Comprehensive Energy Audit
For

Kiana Lift Station

Prepared For
City of Kiana

July 27, 2016

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Table of Contents

PREFACE

This energy audit was conducted using funds provided by the Department of Energy as part of the Rural Alaskan Communities Energy Efficiency (RACEE) Competition. Coordination with the City of Kiana has been undertaken to provide maximum accuracy in identifying audits and coordinating potential follow up retrofit activities.

The Rural Energy Initiative at the Alaska Native Tribal Health Consortium (ANTHC) prepared this document for the City of Kiana, Alaska. The authors of this report are Bailey Gamble, Mechanical Engineer I; and Chris Mercer, Senior Engineering Project Manager and Certified Energy Manager (CEM).

The purpose of this report is to provide a comprehensive document of the findings and analysis that resulted from an energy audit conducted in July of 2016 by the Energy Projects Group of ANTHC. This report analyzes historical energy use and identifies costs and savings of recommended energy conservation measures. Discussions of site-specific concerns, non-recommended measures, and an energy conservation action plan are also included in this report.

ACKNOWLEDGMENTS

The ANTHC Energy Projects Group gratefully acknowledges the assistance of Water Treatment Plant Operator Richard Teel, Remote Maintenance Worker Chris Cox, and City of Kiana Mayor Darin Douglas.

1. EXECUTIVE SUMMARY

This report was prepared for the City of Kiana. The scope of the audit focused on Kiana Lift Station. The scope of this report is a comprehensive energy study, which included an analysis of building shell, interior and exterior lighting systems and heating and ventilation systems.

Based on electricity and fuel oil prices in effect at the time of the audit, the total predicted energy costs are $12,559 per year. Electricity represents the largest portion with an annual cost of approximately $9,804. This includes about $3,481 paid by the city and about $6,323 paid by the Power Cost Equalization (PCE) program through the State of Alaska. Fuel represents the remaining portion, with an annual cost of approximately $2,755.

The State of Alaska PCE program provides a subsidy to rural communities across the state to lower electricity costs and make energy affordable in rural Alaska. In Kiana, the cost of electricity without PCE is $0.49/kWh and the cost of electricity with PCE is $0.165/kWh.

An energy audit report was also developed for the Kiana Water Treatment Plant. This report compliments the Lift Station energy audit and covers the treatment, heating and distribution of water. This report will be distributed separately from the Kiana Lift Station Report.

Table 1.1 lists the total usage of electricity and #1 heating oil in the Kiana Lift Station before and after the proposed retrofits.

Table 1.1: Predicted Annual Fuel Use for the Lift Station

Predicted Annual Fuel Use		
Fuel Use	**Existing Building**	**With Proposed Retrofits**
Electricity	18,496 kWh	10,742 kWh
#1 Oil	501 gallons	219 gallons

Benchmark figures facilitate comparing energy use between different buildings. Table 1.2 lists several benchmarks for the audited building. More details can be found in section 3.2.2.

Table 1.2: Building Benchmarks for the Lift Station

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	134.6	8.59	$13.08
With Proposed Retrofits	68.3	4.36	$7.58
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.			

Table 1.3 below summarizes the energy efficiency measures analyzed for the Kiana Lift Station. Listed are the estimates of the annual savings, installed costs, and two different financial measures of investment return.

Table 1.3: Summary of Recommended Energy Efficiency Measures

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**
1	Setback Thermostat: Pump Room	Implement a Heating Temperature Unoccupied Setback to 40.0 deg F for the Pump Room space.	$777	$500	20.98	0.6	2,981.2
2	Setback Thermostat: Wet Well Room	Implement a Heating Temperature Unoccupied Setback to 36.0 deg F for the Wet Well Room space.	$880	$2,000	5.94	2.3	3,374.4
3	Air Tightening	Perform air sealing to reduce air leakage by 250 cfm at 50 Pascals.	$164	$500	3.04	3.1	628.5
4	Other Electrical - Power Retrofit: 15 kVA Transformer	Replace 15 kVA transformer with a 5 kVA transformer.	$924	$3,500	2.98	3.8	3,433.1
5	Lighting - Power Retrofit: Pump Room Lights	Replace with new energy-efficient LED lighting.	$11	$60	2.16	5.2	42.6
6	Lighting - Power Retrofit: Settling Tank Room Lights	Replace with new energy-efficient LED lighting.	$19	$100	2.16	5.2	71.0
7	HVAC And DHW	Install Toyotomi stove to meet space heating demand. Leave boiler in place for instances when settling tank room demands heat.	$420	$4,500	1.61	10.7	1,609.8
8	Other Electrical - Controls Retrofit: Glycol Loop Circ Pump	Only run when temp in settling tank room drops below 36 deg. F. Control using temp alarm.	$179	$1,500	1.35	8.4	663.6
9	Other Electrical - Controls Retrofit: Effluent Pump	Seal manholes and add frost jackets.	$1,815 + $7,000 Maint. Savings	$45,000	1.22	5.1	6,751.6
10	Lighting - Combined Retrofit: Exterior Light	Replace with new energy-efficient LED lighting and add new daylight sensor.	$54	$510	0.64	9.5	199.5

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
11	Exposed Floor: In-ground Settling Tank	Re-insulate settling tank. Allows for lower heating temperature setpoint.	$36	$3,130	0.27	86.9	138.2
12	Window/Skylight: Settling Tank Room Window	Replace existing window with low E/argon fiberglass or insulated vinyl windows.	$5	$608	0.15	116.0	20.1
	TOTAL, all measures		**$5,284 + $7,000 Maint. Savings**	**$61,907**	**1.61**	**5.0**	**19,913.8**

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.

