# Energy Audit

## Skagway K-12 School

City of Skagway

*Final Report*
*February 2012*

Funded by:

Alaska Housing
FINANCE CORPORATION

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# Audit Team

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Section 1

# Executive Summary

An energy audit of the Skagway K-12 School was performed by Alaska Energy Engineering LLC. The investment grade audit was funded by Alaska Housing Finance Corporation (AHFC) to identify opportunities to improve the energy performance of public buildings throughout Alaska.

Skagway School is a 45,518 square foot building that contains commons, classrooms, offices, a music room, a gym, a kitchen, a library, a shop, storage, and mechanical support spaces.

## Building Assessment

The following summarizes our assessment of the building.

### Envelope

The envelope of the Skagway School appears to be well preserved and is providing good service. The shell package is both attractive and efficient in design and construction. Building envelope issues include:

- Complex Framing: The design of the attic mechanical spaces required significant attention to detail during the construction phase to create a contiguous vapor barrier around the conditioned spaces. This is because the vapor barrier on the exterior walls and perimeter ceiling spaces must transition between all of the ceiling joists to the inside of the attic walls and maintain a seal while doing so. The large metal trusses and wood beams in the attic mechanical spaces that penetrate the vapor barrier surface compound the difficulty of this exercise. At the contact point of the drywall and the metal trusses or wooden beams, air infiltration could be felt when the AHU's were operated and the attic space became negatively pressurized. Air infiltration could be reduced along these intersections with the application of a spray foam sealant.
- Failed Insulation: Approximately 40 square feet of insulation have fallen down in the ceiling space above Room 316.
- Arctic Entrances: Double door entries are not installed at the ends of the hallways. As a result the main classroom hallways have been difficult to heat during periods of cold weather. School operations have had to be modified to limit the use of these hallway doors as 'emergency exits' only in an attempt to retain hallway heat. Double door entries should be included on all new construction.
- Exterior Doors: Exterior doors are not thermally broken. Future exterior door replacement selection should include this feature. Weather stripping on several doors is in poor condition and should be replaced.

### Heating System

The school spaces are heated by two fuel oil boilers that provide heat to seven air handling unit systems, unit heaters, and perimeter hydronic systems.

In addition to meeting the heating demands of the school, the boilers have adequate capacity to supply all domestic hot water needs. However, a 250-gallon oil-fired hot water heater is currently utilized for this purpose. Oil-fired hot water heaters have cycling and standby losses and require maintenance, hence operational and maintenance efficiencies are reduced. Staff recognizes that the system is oversized and has isolated and shut down the original 500-gallon unit. The 250-gallon unit presently supplies the entire school. The original water heaters are sized to carry all of the domestic hot water needs, including an excessive anticipated shower water demand. Staff observed that the showers have only been used twice during this school year. This is a common defect in school domestic hot water system sizing; the hot water systems and subsequent boiler sizing are oversized based on a level of shower water consumption that never materializes. Because the boilers are operating the entire school year, both domestic hot water heaters could be removed and replaced with two 120-gallon indirect hot water heaters. In addition, because the boilers are oversized to meet an unnecessarily high hot water heating demand and they are now 28 years old, replacing one unit with a modern and more efficient properly sized unit should be considered.

The remainder of the fuel oil boiler heating system appears to be in good condition; however fairly simple improvements can be made to improve its effectiveness and efficiency. These are outlined in Section 3, Energy Efficiency Measures.

### Ventilation Systems

The building has seven air handling unit systems, three of which are not in use. These include AHU-3 for the shop, AHU-6 for the locker rooms and AHU-7 for the music room. To reduce energy consumption, the remaining units (with the exception of AHU-5 for the gym) have schedules that turn off the units when the school is not occupied.

The ventilation to the classrooms has been reduced by closing the variable air volume boxes serving each classroom. While this measure and the reduction of AHU run-hours has been helpful from an operational cost perspective, air quality is reduced due to the lack of outside air exchanged in the school. The metric for air quality and the need for exchanging new air is the $CO_2$ level within a space. Guidelines suggest that $CO_2$ levels not exceed the ASHRAE action level of 1000 ppm.

The $CO_2$ levels were checked throughout the building and the following levels were found:

| | |
|---|---|
| • Hallways, gym, lockers, multipurpose room, and offices | 500-600 ppm |
| • Individual classes with 5-10 students | 1000-1100 ppm |
| • Room 303 at the end of the hallway | 1130 ppm |

We recommend that AHU-1 and AHU-2 run times be increased and that air flow be reestablished to the classrooms to provide higher quality air to the high school and elementary wings of the building. While the $CO_2$ levels of the locker rooms were acceptable, we also recommend that AHU-6 and EF-1 be operated for at least half an hour per day to exchange the air in those spaces to help reduce moisture levels and the subsequent threat of mold/mildew issues.

### Lighting

Interior lighting consists primarily of T12 and T8 fluorescent fixtures throughout the classrooms, commons, and office spaces. Staff has converted approximately 50% of the T12 fixtures to more efficient T8 lamps and expects to complete the conversion of all fixtures to T8's by next summer. All calculations of potential energy savings have been made using the more efficient T8 fixtures.

Metal halide lighting is used in the library and the gym. Existing gym lighting utilizes 28 pendant-mounted metal halide bulbs to light the space for approximately 60 hours per week to support school-hour class activities and after-school sports and community events. It is estimated that lighting hours could be reduced to 40 hours/week with the selection of a lamp that can start instantaneously because staff currently do not shut off metal halide fixtures once energized so they don't have to wait 10-15 minutes for restart. Only 50% of the lighting in the library is typically utilized because the 250-watt metal halide fixtures over light the space. Staff would like to replace the library metal halide lighting with a more efficient fixture that still provides the ability to be dimmed when necessary.

Exterior lighting primarily consists of metal halide lighting. Only 4 of the 24 outdoor architectural wall lights are utilized, and only for evenings with special events. Because lighting operational hours are controlled by staff, operational costs for lighting with existing infrastructure are kept to a minimum. Replacement of existing exterior metal halide fixtures with more efficient units is a solution for further reducing operational costs.

### Summary

It was the assessment of the energy audit team that the majority of the building energy losses are due to the need to optimize air handling unit schedules and operations, the lack of occupancy sensor control of restroom lighting and fans, and the need to improve lighting efficiency in the gym space.

## Energy Efficiency Measures (EEMs)

All buildings have opportunities to improve their energy efficiency. The energy audit revealed several opportunities in which an efficiency investment will result in a net reduction in long-term operating costs.

### Behavioral and Operational EEMs

The following EEMs require behavioral and operational changes in the building use. The savings are not readily quantifiable but these EEMs are highly recommended as low-cost opportunities that are a standard of high performance buildings.

EEM-1: Replace Broken Window

EEM-2: Install Indirect Hot Water Heaters

EEM-3: Clear Access to Perimeter Heaters

EEM-4: Install Pipe and Valve Insulation

High and Medium Priority EEMs

The following EEMs are recommended for investment. They are ranked by life cycle savings to investment ratio (SIR). This ranking method places a priority on low cost EEMs which can be immediately funded, generating energy savings to fund higher cost EEMs in the following years. Negative values, in parenthesis, represent savings.

| | 25-Year Life Cycle Cost Analysis | | | | |
|---|---|---|---|---|---|
| | **Investment** | **Operating** | **Energy** | **Total** | **SIR** |
| **High Priority** | | | | | |
| EEM-5: Isolate Lag Boiler | $500 | $2,000 | ($39,700) | ($37,200) | 75.4 |
| EEM-6: Electrical Room Heat Recovery | $1,800 | $0 | ($23,100) | ($21,300) | 12.8 |
| EEM-7: Replace Aerators | $800 | $0 | ($6,400) | ($5,600) | 8.0 |
| EEM-8: Perform Boiler Combustion Test | $700 | $12,300 | ($15,100) | ($2,100) | 4.0 |
| EEM-9: Optimize HVAC Systems | $111,000 | $5,100 | ($410,400) | ($294,300) | 3.7 |
| **Medium Priority** | | | | | |
| EEM-10: Upgrade Motors | $6,000 | $0 | ($13,300) | ($7,300) | 2.2 |
| EEM-11: Install Occupancy Sensors | $16,200 | ($600) | ($35,600) | ($20,000) | 2.2 |
| EEM-12: Upgrade Gym Lighting | $29,800 | ($2,100) | ($59,600) | ($31,900) | 2.1 |
| EEM-13: Boiler Room Heat Recovery | $107,500 | $4,300 | ($187,000) | ($75,200) | 1.7 |
| **Totals*** | **$274,300** | **$21,000** | **($790,200)** | **($494,900)** | **2.8** |

*The analysis is based on each EEM being independent of the others. While it is likely that some EEMs are interrelated, an isolated analysis is used to demonstrate the economics because the audit team is not able to predict which EEMs an Owner may choose to implement. If several EEMs are implemented, the resulting energy savings is likely to differ from the sum of each EEM projection.

## Summary

The energy audit revealed numerous opportunities for improving the energy performance of the building. We recommend that the behavioral and high priority EEMs be implemented now to generate energy savings from which to fund the medium priority EEMs.

Another avenue to consider is to borrow money from AHFCs revolving loan fund for public buildings. AHFC will loan money for energy improvements under terms that allow for paying back the money from the energy savings. More information on this option can be found online at http://www.ahfc.us/loans/akeerlf_loan.cfm.

## Section 2

# Introduction

This report presents the findings of an energy audit of the Skagway K-12 School located in Skagway, Alaska. The purpose of this investment grade energy audit is to evaluate the infrastructure and its subsequent energy performance to identify applicable energy efficiencies measures (EEMs).

The energy audit report contains the following sections:

- **Introduction**: Building use and energy consumption.
- **Energy Efficiency Measures**: Priority ranking of the EEMs with a description, energy analysis, and life cycle cost analysis.
- **Description of Systems**: Background description of the building energy systems.
- **Methodology**: Basis for how construction and maintenance cost estimates are derived and the economic and energy factors used for the analysis.

