seattle and Juneau is provided by Alaska Marine Lines and Samson Tug and Barge. There are also local marine freight haulers available.

The population of Wrangell is 2,365 with the median age being 42.3 years old. Wrangell is listed as a subsistence community. The economy of Wrangell is based on commercial fishing, fish processing, seasonal tourism, timber harvesting, and timber processing. The average household income is $67,371. There are 1,402 housing units available in the area with 704 owner occupied units and 365 rentals. Table 2.12-1 shows an energy cost comparison for heating fuels in the community.

Table 2.12-1 : Wrangell Cost of Energy Comparison

Technology, Unit	Input Btu/Unit	Cost/Unit	Assumed Efficiency	Output Btu/Unit	Cost / mmBtu Output
#1 Fuel Oil, Gallon	134,000	$3.95	80%	107,200	$36.85
Propane, Gallon	91,300	$2.76	80%	73,040	$37.79
Electricity, kWh (Resistance)	3,412	$0.10	100%	3,412	$29.31
Electricity, kWh (Heat Pump)	3,412	$0.10	300%	10,236	$9.77

Note: Fuel prices provided by AkWarm software based on the 3/30/2015 library

2.12.1 Wrangell Multifamily and Mixed Use Buildings

THRHA owns and operates two buildings in Wrangell consisting of a Triplex and a mixed use building referred to as the SNO Building. Wrangell has access to low cost hydroelectric power therefore the buildings utilize a mix of electric heat and boilers firing on #1 fuel oil. Current fuel prices are $3.95/gallon for #1 fuel oil and electricity prices range from $0.08 – 0.10/kWh. The city offers a special electric heating rate of $0.08/kWh.

2 Story Mixed Use Stikine Native Organization (SNO) Building:

The SNO building is an 11,841 ft^2 building constructed with a creosote pile foundation. In 2013 the building underwent extensive renovation. The first floor is commercial and the 2nd floor

contains 6 apartments ranging from 1 to 3 bedrooms. Figures 2.12-1 through 2.12-3 show pictures from the renovation of the SNO Building.



Figure 2.12-1 : SNO Building Front



Figure 2.12-2 : SNO Building Siding



Figure 2.12-3 : SNO Building Foundation and Boiler Room

The foundation is creosote pile, driven down to what had formally been the harbor beach. Fill material now surrounds the building, but the high tide still comes in to within 5 -6 feet of the bottom of the floor.

This is a mixed use building in downtown Wrangell located in the heart of the commercial district. The bottom floor has commercial and agency rental space, and a hall at the rear of the

building that is used by the public and the local Tribe, Wrangell Cooperative Association (WCA), and the Alaska Native Brotherhood and Sisterhood (ANB/ANS). The upstairs has apartments, ranging from 1 bedroom to 3 bedroom, the majority of which are low-income native rentals. Dimensions and insulation values for the SNO Building are provided in Table 2.12-2 and 2.12-3.

Table 2.12-2 – Building Dimensions and Areas

Building Section	Length, Feet	Width, Feet	Area, Ft2
First Floor Dimensions	48	142	6,816
GCI Equipment Annex	21	29	609
Second Floor Dimensions	48	92	4,416
		Total	**11,841**

Table 2.12-3 – Insulation Values of Building Components

Building Component	R-Value
Walls	11
Ceiling	30
Floors	19
Windows	2.8
Doors	2.8

Two new Weil McLain WGO-6 boilers were installed and repairs to the heating system piping on the main floor were completed during the 2013 renovation. Most of the upstairs apartments use King Pic-a-watt Electric Wall heaters to take advantage of the City of Wrangell $0.08/KWH rate for electric heating. Table 2.12-4 shows the annual fuel use and costs from calendar year 2014.

Table 2.12-4 – Annual Fuel Use and Cost Summary

Annual #1 Fuel Oil Use, Gallons	Space Heating Oil Cost	Annual Electricity Use, kWh	Space Heating Electric Cost	Total Annual Costs
2,554	$8,071	58,093	$6,158	$14,228

Case Avenue 2 Story Triplex:

The Case Avenue 2 story triplex was built in ~1970, is situated on a concrete foundation with a 4' unconditioned crawlspace, and has a gable-style 4/12 pitch truss metal roof with a cold attic installed over an old hot-tar flat roof. There is a semi-conditioned storage room at the back of the building that will remain. Figures 2.12-4 through 2.12-7 show the Case Avenue 2 story triplex.



Figure 2.12-4 : 2 Story Triplex Outside Shell



Figure 2.12-5 : 2 Story Triplex Side



Figure 2.12-6 : 2 Story Triplex Kitchen



Figure 2.12-7 : 2 Story Triplex Hot Water Tank & Boiler

The building has new insulated vinyl windows, but very little air tightening has been done. Dimensions and insulation values are provided in Table 2.12-5 and 2.12-6.

Table 2.12-5 – Building Dimensions and Areas

Building Section	Length, Feet	Width, Feet	Area, Ft2
First Floor Dimensions	64	28	1,792
GCI Equipment Annex	21	29	609
Second Floor Dimensions	64	28	1,792
		Total	**4,193**

Table 2.12-6 – Insulation Values of Building Components

Building Component	Insulation R-Value
Walls	11
Ceiling	19
Floors	19
Windows	2.8
Doors	28

The building is heated with a Weil McLain WGO-3 hot water boiler rated at 115,000 Btu/hr output. Hydronic baseboard heating in each apartment provides space heating. There is no central ventilation system. Each apartment has exhaust-only fans located in the kitchen and bath. Each apartment is on its own electric meter. Energy use history is not available, but estimated total energy use is 40,000 Btu/sf/year.

2.12.2 Improvement Option Recommendations

The SNO Building has undergone extensive exterior and interior modernization. Additional energy efficiency improvements are considered for the building including:

- **Air Sealing** - THRHA would like to tighten up the ceiling to attic and the lower floor. Costs for air sealing can range from $500 to $3,000 depending on the scope of tightening.
- **Insulation** - THRHA considered adding dense pack insulation to the floor cavity and additional insulation to the attic. Installed costs are estimated at $1.50 per square foot for R-30 insulation.
- **Air Source Heat Pump** - THRHA considered installing a new mini-split heat pump for the 2,400 ft^2 Meeting Hall at the back of the building. The existing oil boiler and hydronic distribution will remain for backup.
- **Heat Recovery Ventilator** - THRHA would like to install a heat recovery ventilator system in the back meeting hall. A heat recovery ventilator system is estimated to cost $50,000.

This system will use additional energy but will improve indoor air quality and occupant comfort.

- **Energy Efficient Lighting** - THRHA considered installing energy efficient interior lighting throughout the building.
- **Appliances** – Refrigerators need to be replaced for aesthetic and efficiency reasons. THRHA would like to install energy star rated appliances during scheduled replacements. Costs are estimated at $1,000 per refrigerator.

THRHA has also considered energy efficiency improvements for the Case Avenue 2 Story Triplex. Energy efficiency improvements are considered for the building including:

- **Air Source Heat Pump** – THRHA considered installing air-to-air "mini-split" heat pumps in each apartment. The upstairs apartment C would have two heads, one at each end of apartment. The existing oil boiler would remain in place as secondary backup. Installed costs are estimated at $5,000 per heat pump.
- **Air Sealing** - THRHA would like to tighten up the ceiling and floor levels. Costs for air sealing can range from $500 to $3,000 depending on the scope of tightening.
- **Inside Insulation** - THRHA considered adding blown in cellulose insulation into the joist cavity on the existing roof and dense pack floor joists with cellulose insulation. A poly vapor retarder will be installed on the ground in the crawlspace. Installed costs are estimated at $1.50 per square foot for R-30 insulation for blown in insulation.
- **Outside Insulation** - Install outside insulation and new rain-screen fiber cement board siding. Installed costs are estimated at $30 per square foot of wall area.
- **Bathroom Ventilation** – THRHA would like to install low-sone continuous duty rated exhaust fans on motion sensors with programmable time delays to meet ASHRAE 62.2-2012 for each bathroom. Installed costs are estimated at $750 per fan.
- **Makeup Air Vents -** THRHA would like to install fresh air makeup vents in the bedrooms and living room. The estimated installed cost for each room is $200.

2.13 YAKUTAT

Yakutat, Alaska is an unincorporated Census Designated Place (CDP) located along the Gulf of Alaska, about 225 miles northwest of Juneau and 220 miles southeast of Cordova. The average annual high temperature is 46.7°F and the average annual low temperature is 33.6°F. Annual Heating Degree Days (HDD) base 65F = 9,349 HDD.

Isolated on the strand that connects the Inside Passage to the rest of Alaska, there are no roads that lead into or out of Yakutat. All travel is either via air or water. There are two state owned runways for small wheeled aircraft. Five airstrips owned by the U.S.F.S. and 1 airstrip operated by the National Park Service at East Alsek River. There is a seaplane base available in the area. The Alaska Marine Highway System provides whistle stop service at the state operated ferry terminal. The Port of Yakutat is a sheltered deep water port and barge offloading is available at the Ocean Cape dock.

The population of Yakutat is 664 with 39.7 being the median age. Yakutat is a subsistence community. Cash sector economics rely on the local cold storage plant, commercial fishing, and fish processing. Other private sector jobs rely on seasonal employment associated with tourism. The average household income is $81,722. There are 450 housing units available in the area with 150 owner occupied units and 118 rentals. Table 3.12-1 shows an energy cost comparison for heating fuels in the community.

Table 2.13-1 : Yakutat Cost of Energy Comparison

Technology, Unit	Input Btu/Unit	Cost/Unit	Assumed Efficiency	Output Btu/Unit	Cost/ mmBtu Output
#1 Fuel Oil, Gallon	134,000	$4.46	80%	107,200	$41.60
Electricity, kWh (Resistance)	3,412	$0.47	100%	3,412	$137.75
Electricity, kWh (Heat Pump)	3,412	$0.47	300%	10,236	$45.92
Wood Pellets, Ton	15,200,000	$430.00	80%	12,160,000	$35.36
Cord Wood, Cord	18,100,000	$250.00	70%	12,670,000	$19.73

Note: Fuel prices provided by AkWarm software based on the 3/30/2015 library. Biomass prices obtained from local providers.

2.13.1 Yakutat Multi-Family Dwellings

THRHA manages the Sunrise Apartments and Yakutat Senior Center and rents half of a building from the Yakutat village corporation Yak-Tat-Kwaan. Yakutat is a high-cost diesel electric community paying $0.47/kWh for electricity and 4.46/gallon for #1 fuel oil. The buildings utilize #1 fuel oil for space heating and domestic hot water.

Yak-Tat-Kwaan "Old Clinic" Building

The Yak-Tat-Kwaan "Old Clinic" Building is owned by the Yakutat village corporation Yak-Tat-Kwaan. This building was built in 1970 and is stick frame construction with a metal roof and a

post foundation. It is comprised of six 1 bedroom senior apartments in one half of the building and office space rented by the Yakutat Tlingit Tribe for their social programs on the other side of the building. The crawlspace height is very limited and inaccessible so all distribution piping is in the attic and most of the floor is uninsulated. The sewer pipes remain under the floor and are broken but inaccessible for repair. Figures 2.13-1 through 2.13-5 show the pictures of the "Old Clinic" Building.



Figure 2.13-1 : Yak-Tat-Kwaan "Old Clinic" Building



Figure 2.13-2 : Yak-Tat-Kwaan "Old Clinic" Building



Figure 2.13-3 : Yak-Tat-Kwaan "Old Clinic" Building - Crawlspace



Figure 2.13-4 : Yak-Tat-Kwaan "Old Clinic" Building – Attic



Figure 2.13-5 : Yak-Tat-Kwaan "Old Clinic" Building - Attic

There is no central ventilation, only exhaust ventilation for each apartment. Table 2.13-2 provides the Building Address, square footage, and insulation values of building components for the Yak-Tat-Kwaan "Old Clinic" Building.

Table 2.13-2 "Old Clinic" Building Address, Insulation Values, and Component Surface Areas

Building Address	Item	Living Area Floors	Wall Section 1	Exterior Doors	Windows	Ceiling
364 Ridge Way	R-Value	25.2	11.3	5.3	2.0	43.6
	Area, ft^2	6,784	2,944	100	871	6,784

The building uses a Weil Mclain hot water boiler firing on #1 fuel oil for space heating. Domestic hot water is produced indirectly using the heating boilers. All hydronic and domestic water pipes are in the attic including multiple zone valves for heating control. Table 2.13-3 provides a breakdown of annual energy use and costs for the Yak-Tat-Kwaan "Old Clinic" Building. Values are provided from AkWarm reports using the 3/30/2015 data library.

Table 2.13-3 : "Old Clinic" Annual Fuel Use and Cost Breakdown

Space Heating #1 Oil Use, Gallons	Space Heating #1 Oil Cost	Space Heating Electric Use, kWh	Space Heating Electric Cost	Water Heating #1 Oil Use, Gallons	Water Heating #1 Oil Cost	Lights & Appliance Electric Use, kWh	Lights & Appliance Electric Cost	Total Annual Costs
1,648	$7,350	547	$257	360	$1,606	38,623	$18,153	$27,366

Note: Fuel use and cost information provided by AkWarm software based on the 3/30/2015 library

Sunrise Apartments

The Sunrise Apartments are both 2 story buildings containing a mixture of 1, 2, and 3 bedroom apartments. Both buildings are identical in construction except that Building A has 11 units and Building B has 9 units. All apartments exit to an exterior balcony and there is no common interior corridor.

The foundation is all-weather wood stem walls on concrete footings. The crawlspace has insulated walls and is a semi-conditioned space. There is no insulation in the floor above the crawlspace to allow building heat to condition the crawlspace. There is no common ventilation system in the buildings. Each unit uses exhaust only ventilation with bath fans on Airtrak programmable timers and range hoods with fresh air makeup vents in windows. Figures 2.13-6 and 2.13-7 show the outside shell of the Sunrise Apartments.



Figure 2.13-6 : Sunrise Apartment Buildings



Figure 2.13-7 Sunrise Apartment Buildings

Table 2.13-4 provides the square footage and insulation values of building components for the Sunrise Apartments.

Table 2.13-4 Sunrise Apartments Insulation Values and Area of Building Components

Unit Type	Item	Living Area Floors	Crawl Space Wall	Rim Joist Wall	House Wall	Exterior Door	Not South Windows	Ceiling
1 Br Lower	R-Value	8.6	20.5	8.6	16.2	2.5	1.1	26.5
	Area, ft^2	616	184	46	352	20	47	616
2 Br Lower	R-Value	12.1	20.5	9.1	16.2	2.5	1.1	26.5
	Area, ft2	713	192	48	368	20	61	713
3 Br Lower	R-Value	12.4	20.5	9.1	16.2	2.5	2.0	26.5
	Area, ft2	961	384	96	740	20	112	961
1 Br Upper	R-Value	34.7	N/A	20.0	15.4	2.5	1.1	30.9
	Area, ft^2	616	N/A	44	355	20	47	616
2 Br Upper	R-Value	34.7	N/A	20.0	16.2	2.5	1.1	25.3
	Area, ft2	713	N/A	48	896	20	61	713
3 Br Upper	R-Value	34.7	N/A	23.4	16.2	2.5	1.1	26.1
	Area, ft2	961	N/A	100	800	20	112	961

Each building uses two Burnham hot water boilers firing on #2 fuel oil with hydronic distribution and baseboard heaters. Domestic hot water is produced indirectly using the heating boilers. Tables 2.13-5 and 2.13-6 provide a breakdown of annual energy use and costs for the Sunrise 9-Unit and 11 Unit Buildings. Values are provided from AkWarm reports using the 3/30/2015 data library.

Table 2.13-5 : Sunrise Apartments 9-Unit Annual Fuel Use and Cost Breakdown

Unit Type	No. of Units	Space Heating #1 Oil Use, Gallons	Space Heating #1 Oil Cost	Space Heating Electric Use, kWh	Space Heating Electric Cost	Water Heating #1 Oil Use, Gallons	Water Heating #1 Oil Cost	Lights & Appliance Electric Use, kWh	Lights & Appliance Electric Cost	Total Annual Costs
3 BR Lower	2	882	$3,934	270	$127	352	$1,570	12,330	$5,795	$11,426
2 BR Lower	1	293	$1,307	90	$42	139	$620	5,769	$2,711	$4,680
1 BR Lower	1	308	$1,374	94	$44	104	$464	5,614	$2,639	$4,520
3 BR Upper	2	678	$3,024	208	$98	432	$1,927	12,330	$5,795	$10,843
2 BR Upper	2	492	$2,194	150	$71	278	$1,240	11,538	$5,423	$8,928
1 BR Upper	1	134	$598	41	$19	101	$450	5,614	$2,639	$3,706
Totals	**9**	**2,787**	**$12,430**	**853**	**$401**	**1,406**	**$6,271**	**53,195**	**$25,002**	**$44,103**

Note: Fuel use and cost information provided by AkWarm software based on the 3/30/2015 library

Table 2.13-6 : Sunrise Apartments 11-Unit Annual Fuel Use and Cost Breakdown

Unit Type	No. of Units	Space Heating #1 Oil Use, Gallons	Space Heating #1 Oil Cost	Space Heating Electric Use, kWh	Space Heating Electric Cost	Water Heating #1 Oil Use, Gallons	Water Heating #1 Oil Cost	Lights & Appliance Electric Use, kWh	Lights & Appliance Electric Cost	Total Annual Costs
3 BR Lower	2	882	$3,934	270	$127	352	$1,570	12,330	$5,795	$11,426
2 BR Lower	2	586	$2,614	180	$85	278	$1,240	11,538	$5,423	$9,361
1 BR Lower	1	308	$1,374	94	$44	104	$464	5,614	$2,639	$4,520
3 BR Upper	2	678	$3,024	208	$98	432	$1,927	12,330	$5,795	$10,843
2 BR Upper	3	738	$3,291	225	$106	417	$1,860	17,307	$8,134	$13,391
1 BR Upper	1	134	$598	41	$19	101	$450	5,614	$2,639	$3,706
Totals	**11**	**3,326**	**$14,834**	**1,018**	**$478**	**1,684**	**$7,511**	**64,733**	**$30,425**	**$53,248**

Note: Fuel use and cost information provided by AkWarm software based on the 3/30/2015 library

Yakutat Senior Center

The Yakutat Senior Center is a single story building consisting of two apartments, common areas for elders to meet, and a kitchen providing hot meals to seniors. There is one 1-bedroom apartment and one 2-bedroom apartment. The apartments rated 5 star plus and 6 star for the Alaska Building Energy Efficiency Standard (BEES).

The building is stick frame construction with an architectural asphalt shingle roof. The outside insulation technique was used and covered with a rain screen and fiberboard siding. Figures 2.13-8 through 2.13-11 shows pictures of the Yakutat Senior Center.



Figure 2.13-8 Yakutat Senior Center North Elevation



Figure 2.13-9 Yakutat Senior Center Interior



Figure 2.13-10 Yakutat Senior Center Northwest Entrance



Figure 2.13-11 Yakutat Senior Center Two Bedroom Apartment

The building is heated with a Wood Gun cord-wood gasification boiler. A Weil McLain Ultra oil boiler is used for backup and peaking. Domestic hot water is produced indirectly using the heating boilers. Two heat recovery ventilators are used to condition ventilation. Figures 2.13-12 through 2.13-15 show the mechanical systems for the Yakutat Senior Center.



Figure 2.13-12 Yakutat Senior Center Wood Gun Cord Wood Boiler



Figure 2.13-13 Yakutat Senior Center Cord Wood Storage



Figure 2.13-14 Yakutat Senior Center Oil Boiler



Figure 2.13-15 Yakutat Senior Center Heat Recovery Ventilator

2.13.2 Improvement Option Recommendations

Energy audits were completed and energy efficiency measures were identified for the Yakutat Sunrise Apartments and the Old Clinic. Blower door tests and walkthrough assessments were conducted by professional energy auditing companies.

Sunrise Apartments

Energy efficiency measures considered for the Yakutat Sunrise Apartments are as follows:

- **Windows** – None of the windows close or latch properly and need replaced.
- **Air Sealing** - THRHA considered reducing air leakage by 10%.
- **Insulation** – THRHA considered adding blown cellulose insulation to the attic space insulation.

A summary of the identified Energy Efficiency Measures for the Sunrise Apartments are shown in Tables 2.13-7 and 2.13-8.

Table 2.13-7 : Sunrise Apartments 9 Unit – Energy Efficiency Measure Cost Benefit Summary

Improvement	Savings	Cost	Simple Payback, Years	SIR
Above-Grade Wall: House: Add R-14 rigid (or same as above grade wall recommendation) to rim joist of above grade wall.	$205	$667	3.3	7.1
Window/Skylight: not south windows replace : Replace existing window with triple pane, low-E, argon window.	$2,793	$39,277	14.1	1.2
Caulk and Seal so that Home Air Leakage is Reduced by 125 CFM at 50 Pascals.	$0	$1,480	N/A	0.0
Ceiling w/ Attic: House: Add R-33 blown cellulose insulation to attic space with Energy Truss.	$934	$9,690	10.4	2.2
Totals	**$3,932**	**$51,114**	**13.0**	

Table 2.13-8 : Sunrise Apartments 11 Unit – Energy Efficiency Measure Cost Benefit Summary

Improvement	Savings	Cost	Simple Payback, Years	SIR
Above-Grade Wall: House: Add R-14 rigid (or same as above grade wall recommendation) to rim joist of above grade wall.	$239	$782	3.3	7.0
Window/Skylight: not south windows: Replace existing window with triple pane, low-E, argon window.	$3,389	$45,894	13.5	1.3
Caulk and Seal so that Home Air Leakage is Reduced by 125 CFM at 50 Pascals.	$0	$1,730	N/A	0.0
Ceiling w/ Attic: House: Add R-33 blown cellulose insulation to attic space with Energy Truss.	$1,114	$11,433	10.3	2.2

Additionally, THRHA considered the possibility of biomass heating systems serving both buildings and using a non-fuel oil option for domestic hot water heating during the non-heating months.

Biomass Heating System - THRHA considered the feasibility of heating the building with wood pellet and cord wood fired biomass boilers located in a separate outbuilding. The recommended systems consist of a 175,000 Btu/hr wood pellet system and 250 gallons of hot water thermal storage or a 140,000 Btu/hr cord wood system and 550 gallons of thermal storage. The financial summaries of each system provided in Table 2.13-9 and 2.13-10. Cost breakdowns are provided in Section 4.0 – Attachments.

Table 2.13-9 : Sunrise Apartments Wood Pellet Heating System Financial Summary

Current Oil Use, Gallons	Current Oil Cost	Estimated Wood Pellet Use, Tons	Estimated Wood Pellet Cost	Estimated O&M Costs	Estimated Oil Cost with Wood Pellet System	Estimated Savings	Estimated Capital Cost	Simple Payback
9,203	$41,045	77	$33,142	$2,500	$2,052	$3,351	150,978	45.1

Note: Assumes an oil offset of 95% with the wood pellet system. The use of hot water thermal storage and management of loads may provide additional offset or the ability to operate efficiently during the non-heating months.

Table 2.13-10 : Sunrise Apartments Cord Wood Heating System Financial Summary

Current Oil Use, Gallons	Current Oil Cost	Estimated Cord Wood Use, Cords	Estimated Cord Wood Cost	Estimated O&M Costs	Estimated Oil Cost with Cord Wood System	Estimated Savings	Estimated Capital Cost	Simple Payback
9,203	$41,045	62	$19,269	$4,000	$8,209	$9,568	142,629	14.9

Note: Assumes an oil offset of 80% with the cord wood system. The use of hot water thermal storage and management of loads may provide additional offset or the ability to operate efficiently during the non-heating months.

Options for heating domestic hot water in the non-heating months without oil include using the biomass systems, propane on demand hot water heaters, or air to hot water heat pumps. Heat pumps and propane systems will likely cost more to operate than oil. Additionally, propane will require a separate storage tank adding to the installation cost. The most cost effective way is likely to use the biomass system in an efficient way by charging the thermal storage tank to 190°F shutting down and letting the tank temperature drop to 130°F before kicking back on. This will allow the system to operate for extended periods of time while charging the tank.

Yanmar Micro CHP System – A propane fired micro CHP system was evaluated for use in the Sunrise Apartments. Installed costs are estimated at $90,000 each with annual savings of $20,000 - $24,000 dollars per year. These savings values estimate that 90% of the oil use is offset

and 100% of the electricity generated in a thermally led system is used in the building. This would result in a 3.8 – 4.5 year payback based on current fuel prices.

Table 2.13-10 : CHP System Savings Summary

Building	Oil Use, Gallons	Oil Boiler Output, mmBtu	Heating Energy Offset with CHP System (90%)	Annual Oil and Electric Cost Savings with CHP System	Estimated Simple Payback, Years
9 Unit Apartment Building	4,193	470	423	$19,939	3.8
11 Unit Apartment Building	5,010	561	505	$23,824	4.5

Note: Uses fuel prices of $3.00/gallon for propane, $4.46/gallon for #1 fuel oil, and $0.47/kWH for electricity to generate costs and savings.

Lighting Upgrade – THRHA considered retrofitting interior and exterior lighting in the Sunrise Apartments. The retrofit would include approximately 65 fixtures in the 11 unit and 56 fixtures in the 9 unit. Interior T-12 fluorescent fixtures would be replaced with T-8's or LED's and exterior wall packs would be replaced with LEDs. Installed costs are estimated at approximately $25,000 for T-8s and annual savings of $3,100 based on $0.47/kWh and 5,110 operating hours.

Yak-Tat-Kwaan "Old Clinic" Building

THRHA considered building improvements for the Old Clinic building due to necessity that are not driven by energy savings. Since THRHA does not own the Old Clinic, savings, costs, and paybacks were not included in the assessment of the building. A summary of possible improvements are listed below:

- Raise the building about 2 feet and install better foundation.
- Run piping under the floor and get it out of the attic, if practicable.
- Insulate the floor.
- Improve wall R-value with Outside Insulation Technique with new siding.
- Install a wood biomass boiler as primary boiler, with the Weil McClain as secondary backup.
- Consider installing an on-demand domestic hot water heater system for the non-heating season.

Yakutat Senior Center

The boiler systems heating the Yakutat Senior Center use thermal storage tanks, however, they are currently piped in an arrangement that causes operation issues. The estimated cost to fix the piping arrangement is $27,000. A report completed by Alaska Energy Engineering, LLC and detailed cost breakdown are provided in Section 4 Attachments.

3.0 POTENTIAL FUNDING SOURCES FOR IMPROVEMENTS

THRHA has identified potential funding sources to implement improvements recommended in the results of the DOE Tribal Energy Grant. THRHA has been successful applicants for many of these programs for previous improvements such as the Kake Senior Center Modernization Project.

- **Indian Housing Block Grant (IHBG) -** These are federal funds THRHA receives through the Native American Housing Assistance and Self Determination Act (NAHASDA), and consist of two types: NEEDS funds and Current Assisted Stock (CAS) funds. These funds come from HUD, and are allocated to Tribes using a formula. The Tribes then authorize THRHA as their Tribally Designated Housing Entity (TDHE) to use these funds for NAHASDA-eligible housing activities.

- **Indian Community Development Block Grant (ICDBG) -** These are federal funds that federally recognized tribes apply for, which the tribes may elect to transfer to THRHA for our projects under a sub-recipient agreement. These funds come from HUD and utilize a competitive grant process.

- **Alaska Housing Finance Corporation (AHFC) Supplemental Grant Program -** These are State of Alaska funds that the State Legislature appropriates annually and are up to a 20% match to HUD funds. This is a competitive grant process available only to Housing Authorities. The funds can only be used for "the cost of on-site sewer and water facilities, road construction to project sites, electrical distribution facilities and energy-efficient design features in the homes."

- **DOE Tribal Energy Funds –** These are Federal funds awarded through a competitive grant application process. Funds are subject to Notice of Funding Availability and generally for feasibility studies.

- **USDA Funds –** Federal grant and loan funds available from the US Department of Agriculture that are subject to availability and specific conditions.

- **Rasmuson Foundation and other Private Grant Funders -** Private grant funds from philanthropic organizations. These utilize a competitive application process, usually with specific conditions on the use of funds.

- **Tribal Transportation Funds -** Federal funds for eligible road projects subject to Tribal road's inventory.

- **HUD Section 184 and Title VI Loan Guarantees -** These are loan funds for Tribes, with a Federal guarantee, that are eligible for the AHFC Supplemental Program 20% match.

- **Other Funds -** Discretionary funds of the Tlingit-Haida Regional Housing Authority.

4.0 ATTACHMENTS

1. Angoon – Multifamily Apartments Biomass Pre-feasibility Report
2. Haines – Wood Pellet System Conceptual Cost Estimate
3. Hoonah – Wood Pellet System Conceptual Cost Estimate
4. Juneau – Fireweed Place AEE Energy Audit
5. Juneau – Marquam George Fireweed Place Enclosure Report
6. Juneau – Glacier Village and Kanat'a Dey'I Assessment Notes
7. Kake – Senior Center AEE Energy Assessment
8. Kake – Lime Solar Feasibility Report
9. Kake – BacGen Solar Feasibility Report
10. Klawock – High Efficiency Low Emission Wood Fired Heating System Pre-Feasibility Report
11. Klawock – Senior Center Energy Rating Information
12. Klawock – Senior Center AEE Energy Assessment
13. Saxman – Senior Center AEE Energy Assessment
14. Saxman – WESEE Wood Pellet System Conceptual Cost Estimate
15. Yakutat – Sunrise Apartments AEE Energy Assessment
16. Yakutat – Sunrise Apartments Biomass Capital Costs
17. Yakutat – Senior Center AEE Energy Assessment
18. Yakutat – Senior Center Status Report
19. Lighting Fixture Analysis
20. Heat Pump Breakeven Summary
21. 3 bedroom single story – 1,300 ft^2 dwelling pellet stove and ASHP conversion
22. THRHA Energy Usage Assessment Report

Attachment 1
Angoon – Multifamily Apartments Biomass Pre-feasibility Report

THRHA Regional Housing Authority
Juneau, Alaska

Angoon Multifamily Apartments Biomass Pre-feasibility Report

Submitted to THRHA and AWEDTG

Greg Koontz, PE Bill Wall, PhD of Alaska Wood Energy Associates



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1.0 EXECUTIVE SUMMARY

1.1 Acknowledgements

This feasibility study was supported by the Alaska Wood Energy Development Task Group and administered by the Fairbanks Economic Development Corporation. The THRHA supported the field study with information and assistance while in Angoon.

1.2 Objective:

The objective of this report is to document the results of a pre-feasibility study performed for the Tlingit Haida Regional Housing Authority (THRHA). The target buildings are 8 multi-plex residential buildings and a community center in Angoon, Alaska. Angoon is not on the road system, but it is accessible by ferry and float plane from Juneau.

In this report, we distinguish between a multi-plex (duplex, triplex, etc) and a residence – when we use the term "residence" we mean a distinct "home" within a multi-plex. A duplex has two residences, and so on. The buildings in the THRHA are currently heated with oil, one oil boiler per residence (and one for the community center). The primary subject of the study is the feasibility of constructing a wood-fired heating plant to serve all nine buildings in the THRHA complex.

A secondary objective is to evaluate the installation of a wood-fired boiler into a "typical" house. This is not part of the original scope for this work, but interest was found in the community for converting to pellet boilers if a supply of pellets were to exist in the community. Thus, the authors decided to give an example of costs and paybacks for a residence.

Because there are no wood chips available in the area, and the THRHA is not interested in stick-fired boiler, this study evaluates only pellet fired boilers.

Feasibility studies are often classified as Level 1 (L1), Level 2 (L2), or Level 3 (L3). Level 1 studies consist of very rough calculations on a small number of important metrics (unit fuel costs, etc). At the other end, L3 studies are commonly called "investment grade studies"; the level of detail and calculation is so high that one could use the results of an L3 study to get an outside entity to fund the implementation of the project. Level 2, then, is the bridge between L1 and L3; it is a screening study done to determine if it is worth the time and expense to initiate an L3 study. Level 3 studies are generally quite expensive, and thus not entered into lightly. The L2 study helps decision makers determine which aspects, if any, of a proposed project are worth the expense of an L3 study.

An L1 study can be done remotely; an L2 study requires at least a minimum amount of site observation of existing conditions, conversations with the affected parties, and research with second-order parties (local foresters, vendors, local contractors, etc). This is a Level 2 study, although classified as pre-feasibility.

Sustainability, Inc (SI) and efour, PLLC (efour) perform L2 and L3 studies across the state of Alaska, from cities to small villages in the bush. We use the same performance and economic models for each type of study. The primary difference between the two studies is the quality of the inputs, which is generally a function of how much time has been spent gathering information, and the depth of that information.

1.3 Sources

The primary sources of information for this study are data collected on site by SI, and data provided by the Fairbanks Economic Development Corporation (FEDC). Data collected on site by SI include existing site conditions, equipment name plate data, current energy cost data, and, equally important, information gathered by talking to the local stakeholders in the Village.

In addition to the site knowledge gathered by SI, additional biomass boiler performance and cost data have been accumulated over the past several years from working with local engineers and contractors, and from completing multiple L2 and L3 wood-fired feasibility studies. Hourly weather data for the performance model was extracted from data collected and reported by the nearby Juneau Airport.

1.4 Scope

In Angoon, the scope of this report is limited to the THRHA complex and one typical house; currently, each residence within each multi-plex has its own boiler. The boilers feed two or more zones of heating within each residence, using hydronic baseboard heat.

Biomass heating systems can be expensive to install; the economics generally work better for larger buildings, or where two or more smaller buildings can be grouped together and served by a single biomass boiler, using buried piping between the buildings to distribute the heat. Significant parts of the cost of a district heating plant (DH Plant) are the interconnections to the individual boilers; in this case, the fact that each residence has a boiler (as opposed to one per multi-plex) potentially increases the capital costs of a project. Thus, more existing boilers means more interconnections and more cost, but no more additional savings. Interconnections are discussed in detail below.

For this report, we have modeled the performance on one DH Plant, and one individual building. The DH Plant contains all nine buildings; subsets of smaller groups of multi-plexes were not analyzed. Smaller DH Plants would have even less economy of scale, and the THRHA showed no interest in having two Plants rather than one. The individual building modeled is the “typical house” referred to above.

Although only one cluster of buildings for the DH Plant was evaluated, four different variations of that Plant (each variation is called a Scenario, abbreviated as Sc) were constructed. The performance is nearly identical between all four; the primary difference is the capital cost. This DH Plant has three disadvantages compared to many other DH Plants SI and efour have evaluated:

1. Not much economy of scale: The total oil consumption for the nine buildings is about 11,400 gallons per year. In many villages, a single building (usually the high school) uses two or more times as much oil as the entire THRHA complex.
2. High cost of wood: In most cases, we evaluate stick wood, and if feasible, wood chips. Both are less expensive on a BTU basis than wood pellets (although not nearly as convenient as pellets).
3. Many small buildings, each with multiple interconnections required. Each building is small (in terms of oil consumption), which makes it harder to pay for the cost of the piping required to get to the building, and the interconnections to the multiple boilers.

For these reasons, we looked at a number of ways to strip costs out of the DH Plant without materially affecting performance. One could say that the Scenario 1 DH Plant is the "Cadillac", and each successive DH Plant (Sc 2 through Sc 4) strips out equipment and features, which, while nice, may not be strictly required for the THRHA Plant. The differences between the Scenarios are detailed in Sections 2 and 3 below.

1.5 Resource Assumptions

As noted above, the only form of biomass modeled in this report is wood pellets. Wood chips are not available, and the THRHA was not interested in stick-fired boilers.

Figure 1.1 below shows the assumptions that have been made for the existing fuels in the Village (oil and electrical energy), in the units in which they are sold:

Village Energy Costs / Properties

description	value	units
No. 1 oil heat content	134.00	kBTU/gal
density	6.68	lb/gal
sulfur content	1,000	ppm
village cost, No. 1 oil	$5.40	per gal
electrical energy	$0.24	per kWh

Figure 1.1

Figure 1.2 shows the assumptions made for the cost of wood fuel, in various forms.

Wood Costs

description	value	units
wood chips, to DH		green ton
stick wood, split, to DH		cord
pellets, to DH	$300.00	ton
bricks, to DH		ton

Figure 1.2

Because each form of fuel has different heat content and is sold in differing units, direct comparisons of the data in Figures 1 and 2 are very difficult. To make the comparison simple, all these energy sources are converted to a common unit, one million BTU (1 mmBTU).

To make the comparison even more relevant, the conversion efficiency of each source has been factored in. In this case, the conversion efficiency is the boiler efficiency. It is different for each fuel – using drier wood results in better boiler efficiency, and the oil boilers have their own efficiencies as well. In Figure 1.3 below, therefore, the mmBTUs references are those coming out of the boiler into the space, not the gross heat content of the fuel going into the boiler.

Unit Energy Costs, comparison
(to village, boiler eff accounted for)

fuel	value	units
No. 1 oil	$47.97	per mmBTU
electrical energy	$70.34	per mmBTU
recovered heat		per mmBTU
pellets, at $360/ton	$24.50	per mmBTU
pellets, at $300/ton	$20.42	per mmBTU

Figure 1.3

As Fig 1.3 shows, electrical energy is about one half again as expensive as No.1 oil, which, in turn, is about two and quarter times more expensive than wood pellets. The wood pellets are assumed to contain 8,162 BTU/lb.

1.6 Summary of Findings

The following Figures summarize the performance and economic modeling that SI and efour performed. The model is based on a pellet cost of $300 per ton delivered to Angoon, but that may vary. The summary results are presented twice and include a graph, which shows the sensitivity of net simple payback to pellet cost.

Summary of Scenario Results pellet price, per ton delivered **$300**
(Financial) client discount rate **4.00%**
term for net present value calcs **20.0 yrs**

	Sc 1	Sc 2	Sc 3	Sc 4
(1) project implementation cost	$399,092	$320,271	$292,728	$251,274
Base Fuel cost (oil only)	$61,544	$61,544	$61,544	$61,544
(2) Proposed Fuel costs (wood, oil, elec)	$33,060	$33,459	$33,459	$33,459
estimated annual savings	$28,484	$28,085	$28,085	$28,085
(3) Increased maintenance costs				
total savings	**$28,484**	**$28,085**	**$28,085**	**$28,085**
net simple payback	14.0 yrs	11.4 yrs	10.4 yrs	8.9 yrs
20 year sum of savings stream	$917,956	$907,773	$907,773	$907,773
net present value of savings stream	$532,153	$526,055	$526,055	$526,055
NPV of savings, including imp cost	$246,554	$312,559	$338,025	$376,351
Base oil displaced	0.9996	0.9996	0.9996	0.9996
benefit to cost ratio	**1.604**	**1.976**	**2.162**	**2.519**

(1) implementation cost includes all construction costs, OH&P, and all soft costs (design, etc)
(2) includes wood pellets, any oil for periods when load exceeds DH Plant capacity, and added pumping energy
(3) see explanation below for maintenance costs

Figure 1.4 overall economic summaries with pellets at $300/ton.

Figure 1.5 shows the same metrics with pellets at $360/ton.

Summary of Scenario Results (Financial)			pellet price, per ton delivered	**$360**
			client discount rate	**4.00%**
			term for net present value calcs	**20.0 yrs**
	Sc 1	**Sc 2**	**Sc 3**	**Sc 4**
(1) project implementation cost	**$399,092**	**$320,271**	**$292,728**	**$251,274**
Base Fuel cost (oil only)	$61,544	$61,544	$61,544	$61,544
(2) Proposed Fuel costs (wood, oil, elec)	$39,232	$39,631	$39,631	$39,631
estimated annual savings	$22,312	$21,913	$21,913	$21,913
(3) Increased maintenance costs				
total savings	**$22,312**	**$21,913**	**$21,913**	**$21,913**
net simple payback	17.9 yrs	14.6 yrs	13.4 yrs	11.5 yrs
20 year sum of savings stream	$782,061	$771,878	$771,878	$771,878
net present value of savings stream	$448,815	$442,717	$442,717	$442,717
NPV of savings, including imp cost	$154,482	$220,487	$245,952	$284,279
Base oil displaced	0.9996	0.9996	0.9996	0.9996
benefit to cost ratio	**1.364**	**1.678**	**1.835**	**2.138**

Figure 1.5

As footnote (3) indicates, we have not estimated any increase in annual maintenance with the installation of the pellet-fired boiler. This is because the fuel consistency is so high, the material handling so smooth, and the pellet boilers so reliable that in essence it is as close to being as automatic as an oil fired boiler as a wood fired boiler can get. We would expect that whoever currently cares for the oil boilers will also take care of the pellet boilers, and that no significant additional time or parts expenses will be incurred. Experience has shown that pellet boilers are reliable enough to be used in residences; this would not be the case if there were significant maintenance and expense required.

The net present value and benefit to cost calculation assume a 20 year project life; during that period, costs must be assumed to escalate. Figure 1.6 below shows the proposed escalation factors.

Escalation Factors	client discount rate	**0.040**
variable	rate	
oil	0.030	per year
electrical energy	0.025	per year
recovered heat	0.030	per year
wood chips	0.010	per year
stick wood	0.010	per year
wood pellets, bricks	0.010	per year
maintenance, labor	0.030	per year

Figure 1.6

Using these factors results in the following 20 year cash flows:

Cash Flows pellet price, per ton delivered **$300**

	Sc 1			Sc 2		
yr	existing cists	existing cists	**savings**	existing cists	existing cists	**savings**
1	61,544	33,060	**28,484**	61,544	33,459	**28,085**
2	63,390	33,424	**29,966**	63,390	33,832	**29,558**
3	65,292	33,792	**31,500**	65,292	34,211	**31,081**
4	67,251	34,165	**33,086**	67,251	34,594	**32,656**
5	69,268	34,542	**34,726**	69,268	34,982	**34,286**
6	71,346	34,924	**36,422**	71,346	35,375	**35,971**
7	73,487	35,311	**38,175**	73,487	35,773	**37,713**
8	75,691	35,703	**39,988**	75,691	36,176	**39,515**
9	77,962	36,099	**41,863**	77,962	36,585	**41,377**
10	80,301	36,501	**43,800**	80,301	36,998	**43,302**
11	82,710	36,907	**45,803**	82,710	37,417	**45,292**
12	85,191	37,318	**47,873**	85,191	37,842	**47,349**
13	87,747	37,735	**50,012**	87,747	38,271	**49,475**
14	90,379	38,157	**52,222**	90,379	38,707	**51,672**
15	93,091	38,584	**54,506**	93,091	39,148	**53,943**
16	95,883	39,017	**56,866**	95,883	39,595	**56,289**
17	98,760	39,455	**59,304**	98,760	40,047	**58,712**
18	101,723	39,899	**61,823**	101,723	40,506	**61,217**
19	104,774	40,349	**64,425**	104,774	40,971	**63,804**
20	107,917	40,804	**67,113**	107,917	41,441	**66,476**
sum	1,653,705	735,749	**917,956**	1,653,705	745,932	**907,773**

Cash Flows (continured) pellet price, per ton delivered **$300**

	Sc 3			Sc 4		
yr	existing cists	existing cists	**savings**	existing cists	existing cists	**savings**
1	61,544	33,459	**28,085**	61,544	33,459	**28,085**
2	63,390	33,832	**29,558**	63,390	33,832	**29,558**
3	65,292	34,211	**31,081**	65,292	34,211	**31,081**
4	67,251	34,594	**32,656**	67,251	34,594	**32,656**
5	69,268	34,982	**34,286**	69,268	34,982	**34,286**
6	71,346	35,375	**35,971**	71,346	35,375	**35,971**
7	73,487	35,773	**37,713**	73,487	35,773	**37,713**
8	75,691	36,176	**39,515**	75,691	36,176	**39,515**
9	77,962	36,585	**41,377**	77,962	36,585	**41,377**
10	80,301	36,998	**43,302**	80,301	36,998	**43,302**
11	82,710	37,417	**45,292**	82,710	37,417	**45,292**
12	85,191	37,842	**47,349**	85,191	37,842	**47,349**
13	87,747	38,271	**49,475**	87,747	38,271	**49,475**
14	90,379	38,707	**51,672**	90,379	38,707	**51,672**
15	93,091	39,148	**53,943**	93,091	39,148	**53,943**
16	95,883	39,595	**56,289**	95,883	39,595	**56,289**
17	98,760	40,047	**58,712**	98,760	40,047	**58,712**
18	101,723	40,506	**61,217**	101,723	40,506	**61,217**
19	104,774	40,971	**63,804**	104,774	40,971	**63,804**
20	107,917	41,441	**66,476**	107,917	41,441	**66,476**
sum	1,653,705	745,932	**907,773**	1,653,705	745,932	**907,773**

Figure 1.7

With these escalation factors, the savings increase by a factor of 2.4 over 20 years.

Of course, a primary variable in the financial analysis is the cost of pellets. For that reason, as noted above, we include a graph that shows the effect of pellet cost on net simple payback:

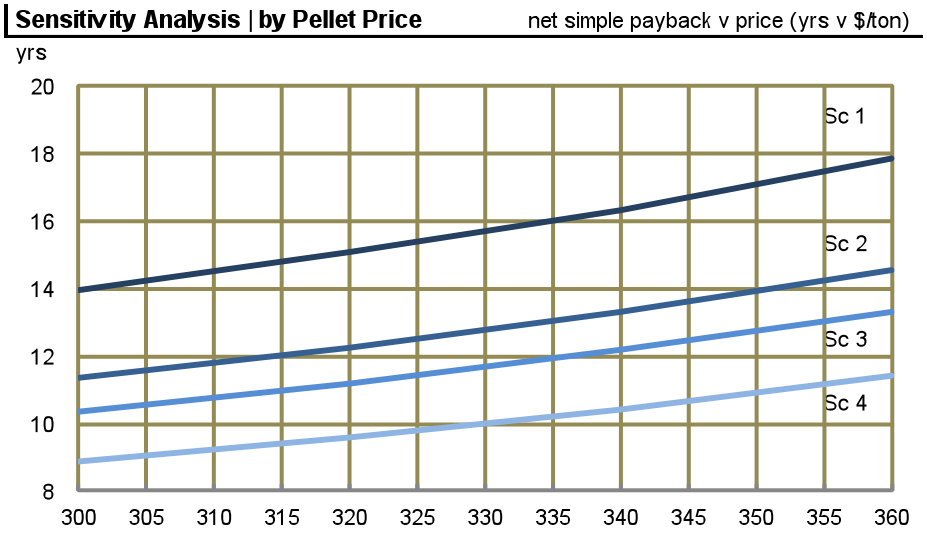


Figure 1.8

Figure 1.9 below is a summary of the cost estimate. The complete construction estimate is contained in Section 2:

Cost Estimate Summary

	Sc 1	Sc 2	Sc 3	Sc 4
total construction	**$323,898**	**$256,242**	**$257,788**	**$221,103**
(see section 2 for construction cost est)				
(1) final design/study 0.070	$22,673	$17,937	$9,534	$7,562
bid assistance 0.005	$1,619	$1,281	$1,289	$1,106
engineer const admin 0.005	$1,619	$1,281	$1,289	$1,106
(2) site construction admin	$16,000	$16,000		
Cx/start up 0.010	$3,239	$2,562	$2,578	$2,211
(3) contingency 0.075	$24,292	$19,218	$14,501	$12,437
subtotal, soft costs	$69,443	$58,280	$29,190	$24,421
fraction of construction cost	0.214	0.227	0.113	0.110
interior storage, at peak permits	$5,000	$5,000	$5,000	$5,000
estimated review cost	$750	$750	$750	$750
subtotal, fees/permits	$5,750	$5,750	$5,750	$5,750
estimated total implementation	**$399,092**	**$320,271**	**$292,728**	**$251,274**

Figure 1.9

There are three notes that must be amended to Figure 1.9:

1. In order to reduce costs, Sc 3 and Sc 4 assume that no final study is done (or a minimal update of this study), for these Scenarios, this line item is cut by 50%, from 7.0 percent to 3.5 percent.
2. Sc 1 and Sc 2 assume an outside construction manager/administrator is living and working in the Village during construction, actively managing the project. However, in talking to THRHA, they indicate they may have the capacity to take on these tasks. Therefore, in Sc 3 and 4, the on-site construction management is eliminated. There is still money for an engineer / manager to answer site questions, review submittals, etc.
3. In order to minimize soft costs, for Sc 3 and Sc 4, the contingency was cut by 25 percent (therefore, it is 0.75 * 0.75 = 0.56 of construction cost).

Finally, Figure 1.10 shows a financial / performance summary for a typical house in Angoon. This is based on a number of assumptions as we were not able to get an amount of oil used annually for a large house. When individual buildings are evaluated, the same cost factors are used, but with a different reporting format, because many elements that go into a DH Plant do not apply when looking at a single boiler / single boiler configuration. In addition, because this is a strictly residential application, many soft costs are not applied. There is no external construction administration, for example, and no design/study costs (the contractor is assumed to be competent to design/execute the interconnection). The boiler is assumed to be in the residence, which eliminates site pipe, etc. Figure 1.10 shows the typical house results at $300 per ton:

1	**Pellet-Fired Boiler**				MES 12	boiler 1	9
in No.						boiler 2	
B14	**House, int Boiler**					boiler 3	
current oil	780 gal	chips req	6 tons		boiler(s)		
unit price	$5.400	unit price	$300		building		
annual cost	$4,212	annual cost	$1,702		mechanical		
					electrical		
proposed oil		electrical	2,838 kWh		controls		
unit price		unit price	$0.240		project costs		
annual cost		annual cost	$681		total cost	$17,386	
oil displaced	780 gal				ann savings	$1,828	
fraction disp	1.000				**NSP**	**9.5 yrs**	
NPV benefit	**$34,735**				**B / C ratio**	**3.039**	

Figure 1.10

Project Performance

Both the DH Plant (Scenario 4) and the typical house have a net simple payback of about nine years. For a Housing Authority looking to control energy costs, budget for the future, and create an alternative to oil, this is likely a reasonable payback – renewable energy projects often have benefits that extend beyond the merely financial. For a home owner, a nine year payback may be harder to swallow. In both cases, however, the benefit to cost ratio is well over 1.0, the minimum standard (2.5 and 3.0, respectively).

Although financial forecasts cannot be made on “maybes”, there is also possibility that as wood pellets become more common in SE Alaska, there will be more suppliers and more economy of scale, causing unit prices to drop below $300 per ton.

1.7 Next steps

THRHA must evaluate these results using their own investment metrics and criteria. However, it appears, based on the findings of this report, that if THRHA can form a team of the right professionals and contractors, and design a lean delivery method that maximizes the assets of the Authority, this is certainly a viable project, financially.

The next step, therefore, is to work with the Authority to determine what elements are required for a project that they consider a "success", and figure out to deliver those elements within a cost and performance structure appropriate for the community.

In addition to financial performance, SI and efour believe that wood energy projects generate benefits to the Village beyond the obvious monetary ones; we call these VBECS (value beyond energy cost savings), a term borrowed from the Rocky Mountain Institute. Among these VBECS are:

- Use of renewable resources
- Reliance on local, rather than remote energy sources
- Reduced carbon footprint
- Reduced secondary emissions (NOx, S, CO, etc)
- Increased fuel price stability (for future budget planning)
- Energy money spent remains in the local economy

There are, no doubt, others as well. As was noted above, a Level 2 study is a screening study, meant to provide enough information to the stakeholders to A) determine how to proceed next, B) determine whether to proceed, or C) halt the project until conditions improve. This study provides the information needed for the THRHA and other stakeholders to make these decisions. The authors believe that the project is strong enough financially and with VBECS to immediately apply to the AEA Renewable Energy Fund for a grant to support this project.

2.0 TECHNICAL SUMMARY

2.1 Existing Conditions:

The following statistics in Figure 2.1 summarize the existing conditions in the THRHA complex:

Existing Conditions	
No. buildings	9
year constructed	1997
age	17 yrs
residential	**8**
duplexes	4
triplexes	2
quadplexes	2
non-residential	**1**
community center	1
total area	21,772 sf
occupied	daily
heating type	hot water baseboard
domestic water	off main boiler
age of boilers	17 yrs
mfg of boilers	Burnham
condition	med to bad
No of boilers	23 (1 per res)
est total oil consumption	11,400 gal per yr

Figure 2.1

The proposed pellet-fired DH Plant would displace over 99 percent of the current fuel consumption; however, the existing boilers would remain in place as back up in all Scenarios. In some Scenarios, they would be the only back-up. This is explained in more detail in subsection 2.4.

2.2 Wood Fuels / Wood Fired Heating Equipment

Figure 2.2 below shows the properties of the pellets that were used in this study:

Composite Pellet Properties

net useable heat	8,162	BTU/lb at burn MC
density as pellets	22.168	lb/cf at burn MC
SOx formed	0.0000	lb/wet lb at burn MC
ash	0.0142	lb/wet lb at burn MC
ash volume	0.0022	cf/wet lb at burn MC

Figure 2.2

The most pertinent value in the Figure is the net useable heat content, 8,162 BTU/lb. Because of the low moisture content (4 percent), pellets are by far the most energy-dense form of wood fuel.

There are a number of manufacturers of pellet boilers; the basis of design boilers used in this study are the PES series of boilers made by Maine Energy Systems (MES). There are eight sizes in the PES series, ranging from 41 kBTU/h to 191 kBTU/h (output).

The basic system components include:

- A pellet bin, which holds bulk amounts of wood pellets.
  - This bin is kept filled by periodic deliveries to the Village by truck and ferry
  - There are a number of delivery and loading methods once within the Village
- A means of getting the pellets from the bin into the boiler (material handling)
  - For MES, this is a vacuum system; the bin may be up to 66 ft away from the boiler
- The boiler
  - The boiler uses onboard controls to modulate the firing rate to meet heating demand
  - Will remain on and operating as long as the bin is kept filled, and no fuel fouling occurs
  - Is a “hands-off” unit
- A vent or boiler stack
  - This vents the products of combustion and boiler emissions into the air through an elevated stack or vent pipe
  - May or may not include additional emissions control equipment

Examples of the MES boilers and accessories are included in Appendix A

2.3 Proposed Conditions, Sc 1

As noted above, the thermal performance of all four Scenarios is about the same. What changes from Scenario to Scenario is the implementation cost, the level of complexity and sophistication, and the level of involvement of THRHA. Subsection 2.3 outlines the configuration of Scenario 1, while subsection 2.4 details how each subsequent Scenario deviates from Sc 1. Some of the features of Scenario 1:

- A new 8 x 34 containerized pellet boiler plant, piped and wired at the manufacturer, and delivered to the site
- The container includes primary piping, two boilers, expansion tanks, ash container, controls as specified, lights, and all electrical lighting and wiring – plus room for variable speed secondary pumps, secondary pumps and a secondary heat exchanger and expansion tank

- An oil-fired boiler is included in the new DH plant to cover failures and high peak load periods.
- A new slab constructed to house the container, with pipe and wiring routed to slab
- Distribution piping from the slab to each building
- Connection from the distribution piping to each of the 23 boilers
- One control valve, HX and flow meter per interconnection (see Section 3)
- DDC controls as required to control the Plant and interconnections
- The new piping will be tied into the existing systems in such a way that will always take the "wood heat" before taking oil/propane heat (Figure 3.2 below)
- However, if for any reason the wood fired system cannot meet load, the existing boilers will automatically start and fire as required to meet load
- Full design and construction administration/management services, with 7.5 percent contingency

Figure 3.1 in the section below shows the "Scenario 1" configuration, as it applies to building interconnections. The means of interconnection is one of the primary differences between the Scenarios.

2.4 Scenarios 2 through 4

Scenarios 2 through 4 differ from Scenario 1 in the following ways:

Scenario 2

- The oil fired back-up boiler at the DH Plant is eliminated, and the existing boilers are assumed to provide back-up
- The interconnection to each boiler is revised from Figure 3.2 to Figure 3.3 – a much less complex and expensive configuration
- The controls are all assumed to be local, with no DDC control
- The secondary pumps are assumed to be constant speed (they are so small, there is little energy penalty)
- In Sc 2, we eliminated some manufacturer's boiler controls, and some features in an attempt to lower costs, but it did not get the financials to a viable point, and it eliminated some desirable features, so these options were added back in in Sc 3 and 4 (thus the container costs are slightly higher)

Scenario 3

All of the Sc 2 modification, plus

- The interconnection detail remains Figure 3.3 – with 23 total connections
- This simplifies the connections and eliminates the need for DDC controls; however, there are still 23 connections required
- Final study and design fees are cut in half; this assumes that THRHA can allocate some resources to the project
- External construction management is handled by THRHA
- This local control allows the contingency to be decreased by 25 percent.

Scenario 4

All of the Sc 3 modification, plus

- The interconnection detail becomes Figure 3.4 or Figure 3.5 (depending on Village needs) – cutting the total connections to 11.

2.5 Energy Savings

Figure 2.3 below summarizes the energy consumption, existing and proposed, on a monthly basis:

Scenario 1: Base Inputs and Costs														
		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
total oil	gal	1,389	1,160	1,288	996	755	541	498	522	662	937	1,228	1,420	11,397
existing cost	$5.40	**$7,502**	**$6,266**	**$6,956**	**$5,381**	**$4,075**	**$2,919**	**$2,687**	**$2,821**	**$3,577**	**$5,060**	**$6,634**	**$7,666**	**$61,544**
total oil	gal	4	0	0									0	5
biomass	tons	12	10	11	9	7	5	5	5	6	8	11	12	103
electrical	kWh	906	788	870	764	694	634	654	654	644	728	837	894	9,068
oil cost	$5.40	$21	$1	$1									$1	$25
biomass cost	$300.00	$3,650	$3,064	$3,400	$2,670	$2,095	$1,577	$1,486	$1,545	$1,865	$2,530	$3,245	$3,733	
electrical cost	$0.24	$218	$189	$209	$183	$167	$152	$157	$157	$155	$175	$201	$215	
proposed cost		**$3,888**	**$3,254**	**$3,610**	**$2,854**	**$2,262**	**$1,729**	**$1,643**	**$1,701**	**$2,019**	**$2,705**	**$3,446**	**$3,949**	**$33,060**
	savings	**$3,614**	**$3,012**	**$3,345**	**$2,527**	**$1,814**	**$1,190**	**$1,044**	**$1,120**	**$1,558**	**$2,355**	**$3,188**	**$3,717**	**$28,484**

Figure 2.3

Figure 2.4 shows the same data for Sc 2 through Sc 4 (the savings for these Scenarios does not change, only the implementation cost):

Scenario 2 through 4: Base Inputs and Costs														
		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
total oil	gal	1,389	1,160	1,288	996	755	541	498	522	662	937	1,228	1,420	11,397
existing cost	$5.40	**$7,502**	**$6,266**	**$6,956**	**$5,381**	**$4,075**	**$2,919**	**$2,687**	**$2,821**	**$3,577**	**$5,060**	**$6,634**	**$7,666**	**$61,544**
total oil	gal	4	0	0									0	5
biomass	tons	12	10	11	9	7	5	5	5	6	8	11	12	103
electrical	kWh	994	893	987	903	856	799	825	825	806	881	954	995	10,719
oil cost	$5.40	$23	$2	$2									$1	$28
biomass cost	$300.00	$3,650	$3,064	$3,400	$2,670	$2,095	$1,577	$1,486	$1,545	$1,865	$2,530	$3,245	$3,733	$30,859
electrical cost	$0.24	$239	$214	$237	$217	$206	$192	$198	$198	$194	$211	$229	$239	$2,572
proposed cost		**$3,911**	**$3,279**	**$3,639**	**$2,887**	**$2,301**	**$1,769**	**$1,684**	**$1,743**	**$2,058**	**$2,742**	**$3,474**	**$3,973**	**$33,459**
	savings	**$3,591**	**$2,987**	**$3,317**	**$2,494**	**$1,775**	**$1,151**	**$1,003**	**$1,078**	**$1,519**	**$2,318**	**$3,160**	**$3,693**	**$28,085**

Figure 2.4

2.6 Cost Estimate:

The construction cost estimate is provided below in Figure 2.5. These are commonly referred to as the “hard costs”. The remaining soft costs, fees, permits, etc, are detailed in Section 1.

Construction Cost Estimate

tag	description		Sc 1	Sc 2	Sc 3	Sc 4
1	boilers		$43,110	$43,110	$43,110	$43,110
2	frieght					
3	install					
4	containerization		$32,000	$30,685	$32,000	$32,000
5	container freight		$8,500	$8,500	$8,500	$8,500
6	boiler stack		$4,500	$4,500	$4,500	$4,500
7						
8	back-up oil boiler		$11,420			
9	oil boiler piping		$750			
10	stack		$900			
11						
12	pumps/VFDs		$7,583	$4,103	$4,103	$4,103
13	secondary piping/HX		$8,132	$3,904	$3,904	$3,904
14						
15	distribution piping (PEX)		$28,464	$28,464	$28,464	$28,464
16	insulation boards		$2,752	$2,752	$2,752	$2,752
17						
18	building interconnects		$59,686	$59,254	$59,254	$28,654
19	slab for container		$12,500	$12,500	$12,500	$12,500
20	gravel fill for slab		$3,000	$3,000	$3,000	$3,000
21						
22	control points		$34,500	$9,000	$9,000	$9,000
23	DDC contol panels, HMI		$11,400	$5,700	$5,700	$5,700
24	prgramming		$1,172	$348	$348	$348
25	wire, conduit for bldg control		$3,408			
26						
27			**Sc 1**	**Sc 2**	**Sc 3**	**Sc 4**
28	**mechanical subtotal**		**$116,895**	**$94,801**	**$96,116**	**$96,116**
29	general conditions	0.020	$2,338	$1,896	$1,922	$1,922
30	equip rental, tools	0.015	$1,753	$1,422	$1,442	$1,442
31	margin	0.120	$16,498	$13,380	$13,566	$13,566
32	**total mechanical**		**$137,485**	**$111,499**	**$113,046**	**$113,046**
33						
34			**Sc 1**	**Sc 2**	**Sc 3**	**Sc 4**
35	**Sitework subtotal**		**$105,970**	**$105,970**	**$105,970**	**$75,370**
36	general conditions	0.025	$2,649	$2,649	$2,649	$1,884
37	equip rental, tools	0.030	$3,179	$3,179	$3,179	$2,261
38	margin	0.120	$15,245	$15,245	$15,245	$10,843
39	**total site**		**$127,043**	**$127,043**	**$127,043**	**$90,358**
40						
41			**Sc 1**	**Sc 2**	**Sc 3**	**Sc 4**
42	**Controls subtotal**		**$50,479**	**$15,048**	**$15,048**	**$15,048**
43	general conditions	0.025	$1,262	$376	$376	$376
44	equip rental, tools	0.010	$505	$150	$150	$150
45	margin	0.120	$7,124	$2,124	$2,124	$2,124
46	**total controls**		**$59,370**	**$17,699**	**$17,699**	**$17,699**
47						
48						
49	**total construction cost**		**$323,898**	**$256,242**	**$257,788**	**$221,103**

Figure 2.5

3.0 INTERCONNECTIONS and Thermal Storage

3.1 Interconnections and the Impact on Construction Cost

One of the most important features of a District Heating system is the interconnection between the DH system and the existing buildings systems. These interconnections can range from complex (and expensive), to very simple, often with one or more variations in between. The simpler the interconnections get, the less they cost. However, even the least expensive connections constitute a significant amount of money. The goal, therefore, is to first minimize the number of connections, and then apply the lowest appropriate level of technology for each connection, minimizing overall construction cost.

One thing that all possible interconnections should have in common is that no operator intervention should be required in the event that the DH Plant fails, or that the biomass boilers cannot meet the peak loads in very cold weather. At the same time, in periods of the very high heating load, the system should ideally use 100 percent of the capacity from the biomass boilers first, and use the "back-up" oil only to cover the peaks.

The following is a summary of some of the things all interconnections should have in common:

- In all systems, it is preferred that a heat exchanger is installed between the distribution piping and the building piping. Many building systems use glycol, while the DH distribution systems use 100 percent water. The heat exchanger provides a physical barrier between the two systems to prevent cross-contamination, while allowing heat to cross over. A control valve is used on the distribution return line to control the hot water return water temperature on the building side of the exchanger.
- Interconnect in such a way that the building hot water return is heated before it gets to the building boiler(s). The basic premise is that the temperature setpoint for the building return water coming off the heat exchanger is 5 deg F (for example) hotter than the setpoint of the boiler itself. The result is simple; if the biomass system heats the building return water to a temperature at or above that of the boiler setpoint, the boiler will not come on, HOWEVER,
- If for any reason, the biomass system cannot heat the building return water all the way to boiler setpoint (failure or very cold weather), the return water temperature will begin to fall, and when it falls below the boiler setpoint, the boiler will automatically add enough heat to make its setpoint.
- This ensures that 100 percent of the available biomass heating capacity is utilized before any back-up fuel is used. Once the load drops to the point where the heat exchanger can heat the return water to above the boiler setpoint, the building boiler will stop firing.

Given the list above, for any given site, there can be many possible variations in the way buildings are connected. In general, the size of the DH Plant, the number and nature of the end-users, and the sophistication of the individual building controls also factor into the decisions on how to interconnect the buildings.

- For large DH Plants with extensive piping systems, the cost of the pumping energy required to distribute the heat through the pipes is significant. For that reason, variable speed secondary hot water pumps are used. At any load less than 100 percent, variable speed pumps cut the pumping energy by 1/4th to 1/8th of the energy of constant volume system at the same flow. In these situations, the preference is to use a good quality motor-actuated control valve to control the flow at each building (actually, at each connection – so there may be more than one per building).

- A motor-actuated valve generally pre-supposes that the building has a pneumatic or DDC control system to control all of the HVAC systems. Larger, more sophisticated buildings tend to have such control systems; smaller buildings use only local controls.
- For a DH Plant that serves multiple buildings with multiple owners, a metering system is installed. This allows the DH Plant to charge the end-users for the exact amount of heat the use.

In Angoon, the existing boiler system configurations present a number of challenges for keeping the interconnection costs as low as possible. The overall housing complex consists of duplexes, triplexes, and quadplexes, as well as the community center. In the multi-plexes, there is one boiler per residence, and each boiler can serve only the residence it was meant to serve. This means that instead of nine connections (the number of buildings), the current configuration requires 23 connections:

- (4) duplexes * 2 connection = 8 connections
- (2) triplexes * 3 connections = 6 connections
- (2) quadplexes * 4 connections = 8 connections
- (1) community center * 1 connection = 1 connection

The total from above is 23 connections. Even if we reduce the unit cost to as low a value as possible, 23 connections represent a large sum of money. For Angoon, therefore, four Scenarios were modeled. Sc 1 was the "base case", which represents the configuration of a large, complex, multi-user system with above average sophistication.

For Scenario 2, some of the sophistication was reduced, some of the equipment, and thus some of the money. In Scenario 3, there is more reduction, and In Scenario 4; the assumption is that some level of re-piping has been done in each building, such that a single point of connection can be made (instead of 2 – 4 per building). The exception is the two north-most duplexes. The individual boilers in these buildings are not in the same room, so they will always have two connections. Figures 3.1 through 3.5 below show some of the interconnection options for Angoon.

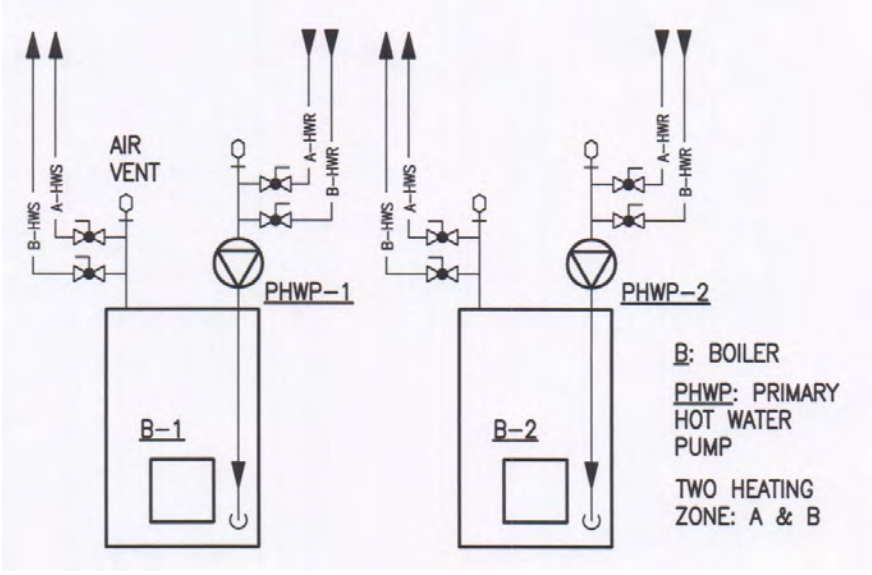


Figure 3.1

Figure 3.1 shows a typical Angoon duplex arrangement. Each boiler can serve only one residence, and there are two zones for each residence, A & B. The boilers cannot cross over and serve the other residence in the event of a failure. There is, as noted above, one boiler per residence.

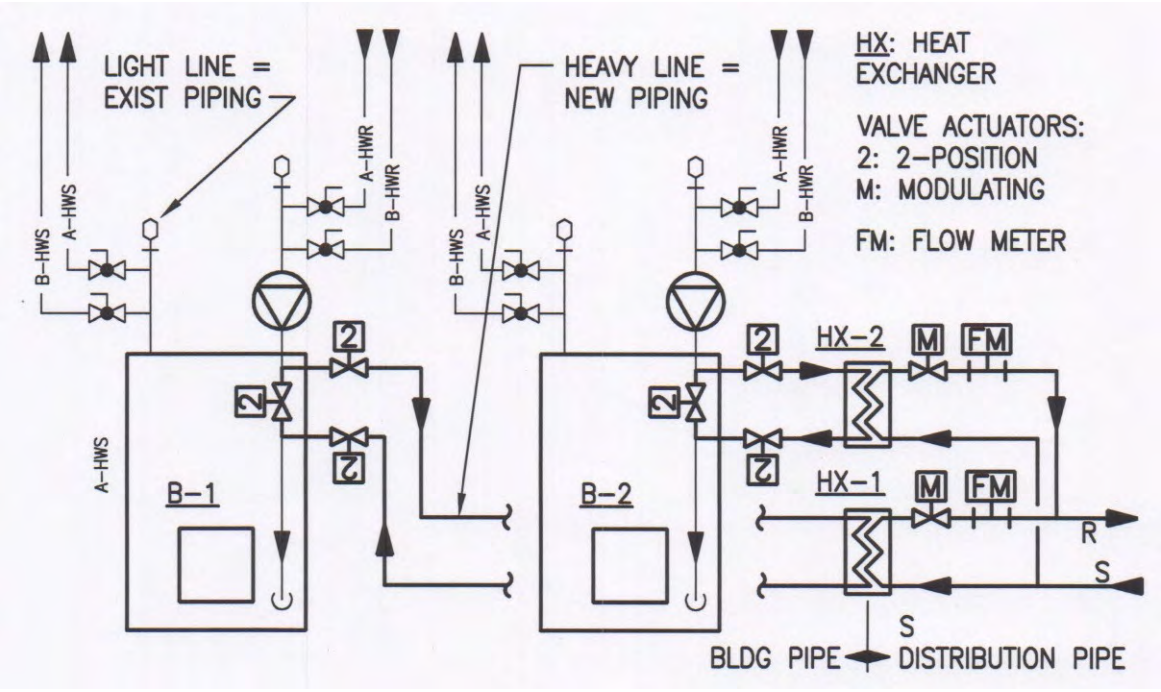


Figure 3.2

Figure 3.2 above shows the most expensive means of interconnecting; this would correspond to the pricing assumptions made in Scenario 1. This assumes that 1) each boiler must be connected separately, 2) that each end-user must be sub-metered, 3) an external control system exists in each building, and 4) the secondary pumping is variable speed.

