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Targeted Energy Efficiency Expert Evaluation (E4) Report:
Bannister Federal Complex
Kansas City, MO

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March 2013

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Pacific Northwest National Laboratory
Richland, Washington 99352

Executive Summary

Since 2007, PNNL has conducted Energy Efficiency Expert Evaluations (E4) field training and facility assessment in the Heartland Region (GSA Region 6) buildings to identify low-cost/no-cost opportunities that have the potential to reduce building energy use by up to 10 percent. Based on a follow-up study and feedback from operation and maintenance (O&M) staff, it was recognized that only 50 percent of the recommended measures were implemented and the lack of control systems expertise was often found to be a major challenge in following up on the E4 recommendations. Hence the region undertook a new initiative in 2011 to perform targeted E4 field audits to identify and assist O&M staff implement control system measures to realize the energy savings.

The Targeted E4 retuning process uses the building automation system (BAS) and the site metering data (ION or other if different) as the central tool in the investigation, monitoring and diagnosis of the operating condition of the building equipment and systems. The Targeted E4 process begins with virtual meetings between the Targeted E4 Team, Regional Energy Engineer, Building Managers/staff and O&M contractor to review the BAS and key building systems. These meetings identify BAS trends to set up and save in the building BAS system, along with establishing a complete trend logging process. A minimum of 2-3 weeks of trend data is used before the first site visit to be analyzed by the Targeted E4 team before arriving at the facility. Energy Charting and Metrics (ECAM) tool is used to process the data that results in several charts and graphs highlighting building performance along with individual HVAC system performance (air handlers, terminal boxes, chiller plant, hot water plant, etc.).

During the Targeted E4 process, particular emphasis is made to provide training and implementation assistance to O&M staff. This training includes setting up and use trends and some graphical diagnostic aids pertinent to economizers and chiller performance. The on-site training emphasizes using trend data to evaluate hot/cold calls as well as diagnosis of the operating conditions of a particular piece of equipment and evaluating the actual schedules of equipment versus the actual hours of operations (including scheduled overtime utilities). Overall, the training focuses on optimizing set points, schedules and sequences to save energy without sacrificing the comfort of the occupants of the building. Training also focuses on steering the operators away from using overrides as a normal operating procedure, and to look at the system as a whole to make energy smart adjustments to the BAS. O&M staff are also trained on how to adjust or reverse any control system changes made during the Targeted E4 process, in the event that the changes do not work as expected. In addition, the Targeted E4 team provided phone and email support to the building staff and O&M staff during the retuning process.

A dedicated regional energy engineer (Linda Baschnagel) is assigned to coordinate and facilitate all Targeted E4 efforts, provide metered data reports and provide support to site staff with implementation of the recommended measures and on-going monitoring of the building performance. This coordination is found to be critical for the success of the Targeted E4 process.

This report summarizes the targeted E4 measures identified and implemented in the Bannister Federal Complex in Kansas City, MO. A total of 15 energy savings measures were identified and eight of them were fully or partially implemented. Some of the measures included in this report were recommended or implemented at the time of the Targeted E4 site visit, but further analysis shows they may have little to no impact. Bannister Complex staff is encouraged to review the proposed action plan and estimated savings in determining the implementation priorities for the remaining measures.

The estimated energy savings of all the identified measures is 3 -4 percent. An analysis of utility billing data since the initial visit (December 2011) shows that the building energy use has decreased by 0.6 percent which represents an increase of 6 percent increase after weather correction. Though there are more vacant spaces in Building 1, there is a 25 percent increase in chilled water use while the electricity consumption decreased by 10 percent. Bannister site staff should continue to monitor the utility bills and determine the cause of this increased chilled water use. Since there are no advanced metering capabilities in this complex, further detailed investigation is recommended by setting trend data collection in the BAS to identify the performance issues if there are any causing the increase in chilled water use. This report includes an action plan for O&M staff to monitor and improve the effectiveness of the targeted E4 measures identified and implemented.

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1.0 Introduction

As part of a new targeted E4 initiative by the Heartland Region, PNNL staff members conducted an energy efficiency field audit at Bannister Federal Complex in December 2011. During that time, discussions with O&M staff and review of mechanical, electrical and control systems were performed to identify energy efficiency improvements. PNNL staff worked with site O&M staff to directly implement many of these recommendations. Some measures were determined to be infeasible, and others required assistance from Johnson Controls (JCI). PNNL followed up with a subsequent visit in February 2012 to modify some of the implemented measures and to implement some of the measures that were not addressed during the December 2011 visit. This report summarizes low-cost/no-cost opportunities identified and building control system changes that were implemented during these two visits. The Bannister Complex consists of six buildings that cover a total of 1.5 million square feet of floor area. This report focuses only on Buildings 1 and 2, which constitute 1.3 million square feet, or 84 percent of the floor area of the complex. Table 1 summarizes the energy saving measures that were identified and the status of implementation. (A detailed discussion on each of these measures is included in the next section.) A preliminary estimate of the potential energy saving for each measure has been calculated as shown in Table 1. Because PNNL has not developed an energy model for the Bannister Complex, the expected savings have been calculated based on reasonable assumptions about each particular measure's efficacy and the fraction of the site that they apply to. In many cases, the measures are complex or based on unknown factors and so savings cannot reasonably be estimated, and these are identified as "Unknown" in Table 1. Estimated savings are meant to convey a conservative estimate of the savings potential.

