U.S. DEPARTMENT OF ENERGY

PNNL-19668

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

American Recovery and Reinvestment Act Federal Energy Management Program Technical Assistance Project 184

U.S. Customs and Border Protection Data Center, Springfield, Virginia

J Arends
WF Sandusky

September 2010

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Pacific Northwest National Laboratory
Richland, Washington 99352

Executive Summary

This report documents the findings of an on-site energy audit of the U.S. Customs and Border Protection (CBP) Data Center in Springfield, Virginia. The landlord for this building is Boston Properties, and the facility is leased by CBP. The focus of the audit was to identify various no-cost and low-cost energy efficiency opportunities that, once implemented, would reduce electricity and natural 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 natural gas) and water savings to further increase the operational efficiency of the building.

The audit identified three energy conservation measures (ECMs) and three water conservation measures that could be implemented immediately along with two capital project ECMs, resulting in a total estimated savings of 7,537 million British thermal units (MMBtu) of electrical and thermal energy that in turn would result in an annual cost savings of $163,032. The estimated cost to implement the measures is $570,820, and the payback time for the investment would be 3.5 years.

Two renewable energy projects were identified related to use of the available solar resource. These projects would save an estimated additional 354 MMBtu of energy, resulting in a cost savings of $7,248 annually. At this point, these capital measures are not cost-effective and would not be recommended unless they are required for increasing the amount of on-site power generation from renewable resources.

Implementation of the no-cost and low-cost measures would decrease greenhouse gas (GHG) emissions to the atmosphere as well as create job opportunities. It was estimated that 1,479 metric tons of GHG emissions to the atmosphere would be avoided and 6.2 jobs would be created for the five no-cost and low-cost measures and two capital project ECMs. If the renewable energy projects were implemented, 7.7 jobs would be created and 65 metric tons of GHG emissions to the atmosphere would be avoided.

If the CBP needs assistance with securing alternative financing for any identified capital projects, they are strongly encouraged to contact the Federal Energy Management Program (FEMP) Federal Financing Specialist (FSS) for their region. For this site, the designated FSS is Tom Hattery. His contact information is Thomas.hattery@ee.doe.gov or (202) 256-5986.

List of 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
CDD	Cooling degree days
CF	Cubic feet (ft^3)
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	U.S. Environmental Protection Agency
EPAct	Energy Policy Act
EUI	Energy Use Intensity
ft^2	Square feet
FEMP	Federal Energy Management Program
FSS	Federal Financing Specialist
GSA	General Services Administration
HDD	Heating degree days
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
PUE	Power utilization efficiency
PV	Photovoltaic
Retro-CX	Retro-commissioning
RTU	Rooftop unit
SHW	Solar domestic hot water
SPV	Solar photovoltaic
USCBP	United States Customs and Border Protection
UV	Ultraviolet
VAV	Variable air volume
Yr	year

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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. To advance that goal and help accelerate agencies' progress, FEMP works to foster collaboration between its Federal agency customers and the U.S. Department of Energy (DOE) national laboratories.

In 2009 and 2010, FEMP has utilized funding from the American Recovery and Reinvestment Act of 2009 (ARRA) to facilitate Federal agency access to the broad range of capabilities expertise at the National Laboratories. Funds were directed to the Laboratories to assist agencies in making their internal management decisions for investments in energy efficiency and deployment of renewable energy sources, with particular emphasis on assisting with the mandates of the Energy Independence and Security Act of 2007 related to Federal facilities and fleets.

FEMP provided major DOE laboratories with funding that will allow them to respond quickly to provide technical advice and assistance. FEMP applied a simple vetting and approval system to quickly allocate work to each of the laboratories in accordance with FEMP allocated funding. All assistance provided by the laboratories was in accordance with the requirements of Federal Acquisition Regulation (FAR) Subpart 35.017 and the laboratories' designation as "Federal Funded Research and Development Center" (FFRDC) facilities.

CBP submitted a request for an energy audit conducted at a laboratory building and a data center building in Springfield, Virginia, and a laboratory building in Houston, Texas, with the goal of identifying ECMs that could be implemented in a timely manner. This request was selected by FEMP and designated as Project 184.

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 CBP Data Center is located at 7681 Boston Boulevard, Springfield, Virginia. The two-story building of 114,028 square feet (ft^2) was originally constructed in 1985. The building is owned by Boston Properties and has been leased by CBP since its construction. The building was originally constructed as a combination office and warehouse. CBP converted the warehouse area into a data center with raised computer room floors.

Major upgrades planned in the near future include replacing T-12 lighting and adding emergency power generators. Figure 1 is an aerial photograph of the data center building.

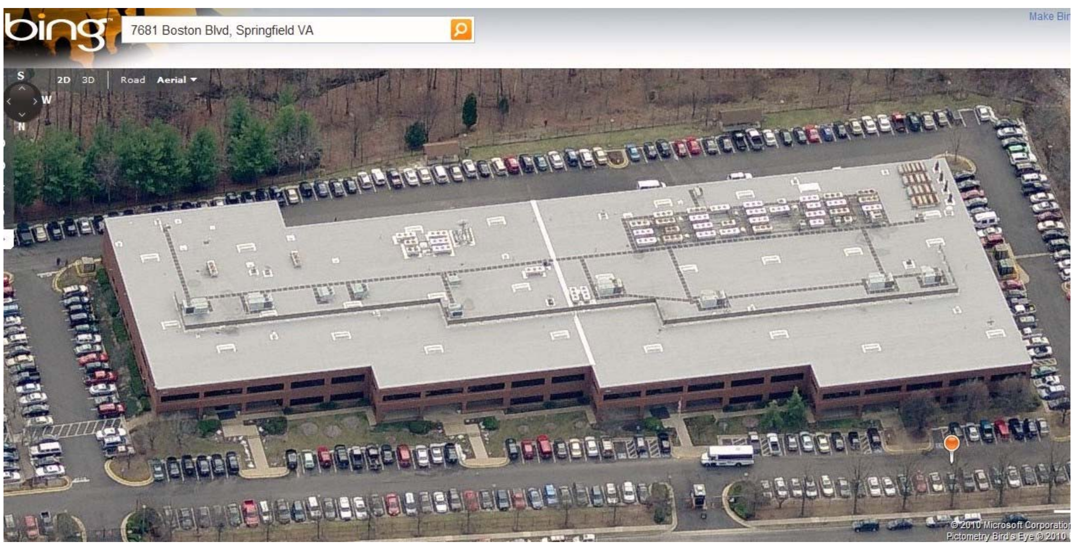

Figure 1. U.S. Customs and Border Protection Data Center in Springfield Virginia

2.2 Major Building Energy Uses

AIR HANDLING SYSTEMS

The building office area is heated and cooled by nine rooftop air handling unit (AHU) systems equipped with natural gas heating and direct expansion (DX) cooling. AHU systems operate continuously because the building is occupied at all times, with a 10% decrease in occupancy at night. These rooftop units

