Comprehensive Energy Audit
For
Kwigillingok Water Treatment Plant

Prepared For

Native Village of Kwigillingok

August 24, 2016

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PREFACE

This energy audit was conducted using funds provided by the United States Department of Agriculture as part of the Rural Alaskan Village Grant (RAVG) program. Coordination with the Native Village of Kwigillingok 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 Kwigillingok, Alaska. The authors of this report are Bailey Gamble, Mechanical Engineer I; and Kevin Ulrich, Assistant Engineering Project Manager and Energy Manager in Training (EMIT).

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 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 Energy Projects Group gratefully acknowledges the assistance of Water Treatment Plant Operator John Carter, Native Village of Kwigillingok Tribal Administrator Andrew Beaver and Tribal Finance Officer Richard John, and Kwig Power Company representative Diane Atti.

1. EXECUTIVE SUMMARY

This report was prepared for the Native Village of Kwigillingok. The scope of the audit focused on Kwigillingok 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, heating and ventilation 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 $63,070 per year. Electricity represents the largest portion with an annual cost of approximately $60,677. This includes about $36,225 paid by the village and about $24,452 paid by the Power Cost Equalization (PCE) program through the State of Alaska. Fuel represents the remaining portion, with an annual cost of approximately $2,390. Recovered heat from the Kwig Power Company (KPC) power plant contributes to the heating demand in the plant as well and is currently provided free of charge.

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 Kwigillingok, the cost of electricity without PCE is $0.67/kWh and the cost of electricity with PCE is $0.40/kWh.

There is a heat recovery system that supplies recovered heat from the power plant to meet the majority of the heating demand in the Water Treatment Plant.

An energy audit report was also developed for the Kwigillingok Washeteria. This report compliments the Water Treatment Plant energy audit. This report will be distributed separately from the Kwigillingok Water Treatment Plant report.

Table 1.1 lists the total usage of electricity, #1 heating oil, and recovered heat in the Kwigillingok Water Treatment Plant before and after the proposed retrofits.

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

Predicted Annual Fuel Use		
Fuel Use	**Existing Building**	**With Proposed Retrofits**
Electricity	90,562 kWh	25,380 kWh
#1 Oil	514 gallons	318 gallons
Recovered Heat	311.84 million Btu	430.84 million Btu

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 Water Treatment Plant

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	333.5	25.68	$30.54
With Proposed Retrofits	270.9	20.86	$8.95
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 Kwigillingok 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	Other Electrical - Controls Retrofit: WTP - Clinic Sewer Heat Tape	Install switch with clear on/off indicator, use heat tape only for freeze-up recovery.	$3,671	$500	45.45	0.1	19,175.6
2	Other Electrical - Controls Retrofit: Pump House - Raw Water Heat Tape	Install switch with clear on/off indicator, use heat tape only for freeze-up recovery.	$3,166	$500	39.19	0.2	16,536.8
3	Other Electrical - Controls Retrofit: WTP - New Laundry Heat Tape	Install switch with clear on/off indicator, use heat tape only for freeze-up recovery.	$2,600	$500	32.19	0.2	13,582.9
4	Other Loads - Water Storage Tank Heat Add Load	Two circ pumps were running in parallel. Pumps should be alternated with only one running at a time.	$903	$500	21.22	0.6	4,691.3
5	Other Electrical - Controls Retrofit: Heat Recovery Circulation Pump	Replace Goldline on heat recovery with Tekmar 156 diff setpoint controller, reprogram so that pump only runs when there is a demand for heat in the Water Treatment Plant.	$2,003	$1,000	12.40	0.5	9,941.4

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
6	Lighting - Combined Retrofit: Main Process Room Lights	Replace with new energy-efficient LED lighting, replace manual switching with occupancy sensor.	$1,415	$1,500	11.07	1.1	6,972.7
7	Other Electrical - Controls Retrofit: Raw Water Heat Tape Section 1, 2 & 3	Install switches with clear on/off indicators, use heat tapes only for freeze-up recovery.	$28,621 + $8,000 Maint. Savings	$40,000	10.79	1.1	149,515.2
8	Other Electrical - Controls Retrofit: WTP - Old Laundry Heat Tape	Install switch with clear on/off indicator, use heat tape only for freeze-up recovery.	$857	$500	10.60	0.6	4,474.4
9	Lighting - Power Retrofit: Loading Door Light	Replace with new energy-efficient LED lighting.	$93	$150	7.32	1.6	488.1
10	Lighting - Combined Retrofit: Boiler Room Lights	Replace with new energy-efficient LED lighting, replace manual switching with occupancy sensor.	$608	$980	7.28	1.6	2,992.9
11	Other Electrical - Controls Retrofit: Old WTP Electric Space Heater	Build smaller plywood box around connection point, install thermostat to run heater only at temps below 36 deg F.	$833	$3,000	3.26	3.6	4,351.6
12	Heating Ventilation, and Domestic Hot Water (DHW)	Reprogram Tekmar boiler controller, clean boilers, replace hi-low limit controls, clean up wiring on boilers, relocate waste heat sensor to return line, insulate, reposition circ pump.	$1,099 + $200 Maint. Savings	$4,400	2.71	3.4	4,934.6
13	Lighting - Combined Retrofit: Office Light	Replace with new energy-efficient LED lighting.	$12	$80	1.73	6.8	58.1
14	Lighting - Combined Retrofit: Bathroom Light	Replace with new energy-efficient LED lighting.	$6	$40	1.73	6.8	29.0

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
15	Setback Thermostat: Kwigillingok	Implement a heating setback of 60 deg F in the Water Treatment Plant during unoccupied hours.	$281	$2,400	1.39	8.5	3,213.0
16	Other Electrical - Controls Retrofit: WST Connection Heat Tapes	Replace with single heat tape, control using thermostat so that heat tape only runs at temps below 36 deg F.	$89	$1,000	1.04	11.3	464.1
17	Lighting - Combined Retrofit: Bathroom Sink Light	Replace with new energy-efficient LED lighting.	$2	$40	0.72	16.3	12.1
18	Air Tightening	Perform air sealing to reduce air leakage by 5%.	$39	$500	0.66	12.8	453.8
19	Lighting - Combined Retrofit: Counter Space Lights	Replace with new energy-efficient LED lighting.	$4	$120	0.36	32.6	18.2
20	Lighting - Combined Retrofit: Chemical Room Lights	Replace with new energy-efficient LED lighting.	$2	$160	0.13	88.9	8.9
21	Other - Generic Load	Replace both circ pumps (one is broken) with Magnas, install flow meter, flow sensor to better control circulation rates, move soda ash injector to avoid clogging heat exchanger, clean heat exchanger. Necessary to realize savings from changes in raw water heat tape controls.	-$1,798 + $350 Maint. Savings	$9,700	-1.79	999.9	-16,891.2
	TOTAL, all measures		**$44,506 + $8,550 Maint. Savings**	**$67,570**	**8.18**	**1.3**	**225,023.5**

Table Notes:

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

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

With all of these energy efficiency measures in place, the annual utility cost can be reduced by $44,552 per year, or 70.3% of the buildings' total energy costs. These measures are estimated to cost $67,570, for an overall simple payback period of 1.3 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**	**Raw Water Heat Add**	**Tank Heat**	**Total Cost**
Existing Building	$1,279	$209	$104	$4,182	$53,309	$230	$3,756	**$63,070**
With Proposed Retrofits	$1,163	$169	$104	$1,906	$11,376	$2,215	$1,553	**$18,487**
Savings	$116	$40	$0	$2,276	$41,933	-$1,985	$2,203	**$44,583**

2. AUDIT AND ANALYSIS BACKGROUND

2.1 Program Description

This audit included services to identify, develop, and evaluate energy efficiency measures at the Kwigillingok 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 treatment

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 Kwigillingok 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.

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

1) Kwigillingok: 2,065 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. KWIGILLINGOK WATER TREATMENT PLANT

3.1. Building Description

The 2,065 square foot Kwigillingok Water Treatment Plant was constructed in 2010, with a normal occupancy of 1 person. The number of hours of operation for this building average 6 hours per day, considering all seven days of the week. The Kwigillingok Water Treatment Plant serves as the watering point from which residents or the operator may collect treated water to deliver to homes.

Raw water is pumped for approximately one 8 hour period every 1-2 months from a man-made reservoir 2600 feet north from the plant. There is a pump house beside the reservoir that supplies power from the Water Treatment Plant to the intake pump and two sections of heat tape.

