

Recommissioning Workshop

October 2, 2013

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Senior Engineer
PECI**

Preview for the Day

Topic	Start time
What is existing building commissioning (EBCx)?	8:30
Costs / benefits	
Case studies	
EBCx process	
Break	9:15
EBCx team	9:30
Benchmarking / utility analysis	
LEED-EBOM	
Xcel Energy Recommissioning program	
Break	10:30
Common findings	10:45
Persistence of benefits	
Resources	
Wrap-up	11:45
Class dismissed!	12:00

The Gist of Energy-Focused EBCx



Going from this....



to this!

But Seriously, EBCx is...

- A systematic process for improving an existing building's performance
- Includes a rigorous investigation to identify problems, especially integration issues
- Primary focus is on identifying low cost operational improvements
- May be done alone or with a retrofit project



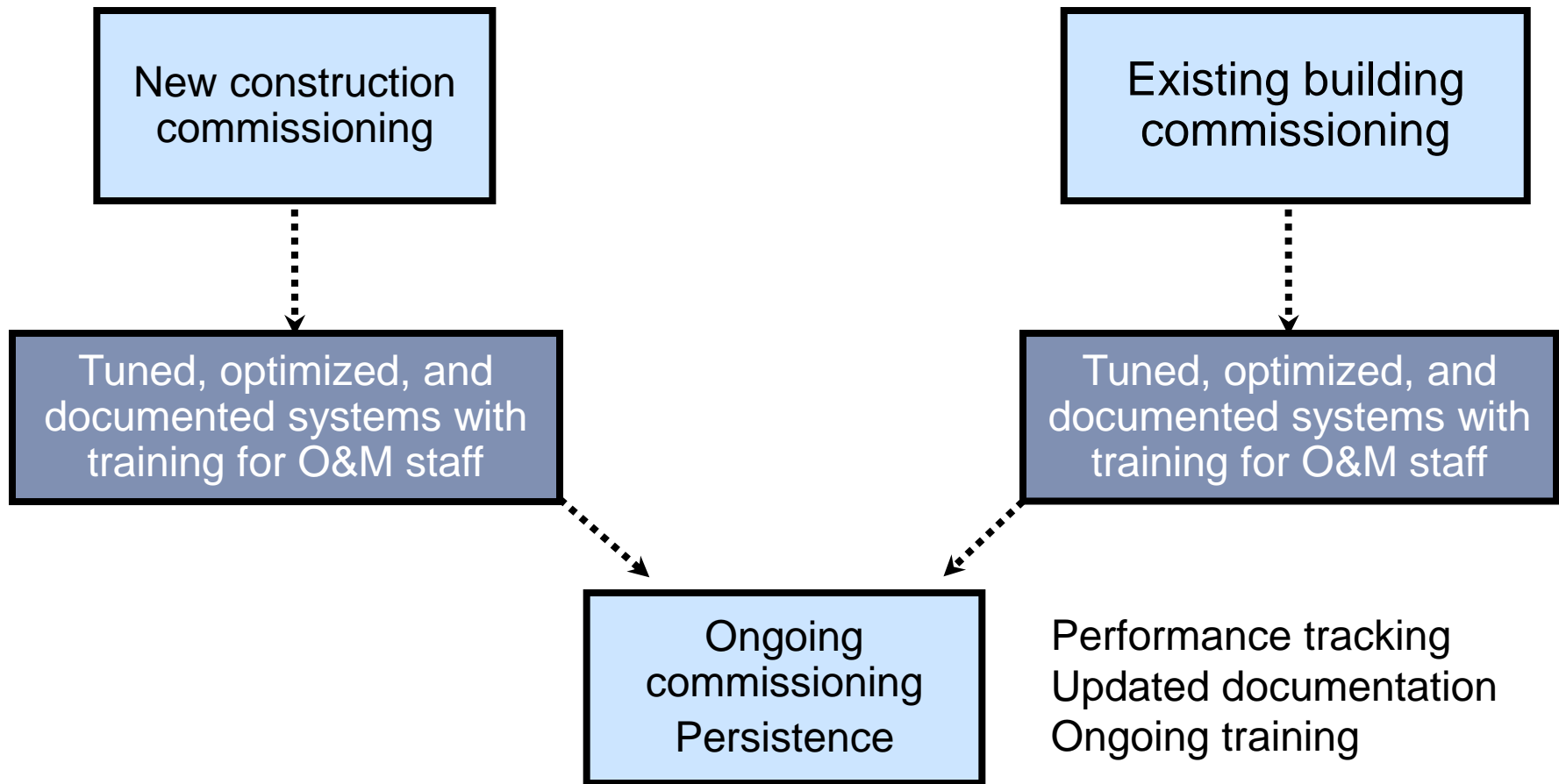
Other Terminology You May Hear



Existing Building Commissioning (EBCx)

- Retrocommissioning (RCx)
- Recommissioning (ReCx)
- Ongoing Commissioning (OCx)
- Monitoring-Based Commissioning (MBCx)

Note: Xcel Energy's program covers both RCx and ReCx



Is EBCx Needed After Cx?

No, it's not.*

***As long as:**

- **No changes are ever made to the building**
- **Cx included system optimization**
- **The building operates exactly the same as after construction.**





Ch-ch-ch-ch-changes

■ What changes typically occur over time in a commercial building?

- _____
- _____
- _____
- _____

Your Turn!

How Does EBCx Differ From a Tune-up?

- Tune-up
- Maintenance
- Components and equipment
- Capacity
- Physical
- Savings Opportunities
- EBCx
- Operation
- Systems and Integration
- Performance
- Mental
- More Savings Opportunities



EBCx includes and moves beyond tune-up procedures.

Revisiting O&M

- Maintenance = Capacity
 - ◆ Caring, cleaning, lubing, repairing
 - ◆ *Primarily physical*

- Operation = Performance
 - ◆ Scheduling, implementing efficient control strategies, sequencing of equipment
 - ◆ *Primarily mental*

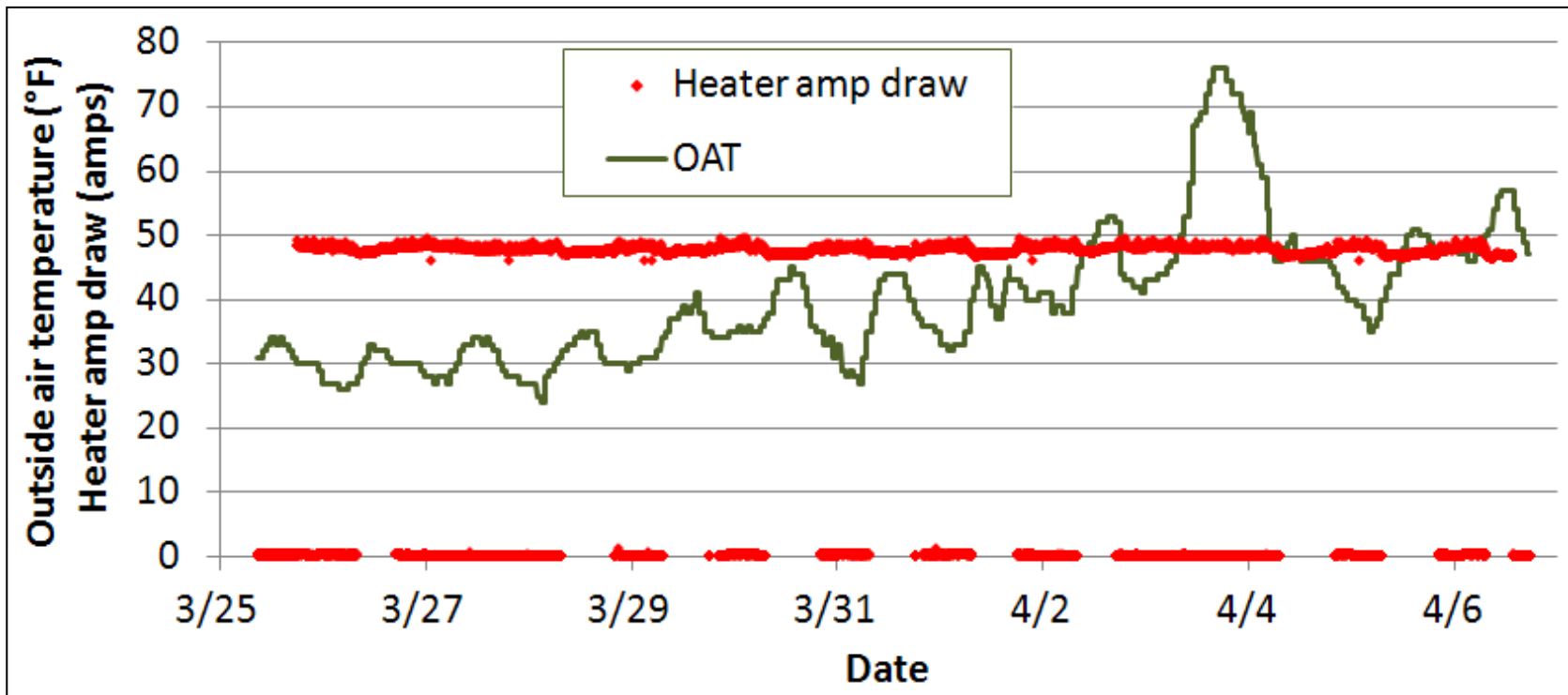


Maintenance Issue Example

- Upper set of dampers should be open.
- Linkage has come loose from actuator.

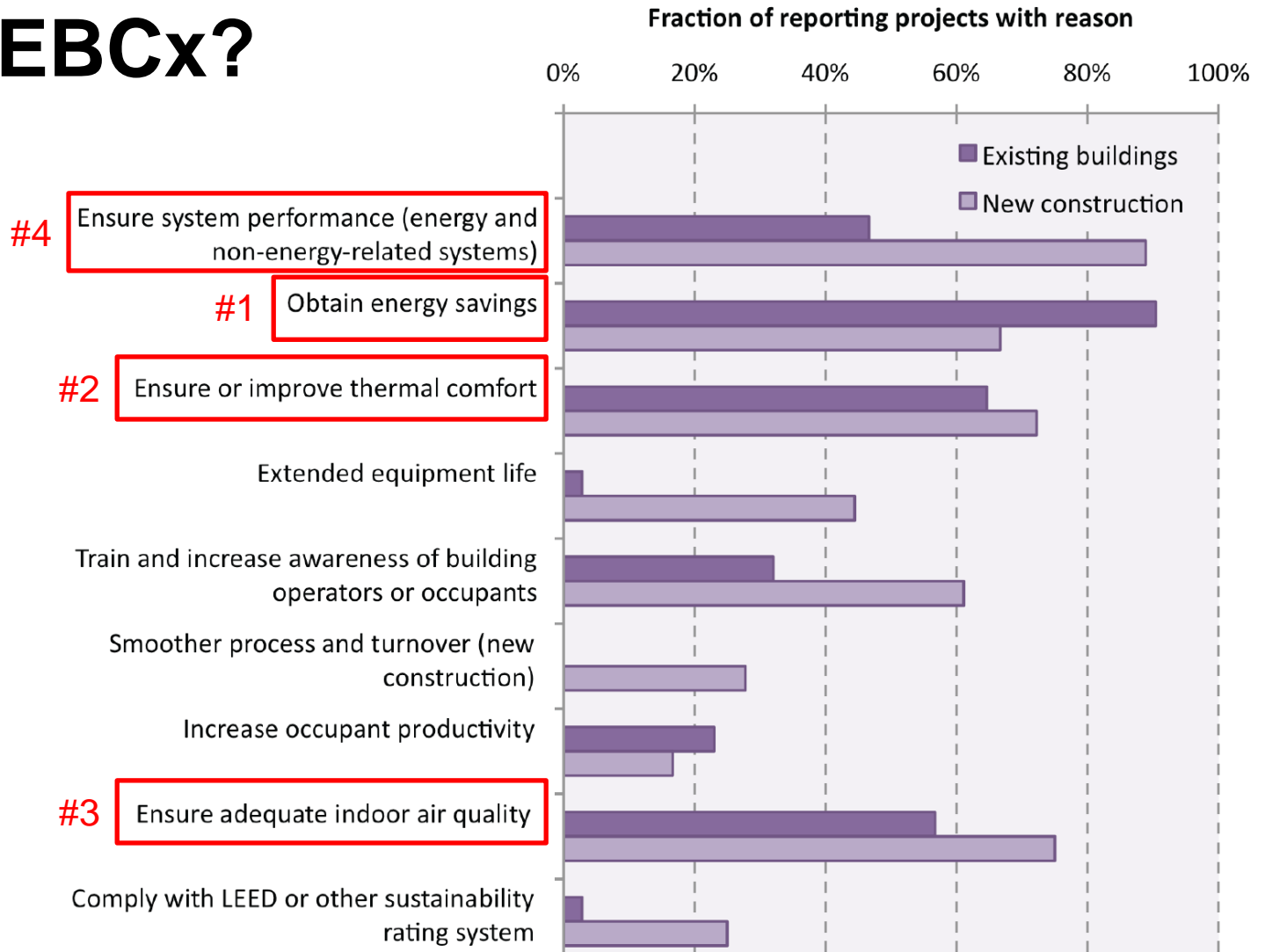


Operational Issue Example



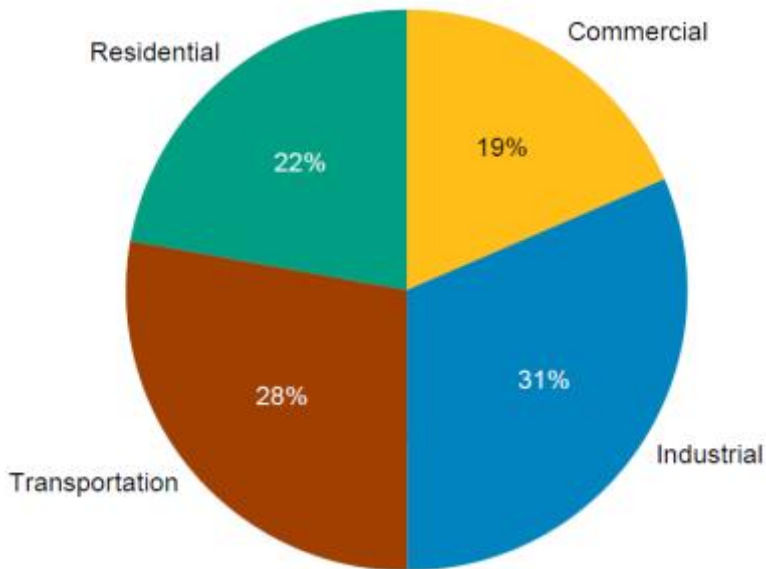
■ Heaters should be off at OATs above 40°F.

