Comprehensive Energy Audit
Beaver Water Plant and Washeteria

Prepared For

Beaver Tribal Council
And Village Safe Water

June 30, 2014

Prepared By:

ANTHC-DEHE
3900 Ambassador Drive, Suite 301
Anchorage, AK 99508

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PREFACE

The Energy Projects Group at the Alaska Native Tribal Health Consortium (ANTHC) prepared this document for The Beaver Tribal Council, Beaver, Alaska and Village Safe Water (VSW). The authors of this report are Carl Remley, Certified Energy Auditor (CEA) and Certified Energy Manager (CEM) and Gavin Dixon. Danny Graham, Structural Engineer for Larsen Consulting Group, Inc. contributed to the on–site portion of this audit.

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 2014 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.

This energy audit was conducted using funds provided by the State of Alaska Village Safe Water (VSW) program. In the near future, a representative of VSW will be contacting the Beaver Tribal Council and the water treatment plant operator to follow up on the recommendations made in this audit report.

In general, the facility is in fair condition. A separate structural evaluation has been prepared to discuss a few concerns. The washeteria equipment including the showers, washers and dryers are near end of life and need to be replaced.

As part of conducting this audit, a meeting was held with the two contractors the Beaver Tribal Council has chosen to upgrade the water treatment plant/washeteria. Those companies are Lars Construction and Alaska BTU. Representing those companies at the meeting was Rex Goolsby and Mike Hirt respectively.

ACKNOWLEDGMENTS

The ANTHC Energy Projects Group gratefully acknowledges the assistance of Chief Rhonda Pitka, Tribal Admin Wilma Pitka, Utility Manager Selena Petruska, and Water Plant Operator Paul Petruska all of the Beaver Tribal Council as well as Susan Randlett of VSW.

Information on the existing PV solar system was graciously provided by Dave Pelunis-Messier of Tanana Chiefs Conference.

1. EXECUTIVE SUMMARY

This report was prepared for the Beaver Tribal Council and VSW. The scope of the audit focused on the Beaver 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, water processing loads, and plug loads.

Based on electricity and fuel oil prices in effect at the time of the audit, the annual predicted energy costs for the water plant/washeteria analyzed are $22,081 for electricity and $15,772 for # 1 fuel oil. The Beaver Tribal Council does not charge the water plant/washeteria for the recovered heat supplied by the power plant. The total energy cost as modeled is $37,871 per year. This compares very favorably with the $38,906 actual energy cost.

It should be noted that this facility did not receive the power cost equalization (PCE) subsidy from the state of Alaska. As a non-state or federal owned facility, the facility should be eligible. The Tribal Council could save as much as $12,000 a year in electricity costs with PCE. Receiving PCE would reduce the electricity cost savings listed in this report.

Table 1.1 below summarizes the energy efficiency measures analyzed for the Beaver water plant/washeteria. Listed below 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	Category	Improvement Description	Annual Energy Savings	Installed Cost	Savings to Investment Ratio, SIR[1]	Simple Payback (Years)[2]
1	Other Electrical – Repair Dryer Pump Controls	Repair relay controls such that dryer pump only runs when dryers do	$7,853	$2,500	36.90	0.3

Table 1.1 PRIORITY LIST – ENERGY EFFICIENCY MEASURES						
Rank	**Category**	**Improvement Description**	**Annual Energy Savings**	**Installed Cost**	**Savings to Investment Ratio, SIR[1]**	**Simple Payback (Years)[2]**
2	Lighting – Convert Exterior Lighting to LED	Replace exterior lighting with LED 20 watt wall packs controlled by a photocell	$605 Plus $40 Maintenance Savings	$2,000	4.72	3.1
3	Lighting – Replace washeteria fluorescent lighting with LED's	Replace existing fluorescent lamps by removing the ballast and installing direct wired 18 watt LED lamps	$136 Plus $10 Maintenance Savings	$800	2.64	5.5
4	Lighting - Replace WTP 4 lamp fluorescent Lighting with LED's	Replace existing fluorescent lamps by removing the ballast and installing direct wired 18 watt LED lamps	$84 Plus $40 Maintenance Savings	$800	2.25	6.5
5	Lighting - Replace WTP2 lamp fluorescent lighting with LED's	Replace existing fluorescent lamps by removing the ballast and installing direct wired 18 watt LED lamps	$341 Plus $80 Maintenance Savings	$3,200	1.91	7.6
6	Building Shell: Replace existing metal exterior door.	Remove existing metal door in the WTP and install standard pre-hung better insulated door.	$100	$1,380	1.70	13.8
7	Building Shell: Replace the Broken Window in Washeteria	Replace existing broken window in the washeteria with double paned glass window.	$75	$849	1.54	11.3
8	Building Shell: Replace existing wood exterior door	Remove existing wood door in the washeteria and install standard pre-hung better insulated door.	$64	$1,030	1.47	16.0
9	Heating and Ventilation: Improve recovered heat system and replace boilers.	Re-commission power plant side of heat recovery system including repairing or replacing variable frequency drives on radiator fans, resizing the pumps as necessary to maximize the heat output, do what is necessary to reduce the temperature difference between the hot and cold side of the power plant heat exchanger, and set up the system such that the first priority for the heat is the water plant/washeteria. In the water plant/washeteria, replace the boilers with more appropriately sized and efficient oil fired boilers.	$1,234 Plus $200 Maintenance Savings	$25,000	1.00	17.4