(RTUs) have variable frequency drives that control both supply and return fans. Outside air is tempered in each of the air handlers by natural gas in the winter and by DX cooling coils in the summer. The AHUs deliver 55°F supply air via ductwork to the building terminal boxes. No humidification is provided in the AHUs.

TERMINAL UNIT DISTRIBUTION BOXES

The perimeter zones of the building are served by variable air volume (VAV) terminal boxes equipped with electric resistance reheat elements. 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 electric resistance heating elements reheat the supply air to maintain space temperatures. No simultaneous heating and cooling is permitted.

The core zones of the building office area are also served by VAV terminal boxes. However, these VAV terminal boxes do not have reheat capability. 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.

DATA ROOM HVAC SYSTEMS

The data center area of the building is heated and cooled by computer room air conditioning (AC) units using DX cooling and electric resistance heating.

OFFICE AREAS

Office equipment and lighting make up the electrical loads in the office areas of the building.

2.3 Climate, Facility Type, and Operations

The climate for the site is considered humid subtropical. Based on data available for Washington, D.C. from the National Climatic Data Center, the maximum mean monthly temperature occurs in July (87.4°F), with the minimum mean monthly temperature occurring in January (21.9°F). The highest recorded temperature during the period from 1971 through 2000 was 104°F on two occasions, while the lowest reported temperature during the period was -18°F on January 22, 1984. Based on the most recent mean data available (1971-2000), the site should experience 29.9 days with a maximum temperature exceeding or equal to 90°F, while the minimum temperature should be at 32°F or below for

112.5 days. Annually, the site should anticipate 4,925 heating-degree-days (HDD) and 1,075 cooling-degree-days (CDD).

Mean annual precipitation for the site is 41.8 inches. The highest daily reported precipitation was 10.67 inches on June 21, 1972. The highest reported monthly precipitation, 18.19 inches, occurred in June 1972. The daily precipitation should be at or greater than 0.01 inch for 120.1 days during the year. Mean annual snowfall for the site is 21.2 inches, but the highest monthly snowfall was reported in January 1996 (30.9 inches). The highest daily snow fall was 22.5 inches on February 11, 1983.

3.0 Energy Use

The building includes a data center and office space. The building is occupied continuously, although staffing levels vary during the night with an occupancy decrease of 10%. The electrical usage is metered by Dominion Virginia Power. Four electric meters serve the data center building. One natural gas meter is served by Washington Gas.

3.1 Current Electricity, Gas, and Water Use

The following figures (Figures 2 and 3) represent the energy usage for the 2009 calendar year for the data center building. The electric utility account numbers are 5526226120, 2196340000, 2601143783, and 5916297509 and the gas utility account number is 3959706213. No water data were provided.

