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Moderator:

Linda Hunter,

B.ChE, CEM, CEA

Tetra Tech, Director of Energy Services

Commissioning and Retro-commissioning

Introduction

Michael Hardy, P.E., CxA, LEED AP BD+C
E M C Engineers, Inc.,
An Eaton Corporation Subsidiary

Celeste Cizik, P.E., CEM, LEED AP
E M C Engineers, Inc.,
An Eaton Corporation Subsidiary

Learning Objectives

Intent: *Learn how to incorporate commissioning into O&M programs.*

Description: *See how commissioning, re-commissioning, and retro-commissioning can be used in your buildings, and how low-to-no-cost options and continuous commissioning can improve energy efficiency.*

AGENDA

1. New Building Commissioning
   - Design Phase
   - Construction/Acceptance Phase
   - Warranty (Post Occupancy) Phase
   - Persistence Phase

2. Existing Building Commissioning
   - Planning Phase
   - Investigation Phase
   - Implementation/Acceptance Phase
   - Turnover Phase
   - Persistence Phase

Types of Commissioning

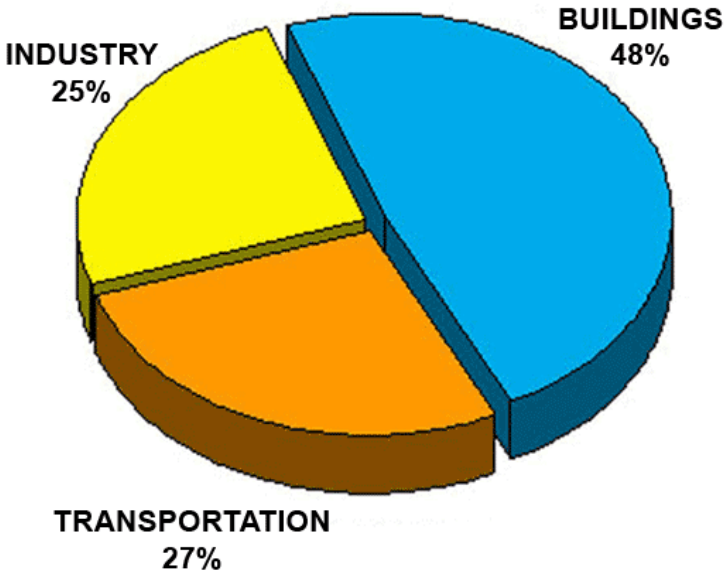
- Commissioning (Cx) - new building or major renovation
- Existing Building Commissioning (EBCx)
  - Retro-Commissioning (RCx) – no previous Cx
  - Re-Commissioning (RCx) – previous Cx
  - Value Re-Commissioning (VCx) – common opportunities, short paybacks
  - Monitoring Based Commissioning (MBCx) – monitoring with analysis training, automation of diagnostics
- Ongoing Commissioning - *same concepts continued over time*
  - Continuous Commissioning™ (CC) - Texas A&M University

Energy Drivers

Buildings account for:

- **76%** of U.S. electrical consumption
- **48%** of total energy use
- **38%** of CO_2 emissions

-AIA Sustainable Design Factsheet (architecture2030.org)



US ENERGY CONSUMPTION

Energy Drivers

*Median Values	Whole Building Energy Savings	Payback Times (yrs)	Cash-on-cash Returns
Existing Building Cx	16%	1.1	91%
New Building Cx	13%	4.2	23%

*Lawrence Berkeley Lab
http://cx.lbl.gov/2009-assessment.html

- High-tech buildings are particularly cost effective
- Comprehensive approach attained twice the median savings
- Non-energy benefits are extensive

New Bldg Cx Compared to EBCx

What is New Bldg Cx?	What is EBCx?
New building commissioning (Cx) is a means to ensuring – through design reviews, functional testing, system documentation, and operator training – that systems and equipment in new buildings are operating properly.	Existing building commissioning (EBCx), which is sometimes referred to as “retro- or re-commissioning”, is the practice of commissioning existing buildings – testing and adjusting the building systems to meet the original design intent and/or optimize the systems to satisfy current operational needs.

~ ***As defined by BCA “Best Practices”***

Why Commission a New Building?

