Evaluation of Retrocommissioning Results After Four Years: A Case Study

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Synopsis

In 1999 and 2000 Intel retro commissioned a total of more than two million square feet, spanning nine buildings on two campuses. That project netted over 3.5 million kWh in energy savings. In 2004, the management authorized a new study to determine how much of the original projected savings were still being captured. The original energy saving measures identified included equipment rescheduling, terminal unit scheduling, economizer optimization and repair, airflow adjustments, and temperature adjustments. Working from the original retro commissioning reports, the status of each of these measures is investigated four years later. Functional testing and system monitoring show that the energy efficiency measures are still in effect in the buildings with direct digital control. However, the effectiveness may be partially compromised by an accumulation of control overrides. Control improvements made in one building with pneumatically actuated terminal boxes are no longer in effect; zone level air delivery needs repair.

About the Authors

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Introduction

Commissioning of eight buildings on the Intel Jones Farm and Hawthorn Farms campuses was performed in 1999-2000. The commissioning studies were funded by Portland General Electric (PGE) through their Existing Building Commissioning program. The purpose of the program was to obtain electrical savings through low cost improvements in building operation. The studies resulted in the implementation of energy efficiency measures (EEMs) which were projected to save almost 3.5 million kWh annually. Four years after the implementation of the recommended energy efficiency measures, the Intel management asked PGE to determine if the energy savings were still being realized.

The scope of the current project was to:

- review the original reports,
- determine if energy measures implemented are still in effect,
- report findings and make recommendations for future work.

Building Descriptions

The Hawthorn Farms Campus consists of three buildings with a total of approximately 640,000 square feet. The buildings are interconnected, but have separate air handling systems served by a central chiller and boiler plant. Lab areas are served by dedicated cooling systems. The campus dates from the 1980s and consists mainly of office and lab space with some manufacturing. The buildings originally had pneumatic control, but HF2 and HF3 were converted to direct digital control (DDC) in 2000. HF1 has DDC control interfaced with pneumatic actuators.

Five buildings on the Jones Farm Campus were included in this study. They total about 1.4 million square feet of offices, labs, and computer rooms; they date from 1980 through 2000. The buildings contain more than 40 major air-handling systems served by two central chiller plants and two heating hot water boiler plants. Locations that contain computer development and test labs represent concentrated cooling loads that require 24/7 cooling. The central air handling serving these areas is supplemented by free-standing, chilled water cooling units.

A majority of the spaces on both campuses are served by variable air volume (VAV) systems. There are hundreds of addressable VAV boxes. Perimeter VAV boxes have hydronic reheat. All air handlers have 100% outside air capability.

Methodology and Test Results

Three reports from 1999 and early 2000 were reviewed for the current study (1,2,3). The commissioning studies were performed by Kaplan Engineering and PECI. The main recommended and implemented EEMs from these reports are summarized in Table 1. Verification of the current status of the EEMs was done by random sampling; functional testing or trending was used as appropriate.

Table 1. Summary of Recommended and Implemented EEMs from Original Studies.

Building	Measure	Description	Projected Savings
HF1	Optimize Terminal Unit Operation to Minimize Reheat	Adjust dampers to modulate to about 40% open when in reheat mode. Completed 12/8/99.	75,300 kWh 43,000 therms
HF Chillers	Reduce Condenser Water Temperature Setpoint	Setpoint was reduced from 75 F to 70 F.	152,000 kWh
HF Chillers	Raise the Chilled Water Temperature Setpoint	Setpoint was raised from 42 F to 45 F.	86,500 kWh
HF 1,2 & 3	AHU Economizers	Control was modified from fixed OSA percentage to allow economizer cycle to function.	383,300 kWh (7,000) therms
JF 1,3,4,5 & JFCC	Zone Scheduling	This EEM switched the terminal units for approximately 80% of the office area to a heating setback and cooling setup. Also the terminal units in these areas were allowed to go to 0 flow in unoccupied hours when setpoints are met.	1,397,000 kWh 110,000 therms
JFChillers	Decreased Condenser Water Temperature Setpoint	Cooling tower leaving condenser water setpoint was changed to 67 F.	908,700 kWh

