Comprehensive Energy Audit
For
Koyukuk Water Treatment Plant and Washeteria

Prepared For

City of Koyukuk

June 17, 2014

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 Koyukuk, Alaska. The authors of this report are Carl Remley, Certified Energy Auditor (CEA) and Certified Energy Manager (CEM) and Gavin Dixon. Eric Hanssen and Cody Uhlig also participated in the on-site portion of this audit which was performed on April 28th and 29th of 2014.

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 2014 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 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 Koyukuk 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 in implementing the recommendations.

ACKNOWLEDGMENTS

The ANTHC Energy Projects Group gratefully acknowledges the assistance of Mayor Agnes Dayton, City Administrator Barbara L. Fleming, city clerk Kristi Folger, and Tribal Administrator Cindy Pilot.

1. EXECUTIVE SUMMARY

This report was prepared for the City of Koyukuk. The scope of the audit focused on Koyukuk Water Treatment Plant and Washeteria. The scope of this report is a comprehensive energy study, which included an analysis of building shell, interior and exterior lighting systems, HVAC systems, water treatment energy use, 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 $17,121 for electricity, and $7,365 for #1 oil for a total energy cost of $24,485 per year.

It should be noted that the Koyukuk water treatment plant received the power cost equalization (PCE) subsidy for its electricity costs from the state of Alaska. For the purposes of this report, the unsubsidized electrical rate was used to identify measures for retrofits. The actual electrical rate paid by the city of Koyukuk was $.55 per kilowatt-hour which resulted in annual electricity costs to the city of $10,463. This report uses the full electrical cost which is $0.95 per kilowatt-hour.

Table 1.1 below summarizes the energy efficiency measures recommended for the Koyukuk Water Treatment Plant and Washeteria. Listed are the estimates of the annual savings, installed costs, and two different financial measures of investment return. Additional details on the retrofit are presented later in this report.

Table 1.1
PRIORITY LIST – ENERGY EFFICIENCY MEASURES

Rank	Category	Improvement Description	Annual Energy Savings	Installed Cost	Savings to Investment Ratio, SIR[1]	Simple Payback (Years)[2]
1	Other Electrical – Repair pressure pump controls	Repair the pressure switch for the pressure pump to reduce run time of the pump.	$3,285	$2,500	9.98	0.8
2	Lighting – Convert exterior lighting to LED	Replace exterior lighting with LED 20 watt wall packs controlled by a photocell.	$1,683 Plus $100 Maintenance Savings	$2,000	7.51	1.1
3	Setback Thermostat: Water treatment plant and washeteria	Implement a heating setback to 60.0 degrees F during un-occupied hours for the water treatment plant and washeteria.	$835	$2,500	4.42	3.0
4	Lighting - Convert rest room CFL lighting to LED	Replace restroom CFL lighting with LED lamps.	$48 Plus $5 Maintenance Savings	$125	3.53	2.4

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Rank	**Category**	**Improvement Description**	**Annual Energy Savings**	**Installed Cost**	**Savings to Investment Ratio, SIR[1]**	**Simple Payback (Years)[2]**
5	Lighting – Convert washeteria lighting to LED	Replace existing fluorescent lamps with LED replacement lamps with no ballast.	$238 Plus $30 Maintenance Savings	$1,000	2.23	3.7
6	Lighting – Convert rest room wrap around fixtures to LED	Replace existing fluorescent lamps with LED replacement lamps with no ballast.	$52 Plus $10 Maintenance Savings	$300	1.71	4.9
7	Air Tightening: Replace two wood frame windows and seal around pipes exiting building.	Perform air sealing and general weatherization to reduce air leakage by 500 cfm at 50 pascals.	$552	$4,000	1.26	7.3
8	Lighting - Convert tank area lighting to LED	Replace existing fluorescent lamps with LED replacement lamps with no ballast.	$117 Plus $30 Maintenance Savings	$1,000	1.23	6.8
9	Lighting – Convert shop lighting to LED	Replace existing fluorescent lamps with LED replacement lamps with no ballast.	$143 Plus $35 Maintenance Savings	$1,250	1.19	7.0
10	Lighting - Convert crawl space lighting to LED	Replace existing fluorescent lamps with LED replacement lamps with no ballast.	$5 Plus $10 Maintenance Savings	$125	1.01	8.4
11	HVAC And DHW – Re-commission solar thermal system and add biomass boiler	Re-commission solar thermal system and add biomass boiler. The thermal solar system should be providing hot water for the showers and washers but is presently not operational. IRHA has provided a cost estimate of $3,000 to upgrade the controls, recharge the system with glycol, and make any other necessary repairs. The biomass boiler would be a Garn cordwood boiler installed as part of a multi building biomass system for public buildings. Heat distribution within the WTP/Washeteria would be via unit heaters and controls would be integrated with the existing hot air furnace controls.	$3,994	$70,500	1.01	17.7
	TOTAL, cost-effective measures		**$10,952 Plus $220 Maintenance Savings**	**$85,300**	**1.56**	**7.6**
	The following measures were *not* found to be cost-effective:					