Table 1. Summary of Energy Efficiency Measures and the Expected Savings

No.	***Description***	***Expected Savings***	***Status / Implementation Notes***
BUILDING 1			
1	Add schedules to Air Handling Unit (AHU) to shut down at night	0.9%+	Implemented during February site visit
2	Reduce existing AHU schedules by 1 hour	0.9 %	Implemented by site staff following December visit
3	Control code changes	Unknown	Partially implemented. Further implementation may require JCI Support
4	Economizer control strategy based on dry-bulb temperature	None	Not implemented
BUILDING 2			
5	Static pressure reset	0.5%	Implemented in December, determined to be working well during February visit
6	Supply air temperature reset	0.6%	Implemented in December
7	Add/adjust AHU schedules	0.6%+	Implemented by site staff following the December visit
8	VAV boxes in vacant spaces	Unknown	Bannister staff partially implemented this measure.
9	Minimum outdoor air during unoccupied hours	0.1%	Not implemented yet. May require JCI Support
10	Change control code for return fans	Unknown	Partially implemented with JCI's assistance in February
11	Scheduling of Restroom Exhaust Fans	Unknown	Cannot be implemented due to a plumbing vent issue
12	Fix steam leak	Unknown	O&M staff following up on recommendation. Work on-going as of February 2012
13	Demand control ventilation	Unknown	Recommendation declined for practical reasons
14	Heating valves open in occupied mode	Unknown	Scheduled to be implemented as of February 2012
15	Miscellaneous improvements	None	GSA staff to review

Section 2 of the report summarizes each of the recommended measures, implementation strategy and estimated energy savings. Section 3 presents the measurement and verification of energy savings using utility billing data obtained from the GSA energy use summary reports. The verification is done by comparing weather adjusted energy use before and after the targeted E4 measures implementation. A list of recommendations for continued monitoring and future implementation actions are presented in Section 4, followed by general conclusions of the impact of targeted E4 in Section 5.

2.0 Recommended Measures

2.1 Measure 1 (Building 1): Add Schedules to AHU's to Shut Down at Night

Observation:

- Five of the existing AHUs were observed (reviewed) from various Metasys screen shots to not have schedules in place, or if they did the historical data indicated that the AHU's were running. The following AHUs were running 24/7 during or just preceding the site visit: PU10-1, PQ16-1 (overridden "On"), PO15-1 (includes Intake and Exhaust Fans), PD15-1 and PD15-2.
- The Training Room (AH-PD15-2) is run manually (there is no schedule) by O&M staff when there is a requirement for the use of the space. Otherwise, this fan system does not run. There may be some other areas that could benefit from this type of "manual" operation in lieu of simply letting the fan system run (Auditorium perhaps or other fan systems that serve lightly loaded spaces, especially in light of reduced staff levels).
- Some schedules were not properly configured in Metasys.

Recommendation Log:

- December 2011: Recommend that schedules be added to these AHUs.

Implementation Details/Action Plan:

- December 2011: Building O&M staff will implement this recommendation.
- PNNL staff reviewed the implementation and effectiveness during the follow-up visit in February 2012. Schedules have been added to all air handlers.

Estimated Savings:

- Assuming that these are each 30 kW fans, and that each fan can be easily shut down overnight for 12 hours a day, 5 days a week, the annual savings would be 469,000 kWh ($26,733; 3.0 percent of site electricity consumption; 0.9 percent of building energy consumption). Additional (but hard to quantify) savings are possible from reduced heating and cooling that is enabled by keeping the fans off.

2.2 Measure 2 (Building 1): Reduce Existing AHU Schedules by 1 hour

Observation:

- The existing schedules for the majority of the AHU's are configured to operate from 5 am or 6 am (startup time) and run until 6 pm or 7 pm (shut down time).

Recommendation Log:

- December 2011: Recommend that each AHU's schedule be tightened up by 30 minutes on both ends (delay startup by 30 minutes each day – except for Monday, and turn off 30 minutes earlier each day).

Implementation Details/Action Plan:

- December 2011: Building O&M staff was provided with suggestions to implement this recommendation.
- On-site staff modified schedule to meet the true occupancy of the building.
- PNNL staff reviewed the implementation during the follow-up visit in February 2012.

Estimated Savings:

- This measure was modeled on another GSA office building with a similar HVAC system and found to save 1.3 percent of building energy consumption.
- If applied to most of building 1, this would represent approximately 2/3 of the site's conditioned floor area.
- Bannister Complex should expect about 0.9 percent site energy savings from implementing this measure. This will be an aggregated savings from reduction in steam, chilled water, and electricity usage.

2.3 Measure 3 (Building 1): Control Code Changes

Observation:

Temperature controls for several AHU's are sporadic and do not seem to be well coordinated either at the control level or at the set point settings. Consider the following:

1. During the summer, the Metasys historical data shows that the computer room (served by AH-PJ9-2) was maintaining space temperatures around 57-60°F. On 09/15/2011, the temperature increased over 10 degrees and has since been holding around 71°F. The 71 degree temperature saves cooling energy compared to 57 degree temperatures (especially in the middle of the summer).
2. AH-PD15-1 was observed to have its economizer (outside air damper) modulating from 33-75 percent open, while the electric heating command was also modulating from 8-30 percent command. The economizer set point was observed to be 55°F and the discharge heating set point was observed to be 73.5°F (heating set point was significantly higher than the economizer set point). This results in excess outside air being introduced into the fan, only to be electrically heated at great cost and energy waste. The economizer set point should be sequenced with the discharge heating set point to mitigate this type of "simultaneous heating and outside air cooling."
3. AH-PM19-1 was observed to have a static pressure set point of 1.0 in. w.c., but only attaining 0.2 inches W.C. most of the time.
4. AH-PF21-1 was observed to have its economizer dampers overridden to be closed (0 percent open) and the mechanical cooling was active (100 percent command).
5. AH-PE10-3 was observed to have its damper commanded to be 100 percent open. The result was that the discharge air temperature, mixed air temperature and return air temperatures were all showing values in the lower 50°F range. This indicates that the space served by this air handler is severely over-cooled!
6. AH-PB15-2 was observed to be off, but the cooling valve was 100 percent open.
7. AH-B2 was observed to have both heating and cooling valves open/active at the same time, at night.
8. Past site visits (2009) noted the same problems (night shutdown resulting in heating valves failing wide open). This results in excess steam loads at night and actually warms the space/building up as the heat migrates from the fan system, out into the building

