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U.S. DEPARTMENT OF ENERGY

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, Reno, Nevada

J Arends
WF Sandusky

June 2010

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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 Reno, Nevada. This report presents the findings of the energy audit team that evaluated construction documents and operating specifications (at the 100% level) and completed a site visit. 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 the 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 prior to finalization of the construction and operation specifications.

A total of eight recommendations were evaluated and documented in this report. During the out briefing, FAA representatives indicated the non-renewable projects (a total of six) were likely to be incorporated into the final construction project currently scheduled for completion in October 2010. Contingency funds from the construction of the facility will be used to implement the recommendations. These 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 six ECMs would result in an electrical energy savings of 130,197 kilowatt hours (kWh) and 2,455 therms of natural gas. Based on the present commodity rates, the annual cost savings for the site would be $18,373. The total cost for implementation is estimated to be $25,300, resulting in a simple payback of 1.4 years.

Two potential renewable projects were identified. The first was solar water heating for domestic use. The second was solar power generation. If those projects were implemented, an additional 107,371 kWh of electrical energy savings would occur, resulting in an annual savings of $12,884. These projects are not cost-effective based on the long simple payback period.

Project implementation would reduce greenhouse gas (GHG) emissions to the atmosphere and create jobs for local workers. It is estimated that 103 metric tons/yr of carbon dioxide equivalent (CO_2e) emissions would be avoided by implementation of the six ECMs, and 0.3 new jobs would be created (based on the premise that $92,000 in project costs equals one new job). With the implementation of the renewable energy projects that were evaluated, an estimated additional 75 metric tons/yr of CO_2e emissions would be avoided, and 7.6 new jobs would be created for 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)
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
UPS	uninterruptible power supply
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) of 2009 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 in need of technical assistance in the following areas:

- Initial screenings or assessments of facility needs and/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
- 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 that could be implemented in a timely manner. This project was accepted by FEMP and designated as Project 209. After project selection, it was determine 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 requested that energy audits be performed during on-going construction at two other sites (Reno, Nevada, and Boise, Idaho). This report represents the findings regarding an energy audit of the Reno site. The results of the other reviews will be documented in separate reports.

1.1 Technical Assistance 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.

PNNL contracted with Redhorse to complete a review of construction design and operation specifications and complete a site visit to the buildings in Reno to identify additional energy conservation measures (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 energy audit team did not have access to the design team's energy model for this project. Recommended ECMs were therefore 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 typical design team energy model. The inputs of the eQUEST model were adjusted until annual energy use estimates from the model matched the load profile of other models used at other FAA sites reviewed by the energy audit team. 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

Construction began in January 2008 on a new 200-ft tall tower with an 11,000–ft^2 base building on property leased by the Reno-Tahoe Airport Authority to the FAA. The new facility is scheduled to be operational in late 2010. The new tower will include the most technologically advanced equipment available and will have unobstructed views of all aircraft movement areas as well as the surrounding airspace.

The construction site for the buildings is located on the eastern side of the airport. Figure 1 is a photo of the control tower and base building now under construction.

Figure 1. Reno FAA Control Tower and Base Building

2.2 Major Building Energy Uses

The major end-uses of energy at the buildings will be lighting, space cooling, ventilation, and equipment uses (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 plants with variable speed pumping, which are located on a concrete pad outside the buildings in an equipment yard. The base building is served by three variable air volume (VAV) roof top units (RTUs), and each of the units is backed by a redundant unit. Hot water heating coils and chilled water cooling coils temper the supply air to deliver 55°F air to the building. Each of the units has 100% outside air capability for economizer operation. Air supplied by the RTUs is distributed throughout the base building to VAV terminal units with hot water reheat coils. The base building data and equipment rooms are served by chilled water computer room air conditioning (CRAC) units.

The control tower observation area is served by a four-pipe fan coil system with chilled water coils and hot water heating coils.

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 (71.3°F), with the minimum mean monthly temperature occurring in December and January (33.6°F). The highest recorded temperature during the period from 1937 through 2009 was 108°F, while the lowest reported temperature during that period was -16°F. Based on the most recent mean data available (1971-2000), the site should experience 53 days with a maximum temperature exceeding or equal to 90°F. The minimum temperature should be at or below 32°F for 167 days. Annually, the site should anticipate 5,660 heating degree days (HDD) and 488 cooling degree days (CDD).