Table 1.1 PRIORITY LIST – ENERGY EFFICIENCY MEASURES						
Rank	Category	Improvement Description	Annual Energy Savings	Installed Cost	Savings to Investment Ratio, SIR[1]	Simple Payback (Years)[2]
	TOTAL, all measures		$10,493 Plus $370 Maintenance Savings	$37,559	3.78	3.5

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 $10,493 per year, or 27.7% of the buildings' total energy costs. These measures are estimated to cost $37,559, for an overall simple payback period of 3.5 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**	**Ventilation Fans**	**Clothes Drying**	**Lighting**	**Other Electrical**	**Raw Water Heat Add**	**Tank Heat**	**Other**	**Service Fees**	**Total Cost**
Existing Building	$5,042	$2,052	$0	$10,855	$3,205	$9,310	$1,334	$2,700	$3,372	$0	**$37,871**
With Proposed Retrofits	$4,074	$999	$0	$3,365	$1,992	$9,310	$1,376	$2,785	$3,477	$0	**$27,377**
Savings	$969	$1,053	$0	$7,490	$1,213	$0	-$41	-$85	-$105	$0	**$10,493**

2. AUDIT AND ANALYSIS BACKGROUND

2.1 Program Description

This audit included services to identify, develop, and evaluate energy efficiency measures at the Beaver water plant/washeteria. The scope of this project included evaluating building shell, lighting and other electrical systems, water process loads, heating and ventilating 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, distribution & 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 Beaver water 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.

The Beaver water plant/washeteria is classified as being made up of the following activity areas:

1) Washeteria: 750 square feet
2) Water Treatment Plant: 930 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; water treatment process loads; 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. Beaver Water Plant/Washeteria

3.1. Building Description

The 1,680 square foot Beaver Water Plant/Washeteria was constructed in 1977 and the last major remodel was in 2008. It has a normal occupancy of approximately two people. One of those people is the water plant operator and the other is a washeteria customer. The building is occupied approximately 13 hours per day, seven days per week.

Raw water is supplied by a nearby well, filtered, chlorinated and pumped to the water storage tank. The underground raw water well line is heated with a temperature controlled glycol trace during the winter months. The 66,000 gallon water storage tank is also heated. Both heat-adds are through heat exchangers off the boiler/recovered heat glycol loop. Pressure pumps are used to maintain distribution pressure for the potable water although the water distribution is limited to the washeteria, community building, and school.

The sewer system is a force main piped through a mostly above ground utilador made of plywood. The utilador is insulated and heated from the same glycol boiler/recovered heat loop as the water supply lines. With some maintenance, the utilador system should have a remaining life of up to ten years. The school heats the utilador from the school to the lagoon. This could become an issue if the school closes due to decreasing enrollment.

The washeteria is used primarily for showers and washing and drying clothes. There are an average of about 3.5 showers taken in the facility per day, and about six loads of clothes per day washed. During the audit, there was one operable shower, one operable washing machine, and two operable dryers. Hot water for the washers and showers is provided from a hot water storage tank heated off the boiler/heat recovery system. Heat for the dryers is provided off the same system but through a separate pump. The pump should only run when a dryer is calling for heat but at present, these controls are not functioning properly and the pump is always on.

The water plant/washeteria has a heat recovery system that recovers heat from the Tribally operated power plant generators and transfers that heat to the water plant to reduce the amount of fuel oil required by the water plant. Although functional, the heat recovery system is not optimized. The amount of heat available as well as the temperature can be increased by re-commissioning the heat recovery system, especially on the power plant side.

A PV solar system was installed in 2007 to help reduce electricity costs at the water plant. A total of 14 panels with a capacity of approximately 180 watts each generate electricity for use at the water plant. This would be a maximum output of 2,520 watts. Over the past seven years, the solar array has generated 13,941 KWHs of electricity. This is an average of approximately 2,000 KWHs per year. Based on this information, the PV solar has been offsetting approximately eight percent of the water plant/washeteria usage. Obviously most of that offset has been in the summer. The system appears to be operating as designed and installed.

Description of Building Shell

The exterior walls are a 2x6 frame with five and a half inches of R-19 fiberglass insulation. There is an additional 1.5 inches of polyurethane insulation with plywood sheathing and siding that has been added to the exterior of the building. The building has a cold roof with 12 inches of loose fill insulation. The building has a piling foundation and a floor with 2x6 framing and approximately 5.5 inches of polyurethane insulation. Typical windows throughout the building are double pane with vinyl frames. The frame on one of the windows in the washeteria is broken and does not close. This window needs to be replaced. The remaining windows should be good for the life of the building.

