U.S. DEPARTMENT OF ENERGY

PNNL-19502

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

American Recovery and Reinvestment Act (ARRA) FEMP Technical Assistance

Federal Aviation Administration Project 209 – Control Tower and Support Building, Boise, Idaho

J Arends
WF Sandusky

June 2010

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Federal Energy Management Program
under Contract DE-AC05-76RL01830

Pacific Northwest National Laboratory
Richland, Washington 99352

(a) Redhorse Corporation

Executive Summary

Pacific Northwest National Laboratory (PNNL) and Redhorse Corporation (Redhorse) conducted an energy audit on the Federal Aviation Administration (FAA) control tower and base building in Boise, Idaho. This report presents findings of the energy audit team that evaluated construction documents and operating specifications (at the 100% level) followed by a site visit of the facility under construction. The focus of the review was to identify measures that could be incorporated into the final design and operating specifications that would result in additional energy savings for FAA that would not have otherwise occurred.

The process that was followed in this review was to first identify various energy conservation measures (ECMs) that should be considered before the construction is complete in the October 2010. A total of seven recommendations were evaluated and documented in this report. During the debriefing, FAA representatives indicated all were likely to be incorporated into the final construction project. Contingency funds from construction of the facility will be used to implement the recommendations. These recommendations included both low-cost and no-cost projects that typically related to operational requirements, as well as capital projects that would result in an actual design change. Implementation of the seven measures would result in an electrical energy savings of 148,766 kilowatt hours (kWh). No savings related to natural gas were identified because the facility does not use natural gas. Based on the present commodity rates, the annual cost savings for the site would be $5,977. The total cost for implementation is estimated to be $27,754, resulting in a simple payback of 4.6 years.

A total of two renewable energy projects were identified – one related to solar domestic hot water and the other solar power electric generation. If these projects were implemented, an additional 191,482 kWh would be saved, resulting in an annual cost savings of $7,057. The cost for implementation is estimated to be $1,401,192, which is not cost-effective unless incentive funds can be secured.

Project implementation would reduce greenhouse gas (GHG) emissions to the atmosphere and create jobs for local workers. It is estimated that 104 metric tons of carbon dioxide equivalent (CO_2e) emissions would be avoided by implementation of the seven ECMs, and 0.3 new jobs would be created (based on the premise that $92,000 in project costs equals one new job). With implementation of the renewable energy projects that were evaluated, an estimated 134 metric tons of CO_2e emissions would be avoided, and 15.2 new jobs would be created for the installation of solar renewable energy systems.

Contents

Figures

Tables

Acronyms and Abbreviations

AC	air conditioning
AHU	air handling unit
ALERT	Assessment of Load and Energy Reduction Techniques
ARRA	American Recovery and Reinvestment Act
ASHRAE	American Society of Heating, Refrigerating & Air Conditioning Engineers
BAS	building automation system
BCS	building control system
BLCC	building life cycle cost
Btu	British thermal unit
CF	cubic feet (ft^3)
CO_2e	carbon dioxide equivalent
CRAC	computer room air conditioning
DC	direct current
DCV	demand controlled ventilation
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
EPAct	Energy Policy Act
ESET	energy savings expert teams
ESPC	energy savings performance contract
EUI	energy use intensity
FAA	Federal Aviation Administration
ft^2	square feet
FEMP	Federal Energy Management Program
GHG	greenhouse gas
GSA	General Services Administration
IAQ	indoor air quality
IR	infrared
kBtu	10^3 Btu

kW	kilowatt
kWh	kilowatt hour (1 kWh = 3412 Btu)
lb/hr	pounds per hour
LBNL	Lawrence Berkeley National Laboratory
Mcf	million cubic feet (natural gas)
mm	millimeter
MMBtu	10^6 Btu
NOFA	notice of funding available
O&M	operation and maintenance
PM	preventive maintenance
ppm	parts per million
PNNL	Pacific Northwest National Laboratory
PV	photovoltaic
Retro-CX	retro-commissioning
SHW	solar domestic hot water
SPV	solar photovoltaic
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. In fiscal year 2009, FEMP received funds specific to the American Recovery and Reinvestment Act (ARRA) to assist in the identification, evaluation, and documentation of energy efficiency and renewable energy projects at Federal sites.

