Comprehensive Energy Audit
For

Shishmaref Water Plant - Washeteria

Prepared For:

City of Shishmaref

March 24, 2015

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PREFACE

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

The Energy Projects Group at the Alaska Native Tribal Health Consortium (ANTHC) prepared this document for The City of Shishmaref, Alaska. The authors of this report are Carl Remley, Certified Energy Auditor (CEA) and Certified Energy Manager (CEM) and Kevin Ulrich. Energy Manager-in-Training (EMIT).

The purpose of this report is to provide a comprehensive document of the findings and analysis that resulted from an energy audit conducted in January of 2015 by the Energy Projects Group of ANTHC. This report analyzes historical energy use and identifies costs and savings of recommended energy conservation measures. Discussions of site-specific concerns, non-recommended measures, and an energy conservation action plan are also included in this report.

ACKNOWLEDGMENTS

The ANTHC Energy Projects Group gratefully acknowledges the assistance of Water Treatment Plant Operators Art Sheldon and Jeff Nayokpuk, Shishmaref Mayor Howard Weyiouanna Sr., Shishmaref Utilities Manager Bill Jones, and Shishmaref City Administrator Zena Barr.

1. EXECUTIVE SUMMARY

This report was prepared for the City of Shishmaref. The scope of the audit focused on Shishmaref Water 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, process loads and plug loads.

Based on electricity and fuel oil prices in effect at the time of the audit, the total predicted energy costs are $45,865 per year and the breakdown of the annual predicted energy costs and fuel use for the buildings analyzed are $15,883 for electricity and $29,982 for #1 Oil.

The total predicted energy cost for the water treatment plant/washeteria (washeteria) is $45,865 per year. Heating oil represents the largest piece with an annual cost of $29,982 per year. The washeteria is predicted to spend $15,883 for electricity. This includes $5,803 paid by the City and $10,080 paid by the Power Cost Equalization (PCE) program through the State of Alaska. These predictions are based on the electricity and fuel prices at the time of the audit.

The State of Alaska PCE program provides a subsidy to rural communities across the state to lower the electricity costs and make energy in rural Alaska affordable. In Shishmaref, the cost of electricity without PCE is $0.52/kWh, and the cost of electricity with PCE is $0.19/kWh.

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

Predicted Annual Fuel Use		
Fuel Use	**Existing Building**	**With Proposed Retrofits**
Electricity	29,512 kWh	23,776 kWh
#1 Oil	8,125 gallons	7,352 gallons

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

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	611.1	38.70	$23.89
With Proposed Retrofits	547.7	34.69	$20.88
EUI: Energy Use Intensity - The annual site energy consumption divided by the structure's conditioned area. EUI/HDD: Energy Use Intensity per Heating Degree Day. ECI: Energy Cost Index - The total annual cost of energy divided by the square footage of the conditioned space in the building.			

Table 1.1 below summarizes the energy efficiency measures analyzed for the Shishmaref Water Plant - Washeteria. Listed are the estimates of the annual savings, installed costs, and two different financial measures of investment return.

