Comprehensive Energy Audit
For

Kivalina Water Treatment Plant and Washeteria

Prepared For

City of Kivalina

June 24, 2016

Prepared By:

ANTHC
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Table of Contents

PREFACE

This energy audit was conducted using funds from the Northwest Arctic Borough. Coordination with The City of Kivalina has been undertaken to provide maximum accuracy in identifying audits and coordinating potential follow up retrofit activities.

The Energy Projects Group at the Alaska Native Tribal Health Consortium (ANTHC) prepared this document for The City of Kivalina, Alaska. The authors of this report are Praveen K.C., Professional Engineer (PE); Kevin Ulrich, Energy Manager-in-Training (EMIT); and Collette Kawagley, Engineering Intern.

The purpose of this report is to provide a comprehensive document of the findings and analysis that resulted from an energy audit conducted over one site visit in May 2016 by the Rural Energy Initiative of ANTHC. This report analyzes historical energy use and identifies costs and savings of 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 Kivalina City Administrator Janet Mitchell, City Clerk Marylyn Swan, and the Kivalina Water Treatment Plant Operator Joe Swan.

1. EXECUTIVE SUMMARY

This report was prepared for the City of Kivalina. The scope of the audit focused on the Kivalina Water Treatment Plant and Washeteria (WTP). 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 $50,619 per year and the breakdown of the annual predicted energy costs and fuel use for the buildings analyzed are $21,003 for electricity and $29,617 for #1 Oil. The price per kWh is $0.50 and the price per gallon is $5.38. These predictions are based on the electricity and fuel prices at the time of the audit.

The WTP is predicted to spend $21,003 for electricity. This includes $8,099 paid by the City and $12,994 paid by the Power Cost Equalization (PCE) program through the State of Alaska.

The State of Alaska PCE program provides a subsidy to rural communities across the state to lower the cost of electricity and make energy in rural Alaska more affordable. In Kivalina, the cost of electricity without PCE is $0.50/kWh, and the cost of electricity with PCE is $0.16/kWh. If the Kivalina WTP and Washeteria were to pay the full price of electricity the community would pay an additional $12,994 every year in electric costs.

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

Predicted Annual Fuel Use		
Fuel Use	**Existing Building**	**With Proposed Retrofits**
Electricity	41,968 kWh	16,268 kWh
#1 Oil	5,505 gallons	813 gallons
Heat Recovery	0.00 million Btu	485.97 million Btu

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

Table 1.2: Building Benchmarks for the Kivalina Water Treatment Plant

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	986.3	58.85	$57.39
With Proposed Retrofits	735.6	43.89	$18.94
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 Kivalina Water Treatment Plant and Washeteria. 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 - School Supply Pump	Shut off pump when the school is not in session.	$1,492	$500	24.69	0.3	5,565.7
2	Other – Clothes Washer Heating	Lower Temperature Set Point to 120° F.	$1,403	$500	18.48	0.4	5,509.1
3	Setback Thermostat - Washeteria	Implement a Heating Temperature Unoccupied Setback to 60° F for the Washeteria space.	$622	$1,500	5.53	2.4	2,430.0
4	Setback Thermostat - Water Treatment Plant	Implement a Heating Temperature Unoccupied Setback to 60° F for the WTP space.	$463	$1,500	4.12	3.2	1,808.2
5	Other – Sewer Hydronic Heat Trace	Insulate septic tank, utilidor, piping, replace glycol, improve controls. Shut off heat tape, and shut down glycol heat trace in the summer.	$4,857	$20,000	3.19	4.1	18,878.3
6	Air Tightening	Replacing door to arctic entry, weather stripping access door to Washeteria, and patch the hole in the floor of the arctic entry.	$726	$5,000	1.33	6.9	2,834.7
7	Window - Process/Mechanical Room - North Wall	Remove existing glass and install triple glass.	$53	$719	1.26	13.5	207.3
8	Window - Laundry Window (Qty 1, 26x37)	Remove existing glass and install triple glass.	$16	$254	1.06	16.1	61.7

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**
9	Heating Ventilation and Domestic Hot Water	Install heat recovery from power plant to WTP, further details will be provided in the feasibility study. Clean inside of boilers. 255K for heat recovery, 20K for everything else.	$15,254 + $500 Maint. Savings	$275,000	1.01	17.5	50,871.4
10	Other – Raw Water Heat Add	Replace glycol heating line, eliminate use for electric heat, electric heat tape. Maintenance saving represent the avoided fuel use of a now functional raw water heat add.	$9,019 + $4,000 Maint. Savings	$250,000	0.76	19.2	28,970.3
11	Lighting - Power Retrofit: Restroom 3	Replace with new energy-efficient LED lighting.	$2	$80	0.33	35.6	8.0
12	Window - Process/Mechanical Room - East Wall	Remove existing glass and install triple glass.	$3	$648	0.06	241.0	15.2
13	Window - Laundry Room Windows - North Wall (Qty 3)	Remove existing glass and install triple glass.	$3	$688	0.06	241.1	16.1
	TOTAL, all measures		**$33,915 + $4,500 Maint. Savings**	**$556,388**	**1.03**	**14.5**	**117,176.0**

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 $33,915 per year, or 67.0% of the buildings' total energy costs. These measures are estimated to cost $556,388, for an overall simple payback period of 14.5 years. If only the cost-effective measures are implemented, the annual utility cost can be reduced by $24,888 per year, or 49.2% of the buildings' total energy costs. These measures are estimated to cost $304,973, for an overall simple payback period of 12.0 years. It is important to note that the two heat recovery measures must be implemented in unison for all the listed savings to be realized.

