D. Energy Conservation Measures

Ameresco analyzed 15 energy conservation measures and decided to utilize 11 ECMs in the final scope of work for the proposed Energy Savings Performance Contract. This decision was based on optimal engineering practice as well as feedback from the City during the preliminary Investment Grade Audit meeting. Not all measures apply to all facilities. The table on the next page provides the building(s) where each ECM has been applied.

For transparency, this section describes the scope of work for each measure, the methodology employed to calculate energy savings, and the breakdown of the construction costs. The pro forma reflects these estimated implementation expenses as a guaranteed maximum cost for the overall project. Section A - Overview indicates the projected savings and guaranteed savings that the Investment Grade Audit improvements are expected to produce when implemented under an Energy Savings Performance Contract. The following assumptions have been incorporated into the implementation cost for the project:

1. City of Greeley will provide all utilities (electricity, water, sewer, natural gas, etc.) necessary during construction at no charge. Ameresco will provide any utility infrastructure required during construction.
2. Ameresco is not including any costs for temporary heating and cooling equipment or systems during construction. All heating and cooling equipment replacements will be implemented during periods of moderate temperatures to minimize occupant discomfort.
3. City of Greeley will provide a storage space for tools and materials during construction. Ameresco will be responsible for securing and protecting all tools and materials.
4. Due to the fact and Energy Savings Performance Contract is essentially a design-build contract, Ameresco would not anticipate any change orders arising from the current scope of work. However, any change orders initiated by City of Greeley will use the same markups and fees as the base contract.
5. The room by room audit and retrofit information will serve as the construction documents for the lighting retrofits and lighting controls measures.
6. The estimated construction costs do not include any taxes.
7. The anticipated utility rebate is estimated from the projected energy savings. Ameresco cannot be held responsible for the utility company's decision to approve a specific amount of rebate and/or incentive nor can Ameresco be held responsible for any utility company's changes to the incentive program during the course of the project.

Ameresco is pleased to provide the City of Greeley with a viable and verifiable means of achieving energy conservation and renewable energy savings without capital investment on the part of the City. An Energy Savings Performance Contract offers the City an opportunity to finance improvements through energy savings. With an ESPC, there is limited staff commitment required during the design and construction phases. The energy efficiency improvements will benefit staff and the City's citizens by providing enhanced occupant comfort, better facility function, and in many cases reduced maintenance. Ameresco will serve as the single point of accountability and will deliver the overall project within a short time frame, for maximum quality and value.

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Matrix of Energy Conservation Measure Applicability

This chart depicts the buildings where each ECM was applied within the Investment Grade Audit analysis and would be implemented, if the Energy Savings Performance Contract pro forma is approved by the City of Greeley.

Facility	Lighting	Lighting Controls	Envelope	VAV Retrofit	Boiler Retrofit	Premium Efficiency Motors	Retro Commissioning	Demand Controlled Ventilation	Pool Pump VFDs	Variable-flow Pumping	Solar PV
Recreation Center	X	X	X	X	X						
Union Colony Civic Center	X	X	X			X				X	
Senior Center	X	X	X								
FunPlex	X	X	X		X		X	X	X		X
Lincoln Park Annex	X	X	X	X	X	X		X			
Police HQ	X	X	X					X			
Police HQ Secondary Building	X	X	X								

ECM 1 & 2: Lighting and Lighting Controls

The lighting and lighting controls ECMs would retrofit existing lighting systems to achieve improved operation and energy performance.

Existing Conditions

Please refer to Section A for site specific descriptions of existing lighting equipment.

Proposed System Overview and Design Intent

Ameresco engineered solutions for both lighting systems and lighting controls. This section describes the design methodology for each system and the benefit to integrating energy efficient lights with controls to optimize energy savings.

Lighting

Ameresco leveraged our extensive lighting design experience with local government buildings to design the proposed lighting system. Our design maximizes energy savings, while ensuring that proper light levels are maintained or improved.

During Ameresco's audit, several fixture design and condition deficiencies were observed throughout the facilities. Replacement, removal, and the introduction of different fixture types were considered to address these conditions. The Appendices include a complete schedule of these improvements for the City's reference.

New fixtures will replace the existing fixtures that have reached the end of their service life. New lenses will be installed to replace the existing broken or missing lenses to bring uniformity to the facilities. The fixture and lens replacement strategy, as opposed to a strategy that merely replaces the existing lamps and ballasts, represents a higher cost factor, but will support the goal of achieving an overall higher quality design. In selected areas where existing high efficient T8 lamp and ballast combination are already present, re-lamping with 28 watt lamps is proposed.

Throughout the facilities, fixtures will be replaced or retrofitted with two foot and four foot high quality energy-efficient T8 lamps paired with new generation high-efficiency electronic ballasts. Ameresco proposes to replace the majority of existing four foot lamps with new 28 watt T8 fluorescent lamps. The premium lamp and ballast combination will have the ballast output factor tailored to each specific location. The new premium efficiency lamps have a mixture of phosphors that allow them to consume less energy while maintaining light levels. Over the life of the lamp, the 28 watt unit better maintains its light levels as compared to existing 34 watt T12 and 32-watt T8 lamps. Existing four foot U shaped lamps with be replaced by 17 watt linear lamps.

Incandescent lamps used in standard and selected decorative fixtures will be replaced with high-quality compact fluorescent lamps of equal or greater light output.

The HID Exterior lighting primarily currently consists of high pressure sodium and standard probe start metal halide system types. Ameresco will replace high wattage existing probe start metal halide fixtures with new LED, and or induction, and pulse start metal halide ballasts exterior fixtures.

Lighting Controls

Ameresco proposes to install new lighting controls at the City of Greeley facilities in order to ensure that selected lighting does not operate unnecessarily. Energy waste occurs when a fixture is energized but is not being used in an occupied area or when luminance exceeds what is necessary for task performance. Automatic controls can eliminate many energy management problems caused when occupants do not use manual controls effectively.

The existing lighting controls in the district are standard toggle style switches, panel controls, or existing occupancy sensors. During the audit conducted by Ameresco many lighted areas were observed that were not occupied, including administrative, courtroom, athletic, storage, mechanical, classroom, food processing, and custodial areas. There appeared to be a mixed lighting control strategy in place with occupancy sensors found sporadically in all seven facilities audited.

Occupancy Sensors

Project-wide, Ameresco will install 413 wall, ceiling, wireless ceiling, fixture, timer, and day-lighting photo controls to employ a variety of strategies, each of which was customized to the unique space. Appropriate areas were selected for these systems. All proposed areas for occupancy sensors contain controllable fixtures which have intermittent occupancy. In addition care has been taken to avoid placing occupancy sensors where they would present a safety hazard, if a sensor accidently turned the lights off. The fluorescent high-bays in gyms will have fixture mounted motion sensors, allowing each one to operate independently for maximum savings and flexibility.

Wireless Occupancy Controls

Wireless occupancy controls will be installed in areas where ceilings or walls would prevent the practical installation of an occupancy sensor. These sensors utilize a wall switch module and send a signal to the ceiling sensor wirelessly.

Photo Controls

Photo controls will be installed in areas to automatically turn off the lights when daylight is sufficient to properly light the space.

Timers

Programmable timers will be installed in selected areas. Occupants can view the timer running on a digital display. When the time runs out, the lights automatically turn off. Features with warnings such as the lights blinking prior to turning off are available to prevent safety hazards are encountered.

Scope of Work

- Wall mounted occupancy controls will be installed in 212 locations.
- Ceiling mounted occupancy controls will be installed in 119 locations.
- Occupancy controls will be incorporated into each fixture in 63 locations.
- Ceiling mounted dual technology occupancy controls will be installed in 38 locations.
- A timer will be installed in 38 locations.
- Controls that turn lights off when adequate natural light is available will be in installed in four locations.
- Wireless occupancy controls will be installed in two locations.

Ameresco will crate all ballasts, separating the ballasts with PCBs from the other material, and properly label the containers. Ameresco will be responsible for disposal and recycling of all removed materials.

Please refer to the proposed project retrofit table located in Appendix 1 for additional details regarding the scope of work

Impact of ECM on Facility Operations and Maintenance Procedures

Overall operation and maintenance procedures will not change, although there will be an improvement in the time and effort required to maintain lighting systems due to the standardization of lighting stock. The new lighting system will enhance facility operations by providing fixtures and components that have new high-efficiency electronic ballasts. These ballasts will minimize costs incurred to replace existing ballasts as they reach their end of life. In addition, all new T8 and compact fluorescent lamps installed will be low mercury, with higher color rendering indexes.

Equipment, Design, and Construction Documentation

Equipment will be identified in submittals provided to the City of Greeley for approval prior to procurement. Upon approval, these will constitute the construction documents. The shutdown of building equipment will be scheduled with Ameresco and the City prior to starting the proposed work in this ECM. Upon

completion of the construction phase, the documents will be revised as needed to reflect "as-built" conditions, and submitted in multiple sets to the City for record.

Savings Analysis Methodology

Energy savings were generated using a spreadsheet with the following calculations:

- Existing Demand (kW) = existing unit quantity x existing W / 1000
- Existing Consumption (kWh) = existing operating hours x existing kW
- Proposed Demand (kW) = proposed unit quantity x proposed W / 1000
- Proposed Consumption (kWh) = proposed operating hours x proposed kW
- Demand Savings (kW) = existing kW – proposed kW
- Consumption Savings (kWh) = existing kWh – proposed kWh
- Demand Cost Savings ($) = kW savings x demand cost
- Consumption Cost Savings ($) = kWh savings x consumption cost

Please refer to the appendix for detailed savings calculations.

Calculation Assumptions / Key Input Parameters

- The savings for the measure are based on operational schedule information provided by City personnel during site visits.
- The pre and post retrofit operational hours are the same with the exception of any areas that have lighting controls specified. Controlled areas have a percentage of reduced post hours based on industry standard reduction estimates, which can be seen in the detailed calculation in the appendix.
- The lighting fixture watt inputs are shown in the lighting calculations located in the appendix, and include fixtures, ballasts, and other factors.

Operations & Maintenance Savings / Future Avoided Capital

Ameresco is proposing using extended life lamps, which will increase the time between burnouts. Maintenance savings associated with the lighting upgrades were calculated via spreadsheet based on the additional life of the lamps. The savings are based on material costs only, and do not include labor savings. Please refer to the appendix for the detailed calculation of lighting operations & maintenance savings.

ECM 3: Envelope Improvements

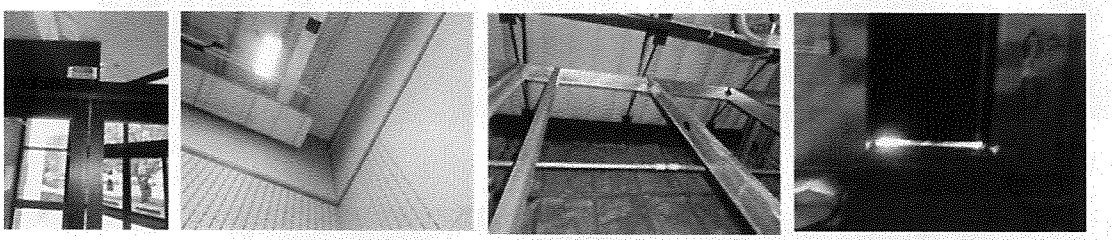
The objective of the Envelope Improvements ECM is to create air-tightness for the building envelope, and compartmentalize components of the building in order to equalize pressure differences, thereby saving energy and improving occupant comfort.

Air leakage can be defined as the uncontrolled migration of conditioned air through the building envelope caused by pressure differences due to wind, stack effects, or mechanical systems. Besides causing energy loss, uncontrolled air leakage can affect thermal comfort of occupants, air quality through ingress of contaminants from outside, the balance of mechanical air systems, and the structural integrity of the building envelope through moisture accumulation.

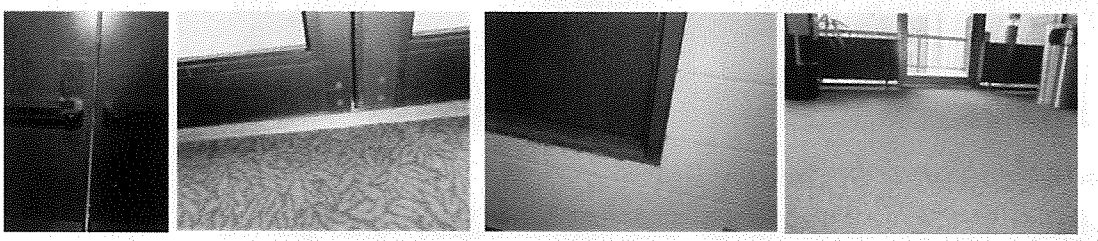
Existing Conditions

The City of Greeley's facilities were found to have numerous minor envelope deficiencies, such as gaps under exterior doors, around window frames, and between structural joints in walls, roofs, and foundations. These deficiencies contribute to air leakage. The following photos give a few of envelope deficiencies found during the audit.

Recreation Center

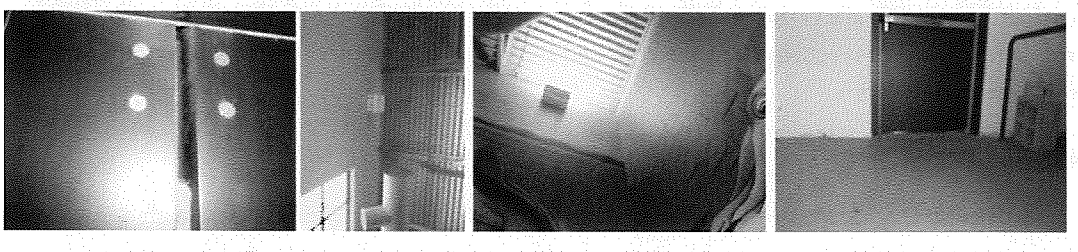


Union Colony Civic Center



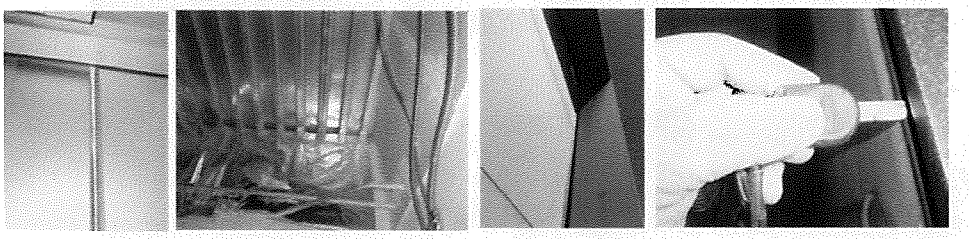
Senior Center

Funplex



Lincoln Park Annex

Police Headquarters



Police Headquarters Secondary Building

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Proposed Measure Overview & Design Intent

Ameresco proposes to control air leakage in the City of Greeley's facilities by sealing gaps, cracks, and holes in the facilities' building envelopes. Materials used will be fire retardant, poly urethane foam, caulks, and weather stripping. The objective is to create air-tightness for the building envelope, and compartmentalize components of the building in order to equalize pressure differences.

Scope of Work

The table and drawings on the following page provide detail regarding the specific scope of work for this measure.

