Comprehensive Energy Audit For

Tyonek Water Treatment Plant

Prepared For

Native Village of Tyonek

June 5, 2017

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PREFACE

This energy audit was conducted using funds provided by the United States Department of Energy as part of the Technical Assistance provider program. Coordination with the Native Village of Tyonek 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 Native Village of Tyonek, Alaska. The authors of this report are Kevin Ulrich, Assistant Engineering Project Manager and Certified Energy Manager (CEM); and Kelli Whelan, Americorps Vista.

The purpose of this report is to provide a comprehensive document of the findings and analysis that resulted from an energy audit conducted in May of 2017 by the Rural Energy Initiative of ANTHC. This report analyzes historical energy use and identifies costs and savings of recommended energy conservation measures. Discussions of site-specific concerns, non-recommended measures, and an energy conservation action plan are also included in this report.

ACKNOWLEDGMENTS

The ANTHC Rural Energy Initiative gratefully acknowledges the assistance of Water Treatment Plant Operator Samuel Bartels, President Arthur Standifer, Tribal Administrator Sandi Kroto, and Tyonek Native Corporation Administrator Tonya Kaloa.

1. EXECUTIVE SUMMARY

This report was prepared for the Native Village of Tyonek. The scope of the audit focused on Tyonek 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 total predicted energy costs are $10,654 per year. Electricity represents the largest portion with an annual cost of approximately $8,786. #1 Fuel Oil represents the remaining portion of the energy costs, with an annual cost of approximately $1,868.

Table 1.1: Predicted Annual Fuel Use for the Tyonek Water Treatment Plant

Predicted Annual Fuel Use		
Fuel Use	**Existing Building**	**With Proposed Retrofits**
Electricity	62,756 kWh	34,501 kWh
#1 Oil	393 gallons	229 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 Tyonek Water Treatment Plant

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	189.9	19.53	$7.60
With Proposed Retrofits	105.6	10.86	$4.22
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 Tyonek Water Treatment Plant. Listed are the estimates of the annual savings, installed costs, and two different financial measures of investment return.

Table 1.3: Summary of Recommended Energy Efficiency Measures

PRIORITY LIST – ENERGY EFFICIENCY MEASURES							
Rank	**Feature**	**Improvement Description**	**Annual Energy Savings**	**Installed Cost**	**Savings to Investment Ratio, SIR[1]**	**Simple Payback (Years)[2]**	**CO_2 Savings**
1	Setback Thermostat: Water Treatment Plant	Program an unoccupied setback of 50 deg. F on the Toyo stove in the office.	$1,020	$300	46.09	0.3	4,554.9

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**
2	Other Electrical: Well Pump 2	Repair leaks and reduce water usage.	$1,819 + $2,000 Maint. Savings	$21,000	3.53	5.5	14,295.8
3	Other Electrical: Well Pump 1	Repair leaks and reduce water usage.	$1,617 + $2,000 Maint. Savings	$21,000	3.35	5.8	12,707.5
4	Lighting: Exterior	Replace with new LED lighting.	$25	$250	1.19	9.8	199.4
5	Air Tightening	Add weather stripping around the main entrance doors.	$24	$300	0.74	12.5	106.9
6	Other Electrical: Lower Village Pressure Pumps	Repair controls so that pump has fewer starts with longer runs.	$50	$1,000	0.58	20.2	559.4
7	Lighting: Office	Replace with new LED lighting.	$20	$560	0.38	27.4	209.7
8	Lighting: Process Room	Replace with new LED lighting.	$34	$960	0.36	28.5	353.6
9	Other Electrical: Indian Creek Pressure Pumps	Increase size of the pressure pumps to a more appropriate size, allowing the pressure pumps to stop when the desired system pressure is reached and start when needed to pressurize the system.	$125	$5,000	0.28	39.9	1,537.8
10	Lighting: Loft	Replace with new LED lighting.	$2	$160	0.10	93.8	20.1
11	Lighting: Chemical Room	Replace with new LED lighting.	$1	$160	0.06	148.6	12.8
	TOTAL, all measures		**$4,738 + $4,000 Maint. Savings**	**$50,690**	**3.18**	**5.8**	**34,558.0**

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 $4,738 per year, or 44.5% of the buildings' total energy costs. These measures are estimated to cost $50,690, for an overall simple payback period of 5.8 years.