The water is pumped through 3300 feet of 4" HDPE above ground, insulated arctic pipe to the Water Treatment Plant. After entering the Water Treatment Plant, if heating is needed, the raw water is heated to 40 degrees F. The raw water is then injected with Soda Ash to raise the pH level.

After Soda Ash injection, the majority of the water continues on through the plant for additional treatment while a small portion is heated to 52.5 degrees F and circulated back to the pump house where it is injected back into the main raw water transmission line. There is currently a major leak in one of these lines that prevents the circulation of heated water. Since this method of heating the raw water cannot currently be used, 3300 feet of heat tape are run for the duration of the winter heating season to prevent freeze-ups in the raw water transmission line.

The water that continues on for further treatment is then injected with potassium permanganate which causes the oxidation of dissolved iron and manganese. Next, it is injected with dilute polymer to cause contaminants to bond together for easier removal. The water is filtered through two greensand filters operating in parallel then injected with a calcium hypochlorite solution for disinfection before being stored in the 212,000 gallon storage tank or passed through pressure pumps for distribution to a haul-vehicle watering point, the washeteria or the clinic.

Figure 1: Aerial view of reservoir, transmission line, water treatment plant and water storage tank

Figure 2: Main room in Kwigillingok Water Treatment Plant

Description of Building Shell

The exterior walls of the water treatment plant are constructed with single stud 2x6 lumber construction with a 16-inch offset. The walls have approximately 5.5 inches polyurethane panel insulation in good condition. There is approximately 2,125 square feet of wall space in the WTP.

The WTP has a cathedral ceiling with 2x6 lumber construction. The roof has standard framing and a 24-inch offset. The ceiling has approximately 5.5 inches of insulated polyurethane panels with minimal damage. There is approximately 2,177 square feet of roof space in the building.

The WTP is built on pilings with the floor constructed of 2x10 joists with a 16-inch offset. The floor is insulated with about 5.5 inch polyurethane panels in good condition. There is approximately 2,065 square feet of floor space in the building.

The building has three total windows, each of which has triple-pane glass and measurements of approximately 4’ x 3’. There are two North facing windows, one in the office and one in the chemical room, and one East facing window in the boiler room.

There are insulated metal doors on the front (West) and back (East) side of the main room of the WTP. The doors are in need of weather stripping along the bottom. The front entrance door measures 3’ x 6’8”. The front loading doors are a double set measuring 8’ x 6’8” and the back door is a single door measuring 3’ x 6’8”.

Description of Heating Plants

The Heating Plants used in the building are:

Boiler 1

Nameplate Information:	Weil McLain Model 80
Fuel Type:	#1 Oil
Input Rating:	344,000 BTU/hr
Steady State Efficiency:	78 %
Idle Loss:	1.5 %
Heat Distribution Type:	Glycol
Boiler Operation:	Oct – May
Fire Rate:	3.4 gallons/hour

Boiler 2

Nameplate Information:	Weil McLain Model 80
Fuel Type:	#1 Oil
Input Rating:	344,000 BTU/hr
Steady State Efficiency:	78 %
Idle Loss:	1.5 %
Heat Distribution Type:	Glycol
Boiler Operation:	Oct – May
Fire Rate:	3.4 gallons/hour

Heat Recovery

Fuel Type:	Recovered heat from KPC power plant
Input Rating:	180,000 BTU/hr
Steady State Efficiency:	99 %
Idle Loss:	0 %
Heat Distribution Type:	Glycol
Boiler Operation:	All Year

The demand for heat in the water treatment plant is seasonal and includes space heating, two raw water heat adds and the water storage tank heat add loads. Heat is delivered by a hydronic system. At present, the majority of the demand is met by recovered heat supplied by the Kwig Power Company power plant. Two Weil McLain Model 80 boilers serve to meet the demand for heat beyond what the heat recovery system is able to supply. Each boiler has its own circulating pump to circulate glycol through.

Figure 3: Heating plants in Kwigillingok Water Treatment Plant

Space Heating Distribution Systems

Space heating is provided by a hydronic loop. The glycol in the hydronic loop is circulated by a Grundfos Magna 3 circulating pump that varies flow rate with heating demand. The heat is distributed through baseboard heaters and four unit heaters. There is one 1/50 HP unit heater in the boiler room and three 1/20 HP unit heaters in the main room of the water treatment plant.

An electric space heater provides heat to a small room in the old water treatment plant where the pipeline enters the water storage tank.

Domestic Hot Water System

Hot water for the bathroom sink is heated by a semi-on-demand oil fired water heater with a 5 gallon heat exchanger.

Heat Recovery Information

The majority of the heating demand in the water treatment plant is met by recovered heat supplied by the Kwig Power Company power plant. A heated glycol loop from the power plant transfers recovered heat to the main water treatment plant glycol loop through the heat exchanger shown in Figure 2.

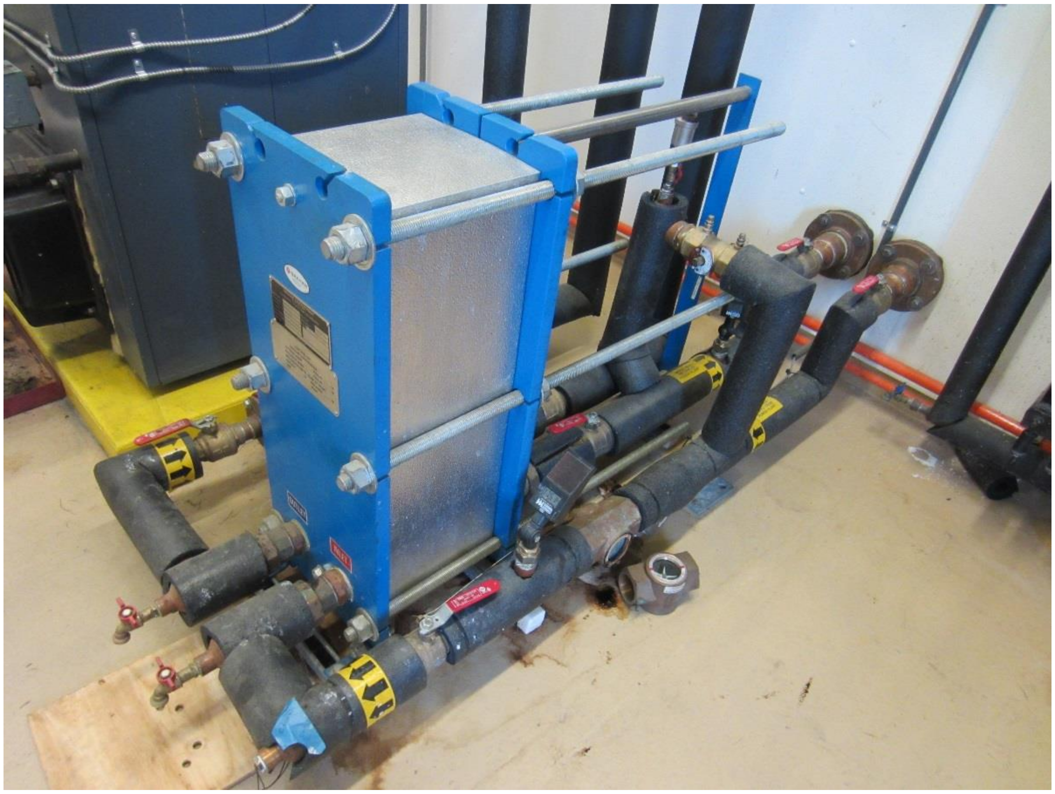

Figure 4: Heat recovery system heat exchanger in water treatment plant.

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

The existing building ventilation system consists of an air handling unit in the main room meant to provide humidity control, a boiler room cooling fan that prevents the temperature in the boiler room from exceeding 85 degrees F, a chemical room exhaust fan and a bathroom exhaust fan.

<u>Lighting</u>

There are a total of 44 light fixtures containing 85 bulbs in the washeteria. The majority of fixtures contain 4’ T8 fluorescent bulbs. Table 3.1 shows a breakdown of lighting by bulb type.

Table 3.1: Breakdown of Lighting by Bulb Type

Type of bulb	Total Number of Bulbs	Location(s)
4’ T8 fluorescent	74	Main room, boiler room, bathroom, entry way, office, chemical room
2’ T8 fluorescent	8	Counter area, bathroom
70 W metal halide	1	Exterior
100 W metal halide	2	Exterior
40 W high pressure sodium	1	Exterior

Lighting in the in the washeteria consumes approximately 6,244 kWh annually constituting about 7% of the building's current electrical consumption.