As noted above, the system is configured to heat the building hot water return before it gets to the boiler. The 2-position valve directly below the pump would be closed, and the other two 2-position valves open; building hot water return flows to the heat exchanger. The building HWR would be heated, and returned to the boiler loop just above the point it enters the boiler. Because the HWR is now hotter than the setpoint for the boiler, the boiler never fires. The modulating valves at the HX control the building HWR temperature, and the flow meters at each HX allow the DH Plant operator to measure the exact amount of heat consumed by each residence within the multi-plex.

This is clearly over-kill for the situation in Angoon. First, the amount of flow in the system is so small that the secondary pumps are less than one horsepower. Thus, while electricity is still expensive, there is no need to use expensive control valves at each HX, and no need to make the secondary pumps variable speed. Second, there are no building control systems to control all the valves shown above. Third, there appears to be no reason to individually meter the heat to each residence.

Item 3.2 above means that a single heat exchanger can be used for each multi-plex – however, we do still have to hook up to each boiler individually. There are still 23 separate connections, although each one is significantly less complex and less expensive than the interconnections priced out in Scenario 1.

This is the basic configuration assumed in Scenarios 2 and 3 (there are other differences between 2 and 3 that affect price; these are detailed elsewhere in this report).

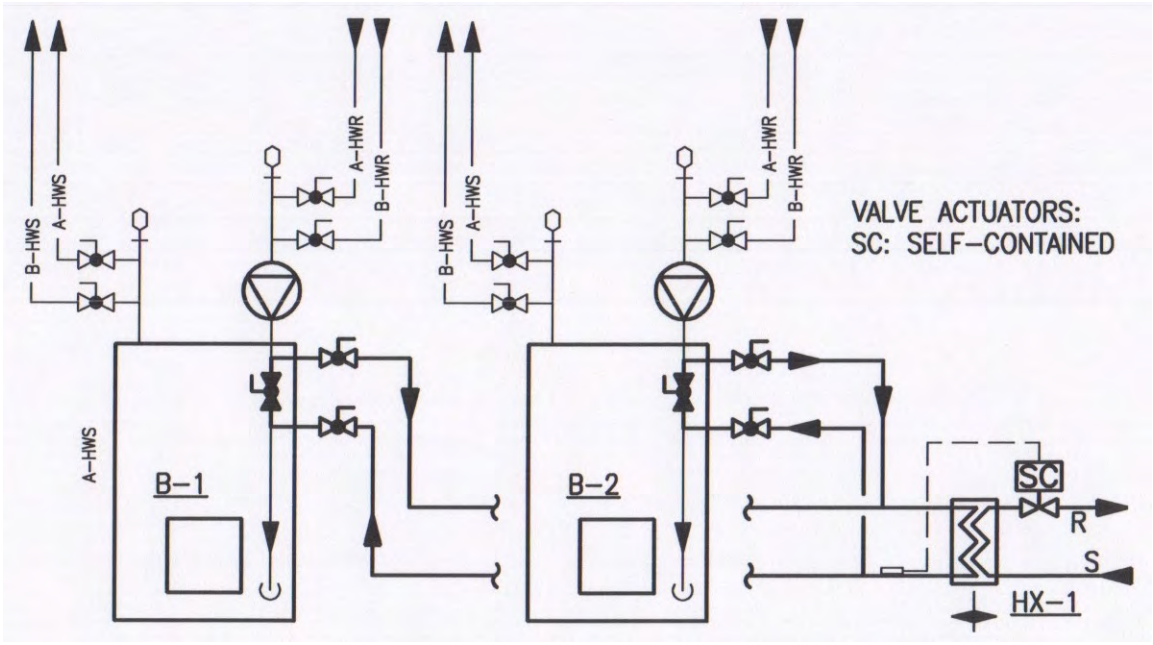


Figure 3.3

In Figure 3.3, all of the actuated valves have been replaced, except that the building HWR temperature is still controlled by what we have labelled as a self-controlled valve. This valve is controlled by the expansion and contraction of a fluid within a "sensing bulb" strapped to the pipe and a fluid-filled line from the bulb to the actuator itself (light dashed line). The hotter the building HWR gets, the more the fluid expands; the resulting pressure moves the actuator in the valve to modulate to control the HWR temperature – no external power source or controller is required. The level of precision is not as high, but is more than enough for the application.

The 2-position valves are replaced with manual valves. They would normally be left as shown (the two horizontal valves are open, the vertical valve is closed). These valve positions would only be reversed if, for some reason, a resident wished to isolate their boiler from the DH Plant.

A single HX is used for the multi-plex, although as noted above, there are still two connections required, and the boilers cannot back one another up (each boiler can still only serve its original residence).

In talking to the Villagers, we learned that there was some thought of converting the multi-plexes such that each one had only one boiler, regardless of the number of residences. This would obviously make the DH Plant much less expensive; in addition to using the much less expensive interconnections, the number on interconnections decreases from 23 to 11 (the two northernmost duplexes cannot easily be converted to one boiler, so 7 buildings * 1 connection + 2 buildings * 2 connections = 11 connections).

No indication was given on the potential timing of such a measure, but the model shows the effect that such a re-configuration of the existing systems would have. Although Sc 2 and Sc 3 have been reduced, the combination of 1) a small overall amount of "base" oil consumption, 2) a long distance

between the buildings (thus lots of buried pipe), and 3) a very large number of interconnections was making Scenarios 1, 2, and 3 appear unattractive, financially.

A final model was run, assuming only 11 interconnects. Rather than assume that the existing boilers had been removed, and a single new boiler added, two ways were presented to reduce the number of connections to one per building while leaving the existing boilers in place. Figures 3.4 and 3.5 show the basic piping schematics.

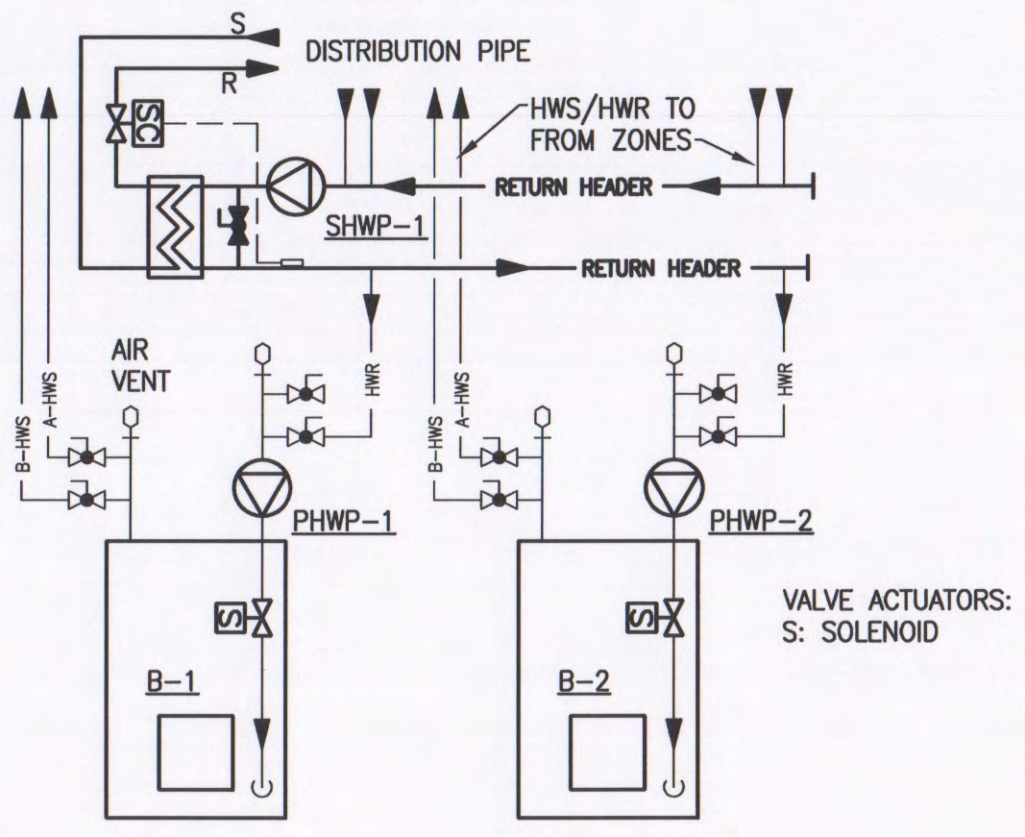


Figure 3.4

In this configuration, a new building return water (HWR) header is installed. All four HWR lines tie into the header. A new secondary building pump is shown, but may not be needed (more field work would be required to determine this). The single heat exchanger can now heat all of the hot water for the whole building with one connection to the new header.

At each boiler, a solenoid valve is added – the valve would be open whenever the associated PHWP was operating. Thus if Residence 2 did not need heat, PHWP-2 would be off. The associated solenoid would close, preventing water that should be flowing only to Residence 1 from flowing through B-2.

Since all of the return lines flow into a common header, there is no need for two HWR lines to each boiler, so one line is removed. This assumes the remaining line can handle the entire HWR flow. ,A subject for future field work.

This configuration represents the aim of reducing the number of connections to one. However, each boiler can still only serve the original residence it "belonged to" – the supply lines off each boiler are still separate and dedicated.

Figure 3.5, therefore, shows an added building hot water supply header as well. In this configuration, there is a single point connection, and any boiler can serve any load in the building.

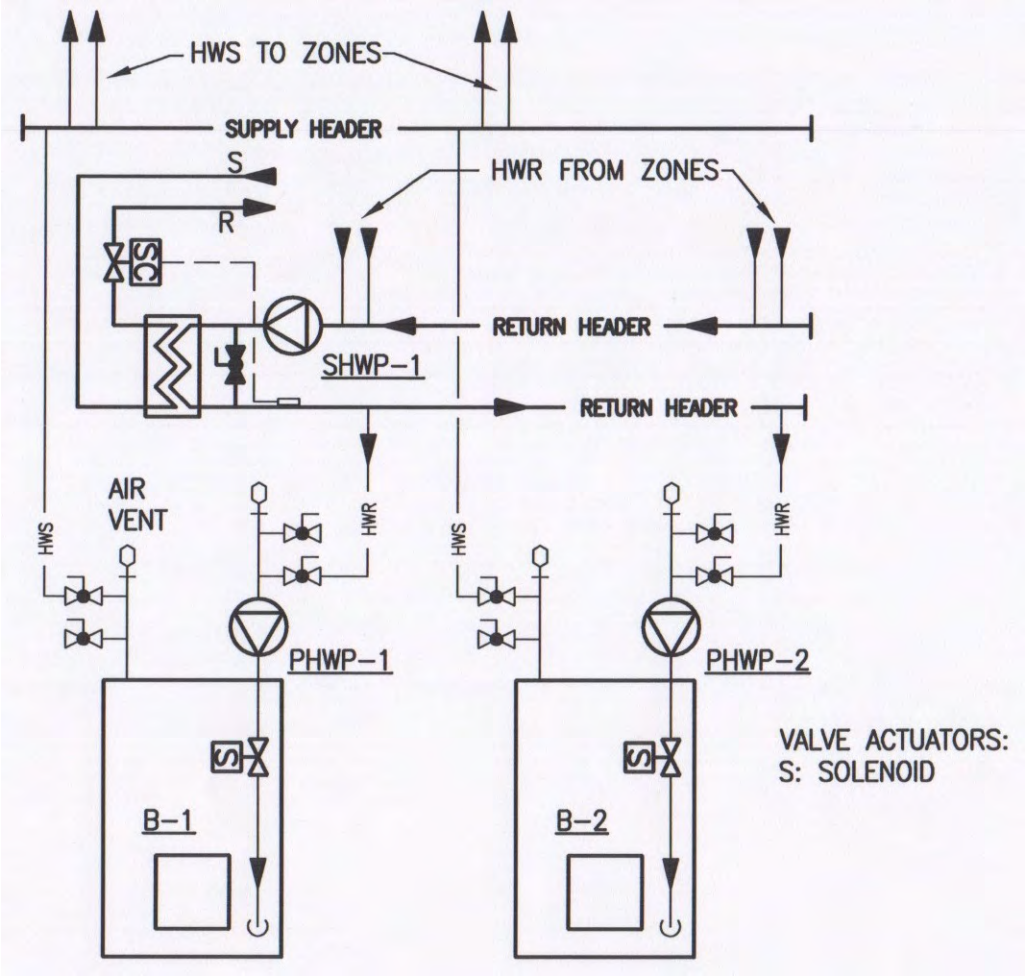


Figure 3.5

NOTE *that while Scenario 4 takes credit for the cost savings associated with reducing the number of connections from 23 to 11, it* ***DOES NOT*** *include the costs associated with adding the header or headers (depending on final configuration). Since THRHA was considering something similar, the change was modeled to show how it would affect the economics of the DH Plant.*

3.2 Thermal Storage

When referring to a hot water heating system, thermal storage simply refers to a hot water tank, which stores hot water (thus thermal storage). The importance of using thermal storage in a biomass-fired heating plant varies, depending on the form the wood.

Stick fired boilers are batch fed, with an operator adding batches of fuel as needed. In this case, thermal storage is almost a requirement. This is because once the fuel starts burning; it is impossible to modulate the rate of burn to match the heat load. Instead, the amount of fuel added is sized to heat the thermal storage, while the pumping/piping system extracts heat from the thermal storage as needed to match the load. The thermal storage "de-couples" the rate of burn from the variations in heating load.

Chip fired boilers are automatically fed, and can modulate to meet load. It would seem then that they would not need thermal storage, and in fact many chip systems are installed without storage. Where storage really provides value in a chip system is when the heating load varies over a very large range, as they do in Alaska. The boiler can only turn down to about 25 percent of full load capacity – below that heating demand, the boiler will cycle off until hot water temperature drops a set amount, and then restart. A good chip boiler will auto-restart, but they still will not cycle On and Off like an oil boiler, for instance. Once the fuel is in a solid fuel burner, it will burn whether the heat is needed or not. They take a long time to cool down, and an equally long time to heat back up. Finally, if the fuel is very wet, the auto-start may take a long time, or in extreme cases, fail. A storage tank can help limit the cycling, the boiler now modulates to keep the tank at setpoint, and as above, the system extracts heat from the tank as needed. The thermal storage can keep the boiler running at very low levels rather than cycling.

The performance of pellet boilers is as close to an oil-fired boiler as is possible with wood. The fuel is very dry, and easy to re-start. The boilers are generally much smaller than chip boilers, so there is not much fuel in the unit at any given time. They are as heavy, so they heat up much quicker. While a thermal storage tank would, again, limit cycling at low loads, pellet boilers generally do not need a tank to modulate and follow loads. However, all good pellet boilers have an auto-cleaning feature, where they clean the tubes, generally once a day. Many models cannot do this while the boiler is actually running, so they shut down. Such boilers generally use thermal storage to "bridge over" the time they are off. The Okofen boilers sold by Maine Energy Systems do not shut down while cleaning, and so while thermal storage can be added to the MES boilers, a determination must be made for storage based on the application, need and cost.

In a district heating application, one is likely to have two, or even three boilers. If each boiler has a 4:1 turndown, then a plant with two boilers can turn down 8:1, and a three-boiler plant can turn down 12:1. The buried piping provides a small but constant load, and even on warm days in AK, nights can be cold. So, in these DH situations, thermal storage is not added, the combined turndown of the boilers is sufficient to minimize cycling.

In a small single building or residential application, a small (50 – 90 gallon) tank may be added, even for an MES boiler, space and money permitting.

Appendix 1. Photos and site map

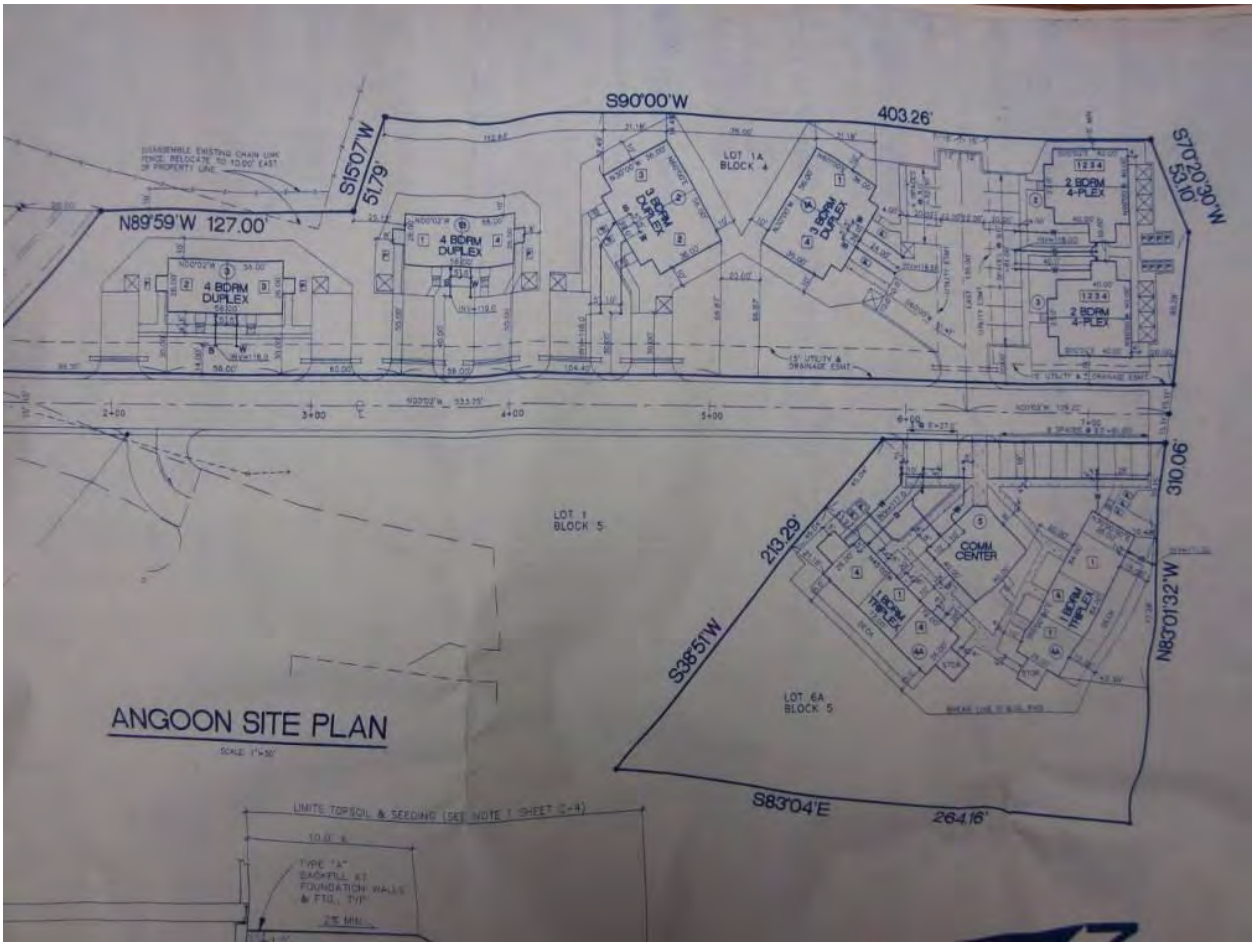


Figure 1. Site plan with potential location of the Pellet District Heat Plant.



Figure 2. Each building has as many boilers as there are apartments in the building.

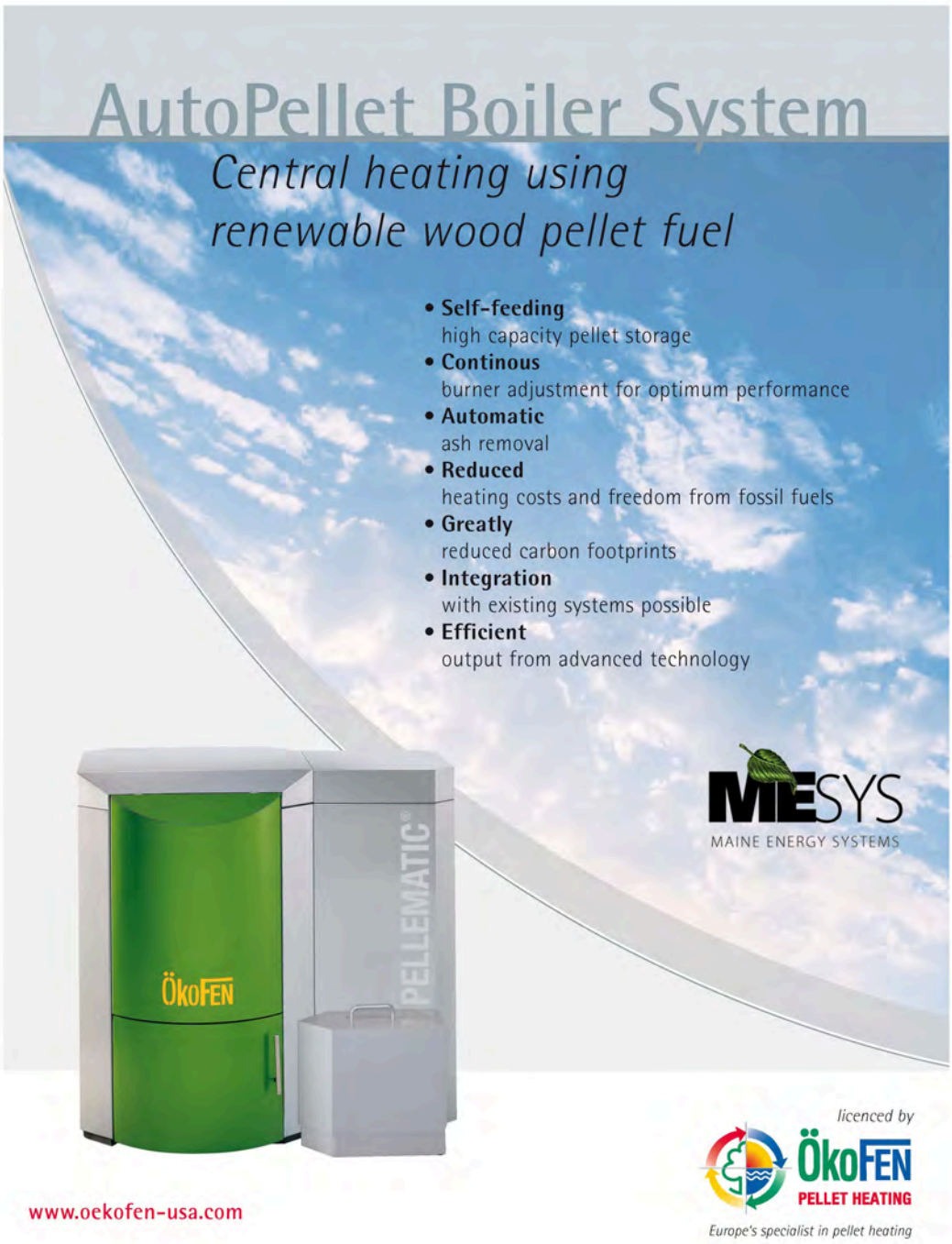


Figure 3. Example of a duplex with two boilers, two oil tanks and two stacks on top of the building.



Figure 4. Example of a four plex. See the 4 stacks on right from adjacent 4-plex and the boiler room for the building.

Appendix 2. Brochure for MES OkFen Pellet Boilers



AutoPellet Boiler System

The AutoPellet boiler systems are UL approved for use with premium grade pellets. Suitable for direct replacement of an existing oil/gas boiler, or as the main heat source while maintaining the existing oil/gas boiler. An AutoPellet system is the ideal solution for decreasing our dependence on fossil fuels in times of unpredictable energy prices without reducing the level of convenience.
Each AutoPellet boiler system comes standard with either an auger or vacuum pellet feed system and automatic ash removal equipment.



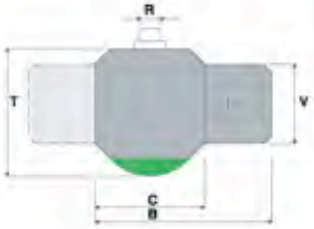


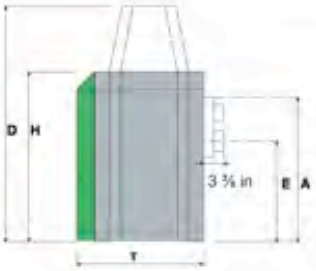
Venting and Installation Requirements:
The boiler must have its own chimney/flue chase approved for solid fuel firing. Use a black smoke pipe for boiler breeching to the chimney. Install a furnished barometric in vertical direction. Slope flue pipe to chimney at least 1/4" per foot upward to the chimney. Ensure adequate combustion air at all times. Extend chimney at least 3 ft above roof penetration and at least 2 ft above any part of the roof within a radius of 10 ft. Follow Table below for minimum chimney heights. Maintain at least 4 ft lateral clearance between pellet boiler and pellet fuel storage.

Boiler - Type			PE(S)12	PE(S)16	PE(S)20	PE(S)25	PE(S)32	PES36	PES49	PES56
Boiler rated power		BTU/hr	41,000	51,000	68,300	85,300	109,500	123,000	164,000	191,000
Width - total	B	Inch	44 ½	44 ½	44 ½	46 ¾	46 ¾	51	51	51
Width - boiler	C	Inch	27 ½	27 ½	27 ½	29 ¾	29 ¾	34	34	34
Height - boiler	H	Inch	43	43	43	50 ¾	50 ¾	61 ¼	61 ¼	61 ¼
Height - vacuum suction system	D	Inch	60	60	60	67 ¼	67 ¼	73	73	73
Depth - boiler	T	Inch	32	32	32	34 ¼	34 ¼	39	39	39
Depth - casing	V	Inch	20	20	20	20	20	20	20	20
Water supply/return - dimensions		Inch	1	1	1	5/4	5/4	2	2	2
Water supply/return - height of connection	A	Inch	35 ¾	35 ¾	35 ¾	43 ¾	43 ¾	52	52	52
Flue size - diameter	R	Inch	5	5	5	6	6	7	7	7
Flue - height of connection	F	Inch	25 ½	25 ½	25 ½	33 ¼	33 ¼	41	41	41
Overall Weight		lb	534	542	561	697	705	1,327	1,336	1,345
Water capacity		Gal	15.0	15.0	15.0	23.6	23.6	30.6	30.6	30.6

Chimney Size	Min. Height
6" x 6"	17 ft
7" x 7"	16 ft
8" x 8"	15 ft
6" round	19 ft
7" round	17 ft

The AutoPellet system must be installed by a trained service technician. The boiler will require cleaning and brushing of the boiler heating surfaces **once a year.**





MESys Certified Contractor

Maine Energy Systems, LLC (MESys) 8 Airport Road P.O. Box 547 Bethel, Maine 04217
207.824.NRGY (6749) info@maineenergysystems.com

Figure 1. Two page Brochure.

Appendix 3. Portion of Tech Brochure for Pex Piping

REHAU

REHAU INSULPEX®
Energy Transfer Pipe



Technical Manual 855.630

1. Introduction

The objective of this technical manual is to provide a fundamental understanding of the features of REHAU's INSULPEX piping system and to assist in the design and specification of these systems. For a list of products, refer to the *INSULPEX Product Catalog*. Installers should consult the *INSULPEX Installation Guide*.

Additional assistance and information and updates (Technical Bulletins) are always available online at www.REHAU-NA.com or by contacting your regional REHAU representative.

1.1 Description

INSULPEX is specially designed for the efficient transfer of hot or chilled water through buried pipelines. A flexible alternative to rigid piping systems, INSULPEX offers ease of installation, combined with the long-term performance of PEX pipe.

INSULPEX consists of RAUPEX® pipe surrounded by a solid layer of CFC-free polyurethane foam insulation. The smooth interior wall of RAUPEX provides superior flow and consistent water pressure, and resists mineral build-up and bacterial growth. INSULPEX is available in one- and two-pipe configurations. The two-pipe configuration combines supply and return pipes, streamlining the installation process.

Connections are made with REHAU's EVERLOC® fitting system, providing reliable joints that allow for immediate pressure testing, and are safe to bury.

INSULPEX is lighter than rigid piping systems and is available in continuous coils of various lengths that reduce the need for joints in the pipeline—features that greatly reduce the costs and time associated with installation. The continuous single layer of insulation minimizes heat loss and water permeability, while the outer LDPE casing offers protection from abrasion.



Fig. 1.1:
INSULPEX pipe

INSULPEX is offered with three different RAUPEX carrier pipes:

- RAUPEX O_2 Barrier, ASTM (copper tube size) pipes in sizes 1", 1 1/4", 1 1/2" and 2"
- RAUPEX Non-barrier, ASTM (copper tube size) pipes in sizes 1", 1 1/4", 1 1/2" and 2"
- RAUPEX O_2 Barrier, Metric pipes in sizes 63, 75, 90 and 110 mm outside diameter

To assist with identification, both ASTM and metric RAUPEX O_2 Barrier pipes are red in color. RAUPEX Non-barrier pipes are natural in color.

The INSULPEX system consists of INSULPEX pipe, fittings, tools, and installation accessories designed for optimal performance and ease of installation.

1.2 Application

INSULPEX is intended for the transfer of water-based heated/chilled fluids. INSULPEX can be buried, or installed above ground indoors or outdoors provided it is sheltered completely from UV light and/or sunlight. The following are possible applications:

- District heating supply
- Energy transfer
- Snow and ice melting supply
- Chilled water
- Process piping
- Hydronic piping
- Potable water

The following should be considered when designing an INSULPEX system:

- RAUPEX O_2 Barrier pipes cannot be used for potable water systems.
- INSULPEX must be permanently and completely sheltered from UV exposure (sunlight).
- INSULPEX may ot be used for permanent, unsheltered outdoor exposure.

1.2.1 Chlorinated Potable Water

RAUPEX Non-barrier pipes can be used for chlorinated potable water subject to the following conditions:

- The pH of the water is 7.0 or higher
- The concentration of free chlorine is 4.0 parts per million (ppm) or lower
- Water temperature is 140°F (60°C) or lower
- Water pressure is 80 psi (550 kPa) or lower

Contact your regional REHAU representative to discuss any chlorinated potable water system with a temperature and/or pressure beyond those listed above.

1.2.2 Non-Chlorinated Potable Water

RAUPEX Non-barrier pipes can be used for non-chlorinated potable water subject to the pressure and temperature limits as found in Tables 2.1 and 2.2.

Attachment 2

Haines – WESEE Wood Pellet System Conceptual Cost Estimate

THRHA Regional Housing Authority
Juneau, Alaska

Haines 12 Unit Multifamily Building
Wood Pellet System Conceptual Cost Estimate

Line Item	Value	Units	$/Unit	Cost[1]
70,000 Btu/hr wood pellet system[2]	-	-	-	$ 15,000
Boiler room addition[3]	250	sf	$ 60	$ 15,000
Pellet storage				$ 7,500
Boiler room equipment	-	-	-	$ 10,000
Site preparation	-	-	-	$ 10,000
Thermal storage 60 gal	-	-	-	$ 5,000
Pex Pipe (1-2" supply and return)	25	lf	$ 150	$ 3,750
On demand propane DHW Heater				$ 2,000
Interconnection to existing boiler room[4]	-	-	-	$ 10,000
Sub-Total				$ 78,250
Contractor Profit	*10%*			*$ 7,825*
Sub-Total				*$ 86,075*
Contingency	*15%*			*$ 12,911*
Sub-Total				*$ 98,986*
Professional Services	*12%*			*$ 11,878*
Total				**$ 110,865**

Notes:
1 - Overhead and bid bond are factored into the estimated item costs and are not broken out.
2 - Includes stack, breeching, and controls.
3 - Pole construction with minimal HVAC requirements.
4 - Cost is prelimary since existing equipment and plumbing have not been evaluated in detail.
5 - All costs are installed costs.
6 - Geotechnical investigations and surveys have not been conducted. Soil and grade dependent items are subject to large changes in cost pending site investigation.
7 - Sizing of the biomass system is based solely on estimated annual fuel usage data listed in AkWarm.

Attachment 3

Hoonah – WESEE Wood Pellet System Conceptual Cost Estimate

Hoonah 12 Unit Multifamily Building
Wood Pellet System Conceptual Cost Estimate

Line Item	Value	Units	$/Unit	Cost[1]
40,000 Btu/hr wood pellet system[2]	-	-	-	$ 12,500
Boiler room addition[3]	250	sf	$ 60	$ 15,000
Pellet storage				$ 7,500
Boiler room equipment	-	-	-	$ 10,000
Site preparation	-	-	-	$ 10,000
Thermal storage 60 gal	-	-	-	$ 5,000
Pellet storage				$ 7,500
Interconnection to existing boiler room[4]	-	-	-	$ 10,000
Sub-Total				$ 77,500
Contractor Profit	*10%*			*$ 7,750*
Sub-Total				*$ 85,250*
Contingency	*15%*			*$ 12,788*
Sub-Total				*$ 98,038*
Professional Services	*12%*			*$ 11,765*
Total				**$ 109,802**

Notes:
1 - Overhead and bid bond are factored into the estimated item costs and are not broken out.
2 - Includes stack, breeching, and controls.
3 - Pole construction with minimal HVAC requirements.
4 - Cost is prelimary since existing equipment and plumbing have not been evaluated in detail.
5 - All costs are installed costs.
6 - Geotechnical investigations and surveys have not been conducted. Soil and grade dependent items are subject to large changes in cost pending site investigation.
7 - Sizing of the biomass system is based solely on estimated annual fuel usage data listed in AkWarm.

Attachment 4

Juneau – Fireweed Place AEE Energy Audit

THRHA Regional Housing Authority
Juneau, Alaska

Energy Audit

Fireweed Place

Juneau, Alaska



Final Report
February, 2015

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
jim@alaskaenergy.us

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Appendix B: Utility Data

Section 1

Executive Summary

INTRODUCTION

This report presents the findings of an energy audit of the Fireweed Place Apartments located in Juneau, Alaska. The purpose of this energy audit is to evaluate the infrastructure and its subsequent energy performance to identify applicable energy efficiency measures (EEMs).

BUILDING ASSESSMENT

The Fireweed Place is a 54,323 sqft, five story apartment building for senior citizens. Electricity is the only energy source for the building, supplying heating, ventilation, equipment, lighting and plug loads. The building has a master meter for all non-apartment energy use and the apartments are individually metered. The apartment energy use is not assessed in this audit.

Building Envelope

The walls are insulated to nearly optimal level and no recommendation to increase the thermal resistance is provided. The floor over the parking garage is under insulated, and the insulation is not aligned with the air boundary (concrete 2nd floor slab), so it is largely ineffective. The space above the insulation provides a routing for piping. There are cost effective opportunities to improve the insulation under this slab and increase its thermal resistance. Refer to the recommendations in the building shell report conducted by Marquam George.

The attic insulation is below optimal values and can be improved by adding blown insulation over the existing fiberglass batts. This will also create a more uniform layer of insulation. The windows are good quality units for the period in which they were installed. While new windows would provide energy savings, the savings would not offset the cost of replacement.

The exterior doors have metal frames that are not thermally broken between the outside panels and the inside panels. Unfortunately, replacing the doors with thermally broken units will not provide a life cycle savings. All of the exterior doors are properly weather-stripped.

Heating System

The apartments and support spaces are heated by electric resistance heaters. They are controlled by wall thermostats or integral thermostats. None of the thermostats are programmable for night temperature setback.

It is possible to reduce heating costs by using heat pumps to heat the common spaces and the ventilation air. Heating the common spaces with heat pumps will not provide a life cycle savings since the heating load of these spaces is low. An EEM is evaluated to heat the ventilation air with an air source heat pump.

Ventilation Systems

The building has two heat recovery ventilating (HRV) units that supply the apartments and common spaces. The energy consumption of these units—fans to circulate the air and heating coils to temper the air—are on the house meter. The units are nearing the end of their service life. Energy efficiency opportunities include:

- Retaining the Existing Units: Scope includes cleaning the heat recovery cells, repairing the controls, and replacing the exhaust fan motor. This EEM includes replacing the existing units in ten years.
- Replace the HRVs: An analysis determined that the HRVs are over-ventilating the building. Considerable energy savings will occur by replacing them with smaller units. This will reduce the air flow to the apartments, which may be noticeable to the tenants.

There is an opportunity to reduce the supply air temperature, which would shift some of the ventilation heating load to the tenants. This may be noticeable to the tenants.

There is also an opportunity to install and air-source heat pump to heat the ventilation air more efficiently than electric coils.

Domestic Hot Water System

The building has four 50 gallon electric hot water heaters supplying laundry rooms, janitor rooms, toilets, and sinks. In addition, there is a 119 gallon HW heater that serves the 2nd floor laundry room, spa, sink, and toilet rooms.

The hot water heaters are not wrapped in an insulating blanket and the hot water piping is not insulated. Since these systems are located in interior spaces, a low percentage of the heat loss is beneficial to the building.

Lighting

Most of the common area lighting is fluorescent with T12 lamps. The lamps are being phased out and will soon not be available. The lighting is controlled from wall switches.

The interior lighting provides some beneficial heating to the building most of the year. A lighting upgrade will reduce lighting heat, with the heating system replacing some of the reduced lighting heat. This typically significantly reduces the net energy savings from upgrading the lighting. It is recommended that a lighting replacement, when it becomes necessary, utilize LED lighting with individual occupancy sensors that can reduce lighting to lower levels when the corridor is unoccupied.

Room lighting controls such as occupancy sensors can also reduce lighting energy. But, if the heating system makes up the lost lighting heat, the net energy savings typically cannot pay for the high cost to install sensors in an existing building. The exception may be support spaces that are not heated. However, building staff is diligent about turning lights off so there is little incentive to install occupancy sensors.

The exit signs are battery-operated LED fixtures.

<u>Building Exterior</u>

Most of the exterior lighting has been converted to LED lamps. There are five T12 fixtures over the main entrance door that are not efficient.

Electric Equipment

Laundry

There is a laundry room on each floor of the building with a total of 5 washing machines and 5 dryers. The washing machines consist of three top load machines and two front load machines. The top load machines use more water and electricity than front loading models.

ENERGY EFFICIENCY MEASURES

Behavioral and Operational EEMs

These EEMs are highly recommended as low-cost opportunities.

- EEM-1: Replace Clothes Washers with Front-Loading Models. This EEM should be implemented as machines require replacement.
- EEM-2: Reduce HRV Supply Air Setpoint. This EEM can be implemented to shift some of the apartment ventilation heating load from the house meter to the apartment meters. Supplying cooler air may affect tenant comfort.

High and Medium Priority EEMs

EEMs that are recommended for investment are shown in the following table. They are ranked by life cycle savings to investment ratio (SIR). This ranking method places a priority on low cost EEMs which can be immediately funded, generating energy savings to fund higher cost EEMs in the following years.

Energy Efficiency Measure	Annual Costs			Life Cycle Costs				
	Operating	Energy	Total	Investment	Operating	Energy	Total	SIR
High Priority								
EEM-3: Reduce HW Heater Capacity	$0	($900)	($900)	$500	$0	($16,800)	($16,300)	33.6
EEM-4: Air Seal Shafts	$0	($3,520)	($3,520)	$8,900	$0	($65,300)	($56,400)	7.3
EEM-5: Insulate HW Heaters and Piping	$0	($180)	($180)	$800	$0	($3,300)	($2,500)	4.1
EEM-6: Combine Electric Meters	$0	($230)	($230)	$2,000	$0	($4,200)	($2,200)	2.1
Medium Priority								
EEM-7: Replace Heat Recovery Ventilators	$0	($15,290)	($15,290)	$163,400	$0	($283,600)	($120,200)	1.7
EEM-8: Upgrade Exterior Lighting	($60)	($30)	($90)	$1,000	($1,000)	($600)	($600)	1.6
EEM-9: Increase Attic Insulation	$0	($3,360)	($3,360)	$57,800	$0	($62,400)	($4,600)	1.1
Totals	($60)	($23,510)	($23,570)	$234,400	($1,000)	($436,200)	($202,800)	1.9

Note: Negative values, in parenthesis, represent savings.

If all of the above EEMs are implemented, they will require a $234,400 investment and provide an annual cost savings of $23,570 for a simple payback of 9.9 years. Annual energy costs will be reduced by 60%. The EEMs are explained in greater detail in the Energy Audit section.

Low Priority EEMs

EEMs that are not recommended for investment are shown in the following table. EEM-10 has a SIR greater than 1 but is not recommended because EEM-7 is a better investment. The other EEMs do not provide a life cycle savings.

Energy Efficiency Measure	Annual Costs			Life Cycle Costs				
	Operating	Energy	Total	Investment	Operating	Energy	Total	SIR
EEM-10: Rehabilitate Heat Recovery Ventilators	$0	($6,430)	($6,430)	$35,500	$65,900	($119,200)	($17,800)	1.5
EEM-11: Upgrade Transformer	$0	($1,570)	($1,570)	$29,386	$0	($29,150)	$236	1.0
EEM-12: Install Air Source Heat Pump	$960	($4,530)	($3,570)	$111,900	$16,300	($84,000)	$44,200	0.6
EEM-13: Install Elevator Room Heat Recovery	$30	($150)	($120)	$6,500	$500	($2,700)	$4,300	0.3

SUMMARY

The building is properly maintained and operated. The lone exception is the cleaning of the heat recovery cells in the HRVs, an issue that exists because the units were not supplied with return air filters to preclude fouling of the heat transfer surfaces. Staff has done a commendable job of optimizing the operation to reduce energy costs. However, the energy audit revealed opportunities for improving the performance of the building. It is recommended that the behavioral and high priority EEMs be implemented now to generate energy savings from which to fund the medium priority EEMs.

Section 2
Introduction

INTRODUCTION

This report presents the findings of an energy audit of the Fireweed Place Apartments located in Juneau, Alaska. The purpose of this energy audit is to evaluate the infrastructure and its subsequent energy performance to identify applicable energy efficiency measures (EEMs).

Report Format

The energy audit report contains the following sections:

- Introduction: Building use and energy consumption.
- Description of Systems: Building envelope, mechanical systems, and electrical systems
- Energy Efficiency Measures: Priority ranking of energy efficiency measures
- Methodology: Basis for construction and maintenance cost estimates and the economic and energy factors used for the analysis

The EEMs that are identified during the energy audit are priority ranked and, where applicable, subjected to energy and life cycle cost analysis. Appendix A contains the energy and life cycle cost analysis spreadsheets.

BUILDING ENERGY CONSUMPTION

Description

The Fireweed Place is a 54,323 sqft, five story apartment building for senior citizens. The first floor contains office and support spaces and the apartments are located on the 2nd through 5th floors. The office and support spaces are occupied during Monday through Friday work hours; the apartments are occupied continuously.

Electricity is the only energy source for the building; it supplies heating, ventilation, equipment, lighting and plug loads. The building has a master meter for all non-apartment electricity use. The apartments are individually metered and their energy use is not assessed in this audit.

Energy Use Index

The following table shows the common area (non-apartment) energy consumption and cost in 2014. The energy consumption includes exterior lighting, parking garage lighting, interior lighting, ventilation energy, elevator energy, and common area plug loads.

The common spaces have an Energy Use Index (EUI) of 106 kBtu/sqft. This value is higher than typical but is reasonable because it includes the ventilation energy for the entire building. Annual energy consumption and cost for the house meter is shown in the following table.

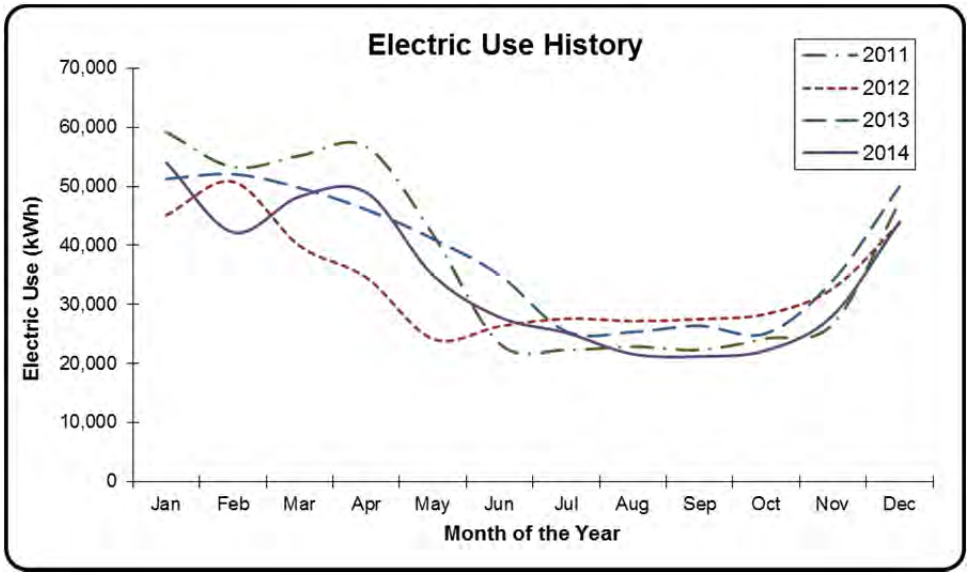
Annual Energy Consumption and Cost

Source	Consumption	Cost	Energy, MMBtu	EUI
Electricity	435,987 kWh	$39,270	1,490	106

Historic Energy Use

The following chart shows a 4-year history of electric use. The shape of the curve is indicative of an electrically heated building with higher use during winter months. Energy use (and demand) from year-to-year varies in the beginning of the year but tracks more closely later in the year. The reason for this early year variation is not known.

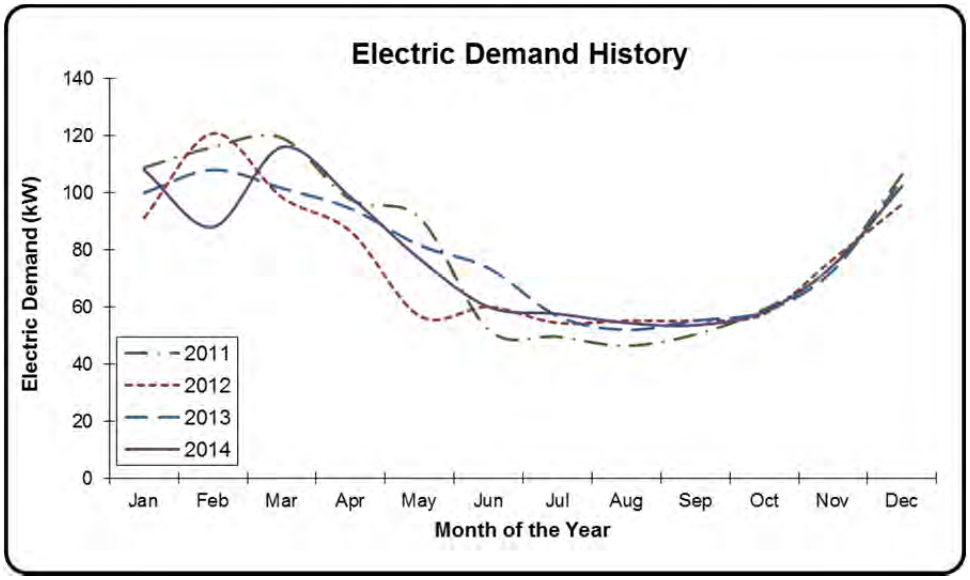
The history shows minimal variation from year to year which indicates that building operation is stable. Electricity use is lower over the last half of 2014 due to an exterior and parking garage lighting upgrade to LED fixtures.



Historic Electric Demand

The following chart shows a 4-year history of electric demand. Demand also varies mildly early in the year.

Juneau has relatively high demand charges, so demand control is essential to keeping electricity costs reasonable. The effective cost—energy costs plus demand charges—is 9.3¢ per kWh, which is on the low end for a commercial building. The utility bill is 67% energy charges, 29% demand charges, and 3% customer charges. The relatively low percentage of demand charges indicates that no large loads are spiking the demand while only operating for a short time.



Section 3

Energy Audit

DESCRIPTION OF SYSTEMS

Fireweed Place is a 54,323 square foot, five story apartment building. The building contains:

- First Floor: Manager's office and support spaces
- 2nd Floor to 5th Floor: Studio, 1-bedroom, and 2-bedroom apartments and common areas such as laundry rooms, lounges and corridors.

The building originally had a commercial kitchen with cooking equipment, kitchen and dishwasher exhaust hoods, and a makeup air fan. These systems have all been decommissioned or removed.

Building Envelope

The building envelope is summarized in the following table:

Building Envelope

Component	Description (inside to outside)	R-value Existing	R-value Optimal
Walls	Gyp bd, 6" wood studs, R-21 batt, sheathing, siding	R-21	R-23
Floor over Parking	Concrete slab, R-30 batt insulation, ceiling	R-30	R-40
Roof - Attic	Gyp bd, R-38 batt insulation	R-30	R-50
Windows	Vinyl, double pane, good weather-stripping	R-2	R-4
Doors	Main: Metal w/o thermal break, dbl pane, good weather-stripping	R-1.5	R-3
	Entrance: Metal w/o thermal break	R-2	R-5
	Overhead: Metal w/o thermal break, no weather-stripping	R-1	R-4

The exterior doors have metal frames that are not thermally broken between the outside panels and the inside panels. Unfortunately, replacing the doors with thermally broken units will not provide a life cycle savings. All of the exterior doors are properly weather-stripped.

Heating System

The apartments and support spaces are heated by electric resistance heaters. They are controlled by wall thermostats or integral thermostats. None of the thermostats are programmable for night temperature setback.

Ventilation Systems

The building has the following heat recovery ventilating (HRV) units:

- HRV-1 and HRV-2 serve the 2nd through 5th floors
- HRV-3 served the first floor but has been turned off for over 19 years.

Each HRV has a supply fan, heat recovery cell, and exhaust fan. The supply fan draws in 100% outside air and supplies it to the rooms. The exhaust fan draws exhaust air from bathrooms, janitor's closets and laundry rooms. Both air streams flow through a heat recovery cell that transfers heat from the exhaust air to the supply air. The supply air is additionally heated by an electric heating coil to maintain a supply air temperature of 60°F in summer and 70°F in winter.

Temperature readings of air flows into and out of the HRVs show that they are operating at an effectiveness of 45-50% on a 44°F day. This is lower than expected but there is no performance data available to reference. Inspection revealed that there are no filters on the return air stream and the heat exchanger passages are nearly plugged on the return air side. This would explain the lower than expected effectiveness.

HRV-1 and HRV-2 have dampers on the outside air intake, the exhaust air outlet, and a bypass damper. The outside and exhaust air dampers are stuck wide open; this is not an issue since the unit operates continuously. The bypass damper provides both frost protection and a warm weather bypass of the heat recovery function.

There are integral controls for frost protection, warm weather bypass and modulation of the electric heating coil for supply air temperature control. The sequence of control is:

- Defrost Protection: The bypass damper modulates to allow the supply air to bypass the heat recovery cell during cold weather to ensure that the exhaust air temperature stays above freezing so moisture does not freeze on the cell.
- Warm Weather Bypass: The bypass damper modulates to allow the supply air to bypass the heat recovery cell during warm weather to provide natural cooling.
- Supply Air Temperature Control: The electric heating coil modulates to maintain a supply air temperature setpoint.

An assessment of the controls determined that they are not properly calibrated or operational. They should be assessed by a control technician and set as follows:

- Defrost Protection: Set to maintain the exhaust air discharge temperature above 35°F.
- Warm Weather Bypass: Set to maintain limit the supply air temperature to 72°F.
- Supply Air Temperature Control: Set to maintain a supply air temperature of 70°F and 60°F during summer and winter, respectively.

Domestic Hot Water System

Apartments

Each apartment has an electric hot water heater connected to the apartment utility meter. A high percentage of the heat loss from these heaters is beneficial toward heating the apartment. No energy efficiency measures are recommended.

Common Areas

Commercial Kitchen: The kitchen HW heater has been turned off.

Laundry Rooms (3rd, 4th, 5th Floors): Each laundry room has a 50 gallon electric HW heater. The heater and HW piping is not insulated.

Toilet Rooms and Janitor's Closet (1st and 2nd Floors): A 50 gallon electric HW heater on the 2nd floor supplies these spaces. The heater and HW piping is not insulated.

Common Spaces (2nd Floor): 119 gallon HW heater with an 18 kW heating capacity. The unit serves the laundry room, spa, sink, and toilet rooms.

The hot water heaters are not wrapped in an insulated blanket and the hot water piping is not insulated. Since these systems are located in interior spaces, a low percentage of the heat loss is beneficial.

Lighting

Common Areas

Most of the common area lighting is fluorescent with T12 lamps. The lamps are being phased out and will soon not be available. The lighting is controlled from wall switches.

The interior lighting provides some beneficial heating to the building most of the year. A lighting upgrade will reduce lighting heat, with the heating system replacing some of the reduced lighting heat. This typically significantly reduces the net energy savings from upgrading the lighting. It is recommended that a lighting replacement, when it becomes necessary, utilize LED lighting with individual occupancy sensors that can reduce lighting to lower levels when the corridor is unoccupied.

Lighting controls such as occupancy sensors can also reduce lighting energy. But, if the heating system makes up the lost lighting heat, the net energy savings typically cannot pay for the sensor. The exception may be support spaces that are not heated. However, building staff is diligent about turning lights off so there is little incentive to install occupancy sensors.

The exit signs are battery-operated LED fixtures.

Parking Garage

The lighting in the parking garage has been recently converted to LED lamps.

Building Exterior

Most of the exterior lighting has been converted to LED lamps. There are five T12 fixtures over the main entrance door that are less efficient. The photocell that controls the lighting had not been properly adjusted.

Electric Equipment

Laundry

There is a laundry room on each floor of the building with a total of 5 washing machines and 5 dryers. The washing machines consist of three top load machines and two front load machines. The top load machines use more water and electricity than front loading models.

The elevator has a 40 HP motor and is regularly in motion during waking hours.

ENERGY EFFICIENCY MEASURES

Introduction

The EEMs are grouped into the following prioritized categories:

- Behavioral or Operational: EEMs that require minimal capital investment but require operational or behavioral changes. The EEMs provide a life cycle savings but an analysis is not performed because the energy savings is difficult quantify.
- High Priority: These are typically EEMs that require a small capital investment and offer a higher savings to investment ratio. Also included in this category are higher cost EEMs that offer significant life cycle savings.
- Medium Priority: These are typically EEMs that require a significant capital investment to provide a life cycle savings. Many medium priority EEMs provide a high life cycle savings and offer substantial incentive to increase investment in building energy efficiency.
- Low Priority: EEMs that will save energy but do not provide a life cycle savings.

Behavioral or Operational

The following EEMs are recommended for implementation. They require behavioral or operational changes that can occur with minimal investment to achieve immediate savings. These EEMs are not easily quantified by economic analysis because behavioral or operation changes cannot be accurately predicted. They are recommended because there is a high likelihood they will offer a life cycle savings, represent good practice, and are accepted features of high performance buildings.

EEM-1: Replace Clothes Washers with Front-loading Model

Purpose: Three of the clothes washers are top-loading models that use more water and energy than front-loading models.

Scope: Replace top-loading washers with front-loading models when they require replacement.

Analysis: This EEM is recommended without analysis.

EEM-2: Reduce HRV Supply Air Setpoint

Purpose: The supply air setpoint for the heat recovery ventilators is manually set at 60°F during summer and 70°F during winter. Reducing the setpoint will shift the ventilation load from the house meter to the tenant meters.

Scope: Investigate if the supply air temperature setpoint can be reduced without adversely affecting the tenant's thermal comfort.

Analysis: This EEM is recommended without analysis.

High Priority

The following EEMs are recommended for implementation because they are low cost measures that offer a high return on investment. The EEMs are listed from highest to lowest priority.

EEM-3: Reduce HW Heater Capacity

Purpose: The recovery rate of the 2nd floor hot water heater serving the laundry and spa area appears to be much higher than is needed to serve the load. Disconnecting one of the heating elements will reduce demand charges while maintaining an adequate HW supply for the fixtures.

Scope: Disconnect one of three 6 kW heating elements to reduce demand charges by 6 kW per month.

Analysis: The analysis assumes that a 12 kW recovery is sufficient. This EEM will reduce annual electric demand by 72 kW and energy costs by $900. The following table summarizes the life cycle cost analysis.

Annual Costs			Life Cycle Costs				
Operating	**Energy**	**Total**	**Investment**	**Operating**	**Energy**	**Total**	**SIR**
$0	($900)	($900)	$500	$0	($16,800)	($16,300)	33.6

Note: Negative values, in parenthesis, represent savings.

EEM-4: Air Seal Shafts

Purpose: Energy will be saved if the plumbing and duct shafts that extend through all floors of the building are sealed to preclude upward air flow into the attic due to stack effect.

Scope: Seal the duct and plumbing shafts at the opening into the attic.

Analysis: This EEM will reduce annual electricity use and energy costs by 56,000 kWh and $3,500, respectively.

Annual Costs			Life Cycle Costs				
Operating	**Energy**	**Total**	**Investment**	**Operating**	**Energy**	**Total**	**SIR**
$0	($3,520)	($3,520)	$8,900	$0	($65,300)	($56,400)	7.3

Note: Negative values, in parenthesis, represent savings.

EEM-5: Insulate Hot Water Heaters and Piping

Purpose: Energy will be saved if additional insulation is added to the hot water tanks and the hot water piping is insulated. While the hot water tanks and piping provide some beneficial heat, they are located in interior spaces with little heating load.

Scope: Install an insulating blanket on each hot water tank and insulate the hot water piping.

Analysis: This EEM will reduce annual electricity use by 1,900 kWh. The energy and life cycle cost analysis is summarized in the following table.

Annual Costs			Life Cycle Costs				
Operating	Energy	Total	Investment	Operating	Energy	Total	SIR
$0	($180)	($180)	$800	$0	($3,300)	($2,500)	4.1

Note: Negative values, in parenthesis, represent savings.

EEM-6: Combine Electric Meters

Purpose: The building has a separate electric meter for the kitchen that creates an additional monthly service charge. Combining the kitchen service with the house service will eliminate the service charge.

Scope: Remover the kitchen meter and feed the kitchen service from the main panel MH.

Analysis: This EEM will reduce annual electric changes by $230. The energy and life cycle cost analysis is summarized in the following table.

Annual Costs			Life Cycle Costs				
Operating	Energy	Total	Investment	Operating	Energy	Total	SIR
$0	($230)	($230)	$2,000	$0	($4,200)	($2,200)	2.1

Note: Negative values, in parenthesis, represent savings.

Medium Priority

Medium priority EEMs require planning and a higher level of investment; they are recommended because they offer a life cycle savings. The EEMs are listed from highest to lowest priority.

EEM-7: Replace Heat Recovery Ventilators

Purpose: Energy will be saved if the heat recovery ventilators HRV-1 and HRV-2 are replaced with smaller units sized for the code ventilation requirement.

Scope: Replace HRV-1 and HRV-2 with 2,000 cfm units and balance the air system for the smaller air flows.

Analysis: This EEM will reduce annual electricity use and costs by 257,000 kWh and $24,000, respectively. The following table summarizes the life cycle cost analysis.

Annual Costs			Life Cycle Costs				
Operating	Energy	Total	Investment	Operating	Energy	Total	SIR
$0	($15,290)	($15,290)	$163,400	$0	($283,600)	($120,200)	1.7

Note: Negative values, in parenthesis, represent savings.

EEM-8: Upgrade Exterior Lighting

Purpose: Energy will be saved if the fluorescent exterior lighting above the front entrance is upgraded to LED lighting.

Scope: Replace five fluorescent T12 light fixtures with LED fixtures.

Analysis: This EEM will reduce annual electricity use by 525 kWh and energy costs by $30. It will also decrease lamp replacement costs. The following table summarizes the life cycle cost analysis.

Annual Costs			Life Cycle Costs				
Operating	**Energy**	**Total**	**Investment**	**Operating**	**Energy**	**Total**	**SIR**
($60)	($30)	($90)	$1,000	($1,000)	($600)	($600)	1.6

Note: Negative values, in parenthesis, represent savings.

EEM-9: Increase Attic Insulation

Purpose: Energy will be saved by installing additional insulation in the attic.

Scope: Add additional blown-in cellulous insulation to increase the attic R-value from R-38 to R-58.

Analysis: This EEM will reduce annual electricity use and energy costs by 34,000 kWh and $2,140, respectively. The following table summarizes the life cycle cost analysis.

Annual Costs			Life Cycle Costs				
Operating	**Energy**	**Total**	**Investment**	**Operating**	**Energy**	**Total**	**SIR**
$0	($3,360)	($3,360)	$57,800	$0	($62,400)	($4,600)	1.1

Note: Negative values, in parenthesis, represent savings.

Low Priority

Low priority EEMs typically do not offer a life cycle energy savings and are not recommended.

EEM-10: Rehabilitate Heat Recovery Ventilators

Purpose: Energy will be saved if the heat recovery ventilators HRV-1 and HRV-2 are rehabilitated. The units were installed in 1994 and have an estimated remaining service life of 10 years. Energy saving opportunities includes cleaning the heat exchangers, rehabilitating the controls, and reducing the supply air temperature.

Scope: Rehabilitate the HRVs by cleaning the heat recovery cells, installing return air filters, replacing the exhaust fan motors and rehabilitating the controls. The supply fan motors are also less efficient than current standards but the motor heat gain is absorbed by the supply air stream and is highly beneficial. The HRVs will be replaced in 10 years at the end of their service life.

Analysis: This EEM will reduce annual electricity use by 68,600 kWh and energy costs by $6,400. The following table summarizes the life cycle cost analysis. This EEM is not recommended because EEM-7 to replace the HRVs has a higher savings to investment ratio.

Annual Costs			Life Cycle Costs				
Operating	Energy	Total	Investment	Operating	Energy	Total	SIR
$0	($6,430)	($6,430)	$35,500	$65,900	($119,200)	($17,800)	1.5

Note: Negative values, in parenthesis, represent savings.

EEM-11: Upgrade Transformer

Purpose: Energy will be saved if the less-efficient 225 kVA transformer in the maintenance office is replaced with an energy efficient model that comply with NEMA Standard TP 1-2001.

Scope: Replace the 225 kVA transformer in the maintenance shop with a NEMA Standard TP 1-2001compiant model.

Analysis: This EEM will reduce annual electricity use by 19,700 kWh, electric demand by 2.3 kW, and energy costs by $1,570. The following table summarizes the life cycle cost analysis.

Annual Costs			Life Cycle Costs				
Operating	Energy	Total	Investment	Operating	Energy	Total	SIR
$0	($1,570)	($1,570)	$29,386	$0	($29,150)	$236	1.0

Note: Negative values, in parenthesis, represent savings.

EEM-12: Install Air Source Heat Pump

Purpose: Energy will be saved if the ventilation air is heated with an air-to-water heat pump instead of with an electric heating coil.

Scope: Install two 25 MBH air source heat pumps and hydronic piping connected to the HRVs in the attic. The heat pumps will operate when outside temperature is below 65°F to heat the ventilation air.

Analysis: This EEM will reduce annual electricity use and costs by 48,000 kWh and $4,500, respectively. The following table summarizes the life cycle cost analysis.

Annual Costs			Life Cycle Costs				
Operating	**Energy**	**Total**	**Investment**	**Operating**	**Energy**	**Total**	**SIR**
$960	($4,530)	($3,570)	$111,900	$16,300	($84,000)	$44,200	0.6

Note: Negative values, in parenthesis, represent savings.

EEM-13: Elevator Machinery Room Heat Recovery

Purpose: The elevator machinery generates significant heat. This heat can be recovered and used to heat the entrance lobby.

Scope: Install a cabinet fan and ductwork to circuit air from the elevator machinery room to the lobby. A thermostat will operate the fan whenever the elevator machinery room temperature is above the setpoint of 70°F.

Analysis: This EEM will reduce annual electricity use by 12,300 kWh and energy costs by $1,090. The energy and life cycle cost analysis is summarized in the following table.

Annual Costs			Life Cycle Costs				
Operating	**Energy**	**Total**	**Investment**	**Operating**	**Energy**	**Total**	**SIR**
$30	($150)	($120)	$6,500	$500	($2,700)	$4,300	0.3

Note: Negative values, in parenthesis, represent savings.

Section 4

Methodology

Information for the energy audit was gathered through on-site observations, review of construction documents, and interviews with operation and maintenance personnel. The EEMs are evaluated using energy and life cycle cost analyses and are priority ranked for implementation.

ENERGY EFFICIENCY MEASURES

Energy efficiency measures are identified by evaluating the building energy systems and comparing them to systems in modern, high performance buildings. The process for identifying the EEMs acknowledges the realities of an existing building that was constructed when energy costs were much lower. Many of the opportunities used in modern high performance buildings—highly insulated envelopes, variable capacity mechanical systems, heat pumps, daylighting, lighting controls, etc.—simply cannot be economically incorporated into an existing building.

The EEMs represent practical measures to improve the energy efficiency of the buildings, taking into account the realities of limited budgets. If a future major renovation project occurs, additional EEMs common to high performance buildings should be incorporated.

LIFE CYCLE COST ANALYSIS

The EEMs are evaluated using life cycle cost analysis which determines if an energy efficiency investment will provide a savings over a 25-year life. The analysis incorporates construction, replacement, maintenance, repair, and energy costs to determine the total cost over the life of the EEM. Future maintenance and energy cash flows are discounted to present worth using escalation factors for general inflation, energy inflation, and the value of money. The methodology is based on the National Institute of Standards and Technology (NIST) Handbook 135 – Life Cycle Cost Analysis.

Life cycle cost analysis is preferred to simple payback for facilities that have long—often perpetual—service lives. Simple payback, which compares construction cost and present energy cost, is reasonable for short time periods of 2-4 years, but yields below optimal results over longer periods because it does not properly account for the time value of money or inflationary effects on operating budgets. Accounting for energy inflation and the time value of money properly sums the true cost of facility ownership and seeks to minimize the life cycle cost.

Construction Costs

The cost estimates are derived based on a preliminary understanding of the scope of each EEM as gathered during the walk-through audit. The construction costs for in-house labor are $60 per hour for work typically performed by maintenance staff and $110 per hour for contract labor.

The cost estimate assumes the work will be performed as part of a larger renovation or energy efficiency upgrade project. When implementing EEMs, the cost estimate should be revisited once the scope and preferred method of performing the work has been determined. It is possible some EEMs will not provide a life cycle savings when the scope is finalized.

Maintenance Costs

Maintenance costs are based on in-house or contract labor using historical maintenance efforts and industry standards. Maintenance costs over the 25-year life of each EEM are included in the life cycle cost calculation spreadsheets and represent the level of effort to maintain the systems.

Energy Analysis

The energy performance of an EEM is evaluated within the operating parameters of the building. A comprehensive energy audit would rely on a computer model of the building to integrate building energy systems and evaluate the energy savings of each EEM. This investment grade audit does not utilize a computer model, so energy savings are calculated with factors that account for the dynamic operation of the building. Energy savings and costs are estimated for the 25-year life of the EEM using appropriate factors for energy inflation.

Prioritization

Each EEM is prioritized based on the life cycle savings to investment ratio (SIR) using the following formula:

Prioritization Factor = Life Cycle Savings / Capital Costs

This methodology puts significant weight on the capital cost of an EEM, making lower cost EEMs more favorable. This approach meshes well with budgeting realities that favor quick implementation of low-cost measures while high cost items work through the budget process.

ECONOMIC FACTORS

The following economic factors are significant to the findings.

- Nominal Interest Rate: This is the nominal rate of return on an investment without regard to inflation. The analysis uses a rate of 5%.
- Inflation Rate: This is the average inflationary change in prices over time. The analysis uses an inflation rate of 2.5%.
- Economic Period: The analysis is based on a 25-year economic period with construction beginning in 2010.

Electricity

Electricity is supplied by Alaska Electric Light & Power Company (AEL&P). The house meter is billed for electricity use under AEL&P's Rate 24, Large Commercial. This rate charges for both electrical consumption (kWh) and peak electric demand (kW). Electrical consumption is the amount of energy consumed and electric demand is the rate of consumption. AEL&P determines the electric demand by averaging demand over a continuously sliding fifteen minute window. The highest fifteen minute average during the billing period determines the peak demand. The following table lists the electric charges.

AEL&P Large Commercial Rate with Demand

Charge [1]	On-peak (Nov-May)	Off-peak (June-Oct)
Energy Charge per kWh	6.11¢	5.73¢
Demand Charge per kW	$14.30	$9.11
Service Charge per month	$99.24	$99.24

Electric Inflation

Over recent history, electricity inflation has been less than 1% per year, lagging general inflation. An exception is a 24% rate hike in 2011 that was primarily due to construction of additional hydroelectric generation at Lake Dorothy. The Lake Dorothy project provides the community a surplus of power which should bring electric inflation back to the historic rate of 1% per year.

However, load growth from electric heat conversions is likely to increase generating and distribution costs. Increasing fuel oil costs make it inevitable that electric load growth will continue. When the hydroelectric surplus is depleted, diesel supplementation and/or additional hydroelectric generation will be needed to supply the load. The combination of these two factors contributes to an assumed electricity inflation rate of 2.5%.

