Recommissioning Workshop

September 12, 2013

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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

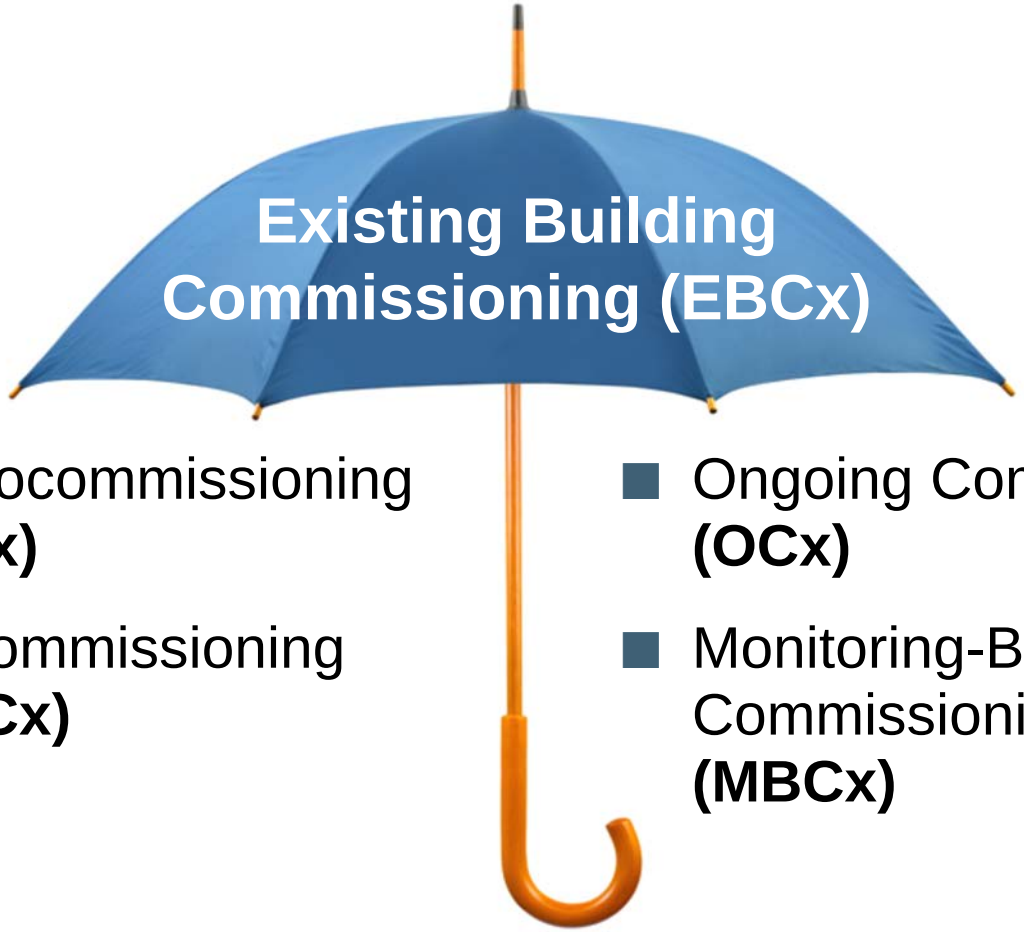
Going from this….

to this!

But Seriously, EBCx is…

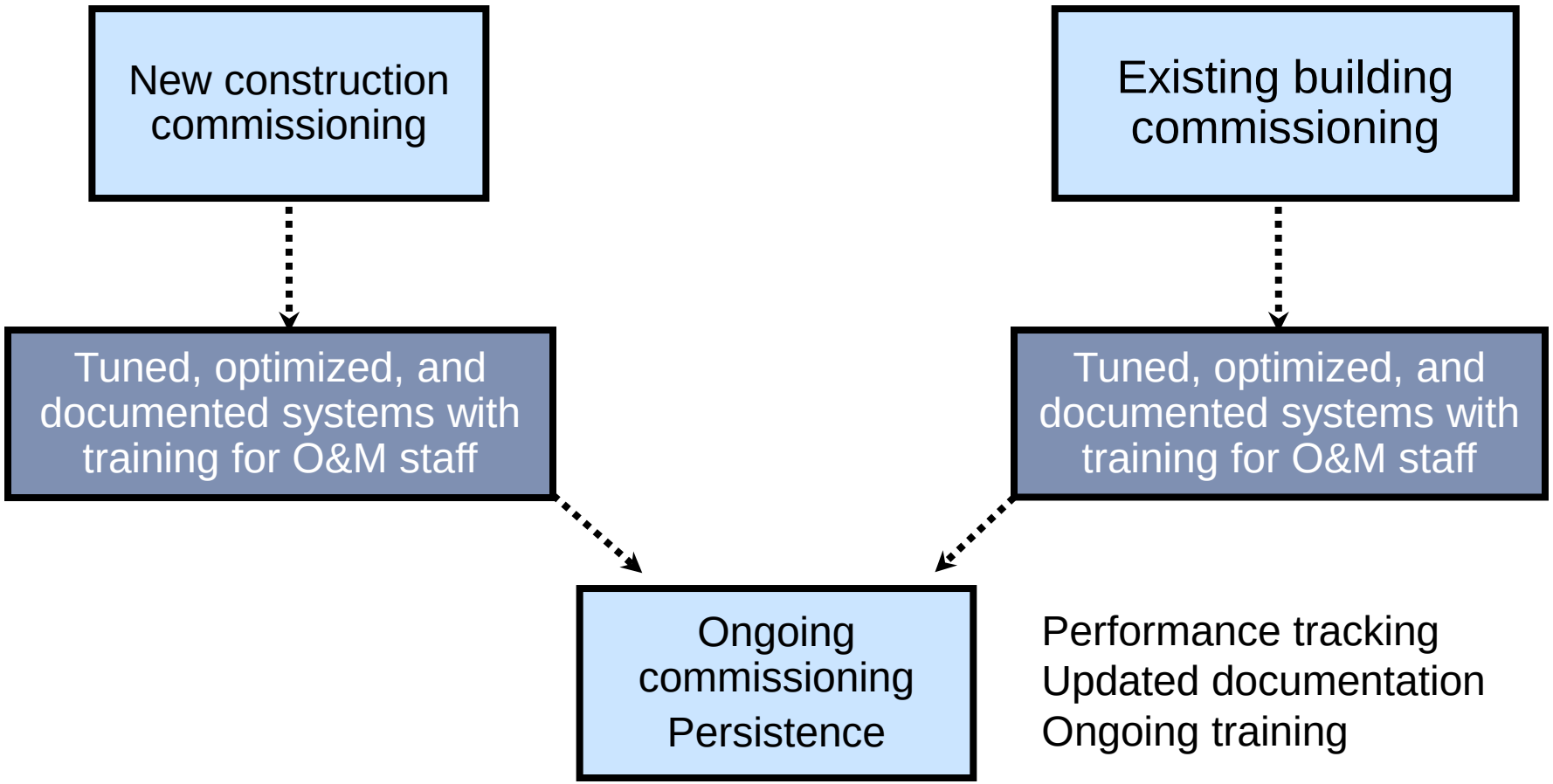
- A systematic process for improving an existing building's performance
- Includes a rigorous investigation to identify problems, especially integration issues
- Primary focus is on identifying low cost operational improvements
- May be done alone or with a retrofit project

Other Terminology You May Hear



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

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


New construction commissioning
Existing building commissioning
Tuned, optimized, and documented systems with training for O&M staff
Tuned, optimized, and documented systems with training for O&M staff
Ongoing commissioning
Persistence
Performance tracking
Updated documentation
Ongoing training

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.

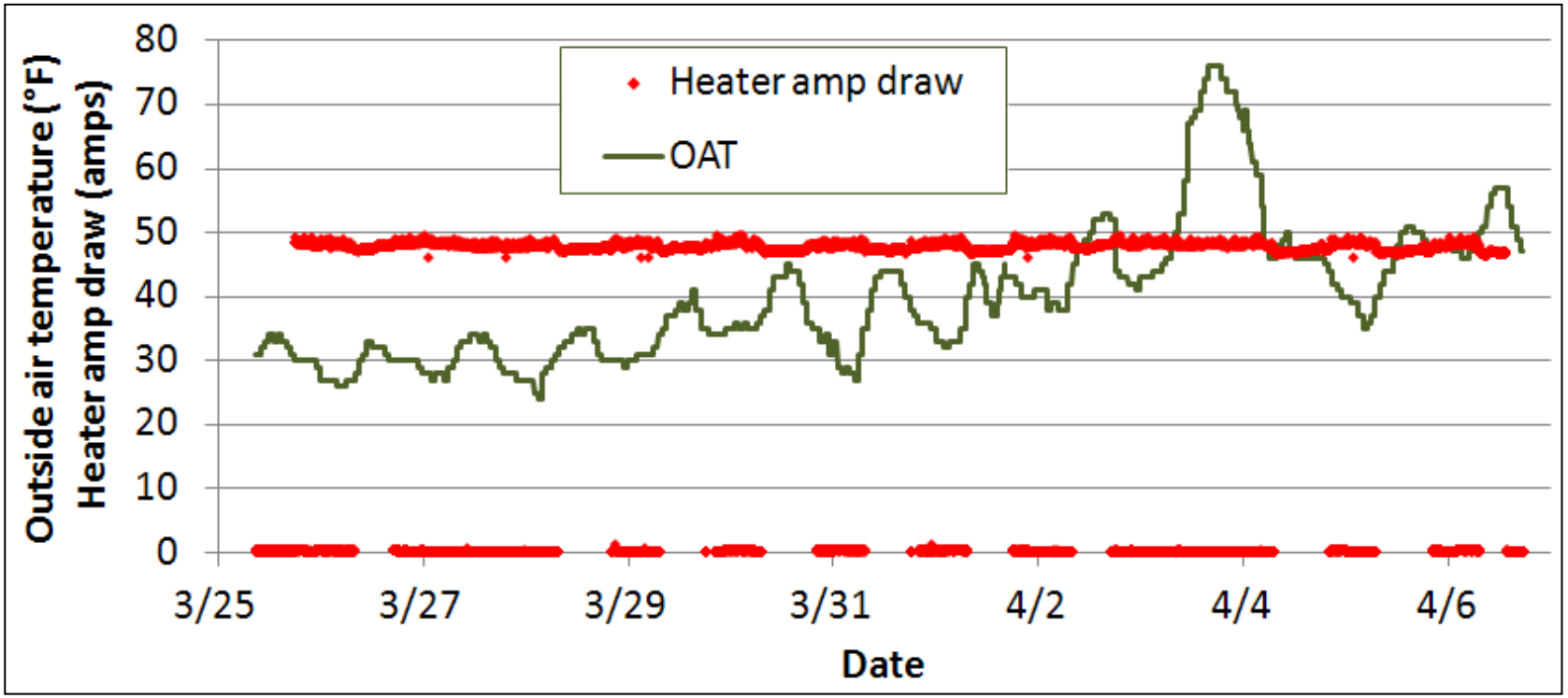
Revisiting O&M

- Maintenance = <u>Capacity</u>
  - Caring, cleaning, lubing, repairing
  - *Primarily physical*
- Operation = <u>Performance</u>
  - Scheduling, implementing efficient control strategies, sequencing of equipment
  - *Primarily mental*

