Comprehensive Energy Audit
For

Kotzebue Pump House and Lift Stations

Prepared For

City of Kotzebue

August 26, 2016
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PREFACE

This energy audit was conducted using funds from the Denali Commission. Coordination with the City of Kotzebue 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 Kotzebue, Alaska. The authors of this report are Praveen K.C., Professional Engineer (P.E, CEM); Kevin Ulrich, Energy Manager-in-Training (EMIT); and Carl Remley, 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 over two site visits in September 2015 and February 2016 by the Rural Energy Initiative 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 Rural Energy Initiative gratefully acknowledges the assistance of Kotzebue City Manager Derek Martin, Director of Public Works Randy Walker, Capital Projects Manager Jason Jessup, Building Maintenance Supervisor Billy Reich, Public Works Administrative Assistant Lorraine Honeycutt, Primary Water Treatment Plant Operator Matthew Lazarus, Secondary Water Treatment Plant Operator Olaf Walker, and Secondary Water Treatment Plant Operator Ryan Snyder.

1. EXECUTIVE SUMMARY

This report was prepared for the City of Kotzebue. The scope of the audit focused on the Kotzebue Pump House and Lift Stations (LS). 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.

In the near future, a representative of ANTHC will be contacting the City of Kotzebue to follow up on the recommendations made in this audit report. ANTHC will work with the City of Kotzebue to assess the future steps to be taken upon the completion of this report.

The total predicted energy cost for the Kotzebue Pump House and Lift Stations is $112,210 per year. Electricity represents the largest portion with an annual cost of approximately $108,146. This includes $46,348 paid by the city and $61,798 paid by the Power Cost Equalization (PCE) program through the State of Alaska. Fuel oil represents the remaining portion with an annual cost of approximately $4,063.

The State of Alaska PCE program provides subsidies to rural communities across the State to lower electricity costs and make energy affordable in rural Alaska. In Kotzebue, the cost of electricity without PCE is $0.35/kWh and the cost of electricity with PCE is $0.15/kWh.

An energy audit report was also developed for the Kotzebue Water Treatment Plant. This report supplements the water treatment plant energy audit and covers the waste disposal system and the water intake system. The Kotzebue Water Treatment Plant Energy Audit Report was distributed in May 2016.

Table 1.1 lists the total usage of electricity and #1 heating oil in the Kotzebue Pump House and Lift Stations before and after the proposed retrofits.

Table 1.1: Predicted Annual Fuel Use for the Pump House and Lift Stations

Predicted Annual Fuel Use		
Fuel Use	**Existing Building**	**With Proposed Retrofits**
Electricity	292,266 kWh	267,037 kWh
#1 Oil	848 gallons	540 gallons

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

Table 1.2: Building Benchmarks for the Pump House and Lift Stations

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	2,773.7	173.01	$280.52
With Proposed Retrofits	2,456.7	153.24	$253.56
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 summarizes the energy efficiency measures analyzed for the Kotzebue Pump House and Lift Stations. 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	Other Electrical: Electric Heating (LS 1,2,4,7,10)	Lower temperature set points to 50 °F.	$5,510	$3,000	21.57	0.5	23,891.8
2	Lighting: Lift Stations 1,2,4,7,10 Lights (HPS) (Exterior)	Replace with direct-wire LED replacement lights.	$656	$500	15.41	0.8	2,844.1
3	Setback Thermostat: Pump House	Lower temperature set points to 50 °F.	$1,714	$2,000	11.05	1.2	7,512.3
4	Other Electrical: Electric Heating (LS 5,6,8)	Lower temperature set points to 50 °F.	$2,094	$3,000	8.20	1.4	9,079.3
5	Lighting - Power Retrofit: Lift Station 1,2,4,7,10 Lights (Incandescent)	Replace with LED equivalent lights.	$126	$750	1.98	5.9	547.5
6	Cathedral Ceiling: Ceiling (Pump House)	Add R-19 to existing insulation.	$143	$2,084	1.51	14.6	627.1
7	Air Tightening	Weatherize the door and water entry points in the pump house building.	$508	$5,000	0.91	9.8	2,224.3
8	Lighting - Power Retrofit: Lift Station 1,2,4,7,10 Lights (T8's)	Replace with direct-wire LED replacement lights.	$16	$400	0.47	25.1	69.2
9	Lighting - Power Retrofit: Pump House Lights	Replace with direct-wire LED replacement lights.	$10	$640	0.17	62.8	43.9
10	Lighting - Power Retrofit: Lift Station 5,6,8 Lights	Replace with direct-wire LED replacement lights.	$9	$1,440	0.07	164.0	38.0
	TOTAL, all measures		**$10,786**	**$18,814**	**6.84**	**1.7**	**46,877.3**