Plug Loads

The water treatment plant has a variety of electronics including a computer, monitor and printer that require a plug into an electrical outlet. The use of these items consumes about 1,315 kWh annually.

Major Equipment

Table 3.2 contains the details on each of the major electricity consuming mechanical components found in the washeteria. Major equipment consumes approximately 11,265 kWh annually constituting about 12% of the building's current electrical consumption.

Table 3.2: Major Equipment List

Major Pumps + Motors	Purpose	Motor Size	Operating Schedule	Annual Energy Consumption (kWh)
Intake Pump	Transmit water from reservoir to water treatment plant	1.5 HP	~ 24 hours per month	361
Circ Pump – Raw Water Circ Line x 2	Circulate heated water back to pump house, inject into raw water line	0.84 HP	*not currently in use due to leak in raw water transmission line	0
Circ Pump – Heat Recovery	Circulate heated glycol from power plant through water treatment plant heat exchanger	1 HP	always on	6,312
Circ Pump – Water Storage Tank x 2	Circulate water between storage tank and water treatment plant	0.65 HP	2 running in parallel all the time	2,707
Circ Pump – Washeteria	Circulate water in line between washeteria, clinic and water treatment plant	0.33 HP	always on during winter	1,354
Injection Pump - Polymer	Inject polymer into water for coagulation	0.42 HP	while pumping, ~ 24 hours per month	49
Injection Pump - Chemicals x 3	Inject soda ash, potassium permanganate and calcium hypochlorite	0.06 HP	while pumping, ~ 24 hours per month	41

Pressure Pump x 2	Pressurize water headed to clinic and washeteria	1.42 HP	~ 3% of the time (measured)	278
Fuel Pump	Supply fuel to the boilers	0.33 HP	~ 20% of the time while heating	13
Holding Tank Pump	Send sewage from water treatment plant bathroom to sewer line.	1.45 HP	~ 5% of water treatment plant operating hours	119
Air Scour Motor	Blow air into sand filters to increase effectiveness of backwash	5 HP	after pumping raw water, ~ 15 minutes per month	12
Sand Filter Backwash Pump	Flush accumulated organics out of filters	3 HP	after pumping raw water, ~ 30 minutes per month	12
Mixer - Polymer	Mix dilute polymer solution	0.83 HP	while mixing chemical, ~ 2 hours per month	5
Mixer - Chemical x 3	Mix dilute chemical solutions	0.03 HP	while mixing chemical, ~ 2 hours per month	2
			Total Energy Consumption	11,265

Heat Tape

There are eight heat tapes associated with the water treatment plant that currently run all winter long. Table 3.3 lists details for each segment. All heat tapes combined consume approximately 63,489 kWh annually constituting about 70% of the building's electrical consumption.

Table 3.3: Heat Tapes Associated with the Water Treatment Plant

Heat Tape Location	Length (ft)	Annual Energy Consumption
WTP-Watering Point	15	361
WTP-Old Laundry	60	1,346
WTP-Washeteria	230	4,085
WTP-Clinic, Sewer	360	5,767
Pump House-Intake	100	1,658
Pump House-Raw Water	300	4,973
WST Connection	10	332
Raw Water Transmission Line	1000 x 3	44,967
	Total Energy Consumption	63,489

There is a total of 3400 feet of heat tape that runs along the intake and raw water transmission line from the source to the water treatment plant. The heat tape along the transmission line alone consumes 51,598 kWh annually, 57% of the building's electrical consumption. This section of the pipeline was designed to be protected from freezing by heated water circulating back to the pump house and injected into the raw water line. One major and several minor leaks prevent the operator from heating the line in the intended manner. To compensate for the inability to circulate heated water along the raw water transmission line, the heat tape is run all winter long. Fixing the leaks on this line and enabling the system to be run as designed could lead to savings of nearly $35,000 annually on electricity.

Figure 5: Water flowing from a leak in the raw water transmission line.

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 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 Kwig Power Company (KPC) is the electric utility and runs the power plant in the Native Village of Kwigillingok. The utility provides electricity to the residents of Kwigillingok 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 3.3. This figure includes all surcharges, subsidies, and utility customer charges:

Table 3.4: Energy Rates by Fuel Type in Kwigillingok

Average Energy Cost	
Description	**Average Energy Cost**
Electricity	$ 0.67/kWh
#1 Oil	$ 4.65/gallons
Recovered Heat	$ 0.00/million Btu

3.2.1.1 Total Energy Use and Cost Breakdown

At current rates, the Native Village of Kwigillingok pays approximately $63,070 annually for electricity and other fuel costs for the Kwigillingok Water Treatment Plant.

Figure 6 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.

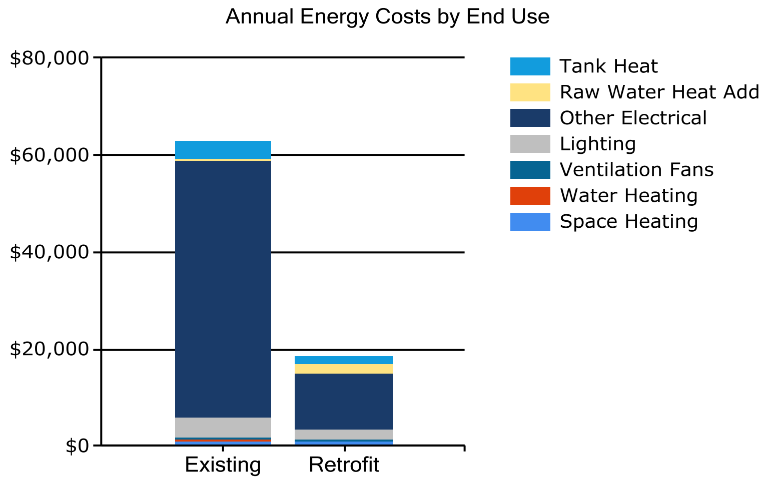

Figure 6: Annual Energy Costs by End Use.

Figure 7 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.

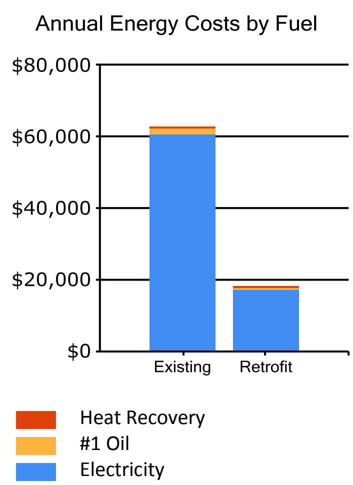

Figure 7: Annual Energy Costs by Fuel Type.

Figure 8 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.

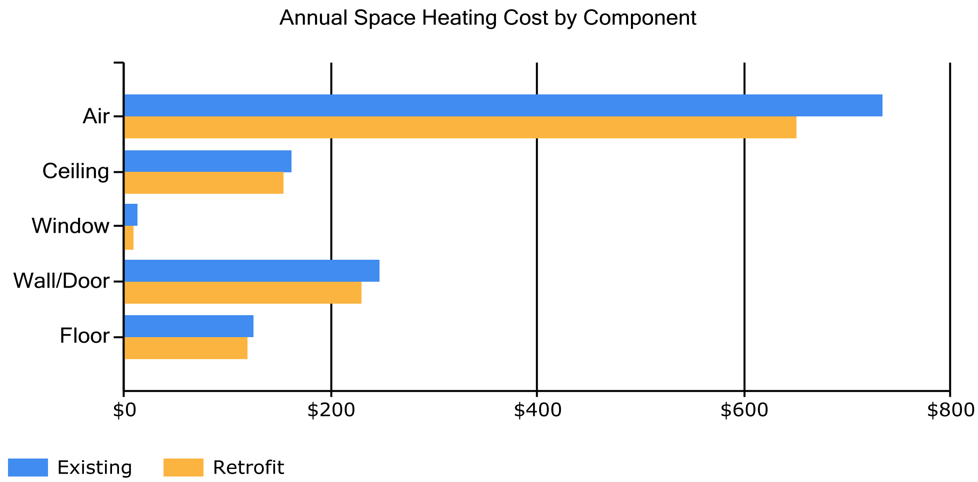

Figure 8: Annual Space Heating Cost by Component.