Appendix A

Energy and Life Cycle Cost Analysis

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Energy and Life Cycle Cost Analysis

January 4, 2015

Fireweed Place

Basis

Economic

Study Period (years)	25	Nominal Discount Rate	5%	General Inflation	2%

Energy

Electricity	$/kWh	$/kW	Inflation	$/kWh (2015)	$/kW (2015)
w/ Demand Charges	$0.061	$12.24	2.5%	$0.063	$12.55
w/o Demand Charges	$0.091	-	3%	$0.094	-

EEM-3: Reduce HW Heater Capacity

Energy Analysis

kW, ex	kW, new	kW savings
-18	12	-6

Life Cycle Cost Analysis	Year	Qty	Unit	Base Cost	Year 0 Cost
Construction Costs					
Disconnect heating element	0	1	LS	$500	$500
Energy Costs					
Electric Demand	1 - 25	-72	kW	$12.55	($16,760)
Net Present Worth					($16,300)

EEM-4: Air Seal Shafts

Energy Analysis

Infiltration	CFM	ΔT	MBH	kWh
	-700	29	-21.9	-56,288

Life Cycle Cost Analysis	Year	Qty	Unit	Base Cost	Year 0 Cost
Construction Costs					
Air seal shafts	0	1	LS	$5,000	$5,000
Estimating contingency	0			15%	$750
Overhead & profit	0			30%	$1,725
Design fees	0			10%	$748
Project management	0			8%	$658
Energy Costs					
Electric Energy	1 - 25	-56,288	kWh	$0.063	($65,297)
Net Present Worth					($56,400)

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Energy and Life Cycle Cost Analysis

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EEM-5: Insulate HW Heaters and Piping

Energy Analysis

Tank Heat Loss

Tanks	Size, gal	T, amb	R.ex	R,new	Area, sqft	Factor	kWh
4	50	70	10	20	26.2	50%	-336
1	119	41	10	20	44.0	100%	-446
							-782

Pipe Insulation

Service	Size	Length	Bare BTUH	Insul BTUH	Factor	kWh
DHW	0.50	50	21	4	50%	-1,091

Life Cycle Cost Analysis	Year	Qty	Unit	Base Cost	Year 0 Cost
Construction Costs					
HW tank blankets	0	5	ea	$100	$500
Pipe Insulation 1/2"	0	50	lnft	$5	$250
Energy Costs					
Electric Energy (Effective Cost)	1 - 25	-1,873	kWh	$0.094	($3,257)
Net Present Worth					($2,500)

EEM-6: Combine Electric Meters

Life Cycle Cost Analysis	Year	Qty	Unit	Base Cost	Year 0 Cost
Construction Costs					
New feeders from Panel MH to Kitchen Service	0	30	lnft	$50	$1,500
Service disconnect and MDP access	0	1	LS	$500	$500
Energy Costs					
Service Charge	1 - 25	-12	mo	$18.80	($4,186)
Net Present Worth					($2,200)

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Energy and Life Cycle Cost Analysis

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EEM-7: Replace Heat Recovery Ventilators

Energy Analysis

Fan	Case	CFM	ΔP	η, fan	BHP	η, motor	kW	Hours	kWh
HRV-1	Existing	-8,800	2.75	50%	-7.6	85.5%	-7	8,760	-58,202
	Optimized	4,000	2.75	50%	3.5	86.5%	3	8,760	26,150
HRV-2	Existing	-8,800	2.75	50%	-7.6	85.5%	-7	8,760	-58,202
	Optimized	4,000	2.75	50%	3.5	86.5%	3	8,760	26,150
									-64,105

Heat Recovery		SA CFM	Tosa	Tsa	η, hrv	MBH	Hours	kWh
HRV-1	Existing	-3,500	41	62	50%	-40	8,760	-101,900
	Optimized	2,000	41	62	55%	20	8,760	52,406
HRV-2	Existing	-3,500	41	62	50%	-40	8,760	-101,900
	Optimized	2,000	41	62	55%	20	8,760	52,406
								-98,989

Life Cycle Cost Analysis	Year	Qty	Unit	Base Cost	Year 0 Cost
Construction Costs					
Attic access: Cut, patch, paint	0	1	LS	$5,000	$5,000
Remove HRV and connecting ductwork, electrical service	0	2	LS	$2,500	$5,000
Install 2,000 cfm HRV	0	4,000	cfm	$12	$48,000
Connect ductwork and electrical	0	2	LS	$7,000	$14,000
Test. Adjust, and balance	0	1	LS	$20,000	$20,000
Estimating contingency	0			15%	$13,800
Overhead & profit	0			30%	$31,740
Design fees	0			10%	$13,754
Project management	0			8%	$12,104
Energy Costs					
Electric Energy (Effective Cost)	1 - 25	-163,094	kWh	$0.094	($283,624)
Net Present Worth					($120,200)

EEM-8: Upgrade Exterior Lighting

Energy Analysis

		Existing			Replacement			
Type	# Fixtures	Lamp	Lamp, watts	Fixture Watts	Lamp	Lamp, watts	Fixture Watts	Savings, kWh
Surface	5	T12	32	64	LED	-	40	-526
								-526

Lamp Replacement

Type	# Fixtures	Lamp	# Lamps	Life, hrs	Lamps//yr	$ / lamp	$ / Replace
Surface	5	T12	-2	12,000	-3.65	$5	$20
Surface	5	LED	1	60,000	0.37	$125	$20

Life Cycle Cost Analysis	Year	Qty	Unit	Base Cost	Year 0 Cost
Construction Costs					
Replace fluorescent fixtures with LED	0	5	LS	$115	$575
Estimating contingency	0			15%	$86
Overhead & profit	0			30%	$198
Design fees	0			10%	$86
Project management	0			8%	$76
Annual Costs					
Existing lamp replacement, T12	1 - 25	-3.65	lamps	$30.00	($1,864)
LED board replacement, 40 watts	1 - 25	0.37	LED board	$145.00	$901
Energy Costs					
Electric Energy	1 - 25	-526	kWh	$0.063	($610)
Net Present Worth					($600)

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Energy and Life Cycle Cost Analysis

January 4, 2015

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EEM-9: Increase Attic Insulation

Energy Analysis

Component	Area	R,exist	R,new	ΔT	MBH	kWh
Roof	13,528	32	62	30	-6.1	-53,757

Life Cycle Cost Analysis	Year	Qty	Unit	Base Cost	Year 0 Cost
Construction Costs					
Blow-in attic insulation	0	13,528	sqft	$2.50	$33,820
Baffles at walkways	0	1	LS	$2,000	$2,000
Estimating contingency	0			15%	$5,373
Overhead & profit	0			30%	$12,358
Project management	0			8%	$4,284
Energy Costs					
Electric Energy	1 - 25	-53,757	kWh	$0.063	($62,362)
Net Present Worth					($4,500)

EEM-10: Rehabilitate Heat Recovery Ventilators

Energy Analysis

Fan	Case	CFM	ΔP	η, fan	BHP	η, motor	kW	Hours	kWh
EF-1	Existing	-4,400	2.75	50%	-3.8	85.5%	-3	8,760	-29,101
	Optimized	4,400	2.75	50%	3.8	89.5%	3	8,760	27,800
EF-2	Existing	-4,400	2.75	50%	-3.8	87.5%	-3	8,760	-28,436
	Optimized	4,400	2.75	50%	3.8	89.5%	3	8,760	27,800
									-1,936

Heat Recovery		SA CFM	Tosa	Tsa	η, hrv	MBH	Hours	kWh
HRV-1	Existing	-4,400	41	62	45%	-55	8,760	-140,914
	Optimized	4,400	41	62	58%	42	8,760	107,607
HRV-2	Existing	-4,400	41	62	45%	-55	8,760	-140,914
	Optimized	4,400	41	62	58%	42	8,760	107,607
								-66,614

Life Cycle Cost Analysis	Year	Qty	Unit	Base Cost	Year 0 Cost
Construction Costs					
Rehabilitate control system	0	2	LS	$8,000	$16,000
Clean heat recovery cells	0	2	LS	$750	$1,500
Install RA filters	0	2	LS	$500	$1,000
Replace HRV-1 EF motor	0	1	LS	$1,500	$1,500
Estimating contingency	0			15%	$3,000
Overhead & profit	0			30%	$6,900
Design fees	0			10%	$2,990
Project management	0			8%	$2,631
Annual Costs					
Replace HRVs	10	8,800	cfm	$10	$65,855
Energy Costs					
Electric Energy (Effective Cost)	1 - 25	-68,550	kWh	$0.094	($119,210)
Net Present Worth					($17,800)

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Energy and Life Cycle Cost Analysis

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Fireweed Place

EEM-11: Upgrade Transformer

Energy Analysis

Number	kVA	ηold	ηnew	KW	kWh
1	225	98.0%	99.0%	-2.3	-19,710

Life Cycle Cost Analysis		Year	Qty	Unit	Base Cost	Year 0 Cost
Construction Costs						
Replace transformer, kVA	225	0	1	LS	$18,200	$18,200
Estimating contingency		0			15%	$2,730
Overhead & profit		0			30%	$6,279
Project management		0			8%	$2,177
Energy Costs						
Electric Energy		1 - 25	-19,710	kWh	$0.063	($22,865)
Electric Demand		1 - 25	-27	kW	$12.55	($6,285)
Net Present Worth						$200

EEM-12: Install Air Source Heat Pump

Energy Analysis

		SA CFM	Tosa	Tsa	η, hrv	MBH	COP	Hours	kWh
HRV-1	Existing	-2,000	41	62	62%	-17	100%	8,760	-44,254
	Optimized	2,000	41	62	62%	17	220%	8,760	20,115
HRV-2	Existing	-2,000	41	62	62%	-17	100%	8,760	-44,254
	Optimized	2,000	41	62	62%	17	220%	8,760	20,115
									-48,277

Life Cycle Cost Analysis	Year	Qty	Unit	Base Cost	Year 0 Cost
Construction Costs					
Install ASHP in Parking Garage	0	2	LS	$8,500	$17,000
Electrical to ASHP and Heating Pump	0	3	LS	$4,000	$12,000
ASHP piping header	0	1	ea	$1,000	$1,000
Heating Pump	0	1	ea	$1,500	$1,500
Shaft: Remove exhaust duct, repair shaft walls after demo/new	0	1	ea	$10,000	$10,000
Hydronic piping to attic	0	200	lnft	$85	$17,000
Connect piping to HRV	0	2	LS	$1,000	$2,000
Commissioning	0	1	LS	$2,500	$2,500
Estimating contingency	0			15%	$9,450
Overhead & profit	0			30%	$21,735
Design fees	0			10%	$9,419
Project management	0			8%	$8,288
Annual Costs					
Maintain ASHP	1 - 25	16	hrs	$60.00	$16,346
Energy Costs					
Electric Energy (Effective Cost)	1 - 25	-48,277	kWh	$0.094	($83,955)
Net Present Worth					$44,300

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Energy and Life Cycle Cost Analysis

January 4, 2015

Fireweed Place

EEM-13: Install Elevator Room Heat Recovery

Energy Analysis

Heat Recovery

Elevator HP	Use	kW	Hours	Loss, kWh	Factor	Recovery, kWh
40	10%	3	8,760	-2,614	90%	-2,353

Fan Energy

HP	η, motor	Hours	kW	kWh
0.25	70%	2,920	0.3	778

Life Cycle Cost Analysis	Year	Qty	Unit	Base Cost	Year 0 Cost
Construction Costs					
300 cfm cabinet fan	0	1	LS	$1,000	$1,000
Ductwork	0	1	LS	$1,500	$1,500
Cut, patch, repair	0	1	LS	$750	$750
Electrical with Thermostat	0	1	LS	$750	$750
Estimating contingency	0			5%	$200
Overhead & profit	0			30%	$1,260
Design fees	0			10%	$546
Project management	0			8%	$480
Annual Costs					
Fan maintenance	1 - 25	0.5	hrs	$60.00	$511
Energy Costs					
Electric Energy	1 - 25	-1,575	kWh	$0.094	($2,738)
Net Present Worth					$4,300

Appendix B

Utility Data

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907-789-1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Billing Data

January 4, 2015

Fireweed Place - Master Meter

ELECTRIC RATE

AEL&P Electric Rate 24	On-Peak Nov-May	Off-peak Jun-Oct
Electricity ($ / kWh)	0.0611	0.0573
Demand ($ / kW)	14.30	9.11
Customer Charge ($ / mo)	99.24	99.24
Sales Tax (%)	0.0%	0.0%

ELECTRICAL CONSUMPTION AND DEMAND

Month	2011		2012		2013		2014		Average
	kWh	kW	kWh	kW	kWh	kW	kWh	kW	
Jan	59,200	109	45,120	91	51,280	100	54,000	108	52,400
Feb	53,280	116	50,800	121	52,080	108	42,240	88	49,600
Mar	55,200	119	39,920	98	49,760	102	48,293	116	48,293
Apr	56,720	98	34,560	86	46,080	94	48,960	98	46,580
May	41,840	91	24,160	57	41,120	82	34,960	77	35,520
Jun	23,360	52	26,320	60	34,960	74	27,840	60	28,120
Jul	22,320	50	27,600	54	25,440	57	25,200	58	25,140
Aug	22,880	46	27,200	55	25,360	52	21,600	54	24,260
Sep	22,320	50	27,520	55	26,400	55	21,200	54	24,360
Oct	24,240	59	28,400	58	25,120	58	22,240	58	25,000
Nov	26,720	74	32,720	77	34,080	73	28,173	75	93,520
Dec	47,360	106	43,760	96	50,000	105	44,040	102	141,120
Total	455,440		408,080		461,680		418,747		435,987
Average	37,953	81	34,007	76	38,473	80	34,896	79	36,332
Load Factor	64.2%		61.5%		65.9%		60.5%		79

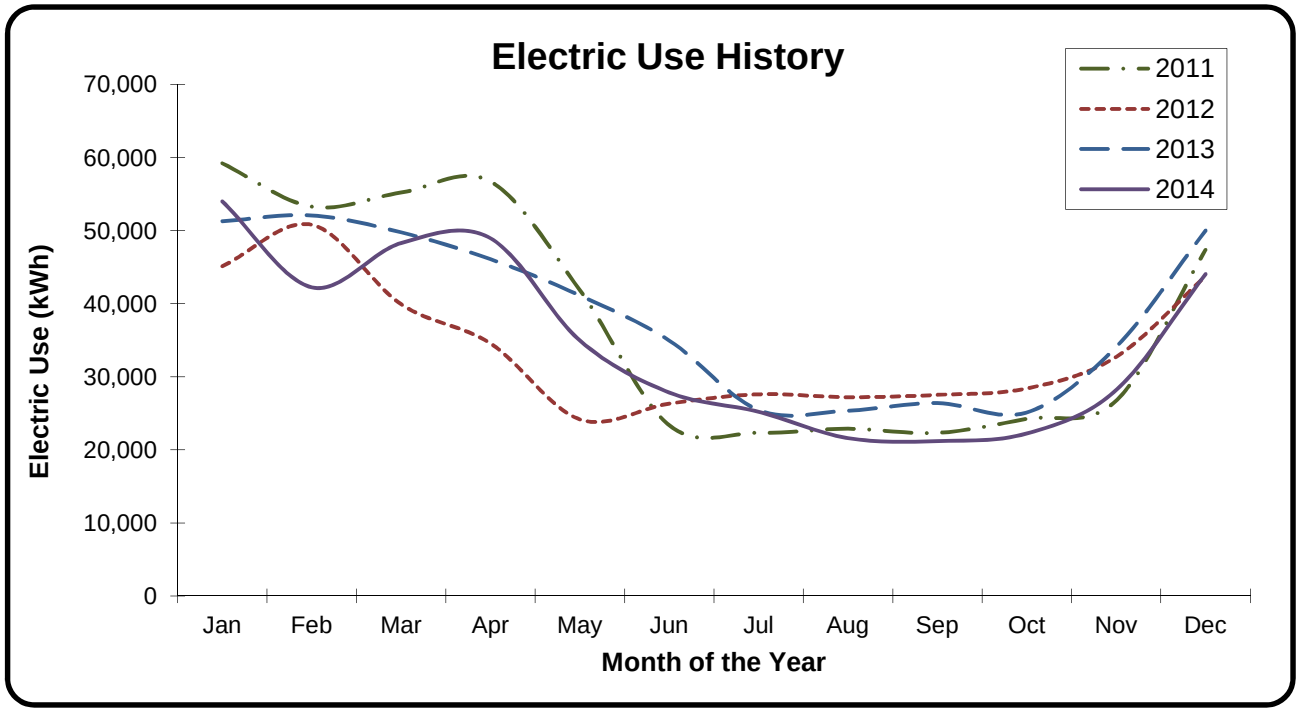
ELECTRIC BILLING DETAILS

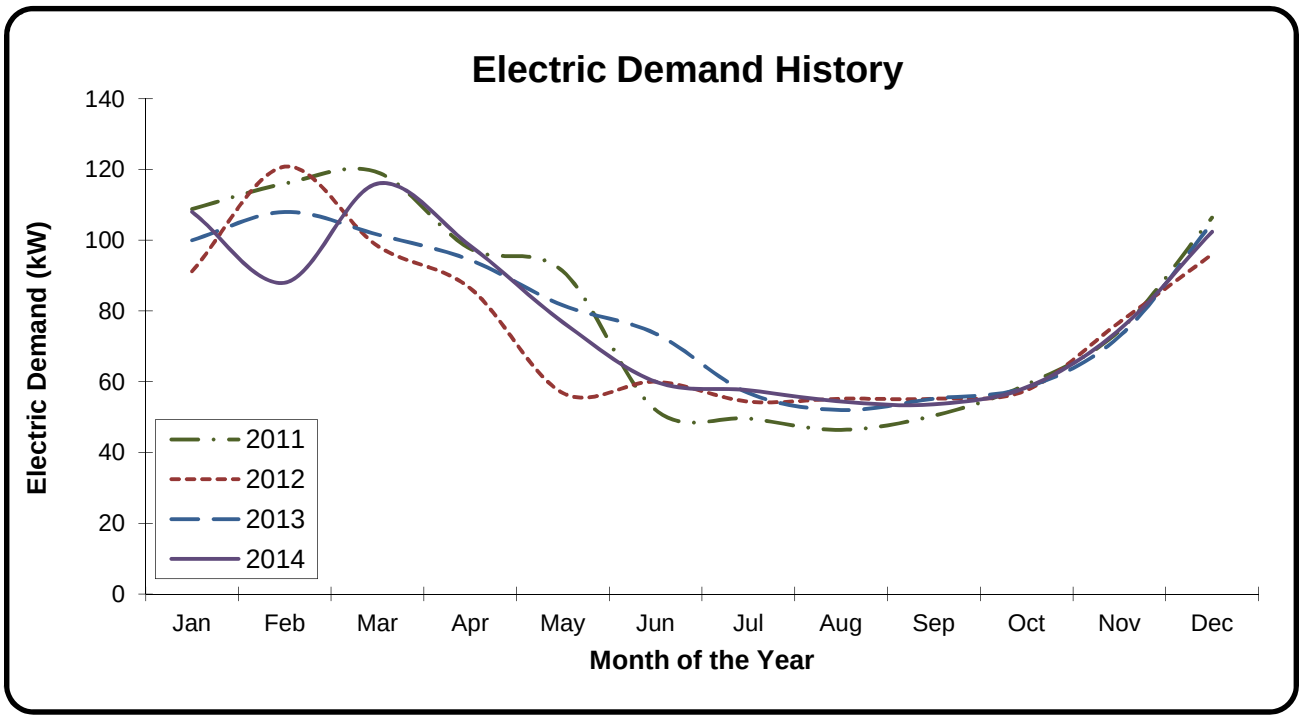
Electrical costs are based on the current electric rates.

Month	2013				2014				% Change
	Energy	Demand	Cust & Tax	Total	Energy	Demand	Cust & Tax	Total	
Jan	3,133	1,430	99	4,662	3,299	1,544	99	4,943	6.0%
Feb	3,182	1,544	99	4,826	2,581	1,258	99	3,939	-18.4%
Mar	3,040	1,453	99	4,592	2,951	1,659	99	4,709	2.5%
Apr	2,815	1,350	99	4,265	2,991	1,407	99	4,498	5.5%
May	2,512	1,167	99	3,779	2,136	1,098	99	3,334	-11.8%
Jun	2,136	670	99	2,906	1,701	547	99	2,347	-19.2%
Jul	1,554	517	99	2,171	1,540	525	99	2,164	-0.3%
Aug	1,549	474	99	2,122	1,320	496	99	1,915	-9.8%
Sep	1,613	503	99	2,215	1,295	488	99	1,883	-15.0%
Oct	1,535	532	99	2,166	1,359	532	99	1,990	-8.1%
Nov	2,082	1,041	99	3,223	1,721	680	99	2,501	-22.4%
Dec	3,055	1,499	99	4,653	2,691	933	99	3,723	-20.0%
Total	$ 28,209	$ 12,180	$ 1,191	$ 41,580	$ 25,585	$ 11,167	$ 1,191	$ 37,944	-8.7%
Average	$ 2,351	$ 1,015	$ 99	$ 3,465	$ 2,132	$ 931	$ 99	$ 3,162	-8.7%
Cost ($/kWh)				$0.090	67%	29%	3%	$0.091	0.6%

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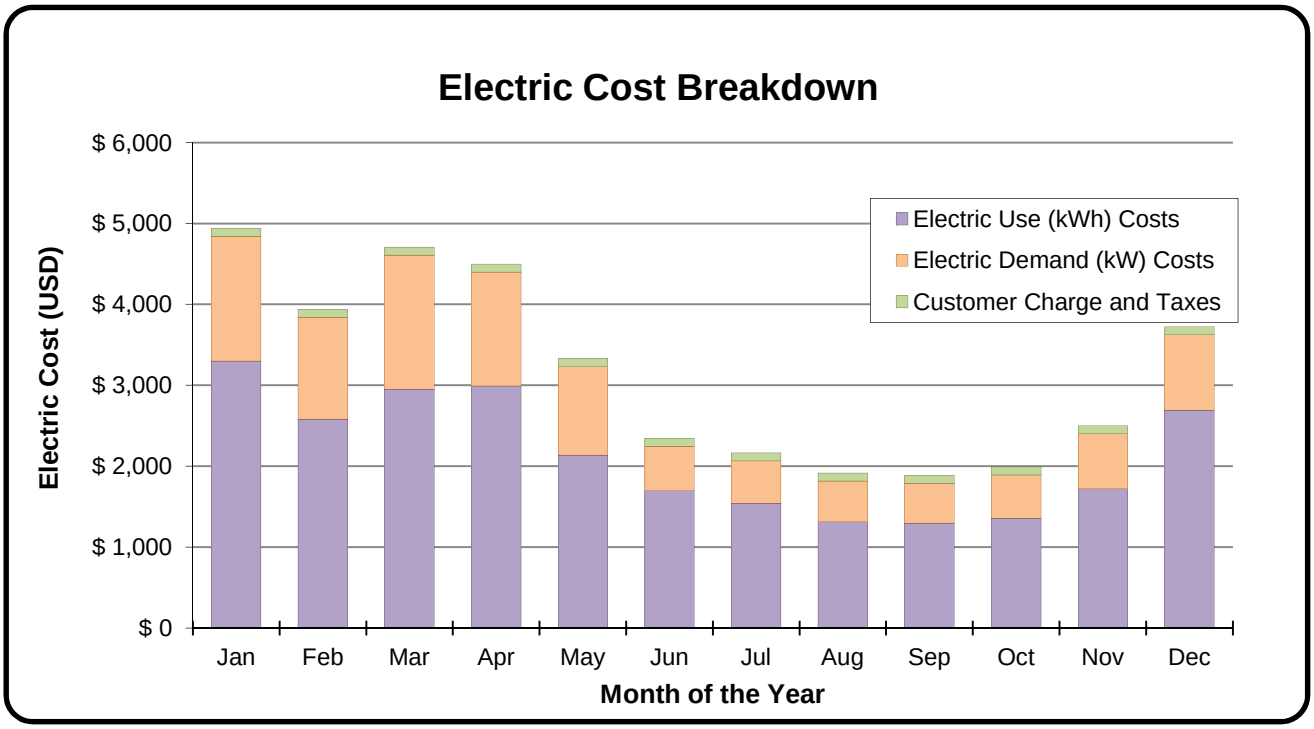
Fireweed Place - Master Meter

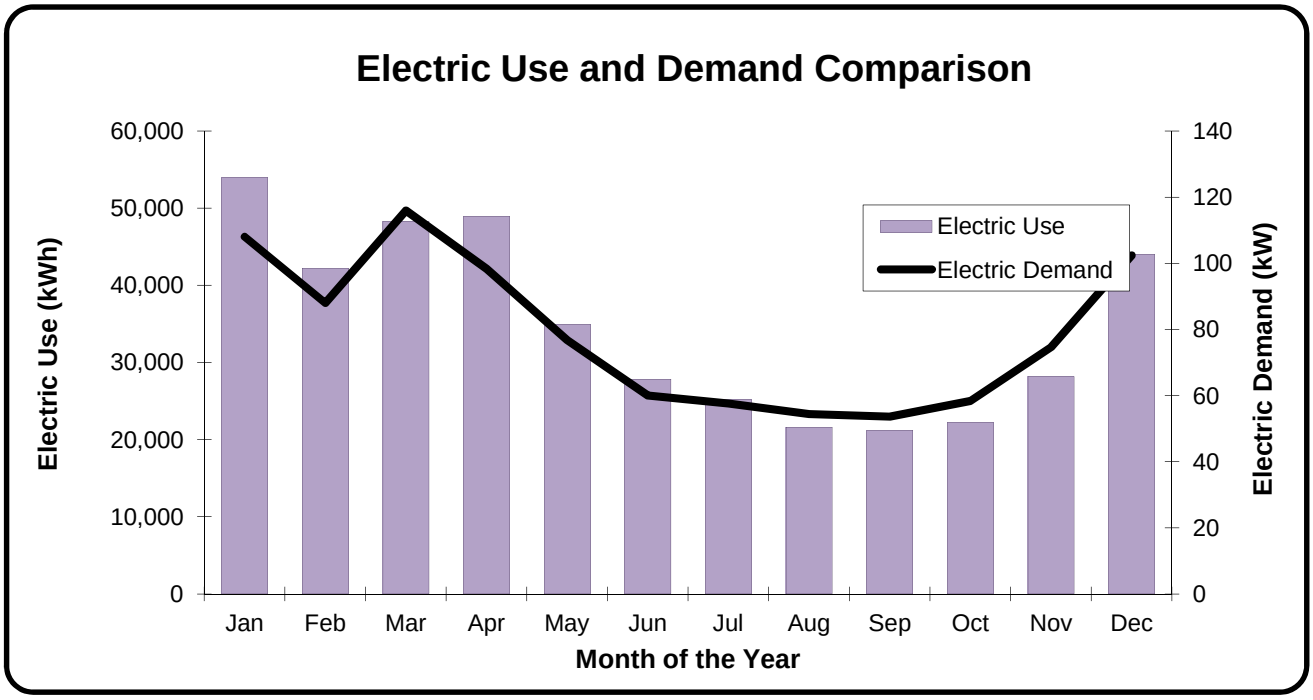




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25200 Amalga Harbor Road Tel/Fax: 907-789-1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Fireweed Place - Master Meter 2014





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Annual Energy Data

Fireweed Place

Energy	Cost	$/MMBtu	Area, sqft	
Electricity	$0.090	$26.40	14,020	Includes just the common areas

Annual Energy Consumption and Cost

Source	Consumption	Cost	Energy, MMBtu	EUI
Electricity	435,987 kWh	$39,270	1,490	106

Attachment 5

Juneau – Marquam George Fireweed Place Enclosure Report

THRHA Regional Housing Authority
Juneau, Alaska

Marquam George LLC
8752 N. Douglas Rd
Juneau, Alaska 99801

4 November 2014

Tlingit Haida Regional Housing Authority
P.O. Box 32237
Juneau, AK 99803

Project: Assess Fireweed Place building enclosure to identify potential measures to reduce energy costs of the building.

Building Description: Fireweed Place is a five story senior housing apartment complex in downtown Juneau. 65 Residential units are located on the 2-5th floors with 16 two bedroom units, 24 one bedroom units, and 25 studio apartments. The building is calculated at 55,907 square feet of heated floor area, 51.705 square feet of above grade surface area, and a conditioned building volume of 499,567 cubic feet.

At ground level there are two entries, from the front and Willoughby Avenue, and from the rear parking garage. At ground level is the building managers office, along with storage and maintenance spaces, additionally there is elevator access and an open stairway to the second floor. There are six exterior doors on the second floor, three provide access to exterior patios with three serving as emergency exits. The second story combines multi-use building spaces with 13 apartments. Multi-use spaces include a commercial kitchen that is no longer in use, a dining area used for occasional activities and in the front is a sitting parlor. The third, fourth, and fifth floors have no exterior doors, the space primarily apartments with minimal group sitting and service spaces.

Building Airtightness Testing: With coordinated support from THRHA field and Fireweed Place personnel on October 22, 2014 blower door testing was undertaken on the Fireweed Place apartment building. It was known from pretest planning that due to the building configuration and tenant needs numerous constraints would be in place resulting in test procedures that would not comply with normal test protocols for air leakage testing.

Two major test obstacles imposed by the building and tenant needs was not being able to temporally prop open tenant doors during testing and that the location of the blower doors was limited to the first and second floors. The above two constraints leave many of the building pressure test measurements taken with low confidence.

Other significant challenges included lack of control with the coming and going through the exterior doors, windows remaining closed, and operating kitchen exhaust fans during testing. Cooperatively in working with the occupants needs the testing method attempted was to restrict building entry access to every other half hour on the hour. Unfortunately this was not always successful but the best measurements the building offered were recorded.

Weather conditions during testing; light rain, wind 5-10 mph, temperatures in the mid 40's.

Four Minneapolis Model 3 Blower Door systems were computer connected for depressurization testing. Three fans were installed in the 2nd floor patio doors and one fan placed in the 1st floor door to the parking garage. Interior common area doors and all fire doors in the two rear stairways were propped open. An exterior walk around the building identified any open windows which were then closed. The two HRVs were powered off and the intake and exhaust openings were temporarily sealed along with sealing the elevator shaft and commercial kitchen exhaust vents.

Fireweed Place Airtightness Test Results: Building data was collected using Energy Conservatory Teclog software, this program provides control for data acquisition and multi-fan testing.

Airflow at -50 Pascals	18539 CFM50 (+/- 4.6%) 2.23 ACH50 0.3316 CFM50/ft² heated floor area 0.3585 CFM50/ft² above grade surface area
Leakage Areas:	EqLA (10 Pa) 1948.3 sq. in. ELA (4 Pa) 1048.0 sq. in.
Building Leakage Curve:	Exponent (n) 0.639 Correlation coefficient 0.99363
Infiltration Estimates:	Estimated average annual infiltration rate; 1598.6 CFM 0.19 ACH 19.5 CFM per person (using bedrooms)

Estimated Design Infiltration Rate:	Winter: 1921.4 CFM	0.23 ACH
	Summer: 928.5 CFM	0.11 ACH

Pressure measurements were taken from the first floor to each of the upper stories as the four blower doors depressurized the building to -50 Pascals. The pressure differential measured between the first floor to the fifth floor was 3.2 Pascals. With this measurement it appeared that all floors were experiencing similar building envelope pressure differentials. At the time of testing the neutral pressure plane of the building was identified between the third and fourth floor.

During the pretest planning there was expressed interest for improving thermal comfort to users and occupants of the second floor. Other than the ground floor this is the only floor with a concrete slab rather than a wood-framed floor platform. The building appears constructed according to the construction drawings. Good building design would align the thermal boundary with the air barrier of the structure. In Fireweed Place, the drawings would indicate that the T-bar ceiling is the air barrier as the fiberglass insulation in laid directly on top of the T-bar ceiling, nearly two feet below the concrete slab creating a conditioned dead air space.

Temperature measurements were taken on the top and bottom concrete slab surfaces, the T-bar ceiling tile, and ambient air conditions in the parking garage.

Ambient indoors:	68°
Top of concrete slab:	65°
Underside of concrete slab:	60°
T-bar ceiling tile:	58°
Ambient outdoors:	47°

With the building depressurized to -50 Pascals a zonal pressure test was established between the building and the space above the T-bar ceiling. The space above the T-bar ceiling measured completely outside the building pressure boundary and the T-bar ceiling is likely not an effective air barrier protecting the batt insulation from wind washing effects.

In blower door testing the building from the 2nd floor to the 3rd, 4th, and 5th floors other than concealed chase ways and the elevator shaft the only open access is through the two rear stairways. The length of tubing necessary to reach from the 2nd to the 5th floor was well over 200 feet, with good practice keeping pressure hoses to less than 100 feet. To test building zonal pressures, pressure hoses were run from the main corridor of the 5th floor to connected interior and exterior zones. Pressure measurements attempted from the 5th floor included; to the interior of the elevator shaft, into the attic space, from the attic to the outdoors and from the 5th floor to the outdoors. Based on the measurements recorded, the location of the blower doors, and the building configuration, the 5th floor responded more as an outdoor space rather than one connected to the lower floors. The measurements taken provided little confidence on how the connected spaces interact within the building and to the outdoors.

Initially the testing plan was to place three blower doors in a single door on the 1st floor. Reconsidering the building size and configuration the testing plan was modified to

install four blower doors spread out as far part as possible attempting to reach the -50 Pa depressurization target. Because of the measurements recorded from the 5th floor to attached interior and exterior zones, a better approach testing Fireweed Place would be placing two blower doors on floors 3, 4, & 5 using windows in lieu of exterior doors. Using windows would pose unique challenges also, as the blower door fans are wider than the open width of the casement windows. If blower doors were installed on upper floors many measurements would be of limited value without the ability to temporarily open all interior doors.

Though depressurization testing did not induce a uniform pressure across all sides of the building, Fireweed Place still moves a tremendous amount of air as easily felt when inside the attic with the attic access hatch open.

Building Enclosure Recommendations: The plumbing, mechanical venting, and electrical service penetrations into the attic show no attempt at air sealing efforts other than placing fiberglass insulation over the openings. The mechanical drawing attic plan indicates 14 plumbing chases into the attic. These plumbing chases vary in size, one was measured at 44 inches by 12 inches. Each HRV has a chase below the supply and return trunk ducts, these chase openings are 6 feet by 2 feet with nearly 4 square feet available of air sealing opportunities per chase. Every attic mechanical penetration was not found or inspected, but estimating the surface area of the holes from the ducting, plumbing, and electrical penetrations inspected into the attic would be dozens of square feet of air leakage paths.

From the extent of service penetrations into the attic, the existing insulation shows significant areas that is compressed or not properly fit into the ceiling joists. After air sealing has been undertaken, existing insulation refitted, blowing 6-12 inches of cellulose should be part of the attic improvement plan. Currently, the majority of the attic is insulated with R-38 batt.

I do not understand how the vent from the elevator shaft interacts within the shaft and the building. The elevator shaft duct is approximately 3 ft. by 2 ft. and when inspected from the roof appears to be without a damper. In pressure testing the building for the neutral pressure plane the elevator doors were used at each floor. When tested, under normal building operations the elevator shaft did not stay entirely negative or positive to the main body of the building but as noted previously negative on the three lower floors and positive on the upper two floors relative to the interior common space.

The elevator shaft has a gypsum board ceiling about four feet above the 5th floor ceiling plane. The installed ceiling insulation of the elevator shaft is R-19.

Speaking with Jim Rehfeldt about the elevator duct he shared code info that an opening is required for smoke, but it could have a damper if it would automatically open upon a fire alarm. Increasing elevator ceiling insulation and damper control of the duct is recommended.

From visual inspections above the T-bar ceiling and inside the attic the building appears to be insulated according to the architectural drawings. If this is the case I believe the 2nd floor concrete slab has less than 20% perimeter edge insulation in place. Construction photographs from 1994 and 2014 show no slab edge insulation and the architectural drawings show slab edge insulation only at the cornices. From the comments received from building users there is noticeable decreased thermal comfort from the concrete slab of the 2nd floor compared to
the wood framed floors of the upper stories. With the assumption of cornice-only perimeter slab edge insulation, and that the under slab insulation is not in contact with the slab but the T-bar ceiling. I believe presently the most meaningful insulation in place for thermal comfort of the slab is the carpet and pad. Recommendation is to align the thermal boundary with the underside of the concrete slab with closed cell foam.

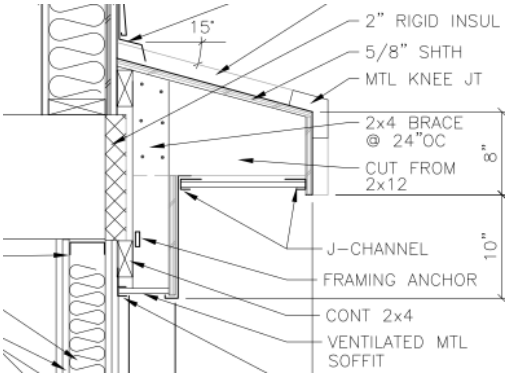
As the commercial kitchen is no longer being used building personnel have already sealed the make up air intake with plastic sheathing and placed closed cell rigid foam board at the capture hood. The ducting for this kitchen exhaust is 12' diameter and it is recommended that sealing at the roof vent should also be included in air sealing activities.

I overheard a conversation in the building regarding installing an arctic entry vestibule at the Willoughby Avenue entrance. This is a great idea. The building uses supplemental electric space heat at the front door to help with tenant comfort as they wait to leave the building. When measuring baseline pressures on the 1st floor under normal building conditions when the front door is opened the building pressure changes dramatically much as a wind gust effect acts on a structure.

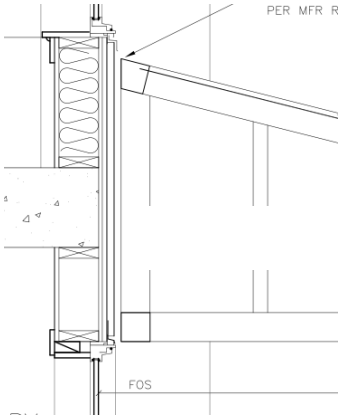
Fireweed Place is a beautiful building. It is obvious that both the building staff and the tenants take pride in the building upkeep and appearance. All of the interior surfaces appear in excellent condition. The building does not have suspect odors, this building has good indoor air quality and that was a common theme voiced often by building staff and tenants. As often confronted with ventilation systems I also heard from a couple of tenants that at times they block off some of their unit diffusers complaining of comfort issues with too cool air temperature delivery.

Building management have replaced most of the exterior lighting with LEDs. The interior lighting is largely 34 watt T-12 fluorescent. Corridors are lit 24 hours a day, each floors corridor have around 100 T-12 bulbs, with about 50% of the bulbs already removed for energy savings. Additionally, above each tenant door is a 26 watt CFL recessed light fixture.

When preparing the building for air leakage testing there were a few windows tenants requested assistance to close and latch their windows. These windows were very difficult to latch as they have likely been damaged by wind or experienced hardware corrosion over time. By far for reducing energy costs through the building enclosure of Fireweed Place is air sealing the conditioned space from the attic and addressing the concrete slab.



Slab edge insulation @ cornice



No slab edge insulation shown @ canopy



2nd floor under slab insulation



Exposed slab edge @ 2014 repairs



Exposed slab edge @ 1994 construction



Exterior wall open during 2014 repairs,



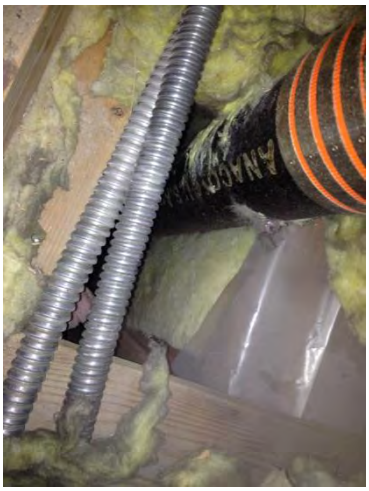
Plumbing chase attic west wing
opening approximately 44” x 12”



Fiberglass insulation covering opposite chase



Duct chase below each HRV from attic
overall opening approximately 6’ x 2’



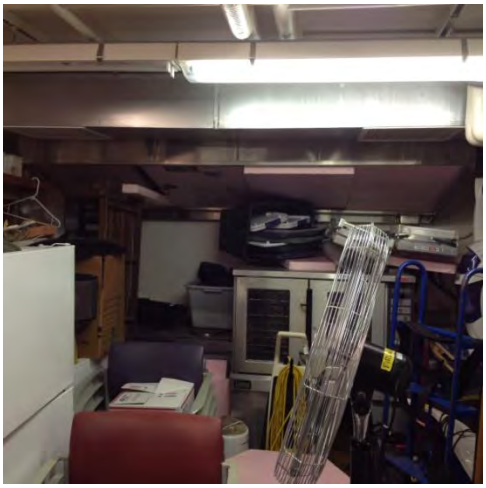
Plumbing penetration into attic



Attic penetrations & insulation



Elevator shaft duct



Exhaust hood sealed in kitchen



Elevator exhaust @left, kitchen exhaust @ right



Electrical penetration



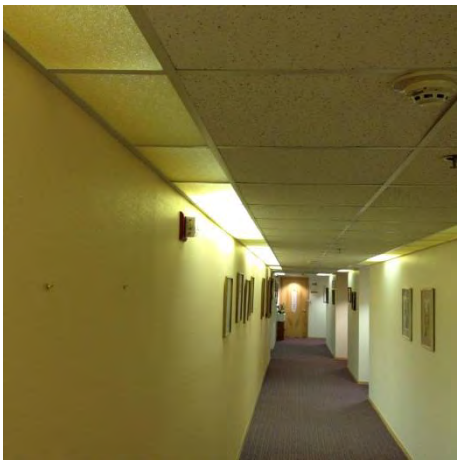
Cornice @ concrete slab



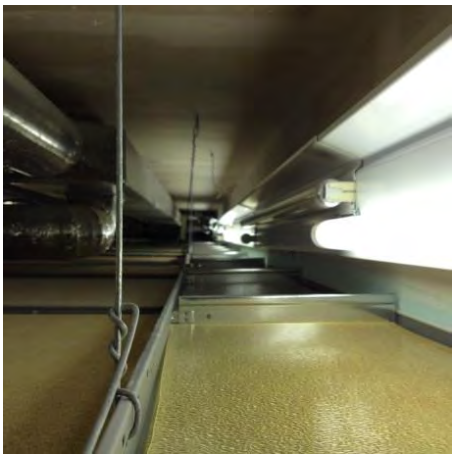
T-bar ceiling zonal diagnostic



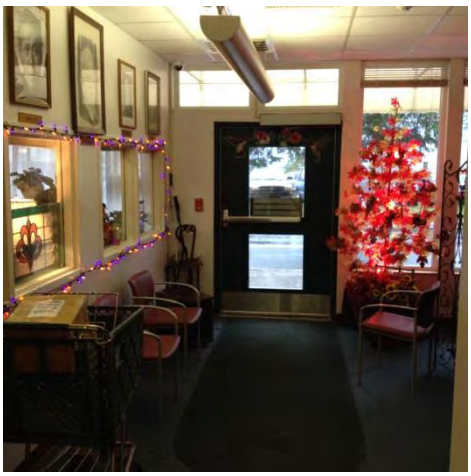
Ductwork entering mechanical chase from residential unit closet



Corridor lighting

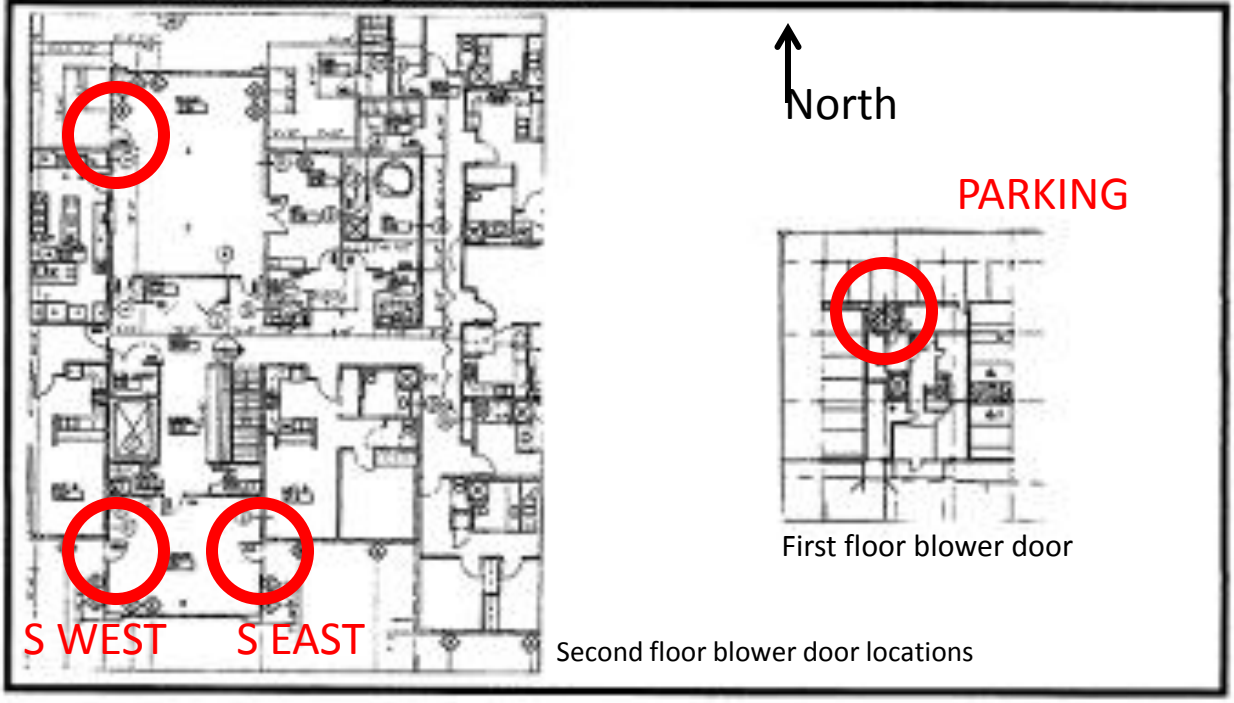


Corridor lighting above drop ceiling



1st floor Willoughby Ave entry

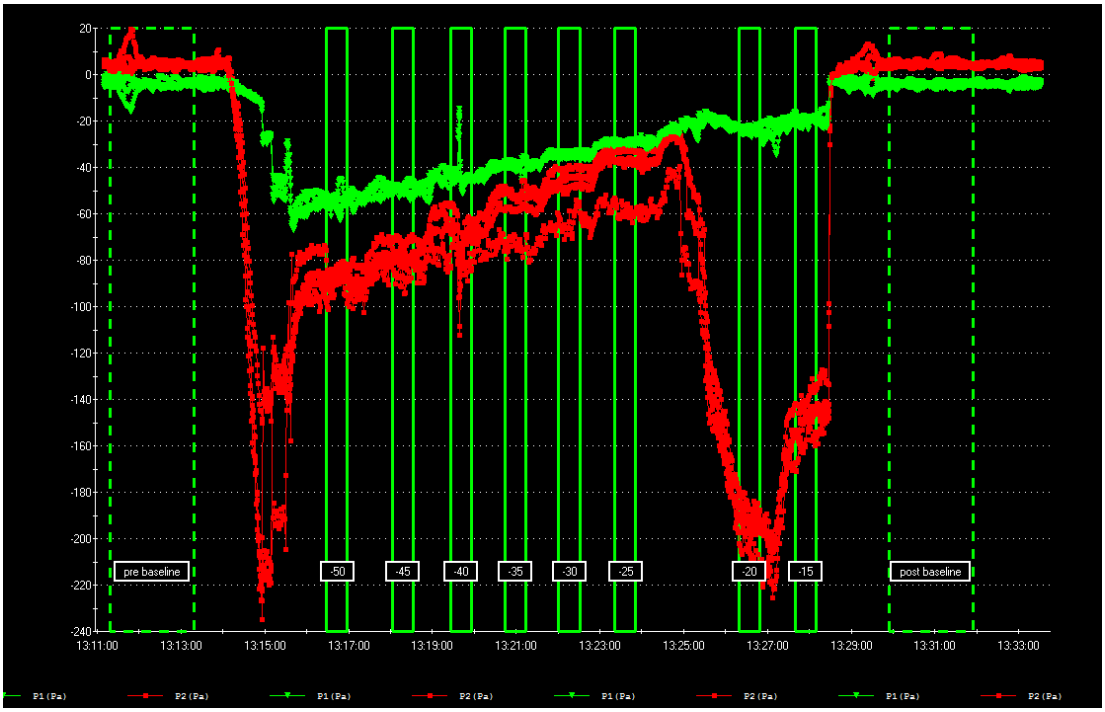
TECLOG3 Device Configuration Worksheet



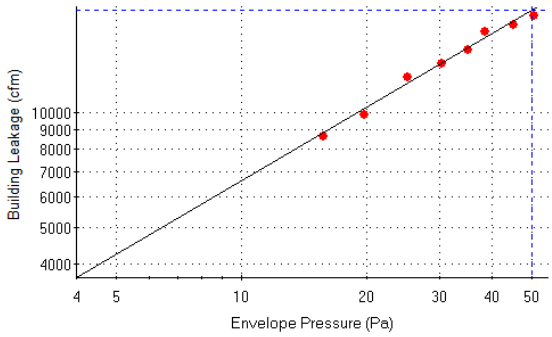
First floor blower door

Second floor blower door locations

Serial 25718	Label S EAST	Serial 30566	Label NORTH
Chan A Pressure	Chan B Flow	Chan A Pressure	Chan B Flow
Serial 38005	Label S WEST	Serial 11665	Label PARKING
Chan A Pressure	Chan B Flow	Chan A Pressure	Chan B Flow
Serial 38340	Label INTERNAL	Serial	Label
Chan A Pressure	Chan B Pressure	Chan A	Chan B
Serial	Label	Serial	Label
Chan A	Chan B	Chan A	Chan B
Serial	Label	Serial	Label
Chan A	Chan B	Chan A	Chan B
Serial	Label	Serial	Label
Chan A	Chan B	Chan A	Chan B
Serial	Label	Serial	Label
Chan A	Chan B	Chan A	Chan B
Serial	Label	Serial	Label
Chan A	Chan B	Chan A	Chan B



Airtightness Results (95% confidence, non-weighted fit)



Reporting Pressure (Pa) 50

Test to View test 1

Test 1: Depressurization

Airflow at 50 Pascals
18539 cfm +/- 4.6 %
Range: 17695 to 19382
---- CFM @50/sq ft

Leakage Areas
EqLA (10 Pa) = 1948.3 in2 +/- 8.5 %
ELA (4 Pa) = 1048.2 in2 +/- 14.9 %

Building Leakage Curve
Coef. (C) = 1523.5 cfm/Pa^n +/- 24.8 %
Exponent (n) = .639 +/- 0.072
Correlation Coef. (r) = .99363
Corr Coef Squared (r^2) = .98730

Label	Base?	start	end	nobs	Avg Pressu	Total Flow
pre baseline	True	10	125	116	-4.47	0
-50	False	312	341	30	-54.82	18000.9
-45	False	405	432	28	-49.4	17066.5
-40	False	484	513	30	-42.74	16326.4
-35	False	560	588	29	-39.37	14712.6
-30	False	637	665	29	-34.56	13523.1
-25	False	713	742	30	-29.48	12418.8
-20	False	885	914	30	-24.1	9927.8
-15	False	965	994	30	-20.13	8718.8
post baselir	True	1097	1213	117	-4.42	0

View / Edit Test Details

Export to Tectite Express...

OK

Copy Data Table to Clipboard

Teclog 3 envelope pressure-fan flows Fireweed Place 10.22.14



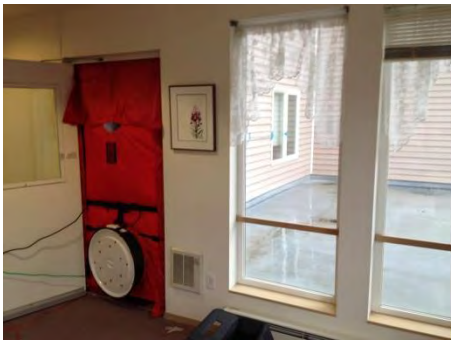
Multi-fan automated blower door testing



2nd floor north blower door; gauge 30566



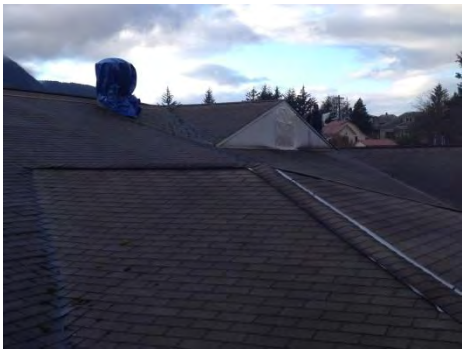
2nd floor SW blower door; gauge 38005



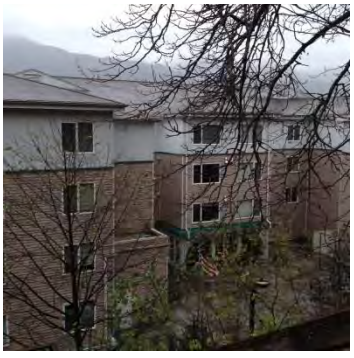
2nd floor SE blower door; gauge 25718



1st floor parking blower door; gauge 11665



Temporary sealing of vent hoods & intakes



Fireweed Place; rear & north



Fireweed Place; front & south

Fireweed Place 10.22.14 Zonal Diagnostics w/ Building Depressurized -50 Pa			
Zone	WRT	Zone	Pascals
5th floor		Elevator Shaft	-38.8
5th floor		Outdoors	0.7
Attic		Outdoors	-38.8
Attic		Elevator Shaft	-4.3
1st floor common		Parking T-bar Ceiling	-52.6
Parking T-bar Ceiling		Outdoors	2.1
5th Floor Hall		Under Tenant Door	-17.6
4th Floor Hall		Under Tenant Door	-14.1
3nd Floor Hall		Under Tenant Door	1.5
2nd Floor Hall		Under Tenant Door	-15
1st floor		2nd floor	1.3
1st floor		3rd floor	2.1
1st floor		4th floor	2.4
1st floor		5th floor	3.2

Building in Normal Operating Conditions	
Unit 416; 1 bedroom was used for lighting inventory and fan flows	
Kitchen exhaust fan over range	71 cfm
HRV kitchen exhaust	32 cfm
HRV bath exhaust	25 cfm
HRV living room supply	19 cfm
HRV bedroom supply	16 cfm
Kitchen; 8 - 4ft T-12 34W	
Dining; 5- 53W incandescent	
Living; 2-26W cfl	
Hall; 2-26W cfl	
Bath; 6-3ft T-12 30W	
Bath; 1- incandescent heat lamp, no wattage listed	
Bedroom; 4-53W incandescent	

Attachment 6

Juneau – Glacier Village and Kanat'a Dey'I Assessment Notes

Marquam George LLC

Memo

To: Craig Moore

CC:

From: Marquam George

Date: 03.15.15

Re: Glacier Village & Kanat'a Dey'I Assessment Notes

All units inspected should be considering future lighting upgrades. In both Kanat'a Dey'I and Glacier Village 2/3 units it was commonly found that kitchen and laundry rooms have T-12 fixtures, CFL bulbs in bedrooms and hallway, with the bathroom vanity light bar having incandescent bulbs. Exterior lighting was an equal blend of CFL and incandescent bulbs. A few LEDs were noted, but very uncommon.

No attic hatches inspected meet the Alaska weatherization standards for access dams. All units need attic hatch upgrades. Attic hatches on Kanat'a were normally insulated with R-38 batt in the hatch build-up, while GV 2 & 3 would have 3 inches of XPS attached to the gypsum board lid. All attic hatches would benefit from improved gasket materials for air sealing.

All Kanat'a Dey'I crawlspaces are insulated in the floor joists with foundation vents in the top of the stem wall, no foundation vents were found closed at time of inspection.

4060-4064 Granite
4060- is missing about 40 sq. ft. of ceiling insulation; it has been displaced over time and is roughly 10 feet away from its intended location. Insulation is missing from inside the attic hatch.
Boiler was operating at time of inspection, plus the occupants were running multiple electric resistance heaters, thermostat on wall was 78°F
4064- smoke detectors chirping.

At inspection both units' inline fan whole house ventilation systems were operating. If these fans are not used, both units ceiling bath fans were not meeting minimum intermittent flows.

4443-4445 Kanat'a
4443- HRV is being used, ventilator needs cleaning both inside the machine and at exterior hoods. No CO alarm was present; attic ventilation is every truss bay with sagging cardboard baffles.
4445- HRV is not being used in this unit. Kitchen cabinets are heading towards repairs or replacement.

Bathroom ceiling fans in both units flows were too low for a flow box measurement, ceiling fan needs cleaning at a minimum.

This lot would benefit from improved site drainage, extending gutter downspout piping further away from the building.

4043-4039 Granite
Both of these units have vaulted ceilings above the living/kitchen areas of the first floor. These vaulted attics could not be inspected as they each had exterior doors for attic hatches with locks not able to be opened by the GV 2 master key.

4039-The supply-side whole house fan needs to be replaced; it transmits a horrendous whine when operating. The exhaust-side fan should be inspected as it has a harmonic vibration when turned on. Without the whole house ventilation system operating, both bath fans need to be replaced as they measured below minimum intermittent flows required.

4043-Whole-house ventilation is operational and being used.

4530-4532 Kanat'a
Both units HRVs were plugged in and running at inspection. Each of the interiors of the HRVs are in desperate need of cleaning.

4530- Indirect storage tank is placed directly on a concrete slab. Attic hatch in mechanical room needs repair, and the hatch insulated. Bathroom fans should be replaced.

4532- Bathroom fans should be replaced

4481-4483 Kanat'a
Neither unit is operating the HRV. The supply intake hoods on both units are completely blocked. The interior relative humidity was very high in 4483 at inspection, upon leaving I turned the HRV on and showed an occupant how the controls operated the unit. 4483 has a very new Fantech SHR 1504 model.

4481-Unit has a steel access panel covering the attic hatch. Typically in these installations a plywood box has been air sealed and insulated above the steel access panel, this plywood hatch has been removed and repairs are necessary on this hatch. Because of the missing hatch parts, significant air leakage is occurring at the steel access panel. A couple fiberglass batts have fallen from the crawlspace joists and need to be reinstalled.

4483-Rear yard is very wet, improve drainage and extend downspouts. If HRV does not continue to be operated, bathroom exhaust fans should be replaced.

8414-8416-8418-8420 Valley Blvd.
All units had their whole-house inline fan ventilation fans operating. This is also a very wet lot, and the only crawlspace of the 14 inspected units that showed signs of water intrusion into the crawlspaces.

In addition to the improvement options selected within the AkWarm files, further recommendations include:

The area of the GV multi-family subdivision exhibits a very high water table with the multi-family units I believe installing a ground source heat pump would be a good investment.

- All units assessed would benefit from air sealing as long as the ventilation systems are functioning and being used.
- THRHA should assume a diligent maintenance schedule with rental properties; cleaning and maintaining ventilation systems, opening and closing of foundation passive vents, cleaning gutters and reconnecting downspouts to rapidly remove surface water away from the building.
- Increasing attic insulation to a minimum R-49
- Foundations that are passively vented to the outdoors should consider installing a minimum of R-10 rigid insulation below the floor joists.

Attachment 7

Kake – Senior Center AEE Energy Assessment

THRHA Regional Housing Authority
Juneau, Alaska

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
jim@alaskaenergy.us

Technical Memorandum

June 19, 2015

to: **Craig Moore, THRHA**

subject: **Energy Assessment**

project: **Kake Senior Center**

INTRODUCTION

This memorandum presents the findings of an energy assessment of the Kake Senior Center owned by Tlingit-Haida Regional Housing Authority. The site was visited by Jim Rehfeldt, P.E. of Alaska Energy Engineering LLC on June 2, 2015. The purpose of the trip was:

- To review and observe the operation of the heating and ventilation systems and controls.
- Develop an energy monitoring plan for the building systems

Construction was occurring during the site visit. The contractor is completing the 1st phase which added an addition to the building. The addition included a dining room and commercial kitchen, lobby, offices, conference room, and heating and ventilation systems.

HEATING SYSTEM

Background

The building will be heated by a wood pellet boiler and two propane boilers. The current plan is to operate the wood pellet boiler during the heating season and the propane boilers during warmer weather. A primary/secondary pumping system distributes heating water to the building.

Assessment

Boilers

The total capacity of the heating plant is 901 MBH, which comes to 55 Btuh/sqft. Taking into account a reasonable level of redundancy, this capacity is very high for this well-insulated residential apartment building.

It is likely that the domestic hot water load contributed to the heating system sizing. Actual hot water consumption data for senior housing has shown much lower use than what is predicted by design standards.

A heating plant consisting of one wood boiler and one propane boiler would be less complex while providing sufficient redundancy.

The wood boiler has a 3-way valve for boiler protection that automatically protects the boiler from low temperature return water. The valve has no visual indication of its position which makes it harder for operators to verify that it is operating properly.

The propane boiler is a highly efficient condensing model. The opportunity to utilize the boiler in condensing mode is greatly diminished because the heating system is designed for higher temperatures outside of the condensing range. Condensing operation may be possible during the summer months if the heating units can deliver sufficient heat at condensing temperatures. However, the boilers will need to operate at higher temperatures to heat hot water.

Boiler (Primary) Pumps

The wood boiler has a constant speed pump and the propane boilers have variable speed pumps that can modulate with the heating load.

Building (Secondary) Pumps

The building pumps consist of two variable speed pumps operating in a lead/standby configuration.

Controls

The boilers and boiler pumps will be controlled by the respective integral boiler controllers.

- The wood boiler has a controller that provides a setpoint for the heating storage tank, a maximum temperature setpoint that shuts off the fuel flow and a minimum setpoint that restarts the firing process. The control sequences do not specify these values but they have been set at 180°F heating tank setpoint, 190°F boiler off setpoint, and 150°F boiler on setpoint.
- The propane boilers have a master controller on boiler B-1 and a slave controller on boiler B-2. The master panel operates the boilers in a lead/lag configuration to maintain a heating setpoint that is reset with outside temperature. The settings for these boilers are not in the control sequences.

The challenge for the boiler controls is to allow the wood boiler to operate as the lead boiler without turning on the propane boilers unless the wood boiler is not supplying sufficient heat. The settings will need to be developed in recognition that the wood boiler responds slowly to load variations while propane boilers can respond quickly. Another challenge is to maximize condensing operation while increasing the temperature to generate hot water whenever there is hot water flow. The controls will also need to accommodate easily making the propane boilers the lead during the summer months.

Recommendation

The following are recommended:

- The designers should provide complete control sequences for the heating plant that covers lead/lag/standby operation of the three boilers during the heating and summer seasons. The sequence should address summer operation when the wood boiler is anticipated to be turned off. The sequences should maximum propane boiler condensing operation during summer months while also meeting the domestic hot water load. The boiler pump controls for the propane boilers should be set to vary the pump flow rate with boiler modulation.
- Commission the system during both the summer and heating seasons to assure stable operation under varying loads.

DOMESTIC HOT WATER SYSTEM

Background

Building Hot Water System: Consists of a heat exchanger with a corresponding hot water pump and two indirect hot water heaters. Whenever hot water flow occurs, the hot water pump produces flow through the heat exchanger to preheat the water before it flows to the hot water heaters where it is further heated—if needed—and stored. A thermostatic mixing valve provides anti-scaled protection.

Kitchen and Laundry Room Hot Water Systems: Each area has a separate instantaneous propane water heater with thermostatic mixing valve.

Assessment

The building hot water heating equipment has a total capacity of 1,000 MBH, which exceeds the heating plant size and is much higher than actual hot water loads, especially when the storage volume is considered. An opportunity exists to reduce the hot water load and simplify the system by bypassing the heat exchanger. This will also increase condensing operation of the propane boilers in the summer since domestic hot water heating will then only occur when the tank temperature drops, rather than every time someone uses hot water.

Recommendation

The following are recommended:

- Evaluate the need for the hot water heat exchanger
- Commission the system

HEAT RECOVERY VENTILATORS HRV-1 AND HRV-2

Background

Heat recovery ventilators HRV-1 and HRV-2 supply the addition and the residential wing, respectively. The units contain a supply fan, an exhaust fan, two heat recovery cells, and a control damper. While the exhaust air transfers and stores heat in one of the cells, the other cell transfers stored heat to the supply air. The system switches the air flow regularly to transfer heat to/from the cells.

The units have integral controllers to operate the fans and air flow damper. Each unit also has a separate supply air heating coil. A control valve modulates water flow through the heating coil to maintain the supply air temperature reset.

The system was not operating during the site visit.

Assessment

<u>Issues</u>

Each HRV has two ducts to supply and exhaust air from/to the outdoors. A duct from each unit is connected together at the louver. For the units to operate properly, each connected duct pair must supply and exhaust air concurrently. This is likely to not be possible since they will switch supply and exhaust flows to maintain optimal efficiency.

The HRV-1 system is sized for 1,000 cfm. This rate will over-ventilate except during the few hours each week the dining room is fully occupied. The controller may be able to adjust the fan speed to reduce the air flow to a more appropriate level for normal building operations.

The control sequences do not specify all of the operating parameters for optimal operation of the units.

Recommendation

The following are recommended:

- The designers must determine if the two units can synchronize their operation so each duct pair is supplying or exhausting concurrently.
- The designers should develop optimal control sequences for the units, including appropriate air flow for normal building operation.
- A bypass timer should be installed in the Dining Room so the HRV-1 system can be manually turned on for events outside of normal operating hours.
- Commission the system

REFRIGERATION HEAT RECOVERY

Background

The dry storage room has a reach-in refrigerator and freezer.

Issue

The refrigeration units will reject considerable heat to the room, which has little heat loss and no ventilation.

Recommendation

Install an air recirculation system to transfer the heat to the Dining Room. The system will consist of a ceiling exhaust fan, duct, and grille to transfer the warm air from the dry storage room to the dining room. Undercut the storage room door to allow air to flow back into the room.

The dining room has large windows and will have considerable heat loss most of the year. During periods when the Dining Room is too warm, the windows can be opened to remove the heat. A lifecycle cost analysis determined the following:

Energy Efficiency Measure	Annual Costs			Life Cycle Costs				
	Operating	Energy	Total	Investment	Operating	Energy	Total	SIR
EEM-1: Refrigeration Room Heat Recovery	$0	($305)	($305)	$1,950	$0	($8,697)	($6,747)	4.5

Note: Negative values, in parenthesis, represent savings.

PROPOSED MONITORING PLAN

Background

A building monitoring system can provide operational, energy tracking and research benefits to the Owner. The benefits of each are as follows:

- Operational: The monitoring system provides essential information for determining that the systems are operating properly including pump status, fan status, heating system temperature, ventilation system temperature, domestic hot water temperature, and room temperature.
- Energy: The monitoring system can provide data on energy use such as building electric demand, heating system energy use, domestic hot water energy use, and energy use of special areas or systems such as kitchens and lighting.

- Research: The monitoring system provides information useful to future design efforts such as peak heating load, heating system efficiency, domestic hot water load, indoor air quality, and occupancy.

Proposed Building Monitoring System

A proposed building monitoring system and cost estimate is provided in the table at the end of this report. The table lists the data points that would be monitored. All of the monitoring equipment would be located in the mechanical rooms or electrical panels. The costs are identified for a basic operations monitoring system, options for a more comprehensive monitoring system, and for adding a capability to monitor energy data.

The monitoring system will collect data and transmit it via the building's internet provider or over the cellular internet. Using the cellular internet will require a $10 monthly charge, which can be avoided by using the building's internet service.

The monitoring system uses wireless sensors that transmit the data to the manufacturer's cloud storage service. The cost for this service is $3-$5 per year per sensor.

The collected data can be stored on THRHA's own Monitoring Website, which will cost $500 to set up and the monthly fees to the web host provider of $9 per month. If only 3-4 building are monitored by THRHA, there is also an option to share a website setup by the data monitoring consultant for no charge.

Proposed Kake Senior Center Monitoring System

Item	Intent	Operational		Energy Use
		Basic	Option	
Fixed Cost				
Travel, per diem, equipment	Fixed costs	$4,163		
Unit Costs				
General				
Outdoor temperature	Outdoor temperature reference	$30		
Building electric load, kW	Total energy use			$1,897
Heating System				
Propane boiler B-1 enable	Boiler status		$364	
Propane boiler B-2 enable	Boiler status		$364	
Pellet boiler B-3 enable	Boiler status		$364	
Propane boiler B-1 supply temp	Boiler status	$364		
Propane boiler B-2 supply temp	Boiler status	$364		
Pellet boiler B-3 supply temp	Boiler status	$364		
Boiler pump BP-1 enable	Boiler pump status	$364		
Boiler pump HP-2 enable	Boiler pump status	$364		
Boiler pump HP-3 enable	Boiler pump status	$364		
Building pump HWP-1 enable	Building pump status	$364		
Building pump HWP-1 enable	Building pump status	$364		
Building heating supply temperature	Confirms heat to building	$282		
Building heating return temperature	Confirms heat to building		$282	
Building heating supply flow	Determine building heating load			$1,345
Building Domestic Hot Water System				
Heat exchanger outlet temperature	Heat exchanger status	$282		
Hot water heater DHW-1 temp	Hot water heater status	$282		
Hot water heater DHW-4 temp	Hot water heater status	$282		
Building hot water supply temp	Confirms hot water availability	$282		
Building hot water flow rate	Measures hot water demand			$1,114
Cold water makeup temperature	Determine hot water load			$282
Kitchen Domestic Hot Water System				
Hot water heater DWH-2 supply temp	Confirms hot water availability			$282
Kitchen hot water flow rate	Measures hot water demand			$837
Laundry Domestic Hot Water System				
Hot water heater DWH-2 supply temp	Confirms hot water availability			$282
Kitchen hot water flow rate	Measures hot water demand			$837
Heat Recovery Unit HRU-1				
Supply fan enable	Fan status		$364	
Exhaust fan enable	Fan status		$364	
Supply air temperature	Confirm supply air temperature		$302	
Heat Recovery Unit HRU-2				
Supply fan enable	Fan status		$364	
Exhaust fan enable	Fan status		$364	
Supply air temperature	Confirm supply air temperature		$302	
Makeup Fan MUA-1				
Supply fan enable	Fan status		$364	
Supply air temperature	Confirm supply air temperature		$302	
Totals		$8,515	$4,100	$6,876

COST SUMMARY

The following table summarizes the recommendations and their costs. Cost estimates are appended to this memo.

Recommendations

Item	Cost Estimate
Refrigeration Heat Recovery	$2,000
Install cooling fan	
Monitoring System	
Install a basic monitoring system	$ 8,500
Add enhanced monitoring	$ 4,100
Add energy use data	$ 6,900
Total	$ 19,500

by: 

Jim Rehfeldt, P.E.

