Comprehensive Energy Audit
For

Ruby Water Treatment Plant & Washeteria

Prepared For
City of Ruby

July 17, 2015

Prepared By:

Alaska Native Tribal Health Consortium
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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 Energy Projects Group at the Alaska Native Tribal Health Consortium (ANTHC) prepared this document for The City of Ruby, Alaska. The authors of this report are Carl Remley, Certified Energy Auditor (CEA) and 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 June of 2015 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 James Esmailka and Clifford Cleaver, and Ruby City Administrator Jennie Hopson.

1. EXECUTIVE SUMMARY

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

In the near future, a representative of ANTHC will be contacting both the City of Ruby and the water treatment plant operators to follow up on the recommendations made in this audit report. Funding has been provided to ANTHC through a Rural Alaska Village Grant and the Denali Commission to provide the city with assistance in understanding the report and implementing the recommendations. ANTHC will work to complete the recommendations within the 2015 calendar year.

The total predicted energy cost for the Ruby Water Treatment Plant & Washeteria is $39,169 per year. Electricity represents the largest portion with an annual cost of $38,025. This includes $15,844 paid by the city and $22,182 paid by the Power Cost Equalization (PCE) program through the State of Alaska. Additional electricity is provided by a solar photovoltaic system consisting of two large solar panels. These panels produce approximately 3,600 KWH per year. Fuel oil represents the remaining portion of the building energy consumption with an annual cost of $1,143. The majority of the building heating loads are met through the use of an existing heat recovery system from the power plant to the water plant. These predictions are based on the electricity and fuel prices at the time of the audit.

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 Ruby, the cost of electricity without PCE is $0.84/KWH and the cost of electricity with PCE is $0.35/KWH.

The table below lists the total usage of electricity, #1 oil, and recovered heat in the water treatment plant and washeteria before and after the proposed retrofits.

Predicted Annual Fuel Use		
Fuel Use	**Existing Building**	**With Proposed Retrofits**
Electricity	45,268 kWh	23,525 kWh
#1 Oil	190 gallons	175 gallons
Hot Wtr District Ht	115.42 million Btu	150.48 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.

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	136.6	9.86	$18.13
With Proposed Retrofits	117.5	8.48	$9.63
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 1.1 below summarizes the energy efficiency measures analyzed for the Ruby Water Treatment Plant & Washeteria. Listed are the estimates of the annual savings, installed costs, and two different financial measures of investment return.

Table 1.1 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**
1	Setback Thermostat: Lift Station	Lower temperature to 45 deg. When unoccupied and repair door to the wet side of the building.	$3,199	$5,500	8.50	1.7	7,996.5
2	Lighting - Power Retrofit: Arctic Entry Lighting	Replace with new energy-efficient lighting	$29	$40	8.40	1.4	67.5
3	Heating, Ventilation, and Domestic Hot Water heating	Replace circulation pumps with Grundfos Magna pumps, recommission controllers, insulate heat recovery piping, Add a small hot water circulation pump, and add solenoids to the dryer plenum.	$12,244	$25,000	7.17	2.0	29,036.8
4	Other Electrical - Controls Retrofit: Water & Sewer Line Electric Heat Tape	Shut off heat tape and use only for emergency purposes.	$907	$1,500	7.11	1.7	2,039.8
5	Other Electrical - Controls Retrofit: Sewer Discharge Line Heat Tape	Shut off heat tape and use only for emergency purposes.	$742	$1,500	5.81	2.0	1,854.7
6	Lighting - Power Retrofit: Washeteria Lighting	Replace with new energy-efficient lighting	$343	$1,600	2.52	4.7	811.4
7	Lighting - Power Retrofit: Office Lighting	Replace with new energy-efficient lighting	$40	$200	2.35	5.0	94.6
8	Lighting - Power Retrofit: WTP Main Room Lighting	Replace with new energy-efficient lighting	$400	$2,000	2.35	5.0	944.8
9	Lighting - Power Retrofit: Exterior Lighting - Lift Station	Replace with new energy-efficient lighting	$119	$600	2.32	5.1	296.7
10	Lighting - Power Retrofit: Exterior Lighting	Replace with new energy-efficient lighting	$178	$900	2.32	5.1	445.1
11	Lighting - Power Retrofit: Boiler Room Lighting	Replace with new energy-efficient lighting	$140	$800	2.06	5.7	330.2
12	Lighting - Power Retrofit: Bathroom Fluorescent Lighting	Replace with new energy-efficient lighting	$7	$400	0.21	54.9	17.2

Table 1.1 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
13	Lighting - Power Retrofit: Storage Room Lighting	Replace with new energy-efficient lighting	$4	$200	0.21	55.8	8.4
14	Lighting - Power Retrofit: Dryer Plenum Lighting	Replace with new energy-efficient lighting	$7	$400	0.21	56.0	16.8
	TOTAL, all measures		**$18,359**	**$40,640**	**6.40**	**2.2**	**43,960.6**

Table Notes:

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

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

With all of these energy efficiency measures in place, the annual utility cost can be reduced by $18,359 per year, or 46.9% of the buildings' total energy costs. These measures are estimated to cost $40,640, for an overall simple payback period of 2.2 years.