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

Table 3.5: Electrical Consumption Records by Category

Electrical Consumption (kWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space Heating	310	280	260	165	71	24	11	19	55	143	218	314
Ventilation Fans	14	13	14	14	8	7	8	8	7	21	20	21
Lighting	547	498	547	529	509	489	505	505	489	547	529	547
Other Electrical	9304	8479	9304	8312	6693	5378	3061	721	698	9306	9005	9306
Raw Water Heat Add	0	0	0	0	0	0	0	0	0	0	0	0
Tank Heat	368	335	367	354	212	0	0	0	0	365	355	368

Table 3.6: Fuel Oil Consumption Records by Category

Fuel Oil #1 Consumption (Gallons)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space Heating	0	0	0	0	2	1	0	1	2	0	0	0
DHW	4	3	4	4	4	4	4	4	4	4	4	4
Raw Water Heat Add	7	6	7	7	0	0	0	0	0	8	7	7
~~Tank_Heat~~Tank Heat	64	58	62	55	0	0	0	0	0	54	57	64

Table 3.7: Recovered Heat Consumption Records by Category

Recovered Heat Consumption (Million Btu)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space Heating	24	22	20	13	5	2	1	1	4	11	17	24
Raw Water Heat Add	3	3	3	2	0	0	0	0	0	1	2	3
Tank Heat	30	26	25	13	0	0	0	0	0	8	18	30

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 3.8 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 3.8: Kwigillingok 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	90,562 kWh	309,089	3.340	1,032,356
#1 Oil	514 gallons	67,843	1.010	68,522
Recovered Heat	311.84 million Btu	311,841	1.280	399,156
Total		**688,773**		**1,500,033**
BUILDING AREA		2,065	Square Feet	
BUILDING SITE EUI		334	kBTU/Ft²/Yr	
BUILDING SOURCE EUI		726	**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 3.9: Kwigillingok Washeteria Building Benchmarks

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	333.5	25.68	$30.54
With Proposed Retrofits	270.9	20.86	$8.95
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 Kwigillingok Water Treatment Plant was modeled using AkWarm© energy use software to establish a baseline space heating and cooling energy usage. Climate data from Kwigillingok 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 Kwigillingok. This data represents the average ambient weather profile as observed over approximately 30 years. As such, the 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.

Table 4.1: 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	Other Electrical - Controls Retrofit: WTP - Clinic Sewer Heat Tape	Install switch with clear on/off indicator, use heat tape only for freeze-up recovery.	$3,671	$500	45.45	0.1	19,175.6
2	Other Electrical - Controls Retrofit: Pump House - Raw Water Heat Tape	Install switch with clear on/off indicator, use heat tape only for freeze-up recovery.	$3,166	$500	39.19	0.2	16,536.8
3	Other Electrical - Controls Retrofit: WTP - New Laundry Heat Tape	Install switch with clear on/off indicator, use heat tape only for freeze-up recovery.	$2,600	$500	32.19	0.2	13,582.9
4	Other Loads - Water Storage Tank Heat Add Load	Two circ pumps were running in parallel. Pumps should be alternated with only one running at a time.	$903	$500	21.22	0.6	4,691.3
5	Other Electrical - Controls Retrofit: Heat Recovery Circulation Pump	Replace Goldline on heat recovery with Tekmar 156 diff setpoint controller, reprogram so that pump only runs when there is a demand for heat in the Water Treatment Plant.	$2,003	$1,000	12.40	0.5	9,941.4
6	Lighting - Combined Retrofit: Main Process Room Lights	Replace with new energy-efficient LED lighting, replace manual switching with occupancy sensor.	$1,415	$1,500	11.07	1.1	6,972.7
7	Other Electrical - Controls Retrofit: Raw Water Heat Tape Section 1, 2 & 3	Install switches with clear on/off indicators, use heat tapes only for freeze-up recovery.	$28,621 + $8,000 Maint. Savings	$40,000	10.79	1.1	149,515.2

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	Other Electrical - Controls Retrofit: WTP - Old Laundry Heat Tape	Install switch with clear on/off indicator, use heat tape only for freeze-up recovery.	$857	$500	10.60	0.6	4,474.4
9	Lighting - Power Retrofit: Loading Door Light	Replace with new energy-efficient LED lighting.	$93	$150	7.32	1.6	488.1
10	Lighting - Combined Retrofit: Boiler Room Lights	Replace with new energy-efficient LED lighting, replace manual switching with occupancy sensor.	$608	$980	7.28	1.6	2,992.9
11	Other Electrical - Controls Retrofit: Old WTP Electric Space Heater	Build smaller plywood box around connection point, install thermostat to run heater only at temps below 36 deg F.	$833	$3,000	3.26	3.6	4,351.6
12	Heating Ventilation, and Domestic Hot Water (DHW)	Reprogram Tekmar boiler controller, clean boilers, replace hi-low limit controls, clean up wiring on boilers, relocate waste heat sensor to return line, insulate, reposition circ pump.	$1,099 + $200 Maint. Savings	$4,400	2.71	3.4	4,934.6
13	Lighting - Combined Retrofit: Office Light	Replace with new energy-efficient LED lighting.	$12	$80	1.73	6.8	58.1
14	Lighting - Combined Retrofit: Bathroom Light	Replace with new energy-efficient LED lighting.	$6	$40	1.73	6.8	29.0
15	Setback Thermostat: Kwigillingok	Implement a heating setback of 60 deg F in the Water Treatment Plant during unoccupied hours.	$281	$2,400	1.39	8.5	3,213.0
16	Other Electrical - Controls Retrofit: WST Connection Heat Tapes	Replace with single heat tape, control using thermostat so that heat tape only runs at temps below 36 deg F.	$89	$1,000	1.04	11.3	464.1
17	Lighting - Combined Retrofit: Bathroom Sink Light	Replace with new energy-efficient LED lighting.	$2	$40	0.72	16.3	12.1

PRIORITY LIST – ENERGY EFFICIENCY MEASURES							
Rank	Feature	Improvement Description	Annual Energy Savings	Installed Cost	Savings to Investment Ratio, SIR[1]	Simple Payback (Years)[2]	CO_2 Savings
18	Air Tightening	Perform air sealing to reduce air leakage by 5%.	$39	$500	0.66	12.8	453.8
19	Lighting - Combined Retrofit: Counter Space Lights	Replace with new energy-efficient LED lighting.	$4	$120	0.36	32.6	18.2
20	Lighting - Combined Retrofit: Chemical Room Lights	Replace with new energy-efficient LED lighting.	$2	$160	0.13	88.9	8.9
21	Other - Generic Load	Replace both circ pumps (one is broken) with Magnas, install flow meter, flow sensor to better control circulation rates, move soda ash injector to avoid clogging heat exchanger, clean heat exchanger. Necessary to realize savings from changes in raw water heat tape controls.	-$1,798 + $350 Maint. Savings	$9,700	-1.79	999.9	-16,891.2
	TOTAL, all measures		**$44,506 + $8,550 Maint. Savings**	**$67,570**	**8.18**	**1.3**	**225,023.5**

4.2 Interactive Effects of Projects

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

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

Interior lighting, plug loads, facility equipment, and occupants generate heat within the building. When the building is in cooling mode, these items contribute to the overall cooling demands of the building; therefore, lighting efficiency improvements will reduce cooling requirements in air-conditioned buildings. Conversely, lighting-efficiency improvements are anticipated to slightly increase heating requirements. Heating penalties 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)	
18			Air Tightness estimated as: 3100 cfm at 50 Pascals		Perform air sealing to reduce air leakage by 5%.	
Installation Cost	$500		**Estimated Life of Measure (yrs)**	10	**Energy Savings (/yr)**	$39
Breakeven Cost	$326		**Savings-to-Investment Ratio**	0.7	**Simple Payback yrs**	13
Auditors Notes: Install weather stripping on doors to reduce air leakage.						