2.3 Measure 3 (Building 1): Control Code Changes

Recommendation Log:

December 2011: Recommend that the control code be changed to ensure the following is occurring (this list matches the observations above):

1. Keep computer room temperatures at a reasonable temperature that is not over-cooling the spaces (at great cost). Any temperature that is lower than 65 is probably too cold.
2. Modify control code to ensure that economizer dampers are not modulating beyond the required minimum outside air setting while heating is active. This may be a simple set point change or could be more sophisticated automatic set point adjustment, etc.
3. Fix VFD or inlet vanes and the control signal to them to ensure required static pressures are being maintained. If VFD or inlet vanes are operating correctly, verify that the static pressure sensor is working and calibrated correctly.
4. Periodically (at least once/week) review overrides and determine if they are valid for all HVAC systems. The damper overridden to 0 percent open is causing the need for mechanical cooling, which should not be occurring unless there is a economizer failure (which should be repaired)
5. The control sequence and buried objects (CS objects) should be evaluated to determine why the economizer damper is 100 percent open. If the AHU has a CO2 sensor, ensure that the sensor has not failed and showing an excessively high CO2 reading. This can contribute to the controller commanding the economizer dampers to be fully open. Whatever the cause is, it should be determined and resolved to mitigate over-cooling the space.
6. When any air handler system shuts off, the control sequence should close the heating coil control valve, the cooling coil control valves and the outside air dampers. The only time the heating coil control valve should open, is when the outside air temperature is below 35°F and the mixed air temperature is below 45°F (indicating cold air is migrating into the air handler). Otherwise, keep the steam coil control valves closed.
7. Same comment as #6.
8. Same comment as #6.

Implementation Details/Action Plan:

- December 2011: These recommendations may require the support of the local JCI control service technician to implement or troubleshoot why the observed conditions are as they are. Suggest that GSA work with their O&M contractor to bring JCI service technician on-site to look into this.
- February 2012: Most of these sub-recommendations have been implemented by the on-site staff and some are on-going.

Estimated Savings:

- Unknown, difficult to quantify.

2.4 Measure 4 (Building 1): Economizer Control Strategy based -on Dry-bulb Temperature

Observation:

- Economizer controls were observed on some AHU's to be "enthalpy" based, while on other AHU's they were observed to be "dry-bulb" based.
- Past observations of different enthalpy controls have found that there is a significant maintenance effort related to humidity sensor calibration and reliability (and possibly redundancy) which comes at significant cost.

Recommendation Log:

- December 2011: Recommend that the site evaluate how many AHU's have enthalpy economizer control versus dry-bulb economizer control. Dry-bulb economizer control simply uses a temperature sensor (easy to maintain and configure). It may be more reliable and maintainable to convert all AHU's to dry-bulb economizer control.
- December 2011: For existing AHU's with dry-bulb economizer control, the set points were observed to be configured at 65°F (which is the recommended outside dry-bulb set point for summer/humid conditions). During the winter (after October 15), this set point should be adjusted up to 70°F and put back to 65°F (after April 15) to take advantage of less humid conditions that are more optimal for outside economizer operations.

Implementation Details/Action Plan:

- December 2011: GSA and O&M staff need to evaluate and prioritize the recommendation to change the control strategy.

Estimated Savings:

- Assuming the enthalpy controls are working well, no additional energy savings are expected. However, in the past, the humidity sensors were observed to have failed and no economizing was done for extended periods of time.

2.5 Measure 5 (Building 2): Static Pressure Reset

Observation:

- The existing (5) fan house AHU discharge static pressure set points that serve the different areas of Building 2, were noted as being set at a constant set point value of 2.0 inches W.C. These AHU's serve numerous VAV boxes (mostly new) on 2-3 different floors.
- Secondary observation by GSA staff regarding the new VAV boxes. The vendor is "Titus" and the VAV model is "DESV." Per their website, these VAV boxes have no heating coils or cooling coils that require typical high duct static pressure requirements and could very likely work without any issues at static pressures around 1.0" w.c.

Recommendation Log:

- December 2011: Recommend that the discharge static pressure set point be reset from 0.75 inches W.C. up to 1.5 inches W.C. Reset should be based upon the average VAV damper position of all the VAV boxes served by the AHU. When the average VAV damper position is 30 percent or lower, the discharge static pressure set point will be at the lower value (operator adjustable – currently set at 0.75 inches W.C.) and when the average VAV damper position is 60 percent or greater, the discharge static pressure set point will be at the higher value (operator adjustable – currently set at 1.5 inches W.C.).
- February 2012: Static pressure reset is recommended for two additional air handlers: AHU-3B (Mall), AHU-PE10-3 (Atrium), but has not been added yet.

Implementation Details/Action Plan:

- This was implemented during the week of December 12-16, 2011 for Fan House 1 East, Fan House 1 West, Fan House 2 East, Fan House 2 West and Fan House 3. Five new algorithms and 20 blocks of code (including additional control points) were added to the existing Metasys System Extended Architecture (MSEA) for each Fan House AHU.
- Additional code was written to sum the return fan and supply fan VFD KW readings. Preliminary readings were taken before this was implemented. The readings that were taken after implementation indicate an approximate reduction of 20-30 KW per Fan system.
- This recommendation's performance was reviewed with O&M staff during PNNL's follow-up visit in February and it was determined to be effective.
- February 2011: Static Pressure Reset has been added to all of the fan houses and Bannister staff are fine tuning the set points to optimize the controlling logic.

Estimated Savings:

- This measure saves energy by operating the fan at lower power for a given flow rate of air that it delivers. This is true most of the time except during high air flow periods (hot summer days).
- We assume that 75 percent of the time, the fans will be able to operate at a lower power than before, that the average savings is 25 kW/fan, and that there are five fans affected.
- Savings Calculations:
- 25 kw/fan x 5 fans x 9 months x 12 hours/day x 20 days/month = 270,000 kWh ($15,300/year).
- This represents 1.7 percent of site electricity consumption or 0.55 percent of site energy consumption.

