Comprehensive Energy Audit
For
Mountain Village Upper Pump House, 85 Well House and #2 Well House

Prepared For

City of Mountain Village

May 18, 2017

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PREFACE

This energy audit was conducted using funds provided by the Denali Commission. Coordination with the City of Mountain Village has been undertaken to provide maximum accuracy in identifying facilities to audit and coordinating potential follow up retrofit activities.

The Rural Energy Initiative at the Alaska Native Tribal Health Consortium (ANTHC) prepared this document for the City of Mountain Village, Alaska. The author of this report is Bailey Gamble, Mechanical Engineer I; Kevin Ulrich, Assistant Engineering Project Manager and Certified Energy Manager (CEM); and Kameron Hartvigson, Utility Operations Specialist.

The purpose of this report is to provide a comprehensive document of the findings and analysis that resulted from an energy audit conducted in March of 2017 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 ANTHC Rural Energy Initiative gratefully acknowledges the assistance of Water Treatment Plant Operators Donald Kokrine and Charles Long, Mountain Village City Manager Robert Joe, Mountain Village Mayor Peter Andrew, City Administrator Janelle Amos and Village Safe Water Engineering Doug Poage.

1. EXECUTIVE SUMMARY

This report was prepared for the City of Mountain Village. The scope of this audit focused on Mountain Village Upper Pump House, the 85 Well House and #2 Well House – all components of the upper loop of the Mountain Village Water System. The Middle Pump House, Cannery Well House and Lift Stations are included in a separate report. 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 costs for the upper loop facilities are $62,652 per year. Fuel represents the largest portion with an annual cost of approximately $34,270. Electricity represents the remaining portion, with an annual cost of approximately $28,382. This includes about $16,010 paid by the village and about $12,372 paid by the Power Cost Equalization (PCE) program through the State of Alaska.

The State of Alaska PCE program provides a subsidy to rural communities across the state to lower electricity costs and make energy affordable in rural Alaska. In Mountain Village, the cost of electricity for small commercial facilities without PCE is $0.49/kWh for the first 700 kWh/month and $0.39/kWh beyond that. The cost of electricity with PCE is $0.28/kWh for the first 700 kWh/month and $0.22/kWh beyond that, saving the village just over $12,000 a year on electricity for the Upper Pump House and associated buildings.

Table 1.1 lists the total usage of electricity and #1 heating oil in the Mountain Village upper loop facilities before and after the proposed retrofits.

Table 1.1: Predicted Annual Fuel Use for the Upper Pump House and Well Houses

Predicted Annual Fuel Use		
Fuel Use	**Existing Building**	**With Proposed Retrofits**
Electricity	72,774 kWh	66,619 kWh
#1 Oil	6,023 gallons	2,868 gallons

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

Table 1.2: Building Benchmarks for the Upper Pump House and Well Houses

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	1,552.7	115.46	$93.23
With Proposed Retrofits	901.7	67.05	$62.95

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

Table 1.3 below summarizes the energy efficiency measures analyzed for the Mountain Village Upper Pump House, 85 Well House and #2 Well House. 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	Upper Loop and Water Storage Tank Heat Load	Replace heat add controls and decrease heating setpoint to 40 deg F	$17,300	$2,000	117.17	0.1	64,407.2
2	#2 Well House Space Heating Load	Reduce heating setpoint to 40 deg F on Toyostove and set electric heater to lower setting to reduce run time.	$1,112	$200	68.75	0.2	4,788.8
3	85 Well House Space Heating Load	Turn heater down to lower setting to reduce run time.	$905	$200	38.09	0.2	4,175.4
4	Upper Pump House Heat Tape	Turn heat tape off and use only for freeze recovery.	$407	$200	17.15	0.5	1,880.1
5	Lighting: #2 Well House Exterior Light	Replace with new, energy efficient LED lighting with daylight sensor.	$104	$250	3.49	2.4	477.9
6	Upper Pump House Hydronic Heating System	Replace burner heads, upgrade controls for proper operation, clean and tune boilers, rewire circ pumps to promote continuous circulation in main hydronic line and reduce idle loss, provide operator training	$467	$6,000	1.35	12.8	1,734.8
7	Lighting: Upper Pump House Interior Lights	Replace with new, energy efficient LED lights.	$47	$400	0.99	8.5	217.8
8	Lighting: #2 Well House Mechanical Room Light	Replace with new, energy efficient LED lights.	$11	$160	0.58	14.6	50.7
9	Setback Thermostat: Upper Pump House	Install a programmable thermostat and implement a heating setback to 60 deg F when the pump house is unoccupied.	$36	$1,000	0.47	27.5	148.8
10	Lighting: #2 Well House Chemical Room Light	Replace with new, energy efficient LED lights.	$3	$80	0.33	25.4	14.5
11	Lighting: Upper Pump House Artic Entry Light	Replace with new, energy efficient LED lights.	$0	$20	0.06	146.3	0.6
12	Air Tightening	Air seal the upper pump house doors to reduce air leakage by an estimated 20%.	$5	$1,500	0.03	277.7	23.6

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
13	Lighting - Combined Retrofit: Upper Pump House Exterior Light	Replace broken bulb with new, energy efficient LED lighting with daylight sensor.	-$46	$250	-1.55	999.9	-212.8
	TOTAL, all measures		**$20,351**	**$12,260**	**21.92**	**0.6**	**77,707.6**

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 $20,351 per year, or 32.5% of the buildings' total energy costs. These measures are estimated to cost $12,260, for an overall simple payback period of 0.6 years.

Table 1.4 below is a breakdown of the annual energy cost across various energy end use types, such as Space Heating and Water Heating. The first row in the table shows the breakdown for the building as it is now. The second row shows the expected breakdown of energy cost for the building assuming all of the retrofits in this report are implemented. Finally, the last row shows the annual energy savings that will be achieved from the retrofits.

Table 1.4: Detailed Breakdown of Energy Costs in the Building

Annual Energy Cost Estimate						
Description	**Space Heating**	**Water Heating**	**Ventilation Fans**	**Lighting**	**Other Electrical**	**Total Cost**
Existing Building	$4,379	$33,883	$3	$300	$24,088	**$62,652**
With Proposed Retrofits	$2,390	$16,047	$3	$180	$23,681	**$42,301**
Savings	$1,988	$17,835	$0	$120	$407	**$20,351**

2. AUDIT AND ANALYSIS BACKGROUND

2.1 Program Description

This audit included services to identify, develop, and evaluate energy efficiency measures at the Mountain Village Upper Pump House, 85 Well House and #2 Well House. 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 treatment and distribution

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 Mountain Village Upper Pump House, 85 Well House and #2 Well House 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.

The upper loop of the Mountain Village Water System consists of the upper pump house, the 85 well house, the #2 well house, the high school well and a water storage tank. The high school well was not online at the time of the audit. The water storage tank itself contains not energy consuming components, so for the audit the upper loop is classified as being made up of the following activity areas:

1) Upper Pump-House: 672 square feet
2) 85 Well House: estimated 64 square feet
3) #2 Well House: 140 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 resimulated 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. MOUNTAIN VILLAGE UPPER PUMP HOUSE, 85 WELL HOUSE AND #2 WELL HOUSE

3.1. Building Description

This audit focuses on the facilities associated with the upper loop of Mountain Village's water system. The 672 square foot Mountain Village upper pump house was constructed in 1981. One of the local water system operators will visit daily to check on operations, but the building is typically unoccupied. The 85 well house is a small structure constructed in 1985 and situated above the 85 well located about 70 feet to the west of the upper pump house. The well is powered and controlled from the Upper Pump House, so the well house is rarely occupied. The #2 well house, constructed in 2015, is located about 1,300 feet to the east of the upper pump house. The operator will check this facility periodically, but it is rarely occupied.

