



The Solutions Network

Rochester, New York

Tuning-up Through Retrocommissioning

Tudi Haasl – PECl

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Partnerships



Learning Objectives

- ❖ Become familiar with the retro-commissioning process and its benefits
- ❖ Learn how to identify and pre-screen buildings that are good RetroCommissioning candidates
- ❖ Making a Case for RCx
- ❖ Understand Resources available to work through RetroCommissioning projects

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What is RCx?

- ❖ An event in the life a building that applies a systematic process for improving an existing building's performance
- ❖ It provides a rigorous investigation using a systems approach to identify problems and integration issues
- ❖ Generally looks for lower cost operational improvements to obtain comfort and energy savings
- ❖ May be done alone or in concert with a retrofit project
- ❖ Has typical energy cost savings between 5% and 20% with < 2 year simple payback

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How Does RCx Differ From a Tune-up?

❖ Tune-up

- Maintenance
- Components and equipment
- Capacity
- Physical
- Saving Ops

❖ RCx

- Operation
- Systems and Integration
- Performance
- Mental
- More Savings Ops

RCx includes tune-up procedures, but RCx moves beyond tune-up to look at operational issues using a systems approach to improve whole-building performance.



Why RCx?

- ❖ Owners do not typically receive fully functional building systems
- ❖ Owners face increasing numbers of performance problems
- ❖ Buildings are more complex and
- ❖ Building systems are becoming increasingly specialized and integrated



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What Else?

- ❖ Reduces Risk
- ❖ Avoids Costs
- ❖ Increases Bottom line

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Typical RCx Goals

1. Update or create new design (operational) intent to reflect current operating requirements
2. Improve building performance to meet owner's objectives
3. Train operating staff throughout the course of the project
4. Develop persistence strategies so benefits last

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RCx Process Overview

- ❖ Planning
 - Screening
 - Scoping
- ❖ Investigation
 - Testing
 - Analysis
 - Selection
- ❖ Implementation
- ❖ Hand-off

Budget 1 - **Study**



Budget 2 - **Act**

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Planning Phase - Screening

❖ Select good building candidates for RCx

Appropriate building characteristics:

- ~ Existing medium to large commercial customers
- ~ Buildings with existing direct digital controls (DDC or EMCS)
- ~ High energy consumption (BTU/ft²) (optional)
- ~ Proactive management philosophy
- ~ Mechanical equipment in relatively good condition and not at end of life





Planning Phase - Scoping

- ❖ Establish the building's energy baseline and EUI (Energy Use Index or BTU / Sq. Ft.)
- ❖ Assess the potential for low-cost energy and demand reduction opportunities with a site walk through
- ❖ Analyze results
- ❖ If sufficient opportunities exist - develop a scope of work to complete RCx process

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Investigation Phase

- ❖ Review building documentation
- ❖ Understand the current operational requirements
- ❖ Perform diagnostic testing and monitoring
- ❖ Analyze data to determine which improvements provide the greatest benefit
- ❖ Develop a Master List of Findings and Recommendations
 - Focus on long lasting operating improvements with short paybacks first
 - May recommend capital improvement opportunities
- ❖ Select measures for Implementation



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Implementation Phase

- ❖ Develop a detailed implementation plan, scopes of work, specs, and budget
- ❖ Implement the selected cost-effective improvements (and capital measures if included)
- ❖ Verify and document results



How does it all get done?
Who does what?



Hand-off Phase

- ❖ Develop Persistence Strategies
 - Track energy and re-benchmark
 - Develop a Re-commissioning plan
 - Update PM program and service contract
 - Redefine responsibilities
 - Train Staff
- ❖ Develop the Final RCx Report
- ❖ Hold a Project Close-Out Meeting
 - Present Final RCx Report and Persistence Plan



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Making the Case for RCx; Selecting & Planning a Project

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Making the Case for RCx

- ❖ Solving Comfort Problems
- ❖ Cost Effective Energy & Cost Savings
- ❖ Other Non-Energy Benefits

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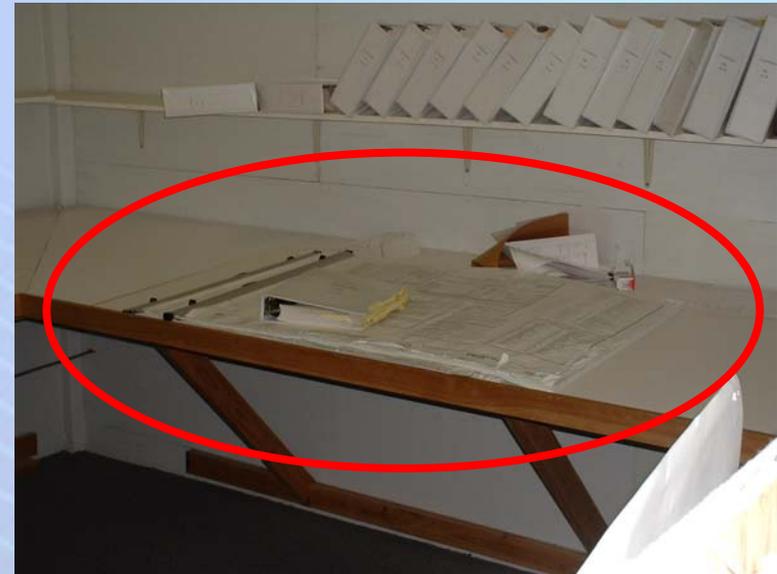
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A Lot of Thought Goes Into Building Design ...