Table Notes:

[1] Savings to Investment Ratio (SIR) is a life-cycle cost measure calculated by dividing the total savings over the life of a project (expressed in today's dollars) by its investment costs. The SIR is an indication of the profitability of a measure; the higher the SIR, the more profitable the project. An SIR greater than 1.0 indicates a cost-effective project (i.e. more savings than cost). Remember

that this profitability is based on the position of that Energy Efficiency Measure (EEM) in the overall list and assumes that the measures above it are implemented first.

[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 $10,786 per year, or 9.6% of the buildings' total energy costs. These measures are estimated to cost $18,814, for an overall simple payback period of 1.7 years.

Table 1.4 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	$6,534	$5,051	$100,325	$112,210
With Proposed Retrofits	$4,177	$4,226	$92,721	$101,423
Savings	$2,357	$825	$7,604	$10,786

2. AUDIT AND ANALYSIS BACKGROUND

2.1 Program Description

This audit included services to identify, develop, and evaluate energy efficiency measures at the Kotzebue Pump House and Lift Stations. The scope of this project included evaluating building shell, lighting and other electrical systems, and 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 & 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 the Kotzebue Pump House and Lift Stations 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.

There are 13 facilities that are covered in this energy audit report, including the Devil's Lake Pump House and 12 lift stations. The Pump House has an area of approximately 400 square feet. The area of each of the eight above-ground lift stations ranges from 160 to 450 square feet approximately and the area of each of the four buried lift stations are approximately 40 Sq.Ft. All buried lift stations have circular wet wells with a buried compartment in the ground where the controls are located.

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 systems; 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.

The site visit for this audit took place alongside the site visit for the Kotzebue Water Treatment Plant. Due to time constraints, the audit team was unable to visit all of the lift stations. As a result, drawings were used for these facilities and generic assumptions were made for each type of lift station in order to supplement the information gathering process. Estimates determined by energy modeling of the lift stations were used to determine a significant portion of the energy usage distribution in the audited facilities.

3. Kotzebue Pump House and Lift Stations

3.1. Building Description

The 400 square foot Devil's Lake Pump House was constructed in 1976 and is occupied for approximately 30 minutes per day for three days each week. The nine traditional lift stations are checked on every other day in a rotating schedule by the operator. The four wet wells and all the sewer lines are maintained by a separate crew employed by the City of Kotzebue.

The Devil's Lake Pump House is located on an elevated platform above Devil's Lake approximately three miles outside of the main part of the town. It houses all components necessary to pump water from the lake to the water treatment plant. Included in the building are heaters to prevent the building space from freezing as well as an air compressor with a dryer and a blower to prevent the lake from freezing over around the intake line and the structural pillars of the elevated platform.

There are 12 total lift stations in the city that are used to collect the sewage from the facilities in Kotzebue and pump them to a sewage lagoon outside of town. Each lift station has large sewer pumps in a wet well. The wet well is the collection point for sewage within a certain region of the community and the pump in the wet well will move the sewage through the force main to the sewage lagoon outside of the town. The lift stations are of three different styles that have been constructed over the years of operation for the sewer system. Three lift stations (5,6, and 8) are newly constructed in 2010 and have sewer pumps that are not submersed into the sewer system. Five lift stations (1,2,4,7, and 10) were constructed in the 1980's and use submersible pumps. Four lift stations (9,11,12, and 13) have no building and instead are in a buried wet well with pumps located in the buried compartment.

There are 13 labeled lift stations but only 12 of them are currently in operation. Lift Station 3 (LS-3) has been inoperable for many years. The labels of the lift stations were not changed after this was shut down and others were constructed.

<u>Description of Building Shell</u>

The Pump House has wall panels with six inches of R-19 fiberglass batt insulation. The floor is elevated on the platform above the lake and is built on 4 pilings. It has one exterior metal door and no windows.

The old lift stations are standard 2x6 lumber construction built on a gravel pad foundation surrounding the wet well. The exterior doors for the wet and dry sides are all metal and all windows are double-paned glass when present.

The new lift stations have panelized wall construction with metal siding and polyurethane foam insulation. The exterior doors for the wet and dry sides are all metal and all windows are double-paned glass when present.