These funds were allocated to extend 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 requesting 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.

The Federal Aviation Administration (FAA) submitted a response to a FEMP call for projects that was issued on May 1, 2009, requesting that energy audits be conducted at four FAA locations in California, with the goal of identifying energy conservation measures (ECMs) that could be implemented in a timely manner. This project was accepted by FEMP and designated as Project 209. After project selection, it was determined that the sites were being considered as part of a larger energy savings performance contract (ESPC) project, so the scope of the project was changed and divided into two parts. The first part consisted of a technical review of the proposed construction and operating specifications for buildings to be constructed at three airport locations (Las Vegas, Nevada, and Palm Springs and Oakland, California). The second part was a request for energy audits during on-going construction at two other sites (Reno, Nevada, and Boise, Idaho). This report presents the findings of the energy audit at the Boise site. The results of the other reviews and audits are documented in separate reports.

1.1 Technical Assistance Activities

This energy and water audit was conducted using the protocols and guidance developed by 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 evaluation (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 achieve additional energy, water, and cost savings.

PNNL contracted with Redhorse to complete a review of construction design and operation specifications and complete a site visit to the buildings in Boise. The purpose was to identify additional ECMs or operating specifications that could be provided to FAA for consideration to meet final construction completion timelines. Redhorse developed estimates of potential energy savings impacts for those design review comments that could be incorporated in the final construction documents.

The design team used the Carrier Hourly Analysis Program (HAP) energy modeling program to model the energy use of the systems selected for the building. Recommended measures were evaluated for potential energy savings using the eQUEST model.

The eQUEST model was developed to provide a quick estimate of the energy savings potential and does not include the fine degree of detail included in the Carrier HAP model. The inputs of the eQUEST model were adjusted until annual energy use estimates from the model matched the design team’s results. The eQUEST model was developed using the schematic wizard function to develop a simple model of the building and its systems. However, some of the items were estimated using case studies, and energy estimates were extrapolated for this project.

2.0 Background

2.1 Site Description

On January 4, 2008, officials broke ground for Boise Air Terminal's latest improvement, a new air traffic control tower to be located at 3001 W. Harvard Street. When completed in late 2010, the new tower will stand 290 feet tall, becoming Idaho's tallest structure and the Pacific Northwest's tallest control tower. The new control tower will provide 525 square feet (ft^2) of space with a full view of the airfield. In addition to the new control tower, a new single-story base support building is under construction with 11,000 ft^2 of office, data center, and support space. The construction site for the buildings is located on the south side of the airport to control an existing Idaho Air National Guard assault strip and a possible new runway south of Gowen Field. Figure 1 is a computer simulation of the proposed control tower and base building.

Figure 1. The Boise Airport Control Tower and Base Building (computer simulation)

2.2 Major Building Energy Uses

The major end uses of energy at the buildings will be lighting, space cooling, ventilation, and equipment (radar and communication). Minor end uses will be space heating, water heating, and pumps and motors.

The base building and control tower are served by two packaged air-cooled chilled water chillers with variable speed pumping, which are located on a concrete pad outside the buildings. The central station variable volume air handling unit (AHU) is located in a mechanical room in the base building. Air supplied by the central station AHU is distributed throughout the base building to variable air volume (VAV) terminal units with electric reheat elements. The base building data and equipment rooms are served by three chilled water computer room air conditioning (CRAC) units.

The control tower is served by a two-pipe fan coil system with chilled water coils and electric heating elements.

2.3 Climate, Facility Type, and Operations

The climate for the site is considered semi-arid and continental, with four distinct seasons. Based on data available from the National Climatic Data Center, the maximum mean monthly temperature occurs in July (74.7°F), with the minimum mean monthly temperature occurring in January (30.2°F). The highest recorded temperature during the period from 1940 through 2001 was 111°F, while the lowest reported temperature during that period was -25°F. Based on the most recent mean data available (1971-2000), the site should experience 46 days with a maximum temperature exceeding or equal to 90°F and 6 days with a maximum temperature exceeding or equal to 100°F. The minimum temperature should be at or below 32°F for 118 days. Annually, the site should anticipate 5,727 heating degree days (HDD) and 807 cooling degree days (CDD).

