Comprehensive Energy Audit
For

Kobuk Water and Sanitiation

Prepared For

City of Kobuk

March 23, 2015

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PREFACE

This energy audit was conducted using funds from the United States Department of Agriculture Rural Utilities Service as well as the State of Alaska Department of Environmental Conservation. Coordination with the State of Alaska Remote Maintenance Worker (RMW) Program and the associated RMW for each community has been undertaken to provide maximum accuracy in identifying audits and coordinating potential follow up retrofit activities.

The Energy Projects Group at the Alaska Native Tribal Health Consortium (ANTHC) prepared this document for The City of Kobuk, Alaska. The authors of this report are Carl Remley, Certified Energy Auditor (CEA) and Certified Energy Manager (CEM) and Kevin Ulrich. Energy Manager-in-Training (EMIT).

The purpose of this report is to provide a comprehensive document of the findings and analysis that resulted from an energy audit conducted in January of 2015 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 Operators Kris McKay and Quinton Horner, and Kobuk Mayor Alex Sheldon.

1. EXECUTIVE SUMMARY

This report was prepared for the City of Kobuk. The scope of the audit focused on Kobuk Water Treatment Plant. The scope of this report is a comprehensive energy study, which included an analysis of building shell, interior and exterior lighting systems, heating and ventilation systems, and plug loads.

Based on electricity and fuel oil prices in effect at the time of the audit, the total predicted energy cost for the Kobuk Water Treatment Plant is $74,550 per year. Electricity represents the largest piece with an annual cost of $56,364 per year. The water treatment plant is predicted to spend $18,186 for fuel oil.

The water plant has a solar photovoltaic (PV) system that was implemented in 2011 to supplement the electricity costs of the water plant. The project was completed by the Northwest Arctic Borough with the solar PV panels mounted on the exterior of the water storage tank.

The Kobuk Water Treatment Plant received funding to install a Garn 1000 biomass boiler from the Renewable Energy Fund through the Alaska Energy Authority. This project was conceived to use wood heating for the purposes of the water plant and displace #1 heating oil. The boiler was installed in February 2015 and the savings are reflected in this report.

The table below lists the total usage of electricity, #1 oil, and biomass in the water treatment plant before and after the proposed retrofits.

Predicted Annual Fuel Use		
Fuel Use	**Existing Building**	**With Proposed Retrofits**
Electricity	76,082 kWh	57,872 kWh
#1 Oil	3,236 gallons	285 gallons
Spruce Wood	0.00 cords	19.12 cords

Benchmark figures facilitate comparing 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	447.4	28.47	$48.57
With Proposed Retrofits	378.6	24.09	$32.85
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 1.1 below summarizes the energy efficiency measures analyzed for the Kobuk Water and Sanitiation. Listed are the estimates of the annual savings, installed costs, and two different financial measures of investment return.

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**
1	Lighting - Power Retrofit: Mechanical Room	Replace with energy-efficient LED lighting.	$469 plus $80 Maint.	$320	25.08	0.6	1,411.2
2	Lighting - Power Retrofit: Main WTP Lighting	Replace with energy-efficient LED lighting.	$4,590 plus $800 Maint.	$3,200	24.58	0.6	13,774.6
3	Lighting - Power Retrofit: Old Washeteria	Replace with energy-efficient LED lighting.	$1,475 plus $360 Maint.	$1,440	18.62	0.8	4,425.3
4	Other Electrical - Airport Lift Station Electric Heat	Lower thermostat set point to 40 degrees.	$3,632	$1,700	17.99	0.5	10,961.1
5	Other Electrical: HUD Lift Station Electric Heat	Replace with electric heat and heat tape and lower set point to 40 degrees.	$2,553	$1,500	14.33	0.6	7,704.2
6	Lighting - Power Retrofit: Exterior Lighting	Replace with energy-efficient LED lighting.	$153 plus $30 Maint.	$300	8.95	1.6	462.3
7	Lighting - Power Retrofit: Rest Room	Replace with energy-efficient LED lighting.	$43 plus $40 Maint.	$160	7.64	1.9	129.5
8	Air Tightening: Old Boiler Stack	Remove old boiler stack, seal the hole, and add insulation.	$391	$1,000	3.53	2.6	1,377.3
9	Window/Skylight: WTP	Replace existing window with triple pane window.	$101	$849	1.96	8.4	354.3
10	Heating, Ventilation, and Domestic Hot Water (DHW)	Install Garn 1000 biomass boiler and control both the oil fired boilers with a Tekmar 268 controller.	$10,716	$200,000	1.01	18.7	61,779.4
	TOTAL, all measures		**$24,123 plus $1,310 Maint.**	**$210,470**	**1.79**	**8.3**	**102,379.0**

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 $24,123 per year, or 32.4% of the buildings' total energy costs. These measures are estimated to cost $210,470, for an overall simple payback period of 8.3 years.