## BUILDING USE

Skagway School is a 45,518 square foot building that contains commons, classrooms, offices, a music room, a gym, a kitchen, a library, a shop, storage, and mechanical support spaces. The school is operated by 15 staff and attended by 58 students. The facility schedule is:

- Teachers: 8:00 am – 4:00 pm (M-F)
- Students: 8:15 am – 3:15 pm (M-F)
- Gym Average of three hours per day between 8:00 am – 4:00 pm (M-F)
  4:00 pm - 6:00 pm (M-F) Sports Practice

### Building History

- 1983 – Original Construction
- 1984 – School Addition

## Energy Consumption

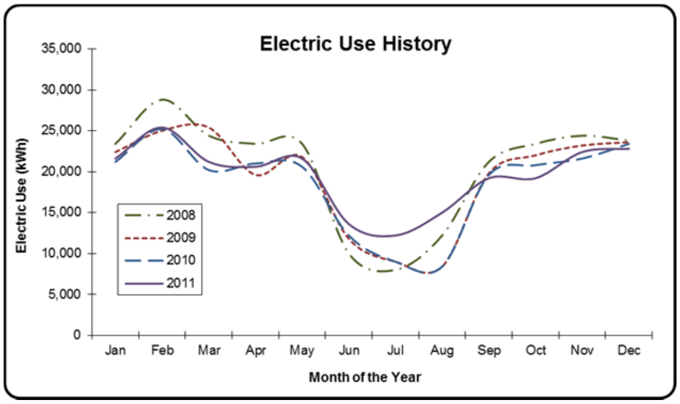
The building energy sources include an electric service and a fuel oil tank. Fuel oil is used for the majority of the heating loads and domestic hot water while electricity serves all other loads. The following table shows annual energy use and cost.

**Annual Energy Consumption and Cost**

| Source | Consumption | | Cost | Energy, MMBtu | |
|---|---|---|---|---|---|
| Electricity | 234,000 | kWh | $50,200 | 798 | 32% |
| Fuel Oil | 12,500 | Gallons | $42,800 | 1,698 | 68% |
| Totals | - | | $93,000 | 2,496 | 100% |

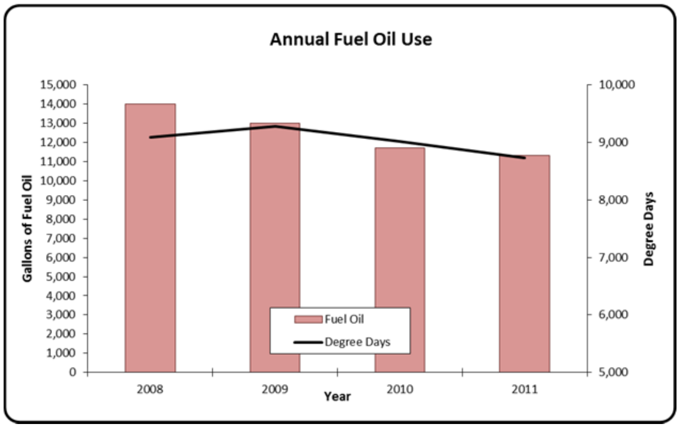
### Electricity

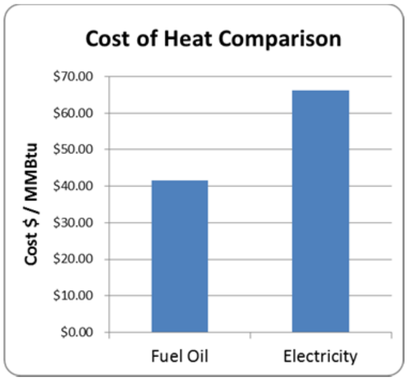
This chart shows electrical energy use from 2008 to 2011. The effective cost—energy costs plus demand charges—is 21.4¢ per kWh.



### Fuel Oil

This chart shows heating energy use from 2008 to 2011. The chart compares annual use with the heating degree days which is a measurement of the demand for energy to heat a building. A year with a higher number of degree days reflects colder outside temperatures and a higher heating requirement.





### Cost of Heat Comparison

This chart shows a comparison of the current cost of fuel oil heat and electric heat. The comparison is based on a fuel oil conversion efficiency of 70% and electric boiler conversion efficiency of 95%. Fuel oil heat is currently less expensive than electric heat.

Section 3

# Energy Efficiency Measures

The following energy efficiency measures (EEMs) were identified during the energy audit. The EEMs are priority ranked and, where applicable, subjected to energy and life cycle cost analysis. Appendix A contains the energy and life cycle cost analysis spreadsheets.

The EEMs are grouped into the following prioritized categories:

- **Behavioral or Operational**: EEMs that require minimal capital investment but require operational or behavioral changes. The EEMs provide a life cycle savings but an analysis is not performed because the guaranteed energy savings is difficult quantify.
- **High Priority**: EEMs that require a small capital investment and offer a life cycle savings. Also included in this category are higher cost EEMs that offer significant life cycle savings.
- **Medium Priority**: EEMs that require a significant capital investment to provide a life cycle savings. Many medium priority EEMs provide a high life cycle savings and offer substantial incentive to increase investment in building energy efficiency.

## BEHAVIORAL OR OPERATIONAL

The following EEMs are recommended for implementation. They require behavioral or operational changes that can occur with minimal investment to achieve immediate savings. These EEMs are not easily quantified by analysis because they cannot be accurately predicted. They are recommended because they offer a life cycle savings, represent good practice, and are accepted features of high performance buildings.

### *EEM-1: Replace Broken Window*

Purpose: A window on the west end of the elementary wing has a hole in the outer pane from a BB gun. Energy will be saved if broken window is repaired.

Scope: Repair broken window.

### *EEM-2: Install Indirect Hot Water Heaters*

Purpose: The boilers have adequate capacity to heat the building and the domestic hot water. However, there are two oil-fired hot water heaters, of which only the smaller 250 gallon unit is in service. The direct heaters have higher heat loss and maintenance requirements than an indirect hot water heater. We recommend that when the oil-fired units reach the end of their service life they are replaced with two indirect hot water heaters.

Scope: When the oil-fired hot water heaters fail, replace them with indirect hot water heaters connected to the hydronic heating system.

### *EEM-3: Clear Access to Perimeter Heaters*

Purpose: In some of the school rooms the furniture and shelving units are pushed up against the perimeter heaters. For the perimeter heating units to operate as effectively and efficiently as possible, they must have a clear path for air flow above and below them. In the stage room where bookshelves were blocking over half of the perimeter heaters, the staff member in the room needed to turn up the thermostat in the space during class hours. Energy will be saved if staff keeps access to the perimeter heaters open.

Scope: Educate staff of the importance to not block air flow to the base or top of the perimeter heating units and verify clear access on a routine basis.

### *EEM-4: Install Pipe and Valve Insulation*

Purpose: Approximately 50 square feet of piping and valves are uninsulated in the boiler room, including the boiler expansion tank and aerator. Energy will be saved if these sections of piping and distribution components are optimally insulated.

Scope: Install insulation on piping and distribution components.

## HIGH PRIORITY

The following EEMs are recommended for implementation because they are low cost measures that have a high savings to investment ratio. The EEMs are listed from highest to lowest priority. Negative values, in parenthesis, represent savings.

### *EEM-5: Isolate Lag Boiler*

Purpose: During periods when the outside temperature is warm enough that only one boiler needs to be operated, circulating hot water through an isolated boiler in a dual boiler system can result in a 3% efficiency loss of the operable boiler due to the isolated boiler acting as a heat sink. Energy will be saved if only a single boiler is on line when temperatures permit.

Scope: Shut down and isolate the lag boiler when only a single boiler is needed to support building operations.

| Annual Costs | | | Life Cycle Costs | | | | |
|---|---|---|---|---|---|---|---|
| Operating | Energy | Total | Investment | Operating | Energy | Total | SIR |
| $120 | ($1,400) | ($1,280) | $500 | $2,000 | ($39,700) | ($37,200) | 75.4 |

### *EEM-6: Electrical Room Heat Recovery*

Purpose: Heat is generated by equipment operating in the electrical room. This heat is removed with an exhaust fan. Energy will be saved if this generated heat is returned within the shell of the building.

Scope: Re-route exhaust air ducting to return electrical room heat to the building.

| Annual Costs | | | Life Cycle Costs | | | | |
|---|---|---|---|---|---|---|---|
| Operating | Energy | Total | Investment | Operating | Energy | Total | SIR |
| $0 | ($810) | ($810) | $1,800 | $0 | ($23,100) | ($21,300) | 12.8 |

### *EEM-7: Replace Aerators*

Purpose: Energy and water will be saved by replacing the lavatory aerators with low-flow models.

Scope: Replace aerators on lavatories with water-conserving fixtures.

| Annual Costs | | | Life Cycle Costs | | | | |
|---|---|---|---|---|---|---|---|
| Operating | Energy | Total | Investment | Operating | Energy | Total | SIR |
| $0 | ($250) | ($250) | $800 | $0 | ($6,400) | ($5,600) | 8.0 |

### *EEM-8: Perform a Boiler Combustion Test*

Purpose: Operating the boiler with an optimum amount of excess air will improve combustion efficiency. Annual cleaning followed by a combustion test is recommended.

Scope: Annually clean and perform a combustion test on the boiler.

| Annual Costs | | | Life Cycle Costs | | | | |
|---|---|---|---|---|---|---|---|
| Operating | Energy | Total | Investment | Operating | Energy | Total | SIR |
| $720 | ($530) | $190 | $700 | $12,300 | ($15,100) | ($2,100) | 4.0 |

### *EEM-9: Optimize HVAC Systems*

Purpose: The building utilizes constant volume heating and ventilation system units to provide conditioned air to interior spaces during the normal operational schedule, after school hours for activities, and as needed on weekends. Under most conditions the space occupancy throughout the majority of these operational hours is less than the design occupancy. This results in an unnecessarily high fuel and electric demand to support school operations. Energy will be saved if modifications are made to the respective air handling systems to reduce air flow when not needed.