Pump House Heating System

The heating plants used in the Pump House are:

Fuel Oil Fired Unit Heater in Pump House

Nameplate Information:	Reznor Model DUH 95
Fuel Type:	#1 Oil
Input Rating:	118,000 BTU/hr
Steady State Efficiency:	70 %
Idle Loss:	0.5 %
Heat Distribution Type:	Glycol
Boiler Operation:	Sep – Jun

Figure 3.1: Fuel Oil-fired Unit Heater in the Pump House

Pump House Electric Space Heater

Fuel Type:	Electricity

Input Rating:	0 BTU/hr
Steady State Efficiency:	95 %
Idle Loss:	0.5 %
Heat Distribution Type:	Air

Figure 3.2: Electric Space Heater in the Pump House

All lift stations have electric space heaters that operate primarily during the winter heating months.

Space Heating Distribution Systems

The pump house has an oil-fired unit heater that heats the space to 60 °F throughout the year. When necessary, a 7.5 kW electric space heater is also available for use.

The old lift stations (1,2,4,7,10) each have electric baseboards in the dry side of the building and 3 kW electric unit heaters in the wet side of the building. These lift stations were all heated much higher than necessary with the Lift Station 2 temperature at 94 °F during the site visit. It was estimated that the average temperature for the lift stations was approximately 80 °F among the five buildings.

The new lift stations (5,6,8) each have 7.6 kW electric space heaters that are used for space heating and freeze protection. The temperatures were less than 60 °F for each building.

The four buried lift stations (9,11,12,13) each have electric space heaters for the small compartments with the pumping equipment and controls. The temperatures were set at 60 °F for each building.

Lighting

Table 3.1 gives information on the various lights in the lift stations.

Table 3.1: Pump House and Lift Stations Lighting

Building	Bulb Type	Fixtures	Total Bulbs	Annual kWh
Pump House	Fluorescent T8 4ft.	8	16	168.1
Pump House	High Pressure Sodium 150W (Exterior)	1	1	759.4
Pump House	High Pressure Sodium 250W (Bridge)	1	1	1,258.9
Lift Stations 1,2,4,7,10	Fluorescent T8 4ft.	5	10	147.5
Lift Stations 1,2,4,7,10	Incandescent 60W	15	15	461.4
Lift Stations 1,2,4,7,10	High Pressure Sodium 150W (Exterior)	5	5	3,977.0
Lift Stations 5,6,8	Fluorescent T8 4ft.	18	36	81.1
Lift Stations 5,6,8	High Pressure Sodium 150W (Exterior)	9	9	6,834.6

Major Equipment

Table 3.2 shows a summary of major equipment in the pump house.

Table 3.2: Pump House Equipment

Building	Equipment	Description	Rating (Watts)	Usage (kWh)
Pump House	Air Dryer	Used to prevent the water from freezing around the pillars of the Pump House platform to protect the facility from structural damage.	437	2,876.3

Pump House	Air Compressor	Used to provide compressed air for the Air Dryer and Air Blower. Always maintains air pressure. Has to operate approximately 25% of the time to build pressure after the dryer and blower usage.	2,860	4,706.1
Pump House	Air Blower	Used to blow air through the ice by the water intake to prevent it from freezing over and to allow access to the water.	375	2,468.3

Table 3.3 shows a summary of the major pumps in all of the buildings.

Table 3.3: Major Pumps in the Kotzebue Pump House and Lift Stations

Building	Equipment	Rating (HP)	Usage (kWh)
Pump House	Well Pump 1	7.5	43,830.0
Pump House	Well Pump 2	15	7,012.8
Lift Stations (5,6,8)	Lift Station Pumps (3 total)	10	10,515.7
Lift Stations (1,2,4,7,10)	Lift Station Pumps (5 total)	20 (one pump), 10 (one pump), 5 (three pumps)	35,312.9
Lift Stations (9,11,12,13)	Lift Station Pumps (4 total)	3	35,785.7

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. One KW of electric demand is equivalent to 1,000 watts running at a particular moment. The basic usage charges are shown as generation service and delivery charges along with several non-utility generation charges.

The 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 Kotzebue Electric Association (KEA) provides electricity to the residents of Kotzebue as well as all the commercial and public facilities.