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Scope of Work for All Facilities

Facility	Scope	Location / Floor	Quantity or Distance in Linear Feet
Recreation Center	Ext. Door(s) to be weather-stripped & sealed, see plan for location(s).	First	19 doors
Recreation Center	Int. Door(s) to be weather-stripped & sealed for isolation.	Gym(s)	2 doors
Recreation Center	Roof / Wall Joint to be Sealed with 1 part foam, see plan for location(s).	Gym(s)	700 feet
Recreation Center	Roof / Wall Joint to be Sealed with 1 part foam, see plan for location(s).	Pool	160 feet
Recreation Center	Roof / Level Change to be Sealed with 2 part foam.	First	80 feet
Recreation Center	Roof / Wall Joint to be Sealed with 2 part foam, see plan for location(s).	First	120 feet
Union Colony Civic Center	Ext. Door(s) to be weather-stripped & sealed, see plan for location(s).	First	19 doors
Union Colony Civic Center	Ext. Door(s) to be weather-stripped & sealed, see plan for location(s).	Third	1 door
Senior Center	Ext. Door(s) to be weather-stripped & sealed, see plan for location(s).	First	10 doors
Senior Center	Window(s) to be sealed, at sill plate only (1 line). See plan for location(s)	First	26 windows
Senior Center	Roof / Level Change to be Sealed with 2 part foam.	First	120 feet
Senior Center	Roof / Wall Joint to be Sealed with 2 part foam, see plan for location(s).	First	520 feet
Senior Center	Roof / Wall Joint to be Sealed with 1 part foam and spray painted.	First	40 feet
FunPlex	Ext. Door(s) to be weather-stripped & sealed, see plan for location(s).	First	30 doors
FunPlex	Roof / Wall Joint to be Sealed with 1 part foam, see plan for location(s).	Gym(s)	400 feet
FunPlex	Roof / Wall Joint to be Sealed with 1 part foam, see plan for location(s).	Pool	330 feet
FunPlex	Ext. Door(s) to be weather-stripped & sealed, see plan for location(s).	Third	1 door
FunPlex	Roof / Level Change to be Sealed.	Pool	80 feet
Lincoln Park Annex	Ext. Door(s) to be weather-stripped & sealed, see plan for location(s).	First	14 doors
Lincoln Park Annex	Ext. Door(s) to be weather-stripped & sealed, see plan for location(s).	Roof	1 door
Police Headquarters	Ext. Door(s) to be weather-stripped & sealed, see plan for location(s).	Main level	5 doors
Police Headquarters	Roof / Wall Joint to be Sealed with 2 part foam, see plan for location(s).	Main level	840 feet
Police Headquarters	Roof / Wall Joint to be Sealed with caulk.	Main level	200 feet
Police Headquarters	Window(s) to be sealed, at sill plate only (1 line). See plan for location(s)	Main level	49 windows
Police Headquarters	Ext. Door(s) to be weather-stripped & sealed, see plan for location(s).	Lower	7 doors
Police Headquarters	Window(s) to be sealed, at sill plate only (1 line). See plan for location(s)	Lower	6 windows
Police Headquarters	Roof / Wall Joint to be Sealed with 1 part foam, see plan for location(s).	Sally Port	100 feet
Police Headquarters	Over-head Door(s) to be sealed on 3 sides, see plan for location(s).	Sally Port	2 ovhd's
Police HQ Secondary Building	Ext. Door(s) to be weather-stripped & sealed, see plan for location(s).	First	16 doors
Police HQ Secondary Building	Roof / Wall Joint to be Sealed with 1 part foam, see plan for location(s).	First	740 feet
Police HQ Secondary Building	Over-head Door(s) to be sealed on 3 sides, see plan for location(s).	First	6 doors

***Note: Any related handling / abatement of asbestos containing material is excluded from the scope of work.**

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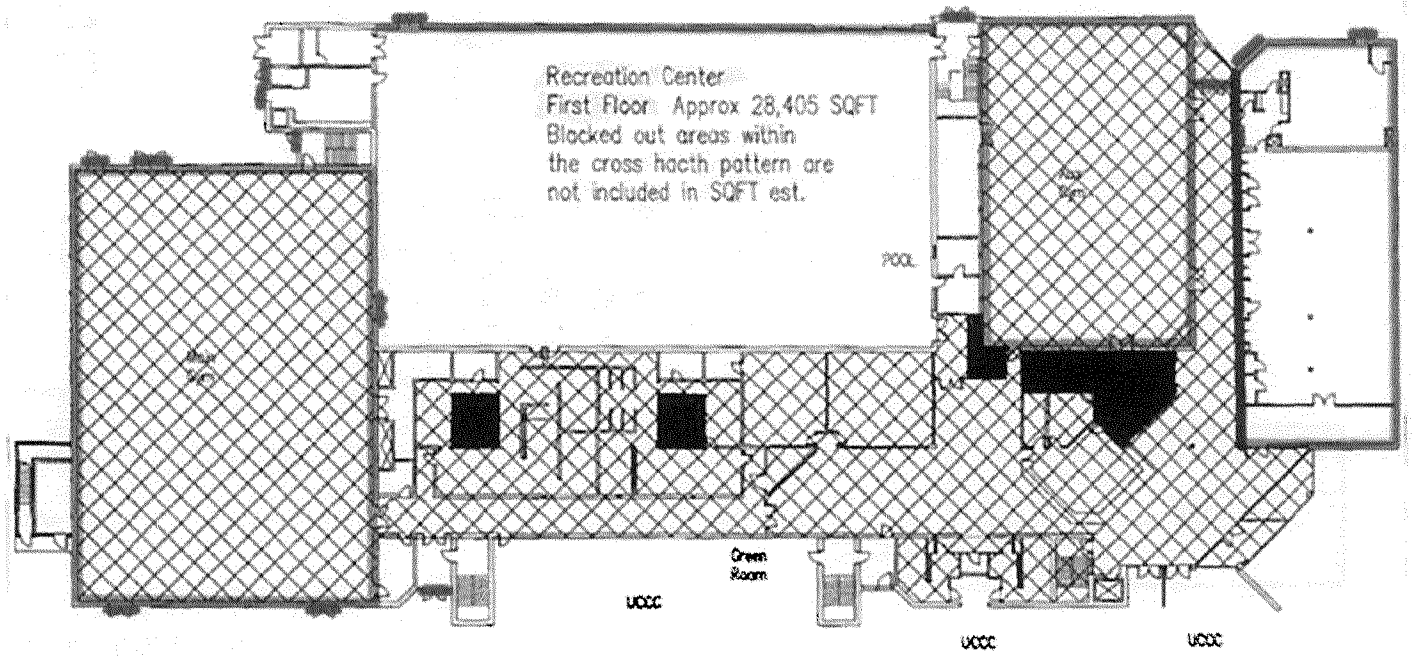
Recreation Center

- Pipe Penetrations and Shafts
- Roof / Level Change
- Roof/ Wall Connection
- Windows
- Door Sweeps Only
- Door to be fully weather stripped inc. sweeps
- Overhead door be fully weather stripped

BES Building Envelope Solutions, LLC

City of Greely
Pre Install
6/29/12 ML



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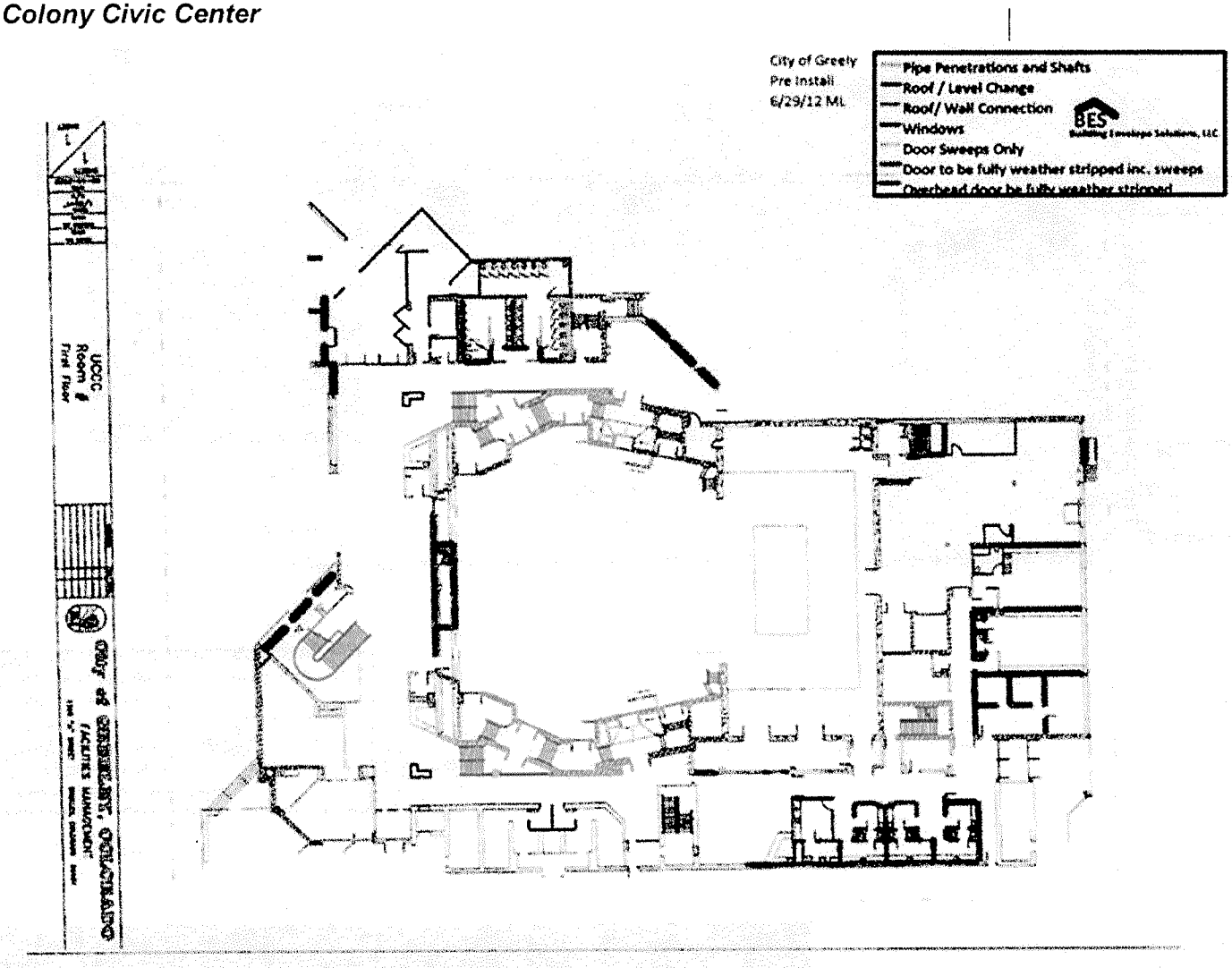
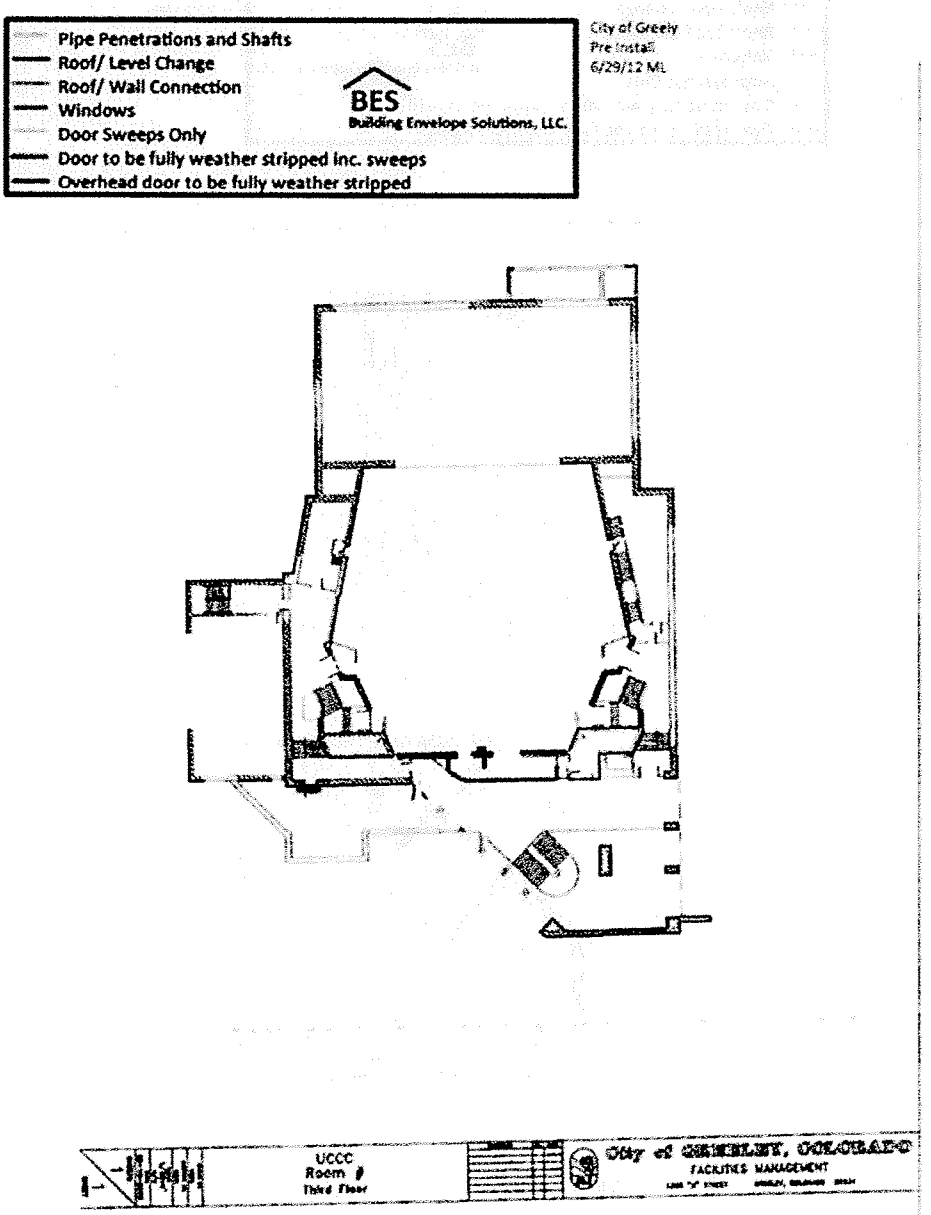
Union Colony Civic Center



Union Colony Civic Center



AMERESCO
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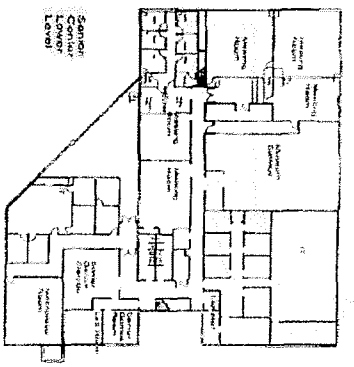
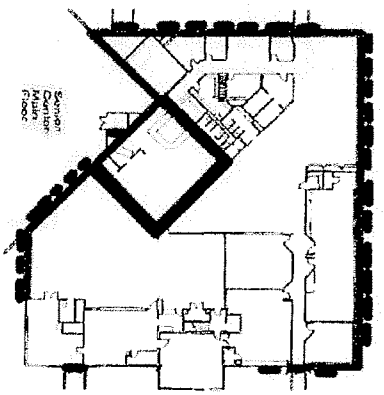
Senior Center

- Pipe Penetrations and Shafts
- Roof/ Level Change
- Roof/ Wall Connection
- Windows
- Door Sweeps Only
- Door to be fully weather stripped inc. sweeps
- Overhead door to be fully weather stripped

BES
Building Envelope Solutions, LLC.

City of Greely
Pre Install
6/29/12 ML



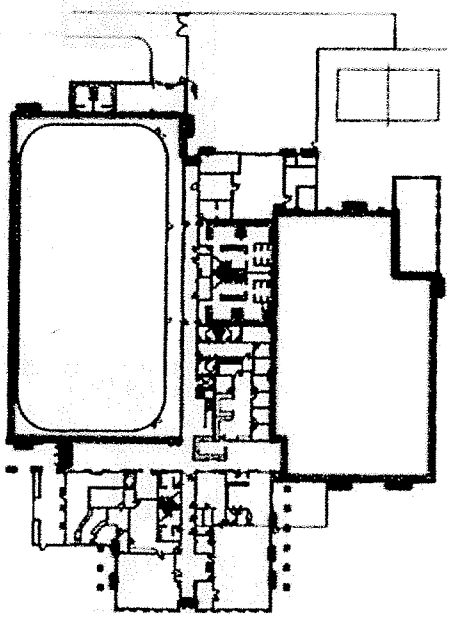


FunPlex

Pipe Penetrations and Shafts
Roof/ Level Change
Roof/ Wall Connection
Windows
Door Sweeps Only
Door to be fully weather stripped inc. sweeps
Overhead door to be fully weather stripped

BES
Building Envelope Solutions, LLC.

City of Greely
Pre Install
6/29/12 ML



Family Fun Plex
Room #
First Floor

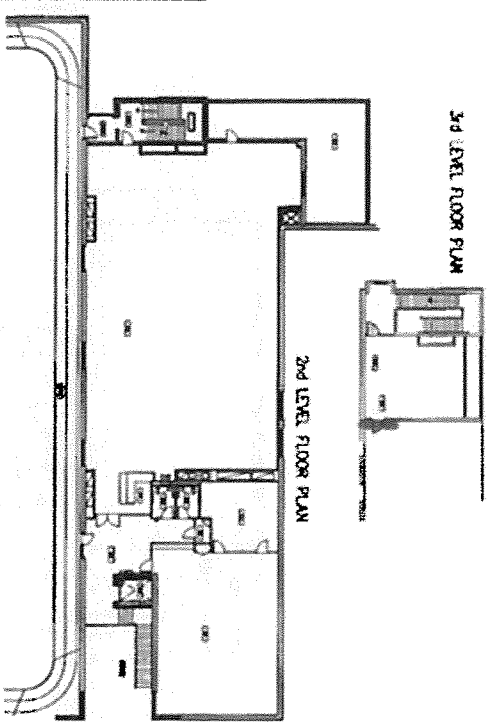
City of GREELEY, COLORADO
FACILITIES MANAGEMENT

FunPlex

Pipe Penetrations and Shafts
Roof/ Level Change
Roof/ Wall Connection
Windows
Door Sweeps Only
Door to be fully weather stripped inc. sweeps
Overhead door to be fully weather stripped

BES
Building Envelope Solutions, LLC.

