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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, Las Vegas NV

J Arends
WF Sandusky

March 2010

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Pacific Northwest National Laboratory
Richland, Washington 99352

(a) Redhorse Corporation

Executive Summary

This report represents findings of a design review team that evaluated construction documents (at the 70% level) and operating specifications for a new control tower and support building that will be built in Las Vegas, Nevada by the Federal Aviation Administration (FAA). The focus of the review was to identify measures that could be incorporated into the final design and operating specification 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 measures that should be considered prior to finalization of the construction and operation specifications. Those measures were evaluated by the FAA and a series of recommendations were selected for further evaluation including estimating the resulting energy savings (electric and gas), cost savings, implementation cost, and simple payback.

A total of 44 recommendations were documented and delivered to the FAA design team. Of that total, six recommendations were selected to be incorporated into the final design document. 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 measures would result in an electrical energy savings of 444,438 kWh and a thermal energy savings of 2,478 therms. Based on the present commodity rates, the annual cost savings for the site would be $47,934. The total cost for implementation is estimated to be $140,300 resulting in a simple payback of 2.9 years.

Project implementation would reduce greenhouse gas emissions to the atmosphere and create jobs for local workers. It is estimated that an emission of 319 metric tons of CO_2 to the atmosphere would be avoided by implementations of the measures and 1.5 new jobs would be created. These values would increase if other recommended measures were ultimately integrated into the final design.

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1.0 Description of ARRA Program

The Federal Energy Management Program (FEMP) facilitates the Federal Government's implementation of sound, cost-effective energy management and investment practices to enhance the nation's energy security and environmental stewardship. In fiscal year 2009, FEMP received funds specific to the American Recovery and Reinvestment Act (ARRA) of 2009 to assist in the identification, evaluation, documentation of energy efficiency and renewable energy projects at Federal sites.

These funds were allocated to expand the Department of Energy's (DOE's) 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 lab 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 labs' expertise.

The Federal Aviation Administration 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 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, NV and Palm

Springs and Oakland, CA). The second part requested that energy audits be performed at on-going construction activities at two other sites (Reno, NV and Boise, ID). This report represents the findings regarding review of the construction and operating specifications (70% design level) for the Las Vegas, NV site. Results of the other reviews will be documented in separate reports.

1.1 Technical Assistance Activities

The Pacific Northwest National Laboratory (PNNL) contracted with the Redhorse Corporation to complete a review of construction design and operation specifications to identify additional energy efficiency measures or operating specifications that could be provided to Federal Aviation Administration (FAA) for consideration to meet final design completion timelines. Upon review of the proposed recommendations by the FAA, Redhorse Corporation developed estimates of potential energy savings impacts for those design review comments that will be incorporated in the final design documents. Table 1 summarizes the potential annual energy savings, both gas and electric, associated with the accepted recommendations.

Table 1 Summary of Annual Estimated Energy Savings Recommended From Design Review

Review Comment Item # of 44 Identified Recommendations	Energy Saving Recommendations	Electrical Savings (kWh)	Natural Gas Savings (therms)
7, 8, 9, 10, and 11	UV Light Cooling Coil Treatment	83,838	0
17	Reheat Water Temperature Reset	0	-2
18 and 30	Supply Air Temperature Reset	18,400	1,863
30	Variable Air Volume (VAV) Static Pressure Reset	96,800	-5
42	Occupancy Sensor Heating, Ventilation and Air Conditioning (HVAC)	81,800	208
44	Exhaust Air Heat Recovery	163,600	415
	Total (Non Interactive)	**444,438**	**2,478**

The design team used the Trane Trace 700 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 design team's Trane Trace 700 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. Each review item is discussed in sections that follow, after the summary table. Some of the suggestions also include a discussion of the challenges associated with implementing the review item.

2.0 Background

2.1 Site Description

Las Vegas was discovered by Spanish explorers, who gave the city its name, meaning “meadows”, because of the verdant grassland fed by natural aquifers. Las Vegas served as a watering place on the Spanish trail to California.

