Comprehensive Energy Audit
For

Quinhagak Water Treatment Plant

Prepared For

City of Quinhagak

May 11, 2016

Prepared By:

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PREFACE

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

The Rural Energy Initiative at the Alaska Native Tribal Health Consortium (ANTHC) prepared this document for The City of Quinhagak, Alaska. The authors of this report are Chris Mercer, Certified Energy Manager (CEM); and Kevin Ulrich, Energy Manager-in-Training (EMIT).

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

ACKNOWLEDGMENTS

The ANTHC Energy Projects Group gratefully acknowledges the assistance of Water Treatment Plant Operators Frank Jones and Patrick Cleveland, Remote Maintenance Worker Bob White, Quinhagak City Administrator Willard Church, Quinhagak City Clerk Fannie Moore, and Quinhagak Director of Public Works George Johnson.

1. EXECUTIVE SUMMARY

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

Additional energy audits for the Quinhagak Utility Building and the Quinhagak Community Health and Sanitation Building were conducted at the same time as this audit. The buildings are all related in their interactions. This is reflected in this energy audit report.

In the near future, a representative of ANTHC will be contacting both the City of Quinhagak and the water treatment plant operators to follow up on the recommendations made in this report. ANTHC will assist the community in searching for funds to perform the retrofits recommended in this report.

The total predicted energy cost for the Quinhagak Water Treatment Plant is $74,543 per year. Electricity represents the largest portion with an annual cost of approximately $41,453. This includes $20,727 paid by the community and $20,699 paid by the Power Cost Equalization (PCE) program through the State of Alaska. Fuel oil represents the remaining portion with an annual cost of $33,090.

The State of Alaska PCE program provides a subsidy to rural communities across the state to lower the electricity costs and make energy affordable in rural Alaska. In Quinhagak, the cost of electricity without PCE is $0.48/kWh and the cost of electricity with PCE is $0.24/kWh.

Table 1.1 lists the total usage of electricity and #1 oil in the water treatment plant before and after the proposed retrofits.

Table 1.1: Predicted Annual Fuel Use for the Water Treatment Plant

Predicted Annual Fuel Use		
Fuel Use	**Existing Building**	**With Proposed Retrofits**
Electricity	86,082 kWh	20,907 kWh
#1 Oil	4,939 gallons	2,816 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 Water Treatment Plant

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	326.3	26.95	$25.72
With Proposed Retrofits	152.9	12.63	$10.22

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 Quinhagak Water Treatment Plant. 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	Heat Add Controls	East Loop water distribution heat-add controls are broken. Replace with new controls and lower set point to 38 deg. F. Use a Belimo modulating valve and a Honeywell T775 temperature controller to match the ARUC standard used in all of their communities.	$10,931	$3,000	63.05	0.3	34,758.3
2	Other Electrical - Raw Water Heat Tape	Two heat tapes on the raw water line operate all winter. Shut these off and use them only for emergency that purposes.	$10,059	$3,000	39.39	0.3	38,434.1
3	Heat Add Controls	Raw water intake heat-add controls are broken. Replace with new controls and lower set point to 38 deg. F. Use a Belimo modulating valve and a Honeywell T775 temperature controller to match the ARUC standard used in all of their communities.	$2,483	$3,000	14.23	1.2	7,960.1

PRIORITY LIST – ENERGY EFFICIENCY MEASURES							
Rank	Feature	Improvement Description	Annual Energy Savings	Installed Cost	Savings to Investment Ratio, SIR[1]	Simple Payback (Years)[2]	CO_2 Savings
4	Heat Add Controls	Water storage tank heat-add controls are broken. Replace with new controls and lower set point to 40 deg. F. Use a Belimo modulating valve and a Honeywell T775 temperature controller to match the ARUC standard used in all of their communities.	$1,969	$3,000	11.43	1.5	6,213.4
5	Other Electrical - Step-Up Transformer	Eliminate Transformer. Run a third wire from the water plant to the well house and run 208 V power for the whole distance.	$10,635	$25,000	5.94	2.4	42,243.5
6	Setback Thermostat: Apartments	Set back thermostat temperature in Apartments to 60 deg. F when unoccupied.	$613	$1,000	8.06	1.6	2,023.6
7	Setback Thermostat: Water Treatment Plant	Set back thermostat temperature in Apartments to 60 deg. F when unoccupied.	$523	$1,000	6.89	1.9	1,727.5
8	Lighting - Hallway Lights	Replace with new energy-efficient LED lighting.	$33	$80	4.67	2.5	127.9
9	Lighting - Garage Bay Lights	Replace with new energy-efficient LED lighting.	$607	$1,600	4.33	2.6	2,393.5
10	Air Tightening	Insulate around garage doors and windows to prevent air leakage.	$223	$500	4.07	2.2	734.3
11	Other Electrical - Step-Down Transformer	Eliminate Transformer. Run a third wire from the water plant to the well house and run 208 V power for the whole distance.	$3,857	$15,000	3.48	3.9	15,732.1

PRIORITY LIST – ENERGY EFFICIENCY MEASURES							
Rank	Feature	Improvement Description	Annual Energy Savings	Installed Cost	Savings to Investment Ratio, SIR[1]	Simple Payback (Years)[2]	CO_2 Savings
12	Heating, Ventilation, and Domestic Hot Water	Clean and tune Boiler #1, Operate both boilers evenly to prevent extra wear and tear from damaging the system. Add roof caps to prevent backdraft into the boilers from the outside.	$2,297	$17,500	2.28	7.6	7,251.5
13	Lighting - Office Closet Light	Replace with new energy-efficient LED lighting.	$19	$100	2.17	5.1	78.4
14	Lighting - WST Room Lights	Replace with new energy-efficient LED lighting.	$24	$150	1.76	6.3	95.6
15	Lighting - Apartment Bedroom 2 + 3 Lights	Replace with new energy-efficient LED lighting.	$39	$300	1.43	7.7	158.9
16	Lighting - Hallway Lights	Replace with new energy-efficient LED lighting.	$9	$80	1.21	9.2	35.0
17	Lighting - WTP Room Lights	Replace with new energy-efficient LED lighting.	$69	$640	1.21	9.3	279.5
18	Window/Skylight: Bedroom 2 Broken Window	Replace existing window with triple pane window.	$69	$1,012	1.13	14.8	226.7
19	Lighting - Apartment Entryway Lights	Replace with new energy-efficient LED lighting.	$15	$160	1.01	10.9	60.0
20	Lighting - Apartment Main Area Lights	Replace with new energy-efficient LED lighting.	$51	$560	1.01	10.9	210.0
21	Lighting - Office Lights	Replace with new energy-efficient LED lighting.	$17	$240	0.78	14.3	67.9
22	Lighting - Boiler Room Lights	Replace with new energy-efficient LED lighting.	$28	$400	0.78	14.3	113.0
23	Lighting - Garage Shop Lights	Replace with new energy-efficient LED lighting.	$17	$320	0.60	18.6	69.5
24	Lighting - Apartment Restroom Lights	Replace with new energy-efficient LED lighting.	$19	$400	0.53	20.8	78.9
25	Window/Skylight: Shop Windows	Replace existing window with triple pane window.	$64	$2,025	0.53	31.8	209.9
26	Lighting - Apartment Kitchen Lights	Replace with new energy-efficient LED lighting.	$7	$160	0.50	21.9	29.9