Table 1.1 PRIORITY LIST – ENERGY EFFICIENCY MEASURES						
Rank	Category	Improvement Description	Annual Energy Savings	Installed Cost	Savings to Investment Ratio, SIR[1]	Simple Payback (Years)[2]
12	Building Shell	Remove existing doors and install standard pre-hung U-0.16 insulated doors and associated hardware	$52	$4,139	0.26	79.0
	TOTAL, all measures		**$11,004 Plus $220 Maintenance Savings**	**$89,439**	**1.50**	**8.0**

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 $11,004 per year, or 44.9% of the buildings' total energy costs. These measures are estimated to cost $89,439, for an overall simple payback period of 8.0 years. If only the cost-effective measures are implemented, the annual utility cost can be reduced by $10,952 per year, or 44.7% of the buildings' total energy costs. These measures are estimated to cost $85,300, for an overall simple payback period of 7.6 years. Due to the damaged condition of the front entrance door, it is recommended that at least that door be replaced.

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**	**Clothes Drying**	**Lighting**	**Other Electrical**	**Service Fees**	**Total Cost**
Existing Building	$5,008	$0	$4,197	$35	$3,859	$4,472	$6,913	$0	**$24,485**
With Proposed Retrofits	$2,399	$0	$2,069	$35	$3,859	$2,079	$3,039	$0	**$13,481**
Savings	$2,609	$0	$2,128	$0	$0	$2,393	$3,874	$0	**$11,004**

2. AUDIT AND ANALYSIS BACKGROUND

2.1 Program Description

This audit included services to identify, develop, and evaluate energy efficiency measures at the Koyukuk Water Treatment Plant and Washeteria. The scope of this project included evaluating building shell, lighting water treatment energy costs, 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 & 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 Koyukuk Water Treatment Plant and Washeteria enable a model of the building's energy usage to be developed, highlighting the building's total energy consumption, energy consumption by specific building component, and equivalent energy cost. The analysis involves distinguishing the different fuels used on site, and analyzing their consumption in different activity areas of the building.

Koyukuk Water Treatment Plant and Washeteria consists of the following activity areas:

1) Water Treatment Plant and Washeteria: 1,089 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 reevaluated 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. Koyukuk Water Treatment Plant and Washeteria

3.1. Building Description

The 1,089 square foot Koyukuk Water Treatment Plant and Washeteria was constructed in 1987, with a normal occupancy of 2-4 people. The number of hours of operation for this building average 8 hours per day, and is open all seven days of the week.

The water treatment process in Koyukuk is fairly basic. The water is piped from a well to the plant, chlorinated and then pumped to a water storage tank within the plant. Pressure pumps are used to maintain system pressure in the distribution system.

The only buildings in Koyukuk with piped water other than the co-located washeteria are the school and a single teacher housing unit. Both of these facilities are located very close to the water plant.

The washeteria consists of rest rooms, two showers, three front load washers and four electric dryers. Both the washers and dryers are in fairly good condition. The rest rooms, showers, washers, and dryers are all used on a regular basis by the residents of the village.

The facility also has a functioning PV solar system that helps reduce the amount of purchased electricity.

Description of Building Shell

The exterior walls are 2x6 construction with 5.5 inches of R-19 fiberglass insulation. The roof of the building is a cold roof with six inches of fiberglass or loose fill, and six inches of R-19 fiberglass insulation. The floor of the building is built on pilings with six inches of xps blue/pink foam insulation. Typical windows throughout the building are double paned glass windows with vinyl frames, but there are several older wood frame single pane windows as well. Doors are metal with an EPS core, a metal edge and no glass.

