U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Retrocommissioning and the Public Sector

July 18th, 2013

DOE's State and Local Technical Assistance Program

DOE's Technical Assistance Program

Priority Area: EE & RE Technologies

- **Peer exchange & trainings**
  - *Re-tuning Training*: DOE & PNNL are offering classroom and hands-on commercial building re-tuning trainings, for public and private sector entities, using train-the-trainer approach, for more information email crystal.mcdonald@ee.doe.gov
  - *Federal Energy Management Program Trainings,* including past webinars: http://apps1.eere.energy.gov/femp/training/
  - *Upcoming TAP Webinars:*
    - Energy Efficiency in Higher Education, Thursday, August 1st
    - States & Emerging Technologies, Thursday, August 15th

    www.eere.energy.gov/wip/solutioncenter/wip_events.html

- **Resources**
  - Pacific Northwest National Lab's *Re-tuning Commercial Buildings*: www.pnl.gov/buildingretuning/
  - Buildings Technology Office's *Operating and Maintaining Efficient Buildings:* www.eere.energy.gov/buildings/commercial/ops_maintenance.html
  - State and Local Energy Efficiency Action Network's *Retrocommissioning for State & Local Governments*: www.eere.energy.gov/seeaction/pdfs/commercialbuildings_factsheet_retrocommissioning_stateandlocal.pdf
  - Improved *Solution Center* portal for technology deployment resources live later this year

How to Tap into These and Other TAP Offerings

- Visit the ***Solution Center***
  www.eere.energy.gov/wip/solutioncenter/

- Submit an ***application*** for assistance
  www.eere.energy.gov/wip/solutioncenter/technical_assistance.html

- Sign up for ***TAP Alerts***, the TAP mailing list, for updates on our latest and greatest
  TechnicalAssistanceProgram@ee.doe.gov

Pacific Northwest
NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

An Overview of Commercial Building Retro-Commissioning

Problems and Solutions

RON UNDERHILL

NREL TAP Webinar, July 18, 2013

PNNL-SA-96750

Why is Building Retro-Commission Training Important?

**“Tell me and I'll forget;
show me and I may remember; involve me and I'll understand”**

Chinese Proverb

Retro-Commissioning by the Numbers

- A number of studies have shown that retro-commissioning buildings can lead to significant energy savings – between 5% to 30%
- Cost of retro-commissioning varies between 0.1$/square feet (sf) to 0.6$/sf
- Cost savings can range between 0.1$/sf to 0.75$/sf
- Simple payback ranges from 3 months to 3 years
- A number of the measures addressed by retro-commissioning relate to our inability to control the building operations

Why is Retro-Commissioning not Widely Used?

- There is a perception that retro-commissioning can be expensive
  - It can be expensive, but typically has a payback within less than 3 years
- Many measures addressed during retro-commissioning do not persist for a long time (> 6 months)
- Some of the gaps in persistence directly relate to operations and maintenance staff who lack sufficient training

Re-tuning Training Can Help Bridge the Gap

- Re-tuning is a systematic process to identify and correct building operational problems that lead to energy waste
- Building re-tuning training is targeted at building operations staff and implemented primarily through the building automation system
- May also include small, low-cost repairs, such as replacing or calibrating faulty sensors
- Once the staff are trained to re-tune buildings, it will address both the cost and the persistence question
- By leveraging information from the building automation systems and targeting operational problems, cost of implementation is significantly lower than retro-commissioning
- Because re-tuning costs a fraction of retro-commissioning, it can be periodically done to ensure persistence

U.S. Department of Energy Building Re-tuning Training Outreach

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

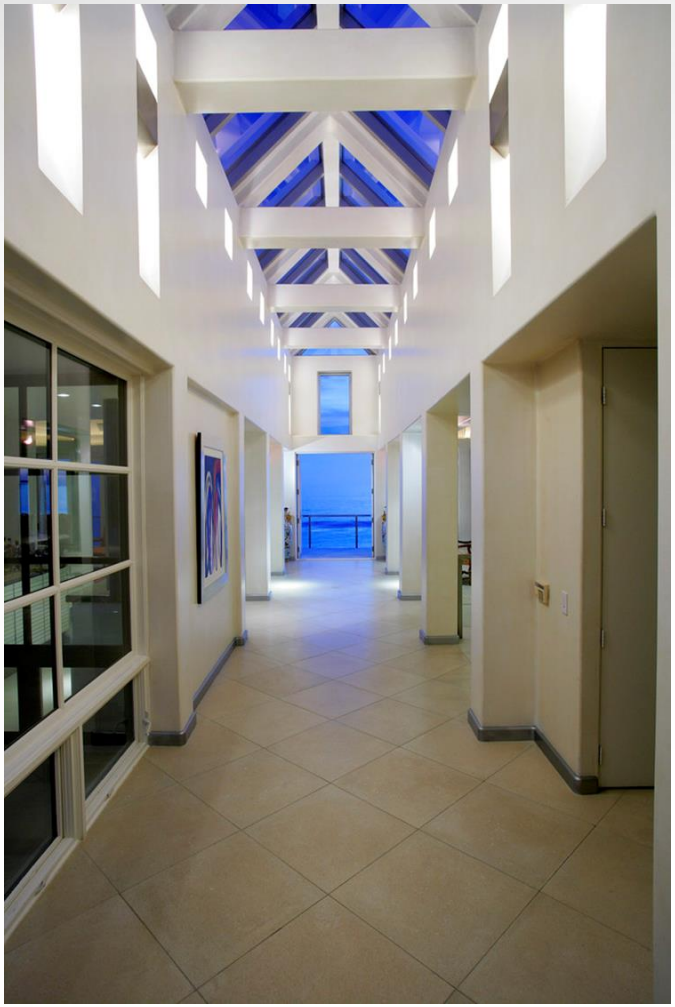
- Building re-tuning training was originally developed as part of a project funded by Washington (WA) State (www.retuning.org)
- Training outreach has been extended beyond WA State (www.pnl.gov/buildingretuning) with U.S. Department of Energy funding
- Intended for building operations staff, retro-commissioning providers, and energy service providers
- Converted the training into an online interactive training
- Recently developed re-tuning training for small/medium-sized building – prescriptive approach