Scope: Perform repairs as follows and recommission all air handling units to perform as a properly integrated system when completed.

- AHU-1 and AHU-2

  These systems are currently only operated to heat the corridors during cold weather. This operating mode does not properly ventilate the classrooms. We recommend operating the systems whenever the classrooms are occupied and improving their efficiency with the following:

  - Convert controls to DDC.
  - Remove corridors from the systems and operate fans with minimum 10% outside air for ventilation.
  - Replace turn vanes with VFD's to modulate fan speed.

- AHU-4 (Cafeteria)

  - Modify controls to provide sequential control of mixing dampers and heating coil to maintain room setpoint with $CO_2$ sensor override of mixing dampers.

- AHU-5 (Gym)

  - Modify controls to provide sequential control of mixing dampers and heating coil to maintain room setpoint with $CO_2$ sensor override of mixing dampers.
  - Install VFD to modulate air flow with cooling requirements; minimum flow of 50%.

- Hydronic Heating System

  - Operate one pump during mild weather and two pumps during cold weather.

| Annual Costs | | | Life Cycle Costs | | | | |
|---|---|---|---|---|---|---|---|
| Operating | Energy | Total | Investment | Operating | Energy | Total | SIR |
| $300 | ($16,290) | ($15,990) | $111,000 | $5,100 | ($410,400) | ($294,300) | 3.7 |

## MEDIUM PRIORITY

Medium priority EEMs will require planning and a higher level of investment. They are recommended because they offer a life cycle savings. The EEMs are listed from highest to lowest priority. Negative values, in parenthesis, represent savings.

### *EEM-10: Upgrade Motors to Premium Efficiency*

Purpose: The equipment inspection identified five motors that can be upgraded with premium efficiency models to save energy. They are:

| | |
|---|---|
| - AHU-5 | 7.5 HP |
| - CP-1 | 2 HP |
| - CP-3 | 3 HP |
| - AC-1 | 2 HP (x2) |

Scope: Replace identified motors with premium efficiency motors.

| Annual Costs | | | Life Cycle Costs | | | | |
|---|---|---|---|---|---|---|---|
| Operating | Energy | Total | Investment | Operating | Energy | Total | SIR |
| $0 | ($680) | ($680) | $6,000 | $0 | ($13,300) | ($7,300) | 2.2 |

### *EEM-11: Install Occupancy Sensors in Locker Rooms*

Purpose: Lighting controls for the gym locker rooms are on a manual switch and frequently remain on even when the rooms are unoccupied. Energy will be saved if a motion detector is installed to minimize unnecessary lighting hours. We recommend that a 10-minute delay time is used on the occupancy sensor.

Lighting and exhaust in the toilet rooms are manually controlled from the wall switch and frequently remain on even when unoccupied. Energy will be saved if an occupancy sensor is installed to minimize unnecessary lighting and exhaust fan run hours. We recommend that a 5-minute delay time is used on the occupancy sensor.

Scope: Install an occupancy sensor in each locker room and toilet room to control lighting and the exhaust fans.

| Annual Costs | | | Life Cycle Costs | | | | |
|---|---|---|---|---|---|---|---|
| Operating | Energy | Total | Investment | Operating | Energy | Total | SIR |
| ($30) | ($1,360) | ($1,390) | $16,200 | ($600) | ($35,600) | ($20,000) | 2.2 |

### *EEM-12: Upgrade Gym Lighting*

Purpose: The existing gym lighting consists of 28 pendant-mounted metal halide fixtures. Staff currently keeps the lighting on all day despite variable occupancy so they don't have to wait 10-15 minutes for restart. We estimate that lighting hours could be reduced by 20 hours per week by using a lamp that can start instantaneously.

Similar light levels could be achieved with multi-lamp T5 lighting. Energy will be saved if the 28 metal halide light fixtures are replaced with 6-bulb T5 units.

Scope: Replace metal halide lights with 6-bulb T5 units.

| Annual Costs | | | Life Cycle Costs | | | | |
|---|---|---|---|---|---|---|---|
| Operating | Energy | Total | Investment | Operating | Energy | Total | SIR |
| ($120) | ($3,030) | ($3,150) | $29,800 | ($2,100) | ($59,600) | ($31,900) | 2.1 |

### *EEM-13: Boiler Room Heat Recovery*

Purpose: Heat generated by the boilers, equipment, and piping is currently rejected outdoors by VF-1. Energy will be saved if this generated heat is transferred as beneficial heat within the building.

Scope: Install an air-to-water heat pump in the boiler room. Distribute the heat via hydronic piping to a fan coil unit installed in each hallway. Replace VF-1 with a motorized damper that opens whenever a boiler is firing.

| Annual Costs | | | Life Cycle Costs | | | | |
|---|---|---|---|---|---|---|---|
| Operating | Energy | Total | Investment | Operating | Energy | Total | SIR |
| $250 | ($5,410) | ($5,160) | $107,500 | $4,300 | ($187,000) | ($75,200) | 1.7 |

Section 4

# Description of Systems

## ENERGY SYSTEMS

This section provides a general description of the building systems. Energy conservation opportunities are addressed in Section 3, Energy Efficiency Measures.

### Building Envelope

| Component | Description (inside to outside) | R-value<br>Existing | Optimal |
|---|---|---|---|
| Exterior Wall | 5/8” Gyp. bd, 2”x8” studs 16” o.c., R-30 batt, ½” plywood, siding | R-32 | R-30 |
| Roof | 24” o.c. joists w/ R-38 batt, 5/8” gyp. bd. (2 layers) | R-38 | R-46 |
| Floor Slab | 4” Concrete slab-on-grade | R-10 | R-10 |
| Foundation | 8” concrete w/ 2” perimeter insulation board | R-10 | R-20 |
| Windows | Double pane windows w/ storm window inserts | R-3 | R-5 |
| Doors | Steel doors w/ non-thermally broken frames | R-1.5 | R-5 |

### Heating System

The building is heated by two fuel oil boilers that provide heat to seven air handling unit systems, unit heaters, and perimeter hydronic systems. The heating system has the following pumps:

- CP-1 supplies heat to AHU’s 1, 2, 3, 6, & 7
- CP-2 and CP-3 supply heat to AHU’s 4 & 5 and the baseboard heaters
- HWCP-1 is the domestic hot water circulation pump

### Ventilation Systems

| Area | Fan System | Description |
|---|---|---|
| High School | AHU-1 | 12,000 cfm 10 hp constant volume air handling unit consisting of a heating coil, mixing box, filter section, and supply fan. Unit is currently serving just the hallway; classroom VAV boxes are disabled. |
| Elementary Hallway | AHU-2 | 12,000 cfm 10 hp constant volume air handling unit consisting of a heating coil, mixing box, filter section, and supply fan. Unit is currently serving just the hallway; classroom VAV boxes are disabled. |
| Shop | AHU-3 | 4,200 cfm 3 hp constant volume air handling unit consisting of a heating coil, mixing box, filter section, and supply fan *(not used)* |
| Multi-purpose Room | AHU-4 | 4,300 cfm 3 hp constant volume air handling unit consisting of a heating coil, mixing box, filter section, and supply fan |
| Gym | AHU-5 | 12,800 cfm 7.5 hp constant volume air handling unit consisting of a heating coil, mixing box, filter section, and supply fan |
| Locker Rooms | AHU-6 | 3,000 cfm 2 hp constant volume air handling unit consisting of a heating coil, mixing box, filter section, heat recovery from EF-1, and supply fan *(not used)* |
| Stage | AHU-7 | 3,900 cfm 2 hp constant volume air handling unit consisting of a heating coil, mixing box, filter section, and supply fan |
| Locker Rooms | EF-1 | 3,300 cfm 2 hp constant volume exhaust fan with heat recovery |
| New Addition Restrooms | EF-1a | 500 cfm constant volume exhaust fan *(not used)* |
| High School Restrooms | EF-2 | 500 cfm constant volume exhaust fan |
| Janitors Closet | EF-4 | 170 cfm constant volume exhaust fan |
| Electrical Room | EF-5 | 160 cfm constant volume exhaust fan |
| Special Education Restroom | EF-6 | 145 cfm constant volume exhaust fan |
| Boiler Room | VF-1 | 5,100 cfm ½ hp constant volume exhaust fan |

### Domestic Hot Water System

The domestic hot water system consists of a 250-gallon oil-fired hot water heater that is on-line and a 500-gallon oil-fired hot water heater that is disconnected. The original water heaters are sized to carry the anticipated shower demand, but staff observed that the showers have only been used twice this school year. Because the boilers are also operating the entire school year, both domestic hot water heaters could be removed and replaced with two smaller indirect hot water heaters.

### Automatic Control System

The building has a DDC system to control the operation of the heating and ventilation systems. Energy can be saved through further optimization of fan system scheduling combined with a retro-commissioning of the air handler systems.

## Lighting

Interior lighting consists primarily of T12 and T8 fluorescent fixtures throughout the classrooms, commons, and office spaces. Staff has completed approximately 50% of the conversion of T12 lighting fixtures to the more efficient T8 models and expects to complete the conversion of all fixtures to T8’s by next summer. All calculations of potential energy savings have been made using the more efficient T8 fixtures.

Metal halide lighting is used in the library and the gym. Existing gym lighting utilizes 28 pendant-mounted metal halide bulbs to light the space for approximately 60 hours per week to support school-hour class activities and after-school sports and community events. We estimate that lighting hours can be reduced to 40 hours/week with the selection of a lamp that can start instantaneously—staff does not currently shut off metal halide fixtures once they are energized so as to avoid a 10-15 minute wait for restart.