Mean annual precipitation for the site is 12.19 inches. The highest daily reported precipitation was 1.91 inches on June 12, 1958. The highest reported monthly precipitation, 4.4 inches, occurred in May 1998. The daily precipitation should be at or greater than 0.01 inch for 90 days during the year. Mean annual snowfall for the site is 19.4 inches, and the highest monthly snowfall was reported in December 1983 (26.2 inches). The highest daily snow depth was 13+ inches on December 2, 1985.

3.0 Energy Use

Historical energy use data for the buildings are not presented because the buildings are under construction.

3.1 Current Energy, Gas, and Water Use

Specific information regarding energy, natural gas, and water use was not obtained because the building is under construction. Information from the existing facility would not be appropriate for use in this report.

3.2 Current Rate Structure

The FAA currently pays 3.5 cents per kilowatt hour (kWh) to Idaho Power. No natural gas is used at this site. This value was used in calculating the baseline energy consumption and the incremental savings from the various proposed measures. United Water Idaho provides water service to the site.

4.0 Energy Conservation Measures Identified

The energy audit team identified a total of seven ECMs that should be considered by the FAA building design team. These ECMs represent a variety of measures and operating specifications for equipment, and include both no-cost/low-cost projects, as well as additional capital investment projects. 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. A summary of those measures, estimated electrical savings, associated electric annual cost savings, along with implementation cost and the simple payback calculation, is provided in Table 1.

Several renewable energy projects were also identified for the building, including installation of a solar domestic hot water (SHW) system and solar photovoltaic (PV) generation. The evaluation did not include the impact of obtaining rebates or incentives.

Table 1: ECMs Recommended for Incorporation in the Final Construction Specifications

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	Static Pressure Reset	12,530	0	43		$ 439	$ -	$ -	$ 439	$ 1,200	2.7
2	DCV CO2 sensors	5,140	0	18		$ 180	$ -	$ -	$ 180	$ 1,000	5.6
3	Lighting & HVAC Occupancy Sensors	73,550	0	251		$ 2,574	$ -	$ -	$ 2,574	$ 4,150	1.6
4	Ultrasonic Humidifiers	53,046	0	181		$ 1,857	$ -	$ -	$ 1,857	$ 14,000	7.5
5	No Touch Sink Faucets 6 ea (1.0 vr 0.25 gpc)	4,500	0	15	79,560	$ 158	$ -	$ 636	$ 794	$ 1,980	2.5
6	No Touch Urinals 2 ea (1.0 vr 0.5 gpf)	0	0	0	10,950	$ -	$ -	$ 88	$ 88	$ 1,356	15.5
7	No Touch Toilets 6 ea (1.6 vs 1.28 gpf)	0	0	0	5,824	$ -	$ -	$ 47	$ 47	$ 4,068	87.3
	Total (Non-interactive)	**148,766**	**0**	**508**	**96,334**	**$ 5,207**	**$ -**	**$ 771**	**$ 5,977**	**$ 27,754**	**4.6**
	Percent Savings (Non-interactive)	**20%**		**20%**							
	Renewable Energy										
8	Solar Domestic Hot Water	410	0	1		$ 369	$ -		$ 369	$ 1,192	3.2
9	Solar Power Generation -140 kW	191,072		652		$ 6,688	$ -		$ 6,688	$ 1,400,000	209.3
	Total Renewable Energy	**191,482**	**0**	**654**		**$ 7,057**	**$ -**		**$ 7,057**	**$ 1,401,192**	**198.6**
	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					**0.0350**	**0.9000**	**0.00800**			
	eQUEST Baseline 2009	759,120	0	2,591	182,719	$ 26,569	$ -	$ 21	NA	$ 26,569	
	eQUEST / Actual Use Ratio	**100.0%**		**100.0%**	Modeling estimates should fall within 5% of actual usage.						
	Design Baseline Estimate	759,000		2,590		$ 26,565	$ -	$ -	$ 26,565	$ 26,565	
	Actual Energy Use Intensity (EUI) - (BTU/SF-YR)	122,870	0	122,870							

4.1 Summary of Proposed Measures

ECM1 - VARIABLE AIR VOLUME (VAV) 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 likewise increases to maintain the space temperature. If space cooling loads decrease, the requirement for cold air flow to cool the space also decreases.

