Comprehensive Energy Audit
For

Golovin Water Treatment Plant

Prepared For

City of Golovin

October 7, 2016

Prepared By:

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PREFACE

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

The Rural Energy Initiative at the Alaska Native Tribal Health Consortium (ANTHC) prepared this document for The City of Golovin, Alaska. The author of this report is Kevin Ulrich, Energy Manager-in-Training (EMIT). Assistance for this energy audit report was provided by Stephen Sutton, Utility Operations Specialist; Max Goggin-Kehm, Engineering Project Manager; and Darrin Bartz, Supervisor of Utility Operations.

The purpose of this report is to provide a comprehensive document of the findings and analysis that resulted from an energy audit conducted in April of 2016 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 Golovin Utilities Clerk Joann Fayers and Golovin City Clerk Virginia Olanna.

1. EXECUTIVE SUMMARY

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

An additional energy audit was conducted for the Golovin Washeteria at the same time as this audit. The buildings are related in their interactions. This is reflected in the energy audit report.

The total predicted energy cost for the Golovin Water Treatment Plant is $28,143. Fuel oil represents the largest portion with an annual cost of $15,980. Electricity represents the remaining portion with an annual cost of approximately $12,162. This includes $4,778 paid by the community and $7,384 paid by the Power Cost Equalization (PCE) program through the State of Alaska.

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 Golovin, the cost of electricity without PCE is $0.56/kWh and the cost of electricity with PCE is $0.22/kWh.

Table 1.1 lists the total usage of electricity and #1 fuel oil before and after the proposed retrofits.

Table 1.1: Predicted Annual Fuel Usage for Each Fuel Type

Predicted Annual Fuel Use		
Fuel Use	**Existing Building**	**With Proposed Retrofits**
Electricity	21,718 kWh	13,601 kWh
#1 Oil	3,196 gallons	1,731 gallons

Benchmark figures facilitate comparing energy use between different buildings. Table 1.2 lists several benchmarks for the audited building. More details can be found in section 3.2.2.

Table 1.2: Building Benchmarks for the Golovin Water Treatment Plant

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	222.2	15.94	$12.61
With Proposed Retrofits	123.1	8.83	$7.29
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 Golovin Water Treatment Plant. Listed are the estimates of the annual savings, installed costs, and two different financial measures of investment return.

Table 1.3: Summarized Priority List of All Energy Recommendations for the Golovin Water Treatment Plant

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	Water Circulation Loop Heat-Add	Lower Temperature to 40 deg. F, Run one pump at a time.	$5,375	$1,000	71.15	0.2	22,415.8
2	Setback Thermostat: Water Treatment Plant	Implement a Heating Temperature Unoccupied Setback to 50.0 deg F for the Water Treatment Plant space.	$2,480	$1,000	33.62	0.4	10,471.2
3	Water Storage Tank Heat-Add	Run only one Heat-Add pump at a time. Lower tank temperature to 40 deg. F.	$947	$2,000	6.28	2.1	3,953.8
4	Lighting: Office	Replace with direct-wire LED equivalent light bulbs.	$62	$160	4.37	2.6	239.0
5	Heating, Ventilation, and Domestic hot Water	Reprogram controls such that only one boiler operates at a time. This improves maintenance and extends the life of the boilers. Add Tiger Loops to boilers. Replace boiler circulation pumps with bigger models for more efficient operation of the heating system. Reduce operation of Building Heat Circulation Pumps during warmer months.	$1,958	$8,500	3.35	4.3	7,678.6
6	Lighting: Process Room Lights	Replace with direct-wire LED equivalent light bulbs and add new occupancy sensor.	$558	$2,040	3.08	3.7	2,147.8
7	Lighting: Loft Lights	Replace with direct-wire LED equivalent light bulbs and add new occupancy sensor.	$228	$1,400	1.83	6.1	877.9

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: Boiler Room	Replace with direct-wire LED equivalent light bulbs and add new occupancy sensor.	$169	$1,320	1.44	7.8	651.1
9	Lighting: Storage Room	Replace with direct-wire LED equivalent light bulbs.	$9	$160	0.65	17.5	35.3
10	Lighting: Exterior Lights	Replace with direct-wire LED equivalent light bulbs.	$85	$1,500	0.16	17.7	332.2
11	Lighting: Soda Ash Room	Replace with direct-wire LED equivalent light bulbs.	$2	$160	0.15	74.9	8.3
	TOTAL, all measures		**$11,874**	**$19,240**	**8.19**	**1.6**	**48,810.8**