Table 1.1 PRIORITY LIST – ENERGY EFFICIENCY MEASURES							
Rank	**Feature**	**Improvement Description**	**Annual Energy Savings**	**Installed Cost**	**Savings to Investment Ratio, SIR[1]**	**Simple Payback (Years)[2]**	**CO_2 Savings**
1	Other – Dryer Pump	Re-commission dryer pump controls	$2,397	$4,000	7.21	1.7	8,188.0
2	Lighting - Power Retrofit: Exterior Lighting - WTP	Replace with energy-efficient LED lighting.	$131	$250	6.19	1.9	286.9
3	Lighting - Power Retrofit: Washeteria	Replace with energy-efficient LED lighting.	$391	$960	4.80	2.5	497.6
4	Lighting - Power Retrofit: Operator Office	Replace with energy-efficient LED lighting.	$144	$360	4.73	2.5	179.7
5	Lighting - Power Retrofit: Main WTP	Replace with energy-efficient LED lighting.	$337	$840	4.73	2.5	419.2
6	Heating, Ventilation and DHW	Add controls to modulate boiler and hot water heater temperatures. Repair heating controls in ladies' restroom. Insulate non-insulated glycol lines in water treatment plant.	$3,698	$14,000	4.38	3.8	16,898.3
7	Lighting - Power Retrofit: Restroom Wraparound	Replace with energy-efficient LED lighting.	$168	$480	4.14	2.8	155.7
8	Lighting - Power Retrofit: Mezanine	Replace with energy-efficient LED lighting.	$125	$480	3.86	3.8	15.3
9	Lighting - Power Retrofit: Exterior Lighting – Washeteria	Replace with energy-efficient LED lighting.	$26	$200	1.54	7.7	21.2
	TOTAL, all measures		**$7,417**	**$21,570**	**4.92**	**2.9**	**26,661.9**

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 $7,417 per year, or 16.2% of the buildings' total energy costs. These measures are estimated to cost $21,570, for an overall simple payback period of 2.9 years.

Table 1.2 below is a breakdown of the annual energy cost across various energy end use types, such as Space Heating and Water Heating. The first row in the table shows the breakdown for the building as it is now. The second row shows the expected breakdown of energy cost for the building assuming all of the retrofits in this report are implemented. Finally, the last row shows the annual energy savings that will be achieved from the retrofits.

Table 1.2

Annual Energy Cost Estimate							
Description	**Space Heating**	**Water Heating**	**Clothes Drying**	**Lighting**	**Other Electrical**	**Tank Heat**	**Total Cost**
Existing Building	$7,044	$10,548	$10,478	$1,943	$3,198	$12,594	**$45,865**
With Proposed Retrofits	$5,966	$9,343	$7,929	$1,381	$3,239	$12,180	**$40,098**
Savings	$1,078	$1,205	$2,549	$562	-$42	$414	**$5,767**

2. AUDIT AND ANALYSIS BACKGROUND

2.1 Program Description

This audit included services to identify, develop, and evaluate energy efficiency measures at the Shishmaref Water Plant - Washeteria. The scope of this project included evaluating building shell, lighting and other electrical systems, and heating and ventilation equipment, process loads, 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, ventilation, and air conditioning equipment (HVAC)
- Lighting systems and controls
- Building-specific equipment
- Water consumption, treatment & 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 Shishmaref 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.

Shishmaref Water Plant - Washeteria is classified as being made up of the following activity areas:

1) WTP-Washeteria: 1,920 square feet

In addition, the methodology involves taking into account a wide range of factors specific to the building. These factors are used in the construction of the model of energy used. The factors include:

- Occupancy hours
- Local climate conditions
- Prices paid for energy

2.3. Method of Analysis

Data collected was processed using AkWarm© Energy Use Software to estimate energy savings for each of the proposed energy efficiency measures (EEMs). The recommendations focus on the building envelope; heating and ventilation; lighting, plug load, and other electrical improvements; process loads; 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. Shishmaref Water Plant - Washeteria

3.1. Building Description

The 1,920 square foot Shishmaref Water Plant - Washeteria was constructed in 1984, with a normal occupancy of 5 people. The number of hours of operation for this building average 7.1 hours per day, considering all seven days of the week.

The Shishmaref Water Treatment Plant – Washeteria serves as the water gathering point for the residents of the community and as a location for Laundromat and shower services. There is one watering point with a 3/4” pipe that provides treated water for community pickup. There are 5 functioning washers and 5 dryers for use in the washeteria.

Water is pumped into the water treatment from the raw water intake that draws water from a nearby pond. The water is pumped through two sand filters before receiving an addition of polymer and chlorine and entering the 1.3 million gallon water storage tank. Pressure pumps are used to keep the pressure up for use in the washeteria and showers. The facility has a single watering point that is used by the residents to collect their own water supply. The rest of the water is used in the washing machines and restrooms.