2.6 Measure 6 (Building 2): Supply Air Temperature Reset

Observation:

- The Fan House A39 discharge temperature set points were observed as being set at a constant set point value of 55°F to 60°F.
- The mixed air set points that control the outside air dampers when in economizer mode were also observed to be incorrectly sequenced with the discharge temperature set points. For instance, Fan House 3 was observed to be over-cooling; the mixed air set point was noted as being very low (50-52°F) while the discharge temperature set point was observed to be 60°F. This can result in more reheat load on the perimeter reheat system that serves the windows to make up for the over-cooling. The actual discharge air temperature was 55°F.

Recommendation Log:

- December 2011: Recommend that the supply air temperature set point be reset from 55°F up to 65°F. Reset should be based upon the return air temperature of the respective AHU. When the return air temperature is 71°F or lower, the supply air temperature set point will be at the higher value (operator -adjustable – currently set at 65°F) and when the return air temperature is 75°F or greater, the set point will be at the lower value (operator adjustable – currently set at 55°F).
- December 2011: Recommend that the mixed air set point be automatically synchronized with the supply air temperature set point (it should run no more than 3°F below the supply temperature set point, to account for heat pickup from the supply fan).
- February 2011: Two additional air handlers have been added to this recommendation: AHU-3B (Mall), AHU-PE10-3 (Atrium).

Implementation Details/Action Plan:

- This was implemented during the week of Dec. 12-16, 2011 for Fan House 1 East, Fan House 1 West, Fan House 2 East, Fan House 2 West and Fan House 3. Five new algorithms and 20 blocks of code (including additional control points) were added to the existing MSEA for each Fan House AHU.
- This recommendation’s performance was reviewed with O&M staff during PNNL’s follow-up visit in February and has been added to all of the fan houses. Staff are fine tuning the set points.

2.6 Measure 6 (Building 2): Supply Air Temperature Reset

Estimated Savings:

- This measure saves energy in the heating season by raising the temperature of air entering the zones via the supply fan, thus lowering the amount of heating that the heating coils must perform.
- To determine a rough estimate of savings, we assume that this measure raises the supply air temperature from an average of 57.5°F to 65°F for three months out of the year and from an average of 57.5°F to 60°F three months out of the year (in each case for 12 hours per day and 20 operating days per month).
- Further assumptions are that this measure applies only to the HVAC units serving the 300,000 sf of floor space in building 2, the supply fans are sized to 1.5 cubic feet per minute (CFM)/sf of floor space, and that the supply fans run at 40 percent speed during the heating season.
- Savings Calculations:
- 300,000sf x 1.5 CFM/sf x .000472 m3/CFM x 1.2 kg/m3 x 1.01 kJ/kg-C * 4.2C = 432kW (3 months).
- 300,000sf x 1.5 CFM/sf x .000472 m3/CFM x 1.2 kg/m3 x 1.01 kJ/kg-C * 1.4C = 144kW (3 months).
- 432 kW x 12 hrs/day x 20 days/month x 3 months x 0.003414 MBtu/kWh = 1061 MBtu.
- 144 kW x 12 hrs/day x 20 days/month x 3 months x 0.003414 MBtu/kWh = 354 MBtu.
- Total Savings: 1416 MBtu = 1185 Mlb steam = 1.3 percent of Bannister Steam consumption ($6,325/yr), or 0.6 percent of site energy consumption.

2.7 Measure 7 (Building 2): Add/Adjust AHU Schedule

Observation:

- Two of the existing Fan House AHU's were observed (reviewed) from various Metasys screen shots, to not have schedules in place. The following AHUs were running 24/7 during or just preceding the site visit: Fan House 2 West and Fan House 2 East. This was discussed with O&M staff while on-site and determined to be related to construction activities.
- Fan House 1 East has a schedule that starts that AHU fan system at 4 AM every weekday. The other Fan House AHU's (Fan House 1 West and Fan House 3) have 5 am start schedules. All of the stop schedules are configured to be at 6:00 pm (except for Fan House 1 East – 5:30 pm).

Recommendation Log:

- December 2011: Recommend that schedules be added to the Fan House 2 AHU's as soon as possible.
- December 2011: Recommend that the schedules for the other Fan Houses be tightened up and synchronized with each other so they are within 15 minutes of each other (recommend starting later, rather than earlier) and also pushed toward 5:30 am, not 4:00 am. Also recommend that the stop times be pushed toward earlier (5:30 pm) times, similar to Fan House 1 East.

Implementation Details/Action Plan:

- Building O&M staff was provided with details to implement this recommendation.
- PNNL staff reviewed the implementation during the follow-up visit in February 2012.
- Schedules have been added to all air handlers. This measure was completed by on-site staff.

Estimated Savings:

- The savings estimates is based on the assumption that each of these fans consumes (on average) 40 kW when running after the static pressure reset.
- Savings from Fan House 2 West and Fan House 2 East, assuming they can be shut off for 12 hours a day, 5 days a week is 249,600 kWh, plus an unknown amount of heating and cooling savings.
- Savings from the remaining three fans by shortening their morning operation (assuming each starts instead at 5:30 a.m. is 26,000 kW.
- Total savings is conservatively estimated to be 275,600 kWh/yr. ($15,665, 1.8 percent of site electricity consumption, or 0.6 percent of site energy consumption). Some additional savings in chilled water and steam are also likely.

2.8 Measure 8 (Building 2): VAV Boxes in Vacant Spaces

Observation:

- Several areas are now vacant, either due to construction or staff changes. This allows several areas the opportunity to save fan energy and reduce reheat energy by using the VAV box local thermostat capability.