Description of Heating Plants

The Heating Plants used in the building are:

Hot Air Furnace 1

Nameplate Information:	W-T Model TMP105-DD-S2
Fuel Type:	#1 Oil
Input Rating:	75,000 BTU/hour
Steady State Efficiency:	80 %
Idle Loss:	1.5 %
Heat Distribution Type:	Air

Hot Air Furnace 2

Nameplate Information:	Same as 1
Fuel Type:	#1 Oil
Input Rating:	75,000 BTU/hour
Steady State Efficiency:	80 %
Idle Loss:	1.5 %
Heat Distribution Type:	Air

Bock Water Heater 1

Fuel Type:	#1 Oil
Input Rating:	75,000 BTU/hour
Steady State Efficiency:	83 %
Idle Loss:	1.5 %
Heat Distribution Type:	Water
Boiler Operation:	All Year

Bock Water Heater 2

Fuel Type:	#1 Oil
Input Rating:	75,000 BTU/hour
Steady State Efficiency:	83 %
Idle Loss:	1.5 %
Heat Distribution Type:	Water
Boiler Operation:	All Year

Monitor 2400

Fuel Type:	#1 Oil
Input Rating:	20,700 BTU/hour

Steady State Efficiency:	80 %
Idle Loss:	1.5 %
Heat Distribution Type:	Air

The water plant also has a non-functional thermal solar water heating system that if functional would work in conjunction with the oil fired water heaters.

Space Heating Distribution Systems

The water plant has two new hot air furnace supply heat to the main floor of the building. The lower level of the facility is heated by a Monitor 2400. Both systems are used to maintain the facility at a temperature of 70 degrees.

Domestic Hot Water System

Two 67 gallon oil fired Bock hot water heaters use about 75,000 btu/hour when firing, and provide the building with about 250 gallons of hot water per day, primarily used in the washeteria. A non-functional thermal solar system is also in the plant. One of our recommendations is to repair and re-commission this system.

Description of Building Ventilation System

The existing building ventilation system is limited to rest room exhaust fans and the dryer exhaust vents.

Lighting

Lighting is primarily made up of T8 fluorescent fixtures with two to four 32 watt bulbs each. Lights are on during typical building occupancy hours, and are conscientiously shut off nightly. There are 10 CFL light bulbs for use in the restrooms and the exterior lighting is 100 watt incandescent fixtures that are controlled manually.

Major Equipment

Water is supplied to the water plant via a three horsepower pump that runs approximately one hour per day. A set of three horsepower pressure pumps are controlled by pressure switches however, the switch that shuts off pump 2 sticks in the closed position and is causing excessive run times.

The washeteria is limited to three front load Speed Queen washers and four three kilowatt Maytag electric dryers. The dryer run time is approximately 25 hours per week.

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. The model used to predict usage was calibrated to approximately match actual usage. The electric utility measures consumption in kilowatt-hours (kWh). One kWh usage is equivalent to 1,000 watts running for one hour. The basic usage charges are shown as generation service and delivery charges along with several non-utility generation charges.

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

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

Electricity: Koyukuk, City of - 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 except power cost equalization (PCE):

Table 3.1 – Average Energy Cost	
Description	**Average Energy Cost**
Electricity	$ 0.95/kWh
#1 Oil	$ 3.95/gallon

3.2.1.1 Total Energy Use and Cost Breakdown

At current rates, City of Koyukuk pays approximately $24,485 annually for electricity and fuel costs for the Koyukuk Water Treatment Plant and Washeteria.

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

Figure 3.1
Annual Energy Costs by End Use

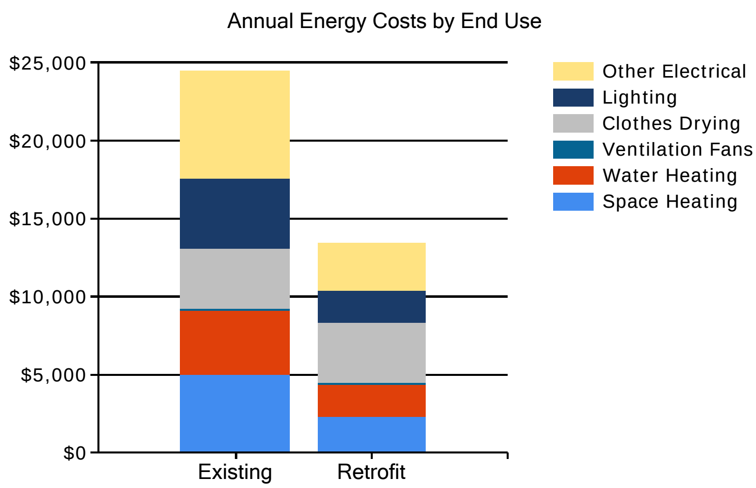
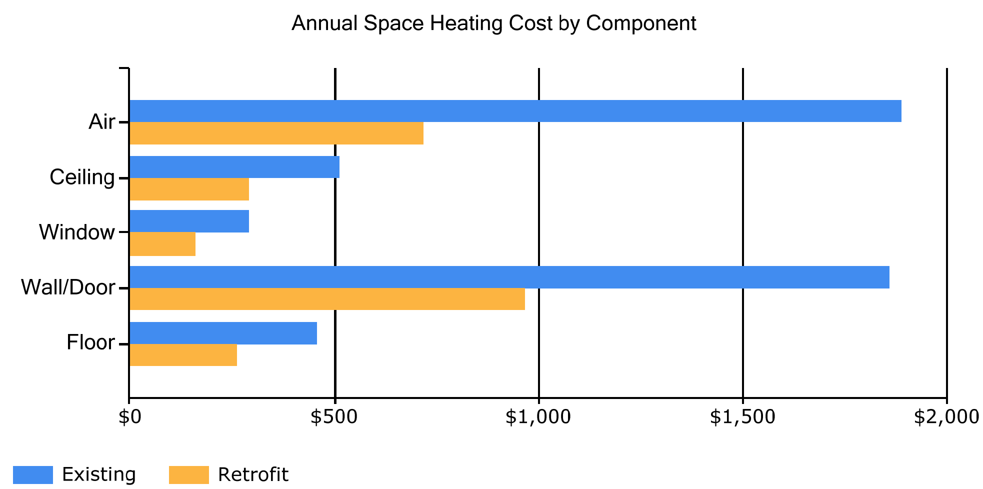