Pacific Northwest
NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

Overview of Large Building Re-tuning Training

Large Commercial Building Re-tuning Training

- Training consists of two parts:
  - Classroom training - 8 hours; limited to 20 to 25 people
  - Field training - 1 to 2 days, depending on the size of the building; limited to 10 to 12 people
- Intent of the training
  - Provide an in-depth training of the re-tuning approach
  - Prepare the participating technicians and operations staff for hands-on field training
  - Provide students an opportunity to ask questions and get clarification on any aspect of the re-tuning process



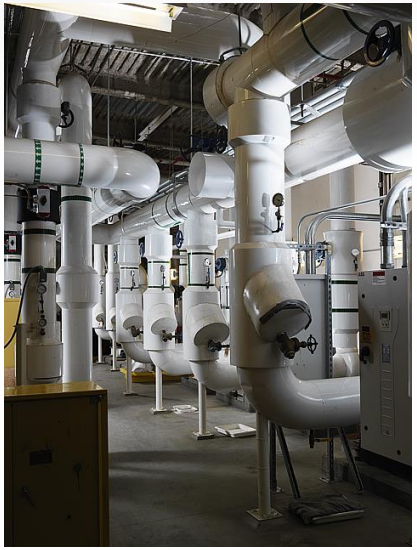
Six Primary Steps of Large Commercial Building Re-tuning

- Collecting initial building information: Basic building information
- Pre-re-tuning phase: Building Automation System (BAS) trend - data collection and analysis
- Building walk-down: Getting to know the building
- Re-tuning: Identifying and correcting operations problems
- Post Re-tuning: Reporting re-tuning findings
- Savings analysis: Determining and reporting the impacts

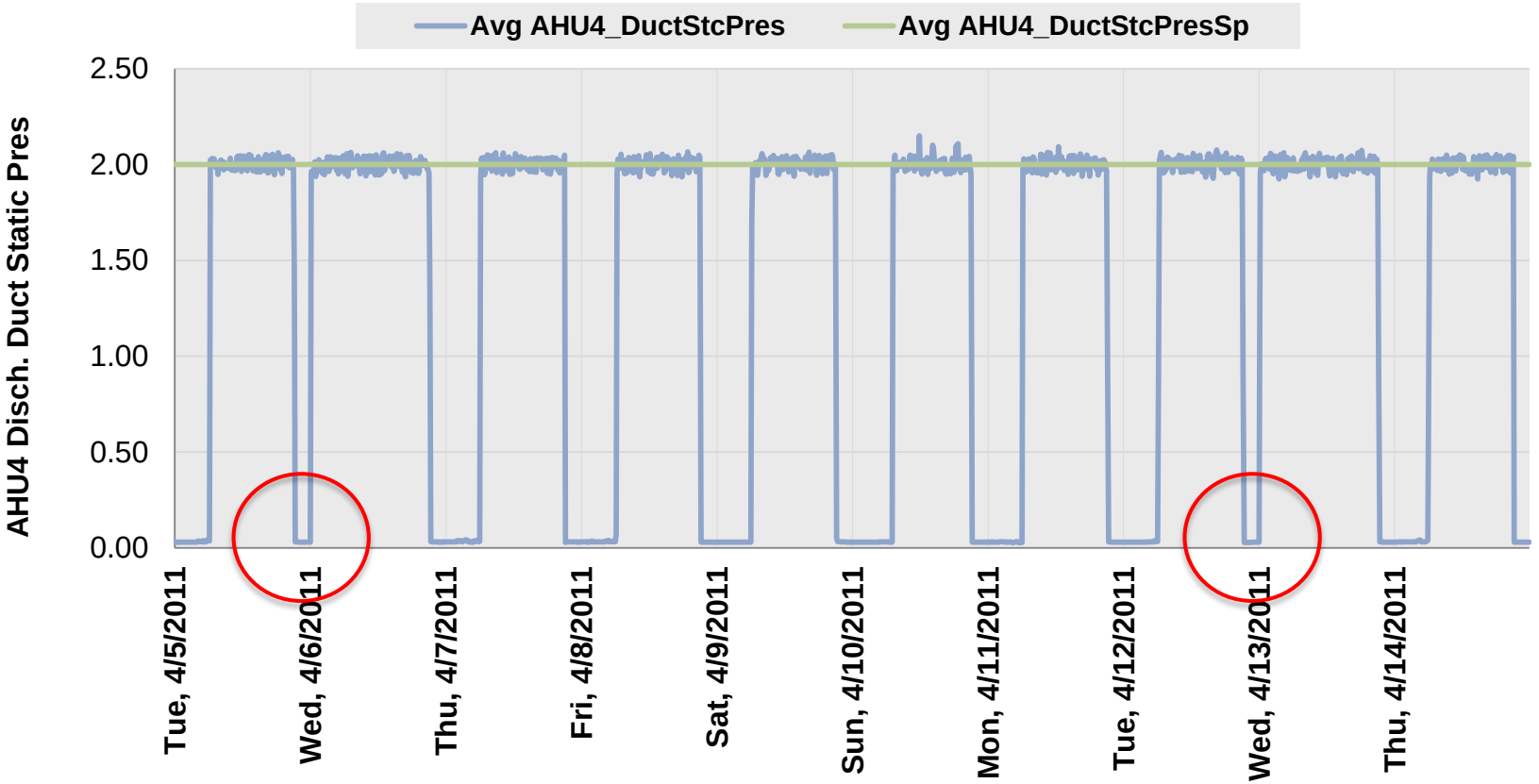
Large Commercial Building Re-tuning- Common BAS Trend Data Problems Identified

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

- Occupied schedules – are they longer than they need to be?
- Night and weekend operations – who is watching the building after hours?
- Equipment running during unoccupied periods (e.g. exhaust fans, lights, circulation pumps, etc.)?
- Discharge-air temperature set points – too low?
- Air-handling unit (AHU) simultaneous heating and
- cooling?
- Discharge static pressure set points – too high?
- Economizer problems – excess outside air?
- Automatic reset of discharge - air temperature?
- Automatic reset of discharge static pressure?
- Central plant – automatic resets on distribution loops (both hot and chilled water differential pressure) and water temperatures?
- Zone conditioning – are zone heating/cooling set points too close?
- Meter profiles



