APPLICATION OF CONTINUOUS COMMISSIONING® AT A CORPORATE HEADQUARTERS FACILITY IN DALLAS, TX

John Kimla

Ken Meline, P.E.

ABSTRACT

A corporate headquarters complex located in Dallas, TX consists of four buildings served by a central utility plant. The Continuous Commissioning® (CC®) process was applied to one building with approximately 688,000 square feet of primarily of data floor space. This building was identified as a candidate for the CC process because it consumed 58% of the 132 million kWh of electricity used by the complex in 2010 and had recently received several HVAC upgrades. CC is an ongoing process for existing buildings and central plant facilities to resolve operating problems, improve comfort, optimize energy use, and identify retrofits based on current building usage rather than original design intent [1].

The data floor optimization process consisted of three components: traditional commissioning activities, CC measure implementation, and low cost retrofits. Various M&V strategies were also utilized to quantify the resulting energy savings in a building whose energy use is dominated by data equipment load.

Using six months of pre- and post-implementation HVAC equipment electrical service meter trend data, a savings of 948,700 kWh was achieved. When these savings are extrapolated to twelve months, this project is expected to reduce the 2010 HVAC electricity usage by 25% ($133,000). Once the central plant savings are included, the overall savings of this project is approximately $146,000/year.

INTRODUCTION

A corporate headquarters complex located in Dallas, TX consists of four buildings (2.54 million square feet) served by a central utility plant. The CC process was applied to building #2 with approximately 688,000 square feet of primarily of data floor space. This building was identified as a candidate for the CC process because it consumed 58% of the 132 million kWh of electricity (Figure 1) used by the complex in 2010 and had recently received several HVAC upgrades.

Figure 1 Site electricity (kWh) from 2010 (left) and building #2 end-use electricity from 2010 (right)

John Kimla is a Project Engineer and Ken Meline is a Principal at Command Commissioning, LLC, Irving, TX.
Building #2 consists of a basement, concourse, and fourteen above grade floors. The typical data floor consists of one variable air volume (VAV) overhead air handling unit (AHU) serving terminal units and 7-9 VAV underfloor AHUs. Generally, the data floors are configured for cold isle containment; however, many deviations were noted and several server types were installed (vertical and horizontal exhaust). A total of eight floors have this configuration accounting for sixty-nine AHUs (1,920 HP total). The AHUs and terminal units on these floors have DDC and pneumatic control respectively. These floors account for the majority of building load and consequently were targeted in the first phase of the project. The remaining six above grade floors, which consist of administrative space, are each served by one overhead AHU serving terminal units (5 AHUs – 130 HP total). The optimization of these floors will occur in the second phase (future) of the project.

Chilled water (CHW) is supplied to the AHUs by six building pumps with VFDs that modulate to maintain a fixed riser differential pressure setpoint. Heating is supplied to the building by boilers located in the central plant. The boilers are only operated when the outside air temperature is below setpoint.

OPTIMIZATION PROCESS

The first phase of optimization in Building #2 consisted of three components: (1) traditional commissioning activities, (2) low cost retrofits, and (3) CC measures. The traditional commissioning activities included calibrating the building CHW flow/temperatures and AHU temperature/pressure sensors, and performing functional testing of dampers and valves. The low cost retrofit projects included installing curtain walls and sealing around equipment and cable openings to improve containment (Figure 2). Finally, the CC measures documented in Table 1 were implemented (top to bottom) to optimize the operation of the HVAC system.

The focus of the first phase was on the data center floor underfloor AHUs because they recently were retrofitted with VFDs and underfloor static pressure sensors. Despite these upgrades, the supply fan VFDs were operated at 100% speed. Furthermore, the CHW valves typically operated 100% open due to either excessively low supply air temperature setpoints or operator commanded values. No sequence modifications were implemented on the overhead AHUs on the data floors. Preliminary testing revealed that these AHUs operated at near optimal conditions given that they served fixed loads and that no zone feedback was available.

During the assessment many scenarios were identified including: missing tiles, perforated tiles where there was no equipment, solid tiles where there was equipment, and return air grilles installed above cold isles rather than hot isles. In order to balance the data floor space, missing floor tiles were replaced and solid/perforated/high velocity tiles were installed as needed based on the client’s criteria of maintaining the top of rack inlet air temperature no higher than 78°F. Furthermore, return air grilles were relocated as necessary to properly set the return air path from the rack discharge (hot isle) back to the AHU. As an example, thirty-four perforated tiles were replaced with solid tiles, eight solid tiles were replaced with perforated tiles, and four return air grille adjustments were completed on one data floor. These steps were repeated as needed based on periodic space temperature measurements taken across the floor.

Once the airflow was balanced across the data floor, the CHW valve control was optimized. A reset was implemented to adjust the supply air temperature (55-64°F) based on the return air temperature (75-82°F). The upper limit of this reset was conservatively selected as the installed HVAC equipment had no humidity control capability. Similarly, the lower limit of this reset was conservatively selected to prevent overcooling as certain areas on the floor lacked cold isle containment.