Maintenance Issue Example

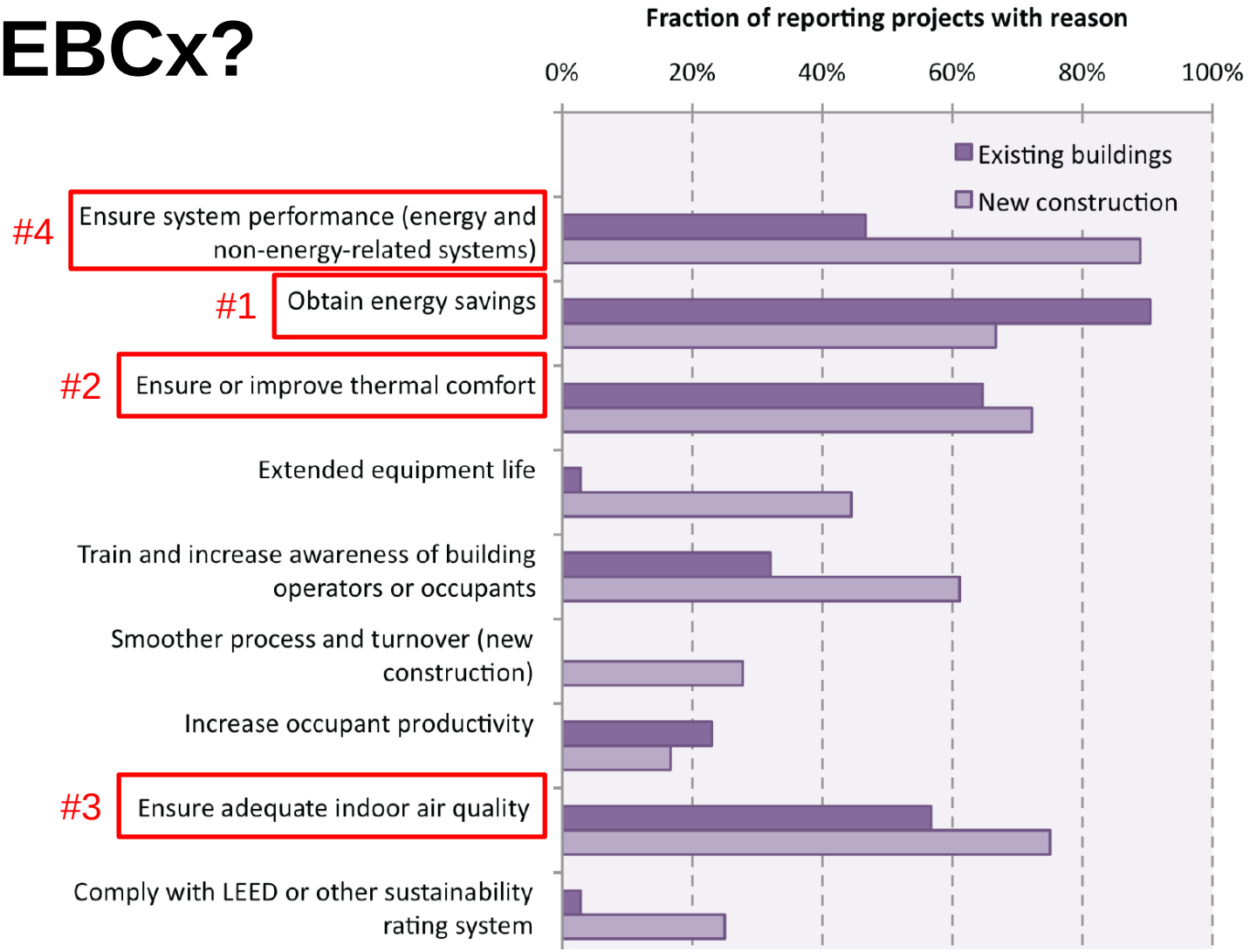
- Upper set of dampers should be open.
- Linkage has come loose from actuator.

Operational Issue Example



- **Heaters should be off at OATs above 40°F.**

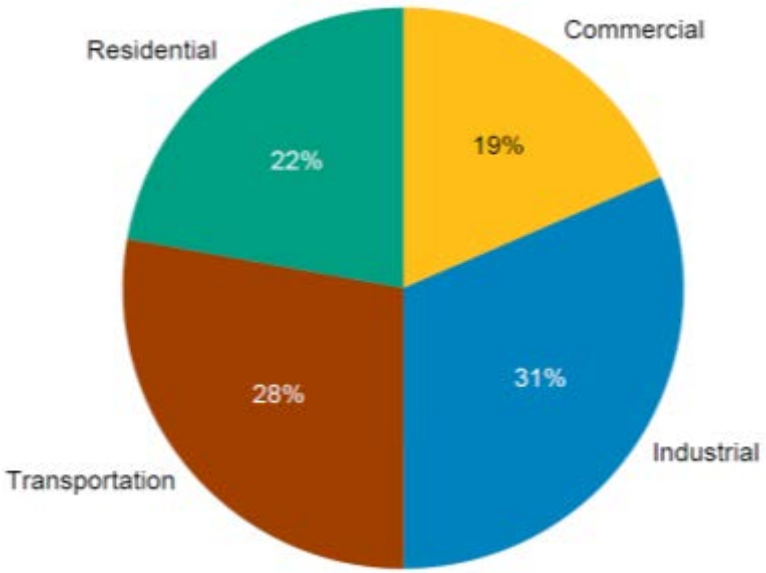
Why EBCx?



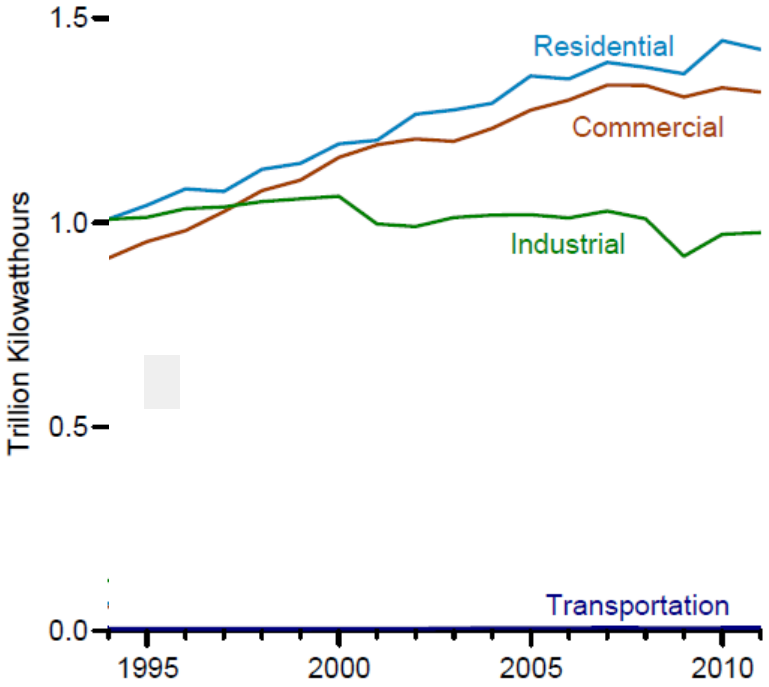
Source: Mills 2009

What's All the Fuss About Energy?

U.S. Energy Usage

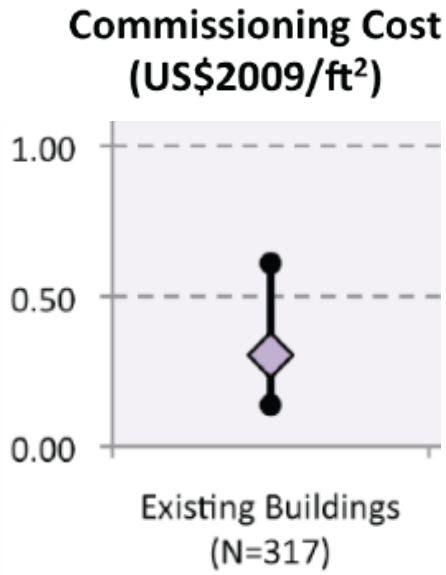


U.S. Electricity Sales

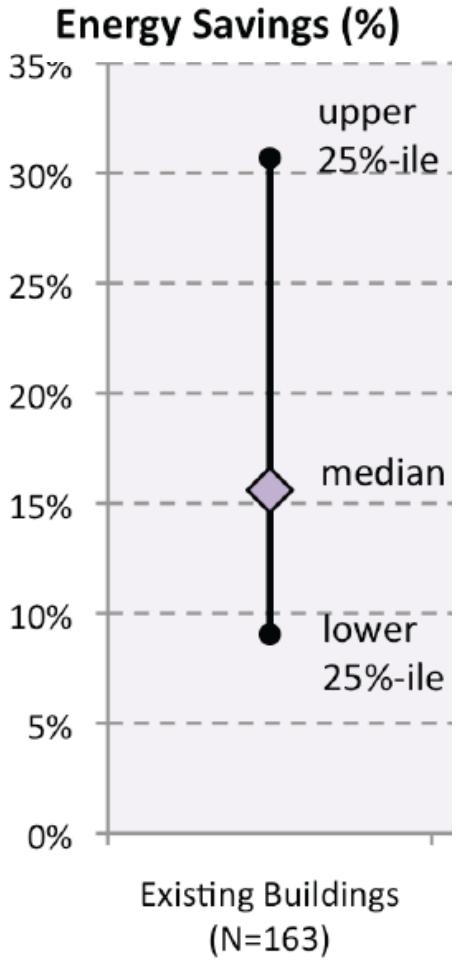


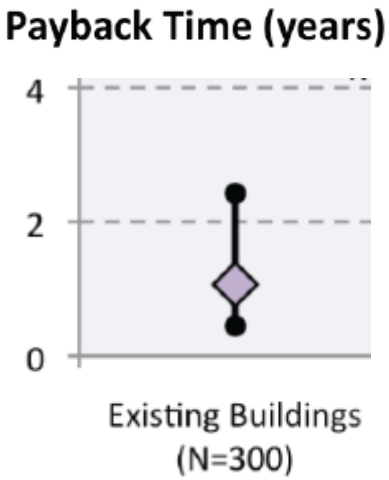
Source: EIA Annual Energy Review 2011

EBCx Costs & Savings



CxA cost = ~45% of total cost





Source: Mills 2009

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	❑ Compile a list of known problems and possible improvements. ❑ Gather up-to-date building documentation.
Investigation	❑ Perform appropriate preventive maintenance tasks early. ❑ Perform simple repairs as the project progresses. ❑ Assist with diagnostic monitoring and functional testing.
Implementation	❑ Assist with implementing the selected improvements.
Hand-Off and Post-EBCx	❑ Help facilitate training. ❑ Maintain improved performance of systems.

