Comprehensive Energy Audit
For

Deering Water Treatment System

Prepared For
City of Deering

October 12, 2012

Prepared By: Chris Mercer

ANTHC-DEHE
3900 Ambassador Drive
Anchorage, AK 99508

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PREFACE

This energy audit was conducted using funds provided by the United States Department of Agriculture as part of the Rural Alaskan Village Grant (RAVG) program. Coordination with the City of Deering has been undertaken to provide maximum accuracy in identifying audits and coordinating potential follow up retrofit activities.

The Rural Energy Initiative at the Alaska Native Tribal Health Consortium (ANTHC) prepared this document for the City of Deering, Alaska. The authors of this report are Chris Mercer, Certified Energy Auditor; and Gavin Dixon.

The purpose of this report is to provide a comprehensive document of the findings and analysis that resulted from an energy audit conducted in August of 2012 by the Rural Energy Initiative 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 Rural Energy Initiative gratefully acknowledges the assistance of Water Treatment Plant Operators Fletcher Gregg and Bruce Barr, and City Administrator Mike Jones.

1. EXECUTIVE SUMMARY

This report was prepared for the City of Deering. The scope of the audit focused on Deering Water Treatment System. 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 $67,886 per year. Electricity represents the largest portion with an annual cost of $36,548. This includes about $15,958 paid by the community and $20,590 paid by the Power Cost Equalization (PCE) program through the State of Alaska. #1 Fuel Oil represents the remaining portion with an annual cost of approximately $31,338.

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 Deering, the cost of electricity without PCE is $0.71/kWh and the cost of electricity with PCE is $0.31/kWh.

There is a heat recovery system that provides heat from the generator cooling loops to the water plant heating system prior to the boilers to offset heating fuel usage. Currently, the heat recovery system has a failed AMOT valve that leaks, causing the hot fluid to bypass the heat exchanger for the heat recovery system and go to the radiators. This causes the heat provided by the power plant to be reduced to nearly zero, and can lead to the water plant boilers actually heating the power plant cooling loop in return. The controls for the heat recovery system will be addressed in this energy audit report.

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

Predicted Annual Fuel Use		
Fuel Use	**Existing Building**	**With Proposed Retrofits**
Electricity	51,536 kWh	32,151 kWh
#1 Oil	6,964 gallons	3,499 gallons
Heat Recovery	0.00 million Btu	294.04 million Btu

Benchmark figures facilitate comparing energy use between different buildings. Table 1.2 lists several benchmarks for the audited building.

Table 1.2: Building Benchmarks for the Deering Water Treatment Plant & Washeteria

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	380.4	23.11	$23.58
With Proposed Retrofits	300.7	18.26	$14.18
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 Deering Water Treatment System. 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	Other Electrical: Electric Heaters for Water Tank Dog House	Reduce temperature setting for dog houses to 50 deg. Reduce runtime of electric heaters.	$4,114	$1,000	48.33	0.2	10,508.4
2	Heating, Ventilation, and Domestic Hot Water	Repair Amot valve at power plant for the heat recovery system.	$13,873 + $50 Maintenance Savings	$10,000	18.91	0.7	57,271.9
3	Other Electrical - Controls Retrofit: Pressure Pump	Fix pressure tank bladder and repair check valve to reduce cycling of the pressure pump.	$1,707	$1,500	13.14	0.9	3,858.3
4	Dryers	Fix outside air intake by opening Louvers. Clean screens to allow for more air usage. Repair Controls for the dryer makeup fans.	$4,826	$2,500	8.81	0.5	10,818.9
5	Lighting - Power Retrofit: Exterior Lighting	Replace with new energy-efficient LED lighting.	$1,009 + $10 Maintenance Savings	$1,200	7.15	1.2	2,576.3
6	Setback Thermostat: Washeteria	Implement a Heating Temperature Unoccupied Setback to 60.0 deg F for the Washeteria space.	$872	$2,000	5.73	2.3	4,053.5
7	Setback Thermostat: Water Plant	Implement a Heating Temperature Unoccupied Setback to 60.0 deg F for the Water Plant space.	$191	$2,000	1.26	10.5	889.1