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**	**Clothes Drying**	**Lighting**	**Other Electrical**	**Other**	**Total Cost**
Existing Building	$5,216	$6,744	$1,840	$1,342	$4,270	$31,148	**$50,619**
With Proposed Retrofits	$1,816	$3,781	$1,678	$1,432	$2,523	$5,415	**$16,705**
Savings	$3,400	$2,962	$163	-$90	$1,747	$25,733	**$33,915**

2. AUDIT AND ANALYSIS BACKGROUND

2.1 Program Description

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

Kivalina Water Treatment Plant and Washeteria is classified as being made up of the following activity areas:

1) Washeteria: 448 square feet
2) Water Treatment Plant: 434 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; Heat and Ventilation; 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. Kivalina Water Treatment Plant and Washeteria

3.1. Building Description

The 882 square foot Kivalina Water Treatment Plant and Washeteria was constructed in 1992, 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, year round. Additionally, during the summer, use of showers and the washers and dryers averages about four hours per day, six days per week. This opportunity is only possible once the sewer system for the facility thaws during the warm weather months.

The Kivalina Water Treatment Plant and Washeteria serves as the water gathering point for the residents of the community and as a location for Laundromat and shower services. There is one watering point with a 1" pipe that provides treated water year round for the community pickup. There are 4 washers and 3 dryers in the washeteria, though at the time of the site visit only one dryer and none of the restrooms were in operation

In summer, the raw water storage tank, 690,000 gallons, is filled by pumping water from the raw water intake that draws water from a nearby river. The raw water storage tank is only filled in the summer. The raw water from the raw water storage tank is pumped through pressure filters before receiving an addition of chlorine and entering the 500,000 gallon treated water storage tank. Pressure pumps are used to keep the pressure up for watering point in WTP for use by the residents. The rest of the water is used in the washing machines, public showers, and restrooms during the summer

<u>Description of Building Shell</u>

The exterior walls are single stud 2X6 frame type and 5.5 inches of R-19 Batt insulation. The insulation appears to be slightly damaged, and the wall space of the building is approximately 1048 square feet.

The roof of the building has what appears to be a small attic space with a standard framing with 16" spacing. There is approximately 12 inches of R-38 Batt insulation that is slightly damaged in the building. The ceiling has approximately 942 square feet of space.

The floor of the building is constructed on top of pilings that are about 24 inches off the ground. It is framed with and I-Joist that has 9.5 inches of R-30 Batt insulation. There is approximately 882 square feet of floor space in the building. The insulation is possibly compromised, there is a crack in the floor and water may have reduced the performance of the existing insulation. There are parts of the floor that are in need of repair, for example look at figure 1.

Figure 1: Hole in floor of the arctic entry that needs to be repaired.

There are 6 total windows in the building, 3 of which are in the washeteria and are double glass and are of the size 14”x26” with and area of about 2.3 square feet each. Also in the washeteria there is a window that is single glass and is the size of 26”x37” with and area of about 6.7 square feet. In the mechanical room there are two windows the size of 26”x37”, both have an area of about 6.7 square feet, but the one facing north is broken with no covering while the other is double glass. All of the windows do not face south.

Figure 2: Broken Window that needs to be replaced, located in the mechanical room, north wall.

There are 3 exterior doors to the Kivalina WTP, one that leads to the mechanical room, and the other two lead to the arctic entry which leads to the washeteria. Yet due to the significant damage to the arctic entry door we considered the door to the washeteria as the exterior door. The door to the WTP is metal with a fiberglass core, the area of the door is approximately 21 square feet. The door to the washeteria is made of wood and has a solid core flush and a thickness of about 1-3/4”, the area is about 21 square feet.

Figure 3: Damaged door leading to the arctic entry that needs to be replaced.

Figure 4: Door leading to the washeteria with a visible gap where air tightening and weatherization needs to be implemented.

Description of Heating and Cooling Plants

The Heating Plants used in the building are:

Boiler 1

Nameplate Information:	Burnham V-904
Fuel Type:	#1 Oil
Input Rating:	404,000 BTU/hr
Steady State Efficiency:	70 %
Idle Loss:	2 %

Heat Distribution Type: Glycol
Boiler Operation: All Year

Boiler 2

Nameplate Information: Burnham V-904
Fuel Type: #1 Oil
Input Rating: 404,000 BTU/hr
Steady State Efficiency: 70 %
Idle Loss: 0 %
Heat Distribution Type: Glycol
Boiler Operation: All Year

Figure 5: Burnham V-904 boilers in the WTP.

Space Heating and Cooling Distribution Systems

The building is heated with three unit heaters and fin tube baseboard heating. There are two unit heaters present in the water treatment plant and one in the washeteria, they are Dayton boilers and they have a rating of 129 MBH. The unit heater in the area next to the treated water storage tank is coming off of its fixtures. Baseboard heating is only used in the restrooms/shower areas.

Figure 6: Unit Heater next to the treated water storage tank, coming off of its fixtures.

Domestic Hot Water System

There is one hot water heater in the WTP that provides hot water to the building for the restrooms and washeteria, it also provides water for the showers but at this time the showers are not functional. The pump that runs to circulate the hot water is on an on demand schedule. The washers use approximately 158,400 gallons of water in one year, of which about 30,000 gallons is hot water from the indirect fired hot water heater.

Lighting

The main room of the washeteria has 6 fixtures with four 17 Watt LED light bulbs per fixture.

