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American Recovery and Reinvestment Act (ARRA) FEMP Technical Assistance U.S. General Services Administration – Project 194 U.S. Customs Cargo Inspection Facility, Detroit, MI

J Arends
WF Sandusky

May 2010

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Pacific Northwest National Laboratory
Richland, Washington 99352

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Executive Summary

This report documents the findings of an on-site audit of the U.S. Customs Cargo Inspection Facility (CIF) in Detroit, Michigan. The Federal landlord for this building is the General Services Administration (GSA). The focus of the audit was to identify various no-cost or low-cost energy-efficiency opportunities that, once implemented, would reduce electrical and gas consumption and increase the operational efficiency of the building. This audit also provided an opportunity to identify potential capital cost projects that should be considered in the future to acquire additional energy (electric and gas) and water savings to further increase the operational efficiency of the building.

The audit identified eight measures that could be implemented immediately, resulting in a total estimated savings of 1,352 million British thermal units (MMBtu) of electrical and thermal energy that in turn would result in an annual cost savings of $16,698. The estimated cost to implement the measures is $61,079, so the payback for such an investment would be 3.7 years.

Two capital item projects were identified related to use of the available solar resource. These projects would result in saving an estimated additional 296 MMBtu of energy, resulting in a cost savings of $6,353 annually. At this point, the economics for implementation of these measures are not cost-effective unless required for increasing the amount of on-site power generation from renewable resources.

Implementation of both the no-cost or low-cost measures would decrease greenhouse gas (GHG) emissions to the atmosphere, as well as create job opportunities. For the no-cost or low-cost measures, it was estimated that 102 metric tons of GHG emissions to the atmosphere would be avoided and 0.7 jobs would be created. If the capital projects were implemented, 7.6 jobs would be created and 57 metric tons of GHG emissions to the atmosphere would be avoided.

Table of Contents

Figures

Tables

Acronyms and Abbreviations

AHU	air handling unit
ALERT	Assessment of Load and Energy Reduction Techniques
ARRA	American Recovery and Reinvestment Act
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
BAS	building automation system
BCS	building control system
BLCC	building life cycle cost
Btu	British thermal unit
CBP	Customs and Border Protection
CF	cubic feet (ft^3)
CIF	Cargo inspection facility
DC	direct current
DDC	direct digital control
DOE	U.S. Department of Energy
DX	direct expansion
E4	Energy efficiency expert evaluations
ECM	energy conservation measure
EISA	Energy Independence and Security Act
ESET	energy savings expert teams
EPA	Environmental Protection Agency
EPAct	Energy Policy Act
EUI	energy use intensity
ft^2	square feet
FEMP	Federal Energy Management Program
GSA	General Services Administration
IR	infrared
kBtu	10^3 Btu
kW	kilowatt
kWh	kilowatt hour (1 kWh = 3412 Btu)
LBNL	Lawrence Berkeley National Laboratory
LED	light emitting diode
LEED	Leadership in energy and environmental design

Mcf	million cubic feet (natural gas)
MMBtu	10^6 Btu
NII	non-invasive inspection
NOFA	notice of funding available
O&M	operation and maintenance
PM	preventive maintenance
PNNL	Pacific Northwest National Laboratory
PV	photovoltaic
Retro-CX	retro-commissioning
RTU	rooftop unit
SHW	solar domestic hot water
SPV	solar photovoltaic
UV	ultraviolet
VAV	variable air volume
Yr	year

1.0 Description of ARRA Program

The Federal Energy Management Program (FEMP) facilitates the Federal government's implementation of sound, cost-effective energy management and investment practices to enhance the nation's energy security and environmental stewardship. Late in fiscal year 2009, FEMP received funds specific to the American Recovery and Reinvestment Act (ARRA) of 2009.

These funds were allocated to expand its laboratory and contractor support to agencies and to quickly provide technical advice and assistance to expand and accelerate project activities. FEMP requested that agencies submit projects in need of technical assistance in the following areas:

- Initial screenings or assessments of facility needs or feasibility of a particular technology
- Project prioritization
- Strategic energy planning and benchmarking
- Technical reviews of designs and proposals
- Energy audit training
- High-performance green building technical support
- Federal vehicle fleet technical support
- Operations and maintenance (O&M)
- Detail of key laboratory staff to work within agencies for a limited duration (normally not more than 24 months)
- All of the above, with special emphasis on particular technologies in the areas of the laboratory's expertise.

GSA submitted a response to this call requesting that an energy audit be conducted at the US Customs Cargo Inspection Facility in Detroit, MI, with the goal of identifying energy conservation measures that could be implemented in a timely manner. This request was selected by FEMP and designed as Project 194.

1.1 Site Audit Activities

This energy and water audit was conducted using the protocols and guidance developed by Pacific Northwest National Laboratory (PNNL) to support previous FEMP activities related to assessment of load and energy reduction techniques (ALERT), energy savings expert teams (ESET), and energy efficiency expert evaluations (E4) audits at Federal sites. The primary focus of the protocols is to identify various no-cost and low-cost opportunities for major energy consuming equipment within the building. During the audit, however, other capital cost equipment opportunities were also considered with respect to future energy-efficiency projects that could be undertaken by the sites to acquire additional energy, water, and cost savings.

2.0 Background

2.1 Site Description

The Detroit U.S. Customs Cargo Inspection Facility (CIF) is located at 2810 West Fort Street, Detroit, Michigan. Structures include:

1. CIF: Single-story building of 46,143 square feet (ft^2) originally constructed in 1993 and expanded from 8 loading bays to 16 during the 2006-2007 renovation.

2. Non-invasive inspection (NII) building (formerly VACIS): Single-story 6,608 ft^2 building used to X-ray semi-trailers.

3. Broker building: Single-story building with 24,148 ft^2 that was opened in 2006.

A portion of the Broker building (9,000 $ft^{2)}$ is leased to shipping brokers. The other half of the Broker building is vacant. CBP leases 14 primary inspection booths and 2 post-inspection booths from the Ambassador Bridge Company. When the site expanded a few years ago the booths had to be built on land owned by the Ambassador Bridge Company). This audit focused on the CIF, but also considered potential energy conservation measures (ECMs) for the Broker and NII buildings.

Most of the major building systems in the CIF were replaced as part of the 2006 - 2007 renovation. The boiler and water heater are original to the building and were installed in 1993. GSA has applied for Leadership in Energy and Environmental Design (LEED) certification for the design of this building.

Major upgrades to the CIF planned in the near future include both upgrades and web access to the building automation system (BAS), parking lot light upgrades, and daylighting on the loading dock (see Section 2.2 for additional details). In addition, upgrades to reduce water use were already installed and include low flow / no touch faucets and toilet fixtures, 1/8-gallon urinals, a rainwater cistern, and low water use landscaping. Figure 1 is a photograph of the CIF.

Figure 1. Detroit U.S. Customs Cargo Inspection Facility

2.2 Major Building Energy Uses

AIR HANDLING SYSTEMS

The CIF building is heated and cooled by three variable air volume (VAV) air handling unit (AHU) systems with gas packs and direct expansion (DX) cooling. AHU systems 1, 2, and 3 are located on the roof and operate continuously because the building is occupied at all times. These rooftop units (RTUs) have variable frequency drives controlling both supply and return fans. Outside air is tempered by hot water heating coils in each of the air handlers. The AHUs deliver 55°F supply air via ductwork to the building terminal boxes. No humidification is provided in the AHUs. Each of the units is equipped with ultraviolet light treatment of the cooling coil section to assure optimum heat transfer with clean coil fins.

