Comprehensive Energy Audit For

Quinhagak Utility Building

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 Utility Building. 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 Water Treatment Plant 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 utility building 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 Utility building is $59,823 per year. Electricity represents the largest portion with an annual cost of approximately $43,166. This includes $21,583 paid by the community and $21,583 paid by the Power Cost Equalization (PCE) program through the State of Alaska. Fuel oil represents a large portion of the energy cost with an annual cost of $10,233. The remaining energy cost is for recovered heat, which has an annual cost of $6,425.

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.

There is a heat recovery project for the building that recovers heat from the generator cooling loops at the Alaska Village Electric Cooperative (AVEC) power plant and transfers it to the Quinhagak Utility Building and the Quinhagak Community Health and Sanitation Building. Construction for the project was completed in 2015 with follow-up tasks still to be performed in both end user buildings. At the time of this audit, the Utility Building had a functional recovered heat system but the Community Health and Sanitation Building was not receiving recovered heat because of complications with the mechanical system. This is reflected in this energy audit report. All existing data does not include a heat recovery system so the data was verified prior to modeling the recent project.

Table 1.1 lists the total usage of electricity, #1 oil, and recovered heat in the utility building before and after the proposed retrofits.

Table 1.1: Predicted Annual Fuel Use for the Utility Building

Predicted Annual Fuel Use		
Fuel Use	**Existing Building**	**With Proposed Retrofits**
Electricity	89,717 kWh	51,892 kWh
#1 Oil	1,527 gallons	1,221 gallons
Heat Recovery	611.87 million Btu	360.32 million Btu

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

Table 1.2: Building Benchmarks for the Utility Building

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	457.0	37.75	$24.42
With Proposed Retrofits	285.2	23.55	$15.23
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 Utility Building. 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	South Loop 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.	$1,891	$3,000	8.04	1.6	8,085.0
2	Heat Add Controls	East Loop 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.	$1,888	$3,000	8.03	1.6	8,074.4

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
3	Heat Add Controls	Water Storage Tank heat-add controls are broken. The 3-way control valve was not functioning. 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.	$1,698	$3,000	7.35	1.8	7,440.5
4	Heat Add Controls	West Loop 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.	$1,497	$3,000	6.31	2.0	6,333.1
5	Setback Thermostat - Utility Building	Implement a Heating Temperature Unoccupied Setback to 60.0 deg F for the Utility Building space.	$427	$1,000	5.24	2.3	1,800.7
6	Other Electrical - Boiler Room Step-Down Transformer	Combine the heat recovery step-down transformer load with this transformer to eliminate waste electricity.	$10,240	$30,000	4.97	2.9	38,947.8
7	Other Electrical - Heat Recovery Step-Down Transformer	Combine this transformer load with the boiler room step-down transformer to eliminate waste electricity.	$4,632	$15,000	4.48	3.2	17,496.7
8	Air Tightening	Adjust controls to generator ventilation so that the vent is properly closed at all times when not in operation	$107	$500	1.87	4.7	461.3
9	Lighting - Wastewater Room	Replace with new energy-efficient LED lighting	$51	$520	1.15	10.2	194.0

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
10	Lighting - WTP Main Room	Replace with new energy-efficient LED lighting	$63	$1,240	0.59	19.7	238.3
11	Lighting - Office	Replace with new energy-efficient LED lighting	$4	$80	0.57	20.4	14.9
12	Lighting - Mezzanine Lights	Replace with new energy-efficient LED lighting	$12	$480	0.29	40.8	44.6
13	Lighting - Bathroom	Replace with new energy-efficient LED lighting	$1	$80	0.14	81.6	3.7
14	Lighting - Storage Room	Replace with new energy-efficient LED lighting	$0	$200	0.01	2,226.1	0.3
	TOTAL, all measures		**$22,510**	**$61,100**	**5.13**	**2.7**	**89,135.3**

Table Notes:

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

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

With all of these energy efficiency measures in place, the annual utility cost can be reduced by $22,510 per year, or 37.6% of the buildings' total energy costs. These measures are estimated to cost $61,100, for an overall simple payback period of 2.7 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**	**Other Electrical**	**Water Circulation Heat**	**Tank Heat**	**Total Cost**
Existing Building	$3,118	$109	$485	$37,022	$13,689	$5,341	**$59,823**

With Proposed Retrofits	$4,049	$2,051	$352	$21,274	$7,675	$1,851	**$37,313**
Savings	-$931	-$1,942	$132	$15,747	$6,013	$3,490	**$22,510**

2. AUDIT AND ANALYSIS BACKGROUND

2.1 Program Description

This audit included services to identify, develop, and evaluate energy efficiency measures at the Quinhagak Utility Building. 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 Utility Building 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 Quinhagak Utility Building is made up of the following activity areas:

1) Utility Building: 2,450 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; HVAC; 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 Utility Building

3.1. Building Description

The 2,450 square foot Quinhagak Utility Building was constructed in 2012, with a normal occupancy of 1 people. The number of hours of operation for this building average 1.4 hours per day, considering all seven days of the week.