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.

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 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 1.2

Annual Energy Cost Estimate							
Description	**Space Heating**	**Lighting**	**Other Electrical**	**Raw Water Heat Add**	**Water Circulation Heat**	**Tank Heat**	**Total Cost**
Existing Building	$3,149	$12,705	$41,719	$5,525	$6,262	$5,130	**$74,550**
With Proposed Retrofits	$2,690	$5,676	$35,622	$2,049	$2,438	$1,892	**$50,427**
Savings	$459	$7,029	$6,097	$3,476	$3,823	$3,238	**$24,123**

2. AUDIT AND ANALYSIS BACKGROUND

2.1 Program Description

This audit included services to identify, develop, and evaluate energy efficiency measures at the Kobuk Water Treatment Plant. 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
- Water consumption, treatment (optional) & 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 Kobuk Water Treatment Plant 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.

Kobuk Water Treatment Plant is classified as being made up of the following activity areas:

1) Water Treatment Plant and Lift Stations: 1,535 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; heating and ventilation; 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. Kobuk Water Treatment Plant

3.1. Building Description

The 1,535 square foot Kobuk Water Treatment Plant was constructed in approximately 1985, with a normal occupancy of one person. The number of hours of operation for this building average 9 hours per day, considering all seven days of the week.

The Kobuk Water Treatment Plant houses a circulating water system with two loops that provides water to the residents of the community. One loop, known as the "City Loop," services the east side of town and is approximately 1700 ft. long. The second loop, known as the "HUD Loop," services the west side of town and is approximately 3150 ft. long.

The raw water is pumped from a groundwater source and processed through two sand filters and injected with chlorine before getting pumped into the 97,000 gallon water storage tank that is adjacent to the building.

The sewer system collects sewage through the use of two lift stations before being pushed through a force main to a sewage lagoon that is on the opposite side of the airport from town.

Description of Building Shell

The exterior walls are constructed from stressed skin panels with 5.5 inches of polyurethane foam insulation. The insulation is in good condition. There is approximately 2,208 square feet of wall space in the building.

The roof of the building has a cathedral ceiling with a total of approximately 1583 square feet of roof space. The roof is constructed with standard framing and 24" spacing with eight inches of polyurethane foam insulation. The roof shows few signs of damage and is in good condition.

The building has a post-and-pad foundation that has approximately 8 inches of clearance between the pad and the ground. The floor is framed with standard lumber and has 8 inches of R-25 batt insulation. There is approximately 1535 square feet of floor space in the building.

There is one window in the building with a total space of 12 square feet. The window is framed with wood, has no glass and is filled with batt insulation and covered with plywood.

There are two single metal doors and one large garage door in the water treatment plant. The metal doors are each insulated with a polyurethane core. One door is for the main entrance and one door is in the generator room. There is approximately 42 square feet of standard door space. The garage door is used in the old washeteria room to transport wood and large equipment in from the outside storage area. It is a sectional door with a 2" thermal break and a polyurethane foam core. There is approximately 44 square feet of garage door space.

Description of Heating Plants

The Heating Plants used in the building are:

Weil McLain 78

Nameplate Information:	Model 578 Series 1
Fuel Type:	#1 Oil
Input Rating:	578,500 BTU/hr
Steady State Efficiency:	85 %
Idle Loss:	1 %
Heat Distribution Type:	Glycol
Boiler Operation:	Sep – Jun

Wel McLain 78

Fuel Type:	#1 Oil
Input Rating:	578,500 BTU/hr
Steady State Efficiency:	85 %
Idle Loss:	1 %
Heat Distribution Type:	Water
Boiler Operation:	Sep - Jun

Space Heating Distribution Systems

The building is heated by two unit heaters that each put out 15,000 BTU/hour. The unit heaters are located in the main water treatment plant room and in the old washeteria room. Electric heaters are present in each lift station.

Lighting

The main water treatment plant room has 20 fixtures with four T12 fluorescent light bulbs in each fixture.

