Comprehensive Energy Audit
For

Klawock Water Treatment Plant

Prepared For
City of Klawock

July 27, 2016

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ANTHC - DEHE
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PREFACE

This energy audit was conducted using funds provided by the Department of Energy as part of the Rural Alaskan Communities Energy Efficiency (RACEE) Competition. Coordination with the City and Cooperative Association of Klawock has been undertaken to provide maximum accuracy in identifying audits and coordinating potential follow up retrofit activities.

The Rural Energy Initiative at the Alaska Native Tribal Health Consortium (ANTHC) prepared this document for the City and Cooperative Association of Klawock, Alaska. The authors of this report are Bailey Gamble, Mechanical Engineer I; and Gavin Dixon, Senior Project Manager and Cody Uhlig P.E., Utility Support Engineer.

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

ACKNOWLEDGMENTS

The ANTHC Energy Projects Group gratefully acknowledges the assistance Wastewater Treatment Plant Operator Harry Jackson, Sr., City of Klawock advisor Phil Downing, City of Kiana Administrator Leslie Isaacs, and Klawock Cooperative Association President Archie W. Demmert, III.

1. EXECUTIVE SUMMARY

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

Based on electricity and fuel oil prices in effect at the time of the audit, the total predicted energy costs are $8,937 per year. Electricity represents the largest portion with an annual cost of approximately $4,665. This includes about $3,320 paid by the city and about $1,345 paid by the Power Cost Equalization (PCE) program through the State of Alaska. Fuel represents the remaining portion, with an annual cost of approximately $4,272.

The State of Alaska PCE program provides a subsidy to rural communities across the state to lower electricity costs and make energy affordable in rural Alaska. In Klawock, the cost of electricity without PCE is $0.28/kWh and the cost of electricity with PCE is $0.201/kWh.

Table 1.1 lists the total usage of electricity and #1 heating oil in the Klawock WTP before and after the proposed retrofits.

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

Predicted Annual Fuel Use		
Fuel Use	**Existing Building**	**With Proposed Retrofits**
Electricity	15,760 kWh	12,685 kWh
#1 Oil	1,537 gallons	1,006 gallons

Benchmark figures facilitate comparing energy use between different buildings. Table 2.1 lists several benchmarks for the audited building. More details can be found in section 3.2.2.

Table 1.2: Building Benchmarks for the Water Treatment Plant

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	154.2	20.80	$5.37
With Proposed Retrofits	105.7	14.26	$4.07
EUI: Energy Use Intensity - The annual site energy consumption divided by the structure's conditioned area. EUI/HDD: Energy Use Intensity per Heating Degree Day. ECI: Energy Cost Index - The total annual cost of energy divided by the square footage of the conditioned space in the building.			

Table 1.3 below summarizes the energy efficiency measures analyzed for the Klawock Water Treatment Plant. Listed are the estimates of the annual savings, installed costs, and two different financial measures of investment return.

Table 1.3: Summary of Recommended Energy Efficiency Measures

PRIORITY LIST – ENERGY EFFICIENCY MEASURES							
Rank	**Feature**	**Improvement Description**	**Annual Energy Savings**	**Installed Cost**	**Savings to Investment Ratio, SIR[1]**	**Simple Payback (Years)[2]**	**CO_2 Savings**
1	Setback Thermostat: Main Mechanical Room	Implement a heating temperature setback to 50.0 deg F when unoccupied.	$1,528	$200	101.13	0.1	11,199.5
2	Setback Thermostat: Office	Implement a heating temperature setback to 60.0 deg F when unoccupied.	$193	$200	12.76	1.0	1,412.2
3	Setback Thermostat: Chlorine Room	Implement a heating temperature setback to 60.0 deg F when unoccupied.	$116	$200	7.66	1.7	846.6
4	Setback Thermostat: Polymer Room	Implement a heating temperature setback to 60.0 deg F when unoccupied.	$50	$200	3.31	4.0	366.5
5	Setback Thermostat: Bathroom	Implement a heating temperature setback to 60.0 deg F when unoccupied.	$68	$800	1.12	11.8	495.1
6	Other Electrical - Controls Retrofit: Polymer Injection Pump	Detect and repair leaks on service lines and WST to reduce water production demand by 35 %.	$180 + $4,000 Maint. Savings	$60,000	1.03	14.4	1,644.6
7	Lighting - Controls Retrofit: Exterior Alarm Light	Determine and address source of alarm so that light turns off.	$8	$500	0.19	60.5	69.0
8	HVAC And DHW	Downsize electric water heater from 30 gal to 12 gal.	$20	$1,500	0.18	74.0	105.7
	TOTAL, all measures		**$2,163 + $4,000 Maint. Savings**	**$63,600**	**1.38**	**10.3**	**16,139.2**

Table Notes:

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

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

With all of these energy efficiency measures in place, the annual utility cost can be reduced by $2,163 per year, or 24.2% of the buildings' total energy costs. These measures are estimated to cost $63,600, for an overall simple payback period of 10.3 years.