The Architectural Contract Documents



The Mechanical Contract Documents

... yet, there is a **disparity** of design information.

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If A Few Problems Aren't Anticipated ...

... then maybe the situation has not been fully comprehended by all parties.

Evidence suggests that not everyone comprehends!

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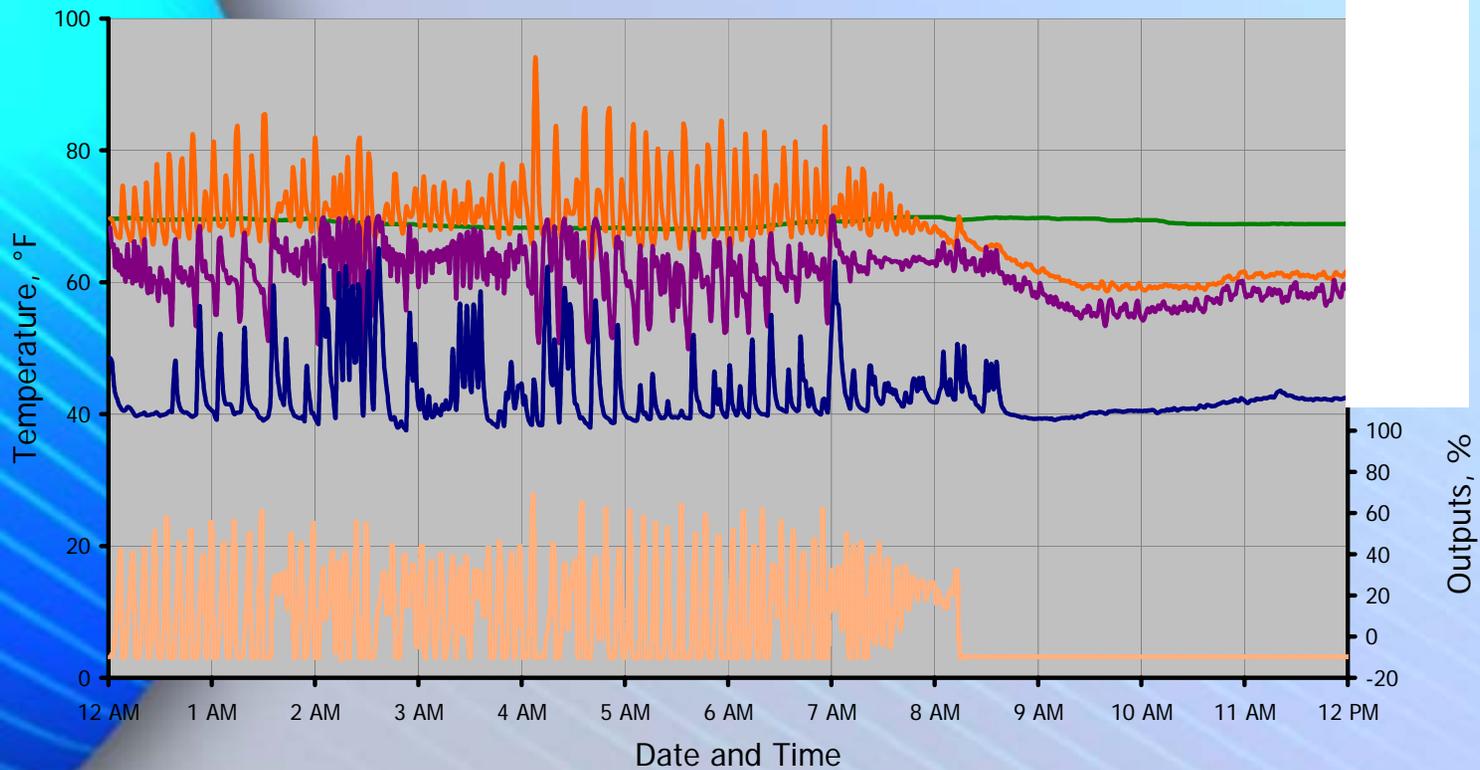
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Example commercial building...