- Fully functional building at first occupancy (within warranty)
- Lower energy and maintenance costs
- Safer and more comfortable buildings
- Fewer disputes between building owner and general contractor
- Problems discovered early when they are less expensive to correct

~ Building Commissioning – An Overview
www.betterbricks.org/commissioning

Phases of New Building Commissioning

- Design
- Construction/Acceptance
- Warranty (Occupancy & Operations)
- Persistence Commissioning

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Design Phase

- Owner's Project Requirements
  - Provide organizational initiatives to be incorporated into the design
  - Provide energy performance standards for incorporation in design
  - Include Performance Requirements pertaining to Maintenance Access
  - Include OEM requirements to match existing equipment
  - Include performance standards for level of maintenance intensity and capability as a design standard
  - Provide access for Design Team to existing Maintenance SOPs
- System Testing Specification Incorporation
- Training on Systems Specification Incorporation
- Continual Monitoring Requirements Incorporation

Construction/Acceptance Phase

- Trade Coordination
- Change Initiatives
- Participate in Functional Testing
- Hands On Training during Testing
- Enhance Energy Saving Measures incorporated during Design with Results from Testing
- Measurement and Verification Calibration
- Continual Monitoring Preventative Maintenance
- Systems Manual Review

Systems Manual

Developing the Systems Manual encompasses gathering all of the information related to the systems, assemblies, and the Commissioning Process and incorporating it into a usable information resource with indexes and cross-references.

- Executive Summary (facility level)
- Owner's Project Requirements (facility level)
- Basis of Design (facility level)
- Construction Record Documents
- Approved Submittals
- Facility Operating Procedures
- List of recommended operational record keeping procedures (at the facility level)
- Maintenance procedures, schedules, and recommendations (facility level)
- Ongoing Optimization (facility level)
- Attachments

Warranty Phase

- Energy Performance Verification at end of Warranty
- Additional Training on Building Operation
- Documentation Update for Systems Modifications after Continuous Operation
- Develop and Implement an Operator's Log
- Issue Tracking and Resolution
- Measurement and Verification Data Collection
- Trend Analysis
- Develop Facility Benchmark

Persistence Phase

- Develop Ongoing Commissioning Plan
  - Identify frequency and intensity of activities
  - Identify resources to be utilized
- Preventative Maintenance Procedure Tracking from System Manual Procedures
- Ongoing Commissioning utilizing internal resources encompassing System Manual Procedures
- Data Tracking
- Energy Consumption Data Logging and Opportunities
- Develop Long Term Fixes for Issues Identified through Operator's Log

Case Study - CDC 106

- What did EMC do to save CDC energy and improve O&M?
  - Systems Manual & Integration Training
  - Pressurization Sensor Placement & Installation
  - Tertiary CHW Bypass Control
  - Chiller Load Demand Control
  - Tracking equipment failure during Construction/Installation
  - Trend development during warranty to resolve long term issues
  - AHU Static Pressure Setpoint Tuning
  - Occupied/Unoccupied command shared across network

Existing Building Commissioning

Optimization and Energy Savings

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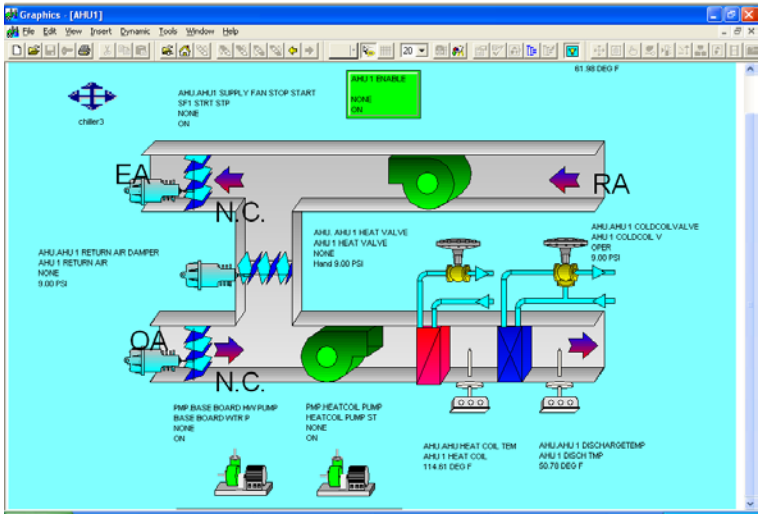
EBCx Overview

- EBCx Drivers and Overview
- Steps of the process
- Implementation and Benefits
- Ongoing Performance Monitoring