[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 $5,284 per year, or 42.1% of the buildings' total energy costs. These measures are estimated to cost $61,907, for an overall simple payback period of 5.0 years.

Table 1.4 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 building as it is now. 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.

Table 1.4: Detailed Breakdown of Energy Costs in the Building

Annual Energy Cost Estimate				
Description	**Space Heating**	**Lighting**	**Other Electrical**	**Total Cost**
Existing Building	$2,853	$207	$9,440	**$12,559**
With Proposed Retrofits	$1,211	$99	$5,905	**$7,275**
Savings	$1,642	$107	$3,535	**$5,284**

2. AUDIT AND ANALYSIS BACKGROUND

2.1 Program Description

This audit included services to identify, develop, and evaluate energy efficiency measures at the Kiana Lift Station. The scope of this project included evaluating building shell, lighting and other electrical systems, heating and ventilation 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 was gathered in preparation for the site survey. The site survey provides critical information in deciphering where energy is used and what opportunities exist within a building. The entire site was surveyed to inventory the following to gain an understanding of how each building operates:

- Building envelope (roof, windows, etc.)
- Heating and ventilation equipment
- Lighting systems and controls
- Building-specific equipment
- Wastewater and sewage disposal

The building site visit was performed to survey all major building components and systems. The site visit included detailed inspection of energy consuming components. Summary of building occupancy schedules, operating and maintenance practices, and energy management programs provided by the building manager were collected along with the system and components to determine a more accurate impact on energy consumption.

Details collected from Kiana Lift Station enable a model of the building's energy usage to be developed, highlighting the building's total energy consumption, energy consumption by specific building component, and equivalent energy cost. The analysis involves distinguishing the different fuels used on site, and analyzing their consumption in different activity areas of the building.

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

1) Wet Well Room: 640 square feet
2) Pump Room: 320 square feet

In addition, the methodology involves taking into account a wide range of factors specific to the building. These factors are used in the construction of the model of energy used. The factors include:

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

2.3. Method of Analysis

Data collected was processed using AkWarm© Energy Use Software to estimate energy savings for each of the proposed energy efficiency measures (EEMs). The recommendations focus on the building envelope; HVAC; lighting, plug load, and other electrical improvements; and motor and pump systems that will reduce annual energy consumption.

EEMs are evaluated based on building use and processes, local climate conditions, building construction type, function, operational schedule, existing conditions, and foreseen future plans. Energy savings are calculated based on industry standard methods and engineering estimations.

Our analysis provides a number of tools for assessing the cost effectiveness of various improvement options. 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 the period of time that includes both the construction cost and 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 improvement. When these savings are added up, changes in future fuel prices as projected by the Department of Energy are included. Future savings are discounted to the present to account for the time-value of money (i.e. money's ability to earn interest over time). The **Investment** in the SIR calculation includes the labor and materials required to install the measure. An SIR value of at least 1.0 indicates that the project is cost-effective—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 savings of the project 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 to 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. As an offsetting simplification, simple payback does not consider the need to earn interest on the investment (i.e. it does not consider 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 implemented in order of cost-effectiveness. The program first calculates individual SIRs, and ranks all measures by SIR, higher SIRs at the top of the list. An individual measure must have an individual SIR>=1 to make the cut. Next the building is modified and re-simulated with the highest ranked measure included. Now all remaining measures are re-evaluated and ranked, and the next most cost-effective measure is implemented. AkWarm goes through this iterative process until all appropriate measures have been evaluated and installed.

It is important to note that the savings for each recommendation is calculated based on implementing the most cost effective measure first, and then cycling through the list to find the next most cost effective measure. Implementation of more than one EEM often affects the savings of other EEMs. The savings may in some cases be relatively higher if an individual EEM is implemented in lieu of multiple recommended EEMs. 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 multiple EEM's are recommended to be implemented, AkWarm calculates the combined savings appropriately.

Cost savings are calculated based on estimated initial costs for each measure. Installation costs include labor and equipment to estimate the full up-front investment required to implement a change. Costs are derived from Means Cost Data, industry publications, and local contractors and equipment suppliers.

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 intended as a final design document. The design professional or other persons following the recommendations shall accept responsibility and liability for the results.

3. Kiana Lift Station

3.1. Building Description

The 960 square foot Kiana Lift Station was constructed in 1985 and is usually unoccupied. The water treatment operator and an assistant typically spend only a few hours there each month pumping sludge.

All of Kiana's sewage flows by gravity into the settling tank in the lift station where solids are settled out. Effluent is pumped from the lift station through the force main to the lagoon approximately 5700 feet to the North. Sludge from the settling tank is removed from the settling tank and transported to the lagoon using a pumper truck.

<u>Description of Building Shell</u>

The exterior walls of the lift station are constructed with single stud 2x6 lumber construction with a 16-inch offset. The walls have approximately 5.5 inches of XPS Blue/Pink Foam panels that are slightly damaged from age. There is approximately 1208 square feet of wall space in the lift station.