RTU2 Temperatures - 1 Minute Sample Rate - December 7, 2001



— Zone Average Temperature — Discharge Airtemp — Mixed Air Temp
— Outside Airtemp — Heating Valve Position

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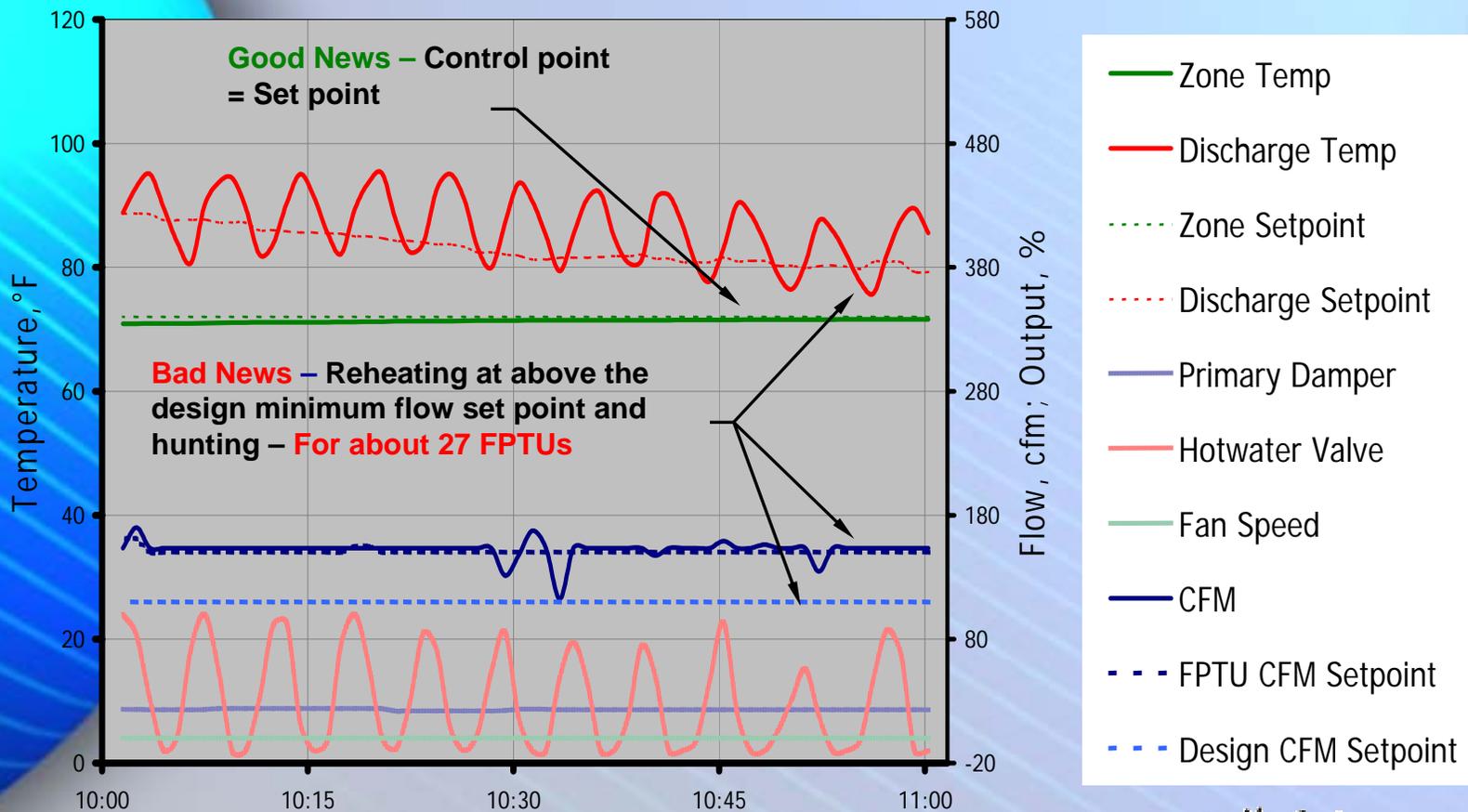
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This doesn't seem like that much ...

FPTU3 - January 10, 2002, 10:00 - 11:00 am



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Wasting \$50 - \$100 of Energy ...

... doesn't seem so bad.

- ❖ Until you multiply it by 27 other terminal units doing the same thing
- ❖ Simple fixes to typical problems lead to short paybacks
 - Tune loops
 - Correct programming mistakes
 - Apply solutions to multiple similar units



10 Actuator Cycles per Hour ...

... doesn't seem so bad.

- ❖ Until you multiply it by 8,760 hrs/year
- ❖ Life cycle testing and fatigue analysis are typically not high on list of operating goals for most commercial buildings ...

... at least not at a conscious level.