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

Table 1.4: Detailed Breakdown of Energy Costs in the Building

Annual Energy Cost Estimate						
Description	**Space Heating**	**Water Heating**	**Ventilation Fans**	**Lighting**	**Other Electrical**	**Total Cost**
Existing Building	$1,879	$425	$8	$206	$8,136	**$10,654**
With Proposed Retrofits	$1,093	$425	$8	$80	$4,311	**$5,916**
Savings	$787	$0	$0	$126	$3,825	**$4,738**

2. AUDIT AND ANALYSIS BACKGROUND

2.1 Program Description

This audit included services to identify, develop, and evaluate energy efficiency measures at the Tyonek 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 and ventilation equipment
- Lighting systems and controls
- Building-specific equipment
- Water consumption, treatment (optional) & disposal

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

Details collected from Tyonek 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.

The Tyonek Water Treatment Plant has a total area of approximately 1,402 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. Tyonek Water Treatment Plant

The Tyonek Water Treatment Plant serves as the central location for all water intake, treatment, and distribution processes for the residential and public facilities in the community. The building is approximately 1,402 square feet in area and was constructed in 2011. The water treatment plant operator occupies the facility when on duty and averages approximately 10 hours per week of logged hours.

Water is collected from two groundwater wells located on the water treatment plant property. Both wells are within 300 ft. of the building. Because of chemical contaminants in the water supplies, both pumps operate constantly throughout the year. Upon entering the facility, the water is treated with chlorine and ferric chloride before it is filtered through two sand filters. After the filters the water is sent to a 212,000 gallon water storage tank for storage and water treatment contact time before it is transported through the two water distribution lines to the Lower Village and Indian Creek regions.

Figure 1: Tyonek Water Treatment Plant Well 1

Figure 2: Tyonek Water Treatment Plant Well 2

Description of Building Shell

The exterior walls are 2x6 lumber construction with spray foam insulation.

The roof of the building is 2x6 lumber construction with spray foam insulation.

The building is constructed on a gravel pad foundation and has spray foam insulation in the floor structure.

There are four total windows in the building. Each of the windows is approximately 35”x23” with an aluminum-covered frame and double-pane glass. Two of the windows are south facing and two of the windows face a different direction other than south.

There are two entrances into the building. The main entrance consists of a set of two insulated metal double-doors with half-lite windows. The chemical room entrance has a single insulated metal door with a half-lite window.

<u>Description of Heating Plants</u>

The heating plants used in the building are:

Toyo Laser 73

Fuel Type:	#1 Oil
Input Rating:	40,000 BTU/hr
Steady State Efficiency:	90 %
Idle Loss:	0 %
Heat Distribution Type:	Air

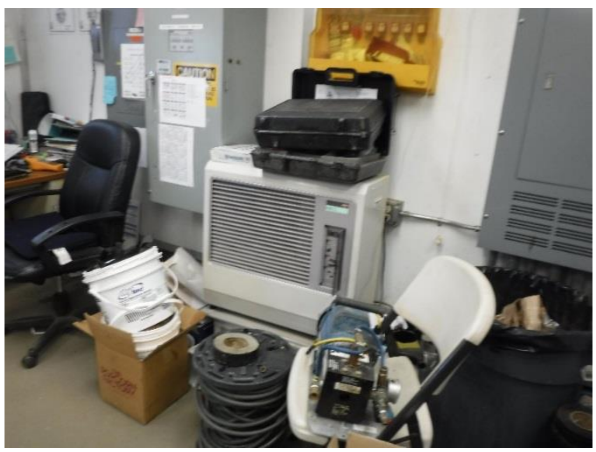


Figure 3: Toyo Stove in the Office Area

Process Room Electric Heater

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

Figure 4: Process Room Electric Heater

Chemical Room Electric Heater

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

Figure 5: Chemical Room Electric Heater

Electric Water Heater

Nameplate Information:	A.O. Smith Promax Lowboy Model #ECL-30
Fuel Type:	Electricity
Input Rating:	0 BTU/hr
Steady State Efficiency:	100 %
Idle Loss:	0 %
Heat Distribution Type:	Water

Boiler Operation:	All Year
Notes:	21 GPH Recovery @ 90 deg. rise

The Toyo stove provides 100% of the existing space heating load in the building. The stove is located in the office area and there is a plastic cover in the doorway between the office area and process room. This cover reduces the effectiveness of the heater for the building but also keeps humidity and condensation from the process equipment from entering the office.

