Comprehensive Energy Audit for the Aniak Fire Station

Prepared For

City of Aniak
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Site Survey Date:

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Energy Audits of Alaska

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Revision Tracking

New Release – September 16, 2018

September 17, 2018: minor edits, added cord wood boiler EEM

Disclaimers

This energy audit is intended to identify and recommend potential areas of energy savings (EEMs), estimate the value of the savings and approximate the costs to implement the recommendations. This audit report is not a design document and no design work is included in the scope of this audit. Any modifications or changes made to a building to realize the savings must be designed and implemented by licensed, experienced professionals in their fields. Lighting recommendations should all be first analyzed through a thorough lighting analysis to assure that the recommended lighting upgrades will comply with any State of Alaska Statutes as well as Illuminating Engineering Society (IES) recommendations. Ventilation recommendations should be first analyzed by a qualified and licensed engineer experienced in the design and analysis of HVAC systems.

Neither the auditor nor Energy Audits of Alaska bears any responsibility for work performed as a result of this report.

Payback periods may vary from those forecasted due to the uncertainty of the final installed design, configuration, equipment selected, and installation costs of recommended EEMs, or the operating schedules and maintenance provided by the owner. Furthermore, EEMs are typically interactive, so implementation of one EEM may impact the cost savings from another EEM. The auditor accepts no liability for financial loss due to EEMs that fail to meet the forecasted savings or payback periods.

This audit meets the criteria of a Level 2 Energy Audit per the Association of Energy Engineers and per the ASHRAE definitions, and is valid for one year. The life of an audit may be extended on a case-by-case basis. This audit is the property of the client.

AkWarm-C© is a building energy modeling software developed under contract by the Alaska Housing Finance Corporation (AHFC).

Acknowledgements

Thank you to the following people and organizations who contributed to this project: AHFC provided funding through Alaska Native Tribal Health Consortium (ANTHC) and the Cold Climate Housing Research Center (CCHRC) provided travel costs by coupling this audit with other work in the community.

Project Location

NORTH

Subject Building

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1. EXECUTIVE SUMMARY

This report was prepared for the City of Aniak, owner of the Aniak Fire Station. The scope of this report is a comprehensive energy study, which included an analysis of building shell, interior and exterior lighting systems, HVAC systems, and plug loads.

This building is a single story, high bay structure with a mezzanine, used as a volunteer fire station, for training, and for certain community activities. In general, the building is in average condition.

No oil consumption or delivery data was available for this building, so the AkWarm-C model was not calibrated to actual fuel oil use and there is a large unknown electric load required to calibrate the model to the actual electric use. The source of this electric load is unknown. There is a waste oil burner in the facility but no information regarding its frequency of use was available so it was entered with no use as the baseline.

Current Cost of Energy

Based on electricity and fuel oil prices in effect at the time of the audit, and the calibrated AkWarm-C© energy model, the total predicted energy costs are $16,080 per year. This number may vary slightly from actual costs since the model is typically calibrated to within 95% of actual energy consumption. The breakdown of the annual predicted energy costs and fuel use for the buildings analyzed are as follows:

$1,830 for Electricity
$0 for Waste Oil
$14,250 for #2 Oil

Predicted Annual Fuel Use		
Fuel Use	**Existing Building**	**With Proposed Retrofits**
Electricity	6,778 kWh	5,476 kWh
Waste Oil	0 gallons	1,011 gallons
#2 Oil	2,504 gallons	1,354 gallons
Birch Cord Wood	0 cords	7.05 cords

Benchmarking

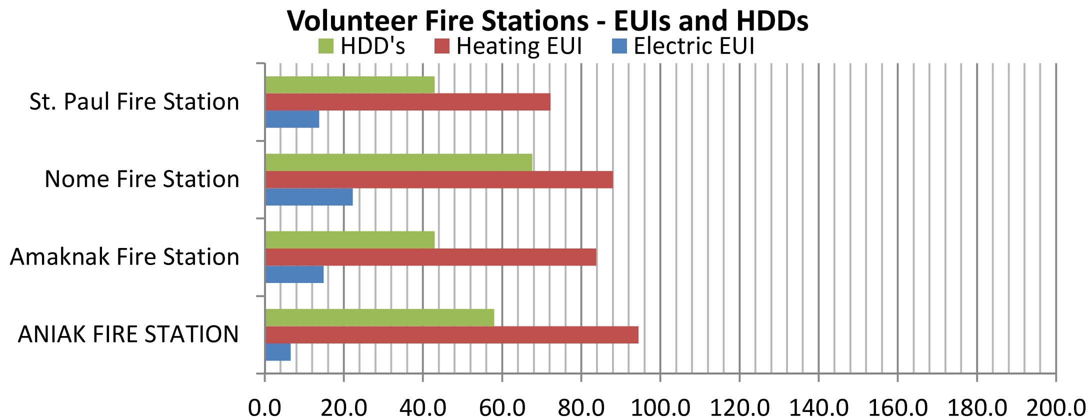
Benchmark figures facilitate the comparison of energy use between different buildings. The table below lists several benchmarks for the audited building. More details can be found in section 3.2.2.

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	105.4	8.21	$4.59
With Proposed Retrofits	96.9	7.55	$1.02

EUI: Energy Use Intensity - The annual site energy consumption divided by the structure's conditioned area.
EUI/HDD: Energy Use Intensity per Heating Degree Day.
ECI: Energy Cost Index - The total annual cost of energy divided by the square footage of the conditioned space in the building.

Comparing Energy Utilization

The subject building's heating and electric EUIs are compared to similar use buildings in the region in the bar chart below. The Heating Degree Days[1] (HDDs) bars are intended to normalize the effect of weather differences. As seen in the bar chart below, the subject building's heating EUI is higher than all of the comparison buildings, despite the fact that the number of HDDs in Aniak is about average when compared to the other buildings. Its electric EUI is by far the lowest of all the comparison buildings. This is attributed to its very low occupancy and hours of use.



Energy Efficiency Measures (EEMs)

Table 1.1 below summarizes the energy efficiency measures analyzed for the Fire Station. Estimates of annual energy and maintenance savings, installed costs, and two different financial measures of investment return are shown for each EEM. A cost of $1 in Tables 1.1 and 4.1 indicate that there is no cost, AkWarm-C does not allow a $0 cost.

No setting back of thermostats is included in these EEMs since the building temperature is normally maintained between 50F and 60F.

Cord Wood Boiler EEM (not calculated in the AkWarm-C model)

EEM #0 in Tables 1.1 and 4.1:

EEM #1 below recommends using the waste oil heater for 40% of the building's heating needs. It is further recommended to perform the required modifications to the biomass boiler that is on site and use it to eliminate remaining fuel oil used by the unit heaters. This would eliminate the remaining 1354 gallons (at a cost of $7704) of fuel oil predicted to be used in the building after the waste oil burner is in use. After the cost of cord wood, the net savings is estimated to be $5237/year. The very rough cost to perform the boiler modifications and install the hydronic loop, circulation pumps, controls and fan coil units in the building is $25,000, so the payback would be 4.6 years. SIR and CO2 savings are not calculated for this EEM.

[1] HDDs are a measure of the severity of cold weather; higher HDDs indicate colder, more severe weather. A building's heating EUI should increase or decrease along with a proportional increase or decrease in HDDs.