Table 1.4 is a breakdown of the annual energy cost across various energy end use types, such as space heating and water heating. The first row in the table shows the breakdown for the building as it is now. The second row shows the expected breakdown of energy cost for the building assuming all of the retrofits in this report are implemented. Finally, the last row shows the annual energy savings that will be achieved from the retrofits.

Table 1.4: Detailed Breakdown of Energy Costs in the Building

Annual Energy Cost Estimate							
Description	**Space Heating**	**Water Heating**	**Ventilation Fans**	**Lighting**	**Other Electrical**	**Service Fees**	**Total Cost**
Existing Building	$5,078	$152	$106	$526	$1,948	$1,128	**$8,937**
With Proposed Retrofits	$3,320	$129	$106	$517	$1,575	$1,128	**$6,774**
Savings	$1,758	$23	$0	$9	$373	$0	**$2,163**

2. AUDIT AND ANALYSIS BACKGROUND

2.1 Program Description

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

2.2 Audit Description

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

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

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

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

1) Office: 255 square feet
2) Polymer Room: 67 square feet
3) Main Mechanical Room: 1,202 square feet
4) Bathroom: 54 square feet
5) Chlorine Room: 87 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 systems; 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. Klawock Water Treatment Plant

3.1. Building Description

The 1,692 square foot Klawock Water Treatment Plant was constructed in 2013, with a normal occupancy of 1 person during operating hours. The number of hours of operation for this building average 8 hours per day, considering all seven days of the week.

Raw water flows by gravity from a surface water impoundment on Half-Mile Creek down through the Water Treatment Plant and on to the Water Storage Tank. The WTP continuously makes water at a rate based upon the water level in the storage tank. The treatment process operates under gravity flow.

Raw water flows into the WTP where a polymer coagulant is added before the water passes through four sand filters (Figure 1). All four filters are run simultaneously. The filters are backwashed twice a week to remove captured organic material. After filtration, chlorine is injected as disinfectant. The treated water then flows by gravity to an 809,000 gallon storage tank and from there is distributed by gravity throughout the community.

Figure 1: Filters in Klawock Water Treatment Plant

Description of Building Shell

The exterior walls of the water treatment plant are constructed with single stud 2x6 lumber construction with a 24-inch offset. The walls have approximately 5.5 inches of R-19 insulated polyurethane panels. There is approximately 2,683 square feet of wall space in the WTP.

The WTP has a cathedral ceiling with 2x6 lumber construction. The roof has standard framing and a 24-inch offset. The ceiling contains approximately 5.5 inches of R-19 insulated polyurethane panels. There is approximately 1832 square feet of roof space in the building.

The WTP is built on an uninsulated concrete pad. There is approximately 1692 square feet of floor space in the building.

The building has eleven total windows, each of which has double-pane glass. Nine of the eleven windows measure 3’4” X 5’4”. Two smaller windows measuring 4’ x 1’6” and 3’4” x 1’10” are found on the mezzanine and in the bathroom respectively. Three of the large windows face south and all have light to no shading.

There are three insulated metal doors on the front (west side) of the WTP – one leading to the mezzanine, one, to the main office and one to the chlorine room. Each measure 3’ x 6’4”. There is a double door in the mechanical room measuring 7’4” x 6’4”. All doors are fairly well sealed.

Description of Heating and Cooling Plants

The Heating Plants used in the building are:

Toyostove Laser 30

Fuel Type:	#1 Oil
Input Rating:	15,000 BTU/hr
Steady State Efficiency:	87 %
Idle Loss:	0.5 %
Heat Distribution Type:	Air

Toyostove Laser 73

Fuel Type:	#1 Oil
Input Rating:	40,000 BTU/hr
Steady State Efficiency:	87 %
Idle Loss:	0.5 %
Heat Distribution Type:	Air

AO Smith Water Heater

Fuel Type:	Electricity
Input Rating:	0 BTU/hr
Steady State Efficiency:	93 %
Idle Loss:	0 %
Heat Distribution Type:	Water
Boiler Operation:	All Year