Occupied Schedule

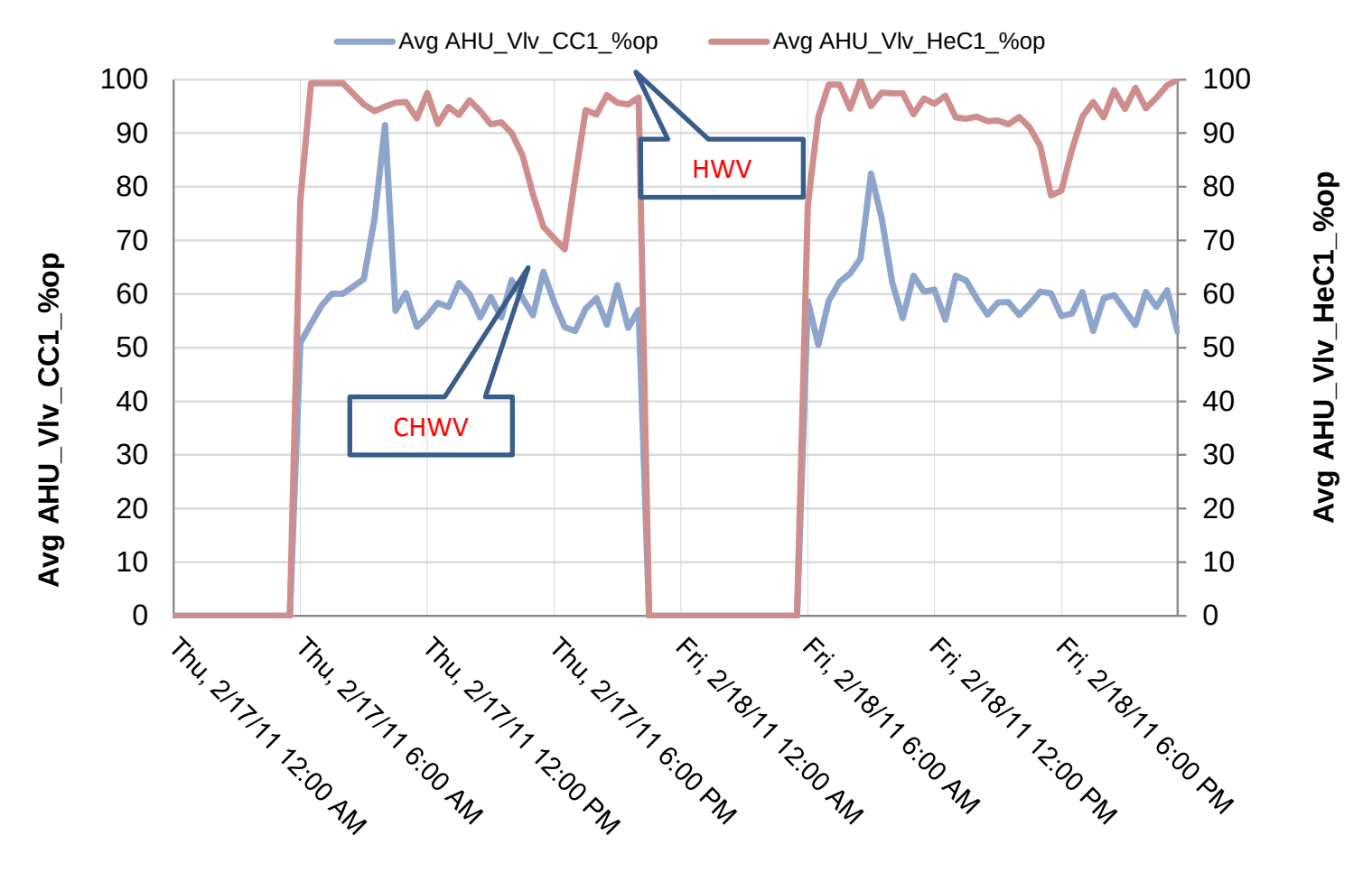


Opportunities?

Pacific Northwest
NATIONAL LABORATORY

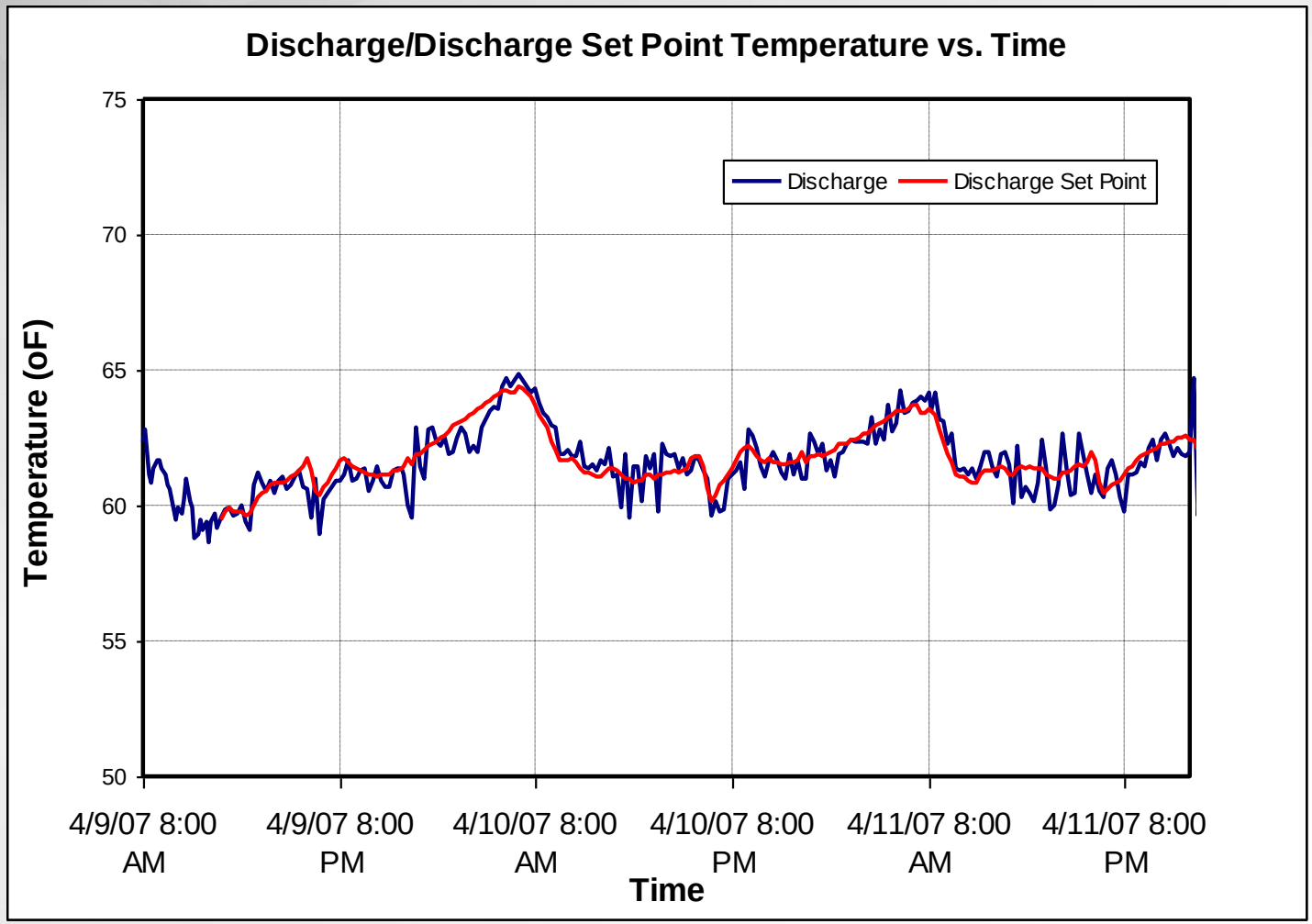
Example of Simultaneous Heating and Cooling

