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ENERGY AUDIT
POST INSTALLATION REPORT

Results and Recommendations from Energy Audit of Kipnuk

For VEEP Grants

City of Kipnuk, Alaska

June 20, 2012

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EXECUTIVE SUMMARY AND PREFACE

This Post Installation Report summarizes the results of an Ameresco Energy Audit of the City of Kipnuk, the initial energy savings measures identified and proposed, and any changes that may have occurred throughout the installation process. The City of Kipnuk is a recipient of an Alaska Energy Authority (AEA) Village Energy Efficiency Program (VEEP) grant of $150,000.

Ameresco engineers conducted an energy audit of the City of Kipnuk on October 22, 2010. The table below shows the buildings audited and their respective square footages.

City of Kipnuk - Building Summary		
Building	**Category**	**Square Footage**
City Office	Public Building	2,000

The audit identified existing types, conditions, operating modes, and energy consumption profiles for a variety of buildings, facilities and systems. The audit also identified all cost-effective system and facility modifications, adjustments, alterations, additions, and retrofits. Systems investigated during the audit included heating, ventilation, interior and exterior lighting, process exhaust, domestic hot water, motors, building envelopes, utility metering systems, and energy management control systems (EMCS). Options for advanced electric meter systems were considered if they did not already exist. Ameresco also explored opportunities for on-site energy production, both non-renewable and renewable.

The table below shows the results of Ameresco's audit and potential calculation savings, allocated by grant. See *Appendix A* for more detailed calculation results. Project costs include costs incurred from the site visit, engineering time, materials cost, and labor cost, as well as Ameresco's markup. It is important to note that the simple paybacks (SPBs) have been determined according to ECO type. For example, the SPB for an electrical ECO is calculated using only the annual kWh savings, even though the equivalent annual fuel gallon monetary savings is reported.

VEEP ECOS - PROJECT COSTS & EXPECTED SAVINGS - KIPNUK			
ECO	**Cost**	**Savings**	**SPB**
REDESIGN BUILDING HEATING SYSTEM	$140,882.65	$ 9,139.73	15.41
C01 - THERMOSTAT UPGRADE	$ 2,753.74	$ 1,302.09	2.11
AVAILABLE FUNDING	$ 6,363.62		
** Remaining funding applied to the City of Kotlik*			
TOTAL GRANT	**$150,000.00**		
KIPNUK PROJECT TOTAL	**$143,636.39**	**$10,441.82**	**13.15**

1.0 BUILDING DESCRIPTIONS

1.1 KIPNUK CITY OFFICE (KANGANAK OFFICE BUILDING)

Description: The Kipnuk City Office building houses the Kipnuk Traditional Council office as well as several other City offices, including the Kipnuk Light Plant. There is also a multipurpose area for larger meetings and gatherings.

General Conditions: The building is in fair condition overall. The mechanical room is not much more than a storage room at this point. Many improvements could be made to the building envelope as well.

Pictures of general conditions found during the field audit immediately follow this building description.

Building Envelope: The standing seam exterior and roof are in good condition and do not appear to have any major faults. Windows are in fair condition; some need to be caulked, and others are broken and have been replaced with plastic. The mechanical room ceiling has deteriorated in many areas. Roof access does not seal properly, and this creates a sizeable escape for conditioned air.

Heating: Building heating is provided mainly by a series of unit and space heaters distributed throughout the building. The multipurpose area is heating by a King Electric unit heater designed for warehouses and garages with ceilings over 10 feet high. Although the installation meets the minimum requirement of mounting 6 feet above the floor, this is a potential fire hazard due to how closely it is mounted to the ceiling, and the air inlet is blocked. This heater remains on constantly. A second, much smaller unit heater provides heating to a large cubicle-style office area. Baseboards, though functional, do not appear to be providing much heat to the building. Two Airtherm electric unit heaters provide heating for the Kipnuk Light Plant office section of the building along with a TPI corporation electric wall heater. The mechanical room houses a collection of no longer functional equipment including 2 Burnham boilers, 3 Trane air handlers, and a Bock domestic water heater. There is also a heat exchanger system with water coming from the Kipnuk Power Plant. The water comes into the building at 140 degrees Fahrenheit, but by the time it is being distributed, the water has reached 115 degrees. Recently the AEA replaced the

generators with more efficient models, thus decreasing the amount of available waste heat for the building; this calls for more electric heating to supplement the building requirements.