Restroom 1 has 1 fixture with one 17 Watt LED light bulb.

Restroom 3 has 1 fixture with two T12 fluorescent light bulbs.

The dryer plenum has 1 fixture with four 17 Watt LED light bulbs.

The boiler room has 6 fixtures with four 17 Watt LED light bulbs per fixture.

The hot water generator room has 3 fixtures with two 17 Watt LED light bulbs per fixture.

Plug Loads

The WTP has a variety of power tools, a telephone, and some other miscellaneous loads that require a plug into an electrical outlet. The use of these items is infrequent and consumes a small portion of the total energy demand of the building.

Major Equipment

Listed in table 3.1 below are the pumps used in the Kivalina Water Treatment Plant and Washeteria.

Table 3.1: Pump Information

Pump, Model	Rating (HP)	Annual Consumption (kWh)
Back Wash, Century	30	2.5
Boiler Hydronic, Grundfos	0.51	751
Chemical Injection	0.05	36.6
Domestic Hot Water, Grundfos	0.50	691.6
Dryer, Grundfos	0.60	324
Pressure, Grundfos	1.48	248.9
Raw Water Tank Transfer, Grundfos	0.40	422.6
School Supply, Grundfos	1.19	7,801.7

There is a heat tape that provides heat to the raw water line. The heat tape uses 2,400 W and consumes approximately 15,336 kWh annually.

There is a heat tape that provides heat to the sewer discharge line to the lift station. The heat tape uses 240 W and consumes approximately 2,104 kWh annually.

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

Electricity: AVEC-Kivalina - Commercial - Sm

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

Table 3.2: Energy Rates for Each Fuel Source

Average Energy Cost	
Description	**Average Energy Cost**
Electricity	$ 0.50/kWh
#1 Oil	$ 5.38/gallons

3.2.1.1 Total Energy Use and Cost Breakdown

At current rates, City of Kivalina pays approximately $50,619 annually for electricity and other fuel costs for the Kivalina Water Treatment Plant and Washeteria.

Figure 5 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.

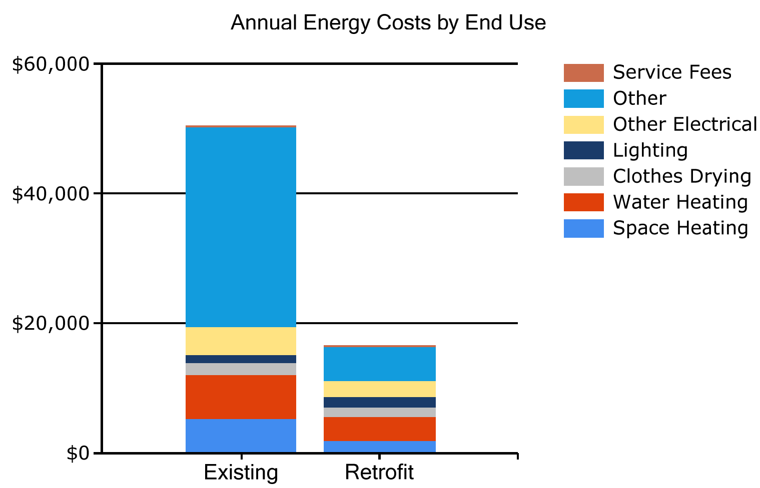

Figure 7: Annual Energy Costs by End Use

Figure 6 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.

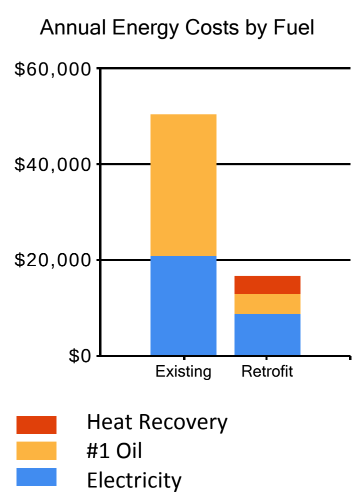

Figure 8: Annual Energy Costs by Fuel Type

Figure 7 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.

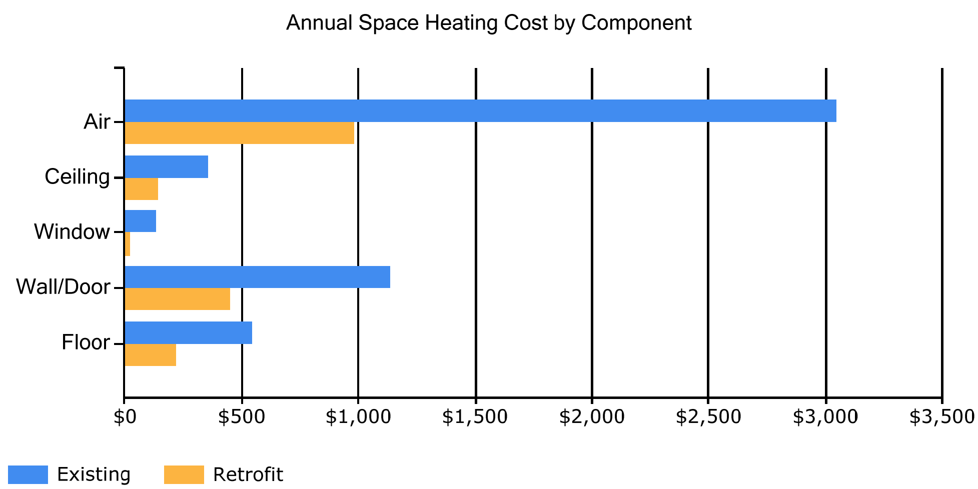

Figure 9: Annual Space Heating Cost by Component

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 3.3: Electrical Consumption by Category