The mechanical room has two fixtures with four T12 fluorescent light bulbs in each fixture.

The old washeteria has nine fixtures with four T12 fluorescent light bulbs in each fixture.

The rest room has one fixture with four T12 fluorescent light bulbs in the fixture.

The exterior of the building has one 50W metal halide bulb above the main entrance.

Plug Loads

The water treatment plant has a variety of power tools, a telephone, and some other miscellaneous loads that require a plug into an electrical outlet. The use of these items is infrequent and consumes a small portion of the total energy demand of the building.

Major Equipment

There is a well pump that pumps water from the ground source to the water treatment plant. The well pump uses approximately 2,922 kWh annually.

There is a pressure pump that pressurizes the water treatment system. The pressure pump uses approximately 1,972 kWh annually.

There is a heat add process pump that circulates the process water through the various heat exchangers to keep the water from freezing. The heat-add process pump uses approximately 1,337 KWH annually.

There is a glycol heat add pump that circulates the heated glycol through the various heat exchangers to keep the water process from freezing. The glycol heat-add pump uses approximately 1,263 KWH annually.

There is a tank heat add pump that is used to circulate the heated water into the water storage tank to prevent freezing. The tank heat-add pump uses approximately 1,337 KWH annually.

There is a circulation pump for the city loop that circulates the water through the distribution system. This pump uses approximately 3,464 KWH annually.

There is a circulation pump for the HUD loop that circulates the water through the distribution system. This pump uses approximately 3,464 KWH annually.

There is a lift station pump in the airport lift station that pumps the sewage through the force main to the sewage lagoon. The pump uses approximately 548 KWH annually.

There is a lift station pump in the HUD loop lift station that pumps sewage through the force main to the sewage lagoon. The pump uses approximately 297 KWH annually.

There is a heat tape line for the water treatment plant sewer line for emergency freeze protection use. The heat tape uses approximately 458 KWH annually.

There is a heat tape line and electric heater in the airport lift station that protects the sewer lines from freezing. The heat tape and electric heater combine to use approximately 19,929 KWH annually.

There is a heat tape line and electric heater in the HUD lift station that protects the sewer lines from freezing. The heat tape and electric heater combine to use approximately 14,008 KWH annually.

There is a variety of water process loads and controls that do various tasks to keep the water treatment plant operational. These loads combine to use approximately 3,653 KWH annually.

There are other miscellaneous loads from items such as phones, tools, and computers that are not tied directly into the water treatment plant operation. These items use approximately 1,753 KWH annually.

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). One kWh usage is equivalent to 1,000 watts running for one hour. The basic usage charges are shown as generation service and delivery charges along with several non-utility generation charges.

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 following is a list of the utility companies providing energy to the building and the class of service provided:

Electricity: Alaska Village Electric Cooperative - Commercial - Small

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 – Average Energy Cost	
Description	**Average Energy Cost**
Electricity	$ 0.74/KWH
#1 Oil	$ 5.62/gallons

3.2.1.1 Total Energy Use and Cost Breakdown

At current rates, ARUC pays approximately $74,550 annually for electricity and other fuel costs for the Kobuk Water Treatment Plant and associated lift stations.

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

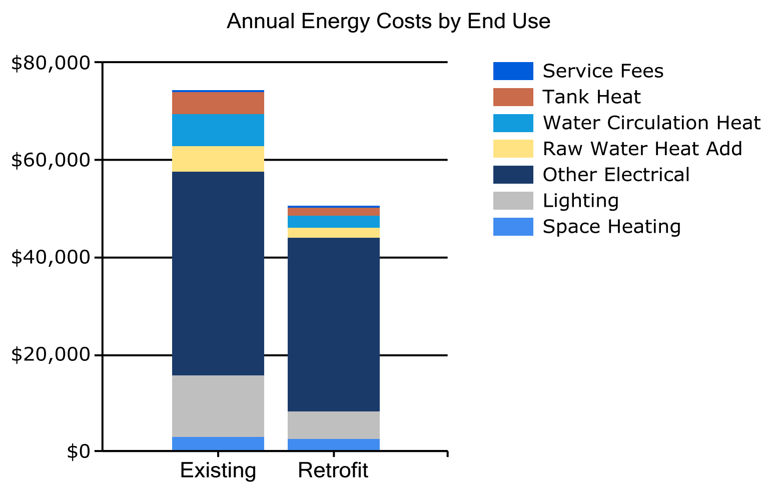


Figure 3.2 below shows how the annual energy cost of the building splits between the different fuels used by the building. The "Existing" bar shows the breakdown for the building as it is now; the "Retrofit" bar shows the predicted costs if all of the energy efficiency measures in this report are implemented.