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 $11,874 per year, or 42.2% of the buildings' total energy costs. These measures are estimated to cost $19,240, for an overall simple payback period of 1.6 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: Annual Energy Cost Estimate Broken Down by Usage Category

Annual Energy Cost Estimate							
Description	Space Heating	Water Heating	Lighting	Other Electrical	Water Circulation Heat	Tank Heat	Total Cost
Existing Building	$8,922	$784	$1,991	$5,229	$7,118	$4,100	**$28,143**
With Proposed Retrofits	$5,607	$289	$582	$5,229	$1,556	$3,006	**$16,269**
Savings	$3,314	$494	$1,408	$0	$5,563	$1,094	**$11,874**

2. AUDIT AND ANALYSIS BACKGROUND

2.1 Program Description

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

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

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

Details collected from Golovin 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.

Golovin Water Treatment Plant is comprised of the following activity areas:

1) Water Treatment Plant: 2,232 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. Golovin Water Treatment Plant

3.1. Building Description

The 2,232 square foot Golovin Water Treatment Plant was constructed in 2014 as the primary facility for water intake, treatment, and distribution within the community. The community uses a fill-and-draw system where large batches of water are made that will last the community for the entire year. The operators will pump water during the summer months for a total of approximately 20-30 days in order to fill the two water storage tanks for the winter. During the time of the year when the water treatment plant is in full operation it is occupied at least nine hours per day by one or more operators. During the time of the year when the water treatment plant is not in full operation, the water treatment plant is occupied daily for approximately one hour per day for a daily check of the system.

Water is pumped from the intake gallery using a 5 HP Grundfos pump. The water is collected from the Chinik Creek and pumped approximately 11,000 feet to the Water Treatment Plant. The water is injected with soda ash to stabilize the pH of the water, ferric chloride to coagulate the dirt and particles for filtration. The treated water is filtered through two large multimedia filters before it is sent to the large 1.8 million gallon water storage tank on site. This water storage tank provides water for the water circulation main line in the community. The main loop serves buildings along the way to the 1.2 Million gallon water storage tank that serves the downhill part of town.

Figure 3.1: Water Intake Gallery

Description of Building Shell

The exterior walls are constructed from 2x8 single stud timber framing with approximately 7.25 inches of polyurethane foam insulation. The average height of the walls is 15 feet and there is approximately 2,568 square feet of wall space in the building.

The building has a cathedral ceiling with 2x12 standard wood framing and 24-inch spacing. The roof is insulated with 12 inches of R38 fiberglass batt insulation and there is approximately 2,353 square feet of roof space in the building.

The building is built on grade with a concrete pad foundation on top of a gravel pad. There is no insulation present between the concrete and the ground. There is approximately 1,856 square feet of floor space in the building.

There are seven windows in the building that are each double-paned glass with wood framing and that measure approximately 16.25" x 46.5".

The main entrance uses a set of insulated metal double doors with a quarter-lite window in each door. The chemical room entrance is a single insulated metal door with no windows present. The storage room entrance uses a set of insulated metal double doors with no glass. All individual doors are a standard size of 3' x 6'8".

Description of Heating Plants

The heating plants used in the building are:

Boiler 1

Fuel Type:	#1 Oil
Input Rating:	122,000 BTU/hr
Steady State Efficiency:	80 %

Idle Loss: 0.5 %
Heat Distribution Type: Glycol
Boiler Operation: Sep – Apr

Boiler 2

Fuel Type: #1 Oil
Input Rating: 122,000 BTU/hr
Steady State Efficiency: 80 %
Idle Loss: 0.5 %
Heat Distribution Type: Glycol
Boiler Operation: Sep – Apr

Figure 3.2: Boilers in the Mechanical Room

Electric Water Heater

Fuel Type: Electricity
Input Rating: 0 BTU/hr
Steady State Efficiency: 95 %
Idle Loss: 0.5 %
Heat Distribution Type: Water
Boiler Operation: All Year

Figure 3.3: Electric Hot Water Heater

Space Heating Distribution Systems

The water treatment plant has four unit heaters present in the building that are used to provide space heat to the facility. Two unit heaters are in the process room and are each rated for 34,800 BTU/hr. One unit heater is in the mechanical room and is rated for 18,400 BTU/hr. One unit heater is located in the storage room and is rated for 18,400 BTU/hr. The unit heaters are supplied glycol by a pair of Grundfos Magna 40-120F circulation pumps that circulate glycol throughout the building to the various heating loads for the facility.