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 and the estimated annual energy savings are 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 and Air-Conditioning Engineers (ASHRAE) Standard 90.1 has required that static air pressure be reset for systems with direct digital controls (DDC): “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 unexpectedly high zone loads that are added to the space after construction;
- Cooling thermostat setpoint below design condition;
- Thermostats with heat releasing equipment under them (such as 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 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 by literally 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. Direct digital control (DDC) systems typically have the ability to limit the range occupants can adjust setpoints from the thermostat. This limitation can prevent, for instance, cooling setpoints that are well below design conditions.
- Request that all thermostats are free of impact from appliances directly under them.
- Fix duct restrictions/sizing issues. This option is clearly a better choice than ignoring the zone and letting it overheat, but the cost to make revisions may be higher that the owner is willing to invest. It is best, of course, to avoid these restrictions in the first place. For instance, the owner should avoid using flexible duct 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.

ECM2 - DEMAND-CONTROLLED VENTILATION (DCV) USING CARBON DIOXIDE (CO_2) SENSING:

ASHRAE recommends a ventilation rate of 15 to 20 cubic feet per minute (cfm) per person in ASHRAE Standard 62-1999 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. Because people constantly exhale CO_2, 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. 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 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 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.

Estimated annual energy savings are summarized in Table 1. The conference room VAV box and AHU-1 are recommended systems to be controlled by CO_2 sensors.

ECM3 - Occupancy Sensor Controlled Heating, Ventilation, and Air Conditioning (HVAC):

Lighting occupancy sensors can be used to reduce the HVAC heating and cooling energy use in spaces that are not occupied. Temperatures in the unoccupied space are allowed to drift from occupied setpoints while the space is unoccupied. The state of the occupancy sensor is tapped by the building energy management system to control the heating or cooling setpoint of the space.

Office buildings with occupancy sensors controlling the lighting typically see electricity savings of between 38 to 48%. When the heating and cooling setpoints of the room are also controlled by the occupancy sensor, the HVAC savings will be less than the lighting energy savings because the ventilation system continues to provide minimum ventilation during the unoccupied periods. An example is an office that is unoccupied during a 2-week period while the occupant is on vacation. If this office is unoccupied during the winter, the office still needs to be kept above some minimum temperature (typically no less than 55°F). In one case study, almost 42% of the lighting and 23% of the cooling energy were saved in the private executive office, with potential for even higher savings in applications such as conference rooms and lunch rooms.

Energy savings estimates are included in Table 1. The recommended VAV terminal boxes for installation of occupancy sensors are VAVs 1, 2, 3, 6, 9, 10, 11 and 14; break room VAV 7 and the conference room VAV box.

ECM4 - Ultrasonic Humidifiers:

The humidifiers installed during construction are electric resistance humidifiers, and this measure recommends their replacement with ultrasonic humidifiers. Ultrasonic humidifiers use a piezo-electric transducer to create a high-frequency mechanical oscillation in a body of water. The water tries to follow the high-frequency oscillation but cannot because of its comparative weight and mass inertia. Thus, a momentary vacuum is created on the negative oscillation, causing the water to cavitate into vapor. The transducer follows with a positive oscillation that creates high pressure compression waves on the water's surface, releasing tiny droplets of water into the air. This mist is extremely fine, with droplets about 1 micron in diameter, which are quickly absorbed into the air flow. Because the mist is created by oscillation, and not heat, the water temperature need not be raised. Ultrasonic humidifiers, therefore, can create instantaneous humidity, and don't have to wait for a heating element to vaporize the water. This precise on/off humidity control is the hallmark of ultrasonic humidifiers. In addition, unlike wet pad humidifiers, ultrasonic units can be of comparatively small size while still providing sufficient humidity.

