ALASKA NATIVE TRIBAL HEALTH CONSORTIUM

Comprehensive Energy Audit
For

Hughes Water Treatment Plant & Washeteria

Prepared For
City of Hughes

November 11, 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 City of Hughes has been undertaken to provide maximum accuracy in identifying audits and coordinating potential follow up retrofit activities.

The Rural Energy Initiative at the Alaska Native Tribal Health Consortium (ANTHC) prepared this document for the City of Hughes, Alaska. The authors of this report are Kevin Ulrich, Assistant Engineering Project Manager and Energy Manager-in-Training (EMIT); Martin Wortman, Supervisor of Utility Operations; and Kameron Hartvigson, Utility Operations Specialist.

The purpose of this report is to provide a comprehensive document of the findings and analysis that resulted from an energy audit conducted in October of 2016 by the Rural Energy Initiative of ANTHC. This report analyzes historical energy use and identifies costs and savings of recommended energy conservation measures. Discussions of site-specific concerns, non-recommended measures, and an energy conservation action plan are also included in this report.

ACKNOWLEDGMENTS

The ANTHC Rural Energy Initiative gratefully acknowledges the assistance of Water Treatment Plant Operators Arlo Beetus & John Cole, Biomass Operator Floyd Saunders Jr., City Clerk Tannya Williams, and City Administrator Thelma Nicholia.

1. EXECUTIVE SUMMARY

This report was prepared for the City of Hughes. The scope of the audit focused on Hughes Water Treatment Plant & Washeteria. 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 $56,797 per year. Electricity represents the largest portion with an annual cost of approximately $34,254. This includes about $7,237 paid by the city and about $27,017 paid by the Power Cost Equalization (PCE) program through the State of Alaska. #1 Fuel Oil represents the remaining portion of the energy costs, with an annual cost of approximately $16,394.

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 Hughes, the cost of electricity without PCE is $0.71/kWh and the cost of electricity with PCE is $0.15/kWh.

The Hughes Water Treatment Plant & Washeteria has undergone many changes and upgrades within the past two years to the facilities and operations. A biomass boiler heating system was constructed in 2015 to serve this facility and the neighboring City Office building. The system consists of two Garn 1000 biomass boilers that are used to heat the circulating glycol loops in each building prior to being pumped through the oil-fired boilers. Operation of the system began in the winter of 2015. A new 40,000 gallon water storage tank was constructed in the summer of 2015. This allows for better contact time for water treatment as well as more water storage. A new intake and filtration system was constructed in summer of 2016. This was inspected less than one week before the site visit for the energy audit and the operators were still learning how to operate the system during the energy audit.

There is a heat recovery system in the power plant that is designed to transport heat from the cooling loops of the generators to the South Loop water main to assist with the heating processes. This heat recovery system failed in winter of 2014 when a sight glass in an uninsulated area of the power plant froze, causing the glass to break and flooding to occur. This has not been repaired and the heat recovery system currently operates solely for space heating within the power plant building. The required repairs of the heat recovery system are covered in this energy audit report.

There are two major operational hazards within the water treatment plant that need to be addressed outside of energy efficiency efforts. The existing fuel tank is a single-walled 500 gallon tank that is original to the construction of the building. The tank is located approximately 30 ft. from the site of the water intake well and there is no catchment or containment system for the fuel tank should a spill occur. This must be addressed with the installation of a double-walled tank with a catchment system and by relocating the tank further away from the well site. Additionally, the backup generator is currently located in the process room next to the water circulation loops and has no provisions for make-up air required for generator operation. The generator must be given make-up air in order to correct code violations and insure the safety of building occupants. Our recommendation is to build a separate small building container for the backup generator and install the unit outside of the building.

Figure 1: The existing fuel tank can be seen with no catchment system for any leaking fuel.

Figure 2: The proximity of the fuel tank to the groundwater well for the community.

Figure 3: The backup generator can be seen with no source of makeup air for its operation.

This effort is funded by the Denali Commission with money available from the State of Alaska RAVG grant for implementing the recommendations and additional operator training. A separate effort involving community-wide energy-efficiency is also being completed through the SPARC program. This energy audit report is intended to benefit both energy-efficiency efforts.

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

Predicted Annual Fuel Use		
Fuel Use	**Existing Building**	**With Proposed Retrofits**
Electricity	48,245 kWh	42,933 kWh
#1 Oil	2,293 gallons	701 gallons

Spruce Wood	31.30 cords	18.47 cords
Heat Recovery	0.00 million Btu	247.96 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 & Washeteria

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	552.3	36.97	$30.34
With Proposed Retrofits	438.7	29.36	$21.87
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 Hughes Water Treatment Plant & 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	Lighting: Exterior Incandescent	Replace with LED-equivalent light bulbs.	$130	$100	15.25	0.8	411.5
2	South Loop Heat Add	Lower temperature set point to 40 deg. F. $500 for lowering the temperature. $1000 for Operator Training.	$1,773	$1,500	14.83	0.8	3,499.7
3	Water Storage Tank	Lower Temperature set point to 36 deg. F. This should be acceptable if the tank mixer inside the water storage tank remains in operation. Turn off heat tape and use only for emergency purposes.	$1,139	$1,000	13.86	0.9	2,889.0
4	Lighting: Water Treatment Plant	Replace with direct-wire LED-equivalent light bulbs.	$282	$400	8.24	1.4	935.5
5	Loft Forced Air Handling Unit	Repair AHU Controls so that AHU only operates during occupied hours when necessary.	$2,559	$5,000	6.01	2.0	8,145.2
6	Setback Thermostat: Water Treatment Plant	Implement a Heating Temperature Unoccupied Setback to 50.0 deg F for the Water Treatment Plant space.	$554	$2,000	3.44	3.6	973.9

PRIORITY LIST – ENERGY EFFICIENCY MEASURES

Rank	Feature	Improvement Description	Annual Energy Savings	Installed Cost	Savings to Investment Ratio, SIR[1]	Simple Payback (Years)[2]	CO_2 Savings
7	Lighting: Washeteria	Replace with direct-wire LED-equivalent light bulbs and add new occupancy sensor	$256	$900	3.32	3.5	846.7
8	Lighting: Restrooms (Men's and Women's) Incandescent	Replace with LED-equivalent light bulbs.	$127	$600	2.47	4.7	419.7
9	Lighting - Combined Retrofit: Boiler Room	Replace with direct-wire LED-equivalent light bulbs and add new occupancy sensor	$129	$660	2.28	5.1	426.6
10	North Loop Heat Add	Lower temperature set point to 40 deg. F. $500 for lowering the temperature. $1000 for Operator Training.	$259	$1,500	2.17	5.8	512.2
11	Lighting - Combined Retrofit: Biomass Lights	Replace with direct-wire LED-equivalent light bulbs and add new occupancy sensor	$124	$980	1.49	7.9	394.5
12	Mechanical Room Heating System	Convert all heating loops into primary/secondary system with existing dryer boiler and a second new boiler of the same model. Move dryers, loft AHU, and hot water heating to the main heating system, replace hot water heater, use biomass boiler for the primary heating source of all operations. Repair Heat Recovery system in the power plant.	$15,472	$197,500	1.23	12.8	34,852.5
13	Lighting: Dryer Room	Replace with direct-wire LED-equivalent light bulbs.	$10	$100	1.22	9.6	34.5
14	Setback Thermostat: Washeteria	Implement a Heating Temperature Unoccupied Setback to 50.0 deg F for the Washeteria space.	$144	$2,000	0.89	13.9	273.5
15	Lighting: Water Treatment Plant – 2-Bulb Fixture and Hallway	Replace with direct-wire LED-equivalent light bulbs.	$17	$240	0.82	14.2	55.9