HOT WATER HEATING BOILER

Hot water delivered to the air handler heating coils is produced by one natural gas hot water heating boiler located inside the building. Heating water is also distributed to the VAV terminal boxes located in the perimeter zones of the building. The Peerless natural draft boiler is original to the building and was installed in 1993. The boiler is set up to operate on a standard schedule if outside air temperatures are below 60°F. There are also ceiling-mounted natural gas heaters for each of the loading bays.

HEATING WATER RESET SCHEDULE

When the outside air is less than or equal to 30°F, the heating water temperature setpoint is 180°F. The heating water temperature is proportionately adjusted downward as the outside air temperature rises and the setpoint is 130°F when the outside air temperature is 70°F.

COOLING UNIT

This facility does not have chillers; each of the rooftop units has DX cooling.

TERMINAL UNIT DISTRIBUTION BOXES

The perimeter zones of the building are served by VAV terminal boxes equipped with hot water reheat coils. Supply air for the perimeter zones is provided by VAV RTUs. Space setpoints are maintained by modulating the air volume to cool the space. If a space requires heating, the VAV box air flow is modulated to its minimum position and the heating coil hot water control valve modulates to maintain space temperatures. No simultaneous heating and cooling is permitted.

The core zones of the building are also served by VAV terminal boxes. However, these VAV terminal boxes do not have reheat coils. Instead, supply air for the core zone is provided by VAV RTUs. Space setpoints are maintained by modulating the air volume when necessary to cool the space.

2.3 Climate, Facility Type, and Operations

The climate for the site is humid continental, and is influenced by its close proximity to the Great Lakes. Based on data available from the National Climatic Data Center, the maximum mean monthly temperature occurs in July (83.4°F), with the minimum mean monthly temperature occurring in January (24.5°F). The highest recorded temperature during the period from 1971 through 2000 was 104°F on June 25, 1988, while the lowest reported temperature during the period was -21°F on January 21, 1984. Based on the most recent mean data available (1971-2000), the site should experience 12 days with a maximum temperature exceeding or equal to 90°F, while the minimum temperature should be at 32°F or below for 130 days. Annually, the site should anticipate 6,422 heating degree days (HDD) and 736 cooling degree days (CDD).

Mean annual precipitation for the site is 32.89 inches. The highest daily reported precipitation was 4.34 inches for July 7, 1998. The highest reported monthly precipitation, 7.83 inches, occurred in August 1975. The daily precipitation should be at or greater than 0.01 inch for 137 days during the year. Mean annual snowfall for the site is 35.1 inches, but the highest monthly snowfall was reported in January 1999 (27.3 inches). The highest daily snowfall was 12.2 inches on January 22, 2005.

The CIF includes cargo bays, a laboratory and office space. The building is occupied continuously, although staffing levels vary during non-peak times.

3.0 Energy Use

The CIF electrical and natural gas usage is metered by Detroit Edison. One electric meter serves the CIF, the NII building and all other site electrical loads except the Broker building. The other electrical meter serves the Broker building. GSA has requested separate advanced electrical metering capabilities for the entire site.

There are three natural gas meters: one serves the CIF building, one serves the NII building, and one serves the Broker building.

3.1 Current Electricity, Gas, and Water Use

The following figures represent the energy and water usage by Federal fiscal year for the CIF. (The electrical meter for this building also serves the NII building and site outdoor lighting.) The fiscal years showing higher-than-average electrical usage may be attributable to construction.

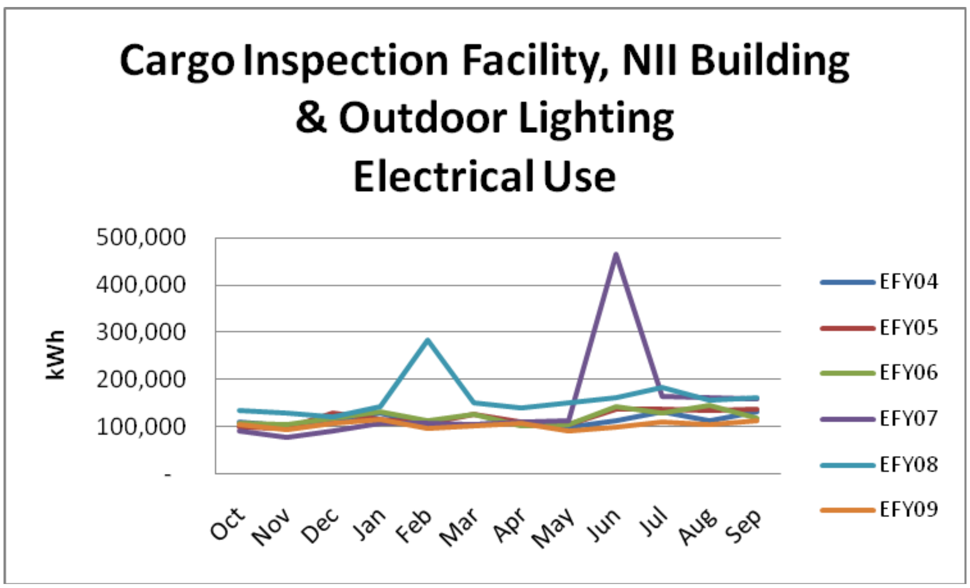

Figure 2. Detroit U.S. Customs Cargo Inspection Facility, NII Building and Outdoor Lighting Electrical Use