One exterior door is a metal door with a polyurethane core with low insulation value. The other door is a wooden door with a solid core with low insulation value. Both of these doors should be replaced.

Description of Heating Plants

The heating systems used in the building are:

Burnham Commercial Boiler

Fuel Type:	#1 Oil
Input Rating:	646,000 BTU/hr
Steady State Efficiency:	80 %
Idle Loss:	1.5 %
Heat Distribution Type:	Glycol
Boiler Operation:	All Year

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Fuel Type:	#1 Oil
Input Rating:	646,000 BTU/hr
Steady State Efficiency:	80 %
Idle Loss:	1.5 %
Heat Distribution Type:	Glycol
Boiler Operation:	All Year

Recovered Heat

Fuel Type:	Recovered Heat (from power plant)
Input Rating:	50,000 BTU/hr
Steady State Efficiency:	98 %
Idle Loss:	0 %
Heat Distribution Type:	Glycol
Operation:	All Year

The two boilers are oversized for the load. Significant savings could be realized by installing new high efficiency appropriately sized boilers to supplement the heat recovery system as needed.

Space Heating Distribution Systems

Space heating in the facility is provided by unit heaters in the dryer make up air area, water plant, and washeteria. There is additionally a small amount of baseboard heating in the water plant.

Domestic Hot Water System

A 90 gallon hot water tank heated by the boilers and recovered heat system provides hot water to the facility. An average of 130 gallons of hot water is used per day, which is used for hot water to the showers and for clothes washing.

Recovered Heat System

The Beaver Tribal Council owns both the power plant and the water plant/washeteria. The generators used to produce electricity also produce heat as a byproduct. In most power plants, this heat is exhausted to the air through radiators. In an attempt to reduce the heating load in the water plant/washeteria, a heat recovery system was installed to recover the heat from the generators and transfer it to the water plant through a series of heat exchangers and an in-ground glycol loop. Although functional, this system needs to be re-commissioned.

Lighting

Lighting in the facility is made up primarily of T8 fluorescent lighting each with a electronic ballast. The fixtures have either two or four lamps each. Four of the fixtures in the washeteria have been retrofitted with LED lamps. Exterior lighting is provided by four high pressure sodium fixtures with 50 watt lamps.

Major Equipment

A 2 horsepower glycol circulation pump is the largest single electrical load in the facility. It is a Grundfos pump with three speeds, currently operating at the highest speed (3). There is one operational washing machine which runs a few hours per day at 150 watts/hour. The pressure pump runs intermittently 24 hours a day. The pump is three horsepower. The well pump is ½ horsepower and operates about 10% of the time year round. The backwash pump is a 2 horsepower pump that runs periodically to backwash the filters when treating water. The lift station (located in the water plant) operates a single pump off a level float, and runs about 4% of the time year round. The pump is 2 horsepower.

3.2 Predicted Energy Use

3.2.1 Energy Usage / Tariffs

The electric usage profile chart (below) represents the predicted electrical usage for the building. The model used to predict usage was calibrated to approximately match actual usage. The electric utility measures consumption in kilowatt-hours (KWH). One KWH usage is equivalent to 1,000 watts running for one hour.

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: Beaver Village Electric Utility - Commercial - Small

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	$ 1.00/kWh
#1 Oil	$ 4.93/gallon
Recovered Heat	$ No Charge

It should be noted that the water plant/washeteria does not presently receive power cost equalization (PCE) from the state program. This issue should be investigated since it could reduce the cost of electricity by approximately one half.

3.2.1.1 Total Energy Use and Cost Breakdown

At current rates, Beaver Tribal Council pays approximately $37,871 annually for electricity and fuel oil for the Beaver water plant/washeteria. The Tribal Council does not charge for the power plant supplied recovered heat.

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. This table does not include potential savings from the PCE program.

Figure 3.1
Annual Energy Costs by End Use

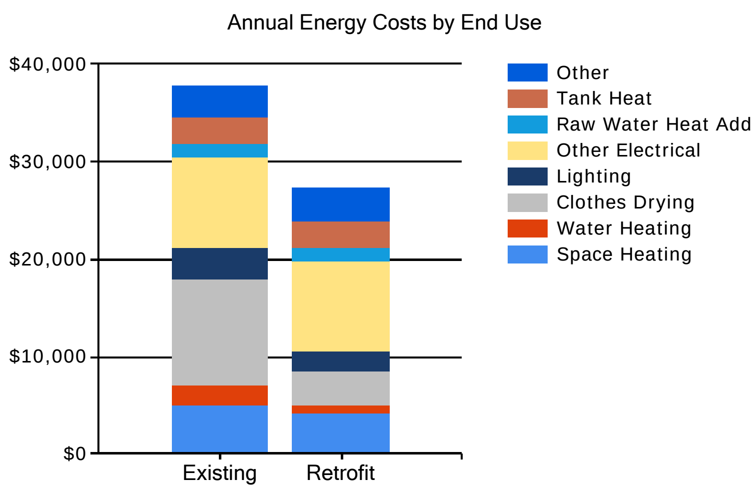


Figure 3.2 below shows how the annual energy cost of the building splits between the different fuels used by the facility. The “Existing” bar shows the breakdown for the building as it is now; the “Retrofit” bar shows the predicted costs if all of the energy efficiency measures in this report are implemented. As mentioned earlier, the Beaver Tribal Council does not charge the water plant/washeteria for the recovered heat.