Table 1.1
PRIORITY LIST – ENERGY EFFICIENCY MEASURES

Rank	Feature	Improvement Description	Annual Energy Savings	Installed Cost	Savings to Investment Ratio, SIR[1]	Simple Payback (Years)[2]	CO_2 Savings
0	HVAC	Use cord wood boiler to eliminate remaining oil use after EEM#1 below is implemented	$5,619 / 0 MMBTU	$25,000		4.3	
1	HVAC And DHW	Use waste oil burner for 40% of the building's heating needs	$5,350 / -25.4 MMBTU	$1	93248.19	0.0	-4,174.9
2	Air Tightening	Perform air sealing to reduce air leakage by 50%.	$1,296 / 55.7 MMBTU	$4,000	3.01	3.1	9,002.2
3	Other Electrical - Controls Retrofit: de-stratification fans	Remove Manual Switching and Add new Clock Timer or Other Scheduling Control	$185 / -0.7 MMBTU	$500	2.21	2.7	1,097.8
4	Lighting - Power Retrofit: High bay: T12-2lamps	Replace with 4 LED (2) 15W Module StdElectronic	$22 + $20 Maint. Savings / 0.3 MMBTU	$295	1.21	7.0	140.1
	TOTAL, cost-effective measures		**$12,472 + $20 Maint. Savings / 29.9 MMBTU**	**$29,796**	**22.26**	**2.4**	**6,065.2**
The following measures were *not* found to be cost-effective from a financial perspective but are still recommended:							
5	Lighting - Power Retrofit: Mezz: T12-2lamps 16x48 pendant	Replace with 8 LED (2) 15W Module StdElectronic	$13 + $20 Maint. Savings / -0.1 MMBTU	$295	0.92	9.0	75.2
6	Lighting - Power Retrofit: Mezz: T12-2lamps strip	Replace with LED (2) 15W Module StdElectronic	$4 + $15 Maint. Savings / 0.0 MMBTU	$222	0.70	12.0	21.2
7	Lighting - Power Retrofit: High bay: HPS-250 - assume used only 50% of time	Replace with 3 LED 72W Module StdElectronic	$17 + $15 Maint. Savings / -0.1 MMBTU	$675	0.45	21.2	99.6
	TOTAL, all measures		**$12,505 + $70 Maint. Savings / 29.7 MMBTU**	**$30,988**	**17.95**	**2.5**	**6,261.3**

Table Notes:

[1] Savings to Investment Ratio (SIR) is a life-cycle cost measure calculated by dividing the total savings over the life of a project (expressed in today's dollars) by its investment costs. The SIR is an indication of the profitability of a measure; the higher the SIR, the more profitable the project. An SIR greater than 1.0 indicates a cost-effective project (i.e. more savings than cost). Remember that this profitability is based on the position of that Energy Efficiency Measure (EEM) in the overall list and assumes that the measures above it are implemented first. The SIR for EEM #0 is not included in the total SIR.

[2] Simple Payback (SP) is a measure of the length of time required for the savings from an EEM to payback the investment cost, not counting interest on the investment and any future changes in energy prices. It is calculated by dividing the investment cost by the expected first-year savings of the EEM.

With all of these energy efficiency measures in place, the annual utility cost can be reduced by $12,505 per year, or 77.8% of the buildings' total energy costs. These measures are estimated to cost $30,988, for an overall simple payback period of 2.4 years.

Table 1.2 below is a breakdown of the annual energy cost across various energy end use types, such as Space Heating and Water Heating. The first row in the table shows the breakdown for the existing building. The second row shows the expected breakdown of energy cost for the building assuming all of the retrofits in this report are implemented. Finally, the last row shows the annual energy savings that will be achieved from the retrofits. Maintenance savings are not included in the savings shown in this table.

Table 1.2

Annual Energy Cost Estimate									
Description	**Space Heating**	**Space Cooling**	**Water Heating**	**Ventilation Fans**	**Lighting**	**Refrigeration**	**Other Electrical**	**Service Fees**	**Total Cost**
Existing Building	$14,351	$0	$0	$1	$139	$168	$1,420	$0	**$16,080**
With Proposed Retrofits	$2,204	$0	$0	$1	$66	$168	$1,136	$0	**$3,575**
Savings	$12,147	$0	$0	$0	$74	$0	$284	$0	**$12,505**

Energy Conservation Measures (ECMs)

No and low-cost EEMs are called ECMs and are usually implemented by the owner or by the existing operations and maintenance staff (they are also called O & M recommendations). ECMs can result in cost and consumption savings, but they also prevent consumption and cost increases, which are more accurately called "avoided costs" rather than cost savings. Listed below are a range of ECMs, many of which may be applicable to the subject building.

1) **Ongoing Energy Monitoring:** Extensive research by a number of organizations has validated the value of building system monitoring as an effective means to reduce and maintain lower energy consumption. HVAC "performance drift" is the deterioration of an HVAC system over time, resulting from a number of preventable issues. Performance drift typically results in a 5% to 15 % increase in energy consumption. It is

recommended to implement a basic energy monitoring system for this building, ***including installing a cumulative fuel oil meter on the oil day tank***.

There is a range of simple to very complex building monitoring systems commercially available, most utilize a user-friendly internet or network based dashboard. They range from a simple do-it-yourself approach utilizing a spreadsheet and graph to public domain packages to proprietary software and hardware packages. A partial listing follows:

ARIS - The Alaska Housing Finance Corporation offers free energy tracking software online. The Alaska Retrofit Information System (ARIS) can help facility owner's track and manage energy use and costs. For more information contact Tyler Boyes (907-330-8115, tboyes@ahfc.us) or Betty Hall at the Research Information Center (RIC) Library at AHFC (907-330-8166, bhall@ahfc.us)

BMON - AHFC has developed a building monitoring software to use with Monnit or other sensors. This software is free to any user, open source, can be modified to user needs, and can absorb and display data from multiple sources. It can manage multiple buildings, and can be installed by anyone with a little IT experience. This software is available at https://code.ahfc.us/energy/bmon.

Monnit – "product model"; sensors are purchased (cost from $500-$1500) and installed, basic network-based dashboard is free. A more comprehensive, higher level of functionality, internet-based dashboard for a building of this size is $60-$100/year. http://www.monnit.com/

2) **Create an organizational "energy champion" and provide training**. It can be an existing staff person who performs a monthly walk-through of the building using an Energy Checklist similar to the sample below. Savings from this activity can vary from zero to 10% of the building's annual energy cost.

ENERGY CHAMPION CHECKLIST - MONTHLY WALK THROUGH	initial
Check thermostat set points and programming	
Note inside and outside temperatures, is it too hot or cold in the building?	
Are computers left on and unattended?	
Are room lights on and unoccupied?	
Are personal electric heaters in use?	
Are windows open with the heat on?	
Review monthly consumption for electric and oil	

3) **Efficient Building Management:** Certain EEMs and ECMs are recommended to improve the efficiency and reduce the cost of building management. As an example, all lights should be upgraded at the same time, all lamps should be replaced as a preventative

maintenance activity (rather than as they fail, one at a time), lamp inventory for the entire building should be limited to a single version of an LED or fluorescent tube (if at all possible), and all appropriate rooms should have similar occupancy controls and setback thermostats.

4) **Air Infiltration:** All entry and roll up doors and windows should be properly maintained and adjusted to close and function properly. Weather stripping should be maintained if it exists or added if it does not.

5) **Turn off plug loads** including computers, printers, faxes, etc. when leaving the room. For workstations where the occupant regularly leaves their desk, add an occupancy sensing plug load management device (PLMD) like the "Isole IDP 3050" power strip produced by Wattstopper.