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
8	Lighting - Power Retrofit: Fluorescent Lighting	Replace with new energy-efficient LED lighting.	$225 + $15 Maintenance Savings	$1,820	1.10	7.6	516.5
9	Lighting - Power Retrofit: Water Plant Lighting	Replace with new energy-efficient LED lighting.	$233 + $20 Maintenance Savings	$1,950	1.09	7.7	535.6
	TOTAL, all measures		**$27,145**	**$23,970**	**12.76**	**0.9**	**91,028.4**

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 $27,050 per year, or 39.8% of the buildings' total energy costs. These measures are estimated to cost $23,970, for an overall simple payback period of 0.9 years.

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

Table 1.4: Detailed Breakdown of Energy Costs in the Building

Annual Energy Cost Estimate						
Description	**Space Heating**	**Clothes Drying**	**Lighting**	**Other Electrical**	**Tank Heat**	**Total Cost**
Existing Building	$21,071	$8,408	$4,675	$18,733	$14,769	**$67,886**
With Proposed Retrofits	$13,336	$1,987	$3,152	$12,673	$9,458	**$40,837**
Savings	$7,734	$6,421	$1,523	$6,060	$5,311	**$27,050**

2. AUDIT AND ANALYSIS BACKGROUND

2.1 Program Description

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

2.2 Audit Description

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

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

The building site visit was performed to survey all major building components and systems. The site visit included detailed inspection of energy consuming components. Summary of building occupancy schedules, operating and maintenance practices, and energy management programs provided by the building manager were collected along with the system and components to determine a more accurate impact on energy consumption.

Details collected from Deering Water Treatment System 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.

Deering Water Treatment System is classified as being made up of the following activity areas:

1) Washeteria: 1,479 square feet
2) Water Plant: 336 square feet
3) Generator Room: 1,064 square feet

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

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

2.3. Method of Analysis

Data collected was processed using AkWarm© Energy Use Software to estimate energy savings for each of the proposed energy efficiency measures (EEMs). The recommendations focus on the building envelope; heating and ventilation; lighting, plug load, and other electrical improvements; and motor and pump systems that will reduce annual energy consumption.

EEMs are evaluated based on building use and processes, local climate conditions, building construction type, function, operational schedule, existing conditions, and foreseen future plans. Energy savings are calculated based on industry standard methods and engineering estimations.

Our analysis provides a number of tools for assessing the cost effectiveness of various improvement options. These tools utilize **Life-Cycle Costing**, which is defined in this context as a method of cost analysis that estimates the total cost of a project over the period of time that includes both the construction cost and ongoing maintenance and operating costs.

Savings to Investment Ratio (SIR) = **Savings** divided by **Investment**

Savings includes the total discounted dollar savings considered over the life of the improvement. When these savings are added up, changes in future fuel prices as projected by the Department of Energy are included. Future savings are discounted to the present to account for the time-value of money (i.e. money's ability to earn interest over time). The **Investment** in the SIR calculation includes the labor and materials required to install the measure. An SIR value of at least 1.0 indicates that the project is cost-effective—total savings exceed the investment costs.

Simple payback is a cost analysis method whereby the investment cost of a project is divided by the first year's savings of the project to give the number of years required to recover the cost of the investment. This may be compared to the expected time before replacement of the system or component will be required. For example, if a boiler costs $12,000 and results in a savings of $1,000 in the first year, the payback time is 12 years. If the boiler has an expected life to replacement of 10 years, it would not be financially viable to make the investment since the payback period of 12 years is greater than the project life.

The Simple Payback calculation does not consider likely increases in future annual savings due to energy price increases. As an offsetting simplification, simple payback does not consider the need to earn interest on the investment (i.e. it does not consider the time-value of money). Because of these simplifications, the SIR figure is considered to be a better financial investment indicator than the Simple Payback measure.

Measures are implemented in order of cost-effectiveness. The program first calculates individual SIRs, and ranks all measures by SIR, higher SIRs at the top of the list. An individual measure must have an individual SIR>=1 to make the cut. Next the building is modified and resimulated 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. Deering Water Treatment System

3.1. Building Description

The 2,879 square foot Deering Water Treatment System was constructed in 1999, with a normal occupancy of 5 people. The number of hours of operation for this building average 8 hours per day, considering all seven days of the week.