The two electric heaters in the process room and chemical room have not been in use because the water chemicals present in the treatment process have corroded the electrical wiring and left the heaters inoperable.

There is a small hot water heater that is located in the office area that is used for the lab sink and the restroom. The hot water heater is located behind a large metal cover in the office area that is secured to the walls of the facility. Access to the hot water is limited as a result.

<u>Description of Building Ventilation System</u>

There is a ventilation fan in the process room that is used for humidity control. This is controlled automatically.

There is a ventilation fan in the chemical room that is used to ventilate exhaust chemicals from the room during occupied hours for health and safety purposes. The fan operates only when the lights in the room are triggered.

The restroom has a small exhaust fan that is only used when occupied.

<u>Lighting</u>

Table 3.1: Breakdown of Lighting by Location and Bulb Type

Location	Bulb Type	Fixtures	Bulbs per Fixture	Annual Usage (kWh)
Process Room	32 W, 4’ T8 fluorescent	12	4	670
Office	32 W, 4’ T8 fluorescent	7	4	391
Loft	32 W, 4’ T8 fluorescent	2	4	41
Chemical Room	32 W, 4’ T8 fluorescent	2	2	57
Exterior	100 W high pressure sodium	1	1	313
			Total Energy Consumption	1472

<u>Plug Loads</u>

There is a variety of tools and office equipment in the building that are used periodically by the operators for daily tasks. The use of these items is infrequent and is not included in this report.

Major Equipment

Table 3.2: Major Equipment Information for the Tyonek Water Treatment Plant

Equipment	Rating (Watts)	Annual Usage (kWh)
Well Pump 1	3,680 (7.5 HP)	23,105
Well Pump 2	4,140 (7.5 HP)	25,993
Indian Creek Pressure Pumps	375 (0.5 HP)	3,287
Lower Village Pressure Pumps	560 (0.75 HP)	2,553
Backwash Pump	2,116 (5 HP)	148
Air Scour	3,700 (5 HP)	131
High Capacity Pump	7,500 (10 HP)	720
Chlorine Pump	22	193
Ferric Chloride Pump	22	193
Dehumidifier	794	1,753
Well Heat Tape	300	41
	Total Energy Consumption	58,117

The backwash pump is used every other day to clean the sand filters. The pump runs approximately 30 minutes for every other day and was measured at 9.2 A average on a 230 V service.

Figure 6: Backwash Pump

The high supply pump is used to provide additional pumping capacity during high usage times, such as when the pipes are being cleaned or in the event of a fire. The pump run time was estimated at approximately four days per year.

Figure 7: High Capacity Pump

The Indian Creek pressure pumps provide pressure to the distribution lines in the Indian Creek region of the community. One of these pumps is in constant operation in order to maintain the desired pressure needed for adequate flow in the services. The pumps were measured at 3.6 A on a 230 V service.

Figure 8: Indian Creek Pressure Pumps

The Lower Village pressure pumps provide pressure to the distribution lines in the Lower Village region of the community. The two pumps alternate and combine to run approximately 52% of the time with 34 starts per hour in order to maintain the desired pressure needed for adequate flow in the services. The pumps were measured at 5.0 A on a 230 V service.

Figure 9: Lower Village Pressure Pumps

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 Chugach Electric Association provides electricity to the residents of the community as well as to all public facilities.

The average cost for each type of fuel used in this building is shown below in Table 3.3. This figure includes all surcharges, subsidies, and utility customer charges:

Table 3.3: Energy Cost Rates for Each Fuel Type

Average Energy Cost	
Description	**Average Energy Cost**
Electricity	$ 0.14/kWh
#1 Oil	$ 4.75/gallons

3.2.1.1 Total Energy Use and Cost Breakdown

At current rates, Native Village of Tyonek pays approximately $10,654 annually for electricity and other fuel costs for the Tyonek Water Treatment Plant.

