2018 Facilities Officers Conference

A Look Into Retro-Commissioning

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Principal, National Commissioning Director,
Senior Mechanical Engineer

- Georgia Tech Bachelor’s Mechanical Degree & Energy Engineering minor, 1978
- 40 years Mechanical Engineering (17 years Commissioning)
- PE registration in 14 states
- Georgia Peach Sustainable Executive Committee Board Member
- Southeast Region BCA Board Member, President
- ASHRAE, ACG, BCA, EMA, LEED AP BD+C
- Commissioning Management for firm’s Cx projects nationwide in the 17 offices
- 17 years Cx services with GSFIC, Current GSFIC projects:
  - GBA-182, Georgia Judicial Complex
  - TCSG-334, North Georgia Technical College Construction Technology & Economic Development Building
  - DOT-088, Jesup Headquarters
  - DOT-089, Cartersville Headquarters
  - J-272B, Clayton State University Phase II Campus Reno
  - J-272C, Clayton State University Phase III Central Plant
  - J-209 Augusta Univ Cancer Research Building
James Brownsmith  
Project Executive  
GSFIC

- Project Executive for the Georgia State Financing and Investment Commission overseeing bond funded projects for various state agencies.

- More than 35 years in the construction industry as a construction project manager, operations manager and owner’s representative.

- For 18 years, James worked for a design-build firm specializing in healthcare facilities in New England, was promoted and relocated to the Atlanta area as a Regional Construction Manager.

- For 10 years, James worked as a general contractor in Denver, Colorado.

- Architecture degree from Howard University in Washington, D. C.
Overview

- Existing Building Commissioning
- Retro-Commissioning
- ARRA Project Retro-Commissioning scope
- Georgia Public Health Lab project

Objectives

- What, Why, How of Retro-Commissioning
- GPHL RCx Scope of Work
- Retro-Cx Modifications
- Energy Model ECM’s Energy Savings
Existing Building Commissioning (EBC\text{x})

Retro-Commissioning (RC\text{x})
What Is It?

Existing Building Commissioning

- A systematic process for investigating, analyzing, and optimizing the performance of building systems through the identification and implementation of low/no cost and capital intensive Facility Improvement Measures and ensuring their continued performance over time.

- Assists in making the building systems perform interactively to meet the Current Facility Requirements.
Why Do It?
Why Do It?

- Greenhouse Carbon (GHC) Emissions
  - Buildings 38%, Transportation 32%, Industrial 30%
- Energy Consumption
  - Buildings use 76% of all electrical consumption
- Operational Problems
  - Only 5% of all new buildings are commissioned
- IAQ – Indoor Air Quality
- Thermal Comfort of Occupants

Source: U.S. Energy Information Administration statistics
Benefits of Retro-Commissioning

• Reduced operating costs
• Better building documentation
• Improved system & equipment function
• Improved O&M
• Improved occupant safety, comfort, and health
• Improved maintainability
• Better trained operating staff/disaster recovery knowledge
• Improved occupant & Owner satisfaction
Benefits of Retro-Commissioning

• One of the most cost effective measures for energy efficiency improvement

• National study shows median payback of 15% savings in energy bills

• Estimated $18B in energy savings potential nationwide
Existing Building Cx Potentials

- Corrections are typically low cost measures to implement
- Savings are realized in energy cost, O&M costs, avoided capital expenditures
- Paybacks typically 6 months to 2 years – 50% to 200% ROI
- Low hanging fruit
  - Calibration of T-stats and sensors
  - BAS programming adjustments
  - VFD programming reset/validation
  - Electronic time clocks
Top 10 List

- Constant Volume Pumping Systems
- No Reset Schedules for HVAC
- No Occupancy Schedules for HVAC or Lighting
- OA Opportunities
- BAS/Controls Problems – Setpoints, Loop Tuning, etc.
- Equipment Efficiency
- Equipment Failures
- Program Changes
- Trending
- Training O&M
## Retro-Commissioning Phases

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning Phase</td>
<td>Benchmarking, Establish Goals, verify Owner Needs &amp; RCx Plan</td>
</tr>
<tr>
<td>Investigation Phase</td>
<td>Building survey— Evaluate Current System Performance with Owner Needs &amp; Identify Improvements, TAB measurements, Develop Energy Conservation Measures (ECM), develop budget, update RCx plan, issue bid documents</td>
</tr>
<tr>
<td>Implementation Phase</td>
<td>Select Contractor, Implement Recommended Improvements and Verify Performance, BAS replacement, TAB, Functional Testing, BAS Trending</td>
</tr>
<tr>
<td>Turnover Phase</td>
<td>Establish Smooth Transition and Hand Over to O&amp;M Staff (O&amp;M review, Training), RCx report, Energy Savings report</td>
</tr>
<tr>
<td>Persistence Phase</td>
<td>Ensure Continuous System Performance Improvement (BAS Trending, energy bills review, deferred testing, Ongoing Cx plan)</td>
</tr>
</tbody>
</table>