City of Greely
Pre Install
6/29/12 ML



Family Fun Plex
Room #
Second and third floor

City of GREELEY, COLORADO
FACILITIES MANAGEMENT

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Lincoln Park Annex

- Pipe Penetrations and Shafts
- Roof/ Level Change
- Roof/ Wall Connection
- Windows
- Door Sweeps Only
- Door to be fully weather stripped inc. sweeps
- Overhead door to be fully weather stripped

BES
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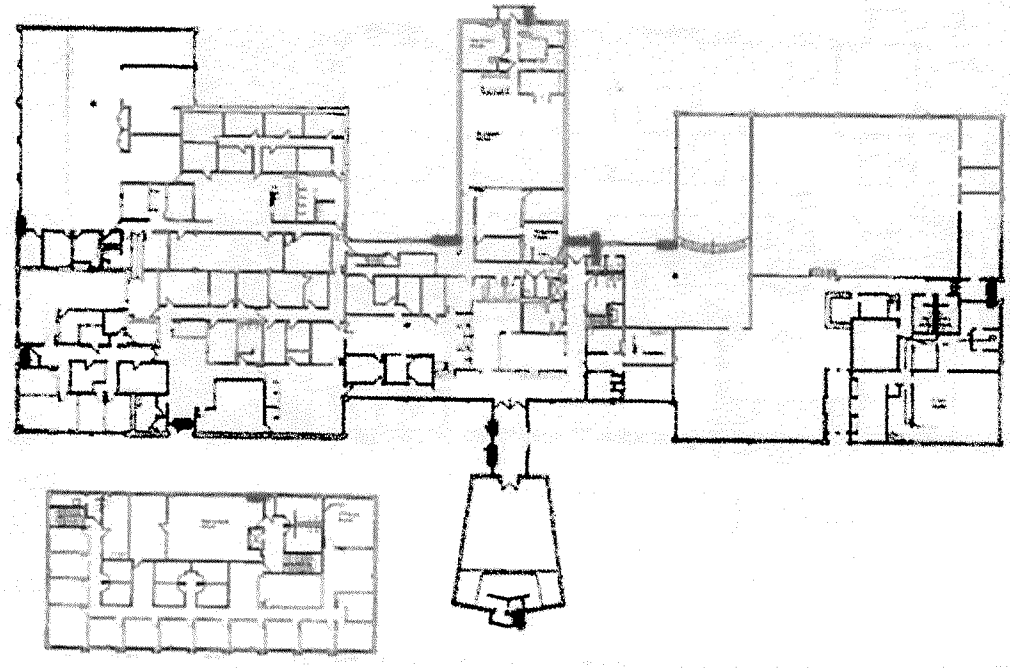
City of Greely
Pre Install
6/29/12 ML



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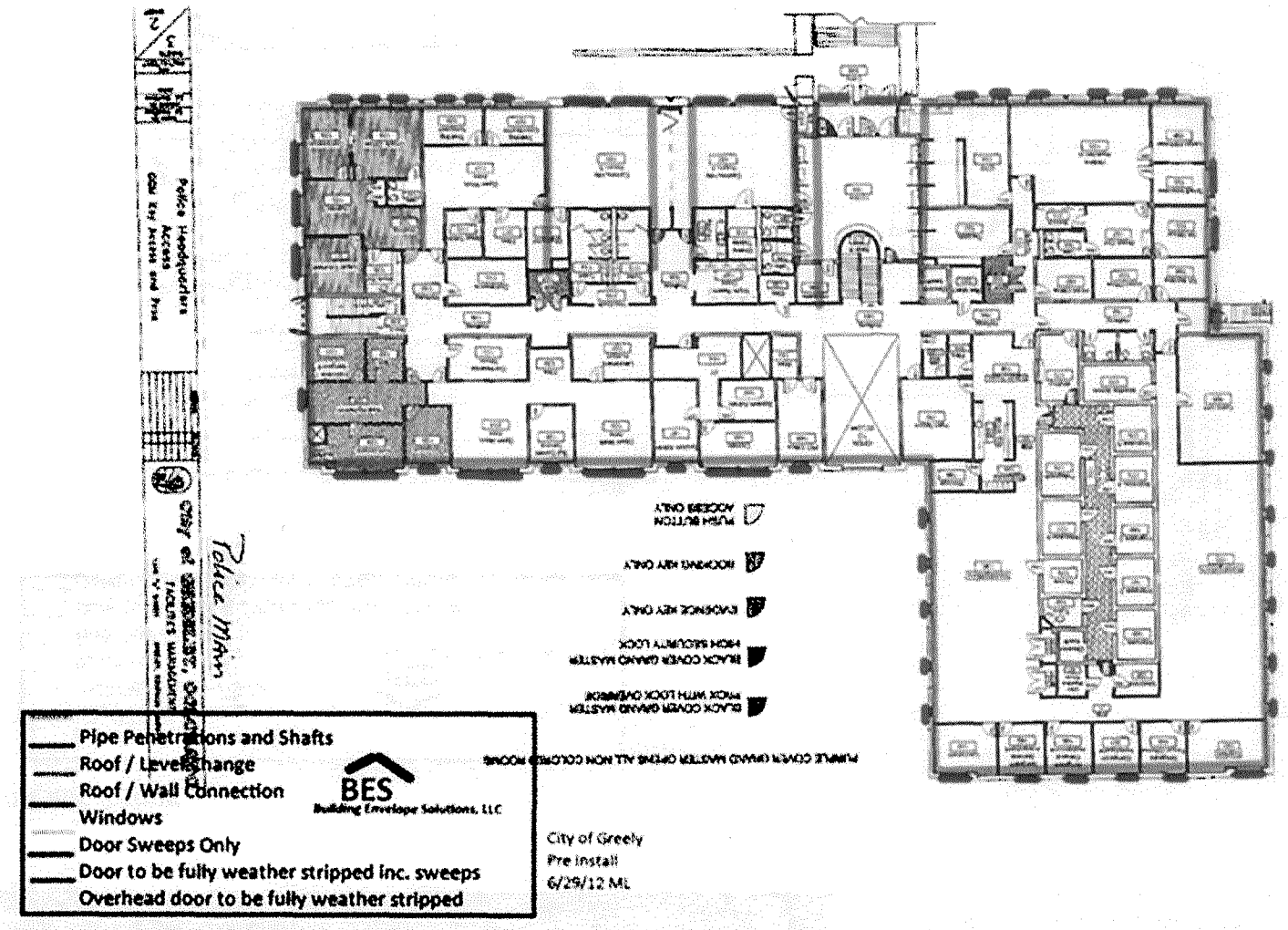
Police Headquarters



AMERESCO
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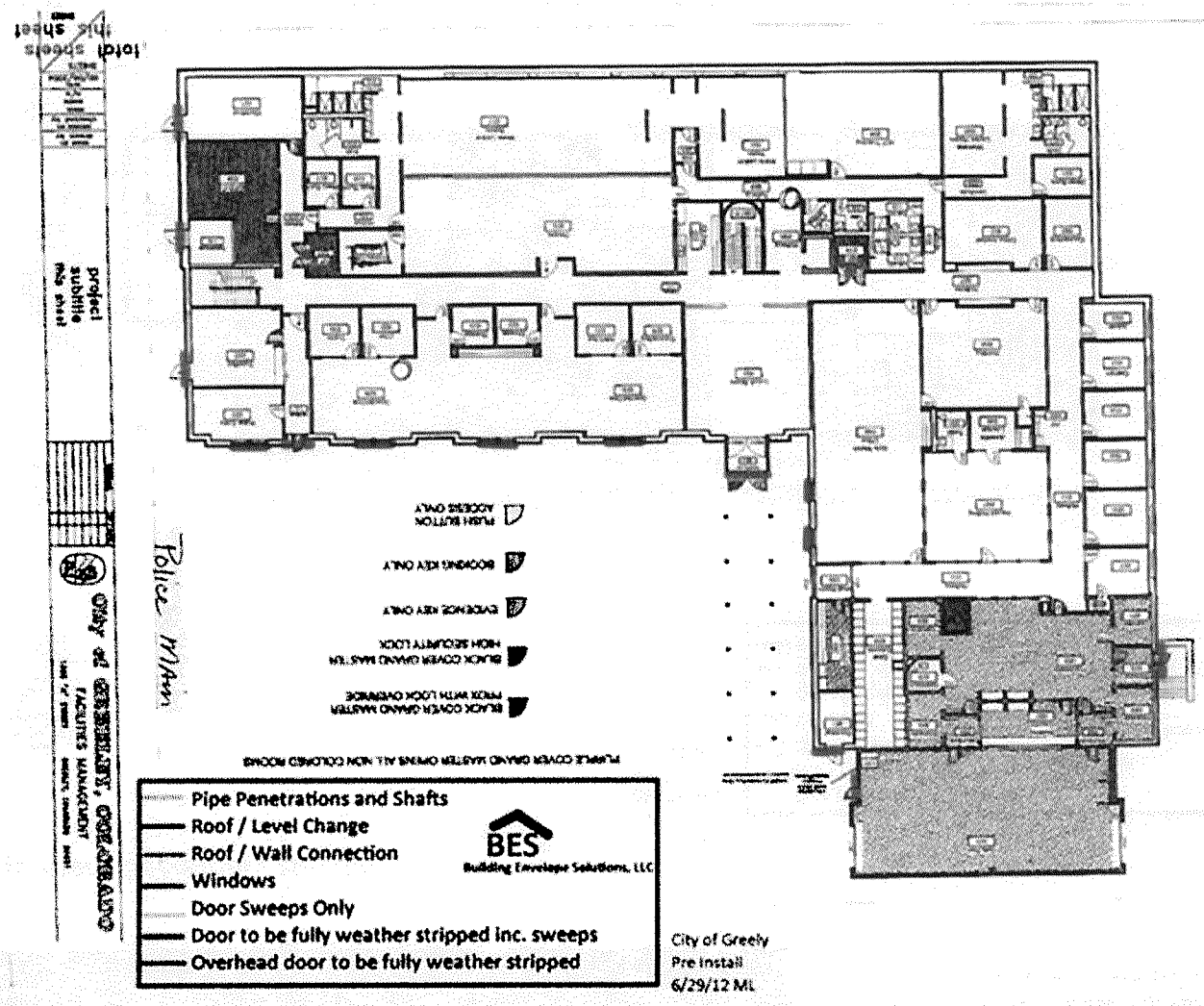
Police Headquarters



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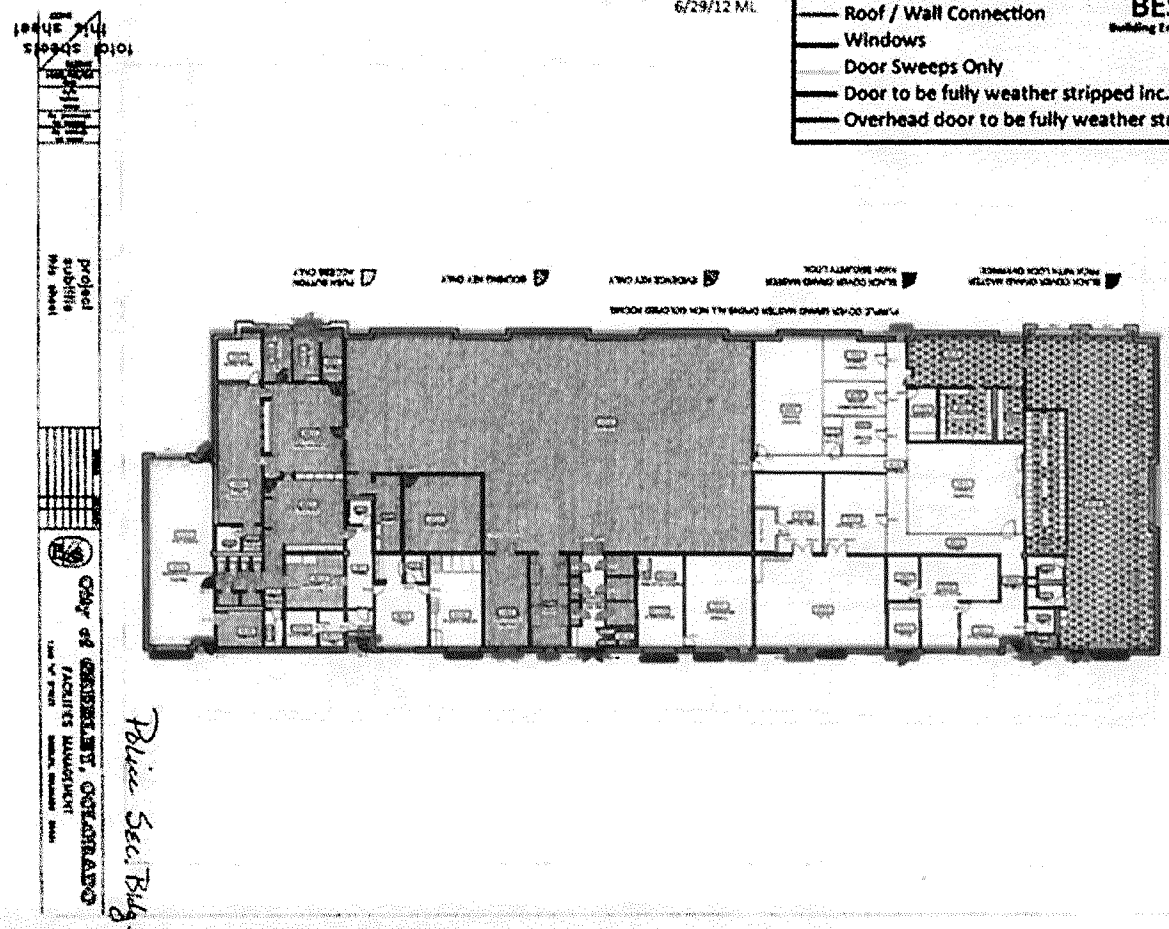
Police Headquarters Secondary Building

City of Greely
Pre Install
6/29/12 ML

- Pipe Penetrations and Shafts
- Roof / Level Change
- Roof / Wall Connection
- Windows
- Door Sweeps Only
- Door to be fully weather stripped inc. sweeps
- Overhead door to be fully weather stripped

BES
Building Envelope Solutions, LLC



Impact of ECM on Facility Operations & Maintenance Procedures

The facility operations and maintenance procedures should remain largely unchanged.

Equipment, Design, & Construction Documentation

Equipment will be identified in submittals provided to the City of Greeley for approval prior to procurement. Upon approval, these will constitute the construction documents. The shutdown of building equipment will be scheduled with Ameresco and the City prior to starting the proposed work in this ECM. Upon completion of the construction phase, the documents will be revised as needed to reflect "as-built" conditions, and submitted in multiple sets to the City for record.

Savings Analysis Methodology

An estimated gap analysis method (EGAM R02-10-02 Derived from EC-128 - Energy Canada study 128, and ASHRAE Calculations) was used to calculate the energy savings resulting from the weatherization of commercial buildings. The calculation is based on local wind speed, heating and cooling season and building style. The primary equations used in the calculations are as follows:

- Gas Heating Loss = ((bldg leakage in sq. mtrs) x (bldg k factor) x (wind pressure factor) x (heating degree days) x (.355)) / (fuel factor)
- Electrical Heating Loss = ((bldg leakage sq. mtrs) x (bldg k factor) x (wind pressure factor) x (heating degree days) / (3.6 x fuel factor)
- Cooling Loss = ((bldg leakage in sq. mtrs) x (bldg k factor) x (wind pressure factor) x (cooling degree days)) / (3.6 x fuel factor)

Calculation Assumptions / Key Input Parameters

Assumptions for k value, wind pressure factor, and fuel factor are facility specific. Gap size for use in savings calculations were estimated by on site by visual inspection. Please refer to the Appendix for detailed savings calculations showing calculation values used.

Operations & Maintenance Savings / Future Avoided Capital

There are no operations & maintenance or future avoided capital cost savings applicable to this measure.

ECM 4: VAV Retrofit, Recreation Center

The measure would convert AHU-9 and AHU-10 from constant volume single zone to variable air volume single zone systems.

Existing Conditions

In the Recreation Center, AHU-9 serves the large gymnasium and AHU-10 serves the small gymnasium. The AHU-9 supply fan is equipped with a Toshiba VFD but it is not wired to the DDC controller. The AHU-10 supply fan is also equipped with a Toshiba VFD but the DDC controller is not wired to the VFD. Fan speed for both air handlers is manually adjusted by the HVAC technicians on a seasonal basis. The following table provides information on each motor. Note that the 7.5 HP AHU-10 return fan does not currently have a VFD.

MOTOR											
MFG.	MODEL NO.	HP	VOLTS	AMPS	RPM	INS	SF	FRAME	ENCL	EFF	SERVICE
DAYTON	2KW92A	20	208-230/460	54-49/24.5	1765	F	1.15	256T	TE	91.0	AHU-9 SA FAN
TOSHIBA	B0154FLF2USH02	15	230/460	37/18.5	1775	F	1.15	254T	TEFC	92.4	AHU-10 SA FAN
EMERSON	R341	7.5	230/460	18.4/9.2	1760	F	1.15	213T	DP	91.0	AHU-10 RA FAN

Proposed System Overview & Design Intent

The intent of this measure is to automate the variable speed operation of AHU-9 and 10. Single zone VAV systems are designed to vary the airflow at constant temperature to provide space temperature control. The variable speed fan controls the amount of airflow provided to the space by modulating the fan motor speed based on the temperature difference between the actual space temperature and the space temperature set point.

Scope of Work

On AHU-9, furnish and install control wiring from the DDC controller to the VFD. (Use spare points or provide an additional controller as needed). Modify the control sequence to provide for constant discharge temperature-variable air volume operation. On the AHU-10 supply fan, furnish and install control wiring from the DDC controller to the VFD. (Use spare points or provide an additional controller as needed). Furnish and install a new VFD to control the 7.5 HP return fan motor. Return fan speed control shall be tracking. Modify the control sequence to provide for constant discharge temperature-variable air volume operation.