Why EBCx?

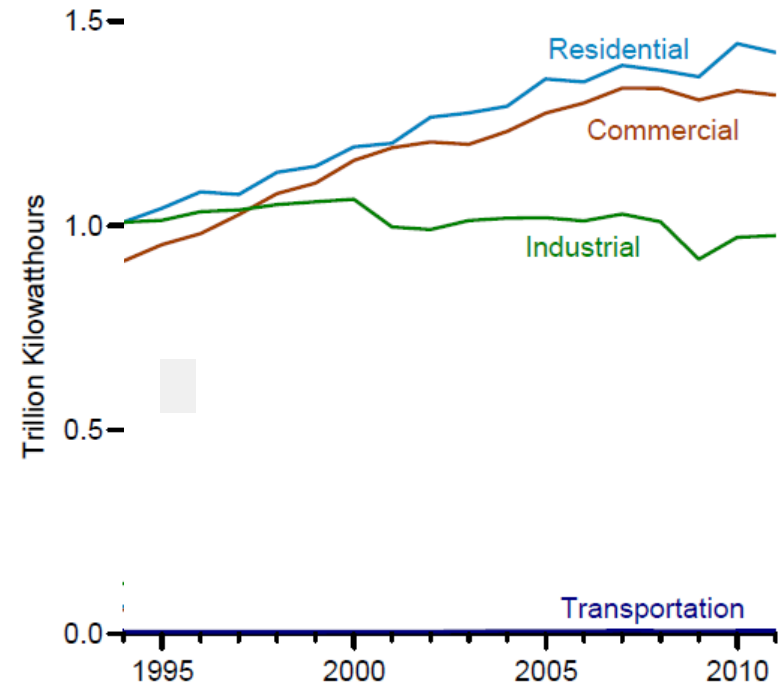


What's All the Fuss About Energy?

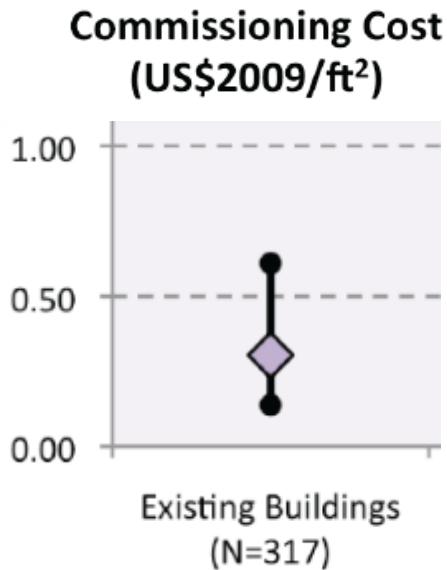
■ U.S. Energy Usage



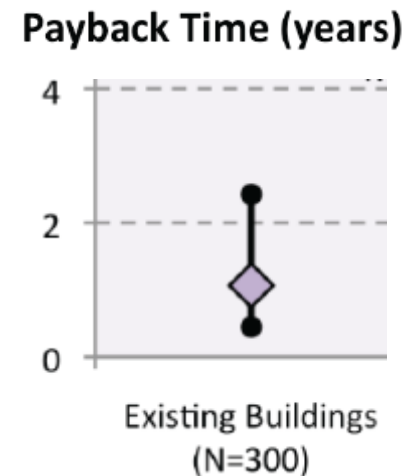
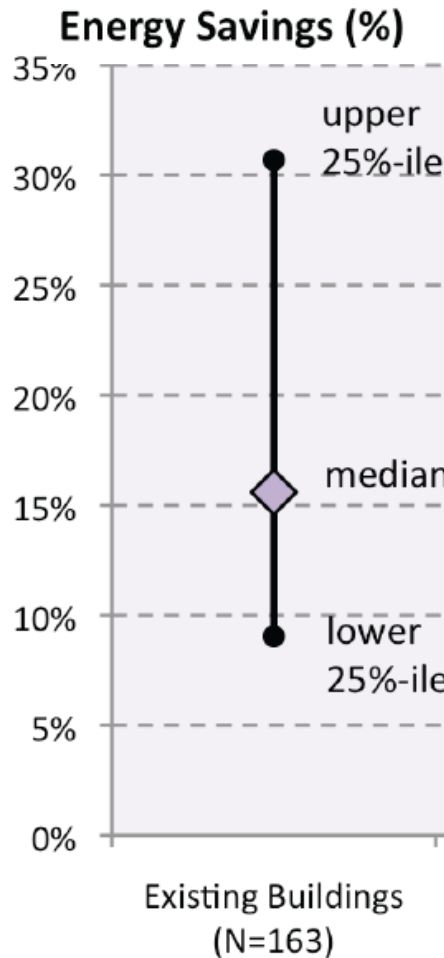
■ U.S. Electricity Sales



EBCx Costs & Savings



CxA cost = ~45% of total cost



Factors Influencing Total Cost

- **Goals of project**
- **Systems to include in project**
 - ◆ **Number of systems, zones**
 - ◆ **System complexity**
- **Ease of obtaining trend data through BAS**
 - ◆ **More costly if data loggers are needed**
- **Owner / operator involvement**

Help Reduce the Cost of EBCx

EBCx Phase	Owner / Operator Action
Planning	<ul style="list-style-type: none"><input type="checkbox"/> Compile a list of known problems and possible improvements.<input type="checkbox"/> Gather up-to-date building documentation.
Investigation	<ul style="list-style-type: none"><input type="checkbox"/> Perform appropriate preventive maintenance tasks early.<input type="checkbox"/> Perform simple repairs as the project progresses.<input type="checkbox"/> Assist with diagnostic monitoring and functional testing.
Implementation	<ul style="list-style-type: none"><input type="checkbox"/> Assist with implementing the selected improvements.
Hand-Off and Post-EBCx	<ul style="list-style-type: none"><input type="checkbox"/> Help facilitate training.<input type="checkbox"/> Maintain improved performance of systems.

Case Studies

Local Case Study – Republic Plaza

- **Downtown Denver High rise office**
 - ◆ **56 stories (fully occupied)**
 - ◆ **1.4MM SF total conditioned space**

- **Key operational findings**
 - ◆ **Sub-optimal HVAC equipment scheduling (three separate findings)**
 - ◆ **Excessive strainer cycle operation**
 - ◆ **High fan speeds due to high duct pressure**



Local Case Study – Republic Plaza

■ Benefits

- ◆ Energy savings: 817,000 kWh/yr
- ◆ Total utility cost savings \$34,200 / yr
- ◆ Implementation cost: \$30,000

■ Incentives

- ◆ Three of the five measures received implementation incentives, reducing cost of implementation to \$22,000

Local Case Study – Gates Corporation

- **Downtown Denver 10-story office**
 - ◆ **285,000 sf total conditioned space**

- **Six operational findings**
 - ◆ **Faulty outside air damper operation**
 - ◆ **Excessive HVAC equipment operation**
 - ◆ **Heating water system deficiencies**
 - ◆ **Condenser water system issues**
 - ◆ **Outside and exhaust fan operation issues**
 - ◆ **High fan speeds due to high duct pressure**



Local Case Study – Gates Corporation

■ Benefits

- ◆ Energy savings: 533,000 kWh/yr
- ◆ Total utility cost savings \$48,500 / yr
- ◆ Implementation cost: \$27,000

- No implementation incentives paid since all measures had a simple payback of less than one year!

EBCx Process Overview



Planning

Investigation

Implementation

Hand-Off

Post-RCx

Screening

- **Select good building candidates for EBCx**
- **Ideal building characteristics:**
 - ◆ **Proactive management philosophy, motivated building operators**
 - ◆ **Commercial or institutional facility with complex HVAC and lighting systems**
 - ◆ **Direct digital control (DDC) down to zone level**
 - ◆ **High energy consumption**
 - ◆ **Mechanical equipment in relatively good condition and not at end-of-life**
 - ◆ **Sensor calibration part of preventive maintenance**

Is EBCx Appropriate?

	Probably	Probably not
■ Most systems are in need of replacement	<input type="checkbox"/>	<input checked="" type="checkbox"/>
■ High energy usage	<input checked="" type="checkbox"/>	<input type="checkbox"/>
■ Motivated operators	<input checked="" type="checkbox"/>	<input type="checkbox"/>
■ Major system design problems	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
■ Catastrophic problems (e.g., asbestos)	<input type="checkbox"/>	<input checked="" type="checkbox"/>
■ Complex HVAC and lighting systems	<input checked="" type="checkbox"/>	<input type="checkbox"/>
■ Excessive comfort complaints	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Your Turn!

Selecting a Provider

- **RFQ (Request for Qualifications) process**
 - ◆ Request experience for similar projects
 - ◆ Request example work products
 - ◆ Ask if EBCx is a core business service

- **RFP (Request for Proposal) process**
 - ◆ Sample RFP available from California Commissioning Collaborative

Sources of EBCx Providers

■ Xcel Energy

◆ www.xcelenergy.com/recomm

■ Building Commissioning Association

◆ www.bcxa.org

■ California Commissioning Collaborative

◆ www.cacx.org/resources/provider_list.html

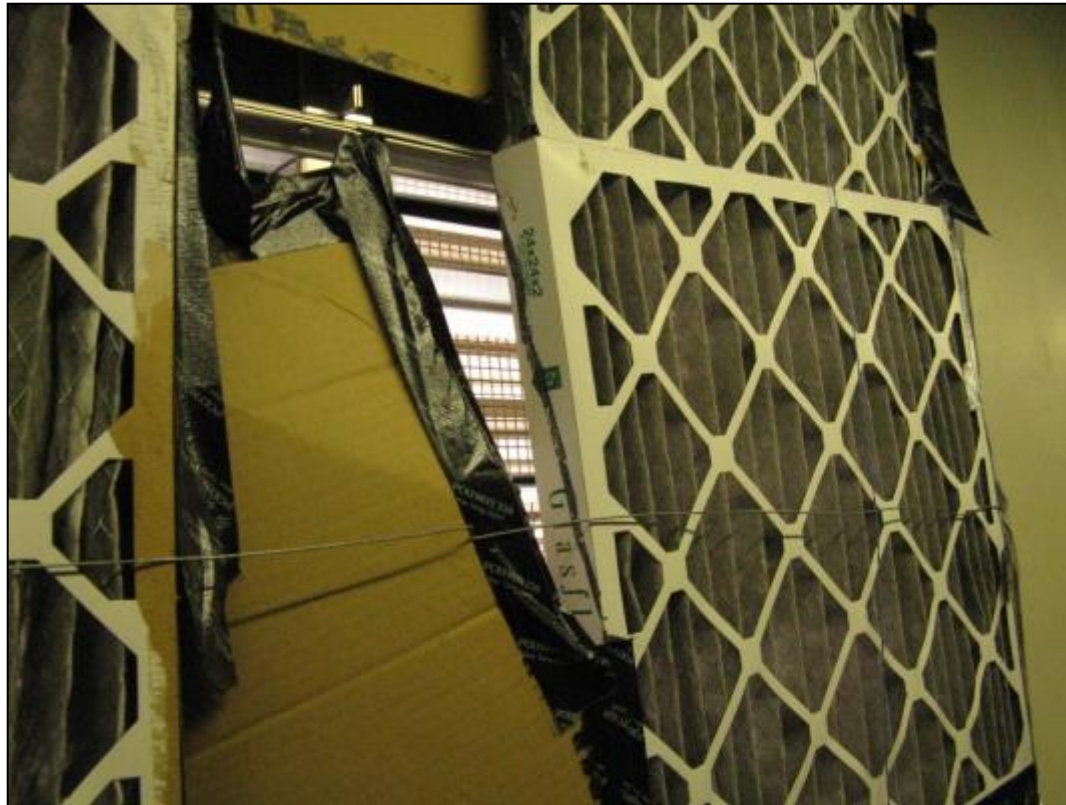
Planning Phase - Scoping

- Analyze the building's energy consumption
- Assess potential with a site walk through
 - ◆ Review building documentation
 - ◆ Understand the current operational requirements
 - ◆ Interview the operating staff
 - ◆ Identify opportunities
- Analyze results
- Develop a scope of work to complete EBCx process

