CONSORTIUM for BUILDING ENERGY INNOVATION

Re-tuning Case Study

GSA National Capital Region Re-tunes Office Building and Courthouse. Washington, D.C.

In the first four months since re-tuning the LBJ Dept. of Education Headquarters, facilities staff from GSA saved an impressive 21.7% on electricity usage.

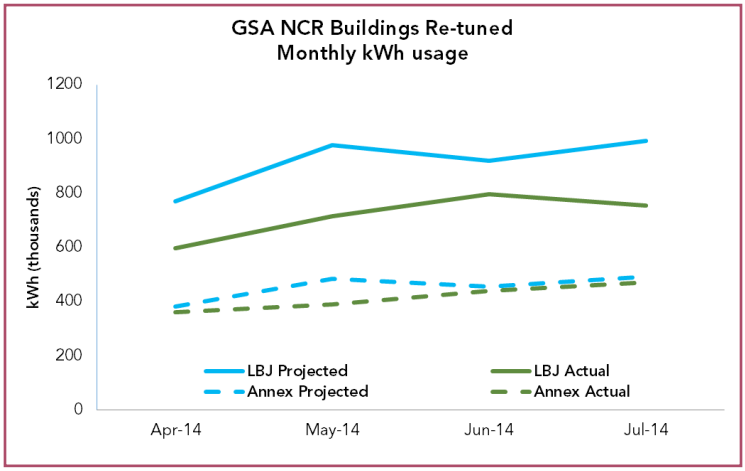

Figure 1. Projected kWh usage based on year's monthly consumption prior to re-tuning and adjusted for weather normalization

The U.S. General Services Administration (GSA), National Capital Region (NCR) is dedicated to providing superior support to the federal government in the Washington, D.C. metropolitan area. NCR's teams of property and energy management professionals help reduce energy consumption and costs in GSA-owned buildings.

In March of 2014, experts from the Pacific Northwest National Laboratory (PNNL) delivered re-tuning training to property managers, building engineers, and O&M contractor staff. The training consisted of a day in the classroom and a day of hands-on practical application in two buildings: Lyndon B. Johnson (LBJ) Department of Education Headquarters Building and William Bryant Courthouse Annex. The 550,800 rentable square feet (rsf) LBJ building was constructed in 1961, underwent a full modernization completed in 1996, and had its HVAC system commissioned in 2010. The 264,842 rsf Annex was constructed in 2005, and houses 9 courtrooms, 8 chambers for Court of Appeals judges, 11 chambers for District judges, and office space for court/federal functions.

Although still early, the immediate benefits of the training have been clear: in the four months since the training, the LBJ building has saved an average of 21.7% on electricity usage (see Figures 1 & 2) and the William Bryant Annex has saved an average of 8.2% on electricity usage (see Figure 1 & 6) compared to projected usage. Building engineers and operators identified a long list (see full list in Tables 1 and 2) of re-tuning efficiency measures in both buildings. GSA is now exploring ways in which the strategies and approach learned in the training can be shared with others within its organization.

Building re-tuning saves energy and money

From late 2013 to early 2015, PNNL helped identify re-tuning measures in 20 office buildings. Many of the measures were implemented by the building operations staff. The measurement and verification process is ongoing. Preliminary results indicate the savings are between 2% and 21% in buildings that implement at least a few measures. The average savings are 14% and the median savings are 12%.

LBJ Office Building saves 21.7% (compared to projected energy usage) after re-tuning

LBJ Department of Education Building
Address: 400 Maryland SW, Washington, DC 20202
Owner: U.S. General Services Administration
Size: 550,800 Rentable Square Feet

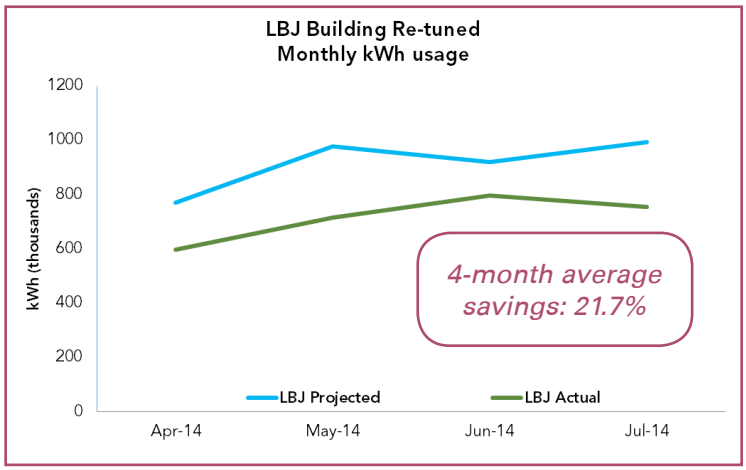

Figure 2. Projected kWh usage in LBJ Building based on monthly consumption prior to re-tuning