Ultrasonic humidifiers generate 1-micron size droplets for as little as 1/13 the price of steam and can save thousands of dollars in annual operating costs. Ultrasonic humidifiers are proven to reduce humidifier energy use by between 90 and 93%.

Maintenance: Because water is purified before entry into the ultrasonic humidifier, there is considerably less maintenance required of an ultrasonic system compared to steam.

Ultrasonic systems provide instant on/off of mist. As soon as the relative humidity drops below the setpoint, an ultrasonic humidifier instantly turns on. Steam canisters have flush cycles that may shut down the humidifier for up to 15 minutes or more. Heating elements inside those systems take significant time to vaporize water to create humidity.

Equipment costs for ultrasonic humidifiers are typically higher than equipment costs for other types of humidifiers, while installation costs are typically lower. A 100 pound per hour (lb/hr) ultrasonic humidifier costs approximately $13,400, with an installation cost of $1,000, or approximately $145 per pound of capacity. A similar sized steam canister humidifier would cost $3,400 with a $2,000 installation cost. Two documented retrofit applications averaged $205 and $269 per pound of capacity, including installation (DOE 1998). In those two instances, however, the total retrofit costs were similar to the estimated costs using electric resistance humidifiers.

Energy savings estimates are included in Table 1. The estimate provided is based on capturing 90% of the operational cost of the existing electric steam unit.

ECM5, 6 & 7 - NO TOUCH SINKS, TOILETS, AND URINALS:

No touch solar (instead of battery) operated sink faucets have 0.25 gallon per cycle operation, and they also promote sanitary cleanliness 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. This 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 O&M costs. Water savings estimates are included in Table 1.

4.2 Renewable Energy Measures Evaluated

Two renewable energy measures were initially recommended, and FAA is in the process of identifying funding for implementation.

ECM9 – SOLAR HEATING OF DOMESTIC HOT WATER:

Solar hot water heating systems are typically mounted on the roof of the building they serve. The roof of the base building is available for the installation of a solar hot water collector. The collector was sized for 20 people in the building. A collector laying flat on the building roof would cover an area of approximately 15 ft^2. One collector unit would provide 60% of the domestic hot water heating needed for the building.

ECM10 – SOLAR POWER GENERATION – 140 KILOWATTS (KW):

Solar power generation is feasible at the site because large areas of open ground space are available. The west side of the site has the largest open area, with a space that is 300 by 500 feet or 150,000 ft^2. A 140-kW system array will require about 14,000 ft^2. This output capacity is suggested because it would provide an output slightly less than the projected typical demand of the facility. The alternative location for the solar array would be the roof of the base building, but the size of the system would be limited to approximately 100 kW.

5.0 Potential Green House Gas Reduction

The potential greenhouse gas emission reductions resulting from the ECMs were calculated based on the U.S. Environmental Protection Agency eGRID data (Pechan 2008), and are tabulated in Table 2. Based on the estimated savings of 148,766 kWh, annual non-baseload carbon dioxide equivalent (CO_2e) emissions would be reduced by 104 metric tons. Implementing the renewable energy projects would result in an additional estimated reduction of 134 metric tons of CO_2e from a renewable energy savings of 191,482 kWh. These calculations do not include any contribution that would be related to line losses.

Table 2: Estimated Greenhouse Gas Reductions

ECM #	Estimated Electrical Savings (kWh)	Natural Gas Savings (Therms)	(Est. Electrical Use Reduction) (metric tons CO2e)	GHG Avoided (Est. Natural Gas Use Reduction) (metric tons CO2e)	Total GHG Avoided (metric tons CO2e)
1	12,530	0	8.77	0	8.77
2	5,140	0	3.60	0	3.60
3	73,550	0	51.49	0	51.49
4	53,046	0	37.13	0	37.13
5	4,500	0	3.15	0	3.15
6	0	0	-	0	-
7	0	0	-	0	-
TOTALS	**148,766**	**0**	**104**		**104**
Renewable Energy Projects					
8	410	0	0.29	0	0.29
9	191,072	0	133.75	0	133.75
TOTALS	**191,482**	**0**	**134**	**-**	**134**

6.0 Action Plan for Implementation of ECMs

The goal of providing technical assistance to agencies is to provide them with sufficient information so they can make informed decisions regarding implementation of the proposed measures.