Useful Documentation

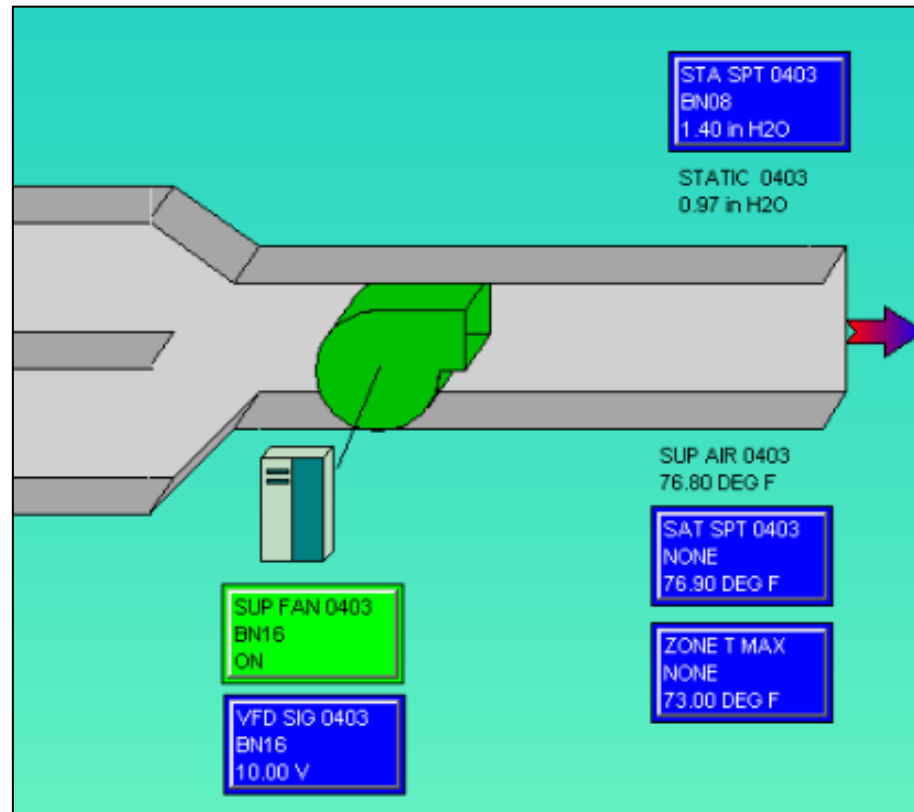
- **Utility data – at least 12 months**
- **Control drawings with full points list**
- **Sequences of operation**
- **Full set of as-built drawings/shop drawings**
 - ◆ **Mechanical**
 - ◆ **Electrical**
 - ◆ **Plumbing**
 - ◆ **Architectural drawings**
- **TAB report(s)**
- **Past energy conservation reports**
- **Original equipment submittals**

Building Walk-Through: HVAC



Your Turn!

Building Walk-Through: BAS



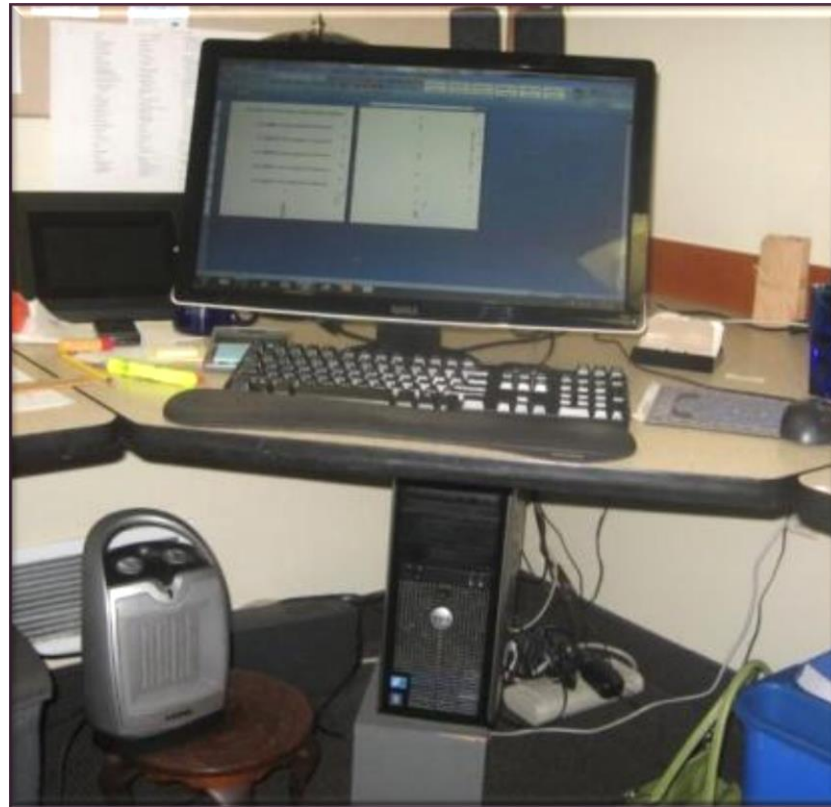
Your Turn!

Building Walk-Through: Lighting



Your Turn!

Building Walk-Through: Plug Loads



Your Turn!

Building Walk-Through: Envelope



Your Turn!

Planning

Investigation

Implementation

Hand-Off

Post-RCx

Investigation Phase Summary

- Conduct detailed document review
- Interview occupants and operating staff
- Evaluate facility performance
- Analyze identified measures



Evaluate Facility Performance

Purpose:

- Determine if current facility requirements are met
- Identify facility improvement measures

Methods:

- Analyze energy usage
- Review interview results
- Review service requests and complaints
- Compare actual conditions to CFR
- Perform diagnostic monitoring
- Conduct site investigation and testing

Planning

Investigation

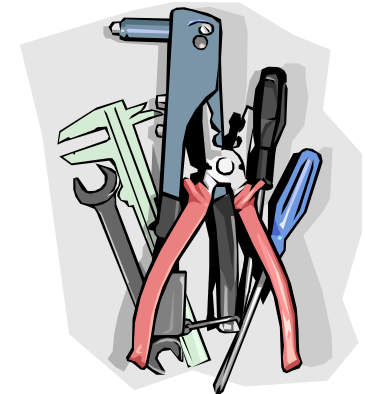
Implementation

Hand-Off

Post-RCx

Implementation Phase Summary

- Select measures for implementation
- Prepare implementation plan
- Implement measures
- Verify successful measure implementation



Planning

Investigation

Implementation

Hand-Off

Post-RCx

Hand-Off Phase Summary

- Update documentation
- Develop persistence strategies
- Conduct training
- Develop Final Report



Planning

Investigation

Implementation

Hand-Off

Post-RCx

Up Next:

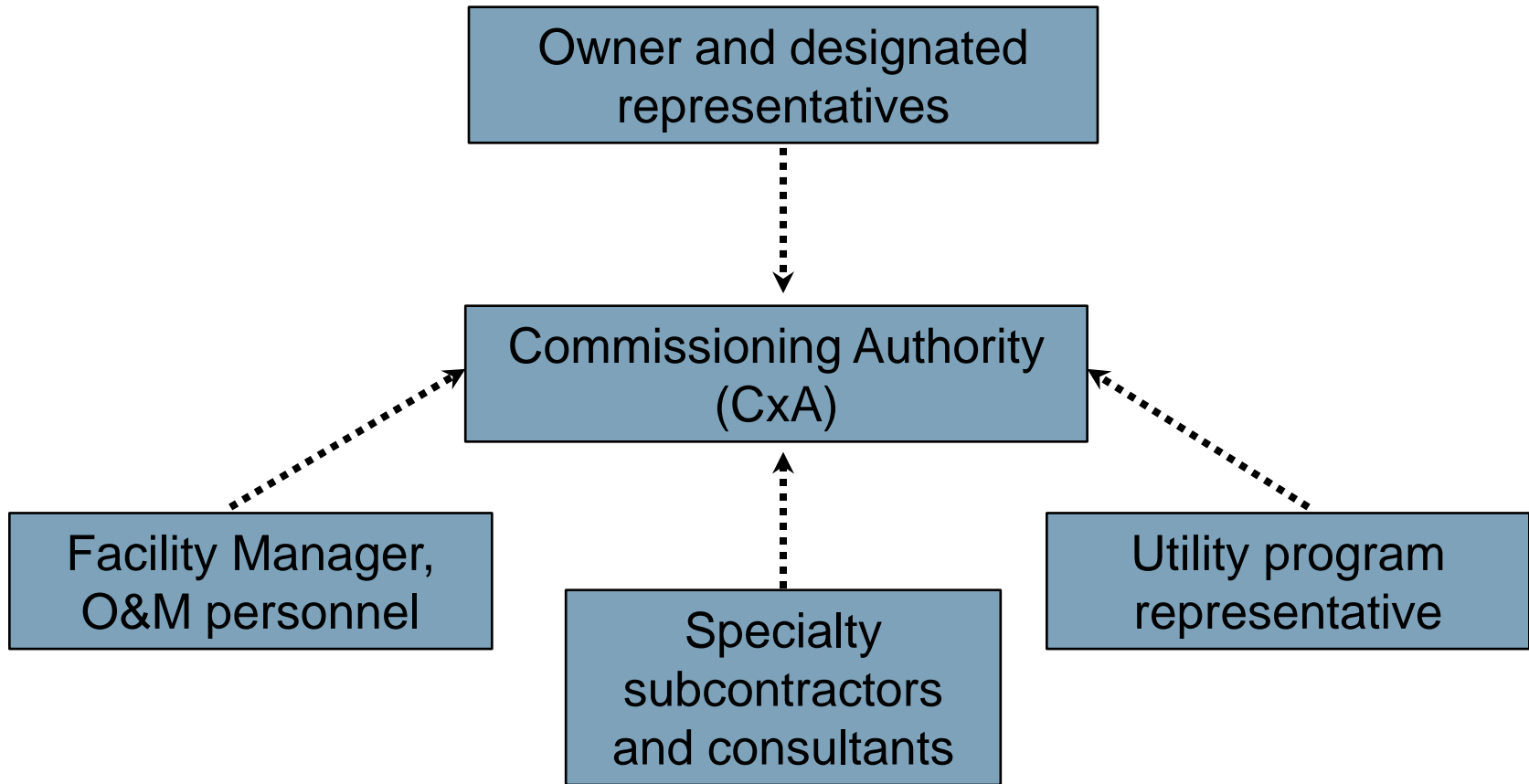
- 15 minute break

When we come back:

- EBCx team roles and responsibilities
- Discuss LEED-EB
- Xcel Energy RCx program overview



The EBCx Team



Owner / Staff Role

■ Management Level

- ◆ Be open to the process as a learning and improvement process
- ◆ Coordinate funding
- ◆ Select EBCx provider

■ Facilities/Ops Level

- ◆ Assist the EBCx team
- ◆ Embrace suggestions for change and improvement



EBCx Service Provider's Role

- Integrate and coordinate the team's effort
- Lead the investigation and hand-off phases of the project
- Work with management and operations team



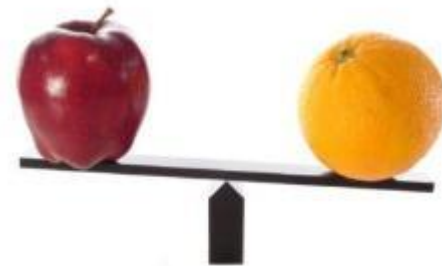
Supplier's and Contractor's Role

- Support investigation as needed
- Implement EBCx measures
- Integrate EBCx recommendations into ongoing contractual work



Energy Benchmarking

- **Comparison to other buildings**
 - ◆ **Similar types**
 - ◆ **Similar size**
 - ◆ **Similar climate**
- **Can use to prioritize projects within portfolio**
- **Big picture indicator of efficiency (or lack of it)**



Benchmarking with ENERGY STAR®

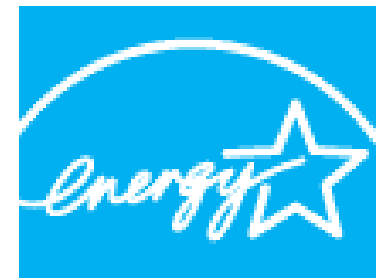
- How does it work?