Figure 10 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.

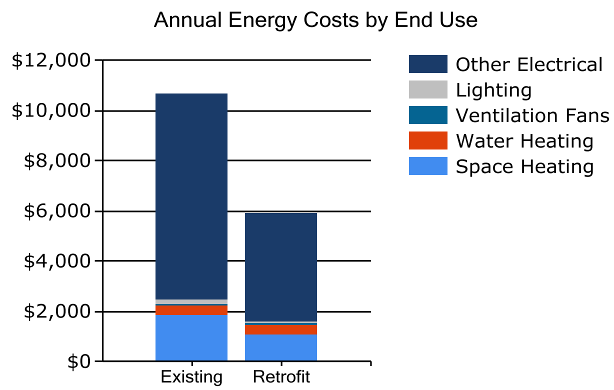


Figure 10: Annual Energy Costs by End Use

Figure 11 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.

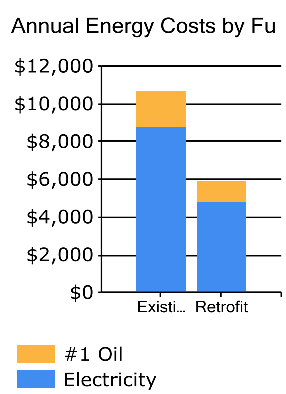
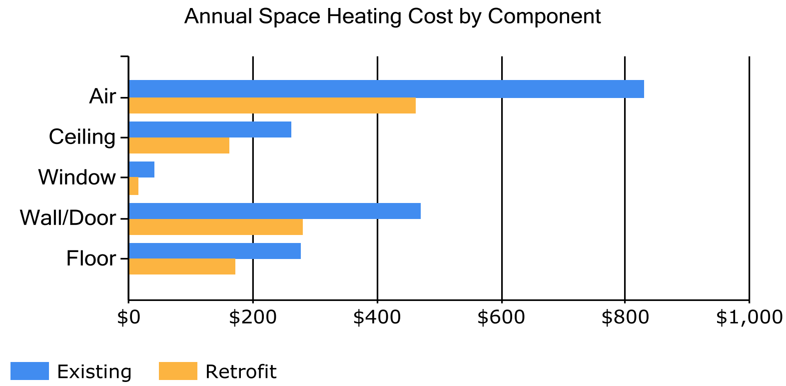


Figure 11: Annual Energy Costs by Fuel Type

Figure 12 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: Estimated Electrical Consumption by Category

Electrical Consumption (kWh)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Space Heating	13	13	11	4	2	0	0	0	1	7	12	14
DHW	258	235	258	249	258	249	258	258	249	258	249	258
Ventilation Fans	5	4	5	4	5	4	5	5	4	5	4	5
Lighting	144	131	144	139	98	95	98	98	95	144	139	144
Other Electrical	5393	4750	5213	5224	4043	4484	4814	4634	3913	5393	5044	5213

Table 3.5: Estimated Fuel Oil Consumption by Category

Fuel Oil #1 Consumption (Gallons)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Space Heating	63	67	54	23	11	0	0	0	4	38	60	73

3.2.2 Energy Use Index (EUI)

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

Energy maintains a Benchmarking Building Energy Performance Program. The ORNL website determines how a building's energy use compares with similar facilities throughout the U.S. and in a specific region or state.

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

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

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

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

Table 3.6: Building EUI Calculations for the Tyonek Water Treatment Plant

Energy Type	Building Fuel Use per Year	Site Energy Use per Year, kBTU	Source/Site Ratio	Source Energy Use per Year, kBTU
Electricity	62,756 kWh	214,187	3.340	715,385
#1 Oil	393 gallons	51,920	1.010	52,439
Total		**266,107**		**767,824**
BUILDING AREA		1,402	Square Feet	
BUILDING SITE EUI		190	kBTU/Ft²/Yr	
BUILDING SOURCE EUI		548	**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: Building Benchmarks for the Tyonek Water Treatment Plant