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**
27	Lighting - Apartment Bedroom 1 Lights	Replace with new energy-efficient LED lighting.	$7	$160	0.50	21.9	29.9
28	Ceiling w/ Attic: Roof	Add R-11 fiberglass batts to attic with Standard Truss.	$145	$9,213	0.36	63.4	480.3
29	Lighting - Restroom Lights	Replace with new energy-efficient LED lighting.	$4	$160	0.30	37.0	17.5
30	Window/Skylight: Bedroom Windows	Replace existing window with triple pane window.	$43	$3,037	0.24	70.0	143.0
31	Window/Skylight: Office Windows	Replace existing window with triple pane window.	$19	$2,025	0.16	104.1	63.9
32	Window/Skylight: Apartment Living Room Windows	Replace existing window with triple pane window.	$29	$3,037	0.16	104.5	95.5
	TOTAL, all measures		**$44,925**	**$97,859**	**6.74**	**2.2**	**162,143.2**

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 $44,925 per year, or 60.3% of the buildings' total energy costs. These measures are estimated to cost $97,859, for an overall simple payback period of 2.2 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**	**Lighting**	**Refrigeration**	**Other Electrical**	**Raw Water Heat Add**	**Water Circulation Heat**	**Tank Heat**	**Total Cost**
Existing Building	-$308	$2,293	$2,967	$496	$36,123	$6,286	$20,885	$5,741	**$74,543**
With Proposed Retrofits	$3,731	$2,439	$1,789	$528	$6,300	$3,354	$8,050	$3,365	**$29,618**
Savings	-$4,040	-$146	$1,177	-$32	$29,823	$2,932	$12,835	$2,376	**$44,925**

2. AUDIT AND ANALYSIS BACKGROUND

2.1 Program Description

This audit included services to identify, develop, and evaluate energy efficiency measures at the Quinhagak Water Treatment Plant. The scope of this project included evaluating building shell, lighting and other electrical systems, and heating and ventilation equipment, motors and pumps. Measures were analyzed based on life-cycle-cost techniques, which include the initial cost of the equipment, life of the equipment, annual energy cost, annual maintenance cost, and a discount rate of 3.0%/year in excess of general inflation.

2.2 Audit Description

Preliminary audit information was gathered in preparation for the site survey. The site survey provides critical information in deciphering where energy is used and what opportunities exist within a building. The entire site was surveyed to inventory the following to gain an understanding of how each building operates:

- Building envelope (roof, windows, etc.)
- Heating and ventilation equipment
- Lighting systems and controls
- Building-specific equipment
- Water consumption, treatment (optional) & disposal

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

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

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

1) Water Treatment Plant: 1,953 square feet
2) Apartments: 945 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. Quinhagak Water Treatment Plant

3.1. Building Description

The 2,898 square foot Quinhagak Water Treatment Plant was constructed in 1996, with a normal occupancy of 3 people. The number of hours of operation for this building average 6.1 hours per day, considering all seven days of the week.

The Quinhagak Water Treatment Plant serves as the water intake and filtration center for the residents of the community and houses all the components for the raw water intake system and the diatomaceous earth (DE) filtration system. The plant also houses the East Water Distribution Loop that originates from the Utility Building and serves the eastern part of town after being heated again at the water treatment plant. The Quinhagak Water Treatment Plant also houses a large apartment in the upstairs portion of the building.

The Quinhagak Water Treatment Plant has one distribution loop that provides service to the east side of the community. The loop is approximately 12,950 ft. long with the total distance including the sections from the utility building to the water treatment plant.

Water is pumped into the water plant from the Kanektok River approximately 2100 feet from the building through a separate intake building. The raw water enters the water treatment plant and is processed through the DE filtration system. The filtration system has two standing units that each contain many individual compartments. These compartments are filled with a chemical compound that is composed of many diatoms, an organic substance that that is ground into a sedimentary composite material. Water is passed through all of these compartments, which act like a natural filter, to get treated before the chemical injection point. Chlorine is then added to the water before it gets pumped into the 45,000 gallon water storage tank. This tank serves as the primary water storage for the east side of town and also as the initial storage for treated water before it gets transferred to the Utility Building.

Description of Building Shell

The exterior walls are constructed with single stud 2X8 timber construction with 7.5 inches of fiberglass batt insulation. There is also approximately 1.5 inches of rigid foam board insulation over the wall studs. The insulation is slightly damaged and there is approximately 2,784 square feet of wall space in the building.

The building has a sloped roof that is built BCI joists and 16-inch spacing. The roof is insulated with a combination of R38 and R19 fiberglass batt insulation. The insulation is slightly damaged and there is approximately 2,227 square feet of roof space on the building.

The building is built on grade with a gravel pad foundation. There is approximately 1,953 square feet of floor space in the shell of the building.

There are two windows in the garage area that are single-paned with wood framing. These windows are both 34x37 inches. There are two windows in the office that are both double-paned with wood framing. These windows are both 34x37 inches. The apartment has four windows that are each 34x34 inches, three of which are in the main area and one which is in bedroom 2. These windows are double-paned and have wood framing. The bedrooms each have a single window that is double-paned and approximately 24x48 inches. The window in bedroom 2 is broken.

There are four entrances into the building. The main entry is a single metal door with an insulated core that is approximately 3x7 ft. in dimension. The back door is also a single metal door with an insulated core that is approximately 3x7 ft. in dimension. The boiler room has a set of wooden double-doors. Each of these doors is approximately 3x7 ft. in dimension. The shop has a set of wooden double-doors with large leaks through the bottom of the entrance. These doors are approximately 4x7 ft. in dimension.

<u>Description of Heating Plants</u>

The heating plants used in the building are:

Boiler 1

Nameplate Information:	Weil Mclain A/B-W60-9
Fuel Type:	#1 Oil
Input Rating:	259,000 BTU/hr
Steady State Efficiency:	50 % (approximate)
Idle Loss:	1.5 %
Heat Distribution Type:	Water
Boiler Operation:	Oct - May
Notes:	This boiler has not been in operation for a long time. The nozzle head is not properly sized and there has been too much soot in the system to allow it to effectively fire.

Boiler 2

Fuel Type:	#1 Oil
Input Rating:	259,000 BTU/hr
Steady State Efficiency:	70 % (approximate)
Idle Loss:	1.5 %
Heat Distribution Type:	Water
Boiler Operation:	All Year

Apartment Hot Water Heater

Fuel Type:	Electricity
Input Rating:	0 BTU/hr
Steady State Efficiency:	95 % (approximate)
Idle Loss:	1.5 %
Heat Distribution Type:	Water
Boiler Operation:	All Year

The boilers are used to heat the glycol distribution loop that heats the building and the east loop. The apartment hot water heater is used occasionally when there are people staying in the apartments. It is dedicated to the kitchen, restroom, and clothes washer in the apartment.

<u>Space Heating Distribution Systems</u>

The building has four unit heaters that are used to provide space heat to the water treatment plant. One unit heater is in the boiler room and produces approximately 5000 BTU/h of heat. Two unit heaters are in the main water treatment plant room and they each produce approximately 10,000 BTU/hr of heat. The garage has one large unit heater that produces approximately 20,000 BTU/hr of heat.

The apartment is heated primarily through the use of baseboard heating.

The glycol distribution pump that is used to circulate the heated glycol from the boiler throughout the building is a Grundfos 65-160 that uses approximately 1,550 Watts when in the highest speed setting. This operates anytime there is a demand for heat.

<u>Domestic Hot Water System</u>

The apartment uses hot water for the kitchen and showers whenever there is an occupant staying there. The only other hot water use is for the single rest room in the water treatment plant space. The water is heated with a GE SmartWater indirect-fire hot water heater with a 4500/3380 Watt rating.

<u>Lighting</u>

The office has three fixtures with two T8 4ft. fluorescent light bulbs in each fixture. These lights operate when the operators are in the building and consume approximately 258 kWh annually.

