# Comprehensive Energy Audit
# For

# Kotzebue Water Treatment Plant

Prepared For

**City Of Kotzebue**

**May 11, 2016**

**Prepared By:**


**ANTHC-DEHE**
**4500 Diplomacy Dr, Suite 454**
**Anchorage, AK 99508**

# Table of Contents

# PREFACE

This energy audit was conducted using funds from the Denali Commission. Coordination with the City of Kotzebue 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 Kotzebue, Alaska. The authors of this report are Praveen K.C., Professional Engineer (P.E, CEM); Kevin Ulrich, Energy Manager-in-Training (EMIT); and Carl Remley, Certified Energy Manager (CEM)

The purpose of this report is to provide a comprehensive document of the findings and analysis that resulted from an energy audit conducted over two site visits in September 2015 and February 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 Kotzebue City Manager Derek Martin, Director of Public Works Randy Walker, Capital Projects Manager Jason Jessup, Building Maintenance Supervisor Billy Reich, Public Works Administrative Assistant Lorraine Honeycutt, Primary Water Treatment Plant Operator Matthew Lazarus, Secondary Water Treatment Plant Operator Olaf Walker, and Secondary Operator Ryan Snyder.

# 1. EXECUTIVE SUMMARY

This report was prepared for the City of Kotzebue. The scope of the audit focused on Kotzebue Water Treatment Plant. The scope of this report is a comprehensive energy study, which included an analysis of building shell, interior and exterior lighting systems, heating and ventilation systems, and plug loads.

In the near future, a representative of ANTHC will be contacting the City of Kotzebue to follow up on the recommendations made in this audit report. The City is pursuing funding to either retrofit the building with energy efficiency improvements or build a new water treatment plant. ANTHC will work with the City of Kotzebue to assess the future steps to be taken upon the completion of this report.

The total predicted energy cost for the Kotzebue Water Treatment Plant is $296,018 per year. Electricity represents the largest portion with an annual cost of approximately $194,242. This includes $83,247 paid by the city and $110,995 paid by the Power Cost Equalization (PCE) program through the State of Alaska. Fuel oil represents a large portion with an annual cost of approximately $87,114. Heat Recovery from the Kotzebue Electric Association (KEA) power plant represents the remaining portion of energy consumption with an annual cost of approximately $14,662 annually.

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 Kotzebue, the cost of electricity without PCE is $0.35/kWh and the cost of electricity with PCE is $0.15/kWh.

There is a heat recovery system that transfers heat from the generator cooling loops at the KEA power plant to the water distribution system at the Kotzebue Water Treatment Plant. The heat is injected directly into the Lagoon Loop distribution where the power plant is one of the furthest customers served on the loop. The heated water from the loop is then pumped back to the water treatment plant and mixed with the water for all of the loops prior to the pressure pumps. The heat recovery system operates on demand from the water treatment plant operators, who will call the power plant operators to request the desired level of heat for the water treatment plant. The system operates from November through April and effectively covers the entire water heating load for the community.

There is a solar photovoltaic (PV) array in the parking lot by the water treatment plant that is used to supplement the electricity for the water treatment plant as a whole. The array produces approximately 3000 kWh annually.

An energy audit report was also developed for the Kotzebue Pump House and Lift Stations. This report complements the water treatment plant energy audit and covers the waste disposal system and the water intake system. This report will be distributed separately from the Kotzebue Water Treatment Plant Report.

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

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

| Predicted Annual Fuel Use | | |
|---|---|---|
| **Fuel Use** | **Existing Building** | **With Proposed Retrofits** |
| Electricity | 554,977 kWh | 452,949 kWh |
| #1 Oil | 18,187 gallons | 14,311 gallons |
| Heat Recovery | 394.68 million Btu | 304.87 million Btu |

Benchmark figures facilitate comparing energy use between different buildings. Table 1.2 lists several benchmarks for the audited building. More details can be found in section 3.2.2.

**Table 1.2: Building Benchmarks for the Water Treatment Plant**

| Building Benchmarks | | | |
|---|---|---|---|
| **Description** | **EUI (kBtu/Sq.Ft.)** | **EUI/HDD (Btu/Sq.Ft./HDD)** | **ECI ($/Sq.Ft.)** |
| **Existing Building** | 722.9 | 45.09 | $45.63 |
| **With Proposed Retrofits** | 576.5 | 35.96 | $36.75 |
| EUI: Energy Use Intensity - The annual site energy consumption divided by the structure's conditioned area.<br>EUI/HDD: Energy Use Intensity per Heating Degree Day.<br>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 Kotzebue Water Treatment Plant. Listed are the estimates of the annual savings, installed costs, and two different financial measures of investment return.

**Table 1.3: Summary of Recommended Energy Efficiency Measures**

| PRIORITY LIST – ENERGY EFFICIENCY MEASURES | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Rank** | **Feature** | **Improvement Description** | **Annual Energy Savings** | **Installed Cost** | **Savings to Investment Ratio, SIR[1]** | **Simple Payback (Years)[2]** | **$CO_2$ Savings** |
| 1 | Other Electrical - Lagoon Circulation Pump | Shut off circulation pumps in the summer months. | $8,648 | $5,000 | 25.27 | 0.6 | 39,532.5 |
| 2 | Other Electrical - Swan Loop Circulation Pump | Shut off circulation pumps in the summer months. | $4,324 | $5,000 | 12.63 | 1.2 | 19,765.9 |
| 3 | Other Electrical - Central Circulation Pump | Shut off circulation pumps in the summer months. | $4,324 | $5,000 | 12.63 | 1.2 | 19,766.1 |
| 4 | Other Electrical -: Front Street Circulation Pump | Shut off circulation pumps in the summer months. | $4,324 | $5,000 | 12.63 | 1.2 | 19,765.9 |
| 5 | Heat Recovery | Lower Set points on Heat Recovery System | $3,336 | $5,000 | 8.68 | 1.5 | 5,208.9 |
| 6 | Other Electrical - Uptown Circulation Pump | Shut off circulation pumps in the summer months. | $2,883 | $5,000 | 8.42 | 1.7 | 13,177.6 |

| 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 | Other Electrical - New Tank Heat Add | Shut off heat tape and use only for emergency thaw purposes. | $571 | $1,000 | 8.35 | 1.7 | 2,612.4 |
| 8 | Lighting - Lift Station | Replace with new energy-efficient LED lighting. | $116 | $160 | 8.02 | 1.4 | 537.5 |
| 9 | Lighting - Exterior 150 HPS | Replace with new energy-efficient LED lighting. | $133 | $300 | 5.23 | 2.2 | 610.0 |
| 10 | Garage Door: Workshop Garage Door | Add insulating blanket to garage door. | $341 | $1,084 | 4.20 | 3.2 | 1,510.0 |
| 11 | Lighting - Water Plant Wrap Around Fluorescent T12 | Replace with new energy-efficient LED lighting. | $341 | $1,040 | 3.62 | 3.1 | 1,578.8 |
| 12 | Lighting - Office Lighting | Replace with new energy-efficient LED lighting. | $184 | $560 | 3.63 | 3.1 | 850.3 |
| 13 | Air Tightening: Exterior man and garage doors | Perform air sealing to reduce air leakage by 33%. | $5,464 | $20,000 | 2.51 | 3.7 | 24,197.0 |
| 14 | Cathedral Ceiling: WTP Roof 3.5 Inch Foam | Remove insulation in 2x6 cavity and replace with R-21 fiberglass batts | $1,053 | $10,224 | 2.38 | 9.7 | 4,662.8 |
| 15 | Above-Grade Wall: WTP Walls 6 Inch Batt | Remove old insulation and install R-21 fiberglass batts in 2x6 wall. | $835 | $8,930 | 2.17 | 10.7 | 3,698.0 |
| 16 | Cathedral Ceiling: WTP Roof 6 Inch | Remove insulation in 2x6 cavity and replace with R-21 fiberglass batts | $2,477 | $26,913 | 2.13 | 10.9 | 10,967.8 |
| 17 | Lighting - Exterior 70 watt HPS | Replace with new energy-efficient LED lighting. | $99 | $600 | 1.94 | 6.0 | 453.8 |
| 18 | Above-Grade Wall: WTP Walls 3.5 Inch Foam | Remove old insulation and install R-21 fiberglass batts in 2x6 wall. | $769 | $9,285 | 1.92 | 12.1 | 3,405.3 |
| 19 | Lighting - Water Plant Wrap Around Fluorescent T8 | Replace with new energy-efficient LED lighting. | $887 | $5,120 | 1.92 | 5.8 | 4,105.1 |
| 20 | Lighting - Lab | Replace with new energy-efficient LED lighting. | $135 | $800 | 1.87 | 5.9 | 625.6 |

| 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** |
| 21 | Heating, Ventilation, and Domestic Hot Water | Reduce boiler sizes to match current water treatment plant load. Convert generator heating from electric to hydronic by installing a small heat exchanger and pump along with a small pipe to circulate glycol from the engine to the heat exchanger. The heat exchanger would tie in to the existing building circulation heat. | $14,785 | $150,000 | 1.59 | 10.1 | 66,252.9 |
| 22 | Other Electrical - Public Works Circulation Pump | Shut off circulation pump during the summer months. | $44 | $500 | 1.02 | 11.5 | 199.1 |
| 23 | Exterior Door: Main Entrance | Remove existing door and install standard insulated door. | $526 | $12,921 | 0.94 | 24.6 | 2,327.9 |
| 24 | Cathedral Ceiling: WTP Roof 5.5 Inch Foam | Remove insulation in 2x6 cavity and replace with R-21 fiberglass batts | $669 | $16,681 | 0.93 | 24.9 | 2,961.1 |
| 25 | Lighting - Tank CFL | Replace with new energy-efficient LED lighting. | $11 | $150 | 0.85 | 13.1 | 53.2 |
| 26 | Lighting - Rest Room | Replace with new energy-efficient LED lighting. | $6 | $160 | 0.43 | 25.9 | 28.6 |
| 27 | Lighting - Boiler Room | Replace with new energy-efficient LED lighting. | $19 | $480 | 0.43 | 25.9 | 85.6 |
| 28 | Above-Grade Wall: WTP Walls 5.5 Inch Foam | Remove old insulation and install R-21 fiberglass batts in 2x6 wall. | $303 | $17,499 | 0.40 | 57.8 | 1,340.6 |
| 29 | Lighting - Generator Room | Replace with new energy-efficient LED lighting. | $5 | $480 | 0.11 | 103.1 | 21.5 |
| | **TOTAL, all measures** | | **$57,609** | **$314,888** | **2.79** | **5.5** | **250,301.4** |

***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 $57,609 per year, or 19.5% of the buildings' total energy costs. These measures are estimated to cost $314,888, for an overall simple payback period of 5.5 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** | **Lighting** | **Other Electrical** | **Raw Water Heat Add** | **Water Circulation Heat** | **Total Cost** |
| **Existing Building** | $53,515 | $426 | $7,456 | $163,985 | $55,974 | $14,662 | **$296,018** |
| **With Proposed Retrofits** | $33,411 | $426 | $4,820 | $138,208 | $50,219 | $11,326 | **$238,409** |
| **Savings** | $20,103 | $0 | $2,636 | $25,778 | $5,756 | $3,336 | **$57,609** |

# 2. AUDIT AND ANALYSIS BACKGROUND

## *2.1 Program Description*

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

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

1) Water Treatment Plant: 6,487 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 systems; 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.