Only 50% of the lighting in the library is typically utilized because 250-watt metal halide fixtures were installed. Staff would like to replace the library metal halide lighting with a more efficient fixture that still provides the ability to be dimmed when necessary.

Exterior lighting consists primarily of metal halide lighting. Only four of the 24 outdoor architectural wall lights are utilized, and only for evenings with special events. Because lighting operational hours are controlled by staff, operational costs for lighting with existing infrastructure are kept to a minimum. Replacement of existing exterior metal halide fixtures with more efficient units is a solution for further reducing operational costs.

## Electric Equipment

Commercial equipment for food preparation is located in the kitchen and surrounding spaces.

Section 5

# Methodology

Information for the energy audit was gathered through on-site observations, review of construction documents, and interviews with operation and maintenance personnel. The EEMs are evaluated using energy and life cycle cost analyses and are priority ranked for implementation.

## Energy Efficiency Measures

Energy efficiency measures are identified by evaluating the building's energy systems and comparing them to systems in modern, high performance buildings. The process for identifying the EEMs acknowledges the realities of an existing building that was constructed when energy costs were much lower. Many of the opportunities used in modern high performance buildings—highly insulated envelopes, variable capacity mechanical systems, heat pumps, daylighting, lighting controls, etc.—simply cannot be economically incorporated into an existing building.

The EEMs represent practical measures to improve the energy efficiency of the buildings, taking into account the realities of limited budgets. If a future major renovation project occurs, additional EEMs common to high performance buildings should be incorporated.

## Life Cycle Cost Analysis

The EEMs are evaluated using life cycle cost analysis which determines if an energy efficiency investment will provide a savings over a 25-year life. The analysis incorporates construction, replacement, maintenance, repair, and energy costs to determine the total cost over the life of the EEM. Future maintenance and energy cash flows are discounted to present worth using escalation factors for general inflation, energy inflation, and the value of money. The methodology is based on the National Institute of Standards and Technology (NIST) Handbook 135 – Life Cycle Cost Analysis.

Life cycle cost analysis is preferred to simple payback for facilities that have long—often perpetual—service lives. Simple payback, which compares construction cost and present energy cost, is reasonable for short time periods of 2-4 years, but yields below optimal results over longer periods because it does not properly account for the time value of money or inflationary effects on operating budgets. Accounting for energy inflation and the time value of money properly sums the true cost of facility ownership and seeks to minimize the life cycle cost.

### Construction Costs

The cost estimates are derived based on a preliminary understanding of the scope of each EEM as gathered during the walk-through audit. The construction costs for in-house labor are $60 per hour for work typically performed by maintenance staff and $110 per hour for contract labor.

The cost estimate assumes the work will be performed as part of a larger renovation or energy efficiency upgrade project. When implementing EEMs, the cost estimate should be revisited once the scope and preferred method of performing the work has been determined. It is possible some EEMs will not provide a life cycle savings when the scope is finalized.

### Maintenance Costs

Maintenance costs are based on in-house or contract labor using historical maintenance efforts and industry standards. Maintenance costs over the 25-year life of each EEM are included in the life cycle cost calculation spreadsheets and represent the level of effort to maintain the systems.

### Energy Analysis

The energy performance of an EEM is evaluated within the operating parameters of the building. A comprehensive energy audit would rely on a computer model of the building to integrate building energy systems and evaluate the energy savings of each EEM. This investment grade audit does not utilize a computer model, so energy savings are calculated with factors that account for the dynamic operation of the building. Energy savings and costs are estimated for the 25-year life of the EEM using appropriate factors for energy inflation.

### Prioritization

Each EEM is prioritized based on the life cycle savings to investment ratio (SIR) using the following formula:

$$\text{Prioritization Factor} = \text{Life Cycle Savings} / \text{Capital Costs}$$

This approach factor puts significant weight on the capital cost of an EEM, making lower cost EEMs more favorable.

## Economic Factors

The following economic factors are significant to the findings.

Nominal Interest Rate: This is the nominal rate of return on an investment without regard to inflation. The analysis uses a rate of 5%.

Inflation Rate: This is the average inflationary change in prices over time. The analysis uses an inflation rate of 2%.

Economic Period: The analysis is based on a 25-year economic period with construction beginning in 2012.

### Fuel Oil

Fuel oil currently costs $4.03 per gallon for a seasonally adjusted blend of #1 and #2 fuel oil. The analysis is based on 6% fuel oil inflation which has been the average for the past 20-years.

### Electricity

Electricity is supplied by Alaska Power and Telephone. The rate schedule is:

**Alaska Power Company Bulk Power A-2**

| | |
|---|---|
| Electricity ($ / kWh ) | $0.0946 |
| Cost of Power Adjustment ($ / kWh) | $0.0901 |
| Demand ( $ / kW ) | $6.95 |
| Customer Charge ( $ / mo ) | $84.52 |

### Summary

The following table summarizes the energy and economic factors used in the analysis.

**Summary of Economic and Energy Factors**

| Factor | Rate or Cost | Factor | Rate or Cost |
|---|---|---|---|
| Nominal Discount Rate | 5% | Electricity | $0.214/kwh |
| General Inflation Rate | 2% | Electricity Inflation | 3% |
| Fuel Oil Cost (2012) | $4.03/gal | Fuel Oil Inflation | 6% |

Appendix A

# Energy and Life Cycle Cost Analysis

# Skagway K-12 School

## Basis

Economic

| | | | | | |
|---|---|---|---|---|---|
| Study Period (years) | 25 | Nominal Discount Rate | 5% | General Inflation | 2% |

Energy

| | 2011 $/gal | Fuel Inflation | 2012 $/gal | | |
|---|---|---|---|---|---|
| Fuel Oil | $4.03 | 6% | $4.27 | | |
| Electricity | $/kWh (2011) | $/kW (2011) | Inflation | $/kWh (2012) | $/kW (2012) |
| w/ Demand Charges | $0.185 | $6.95 | 3% | $0.191 | $7.16 |
| w/o Demand Charges | $0.214 | - | 3% | $0.220 | - |

## *EEM-5: Isolate Lag Boiler*

Energy Analysis

| Boiler | Input MBH | Loss % | Loss MBH | Hours, exist | Hours, new | kBtu | η boiler | Gallons |
|---|---|---|---|---|---|---|---|---|
| B-1 | 1,905 | 0.5% | 10 | 6,480 | 3,240 | -30,857 | 68% | -328 |

| Life Cycle Cost Analysis | Year | Qty | Unit | Base Cost | Year 0 Cost |
|---|---|---|---|---|---|
| Construction Costs | | | | | |
| Establish procedure for isolating boiler | 0 | 1 | ea | $500 | $500 |
| Annual Costs | | | | | |
| Isolate boilers annually | 1 - 25 | 2 | hrs | $60.00 | $2,043 |
| Energy Costs | | | | | |
| Fuel Oil | 1 - 25 | -328 | gal | $4.27 | ($39,671) |
| Net Present Worth | | | | | ($37,100) |

## *EEM-6: Electrical Room Heat Recovery*

Energy Analysis

Fuel Oil

| Watts | Hours | MBH | kBtu | η boiler | Gallons |
|---|---|---|---|---|---|
| -600 | 8,760 | -2 | -17,933 | 68% | -190 |

| Life Cycle Cost Analysis | Year | Qty | Unit | Base Cost | Year 0 Cost |
|---|---|---|---|---|---|
| Construction Costs | | | | | |
| Exhaust fan ductowrk and exhaust grille | 0 | 1 | LS | $1,000 | $1,000 |
| Estimating contingency | 0 | | | 15% | $150 |
| Overhead & profit | 0 | | | 30% | $345 |
| Design fees | 0 | | | 10% | $150 |
| Project management | 0 | | | 8% | $132 |
| Energy Costs | | | | | |
| Fuel Oil | 1 - 25 | -190 | gal | $4.27 | ($23,056) |
| Net Present Worth | | | | | ($21,300) |

# Skagway K-12 School

## *EEM-7: Replace Aerators*

Energy Analysis

| | Gallons per Use | | | | | | η boiler | 68% |
|---|---|---|---|---|---|---|---|---|
| Fixture | Existing | Proposed | Uses/day | Days | Water,Gals | % HW | kBTU | Gallons |
| Lavatories | 0.3 | 0.2 | 200 | 198 | -7,128 | 80% | -3,805 | -40 |
| | | | | | -7,128 | | | -40 |

| Life Cycle Cost Analysis | Year | Qty | Unit | Base Cost | Year 0 Cost |
|---|---|---|---|---|---|
| Construction Costs | | | | | |
| Replace lavatory aerators | 0 | 23 | ea | $35 | $805 |
| Energy Costs | | | | | |
| Water | 1 - 25 | -7 | kgals | $10.960 | ($1,536) |
| Fuel Oil | 1 - 25 | -40 | gal | $4.27 | ($4,891) |
| Net Present Worth | | | | | ($5,600) |

## *EEM-8: Perform Boiler Combustion Test*

Energy Analysis

| Annual Gal | % Savings | Savings, Gal |
|---|---|---|
| 12,500 | -1.0% | -125 |

| Life Cycle Cost Analysis | Year | Qty | Unit | Base Cost | Year 0 Cost |
|---|---|---|---|---|---|
| Construction Costs | | | | | |
| Purchase combustion analyzer | 0 | 1 | LS | $700 | $700 |
| Annual Costs | | | | | |
| Clean and combustion test boiler | 1 - 25 | 12 | hrs | $60.00 | $12,259 |
| Energy Costs | | | | | |
| Fuel Oil | 1 - 25 | -125 | gal | $4.27 | ($15,135) |
| Net Present Worth | | | | | ($2,200) |

