Comprehensive Energy Audit For

Elim Water Treatment Plant

Prepared For
City of Elim

July 8, 2014

Prepared By:

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

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PREFACE

The Energy Projects Group at the Alaska Native Tribal Health Consortium (ANTHC) prepared this document for The City of Grayling, Alaska. The authors of this report are Carl Remley, Certified Energy Auditor (CEA) and Certified Energy Manager (CEM) 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 November of 2013 by the Energy Projects Group of ANTHC. This report analyzes historical energy use and identifies costs and savings of recommended energy conservation measures. Discussions of site-specific concerns, non-recommended measures, and an energy conservation action plan are also included in this report.

This energy audit was conducted using funds 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.

In the near future, a representative of ANTHC will be contacting both the city of Elim and the water treatment plant operator to follow up on the recommendations made in this audit report. A Rural Alaska Village Grant has funded ANTHC to provide the city with assistance in understanding the report and implementing the recommendations.

ACKNOWLEDGMENTS

The ANTHC Energy Projects Group gratefully acknowledges the assistance of Water Treatment Plant Operator Roy Daniels, Finance Officer Esther Aukongak, Elim City Clerk Crystal Ivanoff, and Elim Council Member Tyler Ivanoff.

1. EXECUTIVE SUMMARY

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

The total predicted energy cost for the WTP is $79,883 per year. Electricity represents the largest piece with an annual cost of $40,467 per year. This includes $11,673 paid by the end-users and $28,794 paid by the Power Cost Equalization (PCE) program through the State of Alaska. This means that the city will experience approximately 30% of any electrical savings displayed in this report as the remainder will be saved by the State of Alaska PCE program. The WTP is predicted to spend $39,417 for #1 heating oil. 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 Elim, the cost of electricity without PCE is $0.55/kWh, and the cost of electricity with PCE is $0.18/kWh.

Table 1.1 below summarizes the energy efficiency measures analyzed for the Elim Water Treatment Plant. 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]
1	Other Electrical – Circulation Pumps: Shut pumps off during the summer	Turn off boilers during summer months.	$5,483 plus $75 Maintenance Savings	$1,000	34.41	0.2
2	Circulation Loop Heating: Reduce Heating Levels	Lower the circulation loop temperature from 54 to 40 degrees.	$4,807	$3,000	21.72	0.6
3	Water Storage Tank Heating: Reduce Heating Levels	Lower the water storage tank temperature set point from 60 to 45 degrees.	$3,752	$3,000	16.96	0.8

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]
4	Lighting – Replace light bulbs with LED replacements in Rest Room.	Replace lighting with new energy-efficient LED bulbs and improve controls.	$39 plus $5 Maintenance Savings	$40	15.72	0.9
5	Raw Water Heating: Reduce Temperature	Lower the raw water heating temperature from 50 to 40 degrees.	$3,210	$3,000	14.50	0.9
6	Lighting – Convert Exterior Lighting to LED	Replace lighting with new direct-wired energy-efficient LED bulbs and remove the old fluorescent ballast.	$467 plus $20 Maintenance Savings	$750	9.49	1.5
7	Lighting – Replace office lighting with LED replacement bulbs	Replace lighting with new direct wired energy efficient LED bulbs and remove the old fluorescent ballast.	$112 plus $10 Maintenance Savings	$260	6.64	2.1
8	Lighting – Replace utilidor fluorescent lighting with LED's	Replace lighting with new direct wired energy efficient LED bulbs and remove the old fluorescent ballast.	$477 plus $120 Maintenance Savings	$1,560	5.46	2.6
9	Lighting – Replace water plant fluorescent lighting with LED's	Replace lighting with new direct wired energy efficient LED bulbs and remove the old fluorescent ballast.	$1,411 plus $150 Maintenance Savings	$4,160	5.30	2.7
10	Other Electrical – Replace Well Pump VFD Controls	Install a VFD to control well pump and eliminate need for inefficient manual throttling in the water plant.	$1,884	$3,500	4.53	1.9
11	Other Electrical – Install New Thermostat in Well House	Install a thermostat to be set at 50 degrees and turn off the electric heater in the summer months.	$1,172	$2,500	3.95	2.1
12	HVAC And DHW: Install Garn Biomass Boiler, narrow Heat Add Temperature differential controls, and shut off heat add to water during the summer	Add a Garn biomass boiler, change the differential setting on all the heat add controls from 20 degrees to 2 degrees, and shut off the heat add loops for the months of June, July, and August. It should be noted, this measure is included to show the benefit of the biomass boiler installed in 2012.	$8,730	$120,000	1.40	13.7
13	Other Electrical – Turn off Water Storage Tank Circulation in the summer	Turn off tank heating and circulation to the water storage tank in the summer months.	$179 plus $50 Maintenance Savings	$1,000	1.42	4.4