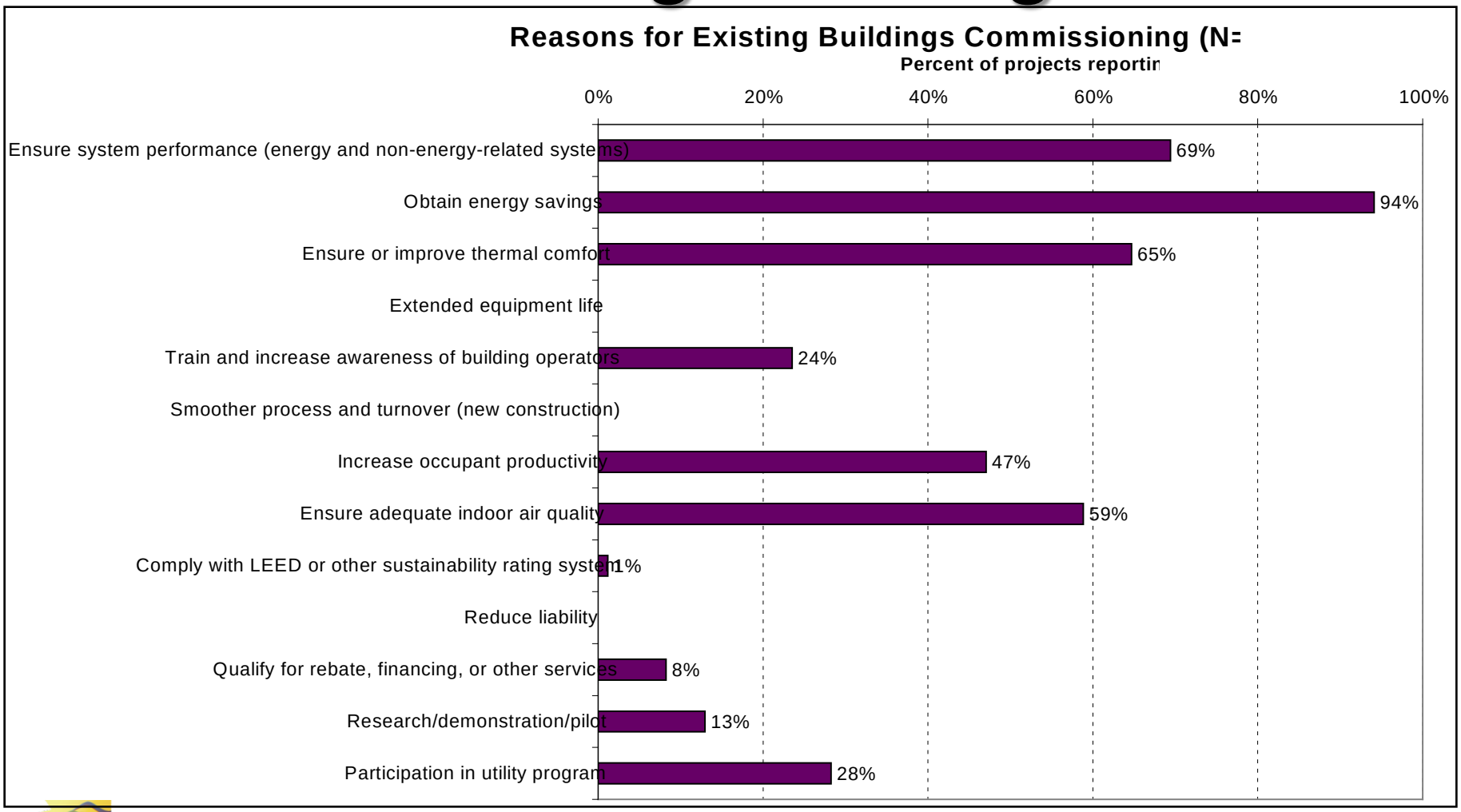
What is EBCx?

- Applying the <u>commissioning process</u> to improve the current conditions/operations of an <u>existing building</u>



- Typically focuses on:
  - HVAC Systems
  - HVAC Controls
  - Lighting Controls
- Evaluates building operation:
  - What were the building systems designed to do?
  - What are the building systems doing now?
  - How can the building systems be optimized?

Reasons for Commissioning Existing Buildings



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Reasons for Commissioning Existing Buildings

- **Common Question:** *"Who put this in override?"*
- **Common Answer:** *"That person doesn't work here anymore."*
- Reality – list of reasons is long
  - Change of personnel/building purpose
  - Maintenance staff made quick fix
  - Design issues, lack of documentation
  - Incomplete controls, lack of BAS training and support

Invisible issues lead to expensive operation, getting to the root cause

Existing Building Cx Phases

Planning Phase	Establish Goals, Owner Needs & EBCx Plan
Investigation Phase	Evaluate Current System Performance with Owner Needs & Identify Improvements
Implementation Phase	Implement Recommended Improvements and Verify Performance
Turnover Phase	Establish Smooth Transition and Hand Over to O&M Staff
Persistence Phase	Ensure Continuous System Performance Improvement

-As defined by BCA "Best Practices"