4.4 Mechanical Equipment Measures

4.4.1 Heating Measure

Rank	Recommendation				
12	Reprogram Tekmar boiler controller, clean boilers, replace hi-low limit controls, clean up wiring on boilers, relocate waste heat sensor to return line, insulate, reposition circ pump				
Installation Cost	$4,400	**Estimated Life of Measure (yrs)**	10	**Energy Savings (/yr)**	$1,149
				Maintenance Savings (/yr)	$200
Breakeven Cost	$12,398	**Savings-to-Investment Ratio**	2.8	**Simple Payback yrs**	3
Auditors Notes: Clean the boilers to increase their efficiency and reduce idle loss. Clean up the wiring on the boilers, replace the hi-lo limits controls, reprogram the Tekmar boiler controller and stage boilers to reduce run time and allow one boiler to run cold more often, further reducing idle loss.. Relocate waste heat sensor to return line and insulate piping to maximize utilization of recovered heat. Reposition horizontal circ pump to the proper vertical position for best performance and longer life.					

4.4.2 Night Setback Thermostat Measures

Rank	Building Space			Recommendation	
15	Kwigillingok			Implement a heating temperature setback 60 60 degrees F when the water treatment plant is unoccupied.	
Installation Cost	$2,400	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$277
Breakeven Cost	$3,285	**Savings-to-Investment Ratio**	1.4	**Simple Payback yrs**	9
Auditors Notes: Program thermostat to implement a heating setback to 60 degrees F so that less fuel is consumed heating the water treatment plant when it is unoccupied.					

4.5 Electrical & Appliance Measures

4.5.1 Lighting Measures

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

4.5.1 Lighting Measures – Replace Existing Fixtures/Bulbs

Rank	**Location**	**Existing Condition**		**Recommendation**	
6	Main Process Room Lights	23 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic with Manual Switching		Replace with new energy-efficient LED lighting and add new occupancy sensor.	
Installation Cost	$1,500	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$1,415
Breakeven Cost	$16,610	**Savings-to-Investment Ratio**	11.1	**Simple Payback yrs**	1
Auditors Notes: This room contains 23 fixtures with two 4' T8 bulbs each to be replaced with LEDs. Add an occupancy sensor to ensure that lights turn off when the room is unoccupied. LEDs use less energy and last longer allowing for less frequent bulb replacement.					

Rank	**Location**	**Existing Condition**		**Recommendation**	
9	Loading Door Light	1 MH 100 Watt StdElectronic with Manual Switching		Replace with new energy-efficient LED lighting.	
Installation Cost	$150	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$127
Breakeven Cost	$1,495	**Savings-to-Investment Ratio**	10.0	**Simple Payback yrs**	1
Auditors Notes: This room contains one fixture with one bulb to be replaced with an LED. LEDs use less energy and last longer allowing for less frequent bulb replacement.					

Rank	**Location**	**Existing Condition**		**Recommendation**	
10	Boiler Room Lights	6 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic with Manual Switching		Replace with new energy-efficient LED lighting and add new occupancy sensor.	
Installation Cost	$980	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$608
Breakeven Cost	$7,138	**Savings-to-Investment Ratio**	7.3	**Simple Payback yrs**	2
Auditors Notes: This room contains 6 fixtures with two 4' T8 bulbs each to be replaced with LEDs. Add an occupancy sensor to ensure that lights turn off when the room is unoccupied. LEDs use less energy and last longer allowing for less frequent bulb replacement.					

Rank	Location	Existing Condition		Recommendation	
13	Office Light	2 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic with Manual Switching		Replace with new energy-efficient LED lighting.	
Installation Cost	$80	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$12
Breakeven Cost	$139	**Savings-to-Investment Ratio**	1.7	**Simple Payback yrs**	7
Auditors Notes: This room contains two fixtures with two 4’ T8 bulbs each to be replaced with LEDs. LEDs use less energy and last longer allowing for less frequent bulb replacement.					

Rank	Location	Existing Condition		Recommendation	
14	Bathroom Light	FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic with Occupancy Sensor		Replace with new energy-efficient LED lighting.	
Installation Cost	$40	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$6
Breakeven Cost	$69	**Savings-to-Investment Ratio**	1.7	**Simple Payback yrs**	7
Auditors Notes: This fixture contains two 4’ T8 bulbs each to be replaced with LEDs. LEDs use less energy and last longer allowing for less frequent bulb replacement.					

Rank	Location	Existing Condition		Recommendation	
17	Bathroom Sink Light	FLUOR T8 4' F32T8 32W Standard Instant StdElectronic with Manual Switching		Replace with new energy-efficient LED lighting.	
Installation Cost	$40	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$2
Breakeven Cost	$29	**Savings-to-Investment Ratio**	0.7	**Simple Payback yrs**	16
Auditors Notes: This fixture contains two 2’ T8 bulbs each to be replaced with LEDs. LEDs use less energy and last longer allowing for less frequent bulb replacement.					

Rank	Location	Existing Condition		Recommendation	
19	Counter Space Lights	3 FLUOR T8 4' F32T8 32W Standard Instant StdElectronic with Manual Switching		Replace with new energy-efficient LED lighting.	
Installation Cost	$120	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$4
Breakeven Cost	$43	**Savings-to-Investment Ratio**	0.4	**Simple Payback yrs**	33
Auditors Notes: This section of the main room contains three fixtures with two 2’ T8 bulbs each to be replaced with LEDs. LEDs use less energy and last longer allowing for less frequent bulb replacement.					

Rank	Location	Existing Condition		Recommendation	
20	Chemical Room Lights	4 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic with Manual Switching		Replace with new energy-efficient LED lighting.	
Installation Cost	$160	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$1
Breakeven Cost	$16	**Savings-to-Investment Ratio**	0.1	**Simple Payback yrs**	119
Auditors Notes: This room contains four fixtures with two 4' T8 bulbs each to be replaced with LEDs. LEDs use less energy and last longer allowing for less frequent bulb replacement.					

4.5.2 Other Electrical Measures

Rank	Location	Description of Existing		Efficiency Recommendation	
1	WTP - Clinic Sewer Heat Tape	Heat Tape with Manual Switching		Make on/off status clearer, us only for freeze-up recovery.	
Installation Cost	$500	**Estimated Life of Measure (yrs)**	7	**Energy Savings (/yr)**	$3,671
Breakeven Cost	$22,723	**Savings-to-Investment Ratio**	45.4	**Simple Payback yrs**	0
Auditors Notes: Install clear on/off switch, use this heat tape only for freeze-up recovery.					

Rank	Location	Description of Existing		Efficiency Recommendation	
2	Pump House - Raw Water Heat Tape	Heat Tape with Manual Switching		Make on/off status clearer, us only for freeze-up recovery.	
Installation Cost	$500	**Estimated Life of Measure (yrs)**	7	**Energy Savings (/yr)**	$3,166
Breakeven Cost	$19,596	**Savings-to-Investment Ratio**	39.2	**Simple Payback yrs**	0
Auditors Notes: Install on/off switch, use this heat tape only for freeze-up recovery.					

Rank	Location	Description of Existing		Efficiency Recommendation	
3	WTP - New Laundry Heat Tape	Heat Tape with Manual Switching		Make on/off status clearer, us only for freeze-up recovery.	
Installation Cost	$500	**Estimated Life of Measure (yrs)**	7	**Energy Savings (/yr)**	$2,600
Breakeven Cost	$16,095	**Savings-to-Investment Ratio**	32.2	**Simple Payback yrs**	0
Auditors Notes: Install clear on/off switch, use this heat tape only for freeze-up recovery.					

Rank	Location	Description of Existing		Efficiency Recommendation	
5	Heat Recovery Circulation Pump	Pump with Other Controls		Replace controller and reprogram to reduce run time.	
Installation Cost	$1,000	**Estimated Life of Measure (yrs)**	7	**Energy Savings (/yr)**	$2,001
Breakeven Cost	$12,385	**Savings-to-Investment Ratio**	12.4	**Simple Payback yrs**	0
Auditors Notes: Replace the Goldline controller with a more user friendly Tekmar 156 differential setpoint controller and reprogram so that pump only runs when there is a demand for heat in the WTP.					

Rank	Location		Description of Existing		Efficiency Recommendation	
7	Raw Water Heat Tape Section 1, 2 & 3		Heat Tape with Manual Switching, Other Controls		Repair leaks that prevent operator from turning these heat tapes off, make on/off status clear, use only for freeze-up recovery.	
Installation Cost		$40,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$28,621
					Maintenance Savings (/yr)	$8,000
Breakeven Cost		$431,705	**Savings-to-Investment Ratio**	10.8	**Simple Payback yrs**	1
Auditors Notes: Repair all leaks in the raw water transmission line so that the operator may circulate heated water and have the confidence to turn the heat tape off during the winter. A thorough repair of the transmission line will save time and money in temporary spot repairs of leaks throughout the year. Cost savings will be realized through the avoidance of freeze-ups and situations where the community loses the ability to pump water to the plant and treat it. This will allow for the operation of the raw water heating and circulation system. Heat tape can then be used only for freeze-up recovery.						