The Deering Water Treatment Plant and 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 that provides treated water for community pickup. There are 5 washers and 5 dryers in the washeteria.

Water is pumped in from the Inmachuk River through a pump house approximately two miles outside of town. From there it is transported to the water treatment plant where it is sent through two bag filters before being injected with chlorine and sent to the water storage tanks. Water is then provided from the water storage tanks to the washeteria, watering point, and the school. The community has a fill-and-draw system where the community pumps water during the summer months that is then stored for use for the entire winter.

Description of Building Shell

The exterior walls are stressed skin panel construction with six inches of polyurethane foam insulation. The walls are approximately 8 ft. tall on average with approximately 2,560 square feet of wall space in the building.

The building has a ceiling with an attic that has standard framing and 24" spacing. The roof has approximately 12 inches of fiberglass batt insulation.

The building is constructed on grade with a gravel pad foundation. The foundation includes two inches of foam insulation beneath the pad and there is a total of approximately 4300 square feet of floor space in the building.

There are 16 total windows in the building, each of which is approximately 4ft x 3 ft. in dimension. The windows are double-paned glass with wood framing.

There are four total exterior doors for the building. Each door is an insulated metal door with no windows.

Description of Heating Plants

The Heating Plants used in the building are:

86 Burnham

Fuel Type:	#1 Oil
Input Rating:	216,150 BTU/hr
Steady State Efficiency:	70 %
Idle Loss:	1.5 %
Heat Distribution Type:	Glycol
Boiler Operation:	All Year

Burnham 86

Fuel Type:	#1 Oil
Input Rating:	216,150 BTU/hr
Steady State Efficiency:	78 %
Idle Loss:	1.5 %
Heat Distribution Type:	Glycol
Boiler Operation:	All Year

Recovered Heat

Fuel Type:	Heat Recovery
Input Rating:	80,000 BTU/hr
Steady State Efficiency:	95 %
Idle Loss:	0 %
Heat Distribution Type:	Water

Boiler Operation: All Year

Space Heating Distribution Systems

The building is heated through the use of baseboard heaters and three unit heaters. One unit heater is in the mechanical room while two unit heaters are in the storage garage. All space heating is provided by one Burnham 86 boiler that is rated for approximately 216,000 BTU/hr.

Domestic Hot Water System

Hot water is provided for the five washers in the washeteria, the showers and restrooms in the washeteria, and sinks in the restrooms and washeteria space.

Heat Recovery Information

There is an existing heat recovery system that provides heat from the generator cooling loops in the community power plant to the heating system in the water treatment plant. The power plant and water plant share the same building with the distance between the generator room and the boiler room being just the width of a wall. The heat recovery system has not been in operation recently because of a leaky AMOT valve in the power plant, which controls the direction that the heated glycol from the cooling loops travels. As a result, heated glycol is not transported to the water plant and the heat recovery system has no visible effect on the heating of the water plant and washeteria.

Lighting

The washeteria space has 14 fixtures with two T8 4ft. fluorescent light bulbs in each fixture. The bulbs are on for approximately eight hours per day for all seven days of the week and they consume approximately 2,355 kWh annually.

The water treatment plant space has 10 fixtures with three T8 4ft. fluorescent light bulbs in each fixture. The bulbs are on for approximately eight hours per day for all seven days of the week and they consume approximately 2,480 kWh annually.

There are exterior lights on the building that are used throughout the winter months. The exterior lighting consists of three low pressure sodium bulbs that are rated for 90 Watts each. The lights consume approximately 1,799 kWh annually.

Plug Loads

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

Major Equipment

The raw water transfer pump is used to transfer water from the water storage tank to the necessary water loads in the facility. It operates throughout the year and consumes approximately 1,168 kWh annually.

The well pump is used to pump water from the Inmachuk River through the well house and to the water treatment plant. The pump is used constantly for a two-month period in the summer to fill up the water storage tanks for year-round use. The pump consumes approximately 2,184 kWh annually.