The site is located in the center of Vegas Valley, a desert region of about 600 square miles, surrounded by the Sierra Nevada Mountains and the Spring Mountains. The seasons are hot, windy, and dry, typical of desert conditions. The mountains around Las Vegas reach elevations of over 10,000 feet, acting as barriers to moisture from the Pacific Ocean. Rainfall at the site is minimal. While the summer days are hot, the nights tend to be cool because of the flow of cooler air down into the valley from the mountains.

2.2 Major Building Energy Uses

The major end-use of energy at the building will be lighting, space heating and cooling, and radar and communication equipment.

2.3 Climate, Facility Type, and Operations

The climate for the site is considered hot and arid. Based on data available from the National Climatic Center, the maximum mean monthly temperature occurs in July (104.1^{0}F), with the minimum mean monthly temperature occurring in December (36.6^{0}F). The highest recorded temperature during the period from 1949 through 2001 was 116^{0}F on August 1, 1979, while the lowest reported temperature during the period of 1948 through 2001 was 8^{0}F on January 13, 1963. Based on the most recent mean data available (1971-2000), the site should experience 133 days with a maximum temperature exceeding or equal to 90^{0}F and 72 days with a maximum temperature exceeding or equal to 100^{0}F. The minimum temperature should be at 32^{0}F or below for 24 days. Annually, the site should anticipate 2239 heating degree days (HDD) and 3214 cooling degree days (CDD).

Mean precipitation level for the site is 4.49 inches per year. The highest daily reported precipitation was 2.58 inches for August 21, 1957. The highest reported monthly precipitation, 4.80 inches, occurred in March 1992. The daily precipitation should be at or greater than 0.01 inches for 29 days during the year. Mean snow fall for the site is 1.0 inches, but the highest monthly snowfall was reported for January 1974 (13.4 inches). The highest daily snow depth is 8 inches on January 5, 1974.

3.0 Energy Use

No historical energy use data exists because the building has yet to be constructed.

3.1 Current Energy, Gas, and Water Use

Specific information regarding energy, gas, and water use was not obtained because the building has yet to be constructed. Information from the existing facility would not be appropriate for use because that building was constructed under a totally different building code.

3.2 Current Rate Structure

The FAA currently pays 10.3 cents per kWh and 92.4 cents per therm from the providers for the existing building. These values were used in estimating the baseline energy consumption and the incremental savings from the various proposed measures.

4.0 Energy Conservation Measures Identified

The design review team identified a total of 44 energy conservation measures that should be considered by the FAA building design team. This included a variety of measures, operating specification for equipment, and potential renewable power generation sources. The FAA design team adopted six measures to be included in the final design. Some of the measures that were accepted were a combination of several recommendations. The measures included both no-cost/low-cost as well as additional capital investment projects. A summary of those measures, estimated electrical and natural gas savings, associated electric, gas and annual cost savings, along with implementation cost and simple payback calculation is provided in Table 2.

Table 2 Energy Conservations Measures Incorporated in the Final Design Specifications

Review Comment Number	Energy Saving Recommendations	Electrical Savings (kWh)	Natural Gas Savings (therms)	Electrical Savings ($)	Natural Gas Savings ($)	Total Annual Savings ($)	Cost to Implement ($)	Simple Payback (Years)
	Cost per unit			0.1027/kWh	0.924/therm			
	Low Cost / No Cost Measures							
17	Reheat Water Temperature Reset	0	-2	-	(1)	(1)	300	-216.5
18 and 30	Supply Air Temperature Reset	18,400	1,863	1,890	1,721	3,611	600	0.2
30	VAV Static Pressure Reset	96,800	-5	9,941	(5)	9,936	2,400	0.2
	Capital Projects							
7, 8, 9, 10, and 11	UV Light - Cooling Coil Treatment	83,838	0	8,610	-	8,610	12,000	1.4
42	Occupancy Sensor HVAC	81,800	208	8,401	192	8,593	25,000	2.9
44	Exhaust Air Heat Recovery	163,600	415	16,802	383	17,185	100,000	5.8
	Total (Non Interactive)	**444,438**	**2,478**	**45,644**	**2,290**	**47,934**	**140,300**	**2.9**