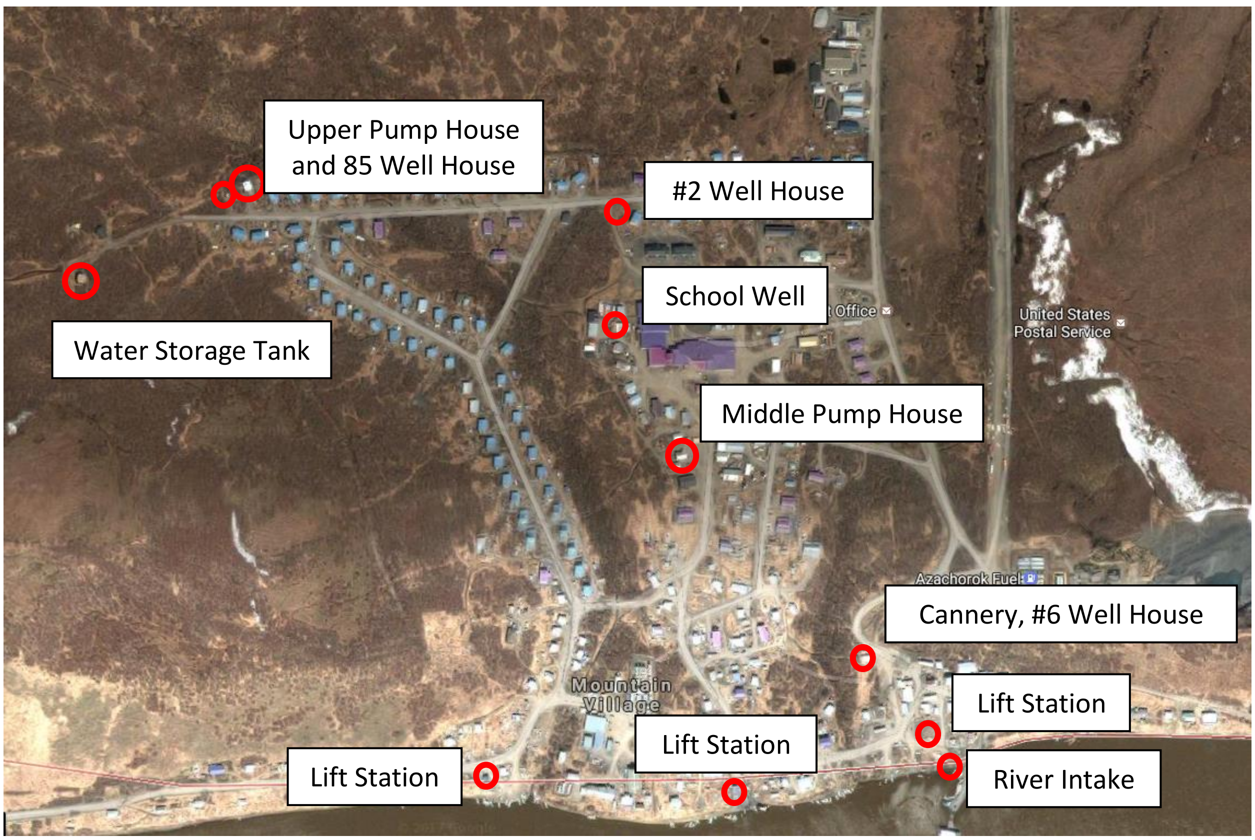


Figure 1: Aerial View of Mountain Village Water System Facilities

At the time of the audit visit, raw water was being continuously pumped from three sources: the 85 well, the #2 well and the cannery well. Three other sources, the #6 well, the high school well and the river intake were not in use. The community plans to put the high school well back online once regulatory compliance is addressed. The #6 well does not typically run when the cannery well is in use and the river intake serves primarily as a back-up in case the ground water sources are not able to meet community water demand.

Raw water pumped from the cannery well is chlorinated at the cannery well house before entering the lower distribution loop. This loop supplies water to the lower half of the village and passes through the middle pump house where heat is added. Once pressure in the lower loop reaches approximately 25 psi, a transfer pump in the middle pump house transfers water over to the upper distribution loop until pressure drops to approximately 16 psi. A circulation pump in the middle pump house keeps water in the lower loop circulating to prevent freezing.

The lower loop, the #2 well and the 85 well all contribute water to the upper distribution loop. Any excess water in the upper loop is delivered to the water storage tank. Chlorine is added to the water at the #2 well house and upper pump house. Heat is added to the water at the upper pump house and circulation pumps keep water in the upper loop circulating to prevent freezing. The HDPE pipe from the 80s that constitutes the upper loop frequently exhibits fusion failure. The repair bands that have been placed along the pipe tend to be weak points, contributing to issues with leaks along this loop. Village Safe Water is currently seeking funding to replace aging portions of the distribution line.

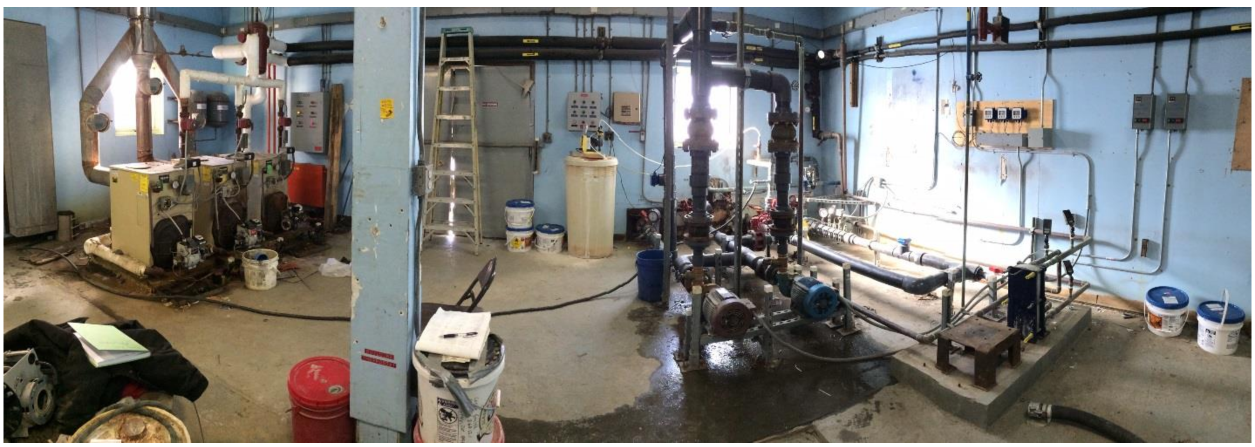


Figure 2: Main Room in Mountain Village Upper Pump House

Figure 3: #2 Well House (left) and 85 Well House (right)

Description of Building Shell

The exterior walls of the upper pump house are constructed with single stud 2x6 lumber construction with a 16-inch offset. The average wall height is approximately 11.5 ft. The walls have approximately 5.5 inches polyurethane panel insulation damaged due to age. There is approximately 979 square feet of wall space in the building.

The upper pump house has a cathedral ceiling with 2x6 lumber construction. The roof has standard framing and a 24-inch offset. The peak ceiling height is approximately 13.5 ft. The ceiling has approximately 5.5 inches of insulated polyurethane panels with damage due to age. There is approximately 693 square feet of roof space in the building.

The WTP is built on pilings. The concrete floor contains an insulated layer of 6 inch fiberglass insulation damaged by age. There is approximately 672 feet of floor space in the building.