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]**
14	Lighting – Replace Connex fluorescent lighting with LED's	Replace lighting with new direct wired energy efficient LED bulbs and remove the old fluorescent ballast.	$9 plus $10 Maintenance Savings	$260	1.10	13.4
	TOTAL, all measures		**$31,732 plus $440 Maintenance Savings**	**$144,030**	**2.98**	**4.5**

Table Notes:

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

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

With all of these energy efficiency measures in place, the annual utility cost can be reduced by $31,732 per year, or 39.7% of the buildings' total energy costs. These measures are estimated to cost $144,030, for an overall simple payback period of 4.5 years.

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

Table 1.2

Annual Energy Cost Estimate										
Description	**Space Heating**	**Space Cooling**	**Water Heating**	**Ventilation Fans**	**Lighting**	**Other Electrical**	**Raw Water Heat Add**	**Water Circulation Heat**	**Tank Heat**	**Total Cost**
Existing Building	$4,178	$0	$0	$0	$5,740	$32,486	$12,023	$13,075	$12,321	**$79,883**
With Proposed Retrofits	$3,991	$0	$0	$0	$2,772	$23,768	$5,963	$5,444	$6,154	**$48,151**
Savings	$187	$0	$0	$0	$2,968	$8,718	$6,060	$7,631	$6,167	**$31,732**

2. AUDIT AND ANALYSIS BACKGROUND

2.1 Program Description

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

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 Elim 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.

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

1) Water Treatment Plant: 1,854 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; HVAC; 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. Elim Water Treatment Plant

3.1. Building Description

The 1,854 square foot Elim Water Treatment Plant was constructed in 1994, with a normal occupancy of 0 people. The number of hours of operation for this building average 8 hours per day, considering all seven days of the week.   The building was constructed in 1994.
The Elim WTP houses a circulating water system with two loops that provide water to the residents of the community. One loop services the west end of town and is approximately 4,700 ft. long. The other loop services the east end of town and is approximately 6,900 ft. long. Both loops are maintained at a temperature of 54 degrees F.

The raw water is pumped from a well house approximately 900 feet away. The raw water is pumped through pressure filters and treated with chlorine before entering the 211,000 gallon water storage tank. The water tank is currently maintained at a year round temperature of 55 degrees.

The sewer system is a gravity-fed system that transports sewage to two large septic tanks on the outside of town near Elim Creek. The sewage is treated in the tanks before getting sent into Norton Bay.

<u>Description of Building Shell</u>

The exterior walls are constructed with 2x8 frames with 6.75" R-22 batt insulation. There is 2648 square feet of wall space and the insulation has little damage from water and ice formation.

The roof of the building is constructed from 2x8 framing with 6.75" R-22 batt insulation. The roof has standard 24" spacing and with 1854 square feet.

The floor and foundation of the building is constructed with a 6" concrete slab with no insulation. There is 1854 square feet of floor space.

The building has one window with approximately 4 square feet of area. This window is double-paned with a vinyl frame.

There are three entrances to the building. The primary entrance consists of two metal double-doors with no insulation. The other two entrances both have single metal doors with no insulation. The total area of the three entrances is 84 square feet of door space.

<u>Description of Heating Plants</u>

The Heating Plants used in the building are:

Weil McLean

Nameplate Information:	78 Boiler Model 578
Fuel Type:	#1 Oil
Input Rating:	532,000 BTU/hr
Steady State Efficiency:	80 %
Idle Loss:	1.5 %
Heat Distribution Type:	Glycol
Boiler Operation:	All Year
Notes:	3.75 GPH Nozzle

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<u>Space Heating Distribution Systems</u>

The building is heated with four Modine unit heaters that each put out 150,000 BTU/hour. The heaters have thermostats attached to them that were set to 70 deg. F. There is an electric heater present in the well house.