The Quinhagak Utility Building houses the water distribution and sewage collection systems for the community. The building has three water loops that provide treated water to the residential and public buildings. The South Loop serves the southern part of town and is approximately 4,200 ft. long. The West Loop serves the western part of town and is approximately 4,380 ft. long. The East Loop serves the eastern part of town and 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 in through a transfer line that transports treated water from the Quinhagak Water Treatment Plant to the Quinhagak Utility Building. The water goes from the 45,000 gallon water storage tank at the water treatment plant to the 250,000 gallon water storage tank at the utility building. The water is then pumped from the large water storage tank to the three distribution loops. These loops are constantly circulating and the water storage tank provides make-up water to each loop as the water is consumed by the end users.

The sewage is collected from the community buildings into a common tank at the utility building. When the pressure is high in the tank, the sewage is discharges through a force main system to a sewage lagoon on the western side of the community.

Description of Building Shell

The exterior walls are constructed with stressed skin panel construction with 5.5 inches of polyurethane foam insulation. The insulation is slightly damaged and there is approximately 3,080 square feet of wall space in the building.

The building has a cathedral ceiling with standard framing and 24-inch framing. The roof has 5.5 inches of polyurethane foam insulation and there is approximately 2,739 square feet of roof space in the building.

The building is built on grade with a gravel pad foundation. There is approximately 2,450 square feet of floor space in the building.

The building has four windows in the main process rooms. Each window is double-paned and is approximately 34x46" in a trapezoidal shape with wood framing. The office has one window that is triple-paned with the outer pane being made of plastic and is approximately 34x46".

There are three entrances in the building. The main entrance 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. There is a set of double-doors next to the office that consists of two metal doors with insulated cores and each door is approximately 3x7 ft. in dimension.

Description of Heating Plants

The heating plants used in the building are:

Boiler 1

Nameplate Information:	Burnham V-904AWO
Fuel Type:	#1 Oil
Input Rating:	420,000 BTU/hr
Steady State Efficiency:	70 %
Idle Loss:	1.5 %
Heat Distribution Type:	Water
Boiler Operation:	All Year

Boiler 2

Nameplate Information:	Burnham V-904AWO
Fuel Type:	#1 Oil
Input Rating:	420,000 BTU/hr
Steady State Efficiency:	70 %
Idle Loss:	1.5 %
Heat Distribution Type:	Water
Boiler Operation:	All Year

Heat Recovery

Fuel Type:	Heat Recovery
Input Rating:	200,000 BTU/hr
Steady State Efficiency:	99 %
Idle Loss:	1.5 %
Heat Distribution Type:	Glycol
Boiler Operation:	All Year

Space Heating Distribution Systems

The building has five unit heaters and four cabinet heaters that are used to provide space heating throughout the facility. Two unit heaters are located in the process room with the sewage discharge system. These heaters are both Modine HSB-63 models and combine to produce approximately 45,600 BTU/hr at their maximum output. One unit heater is located in the boiler room. This heater is a Modine HSB-33 model and produces approximately 21,700 BTU/hr at the maximum output. Two unit heaters are located in the main process room with the distribution loops. These unit heaters are both Modine HSB-47 models that combine to produce approximately 30,000 BTU/hr at their maximum output. There are three cabinet unit heaters in the building that are all Beacon-Morris Trin-Flo III Recessed W42 models. Each unit heater produces approximately 4,660 BTU/hr. There is a larger cabinet unit heater that is a Beacon-Morris Trin-Flo III Recessed W84 model. This unit heater produces approximately 9,180 BTU/hr.

There are two pumps whose usage schedules are tied to the heating systems of the buildings. One pump is a Grundfos UPS 40-160F that is used as a process heating glycol circulation pump. This pump uses approximately 800 Watts. The second pump is a Grundfos 40-80/2F model that is used as a building heating glycol circulation pump. This pump uses approximately 440 Watts.

Domestic Hot Water System

There are two direct-fire hot water heaters that are used to provide hot water to the utility building. One unit is an Amtrol WH-90W model with a 26 gallon tank. The other unit is a Rheem model with a 26 gallon tank. Both of the units heat the water to 135 deg. F for use in the shower, rest room, and utility sink.