Electrical Consumption (kWh)												
Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space_Heating	296	272	256	174	70	0	0	0	0	142	225	293
DHW	51	46	51	49	82	94	98	98	94	51	49	51
Clothes_Drying	0	0	0	0	144	206	213	213	206	0	0	0
Lighting	227	207	227	220	227	220	227	227	220	227	220	227
Other_Electrical	722	658	722	699	722	701	722	722	699	722	699	722
Other	3000	2734	3000	2903	2999	1025	469	469	1759	2999	2903	3000

Table 3.4: Fuel Oil Consumption by Category

Fuel Oil #1 Consumption (Gallons)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space_Heating	152	139	126	76	4	0	0	0	0	55	109	150
DHW	22	20	22	21	153	213	226	226	211	23	21	22
Clothes_Drying	0	0	0	0	35	52	55	55	51	0	0	0
Other	490	471	471	354	193	49	0	1	75	278	386	500

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):

$$\text{Building Site EUI} = \frac{(\text{Electric Usage in kBtu} + \text{Gas Usage in kBtu} + \text{similar for other fuels})}{\text{Building Square Footage}}$$

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

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

Table 3.5: Kivalina Water Treatment Plant and Washeteria EUI Calculations

Energy Type	Building Fuel Use per Year	Site Energy Use per Year, kBTU	Source/Site Ratio	Source Energy Use per Year, kBTU
Electricity	41,968 kWh	143,236	3.340	478,410
#1 Oil	5,505 gallons	726,656	1.010	733,923
Total		**869,893**		**1,212,332**
BUILDING AREA		882	Square Feet	
BUILDING SITE EUI		986	kBTU/Ft²/Yr	
BUILDING SOURCE EUI		1,375	**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 3.6: Kivalina Water Treatment Plant Building Benchmarks

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	**986.3**	**58.85**	**$57.39**
With Proposed Retrofits	**735.6**	**43.89**	**$18.94**
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 Heating and Ventilation 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 Kivalina Water Treatment Plant and Washeteria was modeled using AkWarm© energy use software to establish a baseline space heating and cooling energy usage. Climate data from Kivalina 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 Kivalina. 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. This table is the same as Table 1.3. It is located here for easy referencing when reviewing the details of the recommendations.

Table 4.1: Recommended Energy Efficiency Measures Ranked by Economic Benefit

Kivalina Water Treatment Plant, Kivalina, Alaska 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 - School Supply Pump	Shut off pump when the school is not in session.	$1,492	$500	24.69	0.3	5,565.7
2	Other – Clothes Washer Heating	Lower Temperature Set Point to 120° F.	$1,403	$500	18.48	0.4	5,509.1

Kivalina Water Treatment Plant, Kivalina, Alaska 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
3	Setback Thermostat - Washeteria	Implement a Heating Temperature Unoccupied Setback to 60° F for the Washeteria space.	$622	$1,500	5.53	2.4	2,430.0
4	Setback Thermostat - Water Treatment Plant	Implement a Heating Temperature Unoccupied Setback to 60° F for the WTP space.	$463	$1,500	4.12	3.2	1,808.2
5	Other – Sewer Hydronic Heat Trace	Insulate septic tank, utilidor, piping, replace glycol, improve controls. Shut off heat tape, and shut down glycol heat trace in the summer.	$4,857	$20,000	3.19	4.1	18,878.3
6	Air Tightening	Replacing door to arctic entry, weather stripping access door to Washeteria, and patch the hole in the floor of the arctic entry.	$726	$5,000	1.33	6.9	2,834.7
7	Window - Process/Mechanical Room - North Wall	Remove existing glass and install triple glass.	$53	$719	1.26	13.5	207.3
8	Window - Laundry Window (Qty 1, 26x37)	Remove existing glass and install triple glass.	$16	$254	1.06	16.1	61.7
9	Heating Ventilation and Domestic Hot Water	Install heat recovery from power plant to WTP, further details will be provided in the feasibility study. Clean inside of boilers. 255K for heat recovery, 20K for everything else.	$15,254 + $500 Maint. Savings	$275,000	1.01	17.5	50,871.4

Kivalina Water Treatment Plant, Kivalina, Alaska 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	Other – Raw Water Heat Add	Replace glycol heating line, eliminate use for electric heat, electric heat tape. Maintenance saving represent the avoided fuel use of a now functional raw water heat add.	$9,019 + $4,000 Maint. Savings	$250,000	0.76	19.2	28,970.3
11	Lighting - Power Retrofit: Restroom 3	Replace with new energy-efficient LED lighting.	$2	$80	0.33	35.6	8.0
12	Window - Process/Mechanical Room - East Wall	Remove existing glass and install triple glass.	$3	$648	0.06	241.0	15.2
13	Window - Laundry Room Windows - North Wall (Qty 3)	Remove existing glass and install triple glass.	$3	$688	0.06	241.1	16.1
	TOTAL, all measures		**$33,915 + $4,500 Maint. Savings**	**$556,388**	**1.03**	**14.5**	**117,176.0**

4.2 Interactive Effects of Projects

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

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

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

4.3 Building Shell Measures

4.3.1 Window Measures

Rank	Location	Size/Type, Condition	Recommendation
7	Window/Skylight: Process/Mechanical Room - North Wall	Glass: No glazing - broken, missing Frame: Wood\Vinyl Spacing Between Layers: Half Inch Gas Fill Type: Air Modeled U-Value: 0.94 Solar Heat Gain Coefficient including Window Coverings: 0.11	Remove existing glass and install triple, 2 low-E, argon glass.