Figure 3.2
Annual Energy Costs by Fuel Type

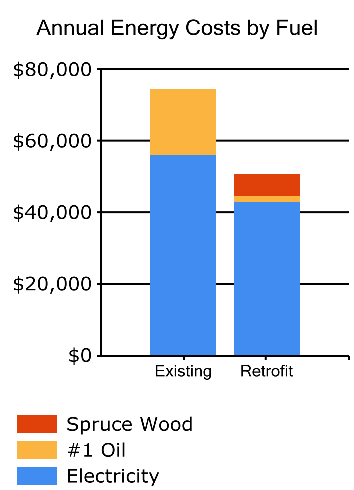
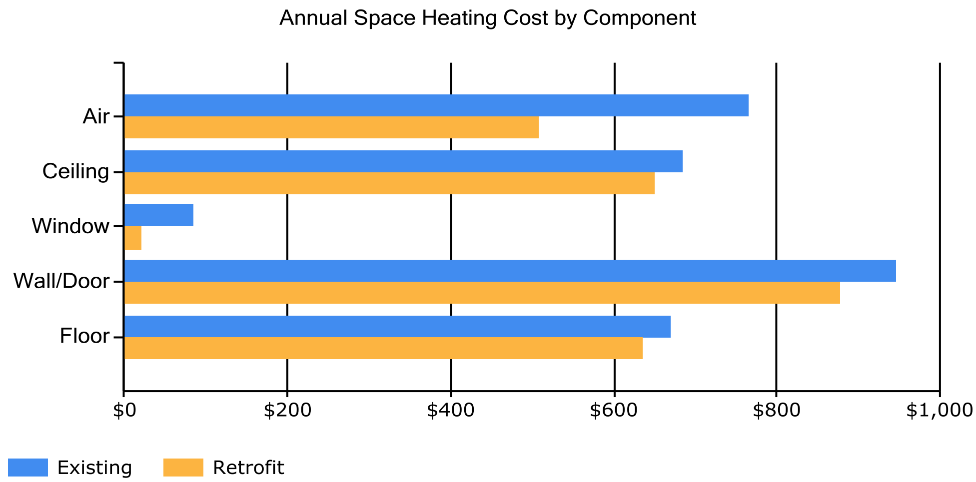


Figure 3.3 below addresses only Space Heating costs. The figure shows how each heat loss component contributes to those costs; for example, the figure shows how much annual space heating cost is caused by the heat loss through the Walls/Doors. For each component, the space heating cost for the Existing 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	359	303	290	213	161	133	0	34	66	189	298	354
Lighting	1469	1339	1469	1422	1425	1379	1425	1425	1379	1469	1422	1469
Other_Electrical	6888	6277	6888	6666	5838	3438	946	946	915	4090	6666	6888
Raw_Water_Heat_Add	4	4	4	5	6	2	2	2	5	5	4	4
Water_Circulation_Heat	4	4	5	5	7	3	3	3	6	5	5	4
Tank_Heat	8	7	6	4	0	0	0	0	0	4	7	8

Fuel Oil #1 Consumption (Gallons)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space_Heating	50	39	29	7	0	0	0	9	7	20	34	49
Raw_Water_Heat_Add	82	76	85	87	98	66	69	69	94	89	81	82
Water_Circulation_Heat	93	86	96	98	112	75	78	78	106	101	92	93
Tank_Heat	174	144	131	71	0	0	0	0	6	74	135	171

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):

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

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

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

Table 3.4
Kobuk Water and Sanitiation 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	76,082 kWh	259,668	3.340	867,290
#1 Oil	3,236 gallons	427,141	1.010	431,412
Total		**686,809**		**1,298,703**
BUILDING AREA		1,535	Square Feet	
BUILDING SITE EUI		447	kBTU/Ft²/Yr	
BUILDING SOURCE EUI		846	**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	**447.4**	**28.47**	**$48.57**
With Proposed Retrofits	**378.6**	**24.09**	**$32.85**
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 Kobuk Water Treatment Plant was modeled using AkWarm© energy use software to establish a baseline space heating and cooling energy usage. Climate data from Kobuk 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 Kobuk. 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 heating and ventilation 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. Calculations and cost estimates for analyzed measures are provided in Appendix C.