Heat Recovery Information

There is a heat recovery system that was implemented through a project in the fall of 2015. The system transfers heat from the generator loop at the AVEC power plant to the glycol circulating loop at the Quinhagak Utility Building prior to entering the main boilers. The project also serves the neighboring Quinhagak Community Health and Sanitation Building but is not operational in that facility. The heat exchanger for the utility building is rated at 250,000 BTU/hr and it was estimated that the building receives around 150-200 MBH throughout the system operations. At the time of this audit there were some follow-up items for the project construction crew to address but the utility building heat recovery system was completely operational. This has been reflected in this energy audit report.

Description of Building Ventilation System

There is a ventilation shaft in the boiler room that is only used for when the generator turns on or in other extreme circumstances. The metal bars closing the shaft are controlled by a switch that will open it when necessary. At the time of the audit, the shaft was open more than needed, leaving a large air gap in the wall next to the boilers.

Lighting

The main process room of the utility building has 16 fixtures with two T8 4ft. fluorescent light bulbs in each fixture. The lights are on approximately two hours per day when the operators are in the building and they consume approximately 480 kWh annually.

The wastewater process room of the utility building has 13 fixtures with two T8 4ft. fluorescent light bulbs in each fixture. The lights are on approximately two hours per day when the operators are in the building and they consume approximately 390 kWh annually.

The mezzanine has six fixtures with two T8 4 ft. fluorescent light bulbs in each fixture. These lights operate an equivalent of about one hour per day and consume approximately 90 kWh annually.

The office has one fixture with two T8 4ft. fluorescent light bulbs that consume approximately 30 kWh annually.

The restroom has one fixture with two T8 4ft. light bulbs that consume approximately 8 kWh annually.

The storage room has two CFL 15 Watt light bulbs that consume approximately 8 kWh annually.

Plug Loads

The utility building 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 circulating pumps on the South Loop that circulate water through the loop to the end users. One of the pumps is in constant operation during the heating months from November through May and they consume approximately 5,686 kWh annually.

There are two circulating pumps on the West Loop that circulate water through the loop to the end users. One of the pumps is in constant operation during the heating months from November through May and they consume approximately 5,686 kWh annually.

There are two circulating pumps on the East Loop that circulate water through the loop to the end users. One of the pumps is in constant operation during the heating months from November through May and they consume approximately 8,748 kWh annually.

There are two discharge pumps that are used to pump waste water and sewage from the collection loops through the force main to the sewage lagoon on the west side of town. The pumps operate about 10% of the time all year long and consume approximately 4,164 kWh annually.

There are circulation pumps that are used to pump water from the water storage to a heat exchanger and back for a water storage tank heat-add system. One of the pumps operates constantly all year long and they consume approximately 381 kWh annually.

There are three pressure pumps that are used to increase the water pressure in the circulation system and create better flow. One of the pumps operates approximately 8% of the tie all year long and they consume approximately 2,455 kWh annually.

There are two transfer pumps that are used to transfer water from the 45,000 gallon water storage tank at the water treatment plant to the 250,000 gallon water storage tank at the utility building. The pumps run on demand with one of them operating about 50% of the time during the heating months from November through May. They consume approximately 1,094 kWh annually.

There is a step-down transformer in the boiler room that transforms incoming three-phase power to single-phase power for use by equipment in the building. The unit is rated for 30 kVa and the three phases measured out an average of 14 Amps. About 5 Amps is being used within the plant and the remaining power consumes approximately 36,695 kWh annually.

There is a step-down transformer dedicated to the new heat recovery system that transforms incoming three-phase power to single-phase power for use by equipment associated with the heat recovery system. The unit is rated for 15kVa and uses approximately 8 Amps. The remaining power consumes approximately 10,958 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
Recovered Heat	$ 10.50/million Btu

3.2.1.1 Total Energy Use and Cost Breakdown

At current rates, [Building Owner] pays approximately $59,823 annually for electricity and other fuel costs for the Quinhagak Utility Building.

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.

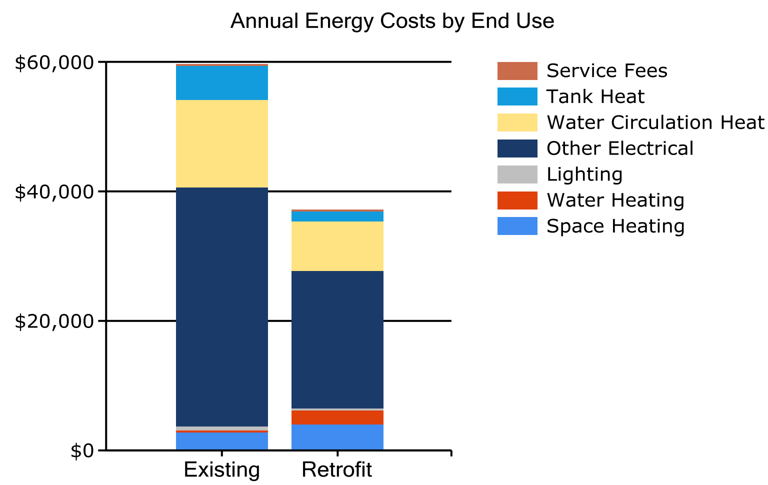


Figure 3.1: Annual Energy Costs by End Use

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.