There is a pressure pump that is used to provide pressure to the water distribution to allow for proper function of the washers, showers, sinks, and the watering point. It operates constantly throughout the year and consumes approximately 9,204 kWh annually.

There are five washers in the washeteria. The usage for the washeteria includes an average of two washers used constantly for the 6.5 hours per day that the washeteria is open. In total, the washers for the washeteria consume approximately 2,351 kWh annually.

The access to the water storage tank controls are heated by two electric heaters throughout the winter to prevent the controls from freezing. The heaters used for this purpose consume approximately 11,676 kWh annually.

3.2 Predicted Energy Use

3.2.1 Energy Usage / Tariffs

The electric usage profile charts (below) represents the predicted electrical usage for the building. If actual electricity usage records were available, the model used to predict usage was calibrated to approximately match actual usage. The electric utility measures consumption in kilowatt-hours (kWh) and maximum demand in kilowatts (kW). One kWh usage is equivalent to 1,000 watts running for one hour. One KW of electric demand is equivalent to 1,000 watts running at a particular moment. The basic usage charges are shown as generation service and delivery charges along with several non-utility generation charges.

The fuel oil usage profile shows the fuel oil usage for the building. Fuel oil consumption is measured in gallons. One gallon of #1 Fuel Oil provides approximately 132,000 BTUs of energy.

The following is a list of the utility companies providing energy to the building and the class of service provided:

Electricity: Ipnatchiaq Electrric Co - Commercial - Sm

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

Table 3.1: Energy Cost Rates for Each Fuel Type

Average Energy Cost	
Description	**Average Energy Cost**
Electricity	$ 0.71/kWh
#1 Oil	$ 4.50/gallons
Heat Recovery	$ 0.00/million Btu

3.2.1.1 Total Energy Use and Cost Breakdown

At current rates, [Building Owner] pays approximately $67,886 annually for electricity and other fuel costs for the Deering Water Treatment System.

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

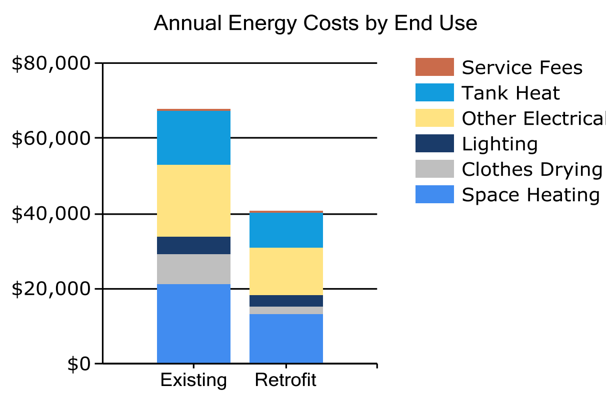


Figure 3.2 below shows how the annual energy cost of the building splits between the different fuels used by the building. The "Existing" bar shows the breakdown for the building as it is now; the "Retrofit" bar shows the predicted costs if all of the energy efficiency measures in this report are implemented.

Figure 3.2: Annual Energy Costs by Fuel Type

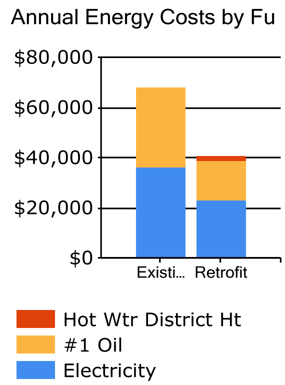
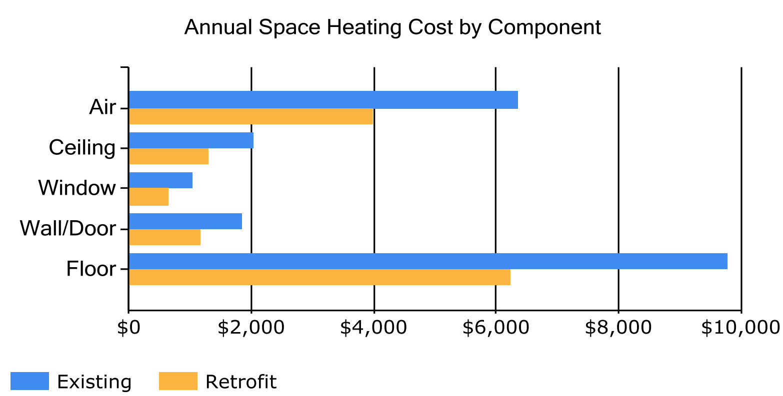


