Comprehensive Energy Audit
For
Shaktoolik Water Treatment Plant

Prepared For

City of Shaktoolik

July 22, 2011

Prepared By:

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Table of Contents

PREFACE

The Energy Projects Group at the Alaska Native Tribal Health Consortium (ANTHC) prepared this document for the City of Shaktoolik. The authors of this report are Carl H. Remley, Certified Energy Auditor (CEA), and Certified Energy Manager (CEM), and Gavin Dixon.

The purpose of this report is to provide a comprehensive document that summarizes the findings and analysis that resulted from an energy audit conducted over the past couple months by the Energy Projects Group of ANTHC. This report analyzes historical energy use and identifies costs and savings of recommended energy efficiency measures. Discussions of site specific concerns and an Energy Efficiency Action Plan are also included in this report.

ACKNOWLEDGMENTS

The ANTHC Energy Projects Group gratefully acknowledges the assistance of Ms. Carleen Sagoonik of the Native Village of Shaktoolik, Mr. Edward Jackson the Water Treatment Plant Operator, and Mr. Phillip Gagnon of Village Safe Water.

1. EXECUTIVE SUMMARY

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

Based on electricity and fuel oil prices in effect at the time of the audit, the annual energy costs for the buildings analyzed were $6,462 for electricity and $43,588 for #1 fuel oil. This results in a total energy cost of $50,050 per year. A small amount of recovered heat was also used but it was at no cost.

It should be noted that this facility received a power cost equalization (PCE) subsidy last year. If it did not receive the PCE, the annual electricity cost would have been $22,452 and the total annual energy cost would have been $66,040. The building also contains a washeteria but it is rarely used.

Table 1.1 below summarizes the energy efficiency measures analyzed for the Shaktoolik Water Treatment Plant. Listed are the estimates of the annual savings, installed costs, and two different financial measures of investment return.

Table 1.1
PRIORITY LIST – ENERGY EFFICIENCY MEASURES

Rank	Feature	Improvement Description	Annual Energy Savings	Installed Cost	Savings to Investment Ratio, SIR[1]	Simple Payback (Years)[2]
1	Other Electrical: Circulation Pumps	Improve Manual Switching	$157	$0	>100	0.0
2	Setback Thermostat: Water Treatment Plant	Implement a Heating Temperature Unoccupied Setback to 50.0 deg F for the Water Treatment Plant space.	$956	$1,000	14.33	1.0
3	HVAC And DHW	Hydronic heating improvements	$5,242	$20,000	5.06	3.8
4	Electric Boiler	Repair insulation on Water Storage Tank roof and add electric boiler to heat tank that operates when excess wind is available from AVEC	$21,564	$200,000	1.64	9.3
5	Heat Recovery System on Circulation loop	This retrofit would replace the 30 year old heat recovery system that is not presently operational.	$9,109	$100,000	1.40	11.0
6	Lighting: WTP Entrance and Office	Replace with 6 LED replacement lamps	$225	$1,440	1.37	6.4
7	Main Entrance	Remove existing door and install standard pre-hung U-0.16 insulated door, including hardware.	$34	$682	1.35	20.0
8	Other Electrical: Appliances	Improve Manual Switching	$19	$100	1.16	5.4

Table 1.1 PRIORITY LIST – ENERGY EFFICIENCY MEASURES						
Rank	Feature	Improvement Description	Annual Energy Savings	Installed Cost	Savings to Investment Ratio, SIR[1]	Simple Payback (Years)[2]
9	Air Tightening: Main entrance and generator room	Perform air sealing to reduce air leakage by 865 cfm at 50 Pascals.	$302	$3,000	1.03	9.9
	TOTAL, all measures		**$37,607**	**$326,222**	**1.81**	**8.7**

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 $37,607 per year, or 75.1% of the buildings' total energy costs. These measures are estimated to cost $326,222, for an overall simple payback period of 8.7 years.