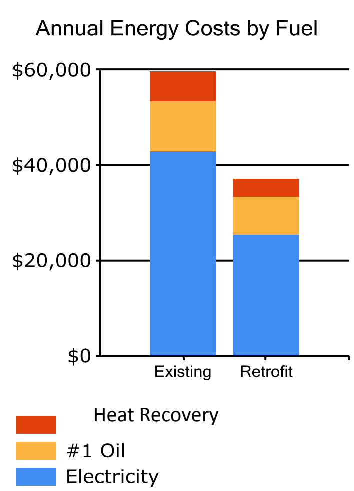


Figure 3.2: Annual Energy Costs by Fuel Type

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.

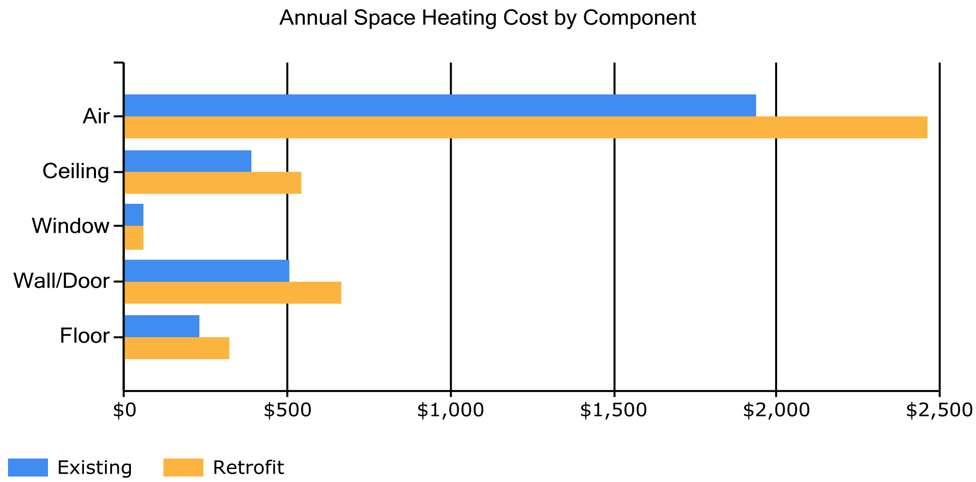


Figure 3.3: Annual Space Heating Cost by Component

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	1090	967	986	893	31	0	0	0	0	115	921	1101
Lighting	85	78	85	83	85	83	85	85	83	85	83	85
Other Electrical	8376	7633	8376	8106	4821	4551	4703	4703	4551	4703	8106	8376
Water Circulation Heat	820	734	774	671	74	3	0	0	22	118	724	824
Tank Heat	133	118	123	102	27	13	6	7	17	38	114	134

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	3	2	0	0	0	0	0	0	0	4	0	3
DHW	0	0	0	0	0	2	4	4	1	0	0	0
Water Circulation Heat	147	130	131	98	69	14	0	0	46	93	118	148
Tank Heat	39	35	36	31	30	59	69	70	35	30	34	39

Table 3.4: Recovered Heat Consumption by Category

Recovered Heat Consumption (Million Btu)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space Heating	3	2	0	0	0	0	0	0	0	3	0	3
Water Circulation Heat	79	68	65	40	18	1	0	0	8	36	56	80
Tank Heat	21	18	18	13	8	5	4	4	6	12	16	21

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 3.5 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 3.5: Quinhagak Utility Building 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	89,717 kWh	306,203	3.340	1,022,718
#1 Oil	1,527 gallons	201,596	1.010	203,612
Heat Recovery	611.87 million Btu	611,872	1.280	783,196
Total		**1,119,670**		**2,009,525**
BUILDING AREA		2,450	Square Feet	
BUILDING SITE EUI		457	kBTU/Ft²/Yr	
BUILDING SOURCE EUI		820	**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 3.6: Quinhagak Utility Building Benchmarks

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	**457.0**	**37.75**	**$24.42**
With Proposed Retrofits	**285.2**	**23.55**	**$15.23**
EUI: Energy Use Intensity - The annual site energy consumption divided by the structure's conditioned area. **EUI/HDD: Energy Use Intensity per Heating Degree Day.** **ECI: Energy Cost Index - The total annual cost of energy divided by the square footage of the conditioned space in the building.**			

3.3 AkWarm© Building Simulation

An accurate model of the building performance can be created by simulating the thermal performance of the walls, roof, windows and floors of the building. The HVAC system and central plant are modeled as well, accounting for the outside air ventilation required by the building and the heat recovery equipment in place.