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Energy and Life Cycle Cost Analysis

June 19, 2015

Kake Senior Center

Basis

Economic

Study Period (years)	25	Nominal Discount Rate	5%	General Inflation	2%

Energy

		$/ton (2015)	Inflation	$/ton (2016)
Pellets		$400.00	4.0%	$416.00

		$/kWh (2015)	Inflation	$/kWh (2016)
Electricity		$0.650	2.5%	$0.666

EEM-1: Refrigeration Room Heat Recovery

Energy Analysis

Wood Pellets

Watts	Hours	Factor	kBtu	η boiler	tons
-1,093	8,760	70%	-22,873	72%	-2.0

Electricity

Watts	dT	CFM	BHP	kW	Hours	kWh
-1,093	10	345	0.13	0.09	8,760	817

Life Cycle Cost Analysis	Year	Qty	Unit	Base Cost	Year 0 Cost
Construction Costs					
Ceiling exhaust fan, duct, and grille in dining room	0	1	LS	$1,200	$1,200
Undercut door	0	1	LS	$150	$150
Electrical power with thermostat	0	1	ea	$600	$600
Energy Costs					
Electric Energy	1 - 25	817	kWh	$0.666	$10,098
Pellets	1 - 25	-2.0	tons	$416.00	($18,794)
Net Present Worth					($6,747)

Attachment 8

Kake – Lime Solar Feasibility Report

THRHA Regional Housing Authority
Juneau, Alaska

Solar Feasibility Study

Kake Senior Center
Kake, Alaska



Lime Solar

Let's Imagine More Energy

7731 E. Northern Lights Unit 250 Anchorage, AK 99504
P: (907) 272-LIME (5463) F: (907) 27-SOLAR (76527)
E: jesse@limesolar.net Website: www.LimeSolar.net

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7731 E. Northern Lights Unit 250 Anchorage, AK 99504 P: (907) 272-LIME (5463) F: (907) 27-SOLAR (76527)
E: jesse@LimeSolar.net Website: www.LimeSolar.net

Scope of Project

The following report is a feasibility study for three separate options to integrate a solar PV array at the Kake Senior Center. This report includes a cost-benefit analysis for each design option below, it also includes an energy comparison analysis for each option, the relative cost for each option and finally an executive summary with the final engineering recommendations and conclusions of each system.

Option 1: The implementation of a Solar PV system to power a percentage of the common house meter with no battery storage. This system will utilize grid tie inverters, solar arrays, and monitoring equipment. It will only operate when the utility is energized, excess power will not be purchased or credited by the utility company. This system is only acceptable if the utility allows the system to be interconnected.

Option 2: The implementation of a Solar PV system to power a percentage of the common house meter with a battery storage system. This system will use the batteries as a buffer, so that the energy produced from solar will provide power to the load, then any excess energy will also be used to charge the batteries. This system has the benefit that it can provide emergency power during brownouts or blackouts.

Option 3: The implementation of a Solar PV system to provide a percentage of the domestic hot water in combination with an air-to-water heat pump, for non-heating and shoulder-season months. This system allows for an additional heat source as a load, that is offset by the energy from the Solar PV. The added expense of this system is contrasted with the value of having the energy provided from the solar electric to be used for heating purposes.

7731 E. Northern Lights Unit 250 Anchorage, AK 99504 P: (907) 272-LIME (5463) F: (907) 27-SOLAR (76527)
E: jesse@LimeSolar.net Website: www.LimeSolar.net

Option 1: Cost Breakdown

Material Cost of the System:	$46,715.79
Installation and Services Cost of the System:	$15,000.00
Total System Cost:	$61,715.79
Federal Tax Credits: 30%	$18,514.74
Net Cost of the System:	$43,201.05
Average Utility Cost:	$0.57/KWH
Material Warranty:	25 Years
Installation Warranty:	2 Years
Monitoring:	Yes
Materials Replacement Cost: in 25 year Period	$0
Maintenance Cost: in 25 year Period	$0

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E: jesse@LimeSolar.net Website: www.LimeSolar.net

Lime Solar

Let's Imagine More Energy

QUOTATION

7731 E. Northern Lights Blvd Unit 250
Anchorage, Alaska 99504
Phone 907-272-5463 Fax 907-277-6527

QUOTATION #758
DATE: MAY 26, 2015

TO:
Kake Senior Center
Kake, Alaska

SHIP TO:

COMMENTS OR SPECIAL INSTRUCTIONS

SALESPERSON	P.O. NUMBER	REQUISITIONER	SHIPPED VIA	F.O.B. POINT	TERMS
Jesse Moe	Kake Senior Center			On Site Kake	

QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL
39	LG 300 Watt Monocrystaline Panels		PACKAGE
3	SMA Sunny Boy 4000 Tranformerless Grid Tie Inverters		PACKAGE
3	Outdoor Rated NEMA 3R 30 Amp DC Disconnect		PACKAGE
3	Outdoor Rated NEMA 3R 30 Amp AC Disconnect		PACKAGE
1,000	UV Resistant USE 2 PV Rated Cable		PACKAGE
485	Unirac Sunframe Cap strip Screws		PACKAGE
18	Unirac Sunframe Rail Splices		PACKAGE
86	Unirac Sunframe L Brackets		PACKAGE
20	Unirac Sunframe Cap strips 16' each		PACKAGE
20	Unirac Sunframe Rail 16' each		PACKAGE
1	Miscellaneous: Breakers, Disconnects, Junction and Combiner Boxes		PACKAGE
300	AC Conduit and Wiring		PACKAGE
1	SMA America Sunny Webbox Solar Monitoring Equipment		
		TOTAL	$46,715.79
		TOTAL DUE	$46,715.79

This quotation is good for 30 days. Upon order the material must be paid in 50% as a deposit, the remaining balance is collected upon inspection of all the product in order when it has been received on site. If you have any questions concerning this quotation, contact Jesse Moe. 907-272-5463 Thank you for your business

Lime Solar

Let's Imagine More Energy

QUOTATION

3090 Mountain View Drive Suite 190
Anchorage, Alaska 99501
Phone 907-272-5463 Fax 907-277-6527

QUOTE #759
DATE: MAY 26, 2015

TO:
Kake Senior Center
Kake, Alaska

SHIP TO:

COMMENTS OR SPECIAL INSTRUCTIONS

SALESPERSON	P.O. NUMBER	REQUISITIONER	SHIPPED VIA	F.O.B. POINT	TERMS
Jesse Moe	Kake Senior Center				

QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL
1	Mechanical Installation of the Panels on Senior Center		$7,000.00
1	Electrical Installation of the Panels on Senior Center		$6,500.00
1	Electrical Engineering- Stamped One Line for PV		$750.00
1	Permitting and Initialization of System		$750.00
	Includes: The entire installation of Solar Racking, Panels, Inverters, Conduit Runs, DC Disconnects, AC Disconnects and wiring complete from solar panels to the breakers in the House Distribution Panel. Also, Includes interconnection application service with the utility company.		
	Excludes: Any engineering necessary for the fabrication or installation of the structural supports for the solar array. This also does not include the installation or material of the House distribution panel.		
		SUBTOTAL	$15,000.00
		SHIPPING & HANDLING	
		TOTAL DUE	$15,000.00

Make all checks payable to Lime Solar, LLC
Payment is due up receipt
If you have any questions concerning this invoice, contact Jesse Moe, 907-272-5463
Thank you for your business

Financial Payback Analysis



General System

Customer's Name:			Kake Senior Center
Contact Information:	P:	- E:	0
Address:			0
State & Country:		USA	Alaska
Utility:			IPEC
Utility Type:			Co-Op
Your Annual Average Monthly Electricity Bill:			$0.57
Tiered Rates Apply:			No
Time of Use Metering Offered:			No
Net Metering Available:			Yes

Estimated System Sizing

Solar Rating:	Good	3.22 kwH/sqm/day
Solar System Capacity Required:		11.70 KW/Hour
Side Area Needed:		715 Sq. Feet
Equivalent Annual Production:		10795.82 KWH/Year

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E: jesse@LimeSolar.net Website: www.LimeSolar.net

Financial Payback Analysis

Estimated System Cost

Assumed Installation Gross Cost "Gross Cost" is the cost before any rebates, incentives, tax credits, etc. are applied.	$ 61,715.79

This is only an estimate based upon many assumptions. Installation costs can vary considerably. We can provide you with a more detailed cost estimate, based on your actual installtion cost and energy usage. If you have any questions at all please feel free to contact a Lime Solar Sales Associate.

Financial Incentives

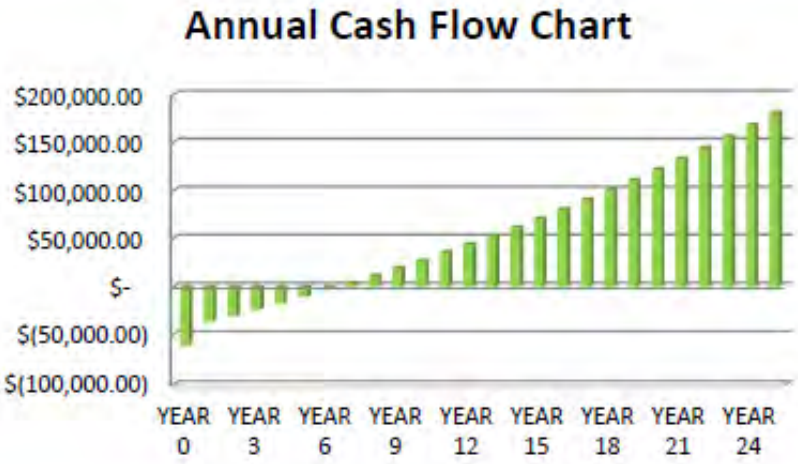
Federal Tax Credit (30% of Gross Cost)	$ 18,514.74
Modified Accelerated Cost Recovery System (MACRS) Depreciation 5 Years	YES
Estimated Net Cost	$ 43,201.05
Cash Amount	$ 43,201.05



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Financial Payback Analysis

Projected Cash Flow



Cash Flow Breakeven is where the chart crosses the $0 point - this is when your investment has paid itself back in cash.

The chart above is a summary of the net cash flow you can expect over time. Net Cash Flow is the total cash after all costs (cut-flows of cash) are reduced by financial incentives, annual utility savings and tax effects (in-flows of cash).

Savings & Benefits

First Year Utility Savings:	$6,153.62
Average Monthly Utility Savings: over 25-year expected life of system	$747.85
Average Annual Utility Savings: over 25-year expected life of system	$8,974.26
25-year Utility Savings:	$224,356.45
Levelized Cost of your Solar Energy:	$0.15 per KWH

7731 E. Northern Lights Unit 250 Anchorage, AK 99504 P: (907) 272-LIME (5463) F: (907) 27-SOLAR (76527)
E: jesse@LimeSolar.net Website: www.LimeSolar.net

Financial Payback Analysis

Savings & Benefits

Return on Investment (ROI):	419%
Profitability Index:	2.94
Greenhouse Gas (CO2) Saved:	235 Tons
Carbon Emission Reduction:	483,951 Auto Miles

Cash Flow By Year

This cash flow table includes tax effects applied to utility savings and loan interest payments (if any). For commercial (business) situations we assume utility savings do not result in loss of some expense write offs against income. "Tax Savings from MACRS depreciation" (below) is the net cash saved on income taxes after the depreciation expense is written off. So the amount that was depreciated would be the cash value shown divided by the income tax.

Year	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Cash Flow	-$61,716	-$37,047	-$30,709	-$24,181	-$17,457	-$10,531
Annual Utility Savings	$6,154	$6,338	$6,528	$6,724	$6,926	$7,134
Utility Rate Inflation	$0.570	$0.587	$0.605	$0.623	$0.642	$0.661

Year	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11
Cash Flow	-$3,397	$3,951	$11,519	$19,314	$27,343	$35,613
Annual Utility Savings	$7,348	$7,568	$7,795	$8,029	$8,270	$8,518
Utility Rate Inflation	$0.681	$0.701	$0.722	$0.744	$0.766	$0.789

Year	YEAR 12	YEAR 13	YEAR 14	YEAR 15	YEAR 16	YEAR 17
Cash Flow	$44,131	$52,905	$61,942	$71,250	$80,837	$90,711
Annual Utility Savings	$8,518	$8,774	$9,037	$9,308	$9,587	$9,875
Utility Rate Inflation	$0.813	$0.837	$0.862	$0.888	$0.915	$0.942

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Financial Payback Analysis

Cash Flow By Year (Continued)

Year	YEAR 18	YEAR 19	YEAR 20	YEAR 21	YEAR 22	YEAR 23
Cash Flow	$ 100,882	$ 111,359	$ 122,149	$ 133,263	$ 144,711	$ 156,502
Annual Utility Savings	$ 10,476	$ 10,790	$ 11,114	$ 11,114	$ 11,448	$ 11,448
Utility Rate Inflation	$0.970	$0.999	$1.029	$1.060	$1.092	$1.125

Year	YEAR 24	YEAR25
Cash Flow	$ 168,646	$ 181,155
Annual Utility Savings	$ 12,509	$ 12,884
Utility Rate Inflation	$1.159	$1.193

First Year Energy Offset Table

	USAGE	SOLAR IRRADIANCE	PRODUCTION	% OFFSET
January	6,160	1.10	328.43	5%
February	6,560	1.55	418.00	6%
March	5,960	2.80	836.01	14%
April	6,040	4.08	1,178.89	20%
May	5,680	5.18	1,546.62	27%
June	5,400	5.25	1,516.95	28%
July	5,520	4.84	1,445.10	26%
August	5,440	4.88	1,457.04	27%
September	5,280	3.45	996.85	19%
October	5,360	1.83	546.39	10%
November	5,560	1.04	300.50	5%
December	5,920	0.75	223.93	4%
Total	68,880	3.06	10,795	

- Usage is measured in KWH/month from Addendum 1
- Solar Irradiance is Measured from PV WATTs from NREL Site for Kake, AK it is measured in kWh / m2 / day

* Production is measured in KWH/month with system losses factored in

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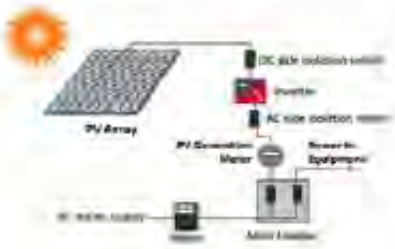
Financial Payback Analysis

Assumptions

Solar resources	Assumed solar availability: As per Solar Radiance chart
Soiling or contamination of the PV panels	Clean, washed frequently: 100% design sunlight transmission
Temperature	25C, calm wind
System configuration (battery or non-battery)	Non-battery
Orientation to the sun	tilted at your latitude, full sun
Shading	None
PV Energy delivered as % of manufacturer's rating	95%
Soiling, wiring & power point tracking losses	9% (91% delivered)
Inverter Efficiency	90%
Total Energy Delivered	95% x 91% x 90% = 78%

Cost to Going Solar





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E: jesse@LimeSolar.net Website: www.LimeSolar.net

Option 1: Summary

Option 1: This option is by far the most inexpensive and least maintenance. It also serves as the best option to offer the quickest rate of return. There is very minimal to no maintenance on a system like this, it has the added benefit of being expandable, so more solar could be added in the future.

Payback: less than 7 years
Energy being offset annually: 10,795 KWH/year
Minimum Energy Offset: 4% in December (223.93 KWH)
Maximum Energy Offset: 28% in June (1,516 KWH)
Maintenance: No
Warranty: Yes 25 Year Performance Warranty
Replacement Parts: No, not in 25 year period

There are a few downsides to this system. The most significant is the fact that IPEC will not purchase or credit power from the solar array. This means that if the solar array is producing more power than it is consuming, there is a chance that it will not all be utilized. This is most likely to occur in the most ideal weather conditions during the peak solar hours of the day, in the months of April-August. The other negative to this system is that it requires that the utility be present to provide energy. Based on UL 1741 the inverters must automatically disconnect from the grid when the grid becomes de-energized.

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Option 2: Cost Breakdown

Material Cost of the System:	$53,861.23
Installation and Services Cost of the System:	$21,200.00
Total System Cost:	$75,061.23
Federal Tax Credits: 30%	$22,518.37
Net Cost of the System:	$52,542.86
Average Utility Cost:	$0.57/KWH
Material Warranty:	25 Years
Installation Warranty:	2 Years
Monitoring:	Yes
Materials Replacement Cost: in 25 year Period	$36, 890 (Batteries at Year 10 and 20)
Maintenance Cost: in 25 year Period	$5,200 (Battery Replacement and Recycle)

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E: jesse@LimeSolar.net Website: www.LimeSolar.net

Lime Solar

Let's Imagine More Energy

QUOTATION

7731 E. Northern Lights Blvd Unit 250
Anchorage, Alaska 99504
Phone 907-272-5463 Fax 907-277-6527

QUOTATION #758
DATE: MAY 26, 2015

TO:
Kake Senior Center
Kake, Alaska

SHIP TO:

COMMENTS OR SPECIAL INSTRUCTIONS

SALESPERSON	P.O. NUMBER	REQUISITIONER	SHIPPED VIA	F.O.B. POINT	TERMS
Jesse Moe	Kake Senior Center			On Site Kake	

QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL
39	LG 300 Watt Monocrystaline Panels		PACKAGE
3	Schneider Electric XW 6848 Inverter/Charger Kit		PACKAGE
32	US Battery AGM 6Volt 400AH		PACKAGE
3	Schneider Electric XW MPPT 80 600 V Charge Controller		PACKAGE
3	Outdoor Rated NEMA 3R 30 Amp DC Disconnect		PACKAGE
3	Outdoor Rated NEMA 3R 30 Amp AC Disconnect		PACKAGE
1,000	UV Resistant USE 2 PV Rated Cable		PACKAGE
485	Unirac Sunframe Cap strip Screws		PACKAGE
18	Unirac Sunframe Rail Splices		PACKAGE
86	Unirac Sunframe L Brackets		PACKAGE
20	Unirac Sunframe Cap strips 16' each		PACKAGE
20	Unirac Sunframe Rail 16' each		PACKAGE
1	Miscellaneous: Breakers, Disconnects, Junction and Combiner Boxes		PACKAGE
300	AC Conduit and Wiring		PACKAGE
1	Schneider Electric XW Combox		PACKAGE
		TOTAL	$53,861.23
		TOTAL DUE	$53,861.23

This quotation is good for 30 days. Upon order the material must be paid in 50% as a deposit, the remaining balance is collected upon inspection of all the product in order when it has been received on site. If you have any questions concerning this quotation, contact Jesse Moe 907-272-5463 Thank you for your business

Lime Solar

Let's Imagine More Energy

QUOTATION

3090 Mountain View Drive Suite 190
Anchorage, Alaska 99501
Phone 907-272-5463 Fax 907-277-6527

QUOTE #759
DATE: MAY 26, 2015

TO:
Kake Senior Center
Kake, Alaska

SHIP TO:

COMMENTS OR SPECIAL INSTRUCTIONS

SALESPERSON	P.O. NUMBER	REQUISITIONER	SHIPPED VIA	F.O.B. POINT	TERMS
Jesse Moe	Kake Senior Center				

QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL
1	Mechanical Installation of the Panels on Senior Center		$10,250.00
1	Electrical Installation of the Panels on Senior Center		$9,450.00
1	Electrical Engineering- Stamped One Line for PV		$750.00
1	Permitting and Initialization of System		$750.00
	Includes: The entire installation of Solar Racking, Panels, Inverters, Conduit Runs, DC Disconects, AC Disconnects and wiring complete from solar panels to the breakers in the House Distribution Panel. Also, Includes interconnection application service with the utility company.		
	Excludes: Any engineering necessary for the fabrication or installation of the structural supports for the solar array. This also does not include the installation or material of the House distribution panel.		
		SUBTOTAL	$21,200.00
		SHIPPING & HANDLING	
		TOTAL DUE	$21,200.00

Make all checks payable to Lime Solar, LLC
Payment is due up receipt
If you have any questions concerning this invoice, contact Jesse Moe, 907-272-5463
Thank you for your business

Financial Payback Analysis





General System

Customer's Name:			Kake Senior Center
Contact Information:	P:	- E:	0
Address:			0
State & Country:		USA	Alaska
Utility:			IPEC
Utility Type:			Co-Op
Your Annual Average Monthly Electricity Bill:			$0.57
Tiered Rates Apply:			No
Time of Use Metering Offered:			No
Net Metering Available:			Yes

Estimated System Sizing

Solar Rating:	Good	3.22 kwH/sqm/day
Solar System Capacity Required:		11.70 KW/Hour
Side Area Needed:		715 Sq. Feet
Equivalent Annual Production:		10795.82 KWH/Year

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Financial Payback Analysis

Estimated System Cost

Assumed Installation Gross Cost "Gross Cost" is the cost before any rebates, incentives, tax credits, etc. are applied.	$ 75,061.23

This is only an estimate based upon many assumptions. Installation costs can vary considerably. We can provide you with a more detailed cost estimate, based on your actual installtion cost and energy usage. If you have any questions at all please feel free to contact a Lime Solar Sales Associate.

Financial Incentives

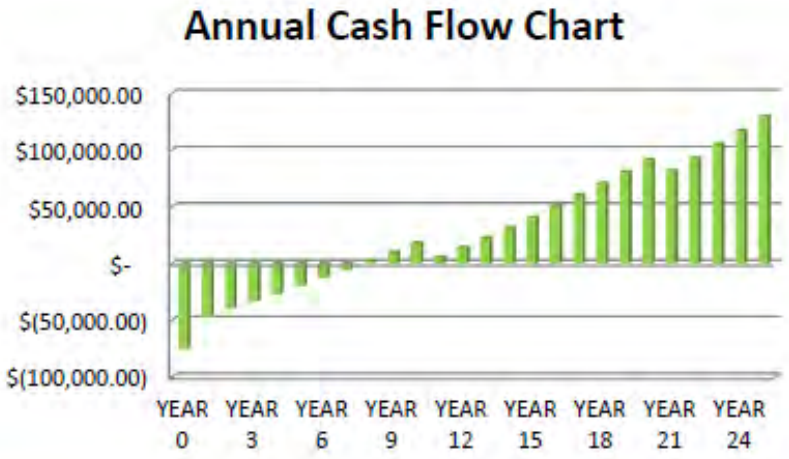
Federal Tax Credit (30% of Gross Cost)	$ 22,518.37
Modified Accelerated Cost Recovery System (MACRS) Depreciation 5 Years	YES
Estimated Net Cost	$ 52,542.86
Cash Amount	$ 52,542.86



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Financial Payback Analysis

Projected Cash Flow



Cash Flow Breakeven is where the chart crosses the $0 point - this is when your investment has paid itself back in cash.

The chart above is a summary of the net cash flow you can expect over time. Net Cash Flow is the total cash after all costs (out-flows of cash) are reduced by financial incentives, annual utility savings and tax effects (in flows of cash).

Savings & Benefits

First Year Utility Savings:	$6,153.62
Average Monthly Utility Savings: over 25-year expected life of system	$747.85
Average Annual Utility Savings: over 25-year expected life of system	$8,974.26
25-year Utility Savings:	$182,266.45
Levelized Cost of your Solar Energy:	$0.34 per KWH

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Financial Payback Analysis

Savings & Benefits

Return on Investment (ROI):	247%
Profitability Index:	1.73
Greenhouse Gas (CO2) Saved:	235 Tons
Carbon Emission Reduction:	483,951 Auto Miles

Cash Flow By Year

This cash flow table includes tax effects applied to utility savings and loan interest payments (if any). For commercial (business) situations we assume utility savings do not result in loss of some expense write offs against income. "Tax Savings from MACRS depreciation" (below) is the net cash saved on income taxes after the depreciation expense is written off. So the amount that was depreciated would be the cash value shown divided by the Income Tax.

Year	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Cash Flow	-$75,061	-$46,389	-$40,051	-$33,523	-$26,798	-$19,872
Annual Utility Savings	$6,154	$6,338	$6,528	$6,724	$6,926	$7,134
Utility Rate Inflation	$0.570	$0.587	$0.605	$0.623	$0.642	$0.661

Year	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11**
Cash Flow	-$12,739	-$5,391	$2,177	$9,972	$18,001	$5,226
Annual Utility Savings	$7,348	$7,568	$7,795	$8,029	$8,270	$8,518
Utility Rate Inflation	$0.681	$0.701	$0.722	$0.744	$0.766	$0.789

Year	YEAR 12	YEAR 13	YEAR 14	YEAR 15	YEAR 16	YEAR 17
Cash Flow	$13,744	$22,518	$31,555	$40,863	$50,450	$60,325
Annual Utility Savings	$8,518	$8,774	$9,037	$9,308	$9,587	$9,875
Utility Rate Inflation	$0.813	$0.837	$0.862	$0.888	$0.915	$0.942

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Financial Payback Analysis

Cash Flow By Year (Continued)

Year	YEAR 18	YEAR 19	YEAR 20	YEAR 21**	YEAR 22	YEAR 23
Cash Flow	$ 70,496	$ 80,972	$ 91,762	$ 81,831	$ 93,279	$ 105,070
Annual Utility Savings	$ 10,476	$ 10,790	$ 11,114	$ 11,114	$ 11,448	$ 11,448
Utility Rate Inflation	$0.970	$0.999	$1.029	$1.060	$1.092	$1.125

Year	YEAR 24	YEAR25
Cash Flow	$ 117,215	$ 129,724
Annual Utility Savings	$ 12,509	$ 12,884
Utility Rate Inflation	$1.159	$1.193

** Battery Replacement after Year 20 Cost: $21,045

First Year Energy Offset Table

	USAGE	SOLAR IRRADIANCE	PRODUCTION	% OFFSET
January	6,160	1.10	328.43	5%
February	6,560	1.55	418.00	6%
March	5,960	2.80	836.01	14%
April	6,040	4.08	1,178.89	20%
May	5,680	5.18	1,546.62	27%
June	5,400	5.25	1,516.95	28%
July	5,520	4.84	1,445.10	26%
August	5,440	4.88	1,457.04	27%
September	5,280	3.45	996.85	19%
October	5,360	1.83	546.39	10%
November	5,560	1.04	300.50	5%
December	5,920	0.75	223.93	4%
Total	68,880	3.06	10,795	

- Usage is measured in KWH/month from Addendum 1
- Solar Irradiance is Measured from PV WATTs from NREL Site for Kake, AK it is measured in kWh / m2 / day

* Production is measured in KWH/month with system losses factored in

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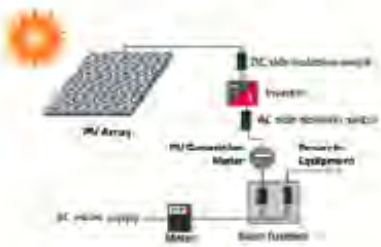
Financial Payback Analysis

Assumptions

Solar resources	Assumed solar availability: As per Solar Radiance chart
Soiling or contamination of the PV panels	Clean, washed frequently: 100% design sunlight transmission
Temperature	25C, calm wind
System configuration (battery or non-battery)	Battery Based System
Orientation to the sun	tilted at your latitude, full sun
Shading	None
PV Energy delivered as % of manufacturer's rating	95%
Soiling, wiring & power point tracking losses	9% (91% delivered)
Inverter Efficiency	90%
Total Energy Delivered	95% x 91% x 90% = 78%

Cost to Going Solar





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E: jesse@LimeSolar.net Website: www.LimeSolar.net

Option 2: Summary

Option 2: This option offers the most reliability because it has the added benefit of a back up battery bank. This also protects from the possibility if the solar array ever produces more energy than the current consumption the excess energy could be stored in the battery bank and be utilized when there is less solar production, such as the evening. This also means that in the event of a power outage, specific emergency loads can be backed up.

Payback: less than 8 years
Energy being offset annually: 10,795 KWH/year
Minimum Energy Offset: 4% in December (223.93 KWH)
Maximum Energy Offset: 28% in June (1,516 KWH)
Maintenance: Minor Battery Maintenance
Backup Capacity: 76.8 KWH
Inverter Capacity 20.4 KW (Continuous)
Warranty: Yes 25 Year Performance Warranty
10 Year Battery Warranty
Replacement Parts: Yes, Batteries would need to be replaced twice in 25 year period.

The primary negative of this system is the need for the batteries to be replaced in year 11 and 21. The batteries are sealed Absorbed Glass Mat which allow the batteries to not have to be maintained, vented and would be considered non-hazmat.

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E: jesse@LimeSolar.net Website: www.LimeSolar.net

Option 3: Cost Breakdown

Material Cost of the System:	$62,252.62
Installation and Services Cost of the System:	$29,350.00
Total System Cost:	$91,602.62
Federal Tax Credits: 30%	$27,480.78
Net Cost of the System:	$64,121.83
Average Utility Cost:	$0.57/KWH
Material Warranty:	25 Years
Installation Warranty:	2 Years
Monitoring:	Yes
Materials Replacement Cost: in 25 year Period	$29,651 (Heater at Year 11 and 21)
Maintenance Cost: in 25 year Period	$8,700 (Maintenance and replacement of Daiken Heater Unit)

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E: jesse@LimeSolar.net Website: www.LimeSolar.net

Lime Solar

Let's Imagine More Energy

QUOTATION

7731 E. Northern Lights Blvd Unit 250
Anchorage, Alaska 99504
Phone 907-272-5463 Fax 907-277-6527

QUOTATION #760
DATE: MAY 28, 2015

TO:
Kake Senior Center
Kake, Alaska

SHIP TO:

COMMENTS OR SPECIAL INSTRUCTIONS

SALESPERSON	P.O. NUMBER	REQUISITIONER	SHIPPED VIA	F.O.B. POINT	TERMS
Jesse Moe	Kake Senior Center			On Site Kake	

QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL
39	LG 300 Watt Monocrystaline Panels		PACKAGE
3	SMA Sunny Boy 4000 Tranformerless Grid Tie Inverters		PACKAGE
3	Outdoor Rated NEMA 3R 30 Amp DC Disconnect		PACKAGE
3	Outdoor Rated NEMA 3R 30 Amp AC Disconnect		PACKAGE
1,000	UV Resistant USE 2 PV Rated Cable		PACKAGE
485	Unirac Sunframe Cap strip Screws		PACKAGE
18	Unirac Sunframe Rail Splices		PACKAGE
86	Unirac Sunframe L Brackets		PACKAGE
20	Unirac Sunframe Cap strips and Rail 16' each		PACKAGE
1	Daiken Air to Hot Water Heater with Pump		PACKAGE
1	Miscellaneous: Breakers, Disconnects, Junction and Combiner Boxes		PACKAGE
300	AC Conduit and Wiring		PACKAGE
1	SMA America Sunny Webbox Solar Monitoring Equipment		PACKAGE
		TOTAL	$62,252.62
		TOTAL DUE	$62,252.62

This quotation is good for 30 days. Upon order the material must be paid in 50% as a deposit, the remaining balance is collected upon inspection of all the product in order when it has been received on site. If you have any questions concerning this quotation, contact Jesse Moe. 907-272-5463 Thank you for your business

Lime Solar

Let's Imagine More Energy

QUOTATION

3090 Mountain View Drive Suite 190
Anchorage, Alaska 99501
Phone 907-272-5463 Fax 907-277-6527

QUOTE #761
DATE: MAY 28, 2015

TO:
Kake Senior Center
Kake, Alaska

SHIP TO:

COMMENTS OR SPECIAL INSTRUCTIONS

SALESPERSON	P.O. NUMBER	REQUISITIONER	SHIPPED VIA	F.O.B. POINT	TERMS
Jesse Moe	Kake Senior Center				

QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL
1	Mechanical Installation of the Panels on Senior Center		$10,250.00
1	Electrical Installation of the Panels on Senior Center		$9,450.00
1	Electrical Engineering- Stamped One Line for PV		$750.00
1	Permitting and Initialization of System		$750.00
1	Mechanical Installation of Daiken Air to Hot Water Pump		$8,150.00
	Includes: The entire installation of Solar Racking, Panels, Inverters, Conduit Runs, DC Disconnects, AC Disconnects and wiring complete from solar panels to the breakers in the House Distribution Panel. Also, Includes interconnection application service with the utility company. Excludes: Any engineering necessary for the fabrication or installation of the structural supports for the solar array. This also does not include the installation or material of the House distribution panel.		
		SUBTOTAL	$29,350.00
		SHIPPING & HANDLING	
		TOTAL DUE	$29,350.00

Make all checks payable to Lime Solar, LLC
Payment is due up receipt
If you have any questions concerning this invoice, contact Jesse Moe, 907-272-5463
Thank you for your business

Financial Payback Analysis- PV vs Oil





General System

Customer's Name:		Kake Senior Center
Contact Information: P:	– E:	0
Address:		0
State & Country:	USA	Alaska
Utility:		IPEC
Utility Type:		Co-Op
Your Annual Average Monthly Electricity Bill:		$0.57
Tiered Rates Apply:		No
Time of Use Metering Offered:		No
Net Metering Available:		Yes

Estimated System Sizing

Solar Rating:	Good	3.22 kwH/sqm/day
Solar System Capacity Required:		11.70 KW/Hour
Side Area Needed:		715 Sq. Feet
Equivalent Annual Production:		10795.82 KWH/Year

7731 E. Northern Lights Unit 250 Anchorage, AK 99504 P: (907) 272-LIME (5463) F: (907) 27-SOLAR (76527)
E: jesse@LimeSolar.net Website: www.LimeSolar.net

Financial Payback Analysis- PV vs Oil

Estimated System Cost

Assumed Installation Gross Cost "Gross Cost" is the cost before any rebates, incentives, tax credits, etc. are applied.	$ 91,602.62

This is only an estimate based upon many assumptions. Installation costs can vary considerably. We can provide you with a more detailed cost estimate, based on your actual installtion cost and energy usage. If you have any questions at all please feel free to contact a Lime Solar Sales Associate.

Financial Incentives

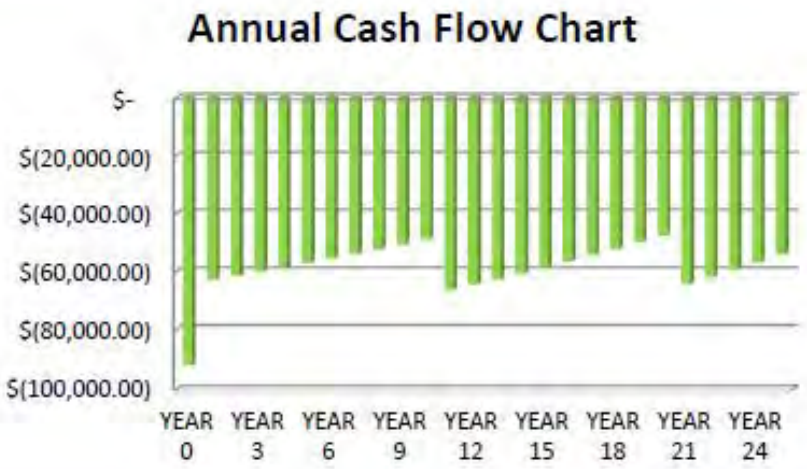
Federal Tax Credit (30% of Gross Cost)	$ 27,480.79
Modified Accelerated Cost Recovery System (MACRS) Depreciation 5 Years	YES
Estimated Net Cost	$ 64,121.83
Cash Amount	$ 64,121.83



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Financial Payback Analysis- PV vs Oil

Projected Cash Flow



Cash Flow Breakeven is where the chart crosses the $0 point - this is when your investment has paid itself back in cash.

The chart above is a summary of the net cash flow you can expect over time. Net Cash Flow is the total cash after all costs (out-flows of cash) are reduced by financial incentives, annual utility savings and tax effects (in-flows of cash).

Savings & Benefits

First Year Utility Savings:	$1,327.89
Average Monthly Utility Savings: over 25-year expected life of system	$161.38
Average Annual Utility Savings: over 25-year expected life of system	$1,936.55
25-year Utility Savings:	$6,323.76
Levelized Cost of your Solar Energy:	$0.38 per KWH

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Financial Payback Analysis- PV vs Oil

Savings & Benefits

Return on Investment (ROI):	-84%
Profitability Index:	-0.59
Greenhouse Gas (CO2) Saved:	235 Tons
Carbon Emission Reduction:	483,951 Auto Miles

Cash Flow By Year

This cash flow table includes tax effects applied to utility savings and loan interest payments (if any). For commercial (business) situations we assume utility savings do not result in loss of some expense write offs against income. "Tax Savings from MACRS depreciation" (below) is the net cash saved on income taxes after the depreciation expense is written off. So the amount that was depreciated would be the cash value shown divided by the income tax.

Year	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Cash Flow	-$91,603	-$62,794	-$61,426	-$60,017	-$58,566	-$57,072
Annual Utility Savings	$1,328	$1,368	$1,409	$1,451	$1,495	$1,539
Utility Rate Inflation	$0.123	$0.127	$0.130	$0.134	$0.138	$0.143

Year	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11**
Cash Flow	-$55,533	-$53,947	-$52,314	-$50,632	-$48,899	-$66,290
Annual Utility Savings	$1,586	$1,633	$1,682	$1,733	$1,785	$1,838
Utility Rate Inflation	$0.147	$0.151	$0.156	$0.160	$0.165	$0.170

Year	YEAR 12	YEAR 13	YEAR 14	YEAR 15	YEAR 16	YEAR 17
Cash Flow	-$64,452	-$62,559	-$60,609	-$58,600	-$56,531	-$54,400
Annual Utility Savings	$1,838	$1,893	$1,950	$2,009	$2,069	$2,131
Utility Rate Inflation	$0.175	$0.181	$0.186	$0.192	$0.197	$0.203

** Heater Replacement after Year 10, Cost: $19,175

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Financial Payback Analysis- PV vs Oil

Cash Flow By Year (Continued)

Year	YEAR 18	YEAR 19	YEAR 20	YEAR 21**	YEAR 22	YEAR 23
Cash Flow	$ (52,206)	$ (49,945)	$ (47,617)	$ (64,394)	$ (61,923)	$ (59,379)
Annual Utility Savings	$ 2,261	$ 2,328	$ 2,398	$ 2,398	$ 2,470	$ 2,470
Utility Rate Inflation	$0.209	$0.216	$0.222	$0.229	$0.236	$0.243

Year	YEAR 24	YEAR25
Cash Flow	$ (56,758)	$ (54,059)
Annual Utility Savings	$ 2,699	$ 2,780
Utility Rate Inflation	$0.250	$0.258

** Heater Replacement after Year 10, Cost: $19,175

	USAGE	SOLAR IRRADIANCE	PRODUCTION	% OFFSET
January	24,611	1.10	328.43	1.3%
February	24,611	1.55	418.00	1.7%
March	24,611	2.80	836.01	3.4%
April	24,611	4.08	1,178.89	4.8%
May	24,611	5.18	1,546.62	6.3%
June	24,611	5.25	1,516.95	6.2%
July	24,611	4.84	1,445.10	5.9%
August	24,611	4.88	1,457.04	5.9%
September	24,611	3.45	996.85	4.1%
October	24,611	1.83	546.39	2.2%
November	24,611	1.04	300.50	1.2%
December	24,611	0.75	223.93	0.9%
Total	295,332	3.06	10,795	

- Usage Represents 600 Gallons of Fuel Oil per month or 4 tons of wood pellets converted to KWH/month
- Solar Irradiance is Measured from PV WATTs from NREL Site for Kake, AK it is measured in kWh / m2 / day

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Financial Payback Analysis- PV vs Wood Pellet





General System

Customer's Name:		Kake Senior Center
Contact Information: P:	– E:	0
Address:		0
State & Country:	USA	Alaska
Utility:		IPEC
Utility Type:		Co-Op
Your Annual Average Monthly Electricity Bill:		$0.57
Tiered Rates Apply:		No
Time of Use Metering Offered:		No
Net Metering Available:		Yes

Estimated System Sizing

Solar Rating:	Good	3.22 kwH/sqm/day
Solar System Capacity Required:		11.70 KW/Hour
Side Area Needed:		715 Sq. Feet
Equivalent Annual Production:		10795.82 KWH/Year

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Financial Payback Analysis- PV vs Wood Pellet

Estimated System Cost

Assumed Installation Gross Cost "Gross Cost" is the cost before any rebates, incentives, tax credits, etc. are applied.	$ 91,602.62

This is only an estimate based upon many assumptions. Installation costs can vary considerably. We can provide you with a more detailed cost estimate, based on your actual installtion cost and energy usage. If you have any questions at all please feel free to contact a Lime Solar Sales Associate.

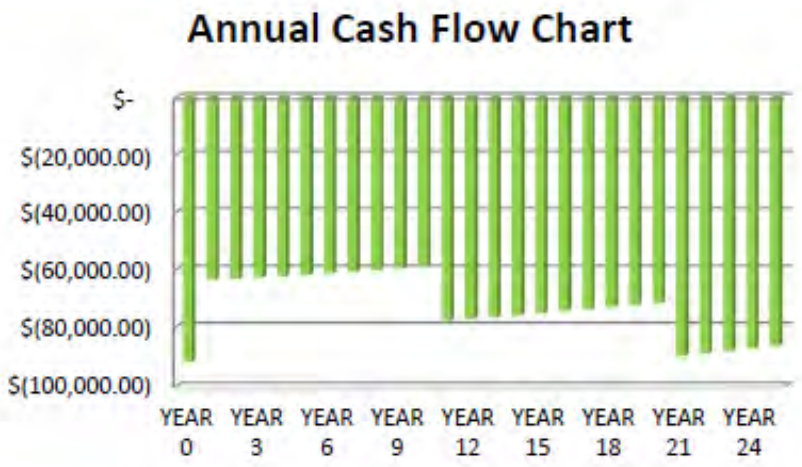
Financial Incentives

Federal Tax Credit (30% of Gross Cost)	$ 27,480.79
Modified Accelerated Cost Recovery System (MACRS) Depreciation 5 Years	YES
Estimated Net Cost	$ 64,121.83
Cash Amount	$ 64,121.83



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Projected Cash Flow



Cash Flow Breakeven is where the chart crosses the $0 point - this is when your investment has paid itself back in cash.

The chart above is a summary of the net cash flow you can expect over time. Net Cash Flow is the total cash after all costs (cut-flows of cash) are reduced by financial incentives, annual utility savings and tax effects (in-flows of cash).

Savings & Benefits

First Year Utility Savings:	$431.83
Average Monthly Utility Savings: over 25-year expected life of system	$52.48
Average Annual Utility Savings: over 25-year expected life of system	$629.77
25-year Utility Savings:	-$26,345.69
Levelized Cost of your Solar Energy:	$0.38 per KWH

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Financial Payback Analysis- PV vs Wood Pellet

Savings & Benefits

Return on Investment (ROI):	-135%
Profitability Index:	-0.95
Greenhouse Gas (CO2) Saved:	235 Tons
Carbon Emission Reduction:	483,951 Auto Miles

Cash Flow By Year

The cash flow table includes tax effects applied to utility savings and loan interest payments (if any). For commercial (business) situations we assume utility savings do not result in loss of some expense write-offs against income. "Tax Savings from MACRS depreciation" (below) is the net cash saved on income taxes after the depreciation expense is written off. So the amount that was depreciated would be the cash value shown divided by the Income Tax.

Year	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Cash Flow	-$91,603	-$63,690	-$63,245	-$62,787	-$62,315	-$61,829
Annual Utility Savings	$432	$445	$458	$472	$486	$501
Utility Rate Inflation	$0.040	$0.041	$0.042	$0.044	$0.045	$0.046

Year	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11**
Cash Flow	-$61,329	-$60,813	-$60,282	-$59,735	-$59,171	-$77,767
Annual Utility Savings	$516	$531	$547	$563	$580	$598
Utility Rate Inflation	$0.048	$0.049	$0.051	$0.052	$0.054	$0.055

Year	YEAR 12	YEAR 13	YEAR 14	YEAR 15	YEAR 16	YEAR 17
Cash Flow	-$77,169	-$76,553	-$75,919	-$75,266	-$74,593	-$73,900
Annual Utility Savings	$598	$616	$634	$653	$673	$693
Utility Rate Inflation	$0.057	$0.059	$0.061	$0.062	$0.064	$0.066

** Heater Replacement after Year 10, Cost: $19,175

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Cash Flow By Year (Continued)

Year	YEAR 18	YEAR 19	YEAR 20	YEAR 21**	YEAR 22	YEAR 23
Cash Flow	$ (73,186)	$ (72,451)	$ (71,694)	$ (90,089)	$ (89,286)	$ (88,459)
Annual Utility Savings	$ 735	$ 757	$ 780	$ 780	$ 803	$ 803
Utility Rate Inflation	$0.068	$0.070	$0.072	$0.074	$0.077	$0.079

Year	YEAR 24	YEAR25
Cash Flow	$ (87,606)	$ (86,729)
Annual Utility Savings	$ 878	$ 904
Utility Rate Inflation	$0.081	$0.084

** Heater Replacement after Year 10, Cost: $19,175

	USAGE	SOLAR IRRADIANCE	PRODUCTION	% OFFSET
January	24,611	1.10	328.43	1.3%
February	24,611	1.55	418.00	1.7%
March	24,611	2.80	836.01	3.4%
April	24,611	4.08	1,178.89	4.8%
May	24,611	5.18	1,546.62	6.3%
June	24,611	5.25	1,516.95	6.2%
July	24,611	4.84	1,445.10	5.9%
August	24,611	4.88	1,457.04	5.9%
September	24,611	3.45	996.85	4.1%
October	24,611	1.83	546.39	2.2%
November	24,611	1.04	300.50	1.2%
December	24,611	0.75	223.93	0.9%
Total	295,332	3.06	10,795	

- Usage Represents 600 Gallons of Fuel Oil per month or 4 tons of wood pellets converted to KWH/month
- Solar Irradiance is Measured from PV WATTs from NREL Site for Kake, AK it is measured in kWh / m2 / day

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Option 3: Summary

Option 3: This option utilizes the energy produced from the PV to power a Daiken air to hot water heater. This system is very similar to option 1 with the exception that the energy is allocated for a specific load. The current heating system is a fuel oil system that is being replaced with a wood pellet heater. The wood pellet heater is actually very efficient and drops heating costs from approximately $36,648/year to $11,760/year. The addition of the solar array would only decrease the cost of energy from using the wood pellets approximately $630/year. This clearly seems like the least economical option with no expected ROI.

Payback: less than 8 years
Energy being offset annually: 10,795 KWH/year
263 Gallons of Fuel
1.46 Tons of Pellets
Minimum Energy Offset: .9% in Dec. (223.93 KWH)
Maximum Energy Offset: 6.3% in June (1,516 KWH)
Maintenance: Minor Heater Maintenance
Warranty: Yes 25 Year Performance Warranty
10 Year Heater Warranty
Replacement Parts: Yes, Heater would need to be replaced twice in 25 year period.
The major negative of this system comes from the lack of efficiency of converting electricity to heat.

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Executive Summary

After evaluating each option, there is clearly some major distinctions. The most important factor when deciding which option is best is determining the primary reason for the system. Cost of the system, reliability, return of Investment, maintenance, and the percentage of energy offset are some of the deciding factors in each option

		Option 1		Option 2		Option 3
Cost of System	1	$61,715	2	$75,061	3	$91,602
Reliability	3	No Power when the grid goes down.	1	76 KWH of backup energy from batteries.	2	300 Gallon Hot Water Storage Tank in System.
Return on Investment	1	Less than 7 year payback 25 yr. Lifetime Savings of : $181, 185	2	Less than 8 year payback 25 yr. Lifetime Savings of : $129, 724	3	NO ROI. Pellet stove is by far more efficient. 25 yr. Lifetime Savings of : $-86, 729
Maintenance	1	Very little, occasionally clearing panels.	2	Annual inspect batteries, replace after 10 and 20 yrs.	3	Routine maintenance and inspection also replacement after 10 and 20 yrs.
Energy Offset Percentage	2	16 % Average Offset of Electricity Cost	1	16 % Average Offset of Electricity Cost	3	3.7% Average Offset of Heating Cost

As the table of displays option 3 is really not a viable option and does not justify the costs. Option 1 and 2 have two very distinct differences, both being very good it just depends which is the primary concern for the customer. Option 1 is a simple system where there is least amount of cost and pretty much no maintenance. There is a possibility of non fully harnessing the system in two cases. The first is that if the utility power goes out, the system will disengage regardless of the weather. The second is if at the peak power of production during the day, if the solar array's energy exceeds the demand from the building, because IPEC has no agreement to purchase or credit any excess power.

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Executive Summary

Option 2 has the benefit of solving both of these two options, because of a battery bank being used to buffer the energy. However, the primary downside to this system is the added cost and replacement cost of the batteries. It adds another level of complexity to the maintenance and service of this system. It is important that all 3 options are expandable, meaning that the amount of solar could be added with option 2 allowing for the battery storage to be added also to increase times of autonomy (hours without power from the utility company or solar).

The timeline for either of the three option would roughly take approximately 3-6 weeks to get the product ordered and on site, and would approximately take 1-2 weeks to install.

It is my opinion that option 1 would be the easiest system to implement, with the lowest cost, and it even has the added capability of adding the battery bank and inverter system from option 2 at a later date.

Executive Summary Completed By

Jesse Moe
Lime Solar
EE/ and Systems Design Engineer
907-272-5463

Mono X™ NeoN

LG300N1C-G3



LG Electronics, Inc. (Korea Exchange: 06657.KS) is one of the globally leading companies and technology innovator for electronics, information and communication products. The LG Electronics currently employs more than 91,000 people worldwide in 117 companies. In fiscal year 2011, 48.97 billion USD of revenue was achieved.

LG is one of the world's largest manufacturers of mobile phones, flat screen TVs, air conditioners, washing machines and refrigerators. As a future-oriented company, LG enables others to use technology consisting of renewable energies. LG's high quality solar products are being manufactured in LG's leading production facility in South Korea.

KM 56457-3 BS EN 61215 Photovoltaic Modules

LG's High Efficient Cell Technology

Driven by LG's own N-type technology, LG's high-efficiency modules will provide customers with high economic benefits.

Convenient Installation

LG modules are carefully designed to benefit installers by allowing quick and easy installations throughout the carrying, grounding, and connecting stages of modules.

Light and Robust

With a weight of just 16.8 kg, LG modules are proven to demonstrate outstanding durability against external pressure up to 5400 Pa.

100% EL Test Completed

All LG modules pass Electroluminescence inspection. This EL inspection detects cracks and other imperfections unseen by the naked eye.

Reliable Warranties

LG stands by its products with the strength of a global corporation and sterling warranty policies. LG offers a 10 year product limited warranty and a 25 year limited linear output warranty.

Positive Power Tolerance

LG provides rigorous quality testing to solar modules to assure customers of the stated power outputs of all modules, with a positive nominal tolerance starting at 0%.

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MonoX™ NeoN

LG300N1C-G3

Mechanical Properties

Cells	6 x 10
Cell vendor	LG
Cell type	Monocrystalline
Cell dimensions	156 x 156 mm² / 6 x 6 in²
# of busbar	3
Dimensions (L x W x H)	1640 x 1000 x 35 mm
	64.57 x 39.37 x 1.38 in
Static snow load	5400 Pa / 113 psf
Static wind load	2400 Pa / 50 psf
Weight	16.8 ± 0.5 kg / 36.96 ± 1.1 lb
Connector type	MC4 connector IP 67
Junction box	IP 67 with 3 bypass diodes
Length of cables	2 x 1000 mm / 2 x 39.37 in
Frame	Anodized aluminum

Certifications and Warranty

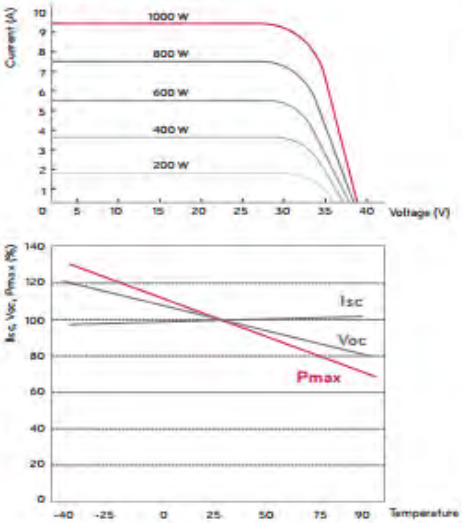
Certifications	IEC 61215, IEC 61730-1/-2, UL 1703,
	ISO 9001, IEC 61701(In progress),
	DLG-Fokus Test "Ammonia Resistance", (In progress)
Product warranty	10 years
Output warranty of Pmax (measurement Tolerance ± 3%)	Linear warranty*

* 1) 1st year: 97%, 2) After 2nd year: 0.7% annual degradation, 3) 80.2% for 25 years

Temperature Coefficients

NOCT	45 ± 2 °C
Pmpp	-0.42 %/K
Voc	-0.31 %/K
Isc	0.03 %/K

Characteristic Curves



Electrical Properties (STC*)

	300 W
MPP voltage (Vmpp)	32.0
MPP current (Impp)	9.42
Open circuit voltage (Voc)	39.5
Short circuit current (Isc)	10.0
Module efficiency (%)	18.3
Operating temperature (°C)	-40 ~ +90
Maximum system voltage (V)	600(UL), 1000(IEC)
Maximum series fuse rating (A)	15
Power tolerance (%)	0 ~ +3

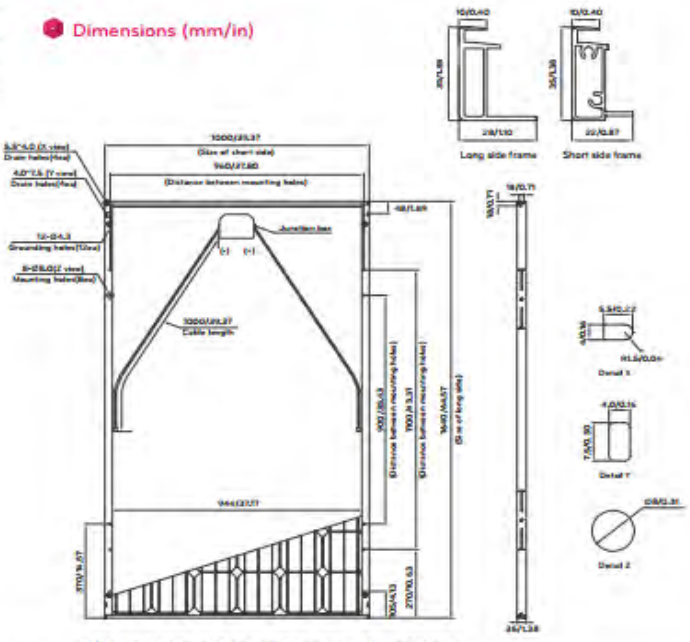
* STC (Standard Test Condition): Irradiance 1000 W/m², module temperature 25 °C, AM 1.5
* The nameplate power output is measured and determined by LG Electronics at its sole and absolute discretion.

Electrical Properties (NOCT*)

	300 W
Maximum power (Pmpp)	220
MPP voltage (Vmpp)	29.3
MPP current (Impp)	7.51
Open circuit voltage (Voc)	36.5
Short circuit current (Isc)	8.08
Efficiency reduction (from 1000 W/m² to 200 W/m²)	< 4.5 %

* NOCT (Nominal Operating Cell Temperature): Irradiance 800 W/m², ambient temperature 20 °C, wind speed 1 m/s

Dimensions (mm/in)



* The distance between the center of the mounting/grounding holes

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SUNNY BOY 3000TL-US / 3800TL-US / 4000TL-US / 5000TL-US / 6000TL-US / 7000TL-US / 7700TL-US



Certified
- UL 1741 and 1699B compliant
- Integrated AFCI meets the requirements of NEC 2011 690.11

Innovative
- Secure Power Supply provides daytime power during grid outages

Powerful
- 97.6% maximum efficiency
- Wide input voltage range
- Shade management with OptiTrac Global Peak MPP tracking

Flexible
- Two MPP trackers provide numerous design options
- Extended operating temperature range

SUNNY BOY 3000TL-US / 3800TL-US / 4000TL-US / 5000TL-US / 6000TL-US / 7000TL-US / 7700TL-US

Setting new heights in residential inverter performance

The Sunny Boy 3000TL-US/3800TL-US/4000TL-US/5000TL-US/6000TL-US/7000TL-US/7700TL-US represents the next step in performance for UL certified inverters. Its transformerless design means high efficiency and reduced weight. Maximum power production is derived from wide input voltage and operating temperature ranges. Multiple MPP trackers and OptiTrac™ Global Peak mitigate the effect of shade and allow for installation at challenging sites. The unique Secure Power Supply feature provides daytime power in the event of a grid outage. High performance, flexible design and innovative features make the Sunny Boy TL-US series the first choice among solar professionals.

MADE IN THE USA OF US AND IMPORTED PARTS

Technical data	Sunny Boy 3000TL-US		Sunny Boy 3800TL-US		Sunny Boy 4000TL-US	
	208 V AC	240 V AC	208 V AC	240 V AC	208 V AC	240 V AC
Input (DC)						
Max. usable DC power (@ cos φ = 1)	3200 W		4200 W		4200 W	
Max. DC voltage	600 V		600 V		600 V	
Rated MPPT voltage range	175 - 480 V		175 - 480 V		175 - 480 V	
MPPT operating voltage range	125 - 500 V		125 - 500 V		125 - 500 V	
Min. DC voltage / start voltage	125 V / 150 V		125 V / 150 V		125 V / 150 V	
Max. operating input current / per MPP tracker	18 A / 15 A		24 A / 15 A		24 A / 15 A	
Number of MPP trackers / strings per MPP tracker	2 / 2					
Output (AC)						
AC nominal power	3000 W		3330 W	3840 W	4000 W	
Max. AC apparent power	3000 VA		3330 VA	3840 VA	4000 VA	
Nominal AC voltage / adjustable	208 V / ●	240 V / ●	208 V / ●	240 V / ●	208 V / ●	240 V / ●
AC voltage range	183 - 229 V	211 - 264 V	183 - 229 V	211 - 264 V	183 - 229 V	211 - 264 V
AC grid frequency; range	60 Hz / 59.3 - 60.5 Hz		60 Hz / 59.3 - 60.5 Hz		60 Hz / 59.3 - 60.5 Hz	
Max. output current	15 A		16 A		20 A	
Power factor (cos φ)	1		1		1	
Output phases / line connections	1 / 2		1 / 2		1 / 2	
Harmonics	< 4%		< 4%		< 4%	
Efficiency						
Max. efficiency	97.2%	97.6%	97.2%	97.5%	97.2%	97.5%
CEC efficiency	96.5%	96.5%	96.5%	97.0%	96.5%	97.0%
Protection devices						
DC disconnection device	●					
DC reverse-polarity protection	●					
Ground fault monitoring / Grid monitoring	● / ●					
AC short circuit protection	●					
All-pole sensitive residual current monitoring unit	●					
Arc fault circuit interrupter (AFCI) compliant to UL 1699B	●					
Protection class / overvoltage category	I / IV					
General data						
Dimensions (W / H / D) in mm (in)	490 / 519 / 185 (19.3 / 20.5 / 7.3)					
DC Disconnect dimensions (W / H / D) in mm (in)	187 / 297 / 190 (7.4 / 11.7 / 7.5)					
Packing dimensions (W / H / D) in mm (in)	617 / 597 / 266 (24.3 / 23.5 / 10.5)					
DC Disconnect packing dimensions (W / H / D) in mm (in)	370 / 240 / 280 (14.6 / 9.4 / 11.0)					
Weight / DC Disconnect weight	24 kg (53 lb) / 3.5 kg (8 lb)					
Packing weight / DC Disconnect packing weight	27 kg (60 lb) / 3.5 kg (8 lb)					
Operating temperature range	-40 °C ... +60 °C (-40 °F ... +140 °F)					
Noise emission (typical)	≤ 25 dB(A)		< 25 dB(A)		< 25 dB(A)	
Internal consumption at night	< 1 W		< 1 W		< 1 W	
Topology	Transformerless		Transformerless		Transformerless	
Cooling	Convection		Convection		Convection	
Electronics protection rating	NEMA 3R		NEMA 3R		NEMA 3R	
Features						
Secure Power Supply	●		●		●	
Display: graphic	●		●		●	
Interfaces: RS485 / Speedwire/Webconnect	o/o		o/o		o/o	
Warranty: 10 / 15 / 20 years	●/o/o		●/o/o		●/o/o	
Certificates and permits (more available on request)	UL 1741, UL 1998, UL 1699B, IEEE1547, FCC Part 15 (Class A & B), CAN/CSA C22.2 107.1-1					
NOTE: US inverters ship with gray lids						
Type designation	SB 3000TL-US-22		SB 3800TL-US-22		SB 4000TL-US-22	

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E: jesse@LimeSolar.net Website: www.LimeSolar.net

NEW Conext XW+ NA inverter/charger

One solution for global power needs

Conext™ XW+ is an adaptable single-phase and three-phase inverter/charger system with grid-tie functionality and dual AC power inputs. Available solar charge controllers, monitoring, and automated generator control modules enable further adaptability. From a single Conext XW+ unit to clusters up to 102 kW, the Conext XW+ is a scalable system that allows for the integration of solar capacity as required. Adaptable and scalable, the Schneider Electric™ Conext XW+ system is the one solution for grid-interactive and off-grid, residential and commercial, solar and backup power applications.



Why choose Conext XW+ NA?

True bankability
- Warranty from a trusted partner with 178 years of experience
- World leader in industrial power drives, UPS and electrical distribution
- Strong service infrastructure worldwide to support your global needs

Higher return on investment
- Excellent load starting with high 30-minute and 5-second power
- Performs in hot environments up to 70°C
- Intelligent functionality enables solar prioritization, load shifting, peak shaving, and assists small generators with heavy loads
- Backup power with grid-tie functionality converts external DC power to AC power for export to the utility grid

Flexible
- Single or three phase systems from 7.0 kW to 102 kW
- Supports DC coupled and AC coupled off-grid and grid-tie architectures
- Supports charging of Lithium Ion battery packs

Easy to service
- Field serviceable with replacement boards and spare parts
- Monitor, troubleshoot or upgrade firmware with Conext ComBox

Designed for reliability
- Extensive quality and reliability testing
- Highly Accelerated Life Testing (HALT)
- Globally proven and recognized field performance

Easy to install
- System configures quickly into compact wall-mounted system
- Integrates both grid and generator power with dual AC inputs
- Balance of system components integrates battery bank, solar charge controllers and generators
- Commission the entire system with PC software tool and Conext ComBox

Product applications


Residential grid-tie solar with backup power


Self-consumption


off-grid solar


Backup power


Community electrification

solar.schneider-electric.com

Schneider Electric

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Specification Sheet

NEW Conext XW+ series (120/240V)

Device short name	XW+ 5548 NA	XW+ 6848 NA
Inverter AC output		
Output power (continuous) at 25°C	5500 W	6800 W
Overload 30 min / 60 sec at 25°C	7000 W / 9500 W	8500 W / 12000 W
Output power (continuous) at 40°C	4500 W	6000 W
Maximum output current 60 seconds (rms)	82 A (120 V); 41 A (240 V)	102 A (120 V); 52 A (240 V)
Output frequency (selectable)	50 / 60 Hz	50 / 60 Hz
Output voltage	L-N: 120 V +/- 3%; L-L: 240 V +/- 3%	L-N: 120 V +/- 3%; L-L: 240 V +/- 3%
Total harmonic distortion (THD) at rated power	< 5%	< 5%
Idle consumption search mode	< 8 W	< 8 W
Input DC voltage range	42 to 60 V (48 V Nominal)	42 to 60 V (48 V Nominal)
Maximum input DC current	150 A	180 A
Charger DC output		
Maximum output charge current	110 A	140 A
Output voltage range	40 - 64 V (48 V Nominal)	40 - 64 V (48 V Nominal)
Charge control	Three stage, two stage, boost, custom	Three stage, two stage, boost, custom
Charge temperature compensation	Battery temperature sensor included	Battery temperature sensor included
Power factor corrected charging	0.98	0.98
Compatible battery types	Flooded (default), Gel, AGM, LiON, custom*	Flooded (default), Gel, AGM,LiON, custom*
Batter bank range (scaled to PV array size)	440 - 10000 Ah	440 - 10000 Ah
AC input		
AC 1 (grid) input current (selectable limit)	3 - 60 A (60 A default)	3 - 60 A (60 A default)
AC 2 (generator) input current (selectable limit)	3 - 60 A (60 A default)	3 - 60 A (60 A default)
Automatic transfer relay rating / typical transfer time	60 A / 8 ms	60 A / 8 ms
AC input voltage limits (bypass/charge mode)	L-N: 78 - 140 V (120 V nominal) L-L: 160 - 270 V (240 V nominal)	L-N: 78 - 140 V (120 V nominal) L-L: 160 - 270 V (240 V nominal)
AC input frequency range (bypass/charge mode)	55 - 65 Hz (default); 52 - 68 Hz (allowable)	55 - 65 Hz (default); 52 - 68 Hz (allowable)
AC grid-tie output		
Grid sell current range on AC1(selectable limit)	0 to 40 A (120 V) / 0 to 20 A (240 V)	0 to 48 A (120 V) / 0 to 27 A (240 V)
Grid sell voltage range on AC1 (auto adjusts entering sell mode)	L-N:105.5 to 132 +/- 1.5 V L-L: 211 to 264 +/- 3.0 V	L-N:105.5 to 132 +/- 1.5 V L-L: 211 to 264 +/- 3.0 V
Grid sell frequency range on AC1 (auto adjust entering sell mode)	59.4 to 60.4 +/- 0.05 Hz	59.4 to 60.4 +/- 0.05 Hz
Efficiency		
Peak	95.7%	95.7%
CEC weighted efficiency	93.0%	92.5%
General specifications		
Part number	865-5548-01	865-6848-01
Product / shipping weight	53.5 kg (118.0 lb) / 75.0 kg (165.0 lb)	55.2 kg (121.7 lb) / 76.7 kg (169.0 lb)
Product dimensions (H x W x D)	58 x 41 x 23 cm (23 x 16 x 9 in)	58 x 41 x 23 cm (23 x 16 x 9 in)
Shipping dimensions (H x W x D)	71.1 x 57.2 x 39.4 cm (28.0 x 22.5 x 15.5 in)	71.1 x 57.2 x 39.4 cm (28.0 x 22.5 x 15.5 in)
IP degree of protection	NEMA Type 1 Indoor	
Operating air temperature range	-25°C to 70°C (-13°F to 158°F) (power derated above 25°C (77°F)	
Warranty (Depending on the country of installation)	2 or 5 years	2 or 5 years
Features		
System monitoring and network communications	Available	
Intelligent features	Grid sell, peak load shave, generator support, prioritized consumption of battery or external DC energy	
Auxiliary port	0 to 12 V, maximum 250 mA DC output, selectable triggers	
Off-grid AC coupling	Frequency control	
Multi-unit operation	Single and split phase: up to four units in parallel, three phase: up to 12 units in multi-cluster configuration with external AC contractor	
Regulatory approval		
Safety	UL1741, CSA 107.1	
EMC directive	FCC and Industry Canada Class B	
Interconnect	IEEE 1547 and CSA 107.1	

Specifications are subject to change without notice.

Conext XW+ works with the following Schneider Electric products

XW+ Power Distribution Panel
Product no. 865-1015-01



Conext System Control Panel
Product no. 865-1050-01



Conext Automatic Generator Start
Product no. 865-1060-01



MPPT 60 150 solar charge controller
Product no. 865-1030-1

MPPT 80 600 solar charge controller
Product no. 865-1032



Conext Combox communication device
Product no. 865-1058



Conext Battery Monitor
Product no. 865-1080-01

XW Configuration Tool
Product no. 865-1155

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US AGM L16

DATA SHEET

Sealed Low Maintenance 6 -Volt

Application: Wherever Sealed Low Maintenance & Leak Proof 6-volt batteries are needed.

Dimensions: 11.61" (295mm)L
7.09" (180mm)W
16.85" (428mm)H

Type: Sealed Non-Spillable Lead Acid (AGM)

Case material: Polypropylene / Heat Sealed

US AGM L16 SPECIFICATIONS

BCI Group Size	Model	1-hr Rate	2-hr Rate	5-hr Rate	6-hr Rate	10-hr Rate	20-hr Rate	48-hr Rate	72-hr Rate	100-hr Rate	Voltage	Standard Terminal Type	AMP HOURS (20 HR. RATE)	MINUTES @ 75 AMPS	MINUTES @ 56 AMPS	MINUTES @ 25 AMPS	Length	Width	Height	wet Weight Lbs (kg)
																	11.61"	7.09"	16.85"	
L16	US AGM L16	260	287	326	335	359	390	411	422	430	6	DUAL	390	255	358	915	(295)	(180)	(428)	121.2(55)

CHARGING INSTRUCTIONS:

	Cyclic Application	Float Application
Maximum Charge Current –	38 to 45 Amperes	38 to 45 Amperes
Charge Voltage (6 Volt)	7.2 – 7.5 volts	6.6 - 6.8 volts

Battery Voltage Temperature Compensation is -0.015 V/ºC or -0.008 V/ºF.

Do not charge at temperature corrected voltages above 7.5 volts (2.5 volts/cell).

Use of a voltage controlled charger is a requirement for warranty coverage.

For best cycle life, limit discharge to less than 50% of the battery's 20 hour capacity.

Deep cycle batteries need to be equalized periodically. Equalizing is an extended, low current charge performed after the normal charge cycle. This extra charge helps keep all cells in balance. Actively used batteries should be equalized once per month. Manually timed chargers should have the charge time extended approximately 3 hours. Automatically controlled chargers should be unplugged and reconnected after completing a charge.

SunFrame®

A Stunning Environmental Statement



Unirac's SunFrame system leads the PV market with its superior aesthetics. Its sleek design is engineered to sit low to the roof without gaps and implements shared rails for the best value.

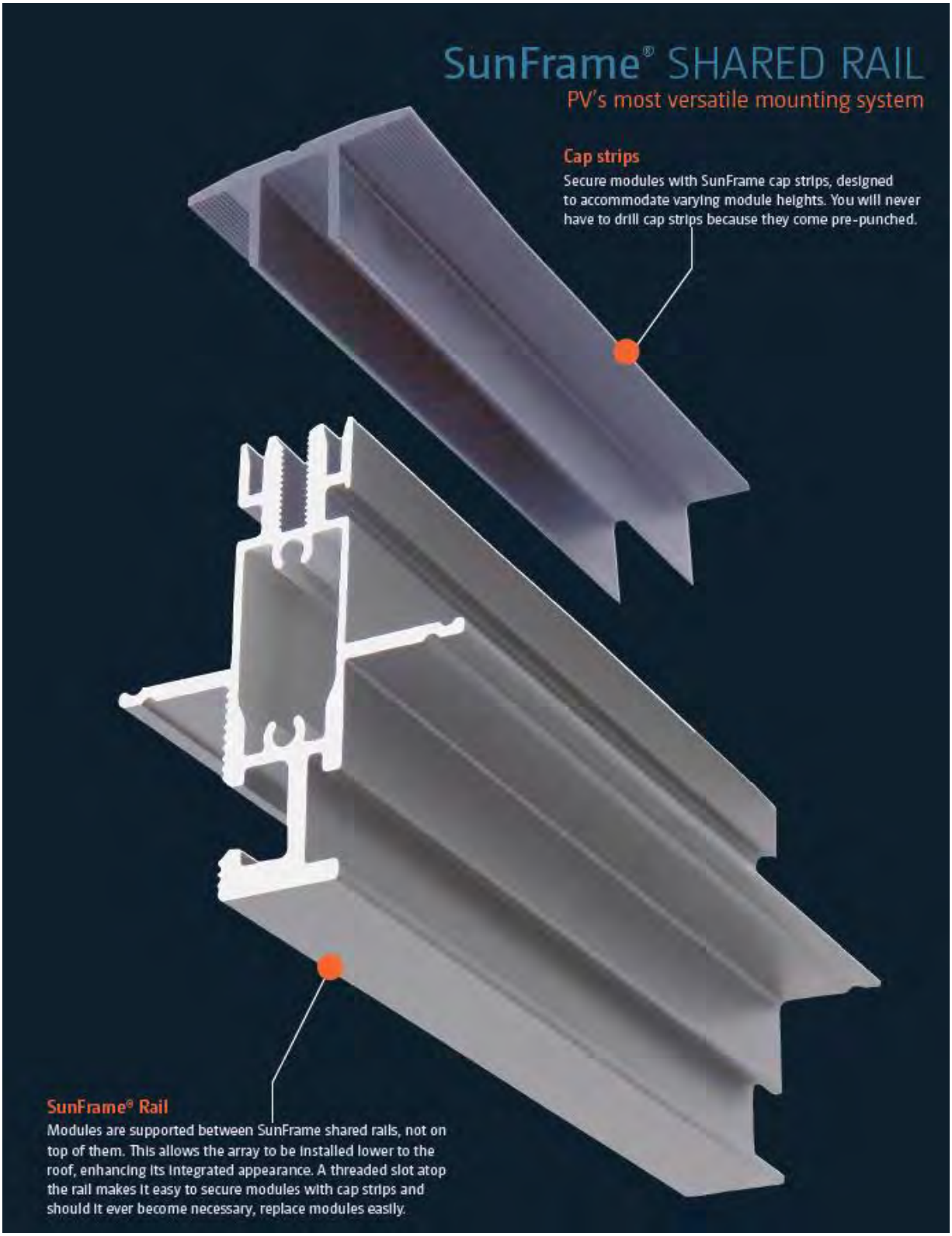
Low and clean lines give SunFrame two advantages. The finished array stands off the roof just enough for cooling air flow to optimize module performance while all modules sit in low, gap-free rows without protrusions from the sides of the array.