The lift station has an attic above the pump room and cathedral ceiling over the settling tank room all with 2x6 lumber construction. The roof has standard framing and a 24-inch offset. The ceiling has approximately 11.5 inches of batt insulation over the pump room and 5.5 inches of batt insulation over the settling tank room all with some damage due to age. There is approximately 980 square feet of roof space in the building.

The pump room is built on pilings with the floor constructed of 2x12 floor joists with a 16-inch offset. The pump room floor is insulated with 6 inches of slightly damaged extruded polystyrene insulation and there is approximately 320 square feet of floor space in this room.

The below ground settling tank and wet well occupy the majority of the floor space in the settling tank room (see Figure 1). The remainder of the floor here is built directly on the ground an insulated with 4 inches of very damaged XPS Blue Foam insulation. There is approximately 640 square feet of floor space in this room

Figure 1: Settling Tank Room

The building has one window which has a single pane of cracked acrylic and measurements of 1.5' x 1.5'. The window is on the South side of the settling tank room.

There are two insulated metal doors, one providing access to each room. Each of the doors has some air leakage. Both doors measure 3' x 6'8".

Description of Heating Plant

The Heating Plant used in the building is:

Boiler

Nameplate Information:	Weil-McLain 68
Fuel Type:	#1 Oil
Input Rating:	181,000 BTU/hr
Steady State Efficiency:	45 %
Idle Loss:	1.5 %
Heat Distribution Type:	Glycol
Boiler Operation:	Sep – May
Notes:	1.5 GPH oil fire rate

The boiler operates to heat the pump and settling tank rooms. At one time the boiler also provided heat to be added to the force main, but is currently not configured to do so. The presence of soot and melted insulation on the boiler suggest that it is burning rich and too hot.

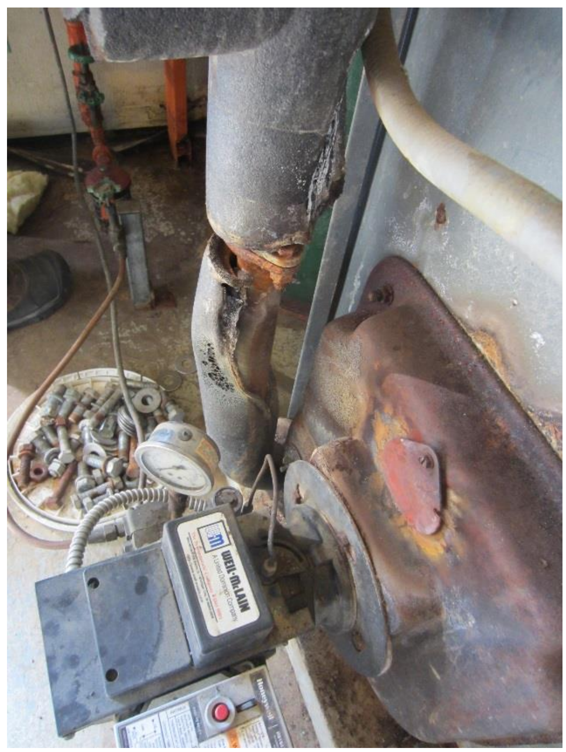

Figure 2: Existing Fuel Boiler Figure 3: Melted Insulation on Boiler

Space Heating Distribution System

There is one unit heater in the pump room of the lift station with an estimated heat output rating of 50 MBH. The settling tank room is heated by a fin type radiator.

Description of Building Ventilation System

The existing building ventilation system consists of a louver in the pump room and pipes in the settling tank and wet well that allow for the venting of any gasses.

Lighting

The pump room of the lift station has 6 fixtures with one 24 W what compact fluorescent spiral bulb in each fixture. Most of the operator time spent in the lift station is pent in the settling tank room, so the lights are only typically only on in the pump room for a fraction of the operator time spent in the lift station – approximately 4 hours per month. They consume approximately 71.3 kWh annually.

The settling tank room has 10 fixtures with one 24 W what compact fluorescent spiral bulb in each fixture. The lights are usually on if the operator is in the lift station, so for about 8-9 hours a month. They consume approximately 118.8 kWh annually.

There is a single fixture on the exterior of the building that contains one 24 W what compact fluorescent spiral bulb. The light is always left on. It consumes approximately 201.6 kWh annually.

Major Equipment

There are two pumps that transport effluent from the wet well in the lift station through the force main to the sewage lagoon. These pumps alternate and are rated for 20 HP. They typically operate year round 12-15% of the time. They operate slightly more often in the winter than in the summer. They consume a combined 13,491.1 kWh annually.

There are two pumps that circulate glycol on the main building heating loop. These pumps alternate and are rated at 85 Watts. They operated continuously during the winter heating season and consume 482 kWh annually.

There are two pumps that previously circulated glycol through a heat trace running along the force main. The pumps are rated at 1.5 HP, but are not currently operated therefore consumes no electricity.

There is a 15 kVA transformer that reduces the 480 V current coming in to the 120/240 V needed to power the lights and control panels in the lift station. The load loss on this transformer is approximately 3% of its capacity or 3944.7 kWh annually.

There is a pump meant to pump sludge to the sewage lagoon. It is rated for 15 HP, but is not currently connected and therefore consumes no electricity.

Figure 4: Two effluent pumps in front, unused sludge pump in back

3.2 Predicted Energy Use

3.2.1 Energy Usage / Tariffs

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.

