Building Recommissioning using Data Analytics at UCSB

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Tuesday, June 27th 2016

California Higher Education & Sustainability Conference (CHESC 2016)
Project Background

• UC campuses have committed to becoming carbon neutral by 2025
  ▪ Since 2005, energy consumption has been reduced by 36%

• In addition to traditional projects, UCSB is exploring alternative approaches to meet sustainability goals

• This project is a deployment of advanced analytics on HVAC data trended natively at the BMS
  ▪ Mechanical drawings, floor plans, work orders, and organizational policies factor into this analysis
Energy Efficient Operations

• “Properly applied off the shelf or state-of-the-shelf technologies are available to achieve low-energy buildings. However, these strategies must be applied together

NEED FOR INTEGRATION OF BEST-IN-CLASS COMPONENTS

• “-There was often a lack of control software or appropriate control logic to allow the technologies to work well together.

NEED INTEGRATED CONTROL SOFTWARE AND UNCERTAINTY ANALYSIS
Advanced Analytics

Automated Fault Detection and Diagnostics (AFDD)

- Learning algorithms used to identify and diagnose faults in buildings or in any dynamical system with the goal of bringing the system back to “Intended Design”

The analytics

- Work on any type of temporal data
- are physics-based
- take full advantage of the power of spectral analysis.

After the system is brought back to the “Intended Design” the fault detection/correction is done in an ongoing fashion and further operational improvements can be designed
Education and Social Science Building

- Constructed in 2009 and connected to high-efficiency campus chilled water loop
- 209,570 sqft total for two modern campus office buildings
- Advanced analytics software deployed to monitor building plant, AHU, and terminal units
- 5,686 points trending on 5-minute intervals
Data Onboarding: Contextualizing Building Data

- Data onboarding allows buildings with dissimilar systems to be uniformly represented within the analytics system.

Mapping

BMS data nomenclature differs building to building

<table>
<thead>
<tr>
<th>Native Name from BMS</th>
<th>DeviceType</th>
<th>DeviceName</th>
<th>PointName</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point1</td>
<td>City Center/TU_VAV/L12/_1211/DMPR COMD</td>
<td>FPB</td>
<td>FPB_L12_1211</td>
</tr>
<tr>
<td>Point2</td>
<td>City Center/HP/L15/_1501/DAT</td>
<td>HP</td>
<td>HP_L15_1501</td>
</tr>
</tbody>
</table>

Points 'mapped' to a clean, uniform name for intake and use in analysis

Relationship Building

Equipment and point hierarchies setup correlating systems/devices that are physically interconnected
Spectral Analysis Overview

• Faults are identified with an AFDD methodology utilizing **spectral analysis**

• Spectral analysis is the representation of signals in a frequency space
Concept

Building Output (ex. Temperature)

Magnitude of Spectral Modes

Sensor

Period

12Hr

24Hr

168Hr (Wk)
Device Data

Evaluated Indicator Functions

Analysis

Fault Description

Report

Analysis Process

<table>
<thead>
<tr>
<th>Device Name</th>
<th>Description</th>
<th>Date First Observed</th>
<th>Number of Days Previously in Top 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAV_5F_WA2_V5</td>
<td>Transmits zero or negative flow rate creating difficulty in diagnostics.</td>
<td>2014/07/25</td>
<td>8</td>
</tr>
<tr>
<td>VAV_5F_WA2_V14</td>
<td>Insufficient cooling capacity; Space temperatures are consistently above setpoint while damper remains 100% open.</td>
<td>2014/08/11</td>
<td>2</td>
</tr>
<tr>
<td>VAV_5F_WA2_V9</td>
<td>Insufficient cooling capacity; Space temperatures are consistently above setpoint while damper remains 100% open.</td>
<td>2014/08/04</td>
<td>5</td>
</tr>
<tr>
<td>VAV_5F_WA2_V2</td>
<td>Room setpoint is above upper comfort temperature limit. New Observation</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>VAV_5F_WA2_V13</td>
<td>Room setpoint is above upper comfort temperature limit. New Observation</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>VAV_GF_WA1_V9</td>
<td>Transmits zero or negative flow rate creating difficulty in diagnostics. New Observation</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>VAV_4F_WA1_V3</td>
<td>Excess cooling capacity; space temperatures are consistently below setpoint while damper remains at minimum position.</td>
<td>2014/08/04</td>
<td>6</td>
</tr>
<tr>
<td>VAV_4F_WA2_V10</td>
<td>Damper not fully open despite space being insufficiently cooled.</td>
<td>2014/08/08</td>
<td>1</td>
</tr>
<tr>
<td>VAV_5F_WA2_V3</td>
<td>Room setpoint is above upper comfort temperature limit. New Observation</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>VAV_GF_WA2_V18</td>
<td>Insufficient cooling capacity; Space temperatures are consistently above setpoint while damper remains 100% open.</td>
<td>2014/08/07</td>
<td>3</td>
</tr>
<tr>
<td>VAV_3F_WA1_V7</td>
<td>Insufficient cooling capacity; Space temperatures are consistently above setpoint while damper remains 100% open.</td>
<td>2014/08/08</td>
<td>2</td>
</tr>
</tbody>
</table>
Reporting