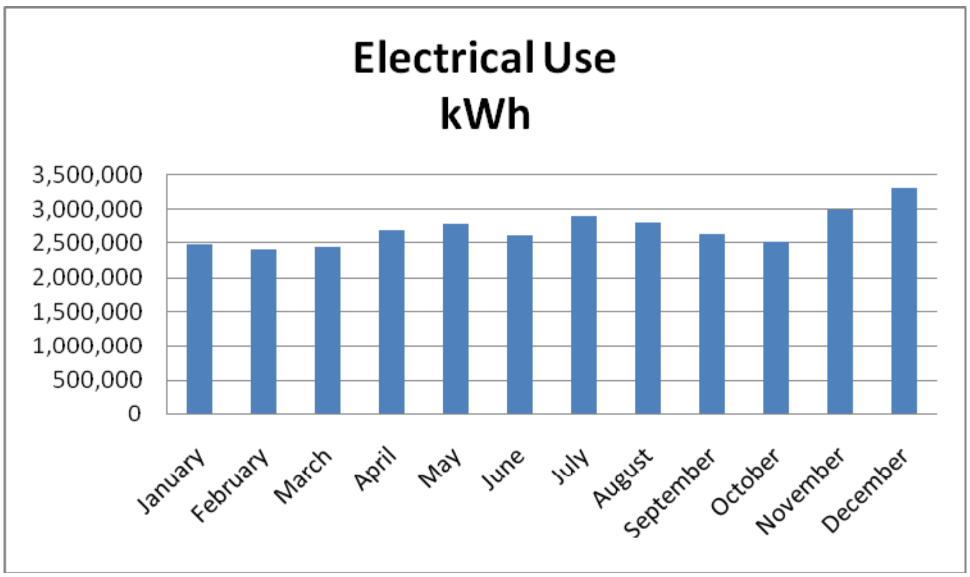

Figure 2. U.S. Customs and Border Protection Data Center Electrical Use

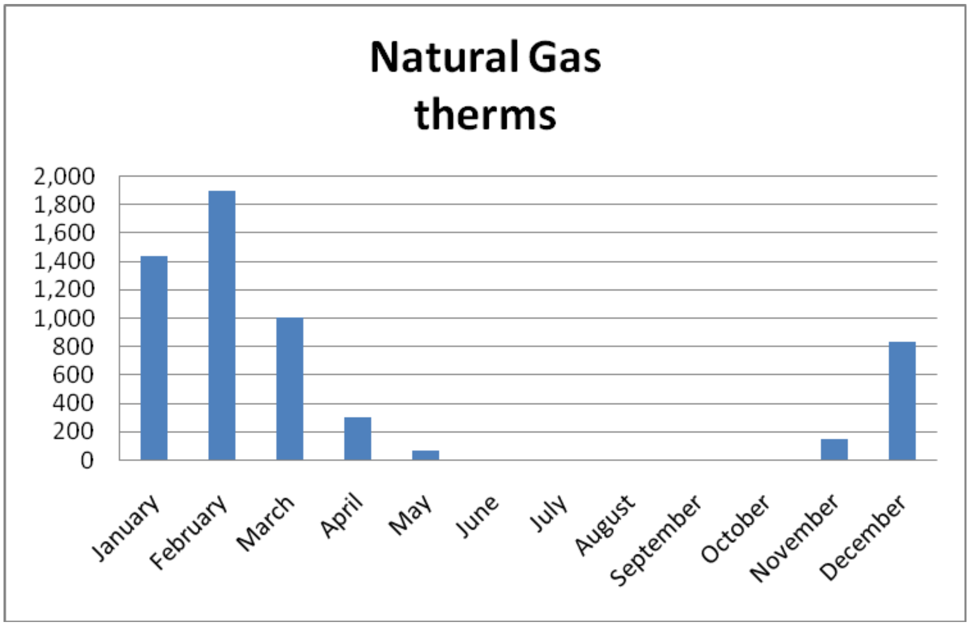

Figure 3. U.S. Customs and Border Protection Data Center Natural Gas Use

3.2 Current Rate Structure

Dominion Virginia Power provides electric service under a commercial service rate. The current rate schedule is GS-3, a large general service secondary voltage tariff, which is a rate available for general service business customers with maximum demand that exceeds 500 kilowatts (kW) during three billing cycles. CBP currently pays an average of $0.0752 per kilowatt hour (kWh) based on 2009 utility bills. Natural gas is provided to the site by Washington Gas. CBP pays an average of $1.1357 per therm based on 2009 utility bills.

Fairfax Water provides water under a commercial service rate. No water data was provided for the site; therefore, a rate of $0.008 per gallon (typical for local utilities) was used to estimate water savings ECMs.

4.0 Energy Conservation Measures Identified

4.1 Summary of Proposed Measures

ECMs 1 and 2 were identified and recommended for immediate implementation requiring minor controls programming. 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:

(1) Data room space temperature setpoint increase
(2) Office AHU supply air temperature reset

Table 1: U.S. CBP Data Center Recommended Energy Conservation Measures (ECMs)

ECM #	Energy Saving Recommendations	Electrical Savings (kWh)	Natural Gas Savings (Therms)	Energy Savings (Millions of BTUs)	Water Savings (Gallons)	Electrical Savings ($)	Natural Gas Savings ($)	Water Savings ($)	Total Annual Savings ($)	Cost to Implement ($)	Simple Payback (Years)
1	Increase Data Space Temperature	50,000	0	171		$ 3,758	$ -		$ 3,758	$ 1,200	0.3
2	Supply Air Temperature Reset	30,000	1,693	272		$ 2,255	$ 1,921		$ 4,176	$ 900	0.2
3	DCV CO2 Sensor	10,000	2,683	302		$ 752	$ 3,045		$ 3,796	$ 5,000	1.3
4	No Touch Faucets		200		62,400	$ -	$ 227	$ 499	$ 726	$ 2,640	3.6
5	No Touch Urinal Valves				31,200	$ -	$ -	$ 250	$ 250	$ 5,424	21.7
6	No Touch Toilet Valves				93,184	$ -	$ -	$ 745	$ 745	$ 8,136	10.9
7	Insulation Data Ceiling	10,000	0	34		$ 752	$ -		$ 752	$ 47,520	63.2
8	Upgrade Old Data Center AC	1,980,000	0	6,758		$ 148,828	$ -		$ 148,828	$ 500,000	3.4
	Total (Non-interactive)	**2,080,000**	**4,577**	**7,537**	**186,784**	**$ 156,345**	**$ 5,193**	**$ 8,552**	**$ 163,032**	**$ 570,820**	**3.5**
	Percent Savings (Non-interactive)	**7%**	**80%**	**8%**							
				Renewable Energy Projects							
9	Solar Domestic Hot Water		518	52		$ -	$ 588		$ 588	$ 9,588	16.3
10	Solar Power Generation (70 kW)	88,609		302		$ 6,660	$ -		$ 6,660	$ 700,000	105.1
	Total Renewable Energy	**88,609**	**518**	**354**		**$ 6,660**	**$ 588**		**$ 7,248**	**$ 709,588**	**97.9**
				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					**0.0752**	**1.1347**	**0.0080**			
	eQUEST Baseline 2009	28,390,000	5,736	97,469	NA	$2,133,953	$ 6,508	NA	NA	$2,140,462	
	eQUEST / Actual Use Ratio	**100.3%**	**100.8%**	**100.3%**	Modeling estimates should fall within 5% of actual usage.						
	Design Baseline Estimate	28,310,760	5,689	97,193		$2,127,997	$ 6,455	NA	NA	$2,134,452	
	Design Energy Use Intensity (EUI) - (BTU/SF-YR)	847,376	4,989	852,365							

The following options were also evaluated:

(1) Demand control ventilation (DCV) with CO_2 sensors
(2) No touch water faucets
(3) No touch toilets
(4) No touch urinals
(5) Replace ceiling tiles over old data center with insulated tiles
(6) Convert part of first-floor office to data center space and upgrade the old data room AC units
(7) Solar power generation
(8) Solar domestic water heating.

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:

(1) Lighting upgrades from T-12 to T-8 with occupancy controls
(2) Upgrade office area building automation system (BAS)
(3) Recover heat rejection from DX units (for domestic hot water or office heating)
(4) Rainwater catch basin for irrigation
(5) Economizer solutions to cool the computer room areas.

ECM1 – Data Center Space Temperature Setting Increase

The current temperature setpoint in the data center is 70°F. Significant energy savings can be realized if the setpoint is adjusted up to 75°F. Data centers across the country have decreased their energy consumption by operating at this higher setpoint. Operating parameters for the data center equipment changed in recent years, and the acceptable space temperature setpoint is now at 75°F. Manufacturers of new data processing equipment are now recommending this higher setpoint, and the data center operators at this site were aware of the new recommendations for higher space temperatures. The operators will be gradually increasing the setpoint to reach the new recommended level. An eQUEST energy model was performed (Appendix A), and the estimated annual energy savings are summarized in Table 1.