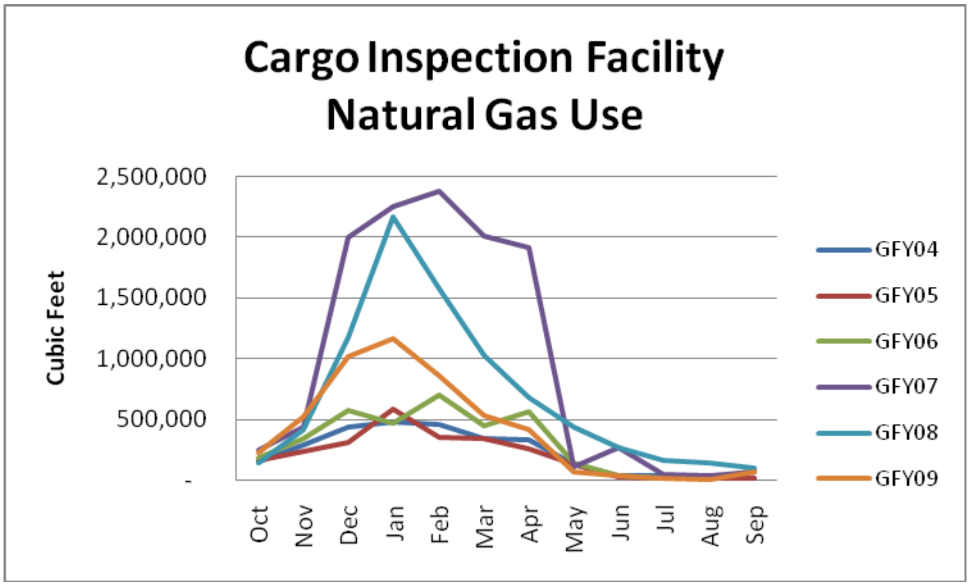

Figure 3. Detroit U.S. Customs Cargo Inspection Facility Natural Gas Use

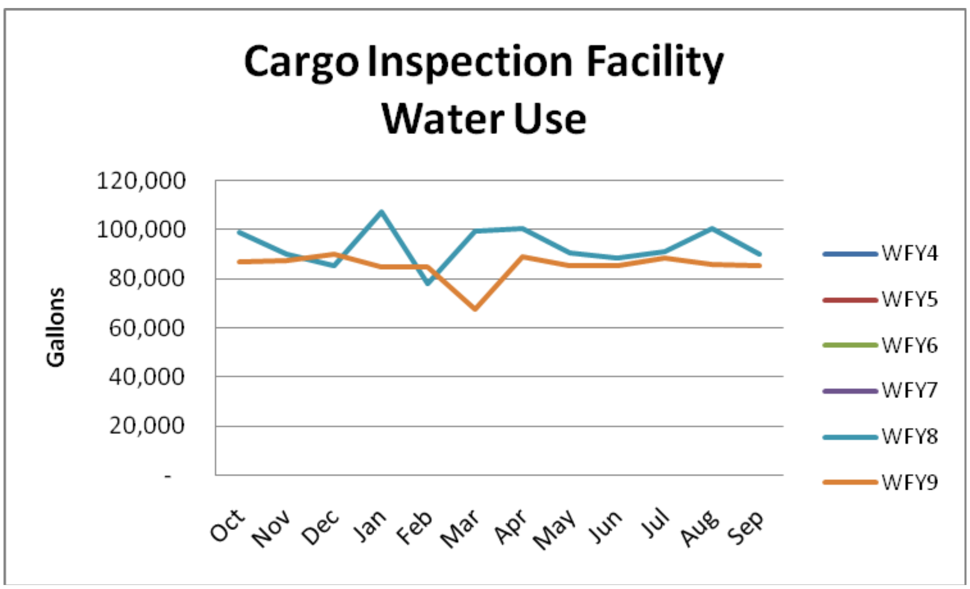

Figure 4. Detroit U.S. Customs Cargo Inspection Facility Water Use

3.2 Current Rate Structure

Detroit Edison provides electric service under a primary supply rate schedule D6 - Rate 220, which is a rate available for general service business customers with maximum demands less than 1,000 kilowatts (kW) and minimum demands that exceed 50 kW. Currently, the site electrical rate is $0.0764/kWh. Detroit Edison provides natural gas under a commercial service rate (GS-1). During the last fiscal year, the consumption was 4.9 million cubic feet (Mcf), which falls under small volume transport for customers consuming less than 14 Mcf. Currently, the site natural gas billing rate is $1.0355 per therm.

The City of Detroit provides water under a commercial service rate of $85/kgal.

4.0 Energy Conservation Measures Identified

4.1 Summary of Proposed Measures

Eight areas were identified where ECMs are recommended for immediate implementation. These ECMs were evaluated in reference to annual energy and cost savings, using a simple payback method. A detailed savings summary is included in Table 1 below. Energy savings estimates are based on individual results and do not represent the interactive effect they have on each other. Savings in Table 1 are estimated reductions in energy use compared with the baseline or existing building energy usage model. The areas identified for immediate implementation were:

- AHUs – (a) static pressure reset; (b) mixed-air temperature sensors
- Boilers — (a) replacement; (b) replace pump motor
- Domestic water heater replacement in CIF (look at potential for combined boiler and domestic water heater from Munchkin) (Note: boiler replacement includes the domestic water heating replacement unit)
- Replace six older gas unit heaters in loading dock area
- Upgrade parking lot lights with more energy-efficient lighting
- Retrocommissioning.

The following options were also evaluated:

- Boilers — oxygen trim controllers; exhaust stack dampers; (Note: boiler replacement has been funded and the measures suggested are eliminated by the replacement of the boiler and boiler pump); implement tune-ups; purchase boiler combustion test equipment
- Solar domestic hot water heating
- Solar power generation.

The evaluation of the solar options did not include the impact of obtaining rebates or incentives.

The team identified (but did not evaluate in detail) the following additional possible recommendations during the visit:

- Wind turbine electrical power generation
- Replace store front windows in waiting area with more energy-efficient windows
- Request separate electrical metering for buildings and high energy equipment and have meters read by utility company

- Minimize refrigeration truck heating load in the winter (air curtain)
- Add weather stripping to loading dock lifts
- Replace CIF roof and add skylights for daylight harvesting
- Use infrared camera surveys to identify areas of building heat loss
- Upgrade Johnson Controls Metasys server to obtain additional trend data and provide web access
- Replace T-12 lighting in customs booths (most of the booths are owned by the Ambassador Bridge Company).

Table 1. Detroit U.S. Customs Cargo Inspection Facility Recommended Energy Conservation Measures (ECMs)

ECM #	Energy Saving Recommendations	Electrical Savings (kWH)	Natural Gas Savings (Therms)	Annual Energy Savings (Millions of Btus)	Water Savings (Gallons)	Electrical Savings ($)	Natural Gas Savings ($)	Water Savings ($)	Total Annual Savings ($)	Cost to Implement ($)	Simple Payback (Years)
1a	Static pressure reset	8,320	-183	10		$ 635	$ (190)		$ 446	$ 1,200	2.7
1b	RTUs — add mixed air temp sensor	8,070	-9	27		$ 616	$ (9)		$ 607	$ 1,000	1.6
2a	Boiler replacement	0	11,382	1,138		$ -	$ 11,787		$ 11,787	$ 30,000	2.5
2b	Boiler — replace pump motor with high efficiency motor	500	0	2		$ 38	$ -		$ 38	$ 510	13.4
3	Domestic water heater replacement	0	14	1		$ -	$ 14		$ 14	$ 300	21.5
4	Natural gas unit heater replacement in loading dock area	0	63	6		$ -	$ 65		$ 65	$ 2,800	42.9
5	Parking Lot Lighting Upgrades	18,407	0	63		$ 1,406	$ -		$ 1,406	$ 13,479	9.6
6	Retrocommissioning	30,590	0	104		$ 2,336	$ -		$ 2,336	$ 11,790	5.0
	Total (Non-interactive)	**65,887**	**11,267**	**1,352**		**$ 5,031**	**$ 11,667**		**$ 16,698**	**$ 61,079**	**3.7**
	Percent Savings (Non-interactive)	**11%**	**23%**	**19%**							
	Renewable Energy										
7	Solar Domestic Hot Water	0	219	22		$ -	$ 227		$ 227	$ 3,000	13.2
8	Solar Power Generation (70 kW)	80,225		274		$ 6,126	$ -		$ 6,126	$ 700,000	114.3
	Total Renewable Energy	**80,225**	**219**	**296**		**$ 6,126**	**$ 227**		**$ 6,353**	**$ 703,000**	**110.7**
					2009 Reference Data						
		Annual Electrical Use (kWH)	**Annual Natural Gas Use (Therms)**	**Annual Energy Use (Millions of Btus)**	**Annual Water Use (Gallons)**	**Electrical Cost**	**Natural Gas Cost**	**Water Cost**	**Total Annual Utility Use ($)**	**Total Annual Energy Use ($)**	
	Cost Per Unit 2009					**0.0764**	**1.0355**	**0.00851**			
	eQUEST Baseline 2009	611,800	49,372	7,025	NA	$ 46,717	$ 51,127	NA	NA	$ 97,844	
	eQUEST / Actual Use Ratio	**100.0%**	**99.9%**	**100.0%**	Modeling estimates should fall within 5% of actual usage.						
	Actual Baseline Usage 2009	611,800	49,402	7,028	1,299,276	$ 46,717	$ 51,158	$ 11,057	$108,932	$ 97,875	
	Actual Energy Use Intensity (EUI) - (BTU/SF-YR)	46,473	109,951	156,424							

ECM1A. - AHU STATIC PRESSURE RESET

Air static pressure in a VAV air handling system is normally maintained by modulating the speed of the fan. Air is distributed throughout the building by ductwork, and VAV terminal boxes control the flow of cool air delivered to the space they serve. As the space cooling load increases, the flow of cold air increases to maintain the space temperature. If space cooling loads decrease, the requirements for cold air flow to cool the space decrease. The air flow to the VAV terminal boxes is delivered at a system static pressure. The static pressure level is established by the minimum pressure required for the terminal boxes to deliver full cooling flows. During the winter, air flow requirements drop to their minimum levels and the static pressure required at terminal boxes decreases. This reduced air flow requirement brings about an opportunity to reduce the system static pressure levels along with reducing energy usage. Static pressure reset control strategies have been in use for more than 20 years and have been proven to provide significant levels of energy savings.