- ◆ Building performance assessment

- Scale of 1-100

- ◆ 1 = least efficient, 100 = most efficient, 50 = average

- Similar buildings nationwide



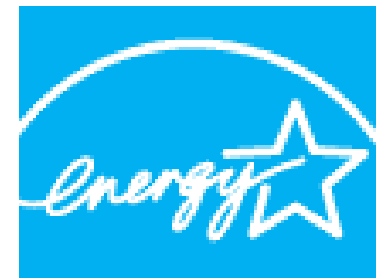
Benchmarking with ENERGY STAR®

■ How does it work?

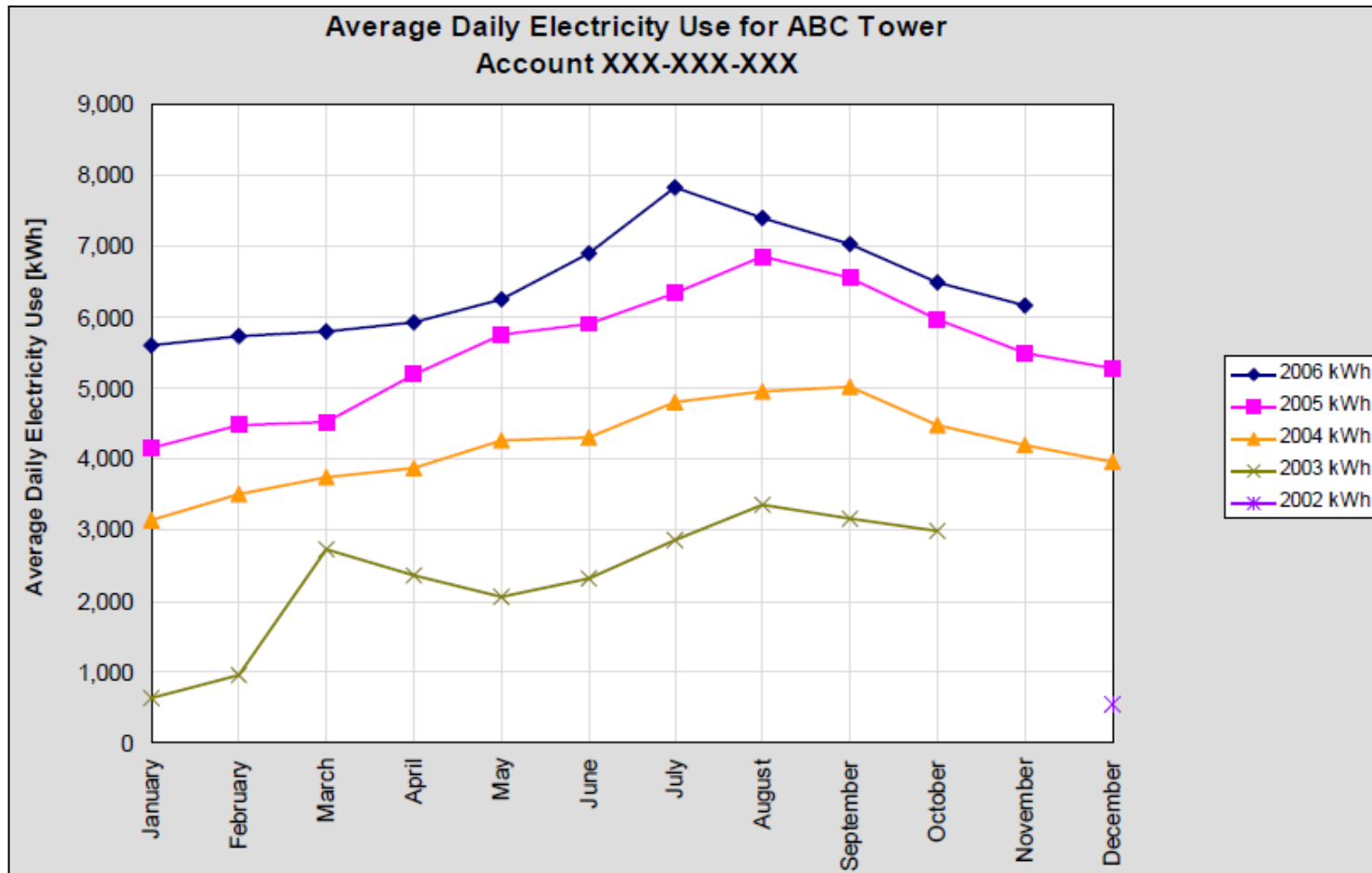
- ◆ Assessment takes into account:
 - Weather
 - Size
 - Location
 - Operating characteristics
- ◆ 75 or higher may qualify for an Energy Star® plaque

■ Why do it?

- ◆ Quick reality check for scoping
- ◆ Tracking tool for persistence



Analyze Monthly Utility Data

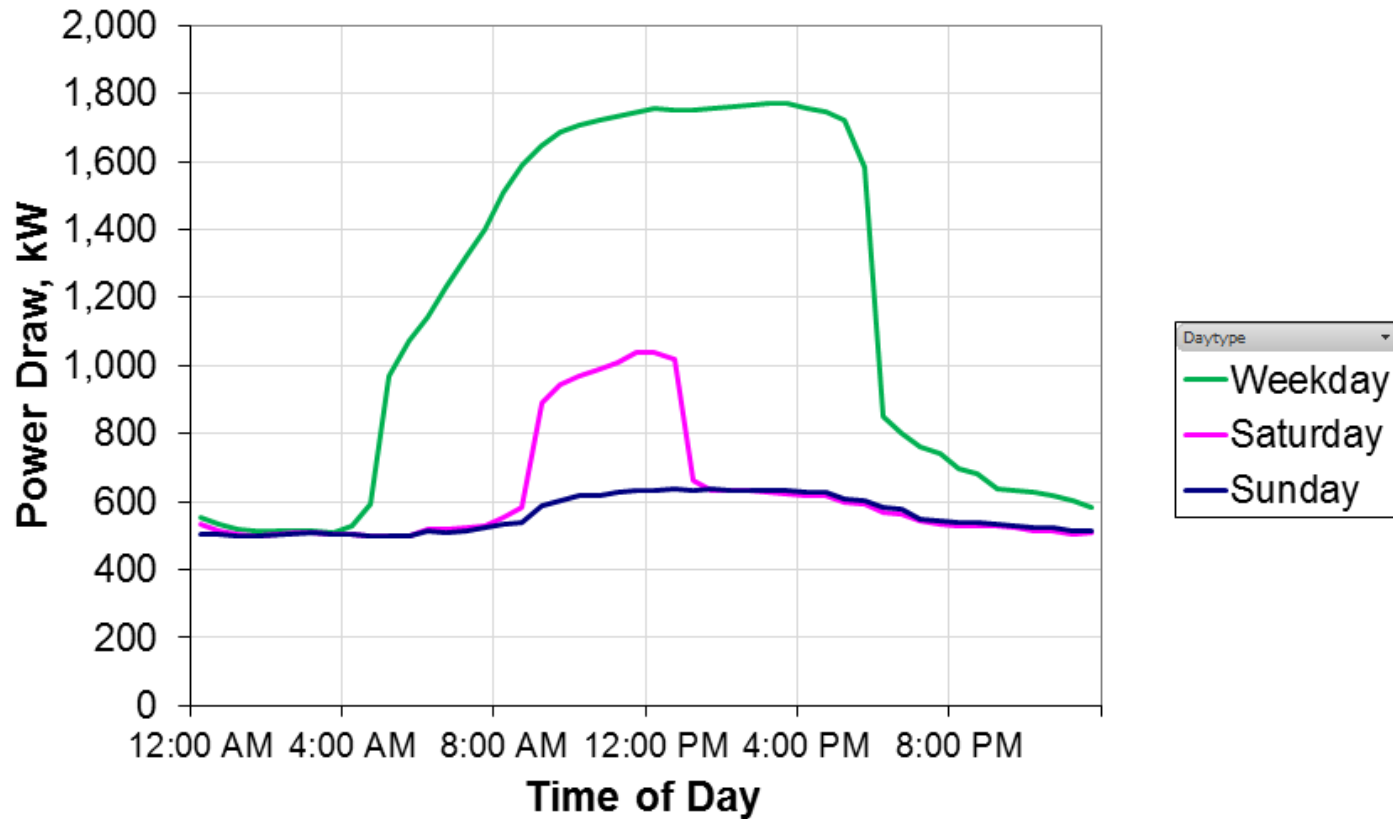




More Useful Utility Data

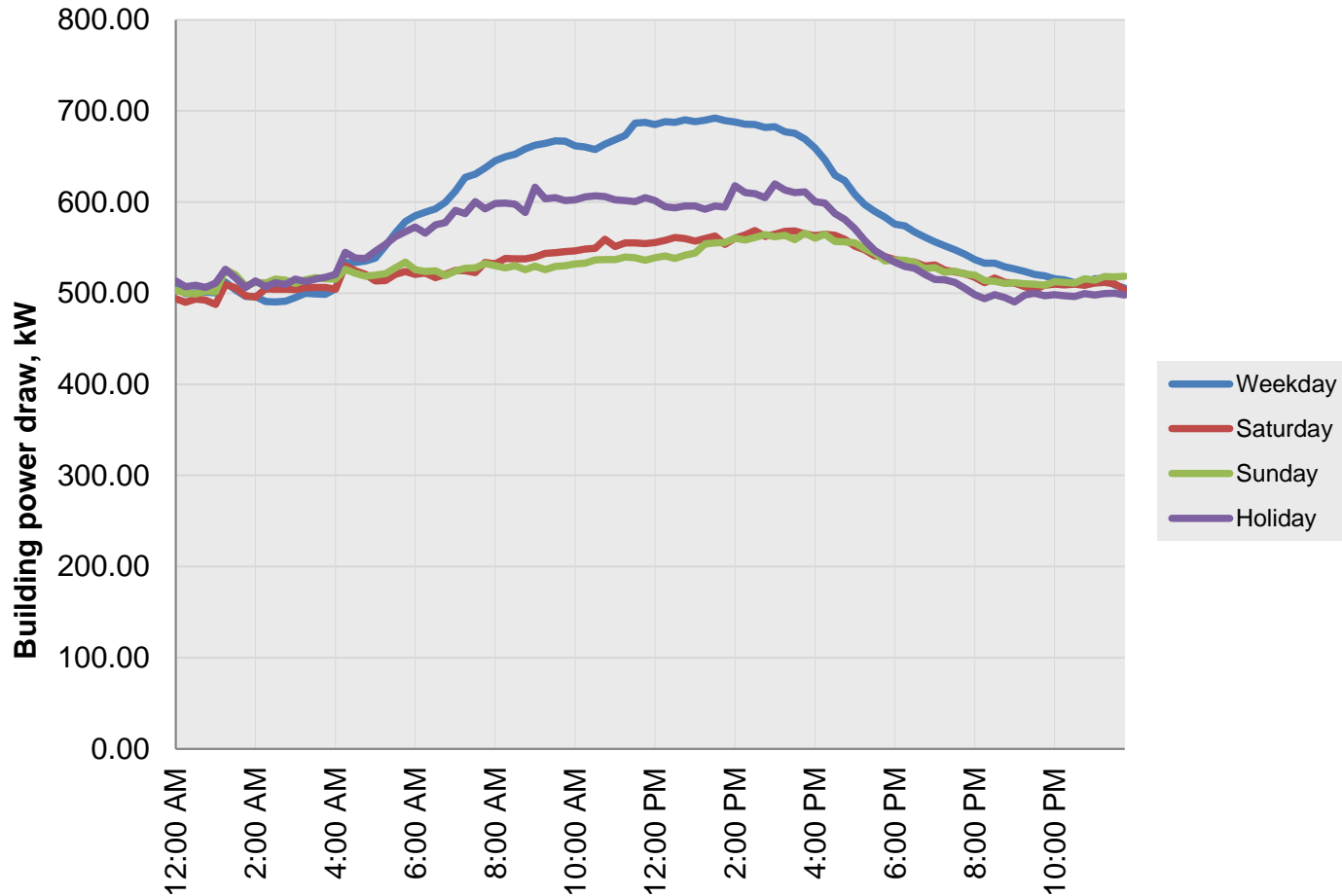
- **Interval utility data (e.g., 15 minute data)**
 - ◆ **Identify base load during unoccupied conditions**
 - ◆ **Identify operational problems during normal building operating hours**
 - ◆ **Available through your Xcel Account Manager**

Using Interval Meter Data



‘Good’ profile

Using Interval Meter Data



Your Turn!

LEED-EB

LEED and Commissioning

- **Leadership in Energy and Environmental Design for Existing Buildings: Operations and Maintenance**
 - ◆ Or, “LEED-EBOM”
- **Certifies the sustainability of ongoing operations of existing commercial and institutional buildings**
 - ◆ Addresses similar categories as LEED-NC
- **Current version is LEED 2009, updated in July of 2013**

When do you use LEED-EBOM?