Table 4.1
Kobuk Water and Sanitiation, Kobuk, 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
1	Lighting - Power Retrofit: Mechanical Room	Replace with energy-efficient LED lighting.	$469 plus $80 Maint.	$320	25.08	0.6	1,411.2
2	Lighting - Power Retrofit: Main WTP Lighting	Replace with energy-efficient LED lighting.	$4,590 plus $800 Maint.	$3,200	24.58	0.6	13,774.6
3	Lighting - Power Retrofit: Old Washeteria	Replace with energy-efficient LED lighting.	$1,475 plus $360 Maint.	$1,440	18.62	0.8	4,425.3
4	Other Electrical - Airport Lift Station Electric Heat	Lower thermostat set point to 40 degrees.	$3,632	$1,700	17.99	0.5	10,961.1
5	Other Electrical: HUD Lift Station Electric Heat	Replace with electric heat and heat tape and lower set point to 40 degrees.	$2,553	$1,500	14.33	0.6	7,704.2
6	Lighting - Power Retrofit: Exterior Lighting	Replace with energy-efficient LED lighting.	$153 plus $30 Maint.	$300	8.95	1.6	462.3

Table 4.1 Kobuk Water and Sanitiation, Kobuk, 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**
7	Lighting - Power Retrofit: Rest Room	Replace with energy-efficient LED lighting.	$43 plus $40 Maint.	$160	7.64	1.9	129.5
8	Air Tightening: Old Boiler Stack	Remove old boiler stack, seal the hole, and add insulation.	$391	$1,000	3.53	2.6	1,377.3
9	Window/Skylight: WTP	Replace existing window with triple pane window.	$101	$849	1.96	8.4	354.3
10	Heating, Ventilation, and Domestic Hot Water (DHW)	Install Garn 1000 biomass boiler and control both the oil fired boilers with a Tekmar 268 controller.	$10,716	$200,000	1.01	18.7	61,779.4
	TOTAL, all measures		**$24,123 plus $1,310 Maint.**	**$210,470**	**1.79**	**8.3**	**102,379.0**

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

4.3.2 Window Measures

Rank	Location	Size/Type, Condition	Recommendation
9	Window/Skylight: WTP	Glass: No glazing - broken, missing Frame: Wood\Vinyl Spacing Between Layers: Half Inch Gas Fill Type: Air Modeled U-Value: 0.94 Solar Heat Gain Coefficient including Window Coverings: 0.11	Replace existing window with triple pane window.

Installation Cost	$849	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$101
Breakeven Cost	$1,662	**Savings-to-Investment Ratio**	2.0	**Simple Payback yrs**	8

Auditors Notes: The current window is broken with no glass and is filled in with loose batt insulation. The opening to the window is covered in plywood. This is a significant hole in the insulation barrier and should be corrected by installing a triple pane window with air or argon.

4.3.4 Air Sealing Measures

Rank	Location	Existing Air Leakage Level (cfm@50/75 Pa)	Recommended Air Leakage Reduction (cfm@50/75 Pa)
8	Old Boiler Stack	Air Tightness estimated as: 1000 cfm at 50 Pascals	Eliminate old boiler stack, seal, and insulate.

Installation Cost	$1,000	**Estimated Life of Measure (yrs)**	10	**Energy Savings (/yr)**	$391
Breakeven Cost	$3,525	**Savings-to-Investment Ratio**	3.5	**Simple Payback yrs**	3

Auditors Notes: There is an old stack next to the hot water tank inside the building that has not been used for many years. The stack was used in a previous configuration of the building. This stack presents a significant air infiltration gap and should be removed with the hole sealed and filled with batt insulation.

4.4 Mechanical Equipment Measures

4.4.1 Heating/Cooling/Domestic Hot Water Measure

Rank	Recommendation
10	Install Garn 1000 biomass boiler and control both the oil fired boilers with a Tekmar 268 controller.

Installation Cost	$200,000	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$10,716
Breakeven Cost	$201,061	**Savings-to-Investment Ratio**	1.0	**Simple Payback yrs**	19

Auditors Notes: A project to implement a biomass boiler in the water treatment plant was funded by the Renewable Energy Fund of the Alaska Energy Authority in 2011. The project called for a Garn 1000 boiler to be installed to heat the glycol loop inside the water plant prior to the loop entering the oil-fired boilers. The old washeteria room was renovated to accommodate the biomass boiler and a small amount of wood storage. The biomass boiler uses wood collected by locals in the community and is fired three times per day. This project was completed in February 2015.