Installation Cost	$719	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$53
Breakeven Cost	$905	**Savings-to-Investment Ratio**	1.3	**Simple Payback yrs**	14

Auditors Notes: This window pane is broken. It is recommended to replace the existing glass with triple pane glass.

Rank	Location	Size/Type, Condition	Recommendation
8	Window/Skylight: Laundry Window (Qty 1, 26x37)	Glass: Single, Glass Frame: Wood\Vinyl Spacing Between Layers: Half Inch Gas Fill Type: Air Modeled U-Value: 0.94 Solar Heat Gain Coefficient including Window Coverings: 0.52	Remove existing glass and install triple, 2 low-E, argon glass.

Installation Cost	$254	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$16
Breakeven Cost	$270	**Savings-to-Investment Ratio**	1.1	**Simple Payback yrs**	16

Auditors Notes: This window was broken in the past, but since then the operator has replaced it with single pane glass.

Rank	Location	Size/Type, Condition	Recommendation
12	Window/Skylight: Process/Mechanical Room - East Wall	Glass: Double, glass Frame: Wood\Vinyl Spacing Between Layers: Half Inch Gas Fill Type: Air Modeled U-Value: 0.51 Solar Heat Gain Coefficient including Window Coverings: 0.46	Remove existing glass and install triple pane, argon glass.

Installation Cost	$648	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$3
Breakeven Cost	$42	**Savings-to-Investment Ratio**	0.1	**Simple Payback yrs**	241

Auditors Notes:

Rank	Location	Size/Type, Condition	Recommendation
13	Window/Skylight: Laundry Room Windows - North Wall (Qty 3)	Glass: Double, glass Frame: Wood\Vinyl Spacing Between Layers: Half Inch Gas Fill Type: Air Modeled U-Value: 0.51 Solar Heat Gain Coefficient including Window Coverings: 0.46	Remove existing glass and install triple pane, argon glass.

Installation Cost	$688	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$3
Breakeven Cost	$44	**Savings-to-Investment Ratio**	0.1	**Simple Payback yrs**	241
Auditors Notes:					

4.3.2 Air Sealing Measures

Rank	Location	Existing Air Leakage Level (cfm@50/75 Pa)	Recommended Air Leakage Reduction (cfm@50/75 Pa)
6		Air Tightness estimated as: 3000 cfm at 50 Pascals	Perform air sealing to reduce air leakage by 500 cfm at 50 Pascals.

Installation Cost	$5,000	**Estimated Life of Measure (yrs)**	10	**Energy Savings (/yr)**	$726
Breakeven Cost	$6,669	**Savings-to-Investment Ratio**	1.3	**Simple Payback yrs**	7
Auditors Notes: Replace existing damaged arctic entry door. Patch hole on the floor in arctic entry. Weather strip access door to washeteria connected with arctic entry.					

4.4 Mechanical Equipment Measures

4.4.1 Heating Domestic Hot Water Measure

Rank	Recommendation
9	Heat Recovery. Install heat recovery from power plant to WTP, further details will be in feasibility study. Clean inside of boilers, tune burners, provide training, repair minor controls. 255K for heat recovery, 20K for everything else.

Installation Cost	$275,000	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$15,254
				Maintenance Savings (/yr)	$500
Breakeven Cost	$278,182	**Savings-to-Investment Ratio**	1.0	**Simple Payback yrs**	17
Auditors Notes: Teaching the WTP operator how to clean and tune the boilers is essential to improving the efficiency of the existing heating system. Heating controls should be adjusted to ensure accurate set points in the facility, including reducing the hot water tank temperature and ensuring the pumps for the heating system operate as needed.					

4.4.2 Night Setback Thermostat Measures

Rank	Building Space	Recommendation
3	Washeteria	Implement a Heating Temperature Unoccupied Setback to 60° F for the Washeteria space.

Installation Cost	$1,500	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$622
Breakeven Cost	$8,300	**Savings-to-Investment Ratio**	5.5	**Simple Payback yrs**	2
Auditors Notes: Install a programmable setback thermostat to control the temperature of the building. When not in use, set temperature inside of washeteria to 60° F, such as at nights and on weekends; anytime the Washeteria is not in used by the general public.					

Rank	Building Space			Recommendation	
4	Water Treatment Plant			Implement a Heating Temperature Unoccupied Setback to 60° F for the Water Treatment Plant space.	
Installation Cost	$1,500	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$463
Breakeven Cost	$6,173	**Savings-to-Investment Ratio**	4.1	**Simple Payback yrs**	3
Auditors Notes: Install a programmable setback thermostat to control the temperature of the building. When not in use, set temperature inside of washeteria to 60° F, such as at nights and on weekends; anytime the WTP is not in used by the general public.					

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.

4.5.1a Lighting Measures – Replace Existing Fixtures/Bulbs

Rank	Location	Existing Condition		Recommendation	
11	Restroom 3	FLUOR (2) T12 4' F40T12 40W Standard StdElectronic with Manual Switching		Replace with LED (2) 17W Module StdElectronic	
Installation Cost	$80	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$2
Breakeven Cost	$26	**Savings-to-Investment Ratio**	0.3	**Simple Payback yrs**	36
Auditors Notes: LED lights not only use less electricity, but they also last longer and functional more effectively in cold temperatures. It is recommended that LED replacements be direct wired so that light function will not be dependent upon the short functional life of ballasts.					