Figure 3.2
Annual Energy Costs by Fuel Type

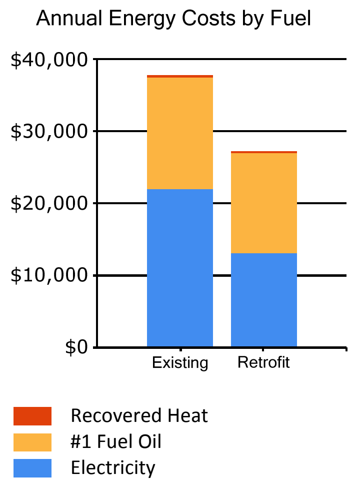
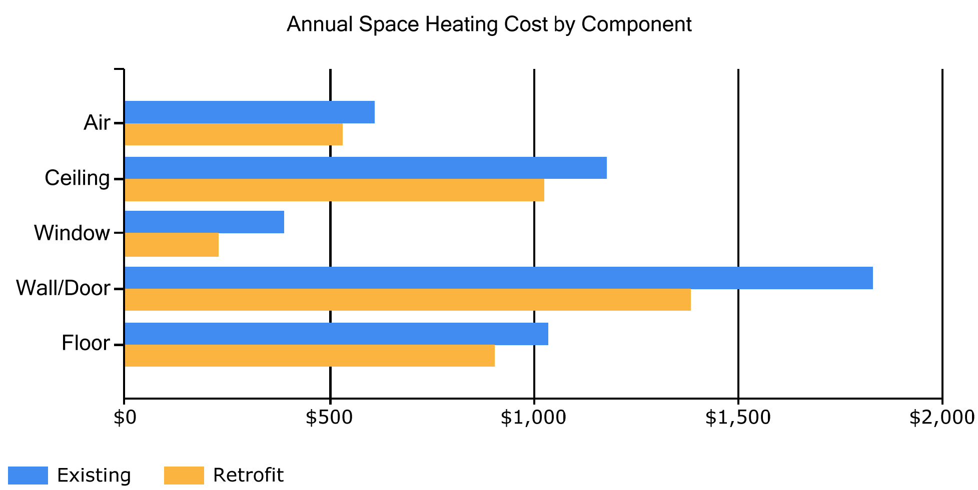


Figure 3.3 below addresses only space heating costs. The figure shows how each heat loss component contributes to those costs; for example, the figure shows how much annual space heating cost is caused by the heat loss through the walls/doors. For each component, the space heating cost for the existing 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	25	21	19	12	8	8	8	9	10	14	20	24
DHW	15	13	15	14	18	17	18	18	17	15	14	15
Clothes_Drying	753	686	753	729	756	732	756	756	732	753	729	753
Lighting	312	284	312	301	206	200	206	206	254	312	301	312
Other_Electrical	1113	1014	1113	1077	614	141	146	146	641	1113	1077	1113
Raw_Water_Heat_Add	8	7	8	8	0	0	0	0	0	8	8	8
Tank_Heat	21	18	16	10	0	0	0	0	0	10	17	21
Other	20	19	21	21	0	0	0	0	0	21	20	20

Fuel Oil #1 Consumption (Gallons)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space_Heating	132	111	102	62	55	53	55	55	53	72	108	130
DHW	22	20	23	23	45	44	45	45	44	24	22	22
Clothes_Drying	23	21	24	24	48	46	48	48	46	25	23	23
Raw_Water_Heat_Add	37	34	38	38	0	0	0	0	0	39	36	37
Tank_Heat	97	81	76	47	0	0	0	0	0	49	78	95
Other	93	85	95	97	0	0	0	0	0	100	92	93

Recovered Heat Consumption (Million Btu)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space_Heating	2	2	2	1	0	0	0	0	0	1	2	2
DHW	1	1	1	1	1	1	1	1	1	1	1	1
Clothes_Drying	1	1	1	1	1	1	1	1	1	1	1	1
Raw_Water_Heat_Add	1	1	1	1	0	0	0	0	0	1	1	1
Tank_Heat	3	2	2	1	0	0	0	0	0	1	2	3
Other	3	3	3	3	0	0	0	0	0	3	3	3

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):

Building Site EUI = *(Electric Usage in kBtu + Fuel Oil Usage in kBtu)* / *Building Square Footage*

Building Source EUI = *(Electric Usage in kBtu X SS Ratio + Fuel Oil Usage in kBtu X SS Ratio)* / *Building Square Footage*

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

Table 3.4
Beaver 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	22,081 kWh	75,363	3.340	251,712
#1 Oil	3,199 gallons	422,282	1.010	426,505
Recovered Heat	89.11 million Btu	89,115	1.280	114,067
Total		**586,759**		**792,283**
BUILDING AREA		1,680	Square Feet	
BUILDING SITE EUI		349	kBTU/Ft²/Yr	
BUILDING SOURCE EUI		472	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.				

