Project 2K12108571 X083 Wireless Pneumatic Thermostats
ED Final Review

This document summarizes the ED review of the Retrocommissioning Verification Report, written by Quest, for the applicant's [redacted] office building. This building, constructed in the early 1970's, has an area of 144,000 square feet total over 15 floors.

The building is conditioned using floor-by-floor VAV reheat air handlers, served by a hot-water and chilled-water central plant. In addition to the boilers and chillers, the central plant also includes a water-side economizer that satisfies the majority of the cooling load. The plant also has two 60 kW microturbine electric generators whose waste heat offsets virtually the entire heating load.

The VAV controls are pneumatic, with the VAV boxes and reheat valves utilizing single-setpoint pneumatic thermostats. The minimum flow ratio of the VAV boxes was apparently set to 60% appears surprisinly high. The project measure consisted of replacing the original pneumatic thermostats with wireless pneumatic thermostats (WPTs). The WPTs measure the temperature electronically, and utilize a transducer to output a pneumatic signal to the existing actuators on the VAV boxes and reheat valves. The WPTs are networked together, and can communicate with a building management system via a BACnet protocol.

The project has gone through several iterations over which savings were proposed to be accruing in different ways. As of the last iteration (for the RCx proposal), savings were proposed to accrue via:

1. Optimum Start/Stop – While normal occupancy starts at 8 am, the building HVAC systems were started as early as 3:30 am. No investigation was conducted to determine why it was necessary to start the systems this early; a 4-1/2 hour prestart is extremely rare for an office building in the Bay Area climate zone. ED can only assume that there were unidentified controls malfunctions; if so, these malfunctions could reside in zonal controls. In any case, the WPT retrofit allows the building operators to easily review zone temperatures, identify and fix malfunctioning zone equipment, and more intelligently control the morning start time.

2. Dead-band implementation – The existing pneumatic thermostats had a single setpoint, with cooling occuring over the upper part of the throttling range, and reheat in the lower part. The WPTs incorporate a dead-band to separate the reheating operation for the cooling.

3. Reduced airflow to unoccupied zones – This measure was not implemented at the present time. And given that the VAV boxes apparently have a minimum flow ratio of 60% (per notes on the original spreadsheet calc), it is not expected that significant savings would accrue from this measure.

4. Duct static pressure reset – This measure is also not implemented at this time. Note that supply fans currently have VFDs whose speed is reset based on return air temperature. Depending on the coordination between new thermostats vs. the existing reset strategy, savings may be impacted in either a positive or negative direction.

For optimal start, the Quest verified that the building startup was delayed until approximately 6 am, for about a 2-hour delay; the original RCx calculations assumed a 3-hour delay. For dead-band

implementation Quest verified that the return air temperature, a proxy for average zone temperature, was in the range of 69°F to 75°F. Quest then attempted to calculate the energy savings, but could not demonstrate positive savings; the building appears to be using more energy than before. Quest attributes this to the fact that the building's EMCS was in the process of being upgraded, and that the supply air temperature was running at a manually-set 53°F; rather than being reset as before. The building's operators assured Quest that the supply air reset would be re-implemented as part of the new EMCS control logic.

Based on this assurance, Quest adjusted the original RCx spreadsheet calculations to include a 2-hour startup delay (rather than 3 hour), and projected energy savings of 70,958 kWh, 26.3 kW, and an incentive of $9,021.27. ED recommends approval of the estimated savings.

Discussion

In ED's original review of this project, we stated in part,

> "The pneumatic control system in this building is apparently over 30 years old. Past experience in the auditing and retrofitting of pneumatic systems suggests that energy savings can be substantial. However, the energy savings of a control system retrofit can be difficult to assess, as the assumptions regarding the baseline and post-retrofit functionality are critical to the savings calculations, but are not well established in many cases. Moreover, in a partial retrofit, the new controls still interact with existing controls which may be malfunctioning, and may skew the savings in either direction. Absent a detailed (and costly) engineering study, the best that can be hoped for are reasonable assumptions that produce reasonable savings estimates. We believe this analysis achieves that goal."

As a reality check on savings, ED created an eQUEST simulation of the building. eQUEST's Wizard feature was used to create a 15-story square high rise of 144,000 sq.ft., 60% single-pane tinted glass, and 60% minimum VAV flow ratios, variable-speed fans, cold-deck reset, chilled-water reset, and a waterside economizer. The building HVAC systems were scheduled to start at either 4 am or 6am, and thermostat heat/cool schedules were specified as either 72/73°F or 70/75°F. eQUEST Wizard defaults were used for most other assumptions (lighting levels, equipment loads, orientation, etc.). The microturbines were ignored, as it is assumed that power consumption during normal occupancy is greater than cogeneration capacity.

eQUEST's predicted savings were about 25% greater than the RCx spreadsheet analysis, which agrees quite well considering the large uncertainty in the assumptions; such as the variance in thermostat setpoints, interaction with HVAC system supply reset temperature, HVAC system supply fan control, etc. It is not known whether the eQUEST results are more accurate, or less accurate, than the RCx analysis. And, as the actual building operation and control is not well documented, it would be futile to take the analysis much further. Actual savings could vary considerably from predicted; potentially ranging from more than twice as large, to negative (net energy increase).