Domestic Hot Water System

There is an electric hot water heater in the building that is used to provide hot water to the restroom and lab sink. Due to the infrequent use of the building the domestic hot water demand is very minimal. The unit is an Eemax model EMT 4.0 and has a rated power of 1440 Watts.

Lighting

Table 3.1 below shows detailed information on the lighting in the water treatment plant. All the lights are used primarily during the approximately 30 days per year when the water intake system is in operation. During the other times of the year the lights are used intermittently when the plant is occupied by the operators.

Table 3.1: Lighting Details for the Golovin Water Treatment Plant

Room	Bulb Type	Fixtures	Bulbs per Fixture	Annual Usage (kWh)
Process Room	Fluorescent T8 4ft.	13	4	1,428
Loft	Fluorescent T8 4ft.	5	4	549
Mechanical Room	Fluorescent T8 4ft.	4	4	439
Office	Fluorescent T8 4ft.	2	4	220
Soda Ash Room	Fluorescent T8 4ft.	2	4	16
Storage Room	Fluorescent T8 4ft.	2	4	32
Restroom	Fluorescent T8 4ft.	2	2	16
Exterior	HPS 50 Watt	3	1	854

Plug Loads

The Golovin 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 water treatment has a number of pumps and motors that are used for the water treatment process. These are used primarily during the short season that water is being made. Table 3.2 shows detailed information on the equipment of the water treatment plant.

Table 3.2: Equipment Details for the Golovin Water Treatment Plant

Equipment	Rating (Watts)	Annual Usage (kWh)
Air Scour	11,000	275
Backwash Pump	11,190	280
High Flow Pump	15,000	63
Pressure Pumps (2)	1,120	982
Circulation Pumps (2)	3,500	5,519
Glycol Makeup Tank Pump	30	171
Soda Ash Injection Pump	750	315
Chemical Injection Pumps (3)	22	28
Soda Ash Mixer	560	235
Intake Pump	3,500	1,470

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 City of Golovin owns and operates Golovin Power Utilities, which provides electricity to the residents of the community as well as all commercial and public facilities.

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

Table 3.3: Energy Rates for Each Fuel Source in Golovin

Average Energy Cost	
Description	**Average Energy Cost**
Electricity	$ 0.56/kWh
#1 Oil	$ 5.00/gallons

3.2.1.1 Total Energy Use and Cost Breakdown

At current rates, City of Golovin pays approximately $28,143 annually for electricity and other fuel costs for the Golovin Water Treatment Plant.

Figure 3.4 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.

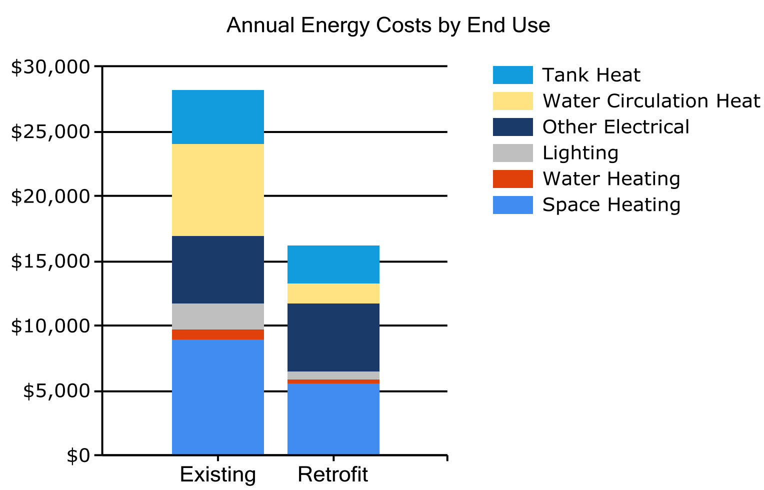


Figure 3.4: Annual Energy Costs by Fuel Use

Figure 3.5 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.