The average cost for each type of fuel used in this building is shown below in Table 3.4. This figure includes all surcharges, subsidies, and utility customer charges:

Table 3.4: Energy Rates for Each Fuel Source for the Kotzebue Pump House and Lift Stations

Average Energy Cost	
Description	**Average Energy Cost**
Electricity	$ 0.35/kWh
#1 Oil	$ 4.79/gallons

3.2.1.1 Total Energy Use and Cost Breakdown

At current rates, City of Kotzebue pays approximately $112,210 annually for electricity and other fuel costs for the Kotzebue Pump House and Lift Stations.

Figure 3.3 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.

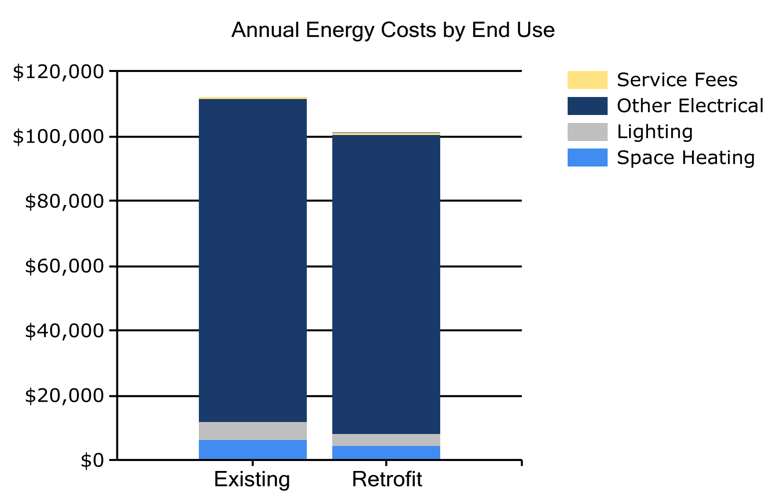


Figure 3.3: Annual Energy Costs by End Use

Figure 3.4 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.

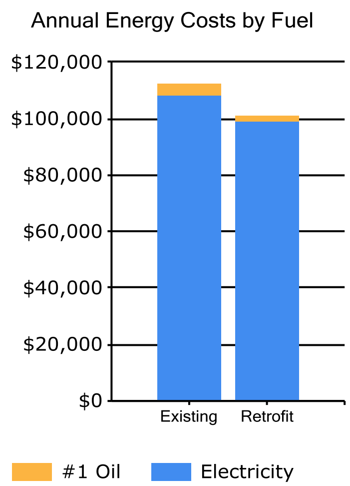


Figure 3.4: Annual Energy Costs by Fuel Type

Figure 3.5 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.

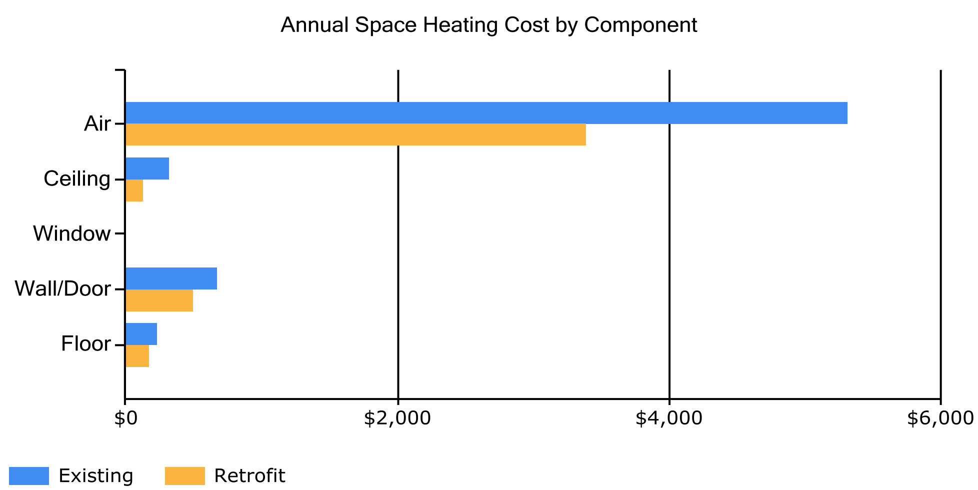


Figure 3.5: Annual Space Heating Cost by Component

Tables 3.5 and 3.6 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.