The model uses local weather data and is trued up to historical energy use to ensure its accuracy. The model can be used now and in the future to measure the utility bill impact of all types of energy projects, including improving building insulation, modifying glazing, changing air handler schedules, increasing heat recovery, installing high efficiency boilers, using variable air volume air handlers, adjusting outside air ventilation and adding cogeneration systems.

For the purposes of this study, the Quinhagak Utility Building 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 Utility Building, 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	South Loop 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.	$1,891	$3,000	8.04	1.6	8,085.0
2	Heat Add Controls	East Loop 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.	$1,888	$3,000	8.03	1.6	8,074.4

Quinhagak Utility Building, 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	Water Storage Tank heat-add controls are broken. The 3-way control valve was not functioning. 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.	$1,698	$3,000	7.35	1.8	7,440.5
4	Heat Add Controls	West Loop 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.	$1,497	$3,000	6.31	2.0	6,333.1
5	Setback Thermostat - Utility Building	Implement a Heating Temperature Unoccupied Setback to 60.0 deg F for the Utility Building space.	$427	$1,000	5.24	2.3	1,800.7
6	Other Electrical - Boiler Room Step-Down Transformer	Combine the heat recovery step-down transformer load with this transformer to eliminate waste electricity.	$10,240	$30,000	4.97	2.9	38,947.8
7	Other Electrical - Heat Recovery Step-Down Transformer	Combine this transformer load with the boiler room step-down transformer to eliminate waste electricity.	$4,632	$15,000	4.48	3.2	17,496.7
8	Air Tightening	Adjust controls to generator ventilation so that the vent is properly closed at all times when not in operation	$107	$500	1.87	4.7	461.3
9	Lighting - Wastewater Room	Replace with new energy-efficient LED lighting	$51	$520	1.15	10.2	194.0
10	Lighting - WTP Main Room	Replace with new energy-efficient LED lighting	$63	$1,240	0.59	19.7	238.3

Quinhagak Utility Building, 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**
11	Lighting - Office	Replace with new energy-efficient LED lighting	$4	$80	0.57	20.4	14.9
12	Lighting - Mezzanine Lights	Replace with new energy-efficient LED lighting	$12	$480	0.29	40.8	44.6
13	Lighting - Bathroom	Replace with new energy-efficient LED lighting	$1	$80	0.14	81.6	3.7
14	Lighting - Storage Room	Replace with new energy-efficient LED lighting	$0	$200	0.01	2,226.1	0.3
	TOTAL, all measures		**$22,510**	**$61,100**	**5.13**	**2.7**	**89,135.3**

4.2 Interactive Effects of Projects

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

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

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

4.3 Building Shell Measures

4.3.1 Air Sealing Measures

Rank	**Location**	**Existing Air Leakage Level (cfm@50/75 Pa)**		**Recommended Air Leakage Reduction (cfm@50/75 Pa)**	
8		Air Tightness estimated as: 4900 cfm at 50 Pascals		Adjust controls to generator ventilation so that the vent is properly closed at all times when not in operation	
Installation Cost	$500	**Estimated Life of Measure (yrs)**	10	**Energy Savings (/yr)**	$107
Breakeven Cost	$937	**Savings-to-Investment Ratio**	1.9	**Simple Payback yrs**	5
Auditors Notes: The generator vent remains partially open despite the generator not being in operation. This cools the room significantly and increases the overall heat load of the building. Repair the controls such that the vent remains closed during normal operations and is used only when necessary.					

4.4 Mechanical Equipment Measures

4.4.1 Night Setback Thermostat Measures

Rank	Building Space	Recommendation
5	Utility Building	Implement a Heating Temperature Unoccupied Setback to 60.0 deg F for the Utility Building space.

Installation Cost	$1,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$427
Breakeven Cost	$5,240	**Savings-to-Investment Ratio**	5.2	**Simple Payback yrs**	2

Auditors Notes: Lowering the temperature when the building is unoccupied will reduce the overall heat demand without affecting the plant operators..

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
9	Wastewater Room	13 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic	Replace with new energy-efficient LED lighting

Installation Cost	$520	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$51
Breakeven Cost	$599	**Savings-to-Investment Ratio**	1.2	**Simple Payback yrs**	10

Auditors Notes: Replace existing fluorescent light bulbs with LED 17 Watt 4ft. equivalents. The room has 13 fixtures with two light bulbs for a total of 26 bulbs to be replaced.