There are two windows in the upper pump house. Both windows measure 31.25” x 36. All windows are triple-pane glass with wood and vinyl frames.

There is a wooden 3’ x 6’8” front entry door with an arctic entry. The door currently utilizes a wrench handle as part of its locking mechanism. There is a wooden 6’ x 6’8” set of double doors on the west side of the mechanical room as well. Significant air leakage is visible along the bottom and center of these doors.

Figure 4: Air leakage visible around side doors.

Description of Heating Plants

The heating plants used in the upper pump house are:

Boiler #1

Nameplate Information:	Weil McLain Gold Oil Boiler, Model No. P-WGO-6
Fuel Type:	#1 Oil
Input Rating:	212,000 BTU/hr
Steady State Efficiency:	84.4 %
Idle Loss:	1 %
Heat Distribution Type:	Water
Boiler Operation:	Nov - Jun
Fire Rate:	1.75 GPH
Notes:	Recorded to be running 100% of the time

Boiler #2

Nameplate Information:	Weil McLain Gold Oil Boiler, Model No. P-WGO-6
Fuel Type:	#1 Oil
Input Rating:	212,000 BTU/hr
Steady State Efficiency:	83.9 %
Idle Loss:	1.5 %
Heat Distribution Type:	Water
Boiler Operation:	Nov - Jun
Fire Rate:	1.75 GPH
Notes:	Recorded to be running 7.3% of the time

Boiler #3

Nameplate Information:	Weil McLain Gold Oil Boiler, Model No. P-WGO-6
Fuel Type:	#1 Oil
Input Rating:	212,000 BTU/hr
Steady State Efficiency:	80 %
Idle Loss:	0 %
Heat Distribution Type:	Water
Boiler Operation:	Nov - Jun
Notes:	Boiler #3 is not currently in operation.

The demand for heat in the upper pump house is seasonal and includes space heating and a heat add system that serves the upper distribution loop and water storage tank. The heat add system was observed to be set to heat water in the loop and tank to 60°F, but did not appear to be functioning properly. Adjustments to the heat add controller did not open and close the actuator valve controlling flow of the hydronic line through the heat exchanger as expected. The valve remained open at all times.

Two Weil McLain Gold Oil boilers serve to meet the upper pump house heating demand. A third boiler of the same model is currently offline. The boilers are turned on and off manually. The operators usually begins running the boilers in early November and shuts them down in early June.

The boilers are controlled by aquastats set to heat the water in the hydronic system to 180°F. The high temperature cut-off switches on both boilers were set to shut the boilers down once the hydronic water line temperature reached 160°F. This configuration, with the high temperature cut-off set 20 degrees lower than the aquastat setpoint led to a situation where:

- Boiler #1 runs 100% of the time, never quite reaching 160°F or meeting the water heating demand.
- Boiler #2 comes on to assist, running 7.3% of the time, but quickly hits 160°F and shuts down before it has the chance to contribute much heat.

Each boiler has an associated circulating pump that turns on when the boiler is firing. These pumps move heated water through the boilers and keep it circulating through the hydronic system when they are on. There are no other circulating pumps associated with the hydronic lines. This configuration, where heated water stops circulating once a boiler stops firing, results in high idle loss.

Figure 5: Boilers in the upper pump house.

The Heating Plant used in the #2 Well House is:

Boiler #4

Nameplate Information:	Toyotomi Laser 300, set to 66 deg F
Fuel Type:	#1 Oil
Input Rating:	15,000 BTU/hr
Steady State Efficiency:	87 %
Idle Loss:	0.2 %
Heat Distribution Type:	Air

<u>Space Heating Distribution Systems</u>

Space heating in the upper pump house by a hydronic heating Loop. Heat is distributed by a 1/12 HP unit heater. A 1500 W electric plug-in space heater heats the 85 well house. A Toyotomi Laser 300 stove heats the mechanical room of the #2 well house and a 1500w electric wall heater heats the chemical room.

<u>Description of Building Ventilation System</u>

Ventilation in the upper pump house is achieved through an air make-up vent beside the front door and a penetration from a currently non-operational ventilation fan. There is a ventilation fan in the #2 well house chemical room as well.

<u>Lighting</u>

Lighting in the upper loop facilities consumes approximately 768 kWh annually constituting only about 1% of the buildings' current electrical consumption.

Table 3.1: Breakdown of Lighting by Location and Bulb Type

Location	Bulb Type	Fixtures	Bulbs per Fixture	Annual Usage (kWh)
Upper Pump House Artic Entry	15 W compact fluorescent spiral	1	1	2
Upper Pump House Mechanical Room	40 W, 4' T12 fluorescent	5	2	283
Upper Pump house Exterior	100 W incandescent	1	1	0, currently non-operational
#2 Well House Mechanical Room	28 W, 4' T5 fluorescent	1	4	77
#2 Well House Chemical Room	28 W, 4' T5 fluorescent	1	2	23
#2 Well House Exterior	70 W high pressure sodium	1	1	384
			Total Energy Consumption	768

Major Equipment

Table 3.2 contains the details on each of the major electricity consuming mechanical components found in the water treatment plant. Major equipment consumes approximately 58,980 kWh annually constituting about 81% of the building's current electrical consumption.

Table 3.2: Major Equipment List

Major Pumps + Motors	Purpose	Motor Size	Operating Schedule	Annual Energy Consumption (kWh)
85 Well Pump	Draw ground water into water system	5 HP	always on, controlled by VFD	28,998
Upper Loop Circ Pump x 2	Circulate water in distribution loop line to prevent freezing	5 HP	always on	8,670
#2 Well Pump	Draw ground water into water system	5 HP	always on, controlled by VFD	21,312
			Total Energy Consumption	58,980

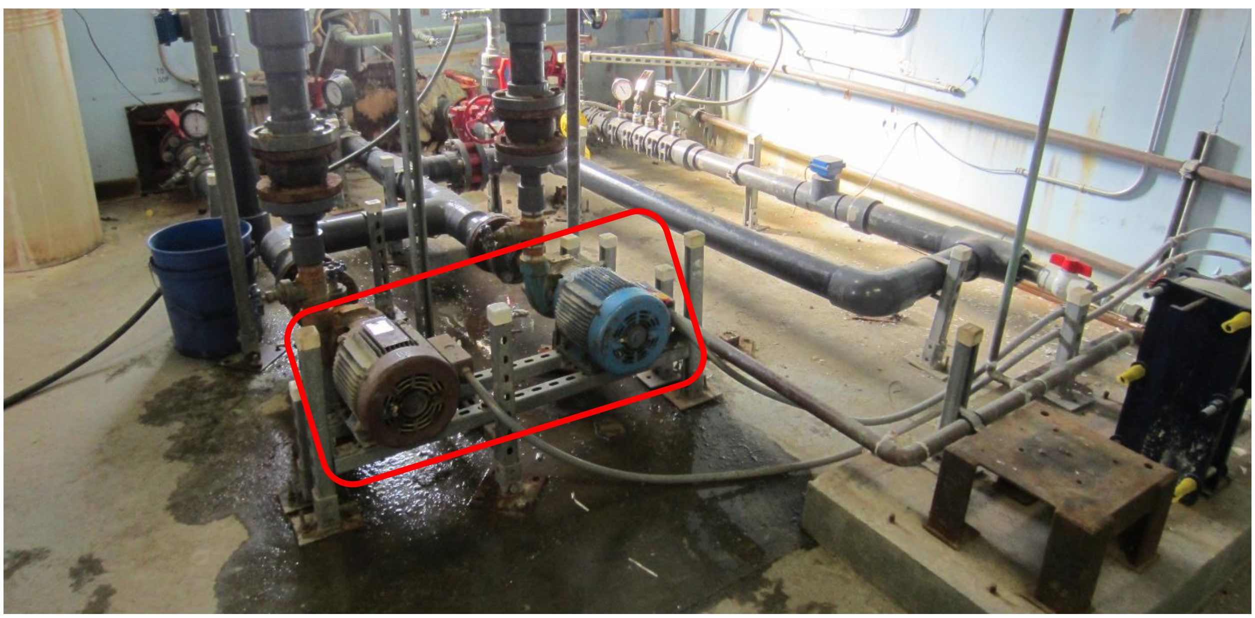


Figure 6: Five horsepower circulating pumps in the Upper Pump House.