Table 3.5: Electrical Consumption by Category

Electrical Consumption (kWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space Heating	1064	963	896	602	209	48	36	167	325	568	786	1031
Lighting	1649	1503	1649	931	962	101	104	962	931	1649	1596	1649
Other Electrical	27766	25302	27766	26870	27766	26870	12483	11242	10879	20303	26870	27766

Table 3.6: Fuel Oil Consumption by Category

Fuel Oil #1 Consumption (Gallons)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Space Heating	138	125	115	77	25	3	1	18	40	72	101	133

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):

Building Site EUI = *(Electric Usage in kBtu + Fuel Oil Usage in kBtu)* / *Building Square Footage*

Building Source EUI = *(Electric Usage in kBtu X SS Ratio + Fuel Oil Usage in kBtu X SS Ratio)* / *Building Square Footage*

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

Table 3.7: Kotzebue Pump House and Lift Stations 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	292,266 kWh	997,503	3.340	3,331,659
#1 Oil	848 gallons	111,978	1.010	113,097
Total		**1,109,480**		**3,444,757**
BUILDING AREA	400		Square Feet	
BUILDING SITE EUI	2,774		kBTU/Ft²/Yr	
BUILDING SOURCE EUI	8,612		**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 3.8: Kotzebue Water Treatment Plant Building Benchmarks

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	2,773.7	173.01	$280.52
With Proposed Retrofits	2,456.7	153.24	$253.56
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 systems 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 Kotzebue Pump House and Lift Stations was modeled using AkWarm© energy use software to establish a baseline space heating energy usage. Climate data from Kotzebue 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.

Limitations of AkWarm© Models

• The model is based on typical mean year weather data for Kotzebue. 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 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 heating loads across different parts of the building.

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 Measures Ranked by Economic Priority

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	Other Electrical: Electric Heating (LS 1,2,4,7,10)	Lower temperature set points to 50 °F.	$5,510	$3,000	21.57	0.5	23,891.8
2	Lighting: Lift Stations 1,2,4,7,10 Lights (HPS) (Exterior)	Replace with direct-wire LED replacement lights.	$656	$500	15.41	0.8	2,844.1
3	Setback Thermostat: Pump House	Lower temperature set points to 50 °F.	$1,714	$2,000	11.05	1.2	7,512.3
4	Other Electrical: Electric Heating (LS 5,6,8)	Lower temperature set points to 50 °F.	$2,094	$3,000	8.20	1.4	9,079.3
5	Lighting - Power Retrofit: Lift Station 1,2,4,7,10 Lights (Incandescent)	Replace with LED equivalent lights.	$126	$750	1.98	5.9	547.5
6	Cathedral Ceiling: Ceiling (Pump House)	Add R-19 to existing insulation.	$143	$2,084	1.51	14.6	627.1
7	Air Tightening	Weatherize the door and water entry points in the pump house building.	$508	$5,000	0.91	9.8	2,224.3
8	Lighting - Power Retrofit: Lift Station 1,2,4,7,10 Lights (T8's)	Replace with direct-wire LED replacement lights.	$16	$400	0.47	25.1	69.2
9	Lighting - Power Retrofit: Pump House Lights	Replace with direct-wire LED replacement lights.	$10	$640	0.17	62.8	43.9

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
10	Lighting - Power Retrofit: Lift Station 5,6,8 Lights	Replace with direct-wire LED replacement lights.	$9	$1,440	0.07	164.0	38.0
	TOTAL, all measures		**$10,786**	**$18,814**	**6.84**	**1.7**	**46,877.3**

4.2 Interactive Effects of Projects

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

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

Interior lighting, plug loads, facility equipment, and occupants generate heat within the building. Lighting-efficiency improvements are anticipated to slightly increase heating requirements. Heating penalties benefits 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
6	Cathedral Ceiling: Ceiling (Pump House)	Framing Type: Standard Framing Spacing: 16 inches Insulated Sheathing: R-19 Batt:FG or RW, 6 inches Bottom Insulation Layer: None Top Insulation Layer: None Insulation Quality: Damaged Modeled R-Value: 21.1	Add R-19 to existing insulation.

Installation Cost	$2,084	**Estimated Life of Measure (yrs)**	30	**Energy Savings (/yr)**	$143
Breakeven Cost	$3,150	**Savings-to-Investment Ratio**	1.5	**Simple Payback yrs**	15

Auditors Notes: The building insulation is old and the building is exposed to weather on all sides because of its elevation from the lake. Add insulation to reduce the heat loss from the building to the atmosphere.