SunFrame is also the choice of solar experts as the optimal solution for custom carport structures. It's accompanied by a technical support system that provides complete installation and code compliance documentation, an on-line estimator and design assistance to help you solve the toughest challenges.

UNIRAC®
A HILTI GROUP COMPANY

Visit us online at www.unirac.com

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SunFrame® SHARED RAIL

PV's most versatile mounting system



Splices

Hidden splices are used to create long rows of modules. If required, install them to allow thermal expansion. Consult SunFrame installation instructions for details on thermal expansion.



Standoffs & Flashings

Two-piece standoffs speed installation on tile roofs. We offer six flashing choices for our aluminum or steel standoffs which can be precisely placed over the secured base of a stand-off prior to the installation of the standoff itself.



L-Feet

Serrated L-feet attach directly to asphalt shingle roofs or rest on adjusting sliders or standoffs.



L-Feet adjusting sliders

L-feet can be easily adjusted along fixed sliders to ensure rails fit snugly against modules.



End caps.

UV resistant black end caps hide the rail end extrusion completing your installation.

KEY BENEFITS

of SunFrame Rail System

Superior aesthetics

- Modules are flush mounted in low-gap-free rows
- Visible components match clear or dark module frames
- End caps cover rail cross-section
- Optimized module performance, system spacing allows convection cooling

Ease of installation

- Installer-friendly components
- Minimized penetration with longer attachment spans than competitive products
- Designed with customer input

Complete technical support

- Installation and code compliance documentation
- Downloadable estimator
- Person-to-person customer service

UNIRAC®
A HILTI GROUP COMPANY

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DAIKIN altherma

3.TECHNICALLY

1 - DAIKIN ALTHERMA™ SPLIT TYPE AIR-TO-WATER HEAT PUMP

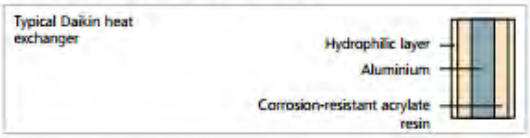
THE OUTDOOR UNIT

- Compact, weather-resistant and easy to install
- Contains an inverter controlled compressor for energy efficiency and precise temperature regulation
- Heat pump operation range: heating and domestic hot water to -4°F (-20°C) outside temperature



HEAT EXCHANGER ANTI-CORROSION TREATMENT

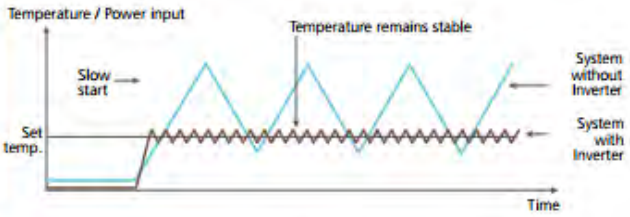
As standard, the heat exchanger in the outdoor unit is provided with an anti-corrosion treatment. This treatment guarantees and noticeably increases the resistance against acid rain and salt corrosion.



SUPER PERFORMANCE THANKS TO THE INVERTER PRINCIPLE

The coefficient of performance (COP) of the Daikin Altherma heat pump is also largely attributable to the Daikin inverter principle. An integrated frequency-converter adjusts the rotational speed of the compressor to suit the heating demand. Therefore, the system seldom operates at full capacity and your customer only pays for the energy which they actually need.

Heating operation:



HIGH EFFICIENCY COMPRESSORS:



The **scroll-compressors** are designed as a compact, robust, low-noise device to guarantee optimal operational reliability (no valves and built-in swing-link coupling) and efficiency (through a low initial flow and a constant compression ratio). It uses Pulse Width Modulation (PWM) Technology.



The **swing-compressors** have been setting trends in the area of energy efficient performance for the past 10 years (leaks and friction are basically non-existent). The design of the swing compressor reduces friction during operation for smoother and quieter rotation with less vibration resulting in a more durable compressor. It also minimizes the leakage of refrigerant gas during compression. The result is a system that operates quietly and efficiently. It uses Pulse Amplitude Modulation (PAM) Technology. The PAM Control reduces energy loss by controlling how often the converter switches on and off.

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DAIKIN

altherma

6.TECHNICAL SPECIFICATIONS

OUTDOOR SPLIT TYPE



ERLQ018/024/030BAVJU

INVERTER



ERLQ036/048/054BAVJU

OUTDOOR UNIT				ERLQ018BAVJU	ERLQ024BAVJU	ERLQ030BAVJU	ERLQ036BAVJU	ERLQ048BAVJU	ERLQ054BAVJU
Nominal capacity (1)		Heating	Btu/hr	19,620	23,340	28,760	38,200	47,800	54,600
		Cooling	Btu/hr	24,570	27,840	28,560	47,600	59,100	60,600
Nominal input (1)		Heating	kW	1.35	1.66	2.21	2.58	3.30	3.97
		Cooling	kW	2.36	2.87	3.06	3.91	5.94	6.94
COP				4.25	4.12	3.81	4.34	4.24	4.03
EER				10.41	9.7	9.33	12.17	9.95	8.73
Fan	Motor	Model		Brushless DC motor			Brushless DC motor		
		Output	W	53			70		
Operation range		Heating	°F (°C)	-4 ~ 77 (-20 ~ 25)			-4 ~ 95 (-20 ~ 35)		
		Cooling	°F (°C)	50 ~ 110 (10 ~ 43)			50 ~ 114.8 (10 ~ 46)		
		Domestic water	°F (°C)	-4 ~ 110 (-20 ~ 43)*			-4 ~ 109.4* (-20 ~ 43)		
Sound power level		Heating	dBA	61	61	62	64	64	66
		Cooling	dBA	63	63	63	64	66	69
Sound pressure level		Heating	dBA	48	48	49	49	51	53
		Cooling	dBA	48	48	50	50	52	54
Air Flow Rate (nominal at 230V) (cfm)		Heating	m³/min	N/A	N/A	N/A	3178	3178	3178
		Cooling	m³/min	N/A	N/A	N/A	3390	3531	3425
Piping connections	Liquid (OD)	Type		Flare connection			Flare connection		
		Diameter (OD)	in.	ø 1/4	ø 1/4	ø 1/4	ø 3/8	ø 3/8	ø 3/8
	Gas	Type	in.	Flare connection			Flare connection		
		Diameter (OD)	in.	ø 5/8	ø 5/8	ø 5/8	ø 5/8	ø 5/8	ø 5/8
	Drain	Type	in.	Socket			Hole		
		Diameter (OD)	in.	ø 7/10	ø 7/10	ø 7/10	ø 1	ø 1	ø 1
	Piping Length	Minimum	ft.	10	10	10	16.4	16.4	16.4
		Maximum	ft.	98	98	98	246	246	246
		Equivalent	ft.	-	-	-	312	312	312
		Chargeless	ft.	33	33	33	98.4	98.4	98.4
	Installation Height Difference	Maximum	ft.	66	66	66	98.4	98.4	98.4
Refrigerant charge	Charge	R-410A	lbs.	3.75			8.15		
	Additional		oz./ft.	0.21			Refer to chart in installation instructions		
Power supply				208-230V/1Ph/60Hz			208-230V/1Ph/60Hz		
Minimum Circuit Amps (MCA)			A	18	18	18	26.5	26.5	26.5
Maximum Overcurrent Protection (MOP)			A	20	20	20	30	30	30
Dimensions (Net)		HxWxD	in.	28 9/10 x 32 1/2 x 11 8/10			46 1/16 x 35 7/16 x 12 5/8		
Weight		Net	lbs.	123	123	123	227	227	227
		Gross	lbs.	134	134	134	251.3	251.3	251.3

Measuring conditions: Heating Ta DB/WB 44.6°F/42.8°F (7/6°C) - LWC 95°F (35°C) (DT=9°F (5°C)
- Cooling Ta 95°F (35°C) - LWE 64.4°F (18°C) (DT=9°F (5°C)
* Booster heater operation from 95°F (35°C) onwards
(1) These conditions are based on under floor heating/cooling application

OUTDOOR MONOBLOC TYPE



OUTDOOR UNIT				HEATING ONLY			REVERSIBLE		
SINGLE PHASE	With bottom plate heater			EDLQ036BA6VJU	EDLQ048BA6VJU	EDLQ054BA6VJU	EBLQ036BA6VJU	EBLQ048BA6VJU	EBLQ054BA6VJU
Nominal capacity (3)		Heating	Btu/hr	38,200	47,700	54,600	38,200	47,700	54,600
		Cooling	Btu/hr	-	-	-	43,800	54,500	57,000
Nominal input (3)		Heating	kW	2.47	3.2	3.78	7.47	3.2	3.79
		Cooling	kW	-	-	-	3.78	5.65	6.28
COP				4.54	4.37	4.22	4.54	4.37	4.22
EER				-	-	-	11.5	9.65	9.1
Operation range		Heating	°F (°C)	5 ~ 95 [1] (-15 ~ 35)			5 ~ 95 [1] (-15 ~ 35)		
		Cooling	°F (°C)	-			50 ~ 114.8 (10 ~ 46)		
		Domestic water	°F (°C)	5 ~ 95 [1][2] (-15 ~ 35)			5 ~ 95 [1][2] (-15 ~ 35)		
Sound power level		Heating	dBA	64	64	66	64	64	66
		Cooling	dBA	-	-	-	65	66	69
Sound pressure level		Heating	dBA	51	51	52	51	51	52
		Cooling	dBA	-	-	-	50	52	54
Refrigerant charge		R-410A	lbs.	6.5			6.5		
Power supply				208-230V/1Ph/60Hz			208-230V/1Ph/60Hz		
Maximum Overcurrent Protection (MOP)			A	30			30		
Dimensions (Net)		HxWxD	in.	55 27/32 x 56 1/2 x 15 1/32			55 27/32 x 56 1/2 x 15 1/32		
Weight		Net	lbs.	397			397		
		Gross	lbs.	441			441		

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Addendum 1

7)

Tlingit-Haida Regional Housing Authority
Kake Senior Center
Account # 1661-082

										500 kWh	over 500 kWh	Fuel Surchg.	Regulatory Cost Chg.	
										0.6308	0.5705	0.0237	0.000568	
										0.6349	0.5742	0.0493	0.000578	
Stmt	Date		Read						Basic	0.6300	0.5698	0.0252		
Date		From	To	Begin	End	Difference	Multiplier	Usage	Charge			-0.0211		Balance
	22-Jan-13	14-Dec-12	15-Jan-13	7,007	7,186	179	40	7,160	$ 15.00	$ 315.40	$ 3,799.53	$ 169.69	$ 4.07	$ 4,303.69
	21-Feb-13	15-Jan-13	14-Feb-13	7,186	7,341	155	40	6,200	$ 15.00	$ 315.40	$ 3,251.85	$ 146.94	$ 3.52	$ 3,732.71
	21-Mar-13	14-Feb-13	14-Mar-13	7,341	7,484	143	40	5,720	$ 15.00	$ 315.40	$ 2,978.01	$ 135.56	$ 3.25	$ 3,447.22
	18-Apr-13	14-Mar-13	15-Apr-13	7,484	7,674	190	40	7,600	$ 15.00	$ 315.40	$ 4,050.55	$ 374.68	$ 4.32	$ 4,759.95
	20-May-13	15-Apr-13	15-May-13	7,674	7,806	132	40	5,280	$ 15.00	$ 317.45	$ 2,744.68	$ 260.30	$ 3.00	$ 3,340.43
	20-Jun-13	15-May-13	14-Jun-13	7,806	7,950	144	40	5,760	$ 15.00	$ 317.45	$ 3,020.29	$ 283.97	$ 3.27	$ 3,639.98
	22-Jul-13	14-Jun-13	15-Jul-13	7,950	8,095	145	40	5,800	$ 15.00	$ 317.45	$ 3,043.26	$ 146.16	$ 3.35	$ 3,525.22
	23-Aug-13	15-Jul-13	14-Aug-13	8,095	8,237	142	40	5,680	$ 15.00	$ 317.45	$ 2,974.36	$ 143.14	$ 3.28	$ 3,453.23
	19-Sep-13	14-Aug-13	13-Sep-13	8,237	8,371	134	40	5,360	$ 15.00	$ 317.45	$ 2,790.61	$ 135.07	$ 3.10	$ 3,261.23
	21-Oct-13	13-Sep-13	14-Oct-13	8,371	8,507	136	40	5,440	$ 15.00	$ 317.45	$ 2,836.55	$ (114.78)	$ 3.14	$ 3,057.36
	19-Nov-13	14-Oct-13	15-Nov-13	8,507	8,657	150	40	6,000	$ 15.00	$ 315.00	$ 3,133.90	$ (126.60)	$ 3.47	$ 3,340.77
	20-Dec-13	15-Nov-13	16-Dec-13	8,657	8,817	160	40	6,400	$ 15.00	$ 315.00	$ 3,361.82	$ (135.04)	$ 3.70	$ 3,560.48
								72,400	$ 180.00	$ 3,796.30	$ 37,985.41	$ 1,419.09	$ 41.47	$ 43,422.27
														72,400
												Cost per kWh:		0.5998

Tlingit-Haida Regional Housing Authority
Kake Senior Center
Account # 1661-082

										500 kWh	over 500 kWh	Fuel Surchg.	Regulatory Cost Chg.	
										0.6300	0.5698	-0.0231	0.000578	
										0.6332	0.5727	-0.0105	0.000754	
Stmt	Date		Read						Basic			0.0078		
Date		From	To	Begin	End	Difference	Multiplier	Usage	Charge			-0.0275		Balance
	21-Jan-14	16-Dec-13	15-Jan-14	8,817	8,971	154	40	6,160	$ 15.00	$ 315.00	$ 3,225.07	$ (142.30)	$ 3.56	$ 3,416.33
	20-Feb-14	15-Jan-14	14-Feb-14	8,971	9,135	164	40	6,560	$ 15.00	$ 315.00	$ 3,452.99	$ (151.54)	$ 3.79	$ 3,635.24
	19-Mar-14	14-Feb-14	14-Mar-14	9,135	9,284	149	40	5,960	$ 15.00	$ 315.00	$ 3,111.11	$ (137.68)	$ 3.44	$ 3,306.87
	22-Apr-14	14-Mar-14	15-Apr-14	9,284	9,435	151	40	6,040	$ 15.00	$ 315.00	$ 3,156.69	$ (63.42)	$ 3.49	$ 3,426.76
	21-May-14	15-Apr-14	15-May-14	9,435	9,577	142	40	5,680	$ 15.00	$ 315.00	$ 2,951.56	$ (59.64)	$ 3.28	$ 3,225.20
	17-Jun-14	15-May-14	13-Jun-14	9,577	9,712	135	40	5,400	$ 15.00	$ 315.00	$ 2,792.02	$ (56.70)	$ 3.12	$ 3,068.44
	21-Jul-14	13-Jun-14	14-Jul-14	9,712	9,850	138	40	5,520	$ 15.00	$ 315.00	$ 2,860.40	$ 43.06	$ 4.16	$ 3,237.62
	19-Aug-14	14-Jul-14	15-Aug-14	9,850	9,986	136	40	5,440	$ 15.00	$ 315.00	$ 2,814.81	$ 42.43	$ 4.10	$ 3,191.34
	18-Sep-14	15-Aug-14	15-Sep-14	9,986	10,118	132	40	5,280	$ 15.00	$ 315.00	$ 2,723.64	$ 41.18	$ 3.98	$ 3,098.80
	22-Oct-14	15-Sep-14	15-Oct-14	10,118	10,252	134	40	5,360	$ 15.00	$ 315.00	$ 2,769.23	$ (147.40)	$ 4.04	$ 2,955.87
	18-Nov-14	15-Oct-14	14-Nov-14	10,252	10,391	139	40	5,560	$ 15.00	$ 315.00	$ 2,883.19	$ (152.90)	$ 4.19	$ 3,064.48
	18-Dec-14	14-Nov-14	15-Dec-14	10,391	10,539	148	40	5,920	$ 15.00	$ 316.60	$ 3,104.03	$ (162.80)	$ 4.46	$ 3,277.29
								68,880	$ 180.00	$ 3,781.60	$ 35,844.74	$ (947.71)	$ 45.61	$ 38,904.24
														68,880
												Cost per kWh:		0.5648

Attachment 9

Kake – BacGen Solar Feasibility Report

SOLAR FEASIBILITY STUDY



KAKE SENIOR CENTER
KAKE ALASKA

June 24, 2015

Submitted By:
BacGen Technologies, Inc, Maud de Bel
Maud@bacgen.com
206-459-9418

Executive Summary

BacGen investigated the feasibility of installing a solar system at the Senior Center in Kake, AK. Only two options are recommended for consideration (with and without battery storage). A third option, finding alternatives for domestic hot water heating in the shoulder season, is discussed in the report but not considered economically viable.

Option 1: 6 kW Grid Connected PV System

Budget Cost of a 6 kW System		$41,000
Annual Production	kWh/y	5,747
% Offset (Assuming 25,000 kWh/y Consumption)		23%
Annual Saving at $0.57/kWh (Assuming no losses to the grid)		$3,276
Simple Payback (No Maintenance Included)	Years	14
Payback with 6% Utility Escalator	Years	10
Present Worth (Maintenance Included) Courtesy Alaska Energy Engineering		$10,400
20 year Production (No Cell Degradation Included)	kWh	114,940
Equivalent kWh Cost over 20 years (No Maintenance Included)		$ 0.36

- Option 1 is the simplest project to install but due to its limited size, will only offset about 23% of the power consumption.
- Its size is limited because in the summer, this system is expected to output about 4.5 kW of instantaneous power, while the load is also expected to be around the 5 kW mark. A larger PV system would back feed power to the grid at peak solar hours, for which credit is not available.
- Before installation can take place, the actual power consumption, instantaneous load and power quality need to be monitored. The inverter will switch off when power quality is poor.
- Another disadvantage is that this system will not be operational during a grid outage.

Option 2: 12 kW Battery Connected PV System

Budget Cost of the System		$72,000
Annual Production	kWh/y	10,675
% Offset (Assuming 25,000 kWh/y Consumption)		43%
Annual Saving at $0.57/kWh		$6,085
Simple Payback (No Maintenance Included)	Years	13
Payback with 6% Utility Escalator	Years	10
Present Worth (Maintenance Included) Courtesy Alaska Energy Engineering		$29,300
20 year Production (No Cell Degradation Included)	kWh	213,500
Equivalent kWh Cost over 20 years (No Maintenance Included)		$ 0.34

- It is assumed that there are some economies of scale for installation of a 12 kW system compared to a 6 kW system. Therefore even though the price of batteries and charge controller needs to be included, over a 20 year period, the price of power would be $0.34/kWh instead of $0.36/kWh in Option 1 and the Present Worth is about three times higher because of the year-on-year saving on Utility cost.
- The $0.34 per kWh is a significant reduction (and will remain stable), compared to the $0.57/kWh paid today to the Utility (which is likely to increase over time).
- The advantage of this system is that upon a grid outage, this system can still be used. 'Dirty' power does not affect operation of the inverter because this system is operated independent of the grid.
- AGM batteries were used for pricing, however those batteries may be sensitive to extended periods of non-use (such as in the winter in AK). Lithium batteries are less sensitive to this, but they are much more expensive. This aspect will require some additional consideration.

Conclusion

Depending on the level of funding, both options are considered viable. If funding of around $70,000 is available, than Option 2 is the preferred option since it offsets a larger amount of power at a lower per kWh price, and offers more security since it operates during 'dirty' power and black-out periods.

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Introduction

Tlingit-Haida Regional Housing Authority (THRHA) owns and operates a Senior Center located at 177 Third Ave. Kake, AK 99830 (Lat/Long. 56.96N -133.93W), on Kupreanof Island, southeast of Juneau.

BacGen was asked to look into the cost and feasibility of building a solar PV system to offset power at the Senior Center.

Kake, Alaska is a high-cost diesel-electric community served by Inside Passage Electrical Cooperative (IPEC). Current electrical rates are around $0.65/kWh (below 500 kWh per month) and $0.57 (for consumption above 500 kWh per month). IPEC will not purchase power back from the building owner and requires any PV power to be isolated from the grid[1] (i.e. there can be no net metering). The building is undergoing modernization. When completed, it will have 14 apartments for independent-living housing for low-income senior citizens. It will also have common spaces including congregate dining room, commercial kitchen, offices, ADA bathrooms, laundry room, basement garages, and storage areas. All apartments will have individual electric meters. The commercial kitchen will be on an independent electric meter too. The rest of the building will be on the common house meter. Only this meter is to be offset with electricity generated by solar PV.

The Center will be heated with a wood pellet boiler, with propane boiler backup. Domestic hot water for apartments and most common spaces will be indirectly heated with the pellet boiler or propane back-up boiler.

The purpose of the feasibility study is to investigate whether solar PV, with or without batteries, would be economically viable. Additionally, BacGen was asked to look into possibilities to offset some of the hot water generation with solar thermal, or air-to-water heat pumps.

Scope of Work

The work will include performing a Solar Feasibility study at the Kake Senior Center in Kake Alaska to determine feasibility, conceptual designs, integration strategies, and cost estimates for supplying cost-effective solar energy solutions to lower operating costs at the Senior Center over a useful life of the building and solar components. The solar arrays are to be ground or wall mounted. The location for the solar array is along the skirted pile foundation on the south-facing, non-shaded side of the existing building, 178 feet in length, with space for panels up to 120” high. They are not to be roof mounted. Targeted capacity is 10,000 Watt minimum. The system will be parallel to the utility grid system, isolated with a non-grid tie inverter, and will not feed back into the utility grid system.

The feasibility study shall look at intervention options including, but not limited to:

1. Solar PV to power a percentage of the common house meter with no battery storage
2. Solar PV to power a percentage of the common house meter with battery storage.

[1] This statement needs to be investigated. It is important to know whether they will allow interconnection, if not net metering.

3. Solar PV to provide a percentage of the domestic hot water in combination with an air-to-water heat pump (Diaken Altherma or equal), for non-heating and shoulder-season months.

The feasibility study for each option shall include:

- A cost-benefit analysis for each intervention option described above.
- An estimate of the percentage of solar energy provided in comparison to total energy required for the common house meter or domestic hot water production.
- An estimate of annual savings in dollars for each option, with standard inflation and maintenance factors applied.
- Adequate preliminary design to provide a rough order of magnitude cost estimate of plus or minus 10% of actual installed costs in 2015 dollars.
- A cost-estimate for each intervention option for consultation, final design work, inspection and commissioning with a solar installation contractor.
- An executive summary with conclusions and recommendations.

Findings from Site Visit, June 2, 2015

During a site visit on June 2, it was found that the Center refurbishment is in advanced stages of completion. Figure 1 shows the pellet boiler (with green cover), the propane back-up boilers (behind pellet boiler) and the hot water storage tanks.



Figure 1 Overview of Heat Plant in Senior Center

The intention is to run the pellet boiler during the winter, with domestic hot water being heated via a secondary loop. In the summer, when building heating is not necessary, it may be more cost effective to rely on the propane boiler (see Figure 2) just to heat domestic water (it will also be easier to respond to demand changes with the propane boiler).



Figure 2 Propane Boilers



Figure 3 Heat Recovery Ventilation Units

The air throughout the facility is conditioned through two heat recovery ventilation (HRV) units (Figure 3). Each has two separate fans (one 1,0000 cfm and one 500 cfm capacity, each with 0.48 kW motor size).

Table 1 shows an estimation of future annual power consumption. Power consumption, in the past (when the common areas and individual units were all on a single meter) was in the 70,000 kWh/y range. Some limited information was available regarding control conditions of the various units. When electrical consumption of all important units is added up, the total is about 25,000 kWh/y, (about one third of previous consumption).

Table 1 Power Consumption Estimation

	Rating	Estimated Average Demand	Estimated hours per year	Total Annual Consumption (kWh/y)
HRV-1 (Ventilation)	1,000 cfm 0.48 kW	0.4 kW	8,760	7,656
HRV-1	500 cfm 0.48 kW	0.2 kW	8,760	
HRV-2	1,000 cfm 0.48 kW	0.4 kW	4,000	
HRV-2	500 cfm 0.48 kW	0.2 kW	4,000	
Pellet Boiler Pump	0.6 kW	0.5 kW	5,840	2,920
Building Hot Water Pump	31-1576 W	0.7 kW	1,100	770
Pump, Hot Water Heat Exchanger	16-442 W	0.2 kW	6,000	1,200
Hot Water Recirc	214 W	0.15 kW	8,760	1,314
Propane Boiler Pump	8.75 – 108 W	0.050 kW	2,900	145
LED Lights (Corridor etc)	10.5W /ea	0.378 kW	8,760	3,311
LED Lights (Common Area)	10.5W /ea	0.378 kW	500	189
Washer/Dryer	500 W	0.5 kW	1,100	500
Misc (Outlets etc)		0.5 kW		6,995
TOTAL		**4.0-4.5 kW**		**25,000**

Additionally, some information was obtained regarding the price, per million BTU, for heating purposes.

Table 2 Price Comparison between Electricity, Propane and Wood Pellets at 2015 prices

Electricity	$0.57/kWh	$167.01/MMBtu
Propane	$2.95/gallon	$32.60/MMBtu
Pellets	$400/ton	$24.39/MMBtu

Lay-out Considerations

Figure 4 shows the area that is earmarked for the solar array on the south side of the building (the building materials will be removed). Figure 5 shows a layout proposal for a 6 kW (20 modules) or 12 kW (40 modules) system. A 12 kW system would span about 110' (of the available 178' length of the building). Figure 6 shows that in a 2 module – landscape orientation, the maximum height of the array is 6'.

The system is perfectly south facing and there are no shading obstacles.



Figure 4 Area Earmarked for Ground Mount Solar PV System

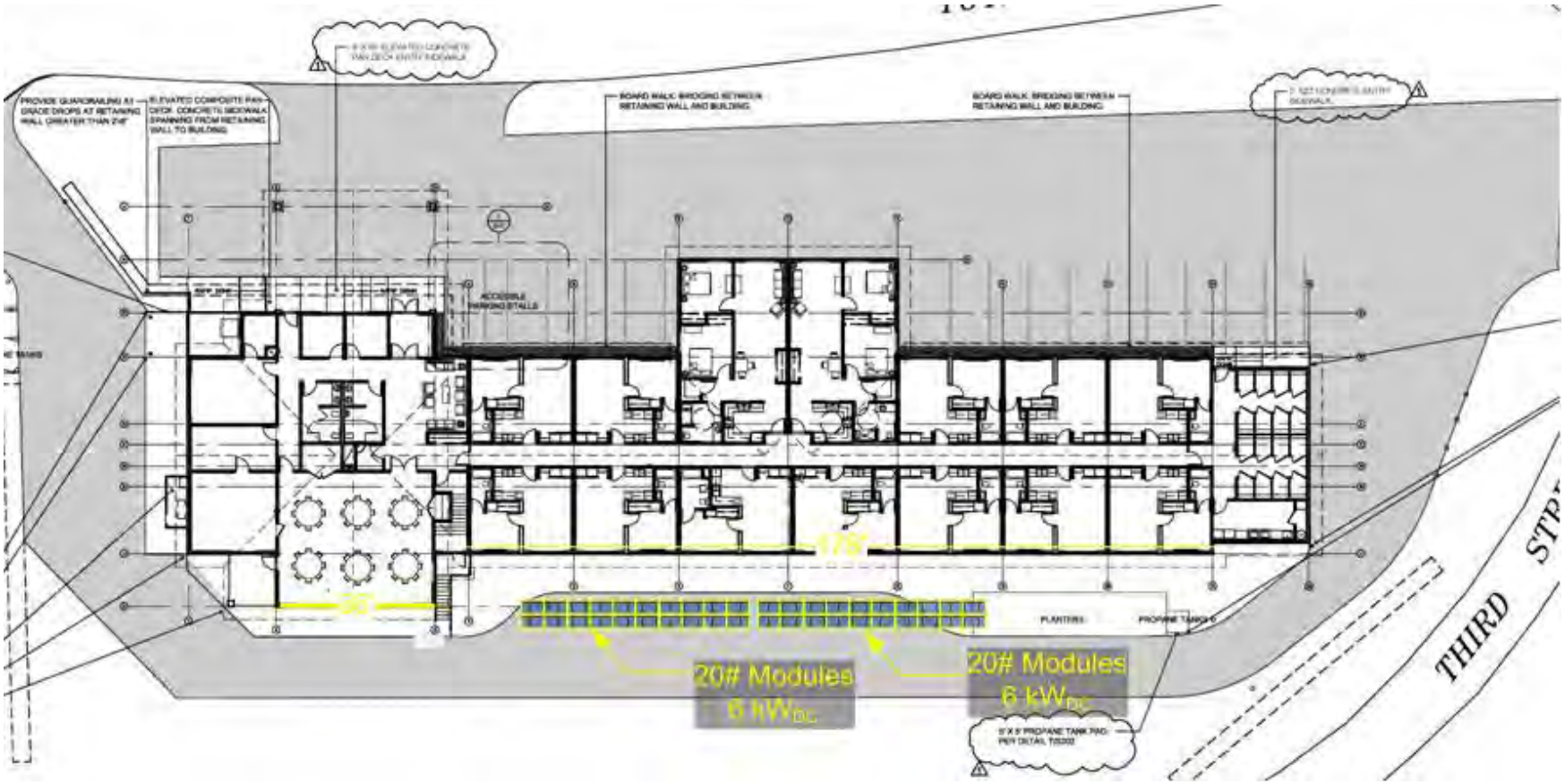


Figure 5 Overview of Solar Array Layout (6 kW and 12 kW)

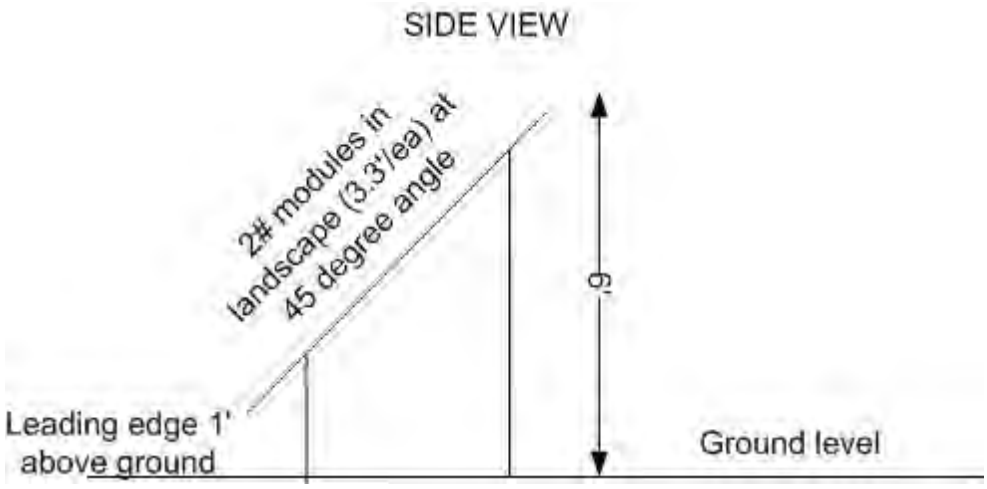


Figure 6 Side view showing maximum height of 6 feet above ground

Some Practical Considerations

The installation of the pilings for the ground mount system is probably the most critical aspect considering the remote location. Because of the high wind loading, the depth of the piling is expected to be > 6 ft. Several techniques are used in the industry, but most require special machinery (for example the use of 'screws' and hydraulic drilling). Digging holes and setting pilings in concrete may be the simplest but would require a lot of concrete (which is expensive in shipping cost).

There are two Washington State based vendors who have installed solar systems in Alaska (Artisan http://artisanelectricinc.com/ and Western Solar http://westernsolarinc.com/). Neither was prepared to quote a solar system claiming heavy workloads at this time.

Alaska Marine Lines ships materials from Seattle, adding an estimated $0.15/Watt to the install price.

EIC Engineers in Anchorage have provided stamped drawings for solar systems in the past (Brian, 907-349-9712; http://www.eicengineers.com/).

Since the power consumption of the future system will be much different than before, and is an unknown at this time, and also since the power quality will determine whether or not battery protection is required, the next step should be to do some type of power monitoring, for example using https://www.egauge.net/). The power consumption and quality will determine the size and type of the system (battery or no battery).

Figure 7 shows the acceptable voltage and frequency ranges for inverter operation (courtesy of Solaren.com).

Inverter type, size and voltage	Voltage range [V]	Clearing time(s) (seconds)	Frequency range [Hz]	Clearing time(s) (seconds)
Residential 240 Vac	V < 211.2	2.00	f > 60.5	0.16
	211.2 < V < 264	operational	f < 59.3	0.16
	264 < V	1.00	59.3 < f < 60.5	operational

Figure 7 Utility Grid Voltage and Frequency Limits for Residential (single Phase) for Grid-Ties PV Inverters

Option 1: Grid Connected Solar PV (no Batteries)

Option 1 was to look at a solar PV without the benefit of battery storage. The estimated size of the solar system should not exceed approximately 6 kW, since it was determined in Table 1 that the instantaneous demand will probably not exceed 4.5 kW. A solar size above 6 kW would back-feed electricity to the grid in the middle of the summer, for which there is no credit.

Table 3 shows the monthly production for Kake (NREL Weather Data Source: (TMY2) ANNETTE, AK 162 mi). The solar radiation in kWh/ m^2/day is a measure of the sun hours (at 100% efficiency).

Table 3: Production and Offset Estimate of a 6 kW_{DC} Solar PV System (Source: PVWatts, NREL)

6 kW system (14% losses)					
Month	**Solar Radiation**	**AC Energy**	**Consumption**	**% offset**	**Energy Value**
	(kWh / m^2/day)	**(kWh)**	**(kWh)**		**$**
January	1.5	241	2083	12%	$ 137
February	1.81	265	2083	13%	$ 151
March	3.1	488	2083	23%	$ 278
April	4.17	629	2083	30%	$ 359
May	5	761	2083	37%	$ 434
June	4.87	721	2083	35%	$ 411
July	4.55	689	2083	33%	$ 393
August	4.88	722	2083	35%	$ 412
September	3.72	541	2083	26%	$ 308
October	2.1	327	2083	16%	$ 186
November	1.3	200	2083	10%	$ 114
December	1.01	163	2083	8%	$ 93
Annual	**3.17**	**5,747**	**25,000**	**23%**	**$3,276**

If the annual consumption is about 25,000 kWh/y, the monthly offset can be calculated. The monthly consumption was previously fairly stable for all seasons. It shows that a 6 kW system could offset about 30-35% of the consumption during the summer, provided there is no back-feed to the grid. On an annual basis, about 23% of electricity consumption can be offset by the solar PV system, with a value of about $3,276 in the first year.

Table 4 shows typical hourly solar production in February, June and October against the hypothetical load profile. Figure 8 shows the hourly output, in kW AC Power from a 6 kW solar PV System in Kake. Note that only on a few occasions, the output exceeds 4.5 kW. There are 208 hours in the year that the power production exceeds 4,000 $Watts_{AC}$ and only 17 hours per year that the production exceeds 4,500 Watts, therefore the 'loss' to the grid in this scenario is less than 1% on an annual basis.

Table 4 Typical Demand and Solar Production of a 6 kW Grid Connected Solar System in Kake, AK in Different Seasons

Hour	Typical Demand (Hypothetical) (kW)	Typical Solar Production on February 6 (Watts)	Typical Solar Production on June 24 (Watts)	Typical Solar Production on October 23 (Watts)
0	2	-	-	-
1	2	-	-	-
2	2	-	-	-
3	2	-	88	-
4	2	-	273	-
5	2	-	385	-
6	2.2	-	775	25
7	2.4	87	1,320	651
8	3	990	1,619	1,901
9	3	1,238	2,606	2,109
10	3	1,563	3,896	959
11	3.5	1,588	4,552	1,000
12	4.5	1,166	4,611	728
13	4.5	1,736	4,187	504
14	4	436	3,549	285
15	3	106	2,579	214
16	2.5	18	1,539	-
17	2	-	529	-
18	2	-	371	-
19	2	-	492	-
20	2	-	71	-
21	2	-	-	-
22	2	-	-	-
23	2	-	-	-

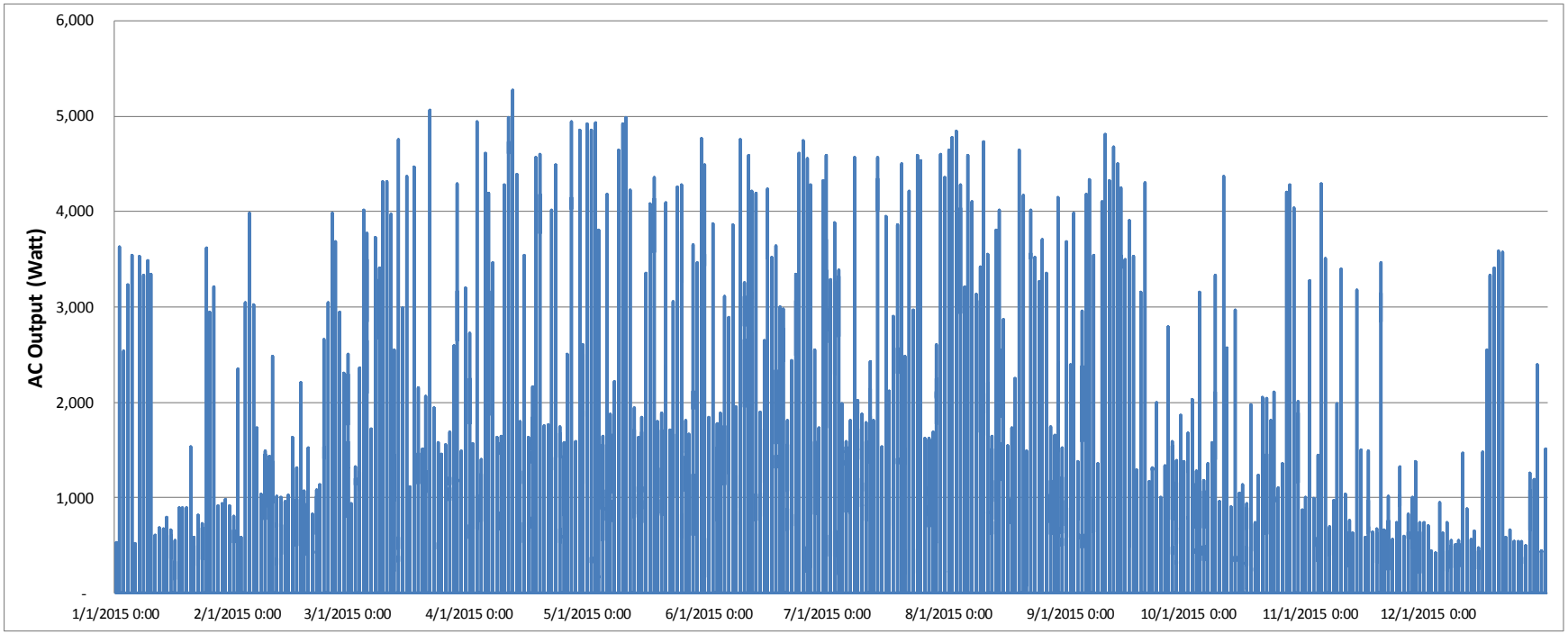


Figure 8 PVWatts Prediction of Typical Hourly Solar Output from a 6 kW PV System

Table 5: Cost Estimate for 6 kW Grid Connected System

	Unit Price	Price
Modules, Racking, Inverters, Wiring, Balance of System	$3/$W_{DC}$	$ 18,000
Stamped Design	$3,000	$ 3,000
Shipping	$0.50/lbs	$ 1,000
Ferry		$ 1,000
Labor (Civil, Mechanical and Electrical)		$ 15,000
Miscellaneous		$ 3,000
TOTAL		**$ 41,000**
Overall Price per Watt		$ 6.83
Annual Saving		$3,276
Simple Payback (No Maintenance Included)	Years	13
Payback with 6% Utility Escalator	Years	10
20 year Production (No Cell Degradation Included)	kWh	114,940
Equivalent kWh Cost (No Maintenance Included)		$ 0.36

Maintenance is expected to be done in-house and generally consists of cleaning the modules, and periodically checking the output of the system. Adequate training should be obtained at time of installation. Inverters are typically under warranty for 10 years. An inverter replacement would cost about $2,500- $3,000 for this system.

Appendix A contains a Net Present Worth analysis of the 6 kW and the 12 kW systems that includes the annual maintenance and inverter (/battery) replacement.

Option 2: 12 kW Battery Back-up PV System

Table 6: Production and Offset Estimate of a 12 kW_{DC} Solar PV System (Source: PVWatts, NREL)

12 kW System (20% losses)					
Month	**Solar Radiation**	**AC Energy**	**Consumption**	**% offset**	**Saving**
	(kWh / m^2/day)	**(kWh)**	**(kWh)**		**($)**
January	1.5	448	2083	22%	$ 255
February	1.81	491	2083	24%	$ 280
March	3.1	906	2083	43%	$ 516
April	4.17	1,170	2083	56%	$ 667
May	5	1,414	2083	68%	$ 806
June	4.87	1,340	2083	64%	$ 764
July	4.55	1,280	2083	61%	$ 730
August	4.88	1,342	2083	64%	$ 765
September	3.72	1,005	2083	48%	$ 573
October	2.1	606	2083	29%	$ 345
November	1.3	371	2083	18%	$ 211
December	1.01	302	2083	14%	$ 172
Annual	**3.17**	**10,675**	**25,000**	**43%**	**6,085**

Option 2 is a 12 kW system with battery storage. This system is not connected to the grid. Compared to Option 1, slightly higher losses were assumed due to the 'extra step' of storing DC power in the batteries and then converting it to AC Power. Overall, this system would offset about 43% of annual power consumption.

Table 7 shows a cost estimate for this system. Economies of scale were assumed for the electrical design, the labor cost and miscellaneous cost. The additional cost for batteries and charge controller was assumed to be \$1/W_{DC}. Due to the economies of scale, the overall price per Watt installed is lower in this option, and the 20-year cost of solar is expected to be \$0.34/kWh (compared to 0.36/kWh in Option 1).

Maintenance cost are expected to be similar to Option 1, however batteries are expected to be due for replacement after about 10 years. The replacement cost would obviously depend on the number of batteries installed in the first place. BacGen would recommend installing 16 batteries (AGM, 6 V, ~400 amph) which cost about \$400/ea. Replacement of 16 batteries would be about \$7,500 in 2015 prices.

Table 7: Cost Estimate for 12 kW Battery Back-up System

	Unit Price	**Price**
Modules, Racking, Inverters, Batteries, Wiring, Balance of System	$4/$W_{DC}$	$48,000
Stamped Design	$ 3,000	$3,000
Shipping	$0.50/lbs	$ 2,000
Ferry		$ 1,000
Labor		$ 15,000
Miscellaneous		$ 3,000
TOTAL		**$ 72,000**
Overall Price per Watt Installed		$ 6.00
Annual Saving (No escalator on Utility Price)		$ 5,554
Simple Payback (No Maintenance Included)	Years	13
Payback with 6% Utility Escalator	Years	10
20 year production (no cell degradation included)	kWh	209,860
Equivalent kWh Cost (No Maintenance Included)		$ 0.34

Table 8 Battery Cost Estimate (in 2015 Pricing)

# batteries	$/ea	total	lbs/ea	shipping	total
32	$400	$12,800	120	$ 1,920	$14,720
16	$400	$6,400	120	$ 960	$7,360
12	$400	$4,800	120	$ 720	$5,520

Other Options

Other options that were suggested were as follows:

- Using an air-to-water heat pump water heating, to avoid running the pellet boiler for domestic hot water heating in the summer
- Installing solar thermal for water heating, to avoid running the pellet boiler for domestic hot water heating in the summer
- Instead of using batteries as part of the solar PV system, dump excess electricity into an electric heat coil in the hot water tank

Table 9 Price Comparison between Electricity, Propane and Wood Pellets

Electricity (from Diesel)	$0.57/kWh	$167/MMBtu	
Electricity (from solar PV)	$0.34/kWh	$99.62/MMBtu	
Propane	$2.95/gallon	$32.60/MMBtu	(0.11/kWh)
Pellets	$400/ton	$24.39/MMBtu	(0.08/kWh)

To calculate whether any of these options are economically viable, it was assumed that the daily domestic hot water heating volume is 500 liters (132 gallons). Using price estimates of Table 9, the results are summarized in Table 10.

The following conclusions can be reached from these calculations:

- It is likely that the propane boiler is the cheapest way to heat the water in the shoulder season, if it can be run independently from the wood pellet boiler.
- Even the wood boiler at 50% efficiency is twice as cheap as using solar PV in an electrical heating coil.
- The cost of installing and running solar thermal or a heat pump would have to be less than $14,000 over its 20 year operating life for it to be economically viable as an alternative to propane. Unless the cost of propane increases dramatically, a heat pump is not .

Table 10 Water Heating Cost Comparison (1 kCal is needed to heat 1 liter of water by 1 degree C)

			Cost if Propane is used at 70% Heat Transfer Efficiency	**Cost if Wood Pellets are used at 50% Heat Transfer Efficiency**	**Cost if Electric Coil is Used (100% Efficiency) (Diesel)**	**Cost if Electric Coil is Used (100% efficiency) (Solar PV)**
Cost per kWh Equivalent	$/kWh		$ 0.11	$ 0.08	$ 0.57	$ 0.34
Volume of Water	Liter gallons	500 132				
Cold Water Temp	C	15				
Hot Water Temp	C	60				
kWh/1,000kCal		1.163				
Efficiency of Heating Inside Tank		70%				
Energy required to heat 500 l tank	kCal	32,143				
Energy and Cost to heat 132 gallons of water	kWh	37.4	$ 5.87	$ 5.98	$ 21.31	$ 12.71
# Days in Shoulder Season		120				
Total Cost of Running Propane Boiler for 20 Years in Shoulder Season			$ 14,098			

Some Notes About The Lime Solar Proposal

Option 1

- The size of 'Option 1' in the Lime proposal (11,700 W_{DC}) would be too large for the future electrical consumption at the Senior Center after separation of the individual units and the kitchen service.
- Average Utility Cost was quoted as $0.57 which is probably correct. The marginal price of power (>500 kWh/month) is $0.57/kWh. Only the first 500 kW is $0.65 and even with a 12 kW solar PV system, the monthly usage will not dip below 500 kWh.
- Lime's solar price quote for materials is equivalent to $4.00/$W_{DC}$ delivered to site. I think in Seattle one would be able to source materials for about $3.00 W_{DC} before shipping so I think $3.00-$4.00/W_{DC} is the ballpark price. Adjusted for 6 kW (instead of 11.7 kW), Lime's quote without batteries would come to $39,000 which is similar to the project cost used in the BacGen report.
- In their financial analysis, Lime used tax credits and MACRS in the payback analysis which are not available to THRHA. Lime states that the levelized cost for solar in Option 1 is $0.15/kWh, but this would only be true if tax credits and MACRS can be taken into account. Discounting for those federal benefits, the levelized cost for the Lime proposal is about the same as in the BacGen analysis ($0.39/kWh).
- Lime used the old Utility bill (when annual consumption was about 70,000 kWh/y) for savings and benefit analysis.
- The solar production estimates used in the Lime report as very similar to what PVWatts predicts for Juneau, AK (which was used in BacGen report).
- On page 12, some assumptions were made for losses due to shading, soiling and inverter efficiency. Lime predicts losses of 22%, but I think we can do better than that. There are no shading losses, and the inverter efficiency of modern inverters exceeds 95%. There will be some soiling and wire losses (say 9%). Overall conversion efficiency should be about 0.91 x 0.95 = 0.86 (overall 14% losses, this number was used in the BacGen report).
- Page 13, the summary page: The simple payback for a 6 kW system is in the 14 year range. The minimum energy offset is about 10% in December and the maximum about 30% in June. There will be some maintenance (cleaning, and potentially inverter replacement). Some money should set aside for that. Module warranty is typically 20 – 25 years but it is hard to obtain a 20 year inverter warranty (10 years is typical).
- It is true that in this option, the Utility grid needs to be switched on to produce power. Anti-islanding demands that the inverter switches off when the grid goes down.
- No mention is made of power quality. Before a system can be installed without a battery, the power quality must be monitored for power quality. It would be our recommendation to start power quality and consumption monitoring as soon as possible, so that a better estimate can be made of the solar PV sizing.

Option 2

- Again Lime's total system cost of $75,000 seems close to BacGen's estimate of $72,000. From the cost breakdown on page 14, it appears that about $18,500 was budgeted for battery replacement (twice in the system's life). This is based on solid state gel batteries (AGM-Absorbed Glass Mat). It could be considered to use lithium-iron batteries (which are more expensive but lighter in weight, and more 'forgiving' when not used). The price of lithium-ion batteries is expected to come down dramatically over time.
- The Lime proposal appears to be based on 32 # 6 V batteries with a rating of 390 amph. If it is assumed that there are 4 # strings of 8 batteries (48 V per string), then the total would be about 4x 390 = 1,560 amph. At 90% charge controller efficiency and 85% discharge depth this would be 0.90 x 0.85 x1,560 x 48 V = 57 kWh.
- In the top months, a 12 kW solar PV system produces about 40 kWh per day (average). If 50% of that can be used immediately, the battery capacity may only need to be 20 kWh.
- On page 15, it appears that the additional cost for batteries and charge controller is only a total of $7,146 compared to Option 1. This is inconsistent with the maintenance cost of $36,890 for batteries (in year 10 and 20) quoted on page 14.
- On page 16 it seems that the battery installation should not be that much more expensive than Option 1 installation cost.
- Page 19: The first year utility saving seems fair and in line with PVWatts prediction. Note again that tax credits and MACRS do not apply in the economic analysis.
- Page 22: Loss calculations seem fair taking into account charge controller losses. Lime uses 22% losses, BacGen uses 20% losses.
- Page 23 quotes 76.8 kWh battery capacity. That does not account for charge controller losses and battery discharge depth.

Option 3

- Option 3 appears to show that the material cost for the heat pump would be about $15,000 before integration into the system. BacGen would concur that this is not an economically viable solution compared to propane heating at today's prices.
- The size of the water tank was assumed to be 300 gallons (132 gallons was used in the BacGen report). If 300 gallons is heated every day for domestic use, then $32,000 would be spent over 20 years on burning propane, in the shoulder season, at today's prices. If one would assume that solar thermal can be installed for less than $15,000 and it would offset 50% of propane, this might be an option (but it should be considered separate from the PV).

Summary

Lime Solar state that the battery option can be installed later but I think it is better to select a battery capable inverter/charge controller unit right from the start.

Appendix A: Life Cycle Cost Analysis

Courtesy Alaska Energy Engineering LLC

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 alaskaenergy@gci.net

Life Cycle Cost Analysis

June 27, 2015

Kake Senior Center

6kW Grid Connected PV System

Basis

20	Study Period (years)	2.8%	General Inflation
4.5%	Nominal Discount Rate	5.0%	Fuel Inflation
1.7%	Real Discount Rate	4.0%	Electricity Inflation
		4.0%	Wood Pellet Inflation

Construction Costs	Year	Qty	Unit	Base Cost	Year 0 Cost
6 kW PV System	0	1	ls	$41,000.00	$41,000
Contingencies					
Estimating contingency	0			0%	$0
Overhead & profit	0			0%	$0
Design fees	0			0%	$0
Project management	0			0%	$0
				Total Construction Costs	**$41,000**

Annual Costs	Maintenance	$40.00	Years	Qty	Unit	Base Cost	Present Value
PV System							
Monthly Maintenance							
Clean modules, check system		2 hrs every 3 months	1 - 20	8	hrs	$40.00	$5,295
Equipment Replacement							
Replace inverter			10 - 10	1	LS	$3,000.00	$2,491
						Total Annual Costs	**$7,800**

Energy Costs	Years	Qty	Unit	Base Cost	Present Value
Fuel Oil	1 - 20		gallon	$4.66	$0
Wood Pellets	1 - 20		ton	$416.00	$0
Electricity	1 - 20	-5,245	kWh	$0.593	($59,153)
				Total Energy Costs	**($59,200)**

Present Worth	($10,400)

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 alaskaenergy@gci.net

Life Cycle Cost Analysis

June 27, 2015

Kake Senior Center

12 kW Battery Backup PV System

Basis

20	Study Period (years)	2.8%	General Inflation
4.5%	Nominal Discount Rate	5.0%	Fuel Inflation
1.7%	Real Discount Rate	4.0%	Electricity Inflation
		4.0%	Wood Pellet Inflation

Construction Costs	Year	Qty	Unit	Base Cost	Year 0 Cost
12 kW PV System	0	1	ls	$72,000.00	$72,000
Contingencies					
Estimating contingency	0			0%	$0
Overhead & profit	0			0%	$0
Design fees	0			0%	$0
Project management	0			0%	$0
				Total Construction Costs	**$72,000**

Annual Costs	Maintenance	$40.00	Years	Qty	Unit	Base Cost	Present Value
PV System							
Monthly Maintenance							
Clean modules, check system		3 hrs every 3 months	1 - 20	12	hrs	$40.00	$7,943
Equipment Replacement							
Replace batteries			10 - 10	16	ea	$400.00	$5,315
Replace inverter			10 - 10	1	LS	$4,500.00	$3,737
						Total Annual Costs	**$17,000**

Energy Costs	Years	Qty	Unit	Base Cost	Present Value
Fuel Oil	1 - 20		gallon	$4.66	$0
Wood Pellets	1 - 20		ton	$416.00	$0
Electricity	1 - 20	-10,493	kWh	$0.593	($118,340)
				Total Energy Costs	**($118,300)**

Present Worth	**($29,300)**

Attachment 10

Klawock – High Efficiency Low Emission Wood Fired Heating System Pre-Feasibility Report

THRHA Regional Housing Authority
Juneau, Alaska

High Efficiency Low Emission Wood Fired Heating System Pre-Feasibility Report

September 2, 2014

Version: Final

Prepared for:
Tlingit-Haida Regional Housing Authority
Klawock Senior Center & Craig Senior Center

In Partnership with :
Fairbanks Economic Development Corporation
Alaska Wood Energy Development Task Group

Prepared By:

WES Energy & Environment, LLC
902 Market Street • Meadville, PA 16335
(814) 337-8223

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1.0 EXECUTIVE SUMMARY

This preliminary feasibility study evaluates options for the Tlingit-Haida Regional Housing Authority to utilize high efficiency low emission wood fired technologies at the Craig Senior Center and the Klawock Senior Center located on Prince of Wales Island, Alaska. Installation of a wood fired heating system would present the Tlingit-Haida Regional Housing Authority with the opportunity to reduce operating costs, utilize a renewable fuel for heating, and keep fuel expenditures within the regional economy.

The two centers are located 7 miles away from each other and are each evaluated for independent wood fired heating systems. Figure 1 shows an aerial picture of the Klawock Senior Center located in Klawock, Alaska.



Figure 1 – Aerial View of the Klawock Senior Center

Image source: Bing Maps

Figure 2 shows an aerial picture of the Craig Senior Center located in Craig, Alaska.



Figure 2 – Aerial View of the Craig Senior Center
Image source: Google Earth

Both buildings utilize #1 fuel oil fired boiler plants for space heating and domestic hot water heating. Two biomass boiler technologies including wood pellet and split cord wood systems were considered for each facility. A summary of the costs and benefits for each option are listed in Table ES1.

Table ES1 – Cost and Benefit Summary

Option	Estimated Capital Cost	1st Year Net Annual Operating Savings	Simple Payback, Years	20 Year Net Present Value	20 Year B/C Ratio
1a – Klawock Senior Center Wood Pellet System	$102,275	$4,168	24.5	(10,626)	0.90
1b – Klawock Senior Center Cord Wood System	$97,405	$6,500	15.0	37,842	1.39
2a – Craig Senior Center Wood Pellet System	$131,497	$1,601	82.2	(93,983)	0.29
2b – Craig Senior Center Cord Wood System	$103,667	$3,182	32.6	(36,461)	0.65

Notes:

1 – Net Annual Operating Savings include costs for wood fuel, supplemental fossil fuel, and operation & maintenance (O&M) costs.

2 – 20 Year Net Present Value takes the present value of the operating savings for each year using a discount rate of 3.0% as published in the "Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis -2013" and the initial capital outlay of the total project cost. A value greater than zero means that savings are greater than expenses over 20 years in the value of today's dollars.

3 – 20 Year Benefit/Cost (B/C) Ratio is calculated by dividing the present value of net annual operating savings over a 20 year period with a discount rate of 3.0% by the Estimated Capital Cost. A value greater than 1 means the benefits exceed the costs over a 20 year period.

2.0 EXISTING FUEL USAGE & HEATING SYSTEM

The Craig and Klawock Senior Centers both use #1 fuel oil fired heating systems. This section gives an overview of the fuel use and descriptions of the heating systems for each facility.

2.1 KLAWOCK SENIOR CENTER

The Klawock Senior Center is a 24,980 ft^2 facility housing approximately 30 residents and staff. The facility used approximately 5,000 gallons of #1 fuel oil annually for space heating and domestic hot water heating. Annual expenditures are approximately $20,650 at the current fuel price of $4.13 per gallon. An above ground 1,100 gallon fuel oil tank is used for onsite storage.

The boiler room contains two model WTGO-7 Weil McLain hot water boilers firing on #1 fuel oil and rated at 210,000 Btu/hr output and 50 psig. The boilers were installed in 2008 and are in excellent condition. The hot water heating distribution system is a primary-secondary piping system with individual zone pumps distributing water throughout the building. Baseboard fin tube radiant heaters provide space heating for rooms. A makeup air handling unit with a hot water coil is used for the kitchen and common area. A digital control system is installed by Delta Controls, however there is no way to interface with the control system without bringing in a service technician with a laptop and appropriate software. Domestic hot water is heated indirectly using the heating boilers and stored in two 120 gallon HTP Superstor tanks. There is potential room in the existing boiler room to locate hot water thermal storage tanks and one wood fired boiler.

Fuel deliveries for calendar year (CY) 2013 are used for the purposes of load modeling and boiler sizing in this memorandum. The heating degree days for CY 2013 were fairly close to the 30 year average for the region. Thus, CY 2013 weather data from Klawock, Alaska is used with the 5,000 gallon annual fuel oil use for the purposes of load modeling and boiler sizing in this study. Figure 2 shows how the daily average heating demand for the Klawock Senior Center would be expected to vary over the course of a year. During a 24-hr period, the actual load will vary above and below this average value. Peak loads are estimated at 130% of the average load. Peak loads would be experienced for short durations over a 24 hour period.

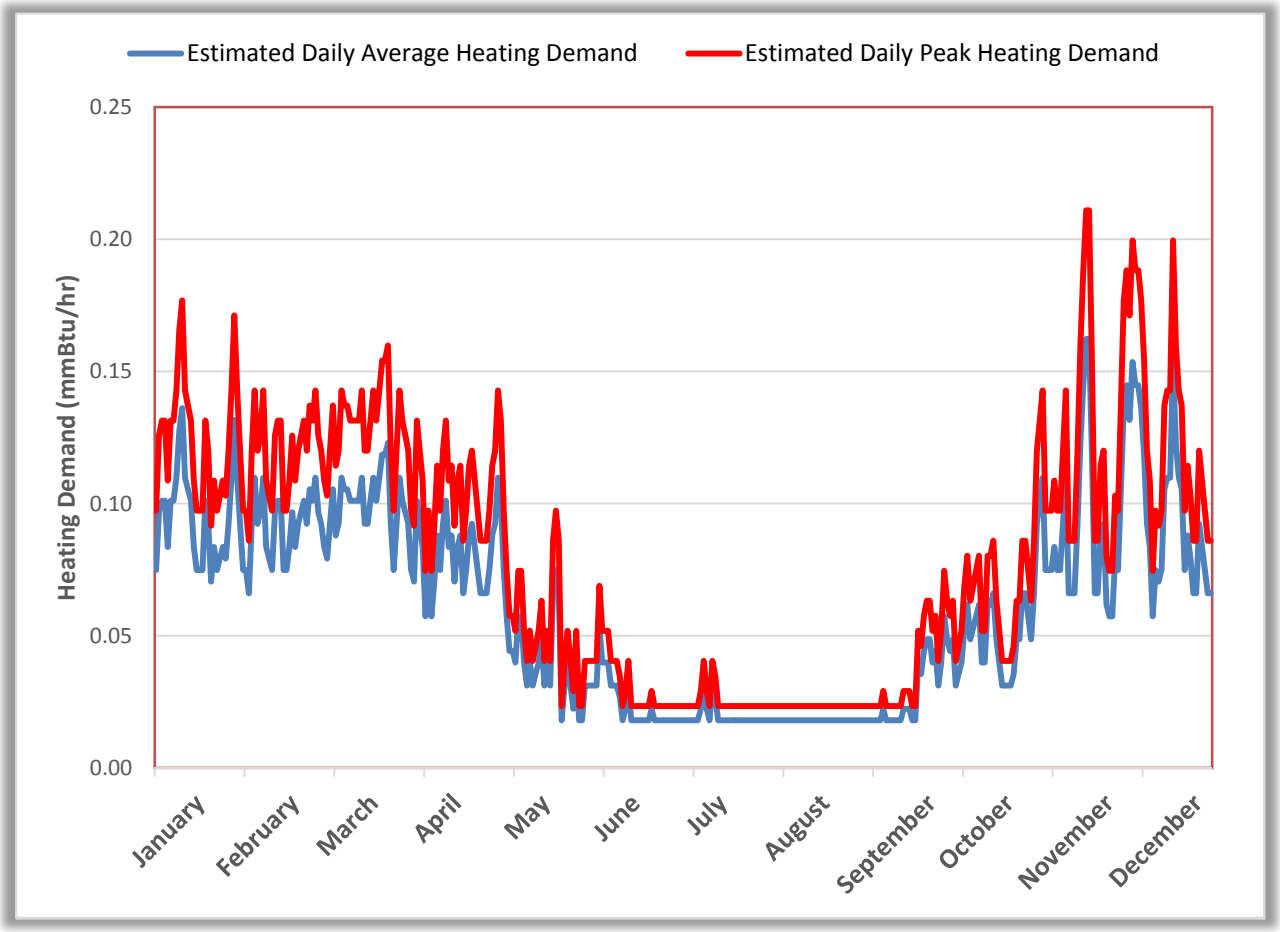


Figure 3 – Klawock Senior Center Estimated Average Daily Heating Demand for CY 2013

Note: The daily average heating demand model is based on local weather data and annual fuel usage provided by the Tlingit-Haida Regional Housing Authority. The model assumes that each person uses 20 gallons of domestic hot water per day for bathing, cooking, laundry, and hand washing. Actual demand would fluctuate above and below the average heating demand values shown over a 24-hr period. The peak demand is estimated as 130% of the average demand and would only be experienced for short durations over a 24 hour period.

A load duration curve was developed using the daily average heating demand curves. Load duration curves sort the daily average heating demand over the course of a year from highest to lowest and plot it over the number of days to show the annual range of facility heating demand. Figure 4 shows the estimated load duration curve for CY 2013.

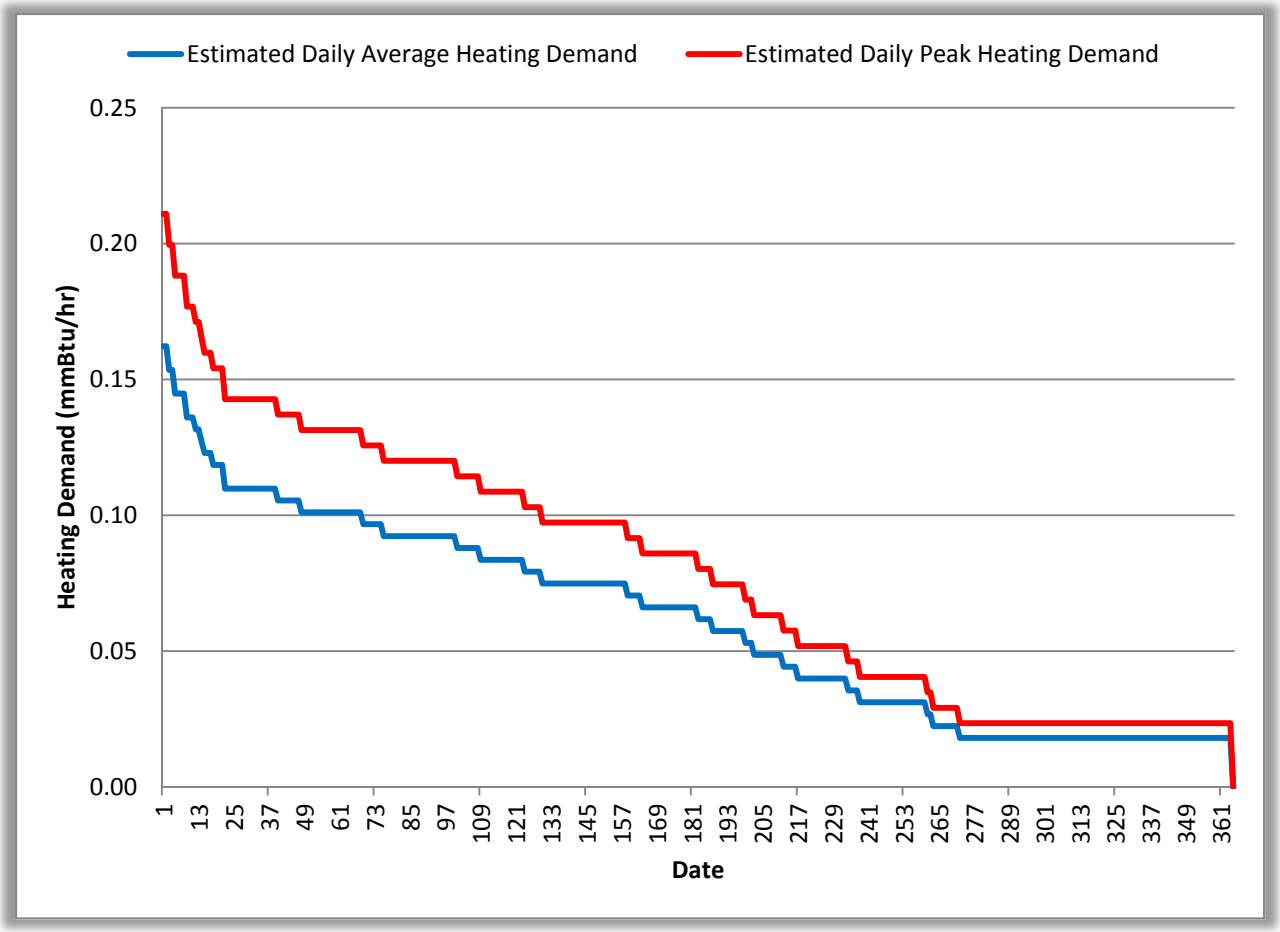


Figure 4 – Klawock Senior Center Estimated Load Duration Curve for CY 2013

Note: The daily average heating demand model is based on local weather data and annual fuel usage provided by the Tlingit-Haida Regional Housing Authority. The model assumes that each person uses 20 gallons per day of domestic hot water. Actual demand would fluctuate above and below the daily average heating demand values shown over a 24-hr period. The peak demand is estimated as 130% of the average demand and would only be experienced for short durations over a 24 hour period.

2.2 CRAIG SENIOR CENTER

The Craig Senior Center is a 5,400 ft^2 facility housing 10 residents. The facility used approximately 3,000 gallons of #1 fuel oil annually for space heating and domestic hot water heating. Annual expenditures are approximately $12,390 at the current fuel price of $4.13 per gallon. An above ground 1,000 gallon fuel oil tank is used for onsite storage.

The boiler room contains two model P-WGO-6 Weil McLain hot water boilers firing on #1 fuel oil and rated at 184,000 Btu/hr output and 50 psig. The boilers were installed in ~2004 and are in good condition. The vent piping shows signs of corrosion from condensation in the flue gas. Return water temperatures should not be below 140°F to the boiler to prevent condensation. This can be accomplished by controlling water distribution temperatures or through the use of a boiler protection valve.

The hot water heating distribution system is a primary-secondary piping system with individual zone pumps distributing water throughout the building. Baseboard fin tube heaters provide

space heating for rooms. Thermostats in each room and control valves on the fin tube heaters are the only control for the system. Domestic hot water is heated indirectly using the heating boilers and stored in a Crown Mega-Stor tank. There is no room in the existing boiler room to locate a wood fired boiler system or thermal storage tanks. Additionally, space constraints around of the building could provide a challenge for siting a system and onsite fuel storage.

Fuel deliveries for calendar year (CY) 2013 are used for the purposes of load modeling and boiler sizing in this memorandum. The heating degree days for CY 2013 were fairly close to 30 year average for the region. Thus, CY 2013 weather data from Klawock, Alaska is used with the 3,000 gallon annual fuel oil use for the purposes of load modeling and boiler sizing in this study. Figure 2 shows how the daily average heating demand for the Craig Senior Center would be expected to vary over the course of a year. During a 24-hr period, the actual load will vary above and below this average value. Peak loads are estimated at 130% of the average load. Peak loads would be experienced for short durations over a 24 hour period.