Provide all programming and graphics as needed for the following points:

- Supply Fan VFD Speed Set point
- Supply Fan VFD Status
- Supply Fan VFD Alarm
- Supply Fan VFD in Hand
- Return Fan VFD Speed Set point
- Return Fan VFD Status
- Return Fan VFD Alarm
  Return Fan VFD in Hand

Impact of ECM on Facility Operations & Maintenance Procedures

The facility operations and maintenance procedures should remain largely unchanged.

Equipment, Design, & Construction Documentation

Equipment will be identified in submittals provided to the City of Greeley for approval prior to procurement. Upon approval, these will constitute the construction documents. The shutdown of building equipment will be scheduled with Ameresco and the City prior to starting the proposed work in this ECM. Upon completion of the construction phase, the documents will be revised as needed to reflect "as-built" conditions, and submitted in multiple sets to the City for record.

Savings Analysis Methodology

The savings methodology for this measure used a modified temperature BIN analysis. Weather data utilized NOAA's Franktown, Colorado site as this location provided the closest proximity to Greeley with a full year's (2011) hourly data set.

An end use analysis (EUA) was used to disaggregate the Recreation Center's demand and energy use. Three year average utility data together with the load fraction of the AC-9 and 10 air handler were used to estimate the AC-9 and 10 annual fan demand and energy use. Although this measure would reduce heating and cooling energy, the savings estimate was based solely on the ventilation load. A copy of the savings calculations is provided in the appendix.

Calculation Assumptions / Key Input Parameters

- The proposal of this measure assumes that all existing equipment and infrastructure, other than that specifically described as being provided or accomplished in the above scope of work, to allow a working system such as existing VFDs, motors, control points, controls, etc. are in working condition. The validity of this measure depends upon the existence of such equipment, per the drawings and specifications.
- The savings estimate assumes a linear relationship between the required air-flow volume and the outside air temperature. The minimum air flow would be 20%.
- The existing air handlers operate approximately 4,700 hours per year following the DDC retrofit with the optimum start sequence.

Operations & Maintenance Savings / Future Avoided Capital

There are no operations & maintenance or future avoided capital cost savings applicable to this measure.

ECM 4: VAV Retrofit, Lincoln Park Annex

The purpose of this measure is to convert the AC-4 multi-zone air handler from constant volume into a hybrid variable air volume system.

Existing Conditions

The 1st and 2nd floor core areas of the LPA are served by an indoor 11 zone multi-zone air handler. It is equipped with a DX cooling coil and hot water heating coil. There are two water cooled reciprocating compressors that serve the DX coil. A single Marley water cooled condenser provides heat rejection. The air handler has a mixed air economizer and is controlled by the JCI Metasys control system. All field devices are pneumatic. The following tables identify the equipment affected by this measure.

AIR HANDLING UNIT											
UNIT NO.	MFG.	MODEL NO.	FAN SECTION				HEATING			COOLING	
			CFM	ESP	OV	HP	ENT AIR	GPM	ENT AIR	LVG AIR	COMP TONS
AC-4	ACME	PACW-50	22,430	0.5	885	25	40	61.7	83DB 61WB	55DB 51.5WB	35 25

SUPPLY FAN MOTOR								
MFG.	MODEL NO.	HP	VOLTS	AMPS	RPM	INS	SF	SERVICE
ALLIS CHALMERS	51-308-425-11	25	230/460	60.2/30.1	1750	B	1.15	AC-4

WATER COOLED CONDENSER					
MARK	MFG.	MODEL NO.	HP	RPM	SERVICE
NA	MARLEY	NA	2	1750	AC-4

Proposed System Overview & Design Intent

The proposed measure would replace the existing constant volume zone dampers and replace them with new (or modified) zone dampers to independently control the heating or cooling airflow to each space. The existing 25 horsepower motor would be replaced with a new premium efficiency inverter rated motor to be controlled by a variable frequency drive. The existing reciprocating compressors, cooling coil and water cooled compressor would be replaced with a new cooling coil and air-cooled condensing unit with digital scroll compressor(s) for modulating capacity control. The existing heating coil would remain in place. The Johnson Controls pneumatic system would be replaced with a new DDC system that would provide new zone temperature sensors, static pressure sensors and other devices as needed for a complete working VAV system. B.G. valves

Scope of Work

Mechanical Scope

Remove the zone damper section of the air handler. Modify the zone dampers in such a manner that the hot deck damper and cold deck damper will operate independently for each zone, i.e., (split the damper rod between the hot and cold decks). Alternatively, furnish a new zone damper box matching the existing box with separate hot deck and cold deck damper rods for each of the eleven zones, (Titus or approved equal). The new or modified damper section must provide sufficient damper rods that will allow for installation of new damper actuators on each hot deck and cold deck zone damper. Reinstall the modified or new damper box and seal ductwork.

Demolish and remove the existing reciprocating refrigerant compressors, (two each) together with the DX cooling coil, and all related refrigerant piping including hangers and supports.

~~Demolish and remove the existing Marley water cooled condenser together with all related condenser water piping including hangers and supports. Permanently isolate, drain and cap the existing make-up water piping to the unit.~~

Demolish and remove the 25 HP supply fan motor and belts. Furnish and install a new premium efficiency, inverter rated 25 HP supply fan motor, (Baldor or approved equal) and new fan belts.

Remove the 2 1/2" heating control valve. Install a new heating control valve to be furnished by the controls subcontractor.

Install new thermo wells in the hot water supply and return water piping.

Furnish and install a new 63 nominal ton air cooled condensing unit with variable capacity scroll compressors (10-100%) for load matching, (AAON CC Series or approved equal). The new unit will generally be placed the same location of the Marley condensing unit. Furnish and install a new matching evaporator coil suitable

for use with variable air flow. Furnish and install new refrigerant piping together with all necessary hanger and support. Furnish and install pipe insulation, (exterior insulation shall include aluminum jacketing).

Controls Scope

Demolish and remove all pneumatics including all sensors, damper actuators, pneumatic tubing and any and all other field devices associated with AC-4. Demolish and remove all pneumatic controls associated with AC-4 including but not limited to sensors, actuators, controllers, transducers, and any other equipment related to the pneumatic controls in order to facilitate a complete DDC retrofit on this air handler and new DX split cooling system. All tubing to be removed to finished wall, ceiling or floor surfaces. Reuse existing cabinets and conduit to the extent practicable. Furnish and install new sensors, wiring and interface to 11 zones located throughout the building. Furnish and install 22 new DDC hot deck and cold deck damper actuators and discharge zone temperature sensors for 11 zones. All exposed wiring shall be in conduit. Plenum rated cable may be used in concealed locations.

Furnish and install a new DDC system, Johnson Metasys or approved equal. The new DDC system shall include all points and field devices needed to control AC-1 and the new air-cooled split DX cooling system.

Update programming and graphics as needed for DDC the new sequences as shown below including configuration of trends and alarms as defined by Ameresco. The following control points or sequences will be required.

Air Handler AC-4

- Comparative economizer control (dry bulb)
- Mixed air temperature set point
- Hot deck reset
- Cold deck reset
- Supply fan enable
- Supply fan speed control
- Supply fan status/speed
- Supply VFD fault
- Hot deck static pressure reset
- Cold deck static pressure reset
- Freezestat
- Optimum start
- High static pressure

VAV Zone Damper Controls (Qty=11)

- Zone temperature
- Discharge Air Temperature
- Hot deck damper position
- Cold deck damper position
- Timed occupant override

DX Cooling System

- Cooling enable
- Compressor status
- Minimum runtime

Impact of ECM on Facility Operations & Maintenance Procedures

This measure would reduce operations and maintenance requirements for this unit as a result of the DDC retrofit and the elimination of the water cooled condenser.

Equipment, Design, & Construction Documentation

Equipment will be identified in submittals provided to The City of Greeley for approval prior to procurement. Upon approval, these will constitute the construction documents. The shutdown of building equipment will be scheduled with Ameresco and the City prior to starting the proposed work in this ECM. Upon completion of the construction phase, the documents will be revised as needed to reflect "as-built" conditions, and submitted in multiple sets to the City for record. New EMS system will provide the following for each building within the District.

Savings Analysis Methodology

The savings methodology for this measure used a modified temperature BIN analysis. Weather data utilized NOAA's Franktown, Colorado site as this location provided the closest proximity to Greeley with a full year's (2011) hourly data set. An end use analysis (EUA) was used to disaggregate the facility's demand and energy use. Three year average utility data together with the load fraction of the AC-4 air handler was used to estimate the AC-4 annual ventilation demand and energy use. Although this measure would reduce heating and cooling energy, the savings estimate was based solely on the ventilation load. A copy of the savings calculation is provided in the appendix.

Calculation Assumptions / Key Input Parameters

- The savings estimate assumes a linear relationship between the required air-flow volume and the outside air temperature. The minimum air flow would be 20%.

- The proposed digital scroll compressor condensing unit and the existing water cooled reciprocating compressors have similar efficiencies and that cooling and heating energy would not be affected by the measure.
- The existing AHU runs 24/7 and would operate approximately 4,700 hours per year following the DDC retrofit with the optimum start sequence.

Operations & Maintenance Savings / Future Avoided Capital

Although the proposed retrofit would reduce O&M expenses, there are no operations & maintenance or future avoided capital cost savings attributed to this measure.

ECM 5: Boiler Retrofit - Domestic Hot Water Boiler Recreation Center

The measure would replace each of the old Lochinvar domestic hot water (DHW) boilers with new, high efficiency condensing boilers.

Existing Conditions

Domestic hot water for this facility is provided by two Lochinvar boilers. Each boiler has a 200 gallon storage tank. Fractional horsepower pumps provide continual circulation between the boilers and storage tank and storage tank to fixtures. The following table describes the existing DHW boilers:

DHW Boiler					
MARK	MFG.	MODEL NO.	INPUT (BTU)	RECOVERY (GPH)	SERVICE
NA	LOCHINVAR	CBN 1435	1,435,000	NA	DHW
NA	LOCHINVAR	CBN 1435	1,435,000	NA	DHW

Proposed System Overview & Design Intent

This measure will remove the existing DHW boilers and storage tank and replace them with new condensing DHW boilers, resulting in energy savings.

Scope of Work

Demolish and remove the existing DHW boilers, flue, piping, circulating pumps, and all other auxiliaries associated with the existing boilers. The existing 200 gallon storage tanks and piping will remain the extent practicable.

Furnish and install two Raypak X Therm WH7-1505 condensing DHW boilers, (or approved equal).

Utilize the existing flue penetration for venting and combustion air. Provide new flashing and counter flashing as needed for a weather tight seal.

Furnish and install new natural gas connection to the new boilers including gas pressure regulator as needed.

Furnish and install a new auxiliaries including but not limited to expansion tank, circulating pump (Grundfos or approved equal), new isolation valves, check valves, condensate neutralizer, temperature gages and any other auxiliaries for a complete working DHW system. All new piping shall be Type L copper. Pipe relief valves to suitable floor drains.

Furnish and install all necessary electrical power conduit and wiring as needed including new circuit breaker and disconnect.

Furnish and install fiberglass pipe insulation with kraft jacketing.

Impact of ECM on Facility Operations & Maintenance Procedures

The facility operations and maintenance procedures should remain largely unchanged

Equipment, Design, & Construction Documentation

Equipment will be identified in submittals provided to The City of Greeley for approval prior to procurement. Upon approval, these will constitute the construction documents. The shutdown of building equipment will be scheduled with Ameresco and the City prior to starting the proposed work in this ECM. Upon completion of the construction phase, the documents will be revised as needed to reflect "as-built" conditions, and submitted in multiple sets to the City for record.

Savings Analysis Methodology

The savings analysis methodology is based on natural gas billing data over a three year average. The methodology assumes that the average monthly use for DHW is approximately 12 percent of the total natural gas consumption for the facility.

A copy of the detailed energy savings calculation is provided in the appendix.

Calculation Assumptions / Key Input Parameters

- The savings estimate assumes the average monthly natural gas usage for the Recreation Center is approximately 12 percent of the total gas consumption.
- The existing water heaters have a thermal efficiency of 78% and the replacement units have a thermal efficiency of 95%.

Operations & Maintenance Savings / Future Avoided Capital

There are no operations & maintenance or future avoided capital cost savings applicable to this measure.

ECM 5:
Boiler Retrofit, Pool Boiler, Recreation Center

The measure would replace the existing atmospheric Teledyne Laars boiler with a new, high efficiency condensing pool boiler.

Existing Conditions

The Recreation Center pool is heated by one Teledyne Laars boiler. The following table describes the existing pool boiler:

DHW Boiler					
MARK	MFG.	MODEL NO.	INPUT (BTU)	OUTPUT (BTU)	SERVICE
NA	TELEDYNE-LAARS	1670 IN 09 C 1A CX	1,670,000	1,352,700	POOL

Proposed System Overview & Design Intent

This measure would remove the existing DHW boilers and storage tank and replace them with new condensing DHW boiler, thereby saving energy.

Scope of Work

Demolish and remove the existing pool boiler, flue, piping, circulating pumps, and all other auxiliaries associated with the existing boilers.

Furnish and install one Raypak X Therm WHP-1505 condensing pool boiler, (or approved equal).

Utilize the existing flue penetration for venting and combustion air. Provide new flashing and counter flashing as needed for a weather tight seal.

Furnish and install new natural gas connection to the new boilers including gas pressure regulator as needed.

Furnish and install a new auxiliaries including but not limited to expansion tank, circulating pump (Grundfos or approved equal), new isolation valves, check valves, condensate neutralizer, temperature gages and any other auxiliaries for a complete working DHW system. All new piping shall be Type L copper. Pipe relief valves to suitable floor drains.

Furnish and install all necessary electrical power conduit and wiring as needed including new circuit breaker and disconnect.

Furnish and install fiberglass pipe insulation with kraft jacketing.

Impact of ECM on Facility Operations & Maintenance Procedures

The facility operations and maintenance procedures should remain largely unchanged

Equipment, Design, & Construction Documentation

Equipment will be identified in submittals provided to The City of Greeley for approval prior to procurement. Upon approval, these will constitute the construction documents. The shutdown of building equipment will be scheduled with Ameresco and the City prior to starting the proposed work in this ECM. Upon completion of the construction phase, the documents will be revised as needed to reflect "as-built" conditions, and submitted in multiple sets to the City for record.

Savings Analysis Methodology

The savings analysis methodology is based on the Shah Method - See "Calculating Evaporation from Indoor Water Pools", HPAC Engineering, March 2004

This Excel spreadsheet calculates heating and dehumidification costs due to evaporation from a swimming pool. The calculations take into account activity level, air and water properties, dehumidifier energy, and more. The spreadsheet was developed and distributed by Washington State University.

A copy of the savings calculations is provided in the appendix.

Calculation Assumptions / Key Input Parameters

- Key assumptions used in the analysis include a pool temperature of ~~82~~ 84F, room temperature of 85F and 50% relative humidity.
- An existing boiler efficiency of 78%.
- Ventilation heat recovery without dehumidification.

Operations & Maintenance Savings / Future Avoided Capital

There are no operations & maintenance or future avoided capital cost savings applicable to this measure.

ECM 5: Boiler Retrofit, Lincoln Park Annex

This measure would remove the existing domestic water heating system and replace it with a new, high efficiency condensing water heater.

Existing Conditions

Domestic hot water for this facility is provided by a Rheem circulating tank water heater together with a storage tank of approximately 100 gallons. Fractional horsepower pumps provide continual circulation between the water heater and storage tank and storage tank to fixtures. The following table describes the existing DHW boiler:

DHW Boiler					
MARK	MFG.	MODEL NO.	INPUT (BTU)	RECOVERY (GPH)	SERVICE
NA	RHEEM	GBC-0181	181,000	179	DHW

Proposed System Overview & Design Intent

The existing water heating system is characterized by its poor combustion efficiency and high standby losses. The proposed system would utilize a single high efficiency condensing water heater to replace the old boiler, circulating pump and storage tank.

Scope of Work

Demolish and remove the DHW existing DHW boiler, flue, storage tank and piping, circulating pumps, expansion tank and all other auxiliaries associated with the existing water heating system.

Permanently cap and seal the existing back up boiler connections to the storage tank.

Furnish and install one AO Smith BTH Xi 199 condensing water heater (or approved equal).

Utilize the existing flue penetration for venting and flash and counter flash as needed for a weather tight seal.

Furnish and install new natural gas connection to the new water heater including gas pressure regulator as needed.
Furnish and install a new auxiliaries including but not limited to expansion tank, circulating pump (Grundfos or approved equal), thermostatic mixing valve, new isolation valves, check valves, condensate neutralizer,

temperature gages and any other auxiliaries for a complete working DHW system. All new piping shall be Type L copper. Provide piping of the relief valve to a suitable floor drain.

Furnish and install all necessary electrical power conduit and wiring as needed including new circuit breaker and disconnect.

Furnish and install fiberglass pipe insulation with kraft jacketing.

Impact of ECM on Facility Operations & Maintenance Procedures

This measure would reduce O&M expenses by replacing the existing boiler, expansion tank, circulating pump and storage tank with a single condensing water heater together with its auxiliary components.