Table 1.2 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 1.2 Annual Energy Cost Estimate										
Description	**Space Heating**	**Space Cooling**	**Water Heating**	**Lighting**	**Other Electrical**	**Circulation Loop Heat**	**Water Tank Heat**	**Ventilation Fans**	**Service Fees**	**Total Cost**
Existing Building	$4,517	$0	$4,132	$1,724	$3,874	$11,530	$24,273	$0	$0	**$50,050**
With All Proposed Retrofits	$1,591	$0	$663	$1,499	$3,559	$2,421	$2,709	$0	$0	**$12,442**
SAVINGS	$2,926	$0	$3,469	$225	$314	$9,109	$21,564	$0	$0	**$37,607**

2. AUDIT AND ANALYSIS BACKGROUND

2.1 Program Description

This audit included services to identify, develop, and evaluate energy efficiency measures at the Shaktoolik Water Treatment Plant. The scope of this project included evaluating building shell, lighting and other electrical systems, and HVAC equipment, process loads, 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, ventilation, and air conditioning equipment (HVAC)
- Lighting systems and controls
- Building-specific equipment
- Water consumption, treatment (optional) & disposal

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

Details collected from Shaktoolik 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.

In addition, the methodology involves taking into account a wide range of factors specific to the building. These factors are used in the construction of the model of energy used. The factors include:

- Occupancy hours
- Local climate conditions
- Prices paid for energy

2.3. Method of Analysis

Data collected was processed using AkWarm© Energy Use Software to estimate energy savings for each of the proposed energy efficiency measures (EEMs). The recommendations focus on the building envelope; HVAC; lighting, plug load, and other electrical improvements; and motor and pump systems that will reduce annual energy consumption.

EEMs are evaluated based on building use and processes, local climate conditions, building construction type, function, operational schedule, existing conditions, and foreseen future plans. Energy savings are calculated based on industry standard methods and engineering estimations.

Our analysis provides a number of tools for assessing the cost effectiveness of various improvement options. These tools utilize **Life-Cycle Costing**, which is defined in this context as a method of cost analysis that estimates the total cost of a project over the period of time that includes both the construction cost and ongoing maintenance and operating costs.

Savings to Investment Ratio (SIR) = **Savings** divided by **Investment**

Savings includes the total discounted dollar savings considered over the life of the improvement. When these savings are added up, changes in future fuel prices as projected by the Department of Energy are included. Future savings are discounted to the present to account for the time-value of money (i.e. money's ability to earn interest over time). The **Investment** in the SIR calculation includes the labor and materials required to install the measure. An SIR value of at least 1.0 indicates that the project is cost-effective—total savings exceed the investment costs.

Simple payback is a cost analysis method whereby the investment cost of a project is divided by the first year's savings of the project to give the number of years required to recover the cost of the investment. This may be compared to the expected time before replacement of the system or component will be required. For example, if a boiler costs $12,000 and results in a savings of $1,000 in the first year, the payback time is 12 years. If the boiler has an expected life to replacement of 10 years, it would not be financially viable to make the investment since the payback period of 12 years is greater than the project life.

The Simple Payback calculation does not consider likely increases in future annual savings due to energy price increases. As an offsetting simplification, simple payback does not consider the need to earn interest on the investment (i.e. it does not consider the time-value of money). Because of these simplifications, the SIR figure is considered to be a better financial investment indicator than the Simple Payback measure.

Measures are implemented in order of cost-effectiveness. The program first calculates individual SIRs, and ranks all measures by SIR, higher SIRs at the top of the list. An individual measure must have an individual SIR>=1 to make the cut. Next the building is modified and re-simulated with the highest ranked measure included. Now all remaining measures are re-evaluated and ranked, and the next most cost-effective measure is implemented. AkWarm goes through this iterative process until all appropriate measures have been evaluated and installed.

It is important to note that the savings for each recommendation is calculated based on implementing the most cost effective measure first, and then cycling through the list to find the next most cost effective measure. Implementation of more than one EEM often affects the savings of other EEMs. The savings may in some cases be relatively higher if an individual EEM is implemented in lieu of multiple recommended EEMs. For example implementing a reduced operating schedule for inefficient lighting will result in relatively high savings. Implementing a reduced operating schedule for newly installed efficient lighting will result in lower relative savings, because the efficient lighting system uses less energy during each hour of operation. If multiple EEM's are recommended to be implemented, AkWarm calculates the combined savings appropriately.

Cost savings are calculated based on estimated initial costs for each measure. Installation costs include labor and equipment to estimate the full up-front investment required to implement a change. Costs are derived from Means Cost Data, industry publications, and local contractors and equipment suppliers.

