Comprehensive Energy Audit
For
Mountain Village Middle Pump House, Cannery Well House and Lift Stations

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 audits and coordinating potential follow up retrofit activities.

The Rural Energy Initiative at the Alaska Native Tribal Health Consortium (ANTHC) prepared this document for the City of Mountain Village, Alaska. The authors of this report are Kevin Ulrich, Assistant Engineering Project Manager and Certified Energy Manager (CEM); Bailey Gamble, Mechanical Engineer I; 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 the audit focused on Mountain Village Middle Pump House, Cannery Well House and Lift Stations. The Upper Pump House, 85 Well House and #2 Well House are included in a separate report which supports the contents of this energy audit. 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 are $43,920 per year. Electricity is the largest portion with an annual cost of approximately $32,393. This includes $18,273 paid by the City and $14,120 paid by the Power Cost Equalization program through the State of Alaska. #1 Fuel oil represents the remaining portion of energy use with an annual cost of approximately $11,526.

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 for any additional usage. The cost of electricity with PCE is $0.28/kWh for the first 700 kWh/month and $0.22/kWh any additional usage.

Table 1.1: Predicted Annual Fuel Use for the Mountain Village Middle Pump House

Predicted Annual Fuel Use		
Fuel Use	**Existing Building**	**With Proposed Retrofits**
Electricity	83,060 kWh	73,974 kWh
#1 Oil	2,026 gallons	1,766 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 Mountain Village Middle Pump House

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	593.6	44.14	$47.33
With Proposed Retrofits	523.3	38.91	$41.92
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 Middle Pump 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	Lift Station 1 Electric Heat	Lower thermostat to 40 °F	$1,573	$500	36.97	0.3	7,262.2
2	Cannery Well House Space Heat	Reprogram Toyo Laser 300 to heat up to 40 °F.	$519	$500	14.06	1.0	1,933.5
3	Other Electrical: Well Heat Tape (Pump House Building)	Shut off heat tape and use only for emergency thaw purposes	$526	$500	12.36	1.0	2,429.0
4	Setback Thermostat: Pump House	Install a new programmable thermostat and implement an unoccupied setback to 60 °F	$409	$1,000	5.55	2.4	1,523.0
5	Other Electrical: Transfer Pump	Slow the speed of the pump down to extend the runtime, lower the amp draw, and reduce the starts and stops of the pump, contributing to a longer lifetime.	$841 + $150 Maint. Savings	$2,000	5.63	2.0	4,077.2
6	Lighting: Cannery Well Exterior	Replace with new LED lighting	$108	$250	5.10	2.3	500.7
7	Lighting: Exterior	Replace with new LED lighting	$79	$250	3.73	3.2	366.0
8	Lift Station 2 Electric Heat	Lower thermostat set point to 40 °F	$157	$500	3.70	3.2	726.2
9	Lighting: Entryway	Replace with new LED lighting	$15	$160	1.07	10.7	71.8
10	Lighting: Tool Storage Room	Replace with new LED lighting	$15	$160	1.07	10.7	71.8
11	Lighting: Process Room	Replace with new LED lighting	$60	$640	1.06	10.7	286.7
12	Boilers	Replace guns, tune and clean boilers, get boiler 2 operational, add controls, replace thermostats in the building.	$331	$6,000	1.00	18.1	1,145.4
13	Lighting: Side Entryway	Replace with new LED lighting	$3	$40	0.87	13.1	14.7
14	Air Tightening	Seal gaps round doors and windows. replace doors and windows.	$252	$3,000	0.78	11.9	937.1
15	Window: Windows (2 boarded)	Replace existing windows with triple pane windows.	$102	$3,521	0.50	34.5	379.7
16	Lighting: Old Chemical Room	Replace with new LED lighting	$2	$80	0.26	43.5	8.8
17	Lighting: Cannery Well Interior	Replace with new LED lighting	$3	$240	0.14	83.3	13.3
18	Window: Windows (2 non-boarded)	Replace existing windows with triple pane windows.	$24	$3,521	0.12	145.1	90.3
	TOTAL, all measures		**$5,021 + $150 Maint. Savings**	**$22,863**	**2.81**	**4.4**	**21,837.4**

Table Notes:

[1] Savings to Investment Ratio (SIR) is a life-cycle cost measure calculated by dividing the total savings over the life of a project (expressed in today's dollars) by its investment costs. The SIR is an indication of the profitability of a measure; the higher the SIR, the more profitable the project. An SIR greater than 1.0 indicates a cost-effective project (i.e. more savings than cost). Remember that this profitability is based on the position of that Energy Efficiency Measure (EEM) in the overall list and assumes that the measures above it are implemented first.

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

With all of these energy efficiency measures in place, the annual utility cost can be reduced by $5,021 per year, or 11.4% of the buildings' total energy costs. These measures are estimated to cost $22,863, for an overall simple payback period of 4.4 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 Mountain Village Middle Pump House

Annual Energy Cost Estimate					
Description	**Space Heating**	**Lighting**	**Other Electrical**	**Water Circulation Heat**	**Total Cost**
Existing Building	$6,438	$787	$28,064	$8,631	**$43,920**
With Proposed Retrofits	$3,923	$482	$26,476	$8,017	**$38,899**
Savings	$2,515	$304	$1,587	$614	**$5,021**

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 Middle Pump 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 Middle Pump 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 lower loop of the Mountain Village Water System consists of the middle pump house, cannery well house, lift station 1, and lift station 2. The area of each facility is listed below:

1) Middle Pump House: 928 square feet
2) Cannery Well House: estimated 144 square feet
3) Lift Station 1: estimated 144 square feet
4) Lift Station 2: estimated 216 square feet

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

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

2.3. Method of Analysis

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

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

Our analysis provides a number of tools for assessing the cost effectiveness of various improvement options. These tools utilize **Life-Cycle Costing**, which is defined in this context as a method of cost analysis that estimates the total cost of a project over the period of time that includes both the construction cost and ongoing maintenance and operating costs.

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

Savings includes the total discounted dollar savings considered over the life of the improvement. When these savings are added up, changes in future fuel prices as projected by the Department of Energy are included. Future savings are discounted to the present to account for the time-value of money (i.e. money's ability to earn interest over time). The **Investment** in the SIR calculation includes the labor and materials required to install the measure. An SIR value of at least 1.0 indicates that the project is cost-effective—total savings exceed the investment costs.

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

The Simple Payback calculation does not consider likely increases in future annual savings due to energy price increases. As an offsetting simplification, simple payback does not consider the need to earn interest on the investment (i.e. it does not consider the time-value of money). Because of these simplifications, the SIR figure is considered to be a better financial investment indicator than the Simple Payback measure.

Measures are implemented in order of cost-effectiveness. The program first calculates individual SIRs, and ranks all measures by SIR, higher SIRs at the top of the list. An individual measure must have an individual SIR>=1 to make the cut. Next the building is modified and re-simulated with the highest ranked measure included. Now all remaining measures are re-evaluated and ranked, and the next most cost-effective measure is implemented. AkWarm goes through this iterative process until all appropriate measures have been evaluated and installed.