Table 1.2 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 1.2

Annual Energy Cost Estimate						
Description	**Space Heating**	**Water Heating**	**Clothes Drying**	**Lighting**	**Other Electrical**	**Total Cost**
Existing Building	$22,683	$728	$536	$3,914	$11,307	**$39,169**
With Proposed Retrofits	$7,373	$669	$496	$2,634	$9,638	**$20,810**
Savings	$15,310	$59	$40	$1,280	$1,669	**$18,359**

2. AUDIT AND ANALYSIS BACKGROUND

2.1 Program Description

This audit included services to identify, develop, and evaluate energy efficiency measures at the Ruby Water Treatment Plant & Washeteria. 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 Ruby Water Treatment Plant & Washeteria 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.

Ruby Water Treatment Plant & Washeteria is classified as being made up of the following activity areas:

1) Washeteria: 992 square feet
2) Water Treatment Plant: 1,168 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. Ruby Water Treatment Plant & Washeteria

3.1. Building Description

The 2,160 square foot Ruby Water Treatment Plant & Washeteria was constructed in 2002. The number of hours of operation for this building is approximately 5 hours per day, considering all seven days of the week.

The Ruby Water Treatment Plant & Washeteria serves as the water gathering point for the residents of the community and as a location for laundromat and shower services. There is one watering point with a ¾" pipe that provides treated water for community pickup. There are 5 washers and 6 dryers in the washeteria, though at the time of the site visit only 2 washers and 1 dryer were in operation.

Water is pumped into the water treatment plant from the raw water intake that draws water from a nearby well. The water is pumped through two pressure filters before receiving an addition of chlorine and entering the 3,000 gallon water storage tank. Pressure pumps are used to keep the pressure up for use in the washeteria and showers. The facility has a single watering point that is used by the residents to collect their own water supply. The rest of the water is used in the washing machines and restrooms.

<u>Description of Building Shell</u>

The exterior walls are constructed with stressed skin panels and 5.5 inches of polyurethane foam insulation. The insulation is slightly damaged and there is approximately 1920 square feet of wall space in the building.

The roof of the building has a cathedral ceiling with a standard framing and 24” spacing. There is approximately 5.5 inches of polyurethane foam insulation that is slightly damaged in the building. The roof is approximately 2159 square feet in total area.

The building is built on pilings with approximately 48 inches of clearance between the pad and the ground. The floor is framed with standard lumber and has 5.5 inches of polyurethane foam insulation. There is approximately 2673 square feet of floor space in the building.

There are eight windows in the building that are all triple-paned with wood framing. None of the windows are south-facing. There is approximately 35 square feet of window space in the building.

There are two exterior doors in the building with one entering the washeteria side of the building and one entering the water treatment plant side of the building. Both doors are metal with an insulated core and combine to have a total of 47 square feet of door space.

Description of Heating Plants

The Heating Plants used in the building are:

Boiler 1
Nameplate Information: Weil McLain 780 Series
WM-780-GPR3.0
Two Stage Fire
Fuel Type: #1 Oil
Input Rating: 655,000 BTU/hr
Steady State Efficiency: 78 %
Idle Loss: 0.5 %
Heat Distribution Type: Glycol
Boiler Operation: Oct - May

Boiler 2
Nameplate Information: Weil McLain 780 Series
WM-780-GPR3.0
Two Stage Fire
Fuel Type: #1 Oil
Input Rating: 655,000 BTU/hr
Steady State Efficiency: 78 %
Idle Loss: 0.5 %
Heat Distribution Type: Glycol
Boiler Operation: Dec - Feb

Heat Recovery System
Fuel Type: Heat Recovery
Input Rating: 300,000 BTU/hr

Steady State Efficiency: 90 %
Idle Loss: 1.5 %
Heat Distribution Type: Glycol
Boiler Operation: All Year

Lift Station Electric Heat

Fuel Type: Electricity
Input Rating: 0 BTU/hr
Steady State Efficiency: 100 %
Idle Loss: 0.1 %
Heat Distribution Type: Air

Space Heating Distribution Systems

There is one unit heater, one cabinet heater, and two dryer plenum heaters present in the water treatment plant and washeteria building. The unit heater is present in the main room of the water treatment plant and produces approximately 22,000 BTU/hr. The cabinet heater is present in the main washeteria room and produces approximately 56,000 BTU/hr. The dryer plenum heaters are located in the dryer plenum room and produce approximately 134,000 BTU/hr. Only one dryer plenum heater is typically in operation at a time.

Heat Recovery Information

There is a heat recovery system in the water treatment plant that provides heat from the local power plant for water heating and hydronic heat purposes. The system extracts heat from the cooling loops of the power plant generators through a glycol line and transports the heated glycol line to transfer the heat to the water treatment plant through a heat exchanger. The system produces an average of approximately 300,000 BTU/hr.