# Skagway K-12 School

## *EEM-9: Optimize HVAC Systems*

Energy Analysis

| Fan | Case | CFM | ΔP | η, fan | BHP | η, motor | kW | Hours | kWh |
|---|---|---|---|---|---|---|---|---|---|
| AHU-1 | Existing | -12,000 | 3.00 | 60% | -9 | 91% | -8 | 1,620 | -12,537 |
|  | Optimized | 8,000 | 2.00 | 60% | 4 | 91% | 3 | 1,620 | 5,572 |
| AHU-2 | Existing | -12,000 | 3.00 | 60% | -9 | 91% | -8 | 1,620 | -12,537 |
|  | Optimized | 8,000 | 2.00 | 60% | 4 | 91% | 3 | 1,620 | 5,572 |
| AHU-5 | Existing | -12,800 | 1.60 | 55% | -6 | 90% | -5 | 1,260 | -6,119 |
|  | Optimized | 8,000 | 1.25 | 55% | 3 | 90% | 2 | 1,260 | 2,988 |
| S-3 | Existing | -6,000 | 3.00 | 55% | -5 | 89% | -4 |  | 0 |
|  | Optimized | 4,000 | 2.00 | 55% | 2 | 93% | 2 |  | 0 |
| S-6 | Existing | -2,400 | 1.25 | 50% | -1 | 86% | -1 |  | 0 |
|  | Optimized | 1,500 | 0.75 | 50% | 0 | 86% | 0 |  | 0 |
| S-7 | Existing | -3,600 | 1.00 | 50% | -1 | 88% | -1 |  | 0 |
|  | Optimized | 1,800 | 0.75 | 50% | 0 | 88% | 0 |  | 0 |
|  |  |  |  |  |  |  | -15 |  | -17,061 |

| Ventilation |  | SA CFM | MAT | T,room | MBH | Hours | kBtu | η boiler | Gallons |
|---|---|---|---|---|---|---|---|---|---|
| AHU-1 | Existing | -8,000 | 60 | 70 | -86 | 1,620 | -139,968 | 68% | -1,486 |
|  | Optimized | 8,000 | 64 | 70 | 52 | 1,620 | 83,981 | 68% | 892 |
| AHU-2 | Existing | -8,000 | 60 | 70 | -86 | 1,620 | -139,968 | 68% | -1,486 |
|  | Optimized | 8,000 | 64 | 70 | 52 | 1,620 | 83,981 | 68% | 892 |
| AHU-4 | Existing | -4,300 | 45 | 70 | -116 | 540 | -62,694 | 68% | -666 |
|  | Optimized | 4,300 | 62 | 70 | 37 | 540 | 20,062 | 68% | 213 |
| AHU-5 | Existing | -12,800 | 62 | 70 | -111 | 1,260 | -139,346 | 68% | -1,480 |
|  | Optimized | 8,000 | 64 | 70 | 52 | 1,260 | 65,318 | 68% | 694 |
| S-7 | Existing | -3,600 | 60 | 70 | -39 |  | 0 | 68% | 0 |
|  | Optimized | 1,800 | 65 | 70 | 10 |  | 0 | 68% | 0 |
|  |  |  |  |  |  |  | -228,634 |  | -2,428 |

Pumping Energy

| Pump | GPM | Head | η pump | BHP | η motor | kW | Hours | kWh |
|---|---|---|---|---|---|---|---|---|
| CP-1 | -116 | 30 | 65% | -1.8 | 89% | -1.5 | 6,480 | -9,838 |
| CP-3 | -160 | 40 | 75% | -2.9 | 89% | -2.4 | 6,480 | -15,680 |
| CP-1 | 116 | 30 | 65% | 1.8 | 89% | 1.5 | 5,040 | 7,651 |
| CP-3 | 160 | 40 | 75% | 2.9 | 89% | 2.4 | 4,320 | 10,453 |
|  |  |  |  |  |  |  |  | -7,413 |

| Life Cycle Cost Analysis | Year | Qty | Unit | Base Cost | Year 0 Cost |
|---|---|---|---|---|---|
| Construction Costs |  |  |  |  |  |
| Convert AHU-1 and AHU-2 to DDC | 0 | 20 | pts | $1,500 | $30,000 |
| Install VFD for AHU-1 and AHU-2 | 0 | 2 | LS | $7,500 | $15,000 |
| AHU-4 and AHU-5: Install CO2 sensor and modify controls | 0 | 2 | ea | $5,000 | $10,000 |
| Install VFD for AHU-5 | 0 | 1 | LS | $7,500 | $7,500 |
| Estimating contingency | 0 |  |  | 15% | $9,375 |
| Overhead & profit | 0 |  |  | 30% | $21,563 |
| Design fees | 0 |  |  | 10% | $9,344 |
| Project management | 0 |  |  | 8% | $8,223 |
| Annual Costs |  |  |  |  |  |
| VFD Maintenance | 1 - 25 | 3 | LS | $100.00 | $5,108 |
| Energy Costs |  |  |  |  |  |
| Electric Energy | 1 - 25 | -24,473 | kWh | $0.191 | ($91,671) |
| Electric Demand | 1 - 25 | -176 | kW | $7.16 | ($24,787) |
| Fuel Oil | 1 - 25 | -2,428 | gal | $4.27 | ($293,942) |
| Net Present Worth |  |  |  |  | ($294,300) |

## Skagway K-12 School

### *EEM-10: Upgrade Motors*

Energy Analysis

| Equip | Number | HP | $\eta_{old}$ | $\eta_{new}$ | kW | Hours | kWh |
|---|---|---|---|---|---|---|---|
| AC-1 | 1 | 2 | 80.8% | 86.5% | -0.09 | 2,920 | -248 |
| CP-1 | 1 | 2 | 78.5% | 89.5% | -0.16 | 6,480 | -1,063 |
| CP-2 | 1 | 3 | 81.4% | 89.5% | -0.18 | 6,480 | -1,175 |
| AHU-5 | 1 | 7.5 | 81.5% | 91.7% | -0.57 | 1,260 | -719 |
| | | | | | -1.0 | | -3,206 |

| Life Cycle Cost Analysis | | Year | Qty | Unit | Base Cost | Year 0 Cost |
|---|---|---|---|---|---|---|
| Construction Costs | HP | | | | | |
| Replace motor | 2 | 0 | 3 | LS | 955 | $2,865 |
| Replace motor | 3 | 0 | 1 | LS | 970 | $970 |
| Replace motor | 7.5 | 0 | 1 | LS | 1,690 | $1,690 |
| Project management | | 0 | | | 8% | $442 |
| Energy Costs | | | | | | |
| Electric Energy | | 1 - 25 | -3,206 | kWh | $0.191 | ($12,007) |
| Electric Demand | | 1 - 25 | -9 | kW | $7.16 | ($1,268) |
| Net Present Worth | | | | | | ($7,300) |

### *EEM-11: Install Occupancy Sensors*

Energy Analysis

| Location | Type | # Fixtures | Lamp | Lamp, watts | Fixture Watts | Hours, exist | Hours, new | Savings, kWh |
|---|---|---|---|---|---|---|---|---|
| Lockers | Surface | 22 | 2T8 | 64 | 74 | -1,620 | 540 | -1,749 |
| Toilets | Surface | 16 | 2T8 | 64 | 74 | -1,620 | 720 | -1,060 |

Lamp Replacement

| Location | # Fixtures | Lamp | # Lamps | Life, hrs | Lamps//yr | $/lamp | $/Replace |
|---|---|---|---|---|---|---|---|
| Lockers | 22 | 2T8 | 1 | 30,000 | -0.79 | $4 | $15 |
| Toilets | 16 | 2T8 | 1 | 30,000 | -0.48 | $4 | $15 |

Exhaust Fans

| Unit | CFM, ex | CFM,new | $\Delta T$ | MBH | Hours | kBtu | $\eta$ boiler | Gallons |
|---|---|---|---|---|---|---|---|---|
| EF-1A | 500 | 200 | 20 | -7 | 1,710 | -11,286 | 68% | -120 |
| EF-2 | 500 | 200 | 20 | -7 | 1,710 | -11,286 | 68% | -120 |
| | | | | -13 | | | | -240 |

| Life Cycle Cost Analysis | Year | Qty | Unit | Base Cost | Year 0 Cost |
|---|---|---|---|---|---|
| Construction Costs | | | | | |
| Install occupancy sensors | 0 | 6 | LS | $1,500 | $9,000 |
| Estimating contingency | 0 | | | 15% | $1,350 |
| Overhead & profit | 0 | | | 30% | $3,105 |
| Design fees | 0 | | | 10% | $1,346 |
| Project management | 0 | | | 8% | $1,184 |
| Adjust photocell | 0 | 1 | LS | $200 | $200 |
| Annual Costs | | | | | |
| Lamp replacements | 1 - 25 | -1.27 | lamps | $26.00 | ($563) |
| Energy Costs | | | | | |
| Electric Energy | 1 - 25 | -1,749 | kWh | $0.191 | ($6,550) |
| Fuel Oil | 1 - 25 | -240 | gal | $4.27 | ($29,020) |
| Net Present Worth | | | | | ($19,900) |

# Skagway K-12 School

## *EEM-12: Upgrade Gym Lighting*

Energy Analysis

| Type | # Fixtures | Lamp | Lamp, watts | Fixture Watts | kW | Hours, exist | Hours, new | Savings, kWh |
|---|---|---|---|---|---|---|---|---|
| MH | -28 | MH | 400 | 460 | -13 | 2,400 | 0 | -30,912 |
| T5 | 28 | 6T5 | 310 | 357 | 10 | 0 | 1,600 | 15,971 |
| | | | | | -3 | | | -14,941 |