Mean annual precipitation for the site is 7.26 inches. The highest daily reported precipitation was 2.29 inches on January 21, 1943. The highest reported monthly precipitation, 5.25 inches, occurred in December 1955. The daily precipitation should be at or greater than 0.01 inches for 51 days during the year. Mean annual snow fall for the site is 22.9 inches, and the highest monthly snowfall was reported in March 1952 (29 inches). The highest daily snow depth was 20+ inches.

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 $0.12 per kilowatt hour (kWh) for electricity and $1.12 per therm for natural gas, NV Energy is the current provider of both utilities. These values were used in the baseline energy consumption and the incremental savings from the various proposed ECMs.

There were no water conservation measures identified for the project. Truckee Meadows Water Authority currently provides water to the site.

4.0 Energy Conservation Measures Identified

The design review team identified a total of eight ECMs that should be considered by the FAA building design team. These ECMs include a variety of measures, operating specifications for equipment, and potential renewable power generation sources. The ECMs include both no-cost/low-cost as well as potential additional renewable energy investment projects. A summary of those ECMs, estimated electrical and natural gas savings, annual cost savings, along with implementation cost and simple payback calculation, is provided in Table 1.

The renewable energy projects that were also identified for the building included 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

Table 1: 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	Static Pressure Reset	7,780	0	27		$ 934	$ (0)		$ 933	$ 1,200	1.3
2	Supply Air Reset	-2,890	1,190	109		$ (347)	$ 1,333		$ 986	$ 900	0.9
3	DCV CO2 Sensor	-320	1,509	150		$ (38)	$ 1,690		$ 1,652	$ 1,000	0.6
4	Economizer UPS & Equip Rooms	690	-14	1		$ 83	$ (16)		$ 67	$ 2,100	31.4
5	HVAC Occupancy Controls	74,540	-230	231		$ 8,945	$ (258)		$ 8,687	$ 6,100	0.7
6	Ultrasonic Humidifier	50,397	0	172		$ 6,048	$ -		$ 6,048	$ 14,000	2.3
	Total (Non-interactive)	**130,197**	**2,455**	**690**		**$ 15,624**	**$ 2,749**		**$ 18,373**	**$ 25,300**	**1.4**
	Percent Savings (Non-interactive)	**18%**	**66%**	**24%**							
Renewable Energy Projects											
7	Solar Domestic Hot Water	0	31	3		$ (0)	$ 35		$ 35	$ 1,192	34.4
8	Solar Power Generation (70 kW)	107,371		366		$ 12,885	$ -		$ 12,885	$ 700,000	54.3
	Total Renewable Energy	**107,371**	**31**	**370**		**$ 12,884**	**$ 35**		**$ 12,919**	**$ 701,192**	**54.3**
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					**0.1200**	**1.1200**				
	eQUEST Baseline 2009	719,950	3,719	2,829	NA	$ 86,394	$ 4,165	NA	NA	$ 90,559	
	eQUEST / Actual Use Ratio	**100.3%**	**99.2%**	**100.1%**	Modeling estimates should fall within 5% of actual usage.						
	Design Baseline Estimate	718,000	3,750	2,826		$ 86,160	$ 4,200	$ -	$ 90,360	$ 90,360	
	Design Energy Use Intensity (EUI) - (BTU/SF-YR)	123,902	18,960	142,862							

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 requirements for cold air flow to cool the space also decrease. The air flow to the VAV terminal boxes is delivered at a system static pressure. The static pressure level is established by the minimum pressure required for the terminal boxes to deliver full cooling flows. During the winter, air flow requirements drop to their minimum levels and the static pressure required at terminal boxes decreases. This reduced air flow requirement brings about an opportunity to reduce the system static pressure levels along with reducing energy usage. Static pressure reset control strategies have been in use for more than 20 years and have been proven to provide significant levels of energy savings.

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

Implementation of the improved air static pressure reset control can greatly increase the energy savings. Since 1999, American Society of Heating, Refrigerating and Air- Conditioning Engineers (ASHRAE) Standard 90.1 (ASHRAE 2007a) has required that static air pressure be reset for systems with direct digital control (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. DDC systems typically have the ability to limit the range occupants can adjust setpoints from the thermostat. This limitation can prevent cooling setpoints that are well below design conditions.
- Request that all thermostats are free of impact from appliances directly under them.
- Fix duct restrictions/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 than 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 – 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 to minimize simultaneous cooling and heating, the supply air temperature is often reset upwards. The reset schedule can be based on either return air temperature or outside air temperature. Resetting the supply air temperature not only impacts the cooling and heating energy consumption, but also the fan power consumption. If the supply air is reset to high, it may result in a fan power consumption penalty.