4.3.2 Air Sealing Measures

Rank	Location	Existing Air Leakage Level (cfm@50/75 Pa)		Recommended Air Leakage Reduction (cfm@50/75 Pa)	
7		Air Tightness estimated as: 3500 cfm at 50 Pascals		Weatherize the door and water entry points in the pump house building.	
Installation Cost	$5,000	**Estimated Life of Measure (yrs)**	10	**Energy Savings (/yr)**	$508
Breakeven Cost	$4,553	**Savings-to-Investment Ratio**	0.9	**Simple Payback yrs**	10
Auditors Notes: Insulate the stack of the heater in the building. Add weather stripping and insulation to the cracks around the doors and to the floor penetrations for the water pipe and air hoses.					

4.4 Mechanical Equipment Measures

4.4.1 Night Setback Thermostat Measures

Rank	Building Space			Recommendation	
3	Pump House			Lower temperature set points to 50 °F.	
Installation Cost	$2,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$1,714
Breakeven Cost	$22,098	**Savings-to-Investment Ratio**	11.0	**Simple Payback yrs**	1
Auditors Notes: Install a thermostat into the pump house and lower the set point to 50 deg. F. Train the operators that the temperature in the pump house does not need to go above 50 deg. F for freeze protection purposes.					

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 loads. The building 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	
2	Lift Station 1,2,4,7,10 Lights (HPS) (Exterior)	5 HPS 150 Watt StdElectronic		Replace with direct-wire LED replacement lights.	
Installation Cost	$500	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$656
Breakeven Cost	$7,705	**Savings-to-Investment Ratio**	15.4	**Simple Payback yrs**	1
Auditors Notes: There are five fixtures with a single light bulb to be replaced with an 80 Watt LED equivalent.					

Rank	Location		Existing Condition		Recommendation	
5	Lift Station 1,2,4,7,10 Lights (Incandescent)		15 INCAN A Lamp, Std 60W		Replace with direct-wire LED replacement lights.	
Installation Cost	$750		**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$126
Breakeven Cost	$1,484		**Savings-to-Investment Ratio**	2.0	**Simple Payback yrs**	6
Auditors Notes: There are 15 incandescent 60Watt light bulbs among the five lift stations to be replaced.						

Rank	Location		Existing Condition		Recommendation	
8	Lift Station 1,2,4,7,10 Lights (T8's)		5 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic		Replace with direct-wire LED replacement lights.	
Installation Cost	$400		**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$16
Breakeven Cost	$187		**Savings-to-Investment Ratio**	0.5	**Simple Payback yrs**	25
Auditors Notes: There are five fixtures with two T8 4ft. fluorescent light bulbs in each fixture for a total of ten light bulbs to be replaced among the five lift stations.						

Rank	Location		Existing Condition		Recommendation	
9	Pump House Lights		8 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic		Replace with direct-wire LED replacement lights.	
Installation Cost	$640		**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$10
Breakeven Cost	$111		**Savings-to-Investment Ratio**	0.2	**Simple Payback yrs**	63
Auditors Notes: There are eight fixtures with two T8 4ft. fluorescent light bulbs in each fixture for a total of 16 light bulbs to be replaced in the Pump House.						

Rank	Location		Existing Condition		Recommendation	
10	Lift Station 5,6,8 Lights		18 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic		Replace with direct-wire LED replacement lights.	
Installation Cost	$1,440		**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$9
Breakeven Cost	$103		**Savings-to-Investment Ratio**	0.1	**Simple Payback yrs**	164
Auditors Notes: There are 18 fixtures with two T8 4ft. fluorescent light bulbs in each fixture for a total of 36 light bulbs to be replaced among the three lift stations.						

4.5.2 Other Electrical Measures

Rank	Location		Description of Existing		Efficiency Recommendation	
1	Electric Heating (LS 1,2,4,7,10)		Electric Heaters		Lower temperature set points to 50 °F.	
Installation Cost	$3,000		**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$5,510
Breakeven Cost	$64,724		**Savings-to-Investment Ratio**	21.6	**Simple Payback yrs**	1
Auditors Notes: Install a thermostat and lower the temperature set point to 50 deg. F for each of the 5 lift stations. Train the operators to keep the set points no higher than 50 deg. F for freeze protection purposes. This includes work in 5 lift stations at an estimated $600 per lift station.						