The office has a storage closet with a standard 60 Watt incandescent light bulb that uses approximately 78 kWh annually.

The rest room has two fixtures with two T8 4ft. fluorescent light bulbs in each fixture. These lights consume approximately 66 kWh annually.

The main hallway has two fixtures that are on throughout the day when the operators are in the building. One fixture has two T8 4ft. fluorescent light bulbs and consumes approximately 132 kWh annually. The other fixture has two T12 4ft. fluorescent light bulbs and consumes approximately 188 kWh annually.

The garage has four fixtures with two T8 4ft. fluorescent light bulbs in each fixture. The fixtures are on approximately 50% of the time throughout the days when the operator is in the building and consume approximately 264 kWh annually. The garage also has four high bay fixtures with metal halide high bay lights that are each rated for 400 Watts. These lights are on the same switch as the fluorescent lights and consume approximately 2,328 kWh annually.

The main water treatment plant room has eight fixtures with two T8 4ft. fluorescent light bulbs in each fixture. The lights are on all day when the operators are in the building and consume approximately 1,057 kWh annually.

The alcove with the water storage tank components has two fixtures with standard 60 Watt incandescent light bulbs that consume approximately 110 kWh annually.

The boiler room has five fixtures with two T8 4ft. fluorescent light bulbs in each fixture. The lights are on periodically throughout the day when the operators are in the building and consume approximately 430 kWh annually.

The apartment main area and entryway combine to have nine fixtures with two T8 4ft. fluorescent light bulbs in each fixture. The lights are used only when the apartment is occupied and consume approximately 649 kWh annually.

The apartment kitchen has two fixtures with two T8 4ft. fluorescent light bulbs in each fixture that consume approximately 81 kWh annually.

The apartment rest room has four fixtures with standard 60 Watt incandescent light bulbs that consume approximately 85 kWh annually.

The apartment bedroom 1 has two fixtures with two T8 4ft. fluorescent light bulbs in each fixture that consumes approximately 81 kWh annually.

The apartment bedrooms 2 & 3 combine to have four fixtures with standard 60 watt incandescent light bulbs that consume approximately 169 kWh annually.

The well house has two fixtures with fluorescent 20 Watt light bulbs that consume 104 kWh annually.

Plug Loads

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

Major Equipment

There are two heat-add pumps for the raw water intake that are used to heat the raw water as it enters the building. One of the pumps operates constantly during the heating months from November through May and they consume approximately 3000 kWh annually.

There is a high pressure pump in the water treatment plant that is used to circulate the water in high demand times. The pump operates minimally throughout the year and consumes approximately 978 kWh annually.

There are two pumps in the DE filtration system that are used to circulate the water during the filtration process. One of the pumps operates whenever the filtration system is used and consumes approximately 3287 kWh annually.

There is a pressure pump in the water treatment plant that is used to boost the system pressure during standard operations. The pump does operate very often and consumes approximately 90 kWh annually.

There is a mini-freezer in the office that is constantly plugged in and uses approximately 1,709 kWh annually.

There are two heat tapes that are used to thaw the raw water intake line between the well house and the water treatment plant building. Both heat tapes run constantly throughout the heating season from November through May and they combine to consume approximately 22,476 kWh annually.

There is a step-up transformer in the boiler room that is used to transform single-phase power to three-phase for use by equipment in the building. The transformed power is also sent to the intake building for use by the equipment in that building. The transformer is rated for 25 kVa and was measured to have 20.8 A transformed with only 7 A being used. The remaining difference is excess power that consumes approximately 29,629 kWh annually.

There is a step down transformer in the intake building that is used to transform the incoming three-phase power from the water plant into single phase power that can be used by the equipment in the intake building. The transformer is rated for 15 kVa and transforms approximately 13 A with 7 A being used. The remaining difference is excess power that consumes approximately 12,711 kWh annually.

The apartment has a clothes washer that is used occasionally whenever somebody is saying in the apartment. The washer uses approximately 101 kWh annually.

The apartment has an electric clothes dryer that is used occasionally whenever somebody is staying in the apartment. The dryer uses approximately 704 kWh annually.

The apartment has a microwave that is used occasionally whenever somebody is staying in the apartment. The microwave uses approximately 438 kWh annually.

The apartment has two refrigerator/freezer units that are in constant operation and use approximately 1,030 kWh annually.

3.2 Predicted Energy Use

3.2.1 Energy Usage / Tariffs

The electric usage profile charts (below) represents the predicted electrical usage for the building. If actual electricity usage records were available, the model used to predict usage was calibrated to approximately match actual usage. The electric utility measures consumption in kilowatt-hours (kWh) 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 to the residents of Quinhagak as well as all the commercial and public facilities.

The average cost for each type of fuel used in this building is shown below in Table 3.1. This figure includes all surcharges, subsidies, and utility customer charges:

Table 3.1: Energy Rates for each Fuel Source

Average Energy Cost	
Description	**Average Energy Cost**
Electricity	$ 0.48/kWh
#1 Oil	$ 6.70/gallons

3.2.1.1 Total Energy Use and Cost Breakdown

At current rates, City of Quinhagak pays approximately $74,947 annually for electricity and other fuel costs for the Quinhagak Water Treatment Plant.

Figure 3.1 below reflects the estimated distribution of costs across the primary end uses of energy based on the AkWarm© computer simulation. Comparing the “Retrofit” bar in the figure to the “Existing” bar shows the potential savings from implementing all of the energy efficiency measures shown in this report.

Figure 3.1 below reflects the estimated distribution of costs across the primary end uses of energy based on the AkWarm© computer simulation. Comparing the “Retrofit” bar in the figure to the “Existing” bar shows the potential savings from implementing all of the energy efficiency measures shown in this report.

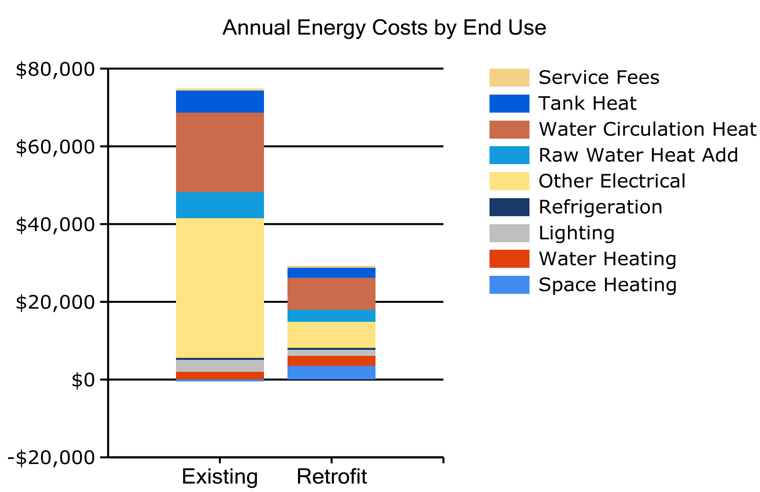


Figure 3.1: Annual Energy Costs by End Use

Figure 3.2 below shows how the annual energy cost of the building splits between the different fuels used by the building. The “Existing” bar shows the breakdown for the building as it is now; the

“Retrofit” bar shows the predicted costs if all of the energy efficiency measures in this report are implemented.