Description of Building Shell

The exterior walls are constructed from stressed skin panels with no plywood sheathing and six inches of polyurethane insulation. The insulation has slight damage and there is approximately 2136 square feet of wall space in the building.

The roof of the building has a cathedral ceiling with a total of approximately 2024 square feet of roof space. The roof is constructed with standard framing with 24” spacing and six inches of polyurethane insulation. The roof shows few signs of damage.

The building has a slab foundation with six inches of PISO insulation. The insulation is slightly damaged from years of use. There is approximately 1920 square feet of floor space in the building.

There are four windows in the building, each has wood framing and two panes of glass. One window has a broken layer of glass while the rest are fine. There is approximately 23 square feet of window space in the building.

There are two entrances and each has a metal door with polyurethane core insulation. The front door to the washeteria has an arctic entryway that is unheated. The doors combine to occupy 49 square feet of space.

Description of Heating Plants

The Heating Plants used in the building are:

Burnham Boiler 1

Nameplate Information:	Burnham PF 514
Fuel Type:	#1 Oil
Input Rating:	620,000 BTU/hr
Steady State Efficiency:	80 %
Idle Loss:	2 %
Heat Distribution Type:	Glycol
Boiler Operation:	All Year

Notes: Boilers are original equipment. Operators turn off manually in summer when washeteria is closed. Turn on one hour before opening. Honeywell boiler control set at 200 F. with deferential of 20 degrees. Actual operating range is from 176 to 198.

Burnham Boiler 2

Fuel Type:	#1 Oil
Input Rating:	620,000 BTU/hr
Steady State Efficiency:	80 %
Idle Loss:	2 %
Heat Distribution Type:	Glycol
Boiler Operation:	All Year

Space Heating Distribution Systems

The building is heated with three unit heaters and baseboard heating. Unit heaters are present in the water plant, operator office, and main washeteria. Baseboard heating is only used in the men's and women's restrooms and shower areas. The baseboard heating controls for the women's restroom is not working properly.

Lighting

The main water treatment plant room has seven fixtures with two T8 fluorescent light bulbs in each fixture. The operator office has three fixtures with two T8 fluorescent light bulbs in each fixture. The washeteria room has eight fixtures with two T8 fluorescent light bulbs in each fixture. The washeteria also has two 12" T9 CFL light bulbs. The restrooms have four fixtures with two T8 fluorescent light bulbs in each fixture. The restrooms also have eight CFL fluorescent lamps that each use 9 Watts. The mezzanine has two fixtures with four T8 fluorescent light bulbs in each fixture. The exterior of the building has one CFL fluorescent Lamp that uses 20 Watts. The exterior of the building also has one standard metal halide light bulb that uses 100 Watts.

Plug Loads

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

Major Equipment

There is a transfer pump that sends water from the water treatment plant to the pump house. The pump uses 700 watts and consumes approximately 1,898 KWH annually.

There are two pressure pumps that work to keep pressure in the system. The pumps operate such that only one pump is in use at a time. The pumps run approximately 1% of the available hours per year. The pumps consume on 3200 watts when operating and consume approximately 281 KWH annually.

There is a reservoir pump that pumps water from a nearby pond into the water treatment system. The pump operates for four months of the year. It draws approximately 350 watts while consuming 949 KWH annually.

There are five washers in the washeteria. The washers run approximately 60% of each 10 hour day and five days per week throughout the year. The washers use approximately 200 watts each and all five washers combine to use approximately 1,044 KWH annually.

There is a variety of controls and equipment that is used in the water treatment plant during the water filtration process. This equipment consumes approximately 1,096 KWH annually.

There are two electric hand dryers in the restrooms that use 1,500 watts when operating and consume approximately 391 KWH annually.

There is a cash register and adding machine in the washeteria that is used for daily operations and washeteria management. The equipment is used 10 hours per day for five days per week throughout the entire year. The two machines consume approximately 130 KWH annually.