2.4 Limitations of Study

All results are dependent on the quality of input data provided, and can only act as an approximation. In some instances, several methods may achieve the identified savings. This report is not intended as a final design document. The design professional or other persons following the recommendations shall accept responsibility and liability for the results.

3. Shaktoolik Water Treatment Plant

3.1. Building Description

The 2,112 square foot water treatment plant was constructed in 1977 and had a significant upgrade in 1991. It has a normal occupancy of one person during occupied hours. The number of hours of operation for this building average 2.6 hours per day, considering all seven days of the week.

The building is mounted on pads, has a 2 X 12 floor joist, six inch panel walls, and a six inch panel sloped roof with a cathedral ceiling. The floor has twelve inches of fiberglass insulation. Overall, the building is in fair condition.

The main entrance to the water treatment plant is a double door that is heavily damaged. The other two doors are in fair condition. The building has a total of six windows that show their age but are in fair condition.

A heated water storage tank is located next to the water treatment plant. The storage tank has a capacity of 794,000 gallons of water. The steel tank is 65 feet in diameter and 32 feet high. The side walls of the tank are covered with 3 ½ inches of polyurethane insulation, with a butyl covering and an outer aluminum sheeting. The roof of the tank was covered with the same insulation and butyl covering with no protective aluminum sheeting. Over the years, structural failures of the roof supports have destroyed the insulation on the roof.

Description of Heating Plant

The Heating Plants used in the building are:

Weil McLain Boiler

Nameplate Information:	Weil McLain Model BL-676WS
Fuel Type:	#1 Oil
Input Rating:	278,000 BTU/hr
Steady State Efficiency:	80 %
Idle Loss:	5 %
Heat Distribution Type:	Water
Boiler Operation:	All Year
Notes:	Nozzle 2.25 GPH

Weil McLean Boiler

Nameplate Information:	Weil McLain BL-676WS
Fuel Type:	#1 Oil
Input Rating:	278,000 BTU/hr
Steady State Efficiency:	80 %
Idle Loss:	5 %
Heat Distribution Type:	Water
Boiler Operation:	All Year
Notes:	Nozzle 2.25 GPH

Heat Recovery System

Nameplate Information:	Heat Recovery from AVEC
Fuel Type:	Hot Wtr District Ht
Input Rating:	210,000 BTU/hr
Steady State Efficiency:	80 %
Idle Loss:	0 %
Heat Distribution Type:	Water
Boiler Operation:	All Year
Notes:	Feeds into water circulation loop only

The vast majority of the 12,750 gallons of #1 fuel oil used this past year was used to heat the water storage tank. Most of this heavy usage was due to the missing insulation on the 65 foot diameter roof of the water storage tank.

The second heaviest load on the boilers was the water circulation loop. A heat recovery system located at the Alaska Village Electric Cooperative (AVEC) power plant was designed to heat both the water circulation loop and the water storage tank. However, this system is no longer functional at all for the water storage tank and only marginally functional for the circulation loop. The majority of the heat for the circulation loop is from the boilers.

The space heating for the water treatment plant is totally dependent on the two boilers. Space heat was never provided by the heat recovery system. The building is kept at 65 degrees year round.

Heating Distribution Systems

At present, the boilers have three heat distribution loops. The largest loop provides heat to the water treatment plant unit heaters, the water storage tank, and the water circulation loop. The hot water heater for the washeteria is on a separate circulation pump. Both of these loops are operated 24 hours per day. The third loop is for the hydronic dryers. This loop is operated on a as needed basis only.

Domestic Hot Water System

As mentioned above, the domestic hot water system is heated by the two boilers but with a separate pumped loop. The loop constantly circulates glycol from the boilers to the 200 gallon hot water storage tank.

Waste Heat Recovery Information

As mentioned earlier, the heat recovery system has largely been abandoned and needs to be replaced.

Lighting

The lighting in the water treatment plant is provided by 36 four lamp four foot fluorescent fixtures. Six of those fixtures are used often and should up-graded. The remaining thirty are not used often enough to justify replacing.

Plug Loads

Plug loads in the water treatment plant are a very small percentage of the overall load.

Major Equipment

The major equipment is associated with the process loads at the water treatment plant. This includes but is not limited to the back wash pumps, the small chemical pumps, the glycol circulation pumps, the potable water circulation pumps, and a compressor. As mentioned earlier, there are also washers and dryers in the washeteria but they are rarely used.