- Initial certification of existing buildings
- Ongoing re-certification of existing buildings first certified under LEED-EBOM (within five years)
- Ongoing re-certification of existing buildings first certified under LEED-NC (within five years)
- www.usgbc.org



Where Does EBCx Fit In?

- **Energy & Atmosphere**

- ◆ **Prerequisite 1: Level 1 energy audit**

- **“Walk-through” audit**

- **Document systems, PM plan, identify savings opportunities**

- ◆ **Prerequisite 2: Minimum E* score of 69**

- **Related credits:**

- ◆ **Credit 1: Optimize Energy Performance**

- **Based on Energy Star score**

- **Possible 18 points**

- ◆ **Compare to 40 minimum points required for LEED-EBOM certification**

Where Does EBCx Fit In?

- ◆ **Credit 2: Existing Building Commissioning**
 - **2.1 Investigation (2 points)**
 - ◆ **ASHRAE Level 2 audit also allowed**
 - **2.2 Implementation (2 points)**
 - **2.3 Ongoing Commissioning (2 points)**
 - ◆ **Develop a plan, and complete some of the work**

Xcel Energy's Recommissioning Program



Topics

- Eligibility
- Rebates
- Process
- Resources

Who is Eligible?

- **Xcel Energy electric and natural gas business customers in Colorado with:**
 - ◆ **Buildings 50,000 square feet or more**
 - ◆ **Any age building**
- **Small Building Tune-up program scheduled to launch 2014***
 - ◆ **Buildings <75,000 square feet**
 - ◆ **RCx “lite” – smaller list of measures**

**Pending regulatory approval*



Study Rebates

- **We'll provide up to 75% of the cost of the study, not to exceed \$25,000**

Implementation Rebates

■ Electric rebates

- ◆ Up to \$400/kW or \$0.08/kWh

- You earn the higher of the two

■ Natural gas rebates (for our retail gas customers)

- ◆ Up to \$4/Dth

Maximum rebate is 60% of measure cost

Payback must be between 1-15 years to earn a rebate

Process

1. Obtain preapproval before beginning

- ◆ Submit application with proposal
- ◆ Proposal should identify building issues, concerns and what the study provider will review

2. Complete the study

- ◆ Study will contain a list of measures you can implement
- ◆ Xcel Energy needs to approve the final study before issuing study rebate

3. Implement measures

- ◆ You choose what to implement
 - Some measures may require measurement and verification (M&V)
- ◆ Rebate is paid after M&V is complete (if needed)

Study Providers

- You choose your own provider
 - ◆ Provider must submit their qualifications if they haven't worked with our program
 - ◆ Look at our list of providers who have participated in the past if you need an idea
 - It's included in your handout

Fast Track Recommissioning Options

■ Fast track study

- ◆ Implementation rebates available for customers who have completed a RCx study on their own (without funding from Xcel Energy)

■ Fast track proposal

- ◆ Implementation rebates available for RCx measures that may be identified in a vendor's proposal

■ Requires preapproval and energy savings calculations must be included with application

Resources

- www.xcelenergy.com/recomm
 - ◆ Xcel Energy case studies
 - Office, school, hospital, hotel, medical and research center
 - Video Case study on Responsiblebynature.com – Front Range Community College
 - ◆ Recommissioning guidebook
 - ◆ Provider list
 - ◆ Applications



How Do I Get Started?

- **Contact your Xcel Energy Account Manager**
- **Call an Energy Efficiency Specialist at
1-800-481-4700**



Questions?

Thank you!

Up Next:

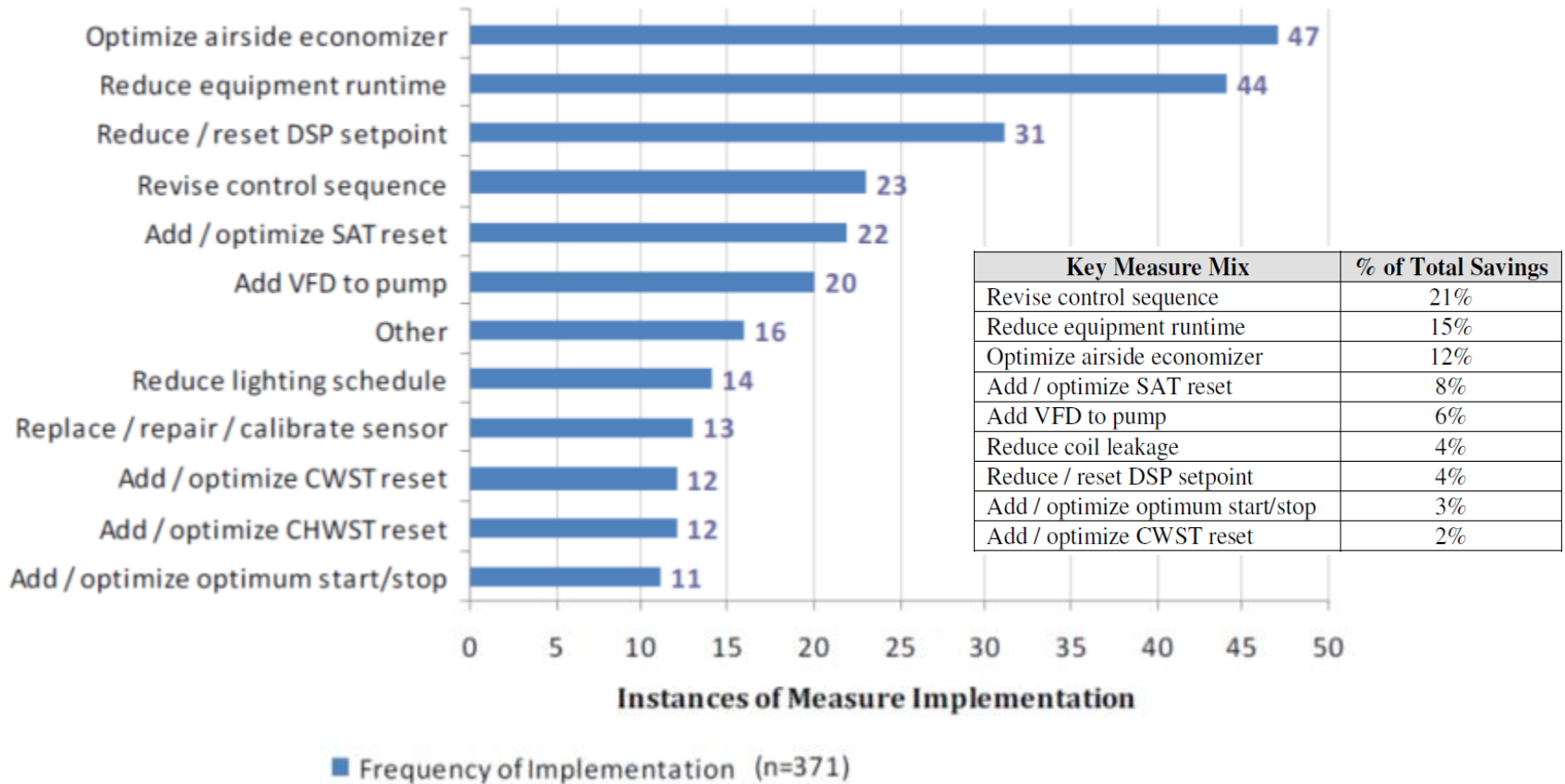
- 15 minute break

When we come back:

- Common findings and case studies
- Persistence of benefits
- Available resources



EBCx Results from the Field



122 EBCx projects, most in CA.

EBCx Results – Denver, CO

- **Prevalent measures (five projects):**
 - ◆ **Revise control sequence**
 - ◆ **Add / optimize SAT reset**
 - ◆ **Reduce equipment runtime**



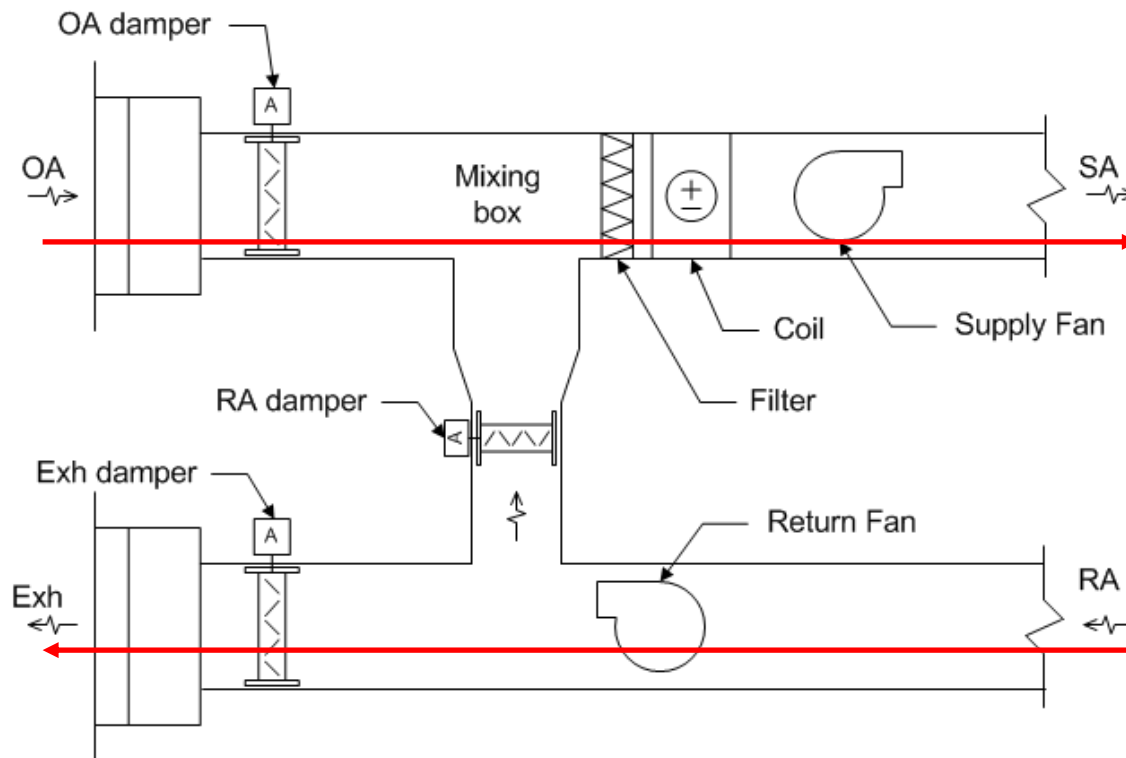
Common Low-cost Opportunities

■ Technical Issues and Case Studies

- ◆ Airside Economizer
- ◆ Schedules
- ◆ Setpoints / Reset Schedules
- ◆ Pumping
- ◆ Ventilation

Economizer dampers

- During cool outside air conditions, more outside air can be brought in to help cool the building
 - ◆ 'Free' cooling



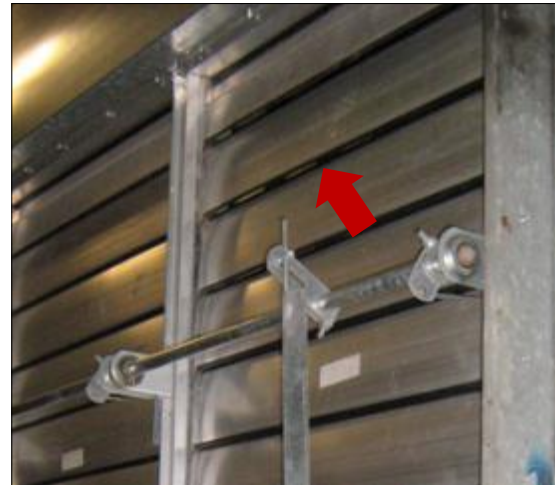
General Economizer Issue Categories

- Damper system design (sizing / arrangement)
 - ◆ E.g., oversized dampers
- Controls sequences and sensor arrangement
 - ◆ E.g., low economizer damper lockout temperature
- Maintenance
 - ◆ E.g., disconnected pneumatic actuator
- Both energy and non-energy benefits can be realized

Evaluate Airside Economizers

Inspect economizer maintenance

- Blade and jamb seals installed, in good condition?
- Actuators adjusted for full closure?
- Actuators connected to dampers?