There is a coffee pot that is used by staff of the water treatment plant and the washeteria The coffee pot consumes approximately 110 KWH annually.

There is a microwave that is used periodically in the washeteria. The microwave consumes approximately 78 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). 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: AVEC-Shishmaref - Commercial - Sm

The average cost for each type of fuel used in this building is shown below in Table 3.1. This figure includes all surcharges, and utility customer charges but not the PCE subsidy:

Table 3.1 – Average Energy Cost	
Description	**Average Energy Cost**
Electricity	$ 0.52/kWh
#1 Oil	$ 3.69/gallons

3.2.1.1 Total Energy Use and Cost Breakdown

At current rates, City of Shishmaref pays approximately $45,865 annually for electricity and other fuel costs for the Shishmaref Water Plant - Washeteria.

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

Figure 3.1
Annual Energy Costs by End Use

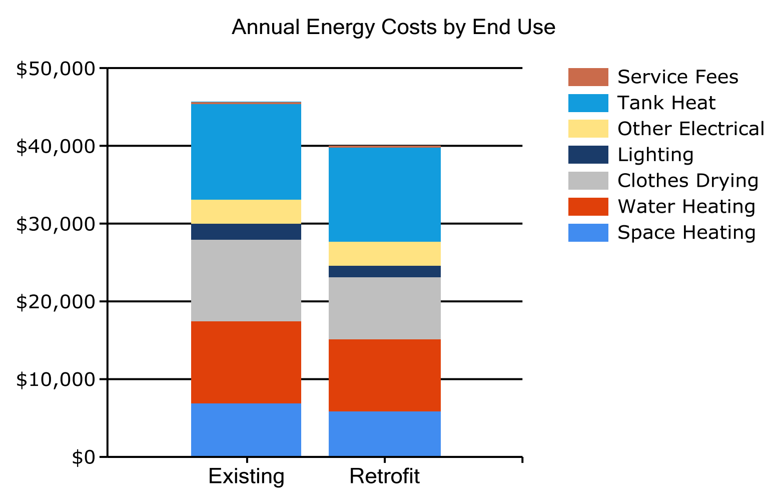


Figure 3.2 below shows how the annual energy cost of the building splits between the different fuels used by the building. The "Existing" bar shows the breakdown for the building as it is now; the "Retrofit" bar shows the predicted costs if all of the energy efficiency measures in this report are implemented.

Figure 3.2
Annual Energy Costs by Fuel Type

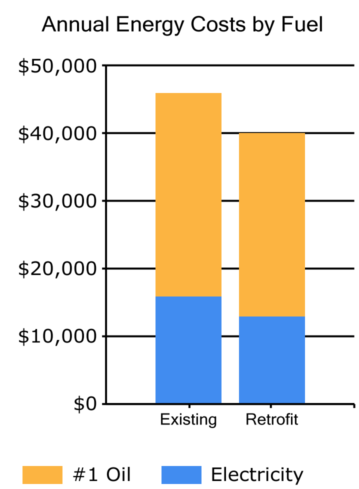
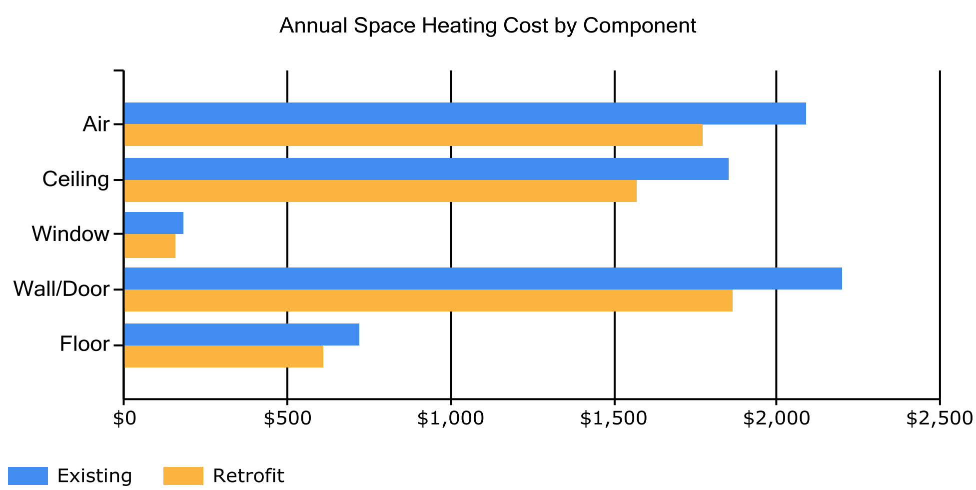