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). One kWh usage is equivalent to 1,000 watts running for one hour. The basic usage charges are shown as generation service and delivery charges along with several non-utility generation charges.

The fuel oil usage profile shows the fuel oil usage for the building. Fuel oil consumption is measured in gallons. One gallon of #1 Fuel Oil provides approximately 132,000 BTUs of energy.

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

Electricity: AVEC-Shaktoolik - Commercial - Sm

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

Table 3.1 – Average Energy Cost	
Description	**Average Energy Cost**
Electricity	$ 0.1580/kWh
#1 Oil	$ 3.42/gallons
Hot Wtr District Ht	$ 0.00/million Btu

3.2.1.1 Total Energy Use and Cost Breakdown

At current rates, City of Shaktoolik pays approximately $50,050 annually for electricity and #1 fuel costs for the Shaktoolik Water Treatment Plant.

Figure 3.1 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 3.1
Annual Energy Costs by End Use

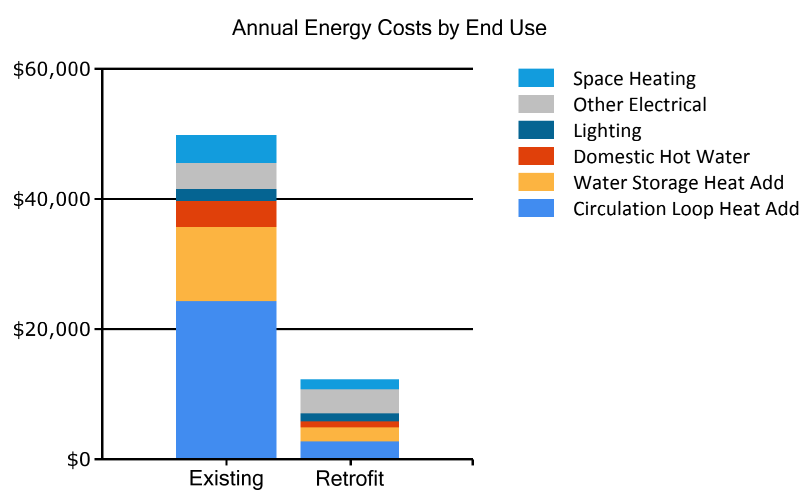


Figure 3.2 below shows how the annual energy cost of the building splits between the different fuels used by the building. The "Existing" bar shows the breakdown for the building as it is now; the "Retrofit" bar shows the predicted costs if all of the energy efficiency measures in this report are implemented.

Figure 3.2
Annual Energy Costs by Fuel Type

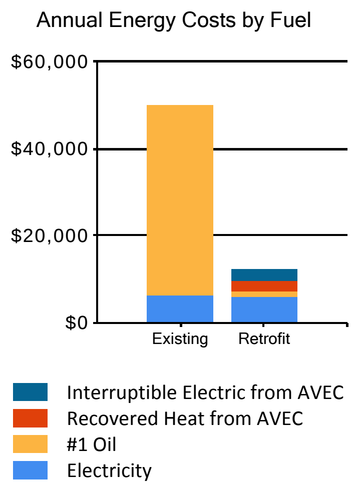
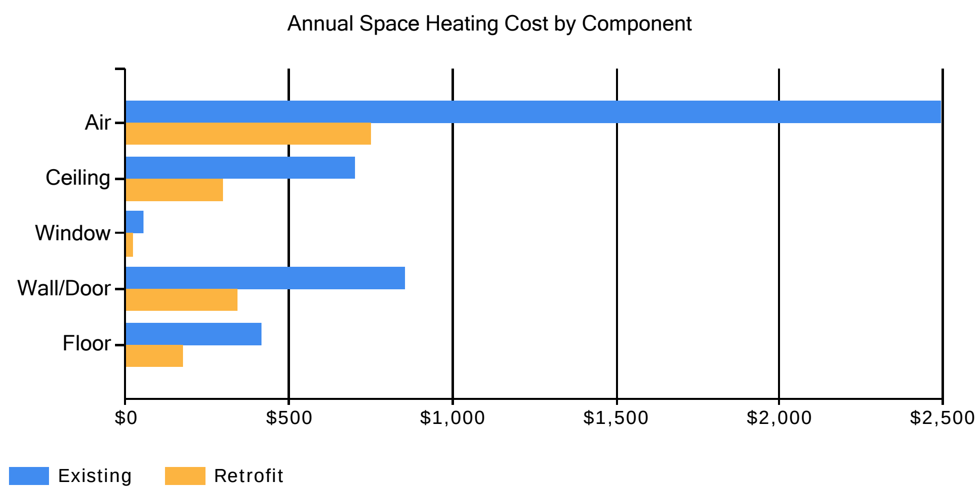