An eQUEST energy model was developed (Appendix A), and the estimated annual energy savings is summarized in Table 1. The energy-efficiency measure wizard option to model static pressure reset is not included in the current version of eQUEST. The magnitude of energy savings was estimated by modeling the baseline VAV system as a forward-curved fan system with inlet vane dampers, and the static pressure reset option was modeled as a standard VAV system with variable speed drives.

Implementation of the improved air static pressure reset control can greatly increase the energy savings. Since 1999, American Society of Heating, Refrigerating & Air Conditioning Engineers (ASHRAE) Standard 90.1 has required that static air pressure be reset for systems with direct digital controls (DDCs) "i.e., the setpoint is reset lower until one zone damper is nearly wide open." However, system design deficiencies often limit the potential energy savings. These design deficiencies create problem zones that cause the reset scheme to underperform because they frequently or constantly generate zone pressure increase requests.

Common causes are:

- Undersized VAV box because of improper selection in the design phase, or because unexpectedly high zone loads are added to the space after construction;
- Cooling thermostat setpoint below design condition;
- Thermostats with heat releasing equipment under them (typically microwaves and coffee pots); and
- Air distribution design problems — high-pressure drop fittings or duct sections.

The first three items cause the zone to frequently demand maximum or near-maximum zone air flow rates. Depending on zone location relative to the fan, a constant demand for high air flow rates indirectly causes the zone to generate frequent or constant pressure requests. The fourth problem directly results in pressure requests: for example, a zone with a fire/smoke damper installed in the 6-inch (150-millimeter [mm]) high-pressure duct at the box inlet. Small smoke dampers have little free area, so pressure drop will be very high.

Ways to mitigate the impact of problem zones on static pressure reset control sequences include:

- Exclude the problem zones from the reset control sequence. They can be excluded by ignoring the problem zone's pressure requests or including logic that ignores the first few pressure requests. Of course, ignoring the zone results in failure to meet zone air flow and temperature setpoints. This failure may be acceptable if the zone is a problem because the temperature setpoint is too low, but it clearly can be an issue if the zone is more critical.

- Limit thermostat setpoint adjustments to a range that is close to space design temperatures. DDC systems typically have the ability to limit the range; occupants can adjust setpoints from the thermostat. This means of mitigation can prevent cooling setpoints that are well below design conditions.

- Request that all thermostats are free of impact from appliances directly under them.

- Fix duct restrictions and sizing issues. This choice is clearly better than ignoring the zone and letting it overheat, but the cost to make revisions may be higher than the owner is willing to invest. It is best, of course, to avoid these restrictions in the first place. For instance, avoid using flexible ducts at VAV box inlets, avoid oversized inlet ducts when they extend a long way from the duct main, and avoid small fire/smoke dampers in VAV box inlet ducts.

- Add auxiliary cooling to augment the VAV zone. If the problem results from an undersized zone or unexpectedly high loads, a second cooling system, such as a split air conditioning (AC) system, can be added to supplement the VAV zone capacity. However, this solution is also expensive.

ECM1B. - AHU MIXED-AIR TEMPERATURE SENSORS

All three RTUs were installed without a mixed-air temperature sensor. Optimum economizer control of outside air requires knowledge of the mixed-air temperature. Without a mixed-air temperature sensor, the system must rely on discharge air temperature sensors to control the economizer strategy. Discharge air temperature control of the economizer strategy can be misleading because of leaking heating coil valves. If the heating coil control valve is leaking, the discharge air temperature will be higher than the true mixed-air temperature and calls for a reduction in outside economizer cooling. Therefore, it is important to have a mixed-air temperature sensor to accurately control outside air economizers. Typical strategies for proper economizer control include the following control sequences:

The controller should measure the mixed-air temperature and modulate the economizer dampers in sequence to maintain a setpoint 2°F adjustable (adj) less than the supply air temperature setpoint. The outside air dampers should maintain a minimum adjustable open position whenever the building is occupied.

The economizer shall be enabled whenever:

> Outside air temperature is less than 68°F (adj)
> AND the outside air enthalpy is less than the return air enthalpy
> AND the supply fan status is on.

The economizer damper and exhaust air dampers should close and the return air damper should open when:

> Mixed-air temperature drops from 40°F (adj) to 35°F (adj)
> OR the freezestat is on
> OR loss of supply fan on status
> OR if unit is commanded off.

If optimal startup is available or when the unit runs during the unoccupied modes, the mixed-air damper control should operate as described in the occupied mode, except that the outside air and relief dampers should be closed unless the unit is operating in economizer mode.

Without mixed-air temperature readings, the strategy for the economizer control sequence may cause the freezestat to trip out and shut the air handler down. The mixed-air sensors and freezestats must be installed in a manner that fully covers the mixed-air plenum and allows the mixed-air sensor to accurately reflect the conditions that the freezestat will detect. Thus, multiple sensors may be required for larger systems. Running the sensing elements for the mixed-air sensor and freezestat together helps to ensure consistent system performance by subjecting these two related sensors to identical conditions.

Sometimes, it is necessary to use a low-limit control strategy for economizers in cold climates. When the economizer is controlled based on the discharge air temperature from the supply fan, employing mixed-air low-limit control during operation will reduce freezestat trips. If the economizer is controlled off the mixed-air temperature, then the mixed-air low-limit control strategy is not necessary.

A properly employed mixed-air low-limit cycle can prevent freezestat trips and not reduce the performance of the system. A control loop is created based on mixed-air temperature that overrides the normal economizer control sequence to prevent the mixed-air plenum from dropping below some limit, typically 40°F.

This limit cycle will hold the mixed-air temperature at a safe level until the temperature at the discharge sensor drops toward the discharge temperature setpoint.

An eQUEST energy model was developed (Appendix A), and the estimated annual energy savings is summarized in Table 1.

ECM2A - BOILERS — REPLACE BOILER AND ADD BACK-UP UNIT

One natural gas boiler currently supplies heating water for the CIF. This unit could be replaced with a high-efficiency condensing boiler system. An eQUEST energy model was performed (Appendix A), and the estimated annual energy savings are summarized in Table 1.

GSA Land Ports of Entry has approved funding, and replacement will include the heating water pump and the domestic hot water heating option. Installation is expected to be completed in 2010.

ECM2B - BOILERS — REPLACE PUMP MOTOR WITH HIGH-EFFICIENCY MOTOR

Heating water is pumped by a 2-horsepower hot water pump motor. The motor could be replaced with a premium efficiency motor. An eQUEST energy model was performed (Appendix A), and the estimated annual energy savings are summarized in Table 1.

ECM3 – DOMESTIC WATER HEATER REPLACEMENT

The existing domestic hot water heater is an older, inefficient unit and could be replaced with a new unit to improve efficiency. An eQUEST energy model was performed (Appendix A), and the estimated annual energy savings are summarized in Table 1.