Recommendation Log:

- December 2011: Set the local thermostat set point adjustment dial as high as it will adjust to (do not implement this on thermostats serving VAV boxes with reheat or on thermostats serving air handlers with heating coils where the thermostat is used directly by the air handler). By setting the VAV box to a higher set point, the controls will reduce the air flow, resulting in less load on the supply fan VFD.

Implementation Details/Action Plan:

- Building O&M staff implemented this recommendation.
- PNNL staff reviewed the implementation during the follow-up visit in February 2012.
- Many areas have been turned off along with some of the air handlers serving these areas.

Estimated Savings:

- Not determined due to the uncertainty in assumptions related to systems serving these spaces.

2.9 Measure 9 (Building 2): Minimum Outdoor Air during Unoccupied Hours

Observation:

- The economizer minimum outside air damper control was observed to be embedded in a PID loop in the JCI controller and is configured presently to open the minimum damper anytime the supply fan status indicates "On." This means that the outside air dampers are opening anytime the fan is running (including night set back, morning warm up or morning cool down periods). There is no requirement to bring in outside air during these periods and this actually puts more heating or cooling load on the AHU's when the outside air conditions are not conducive (either cold or hot/humid). Per the JCI control drawings titled "GSA Fan House Upgrades 2005," the actual sequence of operation document for all the Fan House AHU operations says the following in regards to the damper controls. NIGHT SETBACK/NIGHT SETUP: "WHEN IN 'UNOCCUPIED' MODE, THE UNIT WILL CYCLE AS NECESSARY. THE ECONOMIZER WILL BE DISABLED. THE PREHEAT FACE AND BYPASS DAMPERS AND COOLING COILS WILL BE MODULATED TO MAINTAIN THE ZONE TEMPERATURE AT SET POINT."

Recommendation Log:

- December 2011: Recommend that the control code be reviewed and changed (if necessary) to ensure that the outside air dampers are held closed during the entire unoccupied period, and prior to actual occupancy to mitigate bringing in any more outside air than is absolutely necessary. This will reduce the heating and cooling loads on the building and actually help the building recover quicker from the night setback temperatures.

Implementation Details/Action Plan:

- December 2011: This may require the support of the local JCI control service technician to implement or troubleshoot the existing DX controller code to determine why it is not working correctly. Suggest that GSA work with their O&M contractor to bring JCI service technician on-site to look into this.
- Implementation of this recommendation began during PNNL's follow-up visit in February and will be part of the return fan control code implementation.

Estimated Savings:

- Modeling of this measure for another GSA building showed 0.1 percent of annual building energy savings. It is reasonable to expect similar savings at Bannister.

2.10 Measure 10 (Building 2): Change Control Code for Return Fans

Observation:

- The Fan House AHU's are supposed to be configured to maintain a differential volume offset such that air flow stations are used to measure the air flow being supplied to the space. The supplied air flow is compared to the air being returned from the space. The ability to set a volume difference (usually to allow for maintaining the building pressure slightly positive and to account for miscellaneous exhaust fans and leaks in the building) is supposed to result in the return fan being operated (via VFD speed controls) to match the volumetric set point difference as measured by the air flow stations. However, upon observation, only one fan house appears to be working correctly. Otherwise, all the other fan house AHU systems were observed to have their return fans operating at a speed that was resulting in significantly higher return cubic feet /minute rates than needed and in many cases significantly more air was being returned than was being supplied. This also can be seen in the calculated outdoor air factions and will impact the air handler's ability to use outside air for free cooling during moderate weather. The control sequence document states that return fan speed controls will be overridden in the control code if the space static pressure is outside certain boundaries. Observations of the building static pressure readings did not appear to be an issue. Observations of several return fan power readings were indicating return fans consuming as much (or more) power than the supply fans. This should not be occurring as return fans do not have as much inherent load to overcome as compared to supply fans.

Recommendation Log:

- December 2011: Recommend that the control code be reviewed and changed (if necessary) to ensure that the return fans are operating correctly to maintain the correct CFM volume differentials, or the control code should be changed to operate from some other parameter (perhaps building static pressure only or perhaps power differential).

Implementation Details/Action Plan:

- December 2011: This may require the support of the local JCI control service technician to implement or troubleshoot the existing DX controller code to determine why it is not working correctly. Suggest that GSA work with their O&M contractor to bring JCI service technician on-site to look into this.
- February 2012: Control code was changed on one fan and tested with the assistance of JCI during PNNL's follow-up visit. The recommendation was tested on one unit and found to work correctly. GSA to schedule JCI back on-site to further implement the code changes on the rest on the air handlers in the building.

Estimated Savings:

- Unknown.

2.11 Measure 11 (Building 2): Scheduling of Restroom Exhaust Fans

Observation:

- The exhaust fans that serve different restrooms were observed to be running at night and on weekends (24/7).
- O&M staff indicated that this may be due to exhaust fan control being bypassed either on Metasys or at the starter/control relay in the Penthouse or other areas. This may be due to smells (not specified as to what that meant). If this is due to sewer fumes, this may indicate a problem with the building's plumbing (traps) not being properly primed, etc.

Recommendation Log:

- December 2011: Recommend that consideration be given to adding schedules that run the bathroom exhaust fans during the night and weekend periods, but are configured to operate the exhaust fans for 30 minutes each hour (30 minutes on, 30 minutes off). This effectively will reduce the runtime by 50 percent and also reduce outside infiltration rates by similar percentage.

Implementation Details/Action Plan:

- February 2012: This recommendation was discussed with the O&M staff during PNNL's follow-up visit and determined that it cannot be implemented due to a plumbing vent issue in the building.

Estimated Savings:

- Not estimated.

2.12 Measure 12 (Building 2): Fix Steam Leak

Observation:

- A small steam leak was observed on Fan House 3 Air Handling Heating coil. Perhaps this is the reason for the Mixed Air Set Point on Fan House 3 being set so low (52 °F). If true, using cold outside air to remove excess heat from a leaking steam coil is not energy smart and also means that more mechanical cooling is required to do the same when outside air temperatures are above 50-55 °F.