Lamp Replacement

| # Fixtures | Lamp | # Lamps | Life, hrs | Replace/yr | $/lamp replace |
|---|---|---|---|---|---|
| 28 | MH | -1 | 20,000 | -3.36 | $30 |
| 28 | 6T5 | 6 | 30,000 | 1.49 | $24 |

| Life Cycle Cost Analysis | Year | Qty | Unit | Base Cost | Year 0 Cost |
|---|---|---|---|---|---|
| Construction Costs | | | | | |
| Replace 400 watt MH with T5 Fluorescent | 0 | 28 | LS | $600 | $16,800 |
| Estimating contingency | 0 | | | 15% | $2,520 |
| Overhead & profit | 0 | | | 30% | $5,796 |
| Design fees | 0 | | | 10% | $2,512 |
| Project management | 0 | | | 8% | $2,210 |
| Annual Costs | | | | | |
| Existing lamp replacement, 400 watt MH | 1 - 25 | -3.36 | replacements | $60.00 | ($3,433) |
| New lamp replacement, T5 | 1 - 25 | 1.49 | replacements | $54.00 | $1,373 |
| Energy Costs | | | | | |
| Electric Energy | 1 - 25 | -14,941 | kWh | $0.191 | ($55,965) |
| Electric Demand | 1 - 25 | -26 | kW | $7.16 | ($3,670) |
| Net Present Worth | | | | | ($31,900) |

## *EEM-13: Boiler Room Heat Recovery*

Energy Analysis

Heat Recovery

| Input, MBH | Jacket Loss | MBH | Hours | Loss, kBtu | Factor | Recovery, kBtu | η boiler | Gallons |
|---|---|---|---|---|---|---|---|---|
| 3,810 | -1.0% | -38 | 6,480 | -246,857 | 75% | -185,143 | 82% | -1,630 |

Heat Pump Energy

| Recovery, kBtu | COP | kWh | HP Heat, kBtu | η boiler | Gallons |
|---|---|---|---|---|---|
| -185,143 | 3 | 18,087 | 61,714 | 82% | -543 |

| Life Cycle Cost Analysis | Year | Qty | Unit | Base Cost | Year 0 Cost |
|---|---|---|---|---|---|
| Construction Costs | | | | | |
| Boiler room heat pump | 0 | 1 | LS | $15,000 | $15,000 |
| Hallway fan coil unit | 0 | 2 | LS | $6,000 | $12,000 |
| Motorized combustion air damper | 0 | 1 | LS | $3,500 | $3,500 |
| Piping between heat pump and fan coil | 0 | 1 | LS | $22,000 | $22,000 |
| Controls | 0 | 1 | LS | $8,000 | $8,000 |
| Estimating contingency | 0 | | | 15% | $9,075 |
| Overhead & profit | 0 | | | 30% | $20,873 |
| Design fees | 0 | | | 10% | $9,045 |
| Project management | 0 | | | 8% | $7,959 |
| Annual Costs | | | | | |
| Heat pump maintenance | 1 - 25 | 1 | LS | $250.00 | $4,257 |
| Energy Costs | | | | | |
| Electric Energy | 1 - 25 | 18,087 | kWh | $0.191 | $67,751 |
| Electric Demand | 1 - 25 | 60.0 | kW | $7.16 | $8,443 |
| Fuel Oil | 1 - 25 | -2,174 | gal | $4.27 | ($263,186) |
| Net Present Worth | | | | | ($75,300) |

Appendix B

# Energy and Utility Data

# Skagway K-12 School

## ELECTRIC RATE

| Alaska Power Company Bulk Power A-2 | Haines Skagway |
|---|---|
| Electricity ($ / kWh ) | $0.0946 |
| Cost of Power Adjustment ($ / kWh) | $0.0901 |
| Demand ( $ / kW ) | $6.95 |
| Customer Charge ( $ / mo ) | $84.52 |
| Sales Tax ( % ) | 0.0% |

## ELECTRICAL CONSUMPTION AND DEMAND

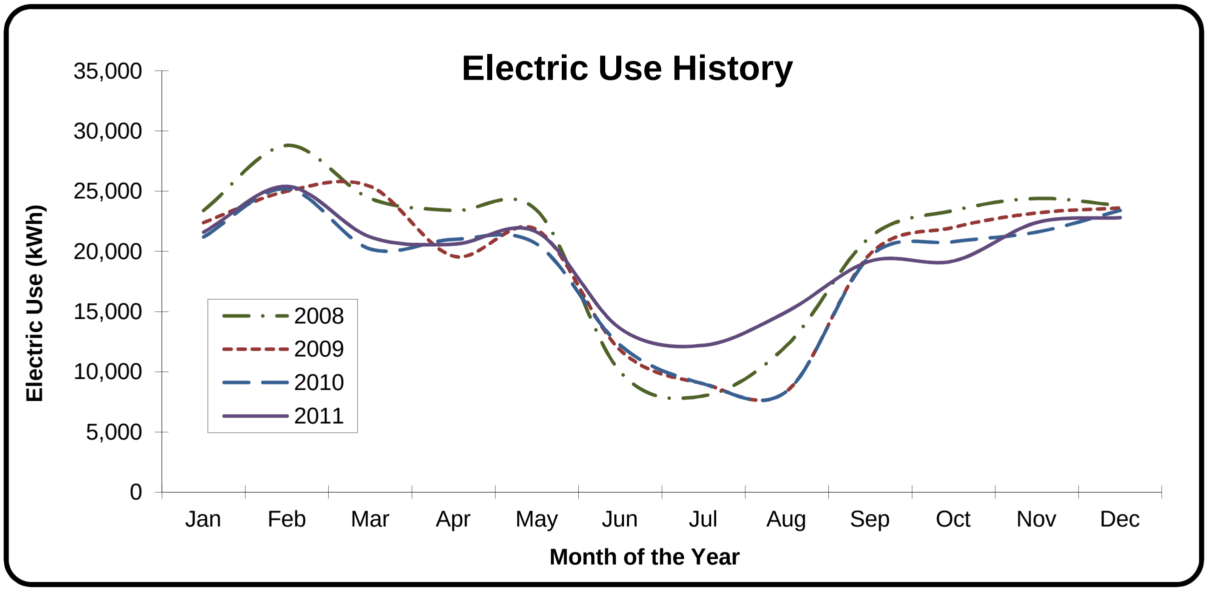
| Month | 2008 | | 2009 | | 2010 | | 2011 | | Average |
|---|---|---|---|---|---|---|---|---|---|
| | kWh | kW | kWh | kW | kWh | kW | kWh | kW | |
| Jan | 23,400 | 104 | 22,400 | 94 | 21,200 | 88 | 21,600 | 84 | 22,150 |
| Feb | 28,800 | 104 | 25,000 | 82 | 25,200 | 82 | 25,400 | 86 | 26,100 |
| Mar | 24,400 | 98 | 25,400 | 88 | 20,200 | 80 | 21,200 | 86 | 22,800 |
| Apr | 23,400 | 86 | 19,600 | 86 | 21,000 | 80 | 20,600 | 80 | 21,150 |
| May | 23,400 | 86 | 21,800 | 88 | 20,600 | 80 | 21,600 | 78 | 21,850 |
| Jun | 10,000 | 80 | 11,800 | 72 | 12,200 | 72 | 13,600 | 78 | 11,900 |
| Jul | 8,000 | 32 | 9,000 | 36 | 9,000 | 34 | 12,200 | 50 | 9,550 |
| Aug | 12,200 | 54 | 8,400 | 36 | 8,400 | 32 | 15,000 | 58 | 11,000 |
| Sep | 21,200 | 82 | 19,800 | 78 | 19,600 | 72 | 19,200 | 66 | 19,950 |
| Oct | 23,400 | 88 | 22,000 | 82 | 20,800 | 76 | 19,200 | 44 | 21,350 |
| Nov | 24,400 | 84 | 23,200 | 82 | 21,600 | 74 | 22,400 | 74 | 22,900 |
| Dec | 23,800 | 88 | 23,600 | 86 | 23,400 | 86 | 22,800 | 74 | 23,400 |
| Total | 246,400 | | 232,000 | | 223,200 | | 234,800 | | 234,100 |
| Average | 20,533 | 82 | 19,333 | 76 | 18,600 | 71 | 19,567 | 72 | 19,508 |
| Load Factor | 34% | | 35% | | 36% | | 37% | | 75 |