Trane Air Heater 1

Fuel Type:	Electricity

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

Train Air Heater 2

Fuel Type: Electricity
Input Rating: 2,050 BTU/hr
Steady State Efficiency: 100 %
Idle Loss: 0 %
Heat Distribution Type: Air

Baseboard Heater

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

There is an electric water heater that heats water for the bathroom sink and for mixing polymer. Other than this, there is no need to add heat to the water in the Klawock. The heating plants serve only to meet the space heating demand. The main office is heated by the Toyotomi Laser 30 and the mechanical room is heated by the Toyotomi Laser 78 oil burning furnace. The bathroom is heated by an electric baseboard heater. The polymer and chlorine rooms are heated by Trane electric space heaters. All of these heating elements are controlled by thermostats.

Figure 2: Toyotomi Laser 30 Oil Furnace

Figure 3: Trane Air Heater

Domestic Hot Water System

AO Smith Water Heater

Fuel Type:	Electricity
Input Rating:	0 BTU/hr
Steady State Efficiency:	93%
Idle Loss:	0%
Heat Distribution Type:	Water
Boiler Operation:	All Year

An AO Smith ECS 30 gallon water heater heats water for the bathroom sink and tempers water used for mixing polymer.

Description of Building Ventilation System

The existing building ventilation system consists of three exhaust fans and a humidity control fan. The bathroom and polymer room both include a Greenheck ceiling exhaust fan that expels air at a rate of 89 CFM. The exhaust fan in the bathroom is controlled by an occupancy sensor. The exhaust fan in the polymer room is controlled by a wall switch. There is a Greenheck Inline Direct Drive exhaust fan in the Chlorine room that expels air at a rate of 200 CFM and is controlled by a wall switch, running when the room is occupied for safety.

There is a second Greenheck Inline Direct Drive exhaust fan in the filter room intended to control humidity. This fan turns on and exchanges indoor for outdoor air when the indoor dew point is greater than 40 degrees F and the outdoor dew point is less than 38 degrees F. This process is important to reducing sweating and rusting within the water treatment plant. Due to weather, this fan operates primarily in the winter and very rarely in the summer and fall.

Lighting

The WTP office has four fixtures with two 4 ft. 15 W LED strips in each fixture. The lights are usually on during operator hours, so for about 6-7 hours a day year round. They consume approximately 404.1 kWh annually.

The polymer room has two fixtures with two 4 ft. 15 W LED strips in each fixture. The lights are on only when the operator enters the polymer room, so for about an hour each week. They consume approximately 38.8 kWh annually.

The bathroom has two fixtures; one with two 4 ft. T8 34 W bulbs and one with two 2 ft. T8 34 W bulbs. The lights are on only when the bathroom is in use so for about an hour each day. They consume approximately 44.2 kWh annually.

The mechanical including the mezzanine has a total of 18 fixtures. There are six fixtures with two 4 ft. 15 W LED strips in each fixture located in front of the filters which would be turned on whenever the operator is in the mechanical room, about 40% of operator hours. There are 3 more fixtures with the same configuration on the backside of the filters that are rarely turned on, but appear to be partially illuminated even when off. There are four more of the same fixtures above the mezzanine, turned on when occupied by the operator, about 10% of operator hours. There are 5 high bay 150 W LED lights running along the center of the room at the highest point on the ceiling. These are turned on about 25% of time during operator hours. Altogether, they consume approximately 1,319 kWh annually.

There are four 8 W LED Exit signs in the building that are always on and consume about 383.1 kWh annually. There are three 8 W LED exterior wall mount lights that are controlled by an indoor switch in combination with a daylight sensor that consume about 35.9 kWh annually. An LED alarm light that is currently always on for an unknown reason consumes about 47.9 kWh annually and 9 Emergency lights that may come on in case of a power outage and consume about 16.7 kWh annually.

Plug Loads

The WTP has a variety of power tools, a computer monitor, printer, minifridge, fax machine, and some other miscellaneous loads that require a plug into an electrical outlet. These loads along with a handful of control panels, sensors, displays and interfaces consume an estimated 2,670 kWh annually.

Major Equipment

There is a polymer injection pump that injects diluted polymer into the water as part of the treatment process. The pump is rated at 1 HP on a variable frequency drive (VFD). The pump is always on, but the electric load will vary with flow. It consumes approximately 3,327 kWh annually.

Figure 4: Dilute Polymer Injection Pump

There is a chlorine injection pump that injects diluted chlorine into the water for disinfection. The pump is rated at 180 Watts and operates constantly. It consumes approximately 1,578 kWh annually.

