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 (EBCx)

Retro-Commissioning (RCx)

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

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

Energy Model Results

The following table displays the results of the energy model:

	Energy Type	**Consumption**	**Annual Cost**
Existing Model	Electricity	12,833 x 10^6 Btu/yr (3,760,120 kWH/yr)	$328,748
Existing Model	Gas	13,880 x 10^6 Btu/yr	$182,966
Existing Model	**Total**	**26,713 x 10^6 Btu/yr**	**$511,715**
Retrofit Model	Electricity	9,936 x 10^6 Btu/yr (2,911,250 kWH/yr)	$254,532
Retrofit Model	Gas	7,023 x 10^6 Btu/yr	$108,027
Retrofit Model	**Total**	**16,959 x 10^6 Btu/yr**	**$362,559**

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

	Energy Type	**Consumption**	**Annual Cost**
Annual Savings	Electricity	2,897 x 10^6 Btu/yr (848,813 kWH/yr)	**$74,217**
Annual Savings	Gas	6,857 x 10^6 Btu/yr	**$74,939**
Annual Savings	Total	9,754 x 10^6 Btu/yr	**$149,156**

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:

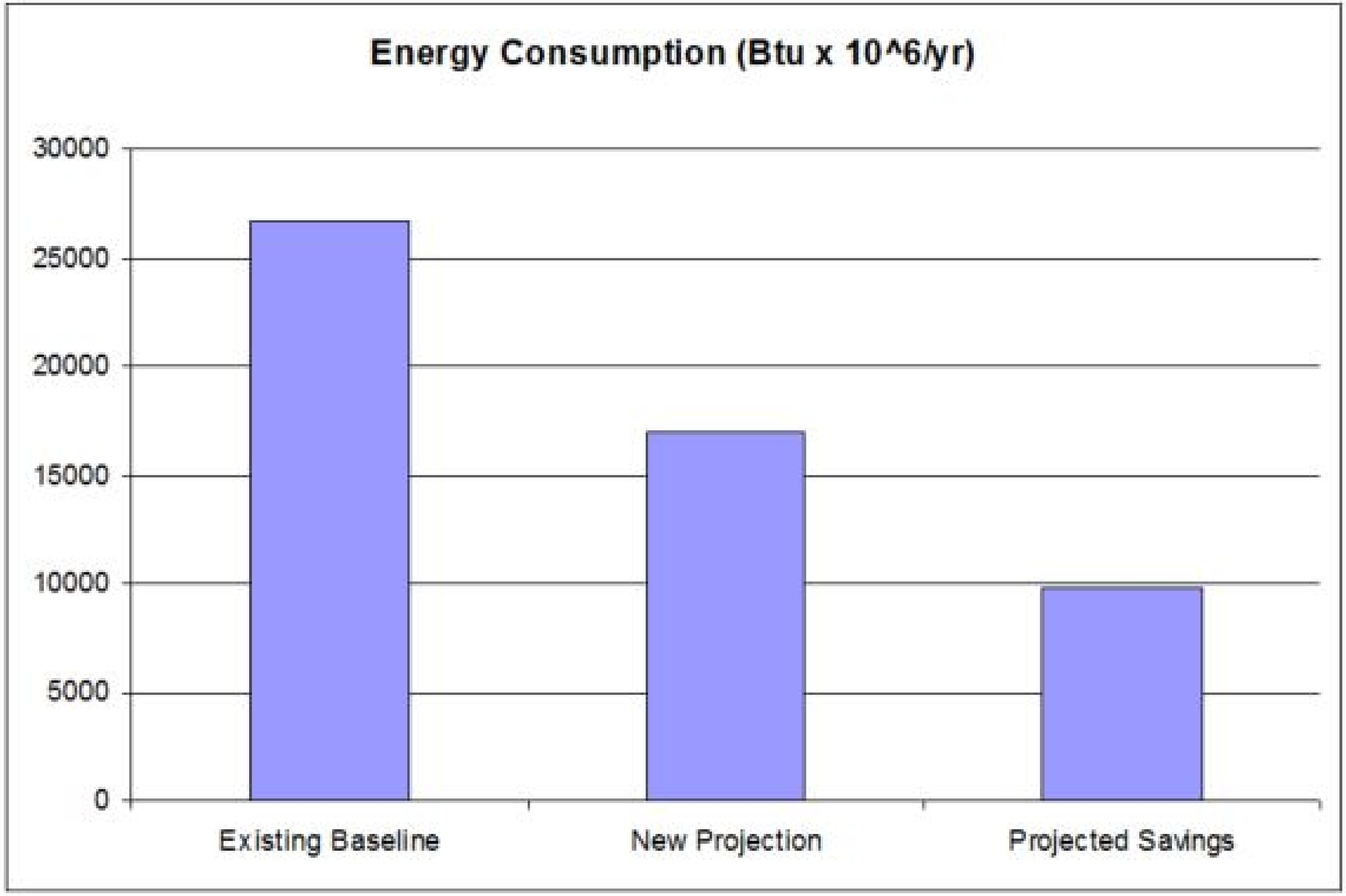
	Total kWH	Total Cost	$/kWH
Dec-10	223360	$16,314	$0.073
Jan-11	220320	$16,456	$0.075
Feb-11	200320	$15,934	$0.080
Mar-11	228640	$18,155	$0.079
Apr-11	260640	$20,646	$0.079
May-11	332320	$26,261	$0.079
Jun-11	334880	$29,829	$0.089
Jul-11	372000	$37,149	$0.100
Aug-11	427520	$43,072	$0.101
Sep-11	356480	$35,581	$0.100
Oct-11	305440	$28,108	$0.092
Nov-11	245440	$19,160	$0.078
Total	**3507360**	$306,665	**$0.08743**