Rank	Location	Existing Condition	Recommendation
10	WTP Main Room	16 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic	Replace with new energy-efficient LED lighting

Installation Cost	$1,240	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$63
Breakeven Cost	$736	**Savings-to-Investment Ratio**	0.6	**Simple Payback yrs**	20

Auditors Notes: Replace existing fluorescent light bulbs with LED 17 Watt 4ft. equivalents. The room has 16 fixtures with two light bulbs for a total of 32 bulbs to be replaced.

Rank	Location	Existing Condition		Recommendation	
11	Office	FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic		Replace with new energy-efficient LED lighting	
Installation Cost	$80	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$4
Breakeven Cost	$46	**Savings-to-Investment Ratio**	0.6	**Simple Payback yrs**	20
Auditors Notes: Replace existing fluorescent light bulbs with LED 17 Watt 4ft. equivalents. The room has one fixture with two light bulbs for a total of 2 bulbs to be replaced.					

Rank	Location	Existing Condition		Recommendation	
12	Mezzanine Lights	6 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic		Replace with new energy-efficient LED lighting	
Installation Cost	$480	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$12
Breakeven Cost	$138	**Savings-to-Investment Ratio**	0.3	**Simple Payback yrs**	41
Auditors Notes: Replace existing fluorescent light bulbs with LED 17 Watt 4ft. equivalents. The room has six fixtures with two light bulbs for a total of 12 bulbs to be replaced.					

Rank	Location	Existing Condition		Recommendation	
13	Bathroom	FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic		Replace with new energy-efficient LED lighting	
Installation Cost	$80	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$1
Breakeven Cost	$11	**Savings-to-Investment Ratio**	0.1	**Simple Payback yrs**	82
Auditors Notes: Replace existing fluorescent light bulbs with LED 17 Watt 4ft. equivalents. The room has one fixture with two light bulbs for a total of 2 bulbs to be replaced.					

Rank	Location	Existing Condition		Recommendation	
14	Storage Room	2 FLUOR (2) CFL, A Lamp 15W		Replace with new energy-efficient LED lighting	
Installation Cost	$200	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$
Breakeven Cost	$1	**Savings-to-Investment Ratio**	0.0	**Simple Payback yrs**	2226
Auditors Notes: Replace existing CFL light bulbs with LED 12 Watt equivalents. The room has 2 fixtures with two light bulbs to be replaced.					

4.5.2 Other Electrical Measures

Rank	Location	Description of Existing		Efficiency Recommendation	
6	Boiler Room Step-Down Transformer	Step-Down Transformer		Combine the heat recovery step-down transformer load with this transformer to eliminate waste electricity.	
Installation Cost	$30,000	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$10,240
Breakeven Cost	$149,238	**Savings-to-Investment Ratio**	5.0	**Simple Payback yrs**	3
Auditors Notes: The two transformers are oversized for the existing load in the utility building and one transformer will be able to handle the load effectively. Replace the two transformers with one smaller unit to eliminate waste electricity necessary to keep the large units in operation.					

Rank	Location	Description of Existing	Efficiency Recommendation
7	Heat Recovery Step-Down Transformer	Step-Down Transformer	Combine this transformer load with the boiler room step-down transformer to eliminate waste electricity.

Installation Cost	$15,000	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$4,632
Breakeven Cost	$67,251	**Savings-to-Investment Ratio**	4.5	**Simple Payback yrs**	3

Auditors Notes: The two transformers are oversized for the existing load in the utility building and one transformer will be able to handle the load effectively. Replace the two transformers with one smaller unit to eliminate waste electricity necessary to keep the large units in operation.

4.5.3 Other Measures

Rank	Location	Description of Existing	Efficiency Recommendation
1		South Loop Circulation Heat Load	South Loop 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.

Installation Cost	$3,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$1,891
Breakeven Cost	$24,114	**Savings-to-Investment Ratio**	8.0	**Simple Payback yrs**	2

Auditors Notes: The heat add controllers were not functioning properly and the distribution loop temperature was higher than necessary. Replace the controllers with the ARUC standard of a Belimo modulating valve and a Honeywell T775 controller to reduce the heat load and provide only the heat necessary for proper operations.

Rank	Location	Description of Existing	Efficiency Recommendation
2		East Loop Circulation Heat Load	East Loop 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.

Installation Cost	$3,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$1,888
Breakeven Cost	$24,083	**Savings-to-Investment Ratio**	8.0	**Simple Payback yrs**	2

Auditors Notes: The heat add controllers were not functioning properly and the distribution loop temperature was higher than necessary. Replace the controllers with the ARUC standard of a Belimo modulating valve and a Honeywell T775 controller to reduce the heat load and provide only the heat necessary for proper operations.