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

3.3 AkWarm© Building Simulation

An accurate model of the building performance can be created by simulating the thermal performance of the walls, roof, windows and floors of the building. The 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 Tyonek Water Treatment Plant was modeled using AkWarm© energy use software to establish a baseline space heating and cooling energy usage. Climate data from Tyonek 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 Tyonek. 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[1]**	**Simple Payback (Years)[2]**	**CO_2 Savings**
1	Setback Thermostat: Water Treatment Plant	Program an unoccupied setback of 50 deg. F on the Toyo stove in the office.	$1,020	$300	46.09	0.3	4,554.9
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4	Lighting: Exterior	Replace with new LED lighting.	$25	$250	1.19	9.8	199.4
5	Air Tightening	Add weather stripping around the main entrance doors.	$24	$300	0.74	12.5	106.9
6	Other Electrical: Lower Village Pressure Pumps	Repair controls so that pump has fewer starts with longer runs.	$50	$1,000	0.58	20.2	559.4
7	Lighting: Office	Replace with new LED lighting.	$20	$560	0.38	27.4	209.7
8	Lighting: Process Room	Replace with new LED lighting.	$34	$960	0.36	28.5	353.6
9	Other Electrical: Indian Creek Pressure Pumps	Increase size of the pressure pumps to a more appropriate size, allowing the pressure pumps to stop when the desired system pressure is reached and start when needed to pressurize the system.	$125	$5,000	0.28	39.9	1,537.8

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**
10	Lighting: Loft	Replace with new LED lighting.	$2	$160	0.10	93.8	20.1
11	Lighting: Chemical Room	Replace with new LED lighting.	$1	$160	0.06	148.6	12.8
	TOTAL, all measures		**$4,738 + $4,000 Maint. Savings**	**$50,690**	**3.18**	**5.8**	**34,558.0**

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. Lighting-efficiency improvements are anticipated to slightly increase heating requirements. Heating penalties were included in the lighting project analysis.

4.3 Building Shell Measures

4.3.1 Air Sealing Measures

Rank	**Location**		**Existing Air Leakage Level (cfm@50/75 Pa)**		**Recommended Air Leakage Reduction (cfm@50/75 Pa)**	
5	Main Entrance		Air Tightness estimated as: 2100 cfm at 75 Pascals		Add weather stripping around the main entrance doors.	
Installation Cost	$300		**Estimated Life of Measure (yrs)**	10	**Energy Savings ($/yr)**	$24
Breakeven Cost	$223		**Simple Payback (yrs)**	13	**Energy Savings (MMBTU/yr)**	0.7 MMBTU
			Savings-to-Investment Ratio	0.7		
Auditors Notes: Add weather stripping around the main entrance doors to prevent air leakage and to reduce the interior space heating load.						

4.4 Mechanical Equipment Measures

4.4.1 Night Setback Thermostat Measures

Rank	Building Space			Recommendation	
1	Water Treatment Plant			Program an unoccupied setback of 50 deg. F on the Toyo stove in the office..	
Installation Cost	$300	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$1,020
Breakeven Cost	$13,828	**Simple Payback (yrs)**	0	**Energy Savings (MMBTU/yr)**	28.3 MMBTU
		Savings-to-Investment Ratio	46.1		
Auditors Notes:					

4.5 Electrical & Appliance Measures

4.5.1 Lighting Measures

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

4.5.1a Lighting Measures – Replace Existing Fixtures/Bulbs

Rank	Location	Existing Condition		Recommendation	
4	Exterior	HPS 100 Watt StdElectronic		Replace with new LED lighting.	
Installation Cost	$250	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$25
Breakeven Cost	$298	**Simple Payback (yrs)**	10	**Energy Savings (MMBTU/yr)**	0.6 MMBTU
		Savings-to-Investment Ratio	1.2		
Auditors Notes: There is a single light bulb to be replaced with an LED outdoor wall pack that Is rated for 40 Watts.					

Rank	Location	Existing Condition		Recommendation	
7	Office	7 FLUOR (4) T8 4' F32T8 32W Standard Instant StdElectronic		Replace with new LED lighting.	
Installation Cost	$560	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$20
Breakeven Cost	$214	**Simple Payback (yrs)**	27	**Energy Savings (MMBTU/yr)**	0.4 MMBTU
		Savings-to-Investment Ratio	0.4		
Auditors Notes: There are seven fixtures with four T8 4ft. fluorescent light bulbs in each fixture. Replace these light bulbs with two 18 Watt LED equivalent light bulbs for a total of 14 new light bulbs.					