Lighting

The water treatment plant main room has 10 fixtures with four T8 fluorescent light bulbs in each fixture.

The boiler room has four fixtures with four T8 fluorescent light bulbs in each fixture.

The dryer plenum has two fixtures with two T8 fluorescent light bulbs in each fixture.

The storage room has one fixture with four T8 fluorescent light bulbs in the fixture.

The office has one fixture four T8 fluorescent light bulbs in the fixture.

The washeteria main room has eight fixtures with four T8 fluorescent light bulbs in each fixture.

The arctic entry has one fixture with one 60W incandescent light bulb in the fixture.

The four restrooms have a total of four fixtures with two T8 light bulbs in each fixture.

The four restrooms also have a total of four fixtures with two 13 Watt twin tube CFL light bulbs in each fixture that are each associated with the ceiling fans.

The exterior of the building has three fixtures with a single high pressure sodium 35 Watt light bulb in each fixture.

The exterior of the lift station has two fixtures with a single high pressure sodium 35 Watt light bulb in each fixture.

Plug Loads

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

Major Equipment

There is a heat tape that provides heat to the water and sewer lines to the clinic. The heat tape uses approximately 2,208 KWH annually.

There is a heat tape that provides heat to the sewer discharge line to the sewage lagoon. The heat tape uses approximately 1,766 KWH annually.

There is a pump in the lift station that sends the sewage to the sewage lagoon. The pump uses approximately 2,194 KWH annually.

There is a well pump that pumps water from the well to the water treatment plant. The pump uses approximately 457 KWH annually.

There are two circulation pumps that circulate heated glycol to the water line to prevent it from freezing. The pumps use approximately 3,025 KWH annually.

There are six dryer pumps that circulate heated glycol through the dryer to provide heat during operation. The pumps combine to use approximately 2,348 KWH annually.

There is a clothes washer in the washeteria that uses approximately 251 KWH annually.

There is a backwash pump that is used to backwash the filters for better water treatment. The pump uses approximately 47 KWH annually.

There is an air compressor that is used during the backwash process that uses approximately 39 KWH annually.

There is an exhaust fan in the boiler room that is used for ventilation of the boilers and hot water generator. The fan uses approximately 833 KWH annually.

There are a total of three exhaust fans in the main restrooms that provide ventilation for the rooms. The fans use a total of approximately 193 KWH annually.

There is an exhaust fan in the handicap bathroom that provides ventilation for the room. The fan uses approximately 101 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 following is a list of the utility companies providing energy to the building and the class of service provided:

Electricity: Ruby, City of - Commercial - Sm

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 – Average Energy Cost	
Description	**Average Energy Cost**
Electricity	$ 0.84/kWh
#1 Oil	$ 6.00/gallons

3.2.1.1 Total Energy Use and Cost Breakdown

At current rates, City of Ruby pays approximately $39,169 annually for electricity and other fuel costs for the Ruby Water Treatment Plant & Washeteria.

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

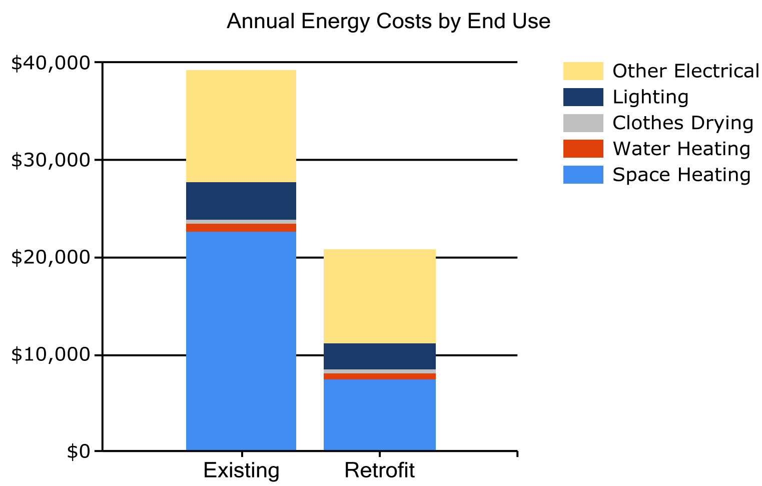


Figure 3.2 below shows how the annual energy cost of the building splits between the different fuels used by the building. The "Existing" bar shows the breakdown for the building as it is now; the "Retrofit" bar shows the predicted costs if all of the energy efficiency measures in this report are implemented.