Recommendation Log:

- December 2011: Recommend fixing steam leaks when they occur or as soon as reasonably possible.

Implementation Details/Action Plan:

- February 2012: Building O&M staff is following up on this recommendation and work is still on-going. PNNL will follow-up with on-site staff to resolve this issue.

Estimated Savings:

- Unknown.

2.13 Measure 13 (Building 2): Demand Control Ventilation

Observation:

- All the Fan House AHU's have CO_2 sensors and minimum outside air dampers. As already noted, the minimum outside air dampers open during unoccupied periods when the sequence of operation document states that they should be closed. To further this discussion, the observation of CO_2 sensors in the return air of each fan system provides the ability to limit the introduction of outside air, even during occupied periods.

Recommendation Log:

- December 2011: Recommend that the current control code be evaluated for inclusion of Demand Control Ventilation (DCV) by using the existing CO_2 sensors. Typical control keeps the minimum outside air dampers closed or at some very small opening (less than 5 percent) unless the CO_2 reading starts to rise above some minimum threshold value (800 PPM is often a target value). If the building has a lot of infiltration or leaks (which is likely, given the age and manner in which the exhaust fans are controlled), than the requirement to introduce additional outside air at the fans is reduced. The other reason to consider this is the fact that the number of staff in the building has been reduced, so the amount of fresh air should also have reduced.

Implementation Details/Action Plan:

- February 2012: This recommendation was discussed with O&M staff during PNNL's follow-up trip, and it was decided that it is not going to be implemented since the minimum air dampers are used for makeup air to the exhaust fans in the building.

Estimated Savings:

- Not calculated due to lack of necessary data.

2.14 Measure 14 (Building 2): Heating Valves Open in Unoccupied Mode

Observation:

- Observation #3 above in Building 1, also applies to Building 2 (night shutdown of air handlers with steam heating coil failing wide open when outdoor air temperature is less than 45°F). The unoccupied control does not differentiate on this and maintains the preheat coil in an "active" mode to try and maintain the space temperature, which is difficult if the fan is not operating.

Recommendation Log:

- December 2011: When any Fan House air handler system shuts off, the control sequence should close the heating coil control valve, the cooling coil control valves, and the outside air dampers. The only time the heating coil control valve should open, is when the outside air temperature is below 35°F and the mixed air temperature is below 45°F (indicating cold air is migrating into the air handler). Otherwise, the steam coil control valves should be closed.

Implementation Details/Action Plan:

- This recommendation will be fixed at the time of the return fan code changes. It requires some modification to the code to control valve from the preheat sensor and not from the mixed air temperature sensor.

Estimated Savings:

- Unknown, further data collection is needed to calculate savings.

2.15 Measure 15 (Building 2): Miscellaneous Observations and Recommendation

Observations and Recommendations:

- There are several minor improvement opportunities that are not “control” improvements, but simply monitoring and diagnostic improvements. This includes using the existing Metasys network to calculate total CFM airflow per AHU (sum the individual VAV box CFM readings) and cooling coil tonnage (delta T x CFM x 1.08/12000). Some of these were implemented during PNNL’s follow-up visit in February, however, this is not completed for all systems and O&M staff are expected to follow-up on this recommendation.
- The individual AHU supply/return fan KW values can also be summed for a total fan KW reading. This was implemented during PNNL’s follow-up visit in February and is currently being trended for all fans.
- Several Metasys controllers were observed to be “Offline” and should be fixed or diagnose the problem that is keeping them offline (control power loss, communication problem, etc.). This includes the following controllers – V2W1-13, V31-12, V31-15, V1EB-3, AHP015-1, AHPF21 (Zones 1-26, Mall Warehouse) and FTS Feeder Root. Many of these problems were fixed during PNNL’s follow-up visit in February. Many of these systems were in areas that are no longer occupied and systems have been shut down.
- The Mall Warehouse Temperature Sensor (Post T-17.5) was observed to be unreliable and should be fixed or replaced. However, this sensor does not exist in Metasys and is not an issue to be addressed for building control.

3.0 Measurement and Verification of Energy Savings

Figure 1 shows a history of energy consumption at Bannister, using energy use intensity (EUI) as the metric for comparison. The chart shows the actual energy use intensity in blue, as well as the weather-corrected EUI in red. Since FY08, there has been a sharp reduction in energy consumption (22.3 percent in absolute terms, and 24.5 percent after correcting for weather). Toward the end of FY11, significant vacancies took place at Bannister. These vacancies affected the last three months of FY11, and from October-December 2011 they were responsible for 2.2 percent of the overall 9.0 percent savings compared to FY11. FY12 is the first full year after these vacancies occurred, and continued reductions in energy consumption were expected as a result. On top of reduced energy use due to vacancies, PNNL estimated 3-4 percent additional total building energy savings from the implemented Targeted E4 measures. The vacancies and energy measures, unfortunately, did not result in a complex-wide reduction in utility-metered energy consumption in FY12. Based on differences in weather alone, energy consumption should have dropped 6 percent (estimated) from FY11 to FY12, but instead it dropped only 0.6 percent. Thus, there are unknown factors that have been responsible for negating the otherwise positive impacts of vacancies, energy conservation measures and more favorable weather in FY12.