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 Beaver water plant/washeteria was modeled using AkWarm© energy use software to establish a baseline space heating and cooling energy usage. Climate data from Beaver 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 Beaver. 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 HVAC 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 Water Plant/Washeteria, Beaver, Alaska PRIORITY LIST – ENERGY EFFICIENCY MEASURES						
Rank	**Feature**	**Improvement Description**	**Annual Energy Savings**	**Installed Cost**	**Savings to Investment Ratio, SIR**	**Simple Payback (Years)**
1	Other Electrical – Repair Dryer Pump Controls	Repair relay controls such that dryer pump only runs when dryers do	$7,853	$2,500	36.90	0.3
2	Lighting – Convert Exterior Lighting to LED	Replace exterior lighting with LED 20 watt wall packs controlled by a photocell	$605 Plus $40 Maintenance Savings	$2,000	4.72	3.1
3	Lighting – Replace washeteria fluorescent lighting with LED's	Replace existing fluorescent lamps by removing the ballast and installing direct wired 18 watt LED lamps	$136 Plus $10 Maintenance Savings	$800	2.64	5.5
4	Lighting - Replace WTP 4 lamp fluorescent Lighting with LED's	Replace existing fluorescent lamps by removing the ballast and installing direct wired 18 watt LED lamps	$84 Plus $40 Maintenance Savings	$800	2.25	6.5
5	Lighting - Replace WTP2 lamp fluorescent lighting with LED's	Replace existing fluorescent lamps by removing the ballast and installing direct wired 18 watt LED lamps	$341 Plus $80 Maintenance Savings	$3,200	1.91	7.6

Table 4.1 Water Plant/Washeteria, Beaver, Alaska PRIORITY LIST – ENERGY EFFICIENCY MEASURES						
Rank	**Feature**	**Improvement Description**	**Annual Energy Savings**	**Installed Cost**	**Savings to Investment Ratio, SIR**	**Simple Payback (Years)**
6	Building Shell: Replace existing metal exterior door.	Remove existing metal door in the WTP and install standard pre-hung better insulated door.	$100	$1,380	1.70	13.8
7	Building Shell: Replace the Broken Window in Washeteria	Replace existing broken window in the washeteria with double paned glass window.	$75	$849	1.54	11.3
8	Building Shell: Replace existing wood exterior door	Remove existing wood door in the washeteria and install standard pre-hung better insulated door.	$64	$1,030	1.47	16.0
9	Heating and Ventilation: Improve recovered heat system and replace boilers.	Re-commission power plant side of heat recovery system including repairing or replacing variable frequency drives on radiator fans, resizing the pumps as necessary to maximize the heat output, do what is necessary to reduce the temperature difference between the hot and cold side of the power plant heat exchanger, and set up the system such that the first priority for the heat is the water plant/washeteria. In the water plant/washeteria, replace the boilers with more appropriately sized and efficient oil fired boilers.	$1,234 Plus $200 Maintenance Savings	$25,000	1.00	17.4
	TOTAL, all measures		**$10,493 Plus $370 Maintenance Savings**	**$37,559**	**3.78**	**3.5**

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, process loads 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

4.3.1 Window Measures

<table>
<tr><th>Rank</th><th colspan="2">Location</th><th colspan="2">Size/Type, Condition</th><th colspan="2">Recommendation</th></tr>
<tr><td>7</td><td colspan="2">Washeteria Window: This window is in the open area of the washeteria.</td><td colspan="2">Glass: No glazing - broken, missing
Frame: Wood\Vinyl
Spacing Between Layers: Half Inch
Gas Fill Type: Air
Modeled U-Value: 0.94
Solar Heat Gain Coefficient including Window Coverings: 0.11</td><td colspan="2">This window does not close properly and thereby is essentially a hole between the heated washeteria and the outside ambient temperature. In Beaver, this results in a significant heat loss. The existing window should either be repaired or replaced with double paned glass window with vinyl frame.</td></tr>
<tr><td colspan="2">Installation Cost</td><td>$849</td><td>Estimated Life of Measure (yrs)</td><td>20</td><td>Energy Savings (/yr)</td><td>$75</td></tr>
<tr><td colspan="2">Breakeven Cost</td><td>$1,306</td><td>Savings-to-Investment Ratio</td><td>1.5</td><td>Simple Payback yrs</td><td>11</td></tr>
<tr><td colspan="7">Auditors Notes: This broken window is allowing for significant heat loss to the outside ambient. Replacing it with a better insulated double paned window will produce substantial savings and significantly improve the comfort level.</td></tr>
</table>

