Comprehensive Energy Audit
For
Marshall Water and Sewer System

Prepared For

City of Marshall

March 31, 2012

Prepared By:

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PREFACE

The Energy Projects Group at the Alaska Native Tribal Health Consortium (ANTHC) prepared this document for the City of Marshall. The authors of this report are Carl Remley, Certified Energy Auditor (CEA), and Certified Energy Manager and Gavin Dixon.

The purpose of this report is to provide a comprehensive document that summarizes the findings and analysis that resulted from an energy audit conducted over the past couple months by the Energy Projects Group of ANTHC. This report analyzes historical energy use and identifies costs and savings of recommended energy efficiency measures. Discussions of site specific concerns and an Energy Efficiency Action Plan are also included in this report.

ACKNOWLEDGMENTS

The Energy Projects Group gratefully acknowledges the assistance of Water Plant Operator Mr. Michael Duny and Mr. Ray Alstrom, Chairman of the Board of YKHC.

1. EXECUTIVE SUMMARY

This report was prepared for the City of Marshall. The scope of the audit focused on Marshall 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.

Based on electricity and fuel oil prices in effect at the time of the audit, the annual predicted energy costs for the buildings analyzed are $14,526 for Electricity and $24,179 for #1 Oil. The total energy costs are $38,705 per year. For the purposes of the retrofits, recovered heat has been valued at a cost of $7.50/1,000,000 BTU's of heat provided. This number is based on standard Alaska Village Electrical Cooperative charges for usage of recovered heat off power plants.

It should be noted that this facility received the power cost equalization (PCE) subsidy from the state of Alaska last year. If this facility had not received PCE, total electricity costs would have been $51,326.

Table 1.1 below summarizes the energy efficiency measures analyzed for the Marshall 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: Process Heat Pump	Replace with turn off the pumps at the breaker in the summer months.	$56	$5	66.52	0.1
2	Other Electrical: Well House #3	Replace with a new temperature controller on the electric heat and change the set point from 64 to 45 degrees.	$811	$250	20.09	0.3
3	Other Electrical: North Lift Station	Replace with a new temperature controller on the electric heat and change the set point from 55 to 45 degrees.	$678	$250	16.80	0.4
4	Setback Thermostat: Water Plant	Implement a Heating Temperature Unoccupied Setback to 50.0 deg F for the Water Plant space.	$565	$500	15.33	0.9

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5	Water Storage Tank	The Water Storage Tank circulation and heat add can be turned off in the summer time. Costs include one day of utility support to fix the controls, specifically the Honeywell 4043A1259 valve, which is incapable of closing, which is in effect supplying heat to the water tank all summer long.	$2,183	$2,100	14.07	1.0
6	Other Electrical: South Lift Station	Replace with a new temperature controller on the electric heat and change the set point from 60 degrees to 45 degrees.	$539	$250	13.35	0.5
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8	Other Electrical: Well House #1	Replace with a new temperature controller on the electric heat and change the set point from 55 to 45 degrees.	$160	$250	3.97	1.6
9	Other Electrical: Well House #2	Replace with a new temperature controller on the electric heat and change the set point from 55 to 45 degrees.	$160	$250	3.97	1.6
10	Water Circulation Loops	Replace the Motors of the Circulation Pumps with premium efficiency motors, and turn the well transmission glycol heat trace off in the summer time. Redo the controls for the water circulation lines and use recovered heat for the majority of the heat added to the circulation loops.	$8,987	$38,500	3.19	4.3
11	HVAC And DHW	Boilers need to be cleaned thoroughly. Boilers should also be shut off in the summer time. Costs include a utility support technician for helping with the boilers for one day. Reactivate the recovered heat system. Additional costs for re-activating the recovered heat are listed in the process heat section.	$3,950	$37,500	1.81	9.5
	TOTAL, all measures		**$18,263**	**$80,355**	**3.05**	**4.4**

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 $18,263 per year, or 47.2% of the buildings' total energy costs. These measures are estimated to cost $80,355, for an overall simple payback period of 4.4 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	Lighting	Refrigeration	Other Electrical	Water Circulation Loops	Water Storage Tank	Ventilation Fans	Service Fees	Total Cost
Existing Building	$6,722	$0	$70	$565	$113	$10,524	$14,130	$6,535	$46	$0	**$38,705**
With All Proposed Retrofits	$2,076	$0	$60	$565	$113	$8,088	$5,143	$4,352	$46	$0	**$20,442**
SAVINGS	$4,647	$0	$10	$0	$0	$2,437	$8,987	$2,183	$0	$0	**$18,263**

2. AUDIT AND ANALYSIS BACKGROUND

2.1 Program Description

This audit included services to identify, develop, and evaluate energy efficiency measures at the Marshall 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
- 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 Marshall 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.