Rank	Location	Existing Condition		Recommendation	
8	Process Room	12 FLUOR (4) T8 4' F32T8 32W Standard Instant StdElectronic		Replace with new LED lighting.	
Installation Cost	$960	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$34
Breakeven Cost	$348	**Simple Payback (yrs)**	29	**Energy Savings (MMBTU/yr)**	0.7 MMBTU
		Savings-to-Investment Ratio	0.4		
Auditors Notes: There are 12 fixtures with four T8 4ft. fluorescent light bulbs in each fixture. Replace these light bulbs with two 18 Watt LED equivalent light bulbs for a total of 24 new light bulbs.					

Rank	Location		Existing Condition		Recommendation	
10	Loft		2 FLUOR (4) T8 4' F32T8 32W Standard Instant StdElectronic		Replace with new LED lighting.	
Installation Cost		$160	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$2
Breakeven Cost		$16	**Simple Payback (yrs)**	94	**Energy Savings (MMBTU/yr)**	0.0 MMBTU
			Savings-to-Investment Ratio	0.1		
Auditors Notes: There are two fixtures with four T8 4ft. fluorescent light bulbs in each fixture. Replace these light bulbs with two 18 Watt LED equivalent light bulbs for a total of four new light bulbs.						

Rank	Location		Existing Condition		Recommendation	
11	Chemical Room		2 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic		Replace with new LED lighting.	
Installation Cost		$160	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$1
Breakeven Cost		$10	**Simple Payback (yrs)**	149	**Energy Savings (MMBTU/yr)**	0.0 MMBTU
			Savings-to-Investment Ratio	0.1		
Auditors Notes: There are two fixtures with two T8 4ft. fluorescent light bulbs in each fixture. Replace these light bulbs with two 18 Watt LED equivalent light bulbs for a total of four new light bulbs.						

4.5.2 Other Electrical Measures

Rank	Location		Description of Existing		Efficiency Recommendation	
2	Well Pump 2		Well Pump		Repair leaks and reduce water usage.	
Installation Cost		$21,000	**Estimated Life of Measure (yrs)**	30	**Energy Savings ($/yr)**	$1,819
Breakeven Cost		$74,158	**Simple Payback (yrs)**	5	**Energy Savings (MMBTU/yr)**	44.4 MMBTU
			Savings-to-Investment Ratio	3.5	**Maintenance Savings ($/yr)**	$2,000
Auditors Notes: Repair leaks and reduce water usage from current 280 gpppd to optimal level of 100 gpppd. This will reduce electric pumping costs and ferric chloride costs (water treatment). All maintenance savings based on reduction of chemical costs for water treatment. 70 houses*$500 labor per house*$100 parts per house /2 (split with other well pump retrofit) = $21,000						

Rank	Location		Description of Existing		Efficiency Recommendation	
3	Well Pump 1		Well Pump with Manual Switching		Improve Manual Switching	
Installation Cost		$21,000	**Estimated Life of Measure (yrs)**	30	**Energy Savings ($/yr)**	$1,617
Breakeven Cost		$70,274	**Simple Payback (yrs)**	6	**Energy Savings (MMBTU/yr)**	39.4 MMBTU
			Savings-to-Investment Ratio	3.3	**Maintenance Savings ($/yr)**	$2,000
Auditors Notes: Repair leaks and reduce water usage from current 280 gpppd to optimal level of 100 gpppd. This will reduce electric pumping costs and ferric chloride costs (water treatment). All maintenance savings based on reduction of chemical costs for water treatment. 70 houses*$500 labor per house*$100 parts per house /2 (split with other well pump retrofit) = $21,000						