4.5.2 Other Electrical Measures

Rank	Location	Description of Existing		Efficiency Recommendation	
1	School Supply Pump	Pump with Manual Switching		Improve Manual Switching	
Installation Cost	$500	**Estimated Life of Measure (yrs)**	10	**Energy Savings (/yr)**	$1,492
Breakeven Cost	$12,345	**Savings-to-Investment Ratio**	24.7	**Simple Payback yrs**	0
Auditors Notes: Shut off pump in the summer time. This pump circulates water to the school to prevent freezing and during the summer there is no risk for freezing so it is unnecessary for the school supply pump to operate during the summer. The pump should be turned on again in the winter when temperatures are consistently below freezing.					

4.5.3 Other Measures

Rank	**Location**	**Description of Existing**		**Efficiency Recommendation**	
2		Washer Heating Load		Lower Temperature Set Point to 120° F	
Installation Cost	$500	**Estimated Life of Measure (yrs)**	7	**Energy Savings (/yr)**	$1,403
Breakeven Cost	$9,242	**Savings-to-Investment Ratio**	18.5	**Simple Payback yrs**	0
Auditors Notes: The hot water generator is currently set at 170 ° F which is too high and potentially dangerous. Instead the washeteria can effectively run the washers and showers when the set point is lowered to 120° F.					

Rank	**Location**	**Description of Existing**		**Efficiency Recommendation**	
5		Sewer Hydronic Heat Trace		Insulate septic tank, utilidor, piping, replace glycol, improve controls. Shut off heat tape, and shut down glycol heat trace in the summer.	
Installation Cost	$20,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings (/yr)**	$4,857
Breakeven Cost	$63,851	**Savings-to-Investment Ratio**	3.2	**Simple Payback yrs**	4
Auditors Notes: To reduce the strain on the sewer hydronic heat trace, the septic tank, utilidor, and piping should be properly insulated. The glycol should be replaced and the controls should be improved as well. Since during the summer the temperature should be warm enough the sewer lines should not freeze, thus the heat tape and heat trace can be shut off during the summer.					

Rank	**Location**	**Description of Existing**		**Efficiency Recommendation**	
10		Raw Water Heat Add		Replace glycol heating line, eliminate use for electric heat, electric heat tape. Maintenance saving represent the avoided fuel use of a now functional raw water heat add.	
Installation Cost	$250,000	**Estimated Life of Measure (yrs)**	20	**Energy Savings (/yr)**	$9,019
				Maintenance Savings (/yr)	$4,000
Breakeven Cost	$188,865	**Savings-to-Investment Ratio**	0.8	**Simple Payback yrs**	19
Auditors Notes: The existing raw water heat add line is damaged and nonfunctional. This should be replaced as part of the heat recovery project. Replacement of the raw water heat add line would increase fuel consumption but would eliminate the need for the electric heat tape, which is currently the only piece of equipment available to prevent freezing of the raw water line. Additionally, the mechanical storage facility adjacent to the raw water storage tank is currently heated by an electric heater. Replacing this with a heater connected to the raw water heat add line to the water plant would reduce the cost of heating the mechanical storage space significantly. Finally, during the summer the outdoor air temperature should be warm enough to not need the heat trace or tape running, thus they should be turned off in the summer.					

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.

There is currently no funding available to implement the energy efficiency measures identified in this report. ANTHC will assist the City of Kivalina in seeking funds to implement the recommendations and encourages the community to employ what measures they can in the short term.

APPENDICES

Appendix A – Energy Audit Report – Project Summary

ENERGY AUDIT REPORT – PROJECT SUMMARY	
General Project Information	
PROJECT INFORMATION	**AUDITOR INFORMATION**
Building: Kivalina Water Treatment Plant and Washeteria	**Auditor Company:** ANTHC
Address: Kivalina	**Auditor Name:** Praveen K.C. and Collette Kawagley
City: Kivalina	**Auditor Address:** 4500 Diplomacy Drive
Client Name: Joe Swan	
Client Address:	**Auditor Phone:** (907) 729-4083
	Auditor FAX:
Client Phone: (907) 645-5105	**Auditor Comment:**
Client FAX:	
Design Data	
Building Area: 882 square feet	**Design Space Heating Load:** Design Loss at Space: 36,015 Btu/hour with Distribution Losses: 36,015 Btu/hour Plant Input Rating assuming 82.0% Plant Efficiency and 25% Safety Margin: 54,901 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: Kivalina	**Design Outdoor Temperature:** -41.4 deg F
Weather/Fuel City: Kivalina	**Heating Degree Days:** 16,758 deg F-days
Utility Information	
Electric Utility: AVEC-Kivalina - Commercial - Sm	**Natural Gas Provider:** None

Annual Energy Cost Estimate										
Description	**Space Heating**	**Space Cooling**	**Water Heating**	**Ventilation Fans**	**Clothes Drying**	**Lighting**	**Other Electrical**	**Other**	**Service Fees**	**Total Cost**
Existing Building	$5,216	$0	$6,744	$0	$1,840	$1,342	$4,270	$31,148	$60	**$50,619**
With Proposed Retrofits	$1,816	$0	$3,781	$0	$1,678	$1,432	$2,523	$5,415	$60	**$16,705**
Savings	$3,400	$0	$2,962	$0	$163	-$90	$1,747	$25,733	$0	**$33,915**

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	986.3	58.85	$57.39
With Proposed Retrofits	735.6	43.89	$18.94