ECM2 – Supply Air Reset

The supply air temperature for a single-duct VAV system is usually set at a constant 55°F. This setpoint is used in the design of air handling systems to calculate the maximum air flow to satisfy the maximum cooling load conditions. If the setpoint is left at 55°F, significant reheat will occur in the winter when air flows reach their minimums and the heating load increases. The system is in a heating mode, and the supply air temperature is often reset upward to minimize simultaneous cooling and heating. The reset schedule can be based on either return air temperature or outside air temperature. Resetting the supply air temperature not only affects the cooling and heating energy consumption, but also the fan power consumption. If the supply air is reset too high, it may result in a fan power consumption penalty.

An eQUEST energy model was performed (Appendix A), and the estimated annual energy savings are summarized in Table 1. The energy efficiency measure wizard option for supply air reset (55/65°F) based on zone loads was used for these estimates.

Air handling systems that serve both the core areas of the building and the perimeter areas of the building have limited opportunities to use supply air reset control strategies. This limitation is most evident in the winter, when the perimeter zones are in heating and the core areas of the building continue to require cooling. If the supply air temperature is reset upwards, the core area VAV terminal boxes will increase air flows to maintain space temperature. This increase in air flow will cause an increase in fan energy. For a net energy savings, this increase in fan energy use would have to be offset by the energy savings in the perimeter zones that would require less reheating at the terminal boxes. The optimal supply air temperature needs to take into account the thermal and electrical energy costs to achieve the minimum total operating costs. Generally, the amount of reset is limited by the percent of building area included in the core areas of the building; perimeter areas are affected by the weather and present greater opportunities for temperature reset. Significant energy saving opportunities can be gained if the building perimeter and core zones are served by separate VAV air handling systems.

During the winter, occupants of the building will complain about cold drafty air flows from a VAV system if the supply air temperature is left at 55°F. These complaints are justified because the VAV boxes throttle back to minimum flows in the winter during heating and the supply air diffusers do not distribute the air as effectively with low air flow velocities. This cold air tends to drop down around the occupants, and many complaints will be registered with the operations staff. Resetting the supply air upwards will reduce comfort complaints. The most common supply air reset schedules vary the supply temperature between 55°F and 65°F.

ECM3 – Demand Controlled Ventilation (DCV) Using Carbon Dioxide (CO_2) Sensors

American Society of Heating, Refrigerating & Air Conditioning Engineers (ASHRAE) recommends a ventilation rate of 15 to 20 cubic feet per minute (cfm) per person in ASHRAE Standard 62.1-2007 (2007) to ensure adequate air quality in buildings. To meet the standard, many ventilation systems are designed to admit air at the maximum level whenever a building is occupied, as if every area were always at full occupancy. The result, in many cases, has been buildings that are highly over-ventilated. The development of CO_2-based DCV was driven in part by the need to satisfy ASHRAE 62 without over-ventilating.

When CO_2 sensors are used to maintain indoor air quality (IAQ), they continuously monitor the air in a conditioned space. The difference between the indoor CO_2 concentration and the outdoor concentration indicates the occupancy or activity level in a space and thus its ventilation requirements because people constantly exhale CO_2. An indoor/outdoor CO_2 differential of 700 parts per million (ppm) is usually assumed to indicate a ventilation rate of 15 cfm/person; a differential of 500 ppm indicates a 20 cfm/person ventilation rate. The CO_2 sensor readings are monitored at the air handling system control panel, which automatically increases ventilation when the CO_2 concentration in a zone rises above a specified level.

The highest payback can be expected in high-density spaces, where occupancy is variable and unpredictable (such as auditoriums, some school buildings, meeting areas, and retail establishments), in locations with high heating or cooling demand (or both), and in areas with high utility rates. Case studies cited in a Federal Technology Alert published by DOE (2004) show DCV offers greater savings for heating than for cooling. In areas where peak power demand and peak prices are an issue, DCV can be used to control loads in response to real-time prices. DCV may result in significant cost savings even with little or no energy savings in those locations. Energy savings can be as high as 10%. The potential energy cost savings for a CO_2-based DCV is estimated to range from \$0.05 to more than \$1 per ft^2 annually.

The reliability of CO_2 sensors has improved in recent years, and they should be considered for use in the modern energy-efficient office. An eQUEST energy model was performed (Appendix A), and the estimated annual energy savings are summarized in Table 1.

ECM4, 5 and 6 – No Touch Faucets, Toilets, and Urinals

No touch solar (instead of battery) operated sink faucets have 0.25 gallon per cycle operation, and they also promote sanitary conditions in the bathroom. No touch toilets and urinals are always flushed, odor-free, and presentable. An infrared sensor and solenoid valves activate water flow and eliminate cross-contamination from touching fixture handles, which also helps to control the spread of infectious diseases. A 1.28 gallon per flush version for the toilet and a 0.5 gallon per flush version of the urinal flush valve are the recommended options to replace the existing 1.6 gallon per flush toilet valves and 1.0 gallon per flush urinal valves.

Automatic operation provides water usage savings over other manual devices and reduces operations and maintenance (O&M) costs. Water and energy savings were estimated (Appendix A), and the estimated savings are summarized in Table 1.

ECM7 – Insulated Ceiling Tiles In Data Room

The data center occupies what was formerly warehouse space, and the high ceilings of the old warehouse are far above the drop ceiling installed in the data center. The warehouse walls and ceilings are not insulated. Ceiling tiles with an R value of 11 could replace the existing ceiling tiles. An eQUEST energy model was performed (Appendix A), and the estimated annual energy savings are summarized in Table 1.

ECM8 – Convert First-Floor Office to Data Center Space and Upgrade Legacy Data Room AC Units

The energy efficiency of the old data center could be improved if additional building space were available to rearrange the data center loads and implement best practices for data center cooling. Currently, there are zones within the data center that have excessively high cooling requirements and the Liebert AC units in those areas are continuously running at full load, while the cooling loads are minimal in other areas of the data center. Additionally, racks for data equipment are partially filled. When racks are not fully loaded and cool air flows up through the racks without fully making use of the cooling capacity of the air, the overall impact on energy use increases because of the energy used to deliver the cool air.