Figure 3.2
Annual Energy Costs by Fuel Type

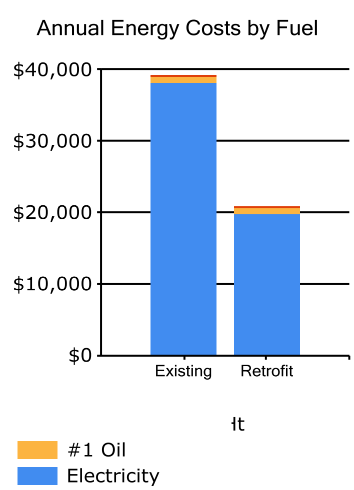
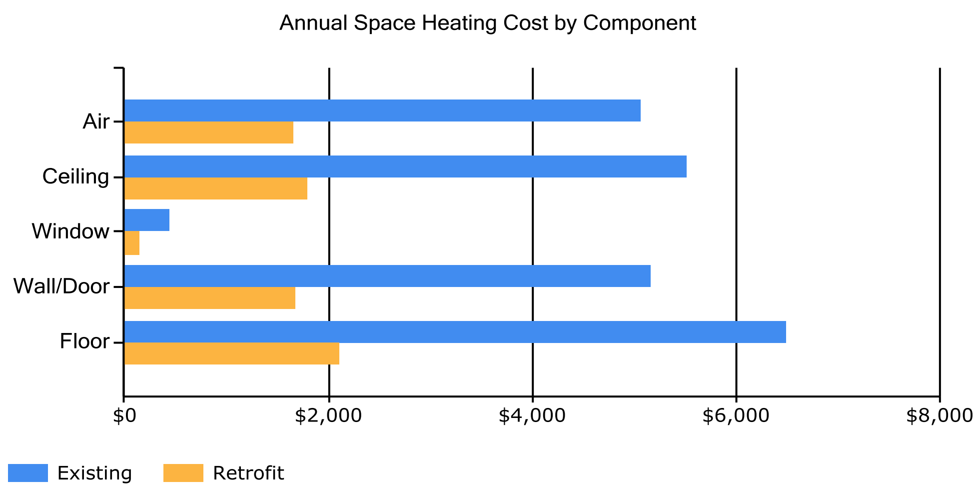


Figure 3.3 below addresses only Space Heating costs. The figure shows how each heat loss component contributes to those costs; for example, the figure shows how much annual space heating cost is caused by the heat loss through the Walls/Doors. For each component, the space heating cost for the Existing 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.

Electrical Consumption (kWh)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Space_Heating	3005	2585	2624	2159	1862	1591	1584	1662	1813	2271	2596	2988
DHW	24	22	24	24	22	22	22	22	22	25	24	24
Clothes_Drying	12	11	12	11	10	10	10	10	10	12	11	12
Lighting	418	381	418	404	418	319	330	330	402	418	404	418
Other_Electrical	2181	1977	842	815	768	664	686	686	916	842	902	2181

Fuel Oil #1 Consumption (Gallons)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Space_Heating	18	0	0	0	0	0	0	0	0	0	0	18
DHW	11	10	11	11	1	1	1	1	1	12	11	11
Clothes_Drying	11	9	10	9	1	1	1	1	1	9	10	11

Hot Water District Ht Consumption (Million Btu)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Space_Heating	7	4	3	0	0	0	0	0	0	0	4	6
DHW	4	4	4	5	5	5	5	5	5	5	4	4
Clothes_Drying	4	3	4	3	3	3	3	3	3	4	3	4

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):

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

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

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

Table 3.4
Ruby WTP-Washeteria 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	45,268 kWh	154,498	3.340	516,024
#1 Oil	190 gallons	25,143	1.010	25,394
Hot Wtr District Ht	115.42 million Btu	115,415	1.280	147,732
Total		**295,056**		**689,150**
BUILDING AREA		2,160	Square Feet	
BUILDING SITE EUI		137	kBTU/Ft^2/Yr	
BUILDING SOURCE EUI		319	**kBTU/Ft^2/Yr**	
* Site - Source Ratio data is provided by the Energy Star Performance Rating Methodology for Incorporating Source Energy Use document issued March 2011.				

Table 3.5

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	**136.6**	**9.86**	**$18.13**
With Proposed Retrofits	**117.5**	**8.48**	**$9.63**
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 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 Ruby Water Treatment Plant & Washeteria was modeled using AkWarm© energy use software to establish a baseline space heating and cooling energy usage. Climate data from Ruby 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. Equipment cost estimate calculations are provided in Appendix D.

Limitations of AkWarm© Models

• The model is based on typical mean year weather data for Ruby. This data represents the average ambient weather profile as observed over approximately 30 years. As such, the gas and electric profiles generated will not likely compare perfectly with actual energy billing information from any single year. This is especially true for years with extreme warm or cold periods, or even years with unexpectedly moderate weather.
• The heating and cooling load model is a simple two-zone model consisting of the building's core interior spaces and the building's perimeter spaces. This simplified approach loses accuracy for buildings that have large variations in cooling/heating loads across different parts of the building.
• The model does not model heating and ventilation systems that simultaneously provide both heating and cooling to the same building space (typically done as a means of providing temperature control in the space).