The initial review of the building heating system by the energy audit engineers did not yield conclusive evidence as to exactly how the building consumes all of the fuel oil shown in the energy usage records. Since there was not heat add to the raw water intake to WTP, It was assumed that a combination of the building space heating system was a large source of additional heat to the water. Between the high rate of air leakage, the damaged insulation, and the large volumes of open water within the building, the various building heating systems act in coordination to consume 18,187 gallons of fuel annually.

# 3. Kotzebue Water Treatment Plant

## *3.1. Building Description*

The 6,487 square foot Kotzebue Water Treatment Plant was constructed in 1976, with a normal occupancy of 3 people. The number of hours of operation for this building average 9 hours per day, considering all seven days of the week.

The Kotzebue Water Treatment Plant serves as the water distribution center for the residents of the city. The facility includes all processes for water treatment, filtration, and distribution. A lift station is also present in the building and serves as part of the sewer components.

The Kotzebue Water Treatment Plant has five distribution loops that are used to provide water service to the community. All loops use buried HDPE pipe. The five loops are the Front Loop, Lagoon Loop, Central Loop, Uptown Loop, and the Swan Loop. The Southern Loop was a sixth distribution loop that has since been combined with the Front Loop. There is no direct heat-add system into any of the loops, but heat is provided via a heat recovery system into the Lagoon Loop, where the heated return water is then distributed throughout all five loops. The Lagoon Loop uses both six-inch and eight-inch HDPE pipe and is approximately 22,735 linear feet long. This loop serves the southern part of the city. The Front Loop uses eight-inch HDPE pipe for approximately 9,265 linear feet. The Front Loop also has four-inch PVC pipe from the old Southern Loop that runs approximately 9,333 linear feet. The Front Loop runs for a total of 18,588 linear feet and serves the western side of the city (where Front Street is located) and the southwestern part of the city. The Central Loop uses eight-inch HDPE pipe and is approximately 11,030 linear feet long. This loop serves the central region of the city. The Uptown Loop uses eight-inch HDPE and is approximately 11,275 linear feet long. This loop serves the northern part of the city. The Swan Loop uses six-inch HDPE pipe and is approximately 13,124 linear feet long. The loop serves the eastern part of the city.

Water is pumped into the pump house at Devil's Lake approximately three miles from the water treatment plant building. From the pump house, the water is transported through a buried pipe to the water treatment plant where it is injected with a variety of chemicals before entering the water filtration process. The water is injected with potassium permanganate, chlorine, powdered activated carbon, aluminum sulfate hydrate, polymer, sodium carbonate, and CM 133. The water goes through a large settlement tank, known as the "surge tank," where the water and aluminum sulfate hydrate is allowed to have proper contact time.

**Figure 1: Surge Tank used for mixing Aluminum Sulfate Hydrate into the water.**

After the water exits the surge tank, it is pumped into two large open-roofed filter tanks that process all the treated water before sending it to the distribution loops.


**Figure 2: Three photos showing one of two open filter process tanks.**

**<u>Description of Building Shell</u>**

The exterior walls are constructed with 2x10 standard lumber with 16-inch spacing. Insulation throughout the building is very damaged with many pieces missing or falling off, water damage, and deterioration of the insulation after decades of exposure to the open air environment. Also, different sections of the building have variable amounts of wall insulation depending on when that section of the water treatment plant building was constructed. Details of the insulation damage can be seen in Figures 3,4, and 5. There is a total of approximately 5,835 square feet of wall space in the building. Of this total, approximately 1,517 square feet has 3.5 inches of polyurethane foam insulation, 2,859 square feet has 5.5 inches of polyurethane foam insulation, and 1,459 square feet has 6 inches of fiberglass batt insulation.

**Figure 3: Insulation damage on the wall near the water storage tank wall penetrations.**

**Figure 4: Visible holes in the wall insulation where air can leak directly to the outside.**


**Figure 5: Insulation damage along the door seam by the process room doors.**

The building has cathedral ceilings with multiple sections where the building was expanded. There is a total of approximately 6,585 square feet of ceiling space in the building. Of this total, approximately 1,251 square feet has 3.5 inches of polyurethane foam insulation, 2,041 square feet has 5.5 inches of polyurethane foam insulation, and 3,293 square feet has 6 inches of fiberglass batt insulation. The insulation throughout the entire building is very damaged with signs of missing pieces, broken chunks, and water damage. This damage is shown in Figures 6 and 7.

**Figure 6: Pieces of insulation are falling off from the ceiling by the raw water intake.**


**Figure 7: A panel of insulation is falling through the ceiling of the building.**

The building is built on grade with a concrete slab foundation. This slab was expanded as the building was expanded. Beneath the slab is approximately 1 inch of rigid foam insulation. There is approximately 6,487 square feet of floor space in the building.

There are five total windows in the building. Four windows are in the office area. In the office, there are two windows with split panes and double-paned glass. These two windows are each approximately 4ft x 4ft and have an area of approximately 16 square feet each. The third office window also has split panes and double-paned glass. This window is approximately 2ft x 4ft and has an area of approximately 8 square feet. A fourth window is broken with a plywood cover and is approximately 2ft x 4ft in dimension for 8 square feet in area. The three functioning windows in the office were left open at times during the site visit due to unseasonable warm temperatures but the operators insisted that the windows are typically closed throughout the year.

There are ten exterior doors in the water treatment plant building. Of the ten doors, there are three sets of double doors with insulated metal construction. Two of these double door sets are rarely used, located in the entryway and process room. The process room doors have significant air leakage through the uninsulated sides of the entrance. This is shown in Figure 8. The third set of double doors is in the water intake room and is used occasionally for direct access to the raw water supply and other maintenance issues. There is one insulated metal door in the boiler room that is rarely used. The main entrance has an uninsulated metal door in an arctic entryway with significant air leakage present. There is a single insulated metal door in the filter room and in the generator room. These two doors are used sparingly. In addition to the exterior doors, there are two large garage doors present in the building. There is one garage door in the generator room that is uninsulated and results in a large quantity of heat loss through the door because the room is unheated space. There is also a garage door in the workshop that is used for transporting chemicals and other equipment into the building.

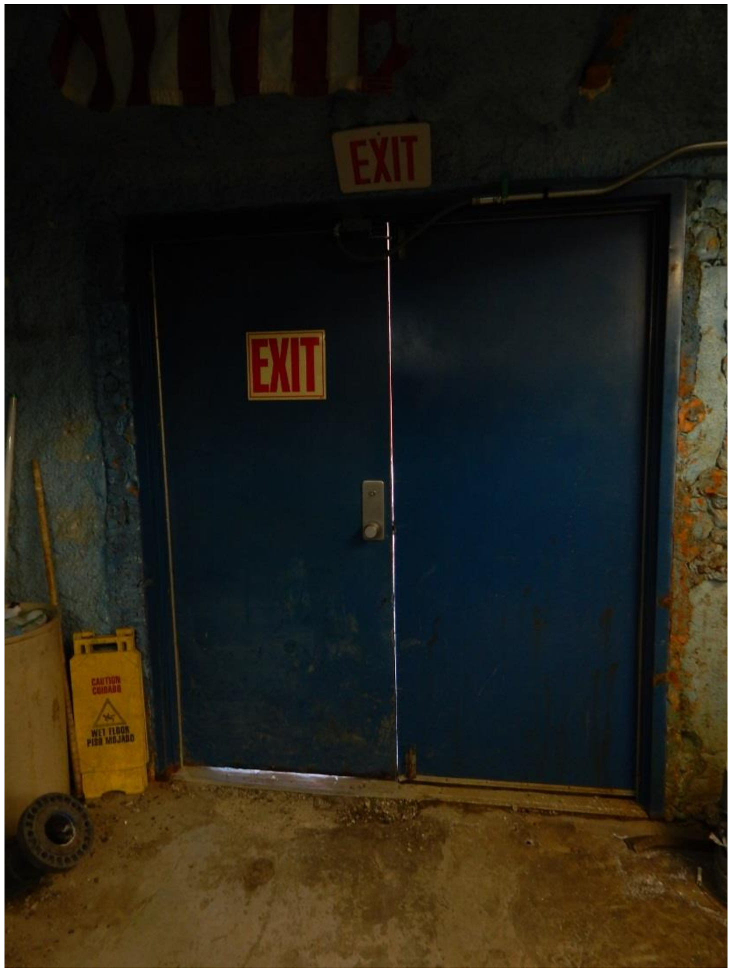



**Figure 8: Visible daylight can be seen through the raw water room doors where air tightening and weatherization needs to be implemented.**

## Description of Heating Plants

The heating plants used in the building are:

**Boiler 1 Weil McLean**

| | |
|---|---|
| Fuel Type: | #1 Oil |
| Input Rating: | 1,600,000 BTU/hr |
| Steady State Efficiency: | 78 % (approximate) |
| Idle Loss: | 2 % |
| Heat Distribution Type: | Glycol |
| Boiler Operation: | All Year |
| Notes: | 1999 Vintage with Beckett Model CF2300A 2 stage burners. This Boiler operates approximately 14.9% of the time. |

**Boiler 2 Weil McLean**

| | |
|---|---|
| Fuel Type: | #1 Oil |
| Input Rating: | 1,600,000 BTU/hr |

Steady State Efficiency: 78 % (approximate)
Idle Loss: 2 %
Heat Distribution Type: Glycol
Boiler Operation: All Year
Notes: 1999 Vintage with Beckett Model CF2300A 2 stage burners. This boiler operates approximately 13.3% of the time.

The two boilers are used for all space heating applications in the building. Additionally, while all of the water loops have heat-add systems, every loop heat-add is valved off such that there is no direct heat-add to the water in the entire plant. Instead, the water is heated through open-air exposure in the surge tank and filters, where unit heaters are operating continuously to meet the 70 deg. F set point. The unit heaters are unable to reach the set point because of the large mass of cold water, causing the heaters to run continuously. Due to the exposure of the water to the convective heating from the unit heaters, the water temperature is effectively raised during the filtration process by approximately 2 deg. F.