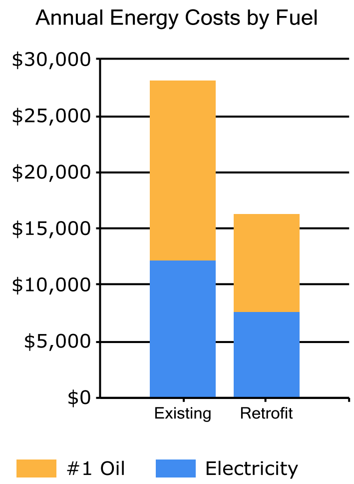
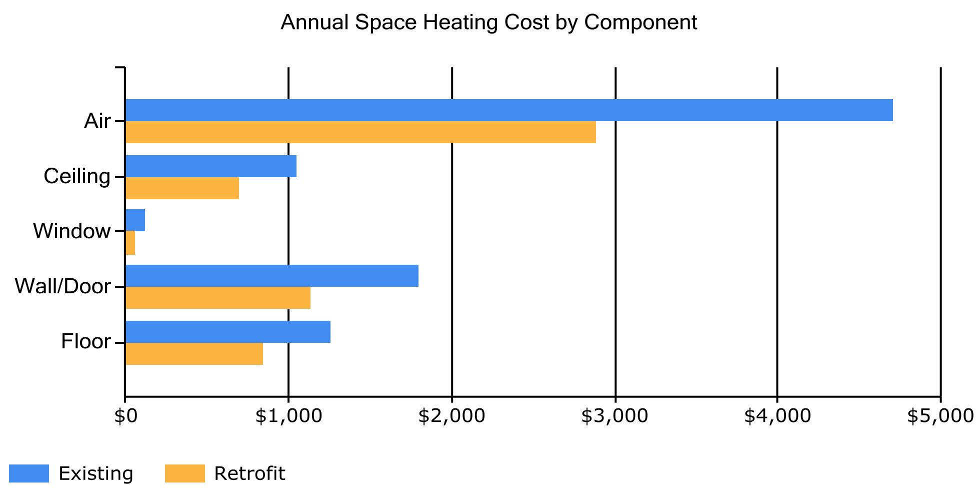


Figure 3.5: Annual Energy Costs by Fuel Type

Figure 3.6 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.



Tables 3.4 and 3.5 show AkWarm's estimate of the monthly fuel use for each of the fuels used in the building. For each fuel, the fuel use is broken down across the energy end uses. Note, in the tables below "DHW" refers to Domestic Hot Water heating.

Table 3.4: Electrical Consumption by Category

Electrical Consumption (kWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space Heating	289	264	289	277	282	272	280	279	272	284	278	290
DHW	119	108	119	115	119	115	119	119	115	119	115	119
Lighting	293	267	293	246	310	190	304	572	246	255	284	293
Other Electrical	757	690	757	448	632	207	425	2579	599	757	732	757
Water Circulation Heat	456	416	455	201	205	0	0	66	323	450	438	456
Tank Heat	81	74	81	35	35	0	0	11	54	77	77	81

Table 3.5: Fuel Oil Consumption by Category

Fuel Oil #1 Consumption (Gallons)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space Heating	214	200	197	143	64	34	12	5	53	110	162	216
Water Circulation Heat	193	188	188	58	11	0	0	0	0	68	130	200
Tank Heat	139	135	136	43	9	0	0	0	0	51	95	144

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):

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

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

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

Table 3.6: Golovin 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	21,718 kWh	74,125	3.340	247,576
#1 Oil	3,196 gallons	421,881	1.010	426,100
Total		**496,006**		**673,676**
BUILDING AREA		2,232	Square Feet	
BUILDING SITE EUI		222	kBTU/Ft²/Yr	
BUILDING SOURCE EUI		302	**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 3.7: Golovin Water Treatment Plant Building Benchmarks

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	222.2	15.94	$12.61
With Proposed Retrofits	123.1	8.83	$7.29
EUI: Energy Use Intensity - The annual site energy consumption divided by the structure's conditioned area. EUI/HDD: Energy Use Intensity per Heating Degree Day. ECI: Energy Cost Index - The total annual cost of energy divided by the square footage of the conditioned space in the building.			