It is important to note that the savings for each recommendation is calculated based on implementing the most cost effective measure first, and then cycling through the list to find the next most cost effective measure. Implementation of more than one EEM often affects the savings of other EEMs. The savings may in some cases be relatively higher if an individual EEM is implemented in lieu of multiple recommended EEMs. For example implementing a reduced operating schedule for inefficient lighting will result in relatively high savings. Implementing a reduced operating schedule for newly installed efficient lighting will result in lower relative savings, because the efficient lighting system uses less energy during each hour of operation. If multiple EEM's are recommended to be implemented, AkWarm calculates the combined savings appropriately.

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

2.4 Limitations of Study

All results are dependent on the quality of input data provided, and can only act as an approximation. In some instances, several methods may achieve the identified savings. This report is not intended as a final design document. The design professional or other persons following the recommendations shall accept responsibility and liability for the results.

3. MOUNTAIN VILLAGE MIDDLE PUMP HOUSE, CANNERY WELL HOUSE AND LIFT STATIONS

3.1. Building Description

The Mountain Village Middle Pump House houses the water heating and circulation components of the water distribution system for the lower half of the community. It also houses the transfer system that moves water from the lower loop to the upper loop of the community. It is approximately 928 square feet and is occupied approximately two hours per day, five days per week by one of the two water treatment plant operators that work for the city.

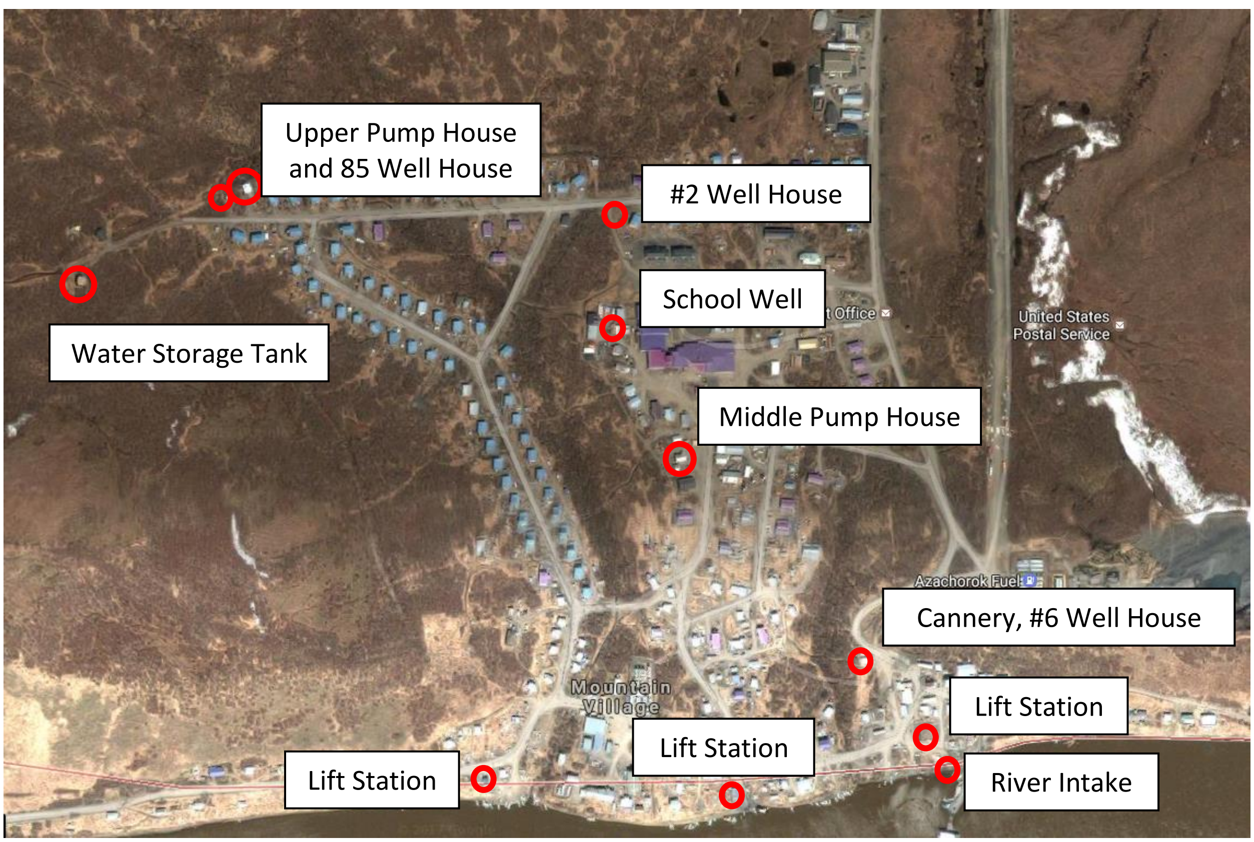


Figure 1: Aerial View of Mountain Village Water System Facilities

Raw water is pumped into the Cannery Well House from two wells that supply the community. These wells are referred to as the Cannery Well and the #6 Well. The water is treated with chlorine in the well house and pumped into the circulation loop. At the Middle Pump House location, water is pumped from the circulation loop into the building, where it is heated and circulated back into the distribution loop through a circulation pump. There is also a transfer line to the upper loop that serves the upper half of the community. Water is transferred to the upper loop when the wells that feed the loop cannot meet the community demand and also when the lower loop pressure is too high. There is no water storage tank to serve the lower portion of the community because the previous tank collapsed during a heavy winter snowfall before this year. As a result, the lower loop will use the upper loop as a means of moderating the system pressure.

There is a garage next to the Middle Pump House that houses maintenance equipment for the water system and for the city. Occupancy of the garage is infrequent and the only energy use comes from incandescent lights in the building.

Figure 2: Middle Pump House Garage

The Cannery Well house is the location of the Cannery Well and #6 Well, which supply the lower portion of the community with water. The building holds the chlorine treatment system as well.

Figure 3: Cannery Well house

There are three lift stations in the lower part of the community that collect sewage from the facilities in the town and transport it to the sewage lagoon outside of town. One of the lift stations has been disconnected from the electric utility and was not included in this audit report. The other two are referred to as Lift Stations 1 and 2 by the community and are located in the southeast and southcentral regions of the community, respectively.

Figure 4: Lift Station 1

Figure 5: Lift Station 2

<u>Description of Building Shell</u>

The exterior walls of the Pump House are 2x6 lumber construction with foam insulation.

The building has a cathedral ceiling with lumber framing and foam insulation.

The building is constructed on piles and elevated above the ground. It is wood framed with a concrete pad on top for the interior surface.

There are four total windows in the Pump House. All windows were measured to be 39” x 34&(1/4)” with double-paned glass and wood framing. Two of the windows are broken with boarded glass. The other two windows are in fair condition.

The primary entrance to the building is a set of wood double-doors that had significant gaps between the door and building sides. There is also a side entrance that had been foamed over along the outside, preventing it from being used.