6) **HVAC Maintenance** should be performed annually to assure optimum performance and efficiency of the boilers, circulation pumps, exhaust fans and thermostats in this building. An unmaintained HVAC component like a boiler can reduce its operating efficiency by 3% or more.

7) **Vacant Offices & Storage Areas**: If there are multiple-person offices and/or other common spaces which are currently vacant, consider moving staff such that the vacant offices are all in one zone, and turn down the heat and turn off lighting in that zone

8) **Additional ECM recommendations**:

    a. Maintain air sealing on the building by sealing all wall and ceiling penetrations including switch, electrical outlet and light fixture junction boxes and window and door caulking. Air sealing can reduce infiltration by 500-1000 cfm.

    b. Purchase and use an electronic timer as a power strip for large copy/scan/fax machines and any other equipment that has a sleep cycle. During their sleep cycle, they can consume from 1 to 3 watts. This can cost from $8-10/year per machine. Timers similar to the sample in Appendix G can be purchased for as little as $15.

    c. At their end of useful life (EOL), replace refrigeration equipment and commercial cooking equipment with Energy Star versions.

    d. Keep refrigeration coils clean.

    e. Keep heating coils in air handlers, unit heaters and fan coil units clean.

2. AUDIT AND ANALYSIS BACKGROUND

2.1 Program Description

This audit identifies and evaluates energy efficiency measures at the Fire Station. The scope of this project included evaluating building shell, lighting and other electrical systems, and HVAC equipment, motors and pumps. Measures were analyzed based on life-cycle-cost techniques, which include the initial cost of the equipment, life of the equipment, annual energy cost, annual maintenance cost, and a discount rate of 3.0%/year in excess of general inflation.

2.2 Audit Description

Preliminary audit information including building plans and utility consumption data (if available) was gathered in preparation for the site survey. An interview was conducted with the building owner or manager (if possible) to understand their objectives, ownership strategy and gather other information the auditor could use to make the audit most useful to the client. The site survey provides critical information in deciphering where energy is used and what savings opportunities exist within a building. The entire building was surveyed, including every accessible room, and the areas listed below were evaluated to gain an understanding of how the building operates:

- Building envelope (roof, windows, etc.)
- Heating, ventilation, and air conditioning equipment (HVAC)
- Lighting systems and controls
- Building-specific equipment including refrigeration equipment
- Plug loads

Summaries of building occupancy schedules, operating and maintenance practices, and energy management programs (if they exist) provided by the building manager/owner were collected along with as much system and component nameplate information as was available.

2.3 Method of Analysis

The details collected from Fire Station enable a model of the building’s overall energy usage to be developed – this is referred to as “existing conditions” or the “existing building”. The analysis involves distinguishing the different fuels used on site, and analyzing their consumption in different activity areas of the existing building.

Building Simulation Model

An accurate model of the building performance can be created by simulating the thermal performance of the walls, roof, windows and floors of the building, adding any HVAC systems, ventilation and heat recovery, adding major equipment, plug loads, any heating or cooling process loads, the number of occupants (each human body generates approximately 450 BTU/hr. of heat) and the hours of operation of the building.

Fire Station is classified as being made up of the following activity areas:

1) Fire Station: 3,500 square feet

The methodology took a range of building-specific factors into account, including:

- Occupancy hours
- Local climate conditions
- Prices paid for energy

For the purposes of this study, the thermal simulation model was created using a modeling tool called AkWarm-C© Energy Use Software. The building characteristics and local climate data were used to establish a baseline space heating and cooling energy usage. The model was calibrated to actual fuel consumption and was then capable of predicting the impact of theoretical EEMs. The calibrated model is considered to represent existing conditions.

Limitations of AkWarm© Models

The model is based on local, typical weather data from a national weather station closest to the subject building. This data represents the average ambient weather profile as observed over approximately 30 years. As such, the monthly fuel use bar charts in Section 3.2 will not likely compare perfectly, on a monthly basis with actual energy billing information from any single year. This is especially true for years with extreme warm or cold periods, or even years with unexpectedly moderate weather. For this reason the model is calibrated to the building's annual consumption of each fuel.

The heating and cooling load model is a simple two-zone model consisting of the building's core interior spaces and the building's perimeter spaces. This simplified approach loses accuracy for buildings that have large variations in cooling/heating loads across different parts of the building and for buildings that can provide simultaneous heating and cooling such as a variable volume air system with terminal re-heat.

Financial Analysis

Our analysis provides a number of tools for assessing the cost effectiveness of various EEMs. These tools utilize **Life-Cycle Costing**, which is defined in this context as a method of cost analysis that estimates the total cost of a project over its life. The total cost includes both the construction cost (also called "first cost") plus ongoing maintenance and operating costs.

Savings to Investment Ratio (SIR) = **Savings** divided by **Investment**

Savings includes the total discounted dollar savings considered over the life of the EEM, including annual maintenance savings. AkWarm© calculates projected energy savings based on occupancy schedules, utility rates, building construction type, building function, existing conditions, and climatic data uploaded to the program based on the zip code of the building. Changes in future fuel prices, as projected by the Department of Energy, are included over the life of the improvement. Future savings are discounted to their present value to account for the time-value of money (i.e. money's ability to earn interest over time). The **Investment** in the SIR calculation is the first cost of the EEM. An SIR value of at least 1.0 indicates that the project is cost-effective, i.e. total savings exceed the investment costs.

Simple payback is a cost analysis method whereby the investment cost of a project is divided by the first year's energy and maintenance savings to give the number of years required to recover the cost of the investment. This may be compared to the expected time before replacement of the system or component will be required. For example, if a boiler costs $12,000 and results in a savings of $1,000 in the first year, the payback time is 12 years. If the boiler has an expected life until replacement of 10 years, it would not be financially viable to make the investment since the payback period of 12 years is greater than the project life.

The Simple Payback calculation does not consider likely increases in future annual savings due to energy price increases, nor does it consider the need to earn interest on the investment (i.e. the time-value of money). Because of these simplifications, the SIR figure is considered to be a better financial investment indicator than the Simple Payback measure.

Measures are ranked by AkWarm© in order of decreasing SIR. The program first calculates individual SIR's and ranks them from highest to lowest. The software then implements the first EEM, re-calculates each subsequent measure and again re-ranks the remaining measures in order of their SIR. An individual measure must have an individual SIR>=1 to be considered financially viable on a stand-alone basis. AkWarm© goes through this iterative process until all appropriate measures have been evaluated and implemented in the proposed building model.

SIR and simple paybacks are calculated based on estimated first costs for each measure. First costs include estimates of the labor and equipment required to implement a change. Costs are considered to be accurate within +/-30% in this level of audit; they are derived from Means Cost Data, industry publications, the auditors experience and/or local contractors and equipment suppliers.

Interactive effects of EEMs:
It is important to note that the savings for each recommendation is calculated based on implementing the most cost effective measure first (highest SIR), then the EEM with the second highest SIR, then the third, etc. Implementation of an EEM out of the order will affect the savings of the other EEMs. The savings may in some cases be higher and in other cases, lower. For example implementing a reduced operating schedule for inefficient lighting will result in relatively high savings. Implementing a reduced operating schedule for newly installed efficient lighting will result in lower relative savings, because the efficient lighting system uses less energy during each hour of operation. If some of the recommended EEMs are not implemented, savings for the remaining EEMs will be affected, in some cases positively, and in others, negatively. If all EEMs are implemented, their order of implementation is irrelevant, because the total savings after full implementation will be unchanged. If an EEM is calculated outside of the AkWarm© model, the interactive effects of that EEM are not reflected in the savings figures of any other EEM.