HF1

Retro commissioning tests in 1999 had revealed that, on average, the reheat mode airflow for the perimeter zone terminal units was 94% of the cooling mode airflow. Subsequently, a facilities' crew serviced all of the HF 1 reheat terminal units and adjusted the dampers to modulate to about 40% open when in the reheat mode. This work was completed in December, 1999. A random sampling was done of five terminal box units on the second floor of HF1. Each unit was tested by putting the unit into full cooling and full heating modes by adjusting the thermostat controlling the unit. A magnehelic gauge was connected to the test ports of the unit and air velocity was determined for each condition.

Result:

Sixty percent of the boxes failed by showing no noticeable damper movement; the remaining boxes averaged about 60% of the maximum cooling airflow. One employee observed that half the floor was usually too hot, while the other half was too cold.

It is reasonable to conclude that the energy savings have not been maintained from this measure. The fault probably lies with the age of the pneumatic system. Engineering staff has recommended conversion to full DDC.

HF 1, 2 & 3

Prior to the original commissioning study the average operating condition for air handlers in HF 1 and 2 was 80% fixed outside air which made the economizers non-functional. These were modified, and the function verified, in December, 1999. At that time it was recommended that the same modifications be made in HF 3 after the DDC retrofit. One air handler in each building was selected for functional testing.

Result

The tests verified that the units were operating according to the programmed sequence which enables economizer function when the outside air temperature drops below the return air temperature and begins to open the cooling valve only after the outside air damper is fully open.. The only problem identified was a correction needed to the damper calibration of one unit.

HF Chillers

The original commissioning report recommended that the condenser water set point be reduced from 75 to 70 degrees F and that the chilled water temperature set point be raised from 42 to 45 degrees F. The current set points were verified by looking at the settings through the Apogee system, examining trends and comparing readings between the control system and manually read gauges on the chiller system.

Result

Setpoints have been maintained at the recommended levels.

JF, All Buildings

At the time of the Kaplan and PECI reports, all air handling units operated 24/7. As a result of the original commissioning, air handling units and terminal boxes were scheduled to reflect actual occupancy patterns to save on fan, heating, and cooling energy. Unoccupied hours were assumed to be 6 PM to 6 AM on weekdays and all day on weekends and holidays. A log was generated showing all of the terminal boxes along with a description, type of occupancy control, and minimum airflow. Log report notes also show air handler scheduling. A random sampling of terminal boxes in each building was trended for space setpoint, controlled temperature, airflow, damper position and heating valve position. JF 5 air handlers were trended for status and variable speed drive position if applicable.

Result

Control is generally working well in JF 3 with only a couple of override issues.

Although no major problems were found in other JF buildings, significant opportunities still exist for energy savings from further air handler and terminal box scheduling. Specific findings and recommendations applicable to JF 1,4,5, and JFCC include:

- 1 of 8 boxes has control override to maintain minimum air.
- A large percentage boxes trended show some degree of air leakage
- Occupancy is scheduled from 6AM – 5PM seven days a week.
- More than half of the boxes trended maintain minimum air 24/7
- About one third of the boxes have control overrides.
- Trends of AHU variable speed drives show little difference between night and day modes.

Figure 1 is an example of how a control override can have unintended consequences; the charted data is for a Sunday and Monday. The minimum airflow has been fixed while a temperature setback is implemented during unoccupied hours. On Monday when the space is occupied the 72 F room setpoint is maintained with cooling only. When the temperature is set back to 67 F with no occupants, the space tends to overcool. This results in the opening of the hot water reheat valve. During the day on Sunday, when the room is unoccupied and the same occupied temperature is scheduled, the heating valve modulates. There is obviously simultaneous heating and cooling, although the root cause remains mysterious since the DDC control system does not have points to monitor discharge air temperature at the VAV box. To further confuse the picture, the control log shows that the space temperature is supposedly overridden to 72 F for all hours. Correct diagnosis will require additional field monitoring.