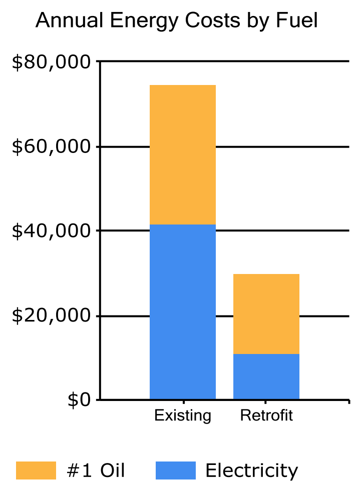


Figure 3.2: Annual Energy Costs by Fuel Type

Figure 3.3 below addresses only Space Heating costs. The figure shows how each heat loss component contributes to those costs; for example, the figure shows how much annual space heating cost is caused by the heat loss through the Walls/Doors. For each component, the space heating cost for the Existing building is shown (blue bar) and the space heating cost assuming all retrofits are implemented (yellow bar) are shown.

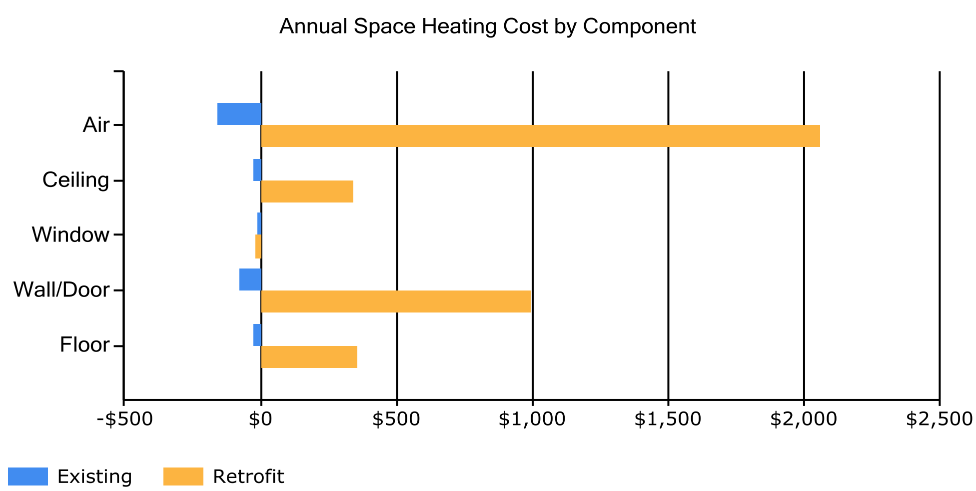


Figure 3.3: Annual Space Heating Cost by Component

The tables below show AkWarm’s estimate of the monthly fuel use for each of the fuels used in the building. For each fuel, the fuel use is broken down across the energy end uses. Note, in the tables below “DHW” refers to Domestic Hot Water heating.

Table 3.2: Electrical Consumption by Category

Electrical Consumption (kWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space Heating	-55	-85	-170	-267	-298	-288	-298	-298	-288	-269	-171	-41
DHW	404	368	404	391	404	391	404	404	391	404	391	404
Lighting	523	477	523	506	523	506	523	523	506	523	506	523
Refrigeration	87	80	87	85	87	85	87	87	85	87	85	87
Other Electrical	8019	7308	8019	7760	6186	4324	4469	4469	4324	4469	7760	8019
Raw Water Heat Add	73	66	72	67	33	0	0	0	1	4	69	73
Water Circulation Heat	161	146	158	147	75	4	2	3	6	13	151	162
Tank Heat	8	7	7	4	2	0	0	0	1	4	6	8

Table 3.3: Fuel Oil Consumption by Category

Fuel Oil #1 Consumption (Gallons)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space Heating	42	29	10	0	0	0	0	0	0	0	9	46
Raw Water Heat Add	159	137	132	81	34	0	0	0	13	75	113	161
Water Circulation Heat	443	387	384	270	166	98	61	67	121	260	339	448
Tank Heat	147	127	123	77	35	4	0	0	16	72	105	149

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):

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

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

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

Table 3.4: Quinhagak Water Treatment 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	86,082 kWh	293,797	3.340	981,281
#1 Oil	4,939 gallons	651,916	1.010	658,435
Total		**945,712**		**1,639,716**
BUILDING AREA		2,898	Square Feet	
BUILDING SITE EUI		326	kBTU/Ft²/Yr	
BUILDING SOURCE EUI		566	**kBTU/Ft²/Yr**	
* Site - Source Ratio data is provided by the Energy Star Performance Rating Methodology for Incorporating Source Energy Use document issued March 2011.				

Table 3.5: Quinhagak Water Treatment Plant Building Benchmarks

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	**326.3**	**26.95**	**$25.72**
With Proposed Retrofits	**152.9**	**12.63**	**$10.22**
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 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 Quinhagak Water Treatment Plant was modeled using AkWarm© energy use software to establish a baseline space heating energy usage. Climate data from Quinhagak 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 Quinhagak. This data represents the average ambient weather profile as observed over approximately 30 years. As such, the fuel oil 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: Recommended Energy Efficiency Measures Ranked by Economic Benefit

Quinhagak Water Treatment Plant, Quinhagak, Alaska PRIORITY LIST – ENERGY EFFICIENCY MEASURES							
Rank	**Feature**	**Improvement Description**	**Annual Energy Savings**	**Installed Cost**	**Savings to Investment Ratio, SIR**	**Simple Payback (Years)**	**CO_2 Savings**
1	Heat Add Controls	East Loop water distribution heat-add controls are broken. Replace with new controls and lower setpoint to 38 deg. F. Use a Belimo modulating valve and a Honeywell T775 temperature controller to match the ARUC standard used in all of their communities.	$10,931	$3,000	63.05	0.3	34,758.3
2	Other Electrical - Raw Water Heat Tape	Two heat tapes on the raw water line operate all winter. Shut these off and use them only for emergency that purposes.	$10,059	$3,000	39.39	0.3	38,434.1

Quinhagak Water Treatment Plant, Quinhagak, Alaska PRIORITY LIST – ENERGY EFFICIENCY MEASURES							
Rank	**Feature**	**Improvement Description**	**Annual Energy Savings**	**Installed Cost**	**Savings to Investment Ratio, SIR**	**Simple Payback (Years)**	**CO_2 Savings**
3	Heat Add Controls	Raw water intake heat-add controls are broken. Replace with new controls and lower setpoint to 38 deg. F. Use a Belimo modulating valve and a Honeywell T775 temperature controller to match the ARUC standard used in all of their communities.	$2,483	$3,000	14.23	1.2	7,960.1
4	Heat Add Controls	Water storage tank heat-add controls are broken. Replace with new controls and lower setpoint to 40 deg. F. Use a Belimo modulating valve and a Honeywell T775 temperature controller to match the ARUC standard used in all of their communities.	$1,969	$3,000	11.43	1.5	6,213.4
5	Other Electrical - Step-Up Transformer	Eliminate Transformer. Run a third wire from the water plant to the well house and run 208 V power for the whole distance.	$10,635	$25,000	5.94	2.4	42,243.5
6	Setback Thermostat: Apartments	Set back thermostat temperature in Apartments to 60 deg. F when unoccupied.	$613	$1,000	8.06	1.6	2,023.6
7	Setback Thermostat: Water Treatment Plant	Set back thermostat temperature in Apartments to 60 deg. F when unoccupied.	$523	$1,000	6.89	1.9	1,727.5
8	Lighting - Hallway Lights	Replace with new energy-efficient LED lighting.	$33	$80	4.67	2.5	127.9
9	Lighting - Garage Bay Lights	Replace with new energy-efficient LED lighting.	$607	$1,600	4.33	2.6	2,393.5