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	
1	Mechanical Room	2 FLUOR (4) T12 4' F40T12 40W Standard (2) EfficMagnetic with Manual Switching		Replace with energy-efficient LED lighting.	
Installation Cost	$320	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$469
				Maintenance Savings (/yr)	$80
Breakeven Cost	$8,025	**Savings-to-Investment Ratio**	25.1	**Simple Payback yrs**	1
Auditors Notes: Replace the existing fluorescent lighting with energy-efficient LED lighting. This involves removing the T12 light bulbs and existing ballasts and replacing them with four 17 Watt LED light bulbs per fixture. Maintenance savings is due to longer bulb life.					

Rank	Location	Existing Condition		Recommendation	
2	Main WTP Lighting	20 FLUOR (4) T12 4' F40T12 40W Standard (2) EfficMagnetic with Manual Switching		Replace with energy-efficient LED lighting.	
Installation Cost	$3,200	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$4,590
				Maintenance Savings (/yr)	$800
Breakeven Cost	$78,669	**Savings-to-Investment Ratio**	24.6	**Simple Payback yrs**	1
Auditors Notes: Replace the existing fluorescent lighting with energy-efficient LED lighting. This involves removing the T12 light bulbs and existing ballasts and replacing them with four 17 Watt LED light bulbs per fixture. Maintenance savings is due to longer bulb life.					

Rank	Location	Existing Condition		Recommendation	
3	Old Washeteria	9 FLUOR (4) T12 4' F40T12 40W Standard (2) EfficMagnetic with Manual Switching		Replace with energy-efficient LED lighting.	
Installation Cost	$1,440	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$1,475
				Maintenance Savings (/yr)	$360
Breakeven Cost	$26,808	**Savings-to-Investment Ratio**	18.6	**Simple Payback yrs**	1
Auditors Notes: Replace the existing fluorescent lighting with energy-efficient LED lighting. This involves removing the T12 light bulbs and existing ballasts and replacing them with four 17 Watt LED light bulbs per fixture. Maintenance savings is due to longer bulb life.					

Rank	Location	Existing Condition		Recommendation	
6	Exterior Lighting	MH 50 Watt Magnetic with Manual Switching		Replace with energy-efficient LED lighting.	
Installation Cost	$300	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$153
				Maintenance Savings (/yr)	$30
Breakeven Cost	$2,684	**Savings-to-Investment Ratio**	8.9	**Simple Payback yrs**	2
Auditors Notes: Replace the existing fluorescent lighting with energy-efficient LED lighting. This involves removing the magnetic light bulb and existing wall pack and replacing it with an LED wall pack. Maintenance savings is due to longer bulb life.					

Rank	Location	Existing Condition		Recommendation	
7	Rest Room	FLUOR (4) T12 4' F40T12 40W Standard (2) EfficMagnetic with Manual Switching		Replace with energy-efficient LED lighting.	
Installation Cost	$160	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$43
				Maintenance Savings (/yr)	$40
Breakeven Cost	$1,223	**Savings-to-Investment Ratio**	7.6	**Simple Payback yrs**	2
Auditors Notes: Replace the existing fluorescent lighting with energy-efficient LED lighting. This involves removing the T12 light bulbs and existing ballasts and replacing them with four 17 Watt LED light bulbs per fixture. Maintenance savings is due to longer bulb life.					

4.5.3 Other Electrical Measures

Rank	Location	Description of Existing		Efficiency Recommendation	
4	Airport Lift Station Electric Heat	Electric Heat and Heat Tape with Manual Switching		Re-commission electric heater controls and set at 40 degrees.	
Installation Cost	$1,700	**Estimated Life of Measure (yrs)**	10	**Energy Savings (/yr)**	$3,632
Breakeven Cost	$30,586	**Savings-to-Investment Ratio**	18.0	**Simple Payback yrs**	0
Auditors Notes: The lift station heat is currently set higher than necessary, causing the electric heater to run more than necessary and also increasing the use of electric heat tape. Re-commissioning the controls and reducing the set point to 40 degrees will reduce the use of the electric heater and heat tape.					