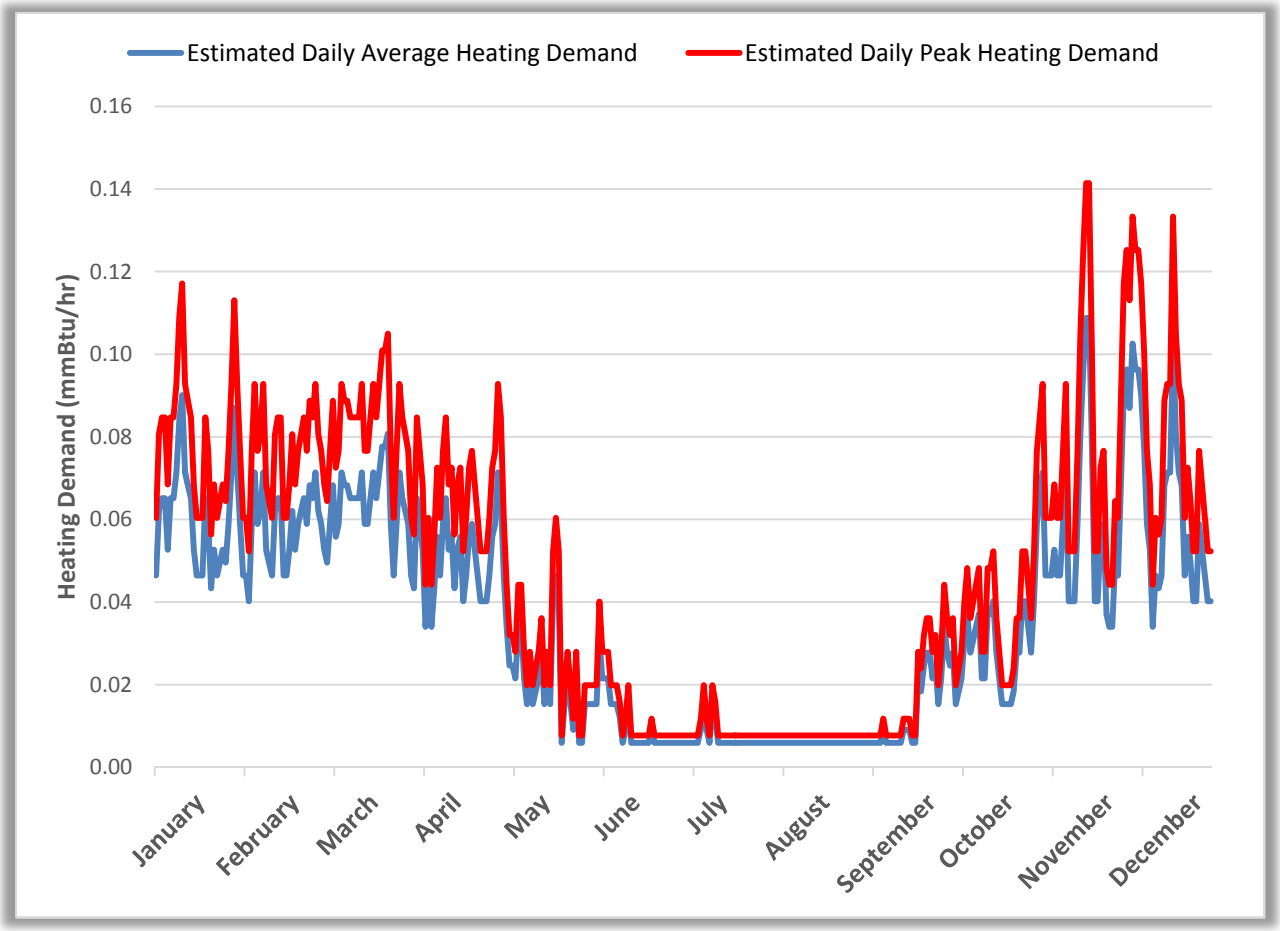


Figure 5 – Craig Senior Center Estimated Average Daily Heating Demand for CY 2013

Note: The daily average heating demand model is based on local weather data and annual fuel usage provided by the Tlingit-Haida Regional Housing Authority. Actual demand would fluctuate above and below the average heating demand values shown over a 24-hr period. The peak demand is estimated as 130% of the average demand and would only be experienced for short durations over a 24 hour period.

A load duration curve was developed using the daily average heating demand curves. Load duration curves sort the daily average heating demand over the course of a year from highest to lowest and plot it over the number of days to show the annual range of facility heating demand. Figure 4 shows the estimated load duration curve for CY 2013.

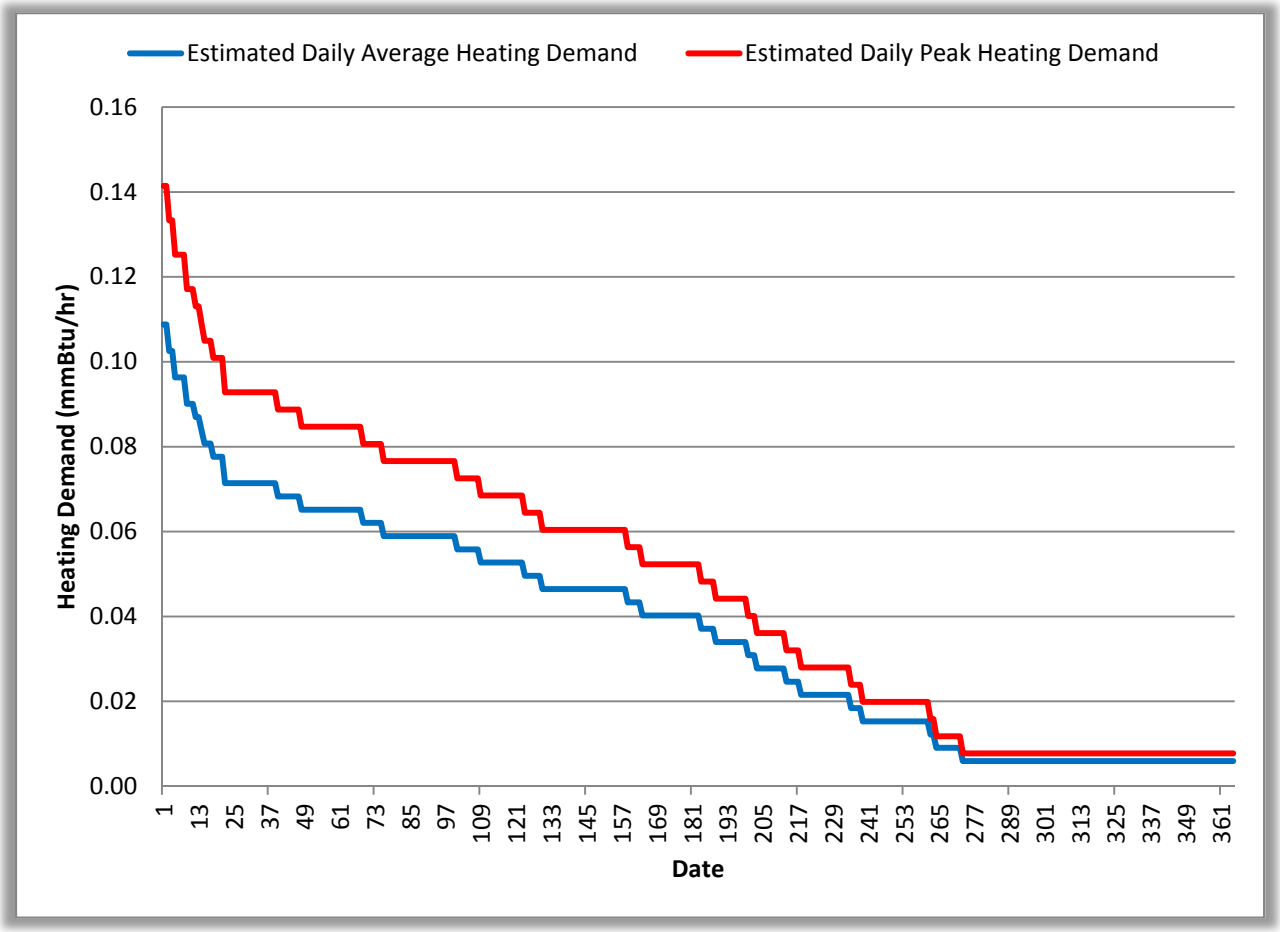


Figure 6 – Craig Senior Center Estimated Load Duration Curve for CY 2013

Note: The daily average heating demand model is based on local weather data and annual fuel usage provided by the Tlingit-Haida Regional Housing Authority. Actual demand would fluctuate above and below the daily average heating demand values shown over a 24-hr period. The peak demand is estimated as 130% of the average demand and would only be experienced for short durations over a 24 hour period.

3.0 FOREST RESOURCE AND FUEL AVAILABILITY

Prince of Wales Island is heavily forested with the majority of the land owned by the US Forest Service and smaller tracts owned by State and private owners. Federal resources on the island are managed by the Tongass Land Management Plan. The most recent version was adopted in 2008.

Potential fuel suppliers were contacted for pricing and availability of biomass fuel. Table 1 lists the companies contacted, location, contact information, and fuels available.

Table 1 – Contacted Fuel Supplier's

Company	Location	Phone	Fuels
Welcome Inn B&B	Thorne Bay	907-828-3950	Palletized Split Cordwood
Viking Lumber	Klawock	907-755-8880	Dry wood chips, Dry Sawdust, Wet Wood Chips, Compressed Bricks
Tongass Forest Enterprises	Ketchikan	907-617-4542	Wood Pellets

The biomass fuels considered for evaluation in this report are wood pellets and split cord wood. Fuel prices used for evaluation are $330 per ton for wood pellets and $250 per 4' x 4' x 8' cord. Table 2 summarizes the available fuels for heating as well as their cost per mmBtu output comparison.

Table 2 – Fuel Pricing and Cost per mmBtu

Fuel, Unit	Cost per Unit	Input Heating Value, mmBtu per Unit	Estimated Boiler Efficiency	Boiler Output Heating Value, mmBtu/Unit	Boiler Output Heating Cost, $/mmBtu
Dry Cord Wood, Cord	$250.00	18.1	70%	12.67	$19.73
Wood Pellets, Ton	$330.00	15.2	80%	12.16	$27.14
#1 Fuel Oil, Gallon	$4.13	0.134	80%	0.1072	$38.53

Note:

1 - Assumes 20% moisture content wet basis for cord wood and 18.1 mmBtu per 4' x 4' x 8' cord of Sitka Spruce.[1]

2 - Input heating value assumes 8% moisture content wet basis for wood pellets with an average High Heating Value of 8,255 Btu/lb of bone dry wood based on a mixture of Sitka Spruce (8,100 Btu/lb) and Western Hemlock (8,410 Btu/lb)[2]*.*

4.0 PROPOSED BIOMASS SYSTEM OPTIONS

Options for using high efficiency low emission biomass systems were evaluated for heating the Klawock and Craig Senior Centers. The Klawock Senior Center has space to fit one boiler firing on cord wood or wood pellets and hot water thermal storage in the existing boiler room. The Craig Senior Center does not have any additional space available and would need to locate the new boiler and thermal storage outside in a shed style building or container. This section described the proposed systems in detail.

4.1 KLAWOCK SENIOR CENTER BIOMASS SYSTEM OPTIONS

Two high efficiency low emission biomass fired boiler systems are evaluated for interconnection with the existing heating system at the Klawock Senior Center. Option 1a considers a boiler system that would fire on wood pellets. Option 1b considers a boiler system that would fire on cord wood.

[1] http://www.alaskawoodheating.com/energy_content.php

[2] Avery, Robert B., Funck, James W., & Wilson, Pamela L. (2010). *Fuelwood Characteristics of Northwestern Conifers and Hardwoods (updated)*. Portland, Or.: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

4.1.1 Option 1a : 160,000 Btu/hr Wood Pellet System

One advanced combustion wood pellet boiler sized at approximately 0.16 mmBtu/hr of heat output would be combined with approximately 200 gallons of thermal storage to efficiently meet the range of heating needs. The rated operating range of the system would be from ~0.05 to ~0.16 mmBtu/hr with thermal storage allowing short term peaks to be met. The hot water thermal storage would be heated to a preset temperature (typically 195°F or higher) that is higher than distributed for building heat. The thermal storage tank(s) would use a 3-way mixing valve to blend hot water in the tank with colder return water from the senior center to maintain a range of supply water temperatures (160°F – 190°F) determined by an outside air temperature reset schedule.

The storage would allow the system to meet a 1-hr peak of ~0.18 mmBtu/hr and a 15 minute peak of ~0.26 mmBtu/hr. The storage would also allow the boiler to operate efficiently to provide domestic hot water heating. The storage will hold approximately 88,000 Btu for domestic hot water usage. This allows the pellet boiler to fire for a period of approximately 30 minutes within its efficient firing range to charge the storage. The heat in the storage is then used to provide domestic hot water needs, until the temperature drops to ~140^{O}F and the system has to fire to charge it once more.

The wood pellet boilers, metering bin, expansion tank, valves, fittings, and boiler pump will be installed in the existing boiler room. A fuel storage bin capable of holding 30 tons of wood pellets will be located next to the building to accept bulk deliveries of wood pellets pneumatically or with an auger. Wood pellets will be automatically transferred using a flexible auger or pneumatic hose from the storage bin to a metering bin that feeds the wood pellet boiler. The wood pellet boiler will heat the hot water thermal storage system located in the existing boiler room. The hot water thermal storage will tie in with the existing heating distribution pipes. The existing fuel oil fired heating boilers would remain to supplement the biomass system during periods of maintenance and if the heating demand is outside the range of the biomass system. Appendix A contains a conceptual site plan, floor plan, and schematic for the biomass system. Figure 7 shows the estimated wood pellet system coverage of the FY 2013 load duration curve.

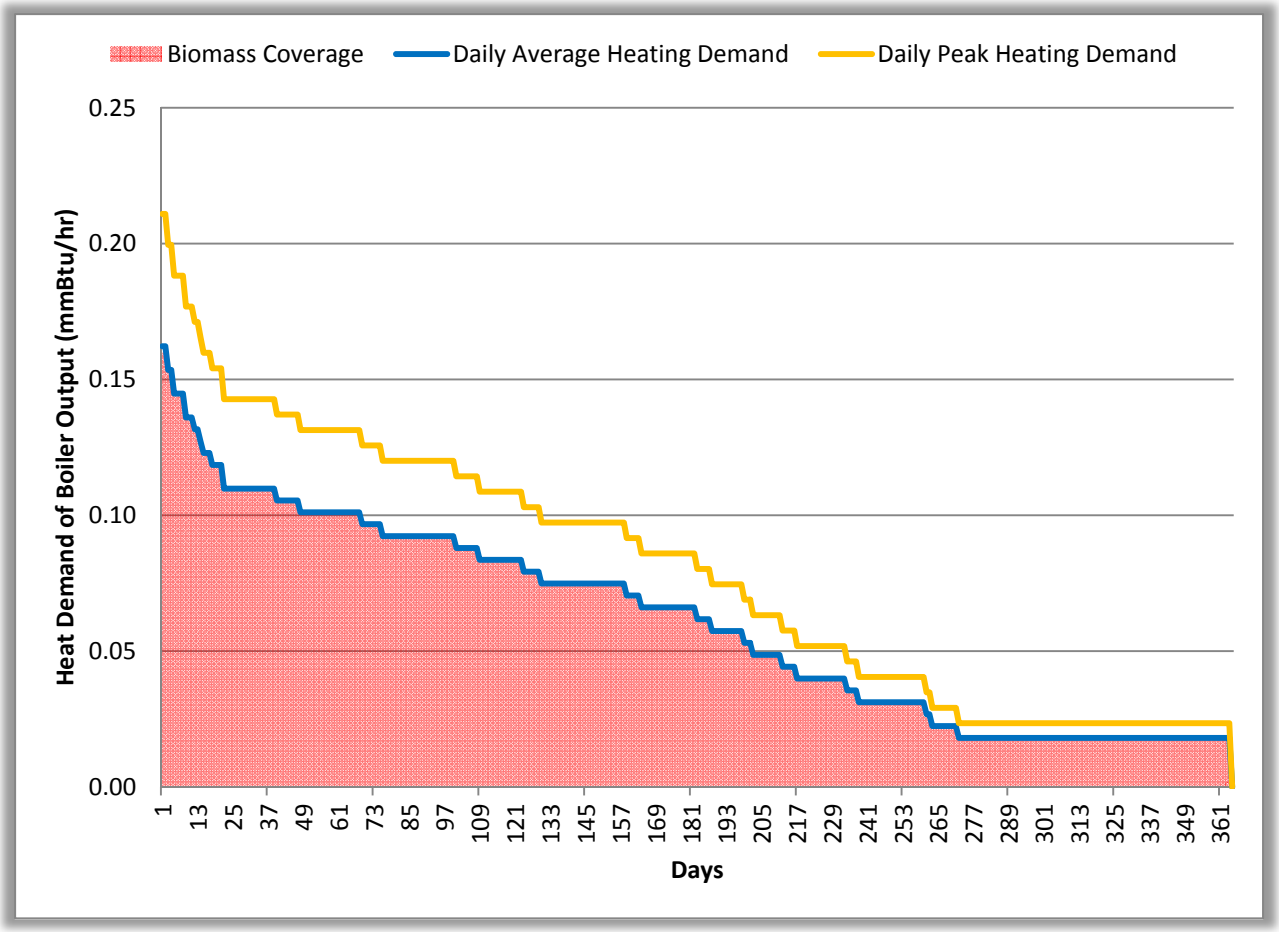


Figure 7 – Estimated Wood Pellet System Coverage of Load Duration Curve

Note: The load duration curve model is based on local weather data and annual fuel delivery volumes provided by Tlingit-Haida Regional Housing Authority. Potential coverage of 99% is shown. Actual coverage will depend on management of loads and the use of thermal storage. The system can be used as described in the text to cover approximately 100% of the annual demand. Management of loads, the use of thermal storage, and operations will determine actual biomass coverage.

Figure 7 shows 99% biomass coverage of the FY 2013 load duration curve. Actual coverage will vary depending on weather conditions, peak demands, equipment operation schedules, and periods when the boilers are shut down for maintenance. This report assumes 95% coverage of fuel oil usage for estimating the potential fuel use and savings for this memorandum.

4.1.2 Option 1b : 100,000 Btu/hr Cord Wood System

An advanced combustion unit and hot water boiler capable of firing on seasoned cord wood sized at approximately 100,000 Btu/hr of heat output is evaluated. The boiler would be combined with approximately 500 gallons of thermal storage to efficiently meet the center's range of heating needs.

Welcome Inn B&B in Thorne Bay provides half cords stacked and wrapped on a pallet. Deliveries could be coordinated with up to 10 cords delivered at once. A local freight company provides the option to tow a forklift behind the truck for unloading. It is assumed that this

option is exercised and a forklift is not included in the budget. A 600 ft^2 cord wood storage building will be constructed across the parking lot of the Klawock Senior Center. This will allow the storage of approximately 15 to 18 cords of wood. The floor will be concrete to allow the use of a pallet jack to roll a half cord at a time from the storage building, across the parking lot, and into a more convenient location in the building to load the boiler.

Cord wood systems are manually loaded and operate efficiently while burning hot and fast. Seasoned wood is loaded into the firebox, is lit, and should be operated at high fire. Cord wood boilers can "turn-down" the heating output by reducing air to the firebox. This causes the wood to smolder and smoke is emitted due to inefficient combustion. If a cord wood system is rated at an average output of 100,000 Btu/hour over 8 hours, most of the heat is generated during the first couple hours and then tapers off over the remaining period. Because of this, hot water thermal storage is crucial for efficient operation. The hot water thermal storage will provide a buffer for the boiler to charge the tank with more heat than is required for the building. The heat stored in the tank will then be used over the course of the day to heat the building. Additionally, the operator should try to gauge how much wood fuel to charge the fire box with based on expected heat load.The firebox will likely not need to be filled to the top if it is operating during the summer for only domestic hot water loads.

The hot water thermal storage will hold approximately 240,000 Btu for domestic hot water usage. Two 120 gallon superstore tanks are currently used for domestic hot water storage that can store up to 125,000 Btu of heat total. If the operator lit the boiler in the morning to charge thermal storage system and the existing hot water super store tanks, the boiler would need to be loaded approximately half full. The tanks could then be charged again at the end of the day if needed. If the demand for hot water during the day exceeds what is stored in all of the tanks, the fuel oil system would fire to bridge the gap. The estimated coverage using the cord wood boiler for the Klawock Senior Center is shown in Figure 8.

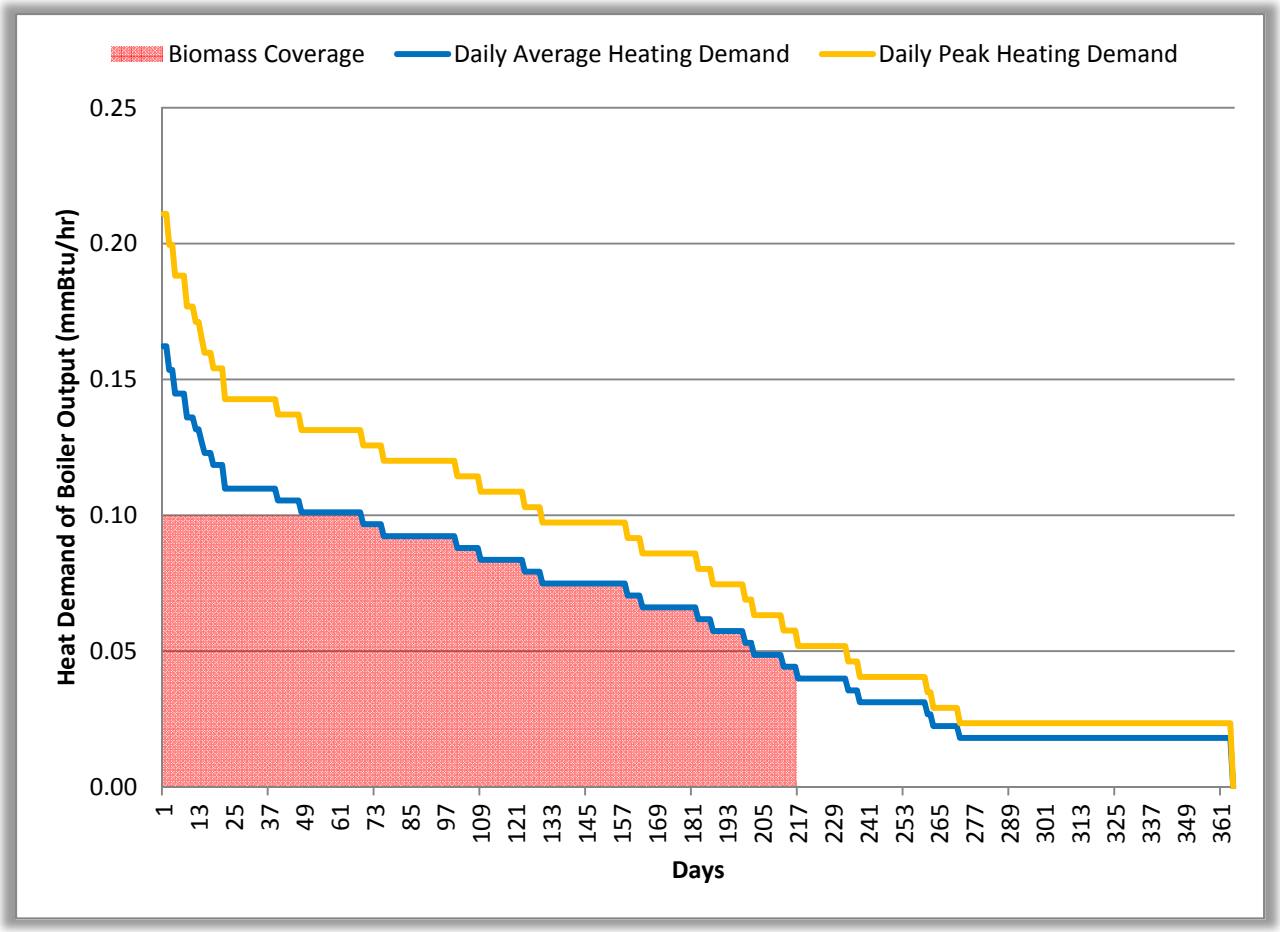


Figure 8 – Estimated Cord Wood System Coverage of Load Duration Curve

Note: The load duration curve model is based on local weather data and annual fuel delivery volumes provided by Tlingit-Haida Regional Housing Authority. Potential coverage of 80% is shown. Actual coverage will depend on management of loads and the use of thermal storage.

Figure 8 shows 80% biomass coverage of the FY 2013 load duration curve as the red shaded portion. The existing fuel oil system will supplement the wood chip boiler during peak loads, low loads, and during periods of maintenance. Actual coverage will vary depending on weather conditions, peak demands, equipment operation schedules, and periods when the boilers are shut down for maintenance. This report assumes 80% coverage of fuel oil usage for estimating the potential fuel use and savings for this memorandum.

There are currently limited manufacturers who offer an ASME rated cord wood boiler. An open non pressurized system could be utilized with a non-ASME rated boiler to heat the system with piping and control modifications. The non-ASME rated boiler transfers heat to the existing pressurized system via a heat exchanger. Cost effective heat exchanger design will reduce the temperature that can be delivered on the pressure side of the system by about 5 °F.

4.2 Craig Senior Center Biomass System Options

Two high efficiency low emission biomass fired boiler systems are evaluated for interconnection with the existing heating system serving the Craig Senior Center. Option 2a

considers a boiler system that would fire on wood pellets. Option 2b considers a boiler system that would fire on cord wood.

4.2.1 Option 2a : 110,000 Btu/hr Wood Pellet System

One advanced combustion wood pellet boiler sized at approximately 0.11 mmBtu/hr of heat output would be combined with approximately 200 gallons of thermal storage to efficiently meet the range of heating needs. The rated operating range of the system would be from ~0.03 to ~0.11 mmBtu/hr with thermal storage allowing short term peaks to be met. The hot water thermal storage would be heated to a preset temperature (typically 195°F or higher) that is higher than distributed for building heat. The thermal storage tank would use a 3-way mixing valve to blend hot water in the tank with colder return water from the senior center to maintain a range of supply water temperatures (160°F – 190°F) determined by an outside air temperature reset schedule.

The storage would allow the system to meet a 1-hr peak of ~0.13 mmBtu/hr and a 15 minute peak of ~0.20 mmBtu/hr. The storage would also allow one boiler to operate efficiently to provide domestic hot water heating. The storage will hold approximately 88,000 Btu for domestic hot water usage. This allows one pellet boiler to fire for a period of approximately 50 minutes within its efficient firing range to charge the storage. The heat in the storage is then used to provide domestic hot water needs, until the temperature drops to ~140^{o}F and the system has to fire to charge it once more.

The wood pellet boiler, thermal storage tank, metering bin, expansion tank, valves, fittings, and distribution pumps will be factory installed in a roll off shipping container. The container can vary depending on the manufacturer selected, but can be a roll off shipping container or wood paneled storage box. A fuel storage bin capable of holding 30 tons of wood pellets will be installed for fuel storage. Smaller storage bins could be used, but typical bulk deliveries are made in ~20 ton loads. This can be located adjacent to the building if a portion of the deck is removed or in the front parking lot. Wood pellets will be automatically transferred using a flexible auger or pneumatic hose from the storage bin to a metering bin that feeds the wood pellet boiler. Heating distribution pipes will be installed from the wood pellet heating plant to the existing fuel oil fired boiler plant. The thermal storage system will be located in the existing fuel oil boiler plant and tie-in with the existing hot water heating system. The existing fuel oil fired heating boilers would remain to supplement the biomass system during periods of maintenance and if the heating demand is outside the range of the biomass system. Appendix A contains a conceptual site plan, floor plan, and schematic for the biomass system. Figure 9 shows the estimated wood pellet system coverage of the FY 2013 load duration curve.

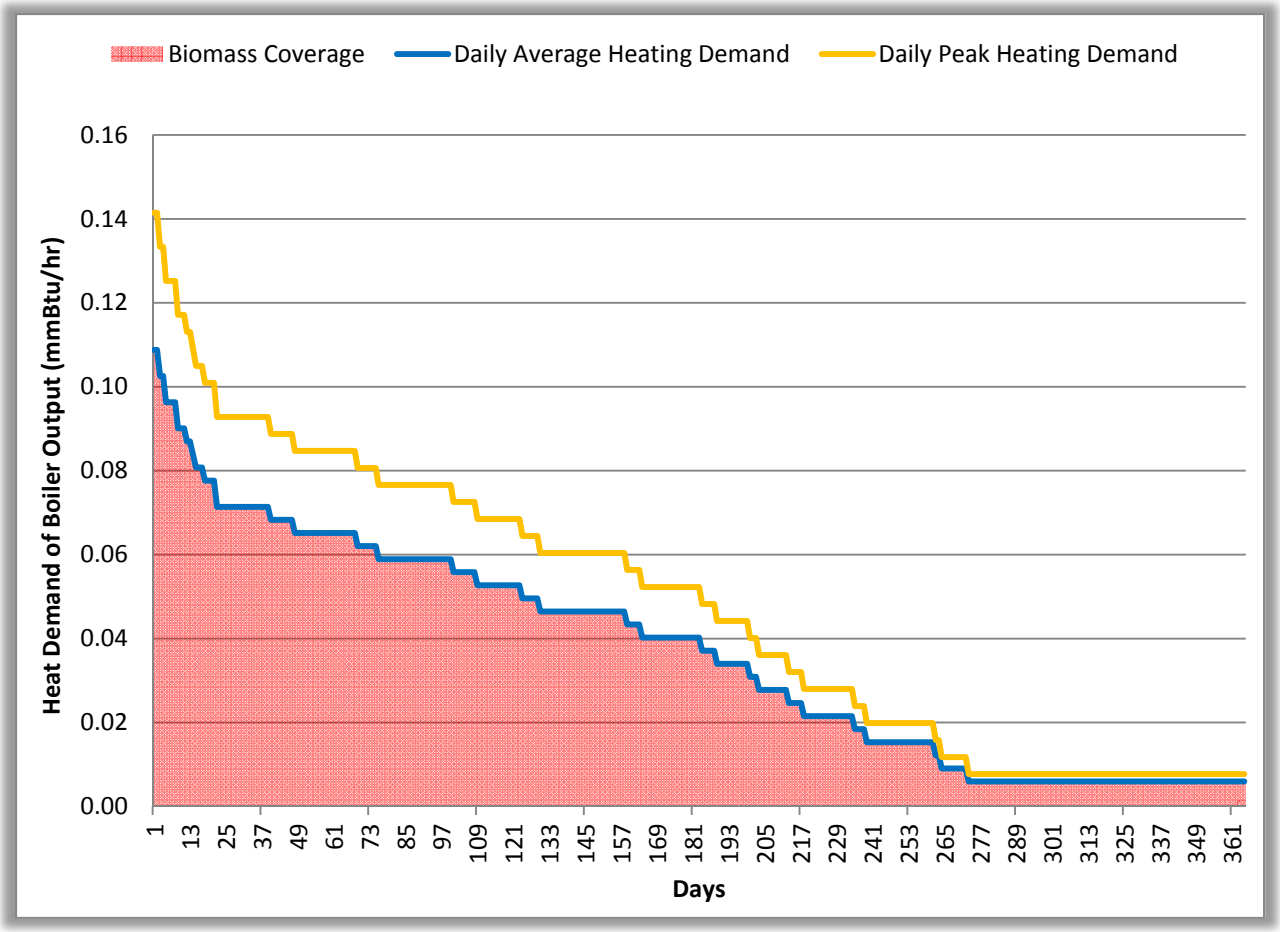


Figure 9 – Estimated Wood Pellet System Coverage of Load Duration Curve

Note: The load duration curve model is based on local weather data and annual fuel delivery volumes provided by Tlingit-Haida Regional Housing Authority. Potential coverage of 100% is shown. Actual coverage will depend on management of loads and the use of thermal storage.

Figure 9 shows 100% biomass coverage of the FY 2013 load duration curve. Actual coverage will vary depending on weather conditions, peak demands, equipment operation schedules, and periods when the boilers are shut down for maintenance. This report assumes 95% coverage of fuel oil usage for estimating the potential fuel use and savings for this memorandum.

4.2.2 Option 2b : 100,000 Btu/hr Cord Wood System

An advanced combustion unit and hot water boiler capable of firing on seasoned cord wood sized at approximately 100,000 Btu/hr of heat output is evaluated. The boiler would be combined with approximately 500 gallons of thermal storage to efficiently meet the center's range of heating needs. This boiler size was chosen because typically it is the smallest boiler offered by manufacturers. The boiler operator would have to take care to charge the firebox based on expected load to ensure that the boiler does not idle and produce excess smoke.

The hot water thermal storage will hold approximately 240,000 Btu for domestic hot water usage. One 100 gallon tank is currently used for domestic hot water storage that can store up to 52,000 Btu of heat total. If the operator lit the boiler in the morning to charge the thermal storage system and the existing hot water super store tanks, the boiler would need to be loaded approximately half full. The tanks could then be charged again at the end of the day if needed. If the demand for hot water during the day exceeds what is stored in all of the tanks, the fuel oil system would fire to bridge the gap. The estimated coverage using the cord wood boiler for the Craig Senior Center is shown in Figure 10.

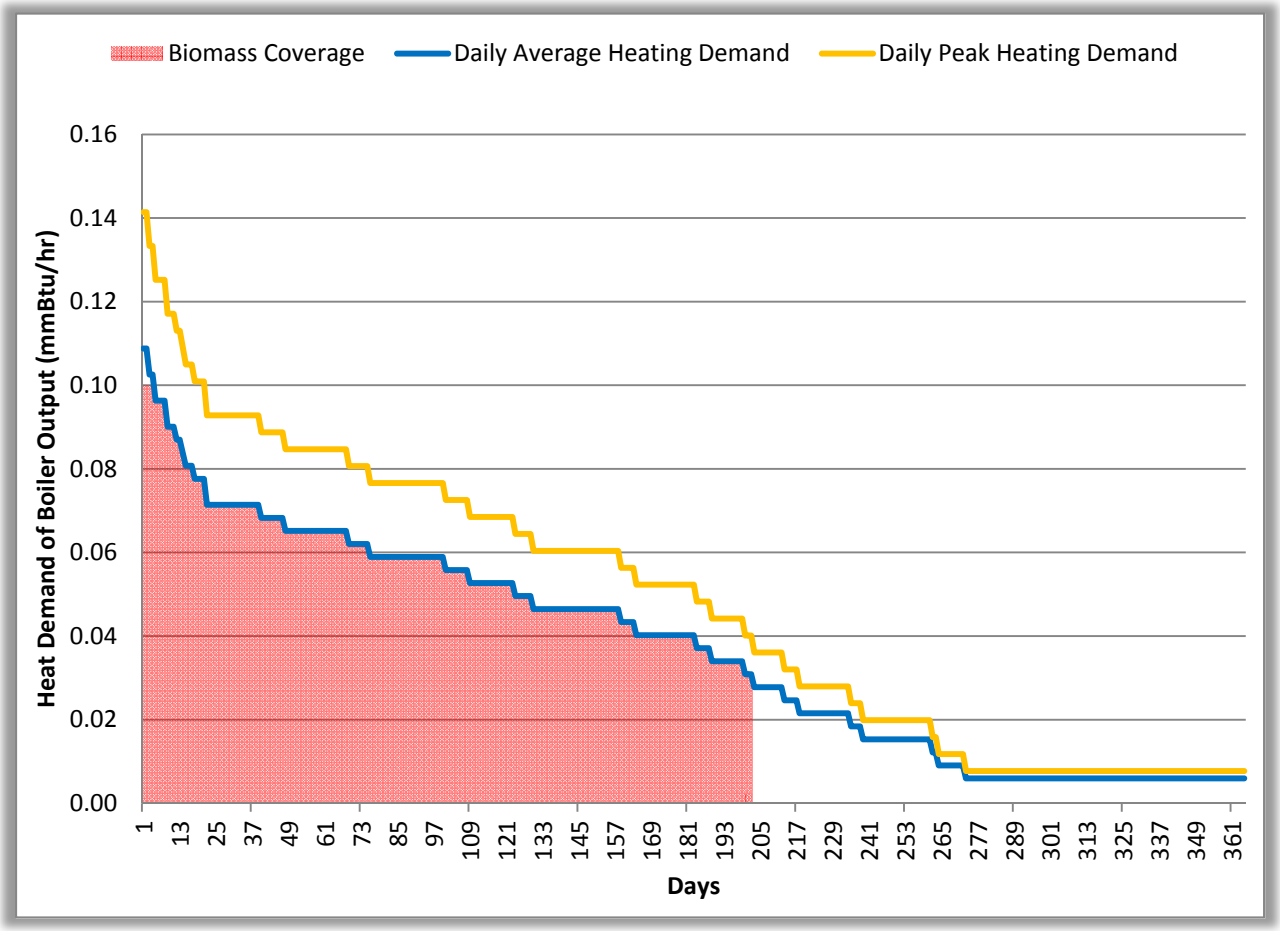


Figure 10 – Estimated Cord Wood System Coverage of Load Duration Curve

Note: The load duration curve model is based on local weather data and annual fuel delivery volumes provided by Tlingit-Haida Regional Housing Authority. Potential coverage of 86% is shown. Actual coverage will depend on management of loads and the use of thermal storage.

Figure 10 shows 86% coverage of the FY 2013 load duration curve using the cord wood system. The existing fuel oil system in the boiler room will supplement the cord wood system as needed. Actual coverage will vary depending on weather conditions, peak demands, equipment operation schedules, and periods when the boilers are shut down for maintenance. This report assumes 80% coverage for the cord wood system for estimating the potential fuel use and savings for the Craig Senior Center.

5.0 BENEFIT/COST ANALYSIS

Capital costs are estimated for each option based on recent quotations and bids provided by boiler manufacturers and recent bids for similar projects. These costs include the fuel storage and handling system, biomass combustion unit, boiler, accessory equipment, installation, integration with the existing heating and domestic hot water systems, professional fees, and contingency. The estimated capital costs for each Option are listed in Table 3. Tables showing the detailed cost breakdowns are found in Appendix B.

Table 3 – Estimated Project Capital Costs

Option	Estimated Capital Cost
1a – Klawock Senior Center Wood Pellet System	$102,275
1b – Klawock Senior Center Cord Wood System	$97,405
2a – Craig Senior Center Wood Pellet System	$131,497
2b – Craig Senior Center Cord Wood System	$103,667

It is assumed that existing staff would coordinate deliveries, empty ash bins, and check on the system. Ash removal costs have been estimated at $70 per ton of ash and $220 per container delivery. Option 1b would generate the largest quantity of ash and would result in approximately 3 cubic yards annually. Wood ash can be used as a direct replacement for lime and costs for removal could be reduced if it is used as a soil amendment on school grounds or other locations.

An increase in electricity use would occur from the circulation pumps and fuel handling system. Electricity costs using a price of $0.1272/ kWh have been estimated considering motors for pumps, augers, and fans for the wood pellet system and motors for pumps and fans for the cord wood system. Annual operation and maintenance (O&M) costs are estimated for each option and are listed in Table 4.

Table 4 – Estimated Annual O&M Costs

Task	Option 1a	Option 1b	Option 2a	Option 2b
Electricity	$350	$180	$360	$180
Ash Removal	$240	$340	$230	$300
Annual Service	$1,000	$1,000	$1,000	$1,000
Totals	**$1,590**	**$1,520**	**$1,590**	**$1,480**

Note:

1 – Electricity costs are estimated at $0.1272/kWh as provided by Tlingit-Haida Regional housing Authority.

2 – Ash removal costs are estimated at $70/ton and $220 per container delivery. Ash generation is estimated at 0.5% by weight for wood pellets and 4% by weight for cord wood. Ash is a valuable product that can be used a soil amendment and costs for removal could be mitigated if used as such.

Annual operating savings are estimated considering fuel costs and O&M costs. Table 5 shows the estimated annual operating savings for each option.

Table 5 – Estimated Annual Operating Savings

Option	Current Annual Fuel Oil Cost	Estimated Annual Biomass Cost	Estimated Annual Fuel Oil Cost with Biomass System	Estimated Additional Annual O&M Costs	Estimated Annual Savings
1a – Klawock Senior Center Wood Pellet System	$20,650	$13,860	$1,033	$1,590	$4,168
1b – Klawock Senior Center Cord Wood System	$20,650	$8,500	$4,130	$1,520	$6,500
2a – Craig Senior Center Wood Pellet System	$12,390	$8,580	$620	$1,590	$1,601
2b – Craig Senior Center Cord Wood System	$12,390	$5,250	$2,478	$1,480	$3,182

A benefits summary is listed in Table 6 showing the estimated capital cost, 1st year net operating savings, simple payback, 20 year Net Present Value, and 20 Year Benefits to Cost (B/C) ratio.

Table 6 – Cost and Benefit Summary

Option	Estimated Capital Cost	1st Year Net Annual Operating Savings	Simple Payback, Years	20 Year Net Present Value	20 Year B/C Ratio
1a – Klawock Senior Center Wood Pellet System	$102,275	$4,168	24.5	(10,626)	0.90
1b – Klawock Senior Center Cord Wood System	$97,405	$6,500	15.0	37,842	1.39
2a – Craig Senior Center Wood Pellet System	$131,497	$1,601	82.2	(93,983)	0.29
2b – Craig Senior Center Cord Wood System	$103,667	$3,182	32.6	(36,461)	0.65

Notes:

1 – Net Annual Operating Savings include costs for wood fuel, supplemental fossil fuel, and operation & maintenance (O&M) costs.

2 – 20 Year Net Present Value takes the present value of the operating savings for each year using a discount rate of 3.0% as published in the "Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis -2013" and the initial capital outlay of the total project cost. A value greater than zero means that savings are greater than expenses over 20 years in the value of today's dollars.

3 – 20 Year Benefit/Cost (B/C) Ratio is calculated by dividing the present value of net annual operating savings over a 20 year period with a discount rate of 3.0% by the Estimated Capital Cost. A value greater than 1 means the benefits exceed the costs over a 20 year period.

A cash flow analysis was completed for financing the projects assuming a 20 year financing term at a 4.0% interest rate. None of the Options had a positive first year cash flow after annual payments. However, Option 1b was very close to breaking even and grant funding or better financing rates could easily make this a positive cash flow project. The detailed analyses are shown in Appendix C.

A sensitivity analysis was completed comparing 20 year net present value for each option over a range of annual oil inflation rates and 3.0% for remaining O&M costs. Table 7 shows the results of the 20 year net present value sensitivity analysis.

Table 7 – 20 Year Net Present Value Sensitivity to Oil Inflation Rate

Option	20 Year NPV with Oil Inflation at 3.0% Annually	20 Year NPV with Oil Inflation at 3.3% Annually	20 Year NPV with Oil Inflation at 4.0% Annually	20 Year NPV with Oil Inflation at 6.8% Annually
1a – Klawock Senior Center Wood Pellet System	($21,353)	($10,626)	$15,914	$146,943
1b – Klawock Senior Center Cord Wood System	$28,614	$37,647	$59,997	$170,338
2a – Craig Senior Center Wood Pellet System	($100,419)	($93,983)	($78,059)	$559
2b – Craig Senior Center Cord Wood System	($41,880)	($36,461)	($23,051)	$43,154

Note: Net Present Values are calculated using annual inflation rates of 3% for wood fuel and O&M costs, the inflation rate for oil stated in the table, the initial capital cost, and a discount rate of 3%

Table 8 lists the assumptions and values used to develop costs and savings in this study.

Table 8 – Assumptions and Values Used in the Report

Item	Value and Unit	Source
Klawock Senior Center annual #1 fuel oil use	5,000 gallons	Tlingit-Haida Regional Housing Authority
Craig Senior Center annual #1 fuel oil use	3,000 gallons	Tlingit-Haida Regional Housing Authority
Option 1a portion of fuel oil replaced	95%	WES E&E estimate
Option 1b portion of fuel oil replaced	80%	WES E&E estimate
Option 2a portion of fuel oil replaced	95%	WES E&E estimate
Option 2b portion of fuel oil replaced	80%	WES E&E estimate
#1 Fuel oil heat content	134,000 Btu/gal	WES E&E assumption
Cord wood moisture content wet basis	20%	WES E&E assumption
Wood pellet moisture content wet basis	8%	WES E&E assumption
Cord wood high heating value (Sitka Spruce)	18.1 mmBtu/Cord	University of Alaska Fairbanks Cooperative Extension Service
Wood pellet high heating value	15.2 mmBtu/ton	WES E&E assumption
#1 Fuel oil boiler efficiency (HHV)	80%	WES E&E assumption
Cord wood boiler efficiency (HHV)	70%	WES E&E assumption
Wood pellet boiler efficiency (HHV)	80%	WES E&E assumption
#1 Fuel oil price	$4.13/gallon	Tlingit-Haida Regional Housing Authority
Electricity price	$0.1274	Tlingit-Haida Regional Housing Authority
Cord wood price	$250.00/Cord	Budget quote
Wood pellet price	$330.00/ton	Budget quote
Discount rate	3.0%	NISTIR 85-3273-28
#1 Fuel oil inflation rate	3.3%	WES E&E assumption
Wood pellet inflation rate	3.0%	WES E&E assumption
O&M inflation rate	3.0%	WES E&E assumption
Cord wood inflation rate	3.0%	WES E&E assumption

6.0 CONCLUSIONS & RECOMMENDATIONS

This study concludes that the Tlingit-Haida Regional Housing Authority can reduce annual operating costs for space heating and domestic hot water heating by installing a high efficiency, low emission wood fired heating system for the Craig and Klawock Senior Centers. The projects will offset approximately 80% to 95% of the fuel oil use depending on the option selected.

The Klawock Senior Center has the potential for a cost effective project by using a high efficiency gasification cord wood boiler system and hot water thermal storage. Depending on the rates and structure of the financing, the project has the potential for a positive first year cash flow. The Craig Senior Center has site space constraints that increase the capital costs of the system. Additionally, there is less fuel oil to be offset, making the economics not as attractive. Outside grant funding and low interest loans would improve economics and potentially make a project possible. If 80% of the project costs were secured through grant funding, simple paybacks would range from 5 years for wood pellets to 3 years for cord wood for the Klawock Senior Center and 16.5 years for wood pellets to 6.5 years for cord wood for the Craig Senior Center. Additional benefits that would be provided by a high efficiency, low emission wood fired system include:

- Purchase of cord wood will immediately impact the local economy since the fuel is currently available in Thorne Bay;

- Purchase of wood pellets will impact the regional economy, with pellet production currently operational in Ketchikan, AK;
- Decreased dependence on imported oil by replacing 2,400 to 2,850 gallons of #1 fuel oil at the Craig Senior Center and 4,000 to 4,750 gallons of #1 fuel oil at the Klawock Senior Center with renewable biomass fuel;
- A hedge against volatility of the fossil fuel market;

As the Tlingit-Haida Regional Housing Authority continues to pursue biomass energy options, WES Energy & Environment recommends that the next level of evaluation includes detailed consideration of the following items:

- Selection of the wood fuel technology most appropriate for each site.
- Siting of the fuel storage at the Klawock Senior Center.
- Siting of the biomass plant and fuel storage at the Craig Senior Center.
- Biomass system capital costs based on detailed site investigations, initial plant layout and design, and direct quotes from manufacturers.
- Alternative funding sources (low interest loans, grants, and incentives).

7.0 GENERAL BIOMASS TECHNOLOGY INFORMATION

This section describes technologies that can be used for efficiently using wood for space heating and domestic hot water heating. Manufacturers of each technology are available both domestically and abroad. A partial list of manufacturers is provided for technologies and does not constitute an endorsement. Other manufacturers are available and individual investigations should be completed prior to purchase. Local codes and regulations may require modifications or additional components for compliance depending on the system considered.

High Efficiency Indoor Wood Pellet Boiler

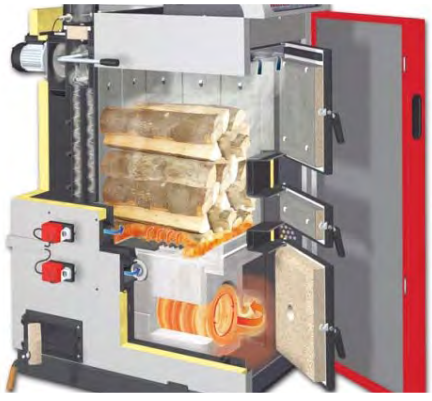
High efficiency indoor wood pellet boilers utilize premium wood pellets as a renewable biomass fuel source for hot water space heating systems. Wood pellets are automatically fed from an adjacent storage hopper into the firebox based on heating demand. Efficiencies can exceed 80% when coupled with a hot water thermal storage system that allows the boiler to operate at high fire to charge the hot water thermal storage tank. Multiple boilers can be operated to increase heating capacity. Equipment costs can vary depending on the heating capacity required. Annual savings can range from $3,000 to $6,000 per year based on a facility using 5,000 gallons of #1 fuel oil per year at current prices. Manual and automatic hopper loading is available. Ash removal is manual. A partial list of manufacturers include ACT Bioenergy, Froling, MESys, Evo World, Windhager, Kedel, and Wood Master.



Source:
http://www.woodboilers.com/products/pellet-boilers/froling-p4-pellet.html

High Efficiency Indoor Cord Wood Boiler

High efficiency indoor cordwood boilers utilize split cordwood as a renewable biomass fuel source for hot water space heating systems. Efficiencies can exceed 70% when coupled with a hot water thermal storage system that allows the cordwood boiler to operate at high fire to charge the hot water thermal storage tank. Equipment costs can range from $7,000 to $15,000 plus installation. Annual savings can range from $1,800 to $2,200 per year based on an average building using 1,500 gallons of #1 fuel oil per year at current prices. Manual loading and ash removal are required. A partial list of manufacturers include Wood Gun, Econoburn, Froling, Windhager, and Wood Master.



Source:
http://www.woodboilers.com/products/woodboilers/froeling-fhg.html

Advanced Biomass Combustion Units and Boilers

Advanced biomass combustion units and boilers are typically an engineered product capable of firing on wood chips, saw mill residue, wood pellets, and saw dust. Fuel is typically delivered in bulk semi-trailer loads and automatically conveyed to the combustion unit. Efficiencies can exceed 70% when coupled with a hot water thermal storage system. Emission controls are typically required to clean up exhaust gasses. Capital costs are high and vary depending on many factors. Annual fuel cost savings can range from $100,000 to $120,000 per year based on a facility using 50,000 gallons of #1 fuel oil per year at current prices. High fuel costs and high fuel usage can potentially make a project feasible. A partial list of manufacturers include Viessman, ACT Bioenergy, Froling, MESys, Evo World, Wood Master, Messersmith Manufacturing, AFS Energy Systems, Solagen, Wellons FEI, and Hurst.



Source:
http://www.afsenergy.com/Biomass%20Energy.htm

Hot Water Thermal Storage System

Thermal storage tanks, also known as accumulator tanks or buffer tanks, can raise the efficiency of hot water heating systems firing on wood. Solid fuels burn more efficiently at higher firing rates than at lower rates or idle modes where the fuel smolders, smokes, and wastes energy. Hot water thermal storage allows the solid fuel boiler to fire efficiently at full output to store the heat at elevated temperatures in storage tanks. For optimum operation a mixing valve is installed to blend cold water returning from the facility with hot water stored in the thermal storage tank. Hot water is sent back to the facility at a temperature that is lower than the storage tanks, providing heat storage and a buffer for short periods of high demand. This method of operation reduces smoldering and smoking from inefficient operation, fuel use, creosote buildup, and the need for frequent stoking.



Source:
http://www.viessmann-us.com/en/District_Heating/Products/dhw/Storage_Tanks.html

District Piping Systems

It can often be cost effective to connect multiple buildings to one central wood fired heating plant. Long runs of buried piping can be installed cost effectively using pre-insulated PEX piping. It is important to use factory injected close cell foam insulation with a High Density Polyethylene (HDPE) insulation jacket to prevent the insulation from being compromised from ground water or leaks. Pipe sizes can range from 3/4" to 5" with roll lengths up to 600 feet. Pipe material costs can be more expensive than traditional iron pipe, however installation costs can be reduced due to longer runs between splices and connections.



Source:
WES Energy & Environment File Photo

Appendix A

Conceptual Drawings

ates • AK • Prince of Wales-Hyder C.A. • Klawock

Klawo□□ Senior Center

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SCALE

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Designed DHB 6-27-14
Drawn DHB 6-30-14
Checked GJF 8-15-14

Approved Date
Title Job Class

Klawo□□ Senior Center

Klawo□□, AK

Site □lan

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Date	Description	Approved

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Existing
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Cord Wood
Storage □5'x20'

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Thermal
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Biomass Boiler

Existing
Boilers

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Klawo□□ Senior Center

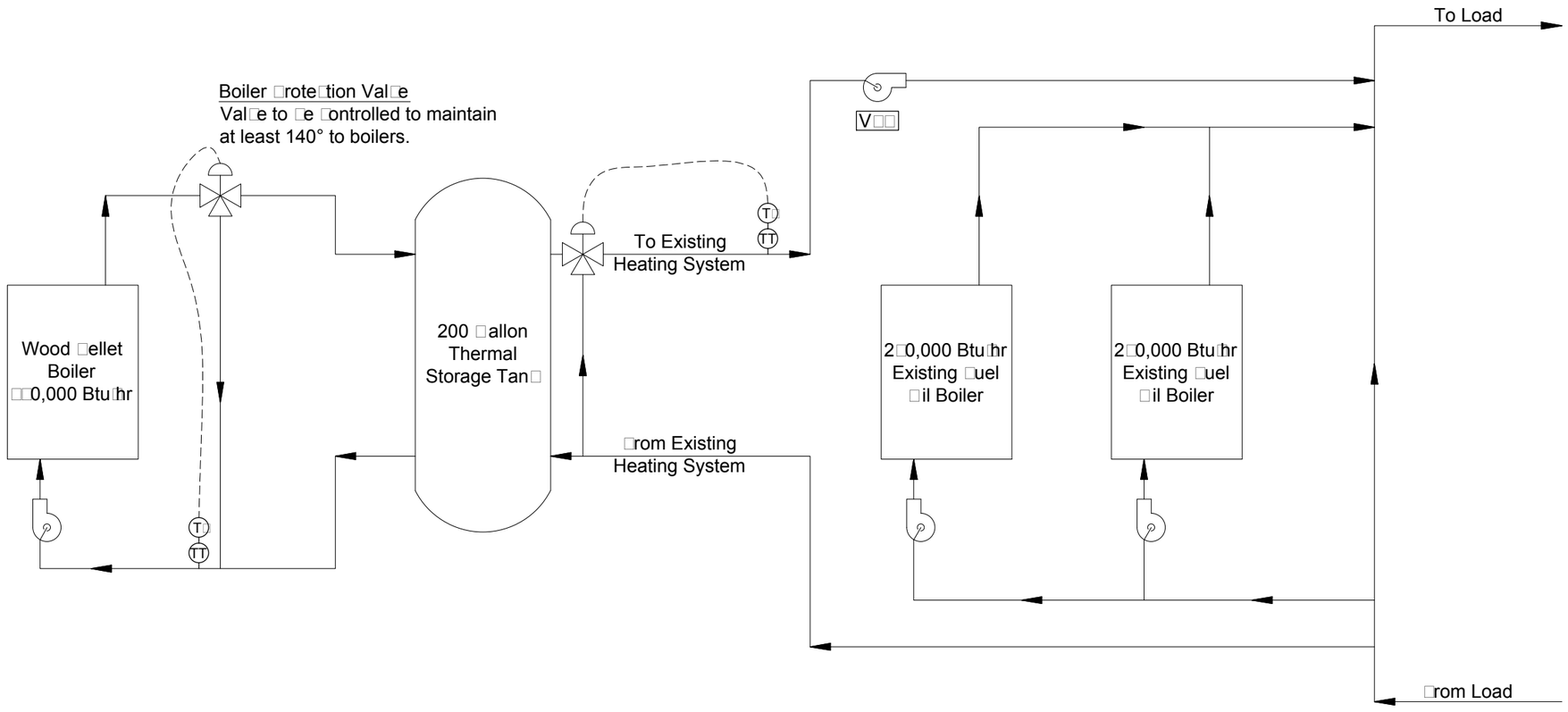
Klawo□□, AK

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Biomass Boiler

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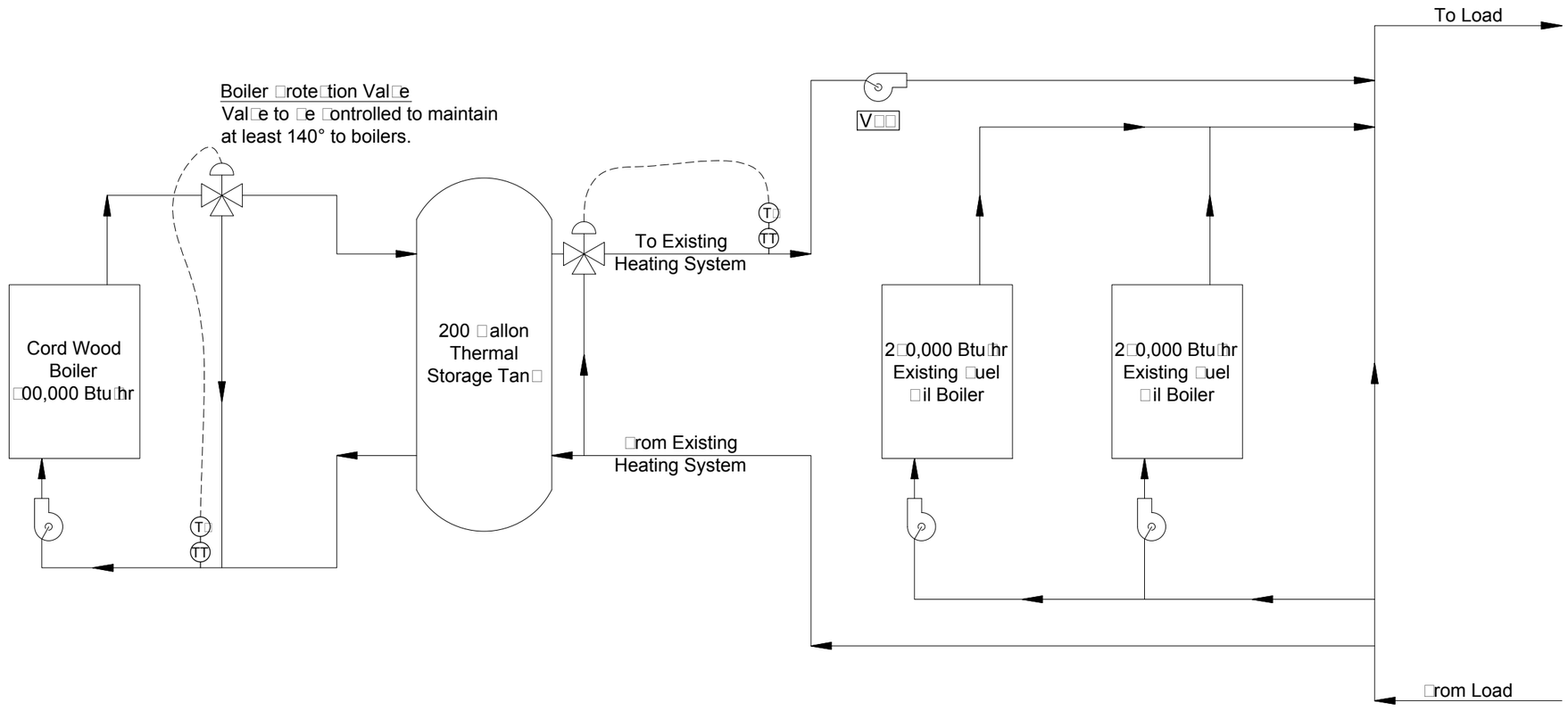
Klawo□□, AK

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Craig Senior Center
Craig, AK

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Craig Senior Center
Craig, AK

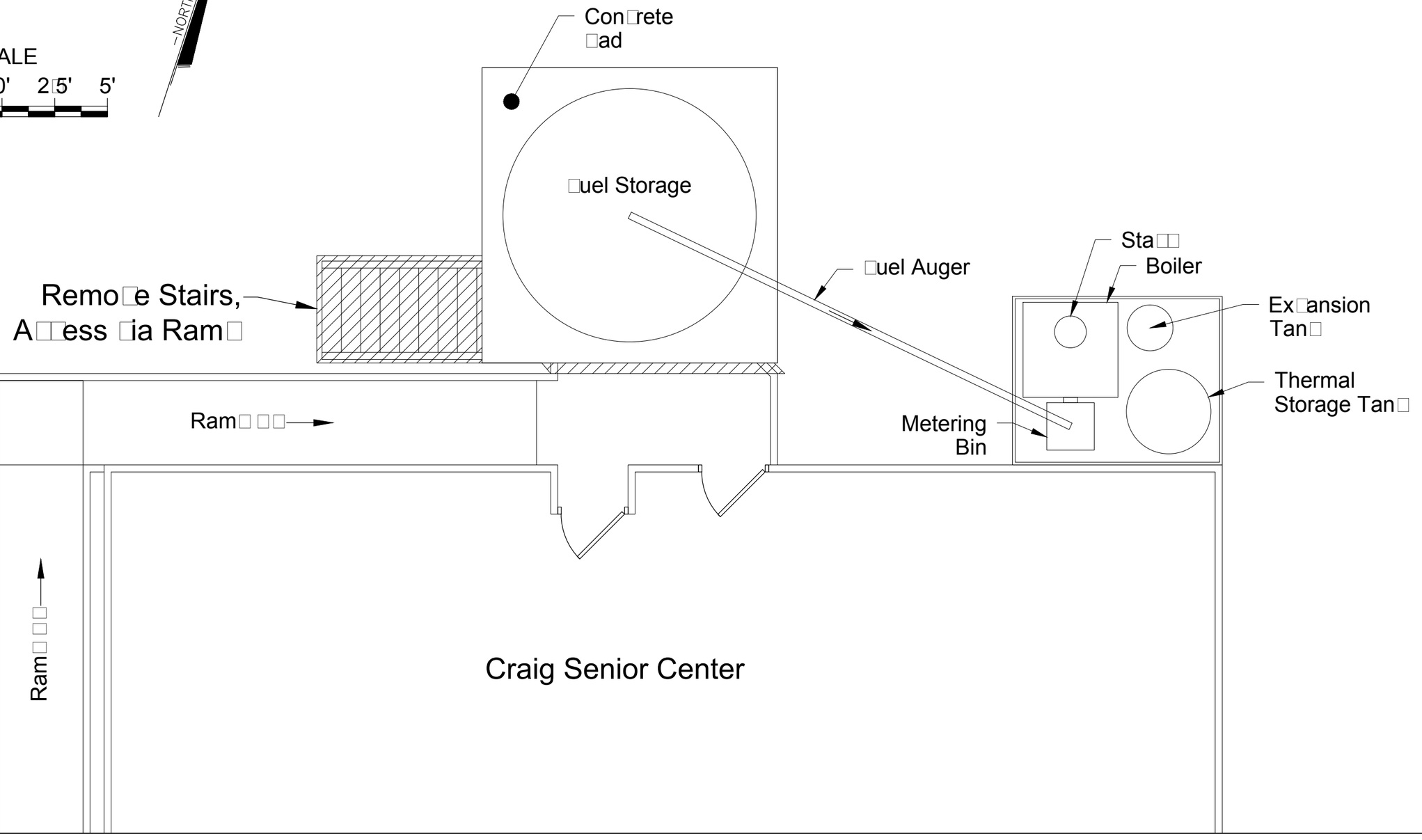
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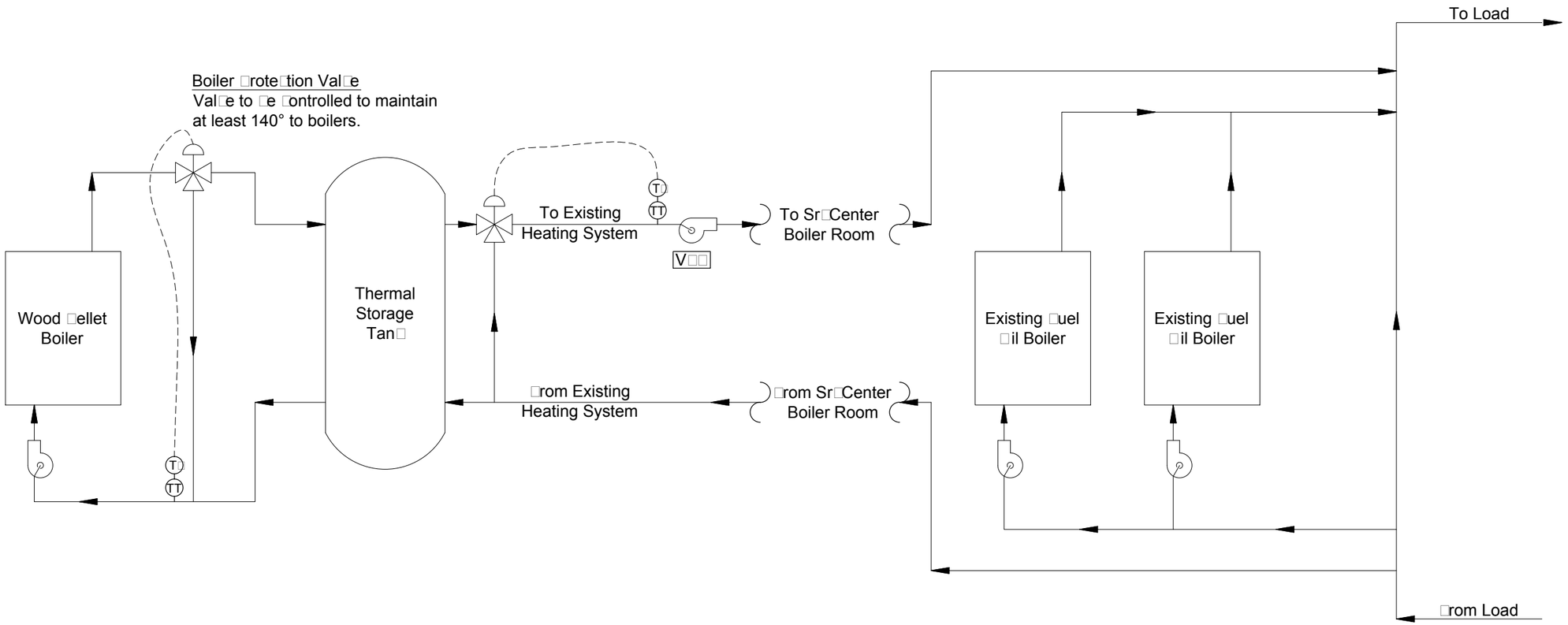
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Craig Senior Center
Craig, AK

□□tion 2□ Site Layout

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Title _____ Job Class _____

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Cord Wood Storage
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Ram□ □□

Ram□ □□

Craig Senior Center

Sta□□

Boiler

Ex□ansion
Tan□

Thermal
Storage Tan□

Designed	DHB	6-27-14
Drawn	DHB	6-30-14
Checked	GJF	8-15-14

Approved ____ Date ____

Title ____ Job Class ____

Craig Senior Center

Craig, AK

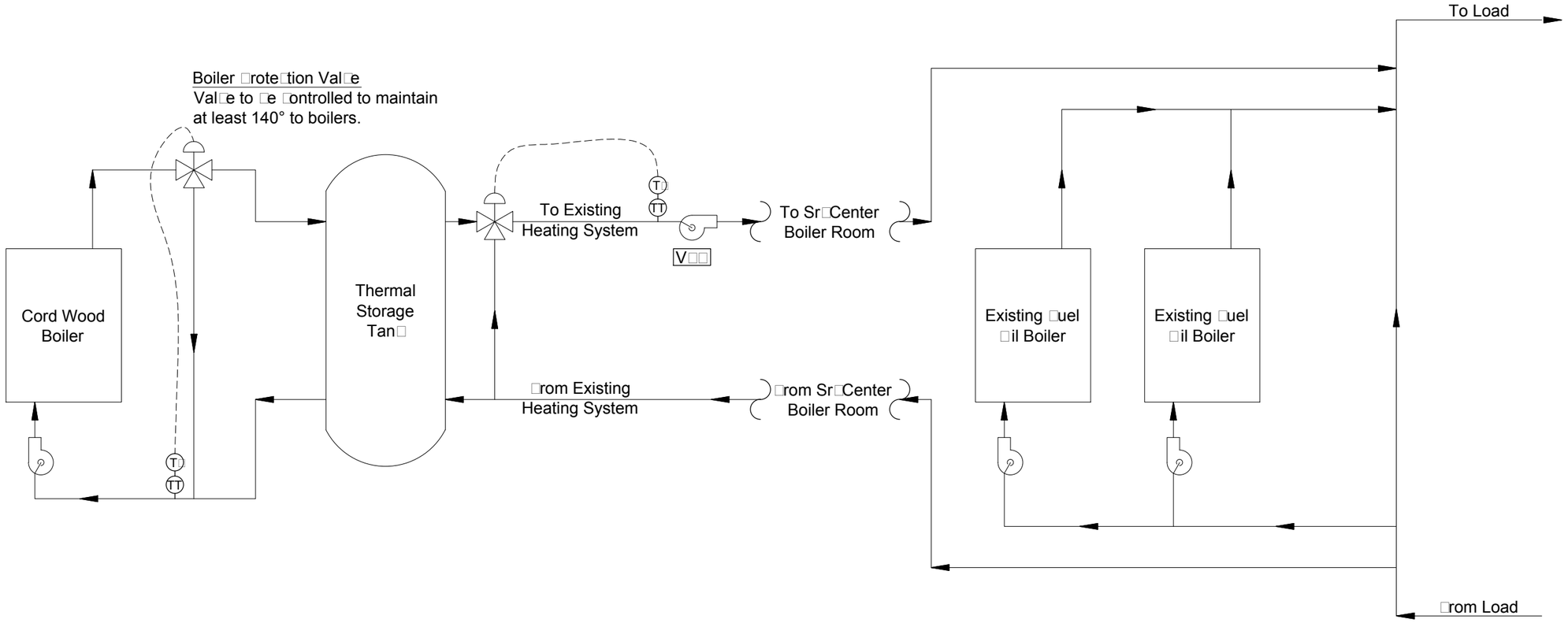
□□tion 2□ Site □lan

WESEE

WES Energy and Environment
wesEnergyAndEnvironment.com
902 Market St. Meadville, PA 16335

REVISIONS

Date	Description	Approved



Legend

- Three Way Mixing Val□e
- □um□
- T: Tem□erature □ndi□ator
- TT: Tem□erature Transmitter
- V□□: Varia□le □re□uen□y □ri□e

□ote□This drawing is a □on□e□tual s□hemati□ for the □ur□oses of showing a general □iomass system arrangement□ E□ui□ment, final si□ing, and □ressures will □ary de□ending on the engineer, manufa□turer and □ontra□tor installing the □iomass system□

Designed DHB 6-27-14
Drawn DHB 6-30-14
Checked GJF 8-15-14
Approved
Date
Title
Job Class

Craig Senior Center
Craig, AK

□□tion 2□ S□hemati□

WESEE
WES Energy and Environment
wesEnergyAndEnvironment.com
902 Market St. Meadville, PA 16335

REVISIONS

Date	Description	Approved

A.12

Appendix B

Preliminary Capital Cost Estimates

Appendix B

Option 1a - Conceptual Cost Estimate - Klawock Senior Center
Wood Pellet Boiler System

Line Item			Cost
One (1) - 160,000 Btu/hr wood pellet hot water boiler, installed		$	30,000
30 ton storage bin		$	15,000
Storage bin site work		$	5,000
Thermal storage 200 gal with insulation		$	7,000
Interconnection with existing boiler room, pumps, installation		$	7,500
Electrical		$	4,500
Mechanical		$	4,500
Sub-Total		$	73,500
Contractor Profit	*10%*	*$*	*7,350*
Sub-Total		*$*	*80,850*
Contingency	*10%*	*$*	*8,085*
Sub-Total		*$*	*88,935*
Profesional Services	*15%*	*$*	*13,340*
Total		**$**	**102,275**

Notes:

1 - The boiler system is to be installed in the existing boiler room. Pricing is based on a one-boiler solution. There are multiple manufacturers that can provide varying boiler sizes. Other boiler sizing combinations to meet a similar output range may also be selected.