4.1 Summary of Proposed Measures

UV Light - Cooling Coils Treatment: Energy savings resulting from the installation of ultraviolet (UV) cooling coil treatment systems can be estimated by comparing the operating costs of systems with and without UV treatment. Field data from systems operating without UV treatment suggest that there is an increase in fan energy use caused by the buildup of debris on the air side of the cooling coils. Several months after a UV cooling coil treatment system was installed, cooling coil surfaces are cleaner and the fan energy use decreases as the static pressure decreases. In addition to the fan energy losses, the bacterial debris on the surface of the cooling coil cause a fouling effect on the heat transfer rate from the coils. Fouling of the heat transfer surface reduces the heat transfer efficiency. When UV treatment is installed on new systems, the energy savings are estimated on the basis of the projected fouling of the cooling coil surfaces because it affects air flow resistance and heat transfer.

Fan energy use can be calculated using the following formula:

> Fan Energy (kW) = (pressure drop) x (Air Flow Rate) / 6350(Fan Efficiency x Motor Efficiency)

Cooling energy savings in kW can be calculated using the following formula:

> Cooling Energy = (Fouling Loss % x Cooling load) / (3413 x Coefficient of Performance)

The cooling load from the surface fouling can be found in the manufacturer's performance specifications, with losses as high as 20%. The coefficient of performance of a new unit is in the 2.6 to 3.0 range.

The operating costs for the UV light treatment are the cost of electricity and the replacement cost of the UV lamps. These costs are typically much less than the cost of cleaning the coils. Table 2 itemizes the energy use that can be avoided.

Reheat Water Temperature Reset: The temperature of the hot water supplied to reheat systems in air handling systems is often required to be as high as 180^0F. This temperature was used in the design of the building systems to meet the maximum heating loads of the building. The requirements for reheat water vary as the outside air temperature varies. During reduced heating loads, the system will provide adequate heating with reheat water temperatures as low as 140^0F when the outside air temperature is 60^0F. Therefore, many systems are set up to provide 180^0F reheat water when the outside air temperature is at or below 0^0F, and incrementally lower the reheat water temperature to 140^0F when the outside air temperature is at 60^0F.

The estimated annual energy savings are summarized in Table 2. The energy efficiency measure wizard option for heating water reset based on zone loads was used for these estimates. The result of the energy simulation show an increase in energy use, which does not support use of reheat water temperature reset for Las Vegas. However, reheat water reset will be implemented because the life of the boiler will be extended as a result.

Supply Air Temperature Reset: The supply air temperature for a single-duct variable air volume (VAV) system is usually set at a constant 55^0F. 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 55^0F, significant reheat will occur in the winter when air flows reach their minimums and the heating load increases. When the system is in a heating mode; to minimize simultaneous cooling and heating, the supply air temperature is often reset upwards. Resetting the supply air temperature not only affects the cooling and heating energy consumption, but also the fan power consumption. If the supply air temperature is reset too high, it may result in a fan power consumption penalty.

The estimated annual energy savings are summarized in Table 2. The energy efficiency measure wizard option for supply air reset (55 to 65^0F) based on the design zone loads were used for these estimates.

Air handling systems that serve both the core and the perimeter areas of the building have limited opportunities to make use of supply air reset control strategies. This limitation is most evident in the winter, when the perimeter zones are in heating and the core areas of the building continue to require cooling. If the supply air temperature is reset upwards, the core area VAV terminal boxes will increase air flows to maintain space temperature. This increase in air flow will cause an increase in fan energy use. 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 provide 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 55^0F. 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 55^0F and 65^0F.