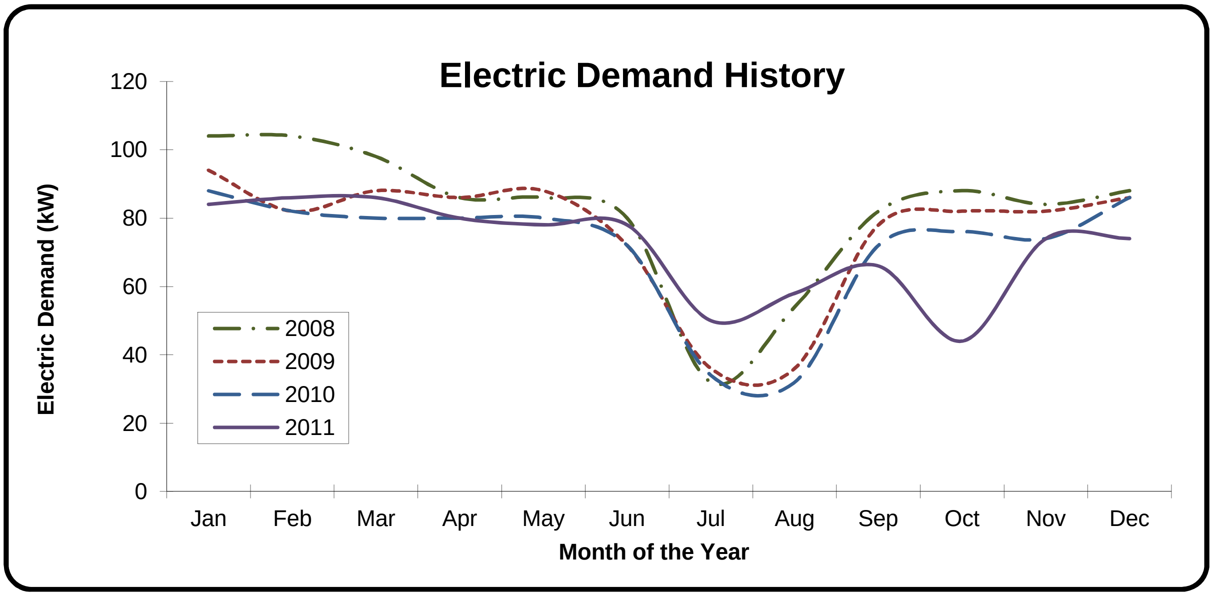
## ELECTRIC BILLING DETAILS

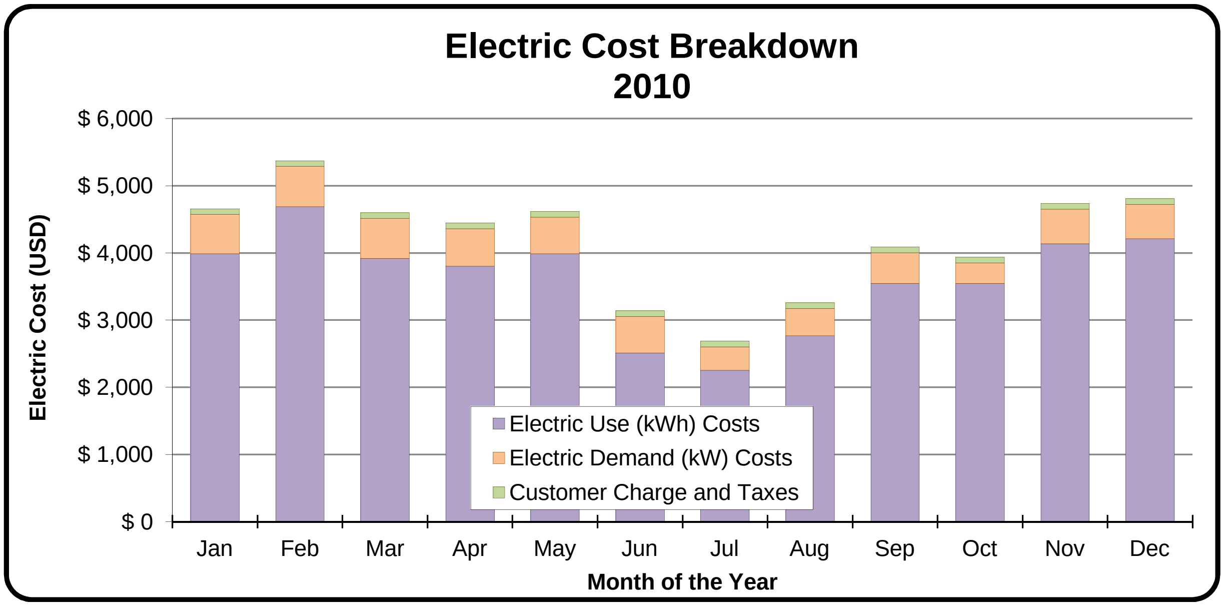
Electrical costs are based on the current electric rates.

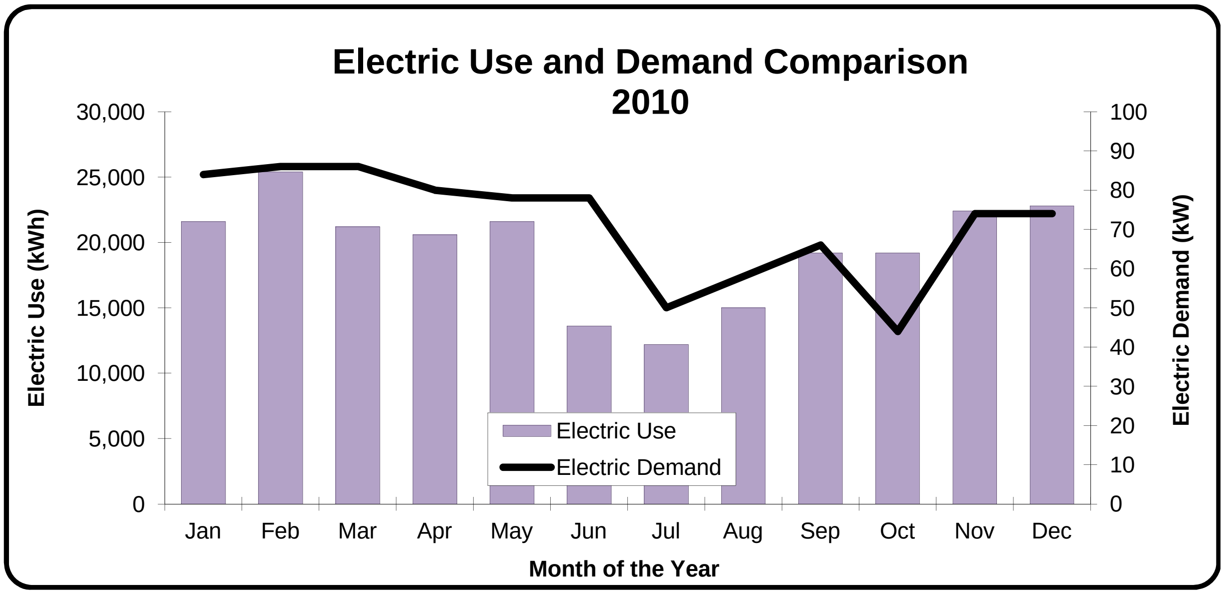
| | 2010 | | | | 2011 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Month | Energy | Demand | Cust & Tax | Total | Energy | Demand | Cust & Tax | Total | % Change |
| Jan | $3,916 | $612 | $85 | $4,612 | $3,990 | $584 | $85 | $4,658 | 1.0% |
| Feb | $4,654 | $570 | $85 | $5,309 | $4,691 | $598 | $85 | $5,374 | 1.2% |
| Mar | $3,731 | $556 | $85 | $4,371 | $3,916 | $598 | $85 | $4,598 | 5.2% |
| Apr | $3,879 | $556 | $85 | $4,519 | $3,805 | $556 | $85 | $4,445 | -1.6% |
| May | $3,805 | $556 | $85 | $4,445 | $3,990 | $542 | $85 | $4,616 | 3.8% |
| Jun | $2,253 | $500 | $85 | $2,838 | $2,512 | $542 | $85 | $3,139 | 10.6% |
| Jul | $1,662 | $236 | $85 | $1,983 | $2,253 | $348 | $85 | $2,685 | 35.4% |
| Aug | $1,551 | $222 | $85 | $1,858 | $2,771 | $403 | $85 | $3,258 | 75.3% |
| Sep | $3,620 | $500 | $85 | $4,205 | $3,546 | $459 | $85 | $4,089 | -2.7% |
| Oct | $3,842 | $528 | $85 | $4,454 | $3,546 | $306 | $85 | $3,937 | -11.6% |
| Nov | $3,990 | $514 | $85 | $4,588 | $4,137 | $514 | $85 | $4,736 | 3.2% |
| Dec | $4,322 | $598 | $85 | $5,004 | $4,211 | $514 | $85 | $4,810 | -3.9% |
| Total | $ 41,225 | $ 5,949 | $ 1,014 | $ 48,188 | $ 43,368 | $ 5,963 | $ 1,014 | $ 50,345 | 4.5% |
| Average | $ 3,435 | $ 496 | $ 85 | $ 4,016 | $ 3,614 | $ 497 | $ 85 | $ 4,195 | 4.5% |
| Cost ($/kWh) | | | | $0.216 | 86% | 12% | 2% | $0.214 | -0.7% |

## Skagway K-12 School

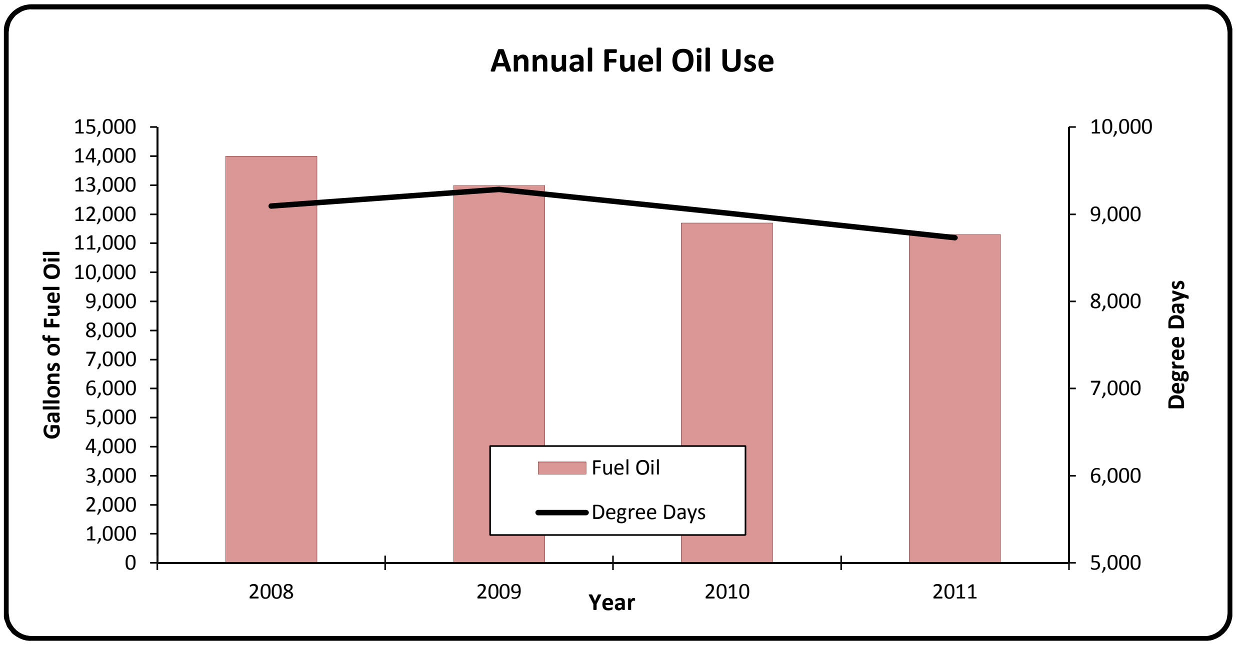





Electric Cost Breakdown
2010
Electric Cost (USD)
$ 6,000
$ 5,000
$ 4,000
$ 3,000
$ 2,000
$ 1,000
$ 0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month of the Year
Electric Use (kWh) Costs
Electric Demand (kW) Costs
Customer Charge and Taxes