Biomass Information

The water is heated by a biomass boiler that uses cordwood to heat glycol, which is then passed through a heat exchanger to heat the water system. The boiler is a Garn 1500 biomass boiler built into a connex with 8" of batt insulation enclosed within a wall around the unit. This heat is exchanged into the water prior to the boiler connection to reduce the runtime of the boilers.

Lighting

There are 20 fixtures containing 4 fluorescent T12 4' F40T12 40 watt Standard magnetic light bulbs each in the water plant building. The biomass connex has two fixtures with 2 fluorescent T8 4' F32T8 32 watt Standard Instant Electronic light bulbs in each fixture. Above the exterior door, there is a high pressure sodium 70 watt magnetic light bulb. The rest room in the water plant building has one fixture with two incandescent 75 watt light bulbs in the fixture. The well house has two incandescent 150 watt light bulbs to light the main building and one high pressure sodium 200 watt light that is used to light the well intake channel.

Plug Loads

The WTP has a variety of power tools, a telephone, and some other miscellaneous loads that require a plug into an electrical outlet. Additionally, the building is outfitted with a variety of controls used to operate the major components of the WTP. The total usage of these loads is estimated to be approximately 200W.

Major Equipment

The circulation loops have a pump that circulates the water throughout the system. The pump is operated constantly all year round and uses 28,665 kWh.

The water storage tank has a circulation pump that keeps the water flowing through the tank. This is operated constantly all year round and uses 964 kWh.

The biomass system has two circulation pumps that circulate the glycol through the biomass boiler to the heat exchanger. The pumps run constantly all year round and use 1074.4 kWh each for a total of 2149 kWh.

The water treatment plant has two pressure pumps that keep pressure in the circulating water system. The two 5HP pumps alternate for a runtime of approximately 11% of the time. This consumes approximately 6306 kWh per year.

The well loop has a circulation pump that pumps the water from the well house to the water plant. This runs constantly all year and uses 2717 kWh.

The well house has a ½ HP well pump that is used to pump the water from the water supply up to the well loop. This operates 14 hours per day throughout the year for about 88% of the time. For the remaining 12% of the time, a 3 HP pump is used for the same purpose and throttled down because it is oversized. This pump is primarily used when the filters need to be cleaned.

The well house is heated by an electric heater that is used approximately 21 hours per day for 8 months per year. It consumes 6613 kWh.

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.

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-Elim - Commercial - Sm

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

Table 3.1 – Average Energy Cost	
Description	**Average Energy Cost**
Electricity	$ 0.52/kWh
#1 Oil	$ 4.21/gallons

3.2.1.1 Total Energy Use and Cost Breakdown

At current rates, City of Elim pays approximately $79,883 annually for electricity and other fuel costs for the Elim Water Treatment Plant.

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

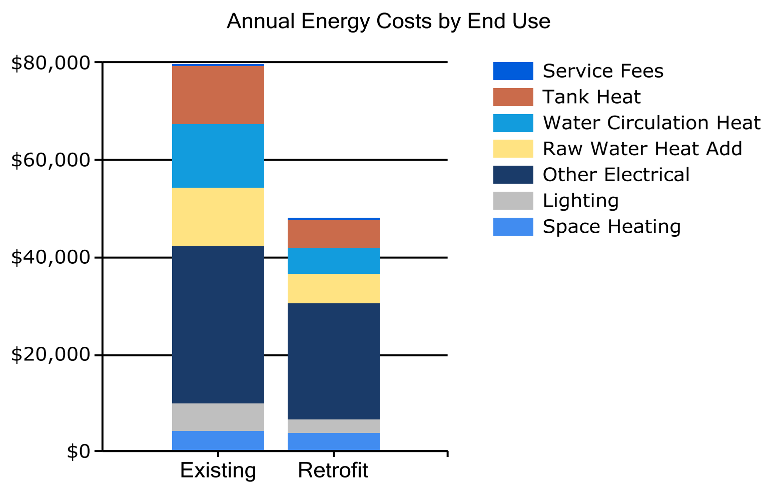


Figure 3.2 below shows how the annual energy cost of the building splits between the different fuels used by the building. The "Existing" bar shows the breakdown for the building as it is now; the "Retrofit" bar shows the predicted costs if all of the energy efficiency measures in this report are implemented.