Finding: Early morning Monday HVAC startups at the LBJ Building

Monday HVAC system schedules for the LBJ building were set to start at 3AM for many AHUs and delay by 1 hour (4AM start time) for the other days of the week. This schedule cooled the building earlier than necessary. During the re-tuning walk-through, operators realized the need to determine optimum schedules for the different HVAC systems and adjust accordingly to match the actual occupancy and loading requirements. Re-tuning measures to address this efficiency opportunity include:

- Consider using optimal start for AHUs. Optimal start allows for setting the BAS schedules for AHU occupancy to 6AM, although building operators selected earlier start-up times. This avoids the everyday start time of 3AM (Monday) to 4AM (other weekdays) and saves multiple hours of AHU energy usage daily.
- Tighten up schedules for systems that serve spaces with little to no perimeter impacts (basement, library, etc.) or non-office spaces (health club, etc.). They are not designed as "working" spaces that need to meet the same mandates for comfort level attainment by the start of the work day (6AM-7AM).
- Lighting schedules on the BAS should also be evaluated for further delay on startup and for earlier shut down (rather than the current 9PM turn off time).

Finding: Leaky valve and need for AHU temperature controls at LBJ Building

Overnight "baking" was found in the LBJ Building, in which building temperatures rose during cold winter evenings and the HVAC system needed to cool the building during startup the next morning. Building engineers can seal the leaky hot water control valve to temper this inefficient energy operation.

Figure 3 is the BAS trend data chart for the LBJ Building's AHU-1 system. The discharge air

What is Re-tuning?

Building re-tuning is a systematic process to identify and correct building operational problems that lead to energy waste. Building Re-Tuning Training is a blend of building walk-throughs and classroom instruction that teaches building operations staff and service personnel how to save energy and increase occupant comfort through low and no-cost operational improvements. There are two versions of the training: one for small/medium sized buildings without a building automation system (BAS) and one for large buildings with BAS. This case study utilized the large building with BAS re-tuning protocol.

No- and low-cost savings opportunities include items such as replacing faulty sensors, adjusting set-points and inefficient schedules, utilizing variable speed fans and economizers, insulating pipes, adding CO2 sensors, widening thermostat dead bands, and sealing building envelope leaks. This process can reduce building energy use up to 20%.

(black line) and mixed air (red line) temperatures on the AHU-1 rise from 90°F to almost 110°F during unoccupied periods. This trend graph seems to indicate that a hot water control valve is leaking, because the hot water control valve's signal (teal line) is indicating 0% open during the same time period in the charts. Engineers remedied this situation on the spot by increasing the output signal to the valve from 8 psi to 12 psi, which closed it completely.

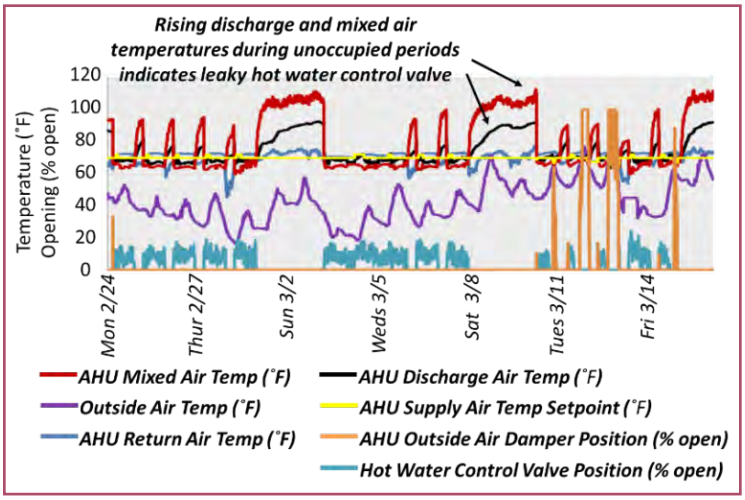

Figure 3. BAS trend data shows AHU-1 discharge air and mixed air temperature data

Recommendation: Utilize BAS Optimal Start Opportunities

BASs often have an "optimal start" function that automatically determines the optimum time to activate the HVAC system to return the space temperatures to within 1 to 2°F of desired set points just prior to scheduled occupancy. Over time, the system "learns" the optimum time (see Figure 4) to pre-start when conditions mandate. This saves energy when compared to thermostats that often start the HVAC system earlier than necessary. To keep the desired indoor