Schedules – Overview

■ Scheduling Issues

- ◆ Often modified for specific, short-term needs
- ◆ Schedule modifications can be forgotten
- ◆ Improper system installation can lead to occupant request for modified schedule

■ How to identify

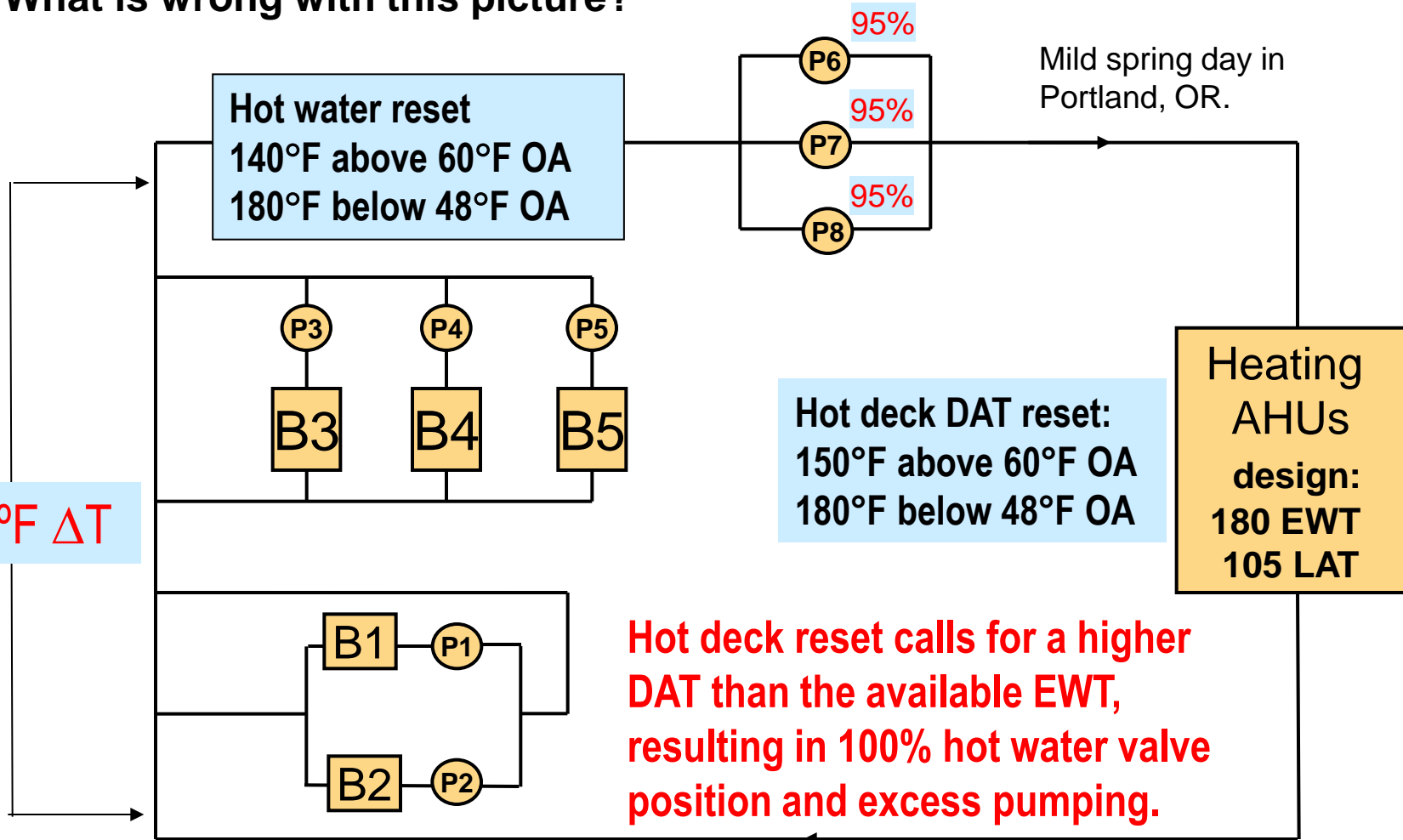
- ◆ Trend data
- ◆ Interval utility data
- ◆ After hours walk-through if possible

Schedules Example – Heat Pumps

- **As-found situation**
 - ◆ **Schedules were modified for short-term requests**
 - **Heat pumps were operating when building was unoccupied**
 - ◆ **Water loop circulation pumps ran continuously**
 - ◆ **Fluid cooler spray pump and fan ran while building was unoccupied**
- **Identified during investigation via system trends and data loggers on the equipment**

Setpoint Example – As-found Condition

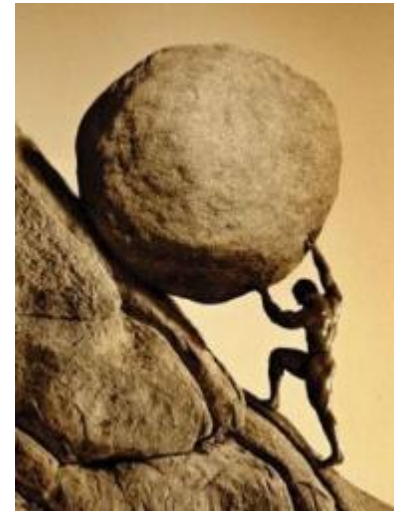
What is wrong with this picture?



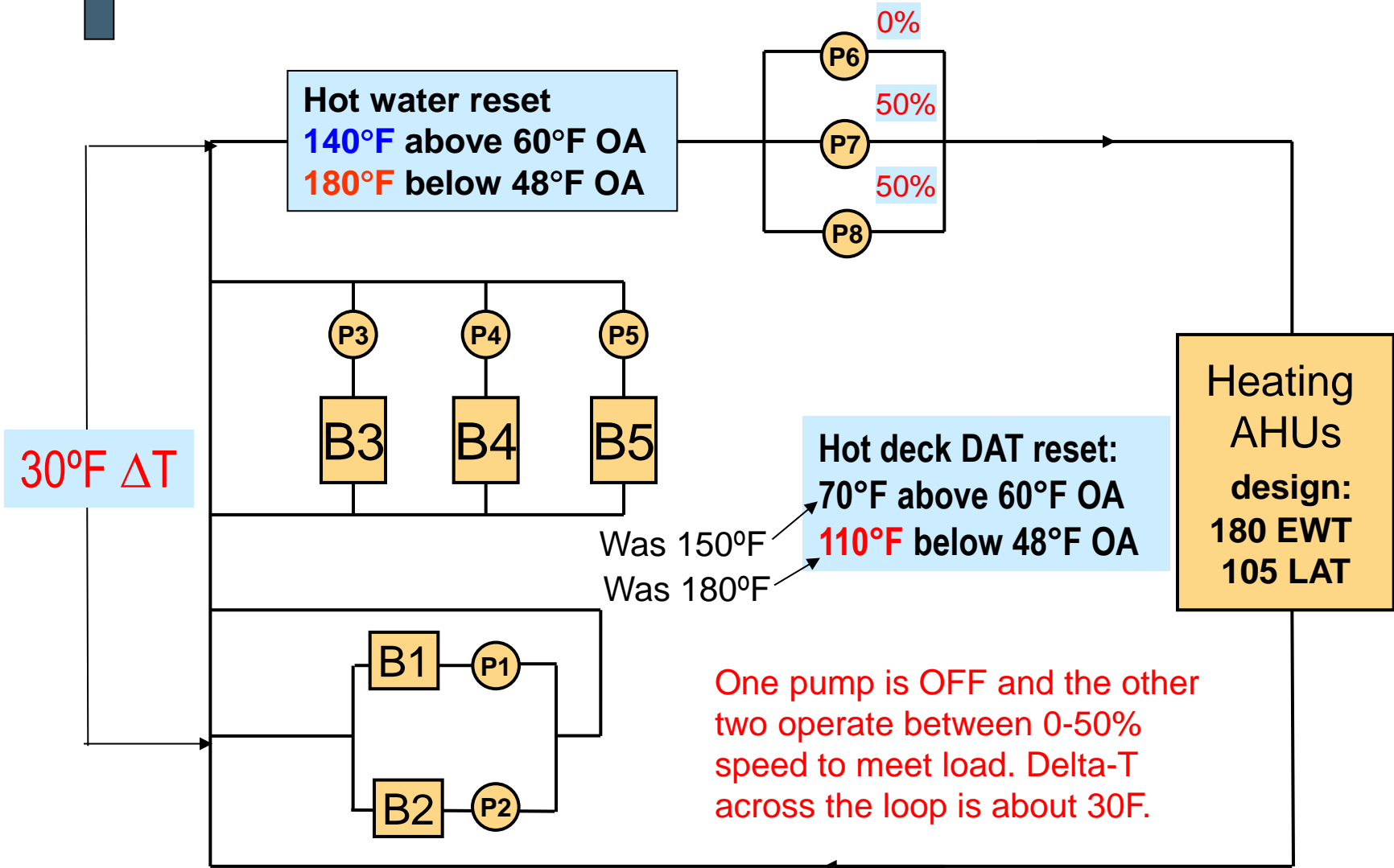
Your Turn!

Setpoint Example

- **Physically impossible for the system to achieve what it's being asked to do**
 - ◆ **But it'll try anyway, which is why all the pumps are on and operating at near 100% speed**



Setpoint Example – Proper Operation



Setpoint Example – Past Project

■ Savings opportunity

- ◆ Energy savings: 29,000 kWh/yr and 4,200 therms/yr
- ◆ Annual cost savings: \$4,800 total

Pumping Opportunities – Overview

■ Pumping Issues

◆ Many pumps are oversized

■ Safety factor

■ Future expansion

■ How to identify

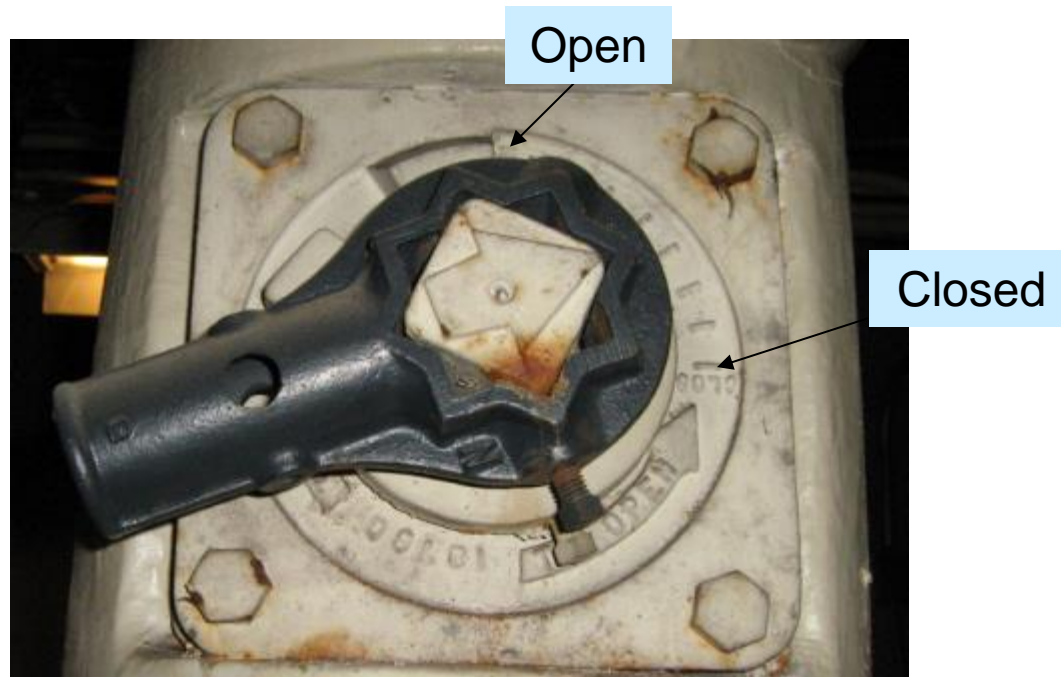
◆ Throttled discharge valve

◆ Both parallel pumps on

◆ Low temperature differential across a loop

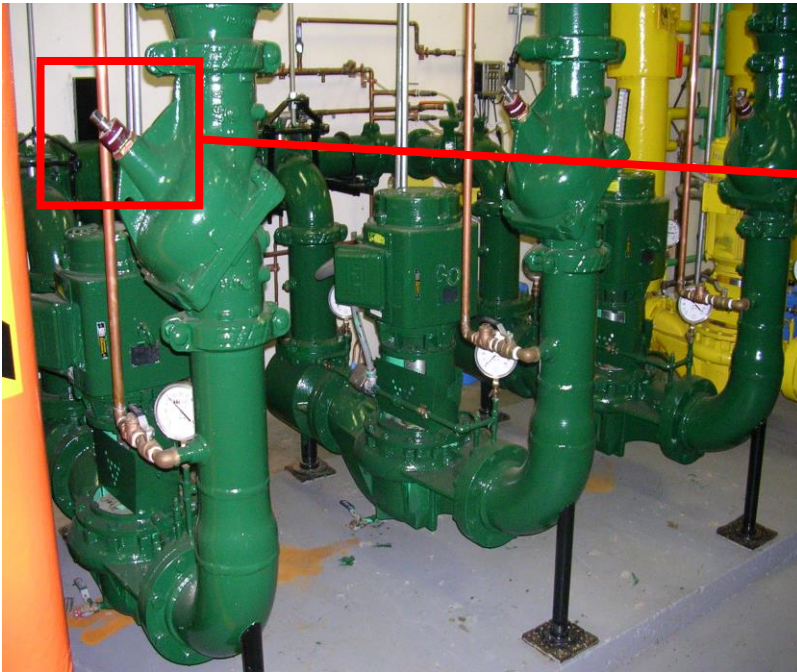
Throttled discharge valve

- Sometimes it's easy to spot a throttled valve ...