<u>Description of Heating Plants</u>

The heating plants used in the building are:

Boiler 1

Nameplate Information:	Weil McLain Model P-WGO-6 Pump = Grundfos UP 26-64F
Fuel Type:	#1 Oil
Input Rating:	184,000 BTU/hr
Steady State Efficiency:	73 %
Idle Loss:	1.5 %
Heat Distribution Type:	Glycol
Boiler Operation:	Oct – May

Fire Rate: 1.75 GPH
Notes: Data logger showed this running 10% of the time

Figure 6: Middle Pump House Boiler 1

Boiler 2

Nameplate Information:	Weil McLain Model P-WGO-6 Pump = Grundfos UP 26-64F
Fuel Type:	#1 Oil
Input Rating:	184,000 BTU/hr
Steady State Efficiency:	75 %
Idle Loss:	0 %
Heat Distribution Type:	Glycol
Boiler Operation:	Oct – May
Fire Rate:	1.75 GPH
Notes:	This is not in operation. Data logger showed this running 0% of the time.

Figure 7: Middle Pump House Boiler 2

Boiler 3

Nameplate Information:	Weil McLain Model P-WGO-6
	Pump = Grundfos UP 26-64F
Fuel Type:	#1 Oil
Input Rating:	184,000 BTU/hr
Steady State Efficiency:	82 %
Idle Loss:	1.5 %
Heat Distribution Type:	Glycol
Boiler Operation:	Oct – May
Fire Rate:	1.75 GPH
Notes:	Data logger showed this running 51% of the time

Figure 8: Middle Pump House Boiler 3

The demand for heat in the middle pump house is seasonal and includes space heating and a heat add system that serves the upper distribution loop and water storage tank. Thermostats in the building appeared to not be functional, but temperature measurements indicated an air temperature of approximately 65 °F.

Two Weil McLain Gold Oil boilers serve to meet the middle 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 October and shuts them down in early May.

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 200°F.

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

Toyo Laser 300 – Well House

Nameplate Information:	Toyotomi Laser 300, set to 70 deg F
Fuel Type:	#1 Oil
Input Rating:	14,400 BTU/hr
Steady State Efficiency:	87 %
Idle Loss:	0 %

Heat Distribution Type: Air

Figure 9: Cannery Well house Toyo 300 Stove

Lift Station 1 Electric Heater

Fuel Type:	Electricity
Input Rating:	0 BTU/hr
Steady State Efficiency:	100 %
Idle Loss:	0 %
Heat Distribution Type:	Air

Figure 10: Lift Station 1 Electric Heater

Lift Station 2 Electric Heater

Fuel Type:	Electricity
Input Rating:	0 BTU/hr
Steady State Efficiency:	100 %

Idle Loss: 0 %
Heat Distribution Type: Air

Figure 11: Lift Station 2 Electric Heater

Space Heating Distribution Systems

Space heating is provided in the Middle Pump House by baseboard heating units that are heated by the hydronic boilers.

The Cannery Well house was heated by a Toyo 300 oil stove. The lift stations are heated by electric heaters.

Lighting

Table 3.1: Lighting Details for the Mountain Village Middle Pump House

Room	Bulb Type	Fixtures	Bulbs per Fixture	Annual Usage (kWh)
Entryway	Fluorescent T12 4ft.	2	2	105
Process Room	Fluorescent T12 4ft.	8	2	422
Old Chemical Room	Fluorescent T12 4ft.	1	2	13
Tool Storage Room	Fluorescent T12 4ft.	2	2	105
Side Entryway	Incandescent A Lamp, 100W	1	1	18
Pump House Exterior	High Pressure Sodium	1	1	260
Cannery Well Interior	Fluorescent T12 4ft.	3	2	17
Cannery Well Exterior	High Pressure Sodium	1	1	387
Lift Station 1 Interior	Fluorescent T12 4ft.	2	2	11
Lift Station 1 Interior	Incandescent A Lamp, 60W	1	1	5

Lift Station 1 Exterior	Metal Halide	1	1	133
Lift Station 2 Interior	Fluorescent T12 4ft.	2	2	11
Lift Station 2 Interior	Incandescent A Lamp, 60W	2	1	9
Lift Station 2 Exterior	Metal Halide	1	1	520

Plug Loads

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

Major Equipment

Table 3.2: Major Electrical Equipment Information for the Mountain Village Middle Pump House

Equipment	Rating (Watts)	Annual Usage (kWh)
Circulation Pump CP-A	3,480 (5 HP)	0
Circulation Pump CP-B	686 (1 HP)	6,014
Transfer Pump	3,266 (7.5 HP)	11,598
Glycol Make-Up Pump	375 (1/2 HP)	329
Well Heat Tape (Pump House Building)	300	1,377
Cannery Well Chlorine Pump	22	193
Cannery Well Heat Tape	500	46
#6 Well Heat Tape	500	46
Cannery Well Pump	3,480 (5 HP)	30,506
#6 Well Pump	5,000 (7.5 HP)	13,365
Lift Station 1 Pump	4,400 (6 HP)	3,086
Lift Station 2 Pump	8,800 (12 HP)	5,400

There are two circulation pumps in the Pump House that are used to pump water from the circulation loop into the building to be heated before going back out to the loop again. This helps keep the loop flowing properly and provides heat to the loop. The pumps must flow constantly in order to adequately supply water for the transfer pumps when needed.

Figure 12: Middle Pump House Circulation Pumps

The transfer pump is used to move water from the lower loop to the upper loop. This occurs when the upper loop wells are unable to meet community demand or when the lower loop reaches the maximum allowable pressure for the system and water is transported to the upper loop to relieve the system pressure.

Figure 13: Middle Pump House Transfer Pump

The Well Heat Tape runs between the Pump House building and the circulation loop to prevent the Pump House intake line from freezing. This currently runs constantly throughout the year.

The Cannery Well Pump is the primary well pump used to supply water to the lower part of the community. This runs constantly throughout the year. The #6 Well Pump is used during the spring months to accommodate additional community demand when the upper loop wells cannot meet community demand and when the river is experiencing breakup.

The pumps in lift station 1 and 2 are used to collect the sewage from the community and transport it to a sewage lagoon outside of town.

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 Alaska Village Electric Cooperative (AVEC) provides electricity services to all residential, commercial, and public facilities in Mountain Village.

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 Cost Rates for Each Fuel Type

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 $43,920 annually for electricity and other fuel costs for the Mountain Village Middle Pumphouse.

Figure 13 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.

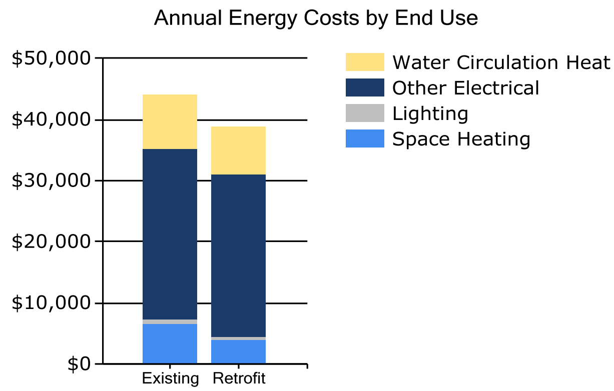


Figure 13: Annual Energy Costs by End Use

Figure 14 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 14: Annual Energy Costs by Fuel Type

Figure 15 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.