Assumptions and conversion factors used in calculations:
The underlying assumptions used in the calculations made in this audit follow:

- 3413 BTU/kWh
- 60% load factor for all motors unless otherwise stated
- 132,000 BTU/gallon of #2 fuel oil
- 91,800 BTU/gallon of propane
- 100,000 BTU/therm or CCF of natural gas
- 24,000,000 BTU/Cord of wood

2.4 Limitations of Study

All results are dependent on the quality of input data provided, and can only act as an approximation. In some instances, several methods may achieve the identified savings. This report is not a design document and the auditor is not proposing designs, or performing design engineering. A design professional who is following the EEM recommendations and who is licensed to practice in Alaska in the appropriate discipline, shall accept full responsibility and liability for the design, engineering and final results.

Unless otherwise specified, budgetary estimates for engineering and design of these projects is not included in the cost estimate for each EEM recommendation; these costs can be approximated at 15% of the materials and installation costs.

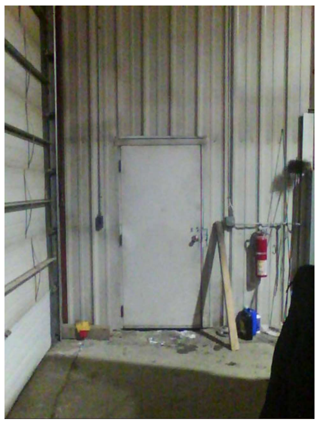
3. FIRE STATION EXISTING CONDITIONS

3.1. Building Description

The 3,500 square foot Fire Station was constructed in the year 2000. It is normally unoccupied except for an occasional training or community activity. For the purposes of the AkWarm-C model an average of two occupants were used, two hours per day, three days per week.

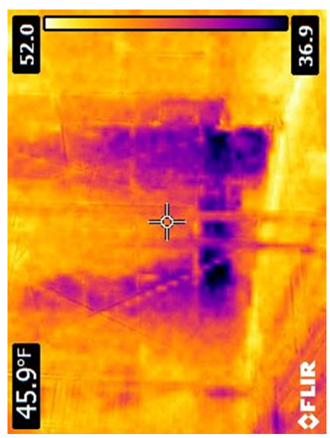
Description of Building Shell

No plans for this building were made available so the details below were observed or assumed based on observations by the auditor.

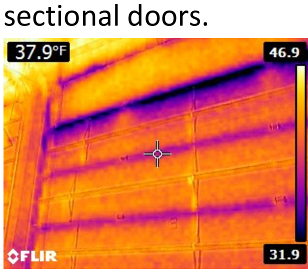


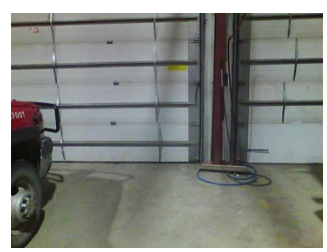
This fabricated steel structure building is constructed on a concrete slab poured on grade. It appears that 8" of fiberglass batt with an estimated insulation value of R-25 fills the cavities between girts, and between the interior metal siding and exterior metal siding. The IR images at left indicate that the wall insulation is in average condition, with heat wicking through the girts and studs as is typical in a metal structure building.

Approximately 6" of foil backed rigid foam has been added to the underside of the painted metal roof deck. The IR images at right show that there are sections where the insulation is not effective, either because it has been dislodged or was not properly installed.



There are no windows, one steel entry door with no glass, and three insulated overhead sectional doors.





The overhead doors are in good condition, showing only minor infiltration at their base and between sections (IR images above).

Description of Heating and Cooling Plants

The functionality and utilization of the waste oil burner in this building is unknown. As a baseline, no use was assumed.

Black Gold Waste Oil Burner

Nameplate Information:	Black Gold model 200
Fuel Type:	#1 Oil
Input Rating:	160,000 BTU/hr
Steady State Efficiency:	60 %
Idle Loss:	0 %
Heat Distribution Type:	Air
Notes:	200 MBH input, 1500 cfm, 1/2 HP motor, assumed 80% thermal efficiency when new, de-rated to 60% for age (manufactured in 2000)

Modine Oil-Fired Unit Heater

Nameplate Information:	Modine POH-145A
Fuel Type:	#2 Oil
Input Rating:	145,000 BTU/hr
Steady State Efficiency:	71 %
Idle Loss:	1.5 %
Heat Distribution Type:	Air
Notes:	145 MBH input, assumed 80% thermal efficiency when new, de-rated to 71% for age (manufactured in 2000)

Space Heating and Cooling Distribution Systems

There is no heat distribution system in this building and no cooling.

Domestic Hot Water System

There is a well providing potable water to this building, but none of the plumbing fixtures appear to be in use and there does not appear to be any production or use of DHW.

Description of Building Ventilation System

There is no mechanical ventilation or operable windows in this building.

Lighting

Interior lighting consists of a mixture of 48" linear florescent fixtures utilizing T12 lamps and magnetic ballasts, 250w HPS wall packs, and LED pendants in the high bay.

Plug Loads

There are very few plug loads in this building. A value of 0.2 w/SF was used in the AkWarm-C model.

3.2 Predicted Energy Use

3.2.1 Energy Usage / Tariffs

Raw utility source data is tabulated in Appendix B. The AkWarm© model was calibrated on an annual basis, to match the actual, baseline electric and fuel oil delivery data and after calibration, the AkWarm© model predicts the annual usage of each fuel. As previously mentioned, the model is typically calibrated to within 95% of actual consumption of each fuel.

The electric usage profile charts (below) represents the predicted electrical usage for the building. If actual electricity usage records were available, the model used to predict usage was calibrated to approximately match actual usage. The electric utility measures consumption in kilowatt-hours (kWh) and maximum demand in kilowatts (kW). One kWh usage is equivalent to 1,000 watts running for one hour. One kW of electric demand is equivalent to 1,000 Watts running at a particular moment. The basic usage charges are shown as generation service and delivery charges along with several non-utility generation charges.

The natural gas usage profile shows the predicted natural gas energy usage for the building. If actual gas usage records were available, the model used to predict usage was calibrated to approximately match actual usage. Natural gas is sold to the customer in units of 100 cubic feet (CCF), which contains approximately 100,000 BTUs of energy.

The propane usage profile shows the propane usage for the building. Propane is sold by the gallon or by the pound, and its energy value is approximately 91,800 BTUs per gallon.

The fuel oil usage profile shows the fuel oil usage for the building. Fuel oil consumption is measured in gallons. One gallon of #1 Fuel Oil provides approximately 132,000 BTUs of energy.

The utility companies providing energy to the subject building, and the class of service provided by each, are listed below:

Electricity: Aniak Light & Power - Commercial - Sm

The average cost for each type of fuel used in this building is shown below in Table 3.1. This figure includes all surcharges, subsidies, and utility customer charges. This building received the PCE discount:

Table 3.1 – Average Energy Cost	
Description	**Average Energy Cost**
Electricity	$ 0.2700/kWh
Waste Oil	$ 0.00/gallons
#2 Oil	$ 5.69/gallons
Cord wood	$ 350/cord

For any historical and comparative analysis in this document, the auditor used current tariff schedules obtained from the utility provider or from invoices, which also included customer

charges, service charges, energy costs and taxes. These current tariffs were used for all years to eliminate the impact of cost changes over the years evaluated in the analysis.
Electric utility providers measure consumption in kilowatt-hours (kWh) and maximum demand in kilowatts (kW). One kWh usage is equivalent to 1,000 watts running for one hour. One kW of electric demand is equivalent to 1,000 watts running at a particular moment.