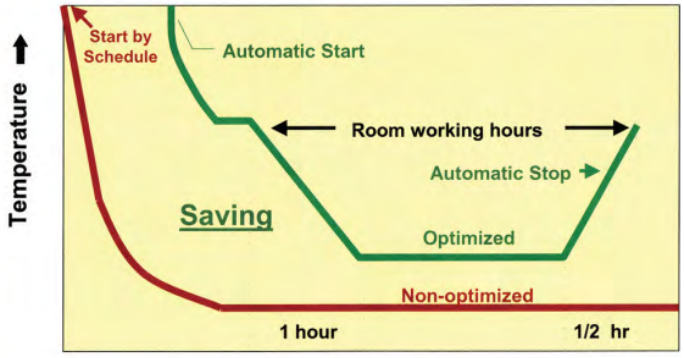

Figure 4. Energy savings over a workday using optimal start versus a BAS schedule

Table 1. No- to low-cost re-tuning measures implemented at the LBJ Building

System	Measure
Scheduling	Manually changed the start-up set points on the main equipment by one hour later. This gives us a new normal Monday morning start up at 4AM, and a Tuesday through Friday start-up of 5AM.
Set Points	For Monday morning startups, building staff manually start equipment. During warm periods, will run the building early to bring in free cooling from outside. Building operations are changed based on outside air temperature. Overall reduction in run time has not increased tenant complaints.
Set Points	Make micro adjustments to temperature and airflow in response to tenant complaints that allow optimal comfort, without distorting the building's airflow balance. Technicians check temperatures shown from the BAS sensors and actual conditions at the location, as well as air flow rates that are being shown compared to the design specs.
Cooling Towers	Lowered the condenser water temperature set point from 83°F to 80°F. The lower condenser water temperatures will improve the chiller performance.
Lighting	Changed primary lighting to LEDs in two large offices and a conference room on the 7th floor. The Department of Education plans to voluntarily incorporate LED lighting in all future interior alterations in the building.
Scheduling	The BAS has the capacity to "learn" optimal HVAC start up times to have the building reach occupied space conditions when it is required. The building's management plans to exercise this BAS option.
Scheduling	Reduced exhaust schedules (no longer 24 hours), and fixed the negative pressure in the building.
Lighting	For desk task lighting, building operators worked with the tenant to turn off lighting via motion sensors.

temperature, the BAS calculates and reads indoor and outdoor temperatures frequently in addition to other influencing variables. It then runs the specific apparatus for the minimum time required to reach the comfort zone at the beginning of the work shift. The LBJ Building would benefit from utilizing optimal start.

Finding: LBJ Building's BAS Reveals Area for Improved Return Fan Speed Control

Air Handling Unit (AHU) static pressure controls for all the AHUs appear to indicate that there may be room for improved return fan speed control. The BAS trend data chart for AHU-1 shows the supply fan speed (red line) and the return fan speed (green line) tracking with each other and never more than 10% (6 Hz) difference. Some AHUs are even tighter (5% or 3 Hz difference).

Generally, return fans are able to move significant amounts of air, even with smaller motors and slower fan speeds as a result of the much lower static pressure drops (no filters, no coils, and no ductwork) that these return fans are moving air through. If not controlled properly, they can contribute to negative building conditions.

Re-tuning measures to address this opportunity include

- Consider implementing a reset of the static pressure set point (adjust between 0.5 inches to up 1.0 inches.)
- Consider installing a sensor that monitors the building static pressure (referenced to outside). With a reliable and properly located building static pressure sensor, the return fan speed control can be better managed to prevent over-speed operations that result in negative pressure building conditions.

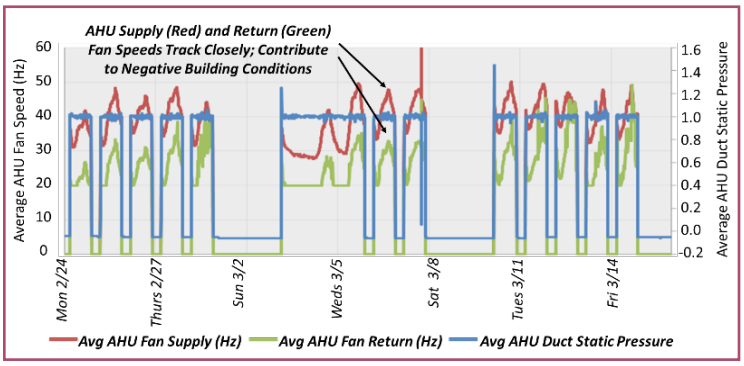

Figure 5. BAS trend data from LBJ AHU-1 system show supply static pressure and fan speed data