Rank	Location	Description of Existing	Efficiency Recommendation
3		Water Storage Tank Heat Load	Water Storage Tank heat-add controls are broken. The 3-way control valve was not functioning. 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.

Installation Cost	$3,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$1,698
Breakeven Cost	$22,053	**Savings-to-Investment Ratio**	7.4	**Simple Payback yrs**	2

Auditors Notes: The 3-way valve for the heat-add loop was not functioning properly and the water storage tank temperature was higher than necessary. Replace the controller with the ARUC standard of a Belimo modulating valve and a Honeywell T775 controller to reduce the heat load and provide only the heat necessary for proper operations.

Rank	Location	Description of Existing	Efficiency Recommendation
4		West Loop Circulation Heat Load	West Loop 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.

Installation Cost	$3,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$1,497
Breakeven Cost	$18,941	**Savings-to-Investment Ratio**	6.3	**Simple Payback yrs**	2

Auditors Notes: The heat add controllers were not functioning properly and the distribution loop temperature was higher than necessary. Replace the controllers with the ARUC standard of a Belimo modulating valve and a Honeywell T775 controller to reduce the heat load and provide only the heat necessary for proper operations.

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 utility building 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 Utility Building	**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: 2,450 square feet	**Design Space Heating Load:** Design Loss at Space: 32,902 Btu/hour with Distribution Losses: 34,634 Btu/hour Plant Input Rating assuming 82.0% Plant Efficiency and 25% Safety Margin: 52,796 Btu/hour Note: Additional Capacity should be added for DHW and other plant loads, if served.
Typical Occupancy: 1 people	**Design Indoor Temperature:** 70 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**	**Other Electrical**	**Water Circulation Heat**	**Tank Heat**	**Total Cost**
Existing Building	$3,118	$109	$485	$37,022	$13,689	$5,341	**$59,823**
With Proposed Retrofits	$4,049	$2,051	$352	$21,274	$7,675	$1,851	**$37,313**
Savings	-$931	-$1,942	$132	$15,747	$6,013	$3,490	**$22,510**

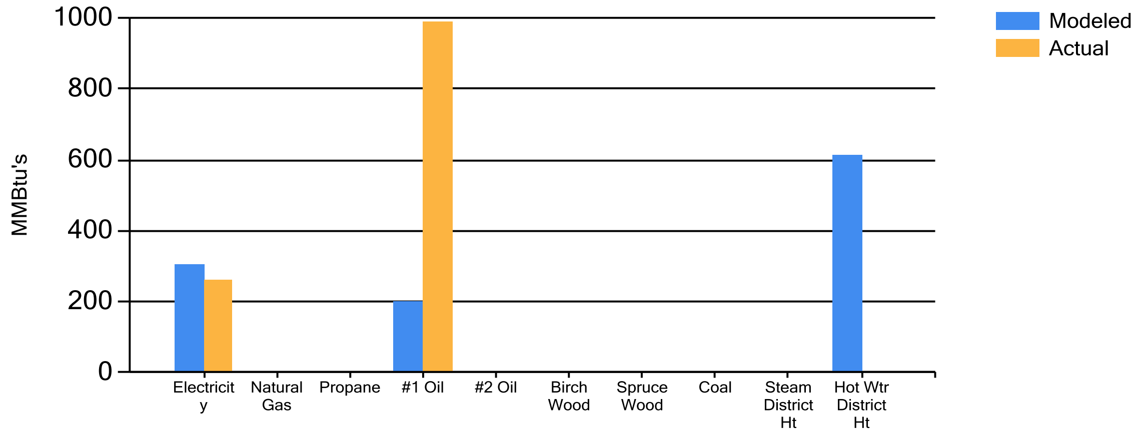
Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	457.0	37.75	$24.42
With Proposed Retrofits	285.2	23.55	$15.23

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.

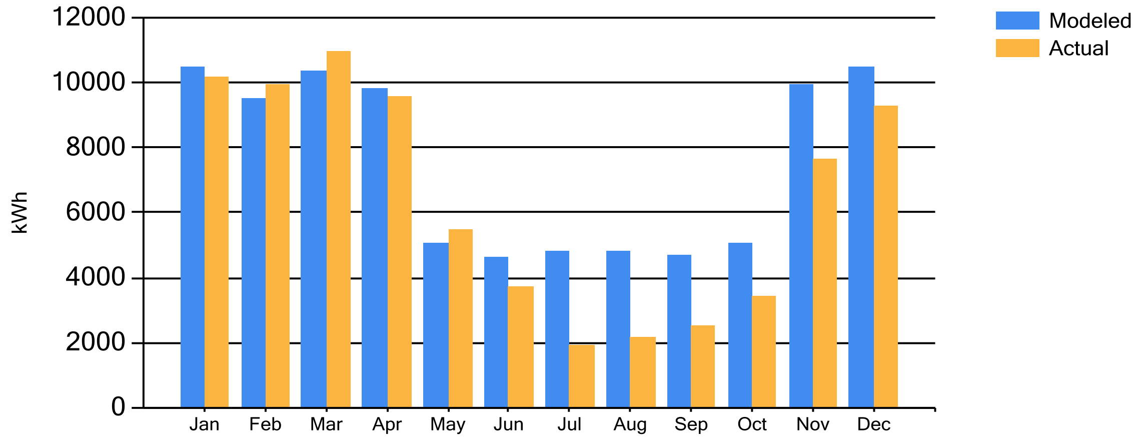
Appendix B – Actual Fuel Use versus Modeled Fuel Use