Figure 3.3 below addresses only Space Heating costs. The figure shows how each heat loss component contributes to those costs; for example, the figure shows how much annual space heating cost is caused by the heat loss through the Walls/Doors. For each component, the space heating cost for the Existing 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	939	868	890	744	602	490	472	497	540	704	814	941
Clothes Drying	731	666	731	707	731	707	731	731	707	731	707	731
Lighting	599	546	599	580	543	475	491	491	531	599	580	599
Other Electrical	2568	2340	2568	2485	1800	2119	2190	1080	1813	2568	2485	2568
Tank Heat	173	163	169	142	55	0	0	0	50	129	149	175

Fuel Oil #1 Consumption (Gallons)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Space Heating	511	478	460	323	162	61	19	52	111	266	396	513
Clothes Drying	41	37	41	40	42	48	58	51	42	41	39	41
Tank Heat	478	456	460	353	110	0	0	0	78	287	383	487

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 3.4: Building EUI Calculations for the Deering Water Treatment Plant & Washeteria

Energy Type	Building Fuel Use per Year	Site Energy Use per Year, kBTU	Source/Site Ratio	Source Energy Use per Year, kBTU
Electricity	51,536 kWh	175,891	3.340	587,477
#1 Oil	6,964 gallons	919,256	1.010	928,448
Heat Recovery	0.00 million Btu	0	1.280	0
Total		**1,095,147**		**1,515,925**
BUILDING AREA		2,879	Square Feet	
BUILDING SITE EUI		380	kBTU/Ft²/Yr	
BUILDING SOURCE EUI		527	**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 for the Deering Water Treatment Plant & Washeteria

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	380.4	23.11	$23.58
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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 systems 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 Deering Water Treatment System was modeled using AkWarm© energy use software to establish a baseline space heating energy usage. Climate data from Deering 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 Deering. 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 load model is a simple two-zone model consisting of the building's core interior spaces and the building's perimeter spaces. This simplified approach loses accuracy for buildings that have large variations in heating loads across different parts of the building.

The energy balances shown in Section 3.1 were derived from the output generated by the AkWarm© simulations.

4. ENERGY COST SAVING MEASURES

4.1 Summary of Results

The energy saving measures are summarized in Table 4.1. Please refer to the individual measure descriptions later in this report for more detail.

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**
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2	Heating, Ventilation, and Domestic Hot Water	Repair Amot valve at power plant for the heat recovery system.	$13,873 + $50 Maintenance Savings	$10,000	18.91	0.7	57,271.9
3	Other Electrical - Controls Retrofit: Pressure Pump	Fix pressure tank bladder and repair check valve to reduce cycling of the pressure pump.	$1,707	$1,500	13.14	0.9	3,858.3
4	Dryers	Fix outside air intake by opening Louvers. Clean screens to allow for more air usage. Repair Controls for the dryer makeup fans.	$4,826	$2,500	8.81	0.5	10,818.9
5	Lighting - Power Retrofit: Exterior Lighting	Replace with new energy-efficient LED lighting.	$1,009 + $10 Maintenance Savings	$1,200	7.15	1.2	2,576.3

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
6	Setback Thermostat: Washeteria	Implement a Heating Temperature Unoccupied Setback to 60.0 deg F for the Washeteria space.	$872	$2,000	5.73	2.3	4,053.5
7	Setback Thermostat: Water Plant	Implement a Heating Temperature Unoccupied Setback to 60.0 deg F for the Water Plant space.	$191	$2,000	1.26	10.5	889.1
8	Lighting - Power Retrofit: Fluorescent Lighting	Replace with new energy-efficient LED lighting.	$225 + $15 Maintenance Savings	$1,820	1.10	7.6	516.5
9	Lighting - Power Retrofit: Water Plant Lighting	Replace with new energy-efficient LED lighting.	$233 + $20 Maintenance Savings	$1,950	1.09	7.7	535.6
	TOTAL, all measures		**$27,145**	**$23,970**	**12.76**	**0.9**	**91,028.4**