Rack-mounted cooling units can also provide significant energy savings through several factors. The cooling units are located closer to the load, which results in less mixing of hot and cold air. The fans can be optimized for a very low total system static pressure because of the microchannel coils and the lack of pressure drop losses in ducts. Furthermore, computer room operators are also finding they do not need to overchill the data centers to eliminate the hot spots, as they must do with the raised-floor cooling only approach. They no longer need the cold aisle to be 62°F in some places to maintain the desired 75°F in other areas that experience the hot bypass air.

A new computer room area was recently completed, and the energy efficiency improvements listed above have been estimated from energy use readings reported by the data center operating staff. The overall power utilization efficiency (PUE) went from 2.0 for the legacy computer room to 1.12 in the new computer room. PUE is defined as the total power used in the computer room for lighting, AC, and data equipment divided by the power used by the data equipment.

To implement this measure, a portion of the first-floor office needs to be converted to data center space to make room to rearrange the old data center computer racks. In addition, extensive engineering assessment of loads and a design layout for the racks needs to be completed. In light of the extensive engineering required, a basic estimate of $500,000 was used for the evaluation. Once the engineering assessment has been completed, CBP can reevaluate the payback of this measure. An eQUEST energy model was performed (Appendix A), and the estimated annual energy savings are summarized in Table 1.

ECM9 – Solar Domestic Hot Water Heating

Domestic hot water is currently used in bathrooms and in the break area kitchens of the 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 (NRC 2010) energy modeling spreadsheets (Appendix A), and the estimated annual energy savings are summarized in Table 1.

ECM10 – Solar Power Generation

Open space on the rooftop areas of the building could be used to install photovoltaic (PV) panels to generate electricity. The space available is somewhat limited because of the presence of the RTUs, however. PV panels should not be sited in areas where the panels may be shaded. 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

ECM11 - Economizer Solutions

The computer room area of the building does not currently have a source of fresh outside air. ASHRAE Standard 62.1-2007 (2007) and local codes require outside air ventilation to all occupied spaces. The quantity required is based on the maximum number of people that might occupy the space, even if people are only temporarily in the space for maintenance or other reasons. Therefore, it is recommended that CBP work with a licensed mechanical engineer to properly assess and design a means for supplying fresh outside air to the computer room space. The air flow typically required is 20 cfm for each person in the space at maximum occupancy.

When outside air flow is provided to the space, there is an opportunity to take advantage of free cooling. Fluid and air-side economizers take advantage of cold outside temperatures to provide free cooling cycles that reduce or eliminate operation of data center cooling system compressors and condenser fans. Using economizers can lower cooling energy usage by between 20 and 60%, depending on the average ambient temperature and regional humidity conditions of the site.

Flexibility:

- Fluid-side and air-side economizer solutions are compatible with Liebert precision cooling systems in sizes from 3 to 60 tons.

- Both upflow and downflow configurations are available to cover raised floor and non-raised applications.

ECM12 - Lighting Occupancy Sensors

Lighting in all office areas, conference rooms, and bathrooms could be managed by occupancy sensors. Lighting occupancy sensors could also be used to control occupied and unoccupied temperature setpoints.

ECM13 - Rainwater Catch Basin for Irrigation

Runoff water from the roof of the building could be collected in a water basin and reused to water grass and plants around the building. When runoff water is reused, it must be filtered to prevent plugging of sprinklers or drip irrigation nozzles.

5.0 Potential Greenhouse Gas Reductions

The proposed ECMs will reduce greenhouse 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 Greenhouse Gas Reductions for Each Proposed ECM
Reference: http://www.epa.gov/rdee/energy-resources/calculator.html

Table 2: Estimated Greenhouse Gas Reductions

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)	Total GHG Avoided (metric tons CO2e)
1	50,000	-	35.00	-	35.00
2	30,000	1,693.3	21.00	8.47	29.47
3	10,000	2,683.3	7.00	13.42	20.42
4	0	200.0	-	1.00	1.00
5	0	-	-	-	-
6	0	-	-	-	-
7	10,000	-	7.00	-	7.00
8	1,980,000	-	1,386.00	-	1,386.00
TOTALS	**2,080,000**	**4,577**	**1,456**	**23**	**1,479**
Estimated Greenhouse Gas Reductions (Renewable Energy Projects)					
9	0	518	-	2.6	2.6
10	88,609	0	62.0	0.0	62.0
TOTALS	**88,609**	**518**	**62**	**3**	**65**

To calculate jobs created and retained, one job for every $92,000 in funds expended was assumed. The baseline non-interactive energy and water efficiency retrofits ($570,820) will result in 6.2 jobs created and 1,479 metric tons of CO_2e emissions avoided. If the proposed renewable energy projects are implemented, the estimated investment would be $709,588. This amount would result in 7.7 jobs created and 65 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.
- Complete retro-commissioning of the building 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 and low-cost recommendations. To implement these measures, CBP can request a proposal to implement the measures from the operations contractor.

Upgrading the AC systems of the old laboratory will require conversion of some of the first-floor office areas and rearranging the data racks to install rack-mounted AC systems.

Installing solar domestic hot water heating or power generation systems are capital projects that require an engineering consultant to begin project development. The owner of the building will have to agree to installation of the solar systems if incentives or rebates from the state or the utility are used because they involve multiyear operating requirements.

Recommended resources for CBP building operations staff:

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

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

6.2 Funding Assistance Available

Dominion Power of Virginia and Washington Gas are the serving utilities for the CBP facilities. Incentives may be available from Dominion via the commercial customer incentive program. All business (non-residential) customers in Dominion's service territory are eligible to participate in a prescriptive rebate program that applies to energy-efficient lighting and heating, ventilation, and air conditioning (HVAC) technologies. Customers will receive a financial incentive payment based on the rebate program's itemized lists at the time of application. For example, replacing T-12 lamps with more efficient T-8 lamps will result in a $6.00/fixture rebate incentive. Similarly, installing a new, energy-efficient air-cooled chiller (1.008 kW/ton) yields incentive funds of $17/ton. The rebate program is available until fully subscribed, and rebate amounts are subject to regulatory modifications without notice. Additionally, an application and coordination with the utility for an inspection is required before installation. Projects must be completed (and probably inspected) before rebates will be paid.