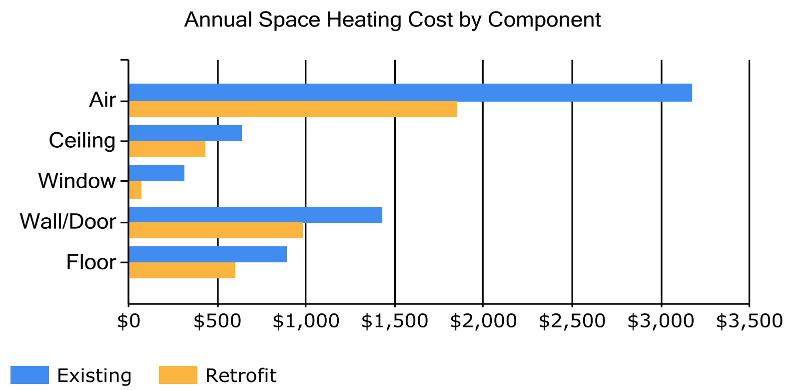


Figure 15: Annual Space Heating Costs

Tables 3.4 and 3.5 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 by Category

Electrical Consumption (kWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space Heating	1628	1465	1478	1117	0	0	0	0	1	323	1264	1630
Lighting	272	247	272	263	61	59	61	61	59	129	263	272
Other Electrical	6527	7888	9134	7340	7036	4586	4739	4739	4586	4816	4816	5752
Water Circulation Heat	26	23	31	38	0	0	0	0	0	8	25	26

Table 3.5: Estimated Fuel Oil Consumption by Category

Fuel Oil #1 Consumption (Gallons)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space Heating	108	97	69	32	2	2	1	3	9	26	65	108
Water Circulation Heat	218	197	258	310	0	0	0	0	0	90	214	218

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 3.6 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: Building EUI Calculations for the Mountain Village Middle Pump House

Energy Type	Building Fuel Use per Year	Site Energy Use per Year, kBTU	Source/Site Ratio	Source Energy Use per Year, kBTU
Electricity	83,060 kWh	283,484	3.340	946,837
#1 Oil	2,026 gallons	267,393	1.010	270,067
Total		**550,877**		**1,216,904**
BUILDING AREA		928	Square Feet	
BUILDING SITE EUI		594	$kBTU/Ft^2/Yr$	
BUILDING SOURCE EUI		1,311	**$kBTU/Ft^2/Yr$**	
* Site - Source Ratio data is provided by the Energy Star Performance Rating Methodology for Incorporating Source Energy Use document issued March 2011.				

Table 3.7: Building Benchmarks for the Mountain Village Middle Pump House

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	593.6	44.14	$47.33
With Proposed Retrofits	523.3	38.91	$41.92
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 Mountain Village Middle Pump House was modeled using AkWarm© energy use software to establish a baseline space heating 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 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: Summary List of Recommended 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[1]**	**Simple Payback (Years)[2]**	**CO_2 Savings**
1	Lift Station 1 Electric Heat	Lower thermostat to 40 °F	$1,573	$500	36.97	0.3	7,262.2
2	Cannery Well House Space Heat	Reprogram Toyo Laser 300 to heat up to 40 °F.	$519	$500	14.06	1.0	1,933.5
3	Other Electrical: Well Heat Tape (Pump House Building)	Shut off heat tape and use only for emergency thaw purposes	$526	$500	12.36	1.0	2,429.0

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**
4	Setback Thermostat: Pump House	Install a new programmable thermostat and implement an unoccupied setback to 60 °F	$409	$1,000	5.55	2.4	1,523.0
5	Other Electrical: Transfer Pump	Slow the speed of the pump down to extend the runtime, lower the amp draw, and reduce the starts and stops of the pump, contributing to a longer lifetime.	$841 + $150 Maint. Savings	$2,000	5.63	2.0	4,077.2
6	Lighting: Cannery Well Exterior	Replace with new LED lighting	$108	$250	5.10	2.3	500.7
7	Lighting: Exterior	Replace with new LED lighting	$79	$250	3.73	3.2	366.0
8	Lift Station 2 Electric Heat	Lower thermostat set point to 40 °F	$157	$500	3.70	3.2	726.2
9	Lighting: Entryway	Replace with new LED lighting	$15	$160	1.07	10.7	71.8
10	Lighting: Tool Storage Room	Replace with new LED lighting	$15	$160	1.07	10.7	71.8
11	Lighting: Process Room	Replace with new LED lighting	$60	$640	1.06	10.7	286.7
12	Boilers	Replace guns, tune and clean boilers, get boiler 2 operational, add controls, replace thermostats in the building.	$331	$6,000	1.00	18.1	1,145.4
13	Lighting: Side Entryway	Replace with new LED lighting	$3	$40	0.87	13.1	14.7
14	Air Tightening	Seal gaps round doors and windows. replace doors and windows.	$252	$3,000	0.78	11.9	937.1
15	Window: Windows (2 boarded)	Replace existing windows with triple pane windows.	$102	$3,521	0.50	34.5	379.7
16	Lighting: Old Chemical Room	Replace with new LED lighting	$2	$80	0.26	43.5	8.8
17	Lighting: Cannery Well Interior	Replace with new LED lighting	$3	$240	0.14	83.3	13.3
18	Window: Windows (2 non-boarded)	Replace existing windows with triple pane windows.	$24	$3,521	0.12	145.1	90.3
	TOTAL, all measures		**$5,021 + $150 Maint. Savings**	**$22,863**	**2.81**	**4.4**	**21,837.4**

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 Window Measures

Rank	Location	Size/Type, Condition	Recommendation
15	Window: Windows (2 boarded)	Glass: No glazing - broken, missing Frame: Wood\Vinyl Spacing Between Layers: Half Inch Gas Fill Type: Air Modeled U-Value: 0.94 Solar Heat Gain Coefficient including Window Coverings: 0.11	Replace existing windows with triple pane windows.

Installation Cost	$3,521	**Estimated Life of Measure (yrs)**	20	**Energy Savings ($/yr)**	$102
Breakeven Cost	$1,775	**Simple Payback (yrs)**	35	**Energy Savings (MMBTU/yr)**	2.4 MMBTU
		Savings-to-Investment Ratio	0.5		

Auditors Notes: Replacing the windows will improve the total wall insulation and air leakage of the building.

Rank	Location	Size/Type, Condition	Recommendation
18	Window: Windows (2 non-boarded)	Glass: Double, glass Frame: Wood\Vinyl Spacing Between Layers: Half Inch Gas Fill Type: Air Modeled U-Value: 0.51 Solar Heat Gain Coefficient including Window Coverings: 0.46	Replace existing windows with triple pane windows.

Installation Cost	$3,521	**Estimated Life of Measure (yrs)**	20	**Energy Savings ($/yr)**	$24
Breakeven Cost	$422	**Simple Payback (yrs)**	145	**Energy Savings (MMBTU/yr)**	0.6 MMBTU
		Savings-to-Investment Ratio	0.1		

Auditors Notes: Replacing the windows will improve the total wall insulation and air leakage of the building.