Figure 3.3 below addresses only Space Heating costs. The figure shows how each heat loss component contributes to those costs; for example, the figure shows how much annual space heating cost is caused by the heat loss through the Walls/Doors. For each component, the space heating cost for the Existing building is shown (blue bar) and the space heating cost assuming all retrofits are implemented (yellow bar) are shown.

Figure 3.3
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.

Electrical Consumption (kWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Lighting	926	844	926	896	926	896	926	926	896	926	896	926
Other_Electrical	2619	2387	2619	2535	2619	467	483	483	2535	2619	2535	2619
Cooking	0	0	0	0	0	0	0	0	0	0	0	0
Clothes_Drying	0	0	0	0	0	0	0	0	0	0	0	0
Ventilation_Fans	0	0	0	0	0	0	0	0	0	0	0	0
DHW	130	118	130	127	137	132	137	137	132	137	126	130
Space_Heating	338	308	336	321	325	315	325	325	315	325	323	338
Space_Cooling	0	0	0	0	0	0	0	0	0	0	0	0

Fuel Oil #1 Consumption (Gallons)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Cooking	382	349	382	370	382	0	0	0	370	382	370	382
Clothes_Drying	805	734	805	779	805	0	0	0	779	805	779	805
DHW	19	17	22	56	164	158	164	164	158	164	32	19
Space_Heating	223	210	205	116	0	0	0	0	0	0	160	225

Hot Water District Ht Consumption (Million Btu)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
DHW	0	0	0	0	0	0	0	0	0	0	0	0
Space_Heating	0	0	0	0	0	0	0	0	0	0	0	0

3.2.2 Energy Use Index (EUI)

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

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

Building Site EUI = (Electric Usage in kBtu + Fuel Usage in kBtu + similar for other fuels)
Building Square Footage

Building Source EUI = (Electric Usage in kBtu X SS Ratio + Fuel Usage in kBtu X SS Ratio + similar for other fuels)
Building Square Footage
where "SS Ratio" is the Source Energy to Site Energy ratio for the particular fuel.

Table 3.4
Shaktoolik 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	40,896 kWh	139,579	3.340	466,194
#1 Oil	12,745 gallons	1,682,340	1.010	1,699,163
Hot Wtr District Ht	0.00 million Btu	0	1.280	0
Total		**1,821,918**		**2,165,357**
BUILDING AREA		2,112	Square Feet	
BUILDING SITE EUI		863	kBTU/Ft²/Yr	
BUILDING SOURCE EUI		1,025	**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.				

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

Limitations of AkWarm© Models

• The model is based on typical mean year weather data for Shaktoolik. 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 and cooling 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 model does not model HVAC systems that simultaneously provide both heating and cooling to the same building space (typically done as a means of providing temperature control in the space).

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. Calculations and cost estimates for analyzed measures are provided in Appendix C.

Table 4.1
Shaktoolik Water Treatment Plant, Shaktoolik, Alaska
PRIORITY LIST – ENERGY EFFICIENCY MEASURES

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1	Other Electrical: Circulation Pumps	Improve Manual Switching	$157	$0	>100	0.0
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3	HVAC And DHW	Hydronic heating improvements	$5,242	$20,000	5.06	3.8
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7	Main Entrance	Remove existing door and install standard pre-hung U-0.16 insulated door, including hardware.	$34	$682	1.35	20.0
8	Other Electrical: Appliances	Improve Manual Switching	$19	$100	1.16	5.4
9	Air Tightening: Main entrance and generator room	Perform air sealing to reduce air leakage by 865 cfm at 50 Pascals.	$302	$3,000	1.03	9.9