An eQUEST energy model was performed, 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 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 exceeded by the energy savings in the perimeter zones that would be required to do 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 area serving the core areas of the building. 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) SENSING:

ASHRAE recommends a ventilation rate of 15 to 20 cubic feet per minute (cfm) per person (ASHRAE 2007b) 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 at from $0.05 to more than $1 per square foot 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. Energy savings were calculated by reducing the cooling and heating energy estimated by the baseline energy model by 20%. A conservative estimate was used because of the unknown occupancy variations for this facility compared with the above case studies. The conference room VAV box and AHU-1 are recommended systems to be controlled by CO_2 sensors.

ECM4 - Economizer Cooling of Uninterruptible Power Supply (UPS) and Equipment Rooms

The uninterruptible power supply (UPS) and equipment rooms are served by fan coil units, and the outside air ducts serving these areas are very limited in capacity. The outside air ductwork will have to be enlarged to provide 100% outside air economizer cooling to take advantage of cooling these rooms with cool outside air. This arrangement would have been relatively inexpensive if it was included in the original design. Increasing the outside air capacity now requires removing the existing outside air intake louvers, enlarging the opening through the wall, installing a new outside air louver, and ducting the air flow to the fan coil unit.

ECM5 - Occupancy Sensor Controlled 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.

Energy savings can be estimated by extrapolating the savings from case studies of similar buildings. Office buildings with occupancy sensors controlling the lighting typically see savings of from 38 to 48%. When the heating and cooling setpoints of the room are also controlled by the occupancy sensor, the heating, ventilation, and air conditioning (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, lunch rooms, and other spaces.

Energy savings estimates included in Table 1 were calculated by reducing the cooling and heating energy from the baseline energy model by 10%. A conservative estimate was used based on the unknown occupancy variations for this facility compared with the above case studies.

ECM6 - ULTRASONIC HUMIDIFIERS:

The humidifiers installed during construction are electric resistance humidifiers, and this measure recommends replacement with ultrasonic humidifiers for the main AHU. 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 is 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.

4.2 Renewable Energy Measures Evaluated

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

ECM7 - 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 solar hot water collectors. 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 of roof area. One collector unit would provide 60% of the domestic hot water heating needed for the building. RETScreen (NRC 2010) spreadsheet calculations were used to determine the output of the collectors. Energy savings estimates are included in Table 1.

ECM8 - SOLAR POWER GENERATION - 70 KW

Solar installations are feasible at the site because large areas of open ground space are available. A 70-kW system array will require about 7,000 ft^2. This output capacity is suggested because it would provide an output slightly less than the projected typical demand of the facility of 88 kW. The east side of the site has the largest open area with a space several acres in size; however, it may not be suitable because it is also the runoff water holding pond. An alternate location for the solar array would be the roof of the base building, but the size of the system would be limited to around 40 kW.

The parking area also provides open area for panel arrays mounted on covered parking structures. Currently, there are a few covered parking spaces, but additional covered parking structures would have to be added to provide enough area for a 70-kW array. The amount of covered parking structure required will be determined by the size of the array selected during the design phase. FAA representatives have a solar power proposal under consideration to use the covered parking structures.

5.0 Potential Green House Gas (GHG) Reduction

The potential GHG emissions reductions from the ECMs were calculated based on the U.S. Environmental Protection Agency eGRID data (Pechan 2008), and are listed in Table 2. Based on the estimated savings of 130,197 kWh of electricity and 2,455 therms of natural gas, annual non-baseload carbon dioxide equivalent (CO_2e) emissions would be reduced by 103 metric tons/yr. Implementing the renewable energy projects would result in an additional estimated reduction of 75 metric tons/yr of CO_2e from a renewable energy savings of 107,371 kWh and 31 therms of natural gas. These calculations do not include any contribution that would be related to line losses.

Table 2 Estimated Green House 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	7,780	(0.3)	5.45	(0.00)	5.44
2	-2,890	1,190.3	(2.02)	5.95	3.93
3	-320	1,509.3	(0.22)	7.55	7.32
4	690	(14.2)	0.48	(0.07)	0.41
5	74,540	(230.2)	52.18	(1.15)	51.03
6	50,397	-	35.28	-	35.28
TOTALS	**130,197**	**2,455**	**91**	**12**	**103**
Estimated Green House Gas Reductions (Renewable Energy Projects)					
7	0	31	(0.0)	0.2	0.2
8	107,371	0	75.2	0.0	75.2
TOTALS	**107,371**	**31**	**75**	**0**	**75**

6.0 Action Plan for Implementation of ECMs

The goal of providing technical assistance to agencies is to provide them sufficient information so they can make informed decisions regarding implementation of the proposed ECMs. This takes the form of an action plan that identifies priorities and next steps as well as identification of funding sources for onsite activities, capital equipment purchases, and the installation and operation of the proposed measures.