Figure 3.2
Annual Energy Costs by Fuel Type

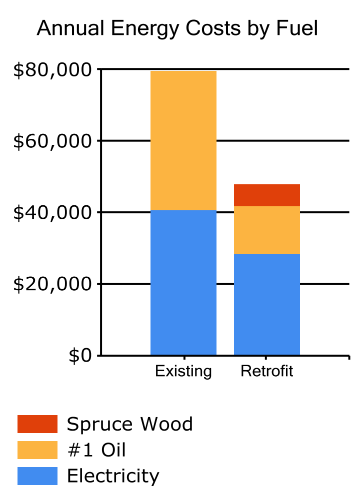
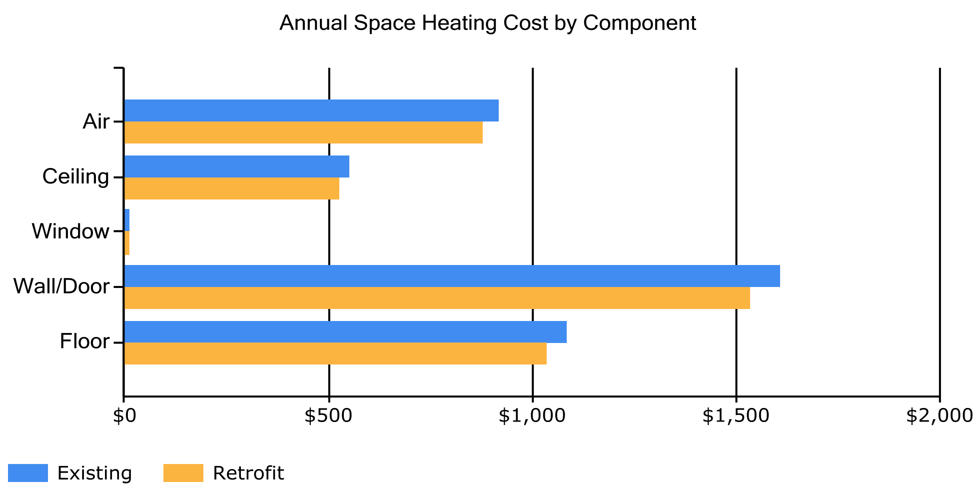


Figure 3.3 below addresses only Space Heating costs. The figure shows how each heat loss component contributes to those costs; for example, the figure shows how much annual space heating cost is caused by the heat loss through the Walls/Doors. For each component, the space heating cost for the Existing 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	344	316	338	306	288	270	279	279	275	303	315	346
Lighting	992	904	992	960	841	814	841	841	964	996	964	996
Other_Electrical	5728	5220	5728	5544	4731	4441	4589	4589	5260	5728	5544	5728
Raw_Water_Heat_Add	21	19	21	20	13	6	7	7	6	21	20	20
Water_Circulation_Heat	23	21	23	22	14	6	6	6	6	23	22	23
Tank_Heat	27	26	27	21	8	2	2	2	3	16	21	28

Fuel Oil #1 Consumption (Gallons)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space_Heating	101	96	90	47	9	0	0	0	3	30	64	104
Raw_Water_Heat_Add	329	299	329	322	208	88	93	93	86	335	321	329
Water_Circulation_Heat	363	331	364	355	226	86	92	92	85	370	355	363
Tank_Heat	436	416	430	329	123	34	23	24	42	258	342	447

3.2.2 Energy Use Index (EUI)

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

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

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

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

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

Table 3.4
Elim 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	78,148 kWh	266,720	3.340	890,846
#1 Oil	9,363 gallons	1,235,872	1.010	1,248,230
Total		**1,502,592**		**2,139,076**
BUILDING AREA		1,854	Square Feet	
BUILDING SITE EUI		810	kBTU/Ft²/Yr	
BUILDING SOURCE EUI		1,154	**kBTU/Ft²/Yr**	
* Site - Source Ratio data is provided by the Energy Star Performance Rating Methodology for Incorporating Source Energy Use document issued March 2011.				