- Heating coil valves, cooling coil valves vs. time: Simultaneous Heating and Cooling



Air-handler Discharge Air Temperatures: Example Use of Graphs

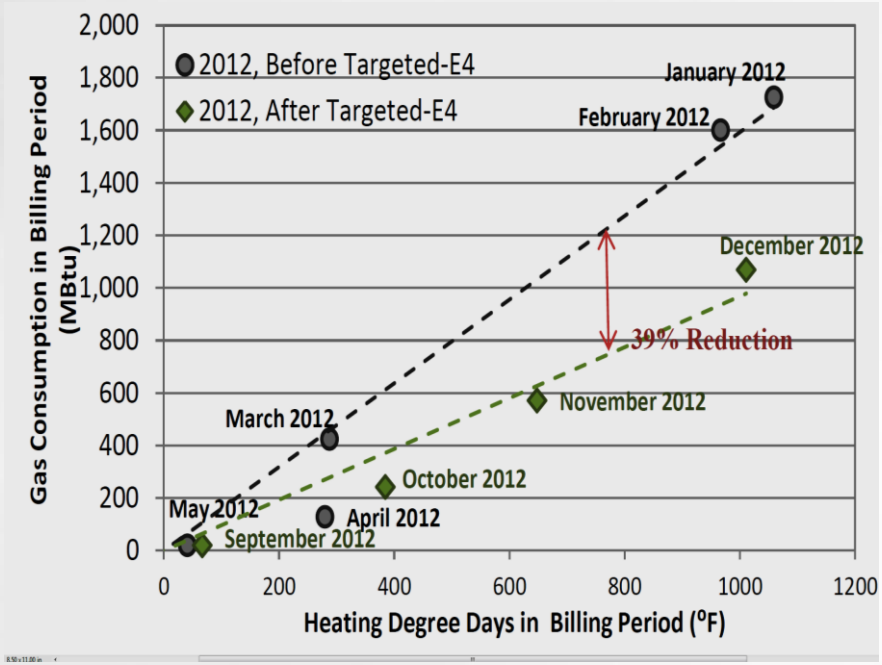
- Discharge air temperature and discharge air temperature set point vs. time – 3 days

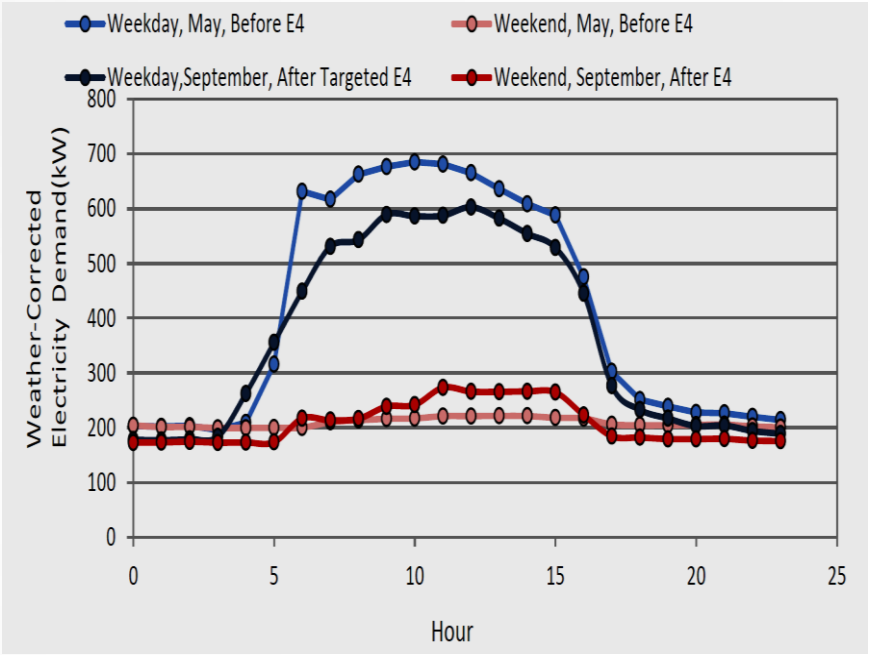


Good Example- Discharge air temperature reset

Large Commercial Building Re-tuning- Common Problems Fixed and the Results

- As much as 30% of energy consumption is wasted because of our inability to operate the buildings efficiently
- Train building managers and operations staff on how to identify and correct operational problems as they arise, rather than years later
- Re-tuning training will result in a **proactive** and more efficient building operations at very little cost to the building owner/manager