Heat Tape

There are three heat tapes associated with the upper loop facilities:

- One heat tape running from the upper pump house to the 85 well house
- One heat tape running from the #2 well house to the #2 well
- One heat tape running from the #2 well house to the upper distribution loop

Heat tape consumes an estimated 2,785 kWh annually constituting about 4% of electrical consumption.

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 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.

Alaska Village Electric Cooperative (AVEC) runs the power plant in the city of Mountain Village. The utility provides electricity to the residents of Mountain Village as well as commercial and public facilities.

The average cost for each type of fuel used in this building is shown below in Table 3.3. This figure includes all surcharges, subsidies, and utility customer charges:

Table 3.3: Energy Rates by Fuel Type in White Mountain

Average Energy Cost	
Description	**Average Energy Cost**
Electricity	$ 0.39/kWh
#1 Oil	$ 5.69/gallons

3.2.1.1 Total Energy Use and Cost Breakdown

At current rates, City of Mountain Village pays approximately $62,652 annually for electricity and other fuel costs for the Mountain Village Upper Pump House, 85 Well House and #2 Well House.

Figure 7 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.

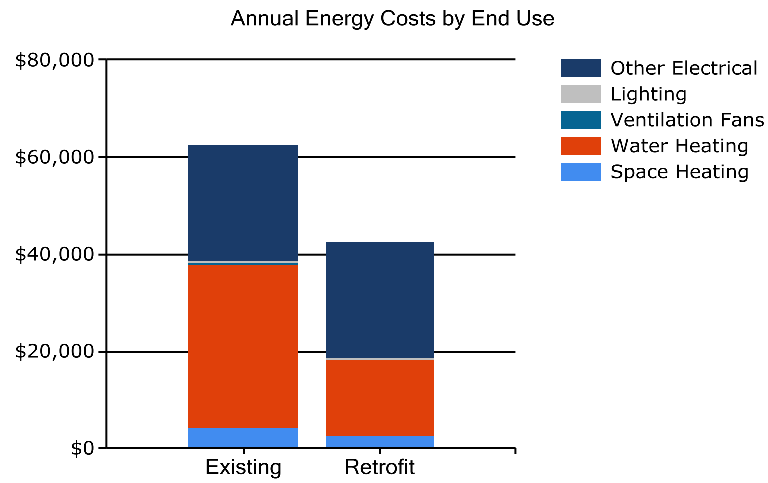


Figure 7: Annual energy costs by end use.

Figure 8 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.

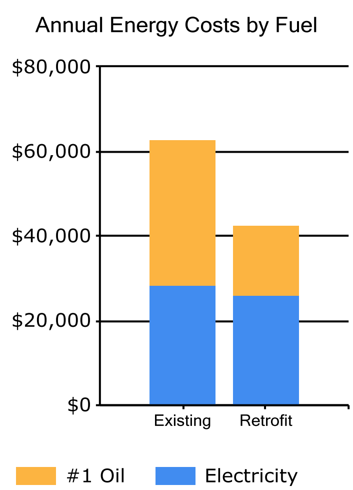


Figure 8: Annual energy costs by fuel type.

Figure 9 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. Note that many components are related – poorly sealed doors and windows contribute to air leakage, increasing space heating demand 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.

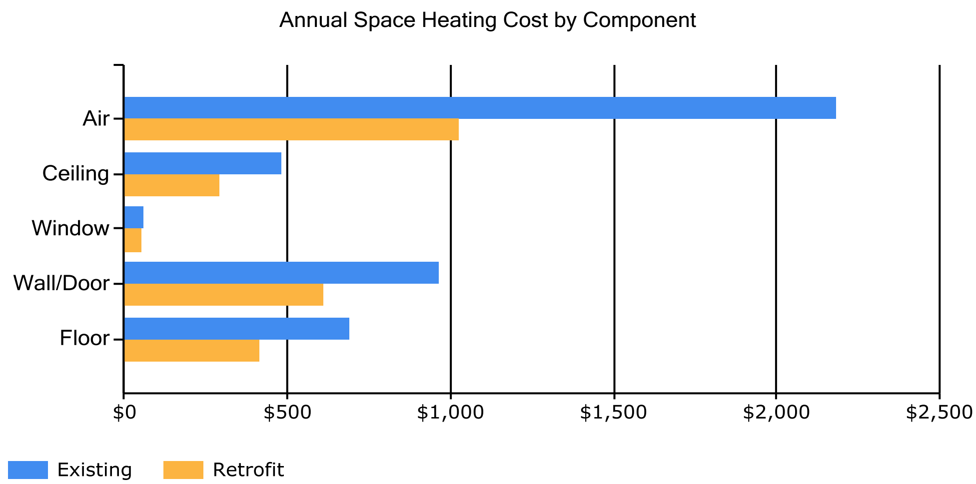


Figure 9: Annual space heating costs by component.

The tables below show AkWarm's estimate of the monthly fuel use for each of the fuels used in the building. For each fuel, the fuel use is broken down across the energy end uses.

Table 3.4: Estimated Electrical Consumption Records by Category

Electrical Consumption (kWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space Heating	1648	1481	1476	1074	332	2	1	2	0	301	1235	1641
Water Heating	156	142	156	151	80	0	0	0	0	50	151	156
Ventilation Fan	1	1	1	1	1	1	1	1	1	1	1	1
Lighting	75	68	65	63	50	48	50	64	63	74	72	75
Other Electrical	5263	4796	5263	5093	4719	4359	4504	4504	5486	5803	5889	6085

Table 3.5: Estimated Fuel Oil Consumption Records by Category

Fuel Oil #1 Consumption (Gallons)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space Heating	24	21	22	16	5	2	1	2	0	5	18	24
Water Heating	879	801	879	851	468	0	0	0	0	277	851	879

3.2.2 Energy Use Index (EUI)

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

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

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

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

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

Table 3.6: Mountain Village Upper Pump House, 85 Well House and #2 Well House 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	72,774 kWh	248,378	3.340	829,582
#1 Oil	6,023 gallons	795,011	1.010	802,961
Total		**1,043,389**		**1,632,543**
BUILDING AREA		672	Square Feet	
BUILDING SITE EUI		1,553	kBTU/Ft²/Yr	
BUILDING SOURCE EUI		2,429	**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 3.7: Mountain Village Building Benchmarks