Note: domestic hot water heating will be provided by the new heating water boiler.

ECM4 – NATURAL GAS UNIT HEATER REPLACEMENT IN LOADING DOCK AREA

Almost half of the natural gas unit heaters in the dock area have been replaced with new, high-efficiency unit heaters. There are six remaining unit heaters that could be replaced. An eQUEST energy model was performed (Appendix A), and the estimated annual energy savings are summarized in Table 1.

ECM5 – PARKING LOT LIGHTING UPGRADES

Pole-mounted 1,000-watt high pressure sodium lamps light the parking lot areas. Potential replacements include 300-watt induction lamps. Lasting up to 100,000 hours, this system can last longer than 100 incandescent, two light emitting diode (LED), or five typical fluorescent lamp changes. Induction lamps will also maintain output from -40 to 122°F. Spreadsheet calculations (Appendix A), were used to estimate the savings summarized in Table 1.

ECM6 – BUILDING RETROCOMMISSIONING

Retro-Cx is a form of commissioning. Commissioning is the process of ensuring that systems are designed, installed, functionally tested, and capable of being operated and maintained according to the owner's operational needs. Retro-commissioning is the same systematic process applied to existing buildings that have never been commissioned to ensure that their systems can be operated and maintained according to the owner's needs. It is recommended that the practices of recommissioning or ongoing commissioning be applied for buildings that have already been commissioned or retro-commissioned.

Recommissioning is the term for applying the commissioning process to a building that has been commissioned previously (either during construction or as an existing building); it is normally done every 3 to 5 years to maintain top levels of building performance or after upgrades to identify new opportunities for improvement.

Researchers at Lawrence Berkeley National Laboratory, Portland Energy Conservation, Inc., and the Energy Systems Laboratory at Texas A&M University concluded in a study published in December 2004 (Mills et al. 2004) that retro-commissioning is one of the most cost-effective means of improving energy efficiency in commercial buildings. The researchers statistically analyzed more than 224 new and existing buildings that had been commissioned, totaling more than 30 million ft^2 of commissioned floorspace (73 percent existing buildings and 27 percent new construction). The results revealed the most common problem areas and showed that both energy and non-energy benefits were achieved. Analysis of commissioning projects for existing buildings showed a median commissioning cost of \$0.27 per ft^2, an energy savings of 15 percent, and a simple payback period of 0.7 year.

Retro-Cx should follow a four-step approach of planning, investigation, implementation, and continuation.

Step 1 is the planning step, which includes assembling the Retro-Cx core team that will work with the Retro-Cx provider and is composed of building management staff with skills in equipment operation, energy management, and engineering. During this step, the overall objectives and strategy are established.

Step 2, the investigation step, includes several significant activities. During a typical Retro-Cx effort, the providers become familiar with the building and its systems via walk-throughs, gathering and reviewing equipment and design documentation, and evaluating O&M practices. As part of the investigation step, a list of potential ECMs for the building is developed. The Department of Energy's (DOE's) Industrial Assessment Center maintains an exhaustive data base of 2,300 potential ECMs, most of which are no cost / low cost (less than $500). The Retro-Cx provider identifies applicable ECMs, develops cost estimates, and prioritizes the opportunities.

Step 3 is implementation of ECMs. ECMs determined to be easy to complete, measure, and most likely to succeed are the first to be addressed. The results of these ECMs are then used to build up credibility for the Retro-Cx approach and gain support to accomplish the full range of ECMs. Completed ECMs are tested and monitored for results with readjustments made as necessary.

Step 4 in the Retro-Cx effort is that of continuing the on-site efforts with activities such as monitoring building energy data, periodic review of operational changes, occupant and operator feedback, and monthly update reports. Ongoing monitoring of building performance helps to ensure that the retro-commissioned building systems continue to operate in their optimized state and that energy savings continue to be realized.

Spreadsheet calculations (Appendix A), were used to estimate the savings summarized in Table 1. Completing the Retro-Cx effort should be planned after the installation of the new heating water boiler system, the upgrade of the control system and the installation of the recommendations.

ECM7 – Solar Domestic Hot Water Heating

Domestic hot water is currently used in bathrooms, laboratory, and in the break area kitchens of the CIF building. Solar collectors could be mounted on the roof of the building to provide solar heating of domestic hot water. Estimates of solar hot water heating were obtained using the RETScreen energy modeling spreadsheets and provided in Appendix A (NRC 2010). The estimated annual energy savings for this ECM are summarized in Table 1.

ECM8 – Solar Power Generation

Open space on the rooftop areas of both the CIF building and the Broker building could be used to install photovoltaic panels to generate electricity. The space available is somewhat limited because of the presence of the RTUs. Photovoltaic (PV) panels should not be sited in areas where shading of the panels may occur. Estimated electrical production for a 70 kW array was obtained using the online PV Watts calculator (Appendix A), and the estimated annual energy savings are summarized in Table 1.

4.2 Summary of Other Measures identified but not Evaluated

BAS UPGRADE FOR JOHNSON CONTROLS METASYS

Trending capability of the existing system is limited, and an upgrade of the hardware and software would enhance trending capability. This update does not save energy directly, but provides data that will allow the identification of problems that result in poor system performance.

Note: Funding is now available and a proposal is being evaluated by GSA.

LIGHTING REPLACEMENT IN CUSTOMS BOOTHS

Lighting in the customs booths is currently provided by 4-foot fluorescent fixtures with T-12 lamps. These fixtures will be replaced with T-8 fixtures by the maintenance contractor. Most of the booths are owned by the Ambassador Bridge Company.

CIF ROOF REPLACEMENT WITH SKYLIGHT ADDITIONS

When the roof is replaced, skylights could be added to provide natural lighting, especially in the dock / warehouse areas. If skylights are added, photocell light level sensors could be added to automatically turn off the lights when enough ambient light is available.

INFRARED (IR) CAMERA SURVEY FOR HEAT LOSS

IR camera surveys can be used to identify energy waste. The survey itself will not save energy, but it may help to identify opportunities to reduce energy losses. Areas to target for the survey include evidence of air loss or inadequate insulation. Roof surveys are useful if the time of year and weather conditions are conducive to survey needs, in other words, dry roof, clear sky, and evening hours. The heating and cooling coils at VAV boxes and similar system heat exchangers should be surveyed for evidence of simultaneous heating and cooling. The local utility may have infrared cameras available for use on a loan basis.

4.3 Summary of Eliminated Proposed Measures

The following measures were identified during the site visits but implementation is not necessary as the heating water boiler is being replaced.

- BOILERS — OXYGEN TRIM CONTROLLERS
- BOILERS — EXHAUST STACK DAMPERS
- BOILERS — IMPLEMENT TUNE-UPS
- BOILERS — PURCHASE BOILER COMBUSTION TEST EQUIPMENT.

5.0 Potential Green House Gas Reduction

The proposed ECMs will reduce green house gas (GHG) emissions. All reported calculations in Table 2 below are based on the U.S. Environmental Protection Agency (EPA) GHG emissions calculator and are reported as carbon dioxide equivalent (CO_2e). The EPA calculator estimates for kWh savings are based on CO_2 only. If the recommended ECMs are implemented, the actual kWh savings can be used to estimate GHG emissions reductions using the EPA eGRID model (Pechan 2008), using actual data from the specific electricity provider, which takes into consideration complex factors such as utility generation mix from coal, natural gas, nuclear, and renewable energy sources.