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Planning Phase

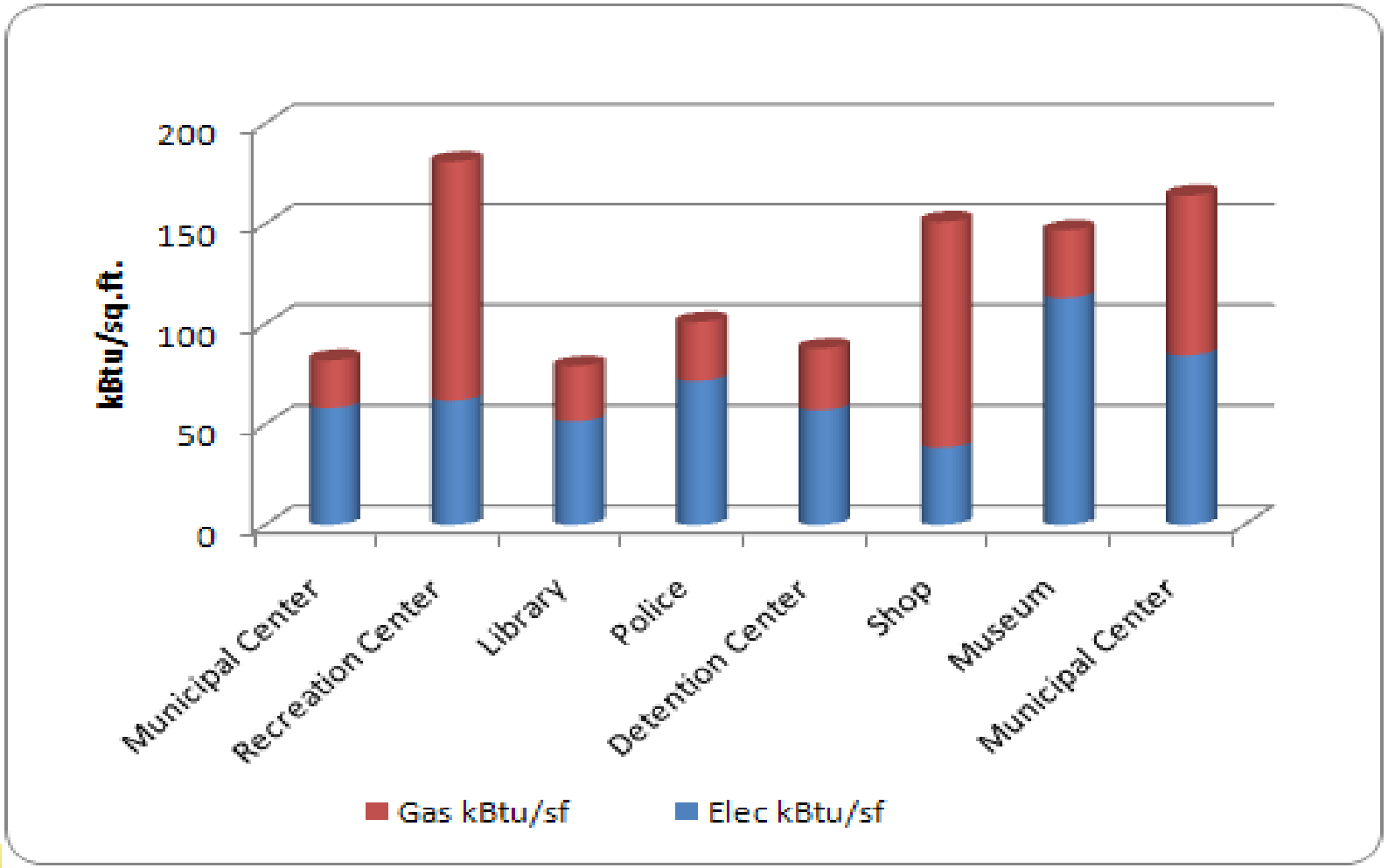
Planning Phase → Establish Goals, Owner Needs & EBCx Plan

Ideal buildings:

- Large (>50,000sq.ft.), high EUI - kBtu/sq.ft./yr
- Benchmark with Energy Star, CBECS (http://www.eia.doe.gov/emeu/cbecs)
- DDC system
- No major renovations planned
- Committed client – energy goals

Planning Phase

Portfolio Comparison



Planning Phase

Benchmarking

			Energy Use/Area				
Building Type	Area (sq.ft.)	Total kBtu	Elec kWh/ sf	Elec kBtu/sf	Gas kBtu/sf	Total kBtu/ sf	Energy Star Rating
Municipal Center	285,627	23,417,464	17.1	58.3	23.7	82.0	77
Recreation Center	52,603	9,488,452	18.1	61.8	119.1	180.4	18
Library	54,002	4,259,678	15.1	51.5	27.4	78.9	57
Police	48,029	4,891,323	21.0	71.8	29.1	101.8	52
Detention Center	173,000	15,186,011	16.8	57.3	30.5	87.8	67
Shop	52,736	7,965,972	11.3	38.5	112.5	151.1	18
Museum	87,426	12,818,476	33.1	112.8	33.9	146.6	22
Municipal Center	75,000	12,307,228	24.7	84.5	79.6	164.1	30

Investigation Phase

Investigation Phase → Evaluate Current System Performance with Owner Needs & Identify Improvements

- Documentation/ Historical Data
- System Evaluation
  - Site observations/interviews
  - Data trending (DDC and/or portable loggers)
  - Point to point controls checkout (typically not all points)
  - Functional performance tests (not always used)
  - Test and balance measurements (rarely used)
- Economic Analysis

Investigation

Site Observations

The "Wall of Shame"

Investigation

Site Observations

When in doubt, put it in hand!