Quinhagak Water Treatment Plant, Quinhagak, Alaska PRIORITY LIST – ENERGY EFFICIENCY MEASURES							
Rank	**Feature**	**Improvement Description**	**Annual Energy Savings**	**Installed Cost**	**Savings to Investment Ratio, SIR**	**Simple Payback (Years)**	**CO_2 Savings**
10	Air Tightening	Insulate around garage doors and windows to prevent air leakage.	$223	$500	4.07	2.2	734.3
11	Other Electrical - Step-Down Transformer	Eliminate Transformer. Run a third wire from the water plant to the well house and run 208 V power for the whole distance.	$3,857	$15,000	3.48	3.9	15,732.1
12	Heating, Ventilation, and Domestic Hot Water	Clean and tune Boiler #1, Operate both boilers evenly to prevent extra wear and tear from damaging the system. Add roof caps to prevent backdraft into the boilers from the outside.	$2,297	$17,500	2.28	7.6	7,251.5
13	Lighting - Office Closet Light	Replace with new energy-efficient LED lighting.	$19	$100	2.17	5.1	78.4
14	Lighting - WST Room Lights	Replace with new energy-efficient LED lighting.	$24	$150	1.76	6.3	95.6
15	Lighting - Apartment Bedroom 2 + 3 Lights	Replace with new energy-efficient LED lighting.	$39	$300	1.43	7.7	158.9
16	Lighting - Hallway Lights	Replace with new energy-efficient LED lighting.	$9	$80	1.21	9.2	35.0
17	Lighting - WTP Room Lights	Replace with new energy-efficient LED lighting.	$69	$640	1.21	9.3	279.5
18	Window/Skylight: Bedroom 2 Broken Window	Replace existing window with triple pane window.	$69	$1,012	1.13	14.8	226.7
19	Lighting - Apartment Entryway Lights	Replace with new energy-efficient LED lighting.	$15	$160	1.01	10.9	60.0
20	Lighting - Apartment Main Area Lights	Replace with new energy-efficient LED lighting.	$51	$560	1.01	10.9	210.0
21	Lighting - Office Lights	Replace with new energy-efficient LED lighting.	$17	$240	0.78	14.3	67.9
22	Lighting - Boiler Room Lights	Replace with new energy-efficient LED lighting.	$28	$400	0.78	14.3	113.0

Quinhagak Water Treatment Plant, Quinhagak, Alaska PRIORITY LIST – ENERGY EFFICIENCY MEASURES							
Rank	**Feature**	**Improvement Description**	**Annual Energy Savings**	**Installed Cost**	**Savings to Investment Ratio, SIR**	**Simple Payback (Years)**	**CO_2 Savings**
23	Lighting - Garage Shop Lights	Replace with new energy-efficient LED lighting.	$17	$320	0.60	18.6	69.5
24	Lighting - Apartment Restroom Lights	Replace with new energy-efficient LED lighting.	$19	$400	0.53	20.8	78.9
25	Window/Skylight: Shop Windows	Replace existing window with triple pane window.	$64	$2,025	0.53	31.8	209.9
26	Lighting - Apartment Kitchen Lights	Replace with new energy-efficient LED lighting.	$7	$160	0.50	21.9	29.9
27	Lighting - Apartment Bedroom 1 Lights	Replace with new energy-efficient LED lighting.	$7	$160	0.50	21.9	29.9
28	Ceiling w/ Attic: Roof	Add R-11 fiberglass batts to attic with Standard Truss.	$145	$9,213	0.36	63.4	480.3
29	Lighting - Restroom Lights	Replace with new energy-efficient LED lighting.	$4	$160	0.30	37.0	17.5
30	Window/Skylight: Bedroom Windows	Replace existing window with triple pane window.	$43	$3,037	0.24	70.0	143.0
31	Window/Skylight: Office Windows	Replace existing window with triple pane window.	$19	$2,025	0.16	104.1	63.9
32	Window/Skylight: Apartment Living Room Windows	Replace existing window with triple pane window.	$29	$3,037	0.16	104.5	95.5
	TOTAL, all measures		**$44,925**	**$97,859**	**6.74**	**2.2**	**162,143.2**

4.2 Interactive Effects of Projects

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

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

Interior lighting, plug loads, facility equipment, and occupants generate heat within the building. Lighting-efficiency improvements are anticipated to slightly increase heating requirements. Heating penalties benefits were included in the lighting project analysis.

4.3 Building Shell Measures

4.3.1 Insulation Measures

Rank	Location	Existing Type/R-Value	Recommendation Type/R-Value
28	Ceiling w/ Attic: Roof	Framing Type: Standard Framing Spacing: 16 inches Insulated Sheathing: None Bottom Insulation Layer: R-38 Batt:FG or RW, 12 inches Top Insulation Layer: R-19 Batt:FG or RW, 6 inches Insulation Quality: Damaged Modeled R-Value: 45.6	Add R-11 fiberglass batts to attic with Standard Truss.

Installation Cost	$9,213	**Estimated Life of Measure (yrs)**	30	**Energy Savings (/yr)**	$145
Breakeven Cost	$3,300	**Savings-to-Investment Ratio**	0.4	**Simple Payback yrs**	63

Auditors Notes: The roof is not insulated as well as it could be and as a result there is some heat lost through the top of the building. Adding insulation to the building will keep more heat into the building and reduce the overall heat demand.

4.3.2 Window Measures

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

Installation Cost	$1,012	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$69
Breakeven Cost	$1,148	**Savings-to-Investment Ratio**	1.1	**Simple Payback yrs**	15

Auditors Notes: This bedroom has a broken window with a fan blocking the exposed gap. Replace this window with a triple-paned window to prevent cold air leakage into the room. The window is approximately 2’x4’.

Rank	Location	Size/Type, Condition	Recommendation
25	Window/Skylight: Shop Windows	Glass: Single, 1/4" Acrylic/Polycarbonate Frame: Wood\Vinyl Spacing Between Layers: Half Inch Gas Fill Type: Air Modeled U-Value: 0.81 Solar Heat Gain Coefficient including Window Coverings: 0.48	Replace existing window with triple pane window.

Installation Cost	$2,025	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$64
Breakeven Cost	$1,070	**Savings-to-Investment Ratio**	0.5	**Simple Payback yrs**	32

Auditors Notes: The shop windows are single pane with a second pane appearing to be missing. Replace the two windows with triple pane windows for better insulation. Each window is 37”x37”.

Rank	Location	Size/Type, Condition	Recommendation
30	Window/Skylight: Bedroom Windows	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 window with triple pane window.

Installation Cost	$3,037	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$43
Breakeven Cost	$730	**Savings-to-Investment Ratio**	0.2	**Simple Payback yrs**	70

Auditors Notes: Replace the bedroom windows with triple pane windows for better insulation vs. air leakage. Each of the two windows is 2'x4'.

Rank	Location	Size/Type, Condition	Recommendation
31	Window/Skylight: Office Windows	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 window with triple pane window.

Installation Cost	$2,025	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$19
Breakeven Cost	$328	**Savings-to-Investment Ratio**	0.2	**Simple Payback yrs**	104

Auditors Notes: Replace the office windows with triple pane windows for better insulation vs. air leakage. Each of the two windows is 37"x34".

Rank	Location	Size/Type, Condition	Recommendation
32	Window/Skylight: Apartment Living Room Windows	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 window with triple pane window.

Installation Cost	$3,037	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$29
Breakeven Cost	$490	**Savings-to-Investment Ratio**	0.2	**Simple Payback yrs**	105

Auditors Notes: Replace the apartment windows with triple pane windows to prevent air leakage. Each of the four windows is approximately 34"x34".