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 Alaska Village Electric Collaborative (AVEC) is the electric utility and power plant in the City of Kiana. The utility provides electricity to the residents of Kiana as well as all commercial and public facilities.

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:

Table 3.1: Energy Rates for Each Fuel Source in Kiana

Table 3.1 – Average Energy Cost	
Description	**Average Energy Cost**
Electricity	$ 0.5301/kWh
#1 Oil	$ 5.50/gallons

3.2.1.1 Total Energy Use and Cost Breakdown

At current rates, [Building Owner] pays approximately $12,559 annually for electricity and other fuel costs for the Kiana Lift Station.

Figure 5 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.

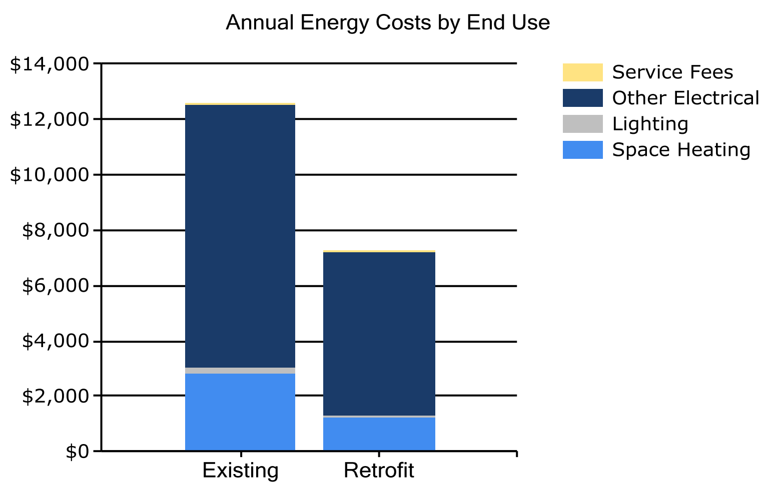

Figure 5: Annual Energy Cost by End Use

Figure 6 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.

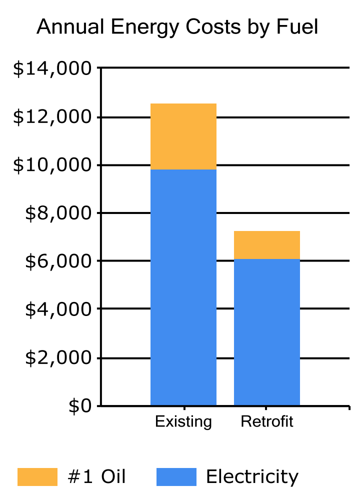

Figure 6: Annual Energy Cost by Fuel Type

Figure 6 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.

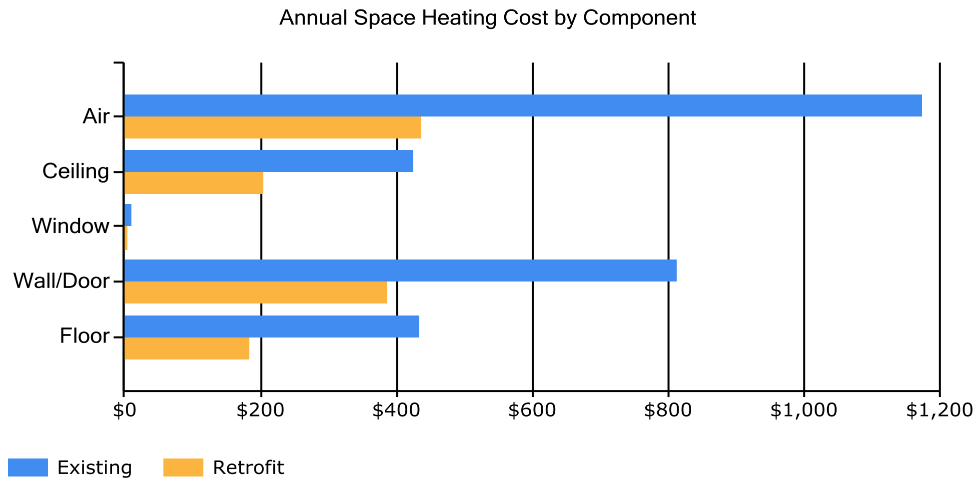

Figure 4: Annual Space Heating Cost by Component

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.

Table 3.2: Electrical Consumption Records by Category

Electrical Consumption (kWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space Heating	41	40	32	9	0	0	0	0	0	2	21	42
Lighting	33	30	33	32	33	32	33	33	32	33	32	33
Other Electrical	1630	1485	1630	1578	1460	1278	1320	1320	1378	1630	1578	1630

Table 3.3: Fuel Oil Consumption Records by Category

Fuel Oil #1 Consumption (Gallons)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space Heating	103	100	81	26	0	0	0	0	15	15	56	105

3.2.2 Energy Use Index (EUI)

Energy Use Index (EUI) is a measure of a building's annual energy utilization per square foot of building. This calculation is completed by converting all utility usage consumed by a building for one year, to British Thermal Units (Btu) or kBtu, and dividing this number by the building square footage. EUI is a good measure of a building's energy use and is utilized regularly for comparison of energy performance for similar building types. The Oak Ridge National Laboratory (ORNL) Buildings Technology Center under a contract with the U.S. Department of Energy maintains a Benchmarking Building Energy Performance Program. The ORNL website determines how a building's energy use compares with similar facilities throughout the U.S. and in a specific region or state.