4.3.2 Door Measures

<table>
<tr><th>Rank</th><th colspan="2">Location</th><th colspan="2">Size/Type, Condition</th><th colspan="2">Recommendation</th></tr>
<tr><td>6</td><td colspan="2">Exterior Door: Water Plant</td><td colspan="2">Door Type: Entrance, Metal, polyurethane core, metal edge
Modeled R-Value: 2.5</td><td colspan="2">Remove existing door and install standard pre-hung better insulated door. Proper weather stripping should be part of the installation.</td></tr>
<tr><td colspan="2">Installation Cost</td><td>$1,380</td><td>Estimated Life of Measure (yrs)</td><td>30</td><td>Energy Savings per year</td><td>$100</td></tr>
<tr><td colspan="2">Breakeven Cost</td><td>$2,347</td><td>Savings-to-Investment Ratio</td><td>1.7</td><td>Simple Payback in years</td><td>14</td></tr>
<tr><td colspan="7">Auditors Notes: Current door doesn't fit properly and is poorly insulated.</td></tr>
</table>

<table>
<tr><th>Rank</th><th colspan="2">Location</th><th colspan="2">Size/Type, Condition</th><th colspan="2">Recommendation</th></tr>
<tr><td>8</td><td colspan="2">Exterior Door: Washeteria</td><td colspan="2">Door Type: Entrance, Wood, solid core flush, 2-1/4"
Modeled R-Value: 3.7</td><td colspan="2">Remove existing door and install standard pre-hung better insulated door. Proper weather stripping should be part of the installation.</td></tr>
<tr><td colspan="2">Installation Cost</td><td>$1,030</td><td>Estimated Life of Measure (yrs)</td><td>30</td><td>Energy Savings per year</td><td>$64</td></tr>
<tr><td colspan="2">Breakeven Cost</td><td>$1,516</td><td>Savings-to-Investment Ratio</td><td>1.5</td><td>Simple Payback in years</td><td>16</td></tr>
<tr><td colspan="7">Auditors Notes: Current door doesn't fit properly and is poorly insulated.</td></tr>
</table>

4.4 Mechanical Equipment Measures

4.4.1 Heating/Domestic Hot Water Measure

Rank	Recommendation				
9	Re-commission power plant side of heat recovery system including repairing or replacing variable frequency drives on radiator fans, resizing the pumps as necessary to maximize the heat output, do what is necessary to reduce the temperature difference between the hot and cold side of the power plant heat exchanger, and set up the system such that the first priority for the recovered heat is the water plant/washeteria. In the water plant/washeteria, replace the boilers with more appropriately sized and efficient oil fired boilers.				
Installation Cost	$25,000	**Estimated Life of Measure (yrs)**	20	**Energy Savings per year**	$1,234
				Maintenance Savings per year	$200
Breakeven Cost	$25,000	**Savings-to-Investment Ratio**	1.0	**Simple Payback in years**	17
Auditors Notes: The system as installed is not optimized. Some of the generator heat is being exhausted to the atmosphere through the power plant radiators. This is mainly due to non-functioning variable frequency drives on the radiator fans. There is also an issue with the pumps or heat exchanger that is resulting in a large temperature differential between the hot and cold sides of the power plant heat exchanger. The re-commissioning should also set up the water plant/washeteria as the first priority for the recovered heat.					

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 lamps 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 lamps give off less heat.

4.5.1a Lighting Measures – Replace Existing Fixtures/Lamps

Rank	Location	Existing Condition		Recommendation	
2	Exterior Lighting	Four HPS 50 Watt Magnetic with Photocell Switching		Replace by installing four 20 W LED wall packs with photocell controls to ensure lights only come on when it is dark.	
Installation Cost	$2,000	**Estimated Life of Measure (yrs)**	20	**Energy Savings per year**	$605
				Maintenance Savings per year	$40
Breakeven Cost	$9,434	**Savings-to-Investment Ratio**	4.7	**Simple Payback in years**	3
Auditors Notes: Replacing exterior fixtures with LED wall packs will reduce energy use, improve functionality in the cold, and require less bulb maintenance. Installing photocell controls will reduce run time so that the fixtures only operate when it is dark.					

Rank	Location	Existing Condition		Recommendation	
3	Washeteria; 2 Lamp Fluorescent	4 Fluorescent 2 lamp T8 4' F32T8 32W lamps electronic ballasts with manual switching and occupancy sensor		Replace existing fluorescent lamps by removing the ballast and installing direct wired 18 watt LED lamps.	
Installation Cost	$800	**Estimated Life of Measure (yrs)**	20	**Energy Savings per year**	$136
				Maintenance Savings per year	$10
Breakeven Cost	$2,112	**Savings-to-Investment Ratio**	2.6	**Simple Payback in years**	5
Auditors Notes: Four of the eight fixtures are already LED in the washeteris area. LED replacement lamps use less energy last longer, and contain no poisonous mercury. They can be direct wired without using a ballast.					