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 increases to maintain the space temperature. If space cooling loads decrease, the requirements for cold air flow to cool the space likewise 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.

The estimated annual energy savings is summarized in Table 2. 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 therefore estimated by modeling the baseline VAV system as a forward curved fan system with inlet vane dampers, and the static pressure reset option was modeled as a standard VAV system with variable speed drives.

Implementation of the improved air static pressure reset control can greatly increase the energy savings. Since 1999, American Society of Heating, Refrigerating & Air-Conditioning Engineers (ASHRAE) 90.1 has required that static air pressure be reset for systems with direct digital controls, so that "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 increase requests for zone pressure.

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 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, however, 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 thermostats.
- 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.

Occupancy Sensor Controlled HVAC: Lighting occupancy sensors can be used to reduce the heating, ventilation, and air conditioning (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 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 might be an office that is unoccupied during a 2-week period while the occupant is on vacation. Even if this office was vacant during the winter, it would still need to be kept above some minimum temperature (typically no less than 55^{0}F).

Energy savings estimates included in Table 2 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.

Exhaust Air Heat Recovery: Exhaust air heat recovery systems require detailed planning during the design of air handling systems. The most popular system is the air-to-air heat energy recovery unit. This unit requires a ductwork layout that brings the return air and the outside air ducts into and out of the energy recovery unit. Installation of energy recovery units could save up to 40% (one equipment manufacturer's estimate) of the energy required to heat and cool outside air for the facility.

Energy savings estimates included in Table 2 were calculated by reducing the cooling and heating energy from the baseline energy model by 20%.

4.2 Renewable Energy Measures Evaluated

Several renewable energy measures were initially recommended, but were not ultimately accepted. This included installation of a solar thermal system to provide hot water for domestic hot water use, installation of a solar absorption chiller, and installation of wind power generation units instead of the metal shading planned for the courtyard. The latter item was a Broad Star wind system that uses an airplane wing design concept with a reported 30% greater efficiency than typical turbine systems. These systems can be sited in turbulent environments and produce low noise pollution while operating. Because of the low rotational speed of the turbine, radar interference is eliminated.

5.0 Potential Green House Gas Reduction

The potential greenhouse gas emissions resulting from the energy savings was calculated based on the Environmental Protection Agency eGRID data (Pechan 2008). Based on the estimated savings of 444,438 kWh, annual non-baseload CO_2 emissions would be reduced by 319 metric tons. This calculation does not include any contribution that would be related to line losses.

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 measures. 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 equipments purchases, and the installation and operation of the proposed measures.

6.1 Priorities and Next Steps

The FAA has incorporated the recommended measures into the final design and operating specifications. They also indicated that they may consider other recommended measures, such as renewable projects, but a separate funding source would have to be identified and assistance 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 documents listed below so the installed equipment can be properly maintained to maximize the useful life of energy related equipment.

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

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

6.2 Funding Assistance Available

The selected measures 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.

7.0 Assessment Team Members and Site Team

Mr. Jim Arends, PE, CEM, of RedHorse Corporations completed the technical review of the design operating specification for the site. Mr. William Sandusky of PNNL was responsible for review of the technical report submitted by Redhorse and formatting of this document.

8.0 References

E.H. Pechan & Associates (Pechan). September 2008. *The Emissions & Generation Resource Integrated Database for 2007 (eGRID 2007).* Report Number 08.09.006/9011.239. Springfield, Virginia.

APPENDIX A

eQuest Modeling Results and Spreadsheet Calculations

Appendix A - Appendix of eQUEST Modeling Results and Spreadsheet Calculations

Energy modeling developed for the annual energy savings estimates were developed in 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 space on the 8th floor.