PRIORITY LIST – ENERGY EFFICIENCY MEASURES

Rank	Feature	Improvement Description	Annual Energy Savings	Installed Cost	Savings to Investment Ratio, SIR[1]	Simple Payback (Years)[2]	CO_2 Savings
16	Air Tightening	Replace and caulk windows, replace doors, add weather stripping to doors, set the WTP door in place, eliminate the stack for unused hot water heater upon completion of the mechanical room work, insulate around stack penetrations, permanently insulate old generator vent in the mechanical room.	$623	$12,500	0.44	20.1	1,177.7
17	Exterior Door: Water Treatment Plant Door	Remove existing door and install standard insulated metal door.	$29	$1,729	0.35	59.8	54.5
18	Exterior Door: Washeteria Door	Remove existing door and install standard insulated metal door.	$34	$2,017	0.35	59.9	63.6
19	Lighting - Power Retrofit: Restrooms (Men's and Women's) T8's	Replace with direct-wire LED-equivalent light bulbs	$5	$320	0.17	70.0	15.1
20	Lighting - Power Retrofit: Loft	Replace with direct-wire LED-equivalent light bulbs	$3	$240	0.17	70.1	11.3
21	Window/Skylight: Mechanical Room Window	Replace existing window with triple pane window.	$6	$1,082	0.08	186.3	11.1
22	Window/Skylight: Washeteria Windows (3)	Replace existing windows with triple pane window.	$17	$3,246	0.08	186.3	33.4
23	Window/Skylight: Water Treatment Plant Window (East)	Replace existing window with triple pane window.	$6	$1,082	0.08	186.3	11.1
24	Lighting - Power Retrofit: Plenum	Replace with direct-wire LED-equivalent light bulbs	$1	$100	0.08	143.0	2.3
25	Window/Skylight: Water Treatment Plant Window (South)	Replace existing window with triple pane window.	$5	$1,082	0.07	216.7	9.9
26	Other Electrical - Controls Retrofit: Water Storage Tank Mixer	Implement new Water Storage Tank for water quality purposes. This was installed in October 2016 as part of a sanitation effort.	-$7,842 + $500 Maint. Savings	$250	-344.59	999.9	24,851.6
	TOTAL, all measures		**$15,863 + $500 Maint. Savings**	**$238,127**	**1.07**	**14.6**	**31,209.2**

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 $15,863 per year, or 27.9% of the buildings' total energy costs. These measures are estimated to cost $238,127, for an overall simple payback period of 14.6 years.

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

Table 1.4: Detailed Breakdown of Energy Costs in the Building

Annual Energy Cost Estimate									
Description	**Space Heating**	**Water Heating**	**Ventilation Fans**	**Clothes Drying**	**Lighting**	**Other Electrical**	**Water Circulation Heat**	**Tank Heat**	**Total Cost**
Existing Building	$16,533	$331	$3	$2,047	$2,394	$15,564	$15,112	$4,812	**$56,797**
With Proposed Retrofits	$5,586	$315	$3	$1,834	$1,229	$23,406	$4,924	$3,638	**$40,934**
Savings	$10,947	$17	$0	$213	$1,166	-$7,842	$10,188	$1,174	**$15,863**

2. AUDIT AND ANALYSIS BACKGROUND

2.1 Program Description

This audit included services to identify, develop, and evaluate energy efficiency measures at the Hughes Water Treatment Plant & 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 and 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 Hughes Water Treatment Plant & 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.

Hughes Water Treatment Plant & Washeteria is made up of the following activity areas:

1) Water Treatment Plant: 1,331 square feet
2) Washeteria: 541 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; heating 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. Hughes Water Treatment Plant & Washeteria

3.1. Building Description

The 1,872 square foot Hughes Water Treatment Plant & Washeteria was constructed in 1988, with a normal occupancy of one person. The water treatment plant will have one operator working for approximately four hours per day, seven days per week. The washeteria is always open for community use and averages 2-3 hours of occupied time per day.

The Hughes Water Treatment Plant & Washeteria serves as the central location for all water intake, treatment, and distribution processes for the community. The building also serves as a central location for laundromat and shower services for the community.

The water treatment plant receives water from a well located in the ground directly beneath the building. The water source is groundwater under the influence of the surface water in the Koyukuk River that runs next to the community. The intake water is pumped into the building and injected with a polymer and with potassium permanganate before getting filtered through the two large sand filters. There are also two large overflow tanks in the building for when the filters get backlogged with pressure. After going through the filters, the water is injected with chlorine before being transported to the 40,000 gallon water storage tank. There is currently a tank mixer within the water storage tank that operates constantly to thoroughly mix the chlorine into the water and reduce the necessary contact time before distribution. After the time in the water storage tank, water is distributed to the community through two water circulation loops. The North Loop serves the northern part of the community with a 3" diameter pipe and is approximately 2800 ft. long. The South Loop serves the southern part of the community with a 6" diameter pipe and is approximately 3650 ft. long. All end users use a pitorifice system to pull water into the service using a pressure differential with the main pipe. As a result, the design flow rates of the circulation loops are very high with the design flow rates for the North and south loops being 160 GPM and 40 GPM respectively. During the site visit it was observed that the actual flow rates for the North and South loops were 28 and 20 GPM respectively. This is a result of an operational concern with the circulation pumps that will be addressed in the Major Equipment section.

The washeteria has four clothes washers and three hydronic clothes dryers for use by the community. Three of the washers have an 18-gallon capacity while the fourth washer has a 30-

gallon capacity. One of the 18-gallon washer units was not functional at the time of the site visit. The three dryers were all functioning with proper heating temperatures observed. The dryers are supplied with heat from a dedicated boiler that operates on demand. The boiler also supplies heat for the air handling unit in the loft that serves the washeteria space.

Figure 4: Hydronic Dryers in the Hughes Washeteria

Figure 5: Clothes Washers in the Hughes Washeteria

Description of Building Shell

The exterior walls are constructed with single stud 2x6 standard lumber construction and approximately 5.5 inches of polystyrene foam insulation. The average height of the walls is 12.5 feet.

The building has a cathedral ceiling with standard lumber framing and 24" spacing. There is approximately 6 inches of polystyrene foam insulation.

The building is constructed on pilings approximately four feet above the ground. The floor is insulated with approximately 6 inches of polystyrene foam insulation. There is approximately 1,872 square feet of floor space in the building.

There are six total windows that each have dimensions of 31" x 26.5". All windows are double-paned with wood framing. Two windows are in the water treatment plant process room with one window being south facing. One window is in the mechanical room. Three windows are in the washeteria room. All window frames suffer from air penetration.

There are two entrances into the building. The washeteria entrance has an arctic entry with poorly insulated doors. The door to the washeteria is a solid wood door with a metal skin. The water treatment plant entrance has a wood door with metal skin that is slightly larger than a standard door with dimensions of 42" x 80". The door is not set in the hinges properly and air leakage is very high as a result.

Figure 6: The washeteria entrance door can be seen with visible gaps around the edge where air leakage occurs.

Description of Heating Plants

The heating plants used in the building are:

Boiler 1

Nameplate Information: Weil McLain CP 1405962
Fuel Type: #1 Oil
Input Rating: 125,200 BTU/hr
Steady State Efficiency: 78 %
Idle Loss: 1.5 %
Heat Distribution Type: Glycol
Boiler Operation: All Year

Figure 7: Boiler 1

Boiler 2

Nameplate Information: Weil McLain CP 1405962

Fuel Type: #1 Oil
Input Rating: 125,200 BTU/hr
Steady State Efficiency: 78 %
Idle Loss: 1.5 %
Heat Distribution Type: Glycol
Boiler Operation: All Year

Figure 8: Boiler 2

Dryer Boiler

Fuel Type: #1 Oil
Input Rating: 347,000 BTU/hr
Steady State Efficiency: 84 %
Idle Loss: 0.5 %
Heat Distribution Type: Glycol
Boiler Operation: All Year

Figure 9: Dryer Boiler

Biomass Boiler #3

Nameplate Information: Garn 1000
Fuel Type: Spruce Wood
Input Rating: 180,000 BTU/hr
Steady State Efficiency: 80 %
Idle Loss: 2 %
Heat Distribution Type: Water
Boiler Operation: Sep – May

Figure 10: Garn 1000 Biomass Boilers

Heat Recovery

Fuel Type: Recovered Heat
Input Rating: 60,000 BTU/hr
Steady State Efficiency: 95 %
Idle Loss: 0 %
Heat Distribution Type: Glycol
Boiler Operation: All Year

Figure 11: Power Plant Building for Hughes Power Co.