There is an air scour blower used as part of the backwashing process to break up accumulated particles in the filter media. The backwashing process is performed twice a week and the air scouring conducted for about 2 minutes on each of the four filters, for a total of about 16 minutes per week. The air scour blower consumes 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.

Alaska Power and Telephone (APT) is the electric utility in the City of Klawock. The utility provides electricity to the residents of Klawock as well as all commercial and public facilities.

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

Table 3.1: Average Energy Cost

Average Energy Cost	
Description	**Average Energy Cost**
Electricity	$ 0.2960/kWh
#1 Oil	$ 2.78/gallons

3.2.1.1 Total Energy Use and Cost Breakdown

At current rates, City of Klawock Public Works pays approximately $8,937 annually for electricity and other fuel costs for the Klawock Water Treatment Plant.

Figure 5 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.

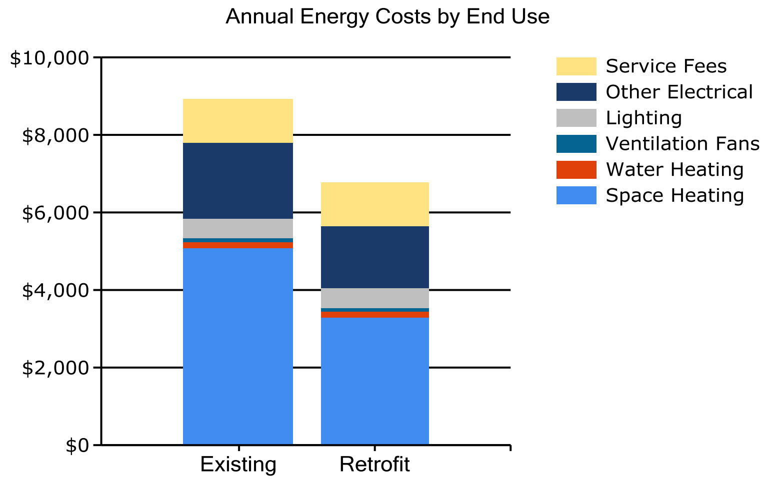


Figure 5: Annual Energy Cost by End Use

Figure 6 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.

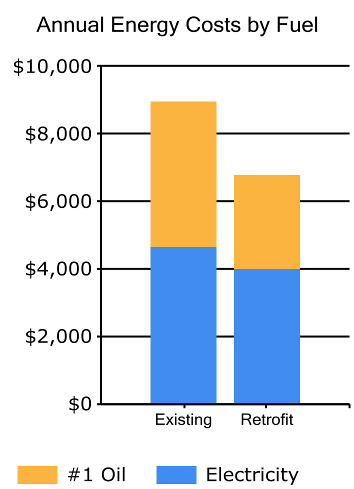


Figure 6: Annual Energy Cost by Fuel Type

Figure 7 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.

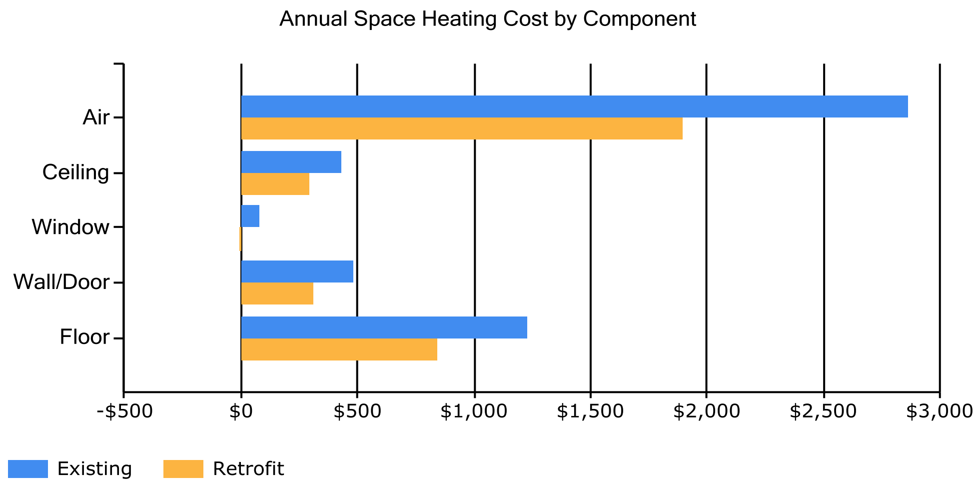


Figure 7: Annual Space Heating Cost by Component

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

Table 3.2: Electrical Consumption Records by Category

Electrical Consumption (kWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space Heating	585	473	476	376	198	58	32	30	74	321	452	543
DHW	57	52	57	56	57	56	57	57	56	57	56	57
Ventilation Fans	63	57	63	61	41	1	1	1	1	63	61	63
Lighting	198	181	198	192	198	192	198	198	192	198	192	198
Other Electrical	735	669	735	711	735	711	735	735	711	735	711	735