4.3.2 Air Sealing Measures

Rank	Location		Existing Air Leakage Level (cfm@50/75 Pa)		Recommended Air Leakage Reduction (cfm@50/75 Pa)	
14			Air Tightness estimated as: 1550 cfm at 50 Pascals		Seal gaps round doors and windows, replace doors and windows.	
Installation Cost	$3,000	**Estimated Life of Measure (yrs)**	10	**Energy Savings ($/yr)**	$252	
Breakeven Cost	$2,340	**Simple Payback (yrs)**	12	**Energy Savings (MMBTU/yr)**	5.8 MMBTU	
		Savings-to-Investment Ratio	0.8			

Auditors Notes: Sealing the gaps around the doors and windows will reduce the total building heating demand by preventing heated air from leaving the building.

4.4 Mechanical Equipment Measures

4.4.1 Heating /Domestic Hot Water Measure

Rank	Recommendation				
12	Replace guns, tune and clean boilers, get boiler 2 operational, add controls, replace thermostats in the building.				
Installation Cost	$6,000	**Estimated Life of Measure (yrs)**	20	**Energy Savings ($/yr)**	$331
Breakeven Cost	$6,016	**Simple Payback (yrs)**	18	**Energy Savings (MMBTU/yr)**	9.0 MMBTU
		Savings-to-Investment Ratio	1.0		

Auditors Notes: The addition of new guns will improve the fuel-firing rate and allow for a more efficient burn in the boiler.

Tuning and cleaning the boilers will improve the combustion efficiency and improve the burn of the fuel in the boiler.

Boiler 2 was not in operation during the site visit. Adding this to the building operations will allow the building to use a lead-lag boiler control system and improve the overall operations of the facility.

Replace Guns	$1500
Tune and Clean Boilers	$1500
Repair Boiler 2	$1000
Add Boiler Controls	$2000
Total	**$6000**

4.4.2 Night Setback Thermostat Measures

Rank	Building Space			Recommendation	
4	Pump House			Install a new programmable thermostat and implement an unoccupied setback to 60 °F	
Installation Cost	$1,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$409
Breakeven Cost	$5,548	**Simple Payback (yrs)**	2	**Energy Savings (MMBTU/yr)**	9.4 MMBTU
		Savings-to-Investment Ratio	5.5		

Auditors Notes: Lowering the temperature when not occupied can prevent the building from using more heat than necessary.

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	
6	Cannery Well Exterior	HPS 150 Watt StdElectronic		Replace with new LED lighting	
Installation Cost	$250	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$108
Breakeven Cost	$1,274	**Simple Payback (yrs)**	2	**Energy Savings (MMBTU/yr)**	0.9 MMBTU
		Savings-to-Investment Ratio	5.1		
Auditors Notes: There is a single HPS light bulb to be replaced.					

Rank	Location	Existing Condition		Recommendation	
7	Exterior	HPS 100 Watt StdElectronic		Replace with new LED lighting	
Installation Cost	$250	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$79
Breakeven Cost	$931	**Simple Payback (yrs)**	3	**Energy Savings (MMBTU/yr)**	0.7 MMBTU
		Savings-to-Investment Ratio	3.7		
Auditors Notes: There is a single HPS light bulb to be replaced.					

Rank	Location	Existing Condition		Recommendation	
9	Entryway	2 FLUOR (2) T12 4' F40T12 40W Standard StdElectronic		Replace with new LED lighting	
Installation Cost	$160	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$15
Breakeven Cost	$171	**Simple Payback (yrs)**	11	**Energy Savings (MMBTU/yr)**	0.1 MMBTU
		Savings-to-Investment Ratio	1.1		
Auditors Notes: There are two fixtures with two light bulbs in each fixture for a total of four light bulbs to be replaced.					

Rank	Location	Existing Condition		Recommendation	
10	Tool Storage Room	2 FLUOR (2) T12 4' F40T12 40W Standard StdElectronic		Replace with new LED lighting	
Installation Cost	$160	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$15
Breakeven Cost	$171	**Simple Payback (yrs)**	11	**Energy Savings (MMBTU/yr)**	0.1 MMBTU
		Savings-to-Investment Ratio	1.1		
Auditors Notes: There are two fixtures with two light bulbs in each fixture for a total of four light bulbs to be replaced.					

Rank	Location	Existing Condition		Recommendation	
11	Process Room	8 FLUOR (2) T12 4' F40T12 40W Standard StdElectronic		Replace with new LED lighting	
Installation Cost	$640	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$60
Breakeven Cost	$681	**Simple Payback (yrs)**	11	**Energy Savings (MMBTU/yr)**	0.4 MMBTU
		Savings-to-Investment Ratio	1.1		
Auditors Notes: There are eight fixtures with two light bulbs in each fixture for a total of 16 light bulbs to be replaced.					

Rank	Location	Existing Condition		Recommendation	
13	Side Entryway	INCAN A Lamp, Std 100W		Replace with new LED lighting	
Installation Cost	$40	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$3
Breakeven Cost	$35	**Simple Payback (yrs)**	13	**Energy Savings (MMBTU/yr)**	0.0 MMBTU
		Savings-to-Investment Ratio	0.9		
Auditors Notes: There is a single incandescent light bulb to be replaced.					

Rank	Location	Existing Condition		Recommendation	
16	Old Chemical Room	FLUOR (2) T12 4' F40T12 40W Standard StdElectronic		Replace with new LED lighting	
Installation Cost	$80	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$2
Breakeven Cost	$21	**Simple Payback (yrs)**	43	**Energy Savings (MMBTU/yr)**	0.0 MMBTU
		Savings-to-Investment Ratio	0.3		
Auditors Notes: There is a single fixture with two light bulbs to be replaced.					

Rank	Location	Existing Condition		Recommendation	
17	Cannery Well Interior	3 FLUOR (2) T12 4' F40T12 40W Standard StdElectronic		Replace with new LED lighting	
Installation Cost	$240	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$3
Breakeven Cost	$34	**Simple Payback (yrs)**	83	**Energy Savings (MMBTU/yr)**	0.0 MMBTU
		Savings-to-Investment Ratio	0.1		
Auditors Notes: There are three fixtures with two light bulbs in each fixture for a total of six light bulbs to be replaced.					

4.5.2 Other Electrical Measures

Rank	Location	Description of Existing		Efficiency Recommendation	
3	Well Heat Tape (Pump House Building)	Heat Tape		Shut off heat tape and use only for emergency thaw purposes	
Installation Cost	$500	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$526
Breakeven Cost	$6,182	**Simple Payback (yrs)**	1	**Energy Savings (MMBTU/yr)**	4.6 MMBTU
		Savings-to-Investment Ratio	12.4		
Auditors Notes: Shutting off the heat tape except for extreme conditions will allow the system to operate with just enough heat to prevent freezing without using excess power.					