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	1,552.7	115.46	$93.23
With Proposed Retrofits	901.7	67.05	$62.95
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 HVAC 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 Mountain Village Upper Pump House, 85 Well House and #2 Well House was modeled using AkWarm© energy use software to establish a baseline space heating and cooling energy usage. Climate data from Mountain Village 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 Mountain Village. 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 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: 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	Upper Loop and Water Storage Tank Heat Load	Replace heat add controls and decrease heating setpoint to 40 deg F	$17,300 / 398.2 MMBTU	$2,000	117.17	0.1	64,407.2
2	#2 Well House Space Heating Load	Reduce heating setpoint to 40 deg F on Toyostove and set electric heater to lower setting to reduce run time.	$1,112 / 15.2 MMBTU	$200	68.75	0.2	4,788.8
3	85 Well House Space Heating Load	Turn heater down to lower setting to reduce run time.	$905 / 7.9 MMBTU	$200	38.09	0.2	4,175.4
4	Upper Pump House Heat Tape	Turn heat tape off and use only for freeze recovery.	$407 / 3.6 MMBTU	$200	17.15	0.5	1,880.1
5	Lighting: #2 Well House Exterior Light	Replace with new, energy efficient LED lighting with daylight sensor.	$104 / 0.9 MMBTU	$250	3.49	2.4	477.9
6	Upper Pump House Hydronic Heating System	Replace burner heads, upgrade controls for proper operation, clean and tune boilers, rewire circ pumps to promote continuous circulation in main hydronic line and reduce idle loss, provide operator training	$467 / 10.8 MMBTU	$6,000	1.35	12.8	1,734.8
7	Lighting: Upper Pump House Interior Lights	Replace with new, energy efficient LED lights.	$47 / 0.4 MMBTU	$400	0.99	8.5	217.8
8	Lighting: #2 Well House Mechanical Room Light	Replace with new, energy efficient LED lights.	$11 / 0.1 MMBTU	$160	0.58	14.6	50.7
9	Setback Thermostat: Upper Pump House	Install a programmable thermostat and implement a heating setback to 60 deg F when the pump house is unoccupied.	$36 / 0.6 MMBTU	$1,000	0.47	27.5	148.8

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
10	Lighting: #2 Well House Chemical Room Light	Replace with new, energy efficient LED lights.	$3 / 0.0 MMBTU	$80	0.33	25.4	14.5
11	Lighting: Upper Pump House Artic Entry Light	Replace with new, energy efficient LED lights.	$0 / 0.0 MMBTU	$20	0.06	146.3	0.6
12	Air Tightening	Air seal the upper pump house doors to reduce air leakage by an estimated 20%.	$5 / 0.1 MMBTU	$1,500	0.03	277.7	23.6
13	Lighting - Combined Retrofit: Upper Pump House Exterior Light	Replace with new, energy efficient LED lighting with daylight sensor.	-$46 / -0.4 MMBTU	$250	-1.55	999.9	-212.8
	TOTAL, all measures		**$20,351 / 437.4 MMBTU**	**$12,260**	**21.92**	**0.6**	**77,707.6**

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 were included in the lighting project analysis.

4.3 Building Shell Measures

4.3.1 Air Sealing Measures

Rank	Location	Existing Air Leakage Level (cfm@50/75 Pa)		Recommended Air Leakage Reduction (cfm@50/75 Pa)	
12		Air Tightness estimated as: 1008 cfm at 50 Pascals		Perform air sealing to reduce air leakage by 20%.	
Installation Cost	$1,500	**Estimated Life of Measure (yrs)**	10	**Energy Savings ($/yr)**	$5
Breakeven Cost	$47	**Simple Payback (yrs)**	278	**Energy Savings (MMBTU/yr)**	0.1 MMBTU
		Savings-to-Investment Ratio	0.0		
Auditors Notes: Air seal front entry and side double doors. Install new door knob and lock on front door, plug two open holes in door. Address old vent fan opening to reduce air leakage and, therefore, reduce space heating demand.					

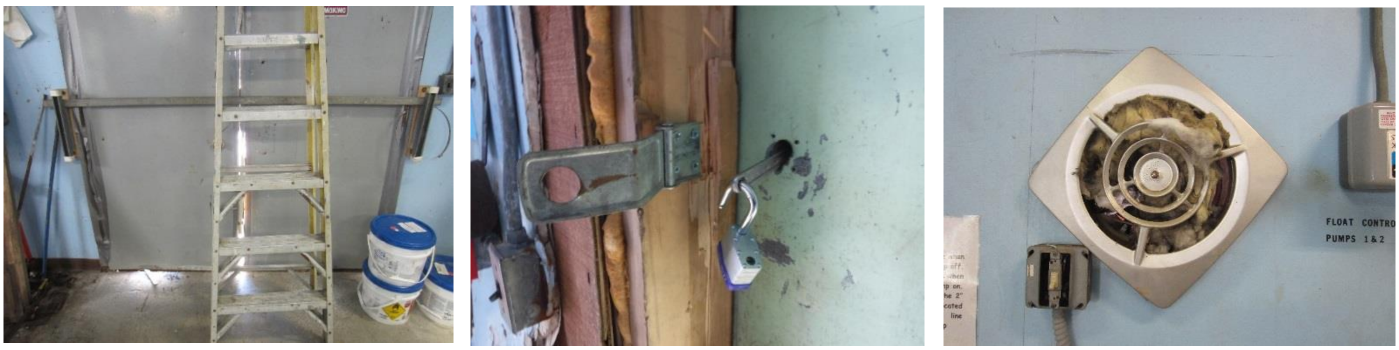


Figure 10: From left to right: Air leakage around side doors, current locking mechanism on front door, old vent fan open to exterior.

4.4 Mechanical Equipment Measures

4.4.1 Heating

Rank	Recommendation				
6	Replace burner heads, upgrade controls for proper operation, clean and tune boilers, rewire circ pumps to promote continuous circulation in main hydronic line and reduce idle loss, provide operator training				
Installation Cost	$6,000	**Estimated Life of Measure (yrs)**	20	**Energy Savings ($/yr)**	$467
Breakeven Cost	$8,128	**Simple Payback (yrs)**	13	**Energy Savings (MMBTU/yr)**	10.8 MMBTU
		Savings-to-Investment Ratio	1.4		
Auditors Notes: Settings on the boilers currently result in boiler 1 running 100% of the time and boiler 2 failing to contribute significantly to heating. Current circ pump wiring allows circ pumps to stop circulating heated water in the system when boilers are not firing resulting in high idle loss. Upgrade controls, set hi-temp cut-off slightly higher than aquastat set point. Rewire circulating pumps to circulate hydronic system after boilers have finished firing. Replace burner units, clean and tune boilers and provide operators training in boiler maintenance and operation.					