The second optimization phase (future) of the project will target the administrative floors and building CHW pumping. Table 2 outlines the baseline and proposed CC measures for Building #2.
**Table 1** Phase 1 CC measures

<table>
<thead>
<tr>
<th>CC Measure</th>
<th>Baseline Control</th>
<th>Current Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimize underfloor air distribution</td>
<td>Less than optimal (1) tile selection and (2) return air grille positioning</td>
<td>Replaced perforated tiles and relocated return air grilles</td>
</tr>
<tr>
<td>Optimize CHW valve control</td>
<td>CHW valve maintained fixed SAT setpoint</td>
<td>CHW valve modulates to maintain SAT setpoint which is reset based on return air temperature</td>
</tr>
<tr>
<td>Optimize static pressure setpoint control</td>
<td>None; VFDs commanded to 100%, back-up units offline</td>
<td>Supply fan VFDs modulate to maintain optimized under floor static pressure setpoint</td>
</tr>
</tbody>
</table>

**Table 2** Phase 2 CC measures

<table>
<thead>
<tr>
<th>CC Measure</th>
<th>Baseline Control</th>
<th>Proposed Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimize static pressure setpoint control</td>
<td>Fixed duct static pressure setpoint (measured 2/3 down the duct)</td>
<td>Duct static pressure setpoint reset based on terminal unit demand</td>
</tr>
<tr>
<td>Optimize SAT setpoint control</td>
<td>Fixed SAT setpoint</td>
<td>SAT setpoint reset up when duct static setpoint is at minimum limit for specified time period</td>
</tr>
</tbody>
</table>

Note: baseline control includes equipment schedules

**RESULTS**

The baseline, implementation, and post-implementation periods are shown in Figure 3. The power distribution unit (PDU) load is also shown to illustrate that the savings achieved are not related to reduced building load. The PDU loads were obtained from monthly readings recorded by the site. It was assumed that the values were constant between the readings.

The whole building electricity is plotted as a function of outside temperature in Figure 4 with each period designated by symbol type. As expected, the building load is relatively independent of ambient conditions. The building ventilation load is minimal and the internal equipment load accounts for nearly 80% of the whole building metered electricity consumption. The reduction in electricity shown in these figures is the result of balancing the airflow on the data floors and implementing underfloor static pressure control of the corresponding AHU supply fan VFDs.
Figure 3 Whole building electricity consumption and PDU load

Figure 4 Monthly average building electricity consumption as a function of outside temperature
Figure 5 illustrates the following points: (1) key sensors must be calibrated at the onset of an energy related project and (2) energy savings potential in buildings dominated by data center equipment load is achievable by serving the load more efficiently rather than reducing the load. Once the building CHW flow sensor was calibrated in March 2010, the building load was relatively constant (850-900 MMBtu/day).

Although there was little opportunity to reduce the building load, the effect of implementing optimized CHW valve control is evident in Figure 6. The CHW flow was reduced and the return water temperature increased about 5°F (55 to 60°F), which led to reduced pump electricity and increased chiller efficiency respectively. Following the implementation of these measures, the trended plant return water temperature showed an average increase of 1°F. Assuming this temperature increase corresponds to a 1% increase in chiller efficiency (0.007kW/ton), the chiller savings over a six month period is approximately $6,520 assuming a building load of 3,038 tons.

The typical measurement and verification (M&V) protocol for CC projects is IPMVP Option C: Whole Facility [3] utilizing facility utility billing data. Option C stipulates that the typical energy savings “should exceed 10% of the baseline energy if you expect to confidently discriminate the savings from the baseline data when the reporting period is shorter than two years.” Since the total amount of energy consumed in the building for HVAC equipment was approximately 10%, this approach was deemed unacceptable. The savings for this project were estimated using HVAC equipment electrical service meter interval trend data.

Using six months of baseline and post-implementation trend data, a savings of 948,700 kWh ($66,400) was achieved. Since this building is dominated by data equipment loads (weather independent), the savings were extrapolated to twelve months. This project is expected to reduce the 2010 HVAC electricity usage by 25% ($133,000). Once the central plant savings are included, the overall savings of this project is approximately $146,000/year.

The typical measurement and verification (M&V) protocol for CC projects is IPMVP Option C: Whole Facility [3] utilizing facility utility billing data. Option C stipulates that the typical energy savings “should exceed 10% of the baseline energy if you expect to confidently discriminate the savings from the baseline data when the reporting period is shorter than two years.” Since the total amount of energy consumed in the building for HVAC equipment was approximately 10%, this approach was deemed unacceptable. The savings for this project were estimated using HVAC equipment electrical service meter interval trend data.

Using six months of baseline and post-implementation trend data, a savings of 948,700 kWh ($66,400) was achieved. Since this building is dominated by data equipment loads (weather independent), the savings were extrapolated to twelve months. This project is expected to reduce the 2010 HVAC electricity usage by 25% ($133,000). Once the central plant savings are included, the overall savings of this project is approximately $146,000/year.

**Figure 5** Monthly daily average chilled water use
CONCLUSIONS

The CC process was successfully applied to a data center facility. In order to make the case for this process it was essential to determine the energy savings potential on the basis of HVAC electricity usage rather than whole building electricity usage. Furthermore, as facilities of this type tend to have small ventilation loads, lower exterior U-values (less glazing), and high fixed data center equipment loads, the energy savings potential is achievable by serving the load more efficiently rather than reducing the load. Finally, an effective M&V plan should target HVAC electrical services and emphasize the immediate calibration of key sensors prior to the collection of baseline data.

REFERENCES


ACKNOWLEDGEMENTS

A special thanks goes to each member of the project team: Troy Skillern P.E., Steve Connelly, and Jay Bell.

Keywords: Data center, Continuous Commissioning®, energy savings

Figure 6 Monthly daily secondary chilled water pump electricity use and supply/return temperatures