Figure 2 shows trend data for a VAV terminal box in JF 3 for which the airflow has been scheduled and is operating correctly. There is a small amount of air leakage during unoccupied hours.

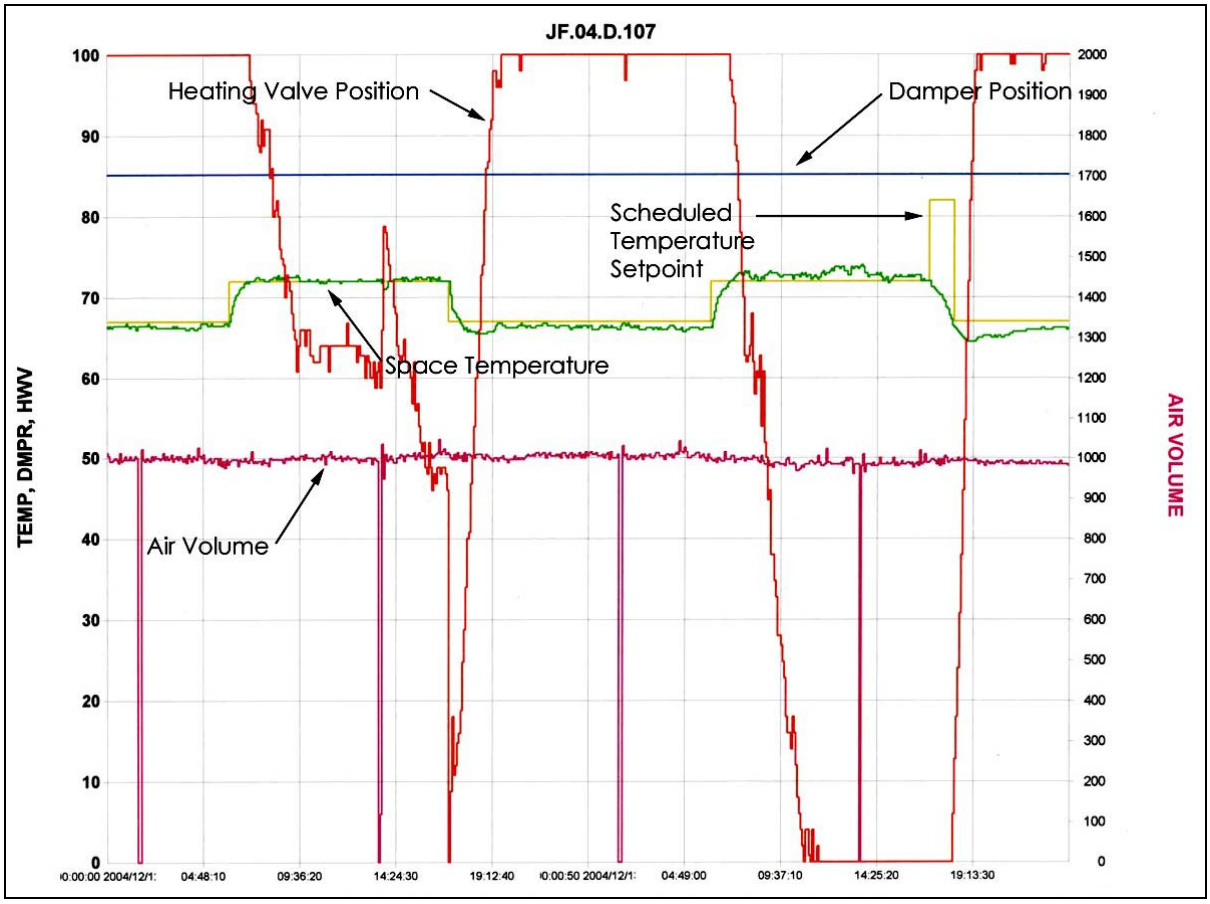

Figure 1: VAV Box Trend Showing Simultaneous Heating and Cooling

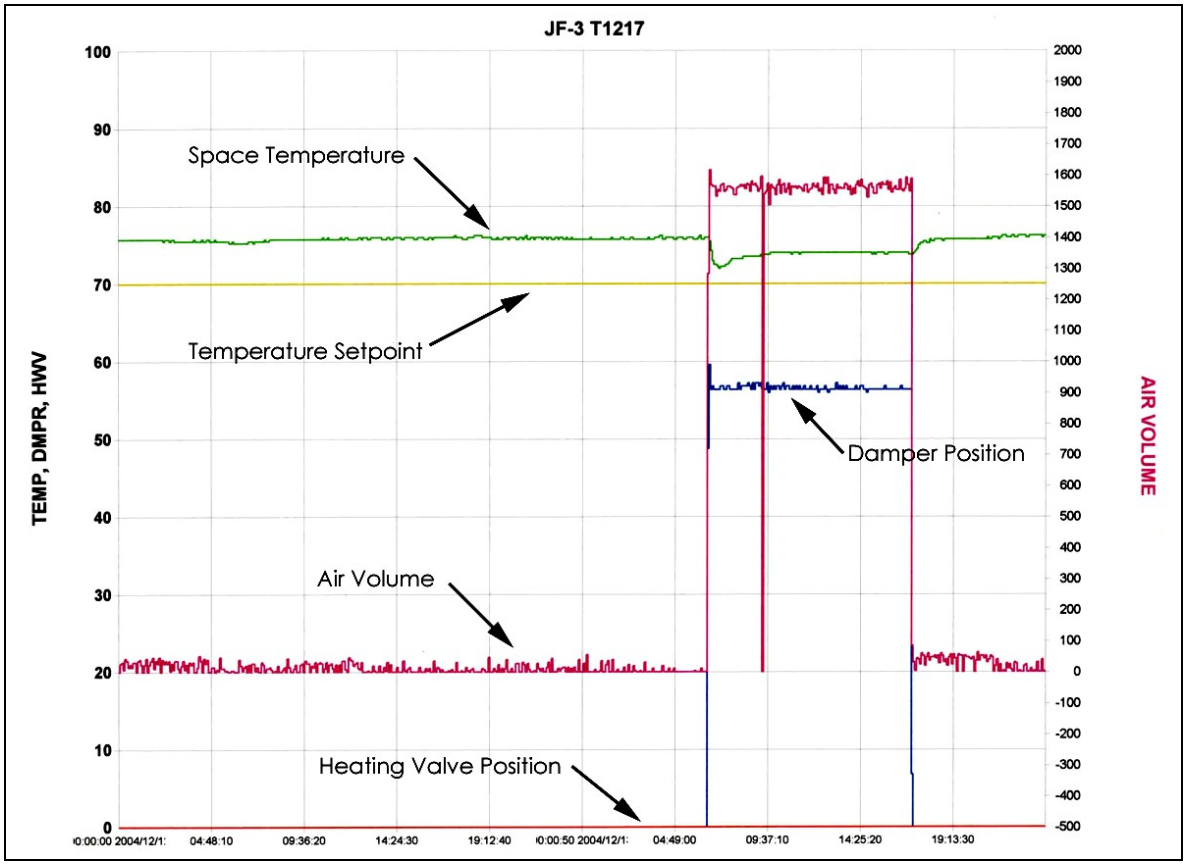

Figure 2: Correctly Operating VAV Box, JF 3

Figure 3 shows a trend of the variable speed drive of one of the main air handlers over a Sunday and Monday. It is difficult to discern a difference between occupied and unoccupied levels, reinforcing the trending observation that minimum airflow is being maintained 24/7 in many cases..

JF Chillers

The three cooling towers were originally found to supply leaving condenser water at a fixed temperature of 80 F. This was adjusted to 67 Fin 2000. This condenser water setpoint is regularly trended, so historical data was used to confirm implementation.

Result

The condenser water set point has been set at 71 F since at least January, 2004. Although this is higher than the initial set point adjustment to 67 F, it is significantly below the original set point of 80 F and demonstrates an ongoing policy of system optimization.