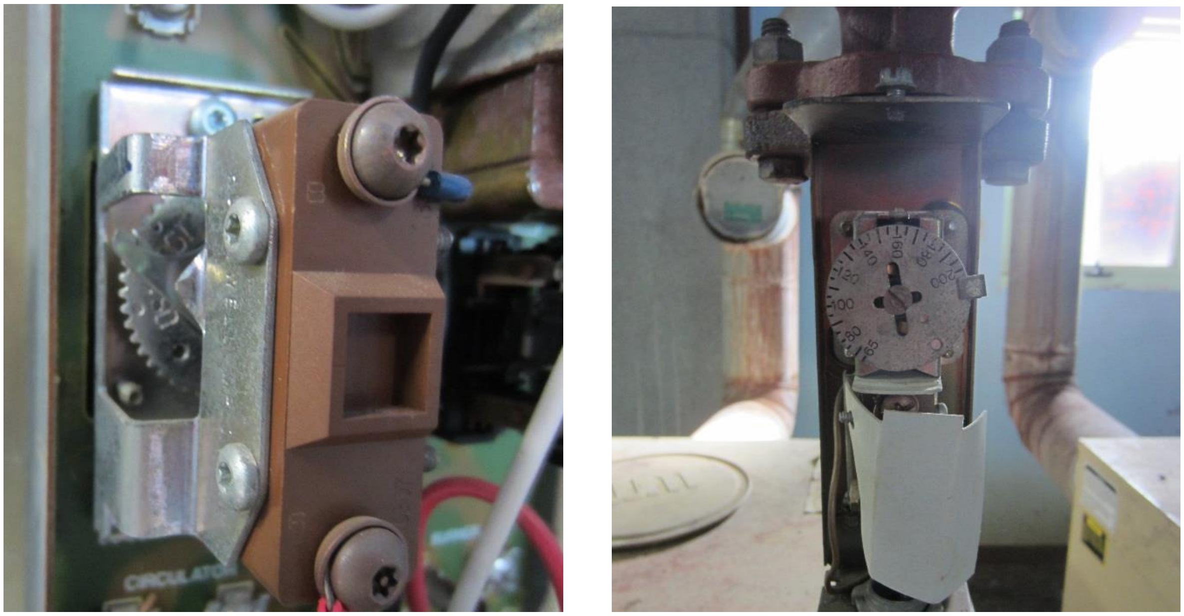


Figure 9: From left to right: Aquastat setpoint at about 180°F and high temperature cut-off set at 160°F on boilers 1 & 2. These settings resulted in boiler 1 never quite coming up to temperature and boiler 2 quickly meeting the high temperature cut-off each time it fired so shutting down before contributing much heat.

4.4.3 Night Setback Thermostat Measures

Rank	Building Space			Recommendation	
9	Upper Pump House			Implement a Heating Temperature Unoccupied Setback to 60.0 deg F for the Water System Facilities - Upper Loop space.	
Installation Cost	$1,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$36
Breakeven Cost	$467	**Simple Payback (yrs)**	27	**Energy Savings (MMBTU/yr)**	0.6 MMBTU
		Savings-to-Investment Ratio	0.5		
Auditors Notes: Install a programmable thermostat in the upper pump house so that a heating temperature setback may be set to 60°F when the pump house is unoccupied. Provide operators training in thermostat programming. Operators may choose to lower these settings even further heating the building to 60°F during operating hours and setback to 50°F when unoccupied.					

4.5 Electrical & Appliance Measures

4.5.1 Lighting Measures

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

4.5.1a Lighting Measures – Replace Existing Fixtures/Bulbs

Rank	Location		Existing Condition		Recommendation	
5	#2 Well House Exterior Light		HPS 70 Watt StdElectronic with Manual Switching		Replace with energy efficient LED lighting.	
Installation Cost		$250	**Estimated Life of Measure (yrs)**	10	**Energy Savings ($/yr)**	$104
Breakeven Cost		$872	**Simple Payback (yrs)**	2	**Energy Savings (MMBTU/yr)**	0.9 MMBTU
			Savings-to-Investment Ratio	3.5		
Auditors Notes: Replace the exterior light fixture with a 20 W LED version with built in daylight sensor.						

Rank	Location		Existing Condition		Recommendation	
7	Upper Pump House Interior Lights		5 FLUOR (2) T12 4' F40T12 40W Standard StdElectronic with Manual Switching		Replace with energy efficient LED lighting.	
Installation Cost		$400	**Estimated Life of Measure (yrs)**	10	**Energy Savings ($/yr)**	$47
Breakeven Cost		$395	**Simple Payback (yrs)**	9	**Energy Savings (MMBTU/yr)**	0.4 MMBTU
			Savings-to-Investment Ratio	1.0		
Auditors Notes: Replace a total of 10 4’ long T12 fluorescent bulbs with their energy efficient LED equivalents.						

Rank	Location		Existing Condition		Recommendation	
8	#2 Well House Mechanical Room Light		FLUOR (4) T5 45.2" F28T5 28W Standard StdElectronic with Manual Switching		Replace with energy efficient LED lighting.	
Installation Cost		$160	**Estimated Life of Measure (yrs)**	10	**Energy Savings ($/yr)**	$11
Breakeven Cost		$92	**Simple Payback (yrs)**	15	**Energy Savings (MMBTU/yr)**	0.1 MMBTU
			Savings-to-Investment Ratio	0.6		
Auditors Notes: Replace a total of 4 4’ long T5 fluorescent bulbs with their energy efficient LED equivalents.						

Rank	Location		Existing Condition		Recommendation	
10	#2 Well House Chemical Room Light		FLUOR (2) T5 45.2" F28T5 28W Standard StdElectronic with Manual Switching		Replace with energy efficient LED lighting.	
Installation Cost		$80	**Estimated Life of Measure (yrs)**	10	**Energy Savings ($/yr)**	$3
Breakeven Cost		$27	**Simple Payback (yrs)**	25	**Energy Savings (MMBTU/yr)**	0.0 MMBTU
			Savings-to-Investment Ratio	0.3		
Auditors Notes: Replace a total of 2 4’ long T5 fluorescent bulbs with their energy efficient LED equivalents.						

Rank	Location	Existing Condition		Recommendation	
11	Upper Pump House Artic Entry Light	FLUOR CFL, Spiral 15 W with Manual Switching		Replace with energy efficient LED lighting.	
Installation Cost	$20	**Estimated Life of Measure (yrs)**	10	**Energy Savings ($/yr)**	$
Breakeven Cost	$1	**Simple Payback (yrs)**	146	**Energy Savings (MMBTU/yr)**	0.0 MMBTU
		Savings-to-Investment Ratio	0.1		
Auditors Notes: Replace the single spiral, compact fluorescent bulb in the artic entry with its LED equivalent.					

Rank	Location	Existing Condition		Recommendation	
13	Upper Pump House Exterior Light	INCAN A Lamp, Std 100W with Manual Switching		Replace with energy efficient LED lighting.	
Installation Cost	$250	**Estimated Life of Measure (yrs)**	10	**Energy Savings ($/yr)**	-$46
Breakeven Cost	-$388	**Simple Payback (yrs)**	1000	**Energy Savings (MMBTU/yr)**	-0.4 MMBTU
		Savings-to-Investment Ratio	-1.6		
Auditors Notes: Replace the currently non-functioning exterior fixture with a 20W LED fixture with built in daylight sensor.					

4.5.3 Other Electrical Measures

Rank	Location	Description of Existing		Efficiency Recommendation	
4	Upper Pump House Heat Tape	Heat Tape with Manual Switching		Improve Manual Switching	
Installation Cost	$200	**Estimated Life of Measure (yrs)**	10	**Energy Savings ($/yr)**	$407
Breakeven Cost	$3,430	**Simple Payback (yrs)**	0	**Energy Savings (MMBTU/yr)**	3.6 MMBTU
		Savings-to-Investment Ratio	17.2		
Auditors Notes: The 85 well continuously draws water, therefore water in the line between the well and upper pump house is constantly flowing and shouldn't need heat tape to prevent freezing. Turn this heat tape off use on in case of need for freeze recovery.					

4.5.6 Other Measures

Rank	Location	Description of Existing		Efficiency Recommendation	
1		Upper Distribution Loop Heat Add		Replace heat add controls and decrease heating setpoint to 40 deg F	
Installation Cost	$2,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$17,300
Breakeven Cost	$234,344	**Simple Payback (yrs)**	0	**Energy Savings (MMBTU/yr)**	398.2 MMBTU
		Savings-to-Investment Ratio	117.2		
Auditors Notes: The distribution loop heat add controller was observed to be set at 60°F. Adjusting controls did not seem to have any influence on the actuating valve controlling flow of the hydronic heating line through the heat exchanger, suggesting malfunction. Water is continuously being heated. Replace controls and add temperature sensors and displays so that the heating setpoint in the loop and tank may set to 40°F and operator can easily observe temperatures in lines exiting and returning to the pump house.					