Table 3.3: Fuel Consumption Records by Category

Fuel Oil #1 Consumption (Gallons)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space Heating	247	200	201	159	85	26	15	14	32	136	191	230

3.2.2 Energy Use Index (EUI)

Energy Use Index (EUI) is a measure of a building's annual energy utilization per square foot of building. This calculation is completed by converting all utility usage consumed by a building for one year, to British Thermal Units (Btu) or kBtu, and dividing this number by the building square footage. EUI is a good measure of a building's energy use and is utilized regularly for comparison of energy performance for similar building types. The Oak Ridge National Laboratory (ORNL) Buildings Technology Center under a contract with the U.S. Department of Energy maintains a Benchmarking Building Energy Performance Program. The ORNL website determines how a building's energy use compares with similar facilities throughout the U.S. and in a specific region or state.

Source use differs from site usage when comparing a building's energy consumption with the national average. Site energy use is the energy consumed by the building at the building site only. Source energy use includes the site energy use as well as all of the losses to create and distribute the energy to the building. Source energy represents the total amount of raw fuel that is required to operate the building. It incorporates all transmission, delivery, and production losses, which allows for a complete assessment of energy efficiency in a building. The type of utility purchased has a substantial impact on the source energy use of a building. The EPA has determined that source energy is the most comparable unit for evaluation purposes and overall global impact. Both the site and source EUI ratings for the building are provided to understand and compare the differences in energy use.
The site and source EUIs for this building are calculated as follows. (See Table 3.4 for details):

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

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

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

Table 3.5: Klawock Water Treatment Plant 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	15,760 kWh	53,791	3.340	179,660
#1 Oil	1,537 gallons	202,859	1.010	204,887
Total		**256,649**		**384,548**
BUILDING AREA		1,665	Square Feet	
BUILDING SITE EUI		154	kBTU/Ft^2/Yr	
BUILDING SOURCE EUI		231	**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 3.6: Klawock Water Treatment Plant Building Benchmarks

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	**154.2**	**20.80**	**$5.37**
With Proposed Retrofits	**105.7**	**14.26**	**$4.07**
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 Klawock Water Treatment Plant was modeled using AkWarm© energy use software to establish a baseline space heating and cooling energy usage. Climate data from Klawock 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 Klawock. 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 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. Calculations and cost estimates for analyzed measures are provided in Appendix C.

Table 4.1: List of Energy Efficiency Recommendations by Economic Priority

PRIORITY LIST – ENERGY EFFICIENCY MEASURES							
Rank	**Feature**	**Improvement Description**	**Annual Energy Savings**	**Installed Cost**	**Savings to Investment Ratio, SIR[1]**	**Simple Payback (Years)[2]**	**CO_2 Savings**
1	Setback Thermostat: Main Mechanical Room	Implement a heating temperature setback to 50.0 deg F when unoccupied.	$1,528	$200	101.13	0.1	11,199.5
2	Setback Thermostat: Office	Implement a heating temperature setback to 60.0 deg F when unoccupied.	$193	$200	12.76	1.0	1,412.2
3	Setback Thermostat: Chlorine Room	Implement a heating temperature setback to 60.0 deg F when unoccupied.	$116	$200	7.66	1.7	846.6
4	Setback Thermostat: Polymer Room	Implement a heating temperature setback to 60.0 deg F when unoccupied.	$50	$200	3.31	4.0	366.5
5	Setback Thermostat: Bathroom	Implement a heating temperature setback to 60.0 deg F when unoccupied.	$68	$800	1.12	11.8	495.1
6	Other Electrical - Controls Retrofit: Polymer Injection Pump	Detect and repair leaks on service lines and WST to reduce water production demand by 35 %.	$180 + $4,000 Maint. Savings	$60,000	1.03	14.4	1,644.6
7	Lighting - Controls Retrofit: Exterior Alarm Light	Determine and address source of alarm so that light turns off.	$8	$500	0.19	60.5	69.0
8	HVAC And DHW	Downsize electric water heater from 30 gal to 12 gal.	$20	$1,500	0.18	74.0	105.7
	TOTAL, all measures		**$2,163 + $4,000 Maint. Savings**	**$63,600**	**1.38**	**10.3**	**16,139.2**