Overview of Small Building Re-tuning Training

Small/Medium-Sized Building Re-tuning: Basic Energy Management Principles

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

- If you don't need it on, turn it off
- If you don't need it at full power, turn it down
- Make "smart" energy decisions when adjusting systems to the real building needs
- Learn and know your building's personality
- Save energy without negatively impacting the comfort of the occupants
- While walking-down to investigate the building condition and operations, be vigilant, use your senses – look, listen, smell and touch (be careful when touching!)
- If possible, perform the walk-down during both occupied hours and also during unoccupied hours (nights and weekends)

Four Primary Steps of Small/Medium-Sized Building Re-tuning and Target Audience

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

- It will use a four-step approach:
  - **Initial data collection phase**: Collection of information about the building
  - **Investigation phase**: Building walk-down to identify and characterize the building operations
  - **Implementation phase**: Application of prescriptive re-tuning measures
  - **Documentation phase**: Reporting of measures implemented and calculation of energy savings

- A prescriptive approach to identify and correct no-cost or low-cost building operational problems that lead to energy waste
- May include identifying other opportunities for improving energy efficiency that require investment

- The target audience includes:
  - Onsite employees (maintenance and operations staff) responsible for day-to-day building operations
  - Onsite supervisors and building managers
  - Offsite contractors (retro-commissioning agents, service providers or control vendors)

Small/Medium-Sized Building Re-tuning Training: Major Focus Areas

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

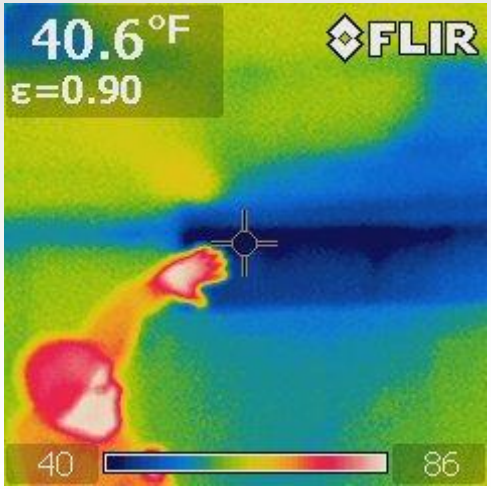
- Building envelope
- Heating, ventilation and air-conditioning (HVAC) systems and controls
  - Packaged air conditioners and heat pumps
  - Gas furnaces
- Lighting and lighting controls
- Hot water
- Office equipment
- Indoor environmental conditions
- Air distribution system
- Meter profile

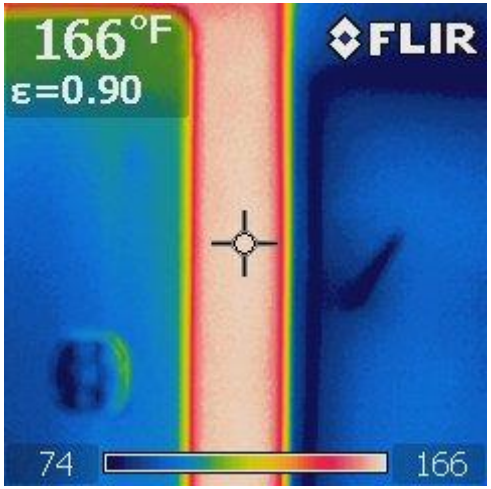
Building Envelope Walk-Down: Doors and Windows

- Focus on the outside conditions of the building
- Doors and windows
  - Are the windows operable?
  - Are the windows single, double or triple pane?
  - Are any windows or outside doors open during the walk-down?
  - Are seals, glazing and caulking in place?
  - Are the exterior doors insulated doors?

Building Envelope Walk-Down: Insulation

- Insulation
  - Use a temperature gun (or infrared camera) and take temperature readings of the walls and the ceiling
  - If the perimeter wall temperature of an office/space is significantly different from the other interior wall temperatures of the same space, the perimeter wall may not have adequate insulation or it has been compromised at strategic locations that should be further evaluated for potential improvements. A well-insulated wall should show a large temperature difference between the outdoor and indoor temperature
  - Look for missing insulation on any piping that carries heated or chilled water or steam
    - Missing insulation will contribute to energy costs and is a low-cost fix