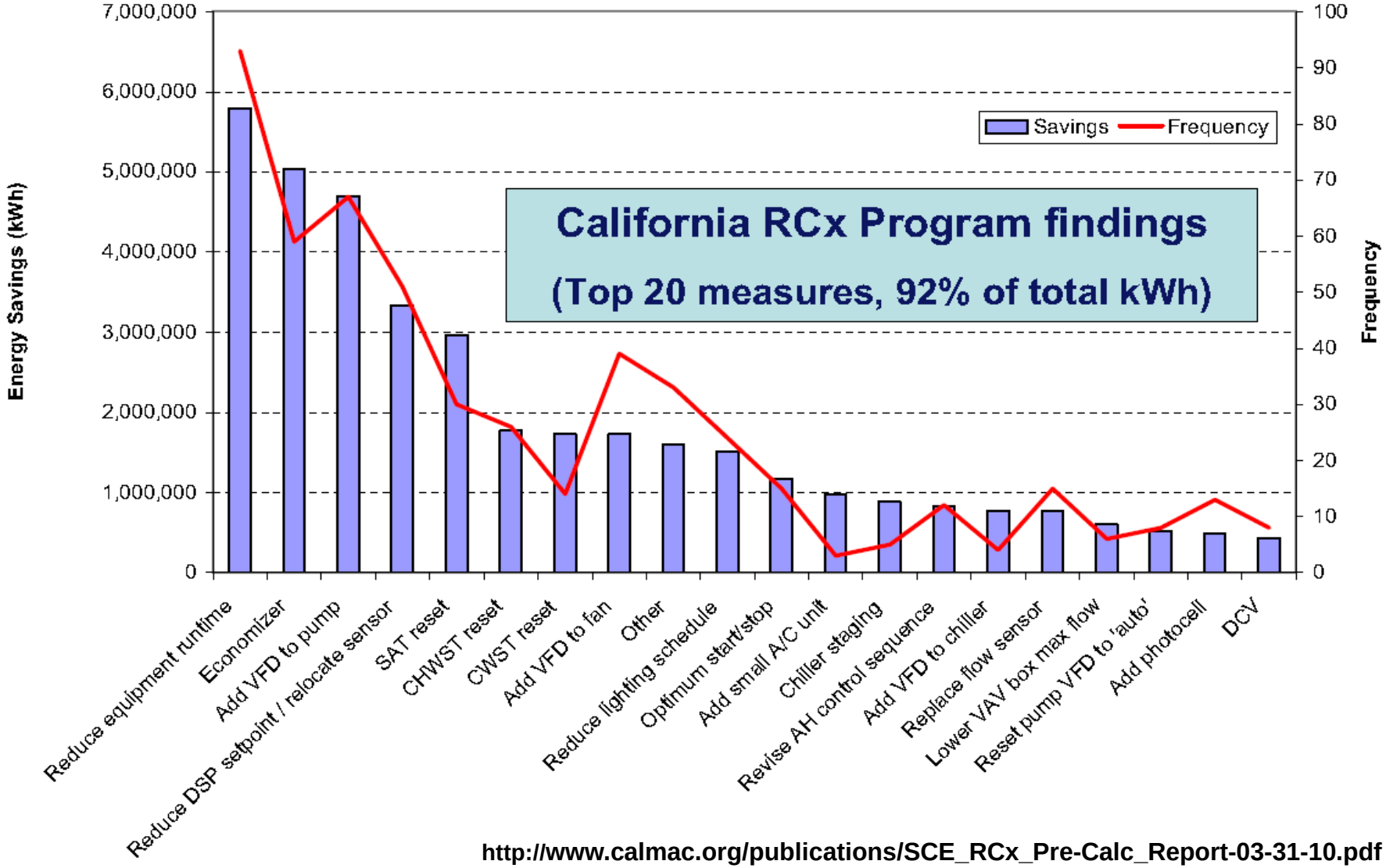
Investigation

Top 10 Measures

1. **Turn off equipment when not needed (Scheduled S/S)**
2. **Optimize outside airflow control (economizer, minimum ventilation)**
3. **Supply air temperature resets**
4. **Chilled water/condenser water supply temperature reset**
5. Reset/reduce supply air static pressure setpoint
6. Return VFDs to variable speed operation (or install VFD)
7. Repair inoperable controls hardware (dampers & valves)
8. Improve chiller/boiler sequencing (including lockout control)
9. Improve cooling tower sequencing/lower cond. water temps
10. Sensors out of calibration