Rank	Location		Description of Existing		Efficiency Recommendation	
4	Electric Heating (LS 5,6,8)		Electric Heating		Lower temperature set points to 50 °F.	
Installation Cost	$3,000		**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$2,094
Breakeven Cost	$24,596		**Savings-to-Investment Ratio**	8.2	**Simple Payback yrs**	1
Auditors Notes: Install a thermostat and lower the temperature set point to 50 deg. F for each of the 3 lift stations. Train the operators to keep the set points no higher than 50 deg. F for freeze protection purposes. Each lift station needs temperature set points for both the wet side and dry side of the building, or two thermostats per building. This requires a total of 6 thermostats with approximately $500 of materials and labor per thermostat for a total of $3000.						

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 the City of Kotzebue to follow up on the recommendations made in this audit report. ANTHC will work with the City of Kotzebue to assess the future steps to be taken upon the completion of this report.

APPENDICES

Appendix A – Energy Audit Report – Project Summary

ENERGY AUDIT REPORT – PROJECT SUMMARY	
General Project Information	
PROJECT INFORMATION	**AUDITOR INFORMATION**
Building: Kotzebue Pump House and Lift Stations	**Auditor Company:** ANTHC-DEHE
Address: Kotzebue, AK	**Auditor Name:** Carl Remley, Praveen KC, and Kevin Ulrich
City: Kotzebue	**Auditor Address:** 4500 Diplomacy Drive, Suite 454 Anchorage, AK 99508
Client Name: Randy Walker	
Client Address: PO Box 46 Kotzebue, AK 99752	**Auditor Phone:** (907) 729-3237
	Auditor FAX:
Client Phone: (907) 442-3401	**Auditor Comment:**
Client FAX:	
Design Data	
Building Area: 400 square feet	**Design Space Heating Load:** Design Loss at Space: 36,570 Btu/hour with Distribution Losses: 36,570 Btu/hour Plant Input Rating assuming 82.0% Plant Efficiency and 25% Safety Margin: 55,747 Btu/hour Note: Additional Capacity should be added for DHW and other plant loads, if served.
Typical Occupancy: 0 people	**Design Indoor Temperature:** 60 deg F (building average)
Actual City: Kotzebue	**Design Outdoor Temperature:** -37 deg F
Weather/Fuel City: Kotzebue	**Heating Degree Days:** 16,032 deg F-days
Utility Information	
Electric Utility: Kotzebue Electric Association	**Average Annual Cost/kWh:** $0.37/kWh

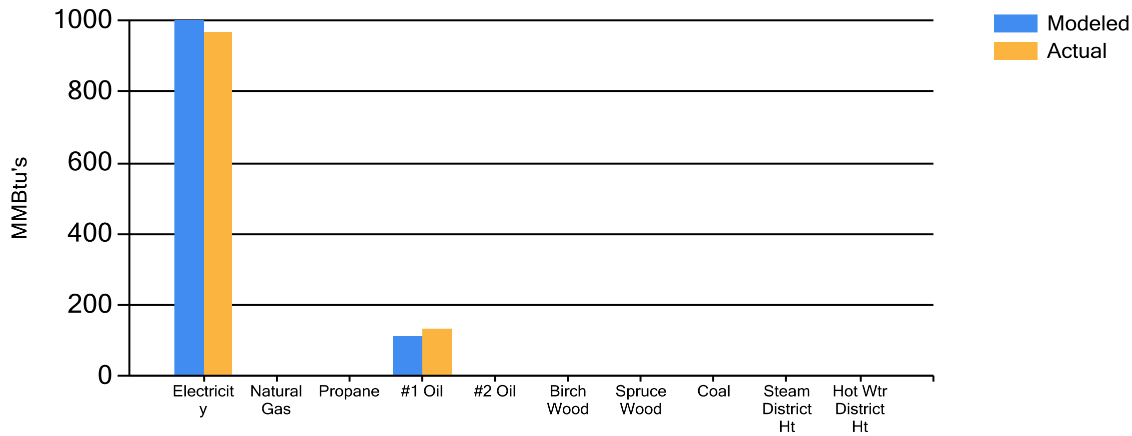
Annual Energy Cost Estimate				
Description	**Space Heating**	**Lighting**	**Other Electrical**	**Total Cost**
Existing Building	$6,534	$5,051	$100,325	**$112,210**
With Proposed Retrofits	$4,177	$4,226	$92,721	**$101,423**
Savings	$2,357	$825	$7,604	**$10,786**

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	2,773.7	173.01	$280.52
With Proposed Retrofits	2,456.7	153.24	$253.56