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

1) Water Plant: 1,344 square feet
2) Watering Point: 216 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. Marshall Water Treatment Plant

3.1. Building Description

The 1,560 square foot Marshall Water Treatment Plant was constructed in 1981, with a normal occupancy of 2 people. The number of hours of operation for this building average 1.7 hours per day, considering all seven days of the week.

The facility circulates water on three circulation loops to the town, uses a well about ¼ mile away and treats water using chlorine and fluoride. The water is pumped automatically based on a float in the water storage tank maintain a tank level of 21 feet. Treated water is made about 9 hours per day. The town uses about 562,200 gallons of water per month.

The north loop has about 60 connections serviced with 6000 feet of buried arctic pipe. The heat exchanger supplying this loop supplies about 34,000 btu/hour in the winter time based on an outgoing temperature setting of 54 degrees. The north loop supplies about 317,220 gallons of water per month.

The south loop has 8 connections serviced by about 2,000 feet of buried arctic pipe. The heat exchanger supplying this loop supplies about 5800 btu/hour in the winter time based on an outgoing temperature of 54 degrees. The south loop supplies about 148,200 gallons of water per month.

The HUD loop has 20 connections serviced by about 3500 feet of buried arctic pipe. The heat exchanger supplying this loop with heat uses about 6,000 btu/hour in the winter time based on an outgoing temperature of 54 degrees. The HUD loop supplies about 106,150 gallons of water per month.

The water storage tank is a 212,000 gallon water storage tank, maintained at 21 feet of water year round. The tank has 2 inches of board stock insulation, 2 inches of pre-curved insulation, with metal siding that is in good condition.

The watering point next door is heated by the water plant, and is used to haul water primarily to the clinic.

The well houses are all of similar size and make. They are small 2x6 construction facilities that feature an electrical panel, an electric heater, heat tape and a well pump. Currently the heat tapes in all three well houses are turned off. The only well house used to pump water currently is well house #3.

There are two lift stations, both are 2x6 construction with a wet well and a control room separated by a wall. The facilities are electrically heated. The north lift station pumps all the communities' sewage into the lagoon and the south lift stations pumps a smaller amount up to the north lift station.

Description of Building Shell

The exterior walls are constructed with structurally insulated panels, with 6 inches of polyurethane insulation.

The roof of the building is a warm roof constructed structurally insulated panels with 6 inches of polyurethane insulation.

The floor of the building is constructed on a concrete slab.

Typical windows throughout the building are double paned glass windows with insulated fiberglass frames.

Doors are metal with urethane insulation.

The watering point next door is 2x6 construction with batt insulation, a cold roof, gravel floor, and two large garage doors in addition to a standard entrance door.

Description of Heating Plants

The Heating Plants used in the building are:

Weil McLain Gold Oil Boiler #2

Fuel Type:	#1 Oil
Input Rating:	242,000 BTU/hr
Steady State Efficiency:	80 %
Idle Loss:	2 %
Heat Distribution Type:	Water
Boiler Operation:	All Year

Weil McLain Gold Oil Boiler #1

Fuel Type:	#1 Oil
Input Rating:	242,000 BTU/hr
Steady State Efficiency:	80 %
Idle Loss:	2 %
Heat Distribution Type:	Water
Boiler Operation:	All Year

Electric Heaters

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

State Hot Water Heater

Fuel Type:	Electricity
Input Rating:	0 BTU/hr
Steady State Efficiency:	100 %
Idle Loss:	0.5 %
Heat Distribution Type:	Water
Boiler Operation:	All Year

Space Heating and Cooling Distribution Systems

There are two unit heaters in the building. There is also a small piece of baseboard heating in the office. Additionally there are two electric heaters, which are set so low that they never come on unless the temperature in the building drops below 40 degrees.

The attached watering point has a single unit heater set to 65 degrees.

Domestic Hot Water System

There is an electric hot water heater that is only used for hot water in the facilities bathroom.

Recovered Heat Recovery Information

The waste heat system installed several years ago is not operational and piped unusually. The potential for significant recovered heat utilization is very high in this facility.