6.1 Priorities and Next Steps

The FAA has indicated it will incorporate the seven ECMs into the final design and operating specifications. FAA representatives also indicated that they may consider other recommended measures, such as additional renewable energy projects, but a separate funding source would have to be identified and assistance would be required to obtain the funding.

The design review team also recommended that operating staff at the new building become familiar with the information contained in the documents listed below so the installed equipment can be properly maintained to maximize the useful life of energy related equipment.

- ✓ FEMP Retro-commissioning after completion of the building
  www.eere.energy.gov/**femp**/pdfs/om_**retro**cx.pdf
- ✓ FEMP Best Practices Operations and Maintenance
  www.eere.energy.gov/**femp**/**operations_maintenance**/om_bpguide.html

6.2 Funding Assistance Available

The ECMs selected are expected to be included in the overall cost to construct and operate the base building and the control tower. Thus, funding assistance is not required for this site, except for the renewable energy projects. The FAA is encouraged to contact its utility representative from Idaho Power regarding potential additional incentives for solar installations and other energy conservation measures.

7.0 Assessment Team Members and Site Team

Mr. Jim Arends, PE, CEM, of Redhorse completed the technical review of the design and operating specifications for the site. Mr. Arends was assisted by Mr. Brent Higginbotham, PE, of Redhorse during the site visit. Mr. Nick Mirhaydari, Mr. Robert Smith and Mr. Mark Brandewie of FAA also participated in the site visit. Ms. Amanda Sahl, DOE Headquarters, also participated in the site visit. Mr. William Sandusky of PNNL was responsible for technical review of this report.

8.0 References

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APPENDIX A

eQUEST Modeling Results and Spreadsheet Calculations

Appendix A: eQUEST Modeling Results and Spreadsheet Calculations

Energy simulations developed for the annual energy savings estimates were modeled using eQUEST version 3.61. 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, one variable volume air handler serving the majority of the base building, with the balance of the building served by constant volume air handling systems. The control tower provides air traffic controller occupied space on the 8th floor.

Baseline eQUEST Model Results

eQUEST Model Results Baseline Use													
Electric Consumption (kWh x000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.85	0.77	0.85	1.94	4.71	7.52	14.93	10.65	6.44	2.51	0.83	0.85	52.84
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	12.23	5.96	4.31	1.89	1.36	0.86	0.85	0.61	0.68	1.98	5.02	11.77	47.52
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	0.38	0.37	0.43	0.42	0.36	0.36	0.33	0.31	0.3	0.32	0.31	0.39	4.27
Vent. Fans	6.28	6.02	6.93	7.09	6.96	7.11	6.76	6.98	7.08	7.16	6.37	6.57	81.3
Pumps & Aux.	6.1	6.99	9.76	10.32	5.66	5.44	3.48	3.68	4.62	6.65	6.83	7.27	76.8
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	34.49	32.24	36.85	36.45	34.49	36.45	36.78	35.69	35.29	35.62	32.96	36.81	424.11
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	5.79	5.48	6.33	6.3	5.79	6.3	6.31	6.06	6.04	6.05	5.51	6.32	72.29
Total	66.12	57.83	65.45	64.4	59.33	64.04	69.43	63.98	60.45	60.27	57.83	69.98	759.12

Static Pressure Reset Model Results

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	0.85	0.77	0.85	1.92	4.63	7.39	14.71	10.48	6.34	2.48	0.83	0.85	52.1
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	12.44	6.03	4.32	1.9	1.36	0.88	0.87	0.63	0.68	1.99	5.06	11.97	48.14
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	0.38	0.37	0.43	0.42	0.36	0.36	0.33	0.31	0.3	0.32	0.31	0.39	4.27
Vent. Fans	5.37	5.24	6.08	6.31	6.14	6.35	5.94	6.19	6.33	6.36	5.54	5.68	71.54
Pumps & Au	5.85	6.69	9.39	9.95	5.48	5.33	3.42	3.6	4.51	6.42	6.54	6.99	74.16
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	34.49	32.24	36.85	36.45	34.49	36.45	36.78	35.69	35.29	35.62	32.96	36.81	424.11
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	5.79	5.48	6.33	6.3	5.79	6.3	6.31	6.06	6.04	6.05	5.51	6.32	72.29
Total	65.18	56.82	64.24	63.24	58.25	63.07	68.36	62.95	59.49	59.23	56.75	69	746.59