Baseline eQUEST Model Results

Baseline eQUEST Results													
Electric Consumption (kWh x000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	15.2	22.6	28.9	64.7	80.4	119	135.5	133.3	106.1	65.7	28.6	17.9	818.00
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	22	20.5	23.2	24.6	25.6	27.9	29.2	29.2	27	24.9	22.1	22.3	298.4
Pumps & Aux.	13.6	12.3	13.6	13.2	13.6	13.2	13.6	13.6	13.2	13.6	13.2	13.6	160.3
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	170	164.4	193.9	185.7	176.1	185.9	181.6	187.9	180	175.9	173.9	181.8	2,157.00
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	37.3	37	44.5	42.5	39.1	42.5	40.8	42.7	40.7	39.1	38.9	40.9	486
Total	258	256.8	304.1	330.6	334.9	388.5	400.8	406.7	367	319.1	276.6	276.5	3,919.80
Gas Consumption (Btu x000,000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0	0	0	0	0	0	0	0	0	0	0	0	0
Heat Reject.	0	0	0	0	0	0	0	0	0	0	0	0	0
Refrigeration	0	0	0	0	0	0	0	0	0	0	0	0	0
Space Heat	373	231.5	208.2	126.2	134.5	64.5	75.1	69.6	82.6	167.1	235.5	307.3	2,075.10
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	14.5	14.8	17.8	16.7	14.3	14	12.4	12.2	11.6	11.8	12.7	14.6	167.6
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	387.5	246.4	226	142.9	148.8	78.5	87.5	81.8	94.3	178.9	248.2	321.9	2,242.70

UV Energy Savings Calculations

Unit	Pressure Drop (Inches H2O)	Air Flow Rate (CFM)	Cooling Heat Transfer Loss	Cooling Load (MBTU)	Cooling Full Load Hours	Cooling Coefficient of Performance	Fan Energy Savings (kWH)	Cooling Heat Transfer Loss (kWH)	Total Annual Energy Savings (kWH)
AHU-1	0.2	33,247	15%	829	628	2.81	16,987	8,143	25,130
AHU-2	0.2	23,822	15%	443	628	2.81	12,172	4,351	16,523
AHU-3	0.2	8,438	15%	263	628	2.81	4,311	2,583	6,895
AHU-4	0.2	11,459	15%	356	628	2.81	5,855	3,497	9,352
AHU-5	0.2	11,509	15%	233	628	2.81	5,880	2,289	8,169
AHU-6	0.2	5,438	15%	105	628	2.81	2,778	1,031	3,810
AHU-7	0.2	2,454	15%	81	628	2.81	1,254	796	2,049
AHU-8	0.2	6,724	15%	218	628	2.81	3,436	2,141	5,577
AHU-9	0.2	5,967	15%	122	628	2.81	3,049	1,198	4,247
AHU-10	0.2	2,932	15%	60	628	2.81	1,498	589	2,087
Total							**57,220**	**26,618**	**83,838**

1) Fan Energy (kWH) = (pressure drop) x (Air Flow Rate) x 8760 Run Hours / (6350 x Fan Efficiency x Motor Efficiency).

2) Cooling Energy (kW) = (Fouling Loss % x Cooling load x Full Load Hours) / (3413 x Coefficient of Performance)

Reheat Water Temperature Reset Model Results

eQUEST Heating Water Temperature Reset Results													
Electric Consumption (kWh x000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	15.2	22.6	28.9	64.7	80.4	119	135.5	133.3	106.1	65.7	28.6	17.9	818.00
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	22	20.5	23.2	24.6	25.6	27.9	29.2	29.2	27	24.9	22.1	22.3	298.4
Pumps & Aux.	13.6	12.3	13.6	13.2	13.6	13.2	13.6	13.6	13.2	13.6	13.2	13.6	160.3
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	170	164.4	193.9	185.7	176.1	185.9	181.6	187.9	180	175.9	173.9	181.8	2,157.00
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	37.3	37	44.5	42.5	39.1	42.5	40.8	42.7	40.7	39.1	38.9	40.9	486
Total	258	256.8	304.1	330.6	334.9	388.5	400.8	406.7	367	319.1	276.6	276.5	3,919.80
Gas Consumption (Btu x000,000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0	0	0	0	0	0	0	0	0	0	0	0	0
Heat Reject.	0	0	0	0	0	0	0	0	0	0	0	0	0
Refrigeration	0	0	0	0	0	0	0	0	0	0	0	0	0
Space Heat	373.1	231.7	208.4	126.4	134.6	64.5	75.2	69.7	82.7	167.2	235.8	307.4	2,076.60
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	14.5	14.8	17.8	16.7	14.3	14	12.4	12.2	11.6	11.8	12.7	14.6	167.6
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	387.6	246.5	226.2	143.1	148.9	78.6	87.6	81.9	94.4	179	248.5	322	2,244.20