RCx's Energy Savings Potential

- ❖ Most projects see a 5% - 25% reduction in utility cost as the result of low cost Retro-commissioning efforts
- ❖ Paybacks of 2 years or less are common
- ❖ See *Retro-Commissioning's Greatest Hit's*, presented at ICEBO 2001 by Tudi Haasl, downloadable from www.peci.org

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Quantifying NEBs

Non-Energy Benefits Including Productivity, Liability, Tenant Satisfaction, and Others: What Participant Surveys Tell Us about Designing and Marketing Commercial Programs

- Dennis Pearson, Seattle City Light
- Lisa A. Skumatz, Skumatz Economic Research Associates, Inc.

Published at 2002 ACEEE Summer Study on Energy Efficiency in Buildings

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NEBs Improve Payback Potential

- ❖ Non-Energy Benefits valued by the beneficiaries at up to 50% of the energy savings benefit
- ❖ Comfort Problems often trigger RCx Projects; can be of more value to some owner/managers

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What Does It Cost?

- ❖ \$1,500 to \$3,000 to scope out a typical project
- ❖ \$0.10 to \$1.00 per square foot for the RCx process depending on:
 - Number of systems
 - System complexity
 - Number of zones
 - Data logger rentals
 - Owner's requirements
 - Subcontractor requirements
 - Implementation involvement
 - Owner involvement

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How Do You Sell It?

- ❖ Simple Payback
 - Traditional approach
 - Easy to assess
 - Limited perspective
- ❖ Net Operating Income (NOI)
 - The bigger picture





Net Operating Income (NOI) =

Gross Income less Operating Expenses

- Rental income
- Parking fees
- Vending receipts

... adjusted for
vacancy rate and
bad debt

- Utilities
- Repairs
- Maintenance
- Insurance
- Management fees
- Supplies
- Taxes

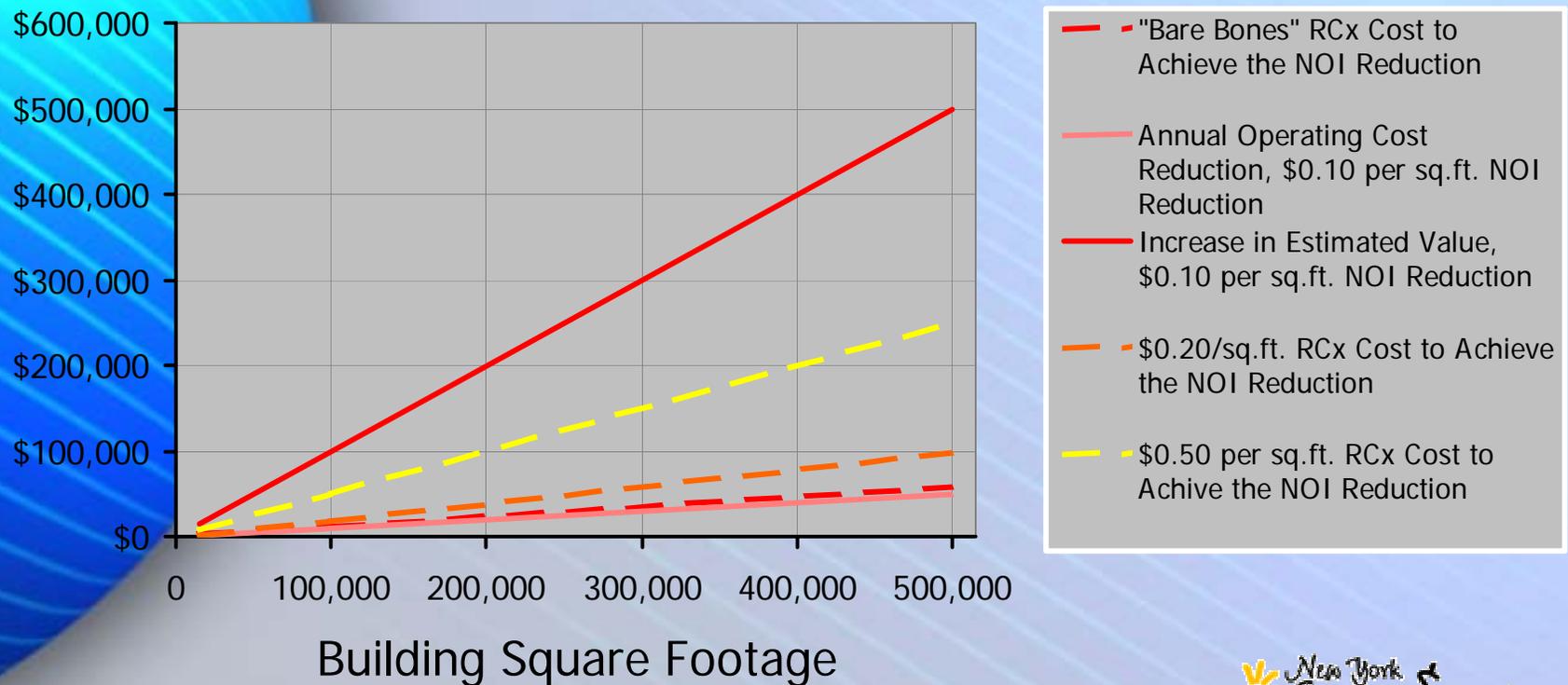
Items and allocations with tenants in both categories
vary from owner to owner and lease to lease



In the Owner's View ...