Courthouse Annex saves 8.2% compared to projected energy usage after Re-tuning

William Bryant Courthouse Annex
Address: 333 Constitution Ave. NW, Washington DC
Owner: U.S. General Services Administration
Size: 264,842 Rentable Square Feet

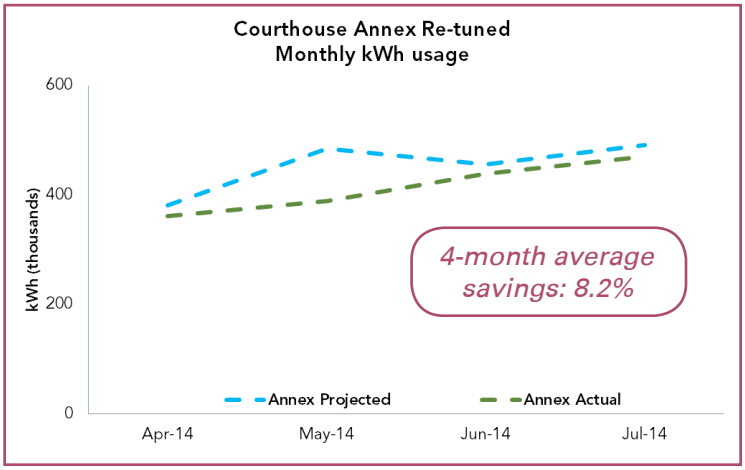

Figure 6. Projected kWh usage in Courthouse Annex based on monthly consumption prior to re-tuning

Why Invest in Building Re-Tuning Training?

Building Re-Tuning Training is a worthwhile investment because saving energy is not reliant on commissioning agents, energy auditors or professional engineers. Facility engineers and building operators - the people who are in the buildings regularly - learn to identify energy saving opportunities and act. The savings are regenerative because the trained building operator or facility engineer is able to continuously re-tune his/her building and maintain optimized conditions.

Finding: Automatic-Reset for Annex Heating Systems to Run at Design Specifications

The Annex reheat system and perimeter heating system are each designed with two pumps, yet only one pump is used to run each system. However, these are VFD-driven pumps, so additional energy savings could be achieved by running both pumps in tandem. The reheat loop temperature was observed to be ~148°F, which is considerably higher than necessary. To address this excess temperature, the set point for the reheat loop should be on an automatic reset algorithm. Building operators could implement an automatic set point reset algorithm based upon either the outdoor air temperature or based upon the average reheat valve position (demand-based). In either case, the reset algorithm should take advantage of the system design (steam heat exchanger), which allows for much lower set points than non-condensing boiler systems. Therefore, building operators could reset the reheat loop set points as low as 100°F to reduce steam consumption and minimize waste heat from leaking valves at terminal boxes.

It was not clear if the reheat system was configured to automatically lockout based upon increasing outdoor air temperatures. Building operators could evaluate this configuration and implement outdoor air lockouts for the reheat system to take advantage of warmer weather. If discharge temperatures are configured to de-humidify (overcool), ensure that this is done judiciously. If not, the reheat system may run when not needed.

Finding: Determine if Annex Economizers are Working Efficiently

The BAS controls for AHU-6E, shown in Figure 7, indicate that the outdoor air temperature is 53°F while the mixed and preheat temperatures are indicating between 58.5°F and 58.9°F. The return air temperature indicates 73.8°F. The

Figure 7. AHU economizer damper commands and temperature sensor data

Table 2. No- to Low-Cost Re-tuning Measures Implemented at the William Bryant Courthouse Annex

System	Measure
Garage Fans	Reduced garage fan operating runtime and frequency from 168 hours/week at 60 hertz to 55 hours/week at 25 hertz, using 7 fans with 40 hp motors and 3 fans with 25 hp motors.
Steam Supply	Shut off steam supply for the AHUs and VAV boxes for the summer months (June-September). The system was designed to both heat and cool during the summer months, GSA NCR has been able to shut the steam off by making constant changes to discharge air temperatures.
Steam	Shut off steam supply to the snow melt system for summer months.
Schedule	Changed building start up times from 3:30am to 6am unless there are extremely hot outside air temperatures for the day – this led to almost a 20% savings on start-up.
Set Points	Changed supply temperature set points from 55 to 58 degrees.
Lighting	Installed ~40 motion sensors in mechanical and electrical areas and public restrooms.
Schedule	Changed chillers shut down times from 6PM to 5:30PM.
Lighting	Changed outside lights that were on the emergency lighting circuit to be on the normal circuit.
Steam	Insulated steam heating lines in the Annex plant.
Chilled	Increased chilled water set point from 42° to 43-45° depending on outside air temperature.
Garage Lighting	Planning a lighting project to replace all garage lighting with LED bulbs using a time clock and motion sensor system. Garage lights were on 24/7, but the system will run 5 days a week (M-F) from 7AM to 6PM. This will reduce lighting time from 168 hours/week to 55 hours/week.
BAS	Planning a BAS upgrade in to enable further energy saving improvements and connect the building's BAS to the GSA network.