Source use differs from site usage when comparing a building's energy consumption with the national average. Site energy use is the energy consumed by the building at the building site only. Source energy use includes the site energy use as well as all of the losses to create and distribute 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, which allows for a complete assessment of energy efficiency in a building. The type of utility purchased has a substantial impact on the source energy use of a building. The EPA has determined that source energy is the most comparable unit for evaluation purposes and overall global impact. Both the site and source EUI ratings for the building are provided to understand and compare the differences in energy use.
The site and source EUIs for this building are calculated as follows. (See Table 3.4 for details):

$$\text{Building Site EUI} = \frac{(\text{Electric Usage in kBtu} + \text{Fuel Usage in kBtu})}{\text{Building Square Footage}}$$

$$\text{Building Source EUI} = \frac{(\text{Electric Usage in kBtu X SS Ratio} + \text{Fuel Usage in kBtu X SS Ratio})}{\text{Building Square Footage}}$$

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

Table 3.4: Kiana WTP 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	18,496 kWh	63,127	3.340	210,844
#1 Oil	501 gallons	66,129	1.010	66,790
Total		**129,256**		**277,634**
BUILDING AREA		960	Square Feet	
BUILDING SITE EUI		135	$kBTU/Ft^2/Yr$	
BUILDING SOURCE EUI		289	$\mathbf{kBTU/Ft^2/Yr}$	
* 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: Kiana WTP Building Benchmarks

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	**134.6**	**8.59**	**$13.08**
With Proposed Retrofits	**68.3**	**4.36**	**$7.58**
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.**			

3.3 AkWarm© Building Simulation

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. The heating and ventilation system and central plant are modeled as well, accounting for the outside air ventilation required by the building and the heat recovery equipment in place.

The model uses local weather data and is trued up to historical energy use to ensure its accuracy. The model can be used now and in the future to measure the utility bill impact of all types of energy projects, including improving building insulation, modifying glazing, changing air handler schedules, increasing heat recovery, installing high efficiency boilers, using variable air volume air handlers, adjusting outside air ventilation and adding cogeneration systems.

For the purposes of this study, the Kiana Lift Station was modeled using AkWarm© energy use software to establish a baseline space heating and cooling energy usage. Climate data from Kiana was used for analysis. From this, the model was be calibrated to predict the impact of theoretical energy savings measures. Once annual energy savings from a particular measure were predicted and the initial capital cost was estimated, payback scenarios were approximated. Equipment cost estimate calculations are provided in Appendix D.

Limitations of AkWarm© Models

• The model is based on typical mean year weather data for Kiana. This data represents the average ambient weather profile as observed over approximately 30 years. As such, the gas and electric profiles generated will not likely compare perfectly 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.
• 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.
• The model does not model HVAC systems that simultaneously provide both heating and cooling to the same building space (typically done as a means of providing temperature control in the space).

The energy balances shown in Section 3.1 were derived from the output generated by the AkWarm© simulations.

4. ENERGY COST SAVING MEASURES

4.1 Summary of Results

The energy saving measures are summarized in Table 4.1. Please refer to the individual measure descriptions later in this report for more detail.

Table 4.1: List of Energy Efficiency Recommendations by Economic Priority

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**
1	Setback Thermostat: Pump Room	Implement a Heating Temperature Unoccupied Setback to 40.0 deg F for the Pump Room space.	$777	$500	20.98	0.6	2,981.2
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7	HVAC And DHW	Install Toyotomi stove to meet space heating demand. Leave boiler in place for instances when settling tank room demands heat.	$420	$4,500	1.61	10.7	1,609.8
8	Other Electrical - Controls Retrofit: Glycol Loop Circ Pump	Only run when temp in settling tank room drops below 36 deg. F. Control using temp alarm.	$179	$1,500	1.35	8.4	663.6
9	Other Electrical - Controls Retrofit: Effluent Pump	Seal manholes and add frost jackets.	$1,815 + $7,000 Maint. Savings	$45,000	1.22	5.1	6,751.6
10	Lighting - Combined Retrofit: Exterior Light	Replace with new energy-efficient LED lighting and add new daylight sensor.	$54	$510	0.64	9.5	199.5

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
11	Exposed Floor: In-ground Settling Tank	Re-insulate settling tank.	$36	$3,130	0.27	86.9	138.2
12	Window/Skylight: Settling Tank Room Window	Replace existing window with low E/argon fiberglass or insulated vinyl windows.	$5	$608	0.15	116.0	20.1
	TOTAL, all measures		**$5,284 + $7,000 Maint. Savings**	**$61,907**	**1.61**	**5.0**	**19,913.8**

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 were included in the lighting project analysis.

4.3 Building Shell Measures

4.3.1 Insulation Measures

Rank	Location		Existing Type/R-Value		Recommendation Type/R-Value	
11	Exposed Floor: In-ground Settling Tank		Framing Type: 2 x Lumber Insulating Sheathing: None Top Insulation Layer: XPS (Blue/Pink Foam), 2 inches Bottom Insulation Layer: XPS (Blue/Pink Foam), 2 inches Insulation Quality: Very Damaged Modeled R-Value: 23.3		Install two new layers of XPS Blue/Pink Foam insulation on the settling tank room floor.	
Installation Cost		$3,130	**Estimated Life of Measure (yrs)**	30	**Energy Savings (/yr)**	$36
Breakeven Cost		$852	**Savings-to-Investment Ratio**	0.3	**Simple Payback yrs**	87
Auditors Notes: Re-insulating the floor in the settling tank room will better insulate the settling tank and wet well. This will help maintain sufficient effluent temperature, preventing concern of freezing in the force main and allowing the heating setpoint in the settling tank room to be lowered to 36 degrees F.						