Rank	Location	Description of Existing		Efficiency Recommendation	
6	Lower Village Pressure Pumps	Pressure Pumps		Repair controls so that pump has fewer starts with longer runs.	
Installation Cost	$1,000	**Estimated Life of Measure (yrs)**	20	**Energy Savings ($/yr)**	$50
Breakeven Cost	$585	**Simple Payback (yrs)**	20	**Energy Savings (MMBTU/yr)**	1.0 MMBTU
		Savings-to-Investment Ratio	0.6		
Auditors Notes: Repair controls so that pump has fewer starts with longer runs. Prevents wear and tear from numerous starts and stops, increases runtime in efficient settings, assume an average power reduction of 25% based on assumptions from the affinity laws					

Rank	Location	Description of Existing		Efficiency Recommendation	
9	Indian Creek Pressure Pumps	Pressure Pumps		Increase size of the pressure pumps to a more appropriate size.	
Installation Cost	$5,000	**Estimated Life of Measure (yrs)**	20	**Energy Savings ($/yr)**	$125
Breakeven Cost	$1,376	**Simple Payback (yrs)**	40	**Energy Savings (MMBTU/yr)**	2.5 MMBTU
		Savings-to-Investment Ratio	0.3		
Auditors Notes: Increase size of the pressure pumps to a more appropriate size, allowing the pressurre pumps to stop when the desired system pressure is reached and start when needed to pressurize the system.					

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 Native Village of Tyonek to follow up on the recommendations made in this report.

APPENDICES

Appendix A –Energy Billing Data

The table below shows the fuel and electricity data used during the energy modeling process to confirm the accuracy of the energy distribution.

Month	Fuel Oil Use (gallons)	Electricity Use (kWh)
January	48	5,520
February	66	4,480
March	45	5,400
April	30	4,600
May	10	4,800
June	18	4,800
July	25	5,040
August	10	4,680
September	19	4,680
October	30	3,720
November	45	4,280
December	66	6,440

Appendix B – Energy Audit Report – Project Summary

ENERGY AUDIT REPORT – PROJECT SUMMARY	
General Project Information	
PROJECT INFORMATION	**AUDITOR INFORMATION**
Building: Tyonek Water Treatment Plant	**Auditor Company:** ANTHC-DEHE
Address: P.O. Box 82009	**Auditor Name:** Kevin Ulrich and Kelli Whelan
City: Tyonek	**Auditor Address:** 4500 Diplomacy Dr. Anchorage, AK 99508
Client Name: Sam Bartels	
Client Address: P.O. Box 82009 Tyonek, AK 82009	**Auditor Phone:** (907) 729-3237
	Auditor FAX:
Client Phone: (907) 602-0665	**Auditor Comment:**
Client FAX:	
Design Data	
Building Area: 1,402 square feet	**Design Space Heating Load:** Design Loss at Space: 49,690 Btu/hour with Distribution Losses: 49,690 Btu/hour Plant Input Rating assuming 82.0% Plant Efficiency and 25% Safety Margin: 75,747 Btu/hour Note: Additional Capacity should be added for DHW and other plant loads, if served.
Typical Occupancy: 0 people	**Design Indoor Temperature:** 65 deg F (building average)
Actual City: Tyonek	**Design Outdoor Temperature:** -1.2 deg F
Weather/Fuel City: Tyonek	**Heating Degree Days:** 9,722 deg F-days
Utility Information	
Electric Utility: Chugach Electric	**Average Annual Cost/kWh:** $0.14/kWh

Annual Energy Cost Estimate

Description	Space Heating	Water Heating	Ventilation Fans	Lighting	Other Electrical	Total Cost
Existing Building	$1,879	$425	$8	$206	$8,136	**$10,654**
With Proposed Retrofits	$1,093	$425	$8	$80	$4,311	**$5,916**
Savings	$787	$0	$0	$126	$3,825	**$4,738**