3.3 AkWarm© Building Simulation

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

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

For the purposes of this study, the Golovin Water Treatment Plant was modeled using AkWarm© energy use software to establish a baseline space heating and cooling energy usage. Climate data from Golovin 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 Golovin. 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	Setback Thermostat: Water Treatment Plant	Implement a Heating Temperature Unoccupied Setback to 50.0 deg F for the Water Treatment Plant space.	$2,480	$1,000	33.62	0.4	10,471.2
3	Water Storage Tank Heat-Add	Run only one Heat-Add pump at a time. Lower tank temperature to 40 deg. F.	$947	$2,000	6.28	2.1	3,953.8
4	Lighting: Office	Replace with direct-wire LED equivalent light bulbs.	$62	$160	4.37	2.6	239.0
5	Heating, Ventilation, and Domestic hot Water	Reprogram controls such that only one boiler operates at a time. This improves maintenance and extends the life of the boilers. Add Tiger Loops to boilers. Replace boiler circulation pumps with bigger models for more efficient operation of the heating system. Reduce operation of Building Heat Circulation Pumps during warmer months.	$1,958	$8,500	3.35	4.3	7,678.6
6	Lighting: Process Room Lights	Replace with direct-wire LED equivalent light bulbs and add new occupancy sensor.	$558	$2,040	3.08	3.7	2,147.8

PRIORITY LIST – ENERGY EFFICIENCY MEASURES							
Rank	Feature	Improvement Description	Annual Energy Savings	Installed Cost	Savings to Investment Ratio, SIR	Simple Payback (Years)	CO_2 Savings
7	Lighting: Loft Lights	Replace with direct-wire LED equivalent light bulbs and add new occupancy sensor.	$228	$1,400	1.83	6.1	877.9
8	Lighting: Boiler Room	Replace with direct-wire LED equivalent light bulbs and add new occupancy sensor.	$169	$1,320	1.44	7.8	651.1
9	Lighting: Storage Room	Replace with direct-wire LED equivalent light bulbs.	$9	$160	0.65	17.5	35.3
10	Lighting: Exterior Lights	Replace with direct-wire LED equivalent light bulbs.	$85	$1,500	0.16	17.7	332.2
11	Lighting: Soda Ash Room	Replace with direct-wire LED equivalent light bulbs.	$2	$160	0.15	74.9	8.3
	TOTAL, all measures		**$11,874**	**$19,240**	**8.19**	**1.6**	**48,810.8**

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				
5	Reprogram controls such that only one boiler operates at a time. This improves maintenance and extends the life of the boilers. Add Tiger Loops to boilers. Replace boiler circulation pumps with bigger models for more efficient operation of the heating system. Reduce operation of Building Heat Circulation Pumps during warmer months.				
Installation Cost	$8,500	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$1,958
Breakeven Cost	$28,487	**Savings-to-Investment Ratio**	3.4	**Simple Payback yrs**	4
Auditors Notes: The boiler pumps were undersized and were not adequately distributing the heated glycol to the necessary locations in the building. As a result, both boilers were firing at approximately the same time to circulate enough heat for the building use. Increasing the size of the boiler pumps will yield better fluid flow and minimize pressure loss so that all the heating loads in the building can be adequately met. The Building Heat Circulation Pumps were running more than necessary during the summer months and can programmed for lower operations costs.					

4.3.2 Night Setback Thermostat Measures

Rank	Building Space			Recommendation	
2	Water Treatment Plant			Implement a Heating Temperature Unoccupied Setback to 50.0 deg F for the Water Treatment Plant space.	
Installation Cost	$1,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$2,480
Breakeven Cost	$33,625	**Savings-to-Investment Ratio**	33.6	**Simple Payback yrs**	0
Auditors Notes: Lower the building temperature to 50 deg. F to reduce heating costs during unoccupied times.					