Rank	Location	Description of Existing		Efficiency Recommendation	
5	Transfer Pump	Transfer Pump		Slow the speed of the pump down to extend the runtime, lower the amp draw, and reduce the starts and stops of the pump, contributing to a longer lifetime.	
Installation Cost	$2,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$841
Breakeven Cost	$11,268	**Simple Payback (yrs)**	2	**Energy Savings (MMBTU/yr)**	4.2 MMBTU
		Savings-to-Investment Ratio	5.6	**Maintenance Savings ($/yr)**	$150
Auditors Notes: Slow the speed of the pump down to extend the runtime and reduce the starts and stops of the pump, contributing to a longer lifetime. This involves repairs to the modulating controls on the VFD system to reduce the RPM's that the pump is actively using. Estimating to increase pump efficiency by 25% on average based on assumptions from the affinity laws. Maintenance savings from extended life of the pump and no need to replace as often.					

4.5.3 Other Measures

Rank	Location	Description of Existing		Efficiency Recommendation	
1		Lift Station 1 Electric Heat		Lower thermostat to 40 °F	
Installation Cost	$500	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$1,573
Breakeven Cost	$18,483	**Simple Payback (yrs)**	0	**Energy Savings (MMBTU/yr)**	13.8 MMBTU
		Savings-to-Investment Ratio	37.0		
Auditors Notes: Lower the thermostat to 40 °F so that the lift station has freeze protection without using excess heating.					

Rank	Location	Description of Existing		Efficiency Recommendation	
2		Cannery Well Space Heat		Reprogram Toyo Laser 300 to heat up to 40 °F.	
Installation Cost	$500	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$519
Breakeven Cost	$7,030	**Simple Payback (yrs)**	1	**Energy Savings (MMBTU/yr)**	11.9 MMBTU
		Savings-to-Investment Ratio	14.1		
Auditors Notes: Lower the Toyo stove to 40 °F so that the well house has freeze protection without using excess heating.					

Rank	Location	Description of Existing		Efficiency Recommendation	
8		Lift Station 2 Electric Heat		Lower thermostat set point to 40 °F	
Installation Cost	$500	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$157
Breakeven Cost	$1,848	**Simple Payback (yrs)**	3	**Energy Savings (MMBTU/yr)**	1.4 MMBTU
		Savings-to-Investment Ratio	3.7		
Auditors Notes: Lower the thermostat to 40 °F so that the lift station has freeze protection without using excess heating.					

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 Mountain Village to follow up on the recommendations made in this report. Funding has been provided to ANTHC through a Rural Alaska Village Grant and the Denali Commission to provide the community with assistance in understanding the report and implementing the recommendations.

APPENDICES

Appendix A – Scanned Energy Billing Data

1. Electricity Billing Data
   Middle Pump House Electric Records

D	_IDBillingI	Demand	Direction	kWh	*Monthly	MeasurementPerioc	Name	SerialNumber	TimeStamp	Tou
25	1	4.82	Delivered	115569	#REF!	Previous	8742593	8742593	1/30/2015 9:00	Total
26	1	5.59	Delivered	118110	2541	Previous	8742593	8742593	2/27/2015 9:00	Total
27	1	5.878	Delivered	120807	2697	Previous	8742593	8742593	3/31/2015 8:00	Total
28	1	5.018	Delivered	123326	2519	Previous	8742593	8742593	4/30/2015 11:09	Total
1	1	4.024	Delivered	124844		Previous	8742593	8742593	5/30/2015 8:00	Total
2	1	2.25	Delivered	125748	904	Previous	8742593	8742593	6/30/2015 8:00	Total
3	1	2.116	Delivered	125916	168	Previous	8742593	8742593	7/30/2015 8:00	Total
4	1	2.577	Delivered	126113	197	Previous	8742593	8742593	8/30/2015 8:00	Total
5	1	1.407	Delivered	126365	252	Previous	8742593	8742593	9/30/2015 8:00	Total
19	1	3.006	Delivered	127380	1015	Previous	8742593	8742593	10/30/2015 8:00	Total
21	1	2.422	Delivered	127462	82	Previous	8742593	8742593	11/1/2015 8:00	Total
22	1	3.103	Delivered	128564	1102	Previous	8742593	8742593	11/30/2015 9:00	Total
24	1	3.088	Delivered	129710	1146	Previous	8742593	8742593	12/30/2015 9:00	Total
7	1	1.976	Delivered	131051	1341	Previous	8742593	8742593	1/31/2016 9:00	Total
10	1	5.439	Delivered	132633	1582	Previous	8742593	8742593	2/29/2016 9:00	Total
11	1	4.525	Delivered	134857	2224	Previous	8742593	8742593	3/29/2016 8:00	Total
13	1	4.629	Delivered	137218	2361	Previous	8742593	8742593	4/29/2016 8:00	Total
14	1	4.212	Delivered	139334	2116	Previous	8742593	8742593	5/31/2016 8:00	Total
15	1	3.78	Delivered	140842	1508	Previous	8742593	8742593	6/30/2016 8:00	Total
16	1	2.923	Delivered	142226	1384	Previous	8742593	8742593	7/31/2016 8:00	Total
17	1	3.632	Delivered	143744	1518	Previous	8742593	8742593	8/31/2016 8:00	Total
18	1	2.89	Delivered	145333	1589	Previous	8742593	8742593	10/1/2016 8:00	Total
20	1	3.027	Delivered	146864	1531	Previous	8742593	8742593	10/31/2016 8:00	Total
23	1	3.171	Delivered	148401	1537	Previous	8742593	8742593	11/30/2016 9:00	Total
6	1	4.114	Delivered	150113	1712	Previous	8742593	8742593	1/1/2017 9:00	Total
8	1	4.604	Delivered	151722	1609	Previous	8742593	8742593	1/31/2017 9:00	Total
9	1	3.56	Delivered	153461	1739	Previous	8742593	8742593	2/28/2017 9:00	Total
12	1	3.481	Delivered	155326	1865	Previous	8742593	8742593	3/29/2017 8:00	Total