Fuel oil consumption is measured in gallons, but unless there is a cumulative meter on the day tank, data provided for analysis is typically gallons delivered, not gallons consumed. It is assumed that all of the oil delivered during the benchmark period was consumed during the benchmark period.

3.2.1.1 Total Energy Use and Cost Breakdown

At current rates, City of Aniak pays approximately $16,080 annually for electricity and other fuel costs for the Fire Station.

Figure 3.1 below reflects the estimated distribution of costs across the primary end uses of energy based on the AkWarm© computer simulation. Comparing the “Retrofit” bar in the figure to the “Existing” bar shows the potential savings from implementing all of the energy efficiency measures shown in this report.

Figure 3.1
Annual Energy Costs by End Use

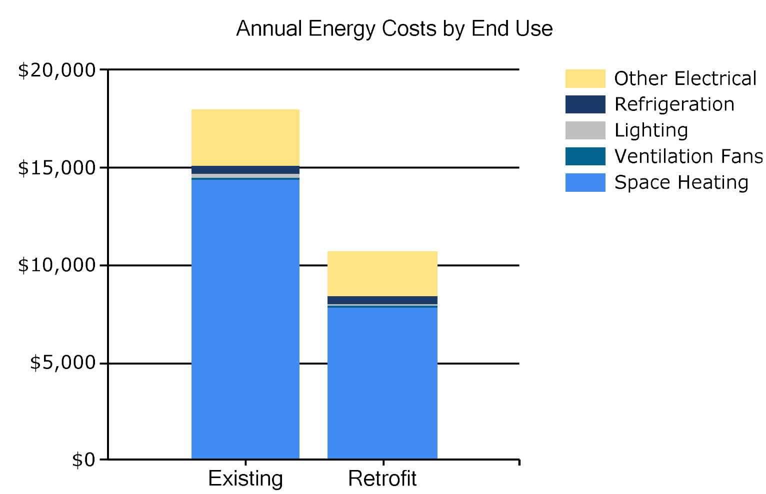


Figure 3.2 below shows how the annual energy cost of the building splits between the different fuels used by the building. The “Existing” bar shows the breakdown for the building as it is now; the “Retrofit” bar shows the predicted costs if all of the energy efficiency measures in this report are implemented.

Figure 3.2
Annual Energy Costs by Fuel Type

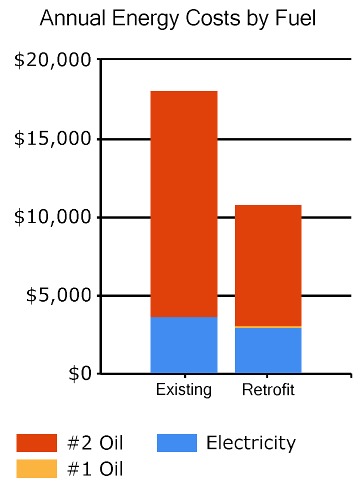
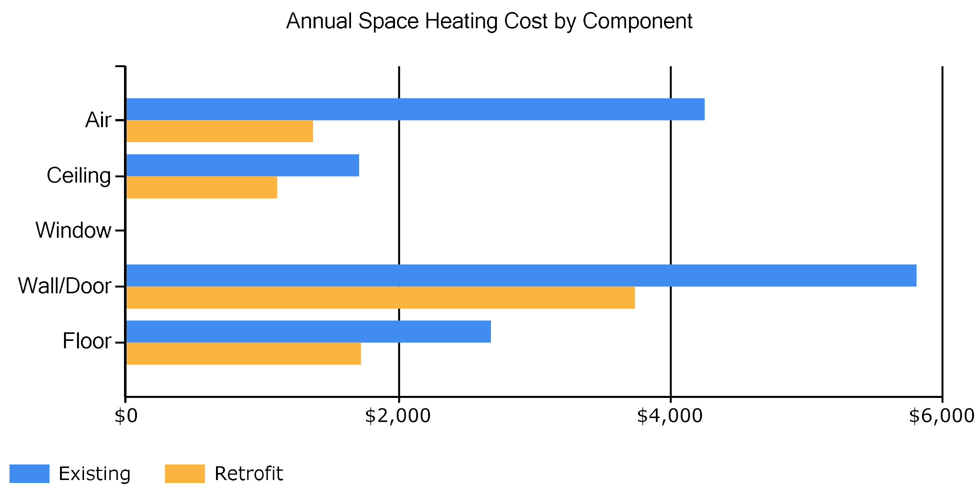


Figure 3.3 below addresses only Space Heating costs. The figure shows how each heat loss component contributes to those costs; for example, the figure shows how much annual space heating cost is caused by the heat loss through the Walls/Doors. For each component, the space heating cost for the Existing building is shown (blue bar) and the space heating cost assuming all retrofits are implemented (yellow bar) are shown.

Figure 3.3
Annual Space Heating Cost by Component



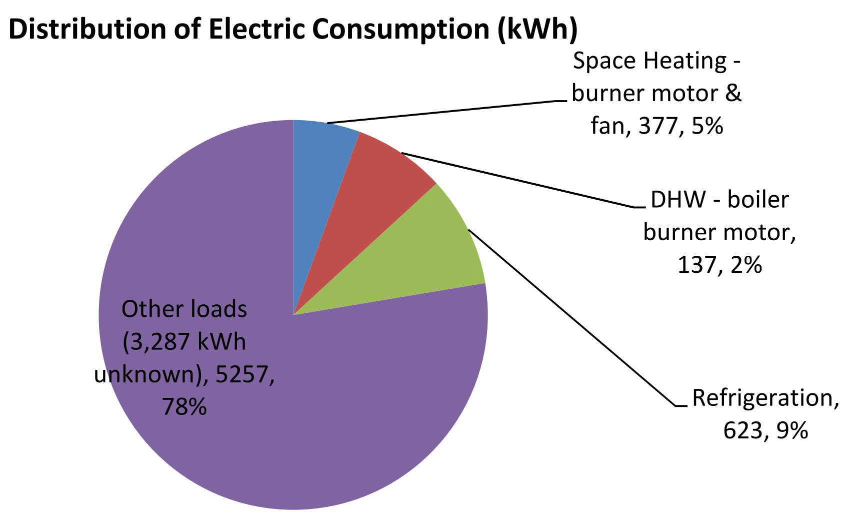
The tables below show AkWarm's estimate of the monthly fuel use for each of the fuels used in the building. For each fuel, the fuel use is broken down across the energy end uses. Note, in the tables below "DHW" refers to Domestic Hot Water heating.

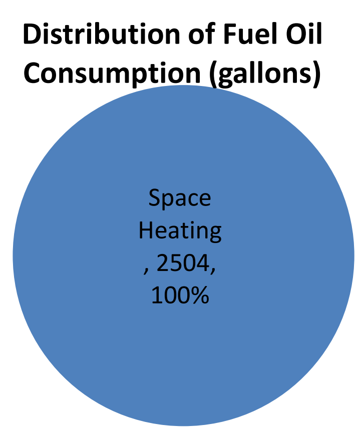
Electrical Consumption (kWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space_Heating	73	54	50	28	8	0	0	1	9	31	53	70
Space_Cooling	0	0	0	0	0	0	0	0	0	0	0	0
DHW	0	0	0	0	0	0	0	0	0	0	0	0
Ventilation_Fans	0	0	0	0	0	0	0	0	0	0	0	0
Lighting	44	40	44	42	44	42	44	44	42	44	42	44
Refrigeration	53	48	53	51	53	51	53	53	51	53	51	53
Other_Electrical	446	407	446	432	446	432	446	446	432	446	432	446

Waste Oil #1 Consumption (Gallons)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space_Heating	0	0	0	0	0	0	0	0	0	0	0	0
DHW	0	0	0	0	0	0	0	0	0	0	0	0

Fuel Oil #2 Consumption (Gallons)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space_Heating	469	350	324	185	64	12	12	16	67	207	346	452
DHW	0	0	0	0	0	0	0	0	0	0	0	0

The pie charts below show the distribution of fuels by end use.