Figure 3.3 below addresses only Space Heating costs. The figure shows how each heat loss component contributes to those costs; for example, the figure shows how much annual space heating cost is caused by the heat loss through the Walls/Doors. For each component, the space heating cost for the Existing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

Figure 3.3
Annual Space Heating Cost by Component



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

Electrical Consumption (kWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space_Heating	953	880	897	769	795	769	795	795	769	795	823	956
DHW	68	62	68	66	69	68	70	70	68	69	66	68
Clothes_Drying	699	637	699	677	700	678	701	701	678	700	677	699
Lighting	325	296	325	278	288	278	288	288	278	329	318	329
Other_Electrical	266	242	568	484	266	257	845	1047	1013	467	257	266
Tank_Heat	125	118	122	99	73	0	0	0	0	87	105	127

Fuel Oil #1 Consumption (Gallons)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space_Heating	59	56	47	25	28	29	31	30	29	27	36	59
DHW	223	202	223	220	237	237	245	245	237	231	218	223
Clothes_Drying	130	118	131	130	143	146	150	150	146	138	129	130
Tank_Heat	555	541	526	353	111	0	0	0	0	229	404	570

3.2.2 Energy Use Index (EUI)

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

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

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

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

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

Table 3.4
Shishmaref Water Plant - 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	29,512 KWH	100,725	3.340	336,421
#1 Oil	8,125 gallons	1,072,513	1.010	1,083,238
Total		**1,173,238**		**1,419,659**
BUILDING AREA		1,920	Square Feet	
BUILDING SITE EUI		611	kBTU/Ft²/Yr	
BUILDING SOURCE EUI		739	**kBTU/Ft²/Yr**	
* Site - Source Ratio data is provided by the Energy Star Performance Rating Methodology for Incorporating Source Energy Use document issued March 2011.				

Table 3.5

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	**611.1**	**38.70**	**$23.89**
With Proposed Retrofits	**547.7**	**34.69**	**$20.88**
EUI: Energy Use Intensity - The annual site energy consumption divided by the structure's conditioned area. **EUI/HDD: Energy Use Intensity per Heating Degree Day.** **ECI: Energy Cost Index - The total annual cost of energy divided by the square footage of the conditioned space in the building.**			

3.3 AkWarm© Building Simulation

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

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

For the purposes of this study, the Shishmaref Water Plant - Washeteria was modeled using AkWarm© energy use software to establish a baseline space heating and cooling energy usage. Climate data from Shishmaref 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 Shishmaref. 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
Shishmaref Water Plant - Washeteria, Shishmaref, Alaska
PRIORITY LIST – ENERGY EFFICIENCY MEASURES