4.2 Interactive Effects of Projects

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

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

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

4.3 Mechanical Equipment Measures

4.3.1 Heating/ Domestic Hot Water Measure

Rank	Recommendation				
2	Repair Heat Recovery system.				
Installation Cost	$10,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$13,873
Breakeven Cost	$189,129	**Simple Payback (yrs)**	1	**Energy Savings (MMBTU/yr)**	164.2 MMBTU
		Savings-to-Investment Ratio	18.9	**Maintenance Savings ($/yr)**	$50
Auditors Notes: The AMOT valve at the power plant is no longer functioning and the heat recovery system is not used as a result. Repair or replace the AMOT valve and verify that all heat recovery system controls are operating properly. Replace any controls if needed.					

4.3.2 Night Setback Thermostat Measures

Rank	Building Space			Recommendation	
6	Washeteria			Implement a Heating Temperature Unoccupied Setback to 60.0 deg F for the Washeteria space.	
Installation Cost	$2,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$872
Breakeven Cost	$11,465	**Simple Payback (yrs)**	2	**Energy Savings (MMBTU/yr)**	32.4 MMBTU
		Savings-to-Investment Ratio	5.7		
Auditors Notes: Reducing the heat to 60 deg. F when unoccupied will keep the boilers from operating more than necessary.					

Rank	Building Space			Recommendation	
7	Water Plant			Implement a Heating Temperature Unoccupied Setback to 60.0 deg F for the Water Plant space.	
Installation Cost	$2,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$191
Breakeven Cost	$2,513	**Simple Payback (yrs)**	10	**Energy Savings (MMBTU/yr)**	7.1 MMBTU
		Savings-to-Investment Ratio	1.3		
Auditors Notes: Reducing the heat to 60 deg. F when unoccupied will keep the boilers from operating more than necessary.					

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 loads. The building 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	
5	Exterior Lighting		3 LPS 90 Watt Magnetic		Replace with new energy-efficient LED lighting.	
Installation Cost		$1,200	**Estimated Life of Measure (yrs)**	10	**Energy Savings ($/yr)**	$1,009
Breakeven Cost		$8,579	**Simple Payback (yrs)**	1	**Energy Savings (MMBTU/yr)**	4.9 MMBTU
			Savings-to-Investment Ratio	7.1	**Maintenance Savings ($/yr)**	$10
Auditors Notes: There are three light bulbs to be replaced with 20 Watt LED equivalent exterior lights.						

Rank	Location		Existing Condition		Recommendation	
8	Fluorescent Lighting		14 FLUOR (2) T8 4' F32T8 25W Energy-Saver Program StdElectronic		Replace with new energy-efficient LED lighting.	
Installation Cost		$1,820	**Estimated Life of Measure (yrs)**	10	**Energy Savings ($/yr)**	$225
Breakeven Cost		$2,003	**Simple Payback (yrs)**	8	**Energy Savings (MMBTU/yr)**	0.2 MMBTU
			Savings-to-Investment Ratio	1.1	**Maintenance Savings ($/yr)**	$15
Auditors Notes: Replace existing fluorescent lighting with LED replacement bulbs. These bulbs can be direct wired and the old fluorescent ballast completely removed. There are 14 fixtures with two bulbs per fixture for a total of 28 bulbs to be replaces.						

Rank	Location		Existing Condition		Recommendation	
9	Water Plant Lighting		10 FLUOR (3) T8 4' F32T8 25W Energy-Saver Program StdElectronic		Replace with new energy-efficient LED lighting.	
Installation Cost		$1,950	**Estimated Life of Measure (yrs)**	10	**Energy Savings ($/yr)**	$233
Breakeven Cost		$2,116	**Simple Payback (yrs)**	8	**Energy Savings (MMBTU/yr)**	0.2 MMBTU
			Savings-to-Investment Ratio	1.1	**Maintenance Savings ($/yr)**	$20
Auditors Notes: Replace existing fluorescent lighting with LED replacement bulbs. These bulbs can be direct wired and the old fluorescent ballast completely removed. There are 10 fixtures with three bulbs per fixture for a total of 30 bulbs to be replaced.						