Rank	Location		Description of Existing		Efficiency Recommendation	
8	WTP - Old Laundry Heat Tape		Heat Tape with Manual Switching		Make on/off status clearer, us only for freeze-up recovery.	
Installation Cost		$500	**Estimated Life of Measure (yrs)**	7	**Energy Savings (/yr)**	$857
Breakeven Cost		$5,302	**Savings-to-Investment Ratio**	10.6	**Simple Payback yrs**	1
Auditors Notes: Install clear on/off switch, use this heat tapes only for freeze-up recovery.						

Rank	Location		Description of Existing		Efficiency Recommendation	
11	Old WTP Electric Space Heater		Heater with Manual Switching		Reduce size of space to be heated, control with thermostat	
Installation Cost		$3,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$833
Breakeven Cost		$9,785	**Savings-to-Investment Ratio**	3.3	**Simple Payback yrs**	4
Auditors Notes: This space heater currently heats a closet size space where the pipeline enters the water storage tank. Build a smaller plywood box around this connection point and insulate so that the heater doesn't have to heat such a large space. Install a thermostat so that electric heater only runs at temperatures below 36 degrees F rather than running constantly.						

Rank	Location		Description of Existing		Efficiency Recommendation	
16	WST Connection Heat Tapes		Heat Tape with Manual Switching		Simplify and control with thermostat	
Installation Cost		$1,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$89
Breakeven Cost		$1,044	**Savings-to-Investment Ratio**	1.0	**Simple Payback yrs**	11
Auditors Notes: There are currently three short heat tapes at this point where the pipeline connects to the waters storage tape. Clean up the piping and consolidate these to a single heat tape. Wire the heat tape to be controlled by the same thermostat as the space heater so that heat tape only turns on at temperatures less than 36 degrees F rather than running constantly.						

4.5.3 Other Measures

Rank	Location		Description of Existing		Efficiency Recommendation	
4			Water Storage Tank Heat Add Load		Alternate pumps and run only during winter.	
Installation Cost		$500	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$903
Breakeven Cost		$10,608	**Savings-to-Investment Ratio**	21.2	**Simple Payback yrs**	1
Auditors Notes: Train operator on ideal circ pump schedule. These pumps should be alternated, only one running at a time and only need to run during the winter heating season.						

Rank	Location		Description of Existing		Efficiency Recommendation	
21			Raw Water Circ Line Heat Add Load		Replace both circ pumps with Magnas, install flow meter, flow sensor to better control circulation rates, move soda ash injector to avoid clogging heat exchanger, clean heat exchanger.	
Installation Cost		$9,700	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	-$1,799
					Maintenance Savings (/yr)	$350
Breakeven Cost		-$17,387	**Savings-to-Investment Ratio**	-1.8	**Simple Payback yrs**	1000
Auditors Notes: In order to realize the savings (~$35,000/year) associated with turning off the 3400 feet of heat tape that runs along the raw water transmission line, it will be necessary to make changes to the raw water circulation line heat add system. Clean the heat exchanger that brings the water up to the desired circulating temperature and move the soda ash injection point which is currently located before the heat exchanger to a point after it to prevent further clogging of the heat exchanger, maximizing the heat exchanger's efficiency. One of the circ pumps associated with this system is currently not functioning. Replace both with Grundfos Magnas and install a flow sensor so that the pumps may reduce flow rate during times when the intake pump is not running.						

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.

ANTHC is currently working with the Native Village of Kwigillingok in an effort to realize the retrofits identified in this report through Rural Alaskan Village Grant (RAVG) program. ANTHC will continue to work with Kwigillingok to secure any additional funding necessary to implement the recommended energy efficiency measures.

APPENDICES

Appendix A – Scanned Energy Billing Data

1. Electricity Billing Data – The electricity that powers the water treatment plant itself as well as the pump house is associated with the water treatment plant electric meter reflected in the “Water Treatment Plant” bill. The electricity that powers the heat tapes and space heater near the water storage tank connection point as well as 3000 feet of heat tape along the raw water line is associated with the old water treatment plant/washeteria electric meter reflected in the “Laundry” bill.

Statement

Kwig Power Company
Kwigillingok, AK 99622

Date
12/31/2015

To:
Kwig IRA Council Attn: Water Treatment Plant P.O. Box 90 Kwigillingok, AK 99622

Amount Due	Amount Enc.
$3,421.02	

Date	Transaction	Amount	Balance
12/31/2014	Balance forward		2,752.26
01/12/2015	PMT #20577. ck # 26802	-2,752.26	0.00
01/31/2015	INV #E19953. Due 01/31/2015. --- Comm Facilities, 4,628 @ $0.61 = 2,823.08	2,823.08	2,823.08
02/06/2015	PMT #20639. ck # 26905	-2,823.08	0.00
02/28/2015	INV #E20057. Due 02/28/2015. --- Comm Facilities, 4,760 @ $0.67 = 3,189.20	3,189.20	3,189.20
03/09/2015	PMT #20701. ck # 27027	-3,189.20	0.00
03/31/2015	INV #E20166. Due 03/31/2015. --- Comm Facilities, 4,521 @ $0.67 = 3,029.07	3,029.07	3,029.07
04/08/2015	PMT #20775. ck # 27133	-3,029.07	0.00
04/30/2015	INV #E20250. Due 04/30/2015. --- Comm Facilities, 3,511 @ $0.67 = 2,352.37	2,352.37	2,352.37
05/11/2015	PMT #20861. ck # 27226	-2,352.37	0.00
05/31/2015	INV #E20385. Due 05/31/2015. --- Comm Facilities, 2,595 @ $0.67 = 1,738.65	1,738.65	1,738.65
06/09/2015	PMT #20924. ck # 27351	-1,738.65	0.00
06/30/2015	INV #E20494. Due 06/30/2015. --- Comm Facilities, 1,928 @ $0.67 = 1,291.76	1,291.76	1,291.76
07/07/2015	PMT #20970. ck # 27458	-1,291.76	0.00
07/31/2015	INV #E20605. Due 07/31/2015. --- Comm Facilities, 1,482 @ $0.67 = 992.94	992.94	992.94
08/10/2015	PMT #21031. ck # 27564	-992.94	0.00
08/31/2015	INV #E20741. Due 08/31/2015. --- Comm Facilities, 1,482 @ $0.67 = 992.94	992.94	992.94
09/08/2015	PMT #21084. ck # 27676	-992.94	0.00
09/30/2015	INV #E20861. Due 09/30/2015. --- Comm Facilities, 1,751 @ $0.67 = 1,173.17	1,173.17	1,173.17
10/06/2015	PMT #21143. ck # 27786	-1,173.17	0.00
10/30/2015	INV #E21100. Due 10/30/2015. --- Comm Facilities, 5,322 @ $0.67 = 3,565.74	3,565.74	3,565.74
10/30/2015	PMT #21253. CK #28057	-3,566.41	-0.67
10/30/2015	PMT #21253. CK #28057	-3,565.74	-3,566.41

CURRENT	1-30 DAYS PAST DUE	31-60 DAYS PAST DUE	61-90 DAYS PAST DUE	OVER 90 DAYS PAST DUE	Amount Due
3,421.02	0.00	0.00	0.00	0.00	$3,421.02

Kwig Power Company
Kwigillingok, AK 99622

Statement

Date
12/31/2015

5-8 watts/ft
5

To:
Kwig IRA Council Attn: Water Treatment Plant P.O. Box 90 Kwigillingok, AK 99622

Amount Due	Amount Enc.
$3,421.02	

Date	Transaction	Amount	Balance
11/30/2015	INV #E20981. Due 12/10/2015. --- Comm Facilities, 5,323 @ $0.67 = 3,566.41	3,566.41	0.00
12/31/2015	INV #E21203. Due 12/31/2015. --- Comm Facilities, 5,106 @ $0.67 = 3,421.02	3,421.02	3,421.02

CURRENT	1-30 DAYS PAST DUE	31-60 DAYS PAST DUE	61-90 DAYS PAST DUE	OVER 90 DAYS PAST DUE	Amount Due
3,421.02	0.00	0.00	0.00	0.00	$3,421.02