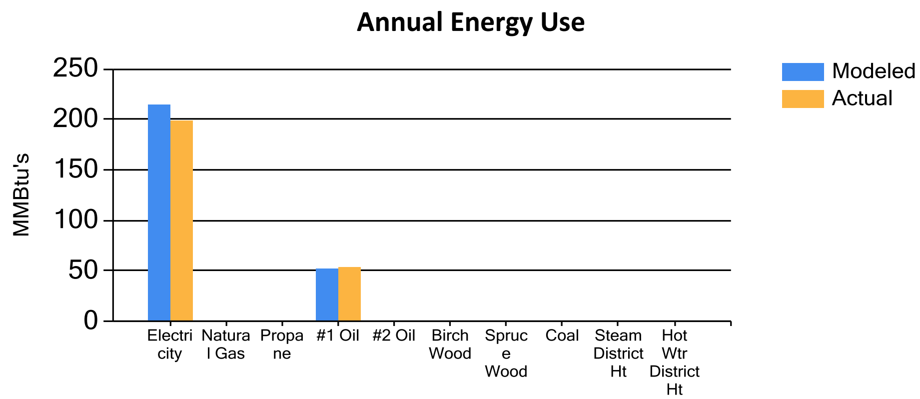
Building Benchmarks

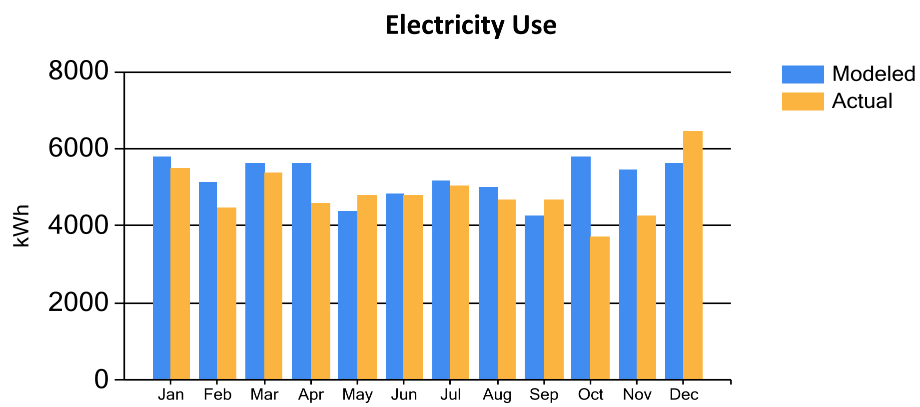
Description	EUI (kBtu/Sq.Ft.)	EUI/HDD (Btu/Sq.Ft./HDD)	ECI ($/Sq.Ft.)
Existing Building	189.9	19.53	$7.60
With Proposed Retrofits	105.6	10.86	$4.22

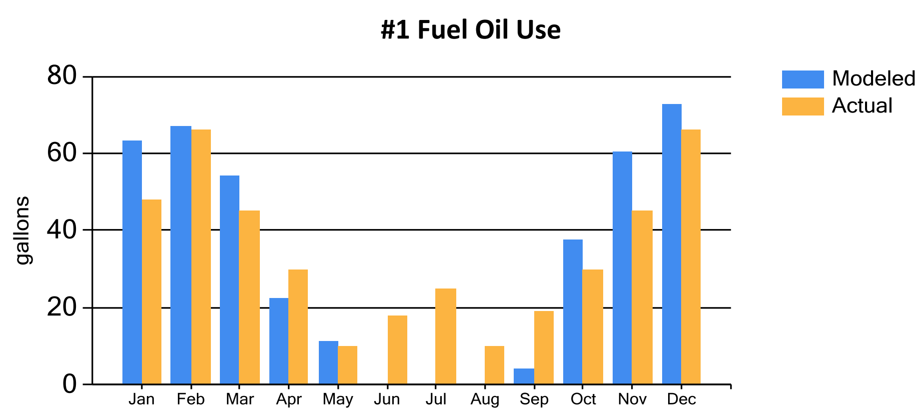
EUI: Energy Use Intensity - The annual site energy consumption divided by the structure's conditioned area.
EUI/HDD: Energy Use Intensity per Heating Degree Day.
ECI: Energy Cost Index - The total annual cost of energy divided by the square footage of the conditioned space in the building.

Appendix C – 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.







Appendix D - Electrical Demands

Estimated Peak Electrical Demand (kW)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Current	16.8	16.1	15.6	15.4	14.7	15.0	14.8	14.1	12.9	12.7	12.0	11.5
As Proposed	12.0	11.3	10.8	10.6	9.9	10.2	10.0	9.3	8.0	7.8	7.1	6.6

AkWarmCalc Ver 2.7.1.0, Energy Lib 3/3/2017