Table 4.1 Shaktoolik Water Treatment Plant, Shaktoolik, Alaska PRIORITY LIST – ENERGY EFFICIENCY MEASURES						
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	TOTAL, all measures		$37,607	$326,222	1.81	8.7

4.2 Interactive Effects of Projects

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

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

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

4.3 Building Shell Measures

4.3.1. Energy Efficiency Measure: Replace Exterior Door

Rank	Size, Type, & Condition	Recommendation	Energy Auditor Comments	Cost	Savings
7	Door Type: Metal - urethane, no therm. break Modeled R-Value: 2.5	Remove existing door and install standard pre-hung U-0.16 insulated door, including hardware.	The main entrance double door is worn out and should be replaced. It does not close or seal properly.	$682	$34

The double doors at the main entrance to the water treatment plant are old, bent, do not close tightly, and as a result are responsible for a significant amount of heat loss from the building. It is recommended that they be replaced.

4.3.2. Energy Efficiency Measure: Seal Air Leaks

Rank	Estimated Air Leakage	Recommended Air Leakage Target	Energy Auditor Comments	Cost	Savings
9	Air Tightness from Blower Door Test: 3600 cfm at 50 Pascals	Perform air sealing to reduce air leakage by 865 cfm at 50 Pascals.	Seal old boiler stack opening near main entrance and re-commission generator dampers so they seal properly.	$3,000	$302

Many buildings, especially older ones, have air leaks allowing heated and cooled air to escape when the air pressure differs between the inside and outside of the building. Because these leaks allow unconditioned air to enter as conditioned air is lost, air leaks can be a significant waste of energy and money. They also make the building drafty. A blower door test was performed as part of our energy audit. We found major leakage in two areas. The first was the open old boiler stack near the front entrance to the building. The second was the deteriorated generator dampers. The old boiler stack should be sealed off and the generator dampers repaired by an experienced HVAC person. Buildings with indoor air pollution caused by combustion heating, tobacco smoking, or moisture problems, may require more ventilation than average buildings.

4.4 Heating Measures

4.4.1. EEM Heating Plants, Cooling Plants, and Distribution Systems

A heating system is expected to last approximately 20-25 years, depending on the system. If the system is nearing the end of its life, it is better to replace it sooner rather than later to avoid being without heat for several days when it fails. This way, you will have time to compare bids, check references and ensure the contractors are bonded and insured.

Recommendation: Hydronic heating improvements

Estimated Cost: $20,000
Estimate Savings per Year: $5,242

Energy Auditor Comments: None

4.4.1.1. EXISTING SYSTEMS

4.4.1.1.1 Weil McLain Boiler
Description: Weil McLain Model BL-676WS heating plant fueled by #1 Fuel Oil, with a Natural draft.
Size : 278,000 BTU/h
Efficiency (Steady State & Idle): 80%

Portion of heat supplied by this unit: 50%
Notes: Nozzle 2.25 GPH

4.4.1.1.2 Weil McLean Boiler
Description: Weil McLain BL-676WS heating plant fueled by #1 Fuel Oil, with a Natural draft.
Size : 278,000 BTU/h
Efficiency (Steady State & Idle): 80%
Portion of heat supplied by this unit: 50%
Notes: Nozzle 2.25 GPH

4.4.1.1.3 Heat Recovery System
Description: Heat Recovery from AVEC heating plant fueled by Hot Wtr District Ht, with a Natural draft.
Size : 210,000 BTU/h
Efficiency (Steady State & Idle): 80%
Portion of heat supplied by this unit: 0%
Notes: Feeds into water circulation loop only

4.4.1.1.4 Distribution System

Notes: At present, space heating loop, tank heat, and circulation loop heat is all on one pump that runs 24/7. Should consider separating them. Hot water is on separate loop and runs 24/7. Circulation pump for dryers has been shut off.