-As defined by BCA “Best Practices”
ARRA Program Overview

- Federal government signed American Recovery and Reinvestment Act of 2009 (ARRA) into law

- Evaluation of State projects – Ten year payback

- $35 million spread across 50 projects

- Joint GEFA - GSFIC Program Administration
  - Procurement
  - Design Review
  - Project Management
  - Quality Assurance
GPHL Retro-Cx Scope of Work

- BSL-2/BSL-3 Lab facility, two-story, 67,000 square foot, 24/7 operation (virology, parasitology, chemistry, & newborn screening)

- Built in 1997 on Clairmont Road (274% increase in newborn screening and addition of new lab equipment & refrigeration)

- BSL areas – Critical airflow pressurization zones (positive, negative)
GPHL Retro-Cx Scope of Work

• Retro-Cx services, engineering design services

• Mechanical systems (equipment operations, BAS/Controls, OA ventilation, fume hood system, steam system)

• Electrical system (lighting)

• Addition of new cooling equipment
GPHL Retro-Cx Scope of Work

- Water cooled chillers – 2 at 200 tons each (42F LWT, 54F EWT)
- Chilled water pumps – 3 at 400 GPM/40’ Head/15 HP
- Induced draft cooling tower – 400 tons
- Condenser water pumps – 3 at 600 GPM/50’ Head/20 HP
- Steam boilers – 2 at 600 BHP each
- Steam-to-water heat exchanger for heating HW distribution
- Hot water pumps – 3 at 324 GPM/50’ Head/7.5 HP
- Fume Hood Exhaust Fans – 6 at 8500 CFM each
- Main AHU – 71,650 CFM (supply), 51,000 CFM (OA), 2 supply fans at 100 HP each
- Air distribution – PIUs (40), VAVs (6), SAVs (56), EAVs (73)
Retro-Cx Modifications

- Replaced 12 year old JCI BAS with new JCC Bluetooth BAS
- Replaced defective steam traps
- Installed new Chiller Optimization Controller with CHWS reset & interfaced with new BAS
- Installed motorized valves at chillers’ piping (added chiller staging sequence)
- Lowered condenser water supply temperature setpoint
Retro-Cx Modifications

- New boiler controls for low & high firing modulation
- AHU-1 supply air temperature reset controls
- AHU-1 replaced two 100HP fan motors with premium efficiency & installed new VFD’s
- Revised poor discharge duct connections to AHU-1 supply plenum
- OA opportunities (reduced lab airflow rates from 20 to 12 air changes per hour, 9400 CFM)
- Install new space humidity sensors for BAS
- Modified HW valves to VAV’s for 2-way
Retro-Cx Modifications

• Add VFD’s to HW pumps with DP sensor controls
• Installed 4” check valve in steam boiler steam outlet piping
• Installed new steam pressure sensors at each steam boiler, interfaced with boiler controls
• Installed new Static Pressure Controllers in the 1st and 2nd floor supply main duct for AHU-1
• Replaced AHU-1 humidifier
Retro-Cx Modifications

- Maintenance Corrections

  - Replaced relief vent valve at steam dearator tank
  - Replaced steam controls valves at 2 steam boilers
  - Installed expansion compensators in HW piping
  - Replaced drain valve at Shell & Tube Heat Exchanger
  - Replaced actuators on OA dampers of AHU-1
  - Installed sheetmetal baffle at AHU-1 OA/RA mixing plenum
  - Replaced AHU-1 cooling coil sized for reduced cooling load & new CHW control valve
Retro-Cx Modifications

- Replaced AHU-1 pre-heat & humidifier steam control valves
- Corrected fume hood exhaust system airflows and VFD controls
- Addition of thimbles to the 15 Biosafety cabinets exhaust duct connections
Energy Model (ECM’s)

• CHWS temperature reset (42°F to 50°F)
• AHU-1 supply air temperature reset (52°F to 58°F)
• AHU-1 reduced OA from 53,700 CFM to 41,000 CFM
• AHU-1 duct changes & airflow reductions (unit static pressure dropped from 5.6” to 4.7”)
• AHU-1 fan motor efficiency increased from 90% to 94.5%
Energy Model (ECM’s)

- Removed vane axial blades controls & fixed blades at best fan efficiency setting (a 40% increase in fan efficiency)
- Condenser water setpoints reduced (85° EWT at chillers to 75° EWT, 95° LWT at chillers to 85° LWT)
- Chiller staging & controls optimization for a 5% increase in chiller efficiency
- Steam boilers staging/replaced steam traps & control valves increased gas savings
Energy Model Results