4.3.2 Window Measures

Rank	Location		Size/Type, Condition		Recommendation	
12	Window/Skylight: Settling Tank Room Window		Glass: Single, 1/4" Acrylic/Polycarbonate Frame: Wood\Vinyl Spacing Between Layers: Half Inch Gas Fill Type: Air Modeled U-Value: 0.81 Solar Heat Gain Coefficient including Window Coverings: 0.48		Replace existing windows with low E/argon fiberglass or insulated vinyl windows.	
Installation Cost		$608	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$5
Breakeven Cost		$91	**Savings-to-Investment Ratio**	0.1	**Simple Payback yrs**	116
Auditors Notes: The window on the lift station is cracked. Although this upgrade is not cost effective, it is Necessary to reduce air flow and improve comfort and natural lighting levels in the facility.						

4.3.4 Air Sealing Measures

Rank	Location		Existing Air Leakage Level (cfm@50/75 Pa)		Recommended Air Leakage Reduction (cfm@50/75 Pa)	
3			Air Tightness estimated as: 1700 cfm at 50 Pascals		Perform air sealing to reduce air leakage by 250 cfm at 50 Pascals.	
Installation Cost		$500	**Estimated Life of Measure (yrs)**	10	**Energy Savings (/yr)**	$164
Breakeven Cost		$1,518	**Savings-to-Investment Ratio**	3.0	**Simple Payback yrs**	3
Auditors Notes: Close louver in the pump house, re-seal and weatherstrip doors						

4.4 Mechanical Equipment Measures

4.4.1 Heating Measure

Rank	Recommendation				
7	Install Toyotomi stove to meet space heating demand. Leave boiler in place for instances when settling tank room demands heat.				
Installation Cost	$4,500	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$420
Breakeven Cost	$7,239	**Savings-to-Investment Ratio**	1.6	**Simple Payback yrs**	11
Auditors Notes: The current boiler is old and inefficient. Install a Toyotomi stove to meet the space heating demand of the pump room. This will eliminate the need to run space heaters. The sewage entering the settling tank at 70 + degrees F should provide enough heat to eliminate the need to supply additional heat to the settling tank room. The old boiler and glycol circulation pumps may be left in place to supply heat to the settling tank room in the case that its temperature falls below 36 degrees F.					

4.4.3 Night Setback Thermostat Measures

Rank	Building Space			Recommendation	
1	Pump Room			Implement a Heating Temperature Unoccupied Setback to 40.0 deg F for the Pump Room space.	
Installation Cost	$500	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$777
Breakeven Cost	$10,491	**Savings-to-Investment Ratio**	21.0	**Simple Payback yrs**	1
Auditors Notes: It is safe to maintain the pump room temperature at 40 degrees F.					

Rank	Building Space			Recommendation	
2	Settling Tank Room			Implement a Heating Temperature Unoccupied Setback to 36.0 deg F for the Wet Well Room space.	
Installation Cost	$2,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$880
Breakeven Cost	$11,875	**Savings-to-Investment Ratio**	5.9	**Simple Payback yrs**	2
Auditors Notes: It is safe to maintain the settling tank room temperature at 36 degrees F. The sewage entering at 70 degrees F should be enough to maintain this temperature. Install an alarm that controls the old oil boiler so that it may heat the room in the case that temperatures drop below 36 degrees F.					

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**	
5	Pump Room Lights	6 FLUOR CFL, Spiral 23 W with Manual Switching		Replace with new energy-efficient LED lighting.	
Installation Cost	$60	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$11
Breakeven Cost	$129	**Savings-to-Investment Ratio**	2.2	**Simple Payback yrs**	5
Auditors Notes: This room contains 6 fixtures with one bulb each for a total of 6 bulbs to be replaced.					

Rank	**Location**	**Existing Condition**		**Recommendation**	
6	Settling Tank Room Lights	10 FLUOR CFL, Spiral 23 W with Manual Switching		Replace with new energy-efficient LED lighting.	
Installation Cost	$100	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$19
Breakeven Cost	$216	**Savings-to-Investment Ratio**	2.2	**Simple Payback yrs**	5
Auditors Notes: This room contains 10 fixtures with one bulb each for a total of 10 bulbs to be replaced.					

Rank	**Location**	**Existing Condition**		**Recommendation**	
10	Exterior Light	FLUOR CFL, Spiral 23 W with Manual Switching		Replace with new energy-efficient LED lighting and add new daylight sensor.	
Installation Cost	$510	**Estimated Life of Measure (yrs)**	7	**Energy Savings (/yr)**	$54
Breakeven Cost	$328	**Savings-to-Investment Ratio**	0.6	**Simple Payback yrs**	10
Auditors Notes: Install a daylight sensor so that this light turns on only when it is dark out.					