Statement

Kwig Power Company
Kwigillingok, AK 99622

Date
12/31/2015

To:
Kwig IRA Council Attn: Laundry P.O. Box 90 Kwigillingok, AK 99622

Amount Due	Amount Enc.
$2,201.24	

Date	Transaction	Amount	Balance
12/31/2014	Balance forward		1,158.98
01/12/2015	PMT #20577. ck 3 26802	-1,158.98	0.00
01/31/2015	INV #E19945. Due 01/31/2015. --- Comm Facilities, 5,830 @ $0.61 = 3,556.30 --- WTP PCE, 5,830 @ $0.4014 = -2,340.16	1,216.14	1,216.14
02/06/2015	PMT #20639. ck # 26905	-1,216.14	0.00
02/28/2015	INV #E20049. Due 02/28/2015. --- Comm Facilities, 5,402 @ $0.67 = 3,619.34 --- WTP PCE, 5,402 @ $0.4014 = -2,168.36	1,450.98	1,450.98
03/09/2015	PMT #20701. ck # 27027	-1,450.98	0.00
03/31/2015	INV #E20157. Due 03/31/2015. --- Comm Facilities, 8,043 @ $0.67 = 5,388.81 --- WTP PCE, 8,043 @ $0.4014 = -3,228.46	2,160.35	2,160.35
04/08/2015	PMT #20775. ck # 27133	-2,160.35	0.00
04/30/2015	INV #E20240. Due 04/30/2015. --- Comm Facilities, 5,854 @ $0.67 = 3,922.18 --- WTP PCE, 5,854 @ $0.4014 = -2,349.80	1,572.38	1,572.38
05/11/2015	PMT #20861. ck # 27226	-1,572.38	0.00
05/31/2015	INV #E20375. Due 05/31/2015. --- Comm Facilities, 3,803 @ $0.67 = 2,548.01 --- WTP PCE, 3,803 @ $0.4014 = -1,526.52	1,021.49	1,021.49
06/09/2015	PMT #20924. ck # 27351	-1,021.49	0.00
06/30/2015	INV #E20486. Due 06/30/2015. --- Comm Facilities, 3,316 @ $0.67 = 2,221.72 --- WTP PCE, 3,316 @ $0.4014 = -1,331.04	890.68	890.68
07/07/2015	PMT #20970. ck # 27458	-890.68	0.00
07/31/2015	INV #E20596. Due 07/31/2015. --- Comm Facilities, 2,532 @ $0.67 = 1,696.44 --- WTP PCE, 2,532 @ $0.3919 = -992.29	704.15	704.15
08/10/2015	PMT #21031. ck # 27564	-704.15	0.00
08/31/2015	INV #E20731. Due 08/31/2015. --- Comm Facilities, 190 @ $0.67 = 127.30 --- WTP PCE, 190 @ $0.3119 = -59.26	68.04	68.04
09/08/2015	PMT #21084. ck # 27676	-68.04	0.00

CURRENT	1-30 DAYS PAST DUE	31-60 DAYS PAST DUE	61-90 DAYS PAST DUE	OVER 90 DAYS PAST DUE	Amount Due
2,201.24	0.00	0.00	0.00	0.00	$2,201.24

Kwig Power Company
Kwigillingok, AK 99622

Statement

Date
12/31/2015

To:
Kwig IRA Council Attn: Laundry P.O. Box 90 Kwigillingok, AK 99622

Amount Due	Amount Enc.
$2,201.24	

Date	Transaction	Amount	Balance
09/30/2015	INV #E20852. Due 09/30/2015. --- Comm Facilities, 189 @ $0.67 = 126.63 --- WTP PCE, 189 @ $0.3119 = -58.95	67.68	67.68
10/06/2015	PMT #21143. ck # 27786	-67.68	0.00
10/30/2015	INV #E21084. Due 10/30/2015. --- Comm Facilities, 3,220 @ $0.67 = 2,157.40 --- WTP PCE, 3,220 @ $0.3119 = -1,004.32	1,153.08	1,153.08
11/30/2015	INV #E20970. Due 12/10/2015. --- Comm Facilities, 3,221 @ $0.67 = 2,158.07 --- WTP PCE, 3,221 @ $0.3119 = -1,004.63	1,153.44	2,306.52
12/29/2015	PMT #21253. CK #28057	-1,153.08	1,153.44
12/29/2015	PMT #21253. CK #28057	-1,153.44	0.00
12/31/2015	INV #E21195. Due 12/31/2015. --- Comm Facilities, 6,147 @ $0.67 = 4,118.49 --- WTP PCE, 6,147 @ $0.3119 = -1,917.25	2,201.24	2,201.24

CURRENT	1-30 DAYS PAST DUE	31-60 DAYS PAST DUE	61-90 DAYS PAST DUE	OVER 90 DAYS PAST DUE	Amount Due
2,201.24	0.00	0.00	0.00	0.00	$2,201.24

2. Fuel Billing Records – The water treatment plant and new washeteria fuel records are combined.

A

ACCOUNTS RECEIVABLE LEDGER

WTP / Laundry — ACCOUNT NO.

S/O Coming — SHEET NO.

DATE	INVOICE NUMBER / DESCRIPTION	CHARGES	CREDITS	BALANCE
	BALANCE FORWARD			1450.01
12.26.14	[illegible]	100.00		1350.01
1.19.15	[illegible]	100.00		1250.01
1.20.15	[illegible]	200.00		1050.01
1.23.15	[illegible]	5.0		1045.01
1.26.15	[illegible]	105.01		940.00
1.31.15	[illegible]	100.00		840.00
2.12.15	[illegible]	100.00		740.00
2/25/15	[illegible]	100.00		640.00
2.26.15	[illegible]	100.0		540.00
3.16.15	[illegible]	100.0		440.00
3.28.15	[illegible]	440.0		ø
5.13.15	Pd		3814.98	
5.13.15	[illegible]	120.15		3694.83
5.18.15	[illegible]	400.0		3294.83
5.19.15	[illegible]	200.0		3094.83
8.1.15	[illegible]	200.0		2894.83
8.3.15	[illegible]	200.0		2694.83
8.12.15	Credit PAID		2150.53	4845.36
9.15.15	[illegible]	300.01		4545.35

Jan

510

325

1

B

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B

ACCOUNTS RECEIVABLE LEDGER

WTP / Laundry

ACCOUNT NO.

SHEET NO.

S/O Coming

DATE	INVOICE NUMBER / DESCRIPTION	CHARGES		CREDITS		BALANCE	
	BALANCE FORWARD					4545.35	
10.16.15	John [illegible]	200.	00			4345	35
11.4.15	Jimmy Phillips	430	89			3914	46
11.5.15	Jimmy Phillips	575.	00			3339.	46
11.6.15	Jimmy Phillips	720	00			2619	46
12.9.15	[illegible]	10.	0			2609	46
1.4.16	J. Phillips	460.	13			2149.	33
1.5.16	J. Phillips	360.	03			1789.	93
2.16.16	J. Phillips	480.	15			1309.	78
4.25.16	J. Phillips	224.	44			1085.	34
4.26.16	J. Phillips	360.	0			725.	34
4.28.16	J. Phillips	482	19			243	15
4.28.16	J. Phillips	243	15			0	

PRODUCT D83

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Appendix B – Energy Audit Report – Project Summary

ENERGY AUDIT REPORT – PROJECT SUMMARY	
General Project Information	
PROJECT INFORMATION	**AUDITOR INFORMATION**
Building: Kwigillingok Water Treatment Plant	**Auditor Company:** Alaska Native Tribal Health Consortium
Address: Kwigillingok	**Auditor Name:** Kevin Ulrich & Bailey Gamble
City: Kwigillingok	**Auditor Address:** 4500 Diplomacy Drive, Suite 454 Anchorage, AK 99508
Client Name: John Carter	
Client Address:	**Auditor Phone:** (907) 729-3237
	Auditor FAX: (907) 729-3729
Client Phone: (907) 588-2022	**Auditor Comment:**
Client FAX:	
Design Data	
Building Area: 2,065 square feet	**Design Space Heating Load:** Design Loss at Space: 91,755 Btu/hour with Distribution Losses: 96,584 Btu/hour Plant Input Rating assuming 82.0% Plant Efficiency and 25% Safety Margin: 147,231 Btu/hour Note: Additional Capacity should be added for DHW and other plant loads, if served.
Typical Occupancy: 1 people	**Design Indoor Temperature:** 70 deg F (building average)
Actual City: Kwigillingok	**Design Outdoor Temperature:** -37.1 deg F
Weather/Fuel City: Kwigillingok	**Heating Degree Days:** 12,990 deg F-days
Utility Information	
Electric Utility: Kwig Power Company - Commercial - Lg	**Natural Gas Provider:** None
Average Annual Cost/kWh: $0.670/kWh	**Average Annual Cost/ccf:** $0.000/ccf