Cannery Well House Electric Records

_ID	_IDBillingI	Demand	Direction	kWh	Difference	Measuren	Name	SerialNum	TimeStamp	Tou
26	1	3.404	Sum	104870		Previous	1.2E+07	1.2E+07	1/30/2015 9:00	Total
27	1	3.312	Sum	106972	2102	Previous	1.2E+07	1.2E+07	2/27/2015 9:00	Total
28	1	3.38	Sum	109382	2410	Previous	1.2E+07	1.2E+07	3/31/2015 8:00	Total
29	1	4.06	Sum	111566	2184	Previous	1.2E+07	1.2E+07	4/30/2015 10:59	Total
1	1	9.5	Sum	114099		Previous	1.2E+07	1.2E+07	5/30/2015 8:00	Total
2	1	9.248	Sum	119492	5393	Previous	1.2E+07	1.2E+07	6/30/2015 8:00	Total
3	1	8.96	Sum	123123	3631	Previous	1.2E+07	1.2E+07	7/30/2015 8:00	Total
4	1	4.56	Sum	125551	2428	Previous	1.2E+07	1.2E+07	8/30/2015 8:00	Total
5	1	3.676	Sum	128030	2479	Previous	1.2E+07	1.2E+07	9/30/2015 8:00	Total
20	1	4.316	Sum	130430	2400	Previous	1.2E+07	1.2E+07	10/30/2015 8:00	Total
22	1	3.592	Sum	130590	160	Previous	1.2E+07	1.2E+07	11/1/2015 8:00	Total
23	1	4.252	Sum	132881	2291	Previous	1.2E+07	1.2E+07	11/30/2015 9:00	Total
25	1	4.484	Sum	135185	2304	Previous	1.2E+07	1.2E+07	12/30/2015 9:00	Total
7	1	11.948	Sum	138254	3069	Previous	1.2E+07	1.2E+07	1/31/2016 9:00	Total
10	1	11.788	Sum	142276	4022	Previous	1.2E+07	1.2E+07	2/29/2016 9:00	Total
11	1	5.848	Sum	142437	161	Previous	1.2E+07	1.2E+07	3/1/2016 17:01	Total
12	1	5.836	Sum	146009	3572	Previous	1.2E+07	1.2E+07	3/29/2016 8:00	Total
14	1	9.632	Sum	150923	4914	Previous	1.2E+07	1.2E+07	4/29/2016 8:00	Total
15	1	7.664	Sum	155227	4304	Previous	1.2E+07	1.2E+07	5/31/2016 8:00	Total
16	1	6.02	Sum	157988	2761	Previous	1.2E+07	1.2E+07	6/30/2016 8:00	Total
17	1	3.752	Sum	160564	2576	Previous	1.2E+07	1.2E+07	7/31/2016 8:00	Total
18	1	9.364	Sum	163162	2598	Previous	1.2E+07	1.2E+07	8/31/2016 8:00	Total
19	1	3.46	Sum	165592	2430	Previous	1.2E+07	1.2E+07	10/1/2016 8:00	Total
21	1	3.404	Sum	167945	2353	Previous	1.2E+07	1.2E+07	10/31/2016 8:00	Total
24	1	3.94	Sum	170408	2463	Previous	1.2E+07	1.2E+07	11/30/2016 9:00	Total
6	1	9.404	Sum	173688	3280	Previous	1.2E+07	1.2E+07	1/1/2017 9:00	Total
8	1	12.172	Sum	177997	4309	Previous	1.2E+07	1.2E+07	1/31/2017 9:00	Total
9	1	12.332	Sum	184384	6387	Previous	1.2E+07	1.2E+07	2/28/2017 9:00	Total
13	1	9.832	Sum	191014	6630	Previous	1.2E+07	1.2E+07	3/29/2017 8:00	Total

Lift Station #1 Electric Records

_ID	_IDBillingN	Demand	Direction	kWh		Measurem	Name	SerialNum	TimeStamp	Tou
2	1	5.1	Sum	1053		Previous	18470078	18470078	1/31/2016 9:46	Total
5	1	5.788	Sum	2163	1110	Previous	18470078	18470078	2/29/2016 9:00	Total
6	1	5.192	Sum	3175	1012	Previous	18470078	18470078	3/29/2016 8:00	Total
8	1	5.9	Sum	4070	895	Previous	18470078	18470078	4/29/2016 8:00	Total
9	1	5.616	Sum	4791	721	Previous	18470078	18470078	5/31/2016 8:00	Total
10	1	5.368	Sum	5197	406	Previous	18470078	18470078	6/30/2016 8:00	Total
11	1	4.996	Sum	5532	335	Previous	18470078	18470078	7/31/2016 8:00	Total
12	1	4.78	Sum	5849	317	Previous	18470078	18470078	8/31/2016 8:00	Total
13	1	5.304	Sum	6372	523	Previous	18470078	18470078	10/1/2016 8:00	Total
14	1	5.968	Sum	7335	963	Previous	18470078	18470078	10/31/2016 8:00	Total
15	1	5.72	Sum	8502	1167	Previous	18470078	18470078	11/30/2016 9:00	Total
1	1	5.872	Sum	10173	1671	Previous	18470078	18470078	1/1/2017 9:00	Total
3	1	6.392	Sum	11679	1506	Previous	18470078	18470078	1/31/2017 9:00	Total
4	1	6.484	Sum	13103	1424	Previous	18470078	18470078	2/28/2017 9:00	Total
7	1	5.064	Sum	14419	1316	Previous	18470078	18470078	3/29/2017 8:00	Total

Lift Station #2 Electric Records

_ID	_IDBillingI	Demand	Direction	kWh		Measuren	Name	SerialNun	TimeStamp	Tou
26	1	4.888	Sum	100400		Previous	11795081	11795081	1/30/2015 9:00	Total
27	1	5.808	Sum	101587	1187	Previous	11795081	11795081	2/27/2015 9:00	Total
28	1	4.04	Sum	103026	1439	Previous	11795081	11795081	3/31/2015 8:00	Total
29	1	5.628	Sum	104409	1383	Previous	11795081	11795081	4/30/2015 10:58	Total
1	1	4	Sum	105046		Previous	11795081	11795081	5/30/2015 8:00	Total
2	1	3.024	Sum	105503	457	Previous	11795081	11795081	6/30/2015 8:00	Total
3	1	3.036	Sum	105813	310	Previous	11795081	11795081	7/30/2015 8:00	Total
4	1	4.456	Sum	106105	292	Previous	11795081	11795081	8/30/2015 8:00	Total
5	1	4.556	Sum	106547	442	Previous	11795081	11795081	9/30/2015 8:00	Total
20	1	7.932	Sum	107146	599	Previous	11795081	11795081	10/30/2015 8:00	Total
22	1	2.088	Sum	107182	36	Previous	11795081	11795081	11/1/2015 8:00	Total
23	1	5.228	Sum	107744	562	Previous	11795081	11795081	11/30/2015 9:00	Total
25	1	4.752	Sum	108380	636	Previous	11795081	11795081	12/30/2015 9:00	Total
7	1	1.52	Sum	108909	529	Previous	11795081	11795081	1/31/2016 9:00	Total
10	1	5.476	Sum	109458	549	Previous	11795081	11795081	2/29/2016 9:00	Total
11	1	3.868	Sum	109479	21	Previous	11795081	11795081	3/1/2016 17:04	Total
12	1	3.872	Sum	109956	477	Previous	11795081	11795081	3/29/2016 8:00	Total
14	1	4.56	Sum	110654	698	Previous	11795081	11795081	4/29/2016 8:00	Total
15	1	4.428	Sum	111174	520	Previous	11795081	11795081	5/31/2016 8:00	Total
16	1	4.224	Sum	111537	363	Previous	11795081	11795081	6/30/2016 8:00	Total
17	1	4.284	Sum	111869	332	Previous	11795081	11795081	7/31/2016 8:00	Total
18	1	7.684	Sum	112368	499	Previous	11795081	11795081	8/31/2016 8:00	Total
19	1	8.572	Sum	112818	450	Previous	11795081	11795081	10/1/2016 8:00	Total
21	1	8.036	Sum	113459	641	Previous	11795081	11795081	10/31/2016 8:00	Total
24	1	4.472	Sum	114109	650	Previous	11795081	11795081	11/30/2016 9:00	Total
6	1	7.044	Sum	114792	683	Previous	11795081	11795081	1/1/2017 9:00	Total
8	1	7.228	Sum	115510	718	Previous	11795081	11795081	1/31/2017 9:00	Total
9	1	3.932	Sum	116134	624	Previous	11795081	11795081	2/28/2017 9:00	Total
13	1	3.7	Sum	116763	629	Previous	11795081	11795081	3/29/2017 8:00	Total