Table 2: Estimated Green House Gas Reductions for Each Proposed ECM
Reference: http://www.epa.gov/rdee/energy-resources/calculator.html

ECM #	Estimated Electrical Savings (kWH)	Estimated Natural Gas Savings (Therms)	GHG Avoided (Est. Electrical Use Reduction) (metric tons CO2e)	GHG Avoided (Est. Natural Gas Use Reduction) (metric tons CO2e)	Estimated Total GHG Avoided (metric tons CO2e)
1a	8,320	-183	5.8	-0.9	5
1b	8,070	-9	5.6	0.0	6
2a	0	11,382	0.0	56.9	57
2b	500	0	0.4	0.0	0
3	0	14	0.0	0.1	0
4	0	63	0.0	0.3	0
5	18,407	0	12.9	0.0	13
6	30,590	0	21.4	0.0	21
TOTALS	65,887	11,267	46	56	102
Estimated Green House Gas Reductions (Renewable Energy Projects)					
7	0	219	0.0	1.1	1
8	80,225	0	56.2	0.0	56
TOTALS	80,225	219	56.2	1.1	57

To calculate jobs created and retained, one job for every $92,000 in funds expended was assumed. The baseline non-interactive energy-efficiency retrofits ($61,079) will result in 0.7 job created and 102 metric tons of CO_2e emissions avoided. If the proposed renewable energy projects are implemented, the estimated investment would be $703,000. This amount would result in 7.6 jobs created and 57 metric tons of CO_2e emissions avoided.

6.0 Action Plan for Implementation of ECMs

6.1 Priorities and Next Steps

There are three ways to implement the recommended measures:

- Use the audit report findings to immediately implement the no-cost and low-cost ECMs identified.
- Further analyze ECMs with moderate cost or longer simple payback times.
- Conduct a more comprehensive audit or recommissioning to identify ECMs that may be less desirable now because of implementation obstacles or capital cost considerations.

The first action item should focus on implementing the no-cost / low-cost recommendations. To implement these measures, GSA can request a proposal to implement the measures from the operations contractor.

Replacing the natural gas boiler, domestic water heater, and natural gas unit heaters are capital projects that require an engineering consultant to begin project development.

Upgrades to lighting systems in the customs booths and parking lot are also capital projects that will require developing agreements with the lease holders.

Recommended resources for Detroit U.S. Customs Cargo Inspection Facility building operations staff:

FEMP Retro-commissioning
http://www1.eere.energy.gov/femp/pdf.om retrocs.pdf

FEMP Best Practices Operations and Maintenance
http:///www1.eere.energy.gove/femp/operations maintenance/om bpguide.html

6.2 Funding Assistance Available

Renewable energy funding may be available through Detroit Edison's Solar Currents program:
http://www.dteenergy.com/businessCustomers/productsPrograms/solarCurrents/solarCurrents.html

The SolarCurrents program, combined with net metering, Federal tax credits and local incentives, could save more than half the cost of a new photovoltaic system.

Federal projects can be financed by various means. The most readily available funding source would be ARRA funds at the agency level. An alternative approach for Federal projects is the use of either energy savings performance contracts (ESPC) or utility savings performance contracts that provide upfront funding to install systems and make modifications with repayment made from the cost savings that result from the energy savings.

7.0 Assessment Team Members and Site Team

The Redhorse ARRA assessment team for the audit included Jim Arends, PE, CEM, Redhorse Corporation Energy Audit Team Technical Lead; and Darcy Anderson, Redhorse Corporation Energy Audit Team Member. Site support was provided by Dennis Turzak, GSA Property Manager. Additional interviews were conducted with Doug McKay with CMC & Maintenance, Inc. (contract operator). Mr. William Sandusky of PNNL was responsible for technical review of this report.

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APPENDIX A

Model Output Files

Appendix A – Model Output Files

Energy Simulation Output: eQUEST Baseline Energy Use

eQUEST Model Results Baseline Use													
Electric Consumption (kWh x000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.06	0.08	0.9	2.31	10	22.95	29.86	25.25	17.96	4.58	1.68	0.05	115.68
Heat Reject.	0	0	0	0	0	0	0	0	0	0	0	0	0
Refrigeration	0	0	0	0	0	0	0	0	0	0	0	0	0
Space Heat	0	0	0	0	0	0	0	0	0	0	0	0	0
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	0	0	0	0	0	0	0	0	0	0	0	0	0
Vent. Fans	6.4	5.82	6.33	6.09	6.36	6.28	6.54	6.54	6.27	6.33	6.1	6.36	75.41
Pumps & Aux.	0.76	0.69	0.75	0.71	0.69	0.63	0.65	0.66	0.65	0.71	0.72	0.76	8.39
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	8.89	8.31	9.49	9.39	8.89	9.39	9.47	9.2	9.09	9.19	8.49	9.48	109.28
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	24.5	22.98	26.38	26.28	24.5	26.28	26.32	25.58	25.22	25.52	23.12	26.35	303.04
Total	40.62	37.88	43.85	44.79	50.44	65.54	72.85	67.23	59.19	46.33	40.1	43	611.80
Gas Consumption (Btu x000,000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0	0	0	0	0	0	0	0	0	0	0	0	0
Heat Reject.	0	0	0	0	0	0	0	0	0	0	0	0	0
Refrigeration	0	0	0	0	0	0	0	0	0	0	0	0	0
Space Heat	783.5	682	569.9	413.3	275.1	153.3	137	155.7	199.4	329.4	488.8	700.3	4,887.70
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	4.4	4.3	4.9	4.8	4.2	4.1	3.9	3.6	3.5	3.7	3.6	4.5	49.5
Vent. Fans	0	0	0	0	0	0	0	0	0	0	0	0	0
Pumps & Aux.	0	0	0	0	0	0	0	0	0	0	0	0	0
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	0	0	0	0	0	0	0	0	0	0	0	0	0
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	787.9	686.3	574.8	418.1	279.3	157.5	140.9	159.2	202.9	333.1	492.5	704.7	4,937.20

Energy Simulation Output: eQUEST Static Pressure Reset

eQUEST Model Results Static Pressure Reset													
Electric Consumption (kWh x000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.06	0.09	0.89	2.25	9.81	22.74	29.64	25.03	17.74	4.46	1.64	0.06	114.41
Heat Reject	0	0	0	0	0	0	0	0	0	0	0	0	0
Refrigeratio	0	0	0	0	0	0	0	0	0	0	0	0	0
Space Heat	0	0	0	0	0	0	0	0	0	0	0	0	0
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	0	0	0	0	0	0	0	0	0	0	0	0	0
Vent. Fans	5.8	5.28	5.71	5.49	5.74	5.72	5.97	5.97	5.71	5.71	5.5	5.75	68.35
Pumps & Au	0.76	0.69	0.75	0.71	0.69	0.63	0.65	0.66	0.65	0.71	0.72	0.76	8.39
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	8.89	8.31	9.49	9.39	8.89	9.39	9.47	9.2	9.09	9.19	8.49	9.48	109.28
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	24.5	22.98	26.38	26.28	24.5	26.28	26.32	25.58	25.22	25.52	23.12	26.35	303.04
Total	40.02	37.34	43.22	44.12	49.65	64.77	72.06	66.44	58.42	45.59	39.46	42.39	603.48
Gas Consumption (Btu x000,000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0	0	0	0	0	0	0	0	0	0	0	0	0
Heat Reject	0	0	0	0	0	0	0	0	0	0	0	0	0
Refrigeratio	0	0	0	0	0	0	0	0	0	0	0	0	0
Space Heat	786.3	684.6	572.7	415.4	276	153.4	137	155.7	199.6	330.8	491.2	703.3	4,906.00
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	4.4	4.3	4.9	4.8	4.2	4.1	3.9	3.6	3.5	3.7	3.6	4.5	49.5
Vent. Fans	0	0	0	0	0	0	0	0	0	0	0	0	0
Pumps & Au	0	0	0	0	0	0	0	0	0	0	0	0	0
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	0	0	0	0	0	0	0	0	0	0	0	0	0
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	790.7	688.9	577.6	420.2	280.1	157.5	140.9	159.3	203.2	334.5	494.9	707.7	4,955.50