4.4 Electrical & Appliance Measures

4.4.1 Lighting Measures

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

4.4.1a Lighting Measures – Replace Existing Fixtures/Bulbs

Rank	Location	Existing Condition		Recommendation	
4	Office	2 FLUOR (4) T8 4' F32T8 32W Standard Instant StdElectronic		Replace with direct-wire LED equivalent light bulbs.	
Installation Cost	$160	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$62
Breakeven Cost	$699	**Savings-to-Investment Ratio**	4.4	**Simple Payback yrs**	3
Auditors Notes: There are two fixtures with four T8 4ft. fluorescent fixtures to be replaced with two LED direct-wire equivalent light bulbs for a total of four light bulbs to be installed.					

Rank	Location	Existing Condition		Recommendation	
6	Process Room Lights	13 FLUOR (4) T8 4' F32T8 32W Standard Instant StdElectronic		Replace with direct-wire LED equivalent light bulbs and add new occupancy sensor.	
Installation Cost	$2,040	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$558
Breakeven Cost	$6,283	**Savings-to-Investment Ratio**	3.1	**Simple Payback yrs**	4
Auditors Notes: There are 13 fixtures with four T8 4ft. fluorescent fixtures to be replaced with two LED direct-wire equivalent light bulbs for a total of 26 light bulbs to be installed.					

Rank	Location	Existing Condition		Recommendation	
7	Loft Lights	5 FLUOR (4) T8 4' F32T8 32W Standard Instant StdElectronic		R Replace with direct-wire LED equivalent light bulbs and add new occupancy sensor.	
Installation Cost	$1,400	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$228
Breakeven Cost	$2,567	**Savings-to-Investment Ratio**	1.8	**Simple Payback yrs**	6
Auditors Notes: There are five fixtures with four T8 4ft. fluorescent fixtures to be replaced with two LED direct-wire equivalent light bulbs for a total of ten light bulbs to be installed.					

Rank	Location	Existing Condition		Recommendation	
8	Boiler Room	4 FLUOR (4) T8 4' F32T8 32W Standard Instant StdElectronic		Replace with direct-wire LED equivalent light bulbs and add new occupancy sensor.	
Installation Cost	$1,320	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$169
Breakeven Cost	$1,902	**Savings-to-Investment Ratio**	1.4	**Simple Payback yrs**	8
Auditors Notes: There are four fixtures with four T8 4ft. fluorescent fixtures to be replaced with two LED direct-wire equivalent light bulbs for a total of eight light bulbs to be installed.					

Rank	Location	Existing Condition		Recommendation	
9	Storage Room	2 FLUOR (4) T8 4' F32T8 32W Standard Instant StdElectronic		Replace with direct-wire LED equivalent light bulbs.	
Installation Cost	$160	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$9
Breakeven Cost	$103	**Savings-to-Investment Ratio**	0.6	**Simple Payback yrs**	18
Auditors Notes: There are two fixtures with four T8 4ft. fluorescent fixtures to be replaced with two LED direct-wire equivalent light bulbs for a total of four light bulbs to be installed.					

Rank	Location	Existing Condition		Recommendation	
10	Exterior Lights	3 HPS 50 Watt StdElectronic		Replace with direct-wire LED equivalent light bulbs.	
Installation Cost	$1,500	**Estimated Life of Measure (yrs)**	3	**Energy Savings (/yr)**	$85
Breakeven Cost	$241	**Savings-to-Investment Ratio**	0.2	**Simple Payback yrs**	18
Auditors Notes: There are three fixtures with a single HPS 50 Watt light bulb in each fixture for a total of three light bulbs to be replaced.					

Rank	Location	Existing Condition		Recommendation	
11	Soda Ash Room	2 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic		Replace with direct-wire LED equivalent light bulbs.	
Installation Cost	$160	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$2
Breakeven Cost	$24	**Savings-to-Investment Ratio**	0.2	**Simple Payback yrs**	75
Auditors Notes: There are two fixtures with two T8 4ft. fluorescent fixtures to be replaced.					

4.4.2 Other Measures

Rank	Location	Description of Existing		Efficiency Recommendation	
1		Water Circulation Loop Heat-Add Load		Lower Temperature to 40 deg. F, Run one pump at a time.	
Installation Cost	$1,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$5,375
Breakeven Cost	$71,150	**Savings-to-Investment Ratio**	71.1	**Simple Payback yrs**	0
Auditors Notes: Lower the water temperature to 40 deg. F to reduce excess heating of the water.					