3.3 AkWarm© Building Simulation

An accurate model of the building performance can be created by simulating the thermal performance of the walls, roof, windows and floors of the building. The 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 Elim Water Treatment Plant was modeled using AkWarm© energy use software to establish a baseline space heating and cooling energy usage. Climate data from Elim 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 Elim. 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 **Elim Water Treatment Plant, Elim, Alaska** **PRIORITY LIST – ENERGY EFFICIENCY MEASURES**						
Rank	**Feature**	**Improvement Description**	**Annual Energy Savings**	**Installed Cost**	**Savings to Investment Ratio, SIR**	**Simple Payback (Years)**
1	Other Electrical – Circulation Pumps: Shut pumps off during the summer	Turn off boilers during summer months.	$5,483 plus $75 Maintenance Savings	$1,000	34.41	0.2
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3	Water Storage Tank Heating: Reduce Heating Levels	Lower the water storage tank temperature set point from 60 to 45 degrees.	$3,752	$3,000	16.96	0.8
4	Lighting – Replace light bulbs with LED replacements in Rest Room.	Replace lighting with new energy-efficient LED bulbs and improve controls.	$39 plus $5 Maintenance Savings	$40	15.72	0.9

Table 4.1 **Elim Water Treatment Plant, Elim, Alaska** **PRIORITY LIST – ENERGY EFFICIENCY MEASURES**						
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5	Raw Water Heating: Reduce Temperature	Lower the raw water heating temperature from 50 to 40 degrees.	$3,210	$3,000	14.50	0.9
6	Lighting – Convert Exterior Lighting to LED	Replace lighting with new direct-wired energy-efficient LED bulbs and remove the old fluorescent ballast.	$467 plus $20 Maintenance Savings	$750	9.49	1.5
7	Lighting – Replace office lighting with LED replacement bulbs	Replace lighting with new direct wired energy efficient LED bulbs and remove the old fluorescent ballast.	$112 plus $10 Maintenance Savings	$260	6.64	2.1
8	Lighting – Replace utilidor fluorescent lighting with LED's	Replace lighting with new direct wired energy efficient LED bulbs and remove the old fluorescent ballast.	$477 plus $120 Maintenance Savings	$1,560	5.46	2.6
9	Lighting – Replace water plant fluorescent lighting with LED's	Replace lighting with new direct wired energy efficient LED bulbs and remove the old fluorescent ballast.	$1,411 plus $150 Maintenance Savings	$4,160	5.30	2.7
10	Other Electrical – Replace Well Pump VFD Controls	Install a VFD to control well pump and eliminate need for inefficient manual throttling in the water plant.	$1,884	$3,500	4.53	1.9
11	Other Electrical – Install New Thermostat in Well House	Install a thermostat to be set at 50 degrees and turn off the electric heater in the summer months.	$1,172	$2,500	3.95	2.1
12	HVAC And DHW: Install Garn Biomass Boiler, narrow Heat Add Temperature differential controls, and shut off heat add to water during the summer	Add a Garn biomass boiler, change the differential setting on all the heat add controls from 20 degrees to 2 degrees, and shut off the heat add loops for the months of June, July, and August. It should be noted, this measure is included to show the benefit of the biomass boiler installed in 2012.	$8,730	$120,000	1.40	13.7
13	Other Electrical – Turn off Water Storage Tank Circulation in the summer	Turn off tank heating and circulation to the water storage tank in the summer months.	$179 plus $50 Maintenance Savings	$1,000	1.42	4.4
14	Lighting – Replace Connex fluorescent lighting with LED's	Replace lighting with new direct wired energy efficient LED bulbs and remove the old fluorescent ballast.	$9 plus $10 Maintenance Savings	$260	1.10	13.4

Table 4.1 Elim Water Treatment Plant, Elim, Alaska PRIORITY LIST – ENERGY EFFICIENCY MEASURES						
Rank	Feature	Improvement Description	Annual Energy Savings	Installed Cost	Savings to Investment Ratio, SIR	Simple Payback (Years)
	TOTAL, all measures		$31,732 plus $440 Maintenance Savings	$144,030	2.98	4.5

4.2 Interactive Effects of Projects

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

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

Interior lighting, plug loads, facility equipment, 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.

4.4 Mechanical Equipment Measures

4.4.1 Heating/ Domestic Hot Water Measure

Rank	Recommendation				
12	Add a Garn biomass boiler, change the differential setting on all the heat add controls from 20 degrees to 2 degrees, and shut off the heat add loops for the months of June, July, and August.				
Installation Cost	$120,000	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$8,730
Breakeven Cost	$167,747	**Savings-to-Investment Ratio**	1.4	**Simple Payback yrs**	14
Auditors Notes: This recommendation was implemented in Fall 2012 with the boilers first running in October 2012. This recommendation is listed to show the total impact of the biomass boiler efforts for the Elim water system.					