**Figure 9: Weil McLain boilers in the boiler room. These boilers are used for the space heating in the building.**

### Recovered Heat from Kotzebue Electric

Fuel Type: Recovered Heat
Input Rating: 1,000,000 BTU/hr
Steady State Efficiency: 95 %
Idle Loss: 0.5 %
Heat Distribution Type: Water
Boiler Operation: Nov – May

The water distribution loops are heated by a heat recovery system that transfers heat from the generator cooling loops at the Kotzebue Electric Association power plant. The heat is injected directly into the Lagoon Loop where it is transferred back to the water treatment plant and mixed with the entire distribution system prior to the pressure pumps. The amount of heat injected is determined by the requirements of the water treatment plant operator, who will call the power plant and request a level of heat to match the desired circulation temperatures. These changes happen 2-3 times per year on average.

All of the water distribution loops are monitored using a computer-based SCADA (supervisory control and data acquisition) system that is used to control the plant operations and provide information regarding the system performance. Currently, the temperature sensors for the SCADA system and the mechanical temperature sensors physically located on the pipe system do not match and the difference in temperature measurements between the two sensor types was observed to be as much as 5 deg. F. These sensors need to be recalibrated or replaced so that any future operations or energy efficiency measures can be performed safely without risk to the water quality or freezing temperatures. For the purpose of the energy audit, the mechanical sensor values were used because they generally indicated lower temperature values, making it the more conservative option.

**Chemical Treatment Hot Water Heater**

| | |
|---|---|
| Fuel Type: | Electricity |
| Input Rating: | 4800 Watts/hour |
| Steady State Efficiency: | 95 % |
| Idle Loss: | 1.5 % |
| Heat Distribution Type: | Water |
| Boiler Operation: | All Year |

This electric hot water heater is used to heat the water used in lab samples and testing process.

**Domestic Hot Water Heater**

| | |
|---|---|
| Fuel Type: | Electricity |
| Input Rating: | 4800 Watts/hour |
| Steady State Efficiency: | 95 % |
| Idle Loss: | 1.5 % |
| Heat Distribution Type: | Water |
| Boiler Operation: | All Year |

**Generator Block Heater**

| | |
|---|---|
| Fuel Type: | Electricity |
| Input Rating: | 2250 Watts/hour |
| Steady State Efficiency: | 100 % |
| Idle Loss: | 0 % |
| Heat Distribution Type: | Glycol |
| Boiler Operation: | All Year |


**Figure 10: Generator Block Heater**

There is a heat add system for the raw water line that was installed with the heat recovery system from the KEA power plant. The water treatment plant has the ability to add heat from the power plant directly to the raw water line if needed. According to KEA, this has not been used since its installation. Further use of this line can be investigated further if problems arise regarding the raw water intake line. In its current operational situation, the water treatment plant is not in need of this heat-add system.

## Space Heating Distribution Systems

There are 12 unit heaters in the water treatment plant that are used to provide space heat to the water treatment plant. The heaters are listed below with information on heat output, operational status, and location.

Unit Heater 1: 93 MBH rating, Raw Water Room

Unit Heater 2: 83.7 MBH rating, Process Room

Unit Heater 3: Eliminated during renovations.

Unit Heater 4: 123 MBH rating, Surge Tank Room, operates continuously to meet the heating demand due to the presence of the large volume water tank with no cover.

Unit Heater 5: 42.9 MBH rating, Garage, rarely used

Unit Heater 6: 130.9 MBH rating, Filter Room center, this operates as needed when the other heaters in the filter room are not capable of handling the full heating demand due to the large volume of water present in the two filters in the room.

Unit Heater 7: 42.9MBH rating, Filter Room corner, this operates as needed when the other heaters in the filter room are not capable of handling the full heating demand due to the large volume of water present in the two filters in the room.

Unit Heater 8: 42.6 MBH rating, Generator Room, not used

Unit Heater 9: 21.7 MBH rating, directly outside the Boiler Room, this heater runs continuously due to a bad switch.

Unit Heater 10: 106 MBH rating, Boiler Room

Unit Heater 11: 123.2 MBH rating, Pump Room, operates whenever the surge tank unit heater cannot meet the air heating demand.

Unit Heater 12: Eliminated during renovations.

Unit Heater 13: 45.6 MBH, Garage

Unit Heater 14: 125 MBH rating, Filter Room by exit corner, operates continuously to meet the heating demand due to the presence of the large volume of water in the two filters with no cover.

**Figure 11: Two photos showing the filtration room door seam with ice buildup due to the humidity from the filters. As a result of poor insulation and excessive air infiltration, the temperature at the door seam was 23 deg. F.**

## Domestic Hot Water System

There are two hot water heaters in the water treatment plant. One heater is used to provide domestic hot water to the building for the restroom and sinks. The second heater is used to heat water used for lab samples and chemical analysis in the lab inside the building. Both heaters are direct-fired units rated for approximately 4500 Watts.

## Heat Recovery Information

There is a heat recovery system that transfers heat from the generator cooling loops at the KEA power plant to the water distribution system at the Kotzebue Water Treatment Plant. The heat is injected directly into the Lagoon Loop distribution where the power plant is one of the furthest customers served on the loop. The heated water from the loop is then pumped back to the water treatment plant and mixed with the water for all of the loops prior to the pressure pumps. The heat recovery system operates on demand from the water treatment plant operators, who will call the power plant operators to request the desired level of heat for the water treatment plant. The system operates from November through April and effectively covers the entire water heating load for the community. Currently, the City of Kotzebue pays approximately $37.15 per million BTUh sold. This is the equivalent of approximately $4.98 per gallon of heating fuel.

## Description of Building Ventilation System

There is a mechanical ventilation system in the boiler room that is rarely used. The system has a mechanical exhaust fan that can blow air from the room directly outside in the event of an excessively high temperature in the room.

## Lighting

The water treatment plant has 64 fixtures with two T8 4ft. fluorescent light bulbs in each fixture. This includes 6 fixtures in the raw water intake room, 16 fixtures in the pump room, 22 fixtures in the filter room, 1 fixture in the hallway, 6 fixtures in the lower filter room, and 13 fixtures in the garage (the garage had 6 fixtures of two T8's, 2 fixtures of 2 T12's, 4 fixtures of 3 T8's, and 1 fixture of 3 T12's. These were all modeled as fixtures of two T8's for simplicity purposes). The lights are on approximately nine hours per day all year long and consume approximately 12,106 kWh annually.

The water treatment plant has 13 fixtures with two T12 4ft. fluorescent energy saver light bulbs in each fixture. The lights are on approximately nine hours per day all year long and consume approximately 3,128 kWh annually.

The office area has 7 fixtures with two T12 4ft. fluorescent energy saver light bulbs in each fixture. The bulbs are on approximately nine hours per day all year long and consume approximately 1,685 kWh annually.

The lab room has 5 fixtures with four T8 4ft. fluorescent light bulbs in each fixture. The lights are on approximately nine hours per day all year long and consume approximately 1,851 kWh annually.

The lift station has 2 fixtures with four T8 4ft. fluorescent light bulbs in each fixture. The lights are on approximately nine hours per day all year long and consume approximately 741 kWh annually.

The boiler room has 6 fixtures with two T8 4ft. fluorescent light bulbs in each fixture. The lights are on approximately two hours per day and consume approximately 252 kWh annually.

The generator room has 6 fixtures with two T8 4ft. fluorescent light bulbs in each fixture. The lights are on approximately 30 minutes per day and consume approximately 63 kWh annually.

The restroom has 2 fixtures with two T8 4ft. fluorescent light bulbs in each fixture. The lights consume approximately 84 kWh annually.

The water storage tank room has 3 fixtures with a single 15 Watt CFL lamp in each fixture. The lights are always on and consume approximately 395 kWh annually.

The exterior of the building has one 150 Watt High Pressure Sodium light and two 70 Watt High Pressure Sodium lights. All the lights run continuously during the winter months from October to May and combine to consume approximately 998 kWh annually.

**Plug Loads**

The water treatment plant 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**

There are circulation pumps on each distribution loop that are used to circulate the water throughout the city. Each loop has two pumps that are each rated for the same size and power demands. All loops run one pump continuously throughout the entire year. The circulation pump information can be seen in Table 3.1.

**Table 3.1: Circulation Loop Pump Information**

| Pump | Rating (HP) | Consumption (kWh) |
|---|---|---|
| Lagoon Loop Circulation Pumps | 15 | 78,473 |
| Front Street Loop Circulation Pumps | 7.5 | 39,237 |
| Central Loop Circulation Pumps | 7.5 | 39,237 |
| Swan Loop Circulation Pumps | 7.5 | 39,237 |
| Uptown Loop Circulation Pumps | 5 | 26,158 |

There is an array of four pressure pumps that are each rated for 7.5 HP. The plant will operate two pumps continuously on average with occasional periods of one pump used during low demand periods and three pumps used during high demand periods. Pressure is maintained by the pressure pumps continuously throughout the entire year. The pumps consume approximately 78,473 kWh annually.

There is a lift station pump in the section of the plant commonly referred to as “Lift Station Zero” that is used to pump sewage from the plant and surrounding facilities through the city sewer system to the sewage lagoon. The lift station pump is rated for 10 HP and operates approximately 25% of the time all year long. The pumps consume approximately 13,079 kWh annually.

There is a small circulation pump that is used to circulate water to the neighboring public works building. The pump runs continuously throughout the entire year and consumes approximately 395 kWh annually.

There is a group of pumps that are used for backwashing purpose that each operate approximately 30 minutes per day. The backwash supply pumps are used to pump water from the water storage tanks for use in the backwash process. These pumps are rated for 20 HP and consume approximately 2,180 kWh annually. The backwash-to-waste pumps are used to pump the backwash water out of the building to the wastewater processing after the backwash process has been completed. These pumps are rated for 20 HP and consume approximately 2,180 kWh annually. The surface wash pumps are used to wash the surface of the water in the filters to prevent contamination during the backwash process. The pumps are rated for 5 HP and consume approximately 545 kWh annually. The filter effluent pumps are used to pump the effluent and dirty water from the filter tanks. Two of these pumps run during the backwash process and each is rated for 10 HP. The pumps consume approximately 2,180 kWh annually. There are two filter mixing pumps that are used to mix the water in the two large filter tanks. Both pumps run continuously and consume approximately 4,366 kWh annually.

The office has a variety of equipment, including a refrigerator, that operates throughout the year and consumes approximately 1,315 kWh annually.

There are two air compressors that are used to provide pressurized air for the pneumatic valves in the water treatment plant. The compressors maintain 100psi air pressure inside the tanks and the pressure is reduced to 70 psi for use in the building. There is also an air dryer present that is used to remove excess moisture from the air around the filters. The compressors operate approximately 20% of the time all year long and consume approximately 2,966 kWh annually.

There is a heat tape that runs from the building to the water storage tank that is used to heat the water line. The heat tape operates continuously and the operators had no knowledge of where the controls for the heat tape were located. The heat tape consumes approximately 1,683 kWh annually.