Lighting

Typical Lighting in the building is made up of 27 T8 fluorescent lighting fixtures with 4 32 watt bulbs each.

Major Equipment

Major equipment in the facility includes the circulation pumps for the three circulation loops, a circulation pump for the glycol loop servicing the well water lines, and heat exchangers for each of those lines.

There is a pair of circulation pumps for heating supply to process loads in the facility, a pair of circulation pumps for supplying heat to the building, a pressure pump for pressurizing the lines, a circulation pump for the water storage tank which also features a heat exchanger for adding heat to the water plant.

There are a set of injection pumps for chlorine and fluoride. There are a pair of circulation pumps for use with the recovered heat system which look to be in good condition, but are not currently in operation. There is a ventilation fan in the chemical room which moves a small amount of the air whenever the room is occupied or the light switch is turned on.

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-Marshal l - 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	$ 0.15/kWh
#1 Oil	$ 4.03/gallon

3.2.1.1 Total Energy Use and Cost Breakdown

At current rates, City of Marshall pays approximately $38,705 annually for electricity and other fuel costs for the Marshall 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. [Type a quote from the document or the summary of an interesting point. You can position the text box anywhere in the document. Use the Drawing Tools tab to change the formatting of the pull quote text box.]

Figure 3.1
Annual Energy Costs by End Use

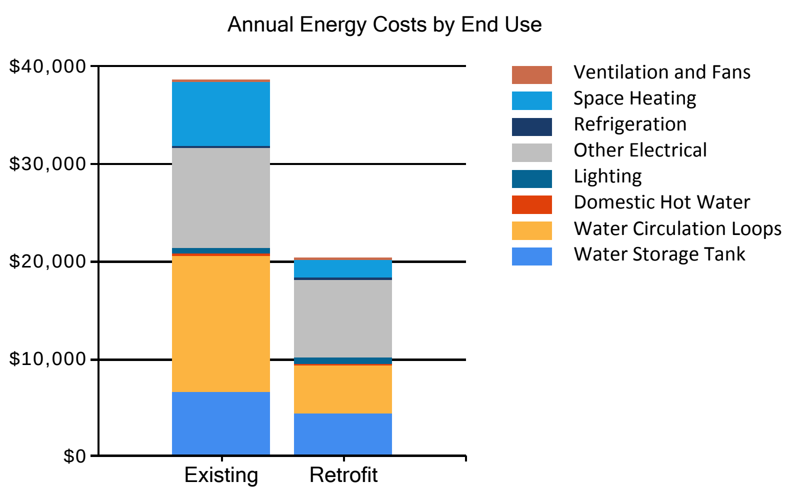


Figure 3.2 below shows how the annual energy cost of the building splits between the different fuels used by the building. The "Existing" bar shows the breakdown for the building as it is now; the "Retrofit" bar shows the predicted costs if all of the energy efficiency measures in this report are implemented.

Figure 3.2
Annual Energy Costs by Fuel Type

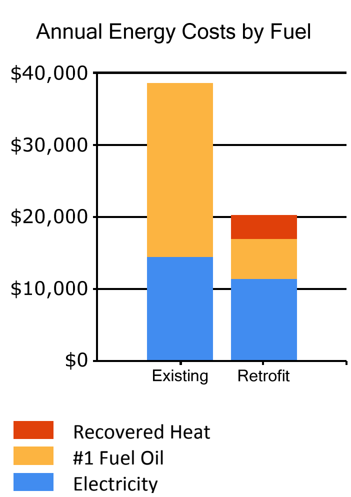
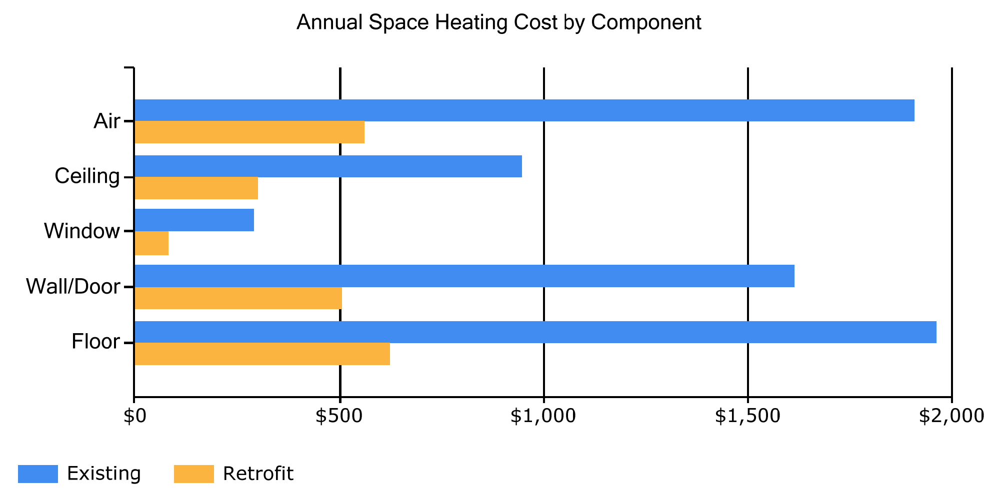