Local Case Study – Grace Church

- 343,000 sf megachurch
- Eden Prairie, MN
- Five EBCx measures
  - AHU runtime reduction
  - Supply air temperature reset
  - Control VAV boxes from occupancy sensors
  - Demand-controlled ventilation
  - Reduce VAV box airflow to match zone needs

Local Case Study – Grace Church

- **Financials**
  - **Total utility cost savings: $108,000 / yr**
  - **Project cost: $182,000**
  - **Xcel Energy incentives: $39,000**
  - **Net simple payback: 1.3 years**

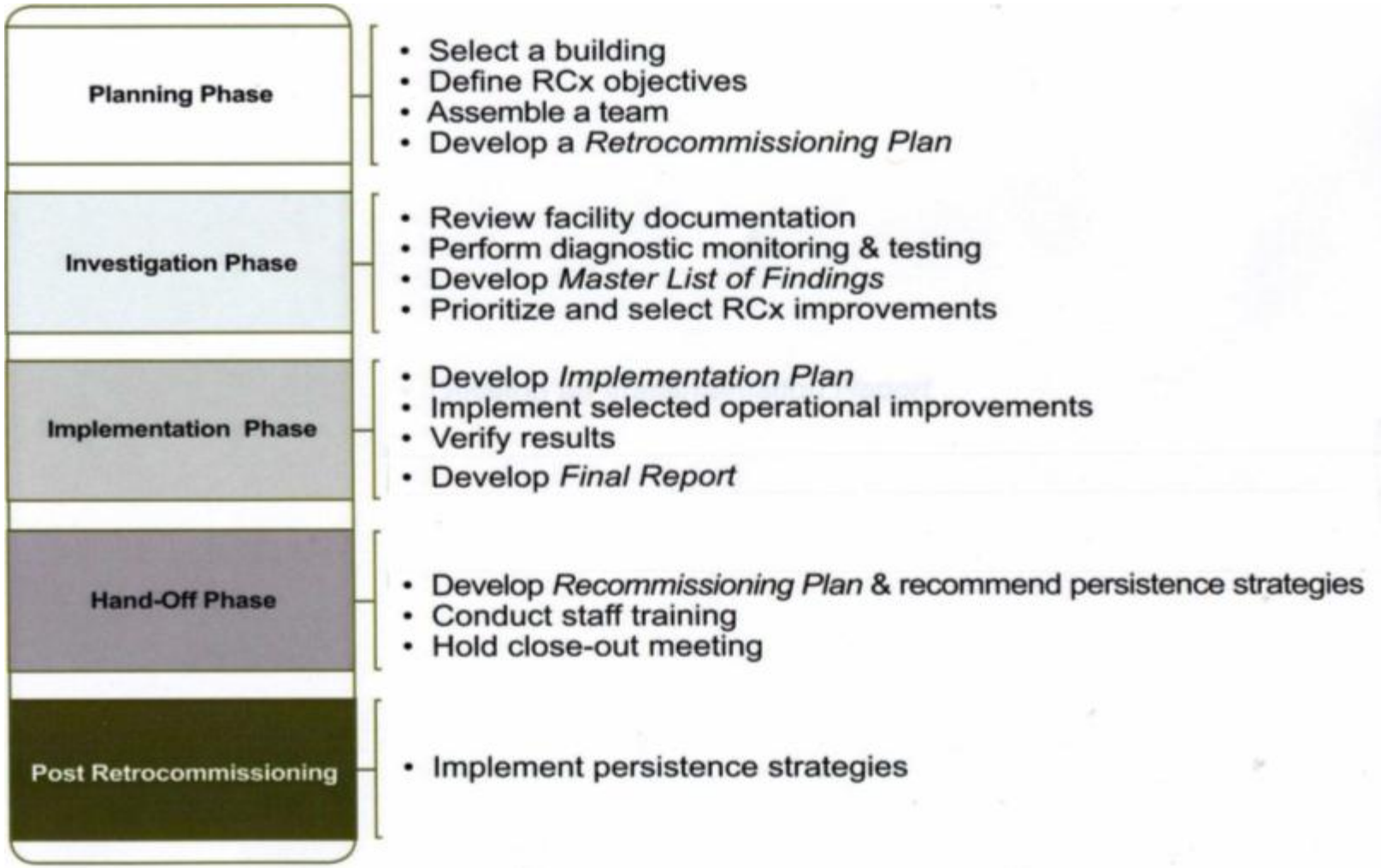
Local Case Study – North Memorial

- Ambulatory care center and medical office
- 200,000 sf facility just northwest of Minneapolis
- EBCx Measures
  - Reduce outside air to surgical suites during unoccupied hours
  - Reduce runtime of clinic area HVAC
  - Supply air temperature reset
  - Unoccupied temperature setback

Local Case Study – North Memorial

- **Financials**
  - **Total utility cost savings: $96,000 / yr**
  - **Project cost: $250,000**
  - **Xcel Energy incentives: $51,000**
  - **Federal stimulus funding: $100,000**
  - **Net simple payback: 1.0 year**

EBCx Process Overview



From the EPA's "A Retrocommissioning Guide For Building Owners".


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	☐	☑
High energy usage	☑	☐
Motivated operators	☑	☐
Major system design problems	☑	☑
Catastrophic problems (e.g., asbestos)	☐	☑
Complex HVAC and lighting systems	☑	☐
Excessive comfort complaints	☑	☐

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

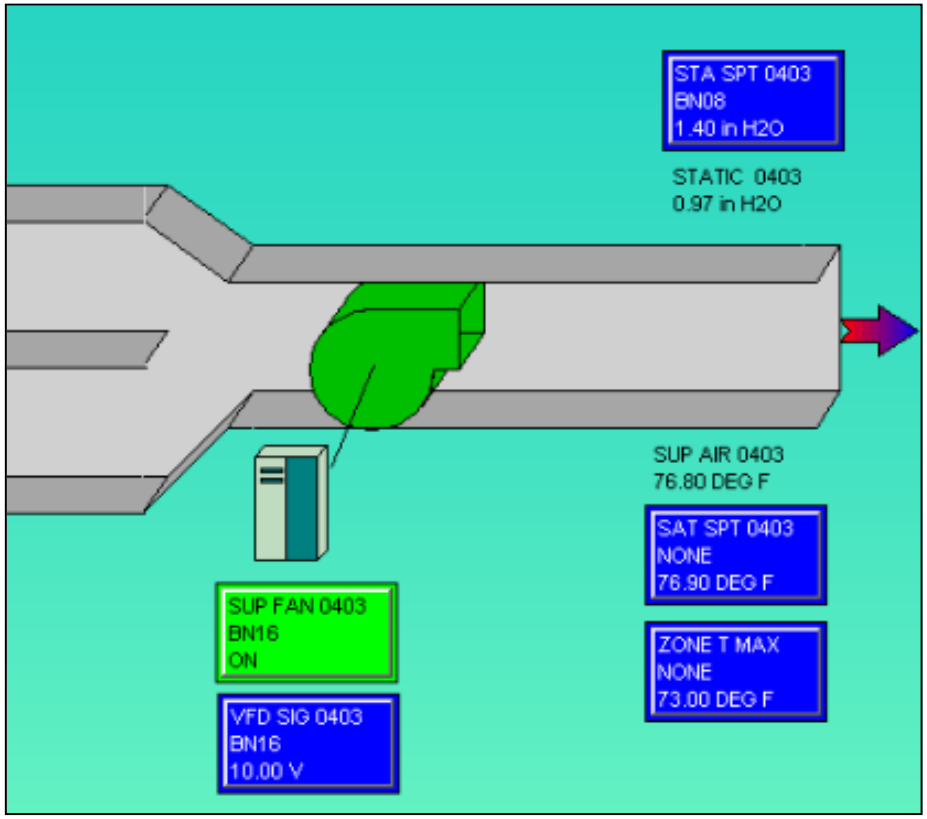
Useful Documentation

- 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
- Develop Master List of Findings

Evaluate Facility Performance

Purpose:

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

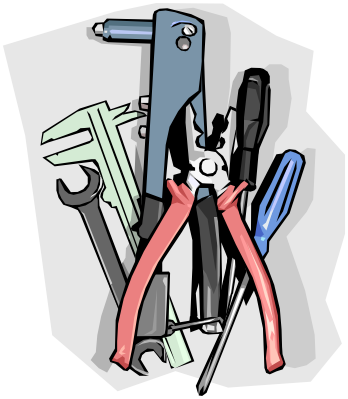
Methods:

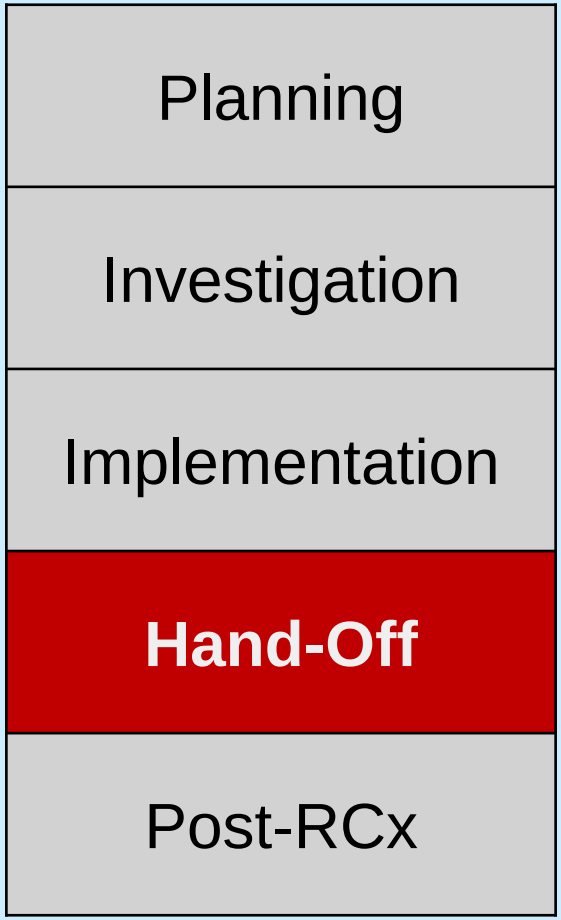
- Analyze energy usage
- Review interview results
- Review service requests and complaints
- Compare actual conditions to CFR
- Perform diagnostic monitoring
- Conduct site investigation and testing


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

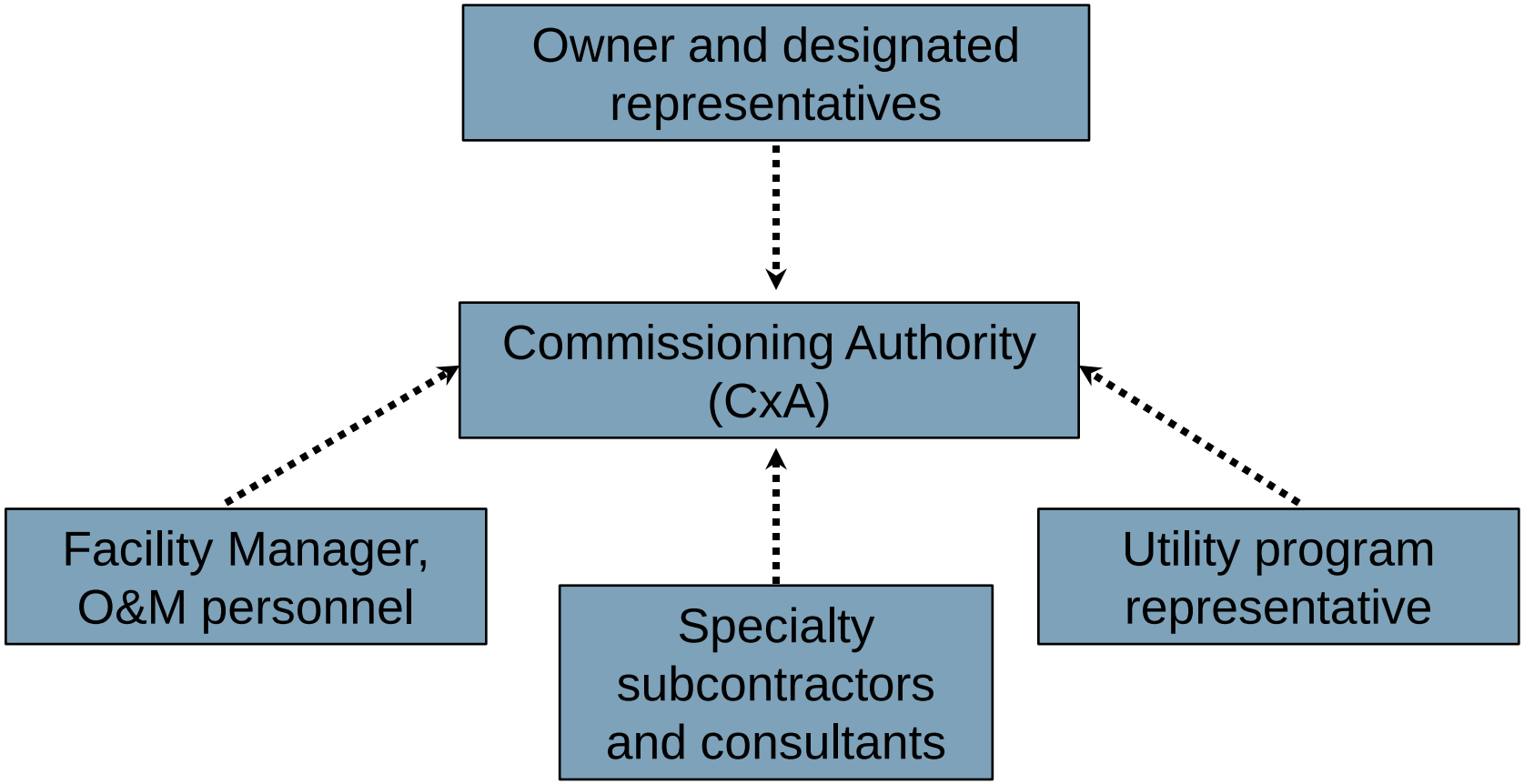
Up Next:

- 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

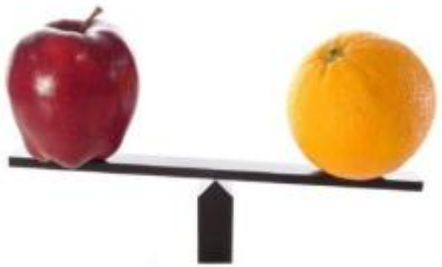
- Integrate and coordinate the team's effort
- Lead the investigation and hand-off phases of the project
- Work with management and operations team

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
- Big picture indicator of efficiency (or lack of it)
- Can use to prioritize projects within portfolio



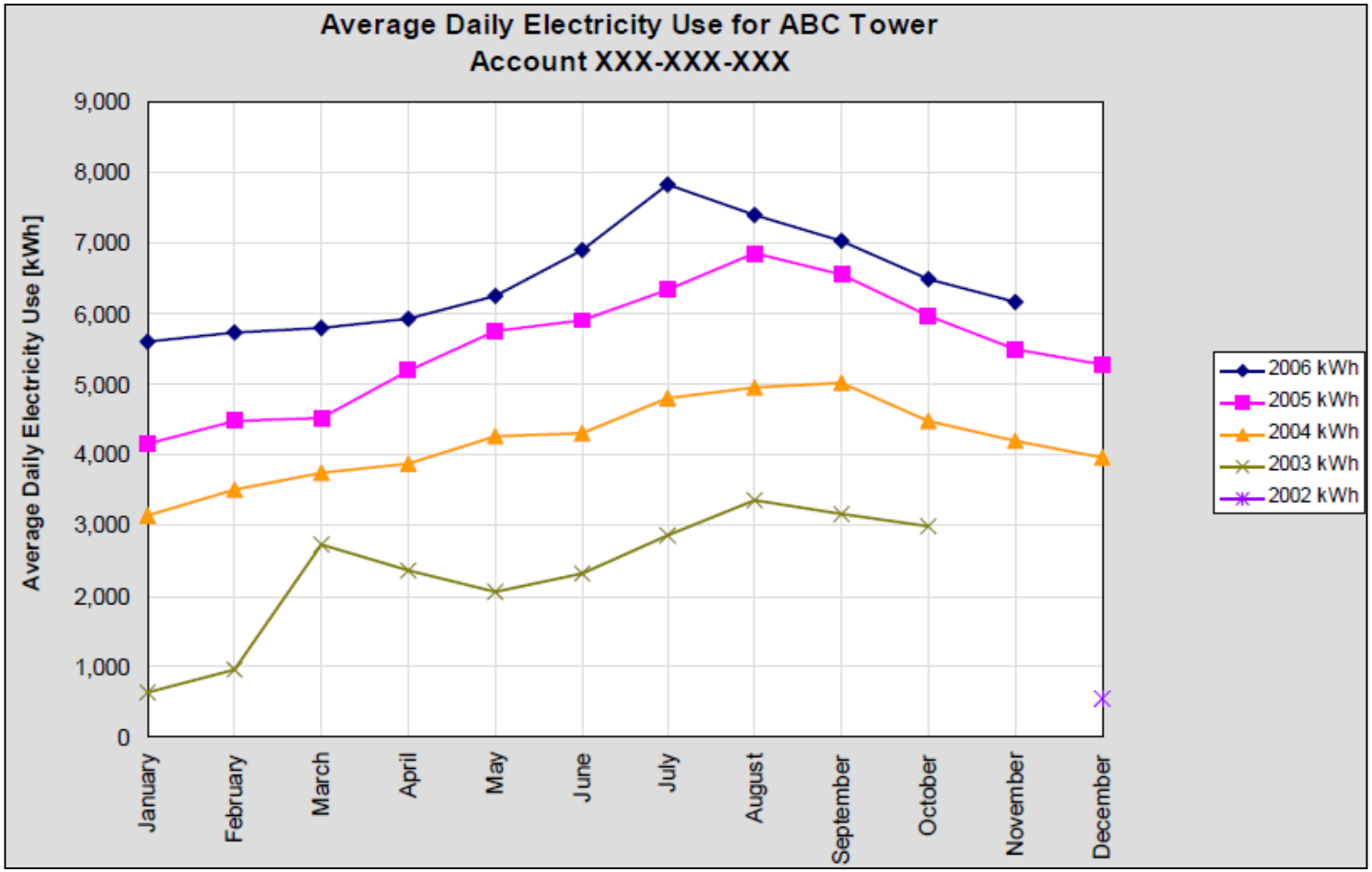
Benchmarking with ENERGY STAR®

- 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

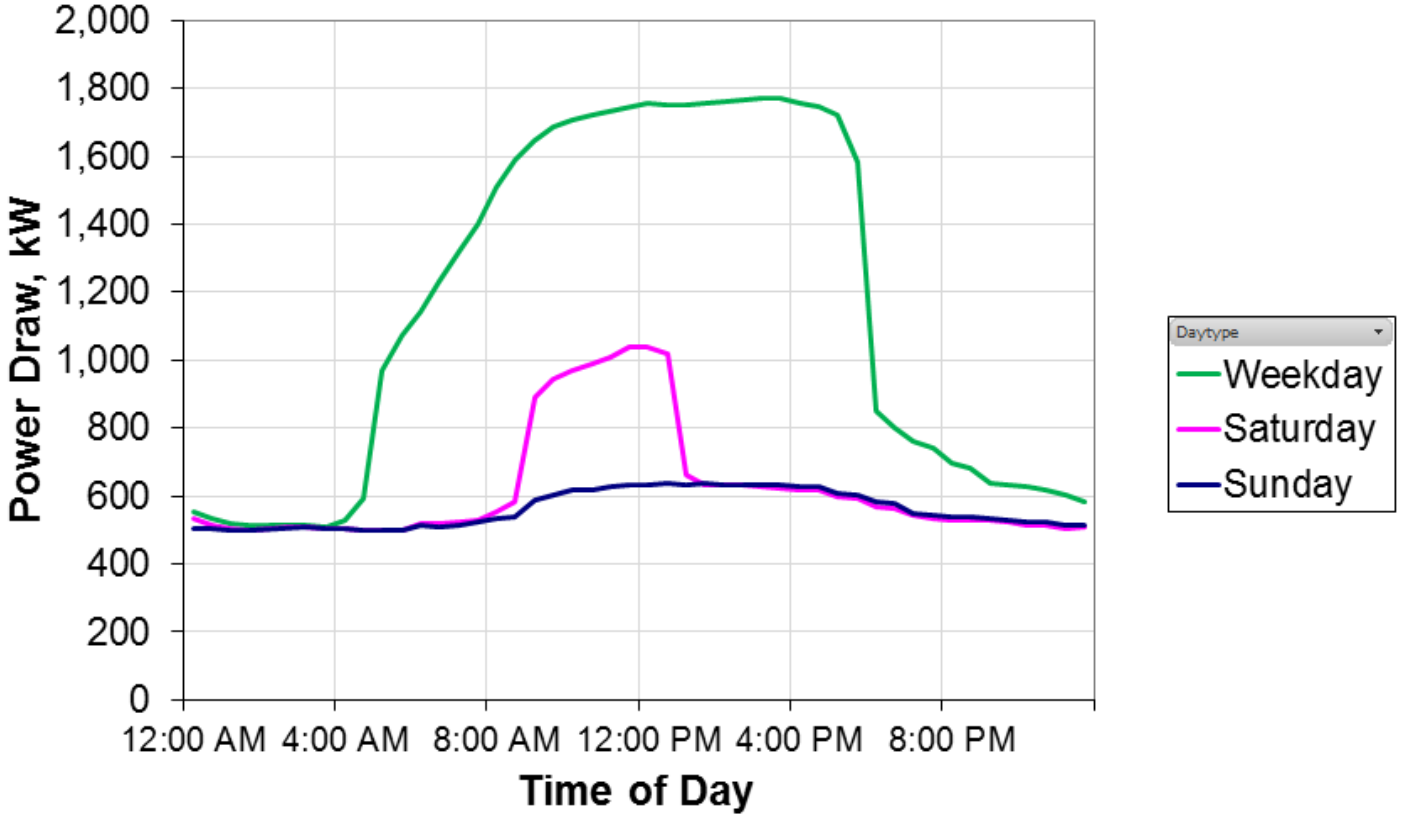
Analyze Monthly Utility Data



More Useful Utility Data

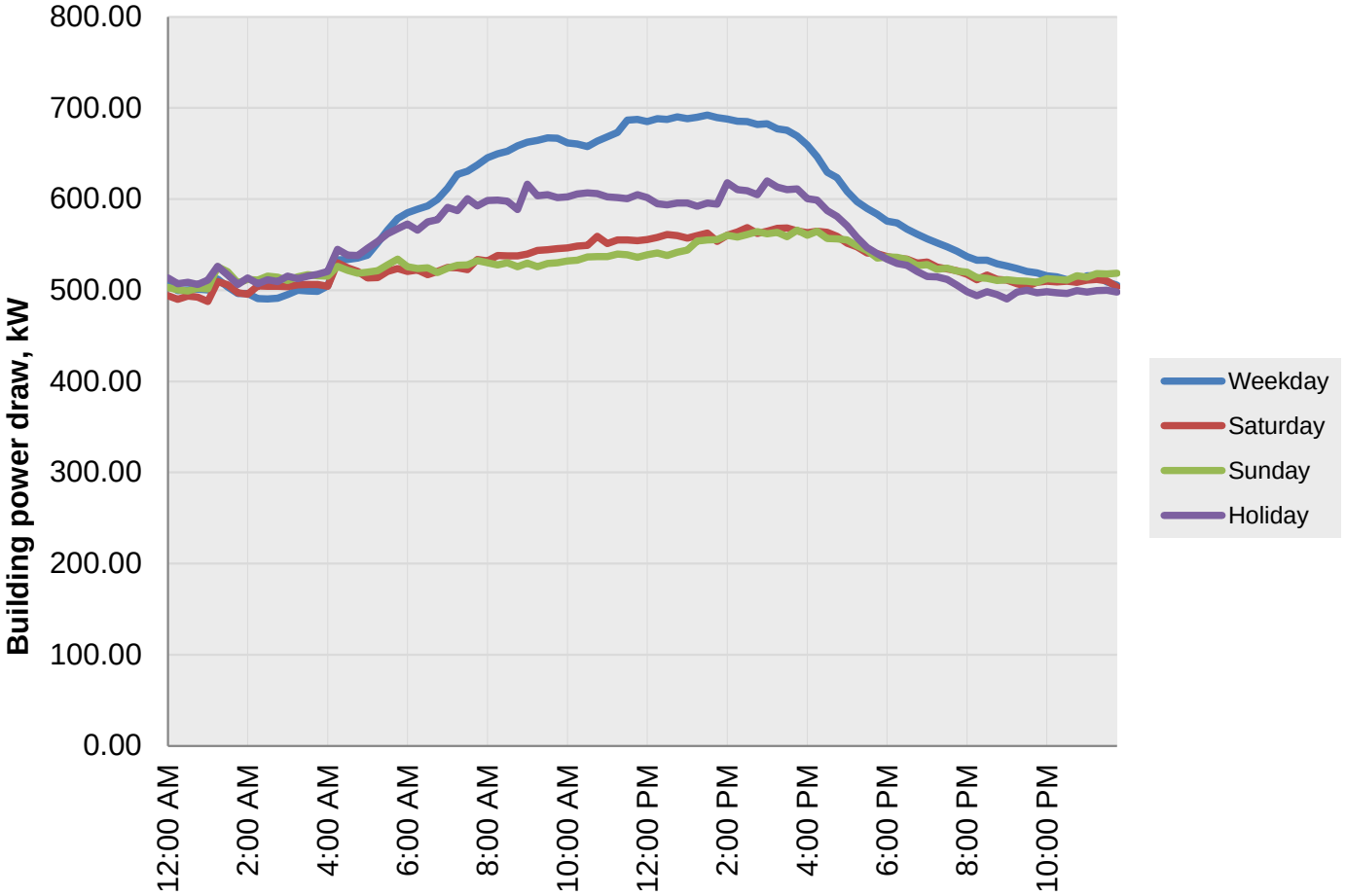
- Interval utility data (e.g., 15 minute data)
  - Identify base load during unoccupied conditions
  - Identify operational problems during normal building operating hours
  - Available through your Xcel Account Manager