Potential sources of error include:

- Thermostat setpoint enforcement – The building has 303 thermostats, and the assumption is that the thermostats are overcooling the building in the summer by an average of 2-3°F each, and overheating the building in the winter by the same amount. However, to ED's knowledge,

no survey was ever taken of the zone temperatures. And, while thermostats may be out of calibration, people will tend to adjust the setting to a comfortable temperature. Therefore, it is not clear whether the intended reset will be achieved (Potential negative savings).

- Minimum VAV flow – It is ED's understanding that the minimum flow ratio of the VAV boxes is 60%; which is unusually high. Because of this, the boxes will be operating at minimum flow the majority of hours, and the zone temperature will flow down toward the point at which reheat is enabled. With the original single setpoint thermostats, raising the temperature in the summer could actually increase energy usage, as reheat would then be enabled. The deadband provision of the WPTs will eliminate this problem (Potential positive energy savings).

- Supply air reset – It is ED's understanding that the supply air temperature of each air handler is reset based on a couple of sensors on each floor. If the WPTs succeed in raising the zone temperatures, but the current reset strategy is not modified, it is possible that the air handlers will run colder than they would otherwise. However, if the WPT information is incorporated into the central control system, then more intelligent reset might be achieved (Savings may be positive or negative, depending on rogue zones, etc.).

- Supply fan speed reset – It is ED's understanding that the supply fan speed is reset based on the return temperature, no static pressure control exists. If so, and the WPTs succeed in raising the zone temperatures, then if this strategy is not modified the fans will run faster than they would otherwise. However, if the WPT information is incorporated into the central control system, then more intelligent fan control might be achieved. (Savings may be positive or negative, depending on rogue zones, etc.)

- Persistence of morning start time – The morning start time has been manually changed from 3:30 am to 6 am; persistence is therefore an issue. Since a 3:30 am start time is highly unusual, and the reason for the need for the early start has not been identified, then it is not clear whether a 6 am start time will now be satisfactory.

While the above issues might possibly act to reduce or negate the potential energy savings, it is also true that the information provided to the building operators may be highly useful in trouble shooting the HVAC systems and controls. And, combined with the new EMCS that is being installed, the information provided should allow for more sophisticated control schemes than have been used to date; allowing for greater savings.

This project has highlighted difficulties in verifying savings from the installation of WPTs in conjunction with other control system changes. As KW Engineering pointed out in its study of this technology as part of the ET program, ED believes WPTs are a promising technology.[1] However, WPTs would not save energy by themselves unless building controls are adjusted using WPTs. Depending on the specifics of a building, energy savings from all types of controls enabled using WPTs might not occur; and if savings appear to occur, they might not be always verifiable.

ED agrees with KW Engineering's conclusion that more field-based studies should be done to assess the savings from different types of controls that were not apparent in the four buildings that were studied. ED, however, is not clear why WPTs should be incented as a hybrid deemed approach as KW Engineering

[1] PGE Wireless Pneumatic Thermostat ET Final Report.pdf, dated December 7, 2012

recommended and how such an approach would work. Since WPTs are really thermostats, which are required by code, a deemed per unit incentive would not be appropriate to offer. The promise of WPTs is in its use in conjunction with other controls. Since technologies required by code cannot be eligible in a retrofit or a deemed program, it seems that the RCx program would be a more appropriate way to install WPTs where savings are not claimed for WPTs but for controls it enables.

RCx projects using WPTs will have to be submitted using the custom route with its applicable documentation requirements that might not justify small projects. If ET field studies are able to identify and quantify the potential of control measures that can use WPTs, then a list of eligible control options using WPTs can be finalized for use in the RCx program. This project demonstrated that savings were being realized from the optimum start measure although inadequate pre-installation document casts doubt on the magnitude of energy savings from this measure. For all other measures, savings could have been positive or negative and that could not have been determined without additional engineering analysis.

Despite the limitations on the verifiability of savings from this project, ED believes that some savings are occurring that cannot be possibly trued-up cost-effectively. ED recommends freezing the PG&E-reviewer-recommended annual energy savings of 70,958 kWh and peak demand savings of 26.3 kW. Going forward, ED recommends that PG&E consider the verifiability of savings from WPT-enabled sites and pursue only those measures that have a reasonable certainty of delivering savings. This will eliminate collection of inadequate and unnecessary data and reduce PG&E's internal review time.