4.3.3 Air Sealing Measures

Rank	**Location**	**Existing Air Leakage Level (cfm@50/75 Pa)**		**Recommended Air Leakage Reduction (cfm@50/75 Pa)**	
10		Air Tightness estimated as: 3000 cfm at 50 Pascals		Insulate around garage doors and windows to prevent air leakage.	
Installation Cost	$500	**Estimated Life of Measure (yrs)**	10	**Energy Savings (/yr)**	$223
Breakeven Cost	$2,033	**Savings-to-Investment Ratio**	4.1	**Simple Payback yrs**	2
Auditors Notes: These doors have large spaces around the edge that allows air infiltration and cool the room down noticeably. Place a cloth or insulating material on the door when not in use to keep the warm air from leaving the building.					

4.4 Mechanical Equipment Measures

4.4.1 Heating /Domestic Hot Water Measure

Rank	**Recommendation**				
12	Clean and tune Boiler #1, Operate both boilers evenly to prevent extra wear and tear from damaging the system. Add roof caps to prevent backdraft into the boilers from the outside.				
Installation Cost	$17,500	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$2,297
Breakeven Cost	$39,965	**Savings-to-Investment Ratio**	2.3	**Simple Payback yrs**	8
Auditors Notes: Boiler 1 is has not been in consistent operation for a while because of issues with the boiler stack and the firing rate. Boiler 1 needs the stack to be repaired, new firing guns, new controls, and general cleaning. Additionally, both boilers should have roof caps installed to reduce the draft from the exterior. This is expected to increase each boiler efficiency approximately 8-10%.					

4.4.2 Night Setback Thermostat Measures

Rank	**Building Space**			**Recommendation**	
6	Apartments			Set back thermostat temperature in Apartments to 60 deg. F when unoccupied.	
Installation Cost	$1,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$613
Breakeven Cost	$8,060	**Savings-to-Investment Ratio**	8.1	**Simple Payback yrs**	2
Auditors Notes: The apartments are not often used and can be set to 60 deg. F when unoccupied. Bedrooms 1 and 2 are located directly above the boiler room and are very warm. These rooms could use insulation to mitigate the hot air rising from the boiler room. A programmable thermostat can be installed to accomplish this.					

Rank	**Building Space**			**Recommendation**	
7	Water Treatment Plant			Set back thermostat temperature in Apartments to 60 deg. F when unoccupied.	
Installation Cost	$1,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$523
Breakeven Cost	$6,892	**Savings-to-Investment Ratio**	6.9	**Simple Payback yrs**	2
Auditors Notes: The water treatment plant can have a programmable thermostat installed and the temperature lowered to 60 deg. F when the plant is not occupied.					

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	
8	Hallway Fixture 1		FLUOR (2) T12 4' F40T12 40W Standard StdElectronic		Replace with new energy-efficient LED lighting.	
Installation Cost		$80	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$33
Breakeven Cost		$374	**Savings-to-Investment Ratio**	4.7	**Simple Payback yrs**	2
Auditors Notes: Replace existing fluorescent light fixtures with LED 17 Watt 4ft. equivalents. This room has one fixture with four lights for a total of 4 bulbs to be replaced.						

Rank	Location		Existing Condition		Recommendation	
9	Garage Bay Lights		4 MH 400 Watt StdElectronic		Replace with new energy-efficient LED lighting.	
Installation Cost		$1,600	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$607
Breakeven Cost		$6,933	**Savings-to-Investment Ratio**	4.3	**Simple Payback yrs**	3
Auditors Notes: Replace existing metal halide light fixtures with high bay LED fixtures with four 25Watt bulbs in each fixture. This will replace the four high bay lights with four fixtures with five lights each for a total of 20 new light bulbs.						

Rank	Location		Existing Condition		Recommendation	
13	Office Closet Light		INCAN A Lamp, Std 60W		Replace with new energy-efficient LED lighting.	
Installation Cost		$100	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$19
Breakeven Cost		$217	**Savings-to-Investment Ratio**	2.2	**Simple Payback yrs**	5
Auditors Notes: Replace existing incandescent fixture with LED 12 Watt equivalents. This room has one bulb to be replaced.						

Rank	Location		Existing Condition		Recommendation	
14	WST Room Lights		2 INCAN A Lamp, Halogen 60W		Replace with new energy-efficient LED lighting.	
Installation Cost		$150	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$24
Breakeven Cost		$264	**Savings-to-Investment Ratio**	1.8	**Simple Payback yrs**	6
Auditors Notes: Replace existing incandescent light fixtures with LED 12 Watt equivalents. This room has two light bulbs to be replaced.						

Rank	Location		Existing Condition		Recommendation	
15	Apartment Bedroom 2 + 3 Lights		4 INCAN A Lamp, Halogen 60W		Replace with new energy-efficient LED lighting.	
Installation Cost		$300	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$39
Breakeven Cost		$428	**Savings-to-Investment Ratio**	1.4	**Simple Payback yrs**	8
Auditors Notes: Replace existing incandescent light fixtures with LED 12 Watt equivalents. This rooms have four light bulbs to be replaced.						

Rank	Location	Existing Condition		Recommendation	
16	Hallway Fixture 2	FLUOR (2) T8 4' F32T8 28W Energy-Saver Instant StdElectronic		Replace with new energy-efficient LED lighting.	
Installation Cost	$80	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$9
Breakeven Cost	$97	**Savings-to-Investment Ratio**	1.2	**Simple Payback yrs**	9
Auditors Notes: Replace existing fluorescent light fixtures with LED 17 Watt 4ft. equivalents. This room has one fixture with two lights for a total of two bulbs to be replaced.					

Rank	Location	Existing Condition		Recommendation	
17	WTP Room Lights	8 FLUOR (2) T8 4' F32T8 28W Energy-Saver Instant StdElectronic		Replace with new energy-efficient LED lighting.	
Installation Cost	$640	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$69
Breakeven Cost	$771	**Savings-to-Investment Ratio**	1.2	**Simple Payback yrs**	9
Auditors Notes: Replace existing fluorescent light fixtures with LED 17 Watt 4ft. equivalents. This room has eight fixtures with two lights for a total of 16 bulbs to be replaced.					

Rank	Location	Existing Condition		Recommendation	
19	Apartment Entryway Lights	2 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic		Replace with new energy-efficient LED lighting.	
Installation Cost	$160	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$15
Breakeven Cost	$161	**Savings-to-Investment Ratio**	1.0	**Simple Payback yrs**	11
Auditors Notes: Replace existing fluorescent light fixtures with LED 17 Watt 4ft. equivalents. This room has two fixtures with two lights for a total of four bulbs to be replaced.					

Rank	Location	Existing Condition		Recommendation	
20	Apartment Main Area Lights	7 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic		Replace with new energy-efficient LED lighting.	
Installation Cost	$560	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$51
Breakeven Cost	$565	**Savings-to-Investment Ratio**	1.0	**Simple Payback yrs**	11
Auditors Notes: Replace existing fluorescent light fixtures with LED 17 Watt 4ft. equivalents. This room has seven fixtures with two lights for a total of 14 bulbs to be replaced.					

Rank	Location	Existing Condition		Recommendation	
21	Office Lights	3 FLUOR (2) T8 4' F32T8 28W Energy-Saver Instant StdElectronic		Replace with new energy-efficient LED lighting.	
Installation Cost	$240	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$17
Breakeven Cost	$187	**Savings-to-Investment Ratio**	0.8	**Simple Payback yrs**	14
Auditors Notes: Replace existing fluorescent light fixtures with LED 17 Watt 4ft. equivalents. This room has three fixtures with two lights for a total of six bulbs to be replaced.					

Rank	Location	Existing Condition		Recommendation	
22	Boiler Room Lights	5 FLUOR (2) T8 4' F32T8 28W Energy-Saver Instant StdElectronic		Replace with new energy-efficient LED lighting.	
Installation Cost	$400	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$28
Breakeven Cost	$311	**Savings-to-Investment Ratio**	0.8	**Simple Payback yrs**	14
Auditors Notes: Replace existing fluorescent light fixtures with LED 17 Watt 4ft. equivalents. This room has five fixtures with two lights for a total of ten bulbs to be replaced.					