4.4.2 Other Electrical Measures

Rank	Location		Description of Existing		Efficiency Recommendation	
1	Electric Heaters for Water Tank Dog House		1 Electric Unit Heater		Reduce temperature setting for dog houses to 50 deg. Reduce runtime of electric heaters.	
Installation Cost		$1,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$4,114
Breakeven Cost		$48,325	**Simple Payback (yrs)**	0	**Energy Savings (MMBTU/yr)**	19.9 MMBTU
			Savings-to-Investment Ratio	48.3		
Auditors Notes: The temperature for the dog boxes needs to be high enough to prevent freezing but does not need to be kept at a high temperature because it is not commonly occupied. Reduce the temperature set points to 50 deg. Such that the heating load is reduced and the electric heaters can operate less.						

Rank	Location		Description of Existing		Efficiency Recommendation	
3	Pressure Pump		Pressure Pump		Fix pressure tank bladder and repair check valve to reduce cycling of the pressure pump.	
Installation Cost		$1,500	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$1,707
Breakeven Cost		$19,714	**Simple Payback (yrs)**	1	**Energy Savings (MMBTU/yr)**	0.5 MMBTU
			Savings-to-Investment Ratio	13.1		
Auditors Notes: The bladder in the pressure tank is broken and causes the pressure pump to run more frequently and with more starts and stops. This leads to poor performance and reduces the life of the pressure pumps. The check valve is also broken and cause the pressure to be lowered during normal operations. Replacing the check valve will lead to a lower requirement for pressure pump use.						

4.4.3 Other Measures

Rank	Location		Description of Existing		Efficiency Recommendation	
4			Dryers		Fix outside air intake by opening Louvers. Clean screens to allow for more air usage. Repair Controls for the dryer makeup fans.	
Installation Cost		$2,500	**Estimated Life of Measure (yrs)**	5	**Energy Savings ($/yr)**	$4,826
Breakeven Cost		$22,025	**Simple Payback (yrs)**	1	**Energy Savings (MMBTU/yr)**	0.1 MMBTU
			Savings-to-Investment Ratio	8.8		
Auditors Notes: The dryers are not operating efficiently because of the buildup of lint in the dryer vents and should be cleaned to improve future use. The dryer makeup fans are not working and should be repaired or replaced to insure proper ventilation is reached for the dryer use.						

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.

APPENDICES

Appendix A – Energy Audit Report – Project Summary

ENERGY AUDIT REPORT – PROJECT SUMMARY	
General Project Information	
PROJECT INFORMATION	**AUDITOR INFORMATION**
Building: Deering Water Treatment System	**Auditor Company:** ARUC
Address: Deering, Alaska	**Auditor Name:** Christopher Mercer
City: Deering	**Auditor Address:** Auditor Address
Client Name: ARUC	
Client Address:	**Auditor Phone:** (907) 729-3560
	Auditor FAX:
Client Phone: (907) 729-3560	**Auditor Comment:**
Client FAX:	
Design Data	
Building Area: 2,879 square feet	**Design Space Heating Load:** Design Loss at Space: 84,747 Btu/hour with Distribution Losses: 84,747 Btu/hour Plant Input Rating assuming 82.0% Plant Efficiency and 25% Safety Margin: 129,188 Btu/hour Note: Additional Capacity should be added for DHW and other plant loads, if served.
Typical Occupancy: 5 people	**Design Indoor Temperature:** 70 deg F (building average)
Actual City: Deering	**Design Outdoor Temperature:** -37.8 deg F
Weather/Fuel City: Deering	**Heating Degree Days:** 16,462 deg F-days
Utility Information	
Electric Utility: Ipnatchiaq Electrric Co - Commercial - Sm	**Average Annual Cost/kWh:** $0.71/kWh

Annual Energy Cost Estimate						
Description	**Space Heating**	**Clothes Drying**	**Lighting**	**Other Electrical**	**Tank Heat**	**Total Cost**
Existing Building	$21,071	$8,408	$4,675	$18,733	$14,769	**$67,886**
With Proposed Retrofits	$13,336	$1,987	$3,152	$12,673	$9,458	**$40,837**
Savings	$7,734	$6,421	$1,523	$6,060	$5,311	**$27,050**