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/or natural gas business customers in Colorado or Minnesota.**
- **Any age building**
- **In Colorado, buildings must be greater than 50,000 square feet or have high-energy use to qualify.**

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 $0.045/kWh**
    - **You earn the higher of the two**
- **Natural gas rebates (for our retail gas customers)**
  - **Up to $5/Dth**

Maximum rebate is 60% of measure cost

Payback must be between 9 months and 15 years to earn a rebate

Implementation Bonus

- On all qualifying recommissioning measures submitted within nine months of the study approval date.
  - An additional $0.03/kWh and/or $3/Dth
- That's in addition to the $0.045/kWh and/or $5/Dth already earned for implementing measures with a 9 month – 15 year payback.

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
  - 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!

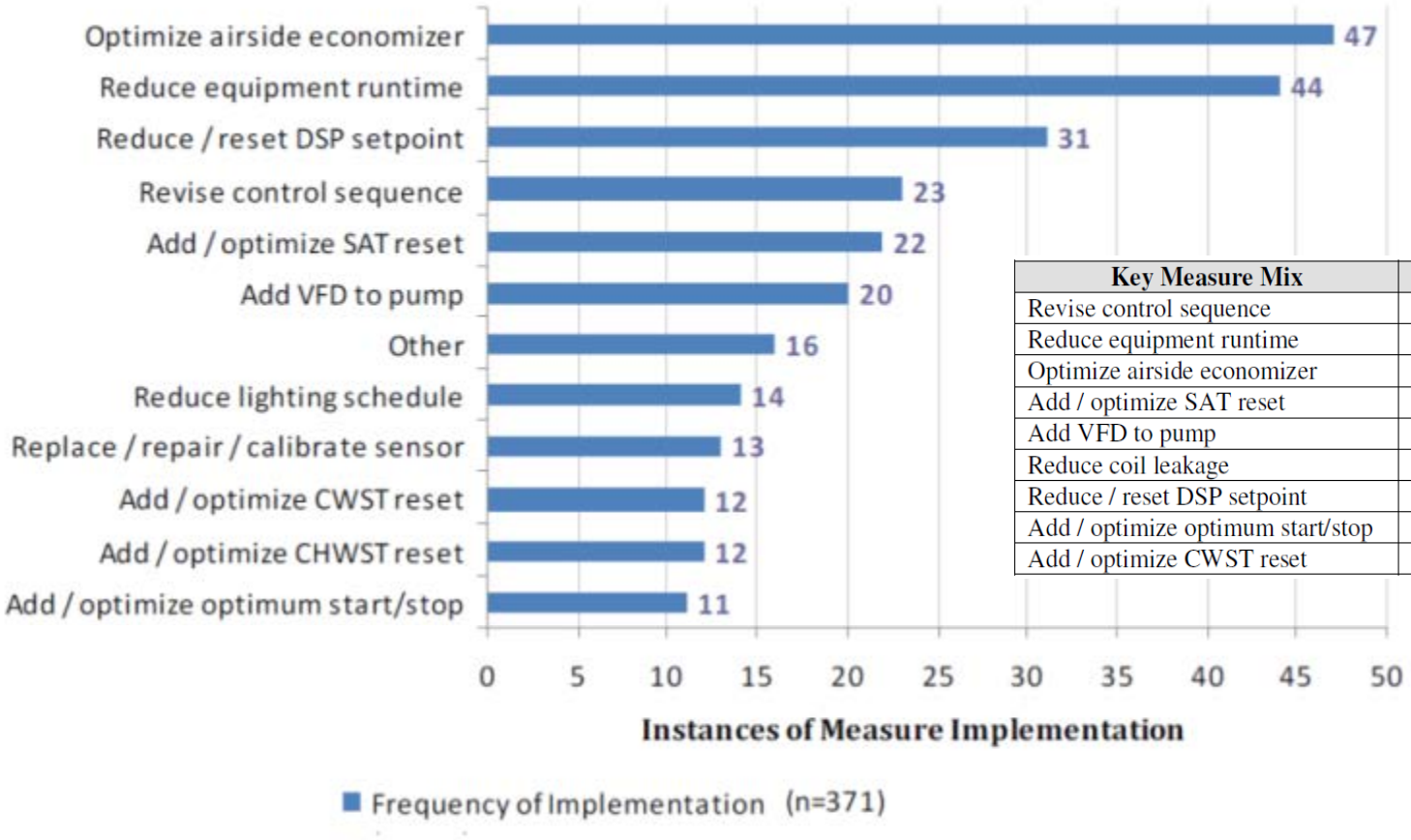
Up Next:

- 15 minute break

When we come back:

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

EBCx Results from the Field



Key Measure Mix	% of Total Savings
Revise control sequence	21%
Reduce equipment runtime	15%
Optimize airside economizer	12%
Add / optimize SAT reset	8%
Add VFD to pump	6%
Reduce coil leakage	4%
Reduce / reset DSP setpoint	4%
Add / optimize optimum start/stop	3%
Add / optimize CWST reset	2%