Throttled discharge valve

... othertimes, not so much.

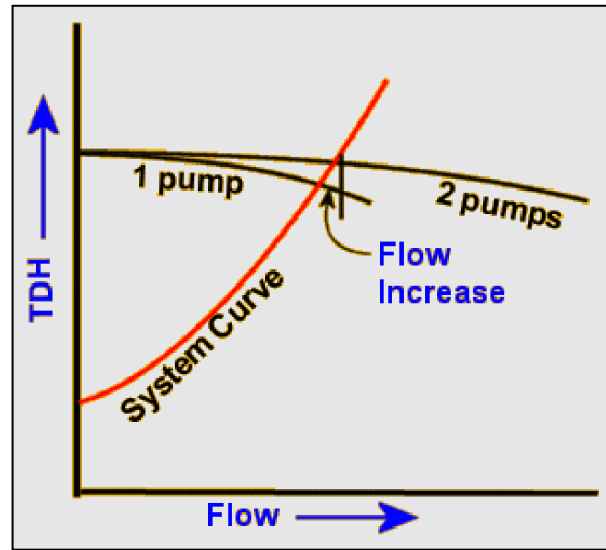
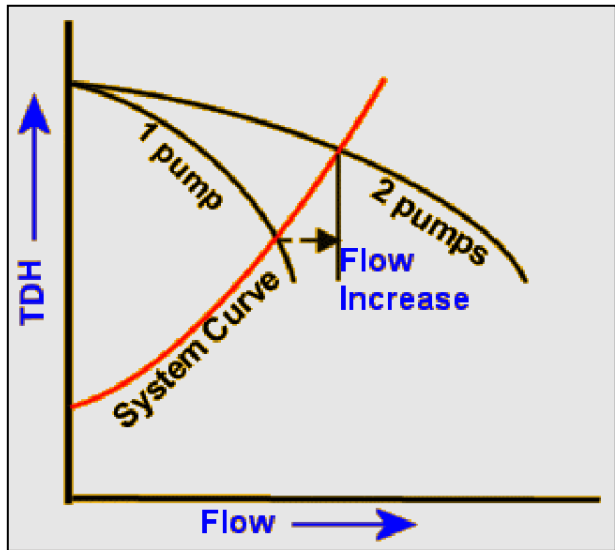


Implementation Options

- **Option 1 - Trim the existing impeller**
 - ◆ **Open pump, trim impeller, reassemble**
- **Option 2 – Replace the impeller with a smaller one**
- **Option 3 – Add a VFD**
 - ◆ **Then dial in speed to match flow**
 - ◆ **May be more costly, but allows for future capacity**

Evaluate HVAC Pumps

- Parallel pumps – shut one off?
- Level of savings depends on pump curve.



Shallow curve – less flow increase



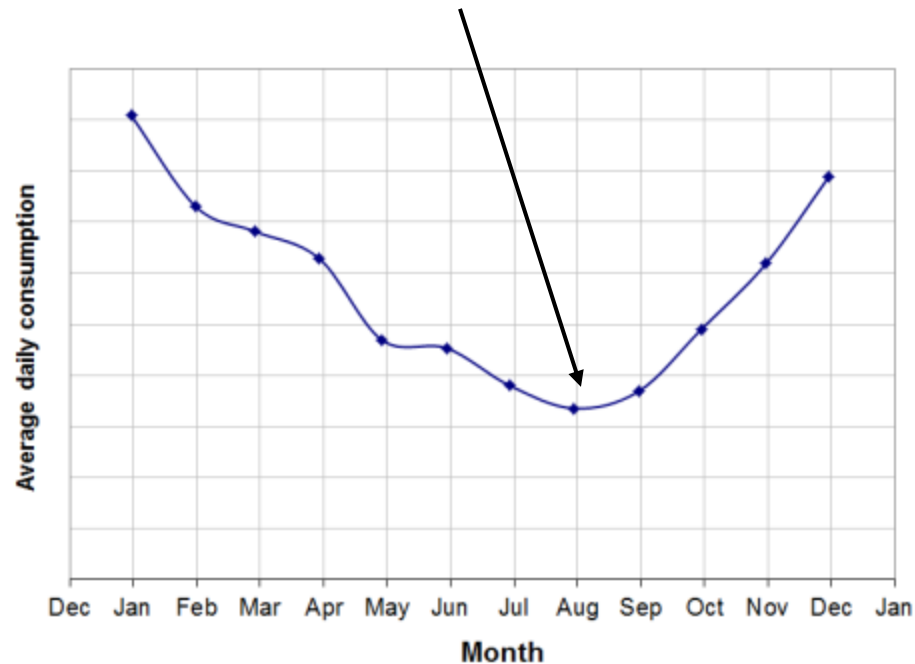
Evaluate Ventilation

- **Ventilation control – typical issues:**
 - ◆ **Actual occupant load less than design**
 - ◆ **Space usage changed**

- **Common opportunities:**
 - ◆ **Add demand-controlled ventilation (DCV)**
 - ◆ **Reduce OA flow rate**
 - ◆ **Reduce VAV box min flow rates**
 - ◆ **Reset VAV box min flow rates**

Evaluate Ventilation - Clues

- Cold complaints in zones with no reheat
- Low measured CO₂ values
- High summertime boiler usage



Evaluate Ventilation

- **Ventilation case study 800,000 sf building.**
- **Issues:**
 - ◆ **Design occupancy: 6,000 people.**
 - ◆ **Actual occupancy: 1,850 people.**
- **Implemented measures:**
 - ◆ **Lower VAV box min flow setpoints**
 - ◆ **Close VAV boxes during unoccupied times**
- **Financials:**
 - ◆ **Cost: \$10,000**
 - ◆ **Annual savings: \$30,000**

Persistence of Benefits

Making Energy Benefits Last

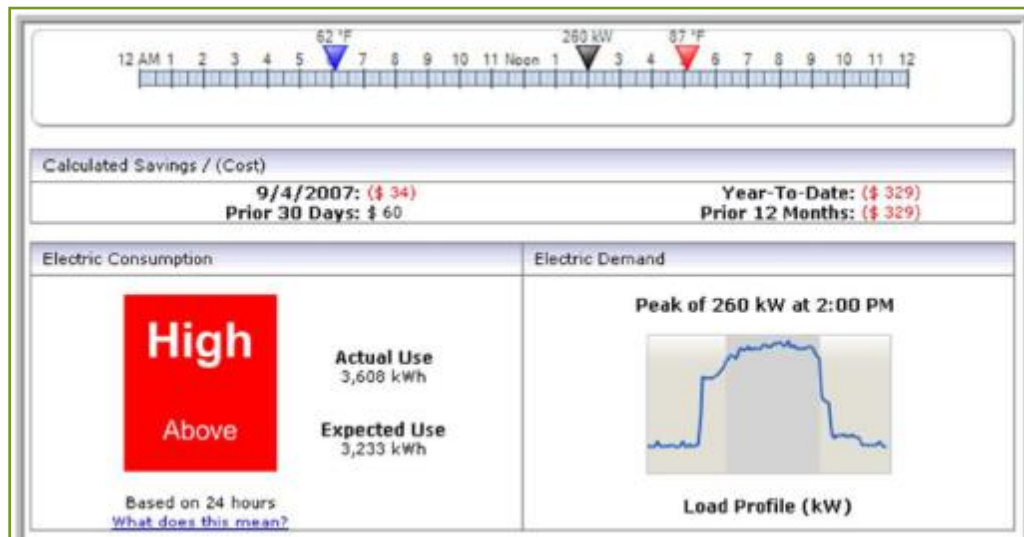
- **Persistence is an issue with EBCx measures**
 - ◆ **Operational measures can easily be undone**

- **Various methods for ensuring persistence:**
 - ◆ **Owner / operator training (key!)**
 - ◆ **Updated building documentation / systems manuals**
 - ◆ **Performance tracking**
 - **Building benchmarking (Energy Star)**
 - **Utility bill / energy use tracking (whole building level)**
 - **Trending of key metrics (systems level)**

Performance Monitoring Tools

Whole-building level

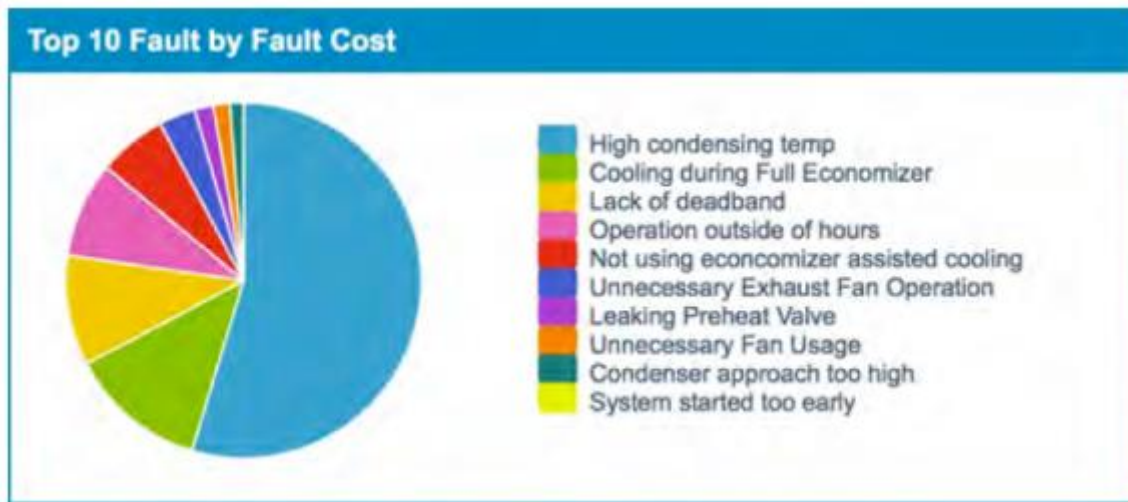
- ◆ Monitor energy consumption, identify anomalies.



Performance Monitoring Tools

System-level

- ◆ **Monitors data from a BAS to continuously identify EBCx opportunities**



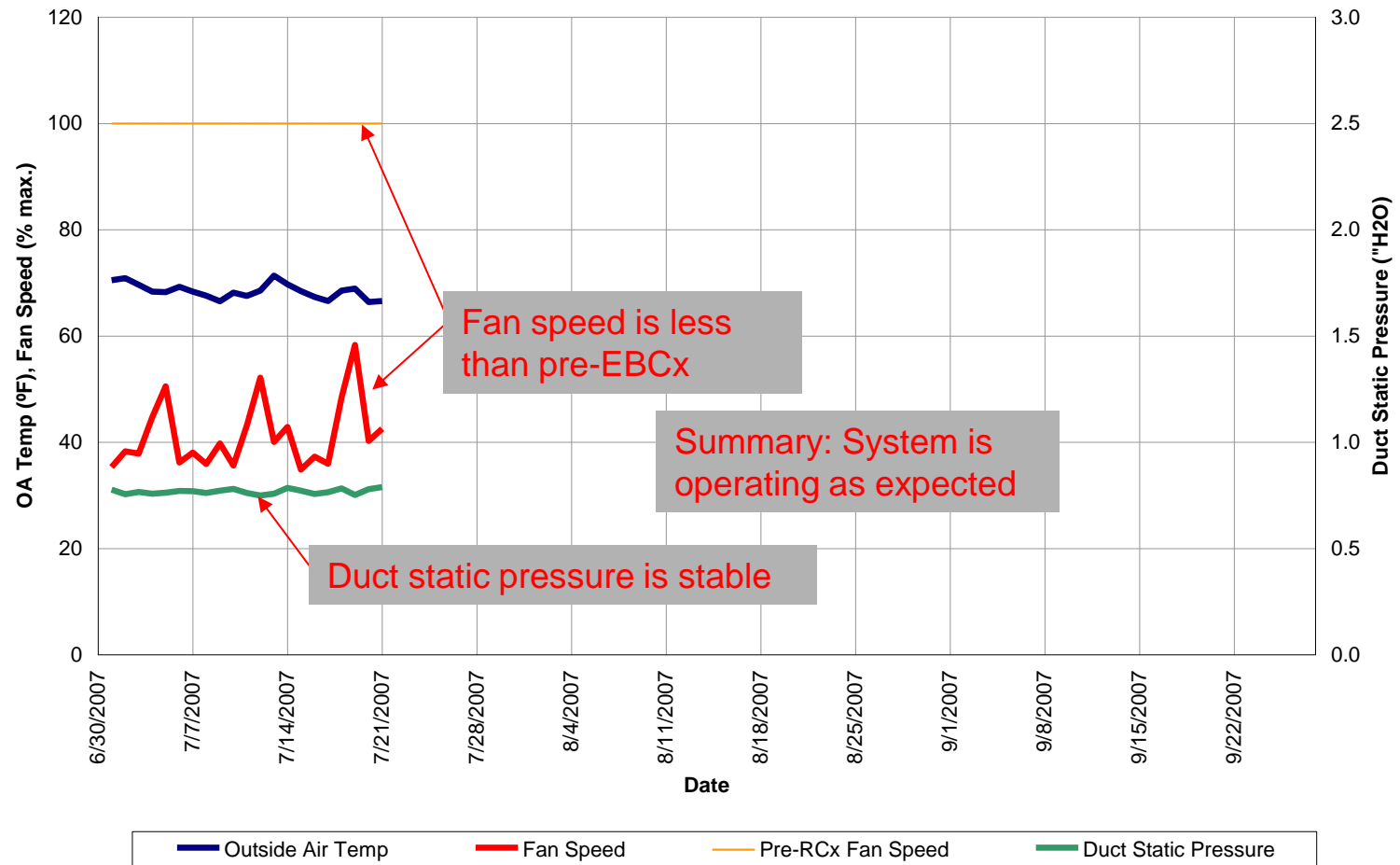
Systems Level Tracking

Fan Speed variation measure

- AH serving public areas. 24/7/365, 60 HP fan.
- Baseline: VFD had failed, operating in bypass.
 - ◆ Excessive reheat due to overcooling.
- Measure: Replace failed VFD. \$18,000 annual savings, \$5,600 implementation cost.
- Tracked during 2007, quarterly reports sent to Owner