Figure 3.2 below shows how the annual energy cost of the building splits between the different fuels used by the building. The “Existing” bar shows the breakdown for the building as it is now; the “Retrofit” bar shows the predicted costs if all of the energy efficiency measures in this report are implemented.

Figure 3.2
Annual Energy Costs by Fuel Type

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

Figure 3.3
Annual Space Heating Cost by Component



The tables below show AkWarm's estimate of the monthly fuel use for each of the fuels used in the building. For each fuel, the 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	140	130	129	92	49	27	20	23	39	78	109	142
Space_Cooling	0	0	0	0	0	0	0	0	0	0	0	0
DHW	81	74	81	79	81	79	81	81	79	81	79	81
Ventilation_Fans	3	3	3	3	3	3	3	3	3	3	3	3
Clothes_Drying	345	314	345	334	345	334	345	345	334	345	334	345
Lighting	416	379	416	403	367	355	367	367	403	416	403	416
Other_Electrical	618	563	618	598	618	598	618	618	598	618	598	618

Fuel Oil #1 Consumption (Gallons)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Space_Heating	146	136	134	96	53	30	23	26	43	82	114	148
DHW	71	64	71	68	71	68	71	71	68	71	68	71

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 facilities 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 = *(Electric Usage in kBtu + Fuel Oil Usage in kBtu + similar for other fuels)* / *Building Square Footage*

Building Source EUI = *(Electric Usage in kBtu X SS Ratio + Gas Usage in kBtu X SS Ratio + similar for other fuels)* / *Building Square Footage*

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

Table 3.4
Koyukuk Water Treatment Plant and Washeteria EUI Calculations

Energy Type	Building Fuel Use per Year	Site Energy Use per Year, kBTU	Source/Site Ratio	Source Energy Use per Year, kBTU
Electricity	18,022 kWh	61,508	3.340	205,437
#1 Oil	1,864 gallons	246,113	1.010	248,574
Total		**307,621**		**454,011**
BUILDING AREA		1,089	Square Feet	
BUILDING SITE EUI		282	kBTU/Ft²/Yr	
BUILDING SOURCE EUI		417	**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 Koyukuk Water Treatment Plant and Washeteria was modeled using AkWarm© energy use software to establish a baseline space heating and cooling energy usage. Climate data from Koyukuk 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 Koyukuk. This data represents the average ambient weather profile as observed over approximately 30 years. As such, the fuel oil 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 cooling/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. Calculations and cost estimates for analyzed measures are provided in Appendix C.