Unfortunately, renewable energy incentives are limited in the State of Virginia relative to other neighboring state's grant, utility, and tax incentive programs. Currently, neither the State of Virginia nor Dominion Power offers any direct incentives for renewable technologies such as solar photovoltaic (PV), solar thermal hot water, wind power, or daylighting; however, there is a possibility of case-by-case incentives for these technologies. Projects that contain bundled demand-side management capability and energy savings could be of interest with a local utility company. Thus, a utility energy service contract (UESC) could be pursued to arrange various energy savings initiatives such as efficient lighting and air conditioning and bundled with a renewable initiative such as solar PV. Incentives for the entire project could be evaluated based on the total planned energy and demand savings.

In addition, Virginia enacted legislation (H.B. 1416) in April 2007 that includes a provision that electricity customers in Virginia have the option to purchase 100% renewable energy from their utility. Dominion Power offers this service; however, customers are also permitted to purchase green power from any licensed retail supplier. For information about the green power utilities and suppliers in Virginia, see the Department of Energy (DOE), Energy Efficiency and Renewable Energy Green Power Network website.

Federal energy projects can be funded or financed by various means. Energy projects can be funded with appropriated funding if the resulting payback period is acceptable to the agency. If no appropriated funding is available, an alternative approach for Federal projects is to pursue financing from a utility (UESC) or energy services company (ESCO) via an energy savings performance contract (ESPC). Both the UESC and ESPC methods enable a customer to finance the construction costs of the project with the savings that will take place after installation. For more information on these programs, please visit the DOE FEMP website.

7.0 Assessment Team Members and Site Team

The Redhorse ARRA assessment team for the audit included Jim Arends, PE, CEM, Energy Audit Team Technical Lead; Mike Savena, PE, Energy Audit Team Member; and Hani Geeso, CEM, Energy Audit Team Member. Site support was provided by Charlie Watts, CBP Operations and Maintenance; Vim Kumar, CBP Data Center Infrastructure Management; and Pat Harrington, CBP Conservation & Energy. Additional interviews were conducted with Walter H. Horn, AMDEX Corporation Environmental Support Supervisor, and Luis Salazar, Boston Properties, Lead Engineer Property Management (contract operators). William Sandusky, PNNL Program Manager, provided technical review of the report.

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American Society of Heating, Refrigerating and Air- Conditioning Engineers (ASHRAE). 2007. *ANSI/ASHRAE Standard 62-2007, Ventilation for Acceptable Indoor Air Quality. ASHRAE. Atlanta, Georgia.*

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APPENDIX A

eQUEST Modeling Results and Spreadsheet Calculations

APPENDIX A – eQUEST Modeling Results and Spreadsheet Calculations

Energy modeling developed for the annual energy savings estimates were developed in eQUEST version 3.63b. The schematic design model was used to develop the building footprint and input basic building systems. Basic model inputs include: 24 hours a day operation for 7 days a week.

Baseline eQUEST Model Results

eQUEST Model Results Baseline Use													
Electric Consumption (kWh x000,000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.48	0.45	0.52	0.54	0.55	0.61	0.65	0.63	0.58	0.54	0.48	0.51	6.54
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	0.09	0.08	0.09	0.09	0.09	0.09	0.1	0.1	0.09	0.09	0.09	0.09	1.12
Pumps & Aux.	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0.02
Misc. Equip.	1.62	1.52	1.73	1.72	1.62	1.72	1.73	1.68	1.66	1.68	1.55	1.73	19.97
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.74
Total	2.26	2.11	2.42	2.42	2.33	2.48	2.54	2.47	2.4	2.38	2.18	2.41	28.39
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	139.91	78.59	51.39	19.07	5.59	0	0	0	1.07	10.24	35.01	59.55	400.42
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	15.43	14.99	17.22	16.76	14.57	14.46	13.52	12.51	12.35	12.98	12.79	15.58	173.15
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	155.34	93.58	68.61	35.84	20.16	14.46	13.52	12.51	13.42	23.22	47.8	75.13	573.57

Data Center Temperature Setpoint Increase Model Results

eQUEST Model Results Data Center Space Temperature Increase to 75 Deg F													
Electric Consumption (kWh x000,000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.48	0.45	0.52	0.54	0.54	0.6	0.65	0.62	0.58	0.54	0.47	0.51	6.49
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	0.09	0.08	0.09	0.09	0.09	0.09	0.1	0.1	0.09	0.09	0.09	0.09	1.12
Pumps & Aux.	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0.02
Misc. Equip.	1.62	1.52	1.73	1.72	1.62	1.72	1.73	1.68	1.66	1.68	1.55	1.73	19.97
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.74
Total	2.26	2.11	2.41	2.41	2.32	2.48	2.54	2.46	2.4	2.37	2.18	2.4	28.34
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	139.91	78.59	51.39	19.07	5.59	0	0	0	1.07	10.24	35.01	59.55	400.42
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	15.43	14.99	17.22	16.76	14.57	14.46	13.52	12.51	12.35	12.98	12.79	15.58	173.15
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	155.34	93.58	68.61	35.84	20.16	14.46	13.52	12.51	13.42	23.22	47.8	75.13	573.57

AHU Supply Temperature Reset Model Results

eQUEST Model Results Supply Air Reset													
Electric Consumption (kWh x000,000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.48	0.45	0.52	0.54	0.54	0.6	0.65	0.62	0.58	0.53	0.47	0.51	6.49
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	0.09	0.09	0.1	0.09	0.1	0.09	0.1	0.1	0.09	0.1	0.09	0.09	1.13
Pumps & Aux.	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0.02
Misc. Equip.	1.62	1.52	1.73	1.72	1.62	1.72	1.73	1.68	1.66	1.68	1.55	1.73	19.97
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.74
Total	2.26	2.11	2.42	2.41	2.32	2.48	2.55	2.47	2.4	2.37	2.17	2.41	28.36
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	113.28	53.14	21.33	1.3	0	0	0	0	0	0.15	10.36	31.84	231.41
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	15.4	14.96	17.19	16.73	14.54	14.44	13.52	12.5	12.33	12.94	12.76	15.54	172.84
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	128.68	68.1	38.52	18.03	14.54	14.44	13.52	12.5	12.33	13.09	23.12	47.38	404.24