Investigation

Energy Savings



http://www.calmac.org/publications/SCE_RCx_Pre-Calc_Report-03-31-10.pdf

Investigation

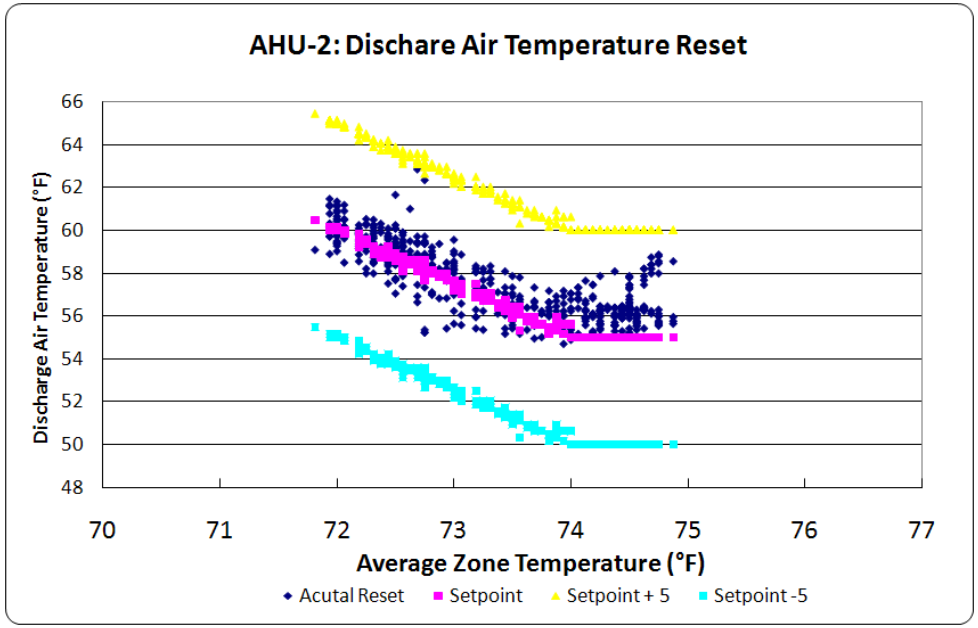
Source of Issues

- Overrides due to other issues (warm-up time, poor comfort, etc.)
- Hardware issues – actuator operation, controls linkage, sensor calibration
- Improper control sequence, changes in space use
- *New Buildings Institute: 64% of economizers tested required adjustment*

Investigation

Identifying Issues

- Trend data, off hours observation, interviews
- Controls programming review
- Point to Point/ Calibration Checks
- Functional Testing



Implementation and Turnover

Implementation Phase → Implement Recommended Improvements and Verify Performance

- Analyze, Prioritize, Select and Implement Energy Conservation Measures (ECMs)
- Verify Successful ECMs Implementation

Turnover Phase → Establish Smooth Transition and Hand Over to O&M Staff

- Update O&M Manuals, As-Built Documentation, Systems Manual
- Training Plan, Lessons Learned
- FEMP O&M Best Practices: http://www1.eere.energy.gov/femp/pdfs/omguide_complete.pdf

The Bottom Line

- Expected savings:
  - Energy savings - 5% to 20% of annual use (median of 16% per LBL)
  - Cost savings - $0.20 to $0.75 per SF
  - Paybacks typically 6 mo to 2 years – **50% to 200% ROI**
  - ***These savings will likely be lost without persistence!***

Persistence – Ongoing Cx

Persistence Phase → Ensure Continuous System Performance Improvement

Changes are easy to make, even easier to override

1. Benchmark the Building Energy Use - Monitor and Track
2. Trend Key System Parameters
3. Document Changes with an Operator's Log
4. Use Fault Detection & Diagnostic (FDD) Tools
5. Implement On-Going Staff Training Plan
6. Implement the Commissioning Process Again