Equipment, Design, & Construction Documentation

Equipment will be identified in submittals provided to The City of Greeley for approval prior to procurement. Upon approval, these will constitute the construction documents. The shutdown of building equipment will be scheduled with Ameresco and the City prior to starting the proposed work in this ECM. Upon completion of the construction phase, the documents will be revised as needed to reflect "as-built" conditions, and submitted in multiple sets to the City for record.

Savings Analysis Methodology

The savings estimate for this measure is based upon the disaggregated end use analysis, (EUA) data together with the three-year average natural gas consumption for the facility. It compares the natural gas consumption of the existing boiler with the proposed high efficiency water heater.

Calculation Assumptions / Key Input Parameters

- The existing boiler thermal efficiency is 78% and the proposed condensing water heater's efficiency is 95%.

Operations & Maintenance Savings / Future Avoided Capital

There are no operations & maintenance or future avoided capital cost savings attributed to this measure.

ECM 5: Boiler Retrofit, Domestic Hot Water Boiler, FunPlex

The measure would replace the old Lochinvar domestic hot water (DHW) boiler with new, high efficiency condensing boiler.

Existing Conditions

Domestic hot water for this facility is provided by one Lochinvar boiler. The boiler has two, 200 gallon storage tanks. Fractional horsepower pumps provide continual circulation between the boilers and storage tank and storage tank to fixtures. The following table describes the existing DHW boiler:

DHW Boiler					
MARK	MFG.	MODEL NO.	INPUT (BTU)	RECOVERY (GPH)	SERVICE
NA	LOCHINVAR	CFN0991PM	990,000	NA	DHW

Proposed System Overview & Design Intent

This measure will remove the existing DHW boiler and replace it with new a condensing DHW boiler.

Scope of Work

Demolish and remove the existing DHW boiler, flue, piping, circulating pumps, and all other auxiliaries associated with the existing boilers.

The existing 200 gallon storage tanks and piping will remain.

Furnish and install one Raypak X Therm WH7-1005 condensing DHW boiler, (or approved equal).
Venting issue

Utilize the existing flue penetration for venting and combustion air. Provide new flashing and counter flashing as needed for a weather tight seal.

Furnish and install new natural gas connection to the new boilers including gas pressure regulator as needed.

Furnish and install a new auxiliaries including but not limited to expansion tank, circulating pump (Grundfos or approved equal), new isolation valves, check valves, condensate neutralizer, temperature gages and any other auxiliaries for a complete working DHW system. All new piping shall be Type L copper. Pipe relief valves to suitable floor drains.

Furnish and install all necessary electrical power conduit and wiring as needed including new circuit breaker and disconnect.

Furnish and install fiberglass pipe insulation with kraft jacketing.

Impact of ECM on Facility Operations & Maintenance Procedures

The facility operations and maintenance procedures should remain largely unchanged

Equipment, Design, & Construction Documentation

Equipment will be identified in submittals provided to The City of Greeley for approval prior to procurement. Upon approval, these will constitute the construction documents. The shutdown of building equipment will be scheduled with Ameresco and the City prior to starting the proposed work in this ECM. Upon completion of the construction phase, the documents will be revised as needed to reflect "as-built" conditions, and submitted in multiple sets to the City for record.

Savings Analysis Methodology

The savings analysis methodology is based on natural gas billing data over a three year average. The methodology assumes that the average monthly use for DHW is approximately five percent of the total natural gas consumption for the facility.

A copy of the savings calculations is provided in the technical appendix.

Calculation Assumptions / Key Input Parameters

- The savings estimate assumes the average monthly natural gas usage for the FunPlex Center is approximately five percent of the total gas consumption.
- The existing water heaters have a thermal efficiency of 78% and the replacement units have a thermal efficiency of 95%.

Operations & Maintenance Savings / Future Avoided Capital

There are no operations & maintenance or future avoided capital cost savings applicable to this measure.

ECM 6: Premium Efficiency Motor Retrofit, Union Colony Civic Center

This measure would remove the existing standard efficiency motors on the supply fans and return fans of three constant volume, single zone RTUs at the Union Colony Civic Center and replace them with new, premium efficiency motors of equal size.

Existing Conditions

There are three Mammoth packaged rooftop units (RTU's 2, 3, & 6) located on the Union Colony Civic Center. Units 3 & 6 provide heating and cooling, while Unit 2 is cooling only. Each unit is equipped with a supply air fan and a return air fan. These fans are currently powered by standard or high efficiency motors. The RTUs and motors are identified in the tables below.

AIR HANDLING UNITS					
Building	Unit No.	Description	Mfg.	Model No.	Service
Civic Center	2	Clg-Only Packaged RTU	MAMMOTH	CEHBFF-502-G640-C/D	3rd Floor
Civic Center	3	Packaged RTU	MAMMOTH	CEHBP-402-G410-C	Small Auditorium
Civic Center	6	Packaged RTU	MAMMOTH	CEHBP-953-G1000-E	Main Auditorium

MOTORS								
Building	Mfg.	Model No.	HP	Volts	Amps	RPM	Efficiency	Service
Civic Center	CENTURY	6-342148-02	15	230/460	36.6/18.3	1755	90%	SA FAN
Civic Center	CENTURY	6-355645-01	5	230/460	12.4/6.2	1745	86.5%	RA FAN
Civic Center	CENTURY	6-355804-01	10	230/460	24.4/12.2	1750	89.5%	SA FAN
Civic Center	CENTURY	6-355645-01	5	230/460	12.4/6.2	1745	86.5%	RA FAN
Civic Center	CENTURY	6-342156-03	40	230/460	97/48.5	1770	93%	SA FAN
Civic Center	CENTURY	6-355804-01	10	230/460	24.4/12.2	1750	89.5%	RA FAN

Proposed System Overview & Design Intent

RTUs 2, 3, and 6 are constant volume and have outdated standard efficiency motors. Retrofitting the motors with premium efficiency models will reduce demand and operating power requirements. Implementation costs will remain low due to the relative simplicity of retrofitting constant speed motors.

Scope of Work

Remove each of the motors listed in the table on the previous page together with the fan belts. Furnish and install new premium efficiency motors with minimum efficiencies as shown in the following table.

HP	Minimum Required Efficiency
5	90%
10	92%
15	93%
40	95%

All motors shall be Baldor or approved equal. Subcontractor shall field verify all installation details including voltage, frame, speed, enclosure and any other required details prior to ordering new motors. Subcontractor shall measure fan speed (RPM) on all motors prior to retrofit. Subcontractor shall match new motor RPM as closely as possible to the old motors. If necessary, subcontractor shall re-sheave new motor or fan in order to match existing fan speed. Subcontractor shall measure pre and post retrofit voltage, current and power factor.

Subcontractor shall reuse the existing electrical service to the extent practicable including wire, conduit, disconnects, starters, fuses, etc. Subcontractor shall be responsible for all electric power wiring. Subcontractor shall measure pre and post retrofit voltage and current for each phase and provide these measurements to the Ameresco project manager.

Impact of ECM on Facility Operations & Maintenance Procedures

Facility operations and maintenance procedures will be unchanged with the implementation of this ECM.

Equipment, Design, & Construction Documentation

Equipment will be identified in submittals provided to The City of Greeley for approval prior to procurement. Upon approval, these will constitute the construction documents. The shutdown of building

equipment will be scheduled with Ameresco and the City prior to starting the proposed work in this ECM. Upon completion of the construction phase, the documents will be revised as needed to reflect "as-built" conditions, and submitted in multiple sets to the City for record.

Savings Analysis Methodology

The savings estimate was made using a spreadsheet calculation that compares the demand and consumption of the existing and new motors. Please refer to the appendix for detailed input parameters.

Calculation Assumptions / Key Input Parameters

- New motors' RPM equal to existing motors
- Load factor is 0.8 for all motors
- Utilization factor is 0.9 for all motors except those in RTU-3 at the Civic Center, whose factor is 0.8
- Unit operating hours:
  - RTU-2 at the Union Colony Civic Center serves the third floor and operates 1,861 hours per year.
  - RTU-3 at the Union Colony Civic Center serves the Hensel Phelps Auditorium (small theater) and operates 660 hours per year.
  - RTU-6 at the Union Colony Civic Center serves the Monfort Auditorium (main theater) and operates 1,861 hours per year.

Operations & Maintenance Savings / Future Avoided Capital

There are no operations & maintenance or future avoided capital cost savings attributed to this measure.

ECM 6: Premium Efficiency Motor Retrofit, Lincoln Park Annex

This measure would remove the existing standard efficiency motor on the supply fan of one constant volume, single zone RTU at the Lincoln Park Annex and replace it with a new, premium efficiency motor of equal size.

Existing Conditions

The Lincoln Park Annex uses one packaged McQuay rooftop unit (RTU), identified as AC-7, to provide heating, cooling, and ventilation to the Library book stacks. The RTU is a constant volume, single zone unit. It is equipped with a standard efficiency 5 HP motor. The tables below identify the packaged unit and the motor.

AIR HANDLING UNITS					
Building	Unit No.	Description	Mfg.	Model No.	Service
Lincoln Park Annex	AC-7	Packaged RTU	McQUAY	RPS018CSW	Book Stacks

MOTORS								
Building	Mfg.	Model No.	HP	Volts	Amps	RPM	Efficiency	Service
Lincoln Park Annex	BALDOR	M3218T	5	230/460	13.2/6.6	1750	87.5%	SA FAN

Proposed System Overview & Design Intent

The RTU AC-7 is constant volume and has an outdated standard efficiency motor. Retrofitting the motor with a premium efficiency model will reduce demand and operating power requirements. Implementation costs will remain low due to the relative simplicity of retrofitting a constant speed motor.

Scope of Work

Remove the existing motor and belt. Furnish and install one 5 HP premium efficiency motor. The new motor shall be a Baldor Super E with a NEMA rated efficiency not less than 90% and 1750 RPM. Measure

and field verify motor voltage prior to ordering the motor. Furnish and install new drive belts. Include removal and reconnection of electrical wiring.

Impact of ECM on Facility Operations & Maintenance Procedures

Facility operations and maintenance procedures will be unchanged with the implementation of this ECM.

Equipment, Design, & Construction Documentation

Equipment will be identified in submittals provided to The City of Greeley for approval prior to procurement. Upon approval, these will constitute the construction documents. The shutdown of building equipment will be scheduled with Ameresco and the City prior to starting the proposed work in this ECM. Upon completion of the construction phase, the documents will be revised as needed to reflect "as-built" conditions, and submitted in multiple sets to the City for record.

Savings Analysis Methodology

The savings estimate was made using a spreadsheet calculation that compares the demand and consumption of the existing and new motors. Please refer to the appendix for detailed inputs and outputs of the calculation.

Calculation Assumptions / Key Input Parameters

- New motor RPM equal to existing motor
- Load factor is 0.8 for all motors
- Utilization factor is 0.9 for all motors
- Facility operating hours:
  - Unit AC-7 at the Lincoln Park Annex serves the Library book stacks. Library hours are Monday through Thursday, 9:00 AM to 8:00 PM, Friday and Saturday 10:00 AM to 5:00 PM, and Sunday 1:00 PM to 5:00 PM, and closed for 12 holidays. The unit it scheduled off during unoccupied hours with no low-limit. It restarts one hour prior to occupancy.

Operations & Maintenance Savings / Future Avoided Capital

There are no operations & maintenance or future avoided capital cost savings attributed to this measure.

ECM 7: Retro-commissioning, Police Headquarters

The Police Department Headquarters is primarily served by two large VAV packaged rooftop units. A third RTU was added after the building was completed. This unit (RTU-3) serves the Investigations Unit. The building is typically an eight to five office building that operates on weekdays. The Investigations Unit is a 24 hour operation. The addition of RTU-3 would allow RTU 1 and 2 to be place into unoccupied mode during night and weekend periods. However, during the site visit, no unoccupied schedules were found within the DDC control system for RTU-1 and 2.

Existing Conditions

The building's occupancy is generally 8:00 AM to 5:00 PM, Monday through Friday except for the Investigations Unit that operates 24/7. A third unit (RTU-3) was installed to serve the Investigations Unit. This RTU runs 24/7 to meet the department schedule and would enable RTU-1 and RTU-2 to be operated with occupied and unoccupied schedules. However, no occupancy or holiday schedules could be found within the DDC system controlling these units.

The following equipment schedule identifies RTU-1 and RTU-2 from the design drawings:

AIR HANDLING UNIT														
				AIR QUANTITIES		SUPPLY			RETURN			COOLING	HEATING	
UNIT NO.	MFG.	MODEL	SERVICE	TOTAL (CFM)	MIN (CFM)	ESP	HP	VOLTS PH	ESP	HP	VOLTS PH	TOTAL SENS. (MBH)	INPUT (MBH)	OUTPUT (MBH)
RTU-1	MCQUAY	RPS050C	1ST FLOOR	16,000	10,500	1.5	15	480/3	0.75	5	480/3	595	990	790
RTU-2	MCQUAY	RPS070C	2ND FLOOR	30,000	6,000	1.5	30	480/3	0.75	15	480/3	778	815	650

Proposed System Overview & Design Intent

This measure would perform retro-commissioning on the DDC system controlling this building with an emphasis on sequence of operations revisions to improve energy efficiency including occupancy schedules, heating and cooling temperature setpoints, static pressure reset, CO2 reset, economizer control, optimum start and other improved sequences.

Scope of Work

Perform retro-commissioning services on the DDC system controlling the headquarters building. The scope of work includes a detailed point-to-point verification of all field devices and functional performance testing of all equipment and control sequences currently under DDC control.

*Note: The deficiencies proposed for repair, or changes to operating parameters identified during the testing process will be funded through the use of an ECM allowance of approximately $14,250, which has been included in the total implementation cost for this measure. The ECM allowance is based upon an estimated quantity of typical mechanical and controls related field devices (listed in the table below), and assumed programming hours for field technicians. Should the implementation cost be less than the included allowance, the remaining funds will be returned to the customer. Any implementation costs greater than the amount in this allowance, or costs that occur after the allowance has been exhausted on other implementation items, are not included in this scope of work and would be at an additional cost, subject to customer consideration and approval.

Following is a List of Typical Field Devices Used in Estimating Retro-commissioning Allowance Carried in Total Implementation Cost

Typical Field Device Name
Damper Actuator
Valve Actuator
Zone Temperature Sensor
Duct Temperature Sensor
Duct Averaging Temperature Sensor
Water Temperature Sensor
Differential Pressure Sensor
Static Pressure Sensor
Freeze Stat
Current Switch
Relay (typical size)
Unitary Controller

Impact of ECM on Facility Operations & Maintenance Procedures

The facility operations and maintenance procedures should remain largely unchanged

Equipment, Design, & Construction Documentation

Equipment will be identified in submittals provided to The City of Greeley for approval prior to procurement. Upon approval, these will constitute the construction documents. The shutdown of building equipment will be scheduled with Ameresco and the City prior to starting the proposed work in this ECM. Upon completion of the construction phase, the documents will be revised as needed to reflect "as-built" conditions, and submitted in multiple sets to the City for record.

Savings Analysis Methodology

The savings methodology for this measure used a modified temperature BIN analysis. Weather data utilized NOAA's Franktown, Colorado site as this location provided the closest proximity to Greeley with a full year's (2011) hourly data set.

An end use analysis (EUA) was used to disaggregate the facility's demand and energy use. The spreadsheet calculates the required heating and cooling energy based on the existing and proposed outdoor air volumes. The savings attributed to retro-commissioning represents the energy savings associated with new occupancy schedules for RTU-1 and 2. It should be noted that the savings derived from retro commissioning are incremental to the savings from ECM 8 Demand Controlled Ventilation as the savings estimates are interactive.

Calculation Assumptions / Key Input Parameters

- It is assumed that the new occupied schedules for RTU-1 and 2 would be 6:00 AM to 7:00 PM, Monday through Friday.

- It is assumed that RTU-2 and 2 would cycle 30% during unoccupied periods to meet the unoccupied temperature set point high and low limits.

Operations & Maintenance Savings / Future Avoided Capital

There are no operations & maintenance or future avoided capital cost savings applicable to this measure.

ECM 8: Demand Controlled Ventilation, Lincoln Park Annex

A large portion of the library's energy consumption is used to heat or cool the fresh air supplied to the building's occupants. Generally, the minimum outside air volume is based upon design (or maximum) occupancy even though the Library is seldom filled with the maximum number of visitors. Consequently, there is more outside air supplied to the library than the amount needed to serve typical occupancy. This results in higher than necessary energy use.

Existing Conditions

The main library area, book stacks and children's library are subject to large changes in occupancy throughout the day. Currently the minimum ventilation for these spaces is based on a fixed percentage. Therefore, during low occupancy, these areas have more than the required volume of outside air. This measure would furnish and install new CO2 sensors in the return air duct on each of the air handlers listed below:

AIR HANDLING UNIT				
UNIT NO.	DESCRIPTION	MFG.	MODEL NO.	SERVICE
AC-6	SPLIT VAV AHU	McQUAY	RDS802BY	MAIN LIBRARY
AC-7	PACKAGED RTU	McQUAY	RPS018CSW	BOOK STACKS
AC-8	PACKAGED RTU	ENGINEERED AIR	FWB-212-CO	CHILDERN'S LIBRARY

Proposed System Overview & Design Intent

This measure would furnish and install new CO2 sensors to measure the number of building occupants together with the required minimum outside air volume to meet the occupancy's requirements. The following scope of work describes the implementation.