Rank	Location	Description of Existing		Efficiency Recommendation	
5	HUD Lift Station Electric Heat	Electric Heat and Heat Tape with Manual Switching		Re-commission electric heater controls and set at 40 degrees.	
Installation Cost	$1,500	**Estimated Life of Measure (yrs)**	10	**Energy Savings (/yr)**	$2,553
Breakeven Cost	$21,498	**Savings-to-Investment Ratio**	14.3	**Simple Payback yrs**	1
Auditors Notes: The lift station heat is currently set higher than necessary, causing the electric heater to run more than necessary and also increasing the use of electric heat tape. Re-commissioning the controls and reducing the set point to 40 degrees will reduce the use of the electric heater and heat tape.					

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.

In the near future, a representative of ANTHC will be contacting both the City of Kobuk and the water treatment plant operator to follow up on the recommendations made in this audit report. Funding has been provided to ANTHC through a Rural Alaska Village Grant and the Denali Commission to provide the city with assistance in understanding the report and implementing the recommendations. ANTHC will work to complete the recommendations within the 2015 calendar year.

APPENDICES

Appendix A – Energy Audit Report – Project Summary

ENERGY AUDIT REPORT – PROJECT SUMMARY	
General Project Information	
PROJECT INFORMATION	**AUDITOR INFORMATION**
Building: Kobuk Water and Sanitiation	**Auditor Company:** ANTHC-DEHE
Address: OBU-WTP-1214	**Auditor Name:** Carl Remley
City: Kobuk	**Auditor Address:** 3900 Ambassador Drive, Suite 301 Anchorage, AK 99508
Client Name: Kris McKay & Quinton Horner	
Client Address: PO Box 51020 Kobuk, AK 99751	**Auditor Phone:** (907) 729-3543
	Auditor FAX:
Client Phone: (907) 948-5180	**Auditor Comment:**
Client FAX:	
Design Data	
Building Area: 1,535 square feet	**Design Space Heating Load:** Design Loss at Space: 2,661 Btu/hour with Distribution Losses: 2,801 Btu/hour Plant Input Rating assuming 82.0% Plant Efficiency and 25% Safety Margin: 4,269 Btu/hour Note: Additional Capacity should be added for DHW and other plant loads, if served.
Typical Occupancy: 0 people	**Design Indoor Temperature:** 70 deg F (building average)
Actual City: Kobuk	**Design Outdoor Temperature:** -44.2 deg F
Weather/Fuel City: Kobuk	**Heating Degree Days:** 15,716 deg F-days
Utility Information	
Electric Utility: Kobuk Valley Electric - Commercial - Sm	**Natural Gas Provider:** None
Average Annual Cost/kWh: $0.741/kWh	**Average Annual Cost/ccf:** $0.000/ccf

Annual Energy Cost Estimate											
Description	**Space Heating**	**Space Cooling**	**Water Heating**	**Ventilation Fans**	**Lighting**	**Other Electrical**	**Raw Water Heat Add**	**Water Circulation Heat**	**Tank Heat**	**Service Fees**	**Total Cost**
Existing Building	$3,149	$0	$0	$0	$12,705	$41,719	$5,525	$6,262	$5,130	$60	**$74,550**
With Proposed Retrofits	$2,690	$0	$0	$0	$5,676	$35,622	$2,049	$2,438	$1,892	$60	**$50,427**
Savings	$459	$0	$0	$0	$7,029	$6,097	$3,476	$3,823	$3,238	$0	**$24,123**

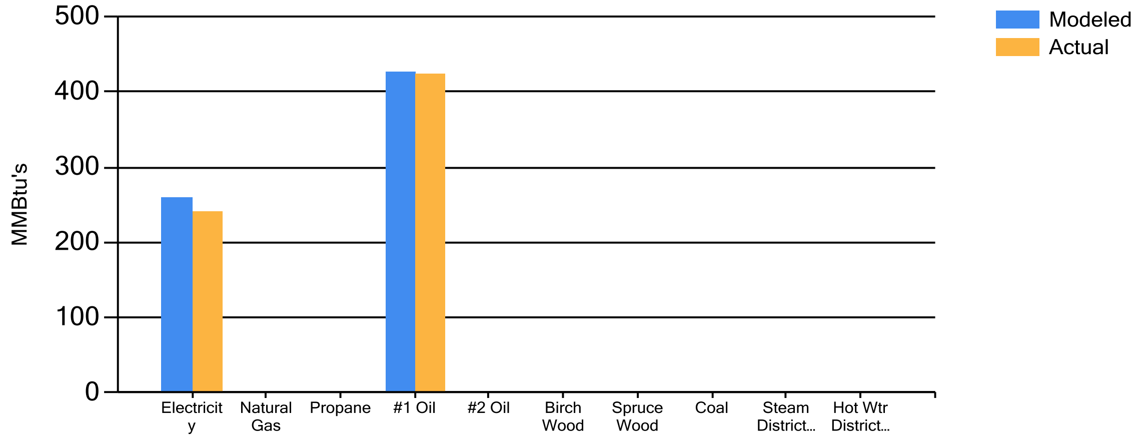
Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	447.4	28.47	$48.57
With Proposed Retrofits	378.6	24.09	$32.85

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.