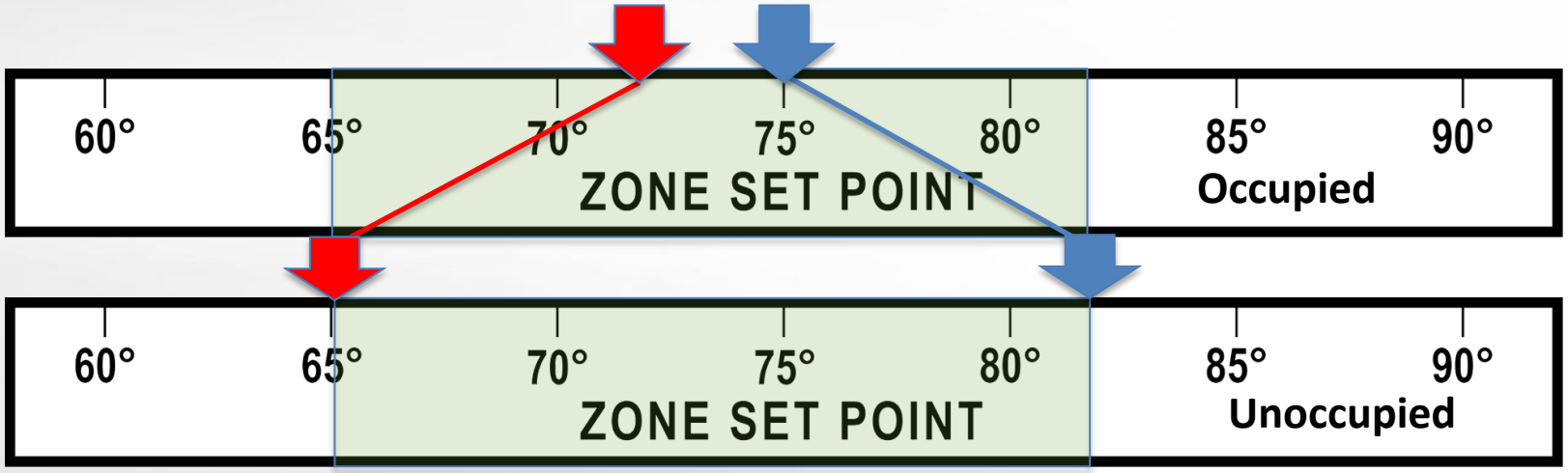


Building Envelope: Attic and Crawl Spaces

- Ventilation of attic and crawl spaces
  - Look for crawl space vents and attic vents that are closed or plugged
- Look for powered exhaust in attics
  - Do they have backdraft dampers?
  - Check if the thermostat control for the exhaust fan is working correctly
- Look for missing or damaged insulation in attic or crawl spaces
  - Damaged by water or animals?
  - Hanging loose from roof deck?
- Look for abandoned exhaust fan vents in lunchrooms or conference rooms (that were used to exhaust stove heat or for cigarette smoke exhaust – smoking rooms). These abandoned legacy exhaust vents can let outdoor air into the building if not properly sealed.

Building Walk-Down: HVAC System Controls – Programmable Thermostat Set Points

- Check the set points
  - Are there unoccupied set-back and set-up set points?
  - Is there at least a 5°F difference between occupied and unoccupied set points? Is there at least a 2°F difference between occupied heating and cooling set points? If not, recommend widening to a minimum of 2°F.
  - In heating mode, the recommended occupied set point is 72°F and the recommended unoccupied set point is 65°F
  - Similarly, in cooling mode, the recommended occupied set point is 75°F and the recommended unoccupied set point is 82°F



Lighting Systems and Controls Implementation: What's Wrong With this Picture?

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

You walk into a conference room and find that it is not in use and has not been occupied in a very long time. What actions might you consider?

- Operable light switch signs (turn off when not in use, etc.)?
- Occupancy sensor(s) working?
- Low-cost improvement opportunity for sensors?
- Over-lit (measure light levels)?
- Dimmable lighting measure?

Questions?

Ronald.Underhill@pnnl.gov

www.pnnl.gov/buildingretuning
http://retuningtraining.labworks.org

Luke Ilderton of Energy Outreach Colorado

- Director of Energy Efficiency Programs
- Experience in ASHRAE Level 1 & 2 energy audits, benchmarking, federal, state, and local energy policy, commissioning agent, technical maintenance training, energy modeling, measurement and validation (M&V), energy behavior change, and is even a former contractor!

Energy Outreach Colorado

We are a private, non-profit dedicated to helping make energy affordable for all Coloradans:

- Utility Bill Payment Assistance
- Advocacy
- Energy Efficiency Programs

Energy Outreach Colorado

Helping all Coloradans afford home energy.

www.EnergyOutreach.org

Our Efficiency Programs

- Three energy efficiency (EE) programs with actual energy savings over 20%
- EOC has spent over$27 million in energy efficiency funding by leveraging federal, state, municipal, utility, and private funding to complete projects
- Energy Education Program- Average Annual Savings of $11,388 or 7.4%

Definition of Topic

- Retro-commissioning (RCx) is a systematic process for identifying and improving less than-optimal energy performance in an existing building's equipment and control systems. The intent is for existing systems to work as efficiently as designed. This evaluation and fine-tuning process can be implemented as a one-time intervention, frequent "re-tuning," or ongoing "continuous commissioning," to ensure that the energy savings persist.
- State and local governments can use RCx as a lead component of their own facilities' energy efficiency programs and also can create RCx programs and policies that encourage or require RCx in private and publically owned buildings.

Examples:

- Local Law 87 of NYC requires an energy audit and RCxing study be produced for buildings > 50K square feet (ft^2)
- CA legislation mandates that all state-owned buildings > 50K ft^2 be retrocommissioned
- San Francisco: Commercial buildings >10K ft^2 must have an energy audit that lists Rcxing measures

Examples of RCx Changes to a Building

1. Enable malfunctioning controls
2. Optimize economizer functionality
3. Optimize schedules and optimum start
4. Eliminate boiler short cycling
5. Non-functional building automation system (BAS), allowing the building to “run wild” & equipment to function independently
6. Dedicated IT cooling

Who is Affected?

- Retro-commissioning policies and programs can affect key stakeholders:
  - Public and private building owners can practice RCx
  - Interest groups that represent property owners and managers, tenants, and energy service providers can help educate customers
- Successful retro-commissioning policies go
  - beyond a one-time effort
  - encouraging building owners to follow up with regular feedback to ensure continued performance.

How Does It Work?

- Public agencies can start by conducting RCx in a sample group of their own buildings, using the results to develop a broader policy that requires all public—and ultimately private—buildings to be retro-commissioned at specified intervals (e.g., New York City specifies every 10 years)
  - at the time of sale
  - at the time of heating, ventilation, and air-conditioning (HVAC) replacement
  - at the time of a major renovation
- Agencies also can reach private markets with voluntary RCx approaches, such as by defining RCx procedures through
  - simple checklists to assist implementation
  - by providing incentives or technical assistance.

Public Buildings

- State and local governments can conduct RCx in a sample of their own buildings, and then use the results to develop a broader policy for all public buildings
- **Incentive Program**: Illinois offers a free RCxing study to local, state, federal, school districts, colleges in a certain utility territory if clients implement $10K in improvements within 10 months of the study

Private Buildings

- State and local governments also can reach private markets with voluntary or mandatory RCx approaches
  - A voluntary approach could include defining RCx procedures via simple checklists or by providing incentives or technical assistance to conduct RCx projects.
  - A mandatory approach could require that buildings undergo RCx at specified intervals
    - At the time of sale, at the time of HVAC replacement
    - at the time of a major renovation
- State and local governments can consider the following steps when developing mandatory RCx policies for the private sector.
- Contact your electric utility or public utilities commission (PUC) first!