Table 4.1
Koyukuk Water Treatment Plant and Washeteria, Koyukuk, Alaska
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Table 4.1 Koyukuk Water Treatment Plant and Washeteria, Koyukuk, Alaska PRIORITY LIST – ENERGY EFFICIENCY MEASURES						
Rank	**Category**	**Improvement Description**	**Annual Energy Savings**	**Installed Cost**	**Savings to Investment Ratio, SIR**	**Simple Payback (Years)**
11	HVAC And DHW – Re-commission solar thermal system and add biomass boiler	Re-commission solar thermal system and add biomass boiler. The thermal solar system should be providing hot water for the showers and washers but is presently not operational. IRHA has provided a cost estimate of $3,000 to upgrade the controls, recharge the system with glycol, and make any other necessary repairs. The biomass boiler would be a Garn cordwood boiler installed as part of a multi building biomass system for public buildings. Heat distribution within the WTP/Washeteria would be via unit heaters and controls would be integrated with the existing hot air furnace controls.	$3,994	$70,500	1.01	17.7
	TOTAL, cost-effective measures		**$10,952 Plus $220 Maintenance Savings**	**$85,300**	**1.56**	**7.6**
	The following measures were *not* found to be cost-effective:					
12	Building Shell	Remove existing doors and install standard pre-hung U-0.16 insulated doors and associated hardware	$52	$4,139	0.26	79.0
	TOTAL, all measures		**$11,004 Plus $220 Maintenance Savings**	**$89,439**	**1.50**	**8.0**

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 Building Shell Measures

4.3.1 Door Measures

Rank	Location	Size/Type, Condition	Recommendation
12	Four doors total when arctic entry door is included.	Door Type: Entrance, Metal, EPS core, metal edge, no glass Modeled R-Value: 2.7	Remove existing door and install standard pre-hung U-0.16 insulated door, including hardware.

Installation Cost	$4,139	**Estimated Life of Measure (years)**	30	**Energy Savings per year**	$52
Breakeven Cost	$1,078	**Savings-to-Investment Ratio**	0.3	**Simple Payback (years)**	79

Auditors Notes: Replace existing doors with new insulated doors to improve heat retention. The main entrance door is damaged and does not shut properly.

4.3.2 Air Sealing Measures

Rank	Location	Existing Air Leakage Level (cfm@50/75 Pa)	Recommended Air Leakage Reduction (cfm@50/75 Pa)
7	Replace two wood frame windows and seal around pipes exiting building.	Air Tightness estimated as: 1500 cfm at 50 Pascals	Perform air sealing to reduce air leakage by 500 cfm at 50 Pascals.

Installation Cost	$4,000	**Estimated Life of Measure (years)**	10	**Energy Savings per year**	$552
Breakeven Cost	$5,037	**Savings-to-Investment Ratio**	1.3	**Simple Payback (years)**	7

Auditors Notes: Perform weatherization through weather stripping, caulking, and sealing to reduce air transfer in the facility. The wood frame windows are original and at the end of life.

4.4 Mechanical Equipment Measures

4.4.1 Heating/Domestic Hot Water Measure

Rank	Recommendation
11	Re-commission solar thermal system and add biomass boiler. The thermal solar system should be providing hot water for the showers and washers but is presently not operational. IRHA has provided a cost estimate of $3,000 to upgrade the controls, recharge the system with glycol, and make any other necessary repairs. The biomass boiler would be a Garn cordwood boiler installed as part of a multi-building biomass system for public buildings. Heat distribution within the WTP/Washeteria would be via unit heaters and controls would be integrated with the existing hot air furnace controls.

Installation Cost	$70,500	**Estimated Life of Measure (years)**	20	**Energy Savings per year**	$3,994
Breakeven Cost	$71,029	**Savings-to-Investment Ratio**	1.0	**Simple Payback (years)**	18

Auditors Notes: This measure is really two separate measures to address the heating in the facility. First: Work must be done to repair the existing solar thermal hot water heating system that currently is designed to provide hot water to the washers and showers. IRHA's $3,000 estimate may be a bit low. The remainder of the funding is to tie in the GARN biomass boiler being installed in the community. Some changes to the buildings heating system would be required to maximize the benefit from the new Biomass system.

4.4.2 Night Setback Thermostat Measure

Rank	**Building Space**			**Recommendation**	
3	Water Treatment Plant and Washeteria			Implement a heating setback to 60 degrees F during un-occupied hours for the water plant and washeteria	
Installation Cost	$2,500	**Estimated Life of Measure (years)**	15	**Energy Savings per year**	$835
Breakeven Cost	$11,043	**Savings-to-Investment Ratio**	4.4	**Simple Payback years**	3
Auditors Notes: Install a setback thermostat to control the heating requirements of the building when it is unoccupied. Controlling the temperature of the building to only 60 degrees, as opposed to 70 will drastically reduce heating demand.					

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 lamps with more energy-efficient equivalents will have a small effect on the building heating loads, the heating load will see a small increase, as the more energy efficient lamps give off less heat.