Appendix B – Performance Results

Boiler Combustion Tests

	Boiler 1	Boiler 3
Oxygen (O_2)	7.7%	9.7%
Carbon Monoxide (CO)	9 ppm	13 ppm
Efficiency	73.5%	82.5%
Carbon Dioxide (CO_2)	9.8%	8.3%
Stack Temperature	769°F	404°F
Air Temperature	67.9°F	64.4°F
Excess Air	54.2%	80.7%

Appendix C – Energy Audit Report – Project Summary

ENERGY AUDIT REPORT – PROJECT SUMMARY	
General Project Information	
PROJECT INFORMATION	**AUDITOR INFORMATION**
Building: Mountain Village Middle Pump House, Cannery Well House, and Lift Stations	**Auditor Company:** ANTHC-DEHE
Address: PO Box 32085	**Auditor Name:** Kevin Ulrich & Bailey Gamble
City: Mountain Village	**Auditor Address:** 4500 Diplomacy Dr. Anchorage, AK 99508
Client Name: Donald Kokrine and Charles Long	
Client Address: PO Box 32085 Mountain Village, AK 99632	**Auditor Phone:** (907) 729-3237
	Auditor FAX:
Client Phone: (907) 591-2929	**Auditor Comment:**
Client FAX:	
Design Data	
Building Area: 928 square feet	**Design Space Heating Load:** Design Loss at Space: 24,464 Btu/hour with Distribution Losses: 24,464 Btu/hour Plant Input Rating assuming 82.0% Plant Efficiency and 25% Safety Margin: 37,293 Btu/hour Note: Additional Capacity should be added for DHW and other plant loads, if served.
Typical Occupancy: 0 people	**Design Indoor Temperature:** 65 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

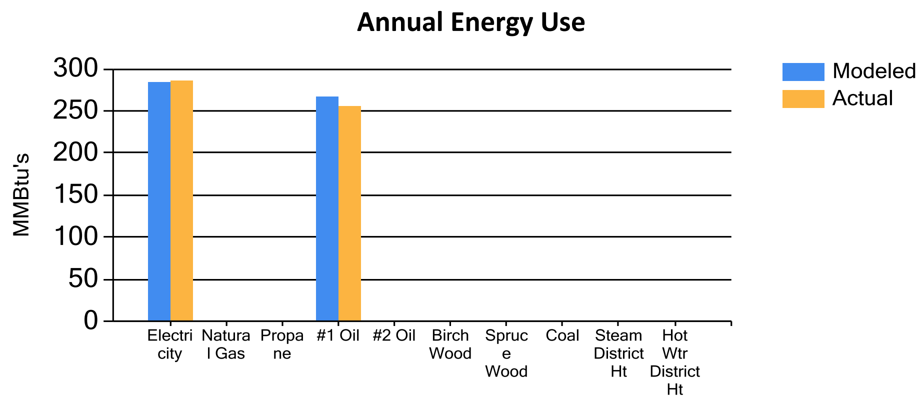
Annual Energy Cost Estimate					
Description	**Space Heating**	**Lighting**	**Other Electrical**	**Water Circulation Heat**	**Total Cost**
Existing Building	$6,438	$787	$28,064	$8,631	**$43,920**
With Proposed Retrofits	$3,923	$482	$26,476	$8,017	**$38,899**
Savings	$2,515	$304	$1,587	$614	**$5,021**

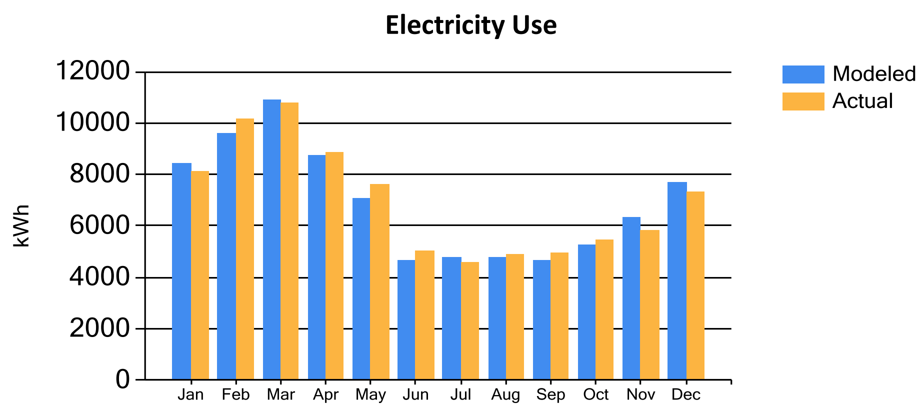
Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	593.6	44.14	$47.33
With Proposed Retrofits	523.3	38.91	$41.92

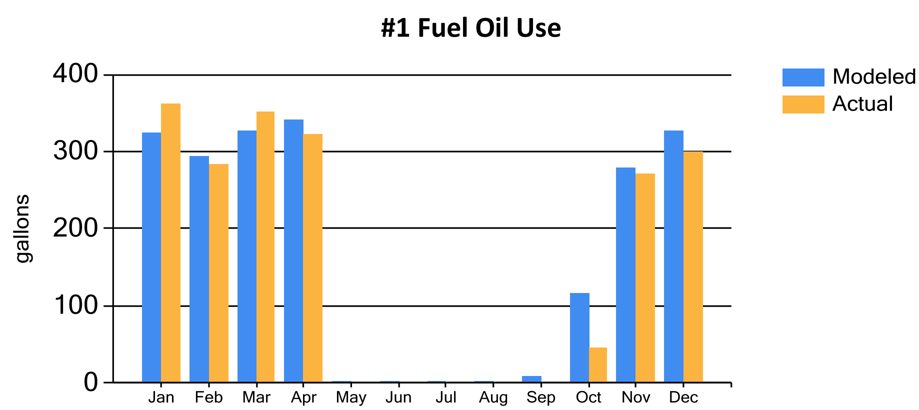
EUI: Energy Use Intensity - The annual site energy consumption divided by the structure's conditioned area.
EUI/HDD: Energy Use Intensity per Heating Degree Day.
ECI: Energy Cost Index - The total annual cost of energy divided by the square footage of the conditioned space in the building.

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	29.9	27.9	25.1	22.5	19.8	14.8	14.8	14.8	14.8	15.0	14.8	16.6
As Proposed	21.2	20.0	18.4	17.0	16.0	11.0	11.0	11.0	11.0	11.1	11.1	14.5

AkWarmCalc Ver 2.6.1.0, Energy Lib 8/9/2016