... energy savings may pale in comparison to other factors.

NOI Relationships, 10% Capitalization Rate



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Persistence is Crucial

- ❖ The results of RCx can have a major impact on asset value
- ❖ Improved asset value will only be realized at the time of sale if the RCx results persist
 - Simple is important
 - Training is important
 - Robust implementations are important

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Want to Know More?

- ❖ Read *Understanding the Value of Commissioning in Income-Producing Office Buildings* by Mark T. Jewell, RealWinWin, Inc. in the proceedings from the *2003 National Conference on Building Commissioning*
- ❖ Go to www.invest-2win.com/Topics.html

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The Bottom Line: RCx Can Improve NOI By:

- ❖ Improving tenant satisfaction
 - Improved comfort
 - Improved productivity
 - Improved IEQ
- ❖ Improving Lease-ability
 - Tenant attraction
 - Tenant retention
- ❖ Saving energy and resources
- ❖ Lowering maintenance costs
- ❖ Improving sustainability



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Retro-commissioning ...



... is not just another good idea.

It's Good Business!

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Prioritizing a Portfolio of Buildings

- ❖ Quick way to eliminate buildings that are unsuitable for a scoping study, saving you time and money
- ❖ Things to consider when prioritizing:
 - Size of building
 - Equipment age
 - Equipment configuration
 - Building maintenance practices
 - Interest of owner and operational staff in participating
 - Utility expenditures

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Building Size and Age of Equipment

- ❖ Building less than 100,000 ft² are generally not cost effective, based on energy savings, to retro-commission
- ❖ Buildings with older equipment are better candidates for equipment retrofits before undertaking a retro-commissioning process

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Prioritizing (cont.)

❖ Control Systems:

- HVAC control equipment that won't stay calibrated (manual, pneumatics and electro-magnetic) are not the best choice for a RCx process

❖ Building Maintenance Practices:

- Equipment that has not been regularly maintained will reduce effectiveness of the process



Prioritizing (cont.)

- ❖ Operational Staff or Service Contractor Buy-in:
 - Staff and or service contractors must be capable and willing (or directed) to assist and learn from the process
- ❖ Owner Interest:
 - Owner's buy-in to the process is crucial for success



Using a Checklist to Prioritize a Portfolio of Multiple Buildings

- ❖ Compare many properties in a portfolio for retro-commissioning opportunities
- ❖ Find most promising buildings
- ❖ First-cut with minimum time and effort
- ❖ Considers a mix of factors

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Who Implements RCx?

A RCx Project is a Team Process

- ❖ Owner and building operating team
- ❖ Consulting engineer and service contractors
- ❖ Commissioning specialist
- ❖ Also typically requires occupant input

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Roles and Responsibilities

- ⊕ How many psychiatrists does it take to change a light bulb?



Only 1 ...

... but the light bulb has to want to change.

The same thing is true for a successful RCx team.

Everyone has to want to RCx!



Owner's Role

Management Level

- Provide a facility
- Be open to the process as a learning and improvement process
- Coordinate funding

Remember: RCx's objectives Do Not include assessing liability or assigning blame for problems that are identified...It's about understanding and improving the building's performance!



Facilities/Ops Level

- Liaison between the building and the team
- Embrace suggestions for change and improvement



RCx Service Provider's Role

❖ Integrate and coordinate the team's effort

- Lead the process
- Plan the process
- Document the process
- Monitor the process



❖ Provide RCx technical expertise

- Techniques
- Solutions

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Supplier's and Contractor's Role

- ❖ Support the team with special skills relative to their equipment
 - Programming
 - Reconfiguring
 - Optimizing
- ❖ Integrate RCx findings and recommendations into ongoing contractual work



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Design Professional's Role

- ❖ Provide technical expertise regarding the design intent of the systems under study
- ❖ Provide technical expertise regarding HVAC and other building processes and systems



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Testing Specialist's Role

- ❖ Provide specialized testing skills and equipment where deemed necessary by the RCx process
 - IEQ monitoring
 - Tracer gas studies
 - Thermography
 - Building envelope
 - Power system



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Typical Responsibility Matrix