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

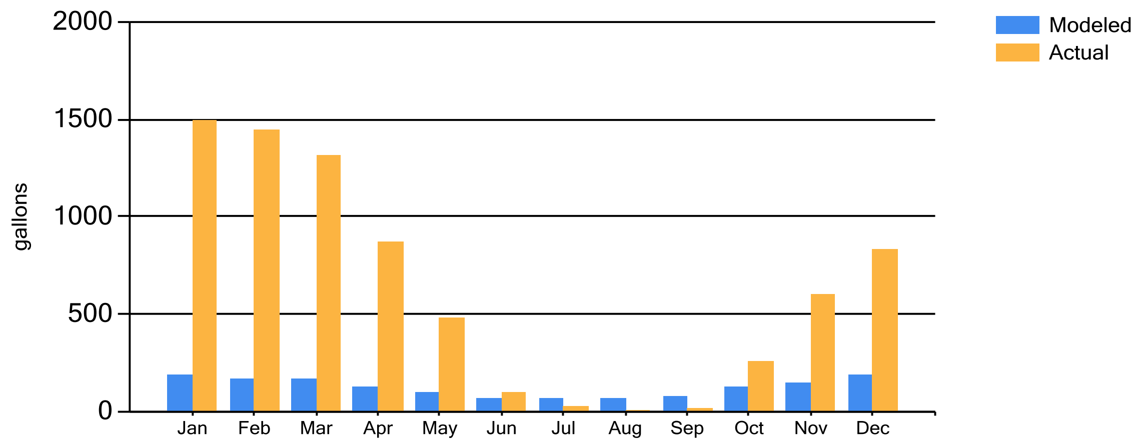
Annual Fuel Use



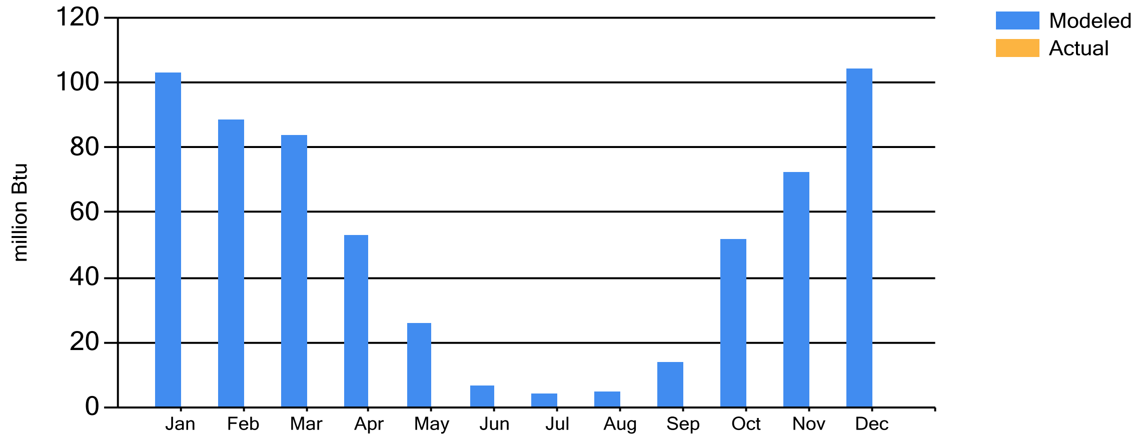
Electricity Fuel Use



#1 Fuel Oil Fuel Use



Heat Recovery Fuel Use



Appendix C - Electrical Demands

Estimated Peak Electrical Demand (kW)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Current	16.7	16.7	16.5	16.4	9.6	9.4	9.4	9.4	9.4	9.6	16.5	16.7
As Proposed	11.6	11.6	11.4	11.2	5.3	5.0	5.0	5.0	5.1	5.4	11.3	11.6

AkWarmCalc Ver 2.4.1.0, Energy Lib 3/30/2015