Rank	Location	Existing Condition		Recommendation	
23	Garage Shop Lights	4 FLUOR (2) T8 4' F32T8 28W Energy-Saver Instant StdElectronic		Replace with new energy-efficient LED lighting.	
Installation Cost	$320	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$17
Breakeven Cost	$191	**Savings-to-Investment Ratio**	0.6	**Simple Payback yrs**	19
Auditors Notes: Replace existing fluorescent light fixtures with LED 17 Watt 4ft. equivalents. This room has four fixtures with two lights for a total of eight bulbs to be replaced.					

Rank	Location	Existing Condition		Recommendation	
24	Apartment Restroom Lights	4 INCAN A Lamp, Halogen 60W		Replace with new energy-efficient LED lighting.	
Installation Cost	$400	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$19
Breakeven Cost	$212	**Savings-to-Investment Ratio**	0.5	**Simple Payback yrs**	21
Auditors Notes: Replace existing incandescent light fixtures with LED 12 Watt equivalents. This room has four light bulbs to be replaced.					

Rank	Location	Existing Condition		Recommendation	
26	Apartment Kitchen Lights	2 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic		Replace with new energy-efficient LED lighting.	
Installation Cost	$160	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$7
Breakeven Cost	$80	**Savings-to-Investment Ratio**	0.5	**Simple Payback yrs**	22
Auditors Notes: Replace existing fluorescent light fixtures with LED 17 Watt 4ft. equivalents. This room has two fixtures with two lights for a total of four bulbs to be replaced.					

Rank	Location	Existing Condition		Recommendation	
27	Apartment Bedroom 1 Lights	2 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic		Replace with new energy-efficient LED lighting.	
Installation Cost	$160	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$7
Breakeven Cost	$80	**Savings-to-Investment Ratio**	0.5	**Simple Payback yrs**	22
Auditors Notes: Replace existing fluorescent light fixtures with LED 17 Watt 4ft. equivalents. The rooms have two fixtures with two lights for a total of four bulbs to be replaced.					

Rank	Location	Existing Condition		Recommendation	
29	Restroom Lights	2 FLUOR (2) T8 4' F32T8 28W Energy-Saver Instant StdElectronic		Replace with new energy-efficient LED lighting.	
Installation Cost	$160	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$4
Breakeven Cost	$48	**Savings-to-Investment Ratio**	0.3	**Simple Payback yrs**	37
Auditors Notes: Replace existing fluorescent light fixtures with LED 17 Watt 4ft. equivalents. This room has two fixtures with two lights for a total of four bulbs to be replaced.					

4.5.2 Other Electrical Measures

Rank	Location	Description of Existing		Efficiency Recommendation	
2	Raw Water Heat Tape	2 Raw Water Heat Tape		Shut off heat tapes and use only for emergency thaw purposes.	
Installation Cost	$3,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$10,059
Breakeven Cost	$118,158	**Savings-to-Investment Ratio**	39.4	**Simple Payback yrs**	0
Auditors Notes: Both heat tapes are in operation throughout the winter when only one should be used at att. The use of the heat tapes is constant as they believe the heat add cannot keep the intake line completely protected vs. freezing. Shut off heat tapes during the winter and determine solutions to insure the line stays clear.					

Rank	Location	Description of Existing		Efficiency Recommendation	
5	Water Treatment Plant Building – Boiler Room	Step-Up Transformer		Eliminate Transformer. Run a third wire from the water plant to the well house and run 208 V power for the whole distance.	
Installation Cost	$25,000	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$10,635
Breakeven Cost	$148,621	**Savings-to-Investment Ratio**	5.9	**Simple Payback yrs**	2
Auditors Notes: The transformers in the water treatment plant and well house are only used to convert the power into three phase power to transport the electricity between the two buildings. As a result, there is a large amount of wasted electricity due to the transformer operation. Removing the transformers and installing a third wire to accommodate three-phase power will lower the electricity load of the transformers and prevent unnecessary waste.					

Rank	Location	Description of Existing		Efficiency Recommendation	
11	Well House Building	Step-Down Transformer		Eliminate Transformer. Run a third wire from the water plant to the well house and run 208 V power for the whole distance.	
Installation Cost	$15,000	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$3,857
Breakeven Cost	$52,158	**Savings-to-Investment Ratio**	3.5	**Simple Payback yrs**	4
Auditors Notes: The transformers in the water treatment plant and well house are only used to convert the power into three phase power to transport the electricity between the two buildings. As a result, there is a large amount of wasted electricity due to the transformer operation. Removing the transformers and installing a third wire to accommodate three-phase power will lower the electricity load of the transformers and prevent unnecessary waste.					

4.5.3 Other Measures

Rank	Location	Description of Existing		Efficiency Recommendation	
1	East Loop	East Loop Circulation		Controls are broken. Replace with new controls and lower set point to 38 deg. F. Use a Belimo modulating valve and a Honeywell T775 temperature controller to match the ARUC standard used in all of their communities.	
Installation Cost	$3,000	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$10,931
Breakeven Cost	$189,135	**Savings-to-Investment Ratio**	63.0	**Simple Payback yrs**	0
Auditors Notes: The controls would not function and the plant is heating the water constantly to a temperature around 58 deg. F. Specifically, the actuator for the heat-add system would not initiate when the control set points were adjusted. Replace the existing controls with a new Honeywell module and set the temperature to 38 deg. F.					

Rank	Location	Description of Existing		Efficiency Recommendation	
3	Raw Water Intake	Raw Water Heat Add Load		Controls are broken. Replace with new controls and lower set point to 38 deg. F. Use a Belimo modulating valve and a Honeywell T775 temperature controller to match the ARUC standard used in all of their communities.	
Installation Cost	$3,000	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$2,483
Breakeven Cost	$42,678	**Savings-to-Investment Ratio**	14.2	**Simple Payback yrs**	1
Auditors Notes: The controls would not function and the plant is heating he water constantly to a temperature around 53 deg. F. Specifically, the actuator for the heat-add system would not initiate when the control set points were adjusted. Replace the existing controls with a new Honeywell module and set the temperature to 38 deg. F.					

Rank	Location	Description of Existing		Efficiency Recommendation	
4	Water Storage Tank	45,000 Gallon Water Storage Tank		Controls are broken. Replace with new controls and lower setpoint to 40 deg. F. Use a Belimo modulating valve and a Honeywell T775 temperature controller to match the ARUC standard used in all of their communities.	
Installation Cost	$3,000	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$1,969
Breakeven Cost	$34,282	**Savings-to-Investment Ratio**	11.4	**Simple Payback yrs**	2
Auditors Notes: The controls would not function and the plant is heating he water constantly to a temperature around 49 deg. F. Specifically, the actuator for the heat-add system would not initiate when the control set points were adjusted. Replace the existing controls with a new Honeywell module and set the temperature to 40 deg. F.					

5. ENERGY EFFICIENCY ACTION PLAN

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

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

In the near future, a representative of ANTHC will be contacting both the City of Quinhagak and the water treatment plant operators to follow up on the recommendations made in this report. ANTHC will assist the community in searching for funds to perform the retrofits recommended in this report.