4.4.1.1.4.1 Building Heat Circulation Pump

Nameplate: Grundfos model UNC 50-80
Notes:

4.4.2.2. PROPOSED SYSTEMS

4.4.2.1.1 Weil McClain Boiler
Description: heating plant fueled by #1 Fuel Oil, with a Natural draft.
Size : 278,000 BTU/h
Efficiency (Steady State & Idle): 80%
Portion of heat supplied by this unit: 50%
Notes:

4.4.2.1.2 Weil McLain Boiler
Description: heating plant fueled by #1 Fuel Oil, with a Natural draft.
Size : 278,000 BTU/h
Efficiency (Steady State & Idle): 85%
Portion of heat supplied by this unit: 50%
Notes:

4.4.2.1.3 AVEC Heat Recovery
Description: heating plant fueled by Hot Wtr District Ht,
Size : 210,000 BTU/h
Efficiency (Steady State & Idle): 75%
Portion of heat supplied by this unit: 0%
Notes: Heat is transferred through circulation water loop.

4.4.2.1.4 Electric Boiler
Description: 50 Kilowatt Electric Boiler heating plant fueled by Steam District Ht, with a Natural draft.
Size : 170,700 BTU/h
Efficiency (Steady State & Idle): 99%
Portion of heat supplied by this unit: 0%
Notes: Uses a special electric rate of $0.05 per KWH for excess wind. The rate is interruptible

4.4.2.1.5 Hydronic Heating Systems

Notes: This EEM would involve shutting off the hot water circulator pump, separating the space heat loop from the process heat loop, and re-insulating the heating lines as necessary. It would also involve installing a hydronic heat controller that controlled all the hydronic heating sources and a space heating loop mixing valve controlled by an outdoor reset controller.

The hot water circulation pump should be shut off since the washeteria is almost never used.

4.4.2 Programmable Thermostat

Location	Existing Situation	Recommended Improvement	Install Cost	Annual Savings	Notes
Water Treatment Plant	Existing Unoccupied Heating Set point: 65.0 deg F	Implement a Heating Temperature Unoccupied Setback to 50.0 deg F for the Water Treatment Plant space.	$1,000	$956	

4.5 LIGHTING UPGRADES

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

4.5.1 Lighting Upgrade – Replace Existing Fixtures and Bulbs

Location	Existing Lighting	Recommended Improvement	Install Cost	Annual Savings	Notes
WTP Entrance and Office	6 FLUOR (4) T12 4' F40T12 34W Energy-Saver Magnetic with Manual Switching	Replace with 18 LED replacement lamps	$1,440	$225	

Description:
This EEM includes replacement of the existing 24 T12 lamps and magnetic ballasts with 18 LED lamps. The new energy efficient, LED lamps will provide adequate lighting and will save the owner on electrical costs due to the better performance of the lamp and elimination of the ballasts. This EEM will also provide maintenance savings through the reduced number of lamps replaced per year. The expected lamp life of a LED lamp is approximately 50,000 burn-hours, in

comparison to the existing T12 lamps which is approximately 20,000 burn hours. The six fixtures listed above are the six normally used.

4.7 Process Loads

4.7.1 Circulation Loop Heat Recovery

Location	Life in Years	Description	Recommendation	Cost	Savings	Notes
Circulation Loop	15	Heat Recovery	This retrofit would replace the 30 year old heat recovery system that is not presently operational.	$100,000	$9,109	

As mentioned earlier, the heat recovery system was installed in 1977 and after 34 years is no longer functional. The majority of the heat from the new system will be used to heat the potable water circulation loop. Some of the heat will also be used to heat the water storage tank. This heat source will be the first to be used of all the sources as it is the most economical.

The savings of approximately $9,109 per year is based on cost of #1 oil in 2010 and has not been adjusted for anticipated increases. The savings are based on the AKWarm analysis of the existing heat loads and the calculated heat load of the water storage tank.

The cost of installing the new system includes all design, purchased materials, shipping, and installation and commissioning costs. These costs are based on recent projects completed by ANTHC throughout Alaska

4.7.2 Electric Boiler

Location	Life in Years	Energy Source	Description	Recommendation	Cost	Savings	Notes
In Series with oil boilers	15	Excess Wind Energy	Electric Boiler	Repair insulation of Water Storage Tank and add electric boiler to heat tank that operates when excess wind is available from AVEC	$200,000	$21,564	

AVEC has excess wind energy and is willing to sell that excess electricity to the water treatment plant at a significant discount. The cost would be $0.05 per kilowatt-hour. It would be supplied at this low interruptible rate whenever it is available.

This energy efficiency measure would install a separate interruptible electric service at the water treatment plant, install a 50 kilowatt electric boiler in series with the existing oil fired boilers, add the necessary controls at both the AVEC power plant and at the water treatment plant and re-insulate the roof of the water storage tank to reduce the heat load of the tank.