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
Ruby WTP-Washeteria, Ruby, 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	Setback Thermostat: Lift Station	Lower temperature to 45 deg. When unoccupied and repair door to the wet side of the building.	$3,199	$5,500	8.50	1.7	7,996.5
2	Lighting - Power Retrofit: Arctic Entry Lighting	Replace with new energy-efficient lighting	$29	$40	8.40	1.4	67.5
3	Heating, Ventilation, and Domestic Hot Water heating	Replace circulation pumps with Grundfos Magna pumps, recommission controllers, insulate heat recovery piping, Add a small hot water circulation pump, and add solenoids to the dryer plenum.	$12,244	$25,000	7.17	2.0	29,036.8
4	Other Electrical - Controls Retrofit: Water & Sewer Line Electric Heat Tape	Shut off heat tape and use only for emergency purposes.	$907	$1,500	7.11	1.7	2,039.8

Table 4.1 Ruby WTP-Washeteria, Ruby, 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**
5	Other Electrical - Controls Retrofit: Sewer Discharge Line Heat Tape	Shut off heat tape and use only for emergency purposes.	$742	$1,500	5.81	2.0	1,854.7
6	Lighting - Power Retrofit: Washeteria Lighting	Replace with new energy-efficient lighting	$343	$1,600	2.52	4.7	811.4
7	Lighting - Power Retrofit: Office Lighting	Replace with new energy-efficient lighting	$40	$200	2.35	5.0	94.6
8	Lighting - Power Retrofit: WTP Main Room Lighting	Replace with new energy-efficient lighting	$400	$2,000	2.35	5.0	944.8
9	Lighting - Power Retrofit: Exterior Lighting - Lift Station	Replace with new energy-efficient lighting	$119	$600	2.32	5.1	296.7
10	Lighting - Power Retrofit: Exterior Lighting	Replace with new energy-efficient lighting	$178	$900	2.32	5.1	445.1
11	Lighting - Power Retrofit: Boiler Room Lighting	Replace with new energy-efficient lighting	$140	$800	2.06	5.7	330.2
12	Lighting - Power Retrofit: Bathroom Fluorescent Lighting	Replace with new energy-efficient lighting	$7	$400	0.21	54.9	17.2
13	Lighting - Power Retrofit: Storage Room Lighting	Replace with new energy-efficient lighting	$4	$200	0.21	55.8	8.4
14	Lighting - Power Retrofit: Dryer Plenum Lighting	Replace with new energy-efficient lighting	$7	$400	0.21	56.0	16.8
	TOTAL, all measures		**$18,359**	**$40,640**	**6.40**	**2.2**	**43,960.6**

4.2 Interactive Effects of Projects

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

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

Interior lighting, plug loads, facility equipment, and occupants generate heat within the building. When the building is in cooling mode, these items contribute to the overall cooling demands of the building; therefore, lighting efficiency improvements will reduce cooling requirements in air-conditioned buildings. Conversely, lighting-efficiency improvements are anticipated to slightly increase heating requirements. Heating penalties and cooling benefits were included in the lighting project analysis.

4.3 Building Shell Measures

4.4 Mechanical Equipment Measures

4.4.1 Heating /Domestic Hot Water Measure

Rank	**Recommendation**				
3	Replace circulation pumps with Grundfos Magna pumps, recommission controllers, insulate heat recovery piping, Add a small hot water circulation pump, and add solenoids to the dryer plenum.				
Installation Cost	$25,000	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$12,244
Breakeven Cost	$179,154	**Savings-to-Investment Ratio**	7.2	**Simple Payback yrs**	2
Auditors Notes: Replace existing glycol circulation pumps with appropriately sized Magna pumps, re-commission Tekmar controller and Honeywell controller on hot water tank, modify controls to run boiler 1 primary pump when recovered heat is called for, insulate recovered heat lines in mechanical room, add a hot water circulation pump that only runs on a call for hot water, and add solenoids such that dryer plenum unit heater coils are only heated on call for heat in the plenum.					

4.5 Electrical & Appliance Measures

4.5.1 Lighting Measures

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

4.5.1a Lighting Measures – Replace Existing Fixtures/Bulbs

Rank	**Location**	**Existing Condition**		**Recommendation**	
2	Arctic Entry Lighting	Incandescent A Lamp, Standard 60W		Replace with new energy-efficient lighting	
Installation Cost	$40	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$29
Breakeven Cost	$336	**Savings-to-Investment Ratio**	8.4	**Simple Payback yrs**	1
Auditors Notes: Convert from standard incandescent light bulb to a 10 Watt LED.					

Rank	**Location**	**Existing Condition**	**Recommendation**

6	Washeteria Lighting	8 FLUOR (4) T8 4' F32T8 32W Standard Instant Standard Electronic		Replace with new energy-efficient lighting	
Installation Cost	$1,600	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$343
Breakeven Cost	$4,031	**Savings-to-Investment Ratio**	2.5	**Simple Payback yrs**	5
Auditors Notes: Convert from T8 32 watt fluorescent to 17 watt LED and eliminate ballast.					