4.5.1a Lighting Measures – Replace Existing Fixtures/Lamps

Rank	**Location**	**Existing Condition**		**Recommendation**	
2	Exterior Lighting	4 INCAN A Lamp, standard 100W with manual switching		Replace with 4 20 watt LED wallpacks	
Installation Cost	$2,000	**Estimated Life of Measure (yrs)**	10	**Energy Savings per year**	$1,683
				Maintenance Savings per year	$100
Breakeven Cost	$15,024	**Savings-to-Investment Ratio**	7.5	**Simple Payback yrs**	1
Auditors Notes: Replacing existing exterior lighting with LED wall packs that operate on photocell controls will reduce electrical usage, improve cold weather lighting performance, and reduce replacement needs.					

Rank	**Location**	**Existing Condition**		**Recommendation**	
4	Rest Room CFL Lighting	10 FLUOR CFL, A Lamp 15W with occupancy sensor		Replace rest room CFL lamps with LED lamps	
Installation Cost	$125	**Estimated Life of Measure (yrs)**	10	**Energy Savings per year**	$48
				Maintenance Savings per year	$5
Breakeven Cost	$442	**Savings-to-Investment Ratio**	3.5	**Simple Payback in years**	2
Auditors Notes: Replacing CFL's with LED replacements will decrease energy use and reduce exposure to mercury found in CFL bulbs.					

Rank	Location		Existing Condition		Recommendation	
5	Washeteria		6 FLUOR (2) T8 4' F32T8 32W Standard Instant with Manual Switching		Replace existing fluorescent lamps with LED replacement lamps with no ballast	
Installation Cost	$1,000	**Estimated Life of Measure (yrs)**	10	**Energy Savings per year**	$238	
				Maintenance Savings per year	$30	
Breakeven Cost	$2,232	**Savings-to-Investment Ratio**	2.2	**Simple Payback in years**	4	
Auditors Notes: Replacing existing interior lighting with LED replacement bulbs by removing the old lamps and ballasts and direct wiring the new lamps into existing fixtures will reduce electrical usage and require less maintenance.						

Rank	Location		Existing Condition		Recommendation	
6	Restroom General Lighting		4 FLUOR T8 4' F32T8 32W occupancy sensor		Replace existing fluorescent lamps with LED replacement lamps with no ballast	
Installation Cost	$300	**Estimated Life of Measure (yrs)**	10	**Energy Savings per year**	$52	
				Maintenance Savings per year	$10	
Breakeven Cost	$513	**Savings-to-Investment Ratio**	1.7	**Simple Payback in years**	5	
Auditors Notes: Replacing existing interior lighting with LED replacement lamps by removing the old lamps and ballasts and direct wiring the new lamps into existing fixtures will reduce electrical usage and require less maintenance.						

Rank	Location		Existing Condition		Recommendation	
8	Tank Area Lighting		3 FLUOR (4) T8 4' F32T8 32W with Manual Switching		Replace existing fluorescent lamps with LED replacement lamps with no ballast	
Installation Cost	$1,000	**Estimated Life of Measure (yrs)**	10	**Energy Savings per year**	$117	
				Maintenance Savings per year	$30	
Breakeven Cost	$1,229	**Savings-to-Investment Ratio**	1.2	**Simple Payback in years**	7	
Auditors Notes: Replacing existing interior lighting with LED replacement lamps by removing the old lamps and ballasts and direct wiring the new lamps into existing fixtures will reduce electrical usage and require less maintenance.						

Rank	Location		Existing Condition		Recommendation	
9	Shop Lighting		8 FLUOR (2) T8 4' F32T8 32W Standard Instant with Manual Switching and Occupancy Sensor		Replace existing fluorescent lamps with LED replacement lamps with no ballast	
Installation Cost	$1,250	**Estimated Life of Measure (yrs)**	10	**Energy Savings per year**	$143	
				Maintenance Savings per year	$35	
Breakeven Cost	$1,487	**Savings-to-Investment Ratio**	1.2	**Simple Payback in years**	7	
Auditors Notes: Replacing existing interior lighting with LED replacement bulbs by removing the old lamps and ballasts and direct wiring the new lamps into existing fixtures will reduce electrical usage and require less maintenance.						

Rank	Location	Existing Condition		Recommendation	
10	Crawl Space	FLUOR (2) T8 4' F32T8 32W with Manual Switching		Replace existing fluorescent lamps with LED replacement lamps with no ballast	
Installation Cost	$125	**Estimated Life of Measure (yrs)**	10	**Energy Savings per year**	$5
				Maintenance Savings per year	$10
Breakeven Cost	$126	**Savings-to-Investment Ratio**	1.0	**Simple Payback in years**	8
Auditors Notes: Replacing existing interior lighting with LED replacement lamps by removing the old lamps and ballasts and direct wiring the new lamps into existing fixtures will reduce electrical usage and require less maintenance.					