Rank	Location	Description of Existing		Efficiency Recommendation	
3		Water Storage Tank Heat Add		Run only one Heat-Add pump at a time. Lower Tank temperature to 40 deg. F.	
Installation Cost	$2,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$947
Breakeven Cost	$12,558	**Savings-to-Investment Ratio**	6.3	**Simple Payback yrs**	2
Auditors Notes: Lower the water temperature to 40 deg. F to reduce excess heating of the water. Both heat-add pumps were in constant operation during the site visit and only one pump is necessary to provide adequate heat for the line.					

5. ENERGY EFFICIENCY ACTION PLAN

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

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

In the near future, a representative of ANTHC will be contacting the City of Golovin to follow up on the recommendations made in this report. ANTHC will work to complete the recommendations in conjunction with the existing construction project.

APPENDICES

Appendix A – Energy Audit Report – Project Summary

ENERGY AUDIT REPORT – PROJECT SUMMARY	
General Project Information	
PROJECT INFORMATION	**AUDITOR INFORMATION**
Building: Golovin Water Treatment Plant	**Auditor Company:** ANTHC-DEHE
Address: PO Box 62059	**Auditor Name:** Kevin Ulrich and Steve Sutton
City: Golovin	**Auditor Address:** 4500 Diplomacy Dr. Anchorage, AK 99508
Client Name: Wayne Henry Sr. and Wayne Henry Jr.	
Client Address:	**Auditor Phone:** (907) 729-3237
	Auditor FAX:
Client Phone: (907) 779-2371	**Auditor Comment:**
Client FAX:	
Design Data	
Building Area: 2,232 square feet	**Design Space Heating Load:** Design Loss at Space: 51,191 Btu/hour with Distribution Losses: 51,191 Btu/hour Plant Input Rating assuming 82.0% Plant Efficiency and 25% Safety Margin: 78,035 Btu/hour Note: Additional Capacity should be added for DHW and other plant loads, if served.
Typical Occupancy: 1 people	**Design Indoor Temperature:** 65 deg F (building average)
Actual City: Golovin	**Design Outdoor Temperature:** -24.3 deg F
Weather/Fuel City: Golovin	**Heating Degree Days:** 13,943 deg F-days
Utility Information	
Electric Utility: Golovin Power Utilities	**Average Annual Cost/kWh:** $0.56/kWh

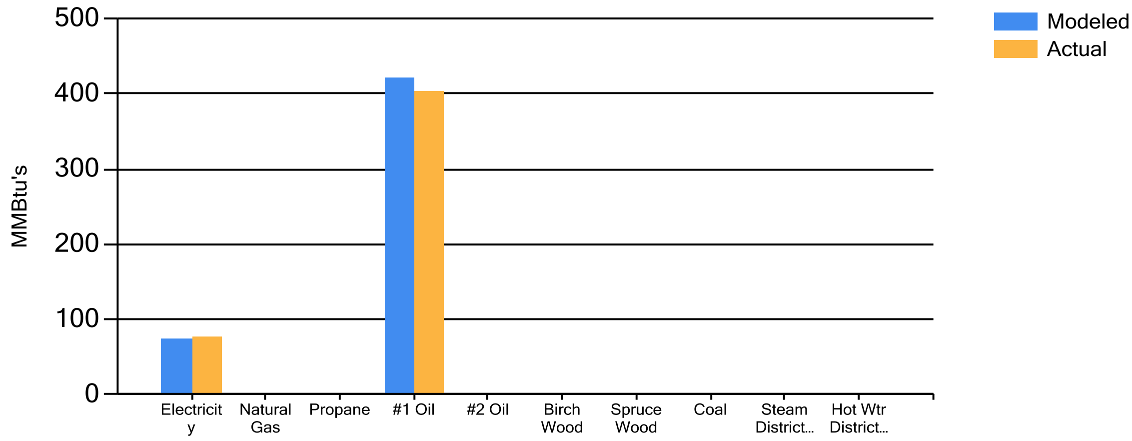
Annual Energy Cost Estimate							
Description	**Space Heating**	**Water Heating**	**Lighting**	**Other Electrical**	**Water Circulation Heat**	**Tank Heat**	**Total Cost**
Existing Building	$8,922	$784	$1,991	$5,229	$7,118	$4,100	**$28,143**
With Proposed Retrofits	$5,607	$289	$582	$5,229	$1,556	$3,006	**$16,269**
Savings	$3,314	$494	$1,408	$0	$5,563	$1,094	**$11,874**

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	222.2	15.94	$12.61
With Proposed Retrofits	123.1	8.83	$7.29
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.			