Rank	**Location**	**Existing Condition**		**Recommendation**	
7	Office Lighting	FLUOR (4) T8 4' F32T8 32W Standard Instant Standard Electronic		Replace with new energy-efficient lighting	
Installation Cost	$200	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$40
Breakeven Cost	$470	**Savings-to-Investment Ratio**	2.4	**Simple Payback yrs**	5
Auditors Notes: Convert from T8 32 watt fluorescent to 17 watt LED and eliminate ballast.					

Rank	**Location**	**Existing Condition**		**Recommendation**	
8	WTP Main Room Lighting	10 FLUOR (4) T8 4' F32T8 32W Standard Instant Standard Electronic		Replace with new energy-efficient lighting	
Installation Cost	$2,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$400
Breakeven Cost	$4,700	**Savings-to-Investment Ratio**	2.4	**Simple Payback yrs**	5
Auditors Notes: Convert from T8 32 watt fluorescent to 17 watt LED and eliminate ballast.					

Rank	**Location**	**Existing Condition**		**Recommendation**	
9	Exterior Lighting - Lift Station	2 HPS 35 Watt Standard Electronic		Replace with new energy-efficient lighting	
Installation Cost	$600	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$119
Breakeven Cost	$1,394	**Savings-to-Investment Ratio**	2.3	**Simple Payback yrs**	5
Auditors Notes: Convert from HPS 35 Watt bulbs to 17 Watt LED.					

Rank	**Location**	**Existing Condition**		**Recommendation**	
10	Exterior Lighting	3 HPS 35 Watt Standard Electronic		Replace with new energy-efficient lighting	
Installation Cost	$900	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$178
Breakeven Cost	$2,091	**Savings-to-Investment Ratio**	2.3	**Simple Payback yrs**	5
Auditors Notes: Convert from HPS 35 Watt bulbs to 17 Watt LED.					

Rank	**Location**	**Existing Condition**		**Recommendation**	
11	Boiler Room Lighting	4 FLUOR (4) T8 4' F32T8 32W Standard Instant Standard Electronic		Replace with new energy-efficient lighting	
Installation Cost	$800	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$140
Breakeven Cost	$1,644	**Savings-to-Investment Ratio**	2.1	**Simple Payback yrs**	6
Auditors Notes: Convert from T8 32 watt fluorescent to 17 watt LED and eliminate ballast.					

Rank	Location	Existing Condition		Recommendation	
12	Bathroom Fluorescent Lighting	4 FLUOR (2) T8 4' F32T8 32W Standard Instant Standard Electronic		Replace with new energy-efficient lighting	
Installation Cost	$400	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$7
Breakeven Cost	$86	**Savings-to-Investment Ratio**	0.2	**Simple Payback yrs**	55
Auditors Notes: Convert from T8 32 watt fluorescent to 17 watt LED and eliminate ballast.					

Rank	Location	Existing Condition		Recommendation	
13	Storage Room Lighting	FLUOR (4) T8 4' F32T8 32W Standard Instant Standard Electronic		Replace with new energy-efficient lighting	
Installation Cost	$200	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$4
Breakeven Cost	$42	**Savings-to-Investment Ratio**	0.2	**Simple Payback yrs**	56
Auditors Notes: Convert from T8 32 watt fluorescent to 17 watt LED and eliminate ballast.					

Rank	Location	Existing Condition		Recommendation	
14	Dryer Plenum Lighting	2 FLUOR (4) T8 4' F32T8 32W Standard Instant Standard Electronic		Replace with new energy-efficient lighting	
Installation Cost	$400	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$7
Breakeven Cost	$84	**Savings-to-Investment Ratio**	0.2	**Simple Payback yrs**	56
Auditors Notes: Convert from T8 32 watt fluorescent to 17 watt LED and eliminate ballast.					

4.5.2 Other Electrical Measures

Rank	Location	Description of Existing		Efficiency Recommendation	
4	Water & Sewer Line Electric Heat Tape	Electric Heat Tape with Manual Switching		Shut off heat tape and use only for emergency purposes.	
Installation Cost	$1,500	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$907
Breakeven Cost	$10,658	**Savings-to-Investment Ratio**	7.1	**Simple Payback yrs**	2
Auditors Notes: Electric heat tape for water and sewer lines in water plant-washeteria should only be used as required to thaw frozen lines.					

Rank	Location	Description of Existing		Efficiency Recommendation	
5	Sewer Discharge Line Heat Tape	Sewer Discharge Line Heat Tape with Manual Switching		Shut off heat tape and use only for emergency purposes.	
Installation Cost	$1,500	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$742
Breakeven Cost	$8,715	**Savings-to-Investment Ratio**	5.8	**Simple Payback yrs**	2
Auditors Notes: Electric heat tape should only be used when required to thaw frozen sewer lines.					