Scope of Work

Furnish and install three each new CO2 sensors. Locate one sensor at the return air duct of AC-6, AC-7 and AC-8. Furnish and install new damper actuators as needed to provide for independent operation of the mixed air dampers.

Provide Demand Control Ventilation control for AC-6, AC-7 and AC-8 to maintain 1,200 PPM CO2 (adj.). Update DDC sequence of operation and graphics, alarms. Maintain minimum outside air damper at 5% (adj) except during night purge or economizer operation. Configure 15 minute trend logs for CO2 setpoint, CO2 current value, and return air and outside air damper positions as needed. Provide alarm at 1,600 PPM (adj.)

Impact of ECM on Facility Operations & Maintenance Procedures

The facility operations and maintenance procedures should remain largely unchanged

Equipment, Design, & Construction Documentation

Equipment will be identified in submittals provided to The City of Greeley for approval prior to procurement. Upon approval, these will constitute the construction documents. The shutdown of building equipment will be scheduled with Ameresco and the City prior to starting the proposed work in this ECM. Upon completion of the construction phase, the documents will be revised as needed to reflect "as-built" conditions, and submitted in multiple sets to the City for record.

Savings Analysis Methodology

The savings methodology for this measure used a modified temperature BIN analysis. Weather data utilized NOAA's Franktown, Colorado site as this location provided the closest proximity to Greeley with a full year's (2011) hourly data set.

An end use analysis (EUA) was used to disaggregate the facility's heating and cooling energy use. Three year average utility data together with the load fraction of the AC-6, 7 and air handlers was used to estimate the annual heating and cooling energy use.

Calculation Assumptions / Key Input Parameters

- The estimate assumes that the typical library occupancy is approximately 30 percent of the maximum design occupancy.
- The savings estimate assumes that the heating/cooling balance point is 52.5 degrees F.

Operations & Maintenance Savings / Future Avoided Capital

There are no operations & maintenance or future avoided capital cost savings applicable to this measure.

ECM 8: Demand Controlled Ventilation, Police HQ

The Police Department Headquarters is primarily served by two large VAV packaged rooftop units. These units have a combined outdoor air volume of 16,500 CFM. The building is generally an office building but it also has a gymnasium and locker rooms. During the site visit it was determined that the building occupancy is typically less than one-half of the design occupancy. Therefore, the outdoor air volume required to ventilate the building is substantially higher than need for typical occupancies.

Existing Conditions

Exhaust min for Locker Rooms

The Police Headquarters Primary building is served by two packaged gas/electric VAV rooftop units of approximately 50 and 70 tons nominal capacity. These units have a combined minimum outdoor air volume of 16,500 cfm. While this volume would satisfy the design conditions, the site audit and interviews with facilities staff determined that design conditions seldom, if ever occur at this site. Therefore, the design ventilation rates are much higher than needed for typical operation. The building is also equipped with two general exhaust fans that serve the gym, locker rooms and restrooms. These exhaust fans have a combined design exhaust rate of 9,540 cfm.

The building's occupancy is generally 8:00 AM to 5:00 PM, Monday through Friday except for the Investigations Unit that operates 24/7. A third RTU was installed to serve the Investigations Unit. This RTU runs 24/7 to meet the department schedule and would enable RTU-1 and RTU-2 to be operated with occupied and unoccupied schedules. However, no occupancy or holiday schedules could be found within the DDC system controlling these units during the site visit. Therefore, RTU-1 and 2 appear to run 24/7.

The following equipment schedule identifies RTU-1 and RTU-2 from the design drawings:

AIR HANDLING UNIT														
				AIR QUANTITIES		SUPPLY			RETURN			COOLING	HEATING	
UNIT NO.	MFG.	MODEL	SERVICE	TOTAL (CFM)	MIN (CFM)	ESP	HP	VOLTS/PH	ESP	HP	VOLTS/PH	TOTAL SENS. (MBH)	INPUT (MBH)	OUTPUT (MBH)
RTU-1	MCQUAY	RPS050C	1ST FLOOR	16,000	10,500	1.5	15	480/3	0.75	5	480/3	595	990	790
RTU-2	MCQUAY	RPS070C	2ND FLOOR	30,000	6,000	1.5	30	480/3	0.75	15	480/3	778	815	650

Proposed System Overview & Design Intent

This measure would convert the ventilation control method from fixed percentage to CO2 based Demand Controlled Ventilation for RTU-1 and 2. The measure would furnish and install new CO2 sensors in the return air duct of RTU 1 and 2. Additional zone CO2 sensors would be furnished and installed for the Men's Locker Room, Women's Locker Room, Gymnasium, and 2nd floor briefing room.

Scope of Work

Furnish and install the new CO2 sensors. Modify the control sequence from fixed percentage to Demand Control Ventilation control for the above listed RTU's to maintain 1,200 PPM CO2 (adj.). Update DDC sequence of operation and graphics, alarms. Maintain minimum outside air damper at 5% (adj) except during night purge or economizer operation. Configure 15 minute trend logs for CO2 setpoint, CO2 current value, and return air and outside air damper positions as needed. Provide alarm at 1,600 PPM (adj.)

Note: The DDC system would monitor both the return air CO2 and the zone level CO2 sensors and control to the location with the highest CO2 concentration.

Provide all necessary programming and graphics as needed for the above points and sequence of operation.

Impact of ECM on Facility Operations & Maintenance Procedures

The facility operations and maintenance procedures should remain largely unchanged

Equipment, Design, & Construction Documentation

Equipment will be identified in submittals provided to The City of Greeley for approval prior to procurement. Upon approval, these will constitute the construction documents. The shutdown of building equipment will be scheduled with Ameresco and the City prior to starting the proposed work in this ECM. Upon completion of the construction phase, the documents will be revised as needed to reflect "as-built" conditions, and submitted in multiple sets to the City for record.

Savings Analysis Methodology

The savings methodology for this measure used a modified temperature BIN analysis. Weather data utilized NOAA's Franktown, Colorado site as this location provided the closest proximity to Greeley with a full year's (2011) hourly data set.

An end use analysis (EUA) was used to disaggregate the facility's demand and energy use. Baseline heating and cooling energy for RTU-1 and RTU-2 were estimated by allocating the percentage of the total heating and cooling capacity to the disaggregated totals. The spreadsheet calculates the required heating and cooling energy based on the existing and proposed outdoor air volumes.

Calculation Assumptions / Key Input Parameters

- It is assumed that the typical occupancy is 50% of the design value for RTU-1 and RTU-2 and that each unit currently operates 24/7.
- There was no TAB report available for these units; therefore, the air flow volumes were obtained from the design drawings.

Operations & Maintenance Savings / Future Avoided Capital

There are no operations & maintenance or future avoided capital cost savings applicable to this measure.

ECM 9: Pool Pump VFD's, FunPlex

The Activity Pool, Current Pool and Children's Pool at the FunPlex are equipped with variable frequency drives. However, the drives are in by-pass with each of the pumps operating at full speed. A review of the pumping flow rates suggests that the full speed capability is not required to meet the code required minimum filtration rates defined by the State of Colorado's Department of Health and Environment.

Existing Conditions

The existing turnover hours for the Activity Pool, Current Pool and Children's Pool filters are approximately 2.6, 1.0 and 0.5 hours respectively. The code required turnover hours for these filters are 6.0, 6.0 and 1.0 hours respectively. This suggests that the existing pumping rates may exceed the required rates. The excessive rates result in unnecessary energy use and costs. A small reduction in pumping volumes would result in large energy savings given the large horsepower associated with the pumps. Note that in some cases local or municipal codes and standards may also affect the minimum required flow rates.

Proposed System Overview & Design Intent

This measure is intended to be implemented together with ECM 11 Retrocommissioning at the FunPlex. The measure would utilize the existing VFD's to tune and control the pump speeds to match the code required minimum flow rates while maintaining sufficient pressure.

Scope of Work

Ameresco proposes to utilize the retrocommissioning process to reprogram the existing VFD's for the correct pumping rates. The scope would require the installation of temporary flow instruments on each circuit and to reset the VFD speed to match the required flow rates. There is no new equipment required for this measure but rather flow measurement, VFD tuning and programming.

Impact of ECM on Facility Operations & Maintenance Procedures

The facility operations and maintenance procedures should remain largely unchanged

Equipment, Design, & Construction Documentation

Equipment will be identified in submittals provided to The City of Greeley for approval prior to procurement. Upon approval, these will constitute the construction documents. The shutdown of building equipment will be scheduled with Ameresco and the City prior to starting the proposed work in this ECM. Upon completion of the construction phase, the documents will be revised as needed to reflect "as-built" conditions, and submitted in multiple sets to the City for record.

Savings Analysis Methodology

The savings estimates for this measure are based on the Affinity Laws for centrifugal pumps. The pump speed would be reduced from the current rates to approximately 80% of the current rates. This would save approximately 50% of the power and energy associated with this process. A copy of the savings calculation is included in appendix.

Calculation Assumptions / Key Input Parameters

- The pump speed reduction to 80% of current rates would provide approximately 65% of the available pumping head that would be sufficient for filter operation.
- The pumps operate 8760 hours per year.

Operations & Maintenance Savings / Future Avoided Capital

There are no operations & maintenance or future avoided capital cost savings applicable to this measure.

ECM 10: Cooling Tower Retrofit

Investigated But Not Recommended

A ducted indoor cooling tower is used to serve two chillers located in the Recreation Center. The cooling tower is currently equipped with a two speed motor to help control the leaving water temperature. This measure would utilize a variable frequency drive (VFD) to control fan speed. However, due to the limited energy savings and relatively high cost of implementing this measure, Ameresco recommends that it be dropped from the scope of work.

Please refer to the information below regarding the specifics of this measure.

Existing Conditions

A cooling tower is used to serve two water cooled chillers. It is equipped with a two-speed motor. The motor insulation is Class F. Motor speed is currently based on return water temperature. The following tables identify the cooling tower and motor.

COOLING TOWER		
MFG	MODEL NO.	SERVICE
BAC	VT L103-K	CHILLERS

MOTOR										
MFG	MODEL NO.	HP	VOLTS	AMPS	RPM	INS	SF	FRAME	ENCL	EFF
US ELECTRIC	HW10PL9C-P	10/2.5	460	12.9/4.9	1760/875	F	1.15	215T	TE	NA

Proposed System Overview & Design Intent

Ameresco proposes to utilize the existing motor but use the high speed windings so as to disable the low speed capability. A new VFD would then be installed to control the motor speed utilizing the existing DDC control system.

Scope of Work

This measure will provide a Variable Frequency Drive (VFD) to control the cooling tower fan speed and discharge water temperature.

Mechanical Scope

Re-wire the electrical service to the two speed motor in such a manner that the motor is only wired for high speed operation.

Furnish and install a 10HP 460VAC VFD (ABB or approved equal). The VFD shall be factory equipped with a bypass switch for emergency operation. Furnish and install all necessary conduit and wiring as needed. Utilize the existing disconnect to the extent practicable.

Controls Scope

Furnish and install all controls as needed for VFD speed control. Utilize the existing return water temperature sensor. Furnish and install new controller (alternatively use spare points on existing controller) for VFD speed control, VFD Alarm, VFD In Hand, Speed Setpoint, Return Water Temperature. Provide revised programming, graphics and trends as needed.

Impact of ECM on Facility Operations & Maintenance Procedures

The facility operations and maintenance procedures should remain largely unchanged.

Equipment, Design, & Construction Documentation

Equipment will be identified in submittals provided to The City of Greeley for approval prior to procurement. Upon approval, these will constitute the construction documents. The shutdown of building equipment will be scheduled with Ameresco and the City prior to starting the proposed work in this ECM. Upon completion of the construction phase, the documents will be revised as needed to reflect "as-built" conditions, and submitted in multiple sets to the City for record.

Savings Analysis Methodology

The savings methodology for this measure used a modified temperature BIN analysis. Weather data utilized NOAA's Franktown, Colorado site as this location provided the closest proximity to Greeley with a full year's (2011) hourly data set.

Calculation Assumptions / Key Input Parameters

- The savings spreadsheet calculation assumes that the two speed motor is used on the high speed winding at temperatures above 67.5 degrees F and that no fan is required when the ambient air temperature is 52.5 degrees F or below. The minimum air flow fraction is 60%.

Operations & Maintenance Savings / Future Avoided Capital

There are no operations & maintenance or future avoided capital cost savings applicable to this measure.

ECM 11: Variable Flow Pumping, Union Colony Civic Center

There are two heating water distribution pumps used to provide hot water to the facility's baseboard convection heaters. The pumps operate in a lead standby configuration. The pumps currently operate at constant volume although the load varies throughout each day. This measure would convert the pumps from constant volume to variable flow.

Existing Conditions

The UCCC hot water distribution pumps currently operate with a bypass loop between the supply and return headers. A pneumatic control valve is used to control static pressure to the heating system by modulating the bypass volume. The bypass valve maintains constant flow through the pumps. A differential static pressure senor is used to control the static pressure through the DDC system.

The following tables define the existing pumps and motors.

PUMP MOTORS										
MFG.	MODEL NO.	HP	VOLTS	AMPS	RPM	FRAME	INS	SF	SERVICE	ENCL.
BALDOR	M3218T	5	208-230/460	14.8-14/7	1725	184T	B	1.15	P-1	DP
LINCOLN	4P5T61	5	230/460	13.8/6.9	1755	184T	F	1.25	P-2	TEFC

HTG PUMP						
MARK	MFG.	MODEL NO.	HP	FT HD	GPM	RPM
P-1	B&G	1510	5	100	45	1750
P-2	B&G	1510	5	100	45	1750

Proposed System Overview & Design Intent

This proposed measure would remove the pump bypass loop and control valve and replace it with new variable frequency drives to control the loop static pressure. The new VFDs would be controlled using the existing Johnson Controls DDC system.

Scope of Work

Demolish and remove the existing bypass valve. Permanently cap the bypass loop at the supply and return headers.

Remove the 5 HP Baldor motor. The Lincoln 5HP motor is to remain in service. Furnish and install a new Baldor premium efficiency motor. Reuse existing electrical service including starter, disconnect, conduit and wiring to the extent practicable.

Furnish and install two new variable frequency drives (VFD's). VFD's shall be ABB or approved equal. Drives shall be equipped with factory installed bypass switches.

Utilize the existing differential pressure sensor to control pump speed and static pressure. Furnish and install new controllers as needed for pump speed control. Furnish and install all necessary field devices for a complete working variable flow pumping system. Revise programming and graphics as needed including trends and alarms for the following points:

- Pump speed setpoint
- Pump status
- Pump Alarm
- Static Pressure Setpoint
- Static Pressure
- Low Static Pressure Alarm
- Pump Running in Hand

Impact of ECM on Facility Operations & Maintenance Procedures

The facility operations and maintenance procedures should remain largely unchanged

Equipment, Design, & Construction Documentation

Equipment will be identified in submittals provided to The City of Greeley for approval prior to procurement. Upon approval, these will constitute the construction documents. The shutdown of building equipment will be scheduled with Ameresco and the City prior to starting the proposed work in this ECM.

Upon completion of the construction phase, the documents will be revised as needed to reflect "as-built" conditions, and submitted in multiple sets to the City for record.

Savings Analysis Methodology

The savings methodology for this measure used a modified temperature BIN analysis. Weather data utilized NOAA's Franktown, Colorado site as this location provided the closest proximity to Greeley with a full year's (2011) hourly data set.

An end use analysis (EUA) was used to disaggregate the facility's demand and energy use. Three year average utility data together with the disaggregated pumping energy was used to estimate the heating pumps demand and annual energy use. A copy of the savings calculation is provided in the appendix.

Calculation Assumptions / Key Input Parameters

- The savings estimates assume a heating/cooling balance point of 62.5 degrees F for this measure.
- The motor load factor is assumed to be 90%.

Operations & Maintenance Savings / Future Avoided Capital

There are no operations & maintenance or future avoided capital cost savings attributed to this measure.

AMERESCO
Green • Clean • Sustainable

ECM 12: Exhaust Fan Speed Control, Police Headquarters

Investigated But Not Recommended

This measure would provide dedicated exhaust fans for the gym and locker rooms at the Police Headquarters, and commission existing RTU-1 and RTU-2 exhaust fans to maintain correct building static pressure, thereby reducing the volume of outside make-up air required and reducing loads on the associated heating and cooling coils to save energy.

However, initial investigations showed that the 16,500 CFM exhaust is through the RTU-1 and RTU-2 return/exhaust fans and not through the ~~general purpose exhaust fans~~. Therefore, it should not be necessary to provide dedicated exhaust fans for the gym or locker rooms since they are already served by the general exhaust fans. The intended results intended for this measure are instead accomplished everything through ECM 8, CO2 Based Demand Controlled Ventilation, which focus on reducing ventilation supplied by RTU-1 and RTU-2.

wrong

ECM 13: Solar PV, FunPlex

This measure would install an array of Solar PV panels to the rooftop of the Funplex to offset existing electricity demand and consumption on the existing electrical grid with renewable energy.