There is an air scour that used to remove air from the water prior to being distributed. The scour runs approximately 30 minutes per day and consumes approximately 1,639 kWh annually.

There are a number of chemical mixing and injection pumps used to treat the water before the filters. The pumps all run continuously throughout the year except for the Aluminum Sulfate Hydrate Pump, which operates approximately one hour per day. The list of chemical pumps in the building can be seen in Table 3.2.

**Table 3.2: Chemical Pump Information**

| Pump | Rating (Watts) | Annual Consumption (kWh) |
|---|---|---|
| Potassium Permanganate Mixing Pump | 249 | 2,183 |
| Potassium Permanganate Injection Pump | 43 | 377 |
| Chlorine Mixing Pump | 420 | 3,682 |
| Powdered Activated Carbon Mixing Pump | 375 | 3,287 |
| Aluminum Sulfate Hydrate Pump and Fan | 625 | 228 |
| Polymer Injection Pump | 265 | 2,323 |
| Sodium Carbonate Mixing Pump | 187 | 1,639 |
| CM133 Mixing Pump | 375 | 3,287 |
| Chemical Exhaust Blower | 75 | 658 |
| Miscellaneous Pumps | 400 | 3,506 |

There is a computer SCADA system that is used to operate and maintain the water treatment plant. The sensors need to be recalibrated as well as the mechanical sensors on the loops to verify the accuracy of the measurements. The system consumes approximately 5,260 kWh annually. There are also a variety of miscellaneous controls throughout the building that consume approximately 2,630 kWh annually.

There is a 45 kVa transformer that is used to convert the incoming three-phase power into useable single-phase power for much of the equipment in the water treatment plant. The transformer was calculated to use approximately 10,000 Watts in excess power and consume approximately 87,660 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 Kotzebue Electric Association (KEA) provides electricity to the residents of Kotzebue as well as all the commercial and public facilities.

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

**Table 3.3: Energy Rates for each Fuel Source**

| Average Energy Cost | |
|---|---|
| **Description** | **Average Energy Cost** |
| Electricity | $ 0.35/kWh |
| #1 Oil | $ 4.79/gallons |
| Heat Recovery | $ 37.15/million Btu |

## 3.2.1.1 Total Energy Use and Cost Breakdown

At current rates, City of Kotzebue pays approximately $296,018 annually for electricity and other fuel costs for the Kotzebue Water Treatment Plant.

Figure 12 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.

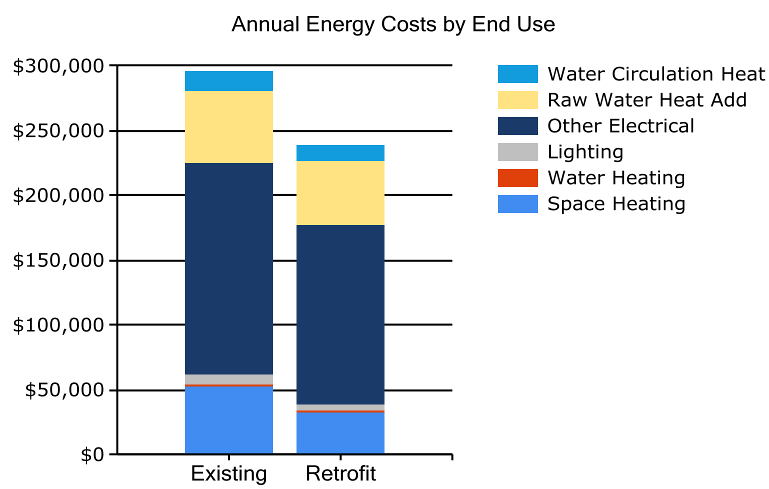



**Figure 12: Annual Energy Costs by End Use**

Figure 13 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.

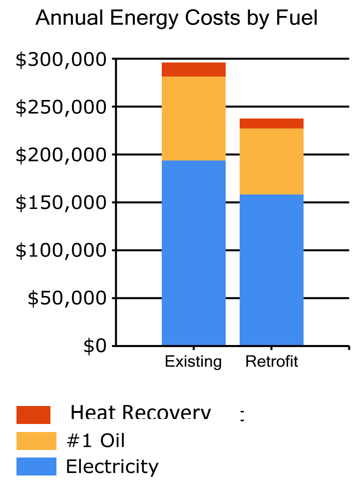



**Figure 13: Annual Energy Costs by Fuel Type**

Figure 14 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.

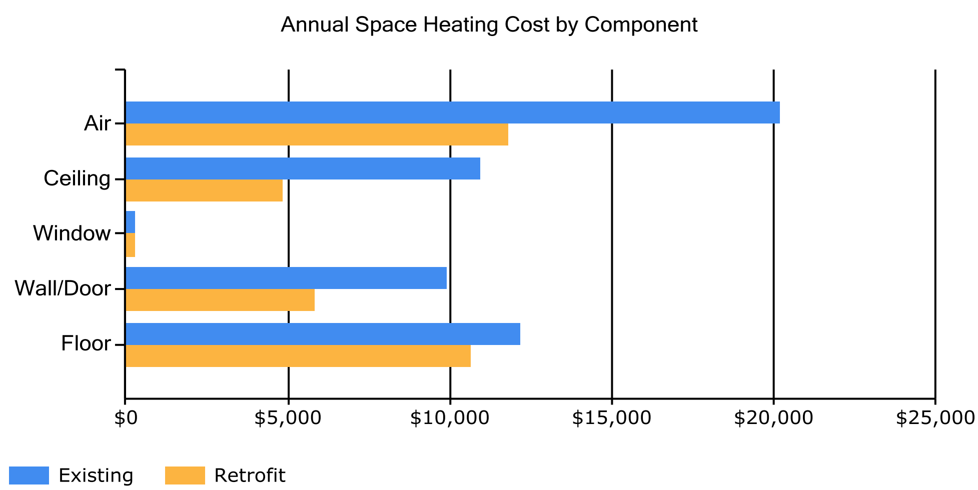



**Figure 14: Annual Space Heating Cost by Component**

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 3.4: Electrical Consumption by Category**

| Electrical Consumption (kWh) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sept** | **Oct** | **Nov** | **Dec** |
| Space Heating | 6293 | 5783 | 6074 | 5373 | 4810 | 4416 | 4530 | 4530 | 4495 | 5233 | 5659 | 6294 |
| DHW | 103 | 94 | 103 | 100 | 103 | 100 | 103 | 103 | 100 | 103 | 100 | 103 |
| Lighting | 1859 | 1694 | 1859 | 1799 | 1789 | 1668 | 1723 | 1723 | 1668 | 1859 | 1799 | 1859 |
| Other Electrical | 39766 | 36238 | 39766 | 38483 | 39766 | 38483 | 39766 | 39766 | 38483 | 39766 | 38483 | 39766 |
| Raw Water Heat Add | 73 | 71 | 69 | 48 | 17 | 0 | 0 | 0 | 0 | 33 | 54 | 75 |

**Table 3.5: Fuel Oil Consumption by Category**

| Fuel Oil #1 Consumption (Gallons) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sept** | **Oct** | **Nov** | **Dec** |
| Space Heating | 955 | 895 | 820 | 493 | 0 | 349 | 361 | 361 | 349 | 324 | 673 | 953 |
| Raw Water Heat Add | 1941 | 1892 | 1847 | 1267 | 420 | 0 | 0 | 0 | 0 | 866 | 1425 | 1995 |

**Table 3.6: Heat Recovery Consumption by Category**

| Heat Recovery Consumption (Million Btu) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sept** | **Oct** | **Nov** | **Dec** |
| Water Circulation Heat | 77 | 70 | 77 | 74 | 19 | 0 | 0 | 0 | 0 | 0 | 39 | 40 |

### 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 3.7 for details):

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

*Building Source EUI =* <u>*(Electric Usage in kBtu X SS Ratio + Fuel Oil Usage in kBtu X SS Ratio)*</u>
*Building Square Footage*
*where "SS Ratio" is the Source Energy to Site Energy ratio for the particular fuel.*

**Table 3.7: Kotzebue Water Treatment Plant EUI Calculations**

| Energy Type | Building Fuel Use per Year | Site Energy Use per Year, kBTU | Source/Site Ratio | Source Energy Use per Year, kBTU |
|---|---|---|---|---|
| Electricity | 554,977 kWh | 1,894,138 | 3.340 | 6,326,420 |
| #1 Oil | 18,187 gallons | 2,400,629 | 1.010 | 2,424,635 |
| Heat Recovery | 394.68 million Btu | 394,680 | 1.280 | 505,190 |
| **Total** | | **4,689,446** | | **9,256,245** |
| | | | | |
| BUILDING AREA | | 6,487 | Square Feet | |
| BUILDING SITE EUI | | 723 | kBTU/Ft²/Yr | |
| **BUILDING SOURCE EUI** | | 1,427 | **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: Kotzebue Water Treatment Plant Building Benchmarks**

| **Building Benchmarks** | | | |
|---|---|---|---|
| **Description** | **EUI (kBtu/Sq.Ft.)** | **EUI/HDD (Btu/Sq.Ft./HDD)** | **ECI ($/Sq.Ft.)** |
| **Existing Building** | **722.9** | **45.09** | **$45.63** |
| **With Proposed Retrofits** | **576.5** | **35.96** | **$36.75** |
| **EUI: Energy Use Intensity - The annual site energy consumption divided by the structure's conditioned area.**<br>**EUI/HDD: Energy Use Intensity per Heating Degree Day.**<br>**ECI: Energy Cost Index - The total annual cost of energy divided by the square footage of the conditioned space in the building.** | | | |

## *3.3 AkWarm© Building Simulation*

An accurate model of the building performance can be created by simulating the thermal performance of the walls, roof, windows and floors of the building. The HVAC system and central plant are modeled as well, accounting for the outside air ventilation required by the building and the heat recovery equipment in place.

The model uses local weather data and is trued up to historical energy use to ensure its accuracy. The model can be used now and in the future to measure the utility bill impact of all types of energy projects, including improving building insulation, modifying glazing, changing air handler schedules, increasing heat recovery, installing high efficiency boilers, using variable air volume air handlers, adjusting outside air ventilation and adding cogeneration systems.

For the purposes of this study, the Kotzebue Water Treatment Plant was modeled using AkWarm© energy use software to establish a baseline space heating and cooling energy usage. Climate data from Kotzebue was used for analysis. From this, the model was be calibrated to predict the impact of theoretical energy savings measures. Once annual energy savings from a particular measure were predicted and the initial capital cost was estimated, payback scenarios were approximated. Equipment cost estimate calculations are provided in Appendix D.

***Limitations of AkWarm© Models***

• The model is based on typical mean year weather data for Kotzebue. 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 cooling/heating loads across different parts of the building.