Rank	Location		Existing Condition		Recommendation	
4	WTP; 4 Lamp Fluorescent		2 fluorescent 4 lamp T8 4' F32T8 32W lamps with electronic ballasts with manual switching		Replace existing fluorescent fixtures by removing the ballast and installing direct wired 18 watt LED lamps.	
Installation Cost	$800	**Estimated Life of Measure (yrs)**		20	**Energy Savings per year**	$84
					Maintenance Savings per year	$40
Breakeven Cost	$1,798	**Savings-to-Investment Ratio**		2.2	**Simple Payback in years**	6
Auditors Notes: LED replacement lamps use less energy last longer, and contain no poisonous mercury. They can be direct wired without using a ballast.						

Rank	Location		Existing Condition		Recommendation	
5	WTP 2 Lamp Fluorescent		16 fluorescent 2 lamp T8 4' F32T8 32W lamps with electronic ballasts with manual Switching		Replace existing fluorescent fixtures by removing the ballast and installing direct wired 18 watt LED bulbs.	
Installation Cost	$3,200	**Estimated Life of Measure (yrs)**		20	**Energy Savings per year**	$341
					Maintenance Savings per year	$80
Breakeven Cost	$6,100	**Savings-to-Investment Ratio**		1.9	**Simple Payback in years**	8
Auditors Notes: LED replacement lamps use less energy last longer, and contain no poisonous mercury. They can be direct wired without using a ballast.						

4.5.2 Other Measures

Rank	Location		Description of Existing		Efficiency Recommendation	
1	Washeteria: Clothes Dryers		Clothes Drying Load		Repair relay controls such that dryer pump only runs when dryers do.	
Installation Cost	$2,500	**Estimated Life of Measure (yrs)**		15	**Energy Savings per year**	$7,853
Breakeven Cost	$92,244	**Savings-to-Investment Ratio**		36.9	**Simple Payback in years**	0
Auditors Notes: When the dryers were installed, a small relay panel was installed that only turned on the pump that provides heat to the dryer coils when one of the dryers is operating (approximately 5% of the time). These relay controls are not functioning at the present time. As a result, the dryer glycol pump is running continuously. This is resulting in both excessive fuel oil use and excessive electricity use. A controls electrician can fairly easily correct this problem.						

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.

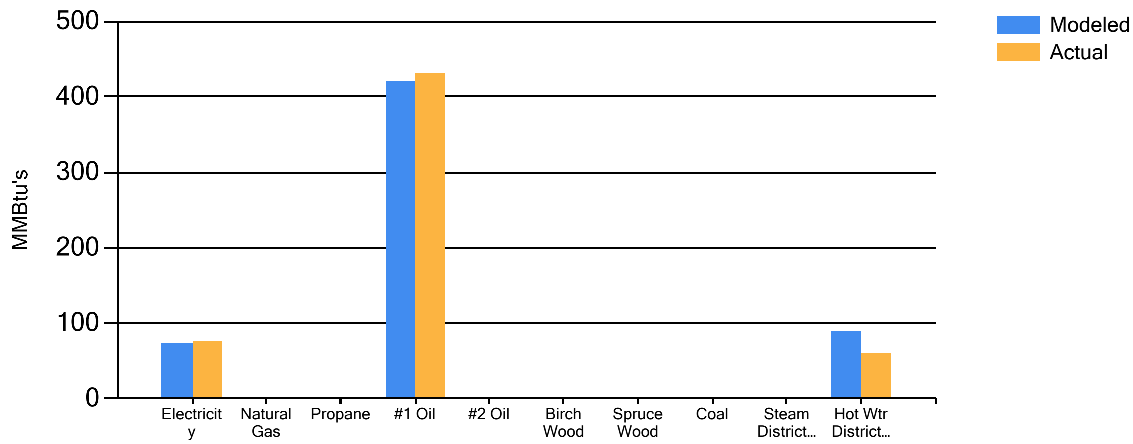
Several types of EEMs can be implemented immediately by building staff, and others will require various amounts of lead time for engineering and equipment acquisition. In some cases, there are logical advantages to implementing EEMs concurrently. For example, if the same electrical contractor is used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

This energy audit was conducted using funds provided by the State of Alaska Village Safe Water (VSW) program. In the near future, a representative of VSW will be contacting the Beaver Tribal Council and the water treatment plant operator to follow up on the recommendations made in this audit report.