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

Appendix B – Actual Fuel Use versus Modeled Fuel Use

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

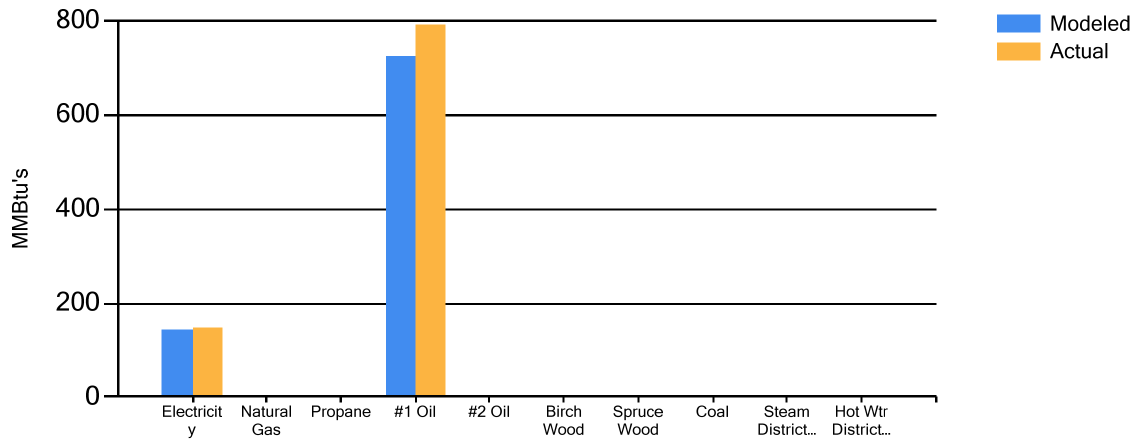

Figure 10: Annual Fuel Use

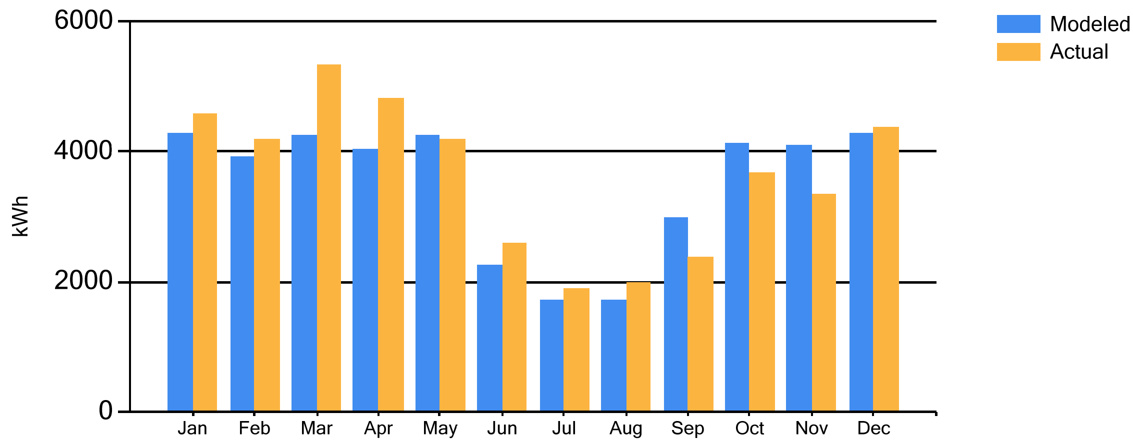

Figure 11: Electricity Fuel Use

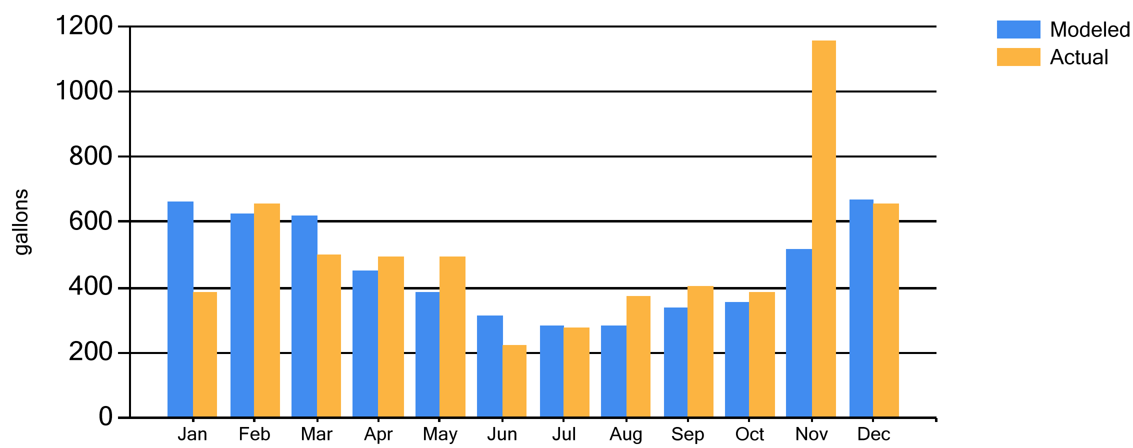

Figure 12: #1 Fuel Oil Fuel Use

Appendix C - Electrical Demands

Estimated Peak Electrical Demand (kW)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Current	7.4	7.4	7.3	7.1	8.2	6.1	5.3	5.3	7.1	7.0	7.2	7.4
As Proposed	4.5	4.5	4.4	4.3	4.9	4.7	4.5	4.9	5.7	4.2	4.4	4.5

AkWarmCalc Ver 2.5.3.0, Energy Lib 3/7/2016

Appendix D – Kivalina "As-Designed" Consumption Comparison

The following graphs reflect the projected fuel and electricity use of the Kivalina water plant and Washeteria if the sewer system was functional, the washers, dryers, and showers were repaired, and the Washeteria remained in operation at design use throughout the winter. This operating condition would allow for additional savings to be recognized through installation of a heat recovery system and lower operating temperature of the hot water.