Figure 12: The water main penetrates the power plant wall to get reheated by the heat recovery system.

Bock Hot Water Heater

Fuel Type:	#1 Oil
Input Rating:	277,000 BTU/hr
Steady State Efficiency:	78 %
Idle Loss:	0 %
Heat Distribution Type:	Water
Boiler Operation:	All Year

Figure 13: Independent Direct-Fired Hot Water Heater

Space Heating Distribution Systems

There are two unit heaters in the process room that are used to provide space heat. Each of the unit heaters is rated for 34,800 BTU's and they have a temperature set point of 60 deg. F.

There is an air handling unit in the loft of the building that has a heating coil supplied by the fryer boiler. This air handling unit circulates air into the washeteria space, providing both heated air and proper air circulation. The unit controls are not functioning and the wiring has been connected such that this is in constant operation. Repairs are needed to the controls to allow the unit to only operate during occupied times in the washeteria space.

There is an air handling unit in the dryer plenum that heats the makeup air for the dryers. This air handling unit is supplied heat by the dryer boiler and operates primarily when the dryers are in use.

The remaining parts of the building are heated using a hydronic baseboard system that is heated by Boiler 1 and Boiler 2. Baseboard heating is present in the washeteria space and in the restrooms.

Domestic Hot Water System

The building has two independent hot water heaters present that provide heated water to the restrooms, showers, sinks, and washers in the building. One of the heaters has been taken offline and the parts used to repair the other heater, leaving only one in operation. Both heaters are Bock units with 100 gallons of storage. It is estimated that the facility uses approximately 23 gallons of hot water per day.

Biomass Boiler Information

A biomass boiler system was installed in the summer of 2015 to be used for heating the Hughes Water Treatment Plant & Washeteria as well as the city office building. A separate building was constructed near the washeteria building and a wood storage lot was implemented between the washeteria and the city office. The biomass boilers heat the hydronic heating loops prior to the fuel oil boilers to reduce the demand for #1 fuel oil. The two boilers combined to use 56 cords during the first year of operation with the washteria estimated to have used 33 of those cords. The initial design called for the ability to use both biomass boilers for either building depending on the demand at the time, but due to pressure balance issues with the water in the two biomass boilers they have been valved off such that boiler 3 is for the Hughes Water Treatment Plant & Washeteria and boiler 4 is for the city office.

The city office was flooded in the summer of 2015 and much of the first floor, including the existing mechanical room, was damaged. The building has since been raised onto pilings and the city is working to renovate the lower floor. At the time of the site visit, the city office heating system had been connected to the biomass heating system and the building was actively being heated by biomass heat.

Figure 14: Biomass Building Module

Figure 15: Chainsaws used for wood processing

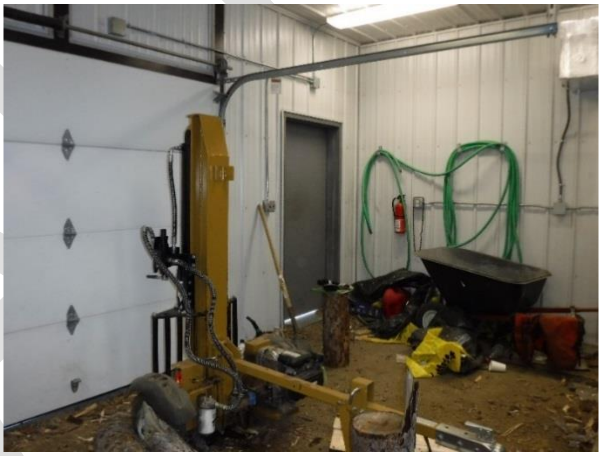


Figure 16: Hydraulic Wood Splitter used for wood processing

Figure 17: Wood Storage Lot between the Hughes Water Treatment Plant & Washeteria and the City Office

Heat Recovery Information

There is a heat recovery system that provides heat from the cooling loops of the power plant generators to the south loop. The system ties in directly to the water main and provides a second heating source along the loop to prevent freezing on the far end of the circulation loop. In the winter of 2015, the water line for the heat recovery froze and a sight glass ruptured, causing the room to flood. Since that rupture, the pipe has not been insulated and the sight glass is still broken. As a result, the heat recovery system currently provides space heat for the power plant building but is not assisting with the water circulation loop.

Figure 18: Heat Recovery System heat exchanger for the water main

Figure 19: Broken Sight Glass where water flooded the power plant.

Description of Building Ventilation System

There is a chemical exhaust fan in the chemical room that is used to ventilate the chemical fumes out of the building when the space is occupied. The exhaust fan and the lights for the room are on the same switch. The fan is a Greenheck S0-65-D-X rated for 120 CFM and 25W. The fan operates less than 30 minutes per day.

Lighting

Table 3.1 below shows detailed information on the lighting in the Hughes Water Treatment Plant & Washeteria as well as in the biomass building.

Table 3.1: Lighting Details for the Hughes Water Treatment Plant & Washeteria

Room	Bulb Type	Fixtures	Bulbs per Fixture	Annual Usage (kWh)
Process Room	Fluorescent T8	5	4	808
Process Room	Fluorescent T8	3	2	249
Loft	Fluorescent T8	3	2	50
Mechanical Room	Fluorescent T8	2	4	259

Dryer Plenum	Incandescent 60W	2	1	22
Plumbing Plenum	CFL Spiral 26W	2	1	3
Washeteria	Fluorescent T8	5	3	485
Restrooms (M+W)	Incandescent 60W	12	1	264
Restrooms (M+W)	Fluorescent T8	4	2	67
Restrooms (M+W)	CFL Plug-in Quad Tube 13W	2	2	20
Chemical Room	LED 17W	1	1	4
Exterior	Incandescent 60W	1	1	247
Exterior	Led 40W	1	1	195
Biomass Building	Fluorescent T8	6	2	309
Biomass Building	Led 40W	1	1	391

Plug Loads

The Hughes Water Treatment Plant & Washeteria 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

Table 3.2: Major Equipment Information for the Hughes Water Treatment Plant & Washeteria

Equipment	Rating (Watts)	Annual Usage (kWh)
Well Pump	1,125	1,409
Backwash Pump	750	39
Air Scour	1,500	78
Chemical Mixing Motors (3)	40	150
Chemical Dosing Pumps (3)	24	90
Pressure Pumps (2)	1,125	1,183
North Loop Circulation Pump	720	4,722
South Loop Circulation Pump	920	8,065
Washers	1,176	1,332
Biomass System Pumps (4)	180	4,722
Biomass Exhaust Fan	40	131

There is a water storage tank mixer that is used to mix the treated water with chlorine to give the water a better chemical distribution and lower the contact time needed in the tank prior to distribution. The tank mixer also has a secondary benefit that by mixing the water in the water storage tank it acts as a freeze protection method and the heat can be lowered inside the tank. The mixer had been turned on less than one week prior to the energy audit site visit. It was measured to draw 10.5A on a 120V service, which yields a power rating of 1,260 Watts. If this is operated constantly throughout the year as intended, it is estimated that electrical consumption will increase by over 11,000 kWh annually and that electrical costs will increase by over $7,800 annually. This is included in the energy audit report as a retrofit to capture the estimated future cost of operating the water treatment plant.

There is a heat tape that runs between the water treatment plant building and the water storage tank that is in constant operation to heat the water in the tank. The heat tape should not need to run constantly and should be used primarily for emergency thaw purposes and freeze protection.

There are three hydronic dryers that are used by the community. These dryers are heated to 190 deg. F by the dryer boiler when in operation. It is estimated that the washeteria has approximately 2-3 washer loads and 2-3 dryer loads per day.

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 City of Hughes owns and operates the Hughes Power & Light Co., which provides electricity to the residents of the community as well as to all public and commercial facilities.