Rank	Location	Description of Existing		Efficiency Recommendation	
2		#2 Well House Space Heating		Reduce heating setpoint to 40 deg F on Toyostove and set electric heater to lowest setting to reduce run time.	
Installation Cost	$200	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$1,112
Breakeven Cost	$13,749	**Simple Payback (yrs)**	0	**Energy Savings (MMBTU/yr)**	15.2 MMBTU
		Savings-to-Investment Ratio	68.7		
Auditors Notes: The #2 well house does not require interior temperatures higher than 40°F. Reduce the Toyostove heating setpoint to 40°F and turn the electric heater in the chemical room down to a lower setting to reduce heater run time.					

Rank	Location	Description of Existing		Efficiency Recommendation	
3		85 Well House Space Heating		Turn heater down to lowest setting to reduce run time.	
Installation Cost	$200	**Estimated Life of Measure (yrs)**	10	**Energy Savings ($/yr)**	$905
Breakeven Cost	$7,618	**Simple Payback (yrs)**	0	**Energy Savings (MMBTU/yr)**	7.9 MMBTU
		Savings-to-Investment Ratio	38.1		
Auditors Notes: The 85 well house does not require interior temperatures higher than 40°F. Turn the electric heater down to a lower setting to reduce heater run time.					

5. ENERGY EFFICIENCY ACTION PLAN

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

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

ANTHC is currently working with the City of Mountain Village in an effort to realize the retrofits identified in this report through funding from the Rural Alaskan Village Grant (RAVG) program. ANTHC will continue to work with Mountain Village to secure any additional funding necessary to implement the recommended energy efficiency measures.

APPENDICES

Appendix A – Scanned Energy Billing Data

1. Electricity Billing Data

Upper Pump House Electric Records

_ID	BillingMe	MeterList							
1									
_ID	_IDBilling	Demand	Direction	kWh	Measuren	Name	SerialNum	TimeStamp	Tou
1	1	6.321	Delivered	208309	Previous	8742570	8742570	5/30/2015 8:00	Total
2	1	6.274	Delivered	211419	Previous	8742570	8742570	6/30/2015 8:00	Total
3	1	5.605	Delivered	213869	Previous	8742570	8742570	7/30/2015 8:00	Total
4	1	5.043	Delivered	216332	Previous	8742570	8742570	8/30/2015 8:00	Total
5	1	4.107	Delivered	218774	Previous	8742570	8742570	9/30/2015 8:00	Total
6	1	7.171	Delivered	278924	Previous	8742570	8742570	1/1/2017 9:00	Total
7	1	6.674	Delivered	234786	Previous	8742570	8742570	1/31/2016 9:00	Total
8	1	8.467	Delivered	283076	Previous	8742570	8742570	1/31/2017 9:00	Total
9	1	8.431	Delivered	287884	Previous	8742570	8742570	2/28/2017 9:00	Total
10	1	7.286	Delivered	238948	Previous	8742570	8742570	2/29/2016 9:00	Total
11	1	7.207	Delivered	242922	Previous	8742570	8742570	3/29/2016 8:00	Total
12	1	7.938	Delivered	292953	Previous	8742570	8742570	3/29/2017 8:00	Total
13	1	7.048	Delivered	246949	Previous	8742570	8742570	4/29/2016 8:00	Total
14	1	6.307	Delivered	250888	Previous	8742570	8742570	5/31/2016 8:00	Total
15	1	6.087	Delivered	254821	Previous	8742570	8742570	6/30/2016 8:00	Total
16	1	6.123	Delivered	258440	Previous	8742570	8742570	7/31/2016 8:00	Total
17	1	6.112	Delivered	262122	Previous	8742570	8742570	8/31/2016 8:00	Total
18	1	6.13	Delivered	266052	Previous	8742570	8742570	10/1/2016 8:00	Total
19	1	6.519	Delivered	222032	Previous	8742570	8742570	10/30/2015 8:00	Total
20	1	6.411	Delivered	270090	Previous	8742570	8742570	10/31/2016 8:00	Total
21	1	6.282	Delivered	222269	Previous	8742570	8742570	11/1/2015 8:00	Total
22	1	6.519	Delivered	226225	Previous	8742570	8742570	11/30/2015 9:00	Total
23	1	6.951	Delivered	274338	Previous	8742570	8742570	11/30/2016 9:00	Total
24	1	7.477	Delivered	230275	Previous	8742570	8742570	12/30/2015 9:00	Total
25	1	7.092	Delivered	192147	Previous	8742570	8742570	1/30/2015 9:00	Total
26	1	7.297	Delivered	196332	Previous	8742570	8742570	2/27/2015 9:00	Total
27	1	6.375	Delivered	200863	Previous	8742570	8742570	3/31/2015 8:00	Total
28	1	7.124	Delivered	205021	Previous	8742570	8742570	4/30/2015 11:09	Total

#2 Well House Electric Records

_ID	BillingMe	MeterList							
1									
_ID	_IDBilling	Demand	Direction	kWh	Measuren	Name	SerialNum	TimeStamp	Tou
1	1	6.556	Sum	22909	Previous	18470077	18470077	1/1/2017 9:00	Total
2	1	6.716	Sum	623	Previous	18470077	18470077	1/31/2016 9:46	Total
3	1	6.368	Sum	26731	Previous	18470077	18470077	1/31/2017 9:00	Total
4	1	5.292	Sum	30037	Previous	18470077	18470077	2/28/2017 9:00	Total
5	1	8.044	Sum	4155	Previous	18470077	18470077	2/29/2016 9:00	Total
6	1	2.868	Sum	5191	Previous	18470077	18470077	3/29/2016 8:00	Total
7	1	3.604	Sum	33487	Previous	18470077	18470077	3/29/2017 8:00	Total
8	1	8.66	Sum	7569	Previous	18470077	18470077	4/29/2016 8:00	Total
9	1	5.44	Sum	9449	Previous	18470077	18470077	5/31/2016 8:00	Total
10	1	2.124	Sum	10323	Previous	18470077	18470077	6/30/2016 8:00	Total
11	1	6.08	Sum	10832	Previous	18470077	18470077	7/31/2016 8:00	Total
12	1	6.1	Sum	12261	Previous	18470077	18470077	8/31/2016 8:00	Total
13	1	4.52	Sum	13210	Previous	18470077	18470077	10/1/2016 8:00	Total
14	1	4.728	Sum	14907	Previous	18470077	18470077	10/31/2016 8:00	Total
15	1	6.6	Sum	18543	Previous	18470077	18470077	11/30/2016 9:00	Total

Appendix B – Performance Results

Boiler Combustion Tests

	Boiler 1	Boiler 2
Oxygen (O_2)	4.2%	4.6%
Carbon Monoxide (CO)	19 ppm	11 ppm
Efficiency	84.4%	83.9%
Carbon Dioxide (CO_2)	12.5%	12.2%
Stack Temperature	447°F	466°F
Air Temperature	44.1°F	49.9°F
Excess Air	23.3%	26.1%