Rank	Feature	Improvement Description	Annual Energy Savings	Installed Cost	Savings to Investment Ratio, SIR	Simple Payback (Years)	CO_2 Savings
1	Other – Dryer Pump	Re-commission dryer pump controls	$2,397	$4,000	7.21	1.7	8,188.0
2	Lighting - Power Retrofit: Exterior Lighting - WTP	Replace with energy-efficient LED lighting.	$131	$250	6.19	1.9	286.9
3	Lighting - Power Retrofit: Washeteria	Replace with energy-efficient LED lighting.	$391	$960	4.80	2.5	497.6
4	Lighting - Power Retrofit: Operator Office	Replace with energy-efficient LED lighting.	$144	$360	4.73	2.5	179.7
5	Lighting - Power Retrofit: Main WTP	Replace with energy-efficient LED lighting.	$337	$840	4.73	2.5	419.2
6	HVAC And DHW	Add controls to modulate boiler and hot water heater temperatures. Repair heating controls in ladies' restroom. Insulate non-insulated glycol lines in water treatment plant.	$3,698	$14,000	4.38	3.8	16,898.3

Table 4.1 Shishmaref Water Plant - Washeteria, Shishmaref, Alaska PRIORITY LIST – ENERGY EFFICIENCY MEASURES							
Rank	**Feature**	**Improvement Description**	**Annual Energy Savings**	**Installed Cost**	**Savings to Investment Ratio, SIR**	**Simple Payback (Years)**	**CO_2 Savings**
7	Lighting - Power Retrofit: Restroom Wraparound	Replace with energy-efficient LED lighting.	$168	$480	4.14	2.8	155.7
8	Lighting - Power Retrofit: Mezanine	Replace with energy-efficient LED lighting.	$125	$480	3.86	3.8	15.3
9	Lighting - Power Retrofit: Exterior Lighting - Washeteria	Replace with energy-efficient LED lighting.	$26	$200	1.54	7.7	21.2
	TOTAL, all measures		**$7,417**	**$21,570**	**4.92**	**2.9**	**26,661.9**

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 Measures

4.3.1 Heating/Cooling/Domestic Hot Water Measure

Rank	**Recommendation**				
6	Add Tekmar controller to lower boiler operating temperature and hot water temperature when washeteria is closed and reset boiler temperature based on outside temperature when washeteria is closed. Repair non operable zone control in ladies restroom. Insulate non insulated glycol lines in WTP.				
Installation Cost	$14,000	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$3,198
				Maintenance Savings (/yr)	$500
Breakeven Cost	$61,325	**Savings-to-Investment Ratio**	4.4	**Simple Payback yrs**	4
Auditors Notes:					

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 – Replace Existing Fixtures/Bulbs

Rank	Location	Existing Condition		Recommendation	
2	Exterior Lighitng - WTP	MH 100 Watt StdElectronic with Manual Switching		Replace with LED 17W Module StdElectronic	
Installation Cost	$250	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$81
				Maintenance Savings (/yr)	$50
Breakeven Cost	$1,548	**Savings-to-Investment Ratio**	6.2	**Simple Payback yrs**	2
Auditors Notes: Replace existing metal halide fixtures with LED.					

Rank	Location	Existing Condition		Recommendation	
3	Washeteria	8 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic with Manual Switching		Replace with 8 LED (2) 17W Module StdElectronic	
Installation Cost	$960	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$151
				Maintenance Savings (/yr)	$240
Breakeven Cost	$4,603	**Savings-to-Investment Ratio**	4.8	**Simple Payback yrs**	2
Auditors Notes: Convert Existing fluorescent to LED and eliminate ballast.					

Rank	Location	Existing Condition		Recommendation	
4	Operator Office	3 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic with Manual Switching		Replace with 3 LED (2) 17W Module StdElectronic	
Installation Cost	$360	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$54
				Maintenance Savings (/yr)	$90
Breakeven Cost	$1,702	**Savings-to-Investment Ratio**	4.7	**Simple Payback yrs**	2
Auditors Notes: Convert existing fluorescent to LED and eliminate ballast.					

Rank	Location	Existing Condition		Recommendation	
5	Main WTP	7 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic with Manual Switching		Replace with 7 LED (2) 17W Module StdElectronic	
Installation Cost	$840	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$127
				Maintenance Savings (/yr)	$210
Breakeven Cost	$3,970	**Savings-to-Investment Ratio**	4.7	**Simple Payback yrs**	2
Auditors Notes: Convert fluorescent to LED and eliminate ballast.					