4.5 Electrical & Appliance Measures

4.5.1 Lighting Measures

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

4.5.1a Lighting Measures – Replace Existing Fixtures/Bulbs

Rank	Location	Existing Condition		Recommendation	
4	Rest Room	INCAN (2) A Lamp, Std 75W with Manual Switching		Replace lighting with new energy-efficient LED bulbs and improve controls.	
Installation Cost	$40	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$39
				Maintenance Savings (/yr)	$5
Breakeven Cost	$629	**Savings-to-Investment Ratio**	15.7	**Simple Payback yrs**	1
Auditors Notes: Replace with LED replacement bulbs. LED's use less energy and last significantly longer than the existing bulbs.					

Rank	Location	Existing Condition		Recommendation	
6	Exterior Lighting	3 HPS 70 Watt Magnetic with Manual Switching		Replace lighting with new energy-efficient LED bulbs and improve controls.	
Installation Cost	$750	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$467
				Maintenance Savings (/yr)	$20
Breakeven Cost	$7,116	**Savings-to-Investment Ratio**	9.5	**Simple Payback yrs**	2
Auditors Notes: Replace the existing high pressure sodium fixtures with new LED wall packs. The LED wall packs consist of with 3 LED 17 watt electronic fixtures with a photo cell control to ensure lights only function when it is dark outside.					

Rank	Location	Existing Condition		Recommendation	
7	Office	FLUOR (4) T12 4' F40T12 40W Standard EfficMagnetic with Manual Switching		Replace lighting with new energy-efficient LED bulbs and improve controls.	
Installation Cost	$260	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$112
				Maintenance Savings (/yr)	$10
Breakeven Cost	$1,726	**Savings-to-Investment Ratio**	6.6	**Simple Payback yrs**	2
Auditors Notes: Replace existing fixtures with direct wired LED replacement bulbs. This includes removing the existing ballast. LED light bulbs use less energy, last longer, and do not contain harmful mercury.					

Rank	Location	Existing Condition		Recommendation	
8	Utilidor Lighting	6 FLUOR (4) T12 4' F40T12 40W Standard StdElectronic with Manual Switching		Replace lighting with new energy-efficient LED bulbs and improve controls.	
Installation Cost	$1,560	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$477
				Maintenance Savings (/yr)	$120
Breakeven Cost	$8,510	**Savings-to-Investment Ratio**	5.5	**Simple Payback yrs**	3
Auditors Notes: Replace existing fixtures with direct wired LED replacement bulbs. This includes removing the existing ballast. LED light bulbs use less energy, last longer, and do not contain harmful mercury.					

Rank	Location	Existing Condition		Recommendation	
9	WTP Lighting	13 FLUOR (4) T12 4' F40T12 40W Standard EfficMagnetic with Manual Switching		Replace lighting with new energy-efficient LED bulbs and improve controls.	
Installation Cost	$4,160	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$1,411
				Maintenance Savings (/yr)	$150
Breakeven Cost	$22,043	**Savings-to-Investment Ratio**	5.3	**Simple Payback yrs**	3
Auditors Notes: Replace existing fixtures with direct wired LED replacement bulbs. This includes removing the existing ballast. LED light bulbs use less energy, last longer, and do not contain harmful mercury.					

Rank	Location	Existing Condition		Recommendation	
14	Connex Lighting	2 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic with Manual Switching		Replace lighting with new energy-efficient LED bulbs and improve controls.	
Installation Cost	$260	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$9
				Maintenance Savings (/yr)	$10
Breakeven Cost	$286	**Savings-to-Investment Ratio**	1.1	**Simple Payback yrs**	13
Auditors Notes: Replace existing fixtures with direct wired LED replacement bulbs. This includes removing the existing ballast. LED light bulbs use less energy, last longer, and do not contain harmful mercury.					

4.5.3 Other Electrical Measures

Rank	Location		Description of Existing		Efficiency Recommendation	
1	Loop Circulation Pump		Circulation Pump with Manual Switching		Turn off circulation pumps during the summer months.	
Installation Cost		$1,000	**Estimated Life of Measure (yrs)**	7	**Energy Savings (/yr)**	$5,483
					Maintenance Savings (/yr)	$75
Breakeven Cost		$34,410	**Savings-to-Investment Ratio**	34.4	**Simple Payback yrs**	0
Auditors Notes: Controls cost is to train operator of the energy and maintenance savings that can be realized by shutting off the circulation pumps in the summer.						