The energy balances shown in Section 3.1 were derived from the output generated by the AkWarm© simulations.

# 4. ENERGY COST SAVING MEASURES

## *4.1 Summary of Results*

The energy saving measures are summarized in Table 4.1. Please refer to the individual measure descriptions later in this report for more detail. This table is the same as Table 1.1. 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**

| Kotzebue Water Treatment Plant, Kotzebue, Alaska<br>PRIORITY LIST – ENERGY EFFICIENCY MEASURES | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Rank** | **Feature** | **Improvement Description** | **Annual Energy Savings** | **Installed Cost** | **Savings to Investment Ratio, SIR** | **Simple Payback (Years)** | **$CO_2$ Savings** |
| 1 | Other Electrical - Lagoon Circulation Pump | Shut off circulation pumps in the summer months. | $8,648 | $5,000 | 25.27 | 0.6 | 39,532.5 |
| 2 | Other Electrical - Swan Loop Circulation Pump | Shut off circulation pumps in the summer months. | $4,324 | $5,000 | 12.63 | 1.2 | 19,765.9 |
| 3 | Other Electrical - Central Circulation Pump | Shut off circulation pumps in the summer months. | $4,324 | $5,000 | 12.63 | 1.2 | 19,766.1 |
| 4 | Other Electrical -: Front Street Circulation Pump | Shut off circulation pumps in the summer months. | $4,324 | $5,000 | 12.63 | 1.2 | 19,765.9 |
| 5 | Heat Recovery | Lower set points on Heat Recovery System | $3,336 | $5,000 | 8.68 | 1.5 | 5,208.9 |

| Kotzebue Water Treatment Plant, Kotzebue, Alaska<br>PRIORITY LIST – ENERGY EFFICIENCY MEASURES | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Rank** | **Feature** | **Improvement Description** | **Annual Energy Savings** | **Installed Cost** | **Savings to Investment Ratio, SIR** | **Simple Payback (Years)** | **$CO_2$ Savings** |
| 6 | Other Electrical - Uptown Circulation Pump | Shut off circulation pumps in the summer months. | $2,883 | $5,000 | 8.42 | 1.7 | 13,177.6 |
| 7 | Other Electrical - New Tank Heat Add | Shut off heat tape and use only for emergency thaw purposes. | $571 | $1,000 | 8.35 | 1.7 | 2,612.4 |
| 8 | Lighting - Lift Station | Replace with new energy-efficient LED lighting. | $116 | $160 | 8.02 | 1.4 | 537.5 |
| 9 | Lighting - Exterior 150 HPS | Replace with new energy-efficient LED lighting. | $133 | $300 | 5.23 | 2.2 | 610.0 |
| 10 | Garage Door: Garage Doors | Add insulating blanket to garage door. | $341 | $1,084 | 4.20 | 3.2 | 1,510.0 |
| 11 | Lighting - Water Plant Wrap Around Fluorescent T12 | Replace with new energy-efficient LED lighting. | $341 | $1,040 | 3.62 | 3.1 | 1,578.8 |
| 12 | Lighting - Office Lighting | Replace with new energy-efficient LED lighting. | $184 | $560 | 3.63 | 3.1 | 850.3 |
| 13 | Air Tightening: Exterior man and garage doors | Perform air sealing to reduce air leakage by 33%. | $5,464 | $20,000 | 2.51 | 3.7 | 24,197.0 |
| 14 | Cathedral Ceiling: WTP Roof 3.5 Inch Foam | Remove insulation in 2x6 cavity and replace with R-21 fiberglass batts | $1,053 | $10,224 | 2.38 | 9.7 | 4,662.8 |
| 15 | Above-Grade Wall: WTP Walls 6 Inch Batt | Remove old insulation and install R-21 fiberglass batts in 2x6 wall. | $835 | $8,930 | 2.17 | 10.7 | 3,698.0 |
| 16 | Cathedral Ceiling: WTP Roof 6 Inch | Remove insulation in 2x6 cavity and replace with R-21 fiberglass batts | $2,477 | $26,913 | 2.13 | 10.9 | 10,967.8 |
| 17 | Lighting - Exterior 70 watt HPS | Replace with new energy-efficient LED lighting. | $99 | $600 | 1.94 | 6.0 | 453.8 |

| Kotzebue Water Treatment Plant, Kotzebue, Alaska<br>PRIORITY LIST – ENERGY EFFICIENCY MEASURES | | | | | | | |
|---|---|---|---|---|---|---|---|
| Rank | Feature | Improvement Description | Annual Energy Savings | Installed Cost | Savings to Investment Ratio, SIR | Simple Payback (Years) | $CO_2$ Savings |
| 18 | Above-Grade Wall: WTP Walls 3.5 Inch Foam | Remove old insulation and install R-21 fiberglass batts in 2x6 wall. | $769 | $9,285 | 1.92 | 12.1 | 3,405.3 |
| 19 | Lighting - Water Plant Wrap Around Fluorescent T8 | Replace with new energy-efficient LED lighting. | $887 | $5,120 | 1.92 | 5.8 | 4,105.1 |
| 20 | Lighting - Lab | Replace with new energy-efficient LED lighting. | $135 | $800 | 1.87 | 5.9 | 625.6 |
| 21 | Heating, Ventilation, and Domestic Hot Water | Reduce boiler sizes to match current water treatment plant load. Convert generator heating from electric to fuel oil by installing a small heat exchanger and pump along with a small pipe to circulate glycol from the engine to the heat exchanger. The heat exchanger would tie in to the existing building circulation heat. | $14,785 | $150,000 | 1.59 | 10.1 | 66,252.9 |
| 22 | Other Electrical - Public Works Circulation Pump | Shut off circulation pump during the summer months. | $44 | $500 | 1.02 | 11.5 | 199.1 |
| 23 | Exterior Door: Man Doors | Remove existing door and install standard insulated door. | $526 | $12,921 | 0.94 | 24.6 | 2,327.9 |
| 24 | Cathedral Ceiling: WTP Roof 5.5 Inch Foam | Remove insulation in 2x6 cavity and replace with R-21 fiberglass batts | $669 | $16,681 | 0.93 | 24.9 | 2,961.1 |
| 25 | Lighting - Tank CFL | Replace with new energy-efficient LED lighting. | $11 | $150 | 0.85 | 13.1 | 53.2 |
| 26 | Lighting - Rest Room | Replace with new energy-efficient LED lighting. | $6 | $160 | 0.43 | 25.9 | 28.6 |
| 27 | Lighting - Boiler Room | Replace with new energy-efficient LED lighting. | $19 | $480 | 0.43 | 25.9 | 85.6 |

| Kotzebue Water Treatment Plant, Kotzebue, Alaska<br>PRIORITY LIST – ENERGY EFFICIENCY MEASURES | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Rank** | **Feature** | **Improvement Description** | **Annual Energy Savings** | **Installed Cost** | **Savings to Investment Ratio, SIR** | **Simple Payback (Years)** | **$CO_2$ Savings** |
| 28 | Above-Grade Wall: WTP Walls 5.5 Inch Foam | Remove old insulation and install R-21 fiberglass batts in 2x6 wall. | $303 | $17,499 | 0.40 | 57.8 | 1,340.6 |
| 29 | Lighting - Generator Room | Replace with new energy-efficient LED lighting. | $5 | $480 | 0.11 | 103.1 | 21.5 |
| | **TOTAL, all measures** | | **$57,609** | **$314,888** | **2.79** | **5.5** | **250,301.4** |

## *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*

The following sections show all of the recommendations associated with the building shell. The recommendations are separated by section to compare the effects of each potential retrofit.

### *4.3.1 Insulation Measures*

| Rank | Location | Existing Type/R-Value | | | Recommendation Type/R-Value | |
|---|---|---|---|---|---|---|
| 14 | Cathedral Ceiling: WTP Roof 3.5 Inch Foam | Framing Type: Standard<br>Framing Spacing: 24 inches<br>Insulated Sheathing: None<br>Bottom Insulation Layer: Polyurethane (PLUR), 2 inches<br>Top Insulation Layer: None<br>Insulation Quality: Very Damaged<br>Modeled R-Value: 10 | | | Remove insulation in 2x6 cavity and replace with R-21 fiberglass batts | |
| **Installation Cost** | $10,224 | **Estimated Life of Measure (yrs)** | 30 | | **Energy Savings (/yr)** | $1,053 |
| **Breakeven Cost** | $24,383 | **Savings-to-Investment Ratio** | 2.4 | | **Simple Payback yrs** | 10 |
| Auditors Notes: The building insulation is aging, damaged, and does not provide adequate insulation for the winter conditions. Replace the existing insulation with 10 inches of R-21 fiberglass batt insulation with a proper inner cover. | | | | | | |

| Rank | Location | Existing Type/R-Value | | | Recommendation Type/R-Value | |
|---|---|---|---|---|---|---|
| 15 | Above-Grade Wall: WTP Walls 6 Inch Batt | Wall Type: Single Stud<br>Siding Configuration: Siding and Sheathing<br>Insul. Sheathing: None<br>Structural Wall: 2 x 10, 16 inches on center<br>R-11 Batt:FG or RW, 3.5 inches<br>Window and door headers: Not Insulated<br>Insulation Quality: Very Damaged<br>Modeled R-Value: 9.5 | | | Remove old insulation and install R-21 fiberglass batts in 2x6 wall. | |
| **Installation Cost** | $8,930 | **Estimated Life of Measure (yrs)** | 30 | | **Energy Savings (/yr)** | $835 |
| **Breakeven Cost** | $19,358 | **Savings-to-Investment Ratio** | 2.2 | | **Simple Payback yrs** | 11 |
| Auditors Notes: The building insulation is aging, damaged, and does not provide adequate insulation for the winter conditions. Replace the existing insulation with 10 inches of R-21 fiberglass batt insulation with a proper inner wall cover. | | | | | | |

| Rank | Location | Existing Type/R-Value | | | Recommendation Type/R-Value | |
|---|---|---|---|---|---|---|
| 16 | Cathedral Ceiling: WTP Roof 6 Inch | Framing Type: Standard<br>Framing Spacing: 24 inches<br>Insulated Sheathing: None<br>Bottom Insulation Layer: R-13 Batt:FG or RW, 3.63 inches<br>Top Insulation Layer: None<br>Insulation Quality: Very Damaged<br>Modeled R-Value: 10.6 | | | Remove insulation in 2x6 cavity and replace with R-21 fiberglass batts | |
| **Installation Cost** | $26,913 | **Estimated Life of Measure (yrs)** | 30 | | **Energy Savings (/yr)** | $2,477 |
| **Breakeven Cost** | $57,381 | **Savings-to-Investment Ratio** | 2.1 | | **Simple Payback yrs** | 11 |
| Auditors Notes: The building insulation is aging, damaged, and does not provide adequate insulation for the winter conditions. Replace the existing insulation with 10 inches of R-21 fiberglass batt insulation with a proper inner cover. | | | | | | |