4.5.2 Other Electrical Measures

Rank	Location	Description of Existing		Efficiency Recommendation	
1	Pressure Pumps	Pressure Pump Controlled with Pressure Switches.		Replace the pressure switch on pump 2	
Installation Cost	$2,500	**Estimated Life of Measure (yrs)**	9	**Energy Savings per year**	$3,285
Breakeven Cost	$24,955	**Savings-to-Investment Ratio**	10.0	**Simple Payback in years**	1
Auditors Notes: The cut off portion of the pressure switch for pump 2 sticks on fairly frequently and results in excessive run times. Replacing this pressure switch will eliminate this problem.					

5. ENERGY EFFICIENCY ACTION PLAN

Through inspection of the energy-using equipment, on-site monitoring, and discussions with site facilities personnel, this energy audit has identified many 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 change the pressure switch on the pressure pump, implementation costs of these measures can be minimized. The costs listed in this report assumes that will be the case.

In the near future, a representative of ANTHC will be contacting both the City of Koyukuk 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 in implementing the recommendations.

Appendix A – Energy Audit Report – Project Summary

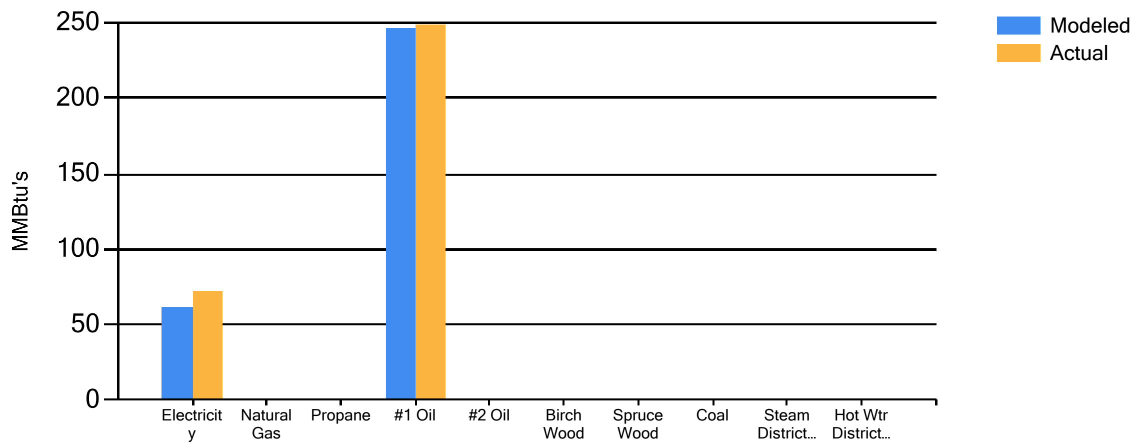
ENERGY AUDIT REPORT – PROJECT SUMMARY	
General Project Information	
PROJECT INFORMATION	**AUDITOR INFORMATION**
Building: Koyukuk Water Treatment Plant and Washeteria	**Auditor Company:** ANTHC-DEHE
Address: PO Box 49	**Auditor Name:** Carl Remley, Eric Hanssen, Cody Uhlig
City: Koyukuk	**Auditor Address:** 3900 Ambassador Drive, Suite 301 Anchorage, AK 99508
Client Name: Killian and Kristi Folger	
Client Address: PO Box 49 Koyukuk, AK 99754	**Auditor Phone:** (907) 729-3543
	Auditor FAX:
Client Phone: (907) 927-2215	**Auditor Comment:**
Client FAX:	
Design Data	
Building Area: 1,089 square feet	**Design Space Heating Load:** Design Loss at Space: 39,067 Btu/hour with Distribution Losses: 39,067 Btu/hour Plant Input Rating assuming 82.0% Plant Efficiency and 25% Safety Margin: 59,553 Btu/hour Note: Additional Capacity should be added for DHW and other plant loads, if served.
Typical Occupancy: 2-4 people	**Design Indoor Temperature:** 70 deg F (building average)
Actual City: Koyukuk	**Design Outdoor Temperature:** -26.2 deg F
Weather/Fuel City: Koyukuk	**Heating Degree Days:** deg F-days
Utility Information	
Electric Utility: Koyukuk, City of - Commercial - Sm	**Natural Gas Provider:** None
Average Annual Cost/kWh: $0.950/kWh	**Average Annual Cost/ccf:** $0.000/ccf