Complementary Policies and Programs

- Retro-commissioning is one part of an effective buildings energy efficiency policy suite, and an organization-wide energy management program.
- Retro-commissioning should be accompanied by benchmarking, rating, and disclosure policies so that building owners are more motivated to undertake RCx and so buildings can clearly demonstrate improved energy performance to the market.
- Retro-commissioning should not be a one-time effort, it should be followed-up with regular performance feedback, continuous improvement efforts, support for in-depth technical analysis of major equipment investment opportunities, technical assistance, and financial incentives.

Financing for Buildings

- Energy Service Company (ESCO)
- Loans
- Utility Incentives
- Small Business Initiatives Programs
- Train facility managers how to benchmark their buildings to determine RCxing opportunity
- Average Cost - $0.27 per sq. ft. or $33K for entire study - recently the implementation cost has doubled over commissioning study fee

Cost Variables

Scope of the project

- Number and complexity of systems
- Size of the facility
- Equipment age and condition
- Commissioning service provider rates
- Level of on-site staff knowledge interfacing with the project
- Presence of an extensive operations & maintenance (O&M) program

Non-energy Benefits to RCxing

- Improved environmental performance of building stock
- Increased thermal comfort and air quality in workspaces
- Increased employee productivity
- Increased O&M staff knowledge of their building and occupants
- Begin budgeting for future energy upgrades

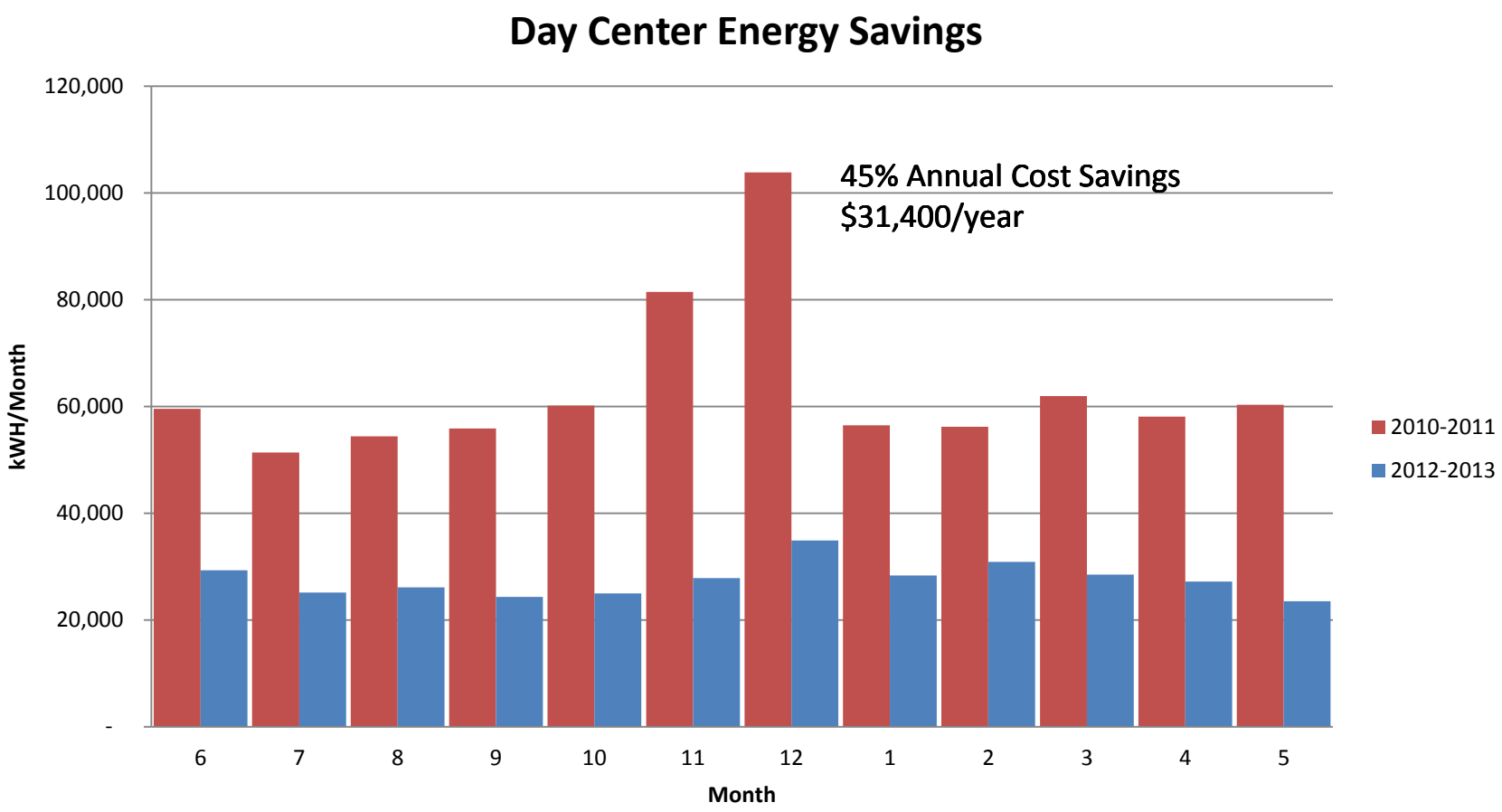
Key Points

- Retro-commissioning is a process for "tuning up" a building's equipment to make it work as efficiently as possible without major capital investment.
- Retro-commissioning for public buildings is a low-cost way to reduce energy costs by 10% to 20% and can free up public funds for other uses.
- Successful retro-commissioning policies go beyond a one-time effort, encouraging building owners to follow-up with regular feedback to ensure continued performance.