Demand Control (CO_2) Ventilation Model Results

eQUEST Model Results DCV CO2													
Electric Consumption (kWh x000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	1.8	1.55	1.64	2.69	5.4	7.78	14.86	10.93	6.93	3.36	1.8	1.62	60.36
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	11.44	5.68	4.09	1.73	1.24	0.83	0.84	0.59	0.61	1.81	4.73	10.98	44.59
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	0.38	0.37	0.43	0.42	0.36	0.36	0.33	0.31	0.3	0.32	0.31	0.39	4.27
Vent. Fans	6.29	6.03	6.93	7.09	6.97	7.1	6.75	6.98	7.08	7.17	6.38	6.57	81.33
Pumps & Aux.	5.02	5.93	8.91	8.98	4.75	5.05	3.06	3.22	4.09	6	5.83	6.2	67.03
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	34.49	32.24	36.85	36.45	34.49	36.45	36.78	35.69	35.29	35.62	32.96	36.81	424.11
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	5.79	5.48	6.33	6.3	5.79	6.3	6.31	6.06	6.04	6.05	5.51	6.32	72.29
Total	65.2	57.27	65.19	63.65	58.99	63.87	68.93	63.78	60.35	60.32	57.53	68.9	753.98

Lighting and HVAC Occupancy Sensor Model Results

eQUEST Model Results Lighting and HVAC Occupancy Sensors													
Electric Consumption (kWh x000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.84	0.76	0.84	1.89	4.61	7.35	14.6	10.42	6.29	2.46	0.82	0.84	51.71
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	12.42	6.03	4.36	1.91	1.35	0.83	0.79	0.58	0.67	1.99	5.07	11.95	47.96
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	0.38	0.37	0.43	0.42	0.36	0.36	0.33	0.31	0.3	0.32	0.31	0.39	4.27
Vent. Fans	6.19	5.93	6.81	6.95	6.83	6.97	6.65	6.85	6.93	7.02	6.27	6.46	79.86
Pumps & Aux.	1.5	1.35	1.5	1.45	1.5	1.45	1.5	1.5	1.45	1.5	1.45	1.5	17.62
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	34.49	32.24	36.85	36.45	34.49	36.45	36.78	35.69	35.29	35.62	32.96	36.81	424.11
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	4.81	4.55	5.26	5.24	4.81	5.24	5.24	5.04	5.02	5.02	4.58	5.25	60.05
Total	60.62	51.22	56.04	54.31	53.95	58.64	65.89	60.38	55.95	53.93	51.46	63.19	685.57

Ultrasonic Humidifiers Model Results

eQUEST Model Results Ultrasonic Humidifiers													
Electric Consumption (kWh x000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.85	0.77	0.85	1.94	4.71	7.52	14.93	10.65	6.44	2.51	0.83	0.85	52.84
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	12.22	5.96	4.31	1.89	1.36	0.86	0.85	0.61	0.68	1.98	5.01	11.77	47.51
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	0.38	0.37	0.43	0.42	0.36	0.36	0.33	0.31	0.3	0.32	0.31	0.39	4.27
Vent. Fans	6.28	6.02	6.93	7.09	6.96	7.11	6.76	6.98	7.08	7.16	6.37	6.57	81.3
Pumps & Aux.	1.52	1.37	1.52	1.47	1.52	1.47	1.52	1.52	1.47	1.52	1.47	1.52	17.87
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	34.49	32.24	36.85	36.45	34.49	36.45	36.78	35.69	35.29	35.62	32.96	36.81	424.11
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	5.79	5.48	6.33	6.3	5.79	6.3	6.31	6.06	6.04	6.05	5.51	6.32	72.29
Total	61.53	52.21	57.21	55.55	55.19	60.07	67.47	61.82	57.29	55.14	52.47	64.22	700.18