Rank	Location	Existing Condition		Recommendation	
7	Restroom Wraparound	4 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic with Manual Switching		Replace with 4 LED (2) 17W Module StdElectronic	
Installation Cost	$480	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$48
				Maintenance Savings (/yr)	$120
Breakeven Cost	$1,988	**Savings-to-Investment Ratio**	4.1	**Simple Payback yrs**	3
Auditors Notes: Convert fluorescent to LED and eliminate ballast.					

Rank	Location	Existing Condition		Recommendation	
8	Mezanine	2 FLUOR (4) T8 4' F32T8 32W Standard Instant StdElectronic with Manual Switching		Replace with 2 LED (4) 17W Module StdElectronic	
Installation Cost	$480	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$5
				Maintenance Savings (/yr)	$120
Breakeven Cost	$1,853	**Savings-to-Investment Ratio**	3.9	**Simple Payback yrs**	4
Auditors Notes: Convert fluorescent to LED and eliminate ballast.					

Rank	Location	Existing Condition		Recommendation	
9	Exterior Lighting - Washeteria	FLUOR CFL, A Lamp 20W with Manual Switching		Replace with LED 10W Module StdElectronic	
Installation Cost	$200	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$6
				Maintenance Savings (/yr)	$20
Breakeven Cost	$309	**Savings-to-Investment Ratio**	1.5	**Simple Payback yrs**	8
Auditors Notes: Convert existing fluorescent to LED.					

4.4.2 Other Measures

Rank	Location	Description of Existing		Efficiency Recommendation	
1		Clothes Drying Load		Re-commission dryer pump controls	
Installation Cost	$4,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$2,097
				Maintenance Savings (/yr)	$300
Breakeven Cost	$28,847	**Savings-to-Investment Ratio**	7.2	**Simple Payback yrs**	2
Auditors Notes: Re-commission the dryer controls such that the pump only runs when at least one of the dryers is operational.					

5. ENERGY EFFICIENCY ACTION PLAN

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

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

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

APPENDICES

Appendix A – Energy Audit Report – Project Summary

ENERGY AUDIT REPORT – PROJECT SUMMARY	
General Project Information	
PROJECT INFORMATION	**AUDITOR INFORMATION**
Building: Shishmaref Water Plant - Washeteria	**Auditor Company:** ANTHC-DEHE
Address: P O Box 83	**Auditor Name:** Carl Remley and Kevin Ulrich
City: Shishmaref	**Auditor Address:** 3900 Ambassador Drive, Suite 301 Anchorage, AK 99508
Client Name: Art Sheldon & Jeff Nayokouk	
Client Address: P O Box 83 Shishmaref, AK 99772	**Auditor Phone:** (907) 729-3543
	Auditor FAX:
Client Phone: (907) 649-4781	**Auditor Comment:**
Client FAX:	
Design Data	
Building Area: 1,920 square feet	**Design Space Heating Load:** Design Loss at Space: 0 Btu/hour with Distribution Losses: 0 Btu/hour Plant Input Rating assuming 82.0% Plant Efficiency and 25% Safety Margin: 0 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: Shishmaref	**Design Outdoor Temperature:** -35.6 deg F
Weather/Fuel City: Shishmaref	**Heating Degree Days:** 15,790 deg F-days
Utility Information	
Electric Utility: AVEC-Shishmaref - Commercial - Sm	**Natural Gas Provider:** None
Average Annual Cost/kWh: $0.538/kWh	**Average Annual Cost/ccf:** $0.000/ccf

Annual Energy Cost Estimate

Description	Space Heating	Space Cooling	Water Heating	Ventilation Fans	Clothes Drying	Lighting	Other Electrical	Tank Heat	Service Fees	Total Cost
Existing Building	$7,044	$0	$10,548	$0	$10,478	$1,943	$3,198	$12,594	$60	**$45,865**
With Proposed Retrofits	$5,966	$0	$9,343	$0	$7,929	$1,381	$3,239	$12,180	$60	**$40,098**
Savings	$1,078	$0	$1,205	$0	$2,549	$562	-$42	$414	$0	**$5,767**