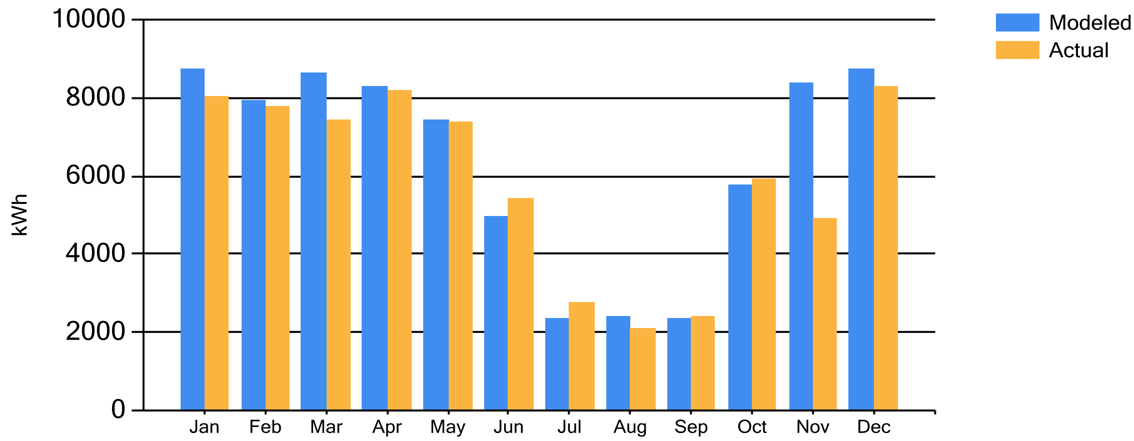
Appendix B – Actual Fuel Use versus Modeled Fuel Use

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

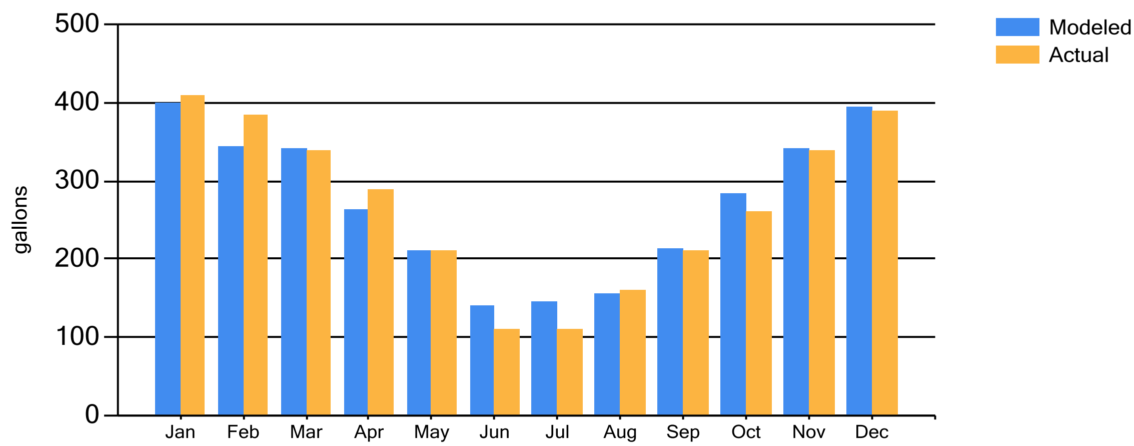
Annual Fuel Use



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	18.2	18.2	18.1	18.0	16.4	13.2	9.6	9.6	9.7	14.2	18.1	18.2
As Proposed	13.6	13.5	13.4	13.3	12.1	9.7	6.5	6.5	6.6	10.2	13.5	13.6

AkWarmCalc Ver 2.3.3.1, Energy Lib 4/11/2014