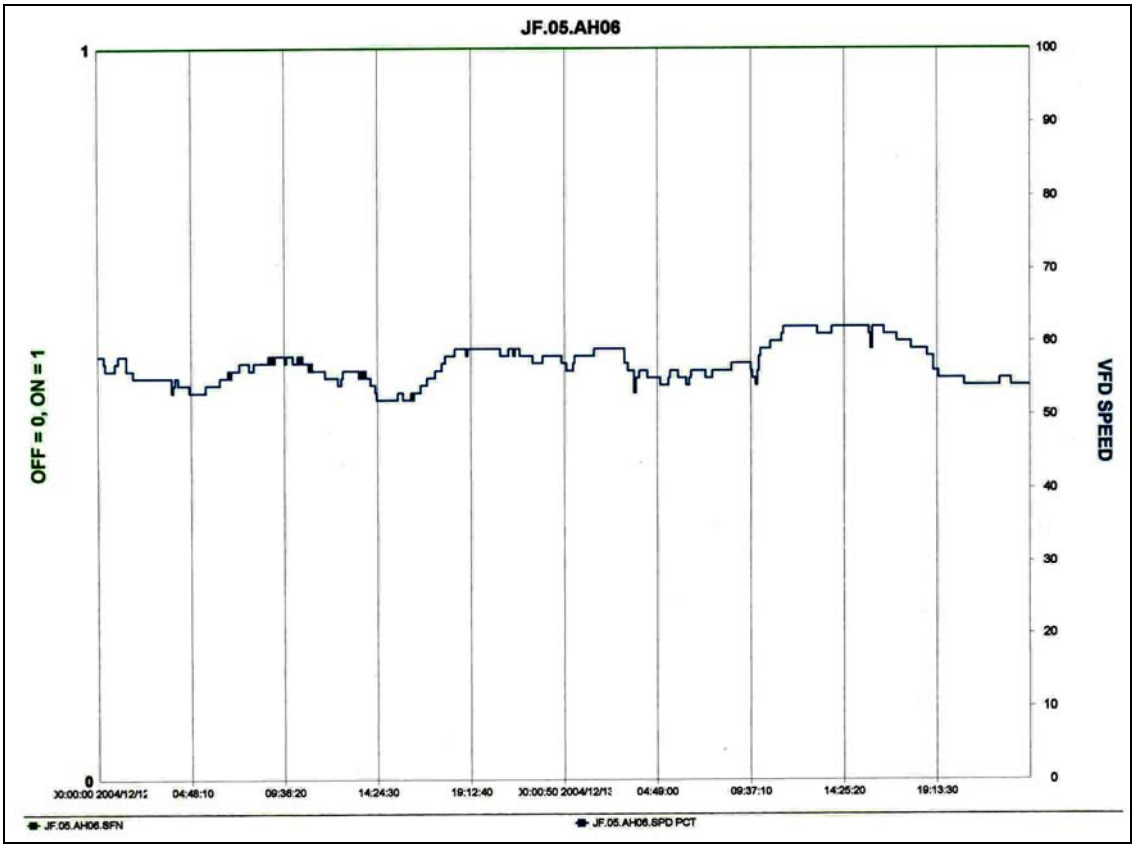

Figure 3: Variable Speed Drive Trend over a Sunday and Monday

Discussion

At the Hawthorn Farms campus, we concluded that the energy savings from chiller plant control modifications and implementation of correct economizer function have largely been maintained. The optimization of terminal unit reheat is no longer functioning in HF1. It was not determined if the failure was due to the control signal or the actuators, but in either case, the older pneumatic system was not able to maintain performance over time. Of the original projected savings at Hawthorn Farms, 89% of the electric savings and 0% of the natural gas savings are still being achieved.

At Jones Farm, the results are more mixed and less quantifiable. The recommended scheduling changes are still programmed at a high level, but it appears that numerous control overrides at a zone or box level have been made. Some overrides may be due to changes in space use (such as, conversion to a lab) but there were many instances in which conference and training rooms were maintaining occupied modes around the clock. The trending done on some of the variable speed air handlers showed little difference between day and nighttime airflow, so terminal box scheduling is not having an impact on overall airflow.

Reference:

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