122 EBCx projects, most in CA.

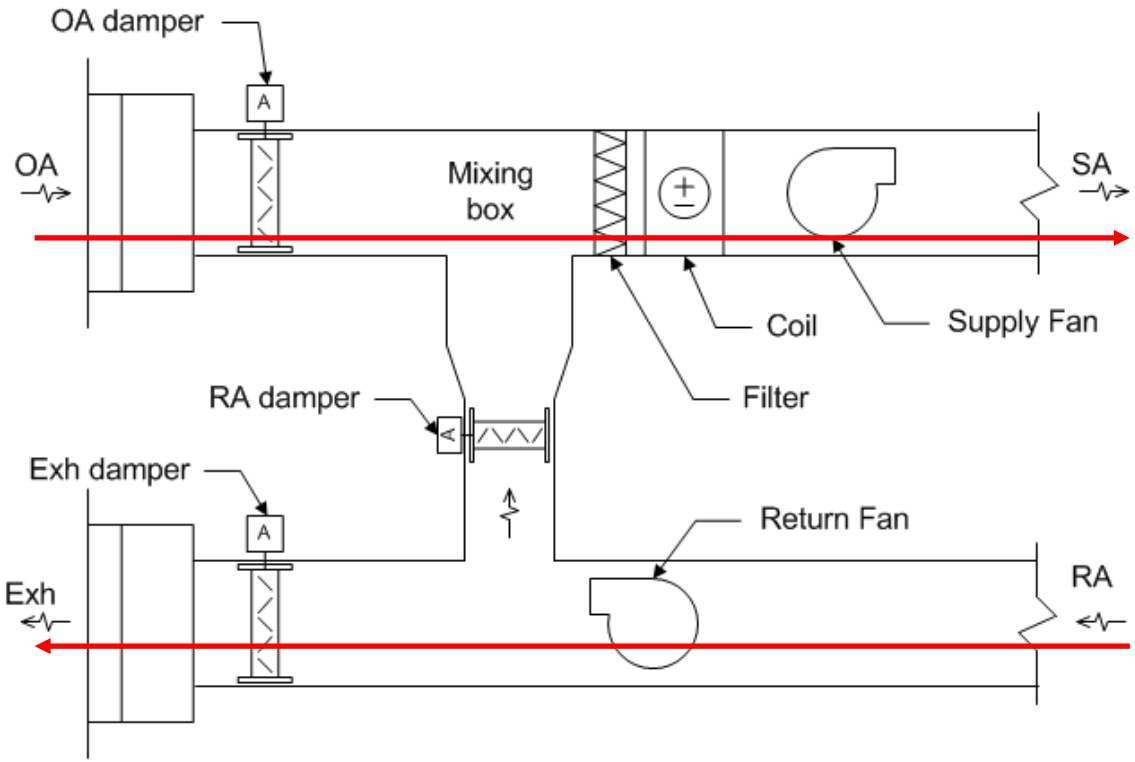
Source: PECI, 2009

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



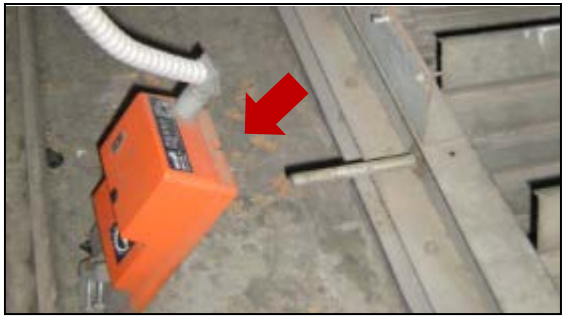
General Economizer Issue Categories

- 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

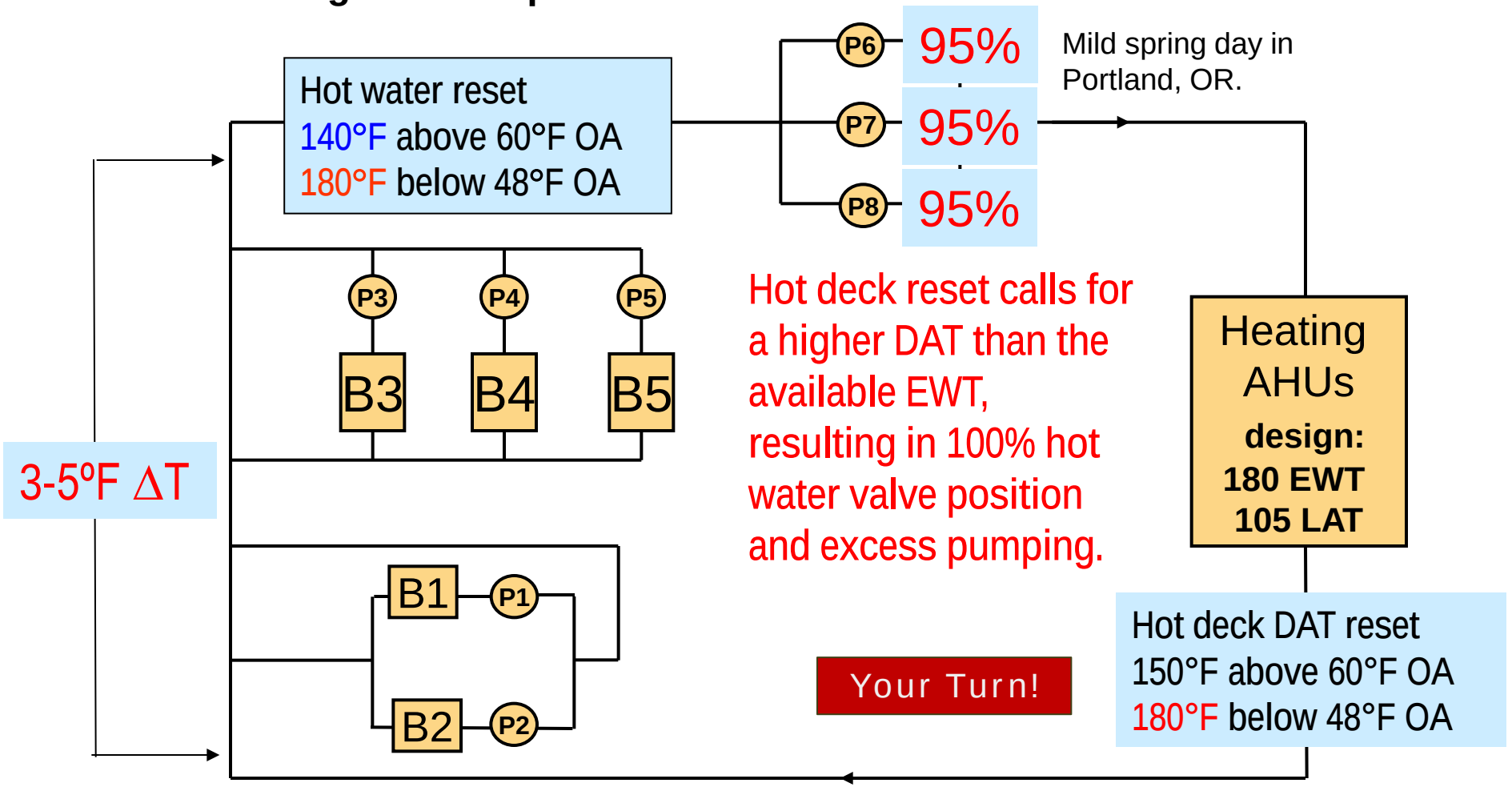
- Scheduling Issues
  - Often modified for specific, short-term needs
  - Schedule modifications can be forgotten
  - Improper system installation can lead to occupant request for modified schedule
- How to identify
  - Trend data
  - Interval utility data
  - After hours walk-through if possible

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

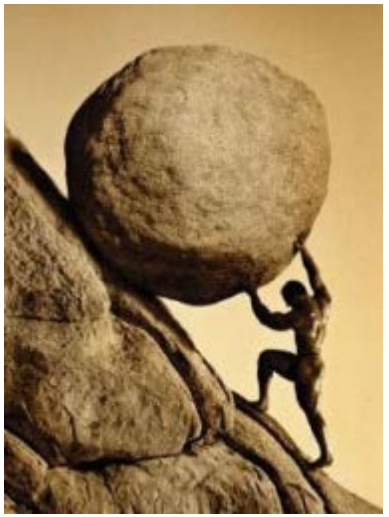
Setpoint Example – As-found Condition

What is wrong with this picture?

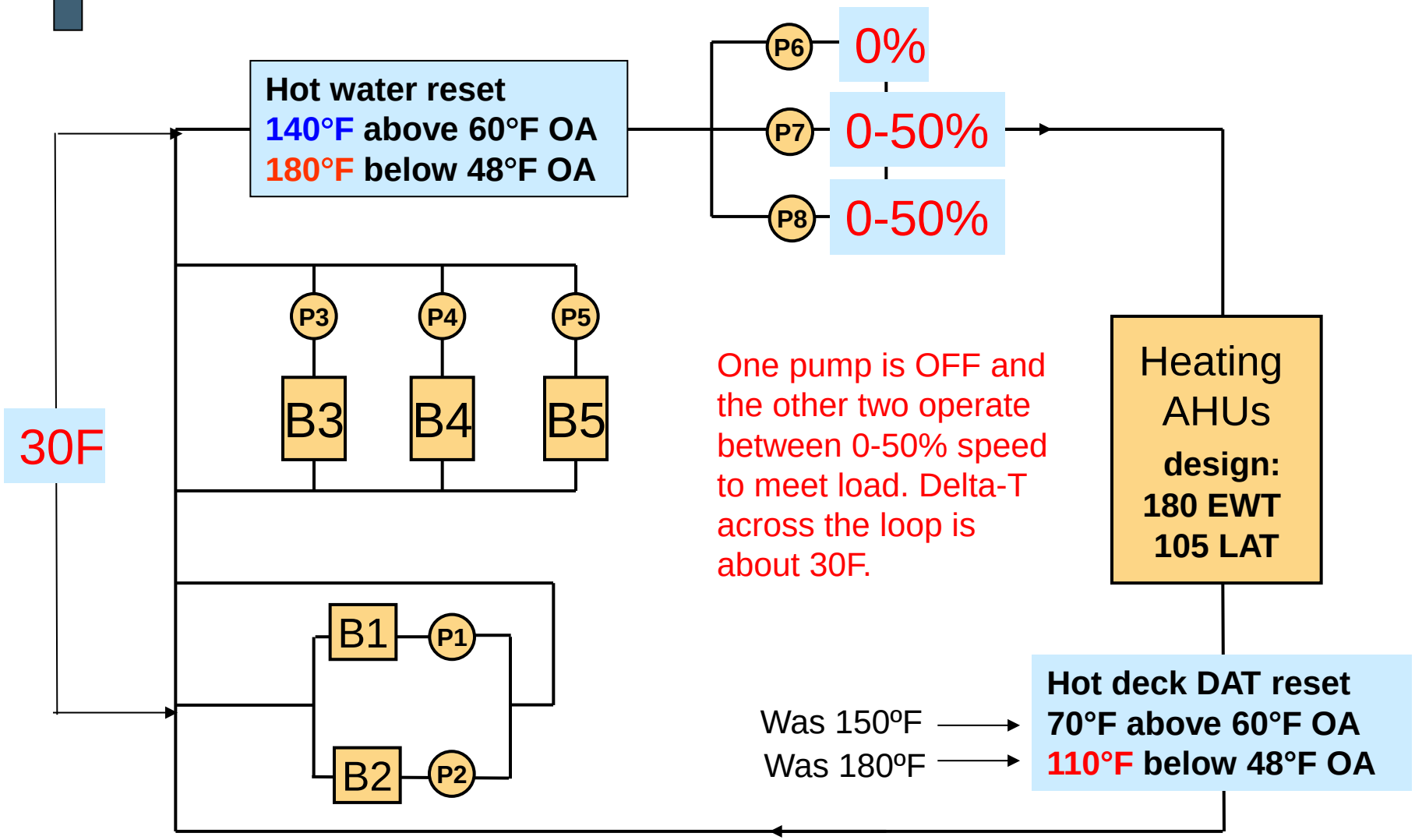


Setpoint Example

- 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

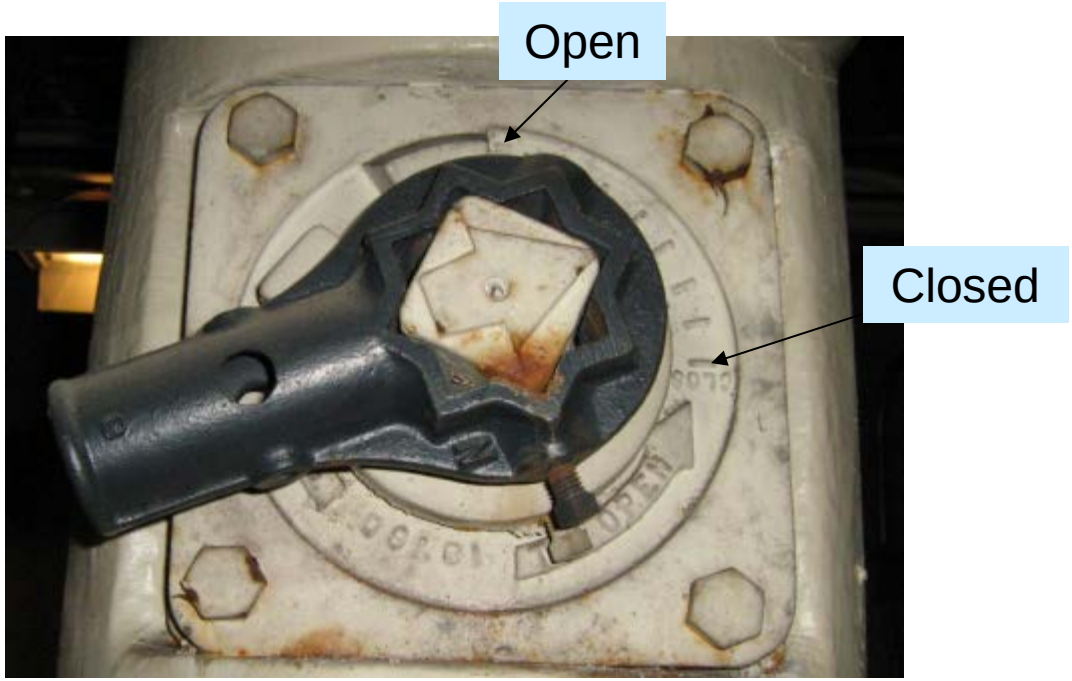
- **Savings opportunity**
  - **Energy savings: 29,000 kWh/yr and 4,200 therms/yr**
  - **Annual cost savings: $4,800 total**

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

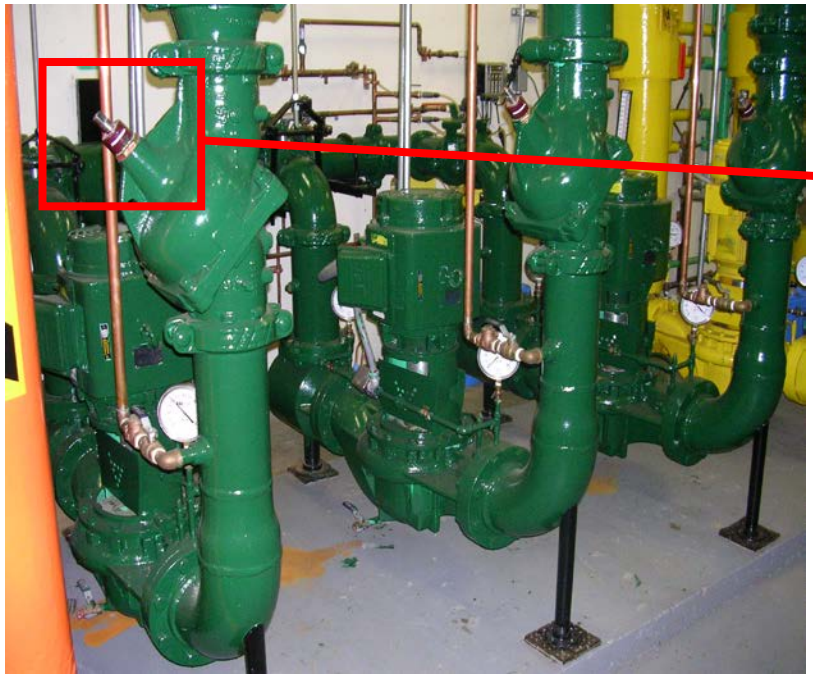
Throttled discharge valve

- **Sometimes it's easy to spot a throttled valve …**



Throttled discharge valve

… othertimes, not so much.