| Rank | Location | | Existing Type/R-Value | | Recommendation Type/R-Value | |
|---|---|---|---|---|---|---|
| 18 | Above-Grade Wall: WTP Walls 3.5 Inch Foam | | Wall Type: Single Stud<br>Siding Configuration: Siding and Sheathing<br>Insul. Sheathing: None<br>Structural Wall: 2 x 10, 16 inches on center<br>Polyurethane (PLUR), 2 inches<br>Window and door headers: Not Insulated<br>Insulation Quality: Very Damaged<br>Modeled R-Value: 9.9 | | Remove old insulation and install R-21 fiberglass batts in 2x6 wall. | |
| **Installation Cost** | | $9,285 | **Estimated Life of Measure (yrs)** | 30 | **Energy Savings (/yr)** | $769 |
| **Breakeven Cost** | | $17,830 | **Savings-to-Investment Ratio** | 1.9 | **Simple Payback yrs** | 12 |
| Auditors Notes: The building insulation is aging, damaged, and does not provide adequate insulation for the winter conditions. Replace the existing insulation with 10 inches of R-21 fiberglass batt insulation with a proper inner wall cover. | | | | | | |

| Rank | Location | | Existing Type/R-Value | | Recommendation Type/R-Value | |
|---|---|---|---|---|---|---|
| 24 | Cathedral Ceiling: WTP Roof 5.5 Inch Foam | | Framing Type: Standard<br>Framing Spacing: 24 inches<br>Insulated Sheathing: None<br>Bottom Insulation Layer: Polyurethane (PLUR), 3.5 inches<br>Top Insulation Layer: None<br>Insulation Quality: Very Damaged<br>Modeled R-Value: 15.1 | | Remove insulation in 2x6 cavity and replace with R-21 fiberglass batts | |
| **Installation Cost** | | $16,681 | **Estimated Life of Measure (yrs)** | 30 | **Energy Savings (/yr)** | $669 |
| **Breakeven Cost** | | $15,488 | **Savings-to-Investment Ratio** | 0.9 | **Simple Payback yrs** | 25 |
| Auditors Notes: The building insulation is aging, damaged, and does not provide adequate insulation for the winter conditions. Replace the existing insulation with 10 inches of R-21 fiberglass batt insulation with a proper inner cover. | | | | | | |

| Rank | Location | | Existing Type/R-Value | | Recommendation Type/R-Value | |
|---|---|---|---|---|---|---|
| 28 | Above-Grade Wall: WTP Walls 5.5 Inch Foam | | Wall Type: Single Stud<br>Siding Configuration: Siding and Sheathing<br>Insul. Sheathing: None<br>Structural Wall: 2 x 10, 16 inches on center<br>Polyurethane (PLUR), 4 inches<br>Window and door headers: Not Insulated<br>Insulation Quality: Very Damaged<br>Modeled R-Value: 14.7 | | Remove old insulation and install R-21 fiberglass batts in 2x6 wall. | |
| **Installation Cost** | | $17,499 | **Estimated Life of Measure (yrs)** | 30 | **Energy Savings (/yr)** | $303 |
| **Breakeven Cost** | | $7,016 | **Savings-to-Investment Ratio** | 0.4 | **Simple Payback yrs** | 58 |
| Auditors Notes: The building insulation is aging, damaged, and does not provide adequate insulation for the winter conditions. Replace the existing insulation with 10 inches of R-21 fiberglass batt insulation with a proper inner wall cover. | | | | | | |

### *4.3.2 Door Measures*

| Rank | Location | | Size/Type, Condition | | Recommendation | |
|---|---|---|---|---|---|---|
| 10 | Garage Door: Garage Doors | | Door Type: 1-piece 8'x7' door, XPS core, 2"<br>Insulating Blanket: None<br>Modeled R-Value: 3.4 | | Add R-3.5 insulating blanket to garage door. | |
| **Installation Cost** | | $1,084 | **Estimated Life of Measure (yrs)** | 15 | **Energy Savings (/yr)** | $341 |
| **Breakeven Cost** | | $4,553 | **Savings-to-Investment Ratio** | 4.2 | **Simple Payback yrs** | 3 |
| Auditors Notes: The garage door in the generator room is not well insulated and cold air is constantly leaking into the building through this door. Add an insulating layer to the garage door to prevent further air leakage and lower the heating demand. | | | | | | |

| Rank | Location | | Size/Type, Condition | | Recommendation | |
|---|---|---|---|---|---|---|
| 23 | Exterior Door: Main Entrance | | Door Type: Entrance, Metal, EPS core, metal edge, no glass<br>Modeled R-Value: 2.7 | | Remove existing door and install standard pre-hung U-0.16 insulated door. | |
| **Installation Cost** | | $12,921 | **Estimated Life of Measure (yrs)** | 30 | **Energy Savings (/yr)** | $526 |
| **Breakeven Cost** | | $12,184 | **Savings-to-Investment Ratio** | 0.9 | **Simple Payback yrs** | 25 |
| Auditors Notes: The main doors are uninsulated and do not seal when closed. Replace the doors with insulated metal doors with a foam core to reduce the air penetration from the main entryway. | | | | | | |

### *4.3.3 Air Sealing Measures*

| Rank | Location | | Existing Air Leakage Level (cfm@50/75 Pa) | | Recommended Air Leakage Reduction (cfm@50/75 Pa) | |
|---|---|---|---|---|---|---|
| 13 | Exterior man and garage doors | | Air Tightness estimated as: 10000 cfm at 50 Pascals | | Perform air sealing to reduce air leakage by 33%. | |
| **Installation Cost** | | $20,000 | **Estimated Life of Measure (yrs)** | 10 | **Energy Savings (/yr)** | $5,464 |
| **Breakeven Cost** | | $50,222 | **Savings-to-Investment Ratio** | 2.5 | **Simple Payback yrs** | 4 |
| Auditors Notes: Add weather stripping and close the gaps in the main entrance and garage doors to prevent air leakage from entering the building. This will save on maintenance by reducing the moisture content inside the building and will reduce the heating demand by keeping the cold air outside of the building. | | | | | | |

## *4.4 Mechanical Equipment Measures*

The following sections show all of the recommendations associated with the mechanical equipment. The recommendations are separated by section to compare the effects of each potential retrofit.

### *4.4.1 Heating/ Domestic Hot Water Measure*

| Rank | Recommendation | | | | |
|---|---|---|---|---|---|
| 21 | Reduce boiler sizes to match current water treatment plant load. Convert generator heating from electric to fuel oil by installing a small heat exchanger and pump along with a small pipe to circulate glycol from the engine to the heat exchanger. The heat exchanger would tie in to the existing building circulation heat. | | | | |
| **Installation Cost** | $150,000 | **Estimated Life of Measure (yrs)** | 20 | **Energy Savings (/yr)** | $14,785 |
| **Breakeven Cost** | $239,167 | **Savings-to-Investment Ratio** | 1.6 | **Simple Payback yrs** | 10 |
| Auditors Notes: The current boilers are oversized and rarely used to half capacity at any given time. Replace both boilers with smaller models rated at approximately 800 MBH to reduce the heating fuel requirement of the boilers. Also, install a heated glycol line from the current heating distribution loop to the generator such that the generator may use the glycol line for preheating rather than the electric heating unit currently used. Keep the electric heating unit as a backup system. Finally, replace the two solenoid valves within the building to insure optimum operations of the plant. | | | | | |

## *4.5 Electrical Equipment Measures*

The following sections show all of the recommendations associated with electrical equipment shell. The recommendations are separated by section to compare the effects of each potential retrofit.

### 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 | |
|---|---|---|---|---|---|
| 8 | Lift Station | 2 FLUOR (4) T8 4' F32T8 32W Standard Instant StdElectronic | | Replace with new energy-efficient LED lighting. | |
| **Installation Cost** | $160 | **Estimated Life of Measure (yrs)** | 15 | **Energy Savings (/yr)** | $116 |
| **Breakeven Cost** | $1,283 | **Savings-to-Investment Ratio** | 8.0 | **Simple Payback yrs** | 1 |
| Auditors Notes: The room has two fixtures with two bulbs in each fixture for a total of four light bulbs to be replaced. | | | | | |

| Rank | Location | Existing Condition | | Recommendation | |
|---|---|---|---|---|---|
| 9 | Exterior 150 HPS | HPS 150 Watt Magnetic | | Replace with new energy-efficient LED lighting. | |
| **Installation Cost** | $300 | **Estimated Life of Measure (yrs)** | 15 | **Energy Savings (/yr)** | $133 |
| **Breakeven Cost** | $1,568 | **Savings-to-Investment Ratio** | 5.2 | **Simple Payback yrs** | 2 |
| Auditors Notes: Replace 150 watt HPS wallpack fixture with 25 watt LED wallpack fixture. | | | | | |

| Rank | Location | Existing Condition | | Recommendation | |
|---|---|---|---|---|---|
| 11 | Water Plant Wrap Around Fluorescent T12 | 13 FLUOR (2) T12 4' F40T12 34W Energy-Saver EfficMagnetic | | Replace with new energy-efficient LED lighting. | |
| **Installation Cost** | $1,040 | **Estimated Life of Measure (yrs)** | 15 | **Energy Savings (/yr)** | $341 |
| **Breakeven Cost** | $3,769 | **Savings-to-Investment Ratio** | 3.6 | **Simple Payback yrs** | 3 |
| Auditors Notes: There are 13 fixtures with two bulbs in each fixture for a total of 26 light bulbs to be replaced. | | | | | |

| Rank | Location | Existing Condition | | Recommendation | |
|---|---|---|---|---|---|
| 12 | Office Lighting | 7 FLUOR (2) T12 4' F40T12 34W Energy-Saver EfficMagnetic | | Replace with new energy-efficient LED lighting. | |
| **Installation Cost** | $560 | **Estimated Life of Measure (yrs)** | 15 | **Energy Savings (/yr)** | $184 |
| **Breakeven Cost** | $2,030 | **Savings-to-Investment Ratio** | 3.6 | **Simple Payback yrs** | 3 |
| Auditors Notes: The room has 7 fixtures with two bulbs in each fixture for a total of 14 light bulbs to be replaced. | | | | | |

| Rank | Location | Existing Condition | | Recommendation | |
|---|---|---|---|---|---|
| 17 | Exterior 70 watt HPS | 2 HPS 70 Watt Magnetic | | Replace with new energy-efficient LED lighting. | |
| **Installation Cost** | $600 | **Estimated Life of Measure (yrs)** | 15 | **Energy Savings (/yr)** | $99 |
| **Breakeven Cost** | $1,166 | **Savings-to-Investment Ratio** | 1.9 | **Simple Payback yrs** | 6 |
| Auditors Notes: Replace 70 watt HPS wallpack fixtures with 25 watt LED wallpack fixtures. There are two light bulbs to be replaced. | | | | | |