6.1 Priorities and Next Steps

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

The energy audit team also recommended that operating staff at the new building become familiar with the information contained in 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 non-renewable ECMs are expected to be included in the overall cost to construct and operate the service building and the control tower. Thus, funding assistance is not required for this site except for the renewable energy projects.

NV Energy currently offers incentives under a custom program for new construction projects. The current incentive rate is $0.10 per kWh in incentives for the first year's estimated electrical savings potential. NV Energy also offers incentives under a prescriptive plan for lighting and HVAC system components. The FAA should explore the opportunity to capture the incentives, if possible, as a potential funding source for other projects or to offset cost for renewable projects.

The FAA also is encouraged to contact their utility representative from NV Energy regarding potential additional incentives for solar installations. NV Energy's SolarGenerations program is currently closed and NV Energy is not accepting applications at this time. NV Energy encourages customers to check their website regularly for program updates and potential new opportunities.

7.0 Assessment Team Members and Site Team

Mr. Jim Arends, PE, CEM, of Redhorse completed the technical review of the design and operating specification for the site. Mr. Arends was assisted by Mr. Brent Higginbotham, PE of Redhorse, during the site visit. Mr. Nick Mirhaydari, Ms. Minh Vo, Mr. Raymond Chan and Mr. Eric A. Stern of FAA also participated in the site visit. Mr. William Sandusky of PNNL was responsible for review of the technical report submitted by Redhorse and formatting of this document.

8.0 References

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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, 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 space on the top 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	4.61	4.59	5.91	6.88	8	12.06	15.69	13.83	10.77	7.16	5.25	4.73	99.49
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	3.66	3.29	3.69	3.64	3.7	3.69	3.83	3.82	3.74	3.79	3.52	3.74	44.11
Pumps & Aux.	2.22	2.01	2.22	2.15	2.22	2.15	2.22	2.22	2.15	2.22	2.15	2.22	26.17
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	35.65	33.33	38.09	37.68	35.65	37.68	38.02	36.89	36.48	36.82	34.08	38.06	438.43
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	8.95	8.47	9.78	9.74	8.95	9.74	9.76	9.37	9.34	9.35	8.52	9.77	111.75
Total	55.1	51.68	59.7	60.1	58.53	65.33	69.52	66.13	62.48	59.34	53.52	58.52	719.95
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	55.86	40.94	36.39	27.12	26.58	16.6	12.99	12.36	15.13	23.85	36.07	50.67	354.57
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	1.52	1.48	1.7	1.67	1.45	1.46	1.37	1.27	1.26	1.31	1.28	1.56	17.32
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	57.38	42.42	38.09	28.78	28.03	18.06	14.37	13.64	16.39	25.16	37.35	52.23	371.89

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	4.6	4.57	5.87	6.82	7.91	11.92	15.5	13.65	10.67	7.09	5.22	4.72	98.53
Heat Reject	0	0	0	0	0	0	0	0	0	0	0	0	0
Refrigeratio	0	0	0	0	0	0	0	0	0	0	0	0	0
Space Heat	0	0	0	0	0	0	0	0	0	0	0	0	0
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	0	0	0	0	0	0	0	0	0	0	0	0	0
Vent. Fans	3.05	2.75	3.1	3.08	3.12	3.15	3.27	3.25	3.2	3.22	2.94	3.15	37.29
Pumps & Au	2.22	2.01	2.22	2.15	2.22	2.15	2.22	2.22	2.15	2.22	2.15	2.22	26.17
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	35.65	33.33	38.09	37.68	35.65	37.68	38.02	36.89	36.48	36.82	34.08	38.06	438.43
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	8.95	8.47	9.78	9.74	8.95	9.74	9.76	9.37	9.34	9.35	8.52	9.77	111.75
Total	54.48	51.12	59.07	59.47	57.86	64.64	68.78	65.39	61.84	58.7	52.91	57.92	712.17
Gas Consumption (Btu x000,000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0	0	0	0	0	0	0	0	0	0	0	0	0
Heat Reject	0	0	0	0	0	0	0	0	0	0	0	0	0
Refrigeratio	0	0	0	0	0	0	0	0	0	0	0	0	0
Space Heat	55.81	40.91	36.37	27.12	26.61	16.64	13.04	12.41	15.16	23.86	36.05	50.63	354.6
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	1.52	1.48	1.7	1.67	1.45	1.46	1.37	1.27	1.26	1.31	1.28	1.56	17.32
Vent. Fans	0	0	0	0	0	0	0	0	0	0	0	0	0
Pumps & Au	0	0	0	0	0	0	0	0	0	0	0	0	0
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	0	0	0	0	0	0	0	0	0	0	0	0	0
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	57.33	42.38	38.07	28.78	28.05	18.1	14.42	13.68	16.42	25.17	37.33	52.18	371.92