4.5.3 Other Electrical Measures

Rank	Location		Description of Existing		Efficiency Recommendation	
4	15 kVA Transformer		Transformer with Manual Switching		Replace 15 kVA with a 5 kVA transformer	
Installation Cost		$3,500	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$924
Breakeven Cost		$10,444	**Savings-to-Investment Ratio**	3.0	**Simple Payback yrs**	4
Auditors Notes: The 15 kVA transformer is oversized for the demands of the lift station. Replace it with a 5 kVA transformer to reduce load loss						

Rank	Location		Description of Existing		Efficiency Recommendation	
8	Glycol Loop Circ Pump		Pump with Manual Switching		Control with alarm in settling tank room.	
Installation Cost		$1,500	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$179
Breakeven Cost		$2,022	**Savings-to-Investment Ratio**	1.3	**Simple Payback yrs**	8
Auditors Notes: Add building cold alarm that will fire boiler and turn on circ pump when temp in settling tank room falls below 36 degrees.						

Rank	Location		Description of Existing		Efficiency Recommendation	
9	Effluent Pump		Pump with Other Controls		Seal and install frost jackets on all 45 manholes.	
Installation Cost		$45,000	**Estimated Life of Measure (yrs)**	7	**Energy Savings (/yr)**	$1,815
					Maintenance Savings (/yr)	$7,000
Breakeven Cost		$54,710	**Savings-to-Investment Ratio**	1.2	**Simple Payback yrs**	5
Auditors Notes: Sealing manholes will reduce the volume of runoff entering the sewer system which will reduce influent in the settling tank as well as the amount of grit present in the influent. Less influent will allow for shorter run times on effluent pumps. Reduced grit will extend the life of the effluent pumps, reducing replacement interval. Installing frost jackets on manholes will help prevent freeze-ups on sewer lines which can save up to $70,000 in a single year and eliminate the need for residents to revert to hauling their waste as they wait for the sewer to come back online utilizing energy intensive home operated heat tapes. Frost jackets and manhole sealing should be done concurrently.						

5. ENERGY EFFICIENCY ACTION PLAN

Through inspection of the energy-using equipment on-site and discussions with site facilities personnel, this energy audit has identified several energy-saving measures. The measures will reduce the amount of fuel burned and electricity used at the site. The projects will not degrade the performance of the building and, in some cases, will improve it.

Several types of EEMs can be implemented immediately by building staff, and others will require various amounts of lead time for engineering and equipment acquisition. In some cases, there are logical advantages to implementing EEMs concurrently. For example, if the same electrical contractor is used to install both lighting equipment and motors, implementation of these measures should be scheduled to occur simultaneously.

ANTHC is currently working with the City of Kiana in the development of a proposal based on the retrofits identified in this report as part of the DOE RACEE competition. If accepted into the third round of this competition, the suggested retrofits could be funded by the DOE as part of RACEE. ANTHC will continue to work with the City of Kiana to secure project funding to implement the energy efficiency measures identified in this report.

APPENDICES

Appendix A– Energy Audit Report – Project Summary

ENERGY AUDIT REPORT – PROJECT SUMMARY	
General Project Information	
PROJECT INFORMATION	**AUDITOR INFORMATION**
Building: Kiana Lift Station	**Auditor Company:** ANTHC
Address: Kiana	**Auditor Name:** Bailey Gamble
City: Kiana	**Auditor Address:** 4500 Diplomacy Dr., Suite 545 Anchorage, AK 99508
Client Name: Richard Teel	
Client Address:	**Auditor Phone:** (907) 729-4501
	Auditor FAX: (907) 729-3729
Client Phone: (907) 475-5115	**Auditor Comment:**
Client FAX:	
Design Data	
Building Area: 960 square feet	**Design Space Heating Load:** Design Loss at Space: 20,906 Btu/hour with Distribution Losses: 22,006 Btu/hour Plant Input Rating assuming 82.0% Plant Efficiency and 25% Safety Margin: 33,545 Btu/hour Note: Additional Capacity should be added for DHW and other plant loads, if served.
Typical Occupancy: 2 people	**Design Indoor Temperature:** 53.3 deg F (building average)
Actual City: Kiana	**Design Outdoor Temperature:** -45 deg F
Weather/Fuel City: Kiana	**Heating Degree Days:** 15,675 deg F-days
Utility Information	
Electric Utility: AVEC-Kiana - Commercial - Sm	**Natural Gas Provider:** None
Average Annual Cost/kWh: $0.530/kWh	**Average Annual Cost/ccf:** $0.000/ccf

Annual Energy Cost Estimate								
Description	**Space Heating**	**Space Cooling**	**Water Heating**	**Ventilation Fans**	**Lighting**	**Other Electrical**	**Service Fees**	**Total Cost**
Existing Building	$2,853	$0	$0	$0	$207	$9,440	$60	**$12,559**
With Proposed Retrofits	$1,211	$0	$0	$0	$99	$5,905	$60	**$7,275**
Savings	$1,642	$0	$0	$0	$107	$3,535	$0	**$5,284**