Existing Conditions

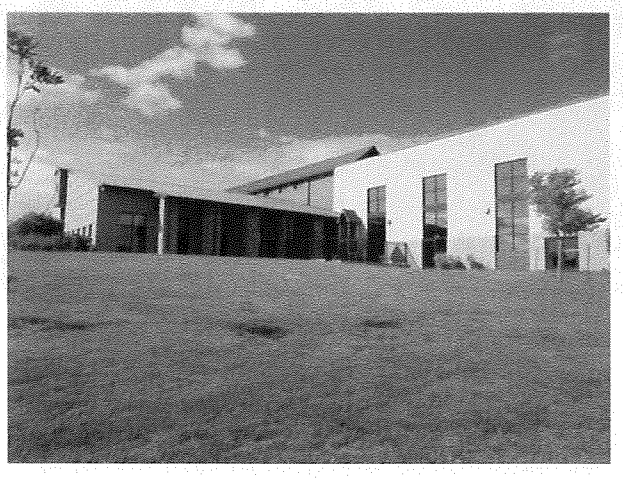
The FunPlex was found to have considerable electrical loads, and a large, open, unshaded structural rooftop area suitable for placement of a solar photovolataic (PV) array.

The existing electric system supplies 460 Volt, three phase power for larger loads, and 277 Volt, single-phase or 120 Volt, single phase power for small distributed loads from a the main service supplied by Xcel energy company. The following table provides an electric utility summary for the facility, and the subsequent photos show the facility structure and rooftop areas.

Funplex Electric Utility Summary

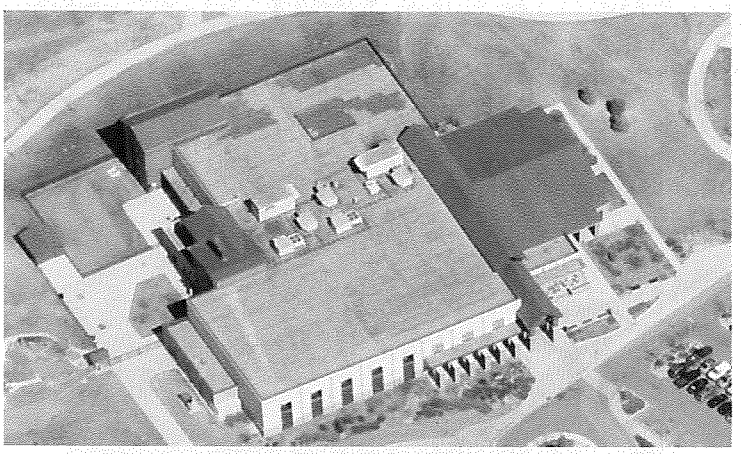
					Electricity						
Building	Building Area (ft2)	Peak Facility Demand (kW)	Minimum Facility Demand (kW)	Average Facility Demand (kW)	Total Annual Demand (kW)	Annual Demand Cost ($)	Annual Consumption (kWh)	Annual Consumption Cost ($)	Total Annual Cost ($)	ECI ($/SF)	EUI (kBtu/SF)
FunPlex	51,400	529	320	439	5,221	$90,896	2,057,760	$75,790	$180,974	$3.52	136.6

Funplex Northern Exposure

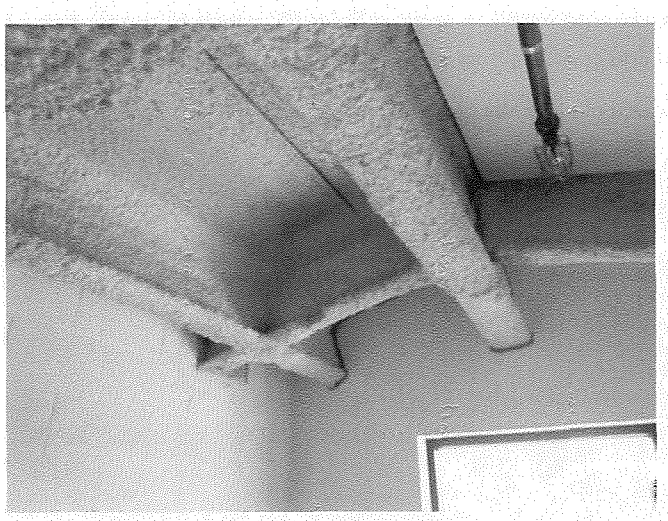


Funplex Northwestern Exposure

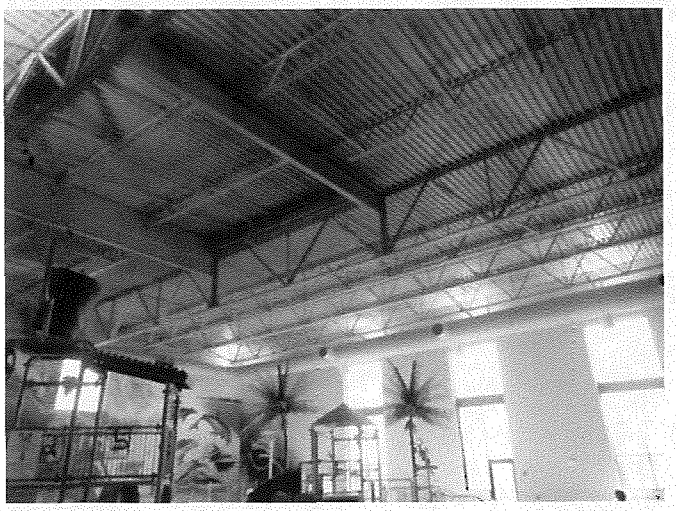
Funplex Aerial View



Funplex Internal Roof Structure



Funplex Internal Roof Structure

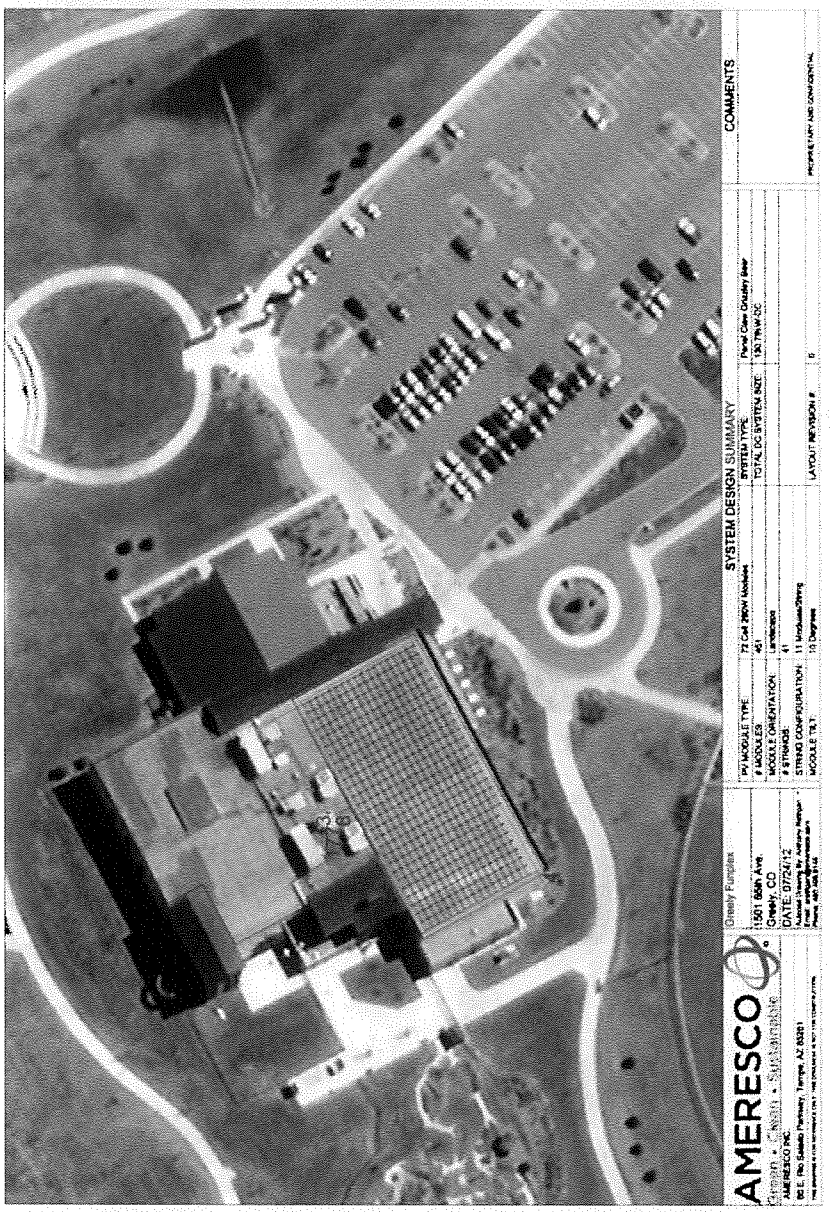


Proposed System Overview & Design Intent

The intent of this measure is to install an array of Solar PV panels to the rooftop of the Funplex Facility to offset existing demand and consumption on the existing electrical grid with renewable energy.

The photographic rendering shows the layout of the proposed solar power generating system.

Solar PV Photographic Rendering



Scope of Work

Ameresco will furnish and install a new solar PV array on the open southern roof area identified in the photographic rendering above. Details of the proposed system and requirements are listed below. Please refer to the appendix for manufacturer specific cut-sheets.

- Quantity of Independent Arrays: 1 Array
- Dimensions of Array: 177 3/8' x 87 3/4'
- Quantity of Panels: 451
- Dimensions of Each Panel: 3.25'x6.416'
- Weight of Each Panel: 60lbs
- Module Total Weight: 27,060 lbs
- Total system including racking, ballast, and modules: Approximately 4 lbs / sq. ft.
- Angle of Array Inclination: 10 degrees
- Solar Panels Manufacturer: Suntech
- Solar Panels Model: STP-290-Vd
- Solar Panel Type: 72 cell polycrystalline
- System Inverter Description: Advanced Energy Model PV Powered 100kW-AC
- Racking / Mounting System Description: Panel Claw Grizzly Bear
- The evaluated rooftop was maximized to potentially take advantage of Xcel Energy incentives.
- The proposed system will generate power utilizing net metering with Xcel Energy.
- The roof mounted system shall be compliant with all applicable codes.
- The system shall include an electronic control module, and the generated power will be conditioned to be compatible with utility grid supplied power and will switch off in the event of utility power outage to prevent back feed to the utility grid.
- The proposed system will be designed to supplement and offset the existing facility electric load during periods of sunshine only, not to store energy.
- The proposed systems will be interconnected with the existing systems and controlled to follow the existing systems' electrical characteristics.
- Ameresco will provide all necessary lifting, hoisting or scaffolding as needed to perform the installation.

- Ameresco will submit a basic, or typical, electrical (at a minimum) one-line diagram showing the system and its interconnection to the facility and existing electrical grid. Contractor shall be responsible for producing full plan set of electrical engineering drawings for permitting at local authority having jurisdiction and provide appropriate revisions as required.
- Ameresco will be responsible for producing structural engineered drawings to validate existing rooftop can support solar array and provide appropriate revisions as required.
- Ameresco will be responsible for producing wind load verification of ballasted array to be in compliance with the local authority having jurisdiction and provide appropriate revisions as required.

Impact of ECM on Facility Operations & Maintenance Procedures

The facility operations and maintenance procedures should remain largely unchanged, however the solar PV system will require service and maintenance, which is expected to be minimal. Details regarding manufacturer recommended inspection and maintenance procedures will be provided in submittal documentation upon project commencement.

Equipment, Design, & Construction Documentation

Equipment will be identified in submittals provided to the City of Greeley for approval prior to procurement. Upon approval, these will constitute the construction documents. The shutdown of building equipment will be scheduled with Ameresco and the City prior to starting the proposed work in this ECM. Upon completion of the construction phase, the documents will be revised as needed to reflect "as-built" conditions, and submitted in multiple sets to the City for record.

Savings Analysis Methodology

The savings were calculated via a computer simulation model PVSys, which accounts for the many dynamic and interrelated parameters associated with a solar power generating system, such as geographic region, weather, array tilt angle, as well as product specifications. Please refer to the appendix for a copy of the savings simulation output and detailed parameters.

Calculation Assumptions / Key Input Parameters

- The existing rooftop structure has sufficient existing life such that placement of solar PV array on the roof structure to remain for an extended period would be considered reasonable.
- The existing rooftop structure can support the Solar PV system.

Operations & Maintenance Savings / Future Avoided Capital

There are no operations & maintenance or future avoided capital cost savings applicable to this measure.

Solar PV Data Acquisition, Monitoring, and Display

As an optional offering to be developed in accordance with the direction and preferences of the City of Greeley, Ameresco proposed the addition of a web-based or stand-alone data acquisition system (DAS) to provide live monitoring and display of system operation or revenue-grade metering for billing and energy management. Both the web-based and stand-alone Kiosk versions would lend themselves well to an interactive lobby display at the FunPlex facility.

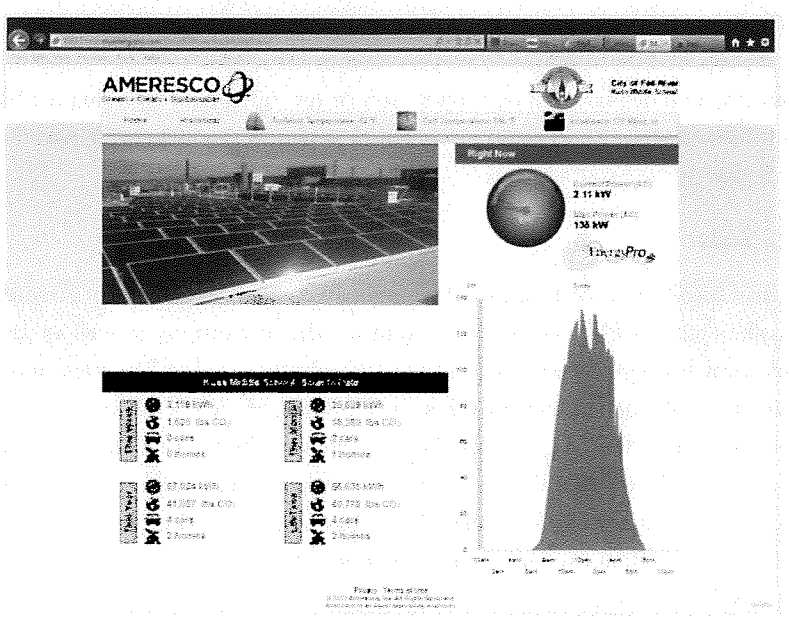
MyEnergyPro Solar

MyEnergyPro Solar is a collection of Energy Information Websites developed for Ameresco solar customers. The main page displays current PV production, current weather conditions, as well as current day's hourly production. A slideshow highlights each solar project with photos, expected savings, and general site descriptions. Summary totals such as current week, current year, lifetime kWh are displayed, along with conversion to greenhouse gas (CO2 e.g.) offset. The main page is linked to a Historical dashboard where users can view detailed graphs of kWh data, CO2 offsets, with cell temperature and/or irradiance overlay. They may graph by site or as a city totals, change date range and intervals of data they view, and export the data to a CSV file for further analysis. Users may also choose between column, line or area charts depending on the style and granularity of data they desire.

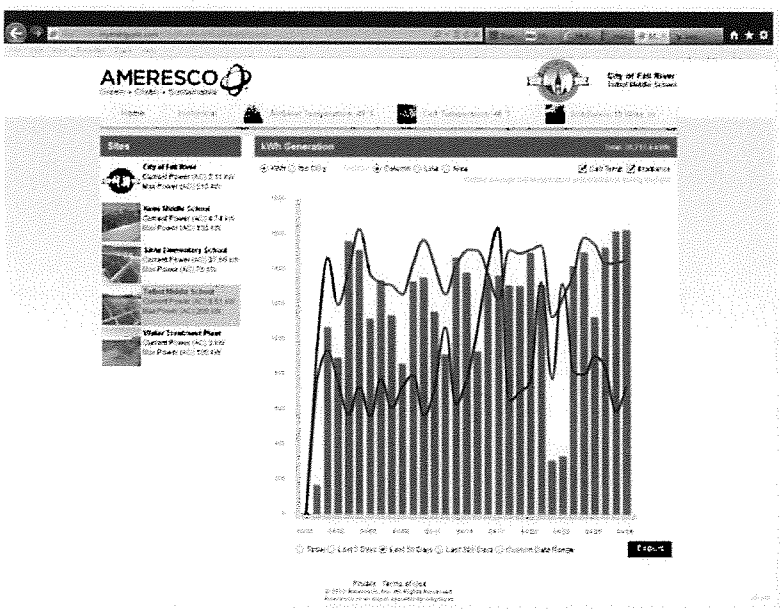
With a standard architectural design, but customizable look and feel, MyEnergyPro Solar can be easily configured to each client's unique needs. It is an ideal solution for multi-site customers where data may be consolidated and centrally displayed on one main website.

A stand-alone Kiosk version of the MyEnergyPro Solar can be a standalone product where just the main page of a selected site is included.