Figure 3.3 below addresses only Space Heating costs. The figure shows how each heat loss component contributes to those costs; for example, the figure shows how much annual space heating cost is caused by the heat loss through the Walls/Doors. For each component, the space heating cost for the Existing 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
Other_Electrical	5955	5427	5955	5763	5955	5763	5955	5955	5763	5955	5763	5955
Lighting	320	291	320	309	320	309	320	320	309	320	309	320
Refrigeration	64	58	64	62	64	62	64	64	62	64	62	64
Water Circulation Loops	2243	2044	2243	2171	2243	133	138	138	133	2243	2171	2243
Water Storage Tank	63	58	63	61	63	61	63	63	61	63	61	63
Ventilation_Fans	26	24	26	25	26	25	26	26	25	26	25	26
DHW	40	36	40	38	40	38	40	40	38	40	38	40
Space_Heating	220	199	213	206	212	199	206	206	204	212	206	220

Fuel Oil #1 Consumption (Gallons)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Water Circulation Loops	344	313	344	333	344	33	34	34	33	344	333	344
Water Storage Tank	135	123	135	131	135	131	135	135	131	135	131	135
Space_Heating	183	163	158	150	142	53	55	55	127	154	152	184

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 = $\frac{\textit{(Electric Usage in kBtu + Fuel Oil Usage in kBtu + similar for other fuels)}}{\textit{Building Square Footage}}$

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

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

Table 3.4
Marshall 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	96,843 kWh	330,525	3.340	1,103,954
#1 Oil	6,000 gallons	791,956	1.010	799,876
Total		**1,122,481**		**1,903,829**
BUILDING AREA		1,560	Square Feet	
BUILDING SITE EUI		720	kBTU/Ft²/Yr	
BUILDING SOURCE EUI		1,220	**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 Marshall Water Treatment Plant was modeled using AkWarm© energy use software to establish a baseline space heating and cooling energy usage. Climate data from Marshall 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 Marshall. 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. Calculations and cost estimates for analyzed measures are provided in Appendix C.

Table 4.1
Marshall Water Treatment Plant, Marshall, Alaska
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11	HVAC And DHW	Boilers need to be cleaned thoroughly. Boilers should also be shut off in the summer time. Costs include a utility support technician for helping with the boilers for one day. Reactivate the recovered heat system. Additional costs for re-activating the recovered heat are listed in the process heat section.	$3,950	$37,500	1.81	9.5
	TOTAL, all measures		**$18,263**	**$80,355**	**3.05**	**4.4**

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. When the building is in cooling mode, these items contribute to the overall cooling demands of the building; therefore, lighting efficiency improvements will reduce cooling requirements in air-conditioned buildings. Conversely, lighting-efficiency improvements are anticipated to slightly increase heating requirements. Heating penalties and cooling benefits were included in the lighting project analysis.

4.3 Mechanical Equipment Measures

4.3.1 Heating/Cooling/Domestic Hot Water Measure

Rank	Recommendation	**Recommendation**

11				Boilers need to be cleaned thoroughly. Boilers should also be shut off in the summer time. Costs include a utility support technician for helping with the boilers for one day. Reactivate the recovered heat system. Additional costs for re-activating the recovered heat are listed in the process heat section.	
Installation Cost	$37,500	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$3,950
Breakeven Cost	$67,788	**Savings-to-Investment Ratio**	1.8	**Simple Payback yrs**	9
Auditors Notes: Boilers need to be cleaned thoroughly. Boilers should also be shut off in the summer time. Costs include a utility support technician for helping with the boilers for one day. Additionally the hot water heater can be turned off at the breaker except when water sampling is done. Additionally, the recovered heat system should be re-piped, activated, and individual circulation pumps should be put on the boilers. Includes time for design, of re-piping, new primary loop pumps, and coordination with AVEC. Additional costs for re-activating the recovered heat are listed in the process heat section.					