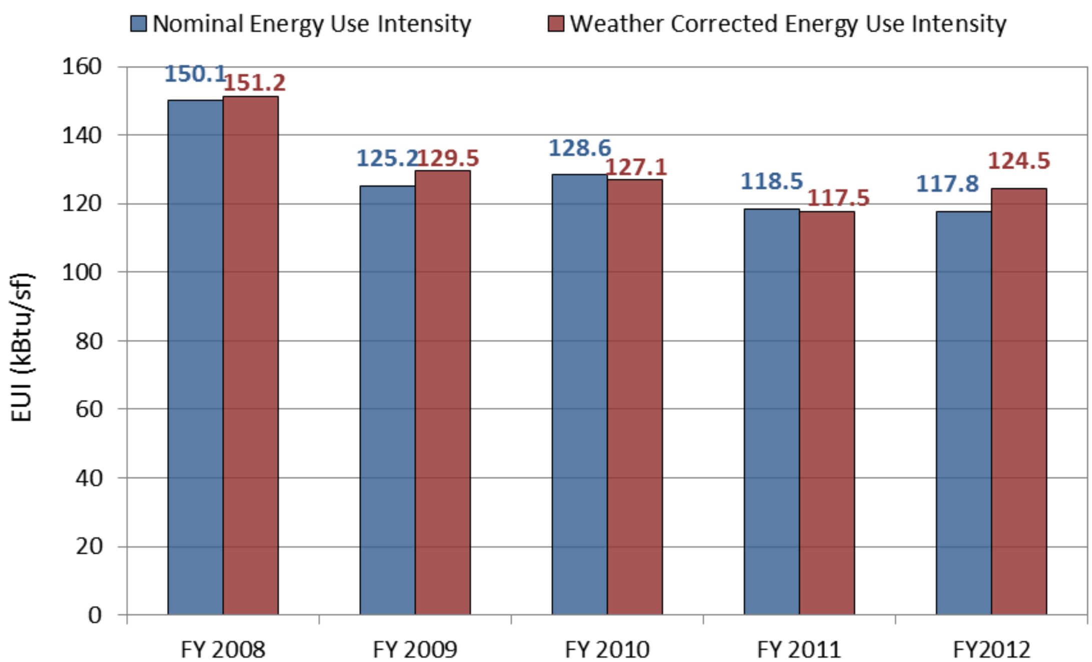

Figure 1. EUI History and Projections for Bannister Complex

Bannister Complex does not have advanced metering or sub-metered data for detailed analysis and verification of energy savings due to Targeted E4 implementations. Hence PNNL analyzed utility billing data as reported by the GSA EUAS system. A rolling twelve month comparison of energy use for periods before and after Targeted E4 is done to assess the impact. Monthly energy use data from the EUAS system for Bannister is presented in Figure 2 to compare monthly energy performance in FY12 to FY11for both the actual and weather-corrected energy consumption.

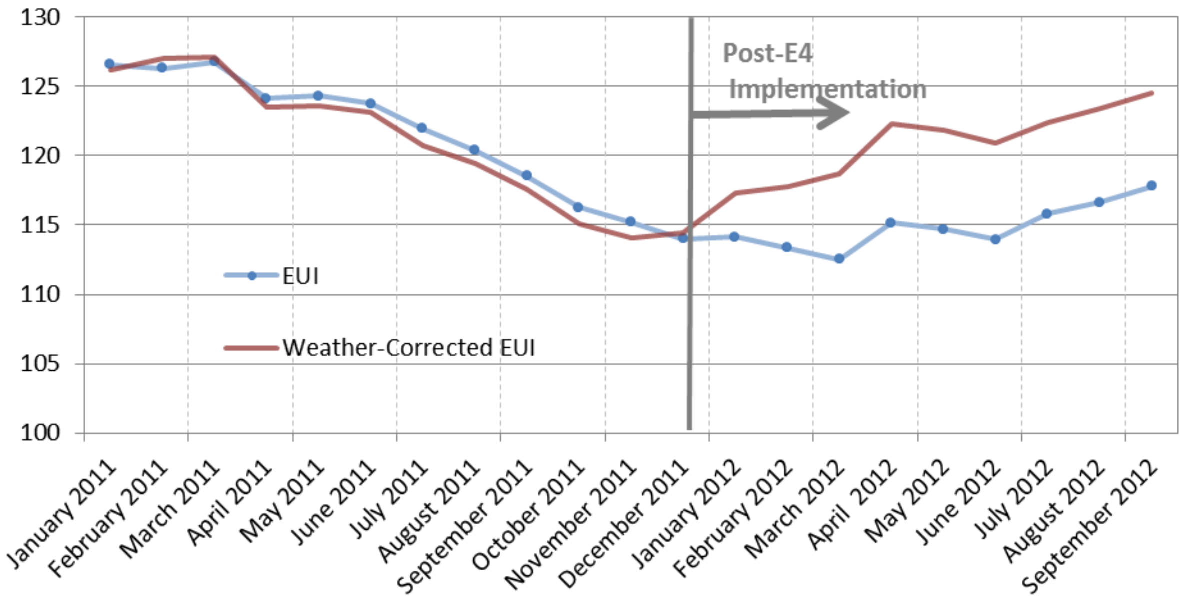

Figure 2. EUAS (Utility Bill) Analysis- Rolling 12-month EUI since January 2011

Figure 2 shows that rather than an energy savings being evident from utility billing data, the site appears to have increased its energy consumption significantly. Energy consumption trends, especially in steam and chilled water, metered at the nearby DOE facility have been unreliable for the last several years, and this year was no exception. It was expected that even without the Targeted E4 improvements, the energy consumption would continue to decline in FY2012 as the effects of recent office vacancies from July 2011 manifested in each month of FY2012 up to July. This was not the case. Steam consumption has increased 8.5 percent relative to FY2011 since the Targeted-E4 December visit (28.4 percent weather-corrected), and chilled water has increased 22.9 percent relative to FY2011 (1.1 percent weather-corrected). However, electricity use decreased by 10.9 percent (13.6 percent weather-corrected). But electricity, accounts for only 25 percent of Bannister's site energy consumption. The implemented Targeted-E4 measures were expected to result in a modest 3-4 percent site energy savings. The much wilder swings in the three utility meters indicate that the "signal-to-noise" ratio is far too low to make any useful conclusions about Targeted E4 effectiveness. The Continuous Monitoring Plan may serve as a better tool to gauge the effectiveness of the measures, even if their energy savings cannot be verified quantitatively.