Demand Control Ventilation Model Results

eQUEST Model Results DCV CO2													
Electric Consumption (kWh x000,000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.48	0.45	0.52	0.54	0.55	0.6	0.65	0.62	0.58	0.54	0.48	0.51	6.53
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	0.09	0.08	0.09	0.09	0.09	0.09	0.1	0.1	0.09	0.09	0.09	0.09	1.12
Pumps & Aux.	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0.02
Misc. Equip.	1.62	1.52	1.73	1.72	1.62	1.72	1.73	1.68	1.66	1.68	1.55	1.73	19.97
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.74
Total	2.26	2.11	2.42	2.42	2.33	2.48	2.54	2.46	2.4	2.38	2.18	2.41	28.38
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	84.71	26.32	4.36	0.78	0	0	0	0	0	0.15	2.15	14.11	132.58
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	15.37	14.93	17.16	16.72	14.53	14.43	13.51	12.49	12.33	12.94	12.73	15.51	172.66
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	100.09	41.26	21.52	17.49	14.53	14.43	13.51	12.49	12.33	13.09	14.88	29.63	305.24

Insulate Old Data Center Ceiling Tiles Model Results

eQUEST Model Results: Ceiling Tile Insulation													
Electric Consumption (kWh x000,000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.48	0.45	0.52	0.54	0.55	0.61	0.65	0.63	0.58	0.54	0.48	0.51	6.54
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	0.09	0.08	0.09	0.09	0.09	0.09	0.1	0.1	0.09	0.09	0.09	0.09	1.11
Pumps & Aux.	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0.02
Misc. Equip.	1.62	1.52	1.73	1.72	1.62	1.72	1.73	1.68	1.66	1.68	1.55	1.73	19.97
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.74
Total	2.26	2.11	2.42	2.42	2.33	2.48	2.54	2.47	2.4	2.38	2.18	2.41	28.38
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	139.91	78.59	51.39	19.07	5.59	0	0	0	1.07	10.24	35.01	59.55	400.42
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	15.43	14.99	17.22	16.76	14.57	14.46	13.52	12.51	12.35	12.98	12.79	15.58	173.15
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	155.34	93.58	68.61	35.84	20.16	14.46	13.52	12.51	13.42	23.22	47.8	75.13	573.57

Upgrade Old Data Space AC Model Results

eQUEST Model Results: Data Center AC Upgrade													
Electric Consumption (kWh x000,000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.33	0.31	0.36	0.38	0.38	0.43	0.46	0.44	0.41	0.38	0.33	0.35	4.56
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	0.09	0.08	0.09	0.09	0.09	0.09	0.1	0.1	0.09	0.09	0.09	0.09	1.12
Pumps & Aux.	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0.02
Misc. Equip.	1.62	1.52	1.73	1.72	1.62	1.72	1.73	1.68	1.66	1.68	1.55	1.73	19.97
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.74
Total	2.11	1.97	2.25	2.25	2.16	2.3	2.36	2.29	2.23	2.21	2.03	2.24	26.41
Gas Consumption (Btu x000,000,000)													
	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	139.91	78.59	51.39	19.07	5.59	0	0	0	1.07	10.24	35.01	59.55	400.42
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	15.43	14.99	17.22	16.76	14.57	14.46	13.52	12.51	12.35	12.98	12.79	15.58	173.15
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	155.34	93.58	68.61	35.84	20.16	14.46	13.52	12.51	13.42	23.22	47.8	75.13	573.57

No Touch Faucets Model Results

U.S. Department of Energy - Energy Efficiency and Renewable Energy

Federal Energy Management Program

Energy Cost Calculator for Faucets and Showerheads

http://www1.eere.energy.gov/femp/technologies/printable_versions/eep_faucets_showerheads_calc.html#output

Vary utility cost, hours of operation, and /or efficiency level.

INPUT SECTION			
Input the following data (if any parameter is missing, calculator will set to the default value).		*Defaults*	
Water Saving Product	Faucet	*Faucet*	*Showerhead*
Flow Rate	2.2	*2.2 gpm*	*2.5 gpm*
Water Cost (including waste water charges)	8 $/1000 gal	*$4/1000 gal*	*$4/1000 gal*
Gas Cost	1.1347 $/therm	*0.60 $/therm*	*0.60 $/therm*
Electricity Cost	0.0752	*0.06 $/kWh*	*0.06 $/kWh*
Minutes per Day of Operation	30 minutes	*30 minutes*	*20 minutes*
Days per Year of Operation	260 days	*260 days*	*365 days*
Quantity to be Purchased	8 unit(s)	*1 unit*	*1 unit*

Reset

OUTPUT SECTION					
Faucet **Performance per**	**Your Choice**	**Base Model**	**FEMP Recommended Level**	**Best Available**	**Self Closing Faucet (gallon per cycle)**
WATER USE ONLY					
Gallon per Minute	2.2 gpm	2.2	2	1.5	0.25
Annual Water Use	17160 gal	17160	15600	11700	3900
Annual Water Cost	137 $	137 $	125 $	94 $	31 $
Lifetime Water Cost	1151 $	1151 $	1050 $	790 $	260 $
8	0	0	1232	4344	10664
Annual Energy Use	54 therms	54	49	37	12

No Touch Toilets Model Results

Toilet Water Use					
Number of toilets		**12**			
Number of people		**400**			
Flushes/person/day		**2**	Use 5 for residential, 2 for office use		
Days used per week		**7**	7 for residential, 5 for office		
Existing single flush volume (US gal)		**1.6**	Generally 5, 3.5 or 1.6 gal/flush		
Water Consumption Calculations					
		Single Flush Toilets		No Touch Toilets	
Flush Volume	gal	1.6		1.28	
Flushes per day	#	800		800	
Water use per day	gal	1280		1024	
Water use per toilet per day	gal	106.7		85.3	
Water use per year	gal	465920		372736	
Daily water use reduction				**256.0**	**gal/day**
Annual Water use reduction				**93184**	**gal/yr**