The savings estimate is based on the difference in cost of the oil now used for this heating and the $0.05 per kilowatt-hour for the electricity and the reduction in usage that will be utilized by insulating the roof of the water storage tank. Extensive calculations were done in estimating the savings.

The cost of this retrofit includes the necessary design activity, the materials, shipping, installation and commissioning and is based on similar installations performed by AVEC in the past and budgetary quotations obtained as part of this audit.

4.7.4 Other Electrical

Location	Life in Years	Description	Recommendation	Cost	Savings	Notes
Circulation Pumps	7	Grundfos 36E854-378, 3 HP with Manual Switching	Improve Manual Switching	$0	$157	Shut off circulation pumps one month earlier
Appliances	7	3 appliances with Manual Switching	Improve Manual Switching	$100	$19	

The potable water circulation pumps are presently shut off during the summer months. Based on discussions with the water plant operator and our experience throughout this part of Alaska, these pumps can be shut off for additional month each year.

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 heating system controls, implementation of these measures should be scheduled to occur simultaneously.

Attached to this report is Appendix A. The objective of the appendix is to provide the City of Shatoolik and the water plant operator with a wide range of websites to further their knowledge of both energy conservation and renewable energy.

Appendix A – Listing of Energy Conservation and Renewable Energy Websites

Lighting

Illumination Engineering Society - http://www.iesna.org/

Energy Star Compact Fluorescent Lighting Program - www.energystar.gov/index.cfm?c=cfls.pr_cfls

DOE Solid State Lighting Program - http://www1.eere.energy.gov/buildings/ssl/

Caliper Program – http://www1.eeere.energy.gov/buildings/ssl/caliper.html

Solid State Lighting Gateway Demonstrations – http://www1/eere/energy.gov/buildings/ssl/gatewaydemos.html

DOE office of Energy Efficiency and Renewable Energy - http://apps1.eere.energy.gov/consumer/your_workplace/

Energy Star – http://www.energystar.gov/index.cfm?c=lighting.pr_lighting

Hot Water Heaters

Tank less DHW Heaters - http://apps1.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=12820

Heat Pump Water Heaters - http://apps1.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=12840

AHRI –Residential Water Heaters - http://ari.org/Content/ResidentialWaterHeaters_594.aspx

American Council for Energy-Efficient Economy - http://www.aceee.org/consumerguide/waterheating.htm#heatpump

Solar Water Heating

DOE Energy and Efficiency and Renewable Energy Solar Energy Technologies Program – http://www1.eere.energy.gov/solar/solar_heating.html

FEMP Federal Technology Alerts – http://www.eere.energy.gov/femp/pdfs/FTA_solwat_heat.pdf
www.eere.energy.gov.femp/pdfs/FTA_para_trough.pdf

FEMP Case Studies – www.eere.energy.gov/femp/technologies/renewable_casestudies.html

Solar Radiation Data Manual – http://rredc.nrel.gov/solar/pubs/redbook

Plug Loads

DOE office of Energy Efficiency and Renewable Energy – http:apps1.eere.energy.gov/consumer/your_workplace/

Energy Star – http://www.energystar.gov/index.cfm?fuseaction=find_a_product

Top 10 energy efficient desktop PCs – http://crave.cnet.co.uk/cnetuk/crave/greentech/0,250000598,10001753,00.htmThe Greenest Desktop Computers of 2008 - http://www.metaefficient.com/computers/the-greenest-pcs-of-2008.html

Wind

AWEA Web Site – http://www.awea.org

- AWEA Small wind toolbox: www.awea.org/smallwind/

NWTC Web Site – http:www.nreal.gov/wind

National Wind Coordinating Collaborative – http:www.nationalwind.org

Utility Wind Interest Group site: http://www.uwig.org

WPA Web Site – http://www.windpoweringamerica.gov

Homepower Web Site: http://homepower.com

Windustry Project: http://www.windustry.com

Best Links: www.freash-energy.org

Solar

NREL – http://www.nrel.gov/rredc/

Firstlook – http://firstlook.3tiergroup.com

TMY or Weather Data – http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/

State and Utility Incentives and Utility Policies - http://www.dsireusa.org