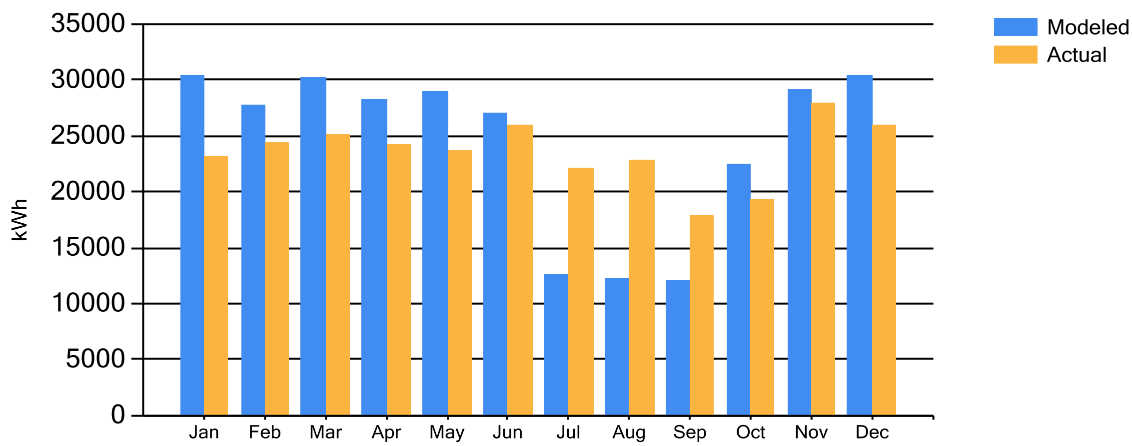
EUI: Energy Use Intensity - The annual site energy consumption divided by the structure's conditioned area.
EUI/HDD: Energy Use Intensity per Heating Degree Day.
ECI: Energy Cost Index - The total annual cost of energy divided by the square footage of the conditioned space in the building.

Appendix B – Actual Fuel Use versus Modeled Fuel Use

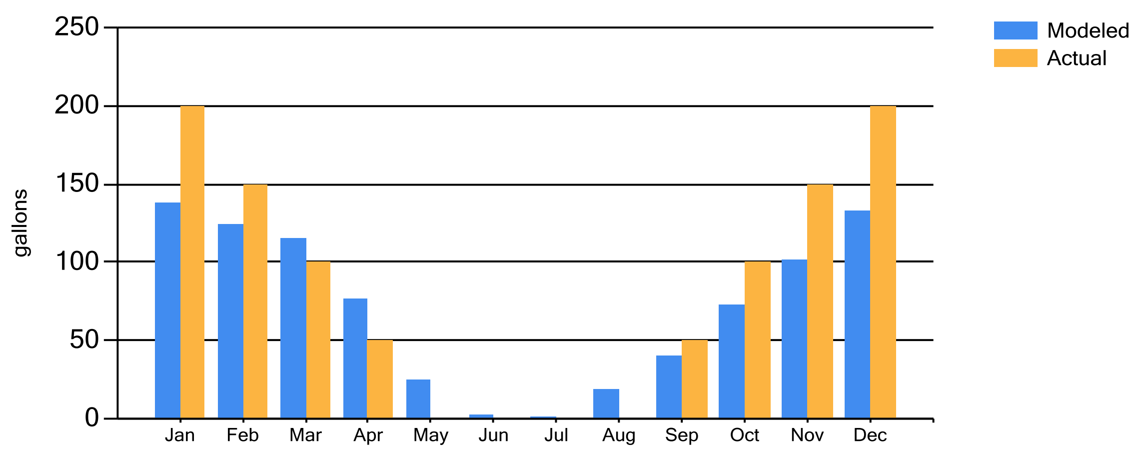
The graphs below show the modeled energy usage results of the energy audit process compared to the actual energy usage report data. The model was completed using AkWarm modeling software. The orange bars show actual fuel use, and the blue bars are AkWarm's prediction of fuel use.



Annual Energy Use



Electricity Use



#1 Fuel Oil Use

Appendix C - Electrical Demands

Estimated Peak Electrical Demand (kW)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Current	52.3	50.4	48.6	47.1	46.0	44.0	23.3	23.3	23.0	34.6	43.7	42.3
As Proposed	44.4	43.1	41.8	40.8	40.2	38.2	21.0	21.1	20.9	30.9	38.9	38.0

AkWarmCalc Ver 2.5.3.0, Energy Lib 3/7/2016