4.2 Interactive Effects of Projects

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

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

Interior lighting, plug loads, facility equipment, and occupants generate heat within the building. 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 Mechanical Equipment Measu***res***

4.3.1 Heating/Cooling/Domestic Hot Water Measure

Rank	Recommendation				
8	Downsize electric water heater from 30 gal to 12 gal.				
Installation Cost	$1,500	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$20
Breakeven Cost	$277	**Savings-to-Investment Ratio**	0.2	**Simple Payback yrs**	74
Auditors Notes: Only a small volume of hot water is used for hand washing in the bathroom and tempering the water for mixing dilute polymer. A 12 gallon water heater would meet this water heating demand and require less energy to operate.					

4.3.2 Night Setback Thermostat Measures

Rank	Building Space			Recommendation	
1	Main Mechanical Room			Implement a heating temperature setback to 50.0 deg F when unoccupied.	
Installation Cost	$200	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$1,528
Breakeven Cost	$20,226	**Savings-to-Investment Ratio**	101.1	**Simple Payback yrs**	0
Auditors Notes: The main mechanical room does not need to be heated above 50 deg. F during unoccupied hours. Implementing a heating setback will reduce the amount of fuel consumed by the Toyotomi.					

Rank	Building Space			Recommendation	
2	Office			Implement a heating temperature setback to 60.0 deg F when unoccupied.	
Installation Cost	$200	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$193
Breakeven Cost	$2,553	**Savings-to-Investment Ratio**	12.8	**Simple Payback yrs**	1
Auditors Notes: The office room does not need to be heated above 60 deg. F during unoccupied hours. Implementing a heating setback will reduce the amount of fuel consumed by the Toyotomi.					

Rank	Building Space			Recommendation	
3	Chlorine Room			Implement a heating temperature setback to 60.0 deg F when unoccupied.	
Installation Cost	$200	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$116
Breakeven Cost	$1,531	**Savings-to-Investment Ratio**	7.7	**Simple Payback yrs**	2
Auditors Notes: The chlorine room does not need to be heated above 60 deg. F during unoccupied hours. Implementing a heating setback will reduce the amount of electricity consumed by the air heater.					

<table>
<tr><td>Rank</td><td colspan="3">Building Space</td><td colspan="2">Recommendation</td></tr>
<tr><td>4</td><td colspan="3">Polymer Room</td><td colspan="2">Implement a heating temperature setback to 60.0 deg F when unoccupied.</td></tr>
<tr><td>Installation Cost</td><td>$200</td><td>Estimated Life of Measure (yrs)</td><td>15</td><td>Energy Savings (/yr)</td><td>$50</td></tr>
<tr><td>Breakeven Cost</td><td>$662</td><td>Savings-to-Investment Ratio</td><td>3.3</td><td>Simple Payback yrs</td><td>4</td></tr>
<tr><td colspan="6">Auditors Notes: The polymer room does not need to be heated above 60 deg. F during unoccupied hours. Implementing a heating setback will reduce the amount of electricity consumed by the air heater.</td></tr>
</table>

<table>
<tr><td>Rank</td><td colspan="3">Building Space</td><td colspan="2">Recommendation</td></tr>
<tr><td>5</td><td colspan="3">Bathroom</td><td colspan="2">Implement a heating temperature setback to 60.0 deg F when unoccupied</td></tr>
<tr><td>Installation Cost</td><td>$800</td><td>Estimated Life of Measure (yrs)</td><td>15</td><td>Energy Savings (/yr)</td><td>$68</td></tr>
<tr><td>Breakeven Cost</td><td>$896</td><td>Savings-to-Investment Ratio</td><td>1.1</td><td>Simple Payback yrs</td><td>12</td></tr>
<tr><td colspan="6">Auditors Notes: The bathroom does not need to be heated above 60 deg. F during unoccupied hours. Implementing a heating setback will reduce the amount of electricity to operate the baseboard heater.</td></tr>
</table>

4.4 Electrical & Appliance Measures

4.4.1 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.