4.4.3 Night Setback Thermostat Measures

Rank	**Building Space**			**Recommendation**	
7	Watering Point			Implement a Heating Temperature Unoccupied Setback to 50.0 deg F for the Watering Point space.	
Installation Cost	$500	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$172
Breakeven Cost	$2,337	**Savings-to-Investment Ratio**	4.7	**Simple Payback yrs**	3
Auditors Notes: A programmable thermostat that can work in conjunction with the Tekmar should be installed so that the building can be heated to a lower temperature when it is not occupied. Since the facility is so rarely occupied it should be mostly kept warm enough to prevent freezeups.					

Rank	**Building Space**			**Recommendation**	
4	Water Plant			Implement a Heating Temperature Unoccupied Setback to 50.0 deg F for the Water Plant space.	
Installation Cost	$500	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$565
Breakeven Cost	$7,664	**Savings-to-Investment Ratio**	15.3	**Simple Payback yrs**	1
Auditors Notes: The temperature on the thermometer should be setback to maintain a temperature of 50 degrees in the facility. The facility is almost never occupied, so it should only be kept warm enough to keep the facility and the objects in it from freezing.					

4.4 Electrical & Appliance Measures

4.4.1 Other Electrical Measures

Rank	**Location**	**Description of Existing**		**Efficiency Recommendation**	
9	Well House #2	Well House #2 electrically heated with Manual Switching		Replace with a new temperature controller on the electric heat and change the set point from 55 to 45 degrees.	
Installation Cost	$250	**Estimated Life of Measure (yrs)**	7	**Energy Savings (/yr)**	$160
Breakeven Cost	$993	**Savings-to-Investment Ratio**	4.0	**Simple Payback yrs**	2
Auditors Notes: The well house is currently heated by electric heat to 55 degrees. The thermostat should be reduced to 45 degrees, because the facility is almost never occupied, and it only needs to be heated well enough to prevent freezeups.					

Rank	Location	Description of Existing		Efficiency Recommendation	
8	Well House #1	Well House #1 electrically heated with Manual Switching		Replace with a new temperature controller on the electric heat and change the set point from 55 to 45 degrees.	
Installation Cost	$250	**Estimated Life of Measure (yrs)**	7	**Energy Savings (/yr)**	$160
Breakeven Cost	$993	**Savings-to-Investment Ratio**	4.0	**Simple Payback yrs**	2
Auditors Notes: The well house is currently heated by electric heat to 55 degrees. The thermostat should be reduced to 45 degrees, because the facility is almost never occupied, and it only needs to be heated well enough to prevent freezeups.					

Rank	Location	Description of Existing		Efficiency Recommendation	
6	South Lift Station	Lift Station with two submersible pumps and electric heat with Manual Switching		Replace with a new temperature controller on the electric heat and change the set point from 60 degrees to 45 degrees.	
Installation Cost	$250	**Estimated Life of Measure (yrs)**	7	**Energy Savings (/yr)**	$539
Breakeven Cost	$3,337	**Savings-to-Investment Ratio**	13.3	**Simple Payback yrs**	0
Auditors Notes: The south lift station is currently being heated by electric heaters to 60 degrees. It should be turned down to 45 degrees, as the facility is rarely occupied, and only needs to be warm enough to prevent freezeups.					

Rank	Location	Description of Existing		Efficiency Recommendation	
3	North Lift Station	Lift Station with two submersible pumps and electric heat. with Manual Switching		Replace with a new temperature controller on the electric heat and change the set point from 55 to 45 degrees.	
Installation Cost	$250	**Estimated Life of Measure (yrs)**	7	**Energy Savings (/yr)**	$678
Breakeven Cost	$4,200	**Savings-to-Investment Ratio**	16.8	**Simple Payback yrs**	0
Auditors Notes: The north lift station is currently heated to 68 degrees, resetting the thermostat to 45 degrees would save a substantial amount of electricity. The facility is rarely occupied and only needs to be kept from freezing.					