2 - Professional Services includes permitting, legal, engineering, & project management. (Assumed that minimal engineering is required.)

3 - Estimate is based on competitive bidding.

Appendix B

Option 1b - Conceptual Cost Estimate - Klawock Senior Center
Cord Wood Boiler System

Line Item				Cost
One (1) - 100,000 Btu/hr cord wood boiler, freight, and installed			$	13,000
Stick frame storage building with poured concrete floor, 600 ft^2 @ \$50/ft^2			$	30,000
Thermal storage 500 gal with insulation			$	9,500
Interconnection with existing boiler room, pumps, installation			$	7,500
Electrical			$	5,000
Mechanical			$	5,000
Sub-Total			$	70,000
	Contractor Profit	*10%*	*$*	*7,000*
Sub-Total			*$*	*77,000*
	Contingency	*10%*	*$*	*7,700*
Sub-Total			*$*	*84,700*
	Profesional Services	*15%*	*$*	*12,705*
Total			**$**	**97,405**

Notes:

1 - The boiler system is to be installed in the existing boiler room. Pricing is based on a one-boiler solution. There are multiple manufacturers that can provide varying boiler sizes. Other boiler sizing combinations to meet a similar output range may also be selected.

2 - Professional Services includes permitting, legal, engineering, & project management. (Assumed that minimal engineering is required.)

3 - Estimate is based on competitive bidding.

Appendix B

Option 2a - Conceptual Cost Estimate - Craig Senior Center
Wood Pellet Boiler System

Line Item			Cost
One (1) - 100,000 Btu/hr wood pellet hot water boiler, containerized		$	50,000
30 ton storage bin		$	15,000
Storage bin site work		$	5,000
Thermal storage 200 gal with insulation		$	7,000
Interconnection with existing boiler room, pumps, installation		$	7,500
Electrical		$	5,000
Mechanical		$	5,000
Sub-Total		$	94,500
Contractor Profit	*10%*	*$*	*9,450*
Sub-Total		*$*	*103,950*
Contingency	*10%*	*$*	*10,395*
Sub-Total		*$*	*114,345*
Profesional Services	*15%*	*$*	*17,152*
Total		**$**	**131,497**

Notes:

1 - The boiler system is to be installed in the existing boiler room. Pricing is based on a one-boiler solution. There are multiple manufacturers that can provide varying boiler sizes. Other boiler sizing combinations to meet a similar output range may also be selected.

2 - Professional Services includes permitting, legal, engineering, & project management. (Assumed that minimal engineering is required.)

3 - Estimate is based on competitive bidding.

Appendix B

Option 2b - Conceptual Cost Estimate - Craig Senior Center
Cord Wood Boiler System

Line Item				Cost
One (1) - 100,000 Btu/hr cord wood boiler, freight, containerized, and installed			$	40,000
Stick frame storage building with poured concrete floor, 200 ft^2 @ \$50/ft^2			$	10,000
Thermal storage 500 gal with insulation			$	9,500
Interconnection with existing boiler room, pumps, installation			$	5,000
Electrical			$	5,000
Mechanical			$	5,000
Sub-Total			$	74,500
	Contractor Profit	*10%*	*$*	*7,450*
Sub-Total			*$*	*81,950*
	Contingency	*10%*	*$*	*8,195*
Sub-Total			*$*	*90,145*
	Profesional Services	*15%*	*$*	*13,522*
Total			**$**	**103,667**

Notes:

1 - The boiler system is to be installed in the existing boiler room. Pricing is based on a one-boiler solution. There are multiple manufacturers that can provide varying boiler sizes. Other boiler sizing combinations to meet a similar output range may also be selected.

2 - Professional Services includes permitting, legal, engineering, & project management. (Assumed that minimal engineering is required.)

3 - Estimate is based on competitive bidding.

Appendix C

20 Year Financing at 4% APR Cash Flow Analysis

Option 1a - Klawock Senior Center Wood Pellet Boiler System
20 Year, 4% Financing

Input Variables	Value	Units
Project Costs Financed	102,275	$
Financing Term	20	# years
Financing Rate (apr)	4.0%	Percent
Current #1 Fuel Oil Usage	5,000	gal
Year 1 #1 Fuel Oil Average Price	$4.13	$/gal
Proposed Annual Wood Pellet Usage	42	tons/yr
Year 1 Wood Pellet Purchase Price	$330	$/ton
Annual #1 Fuel Oil Usage w/ Wood System	250	gal/yr
Fossil Fuel Inflation Rate (apr)	3.3%	Percent
Wood Pellet Inflation Rate (apr)	3.0%	Percent
O&M Inflation Rate	3.0%	Percent
Discount Rate (apr)	3.0%	Percent
Added Annual O&M Costs for Biomass Plant	$ 1,590	$/yr

Year	#1 Fuel Oil Cost, Current System	Wood Pellet Cost	#1 Fuel Oil Cost, w/ Wood System	Added O&M Cost	Net Operating Savings	Annual Financing Payment	Net Cash Flow	Present Value of Cash Flow
1	$ 20,650	$ (13,860)	$ (1,033)	$ (1,590)	$ 4,168	$ (7,526)	$ (3,358)	$ (3,358)
2	$ 21,331	$ (14,276)	$ (1,067)	$ (1,638)	$ 4,351	$ (7,526)	$ (3,174)	$ (3,082)
3	$ 22,035	$ (14,704)	$ (1,102)	$ (1,687)	$ 4,543	$ (7,526)	$ (2,983)	$ (2,812)
4	$ 22,763	$ (15,145)	$ (1,138)	$ (1,737)	$ 4,742	$ (7,526)	$ (2,784)	$ (2,548)
5	$ 23,514	$ (15,600)	$ (1,176)	$ (1,790)	$ 4,949	$ (7,526)	$ (2,577)	$ (2,289)
6	$ 24,290	$ (16,068)	$ (1,214)	$ (1,843)	$ 5,164	$ (7,526)	$ (2,361)	$ (2,037)
7	$ 25,091	$ (16,550)	$ (1,255)	$ (1,899)	$ 5,389	$ (7,526)	$ (2,137)	$ (1,790)
8	$ 25,919	$ (17,046)	$ (1,296)	$ (1,955)	$ 5,622	$ (7,526)	$ (1,904)	$ (1,548)
9	$ 26,775	$ (17,557)	$ (1,339)	$ (2,014)	$ 5,864	$ (7,526)	$ (1,661)	$ (1,311)
10	$ 27,658	$ (18,084)	$ (1,383)	$ (2,075)	$ 6,116	$ (7,526)	$ (1,409)	$ (1,080)
11	$ 28,571	$ (18,627)	$ (1,429)	$ (2,137)	$ 6,379	$ (7,526)	$ (1,147)	$ (853)
12	$ 29,514	$ (19,185)	$ (1,476)	$ (2,201)	$ 6,652	$ (7,526)	$ (874)	$ (631)
13	$ 30,488	$ (19,761)	$ (1,524)	$ (2,267)	$ 6,935	$ (7,526)	$ (590)	$ (414)
14	$ 31,494	$ (20,354)	$ (1,575)	$ (2,335)	$ 7,230	$ (7,526)	$ (295)	$ (201)
15	$ 32,533	$ (20,964)	$ (1,627)	$ (2,405)	$ 7,537	$ (7,526)	$ 11	$ 7
16	$ 33,607	$ (21,593)	$ (1,680)	$ (2,477)	$ 7,856	$ (7,526)	$ 330	$ 212
17	$ 34,716	$ (22,241)	$ (1,736)	$ (2,551)	$ 8,187	$ (7,526)	$ 662	$ 412
18	$ 35,861	$ (22,908)	$ (1,793)	$ (2,628)	$ 8,532	$ (7,526)	$ 1,006	$ 609
19	$ 37,045	$ (23,596)	$ (1,852)	$ (2,707)	$ 8,890	$ (7,526)	$ 1,364	$ 801
20	$ 38,267	$ (24,304)	$ (1,913)	$ (2,788)	$ 9,262	$ (7,526)	$ 1,737	$ 990
							Present Value	**$ (20,922)**

Option 1b - Klawock Senior Center - Cord Wood Boiler System
20 Year, 4% Financing

Input Variables	Value	Units
Project Costs Financed	97,405	$
Financing Term	20	# years
Financing Rate (apr)	4.0%	Percent
Current #1 Fuel Oil Usage	5,000	gal
Year 1 #1 Fuel Oil Average Price	$4.13	$/gal
Proposed Annual Cord Wood Usage	34	Cords/yr
Year 1 Cord Wood Purchase Price	$250	$/Cord
Annual #1 Fuel Oil Usage w/ Wood System	1,000	gal/yr
Fossil Fuel Inflation Rate (apr)	3.3%	Percent
Cord Wood Inflation Rate (apr)	3.0%	Percent
O&M Inflation Rate	3.0%	Percent
Discount Rate (apr)	3.0%	Percent
Added Annual O&M Costs for Biomass Plant	$ 1,530	$/yr

Year	#1 Fuel Oil Cost, Current System	Cord Wood Cost	#1 Fuel Oil Cost, w/ Wood System	Added O&M Cost	Net Operating Savings	Annual Financing Payment	Net Cash Flow	Present Value of Cash Flow
1	$ 20,650	$ (8,500)	$ (4,130)	$ (1,530)	$ 6,490	$ (7,167)	$ (677)	$ (658)
2	$ 21,331	$ (8,755)	$ (4,266)	$ (1,576)	$ 6,734	$ (7,167)	$ (433)	$ (408)
3	$ 22,035	$ (9,018)	$ (4,407)	$ (1,623)	$ 6,987	$ (7,167)	$ (180)	$ (164)
4	$ 22,763	$ (9,288)	$ (4,553)	$ (1,672)	$ 7,250	$ (7,167)	$ 83	$ 74
5	$ 23,514	$ (9,567)	$ (4,703)	$ (1,722)	$ 7,522	$ (7,167)	$ 355	$ 306
6	$ 24,290	$ (9,854)	$ (4,858)	$ (1,774)	$ 7,804	$ (7,167)	$ 637	$ 533
7	$ 25,091	$ (10,149)	$ (5,018)	$ (1,827)	$ 8,097	$ (7,167)	$ 929	$ 756
8	$ 25,919	$ (10,454)	$ (5,184)	$ (1,882)	$ 8,400	$ (7,167)	$ 1,233	$ 973
9	$ 26,775	$ (10,768)	$ (5,355)	$ (1,938)	$ 8,714	$ (7,167)	$ 1,547	$ 1,185
10	$ 27,658	$ (11,091)	$ (5,532)	$ (1,996)	$ 9,040	$ (7,167)	$ 1,872	$ 1,393
11	$ 28,571	$ (11,423)	$ (5,714)	$ (2,056)	$ 9,377	$ (7,167)	$ 2,210	$ 1,597
12	$ 29,514	$ (11,766)	$ (5,903)	$ (2,118)	$ 9,727	$ (7,167)	$ 2,560	$ 1,795
13	$ 30,488	$ (12,119)	$ (6,098)	$ (2,181)	$ 10,090	$ (7,167)	$ 2,923	$ 1,990
14	$ 31,494	$ (12,483)	$ (6,299)	$ (2,247)	$ 10,466	$ (7,167)	$ 3,298	$ 2,181
15	$ 32,533	$ (12,857)	$ (6,507)	$ (2,314)	$ 10,855	$ (7,167)	$ 3,688	$ 2,367
16	$ 33,607	$ (13,243)	$ (6,721)	$ (2,384)	$ 11,259	$ (7,167)	$ 4,092	$ 2,550
17	$ 34,716	$ (13,640)	$ (6,943)	$ (2,455)	$ 11,677	$ (7,167)	$ 4,510	$ 2,729
18	$ 35,861	$ (14,049)	$ (7,172)	$ (2,529)	$ 12,111	$ (7,167)	$ 4,944	$ 2,904
19	$ 37,045	$ (14,471)	$ (7,409)	$ (2,605)	$ 12,560	$ (7,167)	$ 5,393	$ 3,076
20	$ 38,267	$ (14,905)	$ (7,653)	$ (2,683)	$ 13,026	$ (7,167)	$ 5,859	$ 3,244
							Present Value	**$ 28,422**

Appendix C

Option 2a - Craig Senior Center Wood Pellet Boiler System
20 Year, 4% Financing

Input Variables	Value	Units
Project Costs Financed	131,497	$
Financing Term	20	# years
Financing Rate (apr)	4.0%	Percent
Current #1 Fuel Oil Usage	3,000	gal
Year 1 #1 Fuel Oil Average Price	$4.13	$/gal
Proposed Annual Wood Pellet Usage	26	tons/yr
Year 1 Wood Pellet Purchase Price	$330	$/ton
Annual #1 Fuel Oil Usage w/ Wood System	150	gal/yr
Fossil Fuel Inflation Rate (apr)	3.3%	Percent
Wood Pellet Inflation Rate (apr)	3.0%	Percent
O&M Inflation Rate	3.0%	Percent
Discount Rate (apr)	3.0%	Percent
Added Annual O&M Costs for Biomass Plant	$ 1,590	$/yr

Year	#1 Fuel Oil Cost, Current System	Wood Pellet Cost	#1 Fuel Oil Cost, w/ Wood System	Added O&M Cost	Net Operating Savings	Annual Financing Payment	Net Cash Flow	Present Value of Cash Flow
1	$ 12,390	$ (8,580)	$ (620)	$ (1,590)	$ 1,601	$ (9,676)	$ (8,075)	$ (7,840)
2	$ 12,799	$ (8,837)	$ (640)	$ (1,638)	$ 1,684	$ (9,676)	$ (7,992)	$ (7,533)
3	$ 13,221	$ (9,103)	$ (661)	$ (1,687)	$ 1,771	$ (9,676)	$ (7,905)	$ (7,234)
4	$ 13,658	$ (9,376)	$ (683)	$ (1,737)	$ 1,862	$ (9,676)	$ (7,814)	$ (6,943)
5	$ 14,108	$ (9,657)	$ (705)	$ (1,790)	$ 1,956	$ (9,676)	$ (7,719)	$ (6,659)
6	$ 14,574	$ (9,947)	$ (729)	$ (1,843)	$ 2,055	$ (9,676)	$ (7,620)	$ (6,382)
7	$ 15,055	$ (10,245)	$ (753)	$ (1,899)	$ 2,158	$ (9,676)	$ (7,517)	$ (6,112)
8	$ 15,552	$ (10,552)	$ (778)	$ (1,955)	$ 2,266	$ (9,676)	$ (7,410)	$ (5,849)
9	$ 16,065	$ (10,869)	$ (803)	$ (2,014)	$ 2,378	$ (9,676)	$ (7,297)	$ (5,593)
10	$ 16,595	$ (11,195)	$ (830)	$ (2,075)	$ 2,496	$ (9,676)	$ (7,180)	$ (5,343)
11	$ 17,143	$ (11,531)	$ (857)	$ (2,137)	$ 2,618	$ (9,676)	$ (7,058)	$ (5,099)
12	$ 17,708	$ (11,877)	$ (885)	$ (2,201)	$ 2,745	$ (9,676)	$ (6,931)	$ (4,861)
13	$ 18,293	$ (12,233)	$ (915)	$ (2,267)	$ 2,878	$ (9,676)	$ (6,798)	$ (4,629)
14	$ 18,896	$ (12,600)	$ (945)	$ (2,335)	$ 3,016	$ (9,676)	$ (6,659)	$ (4,403)
15	$ 19,520	$ (12,978)	$ (976)	$ (2,405)	$ 3,161	$ (9,676)	$ (6,515)	$ (4,182)
16	$ 20,164	$ (13,367)	$ (1,008)	$ (2,477)	$ 3,311	$ (9,676)	$ (6,365)	$ (3,966)
17	$ 20,829	$ (13,768)	$ (1,041)	$ (2,551)	$ 3,468	$ (9,676)	$ (6,208)	$ (3,756)
18	$ 21,517	$ (14,181)	$ (1,076)	$ (2,628)	$ 3,631	$ (9,676)	$ (6,044)	$ (3,550)
19	$ 22,227	$ (14,607)	$ (1,111)	$ (2,707)	$ 3,802	$ (9,676)	$ (5,874)	$ (3,350)
20	$ 22,960	$ (15,045)	$ (1,148)	$ (2,788)	$ 3,979	$ (9,676)	$ (5,697)	$ (3,154)
							Present Value	**$ (106,437)**

Option 2b - Craig Senior Center - Cord Wood Boiler System
20 Year, 4% Financing

Input Variables	Value	Units
Project Costs Financed	103,667	$
Financing Term	20	# years
Financing Rate (apr)	4.0%	Percent
Current #1 Fuel Oil Usage	3,000	gal
Year 1 #1 Fuel Oil Average Price	$4.13	$/gal
Proposed Annual Cord Wood Usage	21	Cords/yr
Year 1 Cord Wood Purchase Price	$250	$/Cord
Annual #1 Fuel Oil Usage w/ Wood System	600	gal/yr
Fossil Fuel Inflation Rate (apr)	3.3%	Percent
Cord Wood Inflation Rate (apr)	3.0%	Percent
O&M Inflation Rate	3.0%	Percent
Discount Rate (apr)	3.0%	Percent
Added Annual O&M Costs for Biomass Plant	$ 1,480	$/yr

Year	#1 Fuel Oil Cost, Current System	Cord Wood Cost	#1 Fuel Oil Cost, w/ Wood System	Added O&M Cost	Net Operating Savings	Annual Financing Payment	Net Cash Flow	Present Value of Cash Flow
1	$ 12,390	$ (5,250)	$ (2,478)	$ (1,480)	$ 3,182	$ (7,628)	$ (4,446)	$ (4,316)
2	$ 12,799	$ (5,408)	$ (2,560)	$ (1,524)	$ 3,307	$ (7,628)	$ (4,321)	$ (4,073)
3	$ 13,221	$ (5,570)	$ (2,644)	$ (1,570)	$ 3,437	$ (7,628)	$ (4,191)	$ (3,835)
4	$ 13,658	$ (5,737)	$ (2,732)	$ (1,617)	$ 3,572	$ (7,628)	$ (4,056)	$ (3,604)
5	$ 14,108	$ (5,909)	$ (2,822)	$ (1,666)	$ 3,712	$ (7,628)	$ (3,916)	$ (3,378)
6	$ 14,574	$ (6,086)	$ (2,915)	$ (1,716)	$ 3,857	$ (7,628)	$ (3,771)	$ (3,158)
7	$ 15,055	$ (6,269)	$ (3,011)	$ (1,767)	$ 4,008	$ (7,628)	$ (3,620)	$ (2,944)
8	$ 15,552	$ (6,457)	$ (3,110)	$ (1,820)	$ 4,164	$ (7,628)	$ (3,464)	$ (2,734)
9	$ 16,065	$ (6,651)	$ (3,213)	$ (1,875)	$ 4,326	$ (7,628)	$ (3,302)	$ (2,530)
10	$ 16,595	$ (6,850)	$ (3,319)	$ (1,931)	$ 4,495	$ (7,628)	$ (3,133)	$ (2,331)
11	$ 17,143	$ (7,056)	$ (3,429)	$ (1,989)	$ 4,669	$ (7,628)	$ (2,959)	$ (2,137)
12	$ 17,708	$ (7,267)	$ (3,542)	$ (2,049)	$ 4,851	$ (7,628)	$ (2,777)	$ (1,948)
13	$ 18,293	$ (7,485)	$ (3,659)	$ (2,110)	$ 5,039	$ (7,628)	$ (2,589)	$ (1,763)
14	$ 18,896	$ (7,710)	$ (3,779)	$ (2,173)	$ 5,234	$ (7,628)	$ (2,394)	$ (1,583)
15	$ 19,520	$ (7,941)	$ (3,904)	$ (2,239)	$ 5,436	$ (7,628)	$ (2,192)	$ (1,407)
16	$ 20,164	$ (8,179)	$ (4,033)	$ (2,306)	$ 5,646	$ (7,628)	$ (1,982)	$ (1,235)
17	$ 20,829	$ (8,425)	$ (4,166)	$ (2,375)	$ 5,864	$ (7,628)	$ (1,764)	$ (1,067)
18	$ 21,517	$ (8,677)	$ (4,303)	$ (2,446)	$ 6,090	$ (7,628)	$ (1,538)	$ (904)
19	$ 22,227	$ (8,938)	$ (4,445)	$ (2,520)	$ 6,324	$ (7,628)	$ (1,304)	$ (744)
20	$ 22,960	$ (9,206)	$ (4,592)	$ (2,595)	$ 6,567	$ (7,628)	$ (1,061)	$ (587)
							Present Value	**$ (46,279)**

Appendix D

Sensitivity Analysis of Estimated Annual Operating Savings to Oil and Biomass Fuel Prices

Option 1a - Klawock Senior Center Wood Pellet Boiler System
Sensitivity Analysis of 1st Year Operating Savings to Fuel Costs

Price of Wood Pellets per Ton	Price of Fuel Oil per Gallon							
	$3.50	**$3.75**	**$4.00**	**$4.13**	**$4.25**	**$4.50**	**$4.75**	**$5.00**
$225	$5,585	$6,773	$7,960	$8,578	$9,148	$10,335	$11,523	$12,710
$250	$4,535	$5,723	$6,910	$7,528	$8,098	$9,285	$10,473	$11,660
$275	$3,485	$4,673	$5,860	$6,478	$7,048	$8,235	$9,423	$10,610
$300	$2,435	$3,623	$4,810	$5,428	$5,998	$7,185	$8,373	$9,560
$330	$1,175	$2,363	$3,550	$4,168	$4,738	$5,925	$7,113	$8,300
$350	$335	$1,523	$2,710	$3,328	$3,898	$5,085	$6,273	$7,460
$375	($715)	$473	$1,660	$2,278	$2,848	$4,035	$5,223	$6,410

**Note: Excludes financing costs.*

Option 1b - Klawock Senior Center - Cord Wood Boiler System
Sensitivity Analysis of 1st Year Operating Savings to Fuel Costs

Price of Cord Wood per Cord	Price of Fuel Oil per Gallon							
	$3.50	**$3.75**	**$4.00**	**$4.13**	**$4.25**	**$4.50**	**$4.75**	**$5.00**
$150	$7,370	$8,370	$9,370	$9,890	$10,370	$11,370	$12,370	$13,370
$175	$6,520	$7,520	$8,520	$9,040	$9,520	$10,520	$11,520	$12,520
$200	$5,670	$6,670	$7,670	$8,190	$8,670	$9,670	$10,670	$11,670
$225	$4,820	$5,820	$6,820	$7,340	$7,820	$8,820	$9,820	$10,820
$250	$3,970	$4,970	$5,970	$6,490	$6,970	$7,970	$8,970	$9,970
$275	$3,120	$4,120	$5,120	$5,640	$6,120	$7,120	$8,120	$9,120
$300	$2,270	$3,270	$4,270	$4,790	$5,270	$6,270	$7,270	$8,270

**Note: Excludes financing costs.*

Option 2a - Craig Senior Center Wood Pellet Boiler System
Sensitivity Analysis of 1st Year Operating Savings to Fuel Costs

Price of Wood Pellets per Ton	Price of Fuel Oil per Gallon							
	$3.50	**$3.75**	**$4.00**	**$4.13**	**$4.25**	**$4.50**	**$4.75**	**$5.00**
$225	$2,535	$3,248	$3,960	$4,331	$4,673	$5,385	$6,098	$6,810
$250	$1,885	$2,598	$3,310	$3,681	$4,023	$4,735	$5,448	$6,160
$275	$1,235	$1,948	$2,660	$3,031	$3,373	$4,085	$4,798	$5,510
$300	$585	$1,298	$2,010	$2,381	$2,723	$3,435	$4,148	$4,860
$330	($195)	$518	$1,230	$1,601	$1,943	$2,655	$3,368	$4,080
$350	($715)	($3)	$710	$1,081	$1,423	$2,135	$2,848	$3,560
$375	($1,365)	($653)	$60	$431	$773	$1,485	$2,198	$2,910

**Note: Excludes financing costs.*

Option 2b - Craig Senior Center - Cord Wood Boiler System
Sensitivity Analysis of 1st Year Operating Savings to Fuel Costs

Price of Cord Wood per Cord	Price of Fuel Oil per Gallon							
	$3.50	**$3.75**	**$4.00**	**$4.13**	**$4.25**	**$4.50**	**$4.75**	**$5.00**
$150	$3,770	$4,370	$4,970	$5,282	$5,570	$6,170	$6,770	$7,370
$175	$3,245	$3,845	$4,445	$4,757	$5,045	$5,645	$6,245	$6,845
$200	$2,720	$3,320	$3,920	$4,232	$4,520	$5,120	$5,720	$6,320
$225	$2,195	$2,795	$3,395	$3,707	$3,995	$4,595	$5,195	$5,795
$250	$1,670	$2,270	$2,870	$3,182	$3,470	$4,070	$4,670	$5,270
$275	$1,145	$1,745	$2,345	$2,657	$2,945	$3,545	$4,145	$4,745
$300	$620	$1,220	$1,820	$2,132	$2,420	$3,020	$3,620	$4,220

**Note: Excludes financing costs.*

Attachment 11

Klawock – Senior Center Energy Rating Information

KLAWOCK SENIOR CENTER – 8-UNIT ENERGY RATING INFORMATION

Owner: Tlingit-Haida Regional Housing Authority
Site Address: 465 Summit St. Klawock AK. 8-Unit Addition Only

Legal Description: Lot 2A2, Block 25, of Klawock Townsite US Survey 1569, Ketchikan Recording District

8-Unit Addition. Multifamily-rate whole building. 8 each two-bedroom units. 16 persons total. Senior Housing, two person limit per unit.

Start of Construction: Footings poured November, 2006. Snow shut down construction for winter, restarted in late February 2007.

General Contractor: Tlingit-Haida Regional Housing Authority, Juneau, AK
Architect: Ken Ormbrek, TRAHO Architects, Yakima, WA
Mechanical Engineer: Shane Hooten, Modern Mechanical, Juneau, AK
Electrical Engineer: Mark Longmeier, Cayambe Engineering P.S., Spokane, WA

Electrical Subcontractor: Channel Electric, Ketchikan
Mechanical Subcontractor: Ketchikan Mechanical Inc. Ketchikan

8 – Unit Building Dimensions (interior):
77 ft. long x 56.5 ft. wide = 4,350.5 sq. ft. plus covered porch bumpouts = 2 ft. x 8 ft. = 16 sq. ft. x 2 each floor = 32 sq. ft. each floor
TOTAL LIVING AREA EACH FLOOR = 4,382.5 sq. ft.
TOTAL LIVING AREA BOTH FLOORS = 8,675 sq. ft.

Conditioned stairwell from carport to first floor:
15 ft. x 8 ft. = 120 sq. ft. Height 12 ft.

Conditioned Basement area (mechanical room and maintenance shop only):
43 ft. x 31 ft. = 1333 sq. ft.

Unconditioned Carport area = 25.5 ft. x 33.5 ft. = 854.25 Sq. Ft.

ABOVE GRADE SURFACE AREA:

Floor over crawlspace:	34.5 x 56.5	=	1949 sq. ft.
Floor over carport:	24 x 34	=	816 sq. ft.
Basement walls (4 sides):	(42.5+31+34+31) x 11	=	1524 sq. ft.
Basement stair wall:	(15+8+15) x 11	=	418 sq. ft.
Main living walls:	(77+56.5+77+25+8) x 17	=	4140 sq. ft.
Ceiling:	77 x 56.5 + 32	=	4383 sq. ft.
		TOTAL	13,230 sq. ft.

HEATED VOLUME:

Living Area:	4,382.5 SF x 17 ft. high =	74,502.5 cu. ft.
Basement Stairwell:	120 SF x 12 ft. high =	1,440 cu. ft.
Cond. Basement:	1333 SF x 12 ft. high =	15,996 cu. ft.
	TOTAL	91,938.5 cu. ft.

HEATING:

2 each WTGO-7 with Superstor Ultra water makers. GAMA AFUE = 85% AFUE

HOT WATER HEATERS:

Superstor Ultra water makers. Model SSU-119. 119 Gallon capacity each. In conditioned space (basement mechanical room). All piping insulated.

R-VALUES

Floors =	12" I-joist 16" o.c.	R-38 fiberglass batt
Walls =	2 x 6 stud 16" o.c. headers insulated	R-21 fiberglass batt
Ceiling =	Truss (no raised heel to match existing roof plane)	
	24" o.c. Baffles at eaves	R 38 plus R-19 FG batt

Sound insulation between floors = R-15 high density plus soundboard.

Basement slab (maintenance and mechanical room) = 2" rigid XPS (pink) under slab, 2 ft. perimeter, plus 2" rigid XPS down inside of stem wall to footing. Expansion joint between slab and stem wall. No insulation on outside of concrete slab or stemwall.

Rim joists insulated with 2 layers 2" XPS (4" total) and caulked in place between joists.

WINDOWS

Certainteed Insulate Low E Argon vinyl sliders. NFRC U-Values = 0.32

VENTILATION

Each apartment has a bathroom/whole-house exhaust fan, with Reton 80 make-up vents in each bedroom and living room (3 ea. Reton 80's per units)

Bath fans are Panasonic FV-11VQ3 fan on Marktime fan/light time delay switch, set at 5 minute fan-off delay control.

All bath fan flows were tested with Minneapolis Exhaust Fan flow hood. Fan flows ranged between 82 CFM lowest flow to 95 CFM highest flow.

BLOWER DOOR TESTS:

Two tests taken, CFM 50's added together to get whole building CFM 50.

First Test of main 8-unit addition, two floors plus basement stairwell. Temporary visqueen partitions made to seal off corridors of 8-unit addition from corridors of existing 10 unit building. Total Volume tested = 75,943 cu. ft. Blower door test conducted with Open Fan. Tectite results are:

Airflow at 50 Pascals = 3443 CFM 50, 2.72 ACH 50.

Second blower door test performed on basement mechanical room and maintenance room
Dimensions are 31 ft x 43 feet x 11 feet ceiling height.
31 x 43 = 1333 sq. ft. 1333 x 11 = 14, 663 cu. ft. basement
Test results = 1270 CFM 50

TOTAL CFM 50 = 3443 plus 1270 = 4,713 CFM 50

Attachment 12

Klawock – Senior Center AEE Energy Assessment

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
jim@alaskaenergy.us

Technical Memorandum

June 19, 2015

to: **Craig Moore, THRHA**

subject: **Energy Assessment**

project: **Klawock Senior Center**

INTRODUCTION

This memorandum presents the findings of an energy assessment of the Klawock Senior Center owned by Tlingit-Haida Regional Housing Authority. The site was visited by Jim Rehfeldt, P.E. of Alaska Energy Engineering LLC on May 20, 2015. The purpose of the trip is:

- Evaluate the operation of Air Handling Unit AHU-1
- Develop an energy monitoring plan for the building systems

HEATING SYSTEM

Background

The building is heated by two fuel oil boilers connected to a primary/secondary hydronic heating distribution system. The boilers have a capacity of 242 MBH each and supply heat to perimeter baseboards, unit heaters, and the coil in air handling unit AHU-1.

Assessment

Boiler Pumps

The distribution system has 5 pumps that circulate water to the building and hot water heaters. Two variable speed pumps—lead/lag—would provide energy savings and require less maintenance.

Controls

The construction documents and control drawings call for operating the boilers in a lead/lag configuration with monthly switchover. This is not occurring as both boilers were hot and operating on a 70°F day. The control sequences should be fine-tuned and retro-commissioned to ensure the boilers are operating optimally.

Recommendation

The following are recommended:

- Revise the controls for optimal lead/lag operation of the boilers
- Convert the pumps to variable speed when they fail
- Retro-commission the system

DOMESTIC HOT WATER SYSTEM

Background

The domestic hot water system consists of two indirect hot water heaters heated by the boilers. Each hot water heater is supplied by a respective hot water pump. The hot water flows through a thermostatic mixing valve that provides anti-scalding protection.

Assessment

The domestic hot water system is operating properly.

Recommendations

None

AIR HANDLING UNIT AHU-1

Background

Air handling unit AHU-1 supplies ventilation and makeup air to the common areas of the building including the lounge, reading room, and dining room. The system supplies constant 100% outside air flow and consists of an outside air damper, filters, heating coil, and supply fan.

A DDC control system controls and monitors the system.

Assessment

Issues

The design documents indicate that the system should operate when the kitchen hood exhaust fan is operating or the bypass timer is turned on. The control documents indicate that the system should also operate when the dishwasher hood is turned on. The system appears to be operating independently of the hoods or the bypass timer; the bypass timer could not even be found. It is likely that it is being scheduled on by the DDC system.

The operation of the control system could not be assessed because there is no computer terminal interface from which to view the graphical representations of the building and systems and assess their operation. A graphical interface is recommended to make full use of the DDC system investment.

The system supplies constant ventilation air which provides makeup air for the kitchen hood when it operates from Monday to Thursday from 7 am to 1 pm. During all other times, the system over-ventilates the building.

Energy Efficiency

The system supplies 1,700 cfm of air flow. This is much higher than is needed to make-up the kitchen hood (900 cfm) or maintain adequate indoor air quality in the spaces. The air flow can be reduced to 1,200 cfm when the kitchen hood is operating and 500 cfm when it is not. This can be accomplished by installing a variable frequency drive to modulate the fan speed.

A life cycle cost comparison determined that the proposed changes will require a $50,000 investment but will offer a life cycle savings of $111,000 over 25-years.

Energy Efficiency Measure	Annual Costs			Life Cycle Costs				
	Operating	Energy	Total	Investment	Operating	Energy	Total	SIR
EEM-1: Optimize AHU-1 System	$230	($6,760)	($6,530)	$49,700	$3,800	($164,000)	($110,500)	3.2

Note: Negative values, in parenthesis, represent savings.

Recommendation

The following are recommended:

- Convert the system to variable speed and modulate its output with kitchen hood operation
- Revise the controls for optimal operation
- Retro-commission the system

ELECTRICAL ROOM HEAT RECOVERY

Description

The electrical closet on the 2nd floor has high heat gain from a workstation, two switches and three cable modules. The room was 82°F due to the estimated 250 watt heat gain in the room.

Issue

The heat can be recovered by installing a wall fan to blow the warm air into the adjacent lobby. Increase the door undercut to provide makeup air and good crossflow through the room.

Assessment

A life cycle cost analysis determined that installing a wall exhaust fan and makeup air grille will require a $1,800 investment but will offer a life cycle savings of $2,350 over 25-years.

Energy Efficiency Measure	Annual Costs			Life Cycle Costs				
	Operating	Energy	Total	Investment	Operating	Energy	Total	SIR
EEM-2: Electric Closet Heat Recovery	$0	($147)	($147)	$1,800	$0	($4,150)	($2,350)	2.3

Note: Negative values, in parenthesis, represent savings.

CONTROL SYSTEM

Background

The building has a DDC control system that controls AHU-1, the heating system, the domestic hot water system and zone temperatures in the nearer parts of the building.

Assessment

The DDC system has a computer user interface that allows staff to monitor the operation of systems. However, the computer workstation is reportedly non-functional and has been disconnected. This significantly limits the value of the DDC system to the operators.

Recommendation

The following is recommended:

- Reinstall the DDC software on a functioning computer and reestablish the user interface.

PROPOSED MONITORING PLAN

Background

A building monitoring system can provide operational, energy tracking and research benefits to the Owner. The benefits of each are as follows:

- Operational: The monitoring system provides essential information for determining that the systems are operating properly including pump status, fan status, heating system temperature, ventilation system temperature, domestic hot water temperature, and room temperature.
- Energy: The monitoring system can provide data on energy use such as building electric demand, heating system energy use, domestic hot water energy use, and energy use of special areas or systems such as kitchens and lighting.
- Research: The monitoring system provides information useful to future design efforts such as peak heating load, heating system efficiency, domestic hot water load, indoor air quality, and occupancy.

Proposed Building Monitoring System

A proposed building monitoring system and cost estimate is provided in the following table. The costs are identified for a basic operational monitoring system, options that increase the monitoring capability, and options for gathering energy consumption data.

The monitoring system will be installed in the mechanical and boiler rooms. It will send the data to a server for storage and data display via the building's internet connection or via the local cellular network.

The monitoring system will collect data and transmit it via the building's internet provider or over the cellular internet. Using the cellular internet will require a $10 monthly charge, which can be avoided by using the building's internet service.

The monitoring system uses wireless sensors that transmit the data to the manufacturer's cloud storage service. The cost for this service is $3-$5 per year per sensor.

The collected data can be stored on THRHA's own Monitoring Website, which will cost $500 to set up and the monthly fees to the web host provider of $9 per month. If only 3-4 building are monitored by THRHA, there is also an option to share a website setup by the data monitoring consultant for no charge.

Proposed Klawock Senior Center Monitoring System

Item	Intent	Operational		Energy Use
		Basic	Option	
Fixed Cost				
Travel, per diem, equipment	Fixed costs	$4,083		
Unit Costs				
General				
Outdoor temperature	Outdoor temperature reference	$30		
Building electric load, kW	Total energy use			$1,897
Heating System				
Boiler B-1 enable	Boiler status		$364	
Boiler B-2 enable	Boiler status		$364	
Boiler pump P-1 enable	Boiler pump status	$364		
Boiler pump P-2 enable	Boiler pump status	$364		
Heating loop pump P-5 enable	Heating loop pump status	$364		
Heating pump P-6 enable	Building pump status	$364		
Heating pump P-7 enable	Building pump status	$364		
Heating supply temperature	Confirms heat to building	$282		
Heating return temp (Pump P-6 loop)	Confirms heat to building			$282
Heating return temp (Pump P-7 loop)	Confirms heat to building			$282
Heating flow rate (Pump P-6 loop)	Determine heating load			$1,345
Heating flow rate (Pump P-7 loop)	Determine heating load			$1,345
Domestic Hot Water System				
Hot water maker HWM-1 temp	Confirms hot water maker status	$282		
Hot water maker HWM-2 temp	Confirms hot water maker status	$282		
Hot water supply temperature	Confirms TMV operation		$282	
Domestic hot water flow rate	Measures hot water demand			$1,114
Cold water makeup temperature	Determine hot water load			$282
Ventilation System AHU-1				
Supply fan enable	Fan status		$364	
Supply air temperature	Confirm supply air temperature		$282	
Totals		$6,779	$1,656	$6,547

SUMMARY

The following table summarizes the recommendations and their costs.

Recommendations

Item	Cost Estimate
Heating System	$13,000
Revise the controls for optimal lead/lag operation of the boilers	
Retro-commission the system	
Air Handling Unit AHU-1	$50,000
Convert the system to variable speed	
Revise the controls for optimal operation	
Retro-commission the system	
Electrical Room Heat Recovery	$2,000
Install wall fan and Description	
Control System	$17,000
Reinstall the DDC software and reestablish the user interface	
Total	$82,000
Monitoring System	
Install a basic monitoring system	$6,800
Add enhanced monitoring	$1,700
Add energy use monitoring	6,500
Total	$15,000

by: _____

Jim Rehfeldt, P.E.

Alaska Energy Engineering LLC
25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Energy and Life Cycle Cost Analysis

June 19, 2015

Klawock Senior Center

Basis

Economic

Study Period (years)	25	Nominal Discount Rate	5%	General Inflation	2%

Energy

Fuel Oil	$/gal (2015)	Inflation	$/gal (2016)
	$3.30	5.0%	$3.47

Electricity	$/kWh (2014)	Inflation	$/kWh (2012)
	$0.220	2.5%	$0.226

EEM-1: Optimize AHU-1 System

Energy Analysis

Minimum Outside Air	Design	w/Kitch Hood	wo/Kitch Hood
OSA cfm	1,700	1,200	500
People at 15 cfm/ea	113	80	33

Fan Energy

Fan	Case	CFM	ΔP	η, fan	BHP	η, motor	kW	Hours	kWh
SF	Existing	-1,700	1.80	50%	-1.0	85%	-0.8	5,475	-4,627
	w/kitch hood	1,200	1.50	50%	0.6	85%	0.5	1,248	620
	wo/kitch hood	500	1.00	50%	0.2	85%	0.1	4,227	584
							-0.2		-3,423

Ventilation Energy

	SA CFM	MAT	T,room	MBH	Hours	kBtu	η boiler	FO Gallons
Existing	-1,700	42	70	-51	5,475	-281,459	72%	-2,822
w/kitch hood	1,200	42	70	36	1,248	45,287	72%	454
wo/kitch hood	500	42	70	15	4,227	63,912	72%	641
						-172,259		-1,727

Life Cycle Cost Analysis	Year	Qty	Unit	Base Cost	Year 0 Cost
Construction Costs					
Install VFD, 2 HP	0	1	ea	$6,500	$6,500
Modify controls, programming	0	1	ls	$6,000	$6,000
TAB	0	1	ls	$2,500	$2,500
Travel and Per Diem	0	2	ls	$5,000	$10,000
Commissioning	0	1	ls	$3,000	$3,000
Estimating contingency	0			15%	$4,200
Overhead & profit	0			30%	$9,660
Design fees	0			10%	$4,186
Project management	0			8%	$3,684
Annual Costs					
VFD Maintenance	1 - 25	1	ea	$225.00	$3,831
Energy Costs					
Fuel Oil	1 - 25	-1,727	gal	$3.47	($149,638)
Electric Energy	1 - 25	-3,423	kWh	$0.226	($14,320)
Net Present Worth					($110,400)

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Energy and Life Cycle Cost Analysis

June 19, 2015

Klawock Senior Center

EEM-2: Electric Closet Heat Recovery

Energy Analysis

Fuel Oil

Watts	Hours	Factor	kBtu	η boiler	Gallons
-250	8,760	85%	-6,351	72%	-64

Electricity

Watts	dT	CFM	BHP	kW	Hours	kWh
-250	5	150	0.05	0.04	8,760	327

Life Cycle Cost Analysis	Year	Qty	Unit	Base Cost	Year 0 Cost
Construction Costs					
Wall exhaust fan	0	1	LS	$750	$750
Undercut door	0	1	LS	$150	$150
Wall grille	0	1	ea	$300	$300
Electrical power with thermostat	0	1	ea	$600	$600
Energy Costs					
Electric Energy	1 - 25	327	kWh	$0.226	$1,367
Fuel Oil	1 - 25	-64	gal	$3.47	($5,517)
Net Present Worth					($2,350)

Alaska Energy Engineering LLC
25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

CONSTRUCTION COST ESTIMATE

June 19, 2015

THRHA Energy Assessments

Klawock Senior Center

Item	Qty	Unit	Unit Cost	Total
Control System DDC User Interface				
Reinstall computer software and restablish the user interface	1	ea	$1,000.00	$1,000
Retro-commission	1	ea	$2,500.00	$2,500
Travel and per diem	1	ea	$5,000.00	$5,000
Training	4	ea	$150.00	$600
Contingency			15%	$1,365
Overhead and Profit			30%	$3,140
Design Fees			10%	$1,360
Project costs			8%	$1,197
Total				$17,000
Heating System				
Reprogram controls	6	hrs	$150.00	$900
Retro-commission	1	ea	$1,000.00	$1,000
Travel and per diem	1	ea	$5,000.00	$5,000
Training	2	hrs	$150.00	$300
Contingency			15%	$1,080
Overhead and Profit			30%	$2,484
Design Fees			10%	$1,076
Project costs			8%	$947
Total				$13,000
Total				$30,000

Attachment 13

Saxman – Senior Center AEE Energy Assessment

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
jim@alaskaenergy.us

Technical Memorandum

June 19, 2015

to: **Craig Moore, THRHA**

subject: **Energy Assessment**

project: **Saxman Senior Center**

INTRODUCTION

This memorandum presents the findings of an energy assessment of the Saxman Senior Center owned by Tlingit-Haida Regional Housing Authority. The site was visited by Jim Rehfeldt, P.E. of Alaska Energy Engineering LLC on May 19, 2015. The purpose of the trip is:

- Evaluate the operation of Air Handling Unit AHU-1
- Evaluate the operation of the domestic hot water system and air source heat pump HP-1
- Evaluate the operation of the radiant heating system and air source heat pump HP-2
- Develop an energy monitoring plan for the building systems

HEATING SYSTEM

Background

The building has three separate heating systems. The common spaces with radiant floors are heated by an air source heat pump, the remaining common spaces are heated by electric boilers and the apartments have electric heaters.

The radiant floor system consists of an air source heat pump that supplies heating water to three radiant floor manifolds. The system is controlled by a Tekmar controller that enables the heat pump, modulates heating water temperature and flow to the slabs.

The electric boiler system consists of two electric boilers and primary pumps that supply hydronic heating water to the building. The boilers are enabled and the pumps are controlled by a Tekmar controller. An integral boiler controller operates the respective boiler when it is enabled.

Assessment

<u>Boilers</u>

The electric boilers are not identical. Their capacities are:

- Boiler B-1: 30 kW; one 30 kW step
- Boiler B-2: 45 kW; one 15 kW step and one 30 kW step

Two equal size boilers with smaller, multiple steps are recommended to minimize demand charges. The control sequences do not delineate boiler operation to take advantage of the smaller 15 kW step in boiler B-2 during mild weather.

Boiler Pumps

The heating pumps are constant speed pumps that are not capable of modulating with heating load. They appear to be significantly oversized for the building heating load. Properly sized variable speed pumps should be installed when the pumps fail.

The pump HP-2 starter does not operate the pump when in the starter is in the Hand position.

Radiant Heating

The control sequences do not include outside air temperature reset that reduces the heating water temperature during warmer weather. This control will improve heat pump efficiency and reduce heat loss.

Controls

The control sequence specifies lead/lag operation of the boilers but does not specify the necessary parameters to ensure that the lag boiler only operates when needed. The control sequences should be fine-tuned and retro-commissioned to ensure they are operating optimally.

Recommendation

The following are recommended:

- Fix the HP-2 starter so the pump operates in Hand position.
- Revise the radiant heat controls so the heat pump resets the heating supply temperature with outside temperature and the radiant temperature control is set to supply the heating water to the floor loops Convert the pumps to variable speed when they fail.
- Retro-commission the system.

DOMESTIC HOT WATER SYSTEM

Background

The domestic hot water system consists of an air source heat pump HP-1, a buffer tank, an electric hot water heater, and a second buffer tank. The heat pump heats the water in the first buffer tank which flows to the electric tank that keeps it warm until it flows through the second buffer tank to the building.

The heat pump evaporator is located outdoors and is protected from wind driven rain and snow. The exhaust air from AHU-1 is discharged behind the units so they can recover the heat for making domestic hot water.

Assessment

The heat pump was found to be maintaining a buffer tank temperature of 112°F. The setpoint was increased to 120°F so the heat pump supplies the entire pickup load.

The electric hot water heater has three 4 kW heating elements but only one heating stage. A staged controller would allow for each element to be step controlled, minimizing demand charges. This is especially appropriate since the tank only keeps the water warm; it does not provide the much larger pickup load.

The purpose of the second buffer tank is to provide storage for surges in use. The tank is poorly applied as it has no heating coil to maintain temperature. It will lose heat through the night, lowering the hot water supply temperature until there is sufficient flow in the morning to reheat the tank with the flow from the electric hot water heater. The buffer tank is not needed since the addition of the heat pump added heating capacity and storage to the domestic hot water system. The buffer tank should be isolated form the system by opening the bypass valve and closing one of the tank valves (leave the other one open to allow thermal contraction as it cools).

A thermostatic mixing valve is not installed to protect the residents from scalding.

Recommendation

The following are recommended:

- Remove the second buffer tank from the system.
- Install a thermostatic mixing valve

AIR HANDLING UNIT AHU-1

Background

Air handling unit AHU-1 supplies ventilation and natural cooling air to the common areas of the building including the lobby, conference room, lounge, dining room, and corridors. The system consists of a return fan, mixing box with outside, return air and exhaust air dampers, filters, heating coil, and supply fan. The system supplies constant airflow.

A DDC control system controls and monitors the system.

Assessment

Issues

The AHU appears to be properly installed and maintained. However, the system is not operating properly, indicating that the control system was not set up properly when it was constructed or it is no longer functioning properly. Main issues are:

- The mixing dampers are fixed in a full recirculation position. This negates the system's ability to supply ventilation air and naturally cool during warm weather.
- The AHU heating coil and duct coil are overheating the air. The flow through the coils also continues when the AHU is turned off.

It appears that the damper and coil controls are not working as all actuators appear to be in the normal positions.

A review of the control sequences reveals that they were poorly derived and are not optimal for Saxman's climate. Operation of the control system could not be assessed because there is no computer terminal interface from which to view the graphical representations of the building and systems. A graphical interface is recommended to make full use of the DDC system investment.

Energy Efficiency

The design drawings show a minimum outside air flow of 2,800 cfm. This is much higher than is needed to maintain adequate indoor air quality in the spaces. A minimum outside air flow of 500 cfm is more appropriate.

The system has a capacity of 8,300 cfm which is much higher than is needed to ventilate the spaces. Reducing the air flow to 5,000 cfm is more appropriate.

The following are recommended to improve the system's energy performance:

- Modify the control sequences to reduce outside air flow
- Convert the operation to variable speed to reduce fan and heating energy

A life cycle cost comparison determined that the proposed changes will require a $63,000 investment but will offer a life cycle savings of $113,000 over 25-years. Optimization of AHU-1 is recommended.

Energy Efficiency Measure	Annual Costs			Life Cycle Costs				
	Operating	Energy	Total	Investment	Operating	Energy	Total	SIR
EEM-1: Optimize AHU-1 System	$450	($9,880)	($9,430)	$63,100	$7,700	($183,400)	($112,600)	2.8
	Note: Negative values, in parenthesis, represent savings.							

Recommendation

The following are recommended:

- Revise the control sequences for optimal control
- Convert the system to variable speed and reduce outside air flow
- Retro-commission the system

CONTROL SYSTEM

Background

The building has a combination of a DDC control system and Tekmar controllers. The DDC system controls AHU-1, zone temperatures, and the radiant floor heat pump HP-2. The Tekmar controllers operate the heating system.

Assessment

The DDC system does not have a computer user interface to allow staff to monitor the operation of AHU-1 and the zone heating controls. This significantly limits the value of the DDC system to the operators.

The Tekmar controllers are able to properly control the heating system. However, the mixing of DDC controls and Tekmar controllers adds an unnecessary layer of complexity. Since the DDC system is needed for the AHU, the controls could have been simplified by using the DDC system for all controls, with the added benefit of providing a computer user interface for monitoring the entire mechanical system.

Recommendation

The following is recommended:

- Modify the controls as recommended for each system.
- Establish a computer interface for the control system and train the operators in its use.

PROPOSED MONITORING PLAN

Background

A building monitoring system can provide operational, energy tracking and research benefits to the Owner. The benefits of each are as follows:

- Operational: The monitoring system provides essential information for determining that the systems are operating properly including pump status, fan status, heating system temperature, ventilation system temperature, domestic hot water temperature, and room temperature.
- Energy: The monitoring system can provide data on energy use such as building electric demand, heating system energy use, domestic hot water energy use, and energy use of special areas or systems such as kitchens and lighting.
- Research: The monitoring system provides information useful to future design efforts such as peak heating load, heating system efficiency, domestic hot water load, indoor air quality, and occupancy.

Proposed Building Monitoring System

A proposed building monitoring system and cost estimate is provided in the following table. The table lists the data points that would be monitored. All of the monitoring equipment would be located in the mechanical rooms or electrical panels. The costs are identified for a basic operations monitoring system, options for a more comprehensive monitoring system, and for adding a capability to monitor energy data.

The monitoring system will collect data and transmit it via the building's internet provider or over the cellular internet. Using the cellular internet will require a $10 monthly charge, which can be avoided by using the building's internet service.

The monitoring system uses wireless sensors that transmit the data to the manufacturer's cloud storage service. The cost for this service is $3-$5 per year per sensor.

The collected data can be stored on THRHA's own Monitoring Website, which will cost $500 to set up and the monthly fees to the web host provider of $9 per month. If only 3-4 buildings are monitored by THRHA, there is also an option to share a website setup by the data monitoring consultant for no charge.

Proposed Saxman Senior Center Monitoring System

Item	Intent	Operational		Energy Use
		Basic	Option	
Fixed Cost				
Travel, per diem, equipment	Fixed costs	$4,423		
Unit Costs				
General				
Outdoor temperature	Outdoor temperature reference	$30		
Building electric load, kW	Total energy use			$1,697
Heating System				
Boiler B-1 enable	Boiler status		$364	
Boiler B-2 enable	Boiler status		$364	
Boiler pump HP-1 enable	Boiler pump status	$364		
Boiler pump HP-2 enable	Boiler pump status	$364		
Heat pump HP-1 enable	Heat pump status		$364	
Building heating supply temperature	Confirms heat to building	$282		
Building heating return temperature	Confirms heat to building		$282	
Radiant heating supply temperature	Conforms heat to radiant floors	$282		
Radiant heating return temperature	Conforms heat to radiant floors		$282	
Building heating supply flow	Determine building heating load			$1,345
Radiant heating flow	Determine radiant heating load			$1,345
Domestic Hot Water System				
Heat pump HP-2 enable	Heat pump status		$364	
Buffer tank temperature	Confirms heat pump operation	$282		
Hot water supply temperature	Confirms hot water availability	$282		
Domestic hot water flow rate	Measures hot water demand			$1,114
Cold water makeup temperature	Determine hot water load			$282
Electric hot water heater energy	Determine electric hot water heater energy			$1,281
Heat pump energy	Determine heat pump energy			$1,281
Ventilation System AHU-1				
Supply fan enable	Fan status		$364	
Supply air temperature	Confirm supply air temperature		$282	
Totals		$6,309	$2,666	$8,345

COST SUMMARY

The following table summarizes the recommendations and their costs. Cost estimates are appended to this memo.

Recommendations

Item	Cost Estimate
Heating System	$6,000
Fix the HP-2 starter so the pump operates in Hand position.	
Revise the controls for optimal operation	
Convert the pumps to variable speed when they fail	
Retro-commission the system	
Domestic Hot Water System	$8,000
Remove the second buffer tank from the system.	
Install a thermostatic mixing valve	
Air Handling Unit AHU-1	$63,000
Revise the control sequences for optimal control	
Convert the system to variable speed and reduce outside air flow	
Retro-commission the system	
Control System	$34,000
Establish a computer interface; train the operators in its use	
Total	$111,000
Monitoring System	
Install a basic monitoring system	$ 6,300
Add enhanced monitoring	$ 2,700
Add energy use data	$ 8,400
Total	$ 17,300

by: 

Jim Rehfeldt, P.E.

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Energy and Life Cycle Cost Analysis

June 19, 2015

Saxman Senior Center

Basis

Economic

Study Period (years)	25	Nominal Discount Rate	5%	General Inflation	2%

Energy

Electricity	$/kWh (2015)	$/kW (2015)	Inflation	$/kWh (2012)	$/kW (2012)
w/ Demand Charges	$0.090	$2.91	2.5%	$0.092	$2.98
w/o Demand Charges	$0.102	-	2.5%	$0.105	-

EEM-1: Optimize AHU-1 System

Energy Analysis

Minimum Outside Air	Design	Proposed
OSA cfm	2,800	500
People at 15 cfm/ea	187	33

Fan Energy

Fan	Case	CFM	ΔP	η, fan	BHP	η, motor	kW	Hours	kWh
SF	Existing	-8,300	2.00	50%	-5.2	91%	-4	5,475	-23,444
	Proposed	5,000	1.50	50%	2.4	91%	2	5,475	10,592
RF	Existing	-5,500	0.75	45%	-1.4	89%	-1	5,475	-6,619
	Proposed	4,500	0.60	45%	0.9	89%	1	5,475	4,332
							-3		-15,138

Ventilation Energy

	SA CFM	MAT	T,room	MBH	Hours	kBtu	η boiler	kBtu
Existing	-8,300	60	70	-90	5,475	-490,779	95%	-516,609
Proposed	5,000	62	70	43	5,475	236,520	95%	248,968
						-254,259		-267,641

	Vent kBtu	Vent kWh	Fan kWh	Total kWh
Electric Boilers	-267,641	-78,441	-15,138	-93,579

Life Cycle Cost Analysis	Year	Qty	Unit	Base Cost	Year 0 Cost
Construction Costs					
Install VFD, 7.5 HP and 2 HP	0	2	ea	$6,500	$13,000
Modify controls, programming	0	1	ls	$15,000	$15,000
TAB	0	1	ls	$3,500	$3,500
Commissioning	0	1	ls	$4,000	$4,000
Estimating contingency	0			15%	$5,325
Overhead & profit	0			30%	$12,248
Design fees	0			10%	$5,307
Project management	0			8%	$4,670
Annual Costs					
VFD Maintenance	1 - 25	2	ea	$225.00	$7,662
Energy Costs					
Electric Energy	1 - 25	-93,579	kWh	$0.105	($181,523)
Electric Demand	1 - 25	-33	kW	$2.98	($1,836)
Net Present Worth					($112,600)

Alaska Energy Engineering LLC
25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

CONSTRUCTION COST ESTIMATE

June 19, 2015

THRHA Energy Assessments

Saxman Senior Center

Item	Qty	Unit	Unit Cost	Total
Control System DDC User Interface				
DDC Software	1	ea	$2,000.00	$2,000
Develop screens: AHU-1, Floor Plans, Local controllers	24	hrs	$150.00	$3,600
Programming	1	ea	$5,000.00	$5,000
Retro-commission	1	ea	$2,500.00	$2,500
Travel and per diem	1	ea	$5,000.00	$5,000
Training	4	ea	$150.00	$600
Contingency			15%	$2,805
Overhead and Profit			30%	$6,452
Design Fees			10%	$2,796
Project costs			8%	$2,460
Total				$34,000
Heating System				
Repair pump HP-2 starter	1	ea	$750.00	$750
Reprogram Heat Pump and Tekmar controller	6	hrs	$150.00	$900
Retro-commission	1	ea	$1,000.00	$1,000
Training	2	hrs	$150.00	$300
Contingency			15%	$443
Overhead and Profit			30%	$1,018
Design Fees			10%	$441
Project costs			8%	$388
Total				$6,000
Domestic Hot Water System				
Remove 2nd buffer tank	1	ea	$1,000.00	$1,000
Install thermostatic mixing valve	1	ea	$4,500.00	$4,500
Retro-commission	1	ea	$1,000.00	$1,000
Training	2	hrs	$150.00	$300
Contingency			15%	$1,020
Total				$8,000
Total				$48,000

Attachment 14

Saxman – WESEE Wood Pellet System Conceptual Cost Estimate

Saxman 12 Unit Multifamily Building
Wood Pellet System Conceptual Cost Estimate

Line Item	Value	Units	$/Unit	Cost[1]
40,000 Btu/hr wood pellet system[2]	-	-	-	$ 15,000
Boiler room addition[3]	250	sf	$ 60	$ 15,000
Pellet storage				$ 7,500
Boiler room equipment	-	-	-	$ 10,000
Site preparation	-	-	-	$ 10,000
Thermal storage 60 gal	-	-	-	$ 4,000
Pex Pipe (1" supply and return)	25	lf	$ 100	$ 2,500
Interconnection to existing boiler room[4]	-	-	-	$ 10,000
Sub-Total				$ 74,000
Contractor Profit	*10%*			*$ 7,400*
Sub-Total				*$ 81,400*
Contingency	*15%*			*$ 12,210*
Sub-Total				*$ 93,610*
Professional Services	*12%*			*$ 11,233*
Total				**$ 104,843**

Notes:

1 - Overhead and bid bond are factored into the estimated item costs and are not broken out.

2 - Includes stack, breeching, and controls.

3 - Pole construction with minimal HVAC requirements.

4 - Cost is prelimary since existing equipment and plumbing have not been evaluated in detail.

5 - All costs are installed costs.

6 - Geotechnical investigations and surveys have not been conducted. Soil and grade dependent items are subject to large changes in cost pending site investigation.

7 - Sizing of the biomass system is based solely on estimated annual fuel usage data listed in AkWarm.

Attachment 15

Yakutat – Sunrise Apartments AEE Energy Assessment

THRHA Regional Housing Authority
Juneau, Alaska

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
jim@alaskaenergy.us

Technical Memorandum

June 19, 2015

to: **Craig Moore, THRHA**

subject: **Energy Assessment**

project: **Yakutat Sunrise Apartments**

INTRODUCTION

This memorandum presents the findings of an energy assessment of the Yakutat Sunrise Apartments owned by Tlingit-Haida Regional Housing Authority. The site was visited by Jim Rehfeldt, P.E. of Alaska Energy Engineering LLC on June 9, 2015. The purpose of the trip was:

- To review and observe the operation of the heating systems and controls.
- Develop an energy monitoring plan for the building systems

HEATING SYSTEM

There are two apartment buildings, each with identical heating systems.

Background

Each building is heated by two fuel oil boilers connected to a primary only hydronic heat distribution system. The boilers have a capacity of 227 MBH each and supply heat to perimeter baseboards, unit heaters, and the indirect hot water heaters.

Assessment

Each boiler has an aquastat that operates the burner. They are set to identical setpoints because both boilers are needed to meet the peak domestic hot water load. Two hot boilers have twice the jacket losses, resulting in a hot boiler room.

Recommendation

None

DOMESTIC HOT WATER SYSTEM

Background

The domestic hot water system consists of two indirect hot water heaters heated by the boilers. A hot water pump supplies both heaters. The internal tank thermostat turns on the pump and opens a control valve to allow hydronic flow to the coil.

A hot water recirculation pump maintains flow through the building mains.

There is no thermostatic mixing valve.

Assessment

The hot water tanks are 80 gallons each with an effective capacity of 112 gallons. This is insufficient storage for the number of apartments which is why both boilers are needed to provide sufficient recovery to meet the hot water demand. A larger storage capacity would allow one boiler to supply the hot water load.

Installing an additional hot water tank to increase storage would allow one boiler to be turned off for 9-months of the year. Space for the new tank could be created by removing the daytank and glycol tank and connecting the fuel oil piping directly to the boilers with a Tigerloop. A life cycle cost analysis determined that this option does not offer a life cycle savings.

Energy Efficiency Measure	Annual Costs			Life Cycle Costs				
	Operating	Energy	Total	Investment	Operating	Energy	Total	SIR
EEM-1: Increase HW Storage	$0	($1,307)	($1,307)	$37,700	$0	($28,924)	$8,776	0.8

Note: Negative values, in parenthesis, represent savings.

Recommendations

Adding additional hot water storage does not offer sufficient life cycle savings. Installation is not recommended.

Install a thermostatic mixing valve in each boiler room.

BOILER ROOM HEAT RECOVERY

Description

The boiler rooms have heat gain from the boilers and equipment, causing the boiler room temperature to exceed 85°F. A domestic hot water heat pump that recovers boiler room heat to preheat the hot water will utilize the heat. It will also increase hot water storage and recovery so that one of the boilers to be turned off for 9-months of the year.

Assessment

A life cycle cost analysis determined that installing a domestic hot water heat pump in each boiler room does not offer a life cycle savings.

Energy Efficiency Measure	Annual Costs			Life Cycle Costs				
	Operating	Energy	Total	Investment	Operating	Energy	Total	SIR
EEM-2: Domestic Hot Water Heat Pump	$400	($1,590)	($1,190)	$40,300	$6,811	($40,493)	$6,618	0.8

Note: Negative values, in parenthesis, represent savings.

Recommendations

The domestic hot water heat pump provides little savings because of the high cost of electricity to operate it. Installation is not recommended.

PROPOSED MONITORING PLAN

Background

A building monitoring system can provide operational, energy tracking and research benefits to the Owner. The benefits of each are as follows:

- Operational: The monitoring system provides essential information for determining that the systems are operating properly including pump status, fan status, heating system temperature, ventilation system temperature, domestic hot water temperature, and room temperature.

- Energy: The monitoring system can provide data on energy use such as building electric demand, heating system energy use, domestic hot water energy use, and energy use of special areas or systems such as kitchens and lighting.
- Research: The monitoring system provides information useful to future design efforts such as peak heating load, heating system efficiency, domestic hot water load, indoor air quality, and occupancy.

Proposed Building Monitoring System

A proposed building monitoring system for both buildings, with cost estimate, is provided in the following table. The costs are identified for a basic operational monitoring system, options that increase the monitoring capability, and options for gathering energy consumption data.

The monitoring system will be installed in the mechanical and boiler rooms.The monitoring system will collect data and transmit it via the building's internet provider or over the cellular internet. Using the cellular internet will require a $10 monthly charge, which can be avoided by using the building's internet service.

The monitoring system uses wireless sensors that transmit the data to the manufacturer's cloud storage service. The cost for this service is $3-$5 per year per sensor.

The collected data can be stored on THRHA's own Monitoring Website, which will cost $500 to set up and the monthly fees to the web host provider of $9 per month. If only 3-4 building are monitored by THRHA, there is also an option to share a website setup by the data monitoring consultant for no charge.

Proposed Yakutat Sunrise Apartments Monitoring System

Item	Intent	Operational		Energy Use
		Basic	Option	
Fixed Cost				
Travel, per diem, equipment	Fixed costs	$6,380		
Unit Costs				
General				
Outdoor temperature	Outdoor temperature reference	$30		
Building electric load, kW	Total energy use			$3,794
Heating System				
Oil boiler B-1 supply temp	Boiler status	$728		
Oil boiler B-2 supply temp	Boiler status	$728		
Building pump P-1 enable	Building pump status	$728		
Building pump P-2 enable	Building pump status	$728		
Building heating supply temperature	Confirms heat to building	$564		
Building heating return temperature	Confirms heat to building		$564	
Building heating supply flow	Determine building heating load			$2,690
Building Domestic Hot Water System				
Hot water heater supply temp	Hot water heater status	$564		
Hot water supply temp	Confirms mixing valve operation	$564		
Hot water flow rate	Measures hot water demand			$2,228
Cold water makeup temperature	Determine hot water load			$564
Totals for Two Buildings		$9,030	$564	$9,276

SUMMARY

The following table summarizes the recommendations and their costs.

Recommendations

Item	Cost Estimate
Domestic Hot Water System	$19,000
Install a thermostatic mixing valve in each building	
Commission the valve	
Monitoring System	
Install a basic monitoring system	$9,000
Add enhanced monitoring	$600
Add energy use monitoring	9,300
Total	$18,900

by: _____

Jim Rehfeldt, P.E.

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Energy and Life Cycle Cost Analysis

June 19, 2015

Yakutat Sunrise Apartments

Basis

Economic

Study Period (years)	25	Nominal Discount Rate	5%	General Inflation	2%

Energy

		$/gallon (2015)	Inflation	$/ton (2016)
Fuel oil		$4.90	4.0%	$5.10
Electricity		$/kWh (2015)	Inflation	$/kWh (2016)
		$0.500	2.5%	$0.513

EEM-2: Domestic Hot Water Heat Pump

Energy Analysis

Turn Lag Boiler Off (9 months)

Input, MBH	Jacket Loss	MBH	Hours	Loss, kBtu	Factor	Recovery, kBtu	η boiler	Gallons
526	-1.0%	-5	6,480	-34,104	75%	-25,578	72%	-257

Heat Recovery

Input, MBH	Jacket Loss	MBH	Hours	Loss, kBtu	Factor	Recovery, kBtu	η boiler	Gallons
526	-1.0%	-5	8,760	-46,104	75%	-34,578	72%	-347

Electricity

Heat Pump Energy

Recovery, kBtu	COP	kWh	HP Heat, kBtu
-34,578	3.5	2,895	9,879

Life Cycle Cost Analysis	Year	Qty	Unit	Base Cost	Year 0 Cost
Construction Costs					
Domestic hot water heat pump	0	2	LS	$4,000	$8,000
Plumbing	0	2	LS	$4,000	$8,000
Remove daytank, repipe fuel oil with Tigerloop	0	2	LS	$1,500	$3,000
Travel and per diem	0	2	LS	$5,000	$10,000
Electrical power	0	2	ea	$1,000	$2,000
Overhead and profit				30%	$9,300
Annual Costs					
Heat pump maintenance	1 - 25	2	LS	$200.00	$6,811
Energy Costs					
Electric Energy	1 - 25	2,895	kWh	$0.513	$27,532
Fuel Oil	1 - 25	-603.3	gallons	$5.10	($68,026)
Net Present Worth					$6,617

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Energy and Life Cycle Cost Analysis

June 19, 2015

Yakutat Sunrise Apartments

EEM-1: Increase HW Storage

Energy Analysis

Turn Lag Boiler Off (9 months)

Input, MBH	Jacket Loss	MBH	Hours	Loss, kBtu	Factor	Recovery, kBtu	η boiler	Gallons
526	-1.0%	-5	6,480	-34,104	75%	-25,578	72%	-257

Life Cycle Cost Analysis	Year	Qty	Unit	Base Cost	Year 0 Cost
Construction Costs					
Indirect hot water heater	0	2	LS	$4,000	$8,000
Travel and per diem	0	2	LS	$5,000	$10,000
Plumbing	0	2	LS	$3,000	$6,000
Remove daytank, repipe fuel oil with Tigerloop	0	2	LS	$1,500	$3,000
Electrical power	0	2	ea	$1,000	$2,000
Overhead and profit				30%	$8,700
Energy Costs					
Electric Energy	1 - 25	0	kWh	$0.513	$0
Fuel Oil	1 - 25	-256.5	gallons	$5.10	($28,924)
Net Present Worth					$8,776

Alaska Energy Engineering LLC
25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

CONSTRUCTION COST ESTIMATE

June 19, 2015

THRHA Energy Assessments

Yakutat Sunrise Apartments

Item	Qty	Unit	Unit Cost	Total
Domestic Hot Water System				
Install thermostatic mixing valve	2	ea	$4,500.00	$9,000
Travel and per diem	1	ea	$5,000.00	$5,000
Commission	2	ea	$750.00	$1,500
Training	2	hrs	$150.00	$300
Contingency			15%	$2,370
Total				$19,000

Attachment 16

Yakutat – WESEE Biomass System Conceptual Cost Estimate

Yakutat Sunrise Apartments
Wood Pellet System Conceptual Cost Estimate

Line Item				Cost
One (1) - 175,000 Btu/hr wood pellet hot water boiler, installed			$	35,000
Bulk Storage Bin			$	10,000
Stick frame storage building with poured concrete floor, 400 ft^2 @ \$50/ft^2			$	20,000
Thermal storage 250 gal with insulation			$	7,000
Interconnection piping (100 linear feet of 2" preinsulated PEX)			$	20,000
Interconnection with existing boiler room, pumps, installation			$	7,500
Electrical			$	4,500
Mechanical			$	4,500
Sub-Total			$	108,500
	Contractor Profit	*10%*	*$*	*10,850*
Sub-Total			*$*	*119,350*
	Contingency	*10%*	*$*	*11,935*
Sub-Total			*$*	*131,285*
	Profesional Services	*15%*	*$*	*19,693*
Total			**$**	**150,978**

Notes:

1 - The boiler system is to be installed in the existing boiler room. Pricing is based on a one-boiler solution.