Energy Simulation Output: eQUEST Mixed-Air Temperature Sensors

eQUEST Model Results Mixed Air Economizer													
Electric Consumption (kWh x000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.01	0.04	0.82	2.04	8.66	21.65	28.87	23.84	16.35	3.87	1.51	0.02	107.69
Heat Reject.	0	0	0	0	0	0	0	0	0	0	0	0	0
Refrigeration	0	0	0	0	0	0	0	0	0	0	0	0	0
Space Heat	0	0	0	0	0	0	0	0	0	0	0	0	0
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	0	0	0	0	0	0	0	0	0	0	0	0	0
Vent. Fans	6.4	5.82	6.33	6.09	6.34	6.26	6.52	6.52	6.25	6.32	6.1	6.36	75.31
Pumps & Aux.	0.77	0.69	0.75	0.71	0.69	0.63	0.65	0.66	0.65	0.71	0.72	0.77	8.41
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	8.89	8.31	9.49	9.39	8.89	9.39	9.47	9.2	9.09	9.19	8.49	9.48	109.28
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	24.5	22.98	26.38	26.28	24.5	26.28	26.32	25.58	25.22	25.52	23.12	26.35	303.04
Total	40.57	37.84	43.77	44.52	49.09	64.22	71.84	65.8	57.57	45.61	39.93	42.97	603.73
Gas Consumption (Btu x000,000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0	0	0	0	0	0	0	0	0	0	0	0	0
Heat Reject.	0	0	0	0	0	0	0	0	0	0	0	0	0
Refrigeration	0	0	0	0	0	0	0	0	0	0	0	0	0
Space Heat	783.5	682	569.9	413.4	275.3	153.4	137	155.7	199.5	329.6	488.9	700.3	4,888.50
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	4.4	4.3	4.9	4.8	4.2	4.1	3.9	3.6	3.5	3.7	3.6	4.5	49.5
Vent. Fans	0	0	0	0	0	0	0	0	0	0	0	0	0
Pumps & Aux.	0	0	0	0	0	0	0	0	0	0	0	0	0
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	0	0	0	0	0	0	0	0	0	0	0	0	0
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	787.9	686.3	574.8	418.2	279.5	157.6	140.9	159.3	203	333.3	492.5	704.7	4,938.10

Energy Simulation Output: eQUEST Boiler Replacement and Back-up

eQUEST Model Results Boiler - Replacement													
Electric Consumption (kWh x000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.06	0.08	0.9	2.31	10	22.95	29.86	25.25	17.96	4.58	1.68	0.05	115.68
Heat Reject.	0	0	0	0	0	0	0	0	0	0	0	0	0
Refrigeration	0	0	0	0	0	0	0	0	0	0	0	0	0
Space Heat	0	0	0	0	0	0	0	0	0	0	0	0	0
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	0	0	0	0	0	0	0	0	0	0	0	0	0
Vent. Fans	6.4	5.82	6.33	6.09	6.36	6.28	6.54	6.54	6.27	6.33	6.1	6.36	75.41
Pumps & Aux.	0.76	0.69	0.75	0.71	0.69	0.63	0.65	0.66	0.65	0.71	0.72	0.76	8.39
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	8.89	8.31	9.49	9.39	8.89	9.39	9.47	9.2	9.09	9.19	8.49	9.48	109.28
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	24.5	22.98	26.38	26.28	24.5	26.28	26.32	25.58	25.22	25.52	23.12	26.35	303.04
Total	40.62	37.88	43.85	44.79	50.44	65.54	72.85	67.23	59.19	46.33	40.1	43	611.80
Gas Consumption (Btu x000,000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0	0	0	0	0	0	0	0	0	0	0	0	0
Heat Reject.	0	0	0	0	0	0	0	0	0	0	0	0	0
Refrigeration	0	0	0	0	0	0	0	0	0	0	0	0	0
Space Heat	602.7	524.5	437.3	316.5	210.4	117.3	104.8	119	152.5	251.9	374.5	538.1	3,749.50
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	4.4	4.3	4.9	4.8	4.2	4.1	3.9	3.6	3.5	3.7	3.6	4.5	49.5
Vent. Fans	0	0	0	0	0	0	0	0	0	0	0	0	0
Pumps & Aux.	0	0	0	0	0	0	0	0	0	0	0	0	0
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	0	0	0	0	0	0	0	0	0	0	0	0	0
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	607.1	528.8	442.3	321.3	214.5	121.4	108.7	122.6	156	255.6	378.1	542.6	3,799.00

Energy Simulation Output: eQUEST Boiler Pump Motor Replacement

eQUEST Model Results Boiler - Pump Motor Replacement													
Electric Consumption (kWh x000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.06	0.08	0.9	2.31	10	22.95	29.86	25.25	17.96	4.58	1.68	0.05	115.68
Heat Reject.	0	0	0	0	0	0	0	0	0	0	0	0	0
Refrigeration	0	0	0	0	0	0	0	0	0	0	0	0	0
Space Heat	0	0	0	0	0	0	0	0	0	0	0	0	0
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	0	0	0	0	0	0	0	0	0	0	0	0	0
Vent. Fans	6.4	5.82	6.33	6.09	6.36	6.28	6.54	6.54	6.27	6.33	6.1	6.36	75.41
Pumps & Aux.	0.72	0.65	0.71	0.67	0.65	0.59	0.61	0.61	0.61	0.67	0.68	0.72	7.9
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	8.89	8.31	9.49	9.39	8.89	9.39	9.47	9.2	9.09	9.19	8.49	9.48	109.28
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	24.5	22.98	26.38	26.28	24.5	26.28	26.32	25.58	25.22	25.52	23.12	26.35	303.04
Total	40.57	37.84	43.81	44.75	50.4	65.5	72.8	67.18	59.15	46.28	40.06	42.96	611.30
Gas Consumption (Btu x000,000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0	0	0	0	0	0	0	0	0	0	0	0	0
Heat Reject.	0	0	0	0	0	0	0	0	0	0	0	0	0
Refrigeration	0	0	0	0	0	0	0	0	0	0	0	0	0
Space Heat	783.5	682	569.9	413.3	275.1	153.3	137	155.7	199.4	329.4	488.8	700.3	4,887.70
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	4.4	4.3	4.9	4.8	4.2	4.1	3.9	3.6	3.5	3.7	3.6	4.5	49.5
Vent. Fans	0	0	0	0	0	0	0	0	0	0	0	0	0
Pumps & Aux.	0	0	0	0	0	0	0	0	0	0	0	0	0
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	0	0	0	0	0	0	0	0	0	0	0	0	0
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	787.9	686.3	574.8	418.1	279.3	157.5	140.9	159.2	202.9	333.1	492.5	704.7	4,937.20

Energy Simulation Output: Domestic Water Heater Replacement

Energy Cost Calculator for Electric and Gas Water Heaters

http://www1.eere.energy.gov/femp/technologies/eep_waterheaters_calc.html

Vary equipment size, energy cost, hours of operation, and / or efficiency level.