Rank	Location	Description of Existing		Efficiency Recommendation	
2	Well House #3	Well House #3 electrically heated with Manual Switching		Replace with a new temperature controller on the electric heat and change the set point from 64 to 45 degrees.	
Installation Cost	$250	**Estimated Life of Measure (yrs)**	7	**Energy Savings (/yr)**	$811
Breakeven Cost	$5,022	**Savings-to-Investment Ratio**	20.1	**Simple Payback yrs**	0
Auditors Notes: The building is currently being heated to 64 degrees. The facility only needs to be heated to 45 degrees to prevent freezeups. Turning down the thermostat is all that is necessary.					

Rank	Location	Description of Existing		Efficiency Recommendation	
1	Process Heat Pump	Grundfos UPS 32-80F, Model C		Replace with turn off the pumps at the breaker in the summer months.	
Installation Cost	$5	**Estimated Life of Measure (yrs)**	7	**Energy Savings (/yr)**	$56
Breakeven Cost	$333	**Savings-to-Investment Ratio**	66.5	**Simple Payback yrs**	0

Auditors Notes: Pumps can be turned off in the summer time.

4.5.4 Water Circulation Loop Measures

Rank	Location	Description of Existing		Efficiency Recommendation	
10				Replace the Motors of the Circulation Pumps with premium efficiency motors, and turn the well transmission glycol heat trace off in the summer time. Redo the controls for the water circulation lines and use recovered heat for the majority of the heat added to the circulation loops.	
Installation Cost	$38,500	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$8,987
Breakeven Cost	$122,679	**Savings-to-Investment Ratio**	3.2	**Simple Payback yrs**	4

Auditors Notes: Replace the Motors of the Circulation Pumps with premium efficiency motors, and turn the well transmission glycol heat trace off in the summer time. Additionally the heat add controls for the north and south circulation loops need to be redone so that the thermometers measure returning temperature correctly, and that heat add is controlled by a return temperature of 40 degrees. Costs includes materials, one day of an electrician’s time for installing the pumps, and two days of utility support personnel for reconfiguring the heat add controls. Additional installed costs are to re-activate and re-pipe the heat recovery system.

4.5.5 Water Storage Tank Measures

Rank	Location	Description of Existing		Efficiency Recommendation	
5				The Water Storage Tank circulation and heat add can be turned off in the summer time. Costs include one day of utility support to fix the controls, specifically the Honeywell 4043A1259 valve, which is incapable of closing, which is in effect supplying heat to the water tank all summer long.	
Installation Cost	$2,100	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$2,183
Breakeven Cost	$29,549	**Savings-to-Investment Ratio**	14.1	**Simple Payback yrs**	1

Auditors Notes: The Water Storage Tank circulation and heat add can be turned off in the summer time. Costs include one day of utility support to fix the controls, specifically the Honeywell 4043A1259 valve, which is incapable of closing, which is in effect supplying heat to the water tank all summer long.

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 – Listing of Energy Conservation and Renewable Energy Websites

Lighting
Illumination Engineering Society - http://www.iesna.org/

Energy Star Compact Fluorescent Lighting Program - www.energystar.gov/index.cfm?c=cfls.pr_cfls

DOE Solid State Lighting Program - http://www1.eere.energy.gov/buildings/ssl/

DOE office of Energy Efficiency and Renewable Energy - http://apps1.eere.energy.gov/consumer/your_workplace/

Energy Star – http://www.energystar.gov/index.cfm?c=lighting.pr_lighting

Hot Water Heaters

Heat Pump Water Heaters -
http://apps1.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=12840

Solar Water Heating

FEMP Federal Technology Alerts – http://www.eere.energy.gov/femp/pdfs/FTA_solwat_heat.pdf

Solar Radiation Data Manual – http://rredc.nrel.gov/solar/pubs/redbook

Plug Loads

DOE office of Energy Efficiency and Renewable Energy – http:apps1.eere.energy.gov/consumer/your_workplace/

Energy Star – http://www.energystar.gov/index.cfm?fuseaction=find_a_product

The Greenest Desktop Computers of 2008 - http://www.metaefficient.com/computers/the-greenest-pcs-of-2008.html

Wind

AWEA Web Site – http://www.awea.org

National Wind Coordinating Collaborative – http:www.nationalwind.org

Utility Wind Interest Group site: http://www.uwig.org

WPA Web Site – http://www.windpoweringamerica.gov

Homepower Web Site: http://homepower.com

Windustry Project: http://www.windustry.com

Solar

NREL – http://www.nrel.gov/rredc/

Firstlook – http://firstlook.3tiergroup.com

TMY or Weather Data – http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/

State and Utility Incentives and Utility Policies - http://www.dsireusa.org