| Rank | Location | Existing Condition | | Recommendation | |
|---|---|---|---|---|---|
| 19 | Water Plant Wrap Around Fluorescent T8 | 64 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic | | Replace with new energy-efficient LED lighting. | |
| **Installation Cost** | $5,120 | **Estimated Life of Measure (yrs)** | 15 | **Energy Savings (/yr)** | $887 |
| **Breakeven Cost** | $9,843 | **Savings-to-Investment Ratio** | 1.9 | **Simple Payback yrs** | 6 |
| Auditors Notes: There are 64 fixtures with two bulbs in each fixture for a total of 128 light bulbs to be replaced. Some fixtures include more than two light bulbs but only two are necessary to meet adequate lighting requirements. | | | | | |

| Rank | Location | Existing Condition | | Recommendation | |
|---|---|---|---|---|---|
| 20 | Lab | 5 FLUOR (4) T8 4' F32T8 32W Standard Instant StdElectronic | | Replace with new energy-efficient LED lighting. | |
| **Installation Cost** | $800 | **Estimated Life of Measure (yrs)** | 15 | **Energy Savings (/yr)** | $135 |
| **Breakeven Cost** | $1,499 | **Savings-to-Investment Ratio** | 1.9 | **Simple Payback yrs** | 6 |
| Auditors Notes: There are five fixtures with four light bulbs in each fixture for 20 light bulbs to be replaced. | | | | | |

| Rank | Location | Existing Condition | | Recommendation | |
|---|---|---|---|---|---|
| 25 | Tank CFL | 3 FLUOR CFL, A Lamp 15W | | Replace with new energy-efficient LED lighting. | |
| **Installation Cost** | $150 | **Estimated Life of Measure (yrs)** | 15 | **Energy Savings (/yr)** | $11 |
| **Breakeven Cost** | $127 | **Savings-to-Investment Ratio** | 0.8 | **Simple Payback yrs** | 13 |
| Auditors Notes: Replace all 3 CFL lights with 10 Watt LED equivalents. | | | | | |

| Rank | Location | Existing Condition | | Recommendation | |
|---|---|---|---|---|---|
| 26 | Rest Room | 2 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic | | Replace with new energy-efficient LED lighting. | |
| **Installation Cost** | $160 | **Estimated Life of Measure (yrs)** | 15 | **Energy Savings (/yr)** | $6 |
| **Breakeven Cost** | $69 | **Savings-to-Investment Ratio** | 0.4 | **Simple Payback yrs** | 26 |
| Auditors Notes: There are 2 fixtures with two light bulbs in each fixture for a total of 4 light bulbs to be replaced. | | | | | |

| Rank | Location | Existing Condition | | Recommendation | |
|---|---|---|---|---|---|
| 27 | Boiler Room | 6 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic | | Replace with new energy-efficient LED lighting. | |
| **Installation Cost** | $480 | **Estimated Life of Measure (yrs)** | 15 | **Energy Savings (/yr)** | $19 |
| **Breakeven Cost** | $206 | **Savings-to-Investment Ratio** | 0.4 | **Simple Payback yrs** | 26 |
| Auditors Notes: There are 6 fixtures with 2 light bulbs in each fixture for a total of 12 light bulbs to be replaced. | | | | | |

| Rank | Location | Existing Condition | | Recommendation | |
|---|---|---|---|---|---|
| 29 | Generator Room | 6 FLUOR (2) T8 4' F32T8 32W Standard Instant StdElectronic | | Replace with new energy-efficient LED lighting. | |
| **Installation Cost** | $480 | **Estimated Life of Measure (yrs)** | 15 | **Energy Savings (/yr)** | $5 |
| **Breakeven Cost** | $52 | **Savings-to-Investment Ratio** | 0.1 | **Simple Payback yrs** | 103 |
| Auditors Notes: There are 6 fixtures with two light bulbs in each fixture for a total of 12 light bulbs to be replaced. | | | | | |

### *4.5.2 Other Electrical Measures*

| Rank | Location | Description of Existing | | Efficiency Recommendation | |
|---|---|---|---|---|---|
| 1 | Lagoon Circulation Pump | Water Circulation Pump | | Shut off circulation pumps during the summer months. | |
| **Installation Cost** | $5,000 | **Estimated Life of Measure (yrs)** | 20 | **Energy Savings (/yr)** | $8,648 |
| **Breakeven Cost** | $126,345 | **Savings-to-Investment Ratio** | 25.3 | **Simple Payback yrs** | 1 |
| Auditors Notes: The circulation pumps are primarily used to circulate the water to prevent the water from freezing. During the summer months, the risk of freezing is negligible and the pumps do not need to be in operation. In order to implement this recommendation safely, the temperature sensors both on the physical loop and for the SCADA system will need to be either recalibrated or replaced in order to have a verified, accurate temperature reading. Without the accurate readings, a reduction in circulation pump usage may lead to water freezing without properly functioning equipment installed. This effort will require testing, labor, training, and new materials. | | | | | |

| Rank | Location | Description of Existing | | Efficiency Recommendation | |
|---|---|---|---|---|---|
| 2 | Swan Loop Circulation Pump | Water Circulation Pump | | Shut off circulation pumps during the summer months. | |
| **Installation Cost** | $5,000 | **Estimated Life of Measure (yrs)** | 20 | **Energy Savings (/yr)** | $4,324 |
| **Breakeven Cost** | $63,171 | **Savings-to-Investment Ratio** | 12.6 | **Simple Payback yrs** | 1 |
| Auditors Notes: The circulation pumps are primarily used to circulate the water to prevent the water from freezing. During the summer months, the risk of freezing is negligible and the pumps do not need to be in operation. In order to implement this recommendation safely, the temperature sensors both on the physical loop and for the SCADA system will need to be either recalibrated or replaced in order to have a verified, accurate temperature reading. Without the accurate readings, a reduction in circulation pump usage may lead to water freezing without properly functioning equipment installed. This effort will require testing, labor, training, and new materials. | | | | | |

| Rank | Location | Description of Existing | | Efficiency Recommendation | |
|---|---|---|---|---|---|
| 3 | Central Circulation Pump | Water Circulation Pump | | Shut off circulation pumps during the summer months. | |
| **Installation Cost** | $5,000 | **Estimated Life of Measure (yrs)** | 20 | **Energy Savings (/yr)** | $4,324 |
| **Breakeven Cost** | $63,172 | **Savings-to-Investment Ratio** | 12.6 | **Simple Payback yrs** | 1 |

Auditors Notes: The circulation pumps are primarily used to circulate the water to prevent the water from freezing. During the summer months, the risk of freezing is negligible and the pumps do not need to be in operation. In order to implement this recommendation safely, the temperature sensors both on the physical loop and for the SCADA system will need to be either recalibrated or replaced in order to have a verified, accurate temperature reading. Without the accurate readings, a reduction in circulation pump usage may lead to water freezing without properly functioning equipment installed. This effort will require testing, labor, training, and new materials.

| Rank | Location | Description of Existing | | Efficiency Recommendation | |
|---|---|---|---|---|---|
| 4 | Front Street Circulation Pump | Water Circulation Pump | | Shut off circulation pumps during the summer months. | |
| **Installation Cost** | $5,000 | **Estimated Life of Measure (yrs)** | 20 | **Energy Savings (/yr)** | $4,324 |
| **Breakeven Cost** | $63,171 | **Savings-to-Investment Ratio** | 12.6 | **Simple Payback yrs** | 1 |

Auditors Notes: The circulation pumps are primarily used to circulate the water to prevent the water from freezing. During the summer months, the risk of freezing is negligible and the pumps do not need to be in operation. In order to implement this recommendation safely, the temperature sensors both on the physical loop and for the SCADA system will need to be either recalibrated or replaced in order to have a verified, accurate temperature reading. Without the accurate readings, a reduction in circulation pump usage may lead to water freezing without properly functioning equipment installed. This effort will require testing, labor, training, and new materials.

| Rank | Location | Description of Existing | | Efficiency Recommendation | |
|---|---|---|---|---|---|
| 6 | Uptown Circulation Pump | Water Circulation Pump | | Shut off circulation pumps during the summer months. | |
| **Installation Cost** | $5,000 | **Estimated Life of Measure (yrs)** | 20 | **Energy Savings (/yr)** | $2,883 |
| **Breakeven Cost** | $42,115 | **Savings-to-Investment Ratio** | 8.4 | **Simple Payback yrs** | 2 |

Auditors Notes: The circulation pumps are primarily used to circulate the water to prevent the water from freezing. During the summer months, the risk of freezing is negligible and the pumps do not need to be in operation. In order to implement this recommendation safely, the temperature sensors both on the physical loop and for the SCADA system will need to be either recalibrated or replaced in order to have a verified, accurate temperature reading. Without the accurate readings, a reduction in circulation pump usage may lead to water freezing without properly functioning equipment installed. This effort will require testing, labor, training, and new materials.

| Rank | Location | Description of Existing | | Efficiency Recommendation | |
|---|---|---|---|---|---|
| 7 | New Tank Heat Add | Heat Tape | | Shut off heat tape and use only for emergency thaw purposes. | |
| **Installation Cost** | $1,000 | **Estimated Life of Measure (yrs)** | 20 | **Energy Savings (/yr)** | $571 |
| **Breakeven Cost** | $8,349 | **Savings-to-Investment Ratio** | 8.3 | **Simple Payback yrs** | 2 |

Auditors Notes: The heat tape for the water storage tank was operating continuously during the site visit and it was evident that the operators had not paid attention to this before our arrival. The heat tape should only be used for emergency thaw purposes, so this tape can be turned off at all times and used only when needed to prevent the water from freezing.

| Rank | Location | | Description of Existing | | Efficiency Recommendation | |
|---|---|---|---|---|---|---|
| 22 | Public Works Circulation Pump | | Water Circulation Pump | | Shut off circulation pumps during the summer months. | |
| **Installation Cost** | $500 | **Estimated Life of Measure (yrs)** | 15 | | **Energy Savings (/yr)** | $44 |
| **Breakeven Cost** | $512 | **Savings-to-Investment Ratio** | 1.0 | | **Simple Payback yrs** | 11 |
| Auditors Notes: The circulation pumps are primarily used to circulate the water to prevent the water from freezing. During the summer months, the risk of freezing is negligible and the pumps do not need to be in operation. | | | | | | |

### *4.5.3 Other Measures*

| Rank | Location | | Description of Existing | | Efficiency Recommendation | |
|---|---|---|---|---|---|---|
| 5 | | | Water Circulation Heat Load | | Lower set points on Heat Recovery System | |
| **Installation Cost** | $5,000 | **Estimated Life of Measure (yrs)** | 15 | | **Energy Savings (/yr)** | $3,336 |
| **Breakeven Cost** | $43,388 | **Savings-to-Investment Ratio** | 8.7 | | **Simple Payback yrs** | 1 |
| Auditors Notes: The heat recovery system had temperature set points of 50 deg. F with a return temperature at approximately 35 deg. F. This can be lowered such that the outgoing temperature is 44 deg. F and the return temperature is 44 deg. F. | | | | | | |

# 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 Kotzebue to follow up on the recommendations made in this audit report. The City is pursuing funding to either retrofit the building with energy efficiency improvements or build a new water treatment plant. ANTHC will work with the City of Kotzebue to assess the future steps to be taken upon the completion of this report.