Retro-Commissioning Involvement and Responsibility Matrix								
RCx Process Step	Owner		RCx Consultant	Supplier/Contractor			Design Professional	Testing Specialist
	Management	Facilities		Control System	Major Equipment	Service		
Develop an RCx Plan			✓					
Run/Attend the Kick-off Meeting	✓	✓	✓	✓	✓	✓	✓	
Begin Assessment			✓					
Complete Simple Repairs		✓		✓	✓	✓		
Maintain the Master List of Potential Improvements			✓					
Add to the Master List of Potential Improvements	✓	✓	✓	✓	✓	✓	✓	✓
Develop a Diagnostic Monitoring and Test Plan			✓					
Perform EMS Trending and/or Data Logging		✓	✓	✓	✓			✓
Perform Functional Testing as required		✓	✓	✓	✓	✓		✓
Analysis and Selection of Priority Repairs and Improvements	✓	✓	✓				✓	
Implement Repairs and Improvements	✓	✓		✓	✓	✓		
Verify Results (Re-monitor and Re-test)		✓	✓	✓	✓			✓
Correct Deficiencies Identified by Verification, Fine Tune		✓		✓	✓	✓		
Final Report, Re-Commissioning Strategies, Project Hand-off	✓	✓	✓					
On-going Re-commissioning	✓	✓		✓	✓	✓		



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Case Study and Resources

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Hatfield Federal Courthouse

- ❖ 560,000 sq ft
- ❖ Five years old
- ❖ Four 110,000 cfm cooling AHUs,
- ❖ Two 100,000 cfm heating AHUs;
- ❖ Central chilled water and boiler plant
- ❖ Lots of comfort issues

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RCx findings

- ❖ 27 findings
- ❖ \$93,600/yr in estimated savings with just over 2 yr payback including investigation costs
- ❖ 14% to 18% energy bill savings
- ❖ Second stage of implementation in progress

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Major Findings Summary

- ❖ Total Est. Savings for 20 findings: \$104,000 before 10% reduction for interactive affects

<i>Category</i>	<i>Est. Savings</i>
Comfort (4)	\$ 22,000
Energy Waste (9)	\$ 68,000
Optimization (7)	\$ 14,000



Overview of Selected Findings

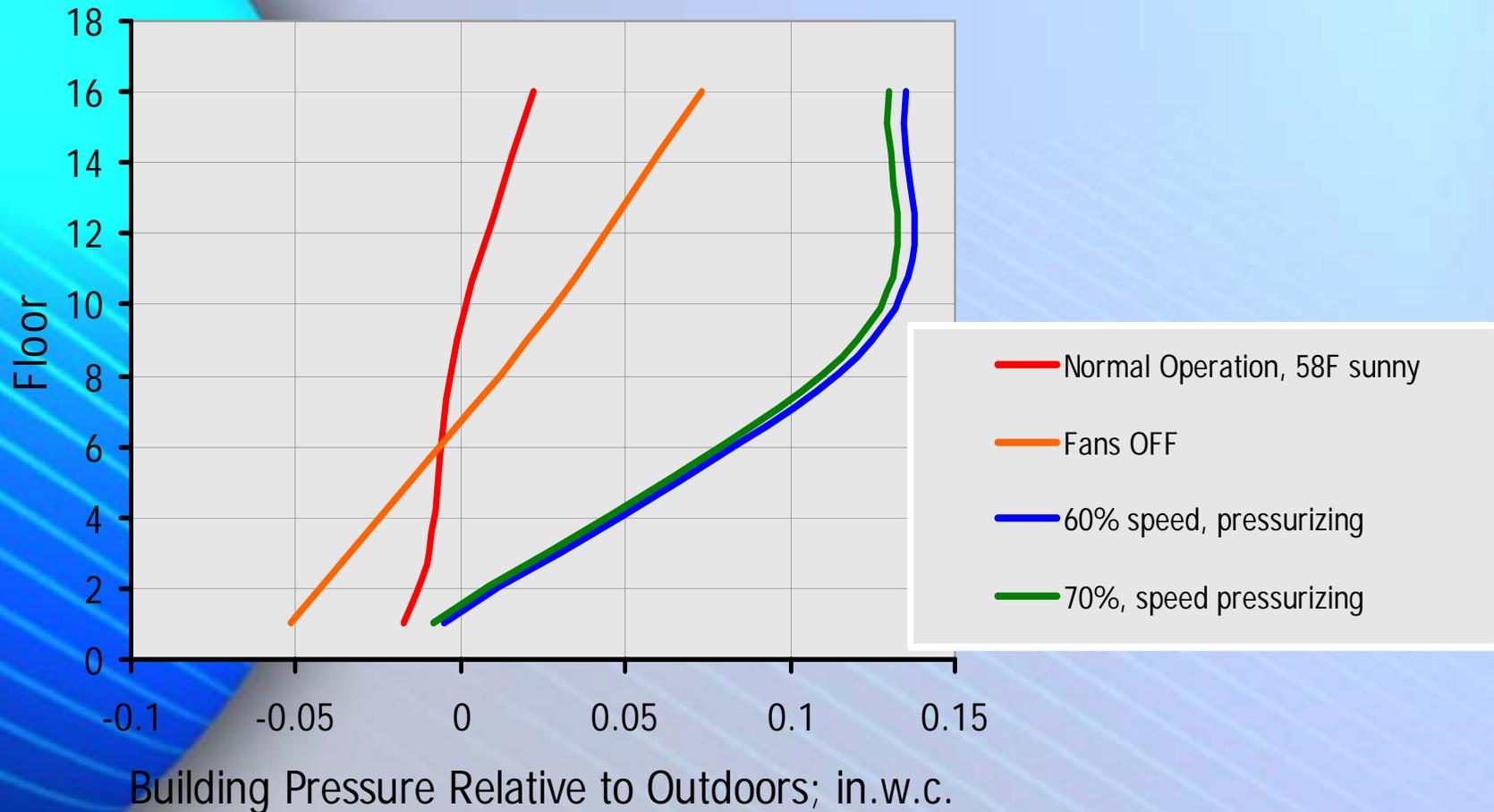
- ❖ Building Pressurization
- ❖ Relief air recirculation into outdoor intake
- ❖ Hot water plant control
- ❖ Warm-up mode controls
- ❖ Chilled water/AHU control instability
- ❖ Lighting sweep