Rank	Location		Description of Existing		Efficiency Recommendation	
10	3 HP Well Pump		Pump with Manual Switching		Replace pump and controls in well house.	
Installation Cost		$3,500	**Estimated Life of Measure (yrs)**	10	**Energy Savings (/yr)**	$1,884
Breakeven Cost		$15,869	**Savings-to-Investment Ratio**	4.5	**Simple Payback yrs**	2
Auditors Notes: Repair, replace or re-commission the variable speed drive on the 3 HP well pump such that the flow is correct at the water plant without manually throttling the valve to increase the head pressure on the pump when it is used.						

Rank	Location		Description of Existing		Efficiency Recommendation	
11	Well House Electric Heater		Electric Heater with Manual Switching		Add thermostat set at 50 degrees and turn off electric heater in the summer months.	
Installation Cost		$2,500	**Estimated Life of Measure (yrs)**	10	**Energy Savings (/yr)**	$1,172
Breakeven Cost		$9,869	**Savings-to-Investment Ratio**	3.9	**Simple Payback yrs**	2
Auditors Notes: Add a wall thermostat set at 50 degrees to more accurately control the well house temperature.						

Rank	Location		Description of Existing		Efficiency Recommendation	
13	Tank Circulation Pump		Tank Circulation Pump with Manual Switching		Turn off tank heating and circulation in the summer months.	
Installation Cost		$1,000	**Estimated Life of Measure (yrs)**	7	**Energy Savings (/yr)**	$179
					Maintenance Savings (/yr)	$50
Breakeven Cost		$1,416	**Savings-to-Investment Ratio**	1.4	**Simple Payback yrs**	4
Auditors Notes: Controls cost is to train operator on the energy and maintenance savings that can be realized by shutting off the tank heat add pump in the summer.						

4.5.6 Other Measures

Rank	Location		Description of Existing		Efficiency Recommendation	
2			Water Circulation Heat Load		Lower the circulation loop temperature from 54 to 40 degrees.	
Installation Cost		$3,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$4,807
Breakeven Cost		$65,163	**Savings-to-Investment Ratio**	21.7	**Simple Payback yrs**	1
Auditors Notes: Reset the circulation loop heat add controls from 54 to 40 degrees.						

Rank	Location	Description of Existing		Efficiency Recommendation	
3		Tank Heat Load		Lower the water storage tank temperature set point from 60 to 45 degrees.	
Installation Cost	$3,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$3,752
Breakeven Cost	$50,867	**Savings-to-Investment Ratio**	17.0	**Simple Payback yrs**	1
Auditors Notes: Reset the tank heat add control from a set point of 60 to 45 degrees.					

Rank	Location	Description of Existing		Efficiency Recommendation	
5		Raw Water Heat Add Load		Lower the raw water heating temperature from 50 to 40 degrees.	
Installation Cost	$3,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$3,210
Breakeven Cost	$43,514	**Savings-to-Investment Ratio**	14.5	**Simple Payback yrs**	1
Auditors Notes: Reset the raw water heat add controls from 50 to 40 degrees.					