2 - Professional Services includes permitting, legal, engineering, & project management. (Assumed that

3 - Estimate is based on competitive bidding.

Yakutat Sunrise Apartments
Cord Wood System Conceptual Cost Estimate

Line Item				Cost
One (1) - 140,000 Btu/hr cord wood boiler, freight, and installed			$	15,000
Stick frame storage building with poured concrete floor, 800 ft^2 @ \$50/ft^2			$	40,000
Thermal storage 550 gal with insulation			$	10,000
Interconnection with existing boiler room, pumps, installation			$	7,500
Interconnection piping (100 linear feet of 2" preinsulated PEX)			$	20,000
Electrical			$	5,000
Mechanical			$	5,000
Sub-Total			$	102,500
	Contractor Profit	*10%*	*$*	*10,250*
Sub-Total			*$*	*112,750*
	Contingency	*10%*	*$*	*11,275*
Sub-Total			*$*	*124,025*
	Profesional Services	*15%*	*$*	*18,604*
Total			**$**	**142,629**

Notes:

1 - The boiler system is to be installed in the existing boiler room. Pricing is based on a one-boiler solution. There are multiple manufacturers that can provide varying boiler sizes. Other boiler sizing combinations to meet a similar output range may also be selected.

2 - Professional Services includes permitting, legal, engineering, & project management. (Assumed that minimal engineering is required.)

3 - Estimate is based on competitive bidding.

Attachment 17

Yakutat – Senior Center AEE Energy Assessment

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
jim@alaskaenergy.us

Technical Memorandum

June 19, 2015

to: **Craig Moore, THRHA**

subject: **Energy Assessment**

project: **Yakutat Senior Center**

INTRODUCTION

This memorandum presents the findings of an energy assessment of the Yakutat Senior Center owned by Tlingit-Haida Regional Housing Authority. The site was visited by Jim Rehfeldt, P.E. of Alaska Energy Engineering LLC on June 8-9, 2015. The purpose of the trip was:

- Assess the design and operation of the heating and ventilation systems and controls.
- Develop an energy monitoring plan for the building systems

HEATING SYSTEM

Background

The building is heated by a cordwood boiler (lead) and an oil fired boiler (lag). The wood boiler was off and the oil boiler was heating the building during the site visit. This is in accordance with the plan to operate the wood pellet boiler during the heating season and the oil boiler during warmer weather when firing the wood boiler generates more heat than the building can use. A primary/secondary pumping system distributes heating water to the building.

Assessment

Configuration: The heating water from the wood and oil boilers flows through the heating storage tanks to the building. While this arrangement adds thermal mass, it does not allow the boiler flow to circulate through the tank and directly back to the boilers. This has been a problematic arrangement as the boilers must completely heat the tanks before delivering heat to the building or hot water heater. Also, the boiler controls would be more effective if the boiler water circulated directly between the tanks and the boilers. A preferred arrangement is to locate the heating tanks between the boilers and the building loop so both loops flow through the tank. A preferred piping schematic is attached at the end of this report.

Oil Boiler:

- The combustion air duct brings outside air to the boiler burn chamber. The duct has an opening into the boiler room. The manufacturer's representative confirmed that this is a preferred installation as it ensures air flow to the boiler if the intake freezes. It also allows the boiler to draw air from the warmer boiler room, improving combustion efficiency.
- The boiler has an electronic aquastat. The settings could not be determined.

Heating Storage Tanks:

- The heating storage tanks should have bypasses so they can be individually isolated for repairs.
- The storage tanks have 1-1/2" of fiberglass insulation but have considerable heat loss. Adding more insulation will decrease losses and cool the boiler room.

Recommendation

The following are recommended:

- Install bypass piping and valves around the heating storage tanks per the attached diagram.
- Add more insulation to the hot water storage tanks.
- Commission the system during both the summer and heating seasons to assure stable operation under varying loads.

DOMESTIC HOT WATER SYSTEM

Background

Building: The hot water system consists of an indirect hot water heater heated by the boilers, a thermostatic mixing valve, and a hot water recirculation pump that maintains hot water temperature in the piping to the apartments.

Kitchen: The kitchen has an electric hot water heater with thermostatic mixing valve.

Assessment

The building hot water heater is connected improperly to the hydronic heating system. In the current configuration heating return water from the building is being supplied to the heater. This cooler water reduces the recovery capacity of the hot water tank. The current arrangement can also allow the flow to recirculate through the hot water heater without being reheated by a boiler.

The thermostatic mixing valve is not supplying constant temperature water to the building.

Recommendation

The following are recommended:

- Reconfigure the heating supply piping to the hot water tank per the attached piping diagram
- Commission the system and thermostatic mixing valve

HEAT RECOVERY VENTILATORS HRV-1 AND HRV-2

Background

Heat recovery ventilators HRV-1 and HRV-2 supply common areas in the core of the building. HRV-1 supplies 420 cfm and HRV-2 supplies 650 cfm.

A heating coil is installed in the combined outside air duct to each unit to provide frost protection for the heat recovery core and heating of the supply air. The controller is set at 45°F. A controller in the outside air operates the circulation pump whenever the outside temperature drops below 35°F to protect against freezing the coil.

The units are controlled from separate wall-mounted controllers. Each controller is operated manually and has an On-Low-High switch and humidity controller. In the low position, the fan operates on low but increases to high if humidity levels exceed the setpoint.

Assessment

Issues

The building occupancy is very light so the units are supplying more ventilation air than is needed for adequate indoor air quality. Operating the units on low speed will reduce ventilation energy.

The unit drains are not piped to a suitable discharge point.

Recommendation

The following are recommended:

- Operate the units on low speed
- Connect to the equipment drains and route to a suitable discharge point
- Commission the system

MAKEUP AIR UNIT

Background

The makeup air unit supplies air to the kitchen to make-up the air exhausted up the kitchen hood. The unit operates when the kitchen hood operates.

Assessment

Issues

The supply air temperature was set to 63°F which was reported to be too cold, causing the kitchen temperature to drop. The setpoint was increased to 68°F.

Recommendation

The following are recommended:

- Commission the system

MISCELLANEOUS

Background

The following miscellaneous issues were observed:

- The Owner elected to install electric kitchen cooking appliances and hot water heater. Propane equipment would have lower energy costs.
- The heating and plumbing piping is not labeled.
- The motor starters are not labeled and the circuits are not identified.
- The electric panel schedules are not accurate.
- The heating piping does not have air vents at the high points.

PROPOSED MONITORING PLAN

Background

A building monitoring system can provide operational, energy tracking and research benefits to the Owner. The benefits of each are as follows:

- Operational: The monitoring system provides essential information for determining that the systems are operating properly including pump status, fan status, heating system temperature, ventilation system temperature, domestic hot water temperature, and room temperature.
- Energy: The monitoring system can provide data on energy use such as building electric demand, heating system energy use, domestic hot water energy use, and energy use of special areas or systems such as kitchens and lighting.
- Research: The monitoring system provides information useful to future design efforts such as peak heating load, heating system efficiency, domestic hot water load, indoor air quality, and occupancy.

Proposed Building Monitoring System

A proposed building monitoring system and cost estimate is provided in the table at the end of this report. The table lists the data points that would be monitored. All of the monitoring equipment would be located in the mechanical rooms or electrical panels. The costs are identified for a basic operations monitoring system, options for a more comprehensive monitoring system, and for adding a capability to monitor energy data.

The monitoring system will collect data and transmit it via the building's internet provider or over the cellular internet. Using the cellular internet will require a $10 monthly charge, which can be avoided by using the building's internet service.

The monitoring system uses wireless sensors that transmit the data to the manufacturer's cloud storage service. The cost for this service is $3-$5 per year per sensor.

The collected data can be stored on THRHA's own Monitoring Website, which will cost $500 to set up and the monthly fees to the web host provider of $9 per month. If only 3-4 building are monitored by THRHA, there is also an option to share a website setup by the data monitoring consultant for no charge.

The following table summarizes the recommendations and their costs. Cost estimates are appended to this memo.

Proposed Yakutat Senior Center Monitoring System

Item	Intent	Operational		Energy Use
		Basic	Option	
Fixed Cost				
Travel, per diem, equipment	Fixed costs	$4,167		
Unit Costs				
General				
Outdoor temperature	Outdoor temperature reference	$30		
Building electric load, kW	Total energy use			$1,897
Heating System				
Wood boiler B-1 enable	Boiler status		$364	
Oil boiler B-2 enable	Boiler status		$364	
Wood boiler B-1 supply temp	Boiler status	$364		
Oil boiler B-2 supply temp	Boiler status	$364		
Wood boiler pump P-7 enable	Boiler pump status	$364		
Heat exchanger pump P-10 enable	Boiler pump status	$364		
Oil boiler pump P-4 enable	Boiler pump status	$364		
Building pump P-1 enable	Building pump status	$364		
Building pump P-2 enable	Building pump status	$364		
Building heating supply temperature	Confirms heat to building	$282		
Building heating return temperature	Confirms heat to building		$282	
Building heating supply flow	Determine building heating load			$1,345
Building Domestic Hot Water System				
Hot water heater supply temp	Hot water heater status	$282		
Hot water supply temp	Confirms mixing valve operation	$282		
Hot water flow rate	Measures hot water demand			$1,114
Cold water makeup temperature	Determine hot water load			$282
Kitchen Domestic Hot Water System				
Hot water heater supply temp	Hot water heater status	$282		
Hot water supply temp	Confirms mixing valve operation	$282		
Hot water flow rate	Measures hot water demand			$837
Heat Recovery Unit HRV-1				
Supply fan enable	Fan status		$364	
Exhaust fan enable	Fan status		$364	
Supply air temperature	Confirm supply air temperature		$302	
Heat Recovery Unit HR-2				
Supply fan enable	Fan status		$364	
Exhaust fan enable	Fan status		$364	
Supply air temperature	Confirm supply air temperature		$302	
Makeup Air Fan MUA-1				
Supply fan enable	Fan status		$364	
Supply air temperature	Confirm supply air temperature		$302	
Totals		$8,155	$3,736	$5,475

COST SUMMARY

The following table summarizes the recommendations and their costs. Cost estimates are appended to this memo.

Recommendations

Item	Cost Estimate
HVAC Systems	
Heating System	$27,000
Install bypass piping and valves around the heating storage tanks per the attached diagram.	
Add more insulation to the hot water storage tanks.	
Commission the system during both the summer and heating seasons	
Domestic Hot Water System	$19,000
Reconfigure the heating supply piping to the hot water tank	
Commission the system and thermostatic mixing valve	
Heat Recovery Ventilators HRV-1 and HRV-2	$5,000
Operate the units on low speed	
Connect to the equipment drains and route to a suitable discharge point	
Commission the system	
Makeup Air Unit	$2,000
Commission the system	
Total	$53,000
Monitoring System	
Install a basic monitoring system	$ 8,200
Add enhanced monitoring	$ 3,700
Add energy use monitoring	$ 5,500
Total	$ 17,400

by: 

Jim Rehfeldt, P.E.

Alaska Energy Engineering LLC
25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

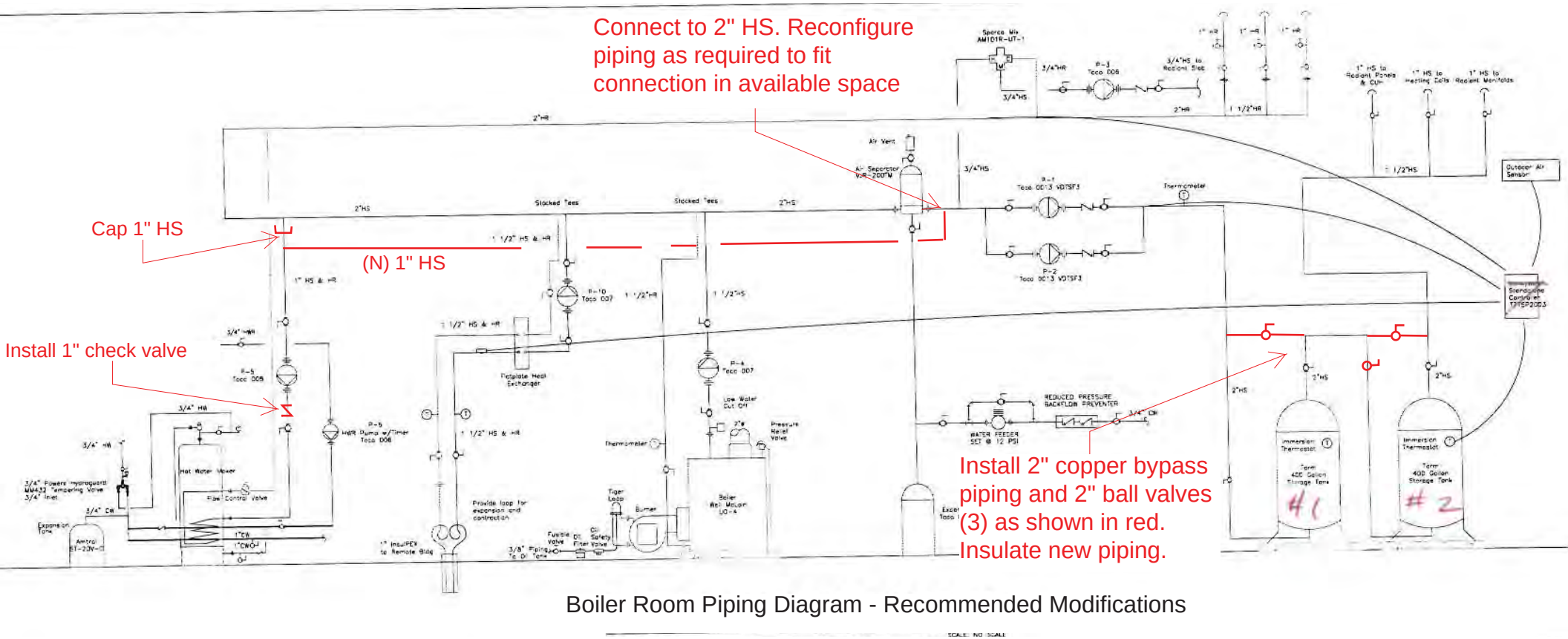
CONSTRUCTION COST ESTIMATE

June 19, 2015

THRHA Energy Assessments

Yakutat Senior Center

Item	Qty	Unit	Unit Cost	Total
Heating System				
Install heating storage tank bypass piping and valves	1	ls	$5,000.00	$5,000
Install heating storage tank insulation	1	ls	$1,000.00	$1,000
Travel and per diem	1	ea	$5,000.00	$5,000
Commissioning	1	ea	$4,000.00	$4,000
Contingency			15%	$2,250
Overhead and Profit			30%	$5,175
Design Fees			10%	$2,243
Project costs			8%	$1,973
Total				$27,000
Hot Water System				
Relocate hot water heater heating supply connection	1	ls	$3,500.00	$3,500
Travel and per diem	1	ea	$5,000.00	$5,000
Commission thermostatic mixing valve	1	ea	$2,000.00	$2,000
Contingency			15%	$1,575
Overhead and Profit			30%	$3,623
Design Fees			10%	$1,570
Project costs			8%	$1,381
Total				$19,000
Heat Recovery Units				
Install equipment drains	2	ea	$250.00	$500
Commissioning	2	ea	$1,000.00	$2,000
Contingency			15%	$375
Overhead and Profit			30%	$863
Design Fees			10%	$374
Project costs			8%	$329
Total				$5,000
Makeup Air Unit				
Commissioning	1	ea	$1,000.00	$1,000
Contingency			15%	$150
Overhead and Profit			30%	$345
Design Fees			10%	$150
Project costs			8%	$132
Total				$2,000
Total				$53,000



Boiler Room Piping Diagram - Recommended Modifications

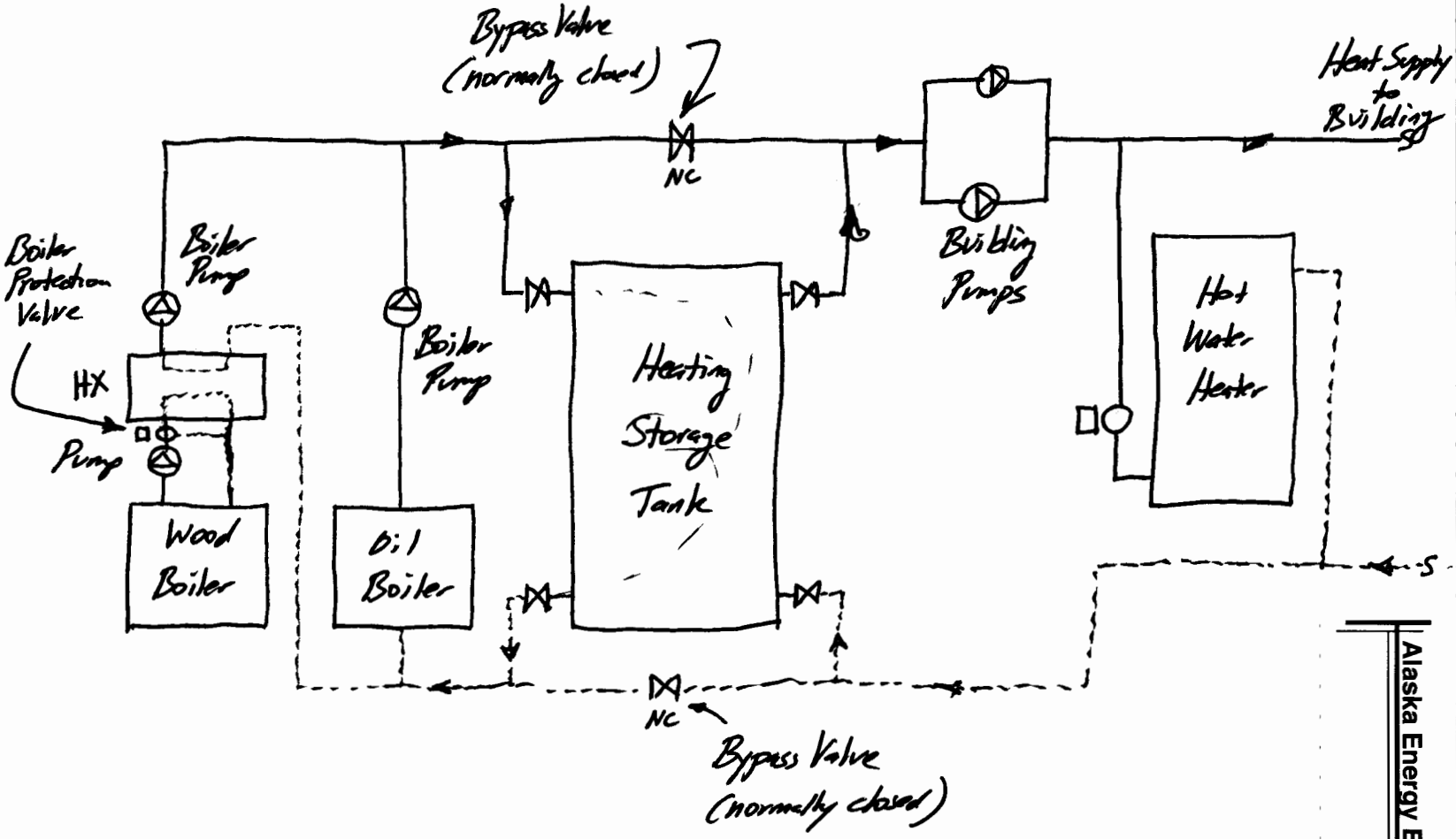
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Preferred Heating System Schematic

Alaska Energy Engineering LLC

Attachment 18

Yakutat – Senior Center Status Report

Tlingit-Haida Regional Housing Authority

Date: September 30, 2013

RE: YAKUTAT SENIOR CENTER STATUS REPORT

From: Craig Moore, V.P. Planning and Development
Development and Construction Management (DCM)

STATUS OF PROJECT:

YTT held their Grand Opening on August 2, and it was a great success. YTT had partially furnished the common areas for the event. Speeches were conducted under the roof of the Porte Cochiere, tours were held, and YTT served a delicious meal.

Final inspections of the building have been completed. Certificate of Occupancy (AHFC form PUR 102) inspection was completed by engineer Fred Monrean and final inspection signed off on 8-28-13. Marquam George has completed energy ratings and PUR 101. The two apartments came it at 5 Star Plus and Six Star. Yakutat Tlingit Tribe has taken full occupancy and management of the Building. Southeast Senior Services (SESS) has started the Senior Lunch Program.



YTT cleared trees and landscaped around the new Senior Center, opening up views. They have also furnished the common areas, and installed art work.

Photos from Grand Opening 8-2-2013






YTT WELCOMES THE
FOLLOWING AGENCIES
USDA
Alaska Housing


Waas'eitA Shaa Hit



















Marge Adams enjoys the view of Monti Bay from the deck.



Wood Gun cord wood gasification boiler





Basement boiler room, with Weil McLain Ultra oil boiler on left, and two 400 Gallon Tarm hot water storage tanks on right.



Two Venmar HRV units in conditioned crawlspace



2-bedroom apartment with radiant in-slab heating and vinyl flooring. Energy Star lighting. 9' ceiling. This apartment rated 5 Star Plus.

Attachment 19

Lighting Fixture Analysis

Angoon Lighting Fixtures

Duplex 1

Area Number	Area	Fixture Type	Existing Wattage per Fixture	Quantity	Existing Operating Hours	Annual Existing Operating Cost	Replacement Fixture	Replacement Wattage	Anticipated Operating Hours	Annual Proposed Operating Cost	Annual Savings	Replacement Cost	Payback, Years	kWh Savings
1	Kitchens	4' 2 lamp t-12	65.8	4	3,650	$596	4' 2 lamp T-8	58	3,650	$527	$69	$800	11.6	111
2	Bedroom 1	4' 2 lamp t-12	65.8	2	3,650	$298	4' 2 lamp T-8	58	3,650	$263	$34	$400	11.6	55
3	Bedroom 2	4' 2 lamp t-12	65.8	2	3,650	$298	4' 2 lamp T-8	58	3,650	$263	$34	$400	11.6	55
4	Bedroom 3	4' 2 lamp t-12	65.8	2	3,650	$298	4' 2 lamp T-8	58	3,650	$263	$34	$400	11.6	55
5	Bedroom 4	4' 2 lamp t-12	65.8	2	3,650	$298	4' 2 lamp T-8	58	3,650	$263	$34	$400	11.6	55
6	Exterior	150w Metal Halide Wall Pack	150.0	2	4,000	$744	80w LED Wall Pack	80	4,000	$397	$347	$460	1.3	560
			Totals	**14**		**$2,531**				**$1,977**	**$554**	**$2,860**	**5.2**	**893**

Assumes 10 hours per day operating hours for inside lights

Duplex 2

Area Number	Area	Fixture Type	Existing Wattage per Fixture	Quantity	Existing Operating Hours	Annual Existing Operating Cost	Replacement Fixture	Replacement Wattage	Anticipated Operating Hours	Annual Proposed Operating Cost	Annual Savings	Replacement Cost	Payback, Years	kWh Savings
1	Kitchens	4' 2 lamp t-12	65.8	4	3,650	$596	4' 2 lamp T-8	58	3,650	$527	$69	$800	11.6	111
2	Bedroom 1	4' 2 lamp t-12	65.8	2	3,650	$298	4' 2 lamp T-8	58	3,650	$263	$34	$400	11.6	55
3	Bedroom 2	4' 2 lamp t-12	65.8	2	3,650	$298	4' 2 lamp T-8	58	3,650	$263	$34	$400	11.6	55
4	Bedroom 3	4' 2 lamp t-12	65.8	2	3,650	$298	4' 2 lamp T-8	58	3,650	$263	$34	$400	11.6	55
5	Exterior	150w Metal Halide Wall Pack	150.0	2	4,000	$744	80w LED Wall Pack	80	4,000	$397	$347	$460	1.3	560
			Totals	**12**		**$2,233**				**$1,714**	**$519**	**$2,460**	**4.7**	**837**

Assumes 10 hours per day operating hours for inside lights

Triplex

Area Number	Area	Fixture Type	Existing Wattage per Fixture	Quantity	Existing Operating Hours	Annual Existing Operating Cost	Replacement Fixture	Replacement Wattage	Anticipated Operating Hours	Annual Proposed Operating Cost	Annual Savings	Replacement Cost	Payback, Years	kWh Savings
1	Kitchens	4' 2 lamp t-12	65.8	6	3,650	$893	4' 2 lamp T-8	58	3,650	$790	$103	$1,200	11.6	166
2	Bedroom 1	4' 2 lamp t-12	65.8	3	3,650	$447	4' 2 lamp T-8	58	3,650	$395	$52	$600	11.6	83
3	Exterior	150w Metal Halide Wall Pack	150.0	3	4,000	$1,116	80w LED Wall Pack	80	4,000	$595	$521	$690	1.3	840
			Totals	**12**		**$2,456**				**$1,781**	**$676**	**$2,490**	**3.7**	**1,090**

Assumes 10 hours per day operating hours for inside lights

Fourplex

Area Number	Area	Fixture Type	Existing Wattage per Fixture	Quantity	Existing Operating Hours	Annual Existing Operating Cost	Replacement Fixture	Replacement Wattage	Anticipated Operating Hours	Annual Proposed Operating Cost	Annual Savings	Replacement Cost	Payback, Years	kWh Savings
1	Kitchens	4' 2 lamp t-12	65.8	8	3,650	$1,191	4' 2 lamp T-8	58	3,650	$1,054	$138	$1,600	11.6	222
2	Bedroom 1	4' 2 lamp t-12	65.8	4	3,650	$596	4' 2 lamp T-8	58	3,650	$527	$69	$800	11.6	111
3	Bedroom 2	4' 2 lamp t-12	65.8	4	3,650	$596	4' 2 lamp T-8	58	3,650	$527	$69	$800	11.6	111
4	Exterior	150w Metal Halide Wall Pack	150.0	4	4,000	$1,488	80w LED Wall Pack	80	4,000	$794	$694	$920	1.3	1,120
			Totals	**20**		**$3,870**				**$2,901**	**$970**	**$4,120**	**4.2**	**1,564**

Assumes 10 hours per day operating hours for inside lights

Craig Lighting Fixtures

Area Number	Area	Fixture Type	Existing Wattage per Fixture	Quantity	Existing Operating Hours	Annual Existing Operating Cost	Replacement Fixture	Replacement Wattage	Anticipated Operating Hours	Annual Proposed Operating Cost	Annual Savings	Replacement Cost	Payback, Years	kWh Savings
1	Main Corridor	2' 2 lamp t-12	41.6	15	5,110	$733	2' 2 lamp t-8	33	5,110	$582	$152	$2,250	14.8	659
2	Unit 1	4' 2 lamp t-12	65.8	5	5,110	$387	4' 2 lamp t-8	58	5,110	$342	$45	$1,000	22.4	194
3	Unit 2	4' 2 lamp t-12	65.8	5	5,110	$387	4' 2 lamp t-8	58	5,110	$342	$45	$1,000	22.4	194
4	Unit 3	4' 2 lamp t-12	65.8	5	5,110	$387	4' 2 lamp t-8	58	5,110	$342	$45	$1,000	22.4	194
5	Unit 4	4' 2 lamp t-12	65.8	5	5,110	$387	4' 2 lamp t-8	58	5,110	$342	$45	$1,000	22.4	194
6	Unit 5	4' 2 lamp t-12	65.8	5	5,110	$387	4' 2 lamp t-8	58	5,110	$342	$45	$1,000	22.4	194
7	Unit 6	4' 2 lamp t-12	65.8	5	5,110	$387	4' 2 lamp t-8	58	5,110	$342	$45	$1,000	22.4	194
8	Unit 7	4' 2 lamp t-12	65.8	5	5,110	$387	4' 2 lamp t-8	58	5,110	$342	$45	$1,000	22.4	194
9	Unit 8	4' 2 lamp t-12	65.8	5	5,110	$387	4' 2 lamp t-8	58	5,110	$342	$45	$1,000	22.4	194
10	Unit 9	4' 2 lamp t-12	65.8	5	5,110	$387	4' 2 lamp t-8	58	5,110	$342	$45	$1,000	22.4	194
11	Exterior	150w Metal Halide Wall Pack	150.0	3	4,000	$414	80w LED Wall Pack	80	4,000	$221	$193	$690	3.6	840
			Totals	**63**		**$4,627**				**$3,881**	**$747**	**$11,940**	**16.0**	**3,247**

Assumes seniors sleep for 10 hours and remaining time lights are on

Juneau Granite Lighting Fixtures

Area Number	Area	Fixture Type	Existing Wattage per Fixture	Quantity	Existing Operating Hours	Annual Existing Operating Cost	Replacement Fixture	Replacement Wattage	Anticipated Operating Hours	Annual Proposed Operating Cost	Annual Savings	Replacement Cost	Payback, Years	kWh Savings
1	Kitchens	4' 2 lamp t-12	65.8	4	2,920	$85	4' 2 lamp T-8	58	2,920	$75	$10	$800	81.9	89
2	Laundrys	4' 2 lamp t-12	65.8	2	2,920	$42	4' 2 lamp T-8	58	2,920	$37	$5	$400	81.9	44
3	Vanity Light Bar	60w Incandescent	60.0	8	730	$39	4 - 23w CFL	23	730	$15	$24	$120	5.0	216
4	Exterior	150w Metal Halide Wall Pack	150.0	8	4,000	$528	80w LED Wall Pack	80	4,000	$282	$246	$1,840	7.5	2,240
			Totals	**22**		**$693**				**$409**	**$285**	**$3,160**	**11.1**	**2,589**

Assumes vanity light is on 2 hours per day
Assumes people work and hours with the lights on are 5 after work and 3 before work for 8 hours total

NOTE: NOT INCLUDED IN REPORT!

Juneau Kanat'a Dey'i Lighting Fixtures

Kanat'a Deyi - Typical Duplex Lighting

Area Number	Area	Fixture Type	Existing Wattage per Fixture	Quantity	Existing Operating Hours	Annual Existing Operating Cost	Replacement Fixture	Replacement Wattage	Anticipated Operating Hours	Annual Proposed Operating Cost	Annual Savings	Replacement Cost	Payback, Years	kWh Savings
1	Kitchens	4' 2 lamp t-12	65.8	4	2,920	$85	4' 2 lamp T-8	58	2,920	$75	$10	$800	81.9	89
2	Laundrys	4' 2 lamp t-12	65.8	2	2,920	$42	4' 2 lamp T-8	58	2,920	$37	$5	$400	81.9	44
3	Vanity Light Bar	60w Incandescent	60.0	8	730	$39	4 - 23w CFL	23	730	$15	$24	$120	5.0	216
4	Exterior	150w Metal Halide Wall Pack	150.0	2	4,000	$132	80w LED Wall Pack	80	4,000	$70	$62	$460	7.5	560
			Totals	**16**		**$297**				**$197**	**$100**	**$1,780**	**17.8**	**909**

note: Fixture quantity includes both units in the duplex.

NOTE: NOT INCLUDED IN REPORT!

Hoonah Lighting Fixtures

Area Number	Area	Fixture Type	Existing Wattage per Fixture	Quantity	Existing Operating Hours	Annual Existing Operating Cost	Replacement Fixture	Replacement Wattage per Fixture	Anticipated Operating Hours	Annual Proposed Operating Cost	Annual Savings	Replacement Cost	Payback, Years	kWh Savings
1	Main Corridor	2' 2 lamp t-12	41.6	14	5,110	$1,696	2' x 2' LED	20	5,110	$816	$881	$11,620	13.2	1,545
2	Unit 1	4' 2 lamp t-12	65.8	5	5,110	$958	4' 2 lamp t-8	58	5,110	$848	$111	$1,000	9.0	194
3	Unit 2	4' 2 lamp t-12	65.8	5	5,110	$958	4' 2 lamp t-8	58	5,110	$848	$111	$1,000	9.0	194
4	Unit 3	4' 2 lamp t-12	65.8	5	5,110	$958	4' 2 lamp t-8	58	5,110	$848	$111	$1,000	9.0	194
5	Unit 4	4' 2 lamp t-12	65.8	5	5,110	$958	4' 2 lamp t-8	58	5,110	$848	$111	$1,000	9.0	194
6	Unit 5	4' 2 lamp t-12	65.8	5	5,110	$958	4' 2 lamp t-8	58	5,110	$848	$111	$1,000	9.0	194
7	Unit 6	4' 2 lamp t-12	65.8	5	5,110	$958	4' 2 lamp t-8	58	5,110	$848	$111	$1,000	9.0	194
8	Unit 7	4' 2 lamp t-12	65.8	5	5,110	$958	4' 2 lamp t-8	58	5,110	$848	$111	$1,000	9.0	194
9	Unit 8	4' 2 lamp t-12	65.8	5	5,110	$958	4' 2 lamp t-8	58	5,110	$848	$111	$1,000	9.0	194
10	Unit 9	4' 2 lamp t-12	65.8	5	5,110	$958	4' 2 lamp t-8	58	5,110	$848	$111	$1,000	9.0	194
11	Unit 10	4' 2 lamp t-13	65.8	5	5,110	$958	4' 2 lamp t-9	58	5,110	$848	$111	$1,000	9.0	194
12	Unit 11	4' 2 lamp t-14	65.8	5	5,110	$958	4' 2 lamp t-10	58	5,110	$848	$111	$1,000	9.0	194
13	Unit 12	4' 2 lamp t-15	65.8	5	5,110	$958	4' 2 lamp t-11	58	5,110	$848	$111	$1,000	9.0	194
11	Exterior	150w Metal Halide Wall Pack	150.0	3	4,000	$1,026	80w LED Wall Pack	80	4,000	$547	$479	$690	1.4	840
			Totals	**77**		**$14,222**				**$11,534**	**$2,688**	**$24,310**	**9.0**	**4,715**

Assumes seniors sleep for 10 hours and remaining time lights are on

Kasaan Lighting Fixtures

Kasaan - Typical Duplex Lighting

Area Number	Area	Fixture Type	Existing Wattage per Fixture	Quantity	Existing Operating Hours	Annual Existing Operating Cost	Replacement Fixture	Replacement Wattage	Anticipated Operating Hours	Annual Proposed Operating Cost	Annual Savings	Replacement Cost	Payback, Years	kWh Savings
1	Exterior	150w Metal Halide Wall Pack	150.0	2	4,000	$264	80w LED Wall Pack	80	4,000	$141	$123	$460	3.7	560
			Totals	**2**		**$264**				**$141**	**$123**	**$460**	**3.7**	**560**

note: Fixture quantity includes both units in the duplex.

Ketchikan Lighting Fixtures

Ketchikan - Typical Fourplex Lighting

Area Number	Area	Fixture Type	Existing Wattage per Fixture	Quantity	Existing Operating Hours	Annual Existing Operating Cost	Replacement Fixture	Replacement Wattage	Anticipated Operating Hours	Annual Proposed Operating Cost	Annual Savings	Replacement Cost	Payback, Years	kWh Savings
1	Exterior	150w Metal Halide Wall Pack	150.0	4	4,000	$264	80w LED Wall Pack	80	4,000	$141	$123	$920	7.5	1,120
			Totals	**4**		**$264**				**$141**	**$123**	**$920**	**7.5**	**1,120**

note: Fixture quantity includes both units in the duplex.

Petersburg Lighting Fixtures

Area Number	Area	Fixture Type	Existing Wattage per Fixture	Quantity	Existing Operating Hours	Annual Existing Operating Cost	Replacement Fixture	Replacement Wattage	Anticipated Operating Hours	Annual Proposed Operating Cost	Annual Savings	Replacement Cost	Payback, Years	kWh Savings
1	Kitchens	4' 2 lamp t-12	65.8	6	2,920	$92	4' 2 lamp T-8	58	2,920	$82	$11	$1,200	112.7	133
2	Bedrooms	4' 2 lamp t-12	65.8	12	2,920	$184	4' 2 lamp T-8	58	2,920	$163	$21	$2,400	112.7	266
3	Vanity Light Bar	60w Incandescent	60.0	16	730	$56	4 - 23w CFL	23	730	$21	$35	$240	6.9	432
4	Exterior	150w Metal Halide Wall Pack	150.0	6	4,000	$288	80w LED Wall Pack	80	4,000	$154	$134	$1,380	10.3	1,680
			Totals	**40**		**$621**				**$420**	**$201**	**$5,220**	**26.0**	**2,512**

Assumes vanity light is on 2 hours per day
Assumes people work and hours with the lights on are 5 after work and 3 before work for 8 hours total

Yakutat Sunrise Lighting Fixtures

Area Number	Area	Fixture Type	Existing Wattage per Fixture	Quantity	Existing Operating Hours	Annual Existing Operating Cost	Replacement Fixture	Replacement Wattage per Fixture	Anticipated Operating Hours	Annual Proposed Operating Cost	Annual Savings	Replacement Cost	Payback, Years	kWh Savings
1	11 Unit Bottom Floor Rooms	4' 2 lamp t-12	65.8	30	5,110	$4,741	4' 2 lamp t-8	58	5,110	$4,193	$548	$6,000	11.0	1,165
2	11 Unit Bottom Floor Rooms	4' 2 lamp t-12	65.8	31	5,110	$4,899	4' 2 lamp t-8	58	5,110	$4,333	$566	$6,200	11.0	1,204
3	9 Unit Top Floor Rooms	4' 2 lamp t-12	65.8	26	5,110	$4,109	4' 2 lamp t-8	58	5,110	$3,634	$475	$5,200	11.0	1,010
4	9 Unit Bottom Floor Rooms	4' 2 lamp t-12	65.8	26	5,110	$4,109	4' 2 lamp t-8	58	5,110	$3,634	$475	$5,200	11.0	1,010
5	Exterior	150w Metal Halide Wall Pack	150.0	8	4,000	$2,256	80w LED Wall Pack	80	4,000	$1,203	$1,053	$1,840	1.7	2,240
			Totals	**121**		**$20,114**				**$16,998**	**$3,115**	**$24,440**	**7.8**	**6,628**

Assumes seniors sleep for 10 hours and remaining time lights are on

Attachment 20

Heat Pump Break Even Summary

Air Source Heat Pump
Break Even Analysis Summary

Community	ASHP Savings Compared to Currently Installed System?	Fuel Prices that would be equivalent to the cost of using an ASHP							
		#1 Fuel Oil, Gallon	#2 Fuel Oil, Gallon	Wood Pellets, Ton	Bio Bricks, Ton (Palletized Unboxed)	Bio Bricks, Ton (Palletized Boxed), $/Ton	Seasoned Hemlock, Full Cord, $/Cord	Propane, $/Gallon	YanMar Propane 5kW Heating, $/Propane Gallon
Angoon	No	$6.49	-	$736.54	-	-	-	$4.42	$7.17
Craig	Yes	$2.41	-	$273.23	$256.15	$256.15	$284.69	$1.64	$2.66
Haines	Yes	-	$2.50	$273.23	-	-	-	$1.64	$2.66
Hoonah	No	-	$6.18	$677.14	-	-	-	$4.07	$6.60
Juneau	Yes	$1.15	$1.19	$130.68	-	-	-	$0.78	$1.27
Kake	Yes	$6.07	-	$689.02	-	-	-	$4.14	$6.71
Kasaan	Yes	$2.30	-	$261.35	-	-	-	$1.57	$2.55
Ketchikan	Yes	$1.15	$1.19	$130.68	-	-	-	$0.78	$1.27
Klawock	Yes	$2.30	-	$261.35	$245.02	$245.02	$272.31	$1.57	$2.55
Petersburg	Yes	-	$0.83	-	-	-	-	$0.55	$0.89
Saxman	Yes	-	$1.08	$118.80	-	-	-	$0.71	$1.16
Wrangell	Yes	$1.05	-	-	-	-	-	$0.71	$1.16
Yakutat	No	$4.92	-	$558.34	-	-	$581.76	$3.35	$5.44

Notes:

1-If fuel prices listed in the table are higher than currently being paid, an ASHP is more expensive to operate than the compared fuel.

2-If fuel prices listed in the table are lower than currently being paid, an ASHP is less expensive to operate than the compared fuel.

3-Cells highlighted in green are the fuels used in the Currently Installed System.

4-Kake currently generates savings over oil since handling costs are high. Wood pellets are less expensive than an ASHP, however have additional delivery/handling issues that are not included.

5-See individual community tabs for detailed fuel cost comparisons.

Attachment 21

3 BR Single Story – 1,300 Ft^2 Dwelling Wood Pellet Stove & Heat Pump Conversion Cost

Air Source Heat Pump & Rinnai Water Heater Cost Estimate

Line Item	Value	Units	$/Unit	Cost[1]
Remove and dispose oil boiler and indirect hot water heater		1	$ 1,600	$ 1,600
18,000 Btu/hr air source heat pump with one indoor head, installed		1	$ 5,000	$ 5,000
Tankless LPG 8 GPM condensing on demand water heater, installed		1	$ 2,500	$ 2,500
Low sone distribution fan and ducting, installed		1	$ 1,000	$ 1,000
Freight		1	$ 1,500	$ 1,500
Sub-Total				$ 11,600
Contractor Profit	*10%*			*$ 1,160*
Sub-Total				*$ 12,760*
Contingency	*15%*			*$ 1,914*
Total				**$ 14,674**

Notes:

1 - Assumes that the existing electric service is of sufficient size for the air source heat pump system.

2 - Includes only one indoor heating unit fed by the ASHP.

3 - Cost assumes that minimal engineering is required and would be provided by the installing contractor.

4 - Electric heaters or fossil fuel backup systems should be used to supplement the ASHP system during periods when the outside temperature is below the operting range of the ASHP system.

Wood Pellet Stove & Rinnai Water Heater Cost Estimate

Line Item	Value	Units	$/Unit		Cost[1]
Remove and dispose oil boiler and indirect hot water heater		16	$100	$	1,600
EPA Certified Pellet Stove rated at ~20,000 Btu/hr, installed		1	$3,700	$	3,700
Hearth Pad		1	$300	$	300
15' of double wall insulated chimney ($60/foot)		15	$60	$	900
Flashing and rain cap		1	$200	$	200
Tankless LPG 8 GPM condensing on demand water heater, installed		1	$2,500	$	2,500
Low sone distribution fan and ducting, installed		1	$1,000	$	1,000
Freight		1	$1,500	$	1,500
Sub-Total				$	11,700
Contractor Profit	*10%*			*$*	*1,170*
Sub-Total				*$*	*12,870*
Contingency	*15%*			*$*	*1,931*
Total				**$**	**14,801**

Notes:
1 - Assumes 15' of chimney. Side wall venting could reduce chimney size and cost.
2 - EPA Certified pellet stoves verify that they meet the minimum air emission limits and are typically more efficient.
3 - Cost assumes that minimal engineering is required and would be provided by the installing contractor.
4 - Electric heaters or fossil fuel backup systems should be used to supplement the wood pellet stove system during in case wood pellets become unavailable.

Attachment 22

THRHA Energy Usage Assessment Report

THRHA Regional Housing Authority
Juneau, Alaska

Alaska Energy Engineering LLC

25200 Amalga Harbor Road
Juneau, Alaska 99801

Tel/Fax: 907.789.1226
jim@alaskaenergy.us

Technical Memorandum

July 16, 2015

to: **Craig Moore, THRHA**

subject: **Energy Usage Assessment Report DRAFT**

project: **Energy Assessments**

INTRODUCTION

Energy data has been compiled for Southeast Alaska housing units owned by the Tlingit-Haida Regional Housing Authority (THRHA). This memo summarizes the data and identifies housing units where energy use is relatively high, indicating opportunity to improve the building's energy performance.

Energy use can vary considerably by the size and type of housing unit. Typically, a smaller unit will have fewer occupants and use less energy than a larger unit. Additionally, apartment buildings with entirely separate apartments will have different energy use than a senior center with common spaces and commercial kitchen serving all tenants.

For this report, the Energy Use Index (EUI, kBtu/sqft) is calculated and compared to identify units with relatively high energy use. Higher energy use may be due to lifestyle, but it may also indicate an opportunity to invest in energy efficiency measures.

ENERGY USE SUMMARY

Energy Use Index

The EUIs for the buildings covers a wide range from 162 down to 3. Half of the buildings fall in a narrower band of 50-70 EUI. Buildings above this band offer incentive to evaluate their energy performance for opportunities to invest in greater energy efficiency.

Buildings below the 50-70 EUI band generally include the following:

- Senior centers and multi-story apartment buildings that have less heat loss per area
- Energy efficient buildings such as the Kasaan Duplexes
- Buildings with wood heating that is not included in the energy use data
- Buildings with intermittent occupancy

Energy Cost Index

Buildings with high energy cost indexes are generally located in communities with high fuel and electric costs. The exception is the energy efficient Kasaan Duplexes which have some of the lowest ECIs. Buildings with high EUIs and high ECIs offer the greatest incentive to improve their energy efficiency.

Energy Data

The following table shows the energy data sorted from highest to lowest EUI. The complete data showing energy use is attached to the end of this report.

Building Name	City	Size	Energy Cost Index (ECI) $/sqft			Energy Use Index (EUI) kBtu/sqft		
		sqft	Fuel Oil	Electricity	Total	Fuel Oil	Electricity	Total
Kake Senior Center	Kake	7,650	$4.79	$5.41	$10.20	130	32	162
Haines Senior Center	Haines	4,824	$3.43	$1.11	$4.55	124	16	140
Juneau Kanat'a Deyi 4468-4470	Juneau	2,268	$1.94	$1.08	$3.02	72	29	101
Juneau Kanat'a Deyi 4480-4482	Juneau	2,824	$2.15	$0.77	$2.93	80	20	100
Angoon Triplex 7A 7B 7C	Angoon	2,250	$2.65	$2.68	$5.33	72	14	87
Juneau Granite Drive 4063-4067	Juneau	2,694	$1.48	$0.89	$2.37	54	24	78
Wrangell Case Avenue	Wrangell	4,160	$1.57	$0.27	$1.84	69	7	76
Juneau Kanat'a Deyi 4543-4545	Juneau	2,266	$1.60	$0.58	$2.18	59	14	73
Juneau Kanat'a Deyi 4492-4494	Juneau	2,720	$1.56	$0.46	$2.02	58	11	69
Juneau Kanat'a Deyi 4481-4483	Juneau	2,266	$1.43	$0.62	$2.05	53	15	68
Juneau Valley Boulevard 8438-8444	Juneau	4,560	$1.69	$0.14	$1.84	63	4	66
Angoon Duplex 1A and 1B	Angoon	2,968	$1.97	$2.34	$4.32	54	13	66
Juneau Kanat'a Deyi 4428-4430	Juneau	2,720	$1.14	$0.87	$2.00	42	23	65
Angoon Duplex 4A and 4B	Angoon	2,250	$1.93	$2.30	$4.22	52	12	64
Juneau Granite Drive 4060-4064	Juneau	2,120	$0.20	$2.05	$2.25	7	57	64
Juneau Kanat'a Deyi 4530-4532	Juneau	2,824	$1.39	$0.48	$1.88	51	12	63
Angoon Duplex 2A and 2B	Angoon	2,968	$1.60	$3.34	$4.95	44	18	62
Juneau Kanat'a Deyi 4503-4505	Juneau	2,266	$1.25	$0.60	$1.85	46	15	61
Juneau Kanat'a Deyi 4449-4451	Juneau	2,824	$1.29	$0.52	$1.81	48	13	61
Angoon 4-plex 5A 5B 5C 5D	Angoon	3,680	$1.84	$1.89	$3.73	50	10	60
Angoon 4-plex 6A 6B 6C 6D	Angoon	3,680	$1.84	$1.89	$3.73	50	10	60
Angoon Triplex 9A 9B 9C	Angoon	2,250	$1.65	$2.72	$4.37	45	15	59
Juneau Kanat'a Deyi 4461-4463	Juneau	2,720	$1.34	$0.37	$1.70	49	10	59
Juneau Valley Boulevard 8414-8420	Juneau	4,560	$1.34	$0.34	$1.68	50	8	58
Ketchikan Fairview	Ketchikan	3,820		$1.68	$1.68		58	58
Juneau Valley Boulevard 8422-8428	Juneau	4,560	$1.28	$0.36	$1.64	47	9	56
Angoon Duplex 3A and 3B	Angoon	2,250	$1.67	$1.69	$3.37	45	9	54
Wrangell Front Street	Wrangell	10,400	$0.77	$0.59	$1.37	34	19	53
Juneau Valley Boulevard 8430-8436	Juneau	4,560	$1.11	$0.40	$1.51	41	10	51
Saxman Senior Center	Saxman	31,300	$0.34	$0.68	$1.02	16	24	41
Juneau Granite Drive 4039-4043	Juneau	2,694	$0.21	$1.03	$1.24	8	28	36
Yakutat Senior Center	Yakutat	4,824	$0.40	$2.55	$2.95	13	18	31
Klawock Senior Center	Klawock	24,946	$0.29	$1.18	$1.46	12	17	29
Craig Senior Center	Craig	9,944	$0.55	$0.64	$1.19	20	9	29
Juneau Granite Drive 4047-4051	Juneau	2,120	$0.18	$0.82	$1.00	7	21	28
Kasaan Duplex 3A/3B	Kasaan	2,880		$1.60	$1.64		26	28
Fireweed Place	Juneau	54,323		$0.75	$0.75		27	27
Yakutat Sunrise Apartments Bldg A	Yakutat	9,944	$0.53	$1.20	$1.73	17	8	26
Hoonah Senior Center	Hoonah	7,650		$4.20	$4.20		24	24
Yakutat Sunrise Apartments Bldg B	Yakutat	9,944	$0.53	$0.97	$1.50	17	7	24
Kasaan Duplex 2A/2B	Kasaan	2,880		$0.78	$0.87		11	14
Kasaan Duplex 1A/1B	Kasaan	2,880		$0.03	$0.11		0	3

BUILDING ENERGY USE COMPARISONS

Juneau Kanat'a Deyi Apartments

Description

The Kanat'a Deyi Apartments consist of 10 similar duplexes. Each duplex has a fuel oil boiler that supplies heat to both apartments.

Energy Use and Cost

Building Name	Size	Energy Cost Index (ECI) $/sqft			Energy Use Index (EUI) kBtu/sqft		
	sqft	Fuel Oil	Electricity	Total	Fuel Oil	Electricity	Total
Juneau Kanat'a Deyi 4468-4470	2,268	$1.94	$1.08	$3.02	72	29	101
Juneau Kanat'a Deyi 4480-4482	2,824	$2.15	$0.77	$2.93	80	20	100
Juneau Kanat'a Deyi 4543-4545	2,266	$1.60	$0.58	$2.18	59	14	73
Juneau Kanat'a Deyi 4492-4494	2,720	$1.56	$0.46	$2.02	58	11	69
Juneau Kanat'a Deyi 4481-4483	2,266	$1.43	$0.62	$2.05	53	15	68
Juneau Kanat'a Deyi 4428-4430	2,720	$1.14	$0.87	$2.00	42	23	65
Juneau Kanat'a Deyi 4530-4532	2,824	$1.39	$0.48	$1.88	51	12	63
Juneau Kanat'a Deyi 4503-4505	2,266	$1.25	$0.60	$1.85	46	15	61
Juneau Kanat'a Deyi 4449-4451	2,824	$1.29	$0.52	$1.81	48	13	61
Juneau Kanat'a Deyi 4461-4463	2,720	$1.34	$0.37	$1.70	49	10	59

The following table shows the energy consumption of the duplexes. Two of the duplexes (4468-4470 and 4480-4482) show much higher energy use—both fuel oil and electricity—than the other buildings. An evaluation is recommended to determine if lifestyle choices are contributing to higher energy use or if there is an opportunity to improve the energy performance of these two buildings.

Juneau Valley Boulevard Apartments

Description

The Valley Boulevard Apartments consist of four 4-plexes. Each 4-plex has a fuel oil boiler that supplies heat to all four apartments.

Energy Use and Cost

One of the building (8438-8444) has higher energy use than the other buildings due to increased fuel oil consumption. An evaluation is recommended to determine if lifestyle choices are contributing to higher energy use or if there is an opportunity to improve the energy performance of this building.

Building Name	Size	Energy Cost Index (ECI) $/sqft			Energy Use Index (EUI) kBtu/sqft		
	sqft	Fuel Oil	Electricity	Total	Fuel Oil	Electricity	Total
Juneau Valley Boulevard 8438-8444	4,560	$1.69	$0.14	$1.84	63	4	66
Juneau Valley Boulevard 8414-8420	4,560	$1.34	$0.34	$1.68	50	8	58
Juneau Valley Boulevard 8422-8428	4,560	$1.28	$0.36	$1.64	47	9	56
Juneau Valley Boulevard 8430-8436	4,560	$1.11	$0.40	$1.51	41	10	51

Angoon Housing

Description

The Angoon Housing consists of 4 duplexes, two triplex, and two 4-plex apartment buildings. Each building has a fuel oil boiler that supplies heat to the apartments.

Energy Use and Cost

The buildings have similar EUIs with the exception of Triplex 7A/7B/7C which has considerably higher heating energy use. An evaluation is recommended to determine if lifestyle choices are contributing to higher energy use or if there is an opportunity to improve the energy performance of this building.

Occupancy has been more sporadic in Duplex 3A/3B which contributes to its lower EUI.

Building Name	City	Size	Energy Cost Index (ECI) $/sqft			Energy Use Index (EUI) kBtu/sqft		
		sqft	Fuel Oil	Electricity	Total	Fuel Oil	Electricity	Total
Angoon Triplex 7A 7B 7C	Angoon	2,250	$2.65	$2.68	$5.33	72	14	87
Angoon Duplex 1A and 1B	Angoon	2,968	$1.97	$2.34	$4.32	54	13	66
Angoon Duplex 4A and 4B	Angoon	2,250	$1.93	$2.30	$4.22	52	12	64
Angoon Duplex 2A and 2B	Angoon	2,968	$1.60	$3.34	$4.95	44	18	62
Angoon 4-plex 5A 5B 5C 5D	Angoon	3,680	$1.84	$1.89	$3.73	50	10	60
Angoon 4-plex 6A 6B 6C 6D	Angoon	3,680	$1.84	$1.89	$3.73	50	10	60
Angoon Triplex 9A 9B 9C	Angoon	2,250	$1.65	$2.72	$4.37	45	15	59
Angoon Duplex 3A and 3B	Angoon	2,250	$1.67	$1.69	$3.37	45	9	54

Apartment Buildings (Wrangell, Ketchikan, Petersburg, Kasaan, Yakutat)

Description

THRHA has apartment buildings located in the following cities:

- Kasaan Duplexes: The Kasaan Apartments consist of three duplexes. The apartments are primarily heated by wood stoves but also have oil stoves. Energy use for the wood stoves was not available. Hot water is heated by propane instantaneous hot water heaters.
- Ketchikan Fairview Avenue Housing: Consists of a 4-plex heated by a single oil boiler for all four apartments.
- Petersburg: Consists of two 6-plex apartment buildings each heated by a single oil boiler for all six apartments.
- Wrangell Case Avenue Housing: Consists of a triplex heated by a single oil boiler for all three apartments.
- Wrangell Front Street Housing – SNO Building: The SNO Building consists of six residential and commercial spaces heated by a shared oil boiler.
- Yakutat Sunrise Apartments Building A: Consists of 9 apartments heated by a shared fuel oil boiler plant.
- Yakutat Sunrise Apartments Building B: Consists of 11 apartments heated by a shared fuel oil boiler plant.

Energy Use and Cost

The Wrangell Case Avenue apartment building has the highest EUI of the group due to relatively higher heating energy consumption. The Ketchikan Fairview and Wrangell Front Street apartments also have relatively high EUIs. An evaluation is recommended to determine if lifestyle choices are contributing to higher energy use or if there is an opportunity to improve the energy performance of these buildings.

The Wrangell buildings are heated by fuel oil boilers. Electric heat costs less than fuel oil heat and should be considered for these buildings.

Energy use for the Kasaan buildings is relatively low because they are well insulated buildings and the tenants use wood stoves—wood energy data is not included—for heat.

The Yakutat Apartment buildings have low EUIs due to low heating energy use. This is likely because the apartments have shared walls, roofs, and floors with adjacent apartments, reducing heat loss. The EUI is similar to Juneau's Fireweed Place, which is also a multi-story apartment building.

Building Name	City	Size	Energy Cost Index (ECI) $/sqft			Energy Use Index (EUI) kBtu/sqft		
		sqft	Fuel Oil	Electricity	Total	Fuel Oil	Electricity	Total
Wrangell Case Avenue	Wrangell	4,160	$1.57	$0.27	$1.84	69	7	76
Ketchikan Fairview	Ketchikan	3,820		$1.68	$1.68		58	58
Wrangell Front Street	Wrangell	10,400	$0.77	$0.59	$1.37	34	19	53
Kasaan Duplex 3A/3B	Kasaan	2,880		$1.60	$1.64		26	28
Yakutat Sunrise Apartments Bldg A	Yakutat	9,944	$0.53	$1.20	$1.73	17	8	26
Yakutat Sunrise Apartments Bldg B	Yakutat	9,944	$0.53	$0.97	$1.50	17	7	24
Kasaan Duplex 2A/2B	Kasaan	2,880		$0.78	$0.87		11	14
Kasaan Duplex 1A/1B	Kasaan	2,880		$0.03	$0.11		0	3

Senior Centers (Kake, Haines, Saxman, Yakutat, Craig, Klawock, Fireweed Place, Hoonah)

Description

Senior Centers are apartment buildings for senior citizens. Each apartment is fully-contained but the building may also have community spaces and/or a commercial kitchen that serves lunches to the tenants as well as other senior community members.

The energy data includes the house meter but does not include the apartment or common kitchen meters.

Energy Use and Cost

The Kake Senior Center has the highest EUI. This is due to a reported fuel oil use that is much higher than expected. The building is undergoing a renovation and expansion that will significantly improve its energy efficiency.

The Haines Senior Center has the second highest EUI due to a high heating EUI. An evaluation is recommended to determine why the building has much higher heating energy use.

The Saxman Senior Center also has a relatively high EUI. The building was recently replaced, and the new energy data is not included in the data.

The Kake and Hoonah buildings have high electrical ECIs due to high electric costs. Opportunities to reduce electricity consumption will have the greatest impact on energy costs.

The Hoonah Senior Center has the lowest EUI because the building is heated with district heat that is not metered or billed. The remaining buildings have similar EUIs.

Building Name	Size	Energy Cost Index (ECI) $/sqft			Energy Use Index (EUI) kBtu/sqft		
	sqft	Fuel Oil	Electricity	Total	Fuel Oil	Electricity	Total
Kake Senior Center	7,650	$4.79	$5.41	$10.20	130	32	162
Haines Senior Center	4,824	$3.43	$1.11	$4.55	124	16	140
Saxman Senior Center	31,300	$0.34	$0.68	$1.02	16	24	41
Yakutat Senior Center	4,824	$0.40	$2.55	$2.95	13	18	31
Craig Senior Center	9,944	$0.55	$0.64	$1.19	20	9	29
Klawock Senior Center	24,946	$0.29	$1.18	$1.46	12	17	29
Hoonah Senior Center	7,650		$4.20	$4.20		24	24

by: 

Jim Rehfeldt, P.E.

Alaska Energy Engineering LLC
25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Building Energy Data

Tlingit-Haida Regional Housing Authority
Energy Cost and Usage Indexes

Building Name	City	Size	Energy Cost Index (ECI) $/sqft			Energy Use Index (EUI) kBtu/sqft		
		sqft	Fuel Oil	Electricity	Total	Fuel Oil	Electricity	Total
Kake Senior Center	Kake	7,650	$4.79	$5.41	$10.20	130	32	162
Haines Senior Center	Haines	4,824	$3.43	$1.11	$4.55	124	16	140
Juneau Kanat'a Deyi 4468-4470	Juneau	2,268	$1.94	$1.08	$3.02	72	29	101
Juneau Kanat'a Deyi 4480-4482	Juneau	2,824	$2.15	$0.77	$2.93	80	20	100
Angoon Triplex 7A 7B 7C	Angoon	2,250	$2.65	$2.68	$5.33	72	14	87
Juneau Granite Drive 4063-4067	Juneau	2,694	$1.48	$0.89	$2.37	54	24	78
Wrangell Case Avenue	Wrangell	4,160	$1.57	$0.27	$1.84	69	7	76
Juneau Kanat'a Deyi 4543-4545	Juneau	2,266	$1.60	$0.58	$2.18	59	14	73
Juneau Kanat'a Deyi 4492-4494	Juneau	2,720	$1.56	$0.46	$2.02	58	11	69
Juneau Kanat'a Deyi 4481-4483	Juneau	2,266	$1.43	$0.62	$2.05	53	15	68
Juneau Valley Boulevard 8438-8444	Juneau	4,560	$1.69	$0.14	$1.84	63	4	66
Angoon Duplex 1A and 1B	Angoon	2,968	$1.97	$2.34	$4.32	54	13	66
Juneau Kanat'a Deyi 4428-4430	Juneau	2,720	$1.14	$0.87	$2.00	42	23	65
Angoon Duplex 4A and 4B	Angoon	2,250	$1.93	$2.30	$4.22	52	12	64
Juneau Granite Drive 4060-4064	Juneau	2,120	$0.20	$2.05	$2.25	7	57	64
Juneau Kanat'a Deyi 4530-4532	Juneau	2,824	$1.39	$0.48	$1.88	51	12	63
Angoon Duplex 2A and 2B	Angoon	2,968	$1.60	$3.34	$4.95	44	18	62
Juneau Kanat'a Deyi 4503-4505	Juneau	2,266	$1.25	$0.60	$1.85	46	15	61
Juneau Kanat'a Deyi 4449-4451	Juneau	2,824	$1.29	$0.52	$1.81	48	13	61
Angoon 4-plex 5A 5B 5C 5D	Angoon	3,680	$1.84	$1.89	$3.73	50	10	60
Angoon 4-plex 6A 6B 6C 6D	Angoon	3,680	$1.84	$1.89	$3.73	50	10	60
Angoon Triplex 9A 9B 9C	Angoon	2,250	$1.65	$2.72	$4.37	45	15	59
Juneau Kanat'a Deyi 4461-4463	Juneau	2,720	$1.34	$0.37	$1.70	49	10	59
Juneau Valley Boulevard 8414-8420	Juneau	4,560	$1.34	$0.34	$1.68	50	8	58
Ketchikan Fairview	Ketchikan	3,820		$1.68	$1.68		58	58
Juneau Valley Boulevard 8422-8428	Juneau	4,560	$1.28	$0.36	$1.64	47	9	56
Angoon Duplex 3A and 3B	Angoon	2,250	$1.67	$1.69	$3.37	45	9	54
Wrangell Front Street	Wrangell	10,400	$0.77	$0.59	$1.37	34	19	53
Juneau Valley Boulevard 8430-8436	Juneau	4,560	$1.11	$0.40	$1.51	41	10	51
Saxman Senior Center	Saxman	31,300	$0.34	$0.68	$1.02	16	24	41
Juneau Granite Drive 4039-4043	Juneau	2,694	$0.21	$1.03	$1.24	8	28	36
Yakutat Senior Center	Yakutat	4,824	$0.40	$2.55	$2.95	13	18	31
Klawock Senior Center	Klawock	24,946	$0.29	$1.18	$1.46	12	17	29
Craig Senior Center	Craig	9,944	$0.55	$0.64	$1.19	20	9	29
Juneau Granite Drive 4047-4051	Juneau	2,120	$0.18	$0.82	$1.00	7	21	28
Kasaan Duplex 3A/3B	Kasaan	2,880		$1.60	$1.64		26	28
Fireweed Place	Juneau	54,323		$0.75	$0.75		27	27
Yakutat Sunrise Apartments Bldg A	Yakutat	9,944	$0.53	$1.20	$1.73	17	8	26
Hoonah Senior Center	Hoonah	7,650		$4.20	$4.20		24	24
Yakutat Sunrise Apartments Bldg B	Yakutat	9,944	$0.53	$0.97	$1.50	17	7	24
Kasaan Duplex 2A/2B	Kasaan	2,880		$0.78	$0.87		11	14
Kasaan Duplex 1A/1B	Kasaan	2,880		$0.03	$0.11		0	3

Alaska Energy Engineering LLC

25200 Amalga Harbor Road Tel/Fax: 907.789.1226
Juneau, Alaska 99801 jim@alaskaenergy.us

Tlingit-Haida Regional Housing Authority

Energy Usage Summary

Building Name	City	Size	Annual Energy Consumption				Current Energy Costs			
		sqft	Fuel Oil gallons	Electricity kWh	Propane gallons	Pellets tons	Fuel Oil $ / gal	Electricity $ / kWh	Propane $ / gal	Pellets $ / ton
Angoon 4-plex 5A 5B 5C 5D	Angoon	3,680	1,325	11,014			$5.10	$0.633		
Angoon 4-plex 6A 6B 6C 6D	Angoon	3,680	1,325	11,014			$5.10	$0.633		
Angoon Duplex 1A and 1B	Angoon	2,968	1,148	10,985			$5.10	$0.633		
Angoon Duplex 2A and 2B	Angoon	2,968	933	15,801			$5.10	$0.628		
Angoon Duplex 3A and 3B	Angoon	2,250	738	5,879			$5.10	$0.648		
Angoon Duplex 4A and 4B	Angoon	2,250	851	7,755			$5.10	$0.666		
Angoon Triplex 7A 7B 7C	Angoon	2,250	1,171	9,518			$5.10	$0.633		
Angoon Triplex 9A 9B 9C	Angoon	2,250	728	9,681			$5.10	$0.633		
Craig Senior Center	Craig	9,944	1,418	26,720			$3.86	$0.239		
Fireweed Place	Juneau	54,323		423,920				$0.096		
Haines Senior Center	Haines	4,824	4,314	22,480			$3.84	$0.239		
Hoonah Senior Center	Hoonah	7,650		54,520				$0.589		
Juneau Granite Drive 4039-4043	Juneau	2,694	150	22,051			$3.75	$0.126		
Juneau Granite Drive 4047-4051	Juneau	2,120	100	13,135			$3.75	$0.133		
Juneau Granite Drive 4060-4064	Juneau	2,120	100	35,677			$4.27	$0.122		
Juneau Granite Drive 4063-4067	Juneau	2,694	1,046	18,827			$3.81	$0.128		
Juneau Kanat'a Deyi 4428-4430	Juneau	2,720	825	18,396			$3.75	$0.128		
Juneau Kanat'a Deyi 4449-4451	Juneau	2,824	969	10,878			$3.75	$0.136		
Juneau Kanat'a Deyi 4461-4463	Juneau	2,720	971	7,658			$3.75	$0.130		
Juneau Kanat'a Deyi 4468-4470	Juneau	2,268	1,176	19,081			$3.75	$0.128		
Juneau Kanat'a Deyi 4480-4482	Juneau	2,824	1,622	16,901			$3.75	$0.129		
Juneau Kanat'a Deyi 4481-4483	Juneau	2,266	866	10,185			$3.75	$0.138		
Juneau Kanat'a Deyi 4492-4494	Juneau	2,720	1,132	8,850			$3.75	$0.141		
Juneau Kanat'a Deyi 4503-4505	Juneau	2,266	754	9,764			$3.75	$0.139		
Juneau Kanat'a Deyi 4530-4532	Juneau	2,824	1,050	9,835			$3.75	$0.139		
Juneau Kanat'a Deyi 4543-4545	Juneau	2,266	965	9,356			$3.75	$0.140		

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Juneau, Alaska 99801 jim@alaskaenergy.us

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Energy Usage Summary

Building Name	City	Size	Annual Energy Consumption				Current Energy Costs			
		sqft	Fuel Oil gallons	Electricity kWh	Propane gallons	Pellets tons	Fuel Oil $ / gal	Electricity $ / kWh	Propane $ / gal	Pellets $ / ton
Juneau Valley Boulevard 8414-8420	Juneau	4,560	1,634	11,285			$3.75	$0.136		
Juneau Valley Boulevard 8422-8428	Juneau	4,560	1,554	12,406			$3.75	$0.134		
Juneau Valley Boulevard 8430-8436	Juneau	4,560	1,351	13,733			$3.75	$0.132		
Juneau Valley Boulevard 8438-8444	Juneau	4,560	2,060	4,930			$3.75	$0.131		
Kake Senior Center	Kake	7,650	7,200	70,640			$5.09	$0.586		
Kasaan Duplex 1A/1B	Kasaan	2,880		330	91			$0.274	$2.57	
Kasaan Duplex 2A/2B	Kasaan	2,880		9,180	98			$0.246	$2.57	
Kasaan Duplex 3A/3B	Kasaan	2,880		21,906	52			$0.210	$2.57	
Ketchikan Fairview	Ketchikan	3,820		64,951				$0.099		
Klawock Senior Center	Klawock	24,946	2,161	126,080			$3.30	$0.233		
Saxman Senior Center	Saxman	31,300	3,693	221,900			$2.91	$0.096		
Wrangell Case Avenue	Wrangell	4,160	2,068	8,948			$3.15	$0.126		
Wrangell Front Street	Wrangell	10,400	2,554	58,093			$3.15	$0.106		
Yakutat Senior Center	Yakutat	4,824	449	25,061			$4.33	$0.491		
Yakutat Sunrise Apartments Bldg A	Yakutat	9,944	1,236	24,224			$4.27	$0.491		
Yakutat Sunrise Apartments Bldg B	Yakutat	9,944	1,236	19,636			$4.27	$0.491		