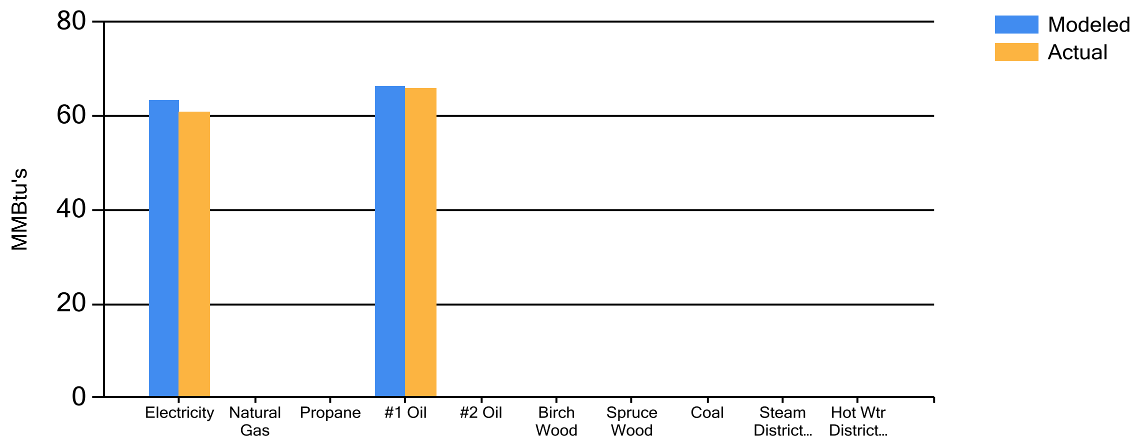
Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	134.6	8.59	$13.08
With Proposed Retrofits	68.3	4.36	$7.58

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.

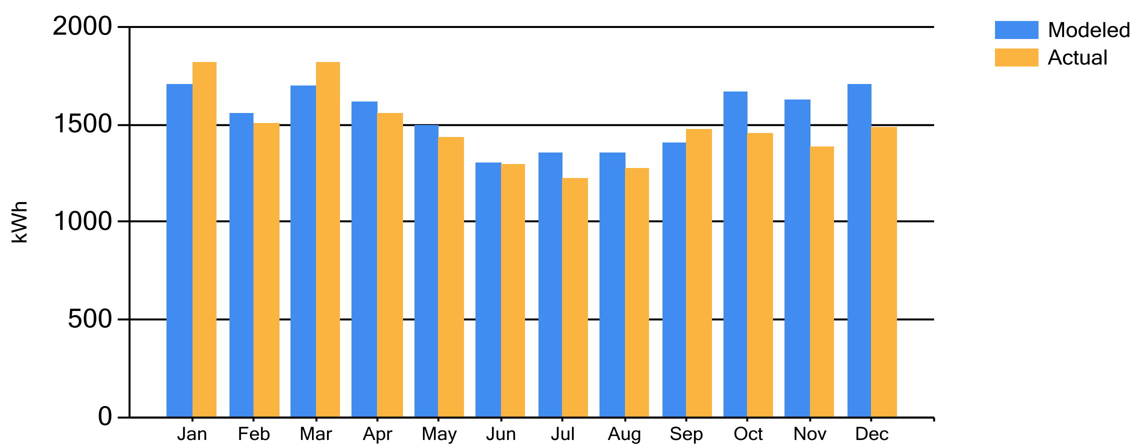
Appendix B – Actual Fuel Use versus Modeled Fuel Use

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

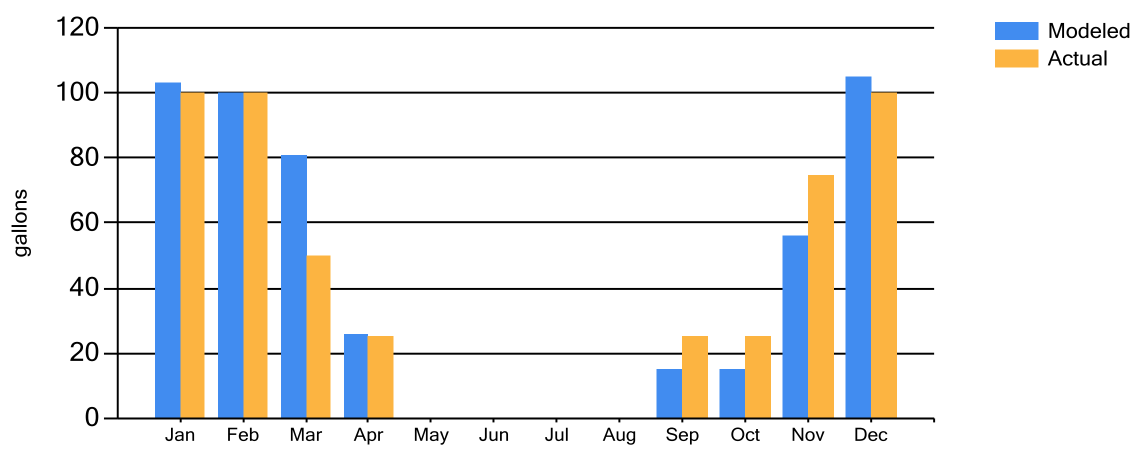
Annual Fuel Use



Electricity Fuel Use



#1 Fuel Oil Fuel Use



Appendix C - Electrical Demands

Estimated Peak Electrical Demand (kW)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Current	2.8	2.8	2.8	2.8	2.6	2.4	2.4	2.4	2.5	2.8	2.8	2.8
As Proposed	1.8	1.8	1.8	1.8	1.6	1.5	1.5	1.5	1.6	1.8	1.8	1.8

Estimated Demand Charges (at $0.00/kW)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Current	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
As Proposed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

AkWarmCalc Ver 2.5.3.0, Energy Lib 3/7/2016