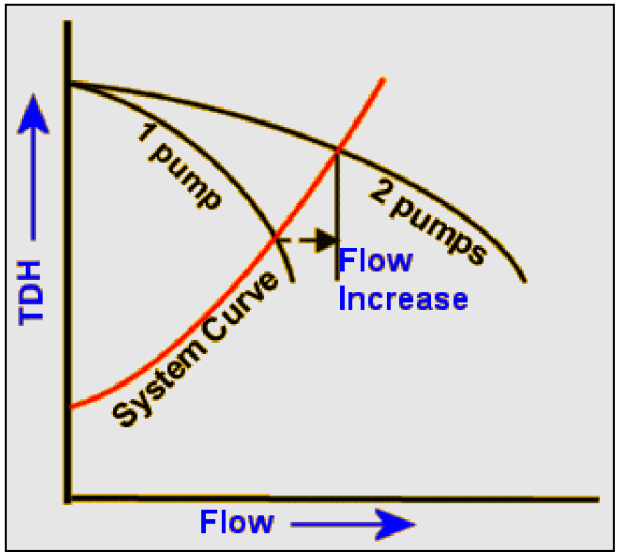


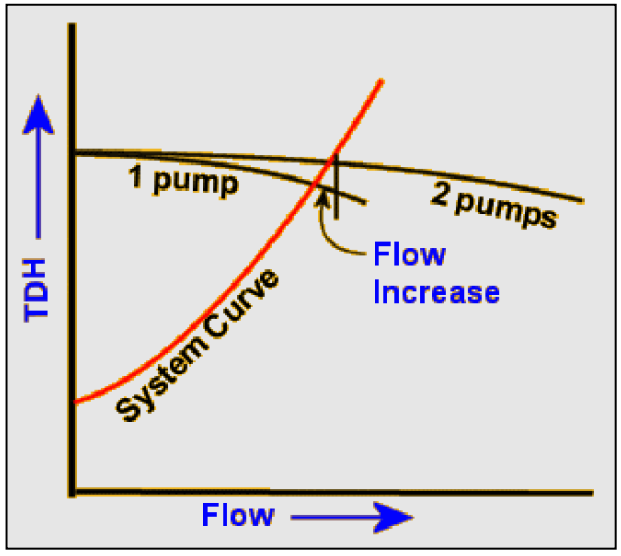
Implementation Options

- 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

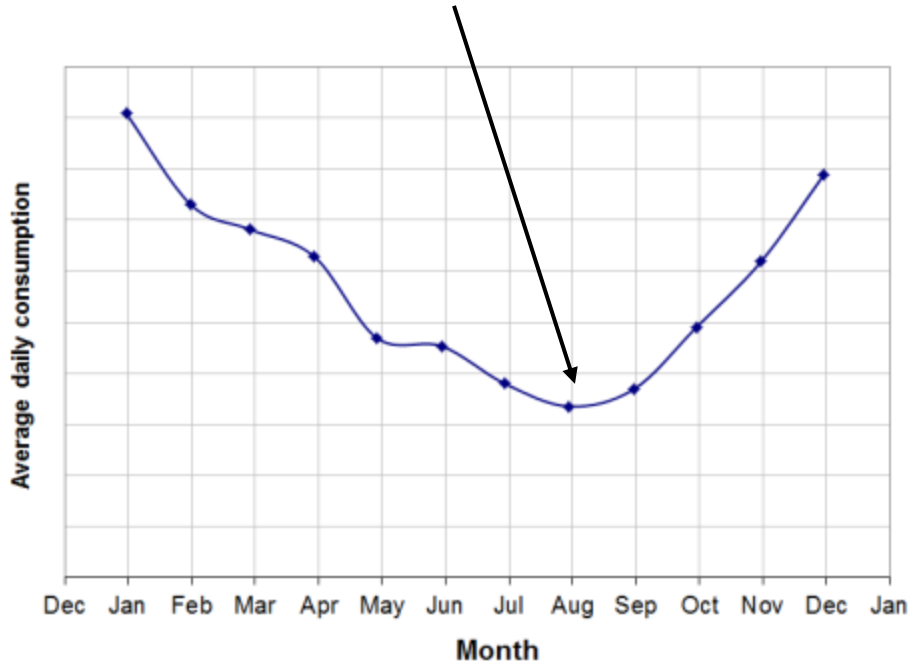
Evaluate Ventilation

- 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 CO_2 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

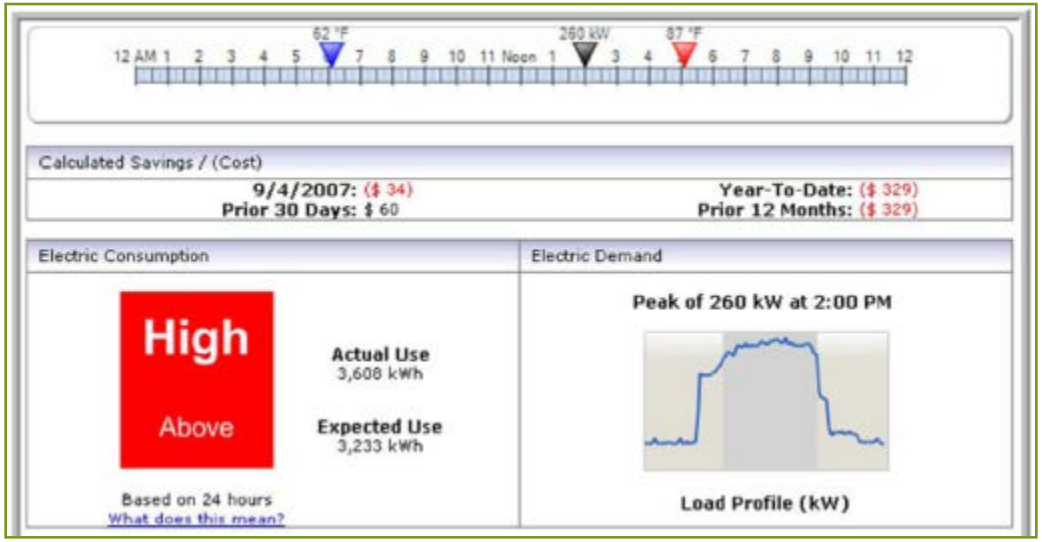
- Persistence is an issue with EBCx measures
  - Operational measures can easily be undone

- 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

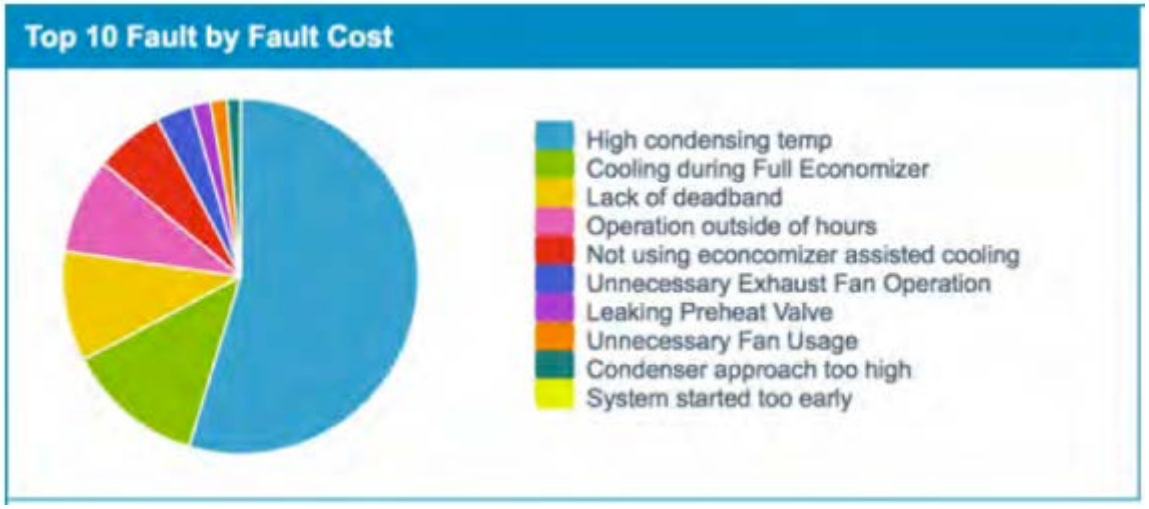
- Monitor energy consumption, identify anomalies.