The following table displays the results of the energy model:

<table>
<thead>
<tr>
<th>Energy Model</th>
<th>Energy Type</th>
<th>Consumption</th>
<th>Annual Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing Model</td>
<td>Electricity</td>
<td>$12,833 \times 10^6 \text{ Btu/yr}$</td>
<td>$328,748</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3,760,120 \text{ kWh/yr})</td>
<td></td>
</tr>
<tr>
<td>Existing Model</td>
<td>Gas</td>
<td>$13,880 \times 10^6 \text{ Btu/yr}$</td>
<td>$182,966</td>
</tr>
<tr>
<td>Existing Model</td>
<td>Total</td>
<td>$26,713 \times 10^6 \text{ Btu/yr}$</td>
<td>$511,715</td>
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<tr>
<td>Retrofit Model</td>
<td>Electricity</td>
<td>$9,936 \times 10^6 \text{ Btu/yr}$</td>
<td>$254,532</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2,911,250 \text{ kWh/yr})</td>
<td></td>
</tr>
<tr>
<td>Retrofit Model</td>
<td>Gas</td>
<td>$7,023 \times 10^6 \text{ Btu/yr}$</td>
<td>$108,027</td>
</tr>
<tr>
<td>Retrofit Model</td>
<td>Total</td>
<td>$16,959 \times 10^6 \text{ Btu/yr}$</td>
<td>$362,559</td>
</tr>
</tbody>
</table>

The estimated energy consumption and cost savings are displayed in the following table:

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>Consumption</th>
<th>Annual Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Savings</td>
<td>Electricity</td>
<td>$2,897 \times 10^6 \text{ Btu/yr}$</td>
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<tr>
<td></td>
<td></td>
<td>(848,813 \text{ kWh/yr})</td>
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<tr>
<td>Annual Savings</td>
<td>Gas</td>
<td>$6,857 \times 10^6 \text{ Btu/yr}$</td>
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<tr>
<td>Annual Savings</td>
<td>Total</td>
<td>$9,754 \times 10^6 \text{ Btu/yr}$</td>
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</table>

Based upon the energy modeling the expected approximate annual utility cost savings for combined gas and electric consumption is $149,156. The total project cost including construction costs, engineering, retro-commissioning, and testing and balancing was approximately $707,503. The resulting simple payback for this investment is 4.7 years.
Energy Model (ECM’s)

Utility Bill Data

Electricity:

<table>
<thead>
<tr>
<th></th>
<th>Total kWh</th>
<th>Total Cost</th>
<th>$/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec-10</td>
<td>223360</td>
<td>$16,314</td>
<td>$0.073</td>
</tr>
<tr>
<td>Jan-11</td>
<td>220320</td>
<td>$16,456</td>
<td>$0.075</td>
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<tr>
<td>Feb-11</td>
<td>200320</td>
<td>$15,934</td>
<td>$0.079</td>
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<tr>
<td>Mar-11</td>
<td>226640</td>
<td>$18,155</td>
<td>$0.078</td>
</tr>
<tr>
<td>Apr-11</td>
<td>280640</td>
<td>$20,646</td>
<td>$0.079</td>
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<tr>
<td>May-11</td>
<td>332320</td>
<td>$26,261</td>
<td>$0.079</td>
</tr>
<tr>
<td>Jun-11</td>
<td>334880</td>
<td>$29,829</td>
<td>$0.090</td>
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<tr>
<td>Jul-11</td>
<td>378000</td>
<td>$37,149</td>
<td>$0.100</td>
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<tr>
<td>Aug-11</td>
<td>427520</td>
<td>$43,072</td>
<td>$0.101</td>
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<tr>
<td>Sep-11</td>
<td>356480</td>
<td>$35,581</td>
<td>$0.100</td>
</tr>
<tr>
<td>Oct-11</td>
<td>305440</td>
<td>$28,108</td>
<td>$0.092</td>
</tr>
<tr>
<td>Nov-11</td>
<td>245440</td>
<td>$19,160</td>
<td>$0.078</td>
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<tr>
<td>Total</td>
<td>3507360</td>
<td>$306,685</td>
<td>$0.08743</td>
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Natural Gas:

<table>
<thead>
<tr>
<th></th>
<th>Thems</th>
<th>$/therm</th>
<th>Gas Charge</th>
<th>Base Charge</th>
<th>Cust Fee</th>
<th>Pipeline fee</th>
<th>Total</th>
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<tbody>
<tr>
<td>Dec-10</td>
<td>21432.74</td>
<td>$0.999</td>
<td>$21,411.31</td>
<td>$1,389.31</td>
<td>$5.95</td>
<td>$1,223.48</td>
<td>$24,030.05</td>
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<td>Jan-11</td>
<td>19301.643</td>
<td>$1.109</td>
<td>$21,405.52</td>
<td>$1,389.31</td>
<td>$5.95</td>
<td>$1,223.48</td>
<td>$24,024.26</td>
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<td>Feb-11</td>
<td>16583.152</td>
<td>$1.109</td>
<td>$18,300.72</td>
<td>$1,389.31</td>
<td>$5.95</td>
<td>$1,223.48</td>
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<td>Mar-11</td>
<td>12336.272</td>
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<td>$13,804.29</td>
<td>$1,389.31</td>
<td>$5.95</td>
<td>$1,223.48</td>
<td>$16,423.03</td>
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<td>Apr-11</td>
<td>11014.068</td>
<td>$1.069</td>
<td>$11,774.04</td>
<td>$1,389.31</td>
<td>$5.95</td>
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<td>May-11</td>
<td>6823.206</td>
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<td>$7,566.94</td>
<td>$1,388.60</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$8,955.54</td>
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<td>Jun-11</td>
<td>7566.468</td>
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<td>$8,618.21</td>
<td>$0.71</td>
<td>$5.95</td>
<td>$1,223.48</td>
<td>$9,848.35</td>
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<td>Jul-11</td>
<td>7719.06</td>
<td>$1.139</td>
<td>$8,792.01</td>
<td>$1,389.31</td>
<td>$5.95</td>
<td>$1,223.48</td>
<td>$11,410.75</td>
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<tr>
<td>Aug-11</td>
<td>7328.904</td>
<td>$1.139</td>
<td>$8,347.62</td>
<td>$1,389.31</td>
<td>$5.95</td>
<td>$1,223.48</td>
<td>$10,966.36</td>
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<tr>
<td>Sep-11</td>
<td>8332.038</td>
<td>$1.139</td>
<td>$9,490.19</td>
<td>$1,364.70</td>
<td>$5.95</td>
<td>$1,200.45</td>
<td>$12,681.29</td>
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<tr>
<td>Oct-11</td>
<td>9025.197</td>
<td>$1.089</td>
<td>$9,828.44</td>
<td>$1,362.27</td>
<td>$5.95</td>
<td>$1,200.45</td>
<td>$12,397.11</td>
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<tr>
<td>Nov-11</td>
<td>11342.496</td>
<td>$1.089</td>
<td>$12,351.98</td>
<td>$1,362.27</td>
<td>$5.95</td>
<td>$1,200.45</td>
<td>$14,920.65</td>
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<tr>
<td>Total</td>
<td>138805.24</td>
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<td>$151,761.25</td>
<td>$15,203.72</td>
<td>$65.45</td>
<td>$13,389.19</td>
<td>$180,439.61</td>
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</tbody>
</table>

Average: $13,805.24

Note: Anomalous customer charges and fees in May-11 and Jun-11 were not included in averages.
Energy Model (ECM’s)
Energy Savings Summary

- **Phase 1**
  - RCx Cost + Construction cost = **$707,503**
  - Payback Analysis: **4.7 years**

- **Phase 2**
  - Replace Chiller CH-1 with high efficiency VFD chiller
  - RCx cost + Construction cost = **$343,000**
  - Payback Analysis: Energy model calibration underway

- **Phase 3**
  - Replaced Chiller #2 with high efficiency VFD chiller
  - RCx cost + Construction cost = **$489,250**
  - Payback Analysis: Energy model calibration underway

- **Phase 4**
  - Replaced cooling tower, chilled and condenser water pumps (high efficiency motors and VFD’s)
  - RCx cost + Construction cost = **$204,000**
  - Payback Analysis: Energy model calibration underway
What buildings should be Retrocommissioned?

- 24/7 facilities (labs, data centers, dorms, libraries, rec centers, indoor aquatics)
- Classroom buildings with labs or technical type training buildings with large exhaust systems
- Standard classroom buildings
- Administration buildings
- Facility operations buildings
Links and Resources

- Building Commissioning Association – [www.bcxa.org](http://www.bcxa.org)
- California Commissioning Collaborative – [www.cxca.org](http://www.cxca.org)
- AABC Commissioning Group - [www.commissioning.org](http://www.commissioning.org)
- American Society of Heating, Refrigerating, and Air-Conditioning Engineers - [www.ashrae.org](http://www.ashrae.org)
- Georgia State Commissioning Guide – gsfic.georgia.gov
- Sheet Metal and Air Conditioning Contractors National Association – [www.smacna.org](http://www.smacna.org)
Thank you

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