Work Order — June 6, 2016

Building ID: 276
Room ID: RM2015
Device Name: VAV_209
Eco ID: 102483

Leaking HW Valve

VAV supply air temperature reaches high values when hot water valve is fully closed.
## The Results

<table>
<thead>
<tr>
<th><strong>Automated Intelligence</strong></th>
<th>Industry expertise built directly into software, reusable libraries of finding classifications</th>
</tr>
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<tbody>
<tr>
<td><strong>Unmatched Accuracy</strong></td>
<td>Spectral analysis used to identify only persistent and important issues.</td>
</tr>
<tr>
<td><strong>Root Cause Diagnostics</strong></td>
<td>Whole system analysis revealing underlying issues.</td>
</tr>
<tr>
<td><strong>Scalable, Rapid Deployment</strong></td>
<td>Software built around replicable analyses + automated data ingestion and mapping processes</td>
</tr>
<tr>
<td><strong>Easy Access Web Application</strong></td>
<td>Web application for easy access to diagnostic information anywhere</td>
</tr>
</tbody>
</table>
Comfort Improvements

Thermal Comfort Index (TCI): Temp Records within 70-76 F/ from 9am-5pm

<table>
<thead>
<tr>
<th>Monthly TCI</th>
<th>Nov 42.7%</th>
<th>Dec 64.6%</th>
<th>Jan 77.6%</th>
<th>Feb 83.9%</th>
<th>Mar 80.2%</th>
<th>Apr 88.2%</th>
<th>May 87.8%</th>
</tr>
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<tr>
<td>42.7%</td>
<td>64.6%</td>
<td>77.6%</td>
<td>83.9%</td>
<td>80.2%</td>
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<td>87.8%</td>
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</table>
Occurrence of Issues

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Energy Savings

2016 Electric Energy Usage (275 & 276 & CHWS)

- Regression Model
- Measured Data

Days
Energy Usage (KWh)

0 20 40 60 80 100 120 140 160
2000 2500 3000 3500 4000 4500 5000 5500 6000
Energy Savings (cont.)

![Graph](image.png)
Analysis Results

<table>
<thead>
<tr>
<th>Design</th>
<th>Operation</th>
<th>Hardware</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unstable Controls</td>
<td>Irregular Control Points</td>
<td>Sensor Failure</td>
</tr>
<tr>
<td>Schedule Optimization</td>
<td>Device Responsiveness / Malfunctions</td>
<td>Communication Interruptions</td>
</tr>
<tr>
<td>Capacity Limits</td>
<td>System Biases</td>
<td>Measurement Noise</td>
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</table>

- Results identified with no prior knowledge of building performance
  - Outcomes from applying data to analytics knowledge base
- Project is ongoing: After correction of overt issues, analysis reports activity as it happens and discovers issues before major effects develop
Project Summary

- Total Cost: $8,950
- Utility Incentives: $35,000 est.
- Annual Savings: $15,000 approx.

- Frequency of new issues lowered by 50%
- Occupant comfort improved by 45%
- HVAC Maintenance requests lowered by 40%
Thank You

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