calculated outdoor air fraction is greater than 70% (not 100%, as indicated by the BAS data). This disparity indicates inefficient economizer usage.

Determine if economizers are working properly. Evaluations should include review of control code as well as mechanical linkage and actuators. The AHU in the BAS graphic appears to be leaking air from the return section, into the mixed air section, resulting in warmer discharge air temperatures. Building engineers should verify that economizer linkages and dampers are working properly.

Finding: Reduce Annex Base Load by Turning off the Snowmelt Pump in Summer

The snow melt pump and heating system was found running while outdoor temperatures were > 50°F. Turning off the snow melt pump provides an opportunity to reduce non-essential base load. To implement this re-tuning measure, operators need to verify that the snow melt controls only activate the pump and heat exchanger when snow melting is really needed. This activation should only occur when the outside air temperatures are below freezing and when the dew point is low enough to cause sufficient freezing of moisture on the surface of the sidewalk or parking ramp (whatever surface is designed to have snow or ice automatically melted). Otherwise, this pump and heating energy are being wasted. Without the re-tuning, this pumping energy could have become part of the Annex's base load and been "missed" as an opportunity to reduce non-essential base load.

Recommendation: Conduct Building Walk throughs to Identify Over-lit Spaces

Building walk-throughs help identify efficiency opportunities such as over-lighting in mechanical spaces and garage areas. Figure 8 shows an over-lit mechanical room in the Annex.

Parking garages often have a significant number of metal-halide fixtures that are on 24/7. Building operators can implement parking garage lighting upgrades with occupancy controls and LEDs to increase efficiency. Mechanical rooms also offer an opportunity for reduced lighting system usage via manual shut-down or occupancy sensors. Sometimes hundreds of light fixtures may be optimized by increasing the amount of time they are turned off. Operators installed ~40 motion sensors in Annex mechanical and electrical areas.

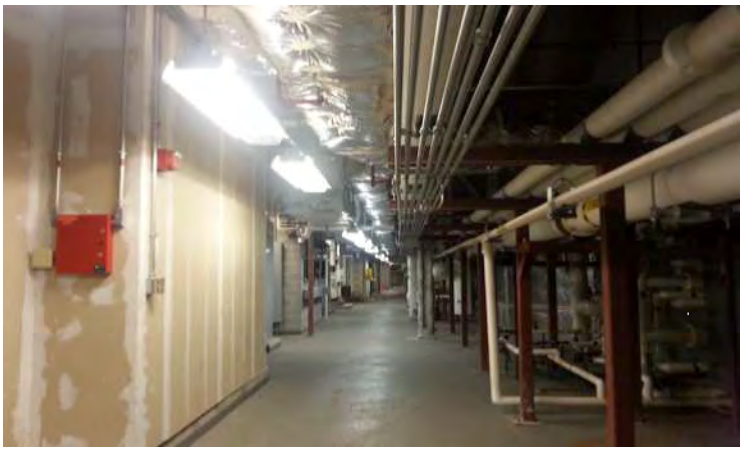

Figure 8. During the Annex Re-tuning building walk-through, operators found lighting in this mechanical room always on

Operators can also make improvements by de-lamping. Reductions can be confirmed by conducting light level measurements or by removing every other light fixture and running a test to determine if adequate light levels still exist. Removing every other fixture reduces energy use by 50% and creates spare lamps and fixtures for future lighting operations.

Acknowledgements:

This case study and related work is funded by the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy. Pacific Northwest National Laboratories created the building re-tuning training program and performed the building re-tuning trainings for this case study.

Re-tuning Training Opportunities and Online Resources

The Department of Energy funded Pacific Northwest National Labs (PNNL) to create the Building Re-Tuning Training program. The Consortium for Building Energy Innovation (CBEI) is leading efforts for DOE to make Building Re-Tuning Training available. See https://www4.eere.energy.gov/workforce/projects/buildings-retuning-training for information about accessing the training. Classroom training material, training instructor manual and online re-tuning interactive training and energy charting and metrics tools are available at http://buildingretuning.pnnl.gov/