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

Table 3.3: Energy Cost Rates for Each Fuel Type

Average Energy Cost	
Description	**Average Energy Cost**
Electricity	$ 0.71/kWh
#1 Oil	$ 4.37/gallons
Spruce Wood	$ 400/cords
Heat Recovery	$ 0.00/million Btu

3.2.1.1 Total Energy Use and Cost Breakdown

At current rates, City of Hughes pays approximately $56,797 annually for electricity and other fuel costs for the Hughes Water Treatment Plant & Washeteria.

Figure 20 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.

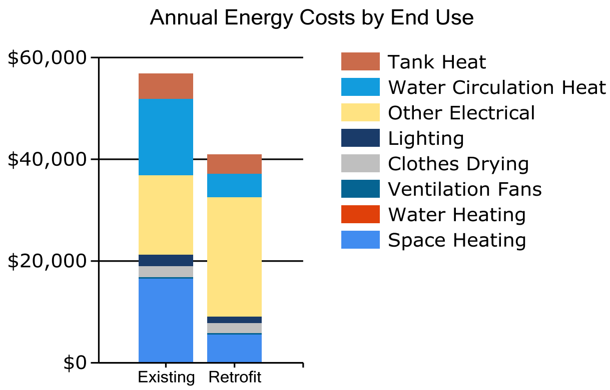


Figure 20: Annual Energy Costs by End Use

Figure 21 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.

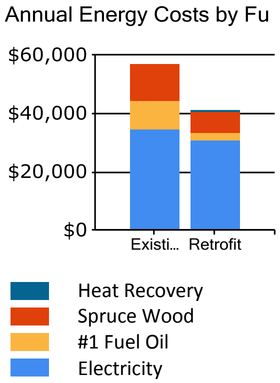


Figure 21: Annual Energy Costs by Fuel Type

Figure 22 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.

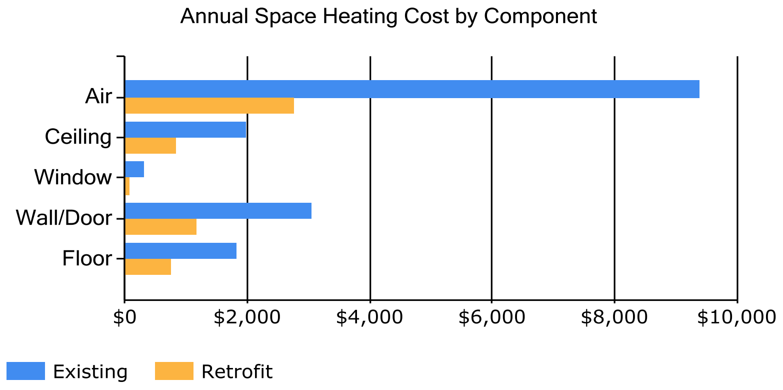


Figure 22: Annual Space Heating Costs

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 3.4: Estimated Electrical Consumption by Category

Electrical Consumption (kWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space Heating	1677	1518	1644	1553	1582	1531	1582	1582	1532	1608	1598	1675
DHW	1	1	1	1	1	1	1	1	1	1	1	1
Clothes Drying	114	104	114	110	113	110	113	113	110	114	110	114
Lighting	322	294	322	275	249	209	216	253	275	322	312	322
Other Electrical	2134	1945	2134	2065	2134	1014	1048	1048	2065	2134	2065	2134
Water Circulation Heat	144	131	144	139	144	0	0	0	139	144	139	144
Tank Heat	163	144	149	127	114	0	0	0	110	132	147	162

Table 3.5: Estimated Fuel Oil Consumption by Category

Fuel Oil #1 Consumption (Gallons)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space Heating	49	37	25	0	0	20	21	21	0	0	30	47
DHW	6	6	6	6	6	6	6	6	6	6	6	6
Clothes Drying	24	21	23	21	20	18	19	19	19	21	22	24
Water Circulation Heat	149	136	151	150	158	0	0	0	153	155	146	149
Tank Heat	73	60	54	27	0	0	0	0	0	28	56	72

Table 3.6: Estimated Cord Wood Consumption by Category

Spruce Wood Consumption (Cords)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Space Heating	1	1	1	0	0	0	0	0	0	0	1	1
Water Circulation Heat	2	2	2	2	2	0	0	0	2	2	2	2
Tank Heat	1	1	1	0	0	0	0	0	0	0	1	1

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):

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

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

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

Table 3.7: Building EUI Calculations for the Hughes Water Treatment Plant & Washeteria

Energy Type	Building Fuel Use per Year	Site Energy Use per Year, kBTU	Source/Site Ratio	Source Energy Use per Year, kBTU
Electricity	48,245 kWh	164,659	3.340	549,961
#1 Oil	2,293 gallons	302,728	1.010	305,756
Spruce Wood	31.30 cords	566,582	1.000	566,582
Heat Recovery	0.00 million Btu	0	1.280	0
Total		**1,033,969**		**1,422,299**
BUILDING AREA		1,872	Square Feet	
BUILDING SITE EUI		552	kBTU/Ft²/Yr	
BUILDING SOURCE EUI		760	**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 3.8: Building Benchmarks for the Hughes Water Treatment Plant & Washeteria

Building Benchmarks			
Description	**EUI (kBtu/Sq.Ft.)**	**EUI/HDD (Btu/Sq.Ft./HDD)**	**ECI ($/Sq.Ft.)**
Existing Building	552.3	36.97	$30.34
With Proposed Retrofits	438.7	29.36	$21.87
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 systems 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 Hughes Water Treatment Plant & Washeteria was modeled using AkWarm© energy use software to establish a baseline space heating energy usage. Climate data from Hughes 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 Hughes. 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.

Table 4.1: Summary List of Recommended Energy Efficiency Measures Ranked by Economic Priority

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	Lighting: Exterior Incandescent	Replace with LED-equivalent light bulbs.	$130	$100	15.25	0.8	411.5
2	South Loop Heat Add	Lower temperature set point to 40 deg. F. $500 for lowering the temperature. $1000 for Operator Training.	$1,773	$1,500	14.83	0.8	3,499.7
3	Water Storage Tank	Lower Temperature set point to 36 deg. F. This should be acceptable if the tank mixer inside the water storage tank remains in operation. Turn off heat tape and use only for emergency purposes.	$1,139	$1,000	13.86	0.9	2,889.0
4	Lighting: Water Treatment Plant	Replace with direct-wire LED-equivalent light bulbs.	$282	$400	8.24	1.4	935.5
5	Loft Forced Air Handling Unit	Repair AHU Controls so that AHU only operates during occupied hours when necessary.	$2,559	$5,000	6.01	2.0	8,145.2
6	Setback Thermostat: Water Treatment Plant	Implement a Heating Temperature Unoccupied Setback to 50.0 deg F for the Water Treatment Plant space.	$554	$2,000	3.44	3.6	973.9

PRIORITY LIST – ENERGY EFFICIENCY MEASURES

Rank	Feature	Improvement Description	Annual Energy Savings	Installed Cost	Savings to Investment Ratio, SIR[1]	Simple Payback (Years)[2]	CO_2 Savings
7	Lighting: Washeteria	Replace with direct-wire LED-equivalent light bulbs and add new occupancy sensor	$256	$900	3.32	3.5	846.7
8	Lighting: Restrooms (Men's and Women's) Incandescent	Replace with LED-equivalent light bulbs.	$127	$600	2.47	4.7	419.7
9	Lighting - Combined Retrofit: Boiler Room	Replace with direct-wire LED-equivalent light bulbs and add new occupancy sensor	$129	$660	2.28	5.1	426.6
10	North Loop Heat Add	Lower temperature set point to 40 deg. F. $500 for lowering the temperature. $1000 for Operator Training.	$259	$1,500	2.17	5.8	512.2
11	Lighting - Combined Retrofit: Biomass Lights	Replace with direct-wire LED-equivalent light bulbs and add new occupancy sensor	$124	$980	1.49	7.9	394.5
12	Mechanical Room Heating System	Convert all heating loops into primary/secondary system with existing dryer boiler and a second new boiler of the same model. Move dryers, loft AHU, and hot water heating to the main heating system, replace hot water heater, use biomass boiler for the primary heating source of all operations. Repair Heat Recovery system in the power plant.	$15,472	$197,500	1.23	12.8	34,852.5
13	Lighting: Dryer Room	Replace with direct-wire LED-equivalent light bulbs.	$10	$100	1.22	9.6	34.5
14	Setback Thermostat: Washeteria	Implement a Heating Temperature Unoccupied Setback to 50.0 deg F for the Washeteria space.	$144	$2,000	0.89	13.9	273.5
15	Lighting: Water Treatment Plant – 2-Bulb Fixture and Hallway	Replace with direct-wire LED-equivalent light bulbs.	$17	$240	0.82	14.2	55.9