Ongoing Cx

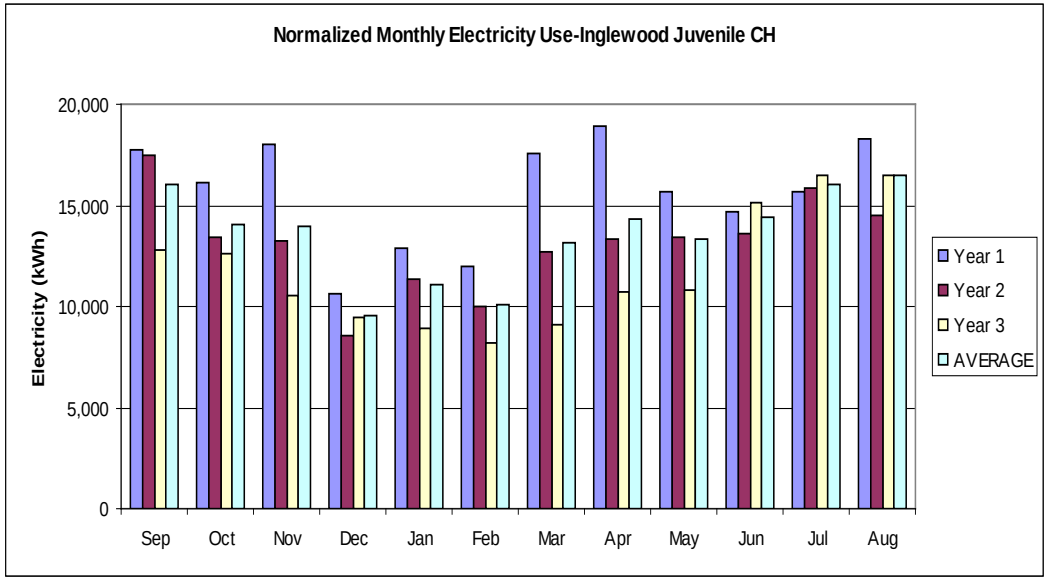
The Concept

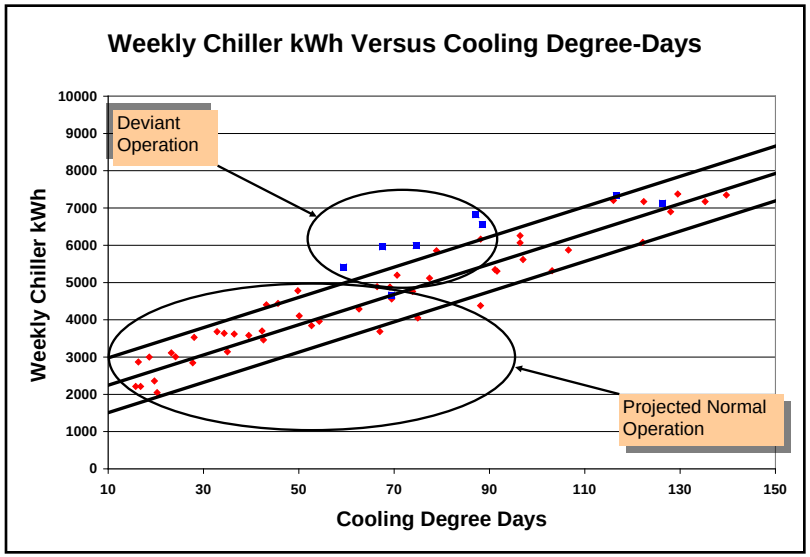
- Monitor at the utility meter and the system level
- Whole building metrics
  - kWh/Cooling Degree-Day
  - Therms/SF

- System level metrics
  - Chiller kWh/Cooling Degree-Day
  - Total Fan kWh/Cooling Degree-Day

Ongoing Cx

Data Evaluation





- Whole building effective when savings > 10% of overall usage
- System level provides detail needed to trouble shoot and optimize

Ongoing Cx

O&M Processes

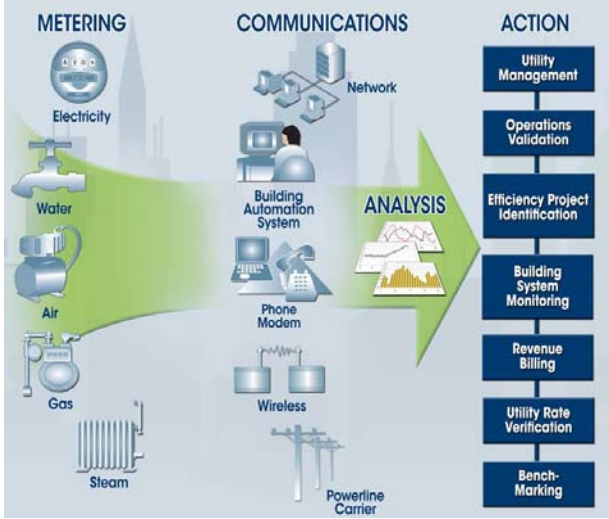
- Daily/Weekly Activities:
  - Control schedules
  - Setpoints and temperature resets
  - Outside Air Volumes
- Semi-Annual/Annual Activities:
  - Check sensors/time clocks
  - Calibrate sensors
  - Check lockout temperatures
  - Chiller cleaning