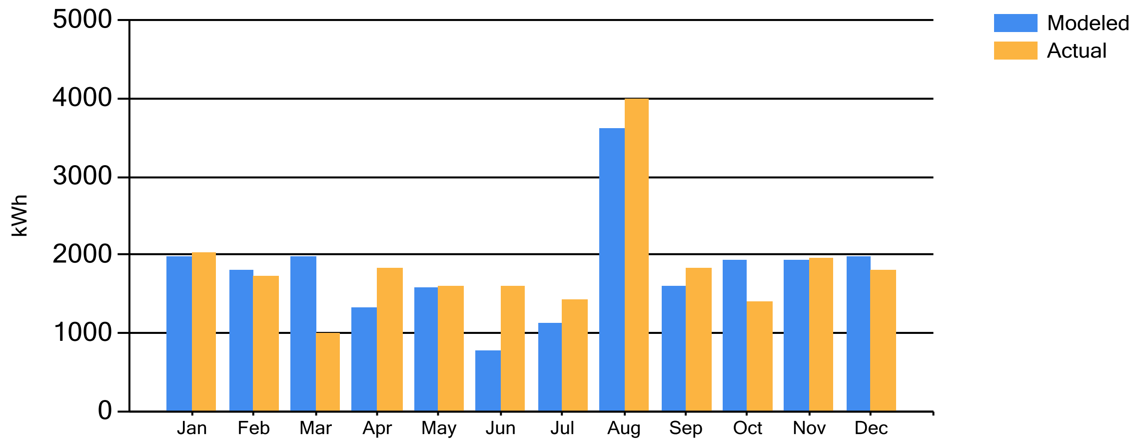
Appendix B – Actual Fuel Use versus Modeled Fuel Use

The graphs below show the modeled energy usage results of the energy audit process compared to the actual energy usage report data. The model was completed using AkWarm modeling software. The orange bars show actual fuel use, and the blue bars are AkWarm's prediction of fuel use.

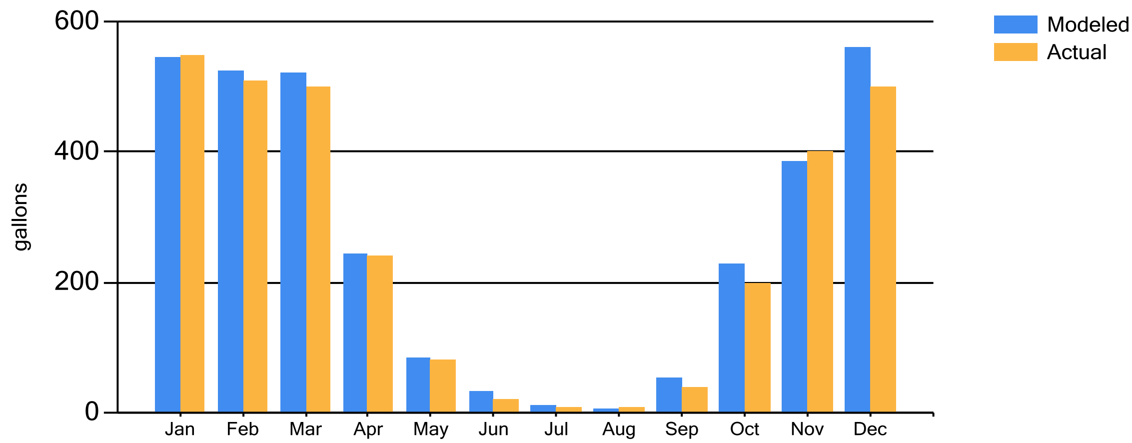
Annual Energy Use



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	7.6	7.4	7.1	5.5	6.5	5.1	7.0	17.4	5.2	5.7	5.4	5.2
As Proposed	3.2	3.1	3.0	2.5	4.7	1.6	5.4	15.2	2.0	2.4	2.4	2.4

AkWarmCalc Ver 2.5.3.0, Energy Lib 3/7/2016