Electric Use and Demand Comparison
2010
Electric Use (kWh)
30,000
25,000
20,000
15,000
10,000
5,000
0
Electric Demand (kW)
100
90
80
70
60
50
40
30
20
10
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month of the Year
Electric Use
Electric Demand

## Skagway K-12 School



| Year | Fuel Oil | Degree Days |
|---|---|---|
| **2,008** | 13,990 | 9,093 |
| **2,009** | 12,986 | 9,284 |
| **2,010** | 11,700 | 9,013 |
| **2,011** | 11,300 | 8,729 |

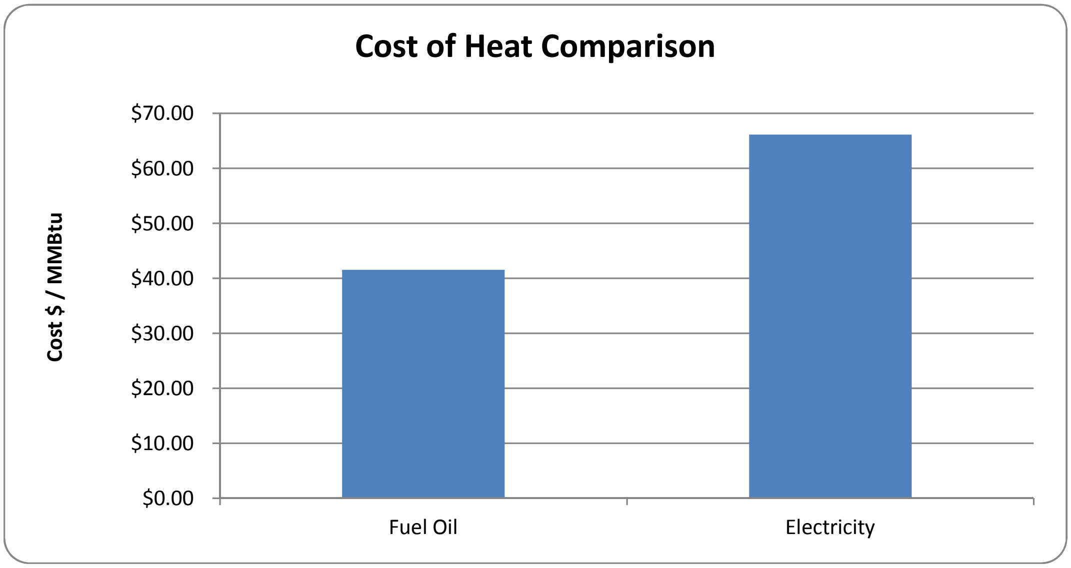
## Annual Energy Consumption and Cost

| Energy | Cost | $/MMBtu |
|---|---|---|
| Fuel Oil | $4.03 | $41.57 |
| Electricity | $0.214 | $66.15 |

| Area | ECI | EUI |
|---|---|---|
| 45,518 | $2.21 | 55 |

**Annual Energy Consumption and Cost**

| Source | Consumption | | Cost | Energy, MMBtu | |
|---|---|---|---|---|---|
| Electricity | 234,000 | kWh | $50,200 | 800 | 32% |
| Fuel Oil | 12,500 | Gallons | $50,400 | 1,700 | 68% |
| Totals | | | $100,600 | 2,500 | 100% |



Appendix C

# Equipment Data

## Skagway K-12 School - Major Equipment Inventory

| Unit ID | Location | Function | Make | Model | Capacity | Motor HP / Volts / RPM / Effic | Notes |
|---|---|---|---|---|---|---|---|
| AHU-1 | Central Fan Room | High School Hallway | Bohn | VCS26ALF | 12000 CFM | 10 HP/ 208 V/ 1745 RPM/ 85.6% | |
| AHU-2 | Central Fan Room | Elementary Hallway | Bohn | HD26ALF | 12000 CFM | 10 HP/ 208 V/ 1745 RPM/ 85.6% | |
| AHU-3 | Central Fan Room | Shop | Bohn | HD08ALF | 4200 CFM | 3 HP/ 208 V/ 1750 RPM/ 82.5% | |
| AHU-4 | Central Fan Room | Multipurpose Room | Bohn | VCS08ACF | 4300 CFM | 3 HP/ 208 V/ 1750 RPM/ 82.5% | |
| AHU-5 | Central Fan Room | Gym | Bohn | VCS26ALF | 12800 CFM | 7.5 HP/ 208 V/ 1765 RPM/ 81.5% | |
| AHU-6 | Central Fan Room | Locker Rooms | Bohn | HD06ALF | 3000 CFM | 2 HP/ 208 V/ 1725 RPM/ 78.5% | |
| AHU-7 | Central Fan Room | Stage | Bohn | HD08ALF | 3900 CFM | 2 HP/ 208 V/ 1760 RPM/ 78.5% | |
| EF-1 | Gym Fan Room | Locker Rooms | Trane | UI6PT3-FC | 3300 CFM | 2 HP/ 208 V/ 1725 RPM/ 78.5% | |
| EF-1A | New Addition | Restrooms | Penn | Zephyr Z12TD | 500 CFM | 120 V/ 208 Watts | |
| EF-2 | High School Wing | Restrooms | Penn | Zephyr Z12TD | 500 CFM | 120 V/ 208 Watts | |
| EF-4 | Janitor Closet | Janitor Closet Exhaust | Penn | Zephyr Z8 | 170 CFM | 120 V/ 105 Watts | Operates off light switch |
| EF-5 | Electrical Room | Electrical Room | Penn | Zephyr Z8 | 160 CFM | 120 V/ 105 Watts | |
| EF-6 | Special Ed. Restroom | Restroom Exhaust | Penn | Zephyr Z8 | 145 CFM | 120 V/ 105 Watts | Operates off light switch |
| VF-1 | Boiler Room | Ventilation Air | Greenheck | SDP-30-6-15 | 5100 CFM | 1/2 HP/ 120 V/47% | |
| B-1 | Boiler Room | Boiler | Weil McLain | H-886-S-W | 1600 MBH | | |
| B-2 | Boiler Room | Boiler | Weil McLain | H-886-S-W | 1600 MBH | Lag boiler Not Isolated | |
| CP-1 | Boiler Room | AHU 1,2,3,6,7 | B&G | 2AC 6 1/8 BF | 116 GPM | 2 HP/ 208 V/ 1725 RPM/ 78.5% | |
| CP-2 | Boiler Room | AHU 4, 5, Baseboard | B&G | 2.5AB 6 5/8 BF | 160 GPM | 3 HP/ 208 V/ 1730 RPM/ 78.5% | |
| CP-3 | Boiler Room | AHU 4, 5, Baseboard | B&G | 2.5AB 6 5/8 BF | 160 GPM | 3 HP/ 208 V/ 1730 RPM/ 78.5% | |
| HWH-1 | Boiler Room | Hot Water Heater | Pvi | 3.8-N-500-A-D | 500 Gallon | 540 MBH | Direct fired fuel oil WH; Not used |
| HWH-2 | Boiler Room | Hot Water Heater | Pvi | 27N250A-MXO | 250 Gallon | 270 MBH / 1/3 HP/60% | Direct fired fuel oil WH |

## Skagway K-12 School - Major Equipment Inventory

| Unit ID | Location | Function | Make | Model | Capacity | Motor HP / Volts / RPM / Effic | Notes |
|---|---|---|---|---|---|---|---|
| HWCP-1 | Boiler Room | Hot Water Circulation Pump | B&G | LR-20WR | 2 GPM | 115 V | |
| ICV-1 | Central Fan Room | Central Vacuum | Spencer | 307740 | 150 CFM | 5 HP/ 208 V/ 3500 RPM/83.3% | |
| AC-1 | Boiler Room | Air Compressor | Quincy | 00020008D00327 | 100 CFM | 2 HP/ 208 V/ 1750 RPM/ 78.5% (x2) | |
| Freezer | Shop | Food Storage | Heat Craft | LET120BK | | 208 V/ 11.7 pmps/ 2700 Watts | |
| EF-7 | Shop | Paint Fume Exhaust | | | | 2 HP/ 208 V/ 1725 RPM/80.8% | |

Appendix D

# Abbreviations

| | |
|---|---|
| AHU | Air handling unit |
| BTU | British thermal unit |
| BTUH | BTU per hour |
| CBJ | City and Borough of Juneau |
| CMU | Concrete masonry unit |
| $CO_2$ | Carbon dioxide |
| CUH | Cabinet unit heater |
| DDC | Direct digital controls |
| DHW | Domestic hot water |
| EAD | Exhaust air damper |
| EEM | Energy efficiency measure |
| EF | Exhaust fan |
| Gyp Bd | Gypsum board |
| HVAC | Heating, Ventilating, Air-conditioning |
| HW | Hot water |
| HWRP | Hot water recirculating pump |
| KVA | Kilovolt-amps |
| kW | Kilowatt |
| kWh | Kilowatt-hour |
| LED | Light emitting diode |
| MBH | 1,000 Btu per hour |
| MMBH | 1,000,000 Btu per hour |
| OAD | Outside air damper |
| PSI | Per square inch |
| PSIG | Per square inch gage |
| RAD | Return air damper |
| RF | Return fan |
| SIR | Savings to investment ratio |
| SF | Supply fan |
| UV | Unit ventilator |
| VAV | Variable air volume |
| VFD | Variable frequency drive |