APPENDICES

Appendix A – Energy Audit Report – Project Summary

ENERGY AUDIT REPORT – PROJECT SUMMARY	
General Project Information	
PROJECT INFORMATION	**AUDITOR INFORMATION**
Building: Quinhagak Water Treatment Plant	**Auditor Company:** ANTHC-DEHE
Address: PO Box 90	**Auditor Name:** Kevin Ulrich and Chris Mercer
City: Quinhagak	**Auditor Address:** 4500 Diplomacy Dr., Anchorage, AK 99508
Client Name: Frank Jones & Patrick Cleveland	
Client Address:	**Auditor Phone:** (907) 729-3237
	Auditor FAX:
Client Phone: (907) 556-2181	**Auditor Comment:**
Client FAX:	
Design Data	
Building Area: 2,898 square feet	**Design Space Heating Load:** Design Loss at Space: 19,054 Btu/hour with Distribution Losses: 20,057 Btu/hour Plant Input Rating assuming 82.0% Plant Efficiency and 25% Safety Margin: 30,575 Btu/hour Note: Additional Capacity should be added for DHW and other plant loads, if served.
Typical Occupancy: 3 people	**Design Indoor Temperature:** 66.6 deg F (building average)
Actual City: Quinhagak	**Design Outdoor Temperature:** -24.1 deg F
Weather/Fuel City: Quinhagak	**Heating Degree Days:** 12,107 deg F-days
Utility Information	
Electric Utility: AVEC-Quinhagak - Commercial - Sm	**Average Annual Cost/kWh:** $0.48/kWh

Annual Energy Cost Estimate

Description	Space Heating	Water Heating	Lighting	Refrigeration	Other Electrical	Raw Water Heat Add	Water Circulation Heat	Tank Heat	Total Cost
Existing Building	-$308	$2,293	$2,967	$496	$36,123	$6,286	$20,885	$5,741	**$74,543**
With Proposed Retrofits	$3,731	$2,439	$1,789	$528	$6,300	$3,354	$8,050	$3,365	**$29,618**
Savings	-$4,040	-$146	$1,177	-$32	$29,823	$2,932	$12,835	$2,376	**$44,925**

Building Benchmarks

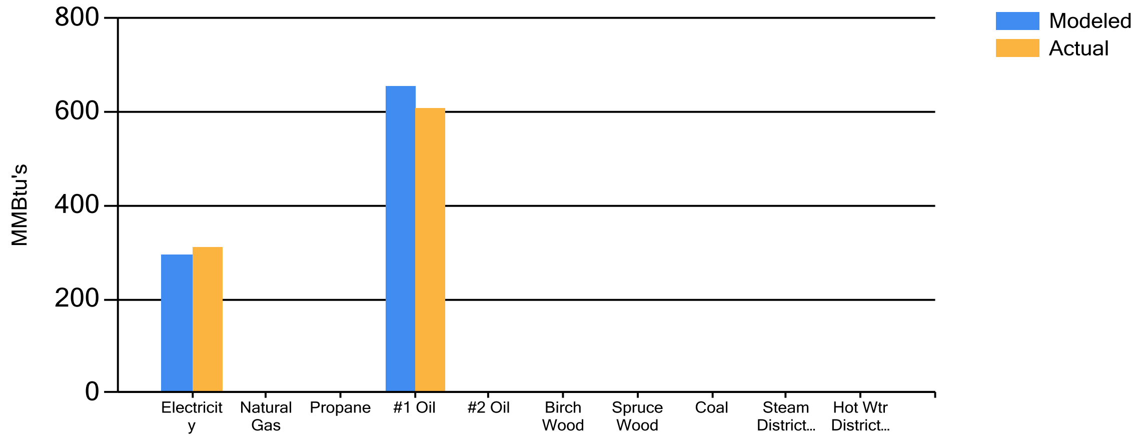
Description	EUI (kBtu/Sq.Ft.)	EUI/HDD (Btu/Sq.Ft./HDD)	ECI ($/Sq.Ft.)
Existing Building	326.3	26.95	$25.72
With Proposed Retrofits	152.9	12.63	$10.22

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

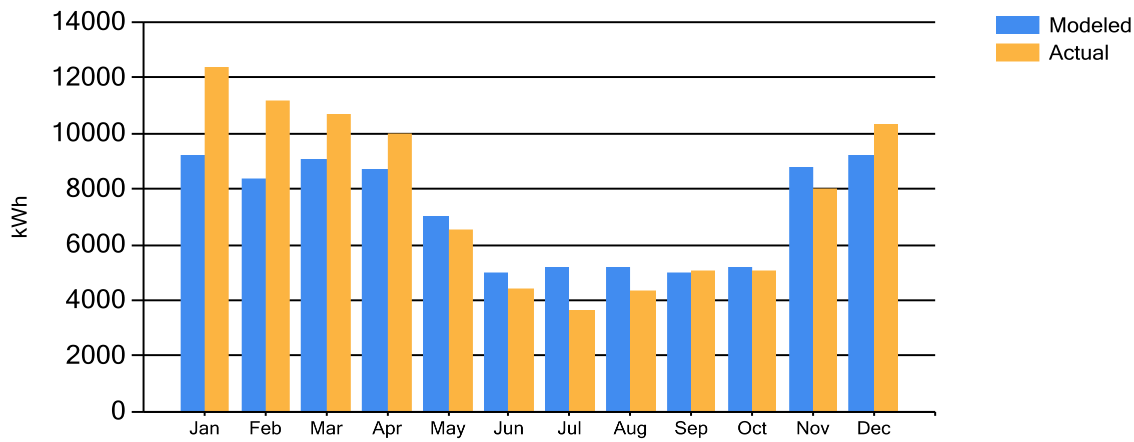
Appendix B – Actual Fuel Use versus Modeled Fuel Use

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

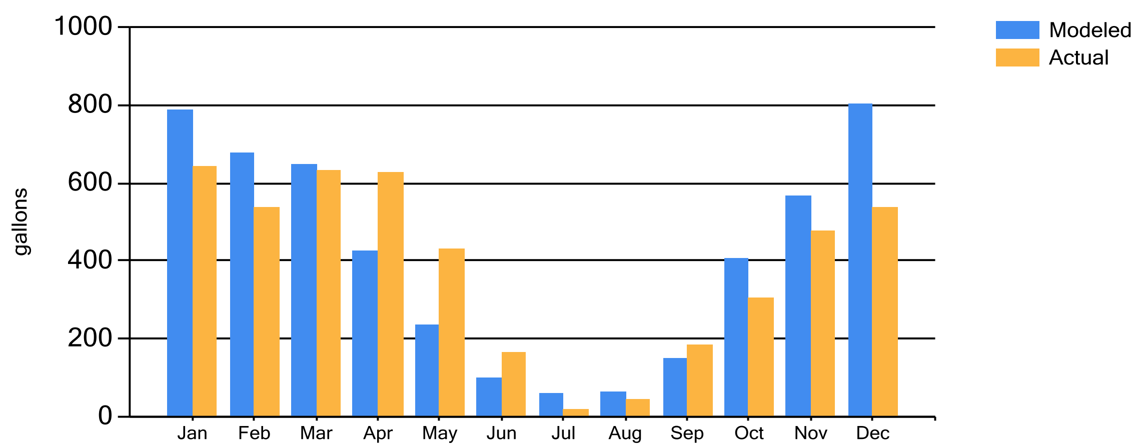
Annual Fuel Use



Electricity Fuel Use



#1 Fuel Oil Fuel Use



Appendix C - Electrical Demands

Estimated Peak Electrical Demand (kW)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Current	13.4	13.9	14.2	14.6	12.4	10.5	11.1	11.6	12.1	12.7	18.5	19.3
As Proposed	3.2	3.7	4.0	4.2	4.4	4.7	5.2	5.7	6.3	7.1	8.2	9.1

AkWarmCalc Ver 2.4.1.0, Energy Lib 3/30/2015