3.2.2 Energy Use Index (EUI)

EUI is a measure of a building's annual energy utilization per square foot of building. It is a good measure of a building's energy use and is utilized regularly for energy performance comparisons with similar-use buildings.

EUIs are calculated by converting all the energy consumed by a building in one year to BTU's and multiplying by 1000 to obtain kBTU. This figure is then divided by the building square footage.

"Source energy" differs from "site energy". Site energy is the energy consumed by the building at the building site only. Source energy includes the site energy as well as all of the losses incurred during the creation and distribution of the energy to the building. Source energy represents the total amount of raw fuel that is required to operate the building. It incorporates all transmission, delivery, and production losses, and allows for a more complete assessment of energy efficiency in a building. The type of energy or fuel purchased has a substantial impact on the source energy use of a building. The EPA has determined that source energy is the best measure to use for evaluation purposes and to identify the overall global impact of energy use. Both the site and source EUI ratings for the building are provided below.

The site and source EUIs for this building are calculated as follows. (See Table 3.4 for details):

Building Site EUI = (*Electric Usage in kBtu + Gas Usage in kBtu + similar for other fuels*)
Building Square Footage

Building Source EUI = (*Electric Usage in kBtu X SS Ratio + Gas Usage in kBtu X SS Ratio + similar for other fuels*)
Building Square Footage

where "SS Ratio" is the Source Energy to Site Energy ratio for the particular fuel.

Table 3.4
Fire Station EUI Calculations

Energy Type	Building Fuel Use per Year	Site Energy Use per Year, kBTU	Source/Site Ratio	Source Energy Use per Year, kBTU
Electricity	6,778 kWh	23,133	3.340	77,265
Waste Oil	0 gallons	0	1.010	0
#2 Oil	2,504 gallons	345,608	1.010	349,064
Total		**368,741**		**426,329**
BUILDING AREA		3,500	Square Feet	
BUILDING SITE EUI		105	kBTU/Ft²/Yr	
BUILDING SOURCE EUI		122	**kBTU/Ft²/Yr**	
* Site - Source Ratio data is provided by the Energy Star Performance Rating Methodology for Incorporating Source Energy Use document issued March 2011.				

Table 3.5

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	**105.4**	**8.21**	**$4.59**
With Proposed Retrofits	**96.9**	**7.55**	**$1.02**
EUI: Energy Use Intensity - The annual site energy consumption divided by the structure's conditioned area. **EUI/HDD: Energy Use Intensity per Heating Degree Day.** **ECI: Energy Cost Index - The total annual cost of energy divided by the square footage of the conditioned space in the building.**			

4. ENERGY COST SAVING MEASURES

4.1 Summary of Results

The energy saving measures considered for this building are summarized in Table 4.1. Please refer to the individual measure descriptions later in this report for more detail, including the auditors notes. Calculations and cost estimates for analyzed measures are provided in Appendix C.

Table 4.1
Fire Station, Aniak, Alaska
PRIORITY LIST – ENERGY EFFICIENCY MEASURES

Rank	Feature	Improvement Description	Annual Energy Savings	Installed Cost	Savings to Investment Ratio, SIR	Simple Payback (Years)	CO_2 Savings
0	HVAC	Use cord wood boiler to eliminate remaining oil use after EEM#1 below is implemented	$5,619 / 0 MMBTU	$25,000		4.3	0
1	HVAC And DHW	Use waste oil burner for 40% of the building's heating needs	$5,350 / -25.4 MMBTU	$1	93248.19	0.0	-4,174.9
2	Air Tightening	Perform air sealing to reduce air leakage by 50%.	$1,296 / 55.7 MMBTU	$4,000	3.01	3.1	9,002.2
3	Other Electrical - Controls Retrofit: de-stratification fans	Remove Manual Switching and Add new Clock Timer or Other Scheduling Control	$185 / -0.7 MMBTU	$500	2.21	2.7	1,097.8
4	Lighting - Power Retrofit: High bay: T12-2lamps	Replace with 4 LED (2) 15W Module StdElectronic	$22 + $20 Maint. Savings / 0.3 MMBTU	$295	1.21	7.0	140.1
	TOTAL, cost-effective measures		**$12,472 + $20 Maint. Savings / 29.9 MMBTU**	**$29,796**	**22.26**	**2.4**	**6,065.2**
The following measures were *not* found to be cost-effective from a financial perspective but are still recommended:							
5	Lighting - Power Retrofit: Mezz: T12-2lamps 16x48 pendant	Replace with 8 LED (2) 15W Module StdElectronic	$13 + $20 Maint. Savings / -0.1 MMBTU	$295	0.92	9.0	75.2

Table 4.1 Fire Station, Aniak, Alaska PRIORITY LIST – ENERGY EFFICIENCY MEASURES							
Rank	Feature	Improvement Description	Annual Energy Savings	Installed Cost	Savings to Investment Ratio, SIR	Simple Payback (Years)	CO_2 Savings
6	Lighting - Power Retrofit: Mezz: T12-2lamps strip	Replace with LED (2) 15W Module StdElectronic	$4 + $15 Maint. Savings / 0.0 MMBTU	$222	0.70	12.0	21.2
7	Lighting - Power Retrofit: High bay: HPS-250 - assume used only 50% of time	Replace with 3 LED 72W Module StdElectronic	$17 + $15 Maint. Savings / -0.1 MMBTU	$675	0.45	21.2	99.6
	TOTAL, all measures		**$12,505 + $70 Maint. Savings / 29.7 MMBTU**	**$30,988**	**17.95**	**2.5**	**6,261.3**

4.2 Interactive Effects of Projects

The savings for a particular measure are calculated assuming all recommended EEMs coming before that measure in the list are implemented. If some EEMs are not implemented, savings for the remaining EEMs will be affected. For example, if ceiling insulation is not added, then savings from a project to replace the heating system will be increased, because the heating system for the building supplies a larger load.

In general, all projects are evaluated sequentially so energy savings associated with one EEM would not also be attributed to another EEM. By modeling the recommended project sequentially, the analysis accounts for interactive affects among the EEMs and does not "double count" savings.

Interior lighting, plug loads, facility equipment, and occupants generate heat within the building. When the building is in cooling mode, these items contribute to the overall cooling demands of the building; therefore, lighting efficiency improvements will reduce cooling requirements in air-conditioned buildings. Conversely, lighting-efficiency improvements are anticipated to slightly increase heating requirements. Heating penalties and cooling benefits were included in the lighting project analysis.