Controls: Zone temperatures are controlled by mechanical thermostats.

Lighting: Interior lighting consists mainly of T8 fluorescent fixtures with electronic ballasts.

Domestic Water: An 80 gallon American Water Heater Group electric water heater provides the building with domestic hot water.

Building Photos: Kipnuk City Office

Airtherm King Electric Unit Heater

American Water Heater Grp – Domestic Water Heater

Blocked Boiler Stack and Ceiling Deterioration

Defunct Burnham Boilers

Alfa Laval Heat Exchanger

"Repaired" Windows

1.2 KIPNUK POWER PLANT

Description: The Kipnuk Power Plant is independently owned by the City.

General Conditions: The building is in good condition overall. The standing seam exterior and roof are in good condition with no noticeable faults. The generators appear to be in good condition and are functioning properly, although some are beginning to show their age. There are a total of 3 generators, but only one is currently running. This larger generator seems to be able to handle the village load, but the 2 smaller generators are available if they need to be turned on.

Loading: At the time of the audit, demand loading was about 240 kW. According to the operator, this is about average; the peak load may increase somewhat, but not much beyond 300 kW.

Building Photos: Kipnuk Power Plant

Power Plant Demand

Power Control Panel

Meters

Generator Control Panels

1.3 KIPNUK SCHOOL

Description: The Kipnuk School houses elementary through high school age students. The school is divided into wings – a high school section, and an elementary and middle school section. The building also contains a cafeteria and gym.

General Conditions: The building is in good condition and is probably the best maintained facility in the village. Structurally, the building appears to have no major defects, and the exterior and roof and in good condition. The HVAC and other mechanical equipment are in good condition and appear to be well-maintained.

Pictures of general conditions found during the field audit immediately follow this building description.

Building Envelope: The building appears to be in good condition. Doors seal properly and have adequate weather-stripping. Windows are double-pane clear glass and are in good condition.

Heating: Two Burnham model PF-505 boilers provide the building with heating. A combustion analysis showed these boilers to be running at 76.2% efficiency with 9.2% oxygen.

Lighting: Interior lighting mainly consists of T8 fluorescent fixtures with electronic ballasts.

Domestic Water: Two oil-fired Bock water heaters provide the school with domestic hot water. One of these water heaters is a model 361E ASME and holds 91 gallons. The other is a model 71E and holds 68 gallons.

Building Photos: Kipnuk School

Burnham Boilers

Bock Water Heaters

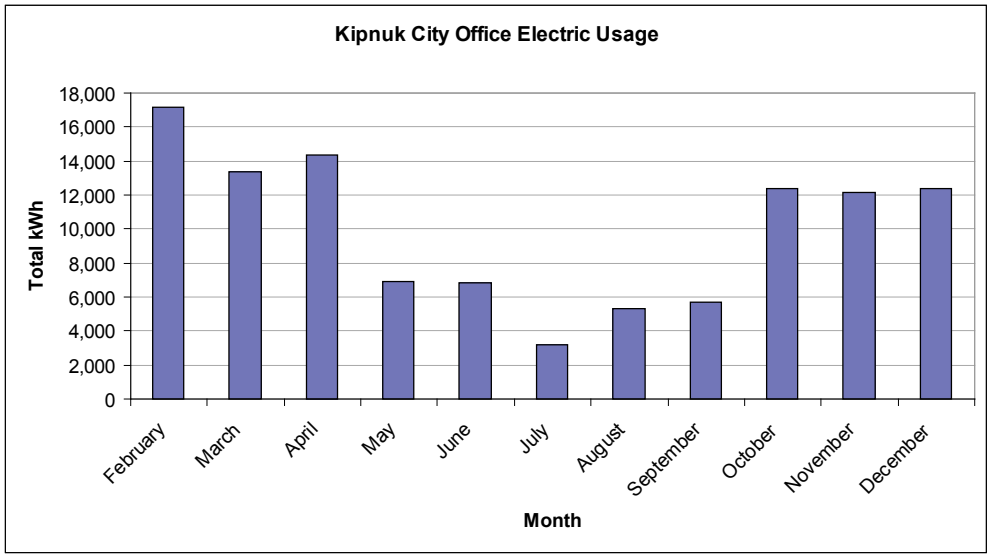
2.0 UTILITIES

2.1 ELECTRICITY

The City of Kipnuk purchases its electricity from the Kipnuk Light Plant. The Light Plant bills Traditional Council for electricity use, but the bills are paid via a credit system; the Council does not directly pay for electricity.

Kipnuk Light Plant kWh Rate	$ 0.32
Average Cost of Power Adjustment Rate (in 2009, this was a charge January – October, and a credit November - December)	$ 0.2640
Average kWh and Fuel Rate (What Customer Pays & Used for Calculations)	$ 0.6056

2.1.1 Electricity Usage Profiles



2.2 FUEL

City buildings within the village of Kipnuk typically purchase their fuel (stove oil) from the Kugkaklik Ltd native store, usually in quantities of 200 gallons. The Kipnuk Light Plant purchases its fuel for electricity generation from Crowley Petroleum Distribution in two bulk shipments each year. The shipment in August of 2010 was for 100,000 gallons.

Average Kugkaklik Fuel Rate (December 2008 – December 2009)	$	6.72
Crowley Fuel Rate (August 2010)	$	3.4384

3.0 OPERATIONS/MAINTENANCE PRACTICES

The village has a number of designated maintenance personnel that seem to possess the basic skills required to clean and maintain selected equipment. From Ameresco's observations, if the equipment should fall into disrepair, the staff does not have the training or experience to repair the equipment per the manufacturer's requirements and tends to piece together the equipment to maintain operation. Over time, the systems no longer function as required, which currently appears to be the case of most equipment and systems with in the village.

Operations and maintenance is one area in energy services where improvement and training costs are lower than equipment replacement costs, and the energy efficiency return is high. During the site audit, Ameresco found that outside of general cleaning, most of the equipment is not maintained to meet standard manufacturers' recommendations. Dirty filters, boilers in disrepair, systems altered, and control systems disconnected are a result of limited funding and lack of system training. This results in excessive energy use, premature equipment failure, and employee and resident discomfort. An annual system check by a qualified burner service technician to perform services such as boiler cleaning, boiler tune ups, system check out, and control system reviews will not only extend the overall life of the equipment, but improve occupant comfort as well as increase and maintain long term energy efficiency.

4.0 ENERGY CONSERVATION OPPORTUNITIES

The village of Kipnuk is unique among many of its peers in that the Energy Conservation Opportunities (ECOs) suggested by Ameresco are not all relatively simple retrofits. ECOs are therefore described in greater detail in this report than previously submitted reports. ***Please Note:*** *Section 4* applies to the initial proposal and the ECOs identified during that stage of the Kipnuk project. There are some ECOs included in this section that were not performed, or the scope of work may have changed. *Section 4* is for reference only. See *Section 5* for updated project information.

VEEP – INITIAL PROPOSAL (FINAL AUDIT REPORT)			
ECO	**Cost**	**Savings**	**SPB**
REDESIGN BUILDING HEATING SYSTEM	$ 146,750.00	$ 9,139.73	16.06
C01 - THERMOSTAT UPGRADE	$ 750.00	$ 1,302.09	0.58
DESIGN/AUDIT	$ 2,500.00		
AVAILABLE FUNDING	$ -		
** Available funding allocated for travel expenses, shipping, additional labor, etc*			
TOTAL	**$ 150,000.00**	**$ 10,441.82**	**14.37**

4.1 KIPNUK CITY OFFICE HEATING SYSTEM REDESIGN – INITIAL REPORTING

As detailed in *Section 1.0* of this report, the heating system at the Kipnuk City Office is currently in considerably poor condition. The majority of building heating is supplied by a series of electrical unit heaters; all of these were running at full capacity at the time of the audit. The sizes of these unit heaters are displayed below:

King Unit Heater (Model KFUH2430-1)	30 kW
Small Unit Heater (Unknown Model)	5 kW
TPI Corporation Wall Mounted UH	3 kW
TOTAL	**38 kW**
TOTAL	**129.69 MBH**

Note: The King electric unit heater is designed for warehouse usage and is a safety hazard in its current installation.

This ECO proposes replacing these electric unit heaters with properly sized fuel oil boilers. Ameresco recommends replacing these unit heaters with two 125 MBH units with AFUE ratings of 88%. The results of savings calculations are displayed as follows:

Current Energy Use

Annual kWh	57,226.90
Annual Equivalent mmBtu	195.32
Annual Gallons Fuel Needed	4,152.90

Proposed Energy Use

Annual mmBtu	209.27
Annual Gallons Fuel Needed	1,494.76

Summary	
Electric Savings (kWh)	57,226.90
Electric Generation for Heat (Gallons)	4,152.90
Electric Generation for Heat ($)	$14,279.32
Fuel Needed for Boilers (Gallons)	1,494.76
Fuel Needed for Boilers ($)	$10,044.79
Fuel Savings (Gallons)	2,658.13
Fuel Savings ($)	$4,234.52
TOTAL SAVINGS ($)	**$4,234.52**

The prior savings calculation is based on the current utility structure in the village. The Kipnuk Light Plant currently makes bulk purchases of fuel from Crowley Petroleum Distribution, Inc. at a rate of $3.4383/gallon, while the rest of the village purchases its fuel oil in smaller bundles from Kugkaklik Ltd Native Store at a rate of $6.72/gallon. Ameresco recommends that the Kipnuk City Office arrange its own fuel agreement with Crowley or combine fuel purchases with the Kipnuk Light Plant. If the City Office is able reach a similar agreement with Crowley, the savings will be as follows:

Summary	
Electric Savings (kWh)	57,226.90
Electric Generation for Heat (Gallons)	4,152.90
Electric Generation for Heat ($)	$14,279.32
Fuel Needed for Boilers (Gallons)	1,494.76
Fuel Needed for Boilers ($)	$5,139.59
Fuel Savings (Gallons)	2,658.13
Fuel Savings ($)	$9,139.73
TOTAL SAVINGS ($)	**$9,139.73**

At a total project cost of $147,500, this project will have a simple payback (SPB) of 16.14 years.

Heating System Redesign											
Building	**Number of Boilers to Install**	**Boiler AFUE Rating**	**Total Cost**	**Electric kWh Savings**	**Fuel mmBtu Savings**	**Total mmBtu Savings**	**Equivalent Fuel Gallons Savings**	**Annual kWh Cost Savings**	**Annual Equivalent Fuel Cost Savings**	**Total Annual Savings**	**Simple Payback**
City Office	2	88.00%	$146,750.00	57,226.90	209.27	-29.40	2,658.13	$0.00	$9,139.73	$9,139.73	16.06

4.2 ADDITIONAL ECOS FUNDED – INITIAL REPORTING

C01 – Thermostat Upgrade

This ECO proposes replacing the outdated mechanical thermostats with 7-day programmable thermostats. The programmable thermostats would allow a building's HVAC system to be scheduled to operate in comfortable conditions while occupied and allow for night set-backs.

4.3 ECOS NOT FUNDED

The following are potential ECOs for the village of Kipnuk, if more funding were to become available. At the time of the audit, not enough funding was available to complete these projects.

B01 – Door Weather-stripping Upgrade

This ECO proposes applying weather stripping to exterior door perimeters to reduce air infiltration into the buildings. Many building doors have existing weather stripping material which is worn or missing.

B02 – Thermal Insulation Upgrade

This ECO proposes installing blown-in roof insulation on existing building envelopes to reduce energy consumption. Insulation can be added to roofs to increase or renew their insulating ratings (R-value).

E01 – Street Lighting Upgrade

This ECO proposes upgrading the existing 150-watt high pressure sodium (HPS) street lighting fixtures to more efficient 40-watt light-emitting diode (LED) fixtures. Village demand would be decreased at night, and savings would be realized in fuel savings from electricity generation.

M01 – Domestic Hot Water Heater Upgrade

This ECO proposes replacing existing electric or fuel oil tank-type water heaters with fuel oil instantaneous Toyotomi OM-128 models. Standby losses will be eliminated, as there is no need to continuously heat tanks of water until they are needed. Where electric water heaters are replaced, additional savings will come from the cost of generating electricity.

5.0 FINAL COSTING AND CHANGES FROM INITIAL REPORTING

Due to the brief nature of these contracts and the high cost of travel to and from the villages, audits were conducted a quickly and efficiently as possible. Once engineers have left the villages, communication is strained at best, and gathering additional information is difficult. Because of this, assumptions must be made during the initial ECO assessments and project cost estimates. Occasionally, Ameresco engineers have found that previously identified projects have been externally funded from another source, but this information usually comes too late in the process. As a result of all these factors, some previously identified projects have been modified or abandoned. Final project costs and expected annual savings can be found in *Appendix A*. ECOs that were categorized as "Not Funded," whether in the initial stages of the proposal or during construction, can be found in *Appendix B*.

5.1 CHANGES FROM INITIAL REPORTING

Heating System Redesign

Installed as planned. See *Section 5.2* and *Appendix A* for updated cost information.

C01 – Programmable Thermostat Upgrade

Installed as planned. See *Section 5.2* and *Appendix A* for updated cost information. Note: The savings on this ECO relies on proper HVAC scheduling. If the settings are tampered with, the savings will not be realized.

5.2 FUNDING ALLOCATION SUMMARY TABLES

VEEP ECOS - PROJECT COSTS & EXPECTED SAVINGS - KIPNUK			
ECO	**Cost**	**Savings**	**SPB**
REDESIGN BUILDING HEATING SYSTEM	$140,882.65	$ 9,139.73	15.41
C01 - THERMOSTAT UPGRADE	$ 2,753.74	$ 1,302.09	2.11
AVAILABLE FUNDING	$ 6,363.62		
** Remaining funding applied to the City of Kotlik*			
TOTAL GRANT	**$150,000.00**		
KIPNUK PROJECT TOTAL	**$143,636.39**	**$10,441.82**	**13.15**

APPENDIX A

VEEP PROJECT COSTS & EXPECTED SAVINGS

APPENDIX A - VEEP PROJECT COSTS & EXPECTED SAVINGS - KIPNUK

Note: The reported simple paybacks are based on the type of ECO listed. For example, electrical ECOs only use the Annual kWh Cost Savings column to calculate the SPB, even though the Annual Equivalent Fuel Cost Savings is still reported.

HEATING SYSTEM REDESIGN

Building	Number of Boilers to Install	Boiler AFUE Rating	Total Cost	Electric kWh Savings	Fuel mmBtu Savings	Total mmBtu Savings	Equivalent Fuel Gallons Savings	Annual kWh Cost Savings	Annual Equivalent Fuel Cost Savings	Total Annual Savings	Simple Payback
City Office	2	$0.88	$140,882.65	57,226.90	209.27	-29.40	2,658.13	$0.00	$9,139.73	$9,139.73	15.41

C01 - PROGRAMMABLE THERMOSTAT UPGRADE

Building	# of Thermostats Installed	Cost Per Thermostat	Total Cost	Electric kWh Savings	Fuel mmBtu Savings	Total mmBtu Savings	Equivalent Fuel Gallons Savings	Annual kWh Cost Savings	Annual Equivalent Fuel Cost Savings	Total Annual Savings	Simple Payback
City Office	2	$1,376.87	$2,753.74	0.00	27.13	27.13	193.76	$0.00	$1,302.09	$1,302.09	2.11

APPENDIX B

ECO CALCULATION RESULTS – NOT FUNDED

APPENDIX B - ECO CALCULATION RESULTS - NOT FUNDED - KIPNUK

Note: The reported simple paybacks are based on the type of ECO listed. For example, electrical ECOs only use the Annual kWh Cost Savings column to calculate the SPB, even though the Annual Equivalent Fuel Cost Savings is still reported.

B01 - WEATHERSTRIPPING

Building	# of Doors	Price Per Door	Total Cost	Electric kWh Savings	Fuel mmBtu Savings	Total mmBtu Savings	Equivalent Fuel Gallons Savings	Annual kWh Cost Savings	Annual Equivalent Fuel Cost Savings	Simple Payback
City Office	4	$560.00	$3,136.00	0.00	7.54	7.54	53.88	$0.00	$362.11	8.66

B02 - THERMAL INSULATION UPGRADE

Building	Current Insulation	Proposed Insulation	Total Cost	Electric kWh Savings	Fuel mmBtu Savings	Total mmBtu Savings	Equivalent Fuel Gallons Savings	Annual kWh Cost Savings	Annual Equivalent Fuel Cost Savings	Simple Payback
City Office	R-20	R-38	$8,680.00	0.00	11.32	11.32	80.83	$0.00	$543.20	15.98

C01 - THERMOSTAT UPGRADE

Building	# of Thermo-stats Installed	Cost Per Thermostat	Total Cost	Electric kWh Savings	Fuel mmBtu Savings	Total mmBtu Savings	Equivalent Fuel Gallons Savings	Annual kWh Cost Savings	Annual Equivalent Fuel Cost Savings	Simple Payback
City Office	2	$290.00	$750.00	0.00	27.13	27.13	193.76	$0.00	$1,302.09	0.58

E01 - STREET LIGHTING UPGRADE

Building	Current Fixture	Proposed Fixture	Total Cost	Electric kWh Savings	Electric kW Savings	Equivalent mmBtu Savings	Equivalent Fuel Gallons Savings	Annual kWh Cost Savings	Annual Equivalent Fuel Cost Savings	Simple Payback
Whole Village	150W HPS	40W LED	$35,910.00	14,454.00	39.60	49.33	1,048.91	$2,504.88	$7,048.69	14.34

M01 - DOMESTIC WATER HEATER UPGRADE

Building	# of Water Heaters to Replace	New Water Heater Efficiency (AFUE)	Total Cost	Electric kWh Savings	Equivalent Fuel mmBtu Savings	New Fuel mmBtu Use	Equivalent Fuel Gallons Savings	Annual kWh Cost Savings	Annual Equivalent Fuel Cost Savings	Simple Payback
City Office	1	88.00%	$2,240.00	3,475.33	11.86	12.13	165.58	$0.00	$1,112.70	2.01

APPENDIX C

EQUATIONS USED IN CALCULATIONS

APPENDIX C - EQUATIONS USED IN CALCULATIONS - KIPNUK

ECO ***Equations***

B01
1. Door Leakage Area (in2) = Door Area x Door Leakage Factor
2. Specific Infiltration (CFM/in2) = [(Stack Coefficient x ΔT) + (Wind Coefficient x [Wind Speed]2)]1/2
3. ΔT = Heating Setpoint Temp - Bin Temp
4. Air Infiltration (CFM) = Specific Infiltration x Door Leakage Area
5. Heat Loss Rate (Btu/hr) = 1.08 x Air Infiltration x ΔT
6. Heating Load (mmBtu) = Heat Loss Rate x Bin Hours / 1,000,000
7. Energy Savings = Baseline - Proposed

Note: This ECO was completed using the RETscreen program.

B02 *Note: This ECO was completed using the RETscreen program.*

Inputs are R-values reported in the appendices as well as the insulation square footage

C01 *Note: This ECO is based on bin data, occupancy, heating peak loads, boiler efficiency, and an assumed night setback*

Baseline Usage = (Peak Load x Occupied Load Profile x All Hours) / Boiler Eff.

ECM Usage = [(Peak Load x Occupied Load Profile x Occupied Hours)
+ (Peak Load x Unoccupied Load Profile x Unoccupied Hours)] / Boiler Eff

mmBtu Saved = Baseline Usage - ECM Usage

E01
1. Baseline Demand (kW) = (Existing Fixture Wattage) x (Qty) X (12 Months) / (1,000)
2. Baseline Usage (kWh) = (Baseline Demand) x (Fixture Hours)
3. Proposed Demand (kW) = (Proposed Fixture Wattage) x (Qty) X (12 Months) / (1,000)
4. Proposed Usage (kWh) = (Proposed Demand) x (Fixture Hours)
5. Annual Energy Savings = (Baseline Energy Usage) - (Proposed Energy Usage)
6. Annual Cost Savings = (Energy Savings) x (Energy Cost)

M01
1. Annual Energy Usage (mmBtu) = (41,045 Btu/Day) x (Total Days/Yr) x (Total Heaters) / (Energy Factor or Thermal Efficiency
2. Annual Energy Usage (kWh) = (12.03 kWh/Day) x (Total Days/Yr) x (Total Heaters) / (Energy Factor or Thermal Efficiency
3. (Commercial Type Heaters) Annual Standby Losses (mmBtu) = (Btu/Hr) x (24 Hrs/Day) x (Total Days/Yr) x (Total Heaters) / (1,000,000
4. (Electric Type Heaters) Annual kW Use = System kW x 12
5. (Commercial Type Heaters) Total Annual Energy Usage (mmBtu) = Annual Energy Usage + Annual Standby Losses
6. Annual Savings = Baseline Conditions - Proposed Conditions

REDESIGN
1. Heat Loss Rate (mmBtu/hr) = MBLC x (Heating Temp Setpoint - Mean Bin Temp)
2. Heat Load (MBH) = Heat Loss Rate x 1000
3. MBH-hr = Heat Load x Bin Heating Hours / (kW/ton)
4. Fuel Used (mmBtu) =[(MBH-hr) / Efficiency] / 1000
5. mmBtu Saved = (mmBtu)Existing - (mmBtu)Proposed

APPENDIX D

POST INSTALLATION PHOTOS

APPENDIX D – POST INSTALLATION PHOTOS – KIPNUK

Mechanical Room Access

Existing Boiler

New Boiler Installation

Project Completion