No Touch Urinals Model Results

U.S. Department of Energy - Energy Efficiency and Renewable Energy				
Federal Energy Management Program				
Energy Cost Calculator for Urinals				
http://www1.eere.energy.gov/femp/technologies/printable_versions/eep_toilets_urinals_calc.html#output				
Vary water cost, frequency of operation, and /or efficiency level.				
INPUT SECTION				
This calculator assumes that early replacement of a urinal or toilet will take place with 10 years of life remaining for existing fixture.				
Input the following data (if any parameter is missing, calculator will set to default value).			*Defaults*	
Water Saving Product	Urinal		*Urinal*	
Gallons per Flush	.5 gpf		*1.0 gpf*	
Quantity to be Purchased	8		*1*	
Water Cost (including waste water charges)	4 $/1000 gal		*$4/1000 gal*	
Flushes per Day	30 flushes		*30 flushes*	
Days per Year	260 days		*260 days*	
Reset				
OUTPUT SECTION				
urinal **Performance per**	**Your Choice**	**Typical Existing Unit**	**Recommended Level (New Unit)**	**Best Available**
Gallon per Flush	.5 gpf	3	1	0
Annual Water Use	3900 gal	23400	7800	0

Solar Domestic Hot Water Model Results

RETScreen Tool		www.retscreen.net		
Technology		Solar water heater		
Load characteristics	**Unit**	**Base case**	**Proposed case**	
Load type		Office		
Number of units	Person	400		
Occupancy rate	%	80%		
Daily hot water use - estimated	gal/d	321		
Daily hot water use	gal/d	300	300	
Temperature	°F	130	130	
Operating days per week	d	5	5	
Supply temperature method		Formula		
Water temperature - minimum	°F	49.9	Springfield City Water	
Water temperature - maximum	°F	64.4	Springfield City Water	
Heating	million Btu	47.4	47.4	
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		37		
Solar collector area	ft²	383.53		
Solar collector cost	$	$ 9,588		
Capacity	kW	0.67		
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		
Summary				
Electricity - pump	MWh	0.0		
Heating delivered	million Btu	38.8		
Solar fraction	%	82%		
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	632.7	114.7	518.0

Solar Power Generation Model Results

PV Watts AC Energy & Cost Savings

Station Identification	
City:	Richmond
State:	Virginia
Latitude:	37.50° N
Longitude:	77.33° W
Elevation:	50 m
PV System Specifications	
DC Rating:	70.0 kW
DC to AC Derate Factor:	0.77
AC Rating:	53.9 kW
Array Type:	Fixed Tilt
Array Tilt:	37.5°
Array Azimuth:	180.0°
Energy Specifications	
Cost of Electricity:	7.5 ¢/kWh

Results			
Month	Solar Radiation ($kWh/m^2/day$)	AC Energy (kWh)	Energy Value ($)
1	3.99	6715	504.97
2	4.37	6549	492.48
3	4.96	8064	606.41
4	5.32	7971	599.42
5	5.49	8403	631.91
6	5.54	7908	594.68
7	5.55	8143	612.35
8	5.31	7920	595.58
9	5.30	7686	577.99
10	4.65	7230	543.70
11	3.95	6208	466.84
12	3.51	5812	437.06
Year	4.83	88609	6663.40

APPENDIX B

Photographs

APPENDIX B - Photographs

Photo 1: Mike Savena, PE, Redhorse, Charlie Watts, CBP, Jim Arends, PE, CEM, Redhorse, and Dr. Pat Harrington, CBP, inspecting RTU during FEMP audit site visit, April 2010.

Photo 2: Dr. Pat Harrington and Charlie Watts, CBP, inspecting condenser units during FEMP energy audit site visit April 2010.

Photo 3: Condenser units on roof of data center building observed during FEMP energy audit site visit April 2010

Photo 4: Hani Geeso, CEM, Mike Savena, PE, and Jim Arends, PE, CEM, Redhorse reviewing O&M data during FEMP energy audit site visit, April 2010.

Photo 5: Jim Arends, PE, CEM, and Mike Savena, PE, Redhorse, inspecting close layout of condenser units during FEMP energy audit site visit, April 2010.

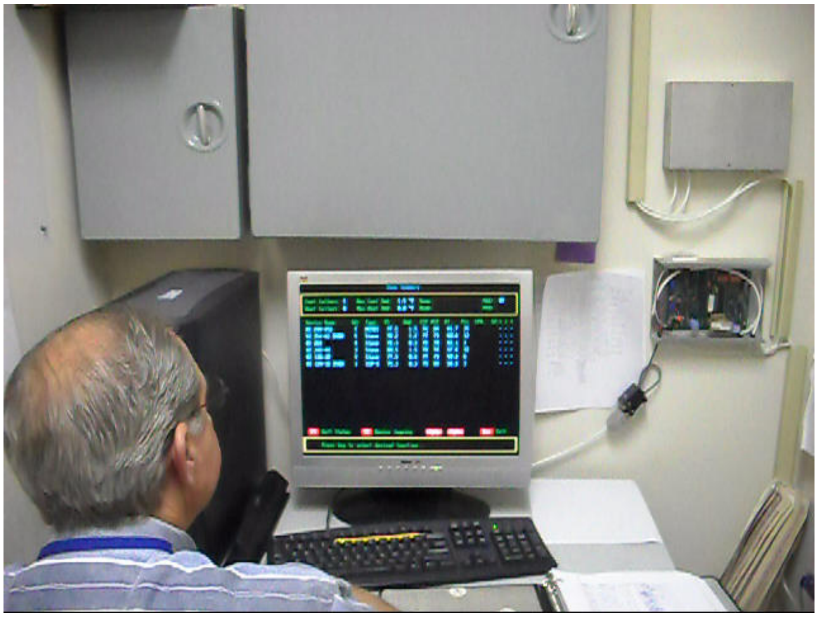

Photo 6: Charlie Watts, CBP, reviewing data with BAS during FEMP energy audit site visit April 2010.