Supply Air Reset Model Results

eQUEST Model Results Supply Air Reset													
Electric Consumption (kWh x000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	4.52	4.46	5.59	6.43	7.43	11.52	15.22	13.27	10.36	6.67	4.94	4.68	95.09
Heat Reject	0	0	0	0	0	0	0	0	0	0	0	0	0
Refrigeratio	0	0	0	0	0	0	0	0	0	0	0	0	0
Space Heat	0	0	0	0	0	0	0	0	0	0	0	0	0
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	0	0	0	0	0	0	0	0	0	0	0	0	0
Vent. Fans	4.07	3.74	4.32	4.35	4.38	4.33	4.37	4.42	4.5	4.62	4.06	4.23	51.4
Pumps & Au	2.22	2.01	2.22	2.15	2.22	2.15	2.22	2.22	2.15	2.22	2.15	2.22	26.17
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	35.65	33.33	38.09	37.68	35.65	37.68	38.02	36.89	36.48	36.82	34.08	38.06	438.43
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	8.95	8.47	9.78	9.74	8.95	9.74	9.76	9.37	9.34	9.35	8.52	9.77	111.75
Total	55.43	52	60.01	60.36	58.64	65.43	69.59	66.18	62.83	59.68	53.75	58.96	722.84
Gas Consumption (Btu x000,000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0	0	0	0	0	0	0	0	0	0	0	0	0
Heat Reject	0	0	0	0	0	0	0	0	0	0	0	0	0
Refrigeratio	0	0	0	0	0	0	0	0	0	0	0	0	0
Space Heat	39.49	27.55	24.04	17.43	16.02	11.94	9.35	7.77	9.29	13.9	21.98	36.8	235.57
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	1.51	1.47	1.7	1.67	1.45	1.46	1.37	1.27	1.26	1.31	1.28	1.55	17.3
Vent. Fans	0	0	0	0	0	0	0	0	0	0	0	0	0
Pumps & Au	0	0	0	0	0	0	0	0	0	0	0	0	0
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	0	0	0	0	0	0	0	0	0	0	0	0	0
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	41.01	29.02	25.75	19.09	17.47	13.4	10.73	9.04	10.55	15.21	23.26	38.35	252.86

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	5	4.83	6.06	7.09	7.99	11.65	14.97	13.31	10.68	7.44	5.57	5.07	99.64
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	3.74	3.27	3.68	3.63	3.7	3.71	3.84	3.83	3.75	3.79	3.54	3.81	44.27
Pumps & Aux.	2.22	2.01	2.22	2.15	2.22	2.15	2.22	2.22	2.15	2.22	2.15	2.22	26.18
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	35.65	33.33	38.09	37.68	35.65	37.68	38.02	36.89	36.48	36.82	34.08	38.06	438.43
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	8.95	8.47	9.78	9.74	8.95	9.74	9.76	9.37	9.34	9.35	8.52	9.77	111.75
Total	55.56	51.9	59.84	60.29	58.52	64.93	68.8	65.63	62.4	59.62	53.85	58.93	720.27
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	48.74	22.84	20.17	15.15	12.1	5.16	0.75	0.91	3.67	10.35	19.57	44.26	203.67
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	1.51	1.47	1.7	1.66	1.44	1.46	1.37	1.27	1.26	1.31	1.27	1.55	17.29
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	50.25	24.32	21.87	16.81	13.55	6.62	2.13	2.18	4.93	11.65	20.84	45.81	220.96