Annual Energy Cost Estimate									
Description	**Space Heating**	**Space Cooling**	**Water Heating**	**Ventilation Fans**	**Clothes Drying**	**Lighting**	**Other Electrical**	**Service Fees**	**Total Cost**
Existing Building	$5,008	$0	$4,197	$35	$3,859	$4,472	$6,913	$0	**$24,485**
With Proposed Retrofits	$2,399	$0	$2,069	$35	$3,859	$2,079	$3,039	$0	**$13,481**
Savings	$2,609	$0	$2,128	$0	$0	$2,393	$3,874	$0	**$11,004**

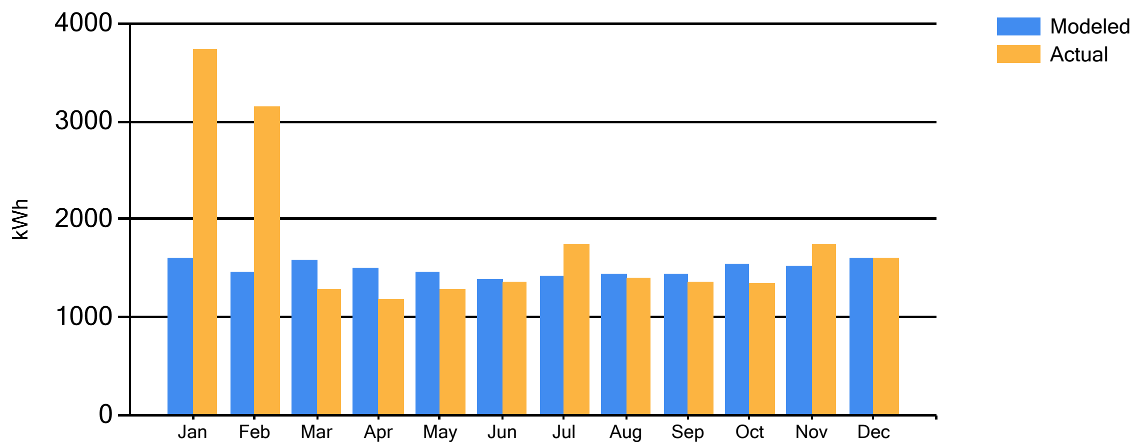
Appendix B– Actual Fuel Use versus Modeled Fuel Use

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

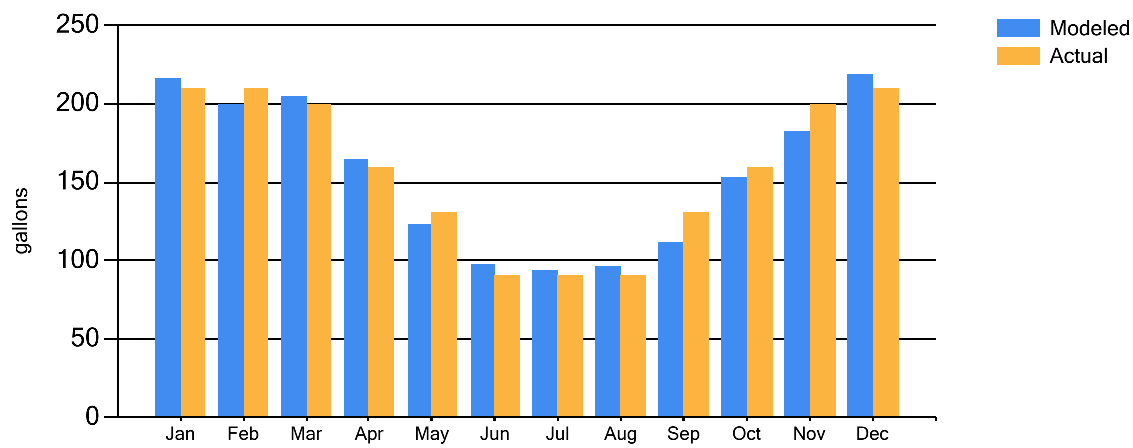
Annual Fuel Use



Electricity Fuel Use



#1 Fuel Oil Fuel Use



Appendix C - Electrical Demands

Estimated Peak Electrical Demand (kW)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Current	8.1	8.1	8.1	8.1	7.7	7.7	7.7	7.7	8.1	8.1	8.1	8.1
As Proposed	7.5	7.5	7.5	7.5	7.4	7.4	7.4	7.4	7.5	7.5	7.5	7.5

Estimated Demand Charges (at $0.00/kW)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Current	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
As Proposed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

AkWarmCalc Ver 2.3.2.1, Energy Lib 4/11/2014