PRIORITY LIST – ENERGY EFFICIENCY MEASURES

Rank	Feature	Improvement Description	Annual Energy Savings	Installed Cost	Savings to Investment Ratio, SIR[1]	Simple Payback (Years)[2]	CO$_2$ Savings
16	Air Tightening	Replace and caulk windows, replace doors, add weather stripping to doors, set the WTP door in place, eliminate the stack for unused hot water heater upon completion of the mechanical room work, insulate around stack penetrations, permanently insulate old generator vent in the mechanical room.	$623	$12,500	0.44	20.1	1,177.7
17	Exterior Door: Water Treatment Plant Door	Remove existing door and install standard insulated metal door.	$29	$1,729	0.35	59.8	54.5
18	Exterior Door: Washeteria Door	Remove existing door and install standard insulated metal door.	$34	$2,017	0.35	59.9	63.6
19	Lighting - Power Retrofit: Restrooms (Men's and Women's) T8's	Replace with direct-wire LED-equivalent light bulbs	$5	$320	0.17	70.0	15.1
20	Lighting - Power Retrofit: Loft	Replace with direct-wire LED-equivalent light bulbs	$3	$240	0.17	70.1	11.3
21	Window/Skylight: Mechanical Room Window	Replace existing window with triple pane window.	$6	$1,082	0.08	186.3	11.1
22	Window/Skylight: Washeteria Windows (3)	Replace existing windows with triple pane window.	$17	$3,246	0.08	186.3	33.4
23	Window/Skylight: Water Treatment Plant Window (East)	Replace existing window with triple pane window.	$6	$1,082	0.08	186.3	11.1
24	Lighting - Power Retrofit: Plenum	Replace with direct-wire LED-equivalent light bulbs	$1	$100	0.08	143.0	2.3
25	Window/Skylight: Water Treatment Plant Window (South)	Replace existing window with triple pane window.	$5	$1,082	0.07	216.7	9.9
26	Other Electrical - Controls Retrofit: Water Storage Tank Mixer	Implement new Water Storage Tank for water quality purposes. This was installed in October 2016 as part of a sanitation effort.	-$7,842 + $500 Maint. Savings	$250	-344.59	999.9	24,851.6
	TOTAL, all measures		**$15,863 + $500 Maint. Savings**	**$238,127**	**1.07**	**14.6**	**31,209.2**

4.2 Interactive Effects of Projects

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

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

Interior lighting, plug loads, facility equipment, and occupants generate heat within the building. Lighting-efficiency improvements are anticipated to slightly increase heating requirements. Heating penalties were included in the lighting project analysis.

4.3 Building Shell Measures

4.3.1 Window Measures

Rank	Location	Size/Type, Condition	Recommendation
21	Window/Skylight: Mechanical Room Window	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	Replace existing window with triple pane window.

Installation Cost	$1,082	**Estimated Life of Measure (yrs)**	20	**Energy Savings ($/yr)**	$6
Breakeven Cost	$91	**Simple Payback (yrs)**	186	**Energy Savings (MMBTU/yr)**	0.2 MMBTU
		Savings-to-Investment Ratio	0.1		

Auditors Notes: Replacing the window will improve the insulation of the wall and reduce air leakage through the frame. This window is 31" x 26.5".

Rank	Location	Size/Type, Condition	Recommendation
22	Window/Skylight: Washeteria Windows (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	Replace existing window with triple pane window.

Installation Cost	$3,246	**Estimated Life of Measure (yrs)**	20	**Energy Savings ($/yr)**	$17
Breakeven Cost	$272	**Simple Payback (yrs)**	186	**Energy Savings (MMBTU/yr)**	0.6 MMBTU
		Savings-to-Investment Ratio	0.1		

Auditors Notes: Replacing the window will improve the insulation of the wall and reduce air leakage through the frame. Each window is 31" x 26.5".

Rank	Location	Size/Type, Condition	Recommendation
23	Window/Skylight: Water Treatment Plant Window (East)	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	Replace existing window with triple pane window.

Installation Cost	$1,082	**Estimated Life of Measure (yrs)**	20	**Energy Savings ($/yr)**	$6
Breakeven Cost	$91	**Simple Payback (yrs)**	186	**Energy Savings (MMBTU/yr)**	0.2 MMBTU
		Savings-to-Investment Ratio	0.1		

Auditors Notes: Replacing the window will improve the insulation of the wall and reduce air leakage through the frame. This window is 31” x 26.5”.

Rank	Location	Size/Type, Condition	Recommendation
25	Window/Skylight: Water Treatment Plant Window (South)	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	Replace existing window with triple pane window.

Installation Cost	$1,082	**Estimated Life of Measure (yrs)**	20	**Energy Savings ($/yr)**	$5
Breakeven Cost	$78	**Simple Payback (yrs)**	217	**Energy Savings (MMBTU/yr)**	0.2 MMBTU
		Savings-to-Investment Ratio	0.1		

Auditors Notes: Replacing the window will improve the insulation of the wall and reduce air leakage through the frame. This window is 31” x 26.5”.

4.3.2 Door Measures

Rank	Location	Size/Type, Condition	Recommendation
17	Exterior Door: Water Treatment Plant Door	Door Type: Entrance, Wood, solid core flush, 1-3/4" Modeled R-Value: 2.6	Remove existing door and install standard insulated metal door.

Installation Cost	$1,729	**Estimated Life of Measure (yrs)**	30	**Energy Savings ($/yr)**	$29
Breakeven Cost	$600	**Simple Payback (yrs)**	60	**Energy Savings (MMBTU/yr)**	1.0 MMBTU
		Savings-to-Investment Ratio	0.3		

Auditors Notes: Replacing the door will improve the overall insulation qualities and reduce air leakage through the door cracks. This door is 42” x 70”.

Rank	Location	Size/Type, Condition	Recommendation
18	Exterior Door: Washeteria Door	Door Type: Entrance, Wood, solid core flush, 1-3/4" Modeled R-Value: 2.6	Remove existing door and install standard insulated metal door.

Installation Cost	$2,017	**Estimated Life of Measure (yrs)**	30	**Energy Savings ($/yr)**	$34
Breakeven Cost	$700	**Simple Payback (yrs)**	60	**Energy Savings (MMBTU/yr)**	1.2 MMBTU
		Savings-to-Investment Ratio	0.3		

Auditors Notes: Replacing the door will improve the overall insulation qualities and reduce air leakage through the door cracks. This door is 36” x 70”.

4.3.3 Air Sealing Measures

Rank	Location	Existing Air Leakage Level (cfm@50/75 Pa)	Recommended Air Leakage Reduction (cfm@50/75 Pa)
16	Throughout the Building	Air Tightness estimated as: 4000 cfm at 50 Pascals	Add weather stripping to doors, caulk windows, insulate old generator vent, and eliminate unused stacks.