Appendix C – Energy Audit Report – Project Summary

ENERGY AUDIT REPORT – PROJECT SUMMARY	
General Project Information	
PROJECT INFORMATION	**AUDITOR INFORMATION**
Building: Mountain Village Upper Pump House, 85 Well House and #2 Well House	**Auditor Company:** Alaska Native Tribal Health Consortium
Address: PO Box 32085	**Auditor Name:** Bailey Gamble
City: Mountain Village	**Auditor Address:** 4500 Diplomacy Dr., Suite 454 Anchorage, AK 99508
Client Name: Robert Joe	
Client Address: PO Box 32085 Mountain Village, AK 99632	**Auditor Phone:** (907) 729-4501
	Auditor FAX: ( ) -
Client Phone: (907) 591-2929	**Auditor Comment:**
Client FAX: (907) 591-2920	
Design Data	
Building Area: 672 square feet	**Design Space Heating Load:** Design Loss at Space: 9,797 Btu/hour with Distribution Losses: 9,797 Btu/hour Plant Input Rating assuming 82.0% Plant Efficiency and 25% Safety Margin: 14,935 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: Mountain Village	**Design Outdoor Temperature:** -40 deg F
Weather/Fuel City: Mountain Village	**Heating Degree Days:** 13,448 deg F-days
Utility Information	
Electric Utility: Alaska Village Electric Cooperative	**Average Annual Cost/kWh:** $0.39/kWh

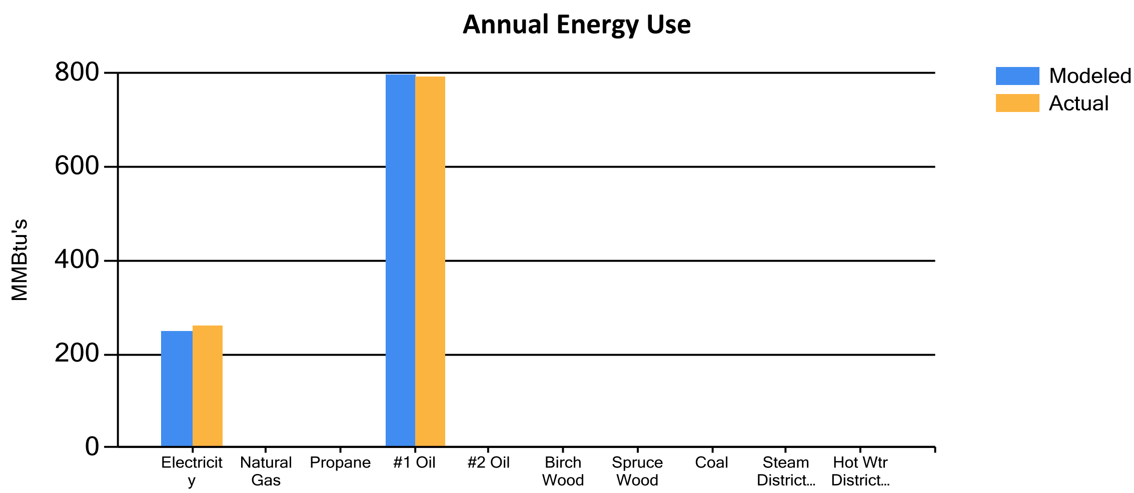
Annual Energy Cost Estimate						
Description	**Space Heating**	**Water Heating**	**Ventilation Fans**	**Lighting**	**Other Electrical**	**Total Cost**
Existing Building	$4,379	$33,883	$3	$300	$24,088	**$62,652**
With Proposed Retrofits	$2,390	$16,047	$3	$180	$23,681	**$42,301**
Savings	$1,988	$17,835	$0	$120	$407	**$20,351**

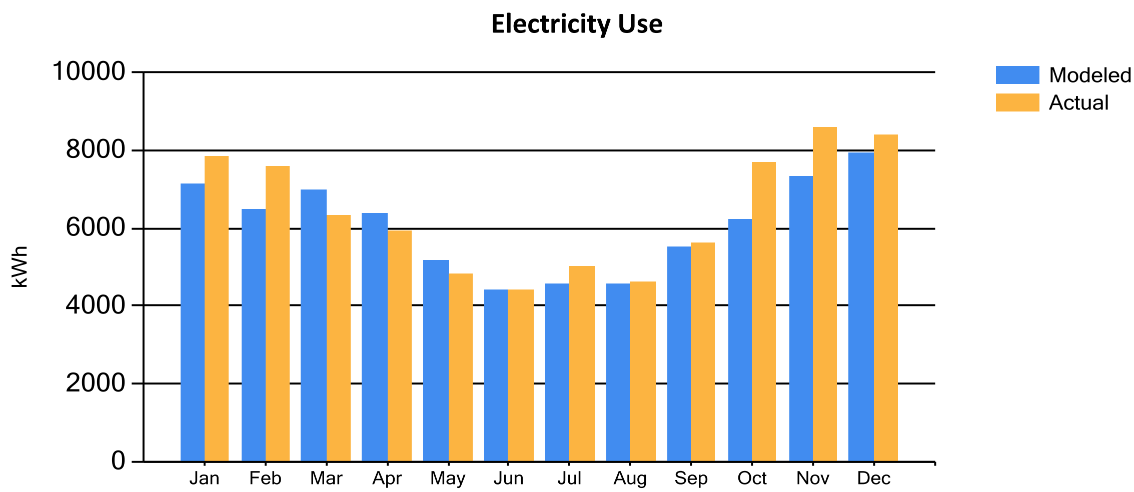
Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	1,552.7	115.46	$93.23
With Proposed Retrofits	901.7	67.05	$62.95

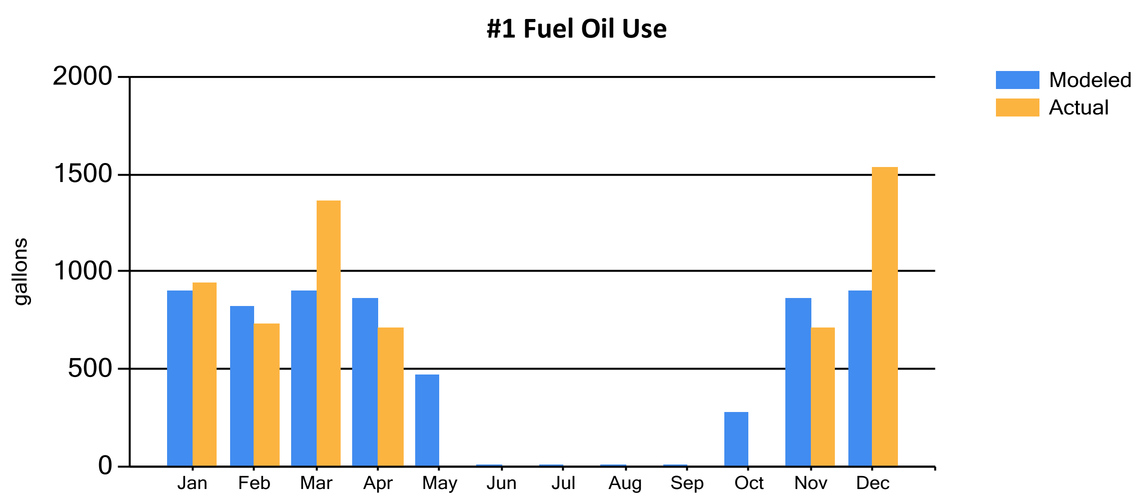
EUI: Energy Use Intensity - The annual site energy consumption divided by the structure's conditioned area.
EUI/HDD: Energy Use Intensity per Heating Degree Day.
ECI: Energy Cost Index - The total annual cost of energy divided by the square footage of the conditioned space in the building.

Appendix D – 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.







Appendix E - Electrical Demands

Estimated Peak Electrical Demand (kW)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Current	25.9	23.0	20.1	17.5	15.2	14.3	14.3	14.3	14.6	14.8	14.6	12.4
As Proposed	18.0	16.2	14.4	12.9	11.9	11.7	11.7	11.7	11.8	12.0	12.0	10.9

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