Performance Monitoring Tools

System-level

- Monitors data from a BAS to continuously identify EBCx opportunities

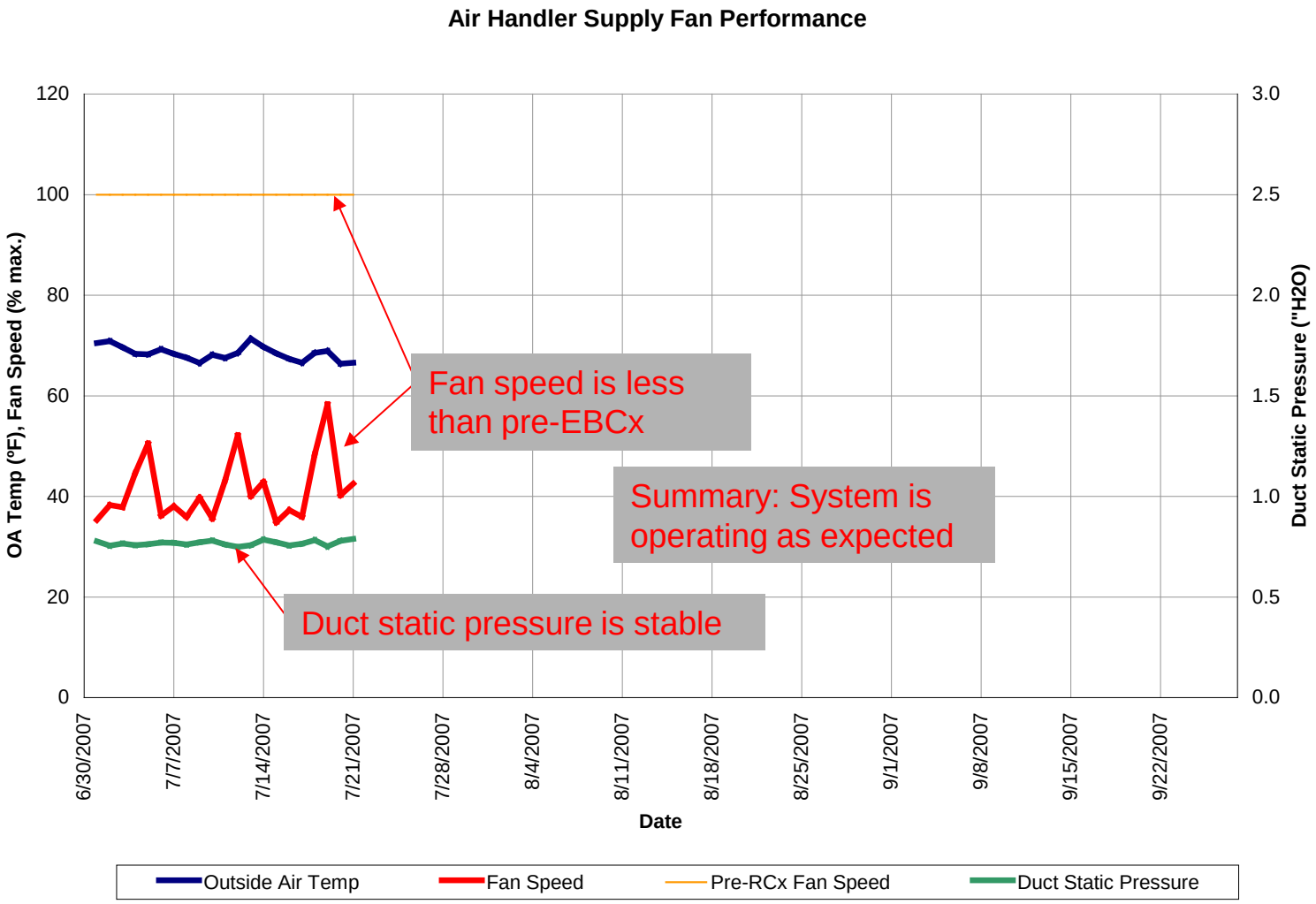


Systems Level Tracking

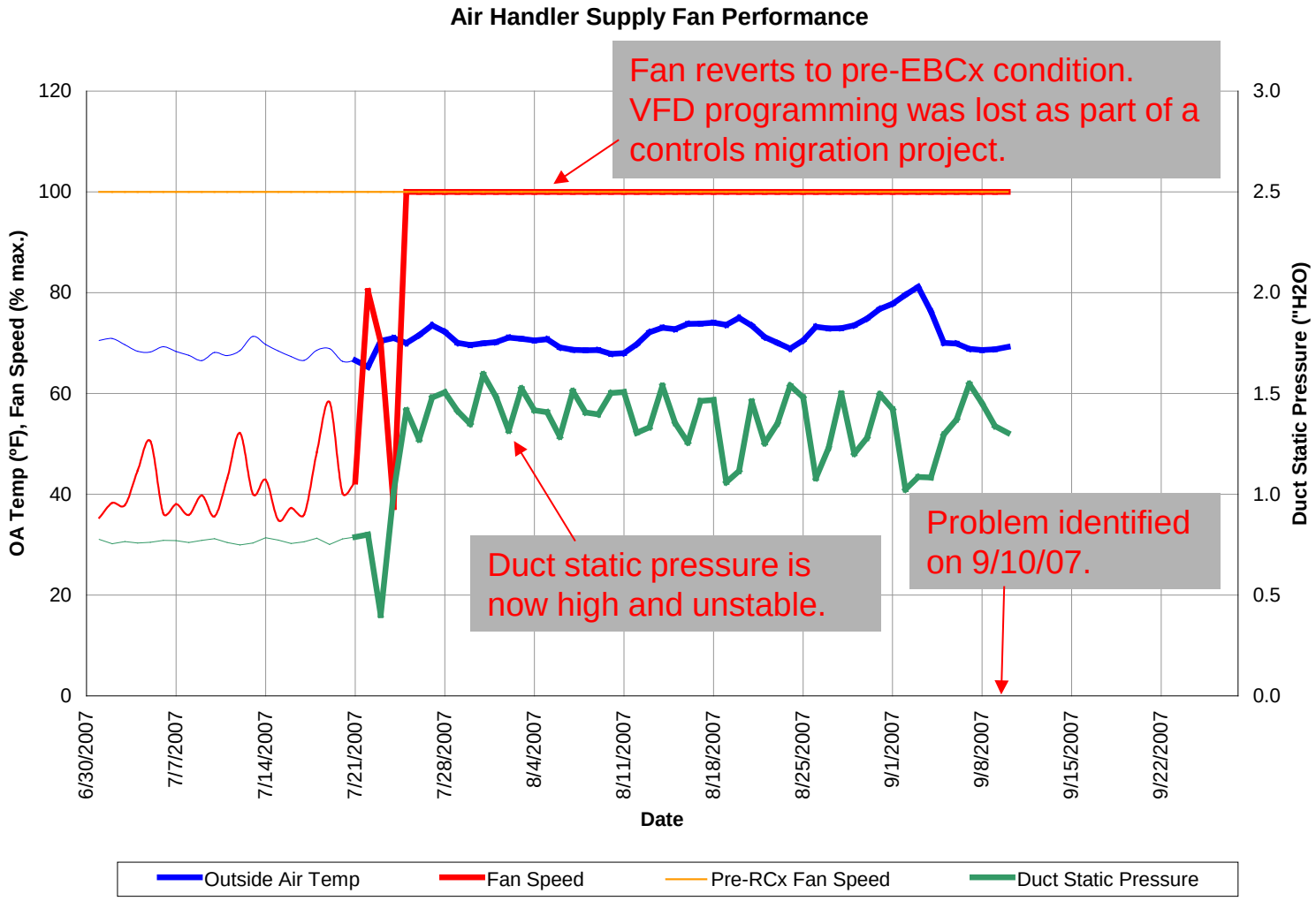
Fan Speed variation measure

- 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

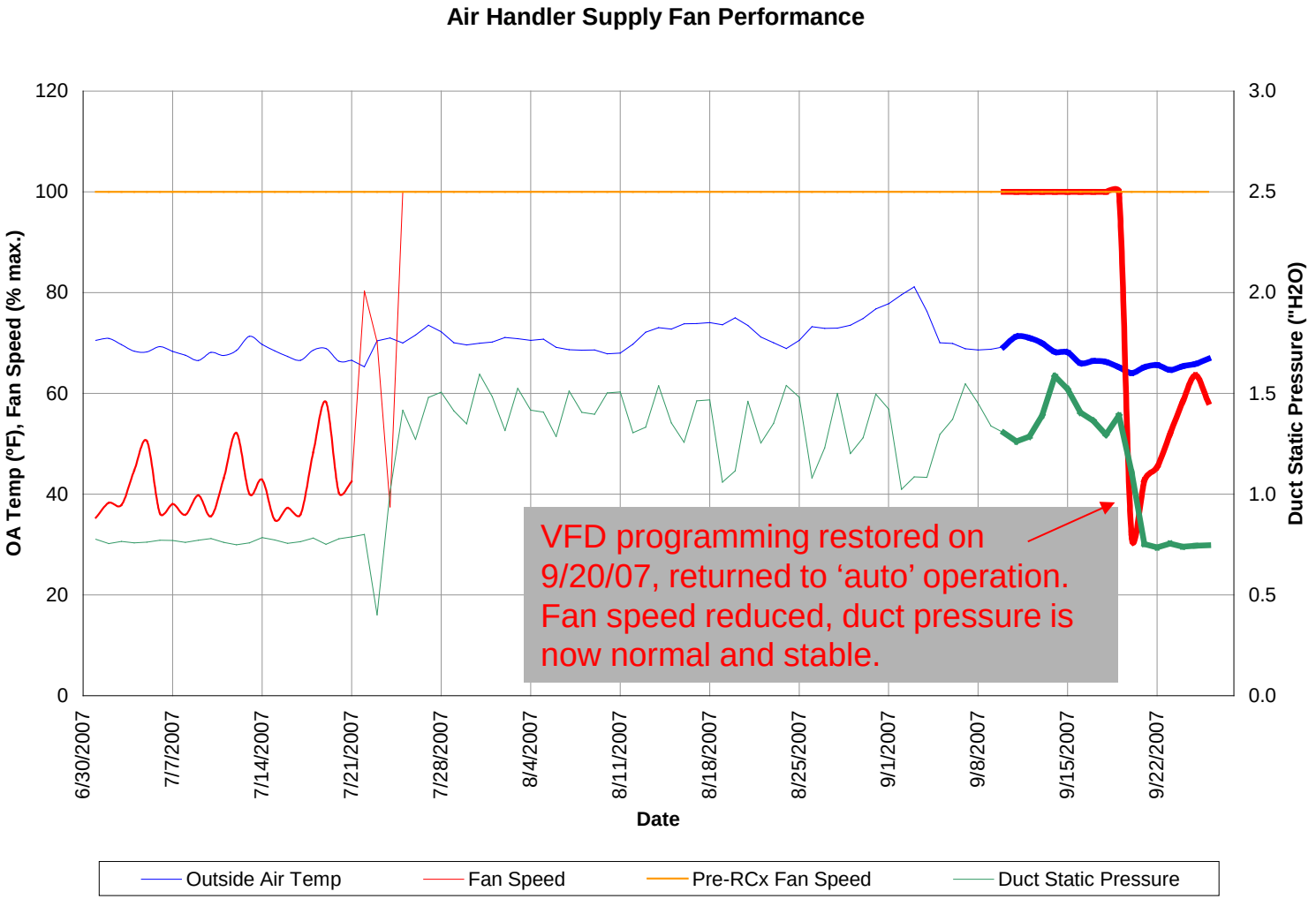
Systems Level Example



Systems Level Example



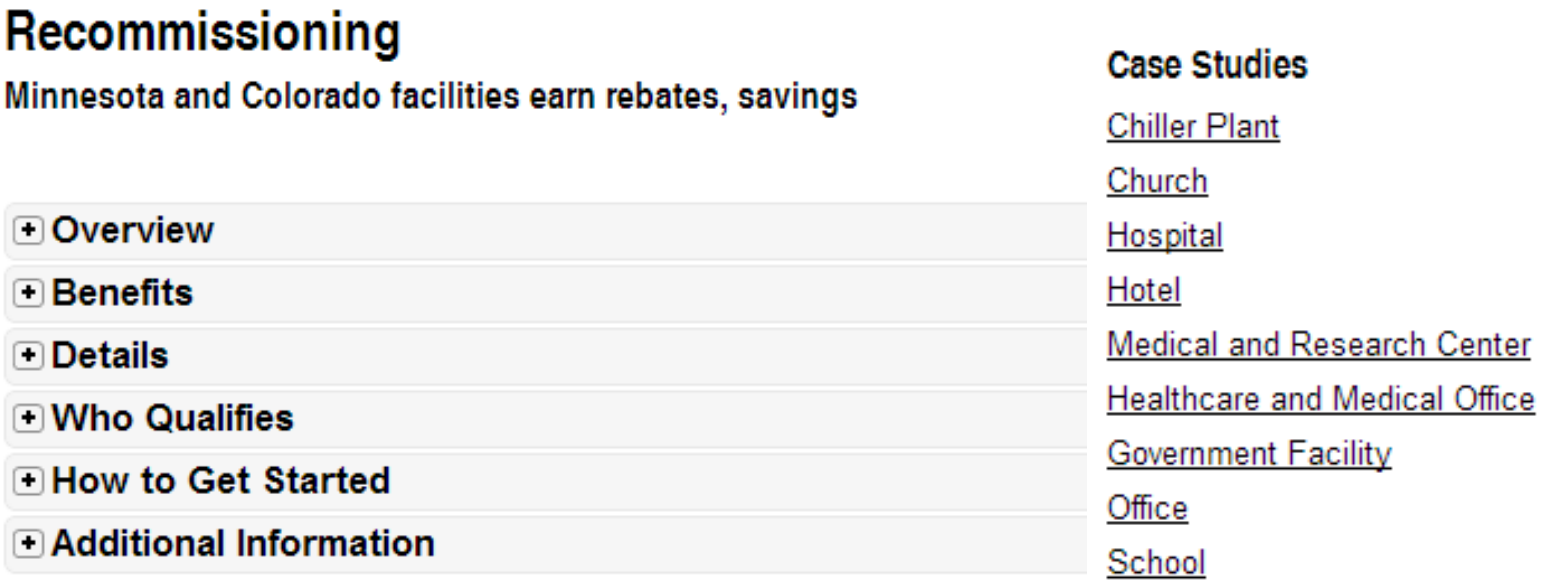
System Level Example



Resources

Resources

- **Xcel Energy: www.xcelenergy.com/recomm**



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.**

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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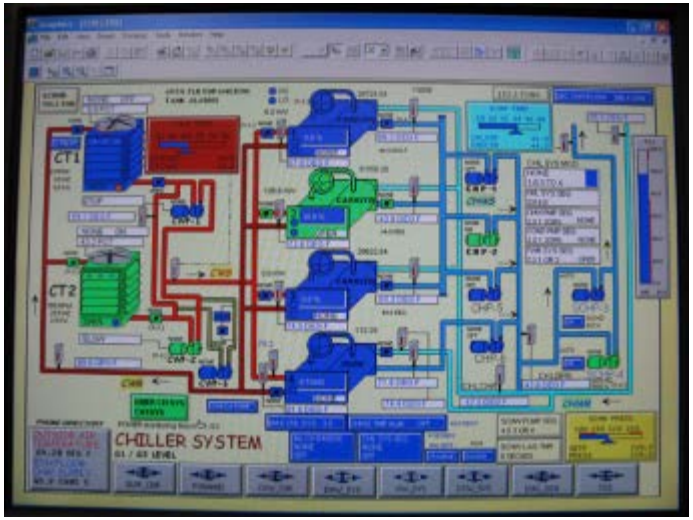


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