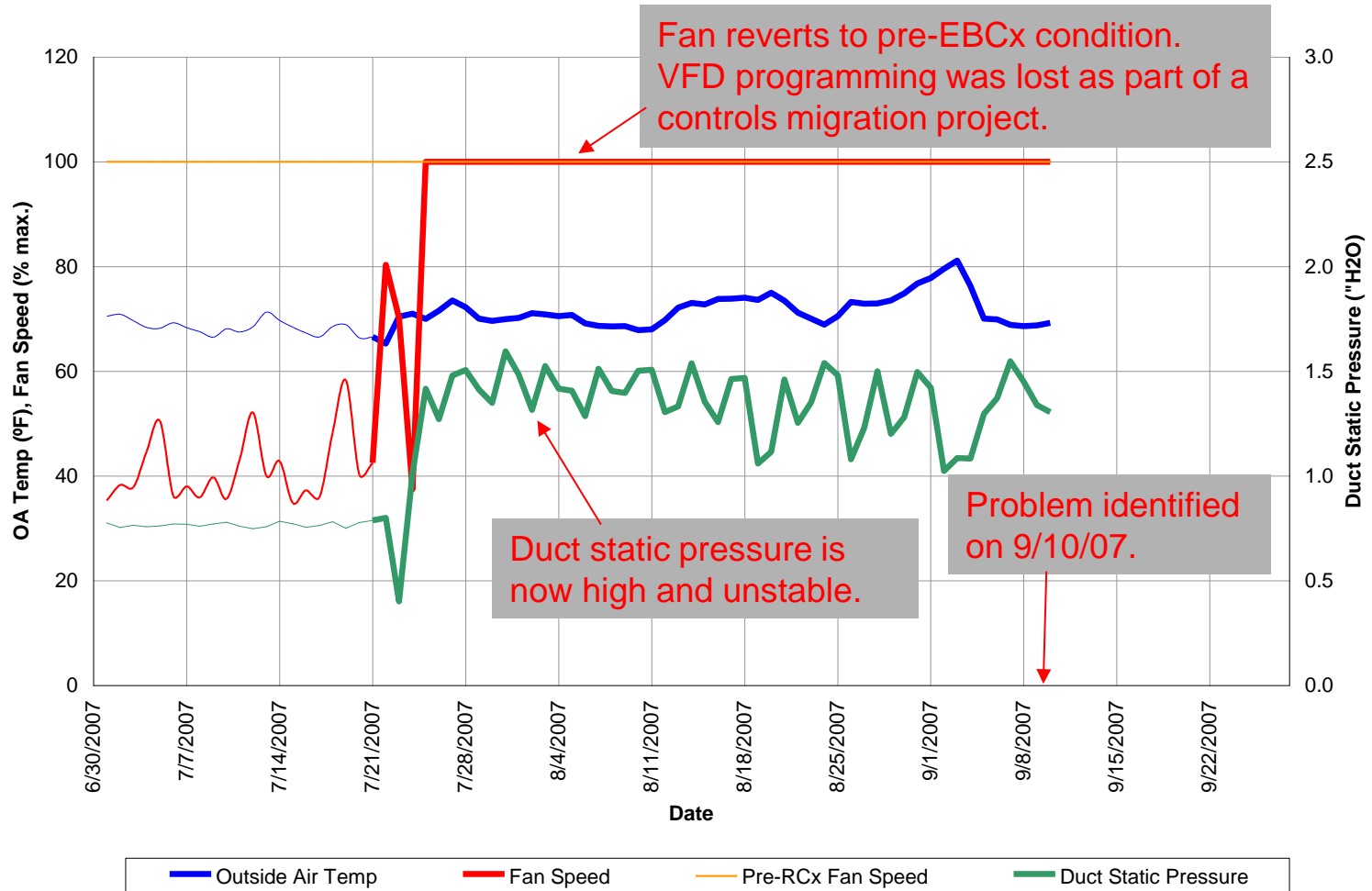
Systems Level Example

Air Handler Supply Fan Performance



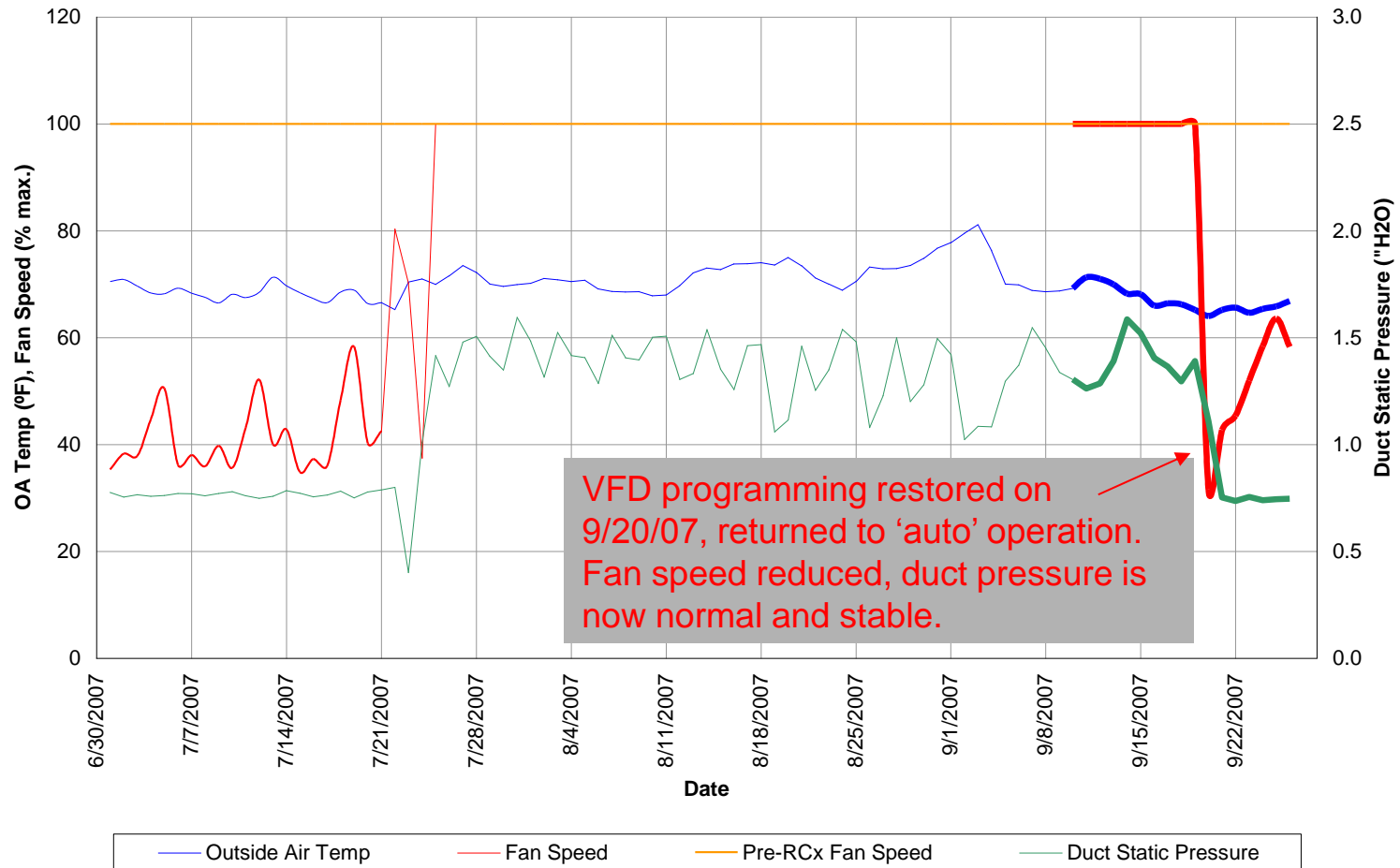
Systems Level Example

Air Handler Supply Fan Performance



System Level Example

Air Handler Supply Fan Performance



Resources

Resources

■ Xcel Energy: www.xcelenergy.com/recomm

Recommissioning

Minnesota and Colorado facilities earn rebates, savings

+ Overview

+ Benefits

+ Details

+ Who Qualifies

+ How to Get Started

+ Additional Information

Case Studies

[Chiller Plant](#)

[Church](#)

[Hospital](#)

[Hotel](#)

[Medical and Research Center](#)

[Healthcare and Medical Office](#)

[Government Facility](#)

[Office](#)

[School](#)

Resources

- **Mills study (2009): “Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse-gas Emissions.”**
Meta-study of Cx and EBCx projects.
- **PECI (2009): “A Study on Energy Savings and Measure Cost Effectiveness of Existing Building Commissioning.”**
Measure-level study.
- **EPA’s “A Retrocommissioning Guide for Building Owners.”**
EBCx desk reference.
- **Building Commissioning Association (BCA), “Best Practices in Commissioning Existing Buildings.”**
A summary of the EBCx process.

Resources

- **Additional EBCx training:**
 - ◆ **PECI**
 - ◆ **AABC Commissioning Group**
 - ◆ **Association of Energy Engineers**
 - ◆ **Building Commissioning Association**
 - ◆ **National Environmental Balancing Bureau**
 - ◆ **Testing Adjusting and Balancing Bureau**
 - ◆ **University of Wisconsin-Madison**

- **CCC's "Building Performance Tracking Handbook."**
Guide for performance tracking.

PECI Cx Training Program

104 Online Lessons

Commissioning Authority Training

- Fundamentals of Commissioning
- Commissioning Systems & Equipment
- Systems Performance & Analysis



Commissioning Authority Training

- + Fundamentals of Commissioning
- Commissioning Systems & Equipment
 - + Facility Envelope Components
 - + Facility Operating Requirements
 - + Facility Energy Considerations
- + Intro to MEP Systems and Equipment
 - + MEP- AHU
 - + Cooling Equipment
 - + Combustion and Boilers
 - + Chilled Water Systems
 - + Hot Water & Steam Heating
 - + Domestic Hot Water Systems
- Electrical Systems and Equipment
 - Electrical Drawings and Documents
 - Electrical Distribution Systems 1
 - Electrical Distribution Systems 2
 - Lighting Systems
 - Lighting Controls
 - Renewable Energy Systems
- + Control Systems Fundamentals
- + Control Systems
- + Systems Performance & Analysis

<http://learn.peci.org/>

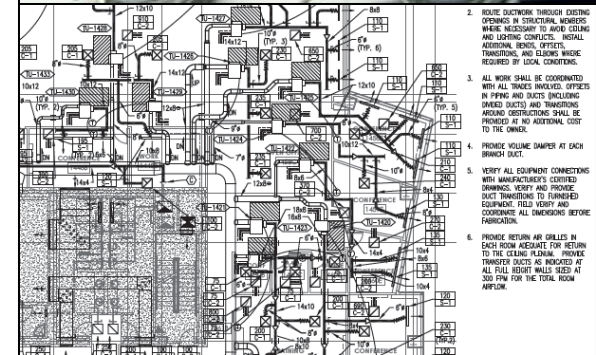


PECI Cx Training Program One Week Lab

10 real-world exercises, including:

- ◆ Energy use analysis
- ◆ Design review
- ◆ BAS trend data analysis
- ◆ BAS sensor location and calibration verification
- ◆ Functional performance test development and observation
- ◆ Pump performance analysis
- ◆ Cx Progress Report development

<http://learn.peci.org/>



Resources

- **California Commissioning Collaborative (www.cacx.org)**
 - ◆ **Case studies**
 - ◆ **Tools and templates**
 - ◆ **Guidelines**

- **Commercial Building Energy Consumption Survey (CBECS)**
 - ◆ **Consumption and expenditure data (country-wide)**
 - ◆ **Energy Star is based on CBECS data**
 - ◆ **<http://www.eia.gov/consumption/commercial/>**

Questions / Discussion

Thank you!

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