4.4.1a Lighting Measures – Lighting Controls

Rank	**Location**		**Existing Condition**		**Recommendation**	
7	Exterior Alarm Light		LED 8W Module StdElectronic with Clock Timer or Other Scheduling Control		Determine and address source of alarm so that light turns off.	
Installation Cost		$500	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$8
Breakeven Cost		$97	**Savings-to-Investment Ratio**	0.2	**Simple Payback yrs**	61
Auditors Notes: Determine source of alarm so that it turns off and train operator in troubleshooting						

4.4.2 Other Electrical Measures

Rank	**Location**		**Description of Existing**		**Efficiency Recommendation**	
6	Polymer Injection Pump		Pump with Other Controls		Detect and repair leaks in service lines and water storage tank.	
Installation Cost		$60,000	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$180
					Maintenance Savings (/yr)	$4,000
Breakeven Cost		$61,815	**Savings-to-Investment Ratio**	1.0	**Simple Payback yrs**	14
Auditors Notes: Detect and repair leaks in service lines and water storage tank to reduce water production and treatment rates by an estimated 35 %. Reducing water production would reduce the amount of chemicals needed for treatment, reduce the load/run time and extend the life of the injection pumps and protect against freeze-ups, therefore saving on maintenance and labor for homeowners and the community operators.						

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.

ANTHC is currently working with the City of Klawock and Klawock Cooperative Association in the development of a proposal based on the retrofits identified in this report as part of the RACEE competition. If accepted into the third round of this competition, the suggested retrofits could be funded by the DOE as part of RACEE. Regardless of the results of the RACEE competition, ANTHC will continue to work with Klawock to secure project funding and implement the energy efficiency measures identified in this report.

Appendix A – Energy Audit Report – Project Summary

ENERGY AUDIT REPORT – PROJECT SUMMARY

General Project Information

PROJECT INFORMATION	AUDITOR INFORMATION
Building: Klawock Water Treatment Plant	**Auditor Company:** ANTHC - DEHE
Address: Klawock	**Auditor Name:** Bailey Gamble, Gavin Dixon
City: Klawock	**Auditor Address:** 4500 Diplomacy Dr., Suite 454 Anchorage, AK 99508
Client Name: Harry Jackson, Bennet Charles	
Client Address:	**Auditor Phone:** (907) 729-4501
	Auditor FAX:
Client Phone: (907) 755-2261	**Auditor Comment:**
Client FAX:	

Design Data

Building Area: 1,665 square feet	**Design Space Heating Load:** Design Loss at Space: 74,836 Btu/hour with Distribution Losses: 74,836 Btu/hour Plant Input Rating assuming 82.0% Plant Efficiency and 25% Safety Margin: 114,079 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: Klawock	**Design Outdoor Temperature:** 15.1 deg F
Weather/Fuel City: Klawock	**Heating Degree Days:** 7,413 deg F-days

Utility Information

Electric Utility: Klawock-APT - Commercial - Sm	**Natural Gas Provider:** None
Average Annual Cost/kWh: $0.296/kWh	**Average Annual Cost/ccf:** $0.000/ccf

Annual Energy Cost Estimate

Description	Space Heating	Water Heating	Ventilation Fans	Lighting	Other Electrical	Service Fees	Total Cost
Existing Building	$5,078	$152	$106	$526	$1,948	$1,128	**$8,937**
With Proposed Retrofits	$3,320	$129	$106	$517	$1,575	$1,128	**$6,774**
Savings	$1,758	$23	$0	$9	$373	$0	**$2,163**

Building Benchmarks

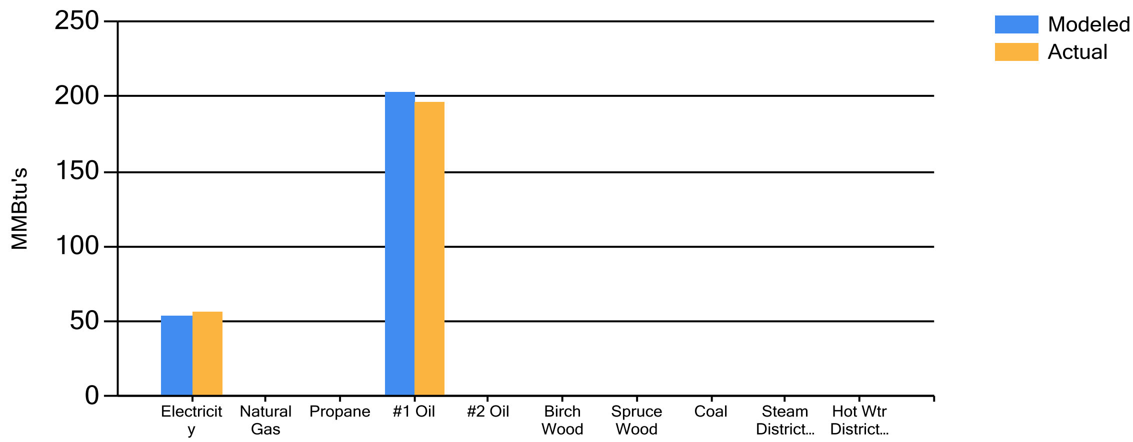
Description	EUI (kBtu/Sq.Ft.)	EUI/HDD (Btu/Sq.Ft./HDD)	ECI ($/Sq.Ft.)
Existing Building	154.2	20.80	$5.37
With Proposed Retrofits	105.7	14.26	$4.07