MyEnergyPro Solar Screenshot of Home Page



MyEnergyPro Solar Screenshot of Historical Data



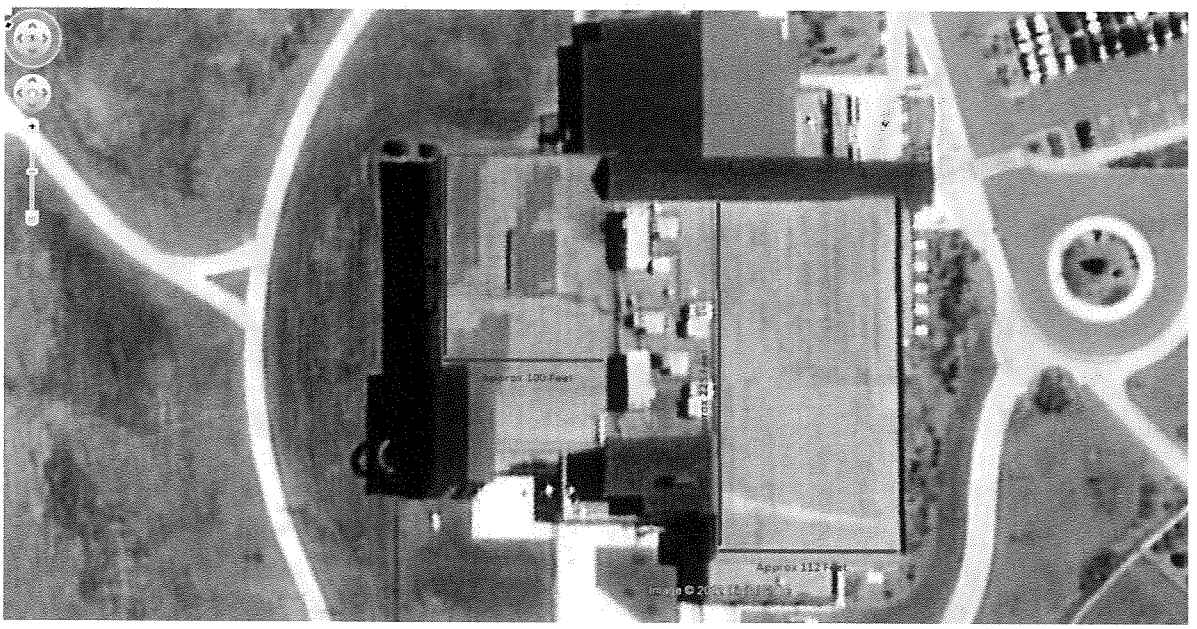
ECM 14: Solar Thermal, FunPlex

Investigated But Not Recommended

This measure would provide solar hot water heating panels on the roof structure of the FunPlex to heat pool water, and offset natural gas consumption by the existing pool heating boiler plant.

However, due to the high cost to savings ratio, and the lack of utility provider incentives, this measure is not recommended. The image below shows the location considered for this measure.

Potential Layout of Solar Thermal System



ECM 15:
Energy Efficient Transformers, FunPlex, Police Headquarters

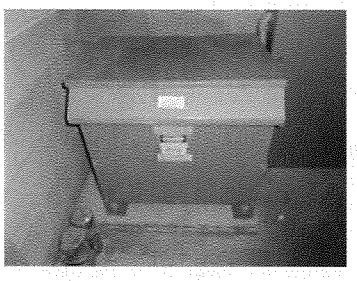
This measure would replace existing transformers with newer, more energy efficiency units in order to save electrical energy.

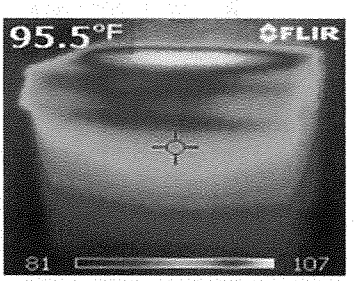
Existing Conditions

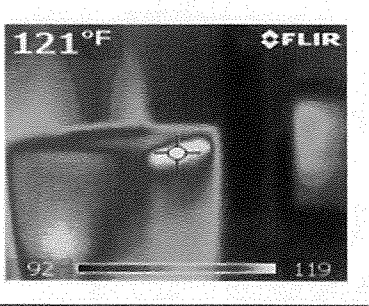
Dry type transformers are used in buildings, and are designed to step down incoming voltage for direct use or power distribution or to step up incoming voltage for direct use for exterior lighting. Dry type transformers are air cooled rather than liquid cooled, that is, the transformer case is ventilated to allow air to flow and cool the coils.

Multiple step-down transformers were found at the Funplex and Police Headquarters buildings, with the majority of voltages being stepped down from a primary service in the 480-750 range. All of the step-down transformers are indoor dry-type transformers, which, for example, would step-down 480V power to 208Y/120V general equipment power, or 277/1 for VAV box / VAV box electric heating coil power. These transformers are relatively inefficient compared to transformers currently available that use high quality materials and technology. In addition, the transformers can represent substantial heat loads within the building. The images below highlight the high temperatures and heat loss generated by step-down transformers. One line diagrams are also provided for both facilities.

Infrared Images of Transformers Showing High Temperatures







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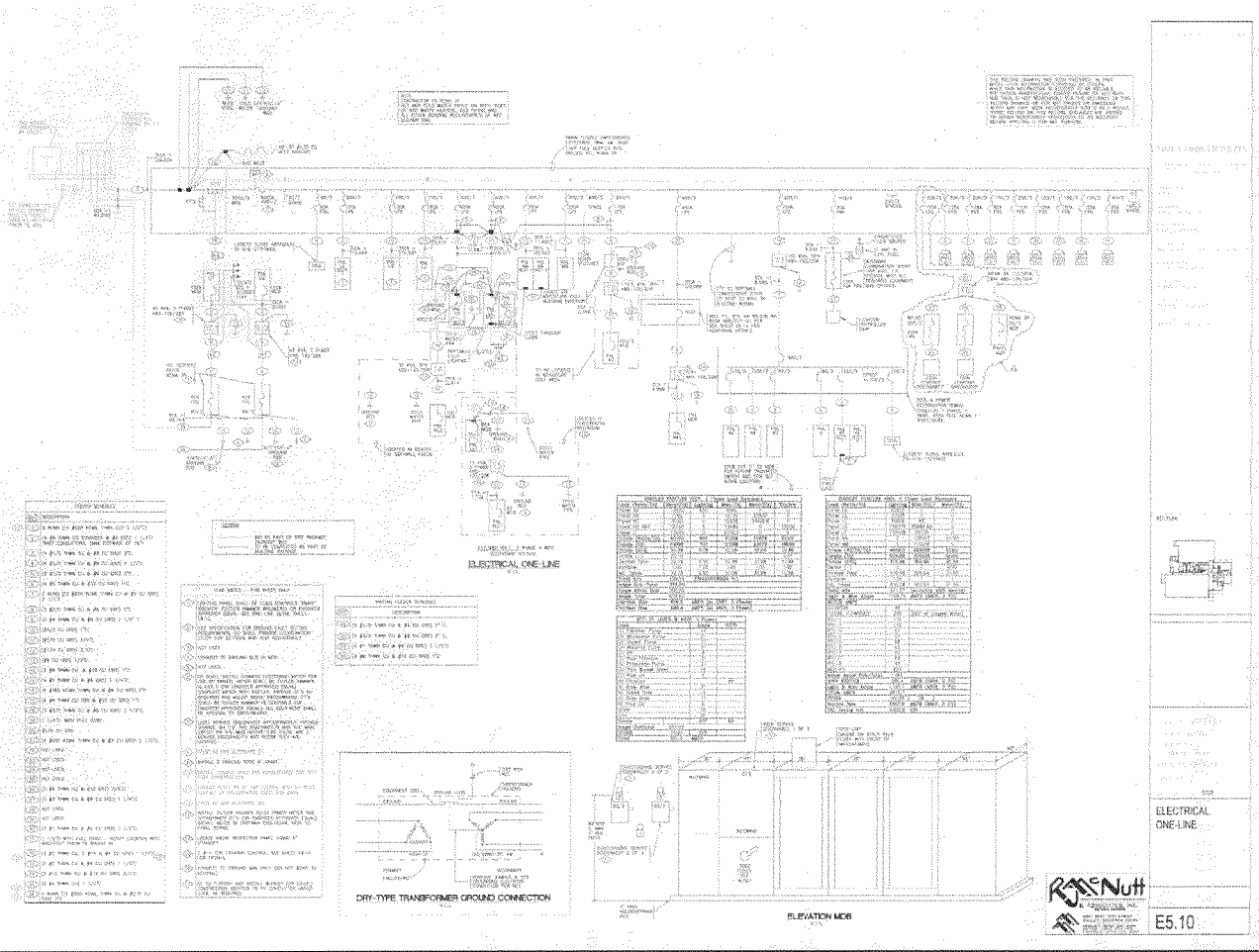
FunPlex Electrical One Line Diagram



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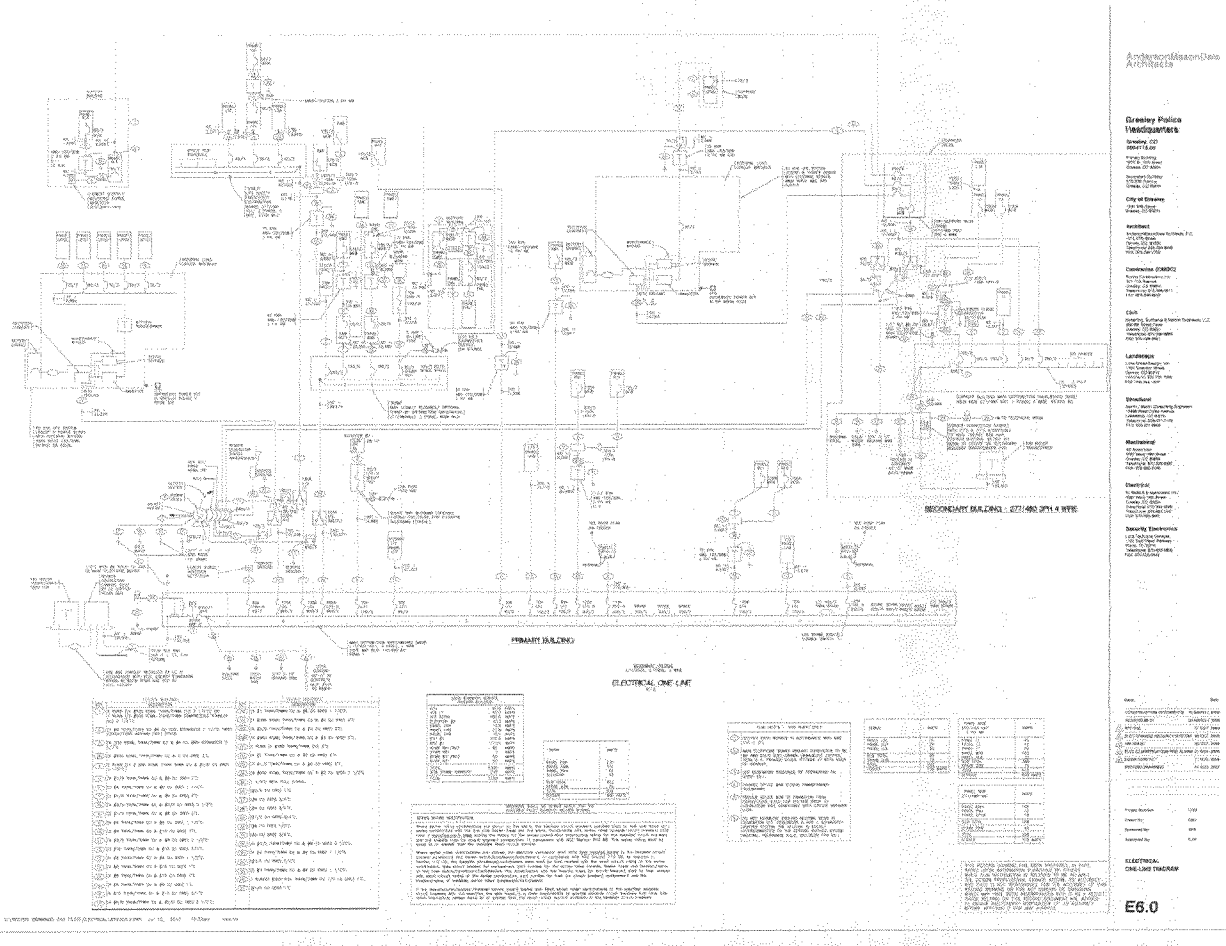
Police Headquarter Electrical One Line Diagram



Proposed System Overview & Design Intent

Ameresco recommends replacing existing step-down transformers with new, energy efficient step-down transformers to save energy and reduce heat gain. Powersmiths E-SAVER model C3 transformers are recommended for this measure.

The table below summarizes the transformers selected for replacement and is per existing electrical one-line diagrams. Please refer to the appendix for product specification sheets.

Facility	Xformer #	kVA	Associated Panel	One Line Diagram	Notes
FunPlex	T1	150	SDB-A	E5.10	
FunPlex	T2	112.5	AG	E5.10	
FunPlex	T6	112.5	N/A	E5.10	
FunPlex	T3	45	RP1	E5.10	
FunPlex	TC1	45	C1	E5.10	
FunPlex	TC2	45	C2	E5.10	
FunPlex	T4	30	LD	E5.10	Not for Replacement
FunPlex	T5	15	LE1	E5.10	Not for Replacement
Police HQ	T	N/A	UPS	E6.1	Not for Replacement
Police HQ	T	112.5	RA1	E6.9	
Police HQ	T	112.5	L1	E6.12	
Police HQ	T	75	EMF	E6.3	
Police HQ	T	75	EME	E6.5	
Police HQ	T	75	RC1	E6.11	
Police HQ	T	45	EMC	E6.4	
Police HQ	T	45	EMH	E6.6	
Police HQ	T	30	RD1	E6.7	
Police HQ	T	30	RB1	E6.8	
Police HQ	T	30	UPS6	E6.10	
Police HQ	T	15	ELS	E6.0	Not for Replacement
Police HQ	T	15	LSC	E6.2	Not for Replacement

Scope of Work

A typical installation sequence of the transformers would be as follows:

- Lockout/tagout panel feeding step-down transformer
- Disconnect primary and secondary feeds into transformer
- Supply temporary power for affected panels, where necessary
- Remove and dispose of existing transformer, recycling where possible
- Install new transformer on same pad or floor footprint
- Reconnect primary and secondary feeds into transformer

Impact of ECM on Facility Operations & Maintenance Procedures

The facility operations and maintenance procedures should remain unchanged.

However, installation of the measure will require isolation of each of the affected transformers and the associated distribution panels that are fed by the transformer while the transformer is removed and the new transformer installed. Planned shutdown of the electrical service connected to the transformers will be scheduled to have a minimum possible impact on the facility, however, systems that could be affected includes fire alarm, building automation systems, security, kitchen equipment, phone, data, and general power receptacles and the outage could last up to 8 hours.

The cost for temporary power to distribution panels such that no power loss will be experienced is included in this measure. This cost includes generator rental, cabling, core drilling, etc., associated with powering particular distribution panels.

Equipment, Design, & Construction Documentation

Equipment will be identified in submittals provided to Ameresco for approval prior to procurement. Documents will be submitted to Ameresco for review and comment. Upon approval, these will constitute the construction documents. The shutdown of building equipment will be scheduled with Ameresco and the City prior to starting the proposed work in this ECM. Upon completion of the construction phase, the documents will be revised as needed to reflect "as-built" conditions, and submitted in multiple sets to the City for record. new EMS system will provide the following for each building within the District.

Savings Analysis Methodology

The proposed energy savings were calculated using a third party calculation spreadsheet. With this tool, the existing and proposed transformers were defined. The following equations form the basis for the calculations performed in the spreadsheet.

$$Savings = DemandSavings + EnergySavings$$

$$DemandSavings = BaselineDemand - PostDemand$$

$$EnergySavings = BaselineEnergy - PostEnergy$$

$$BaselineDemand = \sum_{buildings} \sum_{transformers} \left(kW_{Base} \times \$/kW \right)$$

$$PostDemand = \sum_{buildings} \sum_{transformers} \left(kW_{retro} \times \$/kW \right)$$

$$BaselineEnergy = \sum_{buildings} \sum_{transformers} \left(kW_{Base} \times Hrs_{Base} \times \left(\$/kWh \right) \right)$$

$$PostEnergy = \sum_{buildings} \sum_{transformers} \left(kW_{Retro} \times Hrs_{Base} \times \left(\$/kWh \right) \right)$$

Where:

kWBase = Base transformer kW, as per ECM-11 calculation included in the TEA, subject to metering described below

kWRetro = Retrofit transformer kW, as ECM-11 calculation included in the TEA, subject to metering described below

HrsBase= Baseline transformer operating hours as per ECM-11 calculation included in the TEA

$/kW = Unit cost of electric demand

$/kWh = Unit cost of electric energy

Detailed calculations for this measure are located in the Appendix Section of this report.

Calculation Assumptions / Key Input Parameters

- Seasonal variations in load are unknown.
- The kVA rating of the new transformers will be identical to the kVA ratings of the existing transformers.
- Please refer to the detailed calculation located in the appendix for further assumptions and key calculation input parameters.

Operations & Maintenance Savings / Future Avoided Capital

There are no operations & maintenance or future avoided capital cost savings applicable to this measure.

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