Installation Cost	$12,500	**Estimated Life of Measure (yrs)**	10	**Energy Savings ($/yr)**	$623
Breakeven Cost	$5,449	**Simple Payback (yrs)**	20	**Energy Savings (MMBTU/yr)**	21.8 MMBTU
		Savings-to-Investment Ratio	0.4		

Auditors Notes: The replacement of the doors and windows should include weather stripping of the doors and sealing of the windows, which will reduce the air leakage. The old generator vent in the mechanical room currently is covered by a piece of blue foam insulation with a wooden handle attached that is slid into the gap within the wall. Air exits through this insulation gap that is approximately 3 ft. x 3 ft. This hole needs to be permanently insulated and covered. With the proposed renovations to the mechanical room, there will be unused stacks that will allow air to enter the building. Removing these stacks during the renovation and insulating over the hole will make the building tighter.

4.4 Mechanical Equipment Measures

4.4.1 Heating/ Domestic Hot Water Measure

Rank	Recommendation
12	Convert all heating loops into primary/secondary system with existing dryer boiler and a second new boiler of the same model. Move dryers, loft AHU, and hot water heating to the main heating system, replace hot water heater, use biomass boiler for the primary heating source of all operations. Repair Heat Recovery system in the power plant.

Installation Cost	$197,500	**Estimated Life of Measure (yrs)**	20	**Energy Savings ($/yr)**	$15,472
Breakeven Cost	$242,448	**Simple Payback (yrs)**	13	**Energy Savings (MMBTU/yr)**	83.6 MMBTU
		Savings-to-Investment Ratio	1.2		

Auditors Notes: The existing two oil-fired boilers (Boiler B-1 and B-2, 125 MBH each) were installed with the original water treatment plant construction in 1988. These two boilers were sized for the space heating, north loop, and school service lines. There is one dedicated oil fired boiler (B-3) for the dryer operation that is isolated from B-1 and B-2. Since the construction of the water treatment plant there has been the addition of the south loop and the water storage tank, which has caused the existing boilers to be undersized. It is recommended to replace the existing 125 MBH boilers with one 350 MBH boiler and tie this together with the dryer boiler by creating a primary-secondary system to meet the new water treatment plant heating demand Use the biomass boiler as the primary heating option and the fuel oil boilers as necessary. The fuel day tank and the glycol makeup tank will be relocated as necessaryto accommodate installation of new boiler.

There are two Bock 100 gallon independent hot water heaters that are used for domestic hot water purposes. One of them is inoperable and has been salvaged for the burner. The other heater is rated for 277 MBH. Demolish both existing fuel fired hot water heaters and install a new 125 gallon, 100 MBH indirect water heater. With the installation of a new boiler and a new primary-secondary system, the installation of an indirect-hot water heater into the expanded heating loop will allow the biomass boiler to cover the domestic hot water loads as available.

With the implementation of a primary-secondary system, the existing building primary heat circulation pumps will be inadequately sized for the expanded heating loop. Install new Magna3 VFD pumps to accommodate the mechanical room renovations.

All of the boiler replacement and heating loop renovation work will require a stamped drawing from an engineer and a permit from a fire marshal. This has been budgeted into the cost estimate. Also, if the boiler replacement includes any boiler that is rated for 600,000 BTUh or higher, the mechanical room will have to be inspected to determine if the walls are approved for a 1-hour fire rating.

The dryer circulation pump was operating constantly during the site visit despite the dryers not being in use. Add controls to operate the dryer pump on demand when the dryer is in use.

During the site visit, glycol leaks were observed in the mechanical room. This can reduce the efficiency of the heating system and cause operational problems. Repairs to the piping should be made as soon as possible for operational and energy concerns.

Replace the existing shower heads with new, low-flow shower heads to reduce the hot water demand.

The heat recovery system froze and ruptured in winter 2015. Repair the heat recovery system by installing new piping and sight glass and add insulation to the pipe. Install electric heat tape in water pipes from water main to power plant for freeze protection and thaw recovery. The water piping for the heat recovery either needs to be insulated further or moved from the radiator room to a warmer section of the building. An alternative option is to insulate the radiator room, though the radiator vents allow significant air penetration into the space, which can cause freezing problems during the winter months.

Boiler Replacement: $75,000
Primary-Secondary Conversion: $40,000
Hot Water Heater Replacement: $40,000
Building Heat Pump Replacement: $5,000
Glycol leak repairs: $2,000
Shower Head Replacement: $500
Heat Recovery System Repairs: $35,000

Totals: $197,500

4.4.2 Night Setback Thermostat Measures

Rank	**Building Space**			**Recommendation**	
6	Water Treatment Plant			Implement a Heating Temperature Unoccupied Setback to 50.0 deg F for the Water Treatment Plant space.	
Installation Cost	$2,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$554
Breakeven Cost	$6,880	**Simple Payback (yrs)**	4	**Energy Savings (MMBTU/yr)**	20.4 MMBTU
		Savings-to-Investment Ratio	3.4		
Auditors Notes: Lower the building temperature to 50 deg. F to reduce heating costs during unoccupied times.					

Rank	**Building Space**			**Recommendation**	
14	Washeteria			Implement a Heating Temperature Unoccupied Setback to 50.0 deg F for the Washeteria space.	
Installation Cost	$2,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$144
Breakeven Cost	$1,783	**Simple Payback (yrs)**	14	**Energy Savings (MMBTU/yr)**	5.0 MMBTU
		Savings-to-Investment Ratio	0.9		
Auditors Notes: Lower the building temperature to 50 deg. F to reduce heating costs during unoccupied times.					

4.5 Electrical & Appliance Measures

4.5.1 Lighting Measures

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

4.5.1a Lighting Measures – Replace Existing Fixtures/Bulbs

Rank	**Location**	**Existing Condition**		**Recommendation**	
1	Exterior Incandescent	INCAN A Lamp, Std 60W		Replace with LED 12W Module StdElectronic	
Installation Cost	$100	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$130
Breakeven Cost	$1,525	**Simple Payback (yrs)**	1	**Energy Savings (MMBTU/yr)**	0.6 MMBTU
		Savings-to-Investment Ratio	15.3		
Auditors Notes: There is a single fixture with a single incandescent 60W light bulb to be replaced.					

Rank	**Location**	**Existing Condition**		**Recommendation**	
4	Water Treatment Plant	5 FLUOR (4) T8 4' F32T8 25W Energy-Saver Instant StdElectronic		Replace with 5 LED (2) 17W Module StdElectronic	
Installation Cost	$400	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$282
Breakeven Cost	$3,297	**Simple Payback (yrs)**	1	**Energy Savings (MMBTU/yr)**	0.5 MMBTU
		Savings-to-Investment Ratio	8.2		
Auditors Notes: There are five fixtures with four T8 4ft. fluorescent fixtures to be replaced with two LED direct-wire equivalent light bulbs for a total of ten light bulbs to be installed.					

Rank	Location	Existing Condition	Recommendation
7	Washeteria	5 FLUOR (3) T8 4' F32T8 25W Energy-Saver Instant StdElectronic	Replace with 5 LED (2) 17W Module StdElectronic and Remove Manual Switching and Add new Occupancy Sensor

Installation Cost	$900	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$256
Breakeven Cost	$2,986	**Simple Payback (yrs)**	4	**Energy Savings (MMBTU/yr)**	0.4 MMBTU
		Savings-to-Investment Ratio	3.3		

Auditors Notes: There are five fixtures with three T8 4ft. fluorescent fixtures to be replaced with two LED direct-wire equivalent light bulbs for a total of ten light bulbs to be installed.

Rank	Location	Existing Condition	Recommendation
8	Restrooms (Men's and Women's) Incandescent	12 INCAN A Lamp, Std 60W with Occupancy Sensor	Replace with 12 LED 12W Module StdElectronic

Installation Cost	$600	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$127
Breakeven Cost	$1,480	**Simple Payback (yrs)**	5	**Energy Savings (MMBTU/yr)**	0.2 MMBTU
		Savings-to-Investment Ratio	2.5		

Auditors Notes: There are 12 fixtures with a single incandescent 60W light bulb in each fixture for a total of 12 light bulbs to be replaced.

