Keeping the “Green” Coming in on a Green Building
Avoiding Performance Decay through Continuous Commissioning®

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Learning Objectives

1. The value of “tuning up” or continuously commissioning an existing building
2. Energy management best practices for existing buildings
3. Examples of energy efficiency in existing buildings
4. Performance decay WILL occur in an existing building – you can count on it, year in and year out
• Building At A Glance

  • **Building name**  Caterpillar Financial Headquarters
  • **Location**  Nashville, Tennessee
  • **Size**  324,000 square feet
  • **Building use**  Commercial office space featuring a full-service dining center and fitness center for building occupants
  • **Utilities**  ALL ELECTRIC!
  • **Total building cost**  $60 million in 1999
  • **Year LEED-EB process started**  2008
LEED EB Gold – 2009

First in the State of Tennessee
Initial ENERGY STAR score -- 62

ENERGY STAR application approved on April 16, 2010.

ENERGY STAR score as of May 1, 2011 – 88

42% improvement
Methodology/Strategy

• **Hire Consultant**
  • Serve as LEED Facilitator for LEED EB 2.0
  • Perform Retro Commissioning
    ○ LEED EB 2.0, EA Prerequisite 1 – Retro Cx
  • Establish Minimum Energy Performance
    ○ Energy Star score of at least 69

• **Timeline**
  • Process started in 2007, concluded in mid 2008
Mechanical Systems

- 13 VAV Air Handling Units distribute air to the spaces for ventilation and comfort with electric heat at VAV’s.
- 2 chillers and associated cooling towers, constant volume pumps and valves that supply chilled water.
- 1 central building exhaust fan is used for common exhaust needs.
- 1 central building supply fan is used to introduce outside air into the building.
- Peripheral split system A/C units serve a computer server room.
- Building Automation System
Retro Commissioning

• Air test and balance to verify proper airflow
• Alterations to physical pipe routing in the building domestic hot water operations
• Strategic operating schedules for all Air Handling Units and corresponding Exhaust Fans
• Night setback of all interior and exterior zones during unoccupied times
• Sensor Calibrations
• Chilled Water Supply Reset – 42 degrees to 50 degrees
Retro Commissioning

- AHU Discharge Air Reset Control – 55 degrees to 65 degrees based on outside air temperature
- AHU Static Pressure Reset Control – based on average damper position of VAV boxes (between 75% and 95% open)
- Occupancy Sensors on all toilet room lights
- Thermal Imaging of Building Envelope
On-going activity 2009 - 2011

**Continuous Commissioning®**
- Identify and implement any new optimization and improved maintenance strategies to **maintain or increase** energy efficiencies within the building.
- Currently investigations and verification occur in the spring and fall

**Recent findings and modifications**
- Relocation of bypass valve
  - Revised sequence of operation
  - Improved low load control of chillers(s)
  - Improved operation of VFDs
- Building Envelope leakage
Original Design
Primary Flow

Chilled Water Pumps “ride the curve”

Air Handling Units have constant (i.e. non-reset) Discharge Air Setpoint of 55°F

Bypass valve modulates to maintain 15 psi.

Bypass is sized and positioned for controlling DP, not for maintaining minimum flow.
Bypass Valve and Control Modification

Original Design
With CCx Measures

AHU reset schedule implemented by SSRCx allows Discharge Air Temperature Setpoint reset based on Outside Air

During low load conditions (approximately 30-50°F OA Temperature), Raised DAT Setpoint = Lower CHW usage
“Hybrid” Installation

Independent of SSRCx’s involvement, contractor installs VFD’s on Chilled Water Pumps and modifies sequences.

Pump VFD’s modulate to maintain 15 psi DP at sensor.

Bypass valve opens only if pumps are at minimum and system PSI > setpoint.
“Hybrid” Installation

During low load conditions, VFD’s ramp down via DP sensor for lower flow to AHU’s.

Without the pumps riding the curve (i.e. 100%), the operating chiller would trip off because it was not achieving minimum flow.

PROBLEM!
“Hybrid” Installation

Contractor subsequently modifies sequence to also ramp pumps up when chiller flow is close to trip point. Contractor also locks several AHU valves to a minimum of 10-20% open since the bypass is not sized for minimum flow and there are no 3-way valves.
During low load conditions, pump VFD still ramps up to maintain minimum flow through operational chiller; thereby eliminating energy savings on the pumps at the time of year when VFD’s should be most effective.

AHU’s with chilled water valves locked in minimum position of 20% are overcooling the air. CCx reset schedule is partially nullified (Example: With 35°C OAT, reset schedule provides a DAT setpoint of 65°F. Locked open CHW coil lowers MAT of 65°F to 59°F only to be reheated at VAV’s to satisfy space temperature.)
Variable Primary Chilled Water System

SSRCx directs installation of properly located and sized chilled water bypass line.

Pump VFD’s modulate **ONLY** according to DP.

New bypass valve modulates open **ONLY** to maintain minimum flow to chiller.

AHU CHW valves can now close fully.

Original CHW bypass valve is valved off.
Results

Variable Primary Chilled Water System

Pumps run at minimum speed necessary for flow year round.

AHU CHW reset schedules are once again effective, using less chilled water.

VAV boxes receive higher temperature air during low load conditions (OA < 50 °F), meaning less reheat necessary.
AHU Pre and Post Retro Commissioning

X 13 AHU’s !!
Thermography

• Area of concern located in the image above at rectangle point no. 3.
• There seems to be a significant decrease in the temperature in this area although there is nothing seen to the visible eye that should warrant such temperature change.
• This area could be either a lack of insulation or a water damaged area, or could have been a patch area that was never adequately sealed.
Vent leaks
P-Trap not deep enough, per Manufacturers recommendations
Last But Not Least!!
2006 through 2010 kWh Profile
kWh Baseline vs. Post CCx
Show Me the Money$
July 2008 through April 2011
### % Reduction of Annual Usage (units of energy)

#### Baseline year 2007

<table>
<thead>
<tr>
<th>Year</th>
<th>% Reduction vs. Baseline year (details)</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>2008</td>
<td>% Reduction vs. Baseline year (July through December)</td>
<td>7%</td>
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<tr>
<td>2009</td>
<td>% Reduction vs. Baseline year</td>
<td>17%</td>
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<tr>
<td>2010</td>
<td>% Reduction vs. Baseline year</td>
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<tr>
<td>Year</td>
<td>Savings (kWh)</td>
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<tr>
<td>Baseline year 2007</td>
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<td>2008 (July through December)</td>
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<td>2009 Savings versus Baseline year</td>
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<tr>
<td>2010 Savings versus Baseline year</td>
<td>2,724,000</td>
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CATERPILLAR FINANCIAL RESULTS

Simple Payback: 2.96 years
Financing: Private capital
ROI: 34%
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THANK YOU!
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