Natural Gas:

	Therms	$/therm	Gas Charge	Base Charge	Cust Fee	Pipeline fee	Total
Dec-10	21432.74	$0.999	$21,411.31	$1,389.31	$5.95	$1,223.48	$24,030.05
Jan-11	19301.643	$1.109	$21,405.52	$1,389.31	$5.95	$1,223.48	$24,024.26
Feb-11	16583.152	$1.109	$18,390.72	$1,389.31	$5.95	$1,223.48	$21,009.46
Mar-11	12336.272	$1.119	$13,804.29	$1,389.31	$5.95	$1,223.48	$16,423.03
Apr-11	11014.068	$1.069	$11,774.04	$1,389.31	$5.95	$1,223.48	$14,392.78
May-11	6823.206	$1.109	$7,566.94	$1,388.60	$0.00	$0.00	$8,955.54
Jun-11	7566.468	$1.139	$8,618.21	$0.71	$5.95	$1,223.48	$9,848.35
Jul-11	7719.06	$1.139	$8,792.01	$1,389.31	$5.95	$1,223.48	$11,410.75
Aug-11	7328.904	$1.139	$8,347.62	$1,389.31	$5.95	$1,223.48	$10,966.36
Sep-11	8332.038	$1.139	$9,490.19	$1,364.70	$5.95	$1,200.45	$12,061.29
Oct-11	9025.197	$1.089	$9,828.44	$1,362.27	$5.95	$1,200.45	$12,397.11
Nov-11	11342.496	$1.089	$12,351.98	$1,362.27	$5.95	$1,200.45	$14,920.65
Total	**138805.24**		$151,781.25	$15,203.72	$65.45	$13,389.19	**$180,439.61**
Average		$1.093		$1,382.16	$5.95	$1,217.20	

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
- "A RetroCommissioning Guide for Building Owners" – US EPA www.peci.org/sites/default/files/epaguide_0.pdf
- California Commissioning Collaborative – www.cxca.org
- "Best Practices in Commissioning Existing Buildings" – www.bcxa.org/downloads/bca-ebcx-best-practices.pdf
- AABC Commissioning Group - www.commissioning.org
- American Society of Heating, Refrigerating, and Air-Conditioning Engineers - www.ashrae.org
- Georgia State Commissioning Guide – gsfic.georgia.gov
- US Dept. of Energy Building America Program – www.buildingamerica.gov
- Sheet Metal and Air Conditioning Contractors National Association – www.smacna.org

Thank you

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