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

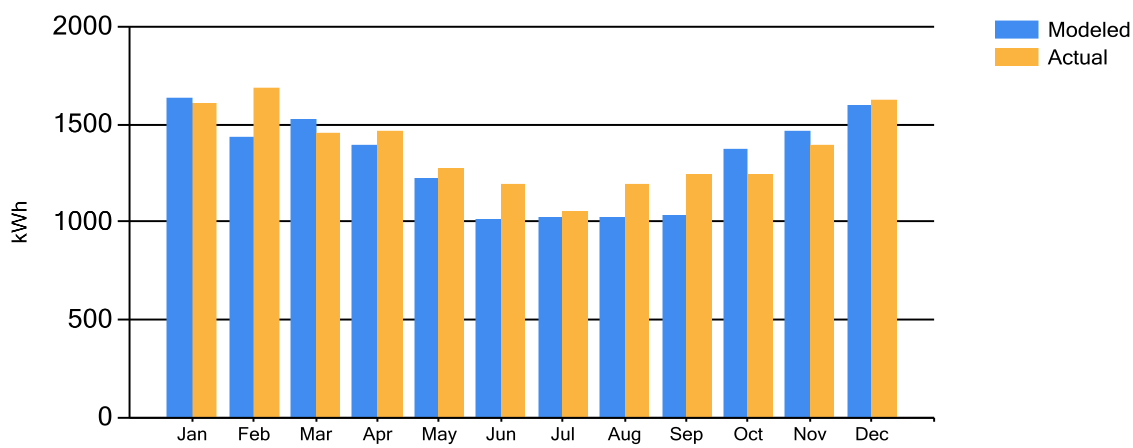
Appendix B – Actual Fuel Use versus Modeled Fuel Use

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

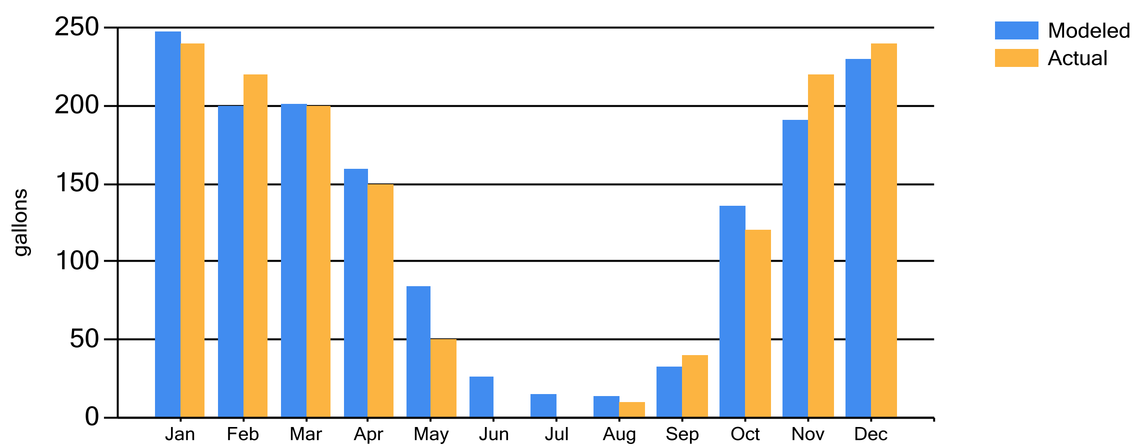
Annual Fuel Use



Electricity Fuel Use



#1 Fuel Oil Fuel Use



Appendix C - Electrical Demands

Estimated Peak Electrical Demand (kW)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Current	10.9	9.8	8.8	8.0	7.2	6.7	6.5	6.4	6.2	6.1	5.4	4.6
As Proposed	8.4	7.6	6.9	6.3	5.8	5.5	5.4	5.3	5.1	5.1	4.7	4.1

Estimated Demand Charges (at $7.96/kW)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Current	$86	$78	$70	$63	$57	$53	$52	$51	$49	$48	$43	$36
As Proposed	$67	$60	$55	$50	$46	$44	$43	$42	$41	$40	$37	$33

AkWarmCalc Ver 2.5.3.0, Energy Lib 3/7/2016