Building Benchmarks

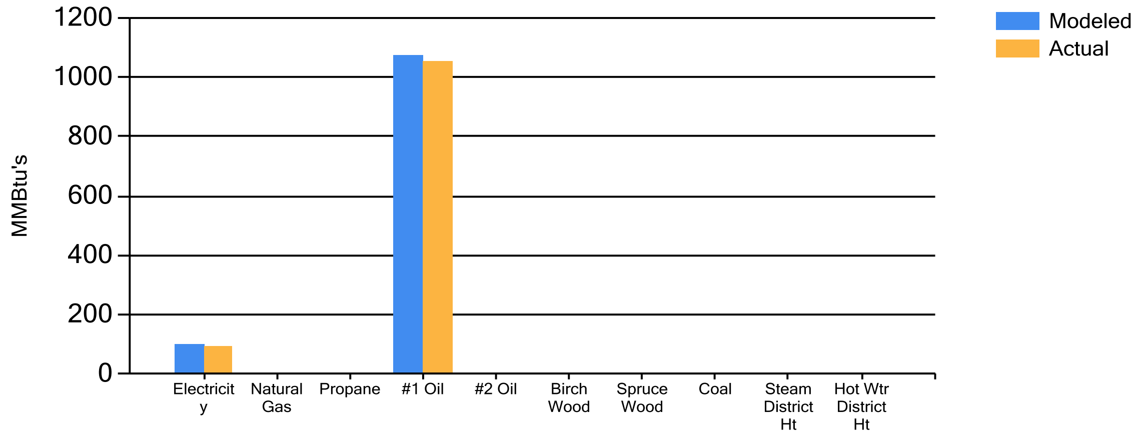
Description	EUI (kBtu/Sq.Ft.)	EUI/HDD (Btu/Sq.Ft./HDD)	ECI ($/Sq.Ft.)
Existing Building	611.1	38.70	$23.89
With Proposed Retrofits	547.7	34.69	$20.88

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.

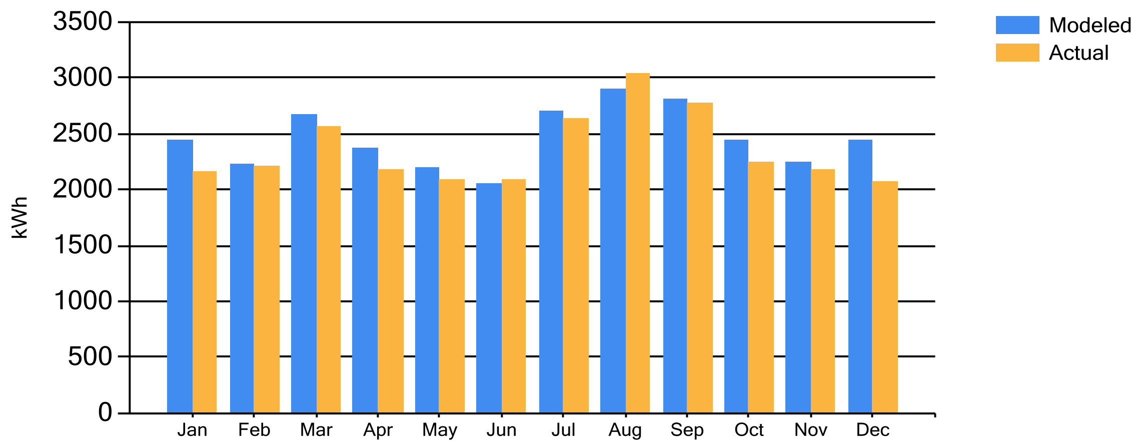
Appendix B – Actual Fuel Use versus Modeled Fuel Use

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