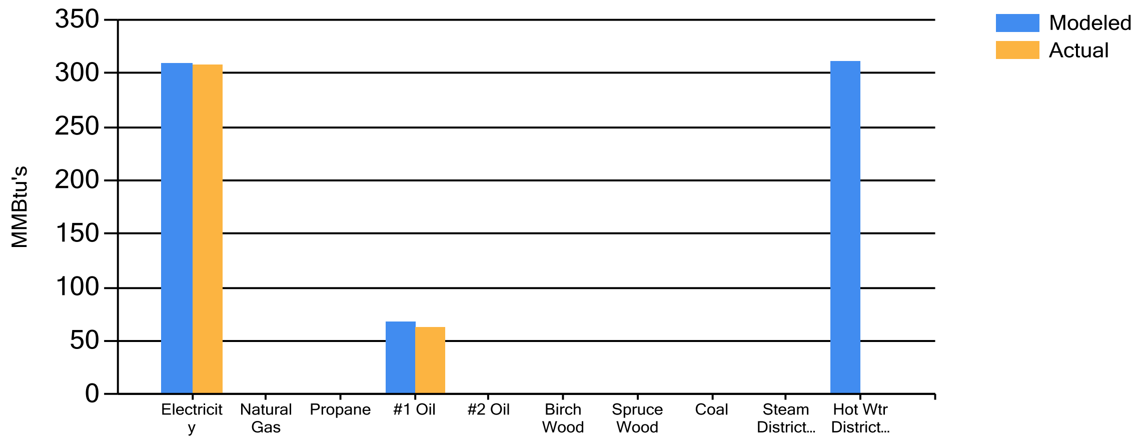
Annual Energy Cost Estimate								
Description	**Space Heating**	**Water Heating**	**Ventilation Fans**	**Lighting**	**Other Electrical**	**Raw Water Heat Add**	**Tank Heat**	**Total Cost**
Existing Building	$1,279	$209	$104	$4,182	$53,309	$230	$3,756	**$63,070**
With Proposed Retrofits	$1,163	$169	$104	$1,906	$11,376	$2,215	$1,553	**$18,487**
Savings	$116	$40	$0	$2,276	$41,933	-$1,985	$2,203	**$44,583**

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	333.5	25.68	$30.54
With Proposed Retrofits	270.9	20.86	$8.95
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.			

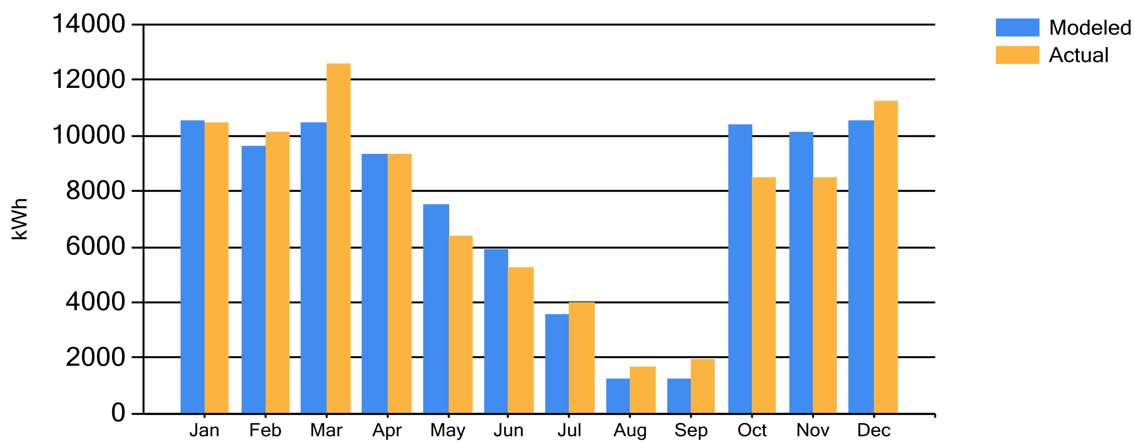
Appendix C – Actual Fuel Use versus Modeled Fuel Use

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.

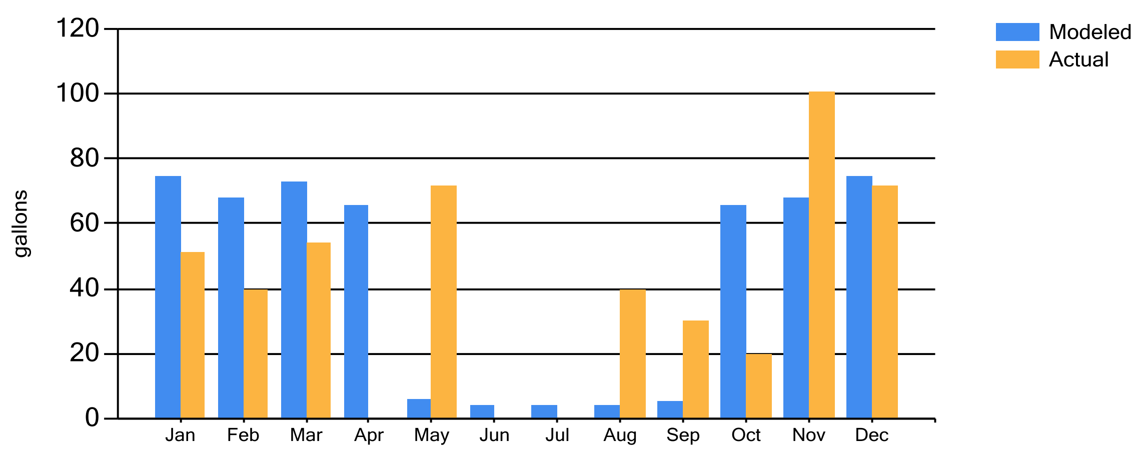
Annual Fuel Use



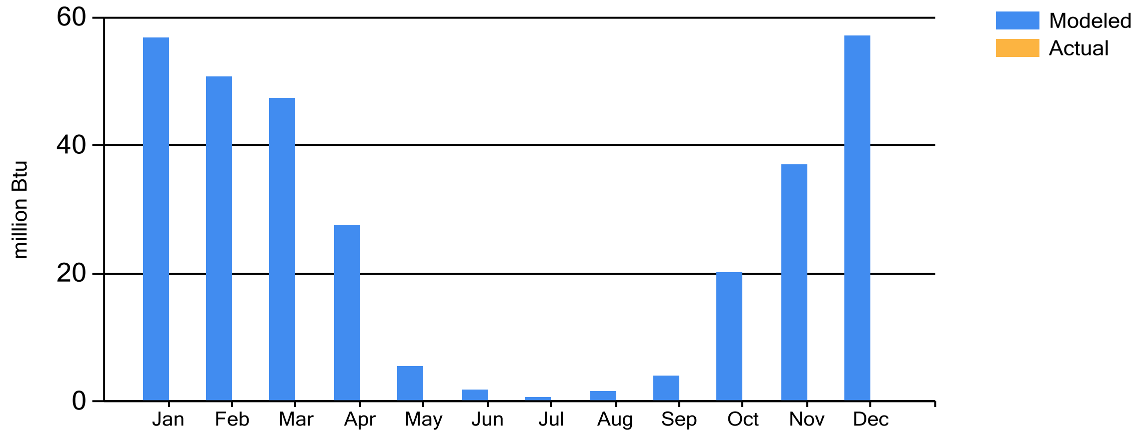
Electricity Use



#1 Fuel Oil Use



Recovered Heat Use



Appendix D - Electrical Demands

Estimated Peak Electrical Demand (kW)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Current	18.3	18.3	18.2	17.1	13.8	11.9	8.6	5.4	5.5	18.0	18.2	18.4
As Proposed	8.2	8.2	8.1	7.9	6.1	4.5	4.3	4.1	4.2	7.9	8.0	8.2

AkWarmCalc Ver 2.5.3.0, Energy Lib 3/7/2016