4.5.3 Other Measures

Rank	Location	Description of Existing		Efficiency Recommendation	
1		Lift Station Space Heating Load		Lower temperature to 45 deg. When unoccupied and repair door to the wet side of the building.	
Installation Cost	$5,500	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$3,199
Breakeven Cost	$46,732	**Savings-to-Investment Ratio**	8.5	**Simple Payback yrs**	2
Auditors Notes: Add thermostat to dry side of lift station, reset thermostat on wet side to 45 degrees when unoccupied, and repair entrance door to wet side such that it can be closed and locked.					

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 Ruby and the water treatment plant operator to follow up on the recommendations made in this audit report. Funding has been provided to ANTHC through a Rural Alaska Village Grant and the Denali Commission to provide the city with assistance in understanding the report and implementing the recommendations. ANTHC will work to complete the recommendations within the 2015 calendar year.

APPENDICES

Appendix A – Energy Audit Report – Project Summary

ENERGY AUDIT REPORT – PROJECT SUMMARY	
General Project Information	
PROJECT INFORMATION	**AUDITOR INFORMATION**
Building: Ruby Water Treatment Plant & Washeteria	**Auditor Company:** Alaska Native Tribal Health Consortium
Address: PO Box 90, Ruby, Alaska	**Auditor Name:** Carl Remley and Kevin Ulrich
City: Ruby	**Auditor Address:** 3900 Ambassador Dr. Anchorage, AK 99508
Client Name: James Esmailka and Clifford Cleaver	
Client Address: PO Box 90 Ruby, AK 99768	**Auditor Phone:** (907) 729-3543
	Auditor FAX:
Client Phone: (907) 468-4627	**Auditor Comment:**
Client FAX:	
Design Data	
Building Area: 2,160 square feet	**Design Space Heating Load:** Design Loss at Space: 20,699 Btu/hour with Distribution Losses: 20,699 Btu/hour Plant Input Rating assuming 82.0% Plant Efficiency and 25% Safety Margin: 31,554 Btu/hour Note: Additional Capacity should be added for DHW and other plant loads, if served.
Typical Occupancy: 0 people	**Design Indoor Temperature:** 70 deg F (building average)
Actual City: Ruby	**Design Outdoor Temperature:** -42.6 deg F
Weather/Fuel City: Ruby	**Heating Degree Days:** 13,858 deg F-days
Utility Information	
Electric Utility: Ruby, City of - Commercial - Sm	**Natural Gas Provider:** None
Average Annual Cost/kWh: $0.840/kWh	**Average Annual Cost/ccf:** $0.000/ccf

Annual Energy Cost Estimate									
Description	**Space Heating**	**Space Cooling**	**Water Heating**	**Ventilation Fans**	**Clothes Drying**	**Lighting**	**Other Electrical**	**Service Fees**	**Total Cost**
Existing Building	$22,683	$0	$728	$0	$536	$3,914	$11,307	$0	**$39,169**
With Proposed Retrofits	$7,373	$0	$669	$0	$496	$2,634	$9,638	$0	**$20,810**
Savings	$15,310	$0	$59	$0	$40	$1,280	$1,669	$0	**$18,359**

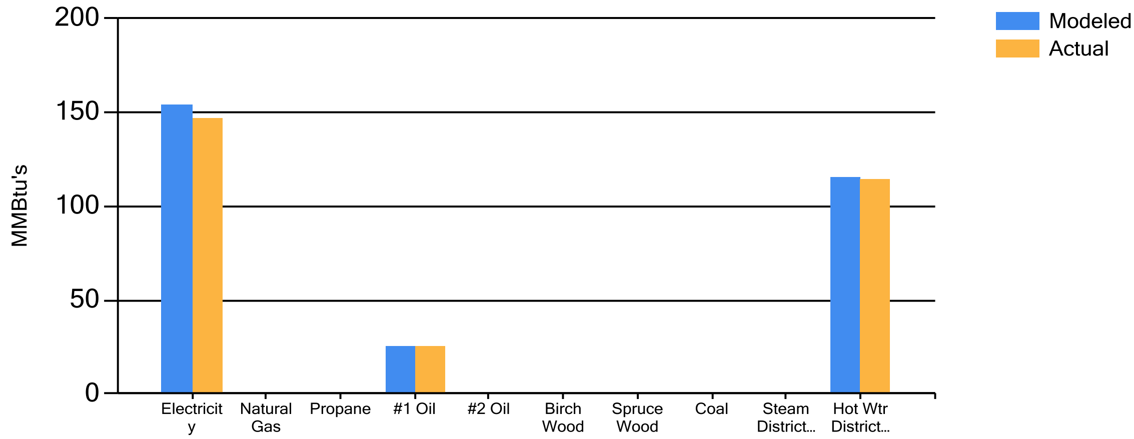
Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	136.6	9.86	$18.13
With Proposed Retrofits	117.5	8.48	$9.63

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.