INPUT SECTION			
Input the following data (if any parameter is missing, calculator will set to default value).			*Defaults*
Type of Water Heater	Gas		*Electric*
Average Daily Usage (gallons per day)*	13 gallons		*64*
Energy Factor†	0.85		*0.92 (electric)* *0.61 (gas)*
Energy Cost	$ / 1.0355	therm	*$0.06 per kWh* *$.60 per therm*
Quantity of Water Heaters to be Purchased	1 unit(s)		*1 unit*

* See assumptions for various daily water use totals.

† The comparison assumes a storage tank water heater as the input type. To allow demand water heaters as the comparison type, users can specify an input EF of up to 0.85; however, 0.66 is currently the best available EF for storage water heaters.

Reset

OUTPUT SECTION

Performance per Water Heater	**Your Choice**	**Base Model**	**FEMP Recommended Level**	**Best Available**
New Energy Factor	0.85	0.59	0.62	0.85
therm **Energy Use**	36	51	49	36

Energy Simulation Output: Natural Gas Unit Heater Replacement

eQUEST Model Results Dock NG Unit Heater - Replacement													
Electric Consumption (kWh x000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.06	0.08	0.9	2.31	10	22.95	29.86	25.25	17.96	4.58	1.68	0.05	115.68
Heat Reject.	0	0	0	0	0	0	0	0	0	0	0	0	0
Refrigeration	0	0	0	0	0	0	0	0	0	0	0	0	0
Space Heat	0	0	0	0	0	0	0	0	0	0	0	0	0
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	0	0	0	0	0	0	0	0	0	0	0	0	0
Vent. Fans	6.4	5.82	6.33	6.09	6.36	6.28	6.54	6.54	6.27	6.33	6.1	6.36	75.41
Pumps & Aux.	0.76	0.69	0.75	0.71	0.69	0.63	0.65	0.66	0.65	0.71	0.72	0.76	8.39
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	8.89	8.31	9.49	9.39	8.89	9.39	9.47	9.2	9.09	9.19	8.49	9.48	109.28
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	24.5	22.98	26.38	26.28	24.5	26.28	26.32	25.58	25.22	25.52	23.12	26.35	303.04
Total	40.62	37.88	43.85	44.79	50.44	65.54	72.85	67.23	59.19	46.33	40.1	43	611.80
Gas Consumption (Btu x000,000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0	0	0	0	0	0	0	0	0	0	0	0	0
Heat Reject.	0	0	0	0	0	0	0	0	0	0	0	0	0
Refrigeration	0	0	0	0	0	0	0	0	0	0	0	0	0
Space Heat	781.6	680.4	569	413.1	275.1	153.3	137	155.7	199.4	329.4	488.5	698.9	4,881.40
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	4.4	4.3	4.9	4.8	4.2	4.1	3.9	3.6	3.5	3.7	3.6	4.5	49.5
Vent. Fans	0	0	0	0	0	0	0	0	0	0	0	0	0
Pumps & Aux.	0	0	0	0	0	0	0	0	0	0	0	0	0
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	0	0	0	0	0	0	0	0	0	0	0	0	0
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	786	684.7	574	417.9	279.3	157.5	140.9	159.2	202.9	333.1	492.1	703.3	4,930.90

Spreadsheet Calculation: Parking Lot Lighting Replacement

	Parking Lot Lighting Replacement		
	Existing Lights	New Lights	Energy Savings KWh
Type	High Pressure Sodium	HD Induction Light	
Power/Lamp in Watts	1000	300	
Number of Lamps/Pole	6	6	
Total Power Consumed /Pole in kW	6	1.8	
Total kWh/Year	26,295.0	7,888.5	18,406.5

Spreadsheet Calculation: Retrocommissioning

eQUEST Model Results	kWh	Therms
Baseline	611,800	49,372
Estimated Savings Percent	5%	5%
Estimated Savings Retrocommissioning	30,590	2,469

Spreadsheet Calculation: Solar Domestic Hot Water

RETScreen Tool				
Technology		**Solar water heater**		
Load characteristics	**Unit**	**Base case**	**Proposed case**	
Load type		Office		
Number of units	Person	100		
Occupancy rate	%	80%		
Daily hot water use - estimated	gal/d	80		
Daily hot water use	gal/d	80	80	
Temperature	°F	130	130	
Operating days per week	d	7	7	
Supply temperature method		Formula		
Water temperature - minimum	°F	39.9	Detroit City Water	
Water temperature - maximum	°F	57.1	Detroit City Water	
Heating	million Btu	19.9	19.9	
Resource assessment				
Solar tracking mode		Fixed		
Slope	°	0.0		
Azimuth	°	0.0		
Solar water heater				
Type	Unglazed			
Manufacturer	Heliocol			
Model	HC-10			
Gross area per solar collector	ft²	10.37		
Aperture area per solar collector	ft²	10.37		
Fr (tau alpha) coefficient		0.87		
Wind correction for Fr (tau alpha)	s/ft			
Fr UL coefficient	(Btu/h)/ft²/°F	3.75		
Wind correction for Fr UL	(Btu/ft³)/°F			
Number of collectors		17		
Solar collector area	ft²	177.62		
Cost	$	$ 3,000		
Capacity	kW	11.46		
Miscellaneous losses	%			
Balance of system & miscellaneous				
Storage		Yes		
Storage capacity / solar collector area	gal/ft²	1		
Storage capacity	gal			
Heat exchanger	yes/no	Yes		
Heat exchanger efficiency	%	60.0%		
Miscellaneous losses	%	10.0%		
Pump power / solar collector area	W/ft²	0.10		
Electricity rate	$/kWh	0.076		
Summary				
Electricity - pump	MWh	0.0		
Heating delivered	million Btu	15.9		
Solar fraction	%	80%		
Heating system		**Base case**	**Proposed case**	**Proposed Savings**
Fuel type		Natural gas - therm	Natural gas - therm	Natural gas - therm
Seasonal efficiency		75%	75%	
Fuel consumption - annual	therm	274.0	55.0	219.0

PV Watts Online Calculator Output: Solar Power Generation

PV Watts AC Energy & Cost Savings

Station Identification			Results		
			Month	Solar Radiation	AC Energy
City:	Detroit				
State:	Michigan			(kWh/m^2/day)	(kWh)
Latitude:	42.42° N		1	2.9	5084
Longitude:	83.02° W		2	3.59	5616
Elevation:	191 m		3	4.13	6887
PV System Specifications			4	4.84	7642
DC Rating:	70kW		5	5.52	8617
DC to AC Derate Factor:	0.77		6	5.58	8167
AC Rating:	53.9kW		7	5.42	8026
Array Type:	Fixed Tilt		8	5.48	8361
Array Tilt:	42.2°		9	5.18	7774
Array Azimuth:	180.0°		10	3.96	6378
			11	2.59	4025
			12	2.15	3647
			Year	4.28	80225

APPENDIX B

Photographs

Appendix B – Photographs

Photo 1: Jim Arends, Redhorse Corporation CEM, reading AHU nameplates during FEMP audit site visit, December 2009.

Photo 2: Jim Arends, Redhorse Corporation CEM, and Doug McKay, contract operator, inspecting rooftop unit during FEMP audit site visit, December 2009.

Photo 3: Open areas on both CIF and Broker building roofs showing available space for solar panel or wind turbine installations, December 2009.

Photo 4: Air conditioning unit on roof with customs booths in background, December 2009.

Photo 5: Cargo bays, unit heater, and high pressure sodium lights, December 2009.

Photo 6: Rainwater cistern at CIF, December 2009.