Supply Air Temperature Reset Model Results

eQUEST Supply Air Temperature Reset Results													
Electric Consumption (kWh x000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	12.2	16.6	23	57.2	72.1	115.8	130.6	129	101.6	56.6	21.7	14.7	750.90
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	24.6	23.7	27.2	28.9	30	32.8	34.2	34.2	31.6	28.9	25.6	25.4	347.2
Pumps & Aux.	13.6	12.3	13.6	13.2	13.6	13.2	13.6	13.6	13.2	13.6	13.2	13.6	160.3
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	170	164.4	193.9	185.7	176.1	185.9	181.6	187.9	180	175.9	173.9	181.8	2,157.00
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	37.3	37	44.5	42.5	39.1	42.5	40.8	42.7	40.7	39.1	38.9	40.9	486
Total	257.6	254	302.1	327.5	331	390.2	400.8	407.4	367	314.1	273.2	276.4	3,901.40
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	78.14	28.88	20.87	2.98	0.47	0	0	0	0	5.78	24.33	51.33	212.76
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	14.46	14.84	17.81	16.68	14.26	14.03	12.42	12.22	11.62	11.77	12.73	14.59	167.42
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	92.6	43.71	38.68	19.66	14.72	14.03	12.42	12.22	11.62	17.55	37.05	65.92	380.18

Static Pressure Reset Model Results

eQUEST Static Pressure Reset Results													
Electric Consumption (kWh x000)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	14.8	21.7	27.9	63.2	78.8	117.2	133.4	131.1	104.4	64	27.5	17.4	801.50
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	14.7	14	16.1	18	18.8	21.8	23	22.9	20.7	18	15.1	15.1	218.2
Pumps & Aux.	13.6	12.3	13.6	13.2	13.6	13.2	13.6	13.6	13.2	13.6	13.2	13.6	160.3
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	170	164.4	193.9	185.7	176.1	185.9	181.6	187.9	180	175.9	173.9	181.8	2,157.00
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	37.3	37	44.5	42.5	39.1	42.5	40.8	42.7	40.7	39.1	38.9	40.9	486
Total	250.3	249.4	296	322.6	326.4	380.6	392.4	398.3	359	310.6	268.6	268.8	3,823.00
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	372.9	232	208.5	127	135.4	64.9	75.6	70	83.2	168	235.9	307.3	2,080.60
HP Supp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hot Water	14.5	14.8	17.8	16.7	14.3	14	12.4	12.2	11.6	11.8	12.7	14.6	167.6
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	387.4	246.8	226.3	143.7	149.7	78.9	88	82.3	94.8	179.7	248.6	321.9	2,248.10

Occupancy Sensor HVAC Calculation

eQUEST Energy Model Runs	Baseline Electrical Use (kWh)	Baseline Natural Gas Use (Therms)	Typical Savings	Cooling Savings (kWh)	Heating Savings (Therms)
Cooling and Heating Energy Use	818,000	2,075	10.0%	81,800	208

Exhaust Air Heat Recovery Calculations

eQUEST Energy Model Runs	Baseline Electrical Use (kWh)	Baseline Natural Gas Use (Therms)	Typical Energy Recovery Savings	Cooling Savings (kWh)	Heating Savings (Therms)
Cooling and Heating Energy Use	818,000	2,075	20.0%	163,600	415