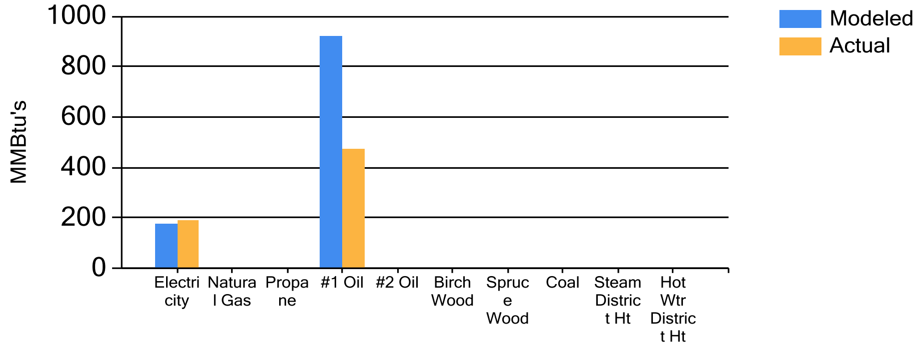
Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	380.4	23.11	$23.58
With Proposed Retrofits	300.7	18.26	$14.18

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.

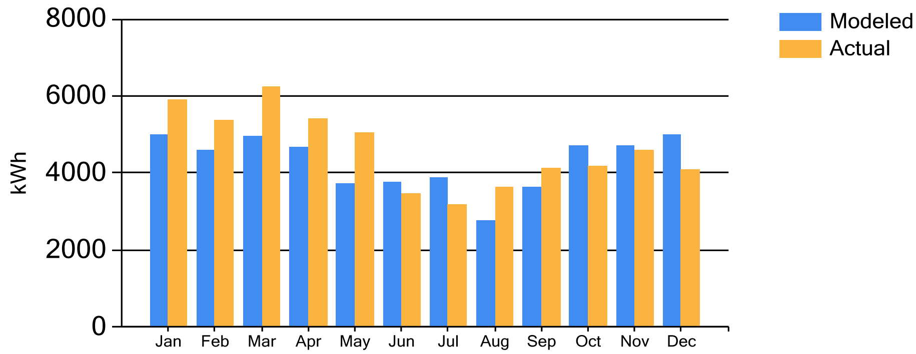
Appendix B – Actual Fuel Use versus Modeled Fuel Use

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

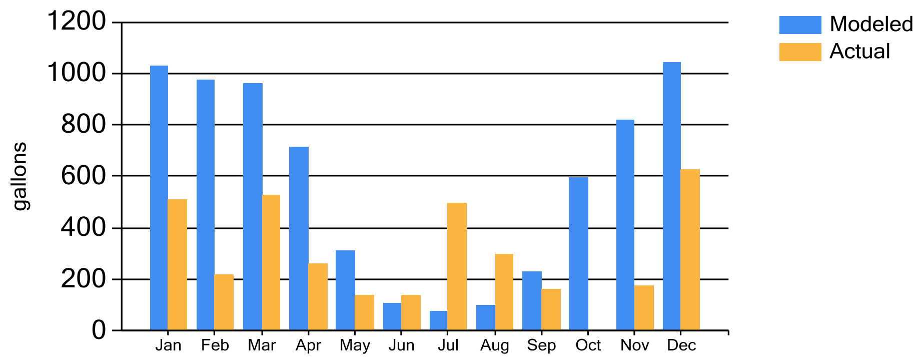
Annual Energy Use



Electricity Use



#1 Fuel Oil Use



Appendix C - Electrical Demands

Estimated Peak Electrical Demand (kW)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Current	10.0	10.0	9.9	9.7	8.3	8.6	8.5	7.0	8.3	9.6	9.8	10.0
As Proposed	7.7	7.8	7.7	7.5	6.7	7.5	7.4	6.0	6.6	7.4	7.6	7.7

AkWarmCalc Ver 2.6.1.0, Energy Lib 4/11/2014