Economizer Cooling Equipment and UPS Rooms Model Results

eQUEST Model Results Economizer Equip & UPS Rooms													
Electric Consumption (kWh x000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	4.56	4.53	5.84	6.81	7.93	12	15.65	13.78	10.72	7.08	5.2	4.69	98.8
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	3.66	3.29	3.69	3.64	3.7	3.69	3.83	3.82	3.74	3.79	3.52	3.74	44.11
Pumps & Aux.	2.22	2.01	2.22	2.15	2.22	2.15	2.22	2.22	2.15	2.22	2.15	2.22	26.17
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	35.65	33.33	38.09	37.68	35.65	37.68	38.02	36.89	36.48	36.82	34.08	38.06	438.43
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	8.95	8.47	9.78	9.74	8.95	9.74	9.76	9.37	9.34	9.35	8.52	9.77	111.75
Total	55.05	51.63	59.63	60.02	58.46	65.27	69.48	66.08	62.43	59.27	53.47	58.48	719.26
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	55.94	41.02	36.48	27.21	26.68	16.75	13.13	12.49	15.43	24.03	36.12	50.72	355.99
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	1.52	1.48	1.7	1.67	1.45	1.46	1.37	1.27	1.26	1.31	1.28	1.56	17.32
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	57.45	42.49	38.18	28.88	28.12	18.21	14.5	13.76	16.69	25.34	37.4	52.27	373.31

HVAC Occupancy Sensor Model Results

eQUEST Model Results HVAC Occupancy Sensors													
Electric Consumption (kWh x000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	4.5	4.46	5.7	6.54	7.5	11.1	14.34	12.69	9.97	6.77	5.05	4.64	93.26
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	3.5	3.13	3.49	3.42	3.46	3.41	3.49	3.49	3.45	3.54	3.33	3.57	41.28
Pumps & Aux.	2.15	1.94	2.15	2.08	2.15	2.08	2.15	2.15	2.08	2.15	2.08	2.15	25.29
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	31.43	29.36	33.52	33.16	31.43	33.16	33.48	32.49	32.12	32.44	30.05	33.5	386.11
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	7.97	7.54	8.7	8.67	7.97	8.67	8.69	8.34	8.31	8.33	7.59	8.69	99.47
Total	49.54	46.43	53.56	53.87	52.51	58.41	62.14	59.16	55.93	53.23	48.09	52.55	645.41
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	60.6	45.06	39.93	29.38	27.33	17.12	12.98	12.38	15.38	24.87	38.47	56.23	379.75
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	1.33	1.29	1.49	1.46	1.27	1.28	1.2	1.11	1.1	1.15	1.12	1.36	15.17
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	61.93	46.35	41.42	30.84	28.6	18.4	14.18	13.49	16.49	26.02	39.6	57.59	394.91

Ultrasonic Humidifier Model Results

eQUEST Model Results	kWh	Therms
Baseline	719,950	3,719
Estimated Savings Percent	7%	0%
Estimated Savings Ultrasonic Humidifiers	50,397	0

Solar Hot Water: RETScreen Spreadsheet Results

RETScreen Tool		www.retscreen.net		
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	7	7	
Supply temperature method		Formula		
Water temperature - minimum	°F	44.1	Reno City Water	
Water temperature - maximum	°F	58.2	Reno 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		
Solar collector 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	621.9		
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	2.3		
Solar fraction	%	69%		
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	45.2	14.2	31.0

Solar Power Generation: PV Watts Online Calculation Results

PV Watts AC Energy & Cost Savings

Station Identification	
City:	Reno
State:	Nevada
Latitude:	39.50° N
Longitude:	119.78° W
Elevation:	1341 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:	39.5°
Array Azimuth:	180.0°
Energy Specifications	
Cost of Electricity:	0.12

Results			
Month	Solar Radiation ($kWh/m^2/day$)	AC Energy (kWh)	Energy Value ($)
1	3.94	6487	259.48
2	4.91	7227	289.08
3	5.87	9331	373.24
4	6.62	10119	404.76
5	6.39	9774	390.96
6	6.80	9762	390.48
7	7.19	10275	411.00
8	7.25	10541	421.64
9	7.37	10497	419.88
10	6.07	9397	375.88
11	4.78	7348	293.92
12	4.04	6615	264.60
Year	5.94	107371	4294.84

APPENDIX B

Photographs

APPENDIX B - Photographs

Photo 1. Reno FAA Building Automation System Control Station: Ray Chan and Nick Mirhaydari, FAA

Photo 2. Reno FAA Control Tower and Base Building Chillers: Brent Higginbotham, Redhorse

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

Photo 4. Reno xeriscaping to minimize water use