http://www1.eere.energy.gov/femp/operations_maintenance/om_bpguide.html

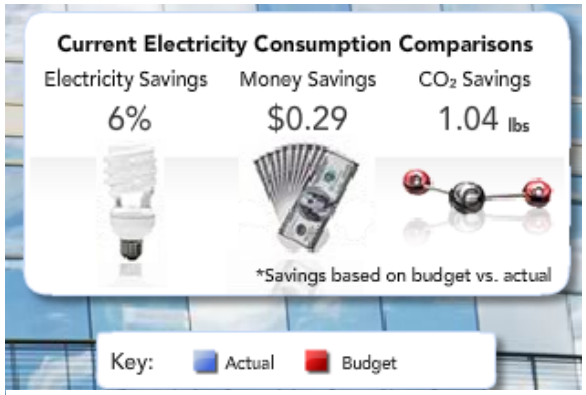
Ongoing Cx

Tools Available

- System level diagnostics
  - Custom programming
  - Control system overlays
  - Specific software available
- Whole building diagnostics
  - Web based applications with remote data collection
  - *What's next from Google?*



FEMP Metering Best Practices
http://www1.eere.energy.gov/femp/pdfs/mbpg.pdf



http://www.qualityattributes.com/

Issues with all approaches – <u>time</u> and <u>COST $$</u> required just to <u>keep</u> savings

Case Study
GSA Multiple Regions

Retro-commissioning Project Scope

- Building systems affecting energy use and indoor environment
- Assist with ARRA project selection (go/no-go)
- Evaluate system operation
  - Equipment condition
  - Setpoints and control sequences
  - Trend data analysis
  - Functional testing for sampling of equipment
  - Identify detailed opportunities
- Testing again after ARRA project upgrades

Case Study
GSA Multiple Regions

RCx ECMs

- Equipment run time
- Optimize OSA damper control (econo)
- Chilled water/condenser water reset
- AHU supply temp/static pressure reset
- Upgrade building controls
- Optimize lighting schedules

Larger Capital ECMs

- Install variable frequency drives
- Upgrade building controls
- Replace/upgrade AHUs, boilers, CTs, chillers
- Upgrade lighting systems
- Install water-saving plumbing fixtures

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Case Study
GSA Multiple Regions

Project Name	Total Square Feet	Estimated Annual Savings	Savings % of Utility Bill
Baker Federal Building - Baker City, OR	58,600	$31,920	Electrical: 24% Natural gas: 43%
Denney Federal Bldg - Lincoln, NE	508,000	$130,207	Electrical: 18% Natural gas: 39%
Eagleton Courthouse - St. Louis, MO	1,310,874	$140,420	Electrical: 13%
Goodfellow Complex - St. Louis, MO	1,633,496	$485,589	Electrical: 21% Natural Gas: 33%
North Platte Federal Building - North Platte, NE	76,791	$14,027	Electrical: 13.2% Natural Gas: 47.2%
Richland Federal Building - Richland, WA	386,585	$48,285	Electrical: 12 % Natural gas: 18 %
Spokane Federal Building - Spokane, WA	125,275	$66,381	Electrical (demand): 36% Natural Gas : 54% Water Usage: 11%
Whittaker Courthouse - Kansas City, MO	753,510	$130,750	Electrical: 16% District Steam: 38%
Richard B. Russell Federal Building – Atlanta, GA	1,315,210	$356,932	Electrical: 30%
Frank M Johnson Federal Complex - Montgomery, AL	425,035	$47,992	Electrical: 8%

Case Study
GSA Multiple Regions

EMCS and Metering

- EPACT 2005 and the Energy Information and Security Act of 2007
- Building level energy metering, report data back to Washington D.C.
- System level energy metering for tracking and optimization
- Control system upgrades for optimal control, web based access, and integration with metering

Objective:

Continue optimized operation over time!

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Resources

- Portland Energy Conservation Inc, www.peci.org
- Building Commissioning Association, www.bcxa.org
- California Commissioning Collaborative, www.cxca.org
- "Practical Guide to Commissioning Existing Buildings," Haasl & Sharp, 1999, ateam.lbl.gov/mv/docs/RetroCommissioningGuide.pdf
- ASHRAE Guideline 0-2005, "The Commissioning Process," www.ashrae.org
- "Continuous Commissioning Guidebook for Federal Energy Managers" http://www.eere.energy.gov/femp/pdfs/ccg01_covers.pdf
- U.S. DOE / FEMP, www.eere.energy.gov/femp
- CBECS, www.eia.doe.gov/emeu/cbecs
- Energy Star Portfolio Manager, www.energystar.gov

Thank You!

Michael Hardy, P.E., LEED AP BD+C, CxA
mhardy@emcengineers.com

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