4.0 Recommended Monitoring Plan

This section provides recommendations for continued monitoring and implementation of several of the measures summarized in Section 2 and implemented as part of the Targeted E4 actions taken during FY12.

Measures 1-4 (Building 1): Consolidated monitoring plan

Monitoring Timeframe: Once Annually

Building 1 has limited BAS digital control and monitoring is limited to high-level verification and physical checks of systems.

- Verify that schedules keeping PU10-1, PQ16-1, PO15-1, PD15-1 and PD15-2 off at night.
- Generate updated lists of tenant scheduled occupancy and new vacant spaces. Determine if any air handlers are being run longer than the occupancy currently requires. If so, tighten air handler schedules.
- Verify that computer room thermostat set points remain above 65^{0}F.
- Verify that economizing (mixed air) set points building-wide are equal to discharge air temperature set points.

Measure 5 (Building 2): Static Pressure Reset

Monitoring Timeframe: 1 day in spring 2013

Times of moderate weather in the spring should provide a good time to test the effectiveness of static pressure reset at Bannister. Zone airflow demands should be low, and static pressure set points are expected to be at or close to minimum programmed levels.

- Make note of current static pressure minimum and maximum set points in Metasys. Are minimum static pressure set points still at 0.75" w.c. and maximum set points still at 1.5" w.c.? If not, why have they changed?
- Trend the static pressure set point for 2-3 air handlers over the course of a typical business day (24 hours). Does the static pressure set point stay near the minimum set point or modulate between the minimum and maximum set point (as desired)?
- If the static pressure set point remains stuck at the maximum set point, can the problem be traced? This should only happen if most of the zone dampers are nearly fully open. If this is not the case, is the static pressure reset algorithm enabled?
- ***Verifying Savings***: Trend supply fan power consumption for 24 hours, then set all minimum and maximum static pressure set points to 2.0" w.c. (previous levels) and trend power consumption for another 24 hours. Export to a spreadsheet and calculate the time-averaged power consumption for all fans in day 1 and day 2. Sum the average consumption across all fans for day 1 and day 2. What fraction of fan energy consumption is the static pressure reset saving? ***100% x [1- (day1 total/ day2 total)]***

  We expect around 40 percent in the spring/fall and 15-25 percent in the summer/winter. Remember to reset the minimum and maximum static pressure set points back to 0.75" w.c. and 1.50" w.c. , respectively after this exercise.
- ***Enabling Further Savings***: Are all of the static pressure set points near their minimum values in the spring? Experiment with lowering the minimum static pressure set points to 0.4 or 0.5" w.c.

Measure 6 (Building 2): Supply Air Temperature Reset

Monitoring Timeframe: 1 day in winter 2012-2013

In the winter, supply air temperatures should be close to their maximum values.

- Make note of current maximum and minimum supply air temperature set points. Are they all set to 65° and 55°F, respectively?
- Trend the supply air temperature set point for 2-3 air handlers over the course of a typical business day (24 hours). Does the supply air temperature for each air handler stay near 65°F. If not, try to determine why:
  - What is the return air temperature for a given air handler? Compare to the zone temperatures in the air handler's network.
  - Is the return air temperature a good approximation of the average zone temperature?
  - If the return air temperature seems significantly higher than the average zone temperature, increase the low-limit return air temperature in the supply air temperature reset algorithm.
- ***Enabling Further Savings***: Are all of the zone temperatures comfortable or cool?
  - Raise the low-limit return air temperature in the supply air temperature reset algorithm 1 degree each hour until one or two zones border on becoming too warm (75-77°F)
  - Raise the high-limit supply air temperature to 70°F

Measure 7 (Building 2): Add/Adjust AHU Schedules

Monitoring Timeframe: One Week during mild weather conditions

- Verify that schedules keeping Fan House 2 West and Fan House 2 East off at night remain in place.
- Trend the fan VFD and several zone temperatures for these two AHUs for one week. Does the fan clearly shut off at night? Does the fan only come back on in order to satisfy zone temperatures that are below nighttime setback set points?

Measure 8 (Building 2): VAV Boxes in Vacant Spaces

Monitoring Timeframe: Once in Winter 2012-2013

- Verify that all VAV boxes without reheat serving vacant spaces have their thermostats set as high as possible.
- If possible on Metasys, set thermostat set points for vacant zones to constant 55°F heating set point at 85^{0}F cooling set point.

Measure 15 (Building 2): Miscellaneous Observations and Recommendations

- Check the temperature differential across the steam heating coil on Fan House 3 to verify that the steam leak has been fixed.
- Verify that the mixed air set point for Fan House 3 has been set higher (was 52°F).
- Trend preheat coil control valve command and corresponding fan VFD for one week in the winter and ensure that the preheat coil control valves remain closed whenever the fan VFD is off.

5.0 Conclusions

Bannister Complex is one of the most challenging buildings in Region 6 to take advantage of Targeted E4 effort due to the age of the facility and limited BAS capabilities. However, PNNL identified opportunities for saving 3-4 percent annually by adjusting schedules, and by implementing temperature/pressure resets on various air handlers. In total, there are 15 energy saving opportunities identified and several of them were already implemented.

During FY12, Bannister Complex actual energy use decreased marginally by 0.6 percent compared to FY11. Recent monthly utility bill analysis indicates a trend reversal of increase in overall energy use. Though overall electricity use has decreased by almost 10 percent, the chilled water/tempered water use has increased by 22 percent. This situation requires O&M staff to investigate the effectiveness of individual measures and review the impact of any recent occupancy changes or operational changes that could contribute to the increase in chilled water/tempered water use.

In order to realize additional savings and further benefit from the recommended and already implemented measures, PNNL has provided an action plan that requires commitment on the part of the building manager and O&M contractor for continued monitoring and adjustments to the control system. It is important to highlight the need for dedicated regional staff to facilitate and coordinate the implementation, and monitor the effectiveness of Targeted E4 measures.