Rank	Location	Existing Condition	Recommendation
9	Boiler Room	2 FLUOR (4) T8 4' F32T8 25W Energy-Saver Instant StdElectronic	Replace with 2 LED (2) 17W Module StdElectronic and Remove Manual Switching and Add new Occupancy Sensor

Installation Cost	$660	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$129
Breakeven Cost	$1,503	**Simple Payback (yrs)**	5	**Energy Savings (MMBTU/yr)**	0.2 MMBTU
		Savings-to-Investment Ratio	2.3		

Auditors Notes: There are two fixtures with four T8 4ft. fluorescent fixtures to be replaced with two LED direct-wire equivalent light bulbs for a total of four light bulbs to be installed.

Rank	Location	Existing Condition	Recommendation
11	Biomass Lights	6 FLUOR (2) T8 4' F32T8 25W Energy-Saver Instant StdElectronic	Replace with 6 LED (2) 17W Module StdElectronic and Remove Manual Switching and Add new Occupancy Sensor

Installation Cost	$980	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$124
Breakeven Cost	$1,462	**Simple Payback (yrs)**	8	**Energy Savings (MMBTU/yr)**	0.6 MMBTU
		Savings-to-Investment Ratio	1.5		

Auditors Notes: There are six fixtures with two T8 4ft. fluorescent fixtures in each fixture for a total of 12 light bulbs to be installed. Install an occupancy sensor to reduce the usage of lights to occupied times only.

Rank	Location	Existing Condition	Recommendation
13	Dryer Room	2 INCAN A Lamp, Std 60W	Replace with 2 LED 12W Module StdElectronic

Installation Cost	$100	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$10
Breakeven Cost	$122	**Simple Payback (yrs)**	10	**Energy Savings (MMBTU/yr)**	0.0 MMBTU
		Savings-to-Investment Ratio	1.2		

Auditors Notes: There are two fixtures with a single incandescent 60 Watt light bulb in each fixture for a total of two light bulbs to be replaced.

Rank	Location	Existing Condition	Recommendation
15	Water Treatment Plant - 2 bulb fixture and hallway	3 FLUOR (2) T8 4' F32T8 25W Energy-Saver Instant StdElectronic	Replace with 3 LED (2) 17W Module StdElectronic

Installation Cost	$240	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$17
Breakeven Cost	$197	**Simple Payback (yrs)**	14	**Energy Savings (MMBTU/yr)**	0.0 MMBTU
		Savings-to-Investment Ratio	0.8		

Auditors Notes: There are three fixtures with two T8 4ft. fluorescent fixtures in each fixture for a total of six light bulbs to be installed.

Rank	Location	Existing Condition	Recommendation
19	Restrooms (Men's and Women's) T8's	4 FLUOR (2) T8 4' F32T8 25W Energy-Saver Instant StdElectronic with Occupancy Sensor	Replace with 4 LED (2) 17W Module StdElectronic

Installation Cost	$320	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$5
Breakeven Cost	$54	**Simple Payback (yrs)**	70	**Energy Savings (MMBTU/yr)**	0.0 MMBTU
		Savings-to-Investment Ratio	0.2		

Auditors Notes: There are four fixtures with two T8 4ft. fluorescent fixtures in each fixture for a total of eight light bulbs to be installed. Install an occupancy sensor to reduce the usage of lights to occupied times only.

Rank	Location	Existing Condition	Recommendation
20	Loft	3 FLUOR (2) T8 4' F32T8 25W Energy-Saver Instant StdElectronic	Replace with 3 LED (2) 17W Module StdElectronic

Installation Cost	$240	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$3
Breakeven Cost	$40	**Simple Payback (yrs)**	70	**Energy Savings (MMBTU/yr)**	0.0 MMBTU
		Savings-to-Investment Ratio	0.2		

Auditors Notes: There are three fixtures with two T8 4ft. fluorescent fixtures in each fixture for a total of six light bulbs to be installed.

Rank	Location	Existing Condition	Recommendation
24	Plenum	2 FLUOR CFL, Spiral 26 W	Replace with 2 LED 12W Module StdElectronic

Installation Cost	$100	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$1
Breakeven Cost	$8	**Simple Payback (yrs)**	143	**Energy Savings (MMBTU/yr)**	0.0 MMBTU
		Savings-to-Investment Ratio	0.1		

Auditors Notes: There are two fixtures with a single CFL spiral 26 Watt light bulb in each fixture for a total of two light bulbs to be replaced.

4.5.2 Other Electrical Measures

Rank	Location	Description of Existing	Efficiency Recommendation
26	Water Storage Tank Mixer	Water Storage Tank Mixer	Implement water storage tank mixer

Installation Cost	$250	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	-$7,842
Breakeven Cost	-$86,148	**Simple Payback (yrs)**	1000	**Energy Savings (MMBTU/yr)**	-37.7 MMBTU
		Savings-to-Investment Ratio	-344.6	**Maintenance Savings ($/yr)**	$500

Auditors Notes: The water storage tank mixer was installed to mix the chlorine with the water and reduce contact time in the tank. This was installed in October 2016 as part of a sanitation effort.

4.5.3 Other Measures

Rank	**Location**	**Description of Existing**		**Efficiency Recommendation**	
2		South Loop Heat Add		Lower temperature setpoint to 40 deg. F.	
Installation Cost	$1,500	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$1,773
Breakeven Cost	$22,248	**Simple Payback (yrs)**	1	**Energy Savings (MMBTU/yr)**	66.9 MMBTU
		Savings-to-Investment Ratio	14.8		

Auditors Notes: Reduce the set point to 40 deg. F to minimize the heating load for the circulation loop. $500 for lowering the temperature. $1000 for operator training.

Rank	**Location**	**Description of Existing**		**Efficiency Recommendation**	
3		Water Storage Tank		Lower Temperature set point to 36 deg. F. This should be acceptable if the tank mixer inside the water storage tank remains in operation. Turn off heat tape and use only for emergency purposes.	
Installation Cost	$1,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$1,139
Breakeven Cost	$13,863	**Simple Payback (yrs)**	1	**Energy Savings (MMBTU/yr)**	25.3 MMBTU
		Savings-to-Investment Ratio	13.9		

Auditors Notes: Reduce the set point to 36 deg. F to minimize the heating load for the circulation loop. This can be lowered to 36 deg. F because of the installation of the tank mixer. Also, turn off the heat tape and use only for emergency thaw purposes.

Rank	**Location**	**Description of Existing**		**Efficiency Recommendation**	
5		Loft Forced Air Handling Unit		Repair AHU Controls so that AHU only operates when necessary.	
Installation Cost	$5,000	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$2,559
Breakeven Cost	$30,049	**Simple Payback (yrs)**	2	**Energy Savings (MMBTU/yr)**	11.6 MMBTU
		Savings-to-Investment Ratio	6.0		

Auditors Notes: The air handling unit in the loft has no working controls and the fan operates constantly because it is wired directly into the electric outlet. This requires an electrician to install new controls such that the air handling unit fan only operates when heat is necessary in the washeteria room. The air handling unit can also be replumbed into the proposed combined heating loop.

Rank	**Location**	**Description of Existing**		**Efficiency Recommendation**	
10		North Loop Heat Add		Lower temperature set point to 40 deg. F.	
Installation Cost	$1,500	**Estimated Life of Measure (yrs)**	15	**Energy Savings ($/yr)**	$259
Breakeven Cost	$3,256	**Simple Payback (yrs)**	6	**Energy Savings (MMBTU/yr)**	9.8 MMBTU
		Savings-to-Investment Ratio	2.2		

Auditors Notes: Reduce the set point to 40 deg. F to minimize the heating load for the circulation loop. $500 for lowering the temperature. $1000 for operator training.

5. ENERGY EFFICIENCY ACTION PLAN

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

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

In the near future, a representative of ANTHC will be contacting the City of Hughes to follow up on the recommendations made in this report. Funding has been provided to ANTHC through a Rural Alaska Village Grant and the Denali Commission to provide the community with assistance in understanding the report and implementing the recommendations. ANTHC will work to complete the recommendations in the 2017.