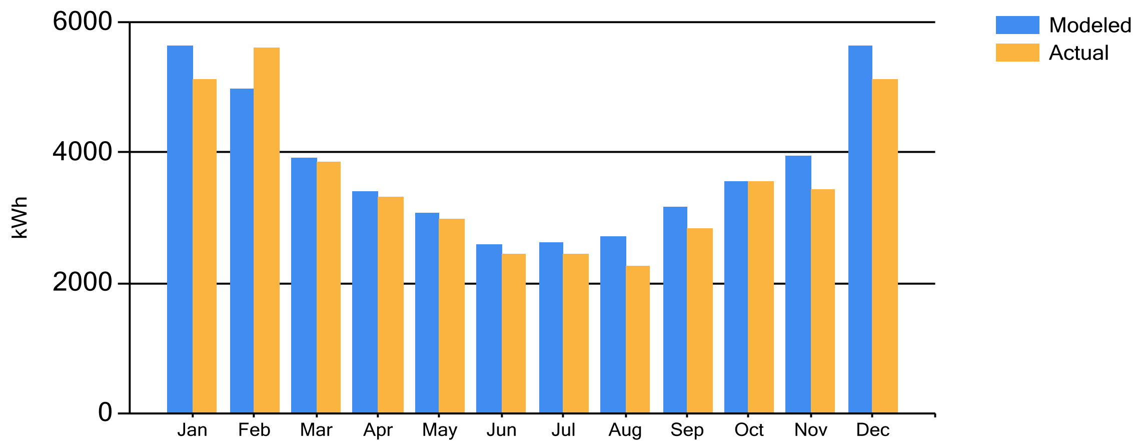
Appendix B – Actual Fuel Use versus Modeled Fuel Use

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

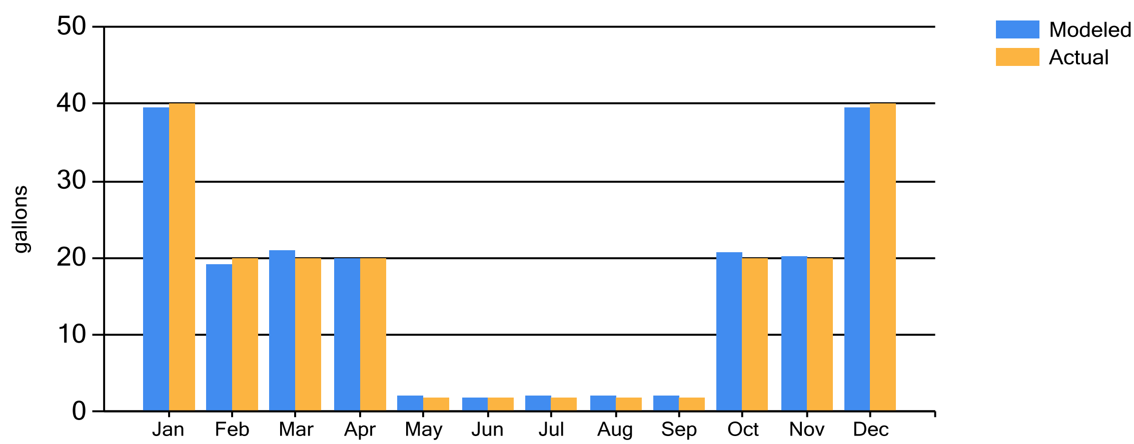
Annual Fuel Use



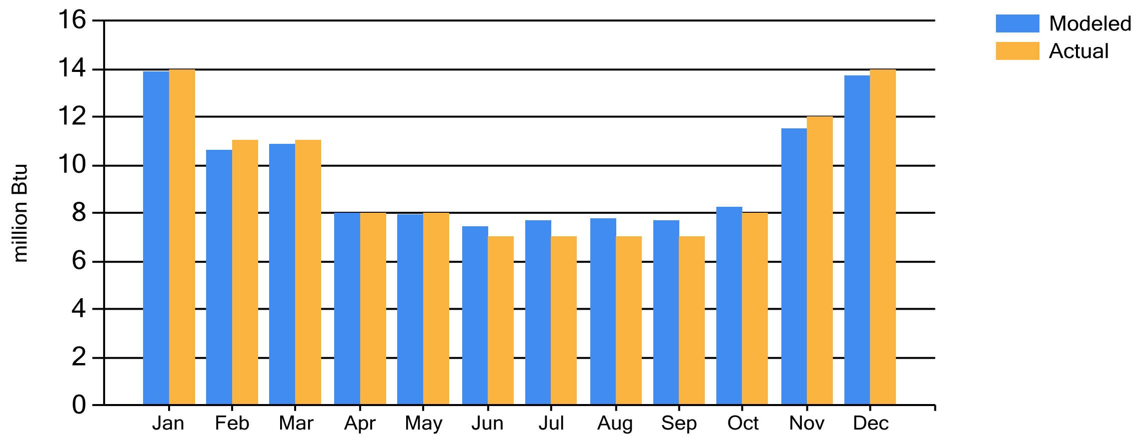
Electricity Fuel Use



#1 Fuel Oil Fuel Use



Hot Wtr District Ht Fuel Use


Modeled
Actual
million Btu
16
14
12
10
8
6
4
2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec