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ENERGY AUDIT
POST INSTALLATION REPORT

Results and Recommendations from Energy Audit of Koyukuk

For VEEP Grants

City of Koyukuk, Alaska

June 20, 2012

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APPENDICES

EXECUTIVE SUMMARY AND PREFACE

This Post Installation Report summarizes the results of an Ameresco Energy Audit of the City of Koyukuk, the initial energy savings measures identified and proposed, and any changes that may have occurred throughout the installation process. The City of Koyukuk is a recipient of an Alaska Energy Authority (AEA) Village Energy Efficiency Program (VEEP) grant of $75,000.

Ameresco engineers conducted an energy audit of the City of Koyukuk on January 12-13, 2011. The table below shows the buildings audited and their respective square footages.

City of Koyukuk - Building Summary

Building	Category	Square Footage
City Office	Public Building	1,800
Clinic & Library	Public Building	1,328
Power Plant	Public Facility	1,363
Washeteria & Water Plant	Public Facility	1,050
School	School	6,912

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).

The table below shows the actual costs of the project and expected annual savings. 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 - KOYUKUK			
ECO	**Cost**	**Savings**	**SPB**
B01 - WEATHERSTRIPPING	$ 8,883.60	$ 664.66	13.37
B02 - THERMAL INSULATION UPGRADE	$15,524.53	$ 976.33	15.90
C01 - THERMOSTAT UPGRADE	$ 3,701.47	$1,811.40	2.04
E01 - T8 LIGHTING UPGRADE	$ 1,275.19	$ 51.47	24.77
E02 - INSTALL OCCUPANCY SENSORS	$13,769.36	$2,722.15	5.06
E03 - PREMIUM EFFICIENCY MOTORS UPGRADE	$13,407.74	$ 119.49	112.21
M02 - FURNACE UPGRADE	$18,508.86	$ 812.83	22.77
TOTAL	**$75,070.74**	**$7,158.33**	**10.49**
TOTAL GRANT	**$75,000.00**		
BUDGET EXCEEDED	**$ (70.74)**		

1.0 BUILDING DESCRIPTIONS

1.1 KOYUKUK CITY OFFICE AND TRIBAL OFFICE BUILDING

Description: The Koyukuk City Office and the village Tribal Office are both housed in the same facility. The city offices are located on the second floor of the building, while the village tribal offices are located on the first floor. Typical operating hours are 0800 to 1700 hours, Monday through Friday.

General Conditions: The building is in fair condition overall, due to the fact it was constructed sometime during the 1970's and has not been renovated.

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

Building Envelope: The roof is in poor condition with little insulation and is leaking water into the building. The walls appear to be in good condition. The double pane windows are in fair condition, and one has a crack in the exterior pane. Weather-stripping, when present, is in poor condition and needs to be upgraded.

Heating: Building heating comes from three separate sources – a fuel oil Williamson Thermoflo furnace, an oil stove, and a wood stove. The wood stove is used as a backup heating system in case the fuel oil freezes in the colder winter months. A combustion analysis was performed on the furnace and showed it to be operating at 80.4% combustion efficiency at the time of the audit.

Controls: Building heating from the furnace is controlled by a mechanical thermostat. The oil-burning stove contains an individual internal thermostat. The wood-burning stove does not have any controls.

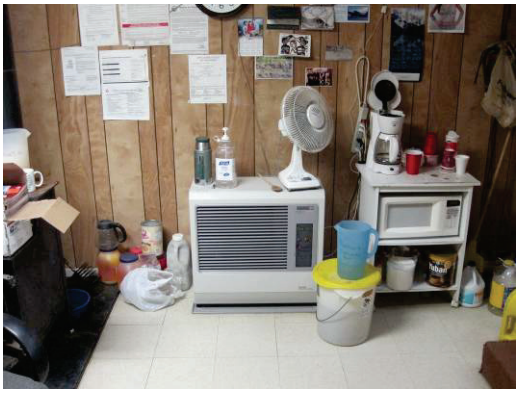
Lighting: Interior lighting consists primarily of T8 fluorescent lamps with electronic ballasts. There are no occupancy sensors in the building.

Domestic Water: This building does not have a domestic water system.

Building Photos: Koyukuk City Office and Tribal Office

Melting Snow on Roof – Poor Insulation

Exterior Door – Poor Seal and Inadequate Insulation



Toyotomi Laser 73 Fuel Oil Stove

Wood Stove

Furnace

Water Damage

1.2 KOYUKUK CLINIC AND LIBRARY

Description: The Koyukuk Clinic is a multifunctional building that also houses the village Library. Typical operational hours are 0900 to 1600 hours, Monday through Friday.

General Conditions: The structure overall is in fair condition, though it seems to still be holding up adequately. The exterior shows many signs of weathering and age, but the greatest concern is the leaking roof. Many opportunities for exist improvements.

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

Building Envelope: The roof is in poor condition and is leaking water into the attic when the snow melts from the escaping heat. The double pane windows are in fair condition. The weather-stripping, where present, is in poor condition and in need of replacement.

Heating: Space heating is provided by a Monitor M441 oil stove and a Toyotomi Laser 56 oil stove. The Monitor oil stove's controls system is not operating the way it ought. Even though the thermostat was set to 72°F at the time of the audit, the stove continued generating hot air into the space, even though the room was well above the set point at 78°F.

Controls: There are no additional building controls.

Lighting: Interior lighting fixtures are mostly T8 fluorescent with electronic ballasts. There are no occupancy sensors in the building.

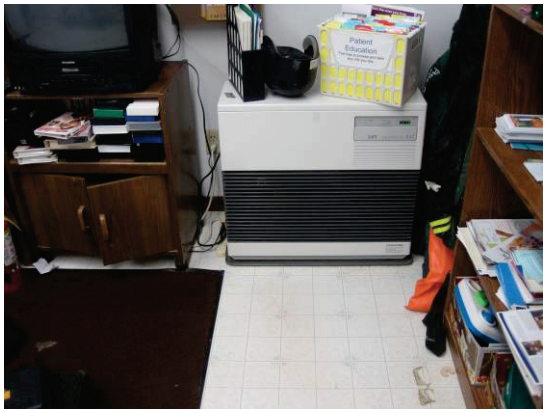
Domestic Water: A tankless Toyotomi water heater provides the building with domestic hot water. The city delivers potable water via truck to this building to meet its domestic water needs.

Building Photos: Koyukuk Clinic and Library

Fuel Tank and Melting Snow on Roof

Exterior Windows

Poor Weather-stripping on Doors



Monitor 441 Heater

Toyotomi Instantaneous Water Heater

Toyostove Laser 56 Heater

1.3 KOYUKUK POWER PLANT

Description: The Koyukuk Power Plant houses the villages 4 electric generators. The plant operates 3 hours a day, 7 days a week. An operator is always on call for emergencies and necessary shut-downs.

General Conditions: The building is in good condition, having been recently constructed in 2006. There is little opportunity for improvement in this facility.

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

Building Envelope: Because of its youth, the Koyukuk Power Plant is in excellent condition. Exterior windows and doors are in good condition with adequate weather-stripping. The roof is in good condition and shows no evidence of inadequate insulation.

Heating: Several unit heaters are scattered throughout the facility to provide additional building heat if the waste heat from the generators is not enough to keep the building at a comfortable level.

Controls: The unit heaters have coordinating mechanical thermostats throughout the building.

Lighting: Interior lighting is primarily T8 fluorescent with electronic ballasts as well as several CFL fixtures scattered throughout the building. There are no occupancy sensors in the building.

Domestic Water: There is not a domestic hot water system at the Power Plant.

Power Equipment and Loading: There are a total of 4 generators in the Koyukuk Power Plant. Generator 1 and Generator 2 are both 64 kW capacity models, while Generator 3 and Generator 4 are 37 kW capacity models. At the time of the audit, Generator 1 did not carry a load, Generator 2 carried a 51.87 kW load, Generator 3 did not carry a load, and Generator 4 did not carry a load.

Building Photos: Koyukuk Power Plant

Extra Floor Insulation

Switchgear

Generators

Dirty Filters

Fuel Storage

1.4 KOYUKUK SCHOOL (ELLA B. VERNETTI SCHOOL)

Description: The Koyukuk School houses elementary through high school students for the village. Typical operating hours are 0800 to 1700 hours, Monday through Friday, but other activities sometimes cause the building to remain open longer. The dental clinic is also located in this building and remains open until 1900 hours, Monday through Friday. The school also accommodates Koyukuk visitors from time to time.

General Conditions: The building is in good condition overall, though there are some serious problems with the heating controls system currently in place. The school is clearly overheated, and reducing the heating output will generate noteworthy energy savings.

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

Building Envelope: The building is in fair condition, showing signs of weathering and age. Like many of the other building in the village, the school was constructed sometime during the 1970's. The roof exterior is in good condition, but there is not enough insulation in the attic to retain building heat. Walls are in good condition, as are exterior doors. Weather-stripping, however, is in fair condition and is due to be replaced.

Heating: Two Burnham V-36 fuel oil boilers provide the building with space heating. At the time of the audit, these boilers were functioning at 80% and 76.9% combustion efficiency. These boilers are older models and are rated as 77% thermally efficient. The waste heat from the generators at the village power plant also supplies the school with additional space heating.

Controls: Building heating is controlled by several mechanical thermostats placed throughout the building. Almost every office or classroom has its own thermostat. The building, however, is currently being overheated. Temperature measurements taken during the audit read 83°, 88°, and 85°F. Heating set points were found to be 85°, 80°, and 85°F. These set points are higher than most villages and most other buildings in Koyukuk. Employees also shared that night set points remain near 85F, and library windows

are sometimes opened to cool the building down. Reducing these set points, especially at night, and installing more efficient boilers would result in significant energy savings.

Lighting: Lighting in the building has already been retrofit to T8 fixtures with electronic ballasts. There are no occupancy sensors in the building. There are also some areas of the building that appear to be over lighted. Delamping some fixtures could result in significant energy savings.

Domestic Water: Two Bock water heaters are housed in the Water Treatment Plant and provide the school with domestic hot water. There is also an indirect water heater somewhere in the school, but Ameresco engineers were unable to locate this water heater at the time of the audit.

Building Photos: Koyukuk School

Overheated Building – Snow Melting on Roof

Windows in Good Condition

Doors Need Weather-stripping

Unit Heaters in Gym

Abundant Light Fixtures in Library

Mechanical Room – Old Boilers, Fuel Day Tank, etc

1.5 KOYUKUK WASHETERIA AND WATER TREATMENT PLANT

Description: The Koyukuk Water Treatment Plant provides clean water to the entire city. The plant has a single operator, but receives extra maintenance help when needed. The Washeteria is also housed in the same building as the Water Treatment Plant. Typical operating hours are 0900 to 1600, 7 days a week.

General Conditions: The building is in fair condition and was constructed in 1987. Most of the equipment housed at the facility has been well-maintained, though there are several outdated pumps and motors that could be replaced with more efficient models. The water plant pumps water to two locations only – the school and one house.

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

Building Envelope: The building is in fair condition due to weathering and age over the years. The roof is in poor condition and is leaking water into the facility. Attic insulation is poor and needs to be upgraded. Doors are in fair condition, and weather-stripping needs to be upgraded. Windows are in good condition.

Heating: Building heating is provided by a Metzger Machine Corp fuel oil furnace as well as a Toyostove Laser 73 fuel oil stove.

Controls: A mechanical thermostat controls the Metzger furnace.

Lighting: The building is lit by a mixture of T8 fluorescent fixtures with electronic ballasts as well as several T12 fixtures with magnetic ballasts in the pump rooms. There are no occupancy sensors in the facility.

Domestic Water: The water treatment plant houses many pumps and motors of varying ages and efficiencies. Opportunities exist here for more efficient replacements. The Water Treatment Plant and Washeteria houses two Bock water heaters.

Vacuum System: Vacuum sewage systems are installed in bush Alaska due to permafrost and lack of available pitch. The system originates at the treatment facility and is in good operational condition. The vacuum pump motor runs 24/7 to meet village requirements. A higher efficiency motor will result in measurable savings for this system.

Heat Trace System: To prevent system freeze ups, hot water heat trace pumps that run throughout the water and sewer distribution system originate from this facility. The system is manually controlled and runs at all times or at operators' discretion. Limiting the operation of the heat trace based on outside air or ground temperatures will provide significant savings to the village.

Laundry Equipment: There are 3 washers and 2 dryers in the Washeteria section of the building to meet villagers' laundering needs. These washers and dryers appear to be in good condition and functioning properly. One of the newer washers is ENERGY STAR rated, but some of the older stacked models could be upgraded to more efficient units.

Building Photos: Koyukuk Washeteria and Water Treatment Plant

Poorly Insulated Roof – Melting Snow

Exterior Windows

Doors Needing Weather-stripping

Washeteria Area

Domestic Water Heaters

Toyostove Laser 73

2.0 UTILITIES

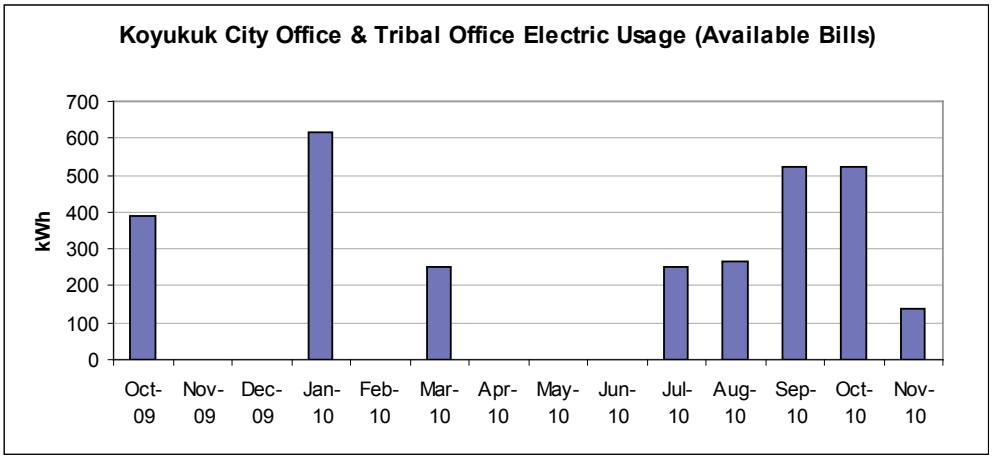
2.1 ELECTRICITY

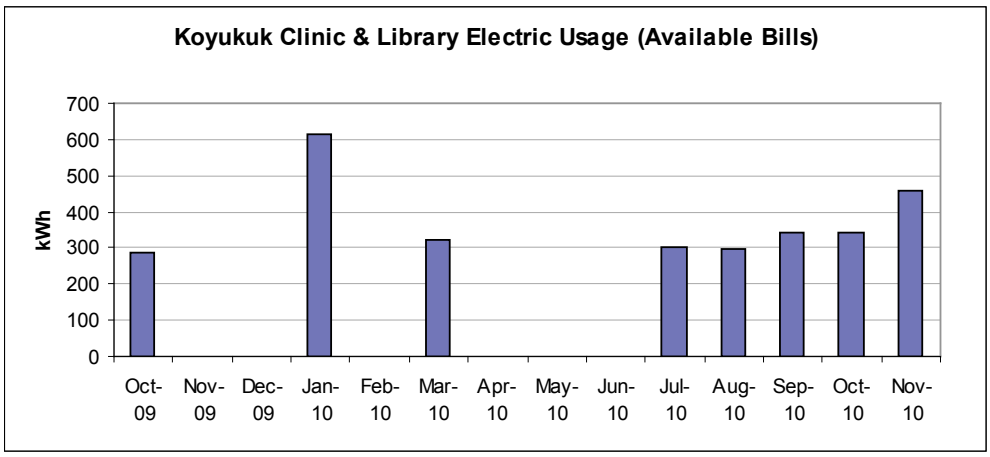
The City of Koyukuk produces its own electricity via the Koyukuk Electric Company (KEC). All buildings surveyed, with the exception of the Koyukuk School receive a Power Cost Equalization (PCE) credit. This has been factored in for calculations. The school pays a separate rate to the KEC. The consumption rates are listed below.

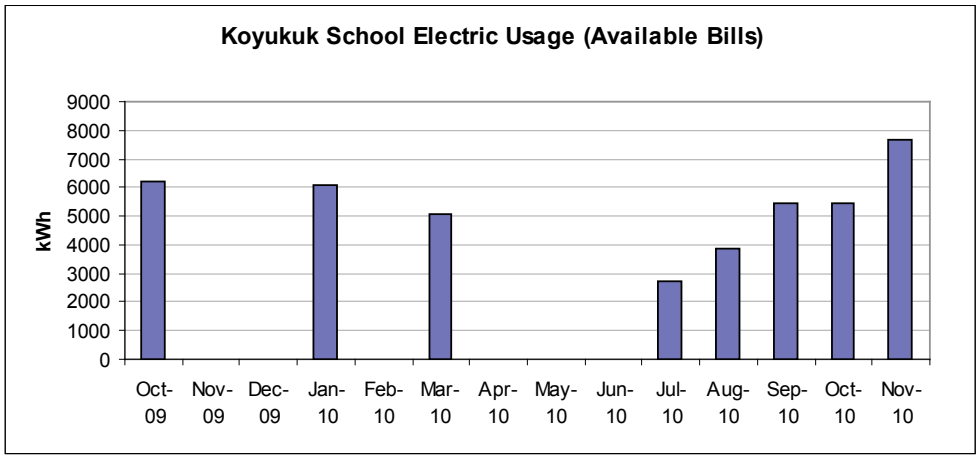
Rate Per kWh, All Buildings But School	$	0.4500
Rate Per kWh, School	$	0.3300
PCE Rate Per kWh	$	0.2767
Rate Per kWh for Calculations (But Not Koyukuk School)	$	0.1733

2.1.1 Electricity Usage Profiles

Note that in the electricity usage profiles below, September and October usage for 2010 is identical. This is because consumption was billed for the months of September and October in one large bill. Ameresco engineers divided this value to more accurately display typical usage.



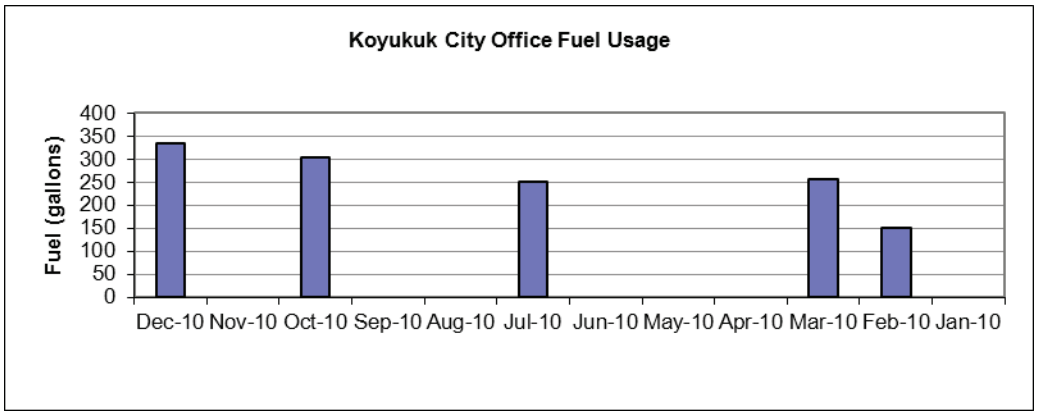

Koyukuk Clinic & Library Electric Usage (Available Bills)
kWh
700
600
500
400
300
200
100
0
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
Nov-10

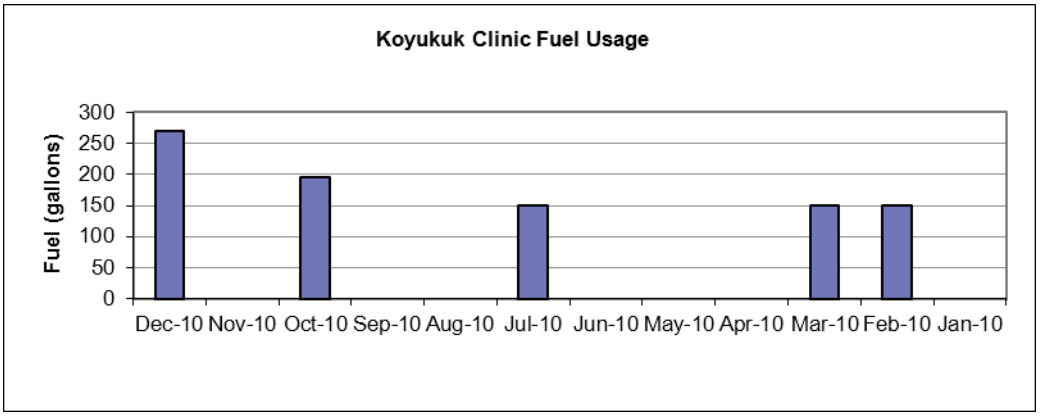

Koyukuk School Electric Usage (Available Bills)
kWh
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
Nov-10

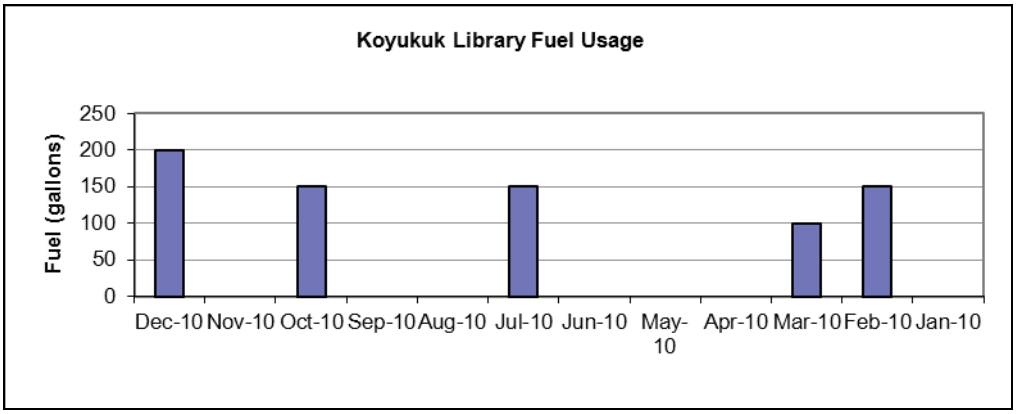
2.2 FUEL

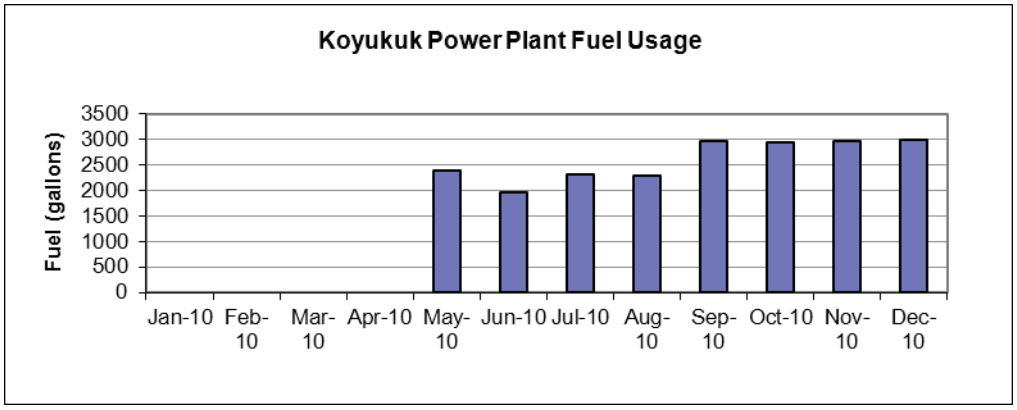
The City of Koyukuk purchases its fuel from Crowley Petroleum Distribution, Inc at a rate of $3.5635/gallon.

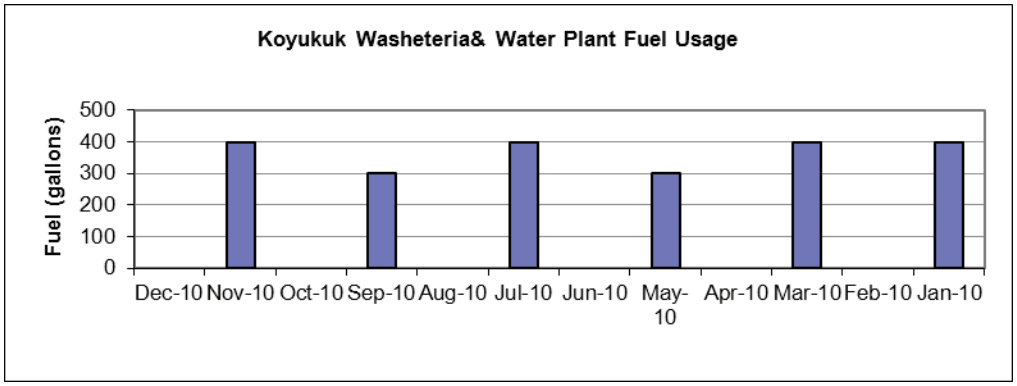
2.2.1 Fuel Usage Profiles








Koyukuk Power Plant Fuel Usage
Fuel (gallons)
3500
3000
2500
2000
1500
1000
500
0
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
Nov-10
Dec-10


Koyukuk Washeteria& Water Plant Fuel Usage
Fuel (gallons)
500
400
300
200
100
0
Dec-10
Nov-10
Oct-10
Sep-10
Aug-10
Jul-10
Jun-10
May-10
Apr-10
Mar-10
Feb-10
Jan-10

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 ECO matrix below summarizes the energy conservation opportunities identified during the site survey and baseline analysis. A description of each energy conservation opportunity follows the matrix. ***Please Note:*** This matrix applies to the initial proposal and the ECOs identified during that stage of the Koyukuk 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.

ECO No.	ECO Description B=Building Envelope; C=Controls; E=Electrical; M=Mechanical; W=Water/Wastewater; R=Renewable	ECO MATRIX KOYUKUK City Office	Clinic & Library	School	Washeteria & Water Treatment
Building Envelope					
B01	Door Weather-stripping Upgrade	X	X	X	X
B02	Insulation Upgrade	X	X		X
Controls					
C01	Thermostat Upgrade	X		X	
Electrical					
E01	T-8 Lighting Upgrade				X
E02	Occupancy Sensors	X	X	X	X
E03	Premium Efficiency Motors				X
Mechanical					
M01	Boiler Tune-Up			X	
M02	Furnace Upgrade	X			

VEEP – INITIAL PROPOSAL (FINAL AUDIT REPORT)			
ECO	**Cost**	**Savings**	**SPB**
B01 - WEATHERSTRIPPING	$ 7,840.00	$ 664.66	11.80
B02 - THERMAL INSULATION UPGRADE	$ 18,132.52	$ 976.33	18.57
C01 - THERMOSTAT UPGRADE	$ 1,218.00	$ 3,940.60	0.31
E01 - T8 LIGHTING UPGRADE	$ 1,170.40	$ 68.63	17.05
E02 - INSTALL OCCUPANCY SENSORS	$ 13,614.16	$ 2,722.15	5.00
E03 - PREMIUM EFFICIENCY MOTORS UPGRADE	$ 2,660.00	$ 119.49	22.26
M01 - BOILER TUNE-UP	$ 4,200.00	$ 3,670.78	1.14
M02 - FURNACE UPGRADE	$ 15,799.00	$ 812.83	19.44
DESIGN/AUDIT	$ 2,500.00		
AVAILABLE FUNDING	$ 7,865.92		
** Available funding allocated for travel expenses, shipping, additional labor, etc*			
TOTAL	**$ 75,000.00**	**$ 12,975.47**	**5.78**

4.1 ECO DESCRIPTIONS – FUNDED – INITIAL REPORTING

Below are the descriptions of the Energy Conservation Opportunities (ECOs) that Ameresco analyzed for the Village of Koyukuk in the Final Audit Report. These include Ameresco's initial project recommendations for the village.

4.1.1 Building Envelope Opportunities

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).

4.1.2 Controls Opportunities

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.

4.1.3 Electrical Opportunities

E01 – T8 Lighting Upgrade

This ECO proposes replacing current T-12 fluorescent lighting and magnetic ballast with T-8 lamps and electronic ballasts. Post-light levels will be nearly equal or better to that of the existing lighting systems.

E02 – Occupancy Sensors

Lighting systems are often left energized in unoccupied areas. This ECO proposes to install sensors to shut off lighting in unoccupied spaces. Common sensing technologies include infrared, ultrasonic, and audible sound, often combining multiple types of sensing in one unit to avoid shutting off lights in an occupied area.

E03 – Premium Efficiency Motors

This ECO proposes installing National Electrical Manufacturers Association (NEMA) premium efficiency motors to replace standard and high efficiency motors. There are various mechanical systems operating with inefficient motors throughout the base. Premium efficiency motors typically increase energy efficiency by 2-3%.

4.1.4 Mechanical Opportunities

M01 – Boiler Tune-Up

This ECO proposes a comprehensive re-commissioning of the boilers in each building to optimize system operations. Such efforts include:

- Replace, repair, calibrate or install sensors or switches
- Repair air linkages
- Conduct combustion efficiency test services
- Clean combustion chambers and stacks

M02 – Furnace Upgrade

This ECO proposes replacing existing fuel oil furnaces with more energy efficient units. Many of the existing units in the village are original to the buildings they serve and have reached the end of their useful service life. Furnaces employing modern technology can be installed to reduce energy consumption, improve system operations, and reduce maintenance costs.

4.2 ECO Descriptions – Not Funded – Initial Reporting

Below are the descriptions of the Energy Conservation Opportunities (ECOs) that Ameresco analyzed for the Village of Koyukuk but did not have enough funding to complete. For the results of the calculations, refer to *Appendix B*.

4.2.1 Building Envelope Opportunities

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).

4.2.2 Mechanical Opportunities

M03 – Boiler Upgrade

This ECO proposes replacing existing hot-water heating boilers with more energy efficient units. Many of the existing units in the village are original to the buildings they serve and have reached the end of their useful service life. Boilers employing modern technology can be installed to reduce energy consumption, improve system operations, and reduce maintenance costs.

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 *Section 5.2* and *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

B01 – Door Weather-stripping Upgrade

Installed as planned.

B02 – Thermal Insulation Upgrade

Installed as planned.

C01 – Programmable Thermostat Upgrade

Three programmable thermostats were originally ordered for the School but could not be installed. The model ordered was a low voltage type, but the school building needs a line voltage type thermostat. One low voltage model has been left with the school. The remaining two thermostats were installed in the City Hall and Washeteria.

E01 – T8 Lighting Upgrade

Only 3 of the proposed 4 lighting fixtures were replaced. See *Section 5.2* and *Appendix A* for updated cost and savings information.

E02 – Occupancy Sensors

Installed as planned.

E03 – Premium Efficiency Motors

Installed as planned, but project costs exceeded initial projections.

M01 – Boiler Tune-Up

Rejected due to lack of funding.

M02 – Furnace Upgrade

Installed as planned, but project costs exceeded initial projections.

5.2 FUNDING ALLOCATION SUMMARY TABLES

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ECOS NOT FUNDED - INITIAL PROPOSAL			
ECO	**Cost**	**Savings**	**SPB**
B02 - THERMAL INSULATION UPGRADE	$ 29,998.08	$ 1,717.54	17.47
M03 - BOILER UPGRADE	$ 40,880.00	$ 9,314.07	4.39
TOTAL	**$ 70,878.08**	**$ 11,031.62**	**6.42**
ECOS NOT FUNDED - REJECTED IN CONSTRUCTION PHASE			
ECO	**Cost**	**Savings**	**SPB**
C01 – THERMOSTAT UPGRADE	$ 1,850.73	$ 3,940.60	0.47
M01 - BOILER TUNE-UP	$ 4,200.00	$ 3,670.78	1.14
TOTAL	**$ 6,050.73**	**$ 7,611.38**	**0.79**

APPENDIX A

VEEP PROJECT COSTS & EXPECTED SAVINGS

APPENDIX A - VEEP PROJECT COSTS & EXPECTED SAVINGS - KOYUKUK

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	Total Annual Savings	Simple Payback
City Office	3	$888.36	$2,665.08	0.00	6.42	6.42	45.83	$0.00	$163.31	$163.31	16.32
Clinic & Library	2	$888.36	$1,776.72	0.00	5.42	5.42	38.70	$0.00	$137.92	$137.92	12.88
School	3	$888.36	$2,665.08	0.00	8.79	8.79	62.81	$0.00	$223.83	$223.83	11.91
Washeteria, etc	2	$888.36	$1,776.72	0.00	5.48	5.48	39.18	$0.00	$139.60	$139.60	12.73

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	Total Annual Savings	Simple Payback
City Office	R-19	R-38	$6,688.40	0.00	16.70	16.70	119.32	$0.00	$425.19	$425.19	15.73
Clinic & Library	R-19	R-38	$4,934.55	0.00	12.03	12.03	85.91	$0.00	$306.14	$306.14	16.12
Washeteria, etc	R-19	R-38	$3,901.57	0.00	9.63	9.63	68.75	$0.00	$245.00	$245.00	15.92

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	Total Annual Savings	Simple Payback
City Hall	1	$1,850.73	$1,850.73	0.00	34.18	34.18	244.15	$0.00	$869.17	$869.17	2.13
Washeteria	1	$1,850.73	$1,850.73	0.00	37.05	37.05	264.67	$0.00	$942.23	$942.23	1.96

E01 - T8 LIGHTING UPGRADE

Building	# of Fixtures	Price Per 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	Total Annual Savings	Simple Payback
Washeteria, etc	3	$425.06	$1,275.19	297.02	2.45	1.01	21.55	$51.47	$76.81	$171.05	24.77

E02 - INSTALL OCCUPANCY SENSORS

Building	# of Sensors	Price Per Sensor	Total Cost	Electric kWh Savings	Electric kW Savings	Equivalent mmBtu Savings	Equivalent Fuel Gallons Savings	Annual kWh Cost Savings	Annual Equivalent Fuel Cost Savings	Total Annual Savings	Simple Payback
City Office	10	$299.33	$2,993.34	685.75	0.00	2.34	49.76	$118.84	$177.33	$296.18	25.19
Clinic & Library	8	$299.33	$2,394.67	1,980.93	0.00	6.76	143.75	$343.29	$512.27	$855.56	6.98
School	22	$299.33	$6,585.34	11,746.48	0.00	40.09	852.43	$2,035.66	$3,037.63	$5,073.30	3.23
Washeteria, etc	6	$299.33	$1,796.00	1,294.59	0.00	4.42	93.95	$224.35	$334.78	$559.13	8.01

E03 - PREMIUM EFFICIENCY MOTORS UPGRADE

Building	# of Motors	Price Per Motor	Total Cost	Electric kWh Savings	Electric kW Savings	Equivalent mmBtu Savings	Equivalent Fuel Gallons Savings	Annual kWh Cost Savings	Annual Equivalent Fuel Cost Savings	Total Annual Savings	Simple Payback
Water Treatment	2	Varies w/HP	$13,407.74	555.25	0.20	1.90	40.29	$119.49	$143.59	$263.07	112.21

M01 - FURNACE UPGRADE

Building	# of Furnaces to Replace	New Furnace Efficiency (AFUE)	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	1	85.00%	$18,508.86	0.00	31.93	31.93	228.10	$0.00	$812.83	$812.83	22.77

APPENDIX B

ECO CALCULATION RESULTS – NOT FUNDED

APPENDIX B - ECO CALCULATION RESULTS - NOT FUNDED - KOYUKUK

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.

ECOS NOT FUNDED - INITIAL PROPOSAL

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
School	R-19	R-38	$29,998.08	0.00	67.48	67.48	481.98	$0.00	$1,717.54	17.47

M03 - BOILER UPGRADE

Building	# of Boilers to Replace	New Boiler Efficiency (AFUE)	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
School	2	86.70%	$40,880.00	0.00	365.92	365.92	2,613.74	$0.00	$9,314.07	4.39

ECOS NOT FUNDED - REJECTED IN CONSTRUCTION PHASE

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
School	1	$1,850.73	$1,850.73	154.82	154.82	1,105.82	0.00	$0.00	$3,940.60	0.47

Note: A programmable thermostat was ordered but not installed for the school building (voltage issue). This thermostat has been left with the school.

M01 - BOILER TUNE-UP

Building	Number of Boilers	Increase in Efficiency	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
School	2	2.00%	$4,200.00	0.00	144.21	144.21	1,030.10	$0.00	$3,670.78	1.14

APPENDIX C

EQUATIONS USED IN CALCULATIONS

APPENDIX C - EQUATIONS USED IN CALCULATIONS - KOYUKUK

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)

E02 1. Baseline Usage (kWh) = (Existing Fixture Wattage) x (Qty) x (Existing Hours) / (1,000)
2. Proposed Usage (kWh) = (Existing Fixture Wattage) x (Qty) x [(Existing Hours) - (Hours Reduced)] / (1,000)
3. Annual Energy Savings = (Baseline Energy Usage) - (Proposed Energy Usage
4. Annual Cost Savings = (Energy Savings) x (Energy Cost)

E03 1. Existing/Proposed Motor Demand (kW) = (Motor HP) x (Load Factor) x (0.746 kW/HP)/ Motor Efficiency
2. Existing/Proposed Motor Consumption (kWh) = (Motor Demand) x (Diversity Factor) x (Annual Hours)
3. kW Savings = [(Baseline kW) - (Proposed kW)] x (12 Months)
4. kWh Savings = (Baseline kWh) - (Proposed kWh)
5. Energy Cost Savings = Energy Savings (kW or kWh) x (Energy Unit Cost)

M01 Savings (MBtu) = (Boiler Input Rating) x ((1/Tested Efficiency)-(1/Desired Efficiency)) x (Hours per Year
Savings ($) = (MBtu Savings) x (Energy Cost)

M02 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

FOR C03

Tables 2A and 2B - 1995 Commercial Building Energy Consumption
2003 ASHRAE Applications Handbook, Chapter 35

	Energy End-Use (1,000 Btu/ft^2-yr)		
Building Characteristics	**Space Heat**	**Cool**	**Ventilation**
Education	32.8	4.8	1.6
Food sales	27.5	13.4	4.4
Food service	30.9	19.5	5.3
Health care	55.2	9.9	7.2
Lodging	22.7	8.1	1.7
Mercantile and service	30.6	5.8	2.5
Office	24.3	9.1	5.2
Public assembly	53.6	6.3	3.5
Public order and safety	27.8	6.1	2.3
Religious worship	23.7	1.9	0.9
Storage/Warehouse	15.7	0.9	0.3
Vacant	11.9	0.6	0.3

FOR E02 - Hours Reduced
From the Energy Management Handbook, Turner, 4th Edition Table 13.8 p361
Savings from installing occupancy sensors are as follows

Offices (Private)	25-50%
Offices (Open Spaces)	20-25%
Rest Rooms	30-75%
Corridors	30-40%
Storage Areas	45-65%
Meeting Rooms	45-65%
Conference Rooms	45-65%
Warehouses	50-75%

FOR E03
Load factor assumed to be 80% except in some cases. Vacuum pumps assumed 100% load factor.
Diversity factor assumed to be 95%.

APPENDIX D

POST INSTALLATION PHOTOS

APPENDIX D – POST INSTALLATION PHOTOS - KOYUKUK

Completed Insulation Upgrade – City Office

Completed Insulation Upgrade - Washeteria

New Furnace at the City Office