APPENDICES

Appendix A – Energy Audit Report – Project Summary

ENERGY AUDIT REPORT – PROJECT SUMMARY

General Project Information

PROJECT INFORMATION	AUDITOR INFORMATION
Building: Hughes Water Treatment Plant & Washeteria	**Auditor Company:** ANTHC-DEHE
Address: P.O. Box 45029	**Auditor Name:** Kevin Ulrich, Kameron Hartvigson
City: Hughes	**Auditor Address:** 4500 Diplomacy Drive Anchorage, Ak 99508
Client Name: Arlo Beetus and John Cole	
Client Address: WTP	**Auditor Phone:** (907) 729-3237
	Auditor FAX:
Client Phone: (907) 889-2214	**Auditor Comment:** EMIT Certification
Client FAX:	

Design Data

Building Area: 1,872 square feet	**Design Space Heating Load:** Design Loss at Space: 49,760 Btu/hour with Distribution Losses: 52,379 Btu/hour Plant Input Rating assuming 82.0% Plant Efficiency and 25% Safety Margin: 79,846 Btu/hour Note: Additional Capacity should be added for DHW and other plant loads, if served.
Typical Occupancy: 2 people	**Design Indoor Temperature:** 60 deg F (building average)
Actual City: Hughes	**Design Outdoor Temperature:** -39.8 deg F
Weather/Fuel City: Hughes	**Heating Degree Days:** 14,942 deg F-days

Utility Information

Electric Utility: Hughes Power & Light Co	**Average Annual Cost/kWh:** $0.71/kWh

Annual Energy Cost Estimate

Description	Space Heating	Water Heating	Ventilation Fans	Clothes Drying	Lighting	Other Electrical	Water Circulation Heat	Tank Heat	Total Cost
Existing Building	$16,533	$331	$3	$2,047	$2,394	$15,564	$15,112	$4,812	**$56,797**
With Proposed Retrofits	$5,586	$315	$3	$1,834	$1,229	$23,406	$4,924	$3,638	**$40,934**
Savings	$10,947	$17	$0	$213	$1,166	-$7,842	$10,188	$1,174	**$15,863**

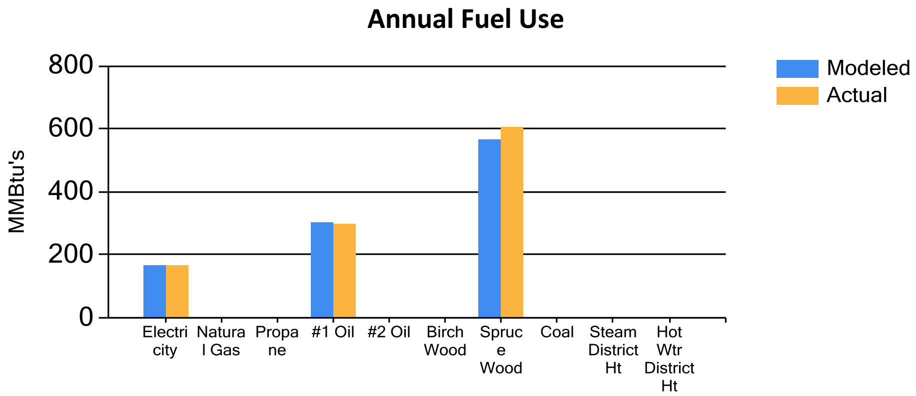
Building Benchmarks

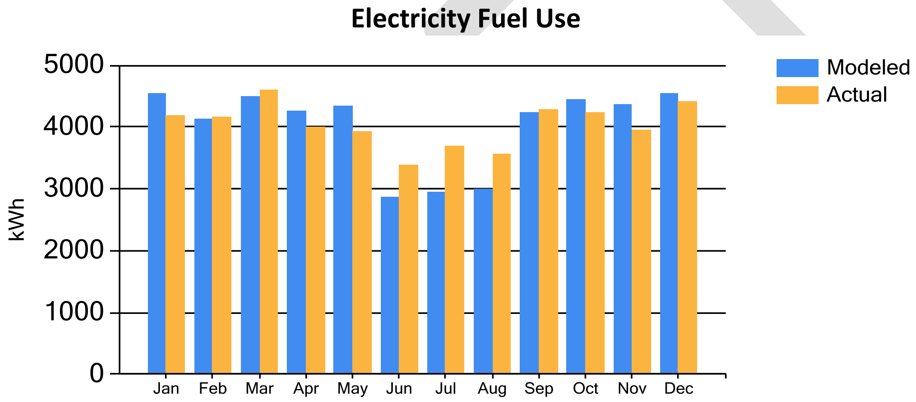
Description	EUI (kBtu/Sq.Ft.)	EUI/HDD (Btu/Sq.Ft./HDD)	ECI ($/Sq.Ft.)
Existing Building	552.3	36.97	$30.34
With Proposed Retrofits	438.7	29.36	$21.87

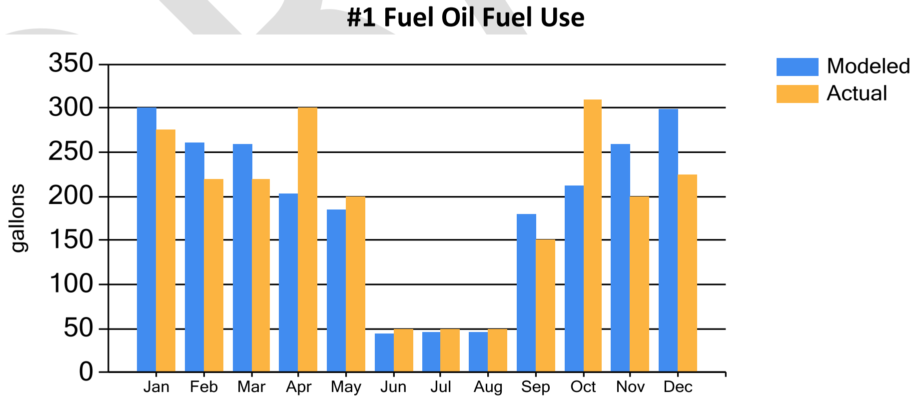
EUI: Energy Use Intensity - The annual site energy consumption divided by the structure's conditioned area.
EUI/HDD: Energy Use Intensity per Heating Degree Day.
ECI: Energy Cost Index - The total annual cost of energy divided by the square footage of the conditioned space in the building.

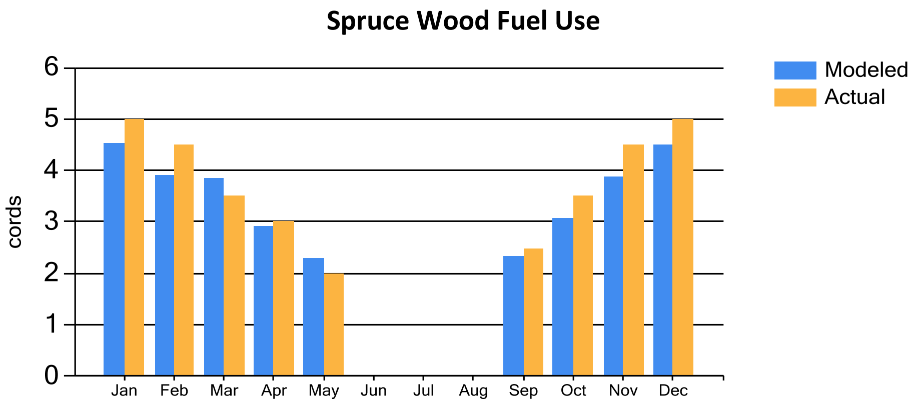
Appendix B – Actual Fuel Use versus Modeled Fuel Use

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









Spruce Wood Fuel Use

Appendix C - Electrical Demands

Estimated Peak Electrical Demand (kW)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Current	11.4	11.4	11.4	11.1	11.1	9.4	9.4	9.4	11.1	11.3	11.4	11.4
As Proposed	11.6	11.6	11.5	11.3	11.3	9.7	9.7	9.7	11.3	11.5	11.5	11.6

AkWarmCalc Ver 2.6.1.0, Energy Lib 8/9/2016