No Touch Sink Faucets Spreadsheet Calculation 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*
Minutes per Day of Operation	30 minutes	*30 minutes*	*20 minutes*
Days per Year of Operation	365 days	*260 days*	*365 days*
Quantity to be Purchased	1 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

No Touch Urinals Spreadsheet Calculation 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	0.5 gpf	*1.0 gpf*
Quantity to be Purchased	1	*1*
Flushes per Day	30 flushes	*30 flushes*
Days per Year	365	*260 days*
Reset		

OUTPUT SECTION

Performance per urinal	**Your Choice**	**Typical Existing Unit**	**Recommended Level (New Unit)**	**Best Available**
Gallon per Flush	0.5 gpf	3	1	0
Annual Water Use	5475 gal	32850	10950	0

No Touch Toilets Spreadsheet Calculation Results

Toilet Water Use					
Number of toilets		**6**			
Number of people		**25**			
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	#	50		50	
Water use per day	gal	80		64	
Water use per toilet per day	gal	13.3		10.7	
Water use per year	gal	29120		23296	
Daily water use reduction				**16.0**	**gal/day**
Annual Water use reduction				**5824**	**gal/yr**

Solar Hot Water Spreadsheet Calculation Results

RETScreen Tool			
Technology		**Solar water heater**	
Load characteristics	**Unit**	**Base case**	**Proposed case**
Load type		Office	
Number of units	Person	20	
Occupancy rate	%	80%	
Daily hot water use - estimated	gal/d	16	
Daily hot water use	gal/d	16	16
Temperature	°F	130	130
Operating days per week	d	5	5
Supply temperature method		Formula	
Water temperature - minimum	°F	43.3	Boise City Water
Water temperature - maximum	°F	59.3	Boise City Water
Heating	million Btu	3.4	3.4
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		1	
Solar collector area	ft²	10.37	
Cost	$	$ 1,192	
Capacity	kW	0.67	
Miscellaneous losses	%		
Balance of system & miscellaneous			
Storage		Yes	
Storage capacity / solar collector area	gal/ft²	1	
Storage capacity	gal	3.0	
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	0.103	
Summary			
Electricity - pump	MWh	0.0	
Heating delivered	million Btu	2.0	
Solar fraction	%	60%	

Heating system		**Base case**	**Proposed case**	**Proposed Savings**
Fuel type		Electrical Costs kWh	Electrical Costs kWh	Electrical Costs kWh
Seasonal efficiency		95%	95%	
Fuel consumption - annual	therm	996.2	586.0	410.2

Solar Power Generation Online Calculation Results

PV Watts AC Energy & Cost Savings

Station Identification			Results		
			Month	Solar Radiation	AC Energy
City:	Boise			(kWh/m^2/day)	(kWh)
State:	Idaho				
Latitude:	43.57° N		1	2.88	9,660
Longitude:	116.22° W		2	4.16	12,574
Elevation:	874 m		3	4.93	16,204
PV System Specifications			4	5.77	17,737
DC Rating:	140.0 kW		5	6.12	18,969
DC to AC Derate Factor:	0.77		6	6.47	18,928
AC Rating:	107.8 kW		7	7.05	20,367
Array Type:	Fixed Tilt		8	6.93	20,539
Array Tilt:	43.6°		9	6.40	18,759
Array Azimuth:	180.0°		10	5.30	16,843
			11	3.48	10,971
			12	2.80	9,521
					191,072

APPENDIX B

PHOTOGRAPHS

Appendix B: Photographs

Photo 1. Boise FAA Control Tower site visit: Amanda Sahl, DOE and Nick Mirhaydari, FAA

Photo 2. Boise FAA Control Tower and Base Building Chillers: Nick Mirhaydari, FAA and Brent Higginbotham, Redhorse

Photo 3. Boise FAA Control Tower and Base Building Chilled Water Pumps; Brent Higginbotham, Redhorse

Photo 4. Boise FAA Base Building: Air Handling Unit