# APPENDICES

# Appendix A – Energy Audit Report – Project Summary

| ENERGY AUDIT REPORT – PROJECT SUMMARY | |
|---|---|
| **General Project Information** | |
| **PROJECT INFORMATION** | **AUDITOR INFORMATION** |
| **Building:** Kotzebue Water Treatment Plant | **Auditor Company:** ANTHC-DEHE |
| **Address:** PO Box 46 | **Auditor Name:** Carl Remley, Praveen KC, and Kevin Ulrich |
| **City:** Kotzebue | **Auditor Address:** 4500 Diplomacy Dr, Suite 454 Anchorage, AK 99508 |
| **Client Name:** Matt Lazarus | |
| **Client Address:** PO Box 46 Kotzebue, AK 99752 | **Auditor Phone:** (907) 729-3543 |
| | **Auditor FAX:** |
| **Client Phone:** (907) 442-5209 | **Auditor Comment:** |
| **Client FAX:** | |
| **Design Data** | |
| **Building Area:** 6,487 square feet | **Design Space Heating Load:** Design Loss at Space: 227,316 Btu/hour<br>with Distribution Losses: 239,279 Btu/hour<br>Plant Input Rating assuming 82.0% Plant Efficiency and 25% Safety Margin: 364,755 Btu/hour<br>Note: Additional Capacity should be added for DHW and other plant loads, if served. |
| **Typical Occupancy:** 3 people | **Design Indoor Temperature:** 60 deg F (building average) |
| **Actual City:** Kotzebue | **Design Outdoor Temperature:** -37 deg F |
| **Weather/Fuel City:** Kotzebue | **Heating Degree Days:** 16,032 deg F-days |
| **Utility Information** | |
| **Electric Utility:** Kotzebue Electric Association | **Average Annual Cost/kWh:** $0.350/kWh |

**Annual Energy Cost Estimate**

| Description | Space Heating | Water Heating | Lighting | Other Electrical | Raw Water Heat Add | Water Circulation Heat | Total Cost |
|---|---|---|---|---|---|---|---|
| **Existing Building** | $53,515 | $426 | $7,456 | $163,985 | $55,974 | $14,662 | **$296,018** |
| **With Proposed Retrofits** | $33,411 | $426 | $4,820 | $138,208 | $50,219 | $11,326 | **$238,409** |
| **Savings** | $20,103 | $0 | $2,636 | $25,778 | $5,756 | $3,336 | **$57,609** |

**Building Benchmarks**

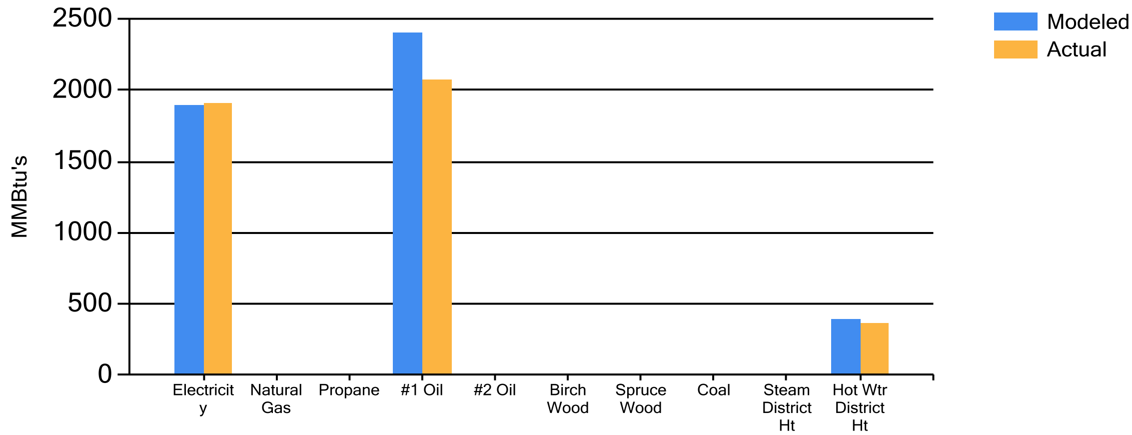
| Description | EUI (kBtu/Sq.Ft.) | EUI/HDD (Btu/Sq.Ft./HDD) | ECI ($/Sq.Ft.) |
|---|---|---|---|
| **Existing Building** | 722.9 | 45.09 | $45.63 |
| **With Proposed Retrofits** | 576.5 | 35.96 | $36.75 |

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.

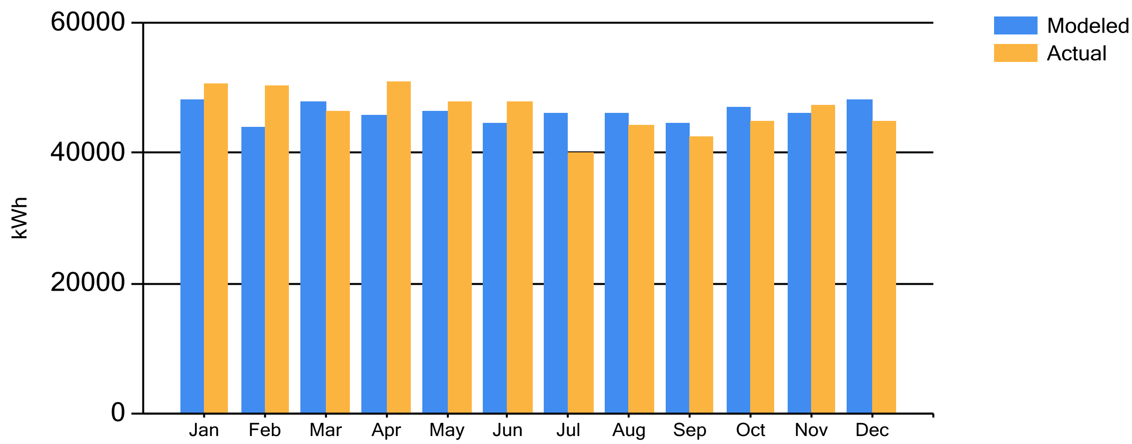
# Appendix B – Actual Fuel Use versus Modeled Fuel Use

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

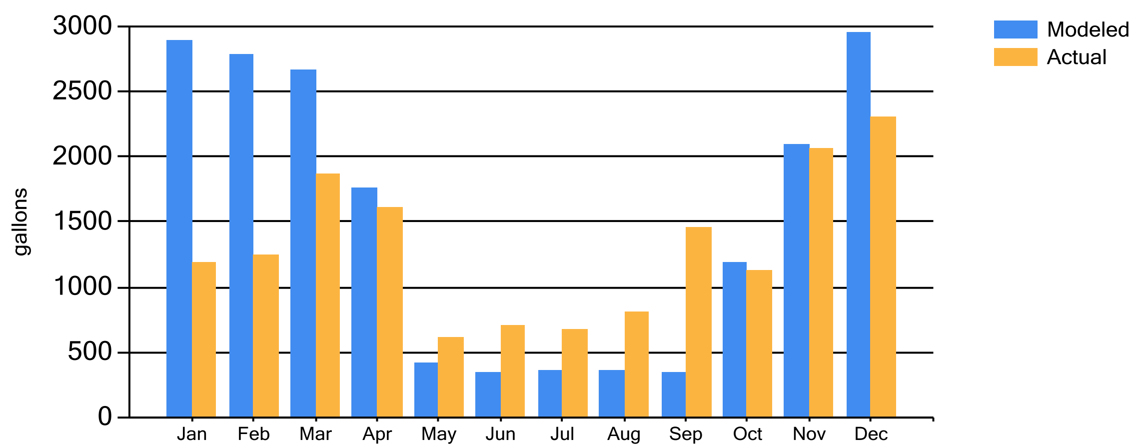
**Annual Fuel Use**



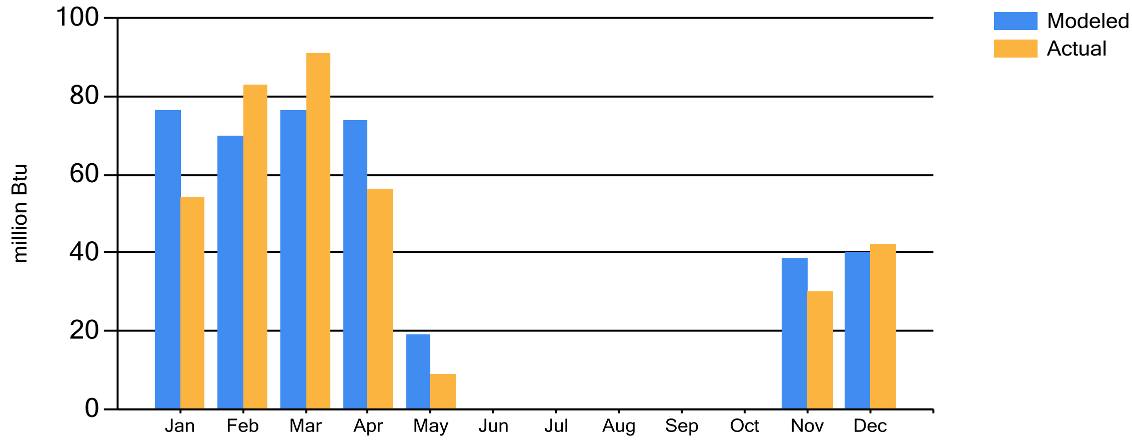

**Electricity Fuel Use**




**#1 Fuel Oil Fuel Use**



**Heat Recovery Fuel Use**



# Appendix C - Electrical Demands

| Estimated Peak Electrical Demand (kW) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| **Current** | 130.6 | 127.4 | 123.5 | 119.2 | 114.4 | 110.6 | 107.2 | 103.9 | 100.8 | 98.7 | 96.6 | 94.1 |
| **As Proposed** | 92.1 | 91.8 | 91.0 | 89.9 | 69.7 | 62.5 | 62.1 | 61.7 | 86.7 | 87.1 | 87.5 | 87.7 |

------------------------------------------
AkWarmCalc Ver 2.4.1.0, Energy Lib 3/30/2015