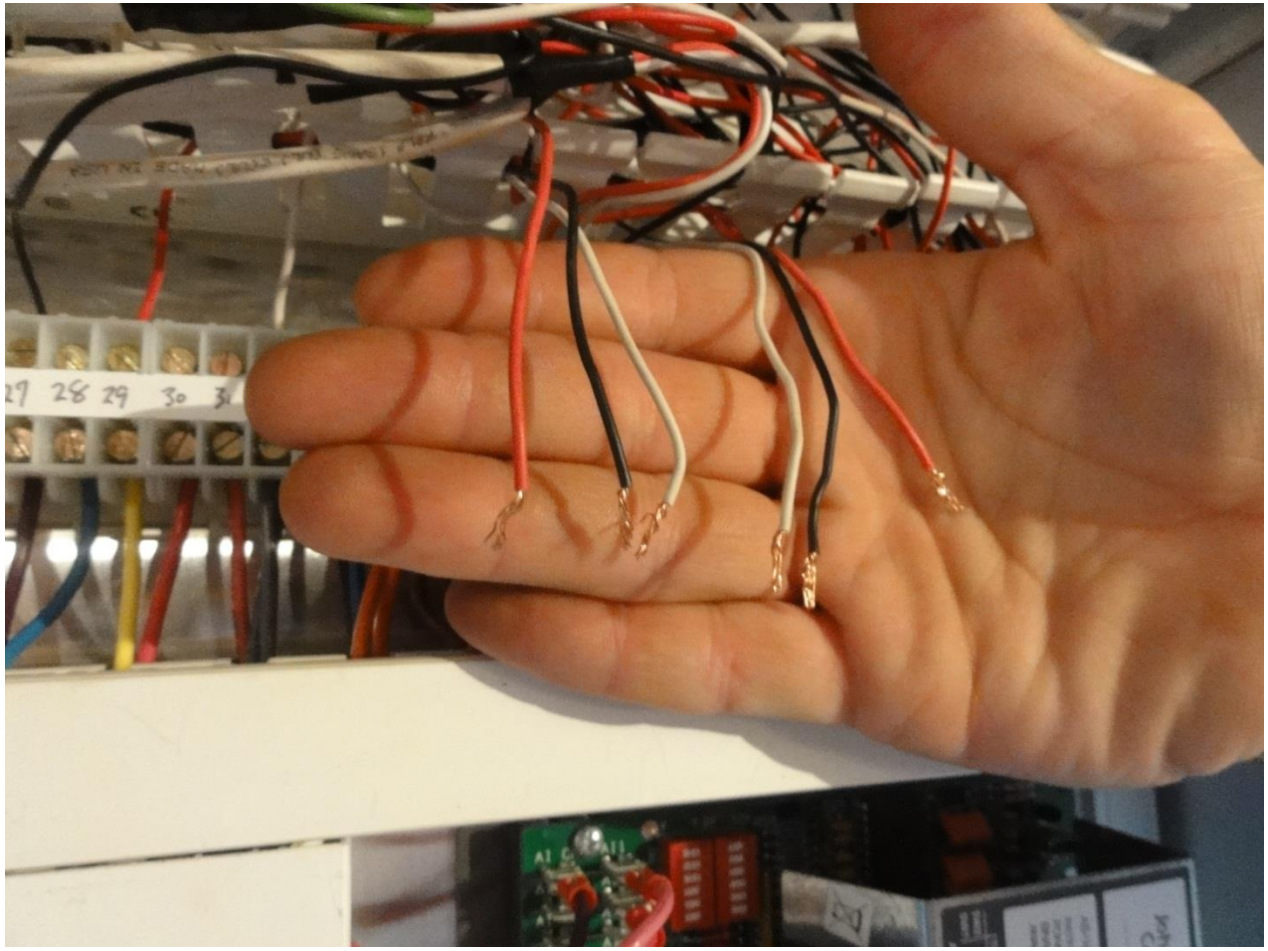
Day Shelter RCxing Project

- 31K ft^2, \$2.48/ft^2, ENERGY STAR® Portfolio Score of 2
- Built in 2007 with very efficient envelop, solar thermal DHW, and Direct Digital Controls (DDC) with demand control ventilation.
- A few years after occupancy the service agreement with the controls contractor was terminated. Several controllers lost communication with the coordinating/scheduling controller.
- Variable air volume (VAV) rooftop unit no longer had a start/stop command and defaulted to running 24/7 and supplying 55°F air. Entire building heated with electric resistance heat and operating 24/7.

Electric Usage/Savings



Disabled Controls



Community Center RCxing Project

- 33K ft^2, built in 1953 with numerous mechanical retrofits, \$1.90/ft^2, 100 panel solar array installed, ENERGY STAR Portfolio Score of 15
- **Rcxing Measures**: Shut down pumps when boiler not in use, correct unoccupied mode outdoor air damper position for all remote terminal units, match building automation & thermostat schedules to actual space occupancy schedules, optimize runtime with morning warm-up/cool-down and standardize set points across all rooftop units, relocate thermostats to improve comfort and avoid simultaneous heating and cooling

Cost-Effectiveness of Projects

Day Shelter Saving: $31,400/year

- Study and Training Cost: $8,700
- Implementation Cost: $27,200
- Simple Payback: 1.1 years

Community Center Saving: $15,790/year

- Study and Training Cost: $3,100
- Implementation Cost: $27,411
- Simple Payback: 1.9 years

New York City LL-8712

Adopted: 2009 / Effective: 2013 through 2022

Affected Property Types: Nonresidential and multifamily public and private buildings that are smaller than 50K ft^2

Key Requirements: Requires affected buildings to undergo an energy audit and RCx every 10 years

- Audits must meet the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)
- Level II Energy Survey and engineering analysis requirements, and must include:
  - Assessment of all base building systems, including building envelope and HVAC, conveying, domestic hot water, electrical, and lighting systems.
  - Recommended improvements, including implementation costs, cost savings, and simple payback.

http://www1.eere.energy.gov/seeaction/pdfs/commercialbuildings_factsheet_retrocommissioning_stateandlocal.pdf

Lessons Learned

- Energy Model ⇨ Mechanical/Electrical Design Engineer ⇨ General Contractor ⇨ Subcontractor
- Modified plans, installation problems, construction schedules shrink, equipment change orders, and facility staff doesn't have time or expertise to detect problems
- RCxing can be a valuable tool when buildings change uses, experience O&M problems, or comfort complaints

Contact Info

- For more information, contact:

Luke Ilderton, CEM, LEED AP

Director of Energy Efficiency Programs

Energy Outreach Colorado

225 E. 16th Ave; Suite 200

Denver, CO 80203

lilderton@energyoutreach.org

Office 303-226-5059