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

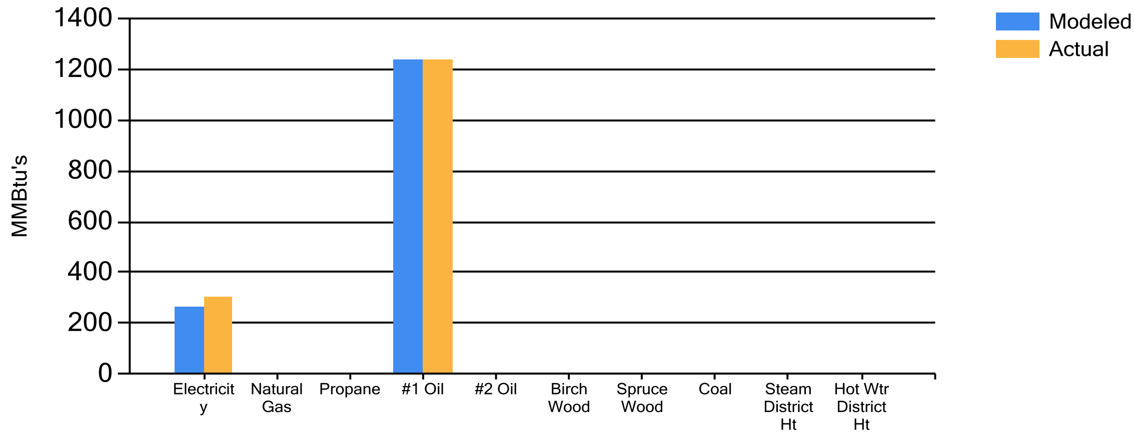
ENERGY AUDIT REPORT – PROJECT SUMMARY	
General Project Information	
PROJECT INFORMATION	**AUDITOR INFORMATION**
Building: Elim Water Treatment Plant	**Auditor Company:** ANTHC-DEHE
Address: PO Box 39009	**Auditor Name:** Carl Remley and Kevin Ulrich
City: Elim	**Auditor Address:** 3900 Ambassador Drive, Suite 301 Anchorage, AK 99508
Client Name: Roy Daniels	
Client Address: PO Box 39009 Elim, AK 99739	**Auditor Phone:** (907) 729-3543
	Auditor FAX:
Client Phone: (907) 880-1091	**Auditor Comment:**
Client FAX:	
Design Data	
Building Area: 1,854 square feet	**Design Space Heating Load:** Design Loss at Space: 11,093 Btu/hour with Distribution Losses: 11,677 Btu/hour Plant Input Rating assuming 82.0% Plant Efficiency and 25% Safety Margin: 17,800 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: Elim	**Design Outdoor Temperature:** -24.3 deg F
Weather/Fuel City: Elim	**Heating Degree Days:** 13,943 deg F-days
Utility Information	
Electric Utility: AVEC-Elim - Commercial - Sm	**Natural Gas Provider:** None
Average Annual Cost/kWh: $0.518/kWh	**Average Annual Cost/ccf:** $0.000/ccf

Annual Energy Cost Estimate											
Description	**Space Heating**	**Space Cooling**	**Water Heating**	**Ventilation Fans**	**Lighting**	**Other Electrical**	**Raw Water Heat Add**	**Water Circulation Heat**	**Tank Heat**	**Service Fees**	**Total Cost**
Existing Building	$4,178	$0	$0	$0	$5,740	$32,486	$12,023	$13,075	$12,321	$60	**$79,883**
With Proposed Retrofits	$3,991	$0	$0	$0	$2,772	$23,768	$5,963	$5,444	$6,154	$60	**$48,151**
Savings	$187	$0	$0	$0	$2,968	$8,718	$6,060	$7,631	$6,167	$0	**$31,732**

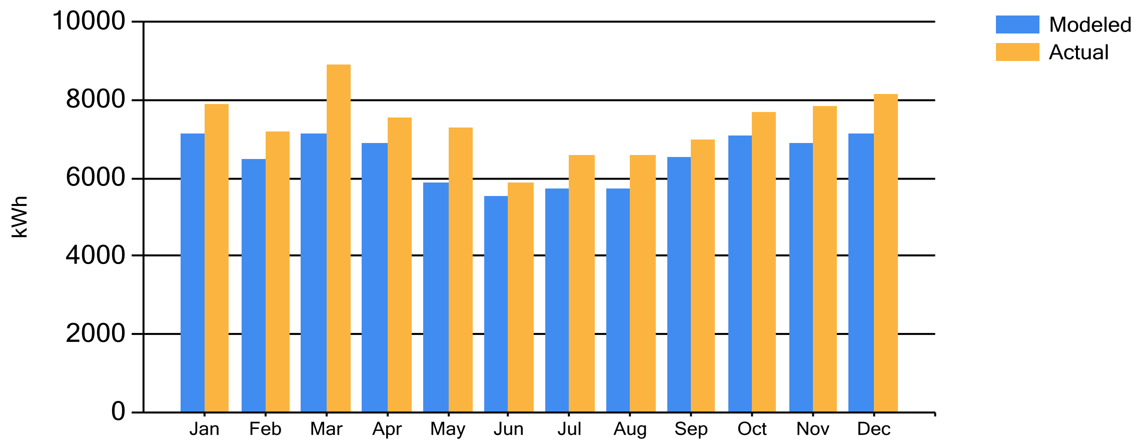
Appendix B – Actual Fuel Use versus Modeled Fuel Use

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