4.3 Building Shell Measures

4.3.1 Insulation Measures (There were no improvements in this category)

4.3.2 Window Measures (There were no improvements in this category)

4.3.3 Door Measures (There were no improvements in this category)

4.3.4 Air Sealing Measures

Rank	Location		Existing Air Leakage Level (cfm@50/75 Pa)		Recommended Air Leakage Reduction (cfm@50/75 Pa)	
2			Air Tightness estimated as: 4000 cfm at 50 Pascals		Perform air sealing to reduce air leakage by 50%.	
Installation Cost		$4,000	**Estimated Life of Measure (yrs)**	10	**Energy Savings ($/yr)**	$1,296
Breakeven Cost		$12,035	**Simple Payback (yrs)**	3	**Energy Savings (MMBTU/yr)**	55.7 MMBTU
			Savings-to-Investment Ratio	3.0		
Auditors Notes:						

4.4 Mechanical Equipment Measures

4.4.1 Heating/Cooling/Domestic Hot Water Measure

The cord wood boiler EEM (EEM #0 in Tables 1.1 and 4.1) was not calculated inside the AkWarm-C model, so no detail is provided in this section.

Rank	Recommendation					
1	Use waste oil burner for 40% of the building's heating needs					
Installation Cost		$1	**Estimated Life of Measure (yrs)**	20	**Energy Savings ($/yr)**	$5,350
Breakeven Cost		$93,248	**Simple Payback (yrs)**	0	**Energy Savings (MMBTU/yr)**	-25.4 MMBTU
			Savings-to-Investment Ratio	93,248.2		
Auditors Notes:						

4.4.2 Ventilation System Measures (There were no improvements in this category)

4.4.3 Night Setback Thermostat Measures (There were no improvements in this category)

4.5 Electrical & Appliance Measures

4.5.1 Lighting Measures

The goal of this section is to present any lighting energy conservation measures that may also be cost beneficial. It should be noted that replacing current bulbs with more energy-efficient equivalents will have a small effect on the building heating and cooling loads. The building cooling load will see a small decrease from an upgrade to more efficient bulbs and the heating load will see a small increase, as the more energy efficient bulbs give off less heat.

4.5.1a Lighting Measures – Replace Existing Fixtures/Bulbs

Rank	Location	Existing Condition		Recommendation	
4	High bay: T12-2lamps	4 FLUOR (2) T12 4' F40T12 40W Standard Magnetic with Manual Switching		Replace with 4 LED (2) 15W Module StdElectronic	
Installation Cost	$295	**Estimated Life of Measure (yrs)**	10	**Energy Savings ($/yr)**	$22
Breakeven Cost	$358	**Simple Payback (yrs)**	7	**Energy Savings (MMBTU/yr)**	0.3 MMBTU
		Savings-to-Investment Ratio	1.2	**Maintenance Savings ($/yr)**	$20
Auditors Notes: Remove or bypass ballast, replace end caps if required and re-wire for line voltage in (4) fixtures @ .75 hrs/fixture labor @ $45/hr. Replace (8) lamps with 15w T8 LED's @ $20 ea. Maintenance savings $5/fixture.					

Rank	Location	Existing Condition		Recommendation	
5	Mezz: T12-2lamps 16x48 pendant	8 FLUOR (2) T12 4' F40T12 40W Standard Magnetic with Manual Switching		Replace with 8 LED (2) 15W Module StdElectronic	
Installation Cost	$295	**Estimated Life of Measure (yrs)**	10	**Energy Savings ($/yr)**	$13
Breakeven Cost	$271	**Simple Payback (yrs)**	9	**Energy Savings (MMBTU/yr)**	-0.1 MMBTU
		Savings-to-Investment Ratio	0.9	**Maintenance Savings ($/yr)**	$20
Auditors Notes: Remove or bypass ballast, replace end caps if required and re-wire for line voltage in (4) fixtures @ .75 hrs/fixture labor @ $45/hr. Replace (8) lamps with 15w T8 LED's @ $20 ea. Maintenance savings $5/fixture.					

Rank	Location	Existing Condition		Recommendation	
6	Mezz: T12-2lamps strip	FLUOR (2) T12 4' F40T12 40W Standard Magnetic with Manual Switching		Replace with LED (2) 15W Module StdElectronic	
Installation Cost	$222	**Estimated Life of Measure (yrs)**	10	**Energy Savings ($/yr)**	$4
Breakeven Cost	$156	**Simple Payback (yrs)**	12	**Energy Savings (MMBTU/yr)**	0.0 MMBTU
		Savings-to-Investment Ratio	0.7	**Maintenance Savings ($/yr)**	$15
Auditors Notes: Remove or bypass ballast, replace end caps if required and re-wire for line voltage in (3) fixtures @ .75 hrs/fixture labor @ $45/hr. Replace (6) lamps with 15w T8 LED's @ $20 ea. Maintenance savings $5/fixture.					

Rank	Location	Existing Condition		Recommendation	
7	High bay: HPS-250 - assume used only 50% of time	3 HPS 250 Watt Magnetic with Manual Switching		Replace with 3 LED 72W Module StdElectronic	
Installation Cost	$675	**Estimated Life of Measure (yrs)**	12	**Energy Savings ($/yr)**	$17
Breakeven Cost	$302	**Simple Payback (yrs)**	21	**Energy Savings (MMBTU/yr)**	-0.1 MMBTU
		Savings-to-Investment Ratio	0.4	**Maintenance Savings ($/yr)**	$15
Auditors Notes: Remove or bypass ballast, replace 250w HPS lamp with 40w-72w LED "corncob" lamp, estimated parts cost $100 ea., estimated labor 1 hr/fixture @ $125/hr. Maintenance savings $5/fixture.					

4.5.1b Lighting Measures – Lighting Controls (There were no improvements in this category)

4.5.2 Refrigeration Measures (There were no improvements in this category)

4.5.3 Other Electrical Measures

Rank	**Location**		**Description of Existing**		**Efficiency Recommendation**	
3	De-stratification fans		2 Unknown brand with Manual Switching		Remove Manual Switching and Add new Clock Timer or Other Scheduling Control	
Installation Cost	$500		**Estimated Life of Measure (yrs)**	7	**Energy Savings ($/yr)**	$185
Breakeven Cost	$1,104		**Simple Payback (yrs)**	3	**Energy Savings (MMBTU/yr)**	-0.7 MMBTU
			Savings-to-Investment Ratio	2.2		
Auditors Notes: Add timer to ceiling fans, to reduce operating time by 60%. Estimated cost $500 total.						

4.5.4 Cooking Measures (There were no improvements in this category)

4.5.5 Clothes Drying Measures (There were no improvements in this category)

4.5.6 Other Measures (There were no improvements in this category)

APPENDICES

Appendix A – Major Equipment List

There is no equipment in addition to that listed in Section 3.1.

Appendix B – Source Energy Billing Data

No oil consumption or delivery data was available and no waste oil consumption data was available. The electric data below was used as a baseline, and used to calibrate the electric side of the AkWarm-C model.

Fire Hall (PCE)		
2016	**2017**	
999	1,008	$270.85
1,117	1,199	$322.17
1,058	1,258	$338.02
340	643	$172.77
401	276	$74.16
471	201	$54.01
243	197	$52.93
321	212	$56.96
283	441	$118.50
638	357	$95.93
582	600	$161.22
1,107	752	$202.06
7,560	**7,144**	**$1,919.59**

Appendix C – Additional EEM Cost Estimate Details

EEM Cost Estimates

Installed costs for the recommended EEMs in this audit include the labor and equipment required to implement the EEM retrofit, but engineering (if they are required) and construction management costs are excluded; they can be estimated at 15% of the overall costs. Cost estimates are typically +/- 30% for this level of audit, and are derived from and one or more of the following:

- The labor costs identified below
- Means Cost Data
- Industry publications
- The experience of the auditor
- local contractors and equipment suppliers
- Specialty vendors

Labor rates used:

Certified Electrician $125/hr

This level of work includes changing street light heads, light fixtures, running new wires for ceiling or fixture-mounted occupancy and/or daylight harvesting sensors, etc.