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Whole Building Pressurization Test



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Building Envelope: Cascading Effects....

Problems:

- ❖ Lack of building pressurization = infiltration = occupant complaints
- ❖ Warm-up mode control strategy based on RAT < or = to 70 ° F.
- ❖ Warm-up occurs if the return air temperature is low, but it is low due to infiltration.
- ❖ Due to infiltration, night low limit control turns air handlers on during the night, even at 50 ° F outside air temperatures.



Sealing Gaps Improves Building Pressure



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So Many More Leaks

To find and seal
Is there another way?



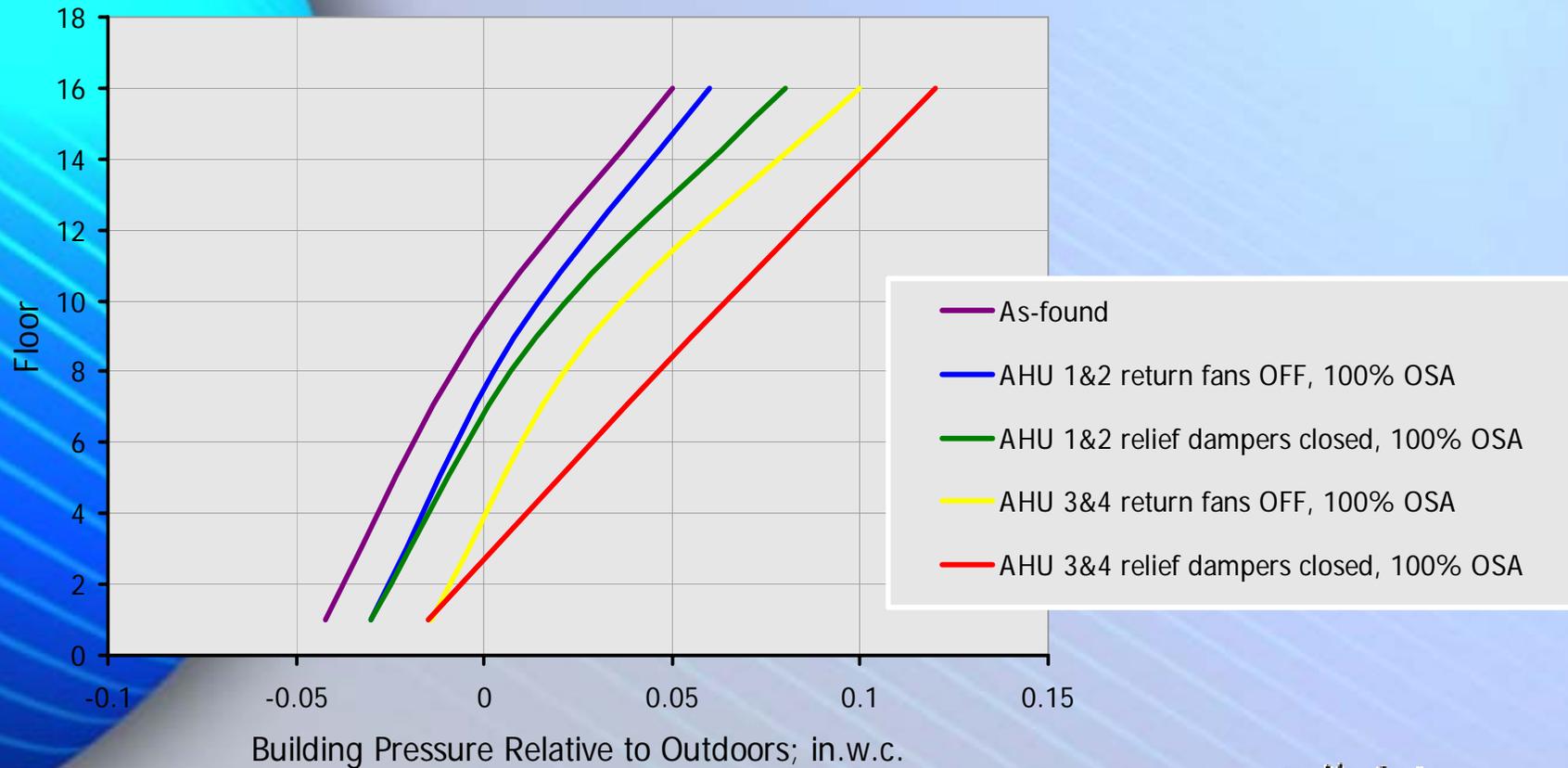
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Using control strategies to mitigate leaks...