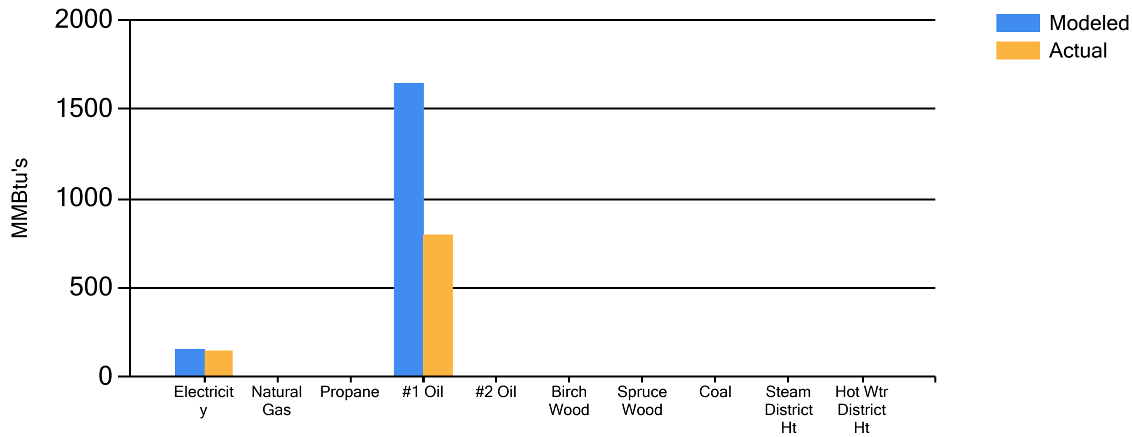

Figure 13: Annual Fuel Use

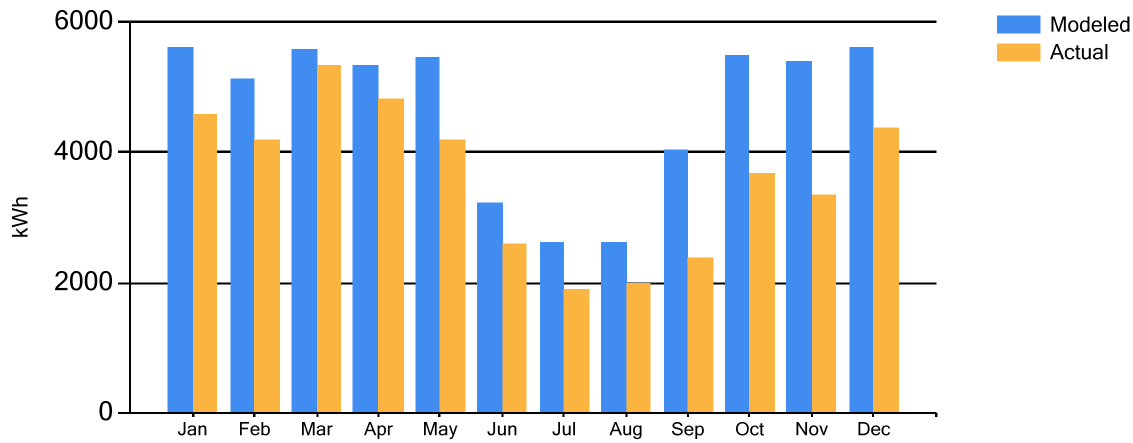

Figure 14: Electricity Fuel Use

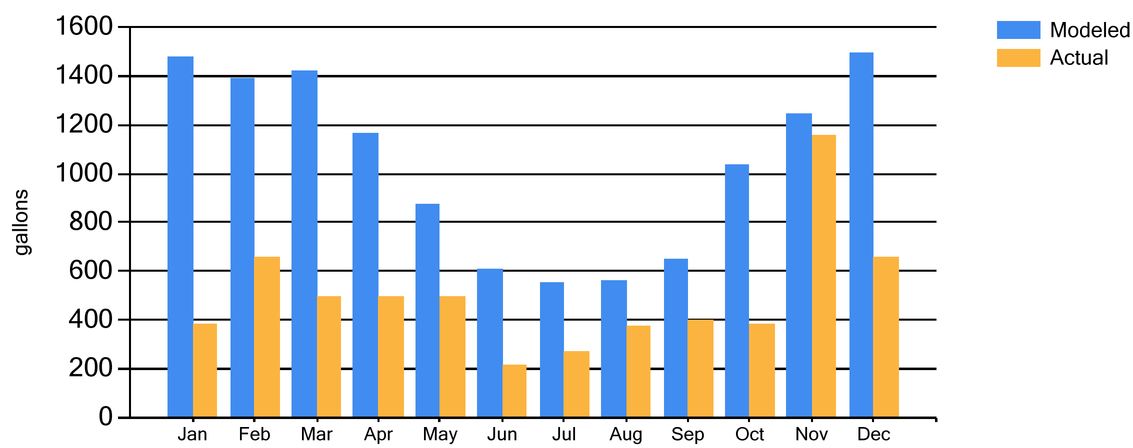

Figure 15: #1 Fuel Oil Fuel Use