Common mechanical & electrical work $ 45/hr

Includes installing switch mounted occupancy sensors which do not require re-wire or pulling additional wires, weather stripping doors and windows, replacing ballasts, florescent lamps and fixtures, exterior HID wall packs with LED wall packs, replacing doors, repairing damaged insulation, etc.

Certified mechanical work $125/hr

Work includes boiler replacement, new or modified heat piping and/or ducting, adding or modifying heat exchangers, etc.

Maintenance activities $45/hr

Includes maintaining light fixtures, door and window weather stripping, changing lamps, replacing bulbs, etc.

Appendix D – Project Summary

ENERGY AUDIT REPORT – PROJECT SUMMARY	
General Project Information	
PROJECT INFORMATION	**AUDITOR INFORMATION**
Building: Fire Station	**Auditor Company:** Energy Audits of Alaska
Address: Aniak, AK	**Auditor Name:** Jim Fowler, PE, CEM
City: Aniak	**Auditor Address:** 200 W 34th Ave, Suite 1018 Anchorage, AK 99503
Client Name: Kevin Toothaker	
Client Address: P.O. box 189 Aniak, AK 99557	**Auditor Phone:** (907) 269-4350
	Auditor FAX:
Client Phone: (907) 675-4481	**Auditor Comment:**
Client FAX:	
Design Data	
Building Area: 3,500 square feet	**Design Space Heating Load:** Design Loss at Space: 102,429 Btu/hour with Distribution Losses: 102,429 Btu/hour Plant Input Rating assuming 82.0% Plant Efficiency and 25% Safety Margin: 156,142 Btu/hour Note: Additional Capacity should be added for DHW and other plant loads, if served.
Typical Occupancy: 2 people	**Design Indoor Temperature:** 56 deg F (building average)
Actual City: Aniak	**Design Outdoor Temperature:** -29.2 deg F
Weather/Fuel City: Aniak	**Heating Degree Days:** 12,829 deg F-days
Utility Information	
Electric Utility: Aniak Light & Power - Commercial - Sm	**Natural Gas Provider:** None
Average Annual Cost/kWh: $0.270/kWh	**Average Annual Cost/ccf:** $0.000/ccf

Annual Energy Cost Estimate									
Description	**Space Heating**	**Space Cooling**	**Water Heating**	**Ventilation Fans**	**Lighting**	**Refrigeration**	**Other Electrical**	**Service Fees**	**Total Cost**
Existing Building	$14,351	$0	$0	$1	$139	$168	$1,420	$0	**$16,080**
With Proposed Retrofits	$2,204	$0	$0	$1	$66	$168	$1,136	$0	**$3,575**
Savings	$12,147	$0	$0	$0	$74	$0	$284	$0	**$12,505**

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	105.4	8.21	$4.59
With Proposed Retrofits	96.9	7.55	$1.02

EUI: Energy Use Intensity - The annual site energy consumption divided by the structure's conditioned area.
EUI/HDD: Energy Use Intensity per Heating Degree Day.
ECI: Energy Cost Index - The total annual cost of energy divided by the square footage of the conditioned space in the building.

Appendix E – Photographs

Cord wood boiler waiting to be installed in the fire station. It was purchased under a grant and intended to use peat as fuel, it must be modified to use wood as a fuel and a hydronic heating loop as well as circulation pumps and fan coil units must be installed to utilize this boiler for building heat.

Heating coils presumably waiting for cord wood boiler to be connected

Vehicle bay

Small kitchenette

Mezzanine training area; note the ceiling insulation

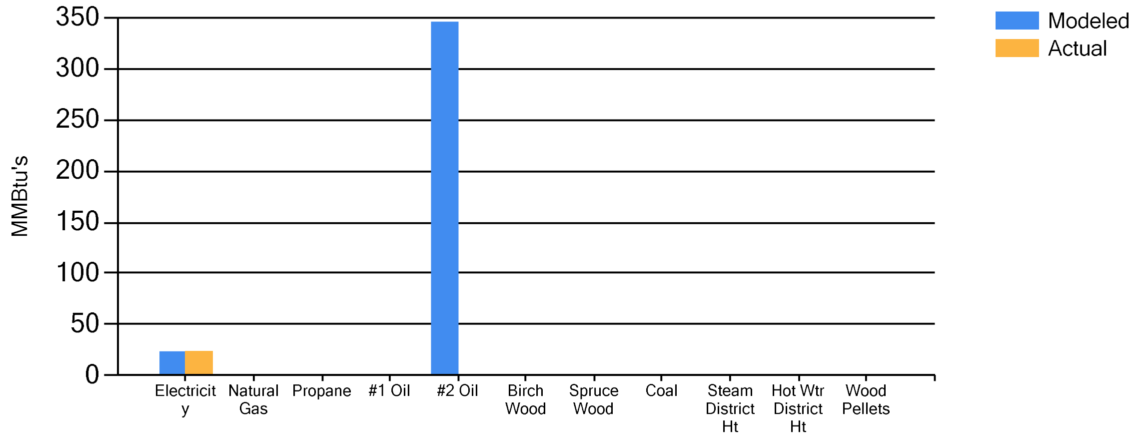
Waste oil burner and both oil fired unit heaters, 1 of which appears to be functional (and was running during the site survey)

Both oil fired unit heater thermostats set to 55F

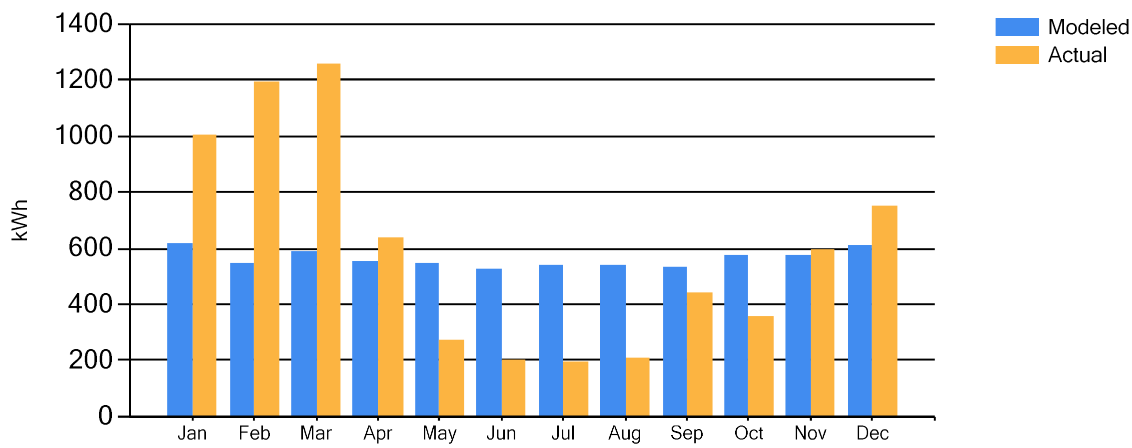
Appendix F – Actual Fuel Use versus Modeled Fuel Use

The Orange bars show Actual fuel use, and the Blue bars are AkWarm's prediction of fuel use.

Annual Fuel Use



Electricity Fuel Use



#2 Fuel Oil Fuel Use