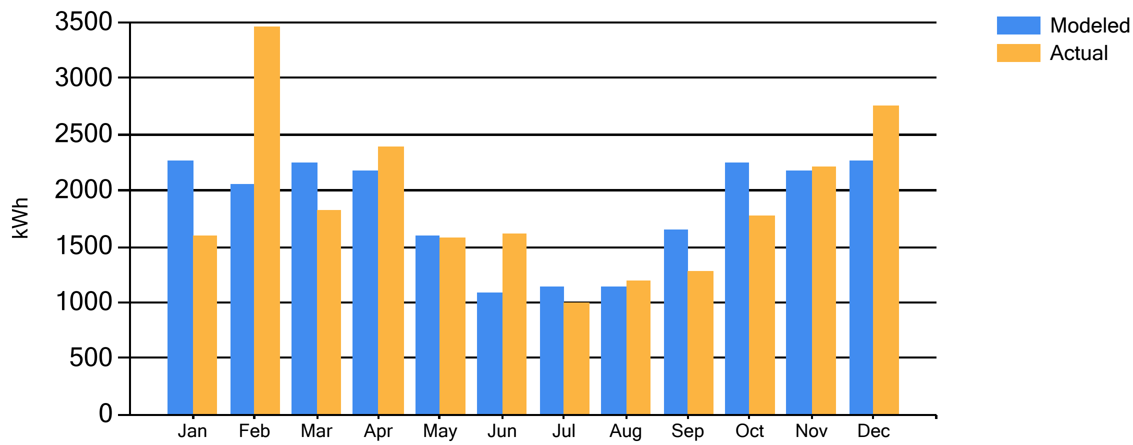
Appendix A – Actual Fuel Use versus Modeled Fuel Use

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

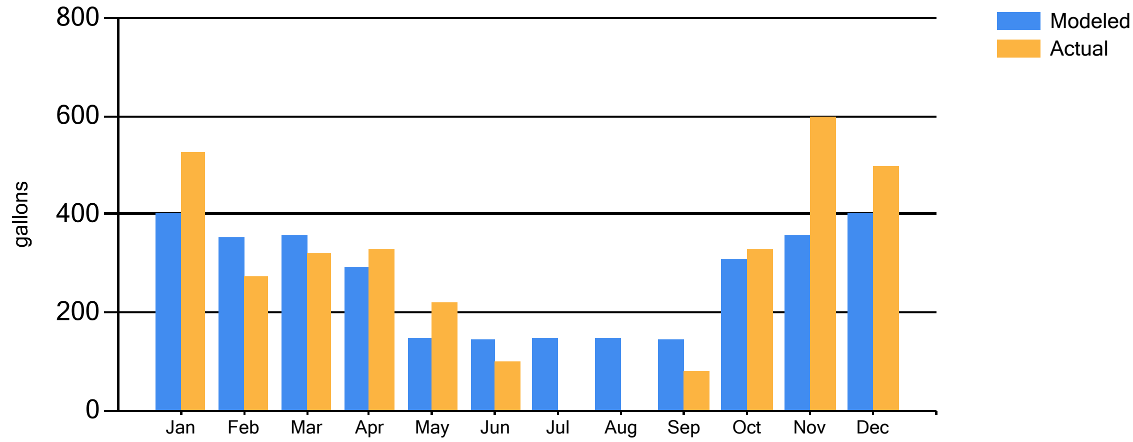
Annual Fuel Use



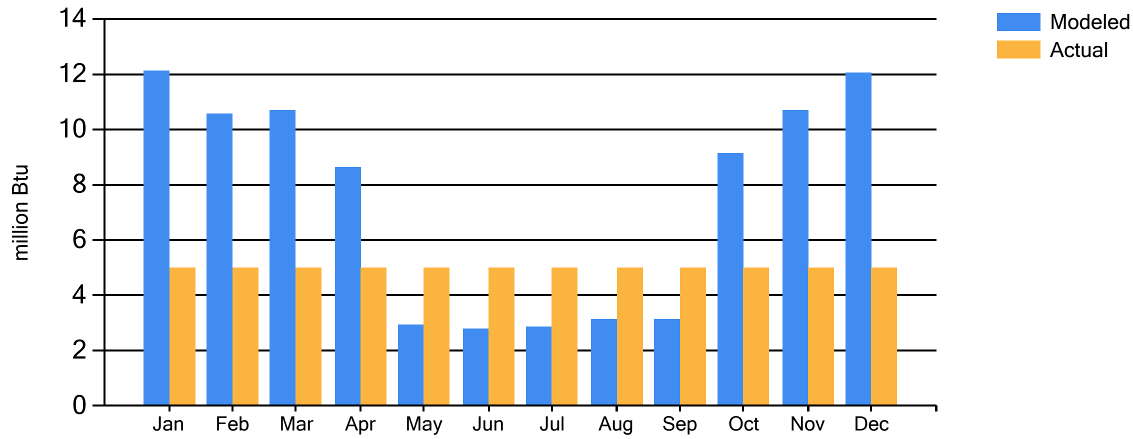
Electricity Fuel Use



#1 Fuel Oil Fuel Use



Recovered Heat



Appendix B - Electrical Demands

Estimated Peak Electrical Demand (kW)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Current	4.2	4.2	4.2	4.2	3.5	2.9	2.9	2.9	3.6	4.2	4.2	4.2
As Proposed	3.9	3.9	3.9	3.9	3.2	2.6	2.6	2.6	3.3	3.9	3.9	3.9

Estimated Demand Charges (at $0.00/kW)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Current	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
As Proposed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

AkWarmCalc Ver 2.3.2.1, Energy Lib 4/11/2014