Building Pressure Test, 2/2/04 43F outside air



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Recirculation of relief air mitigated by turning fans off



Relief

Into OA intake = reduced economizer benefit



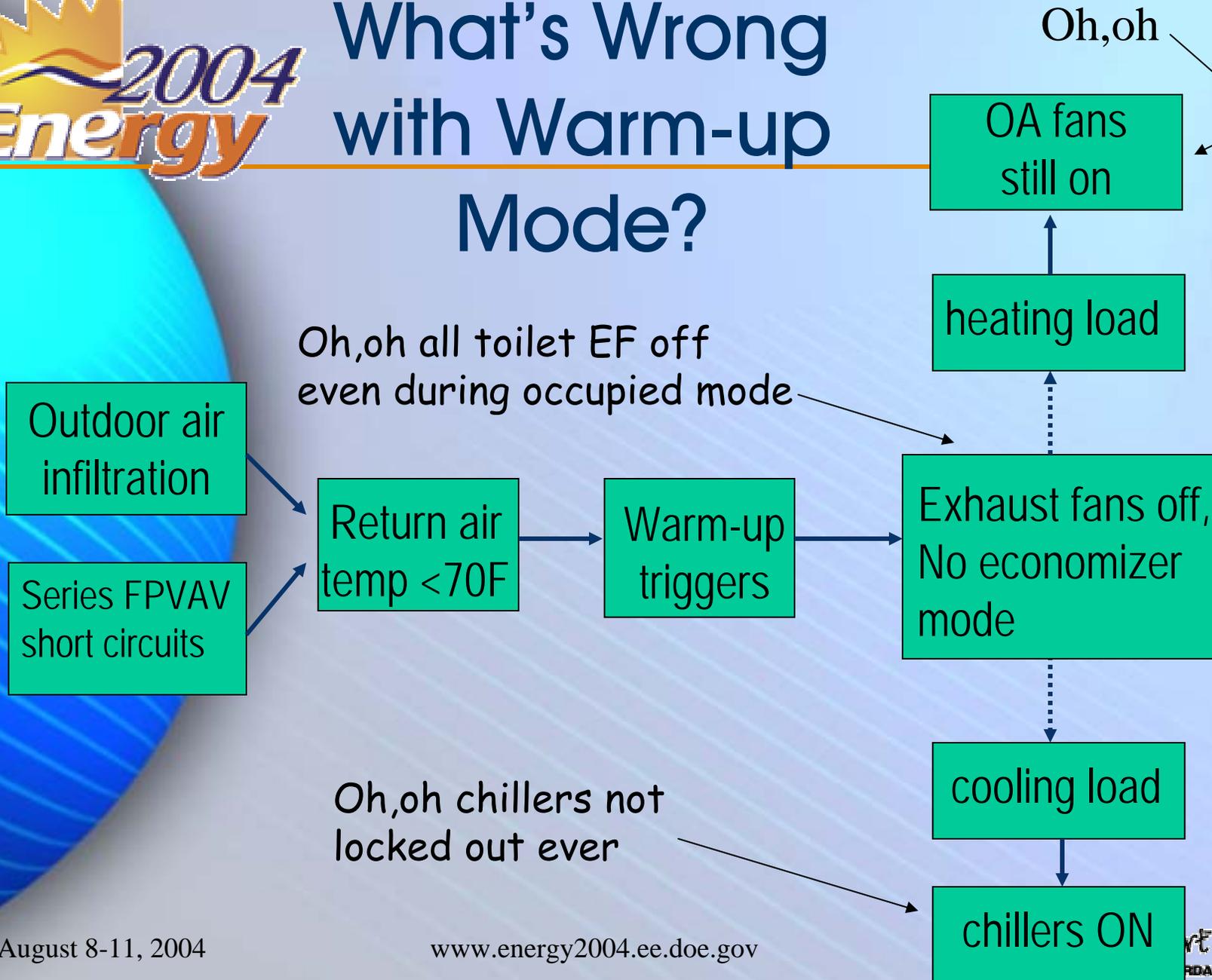
GSA previous efforts - blanked off the relief louvers

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What's Wrong with Warm-up Mode?



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Dual Cause for Heating Plant Problems

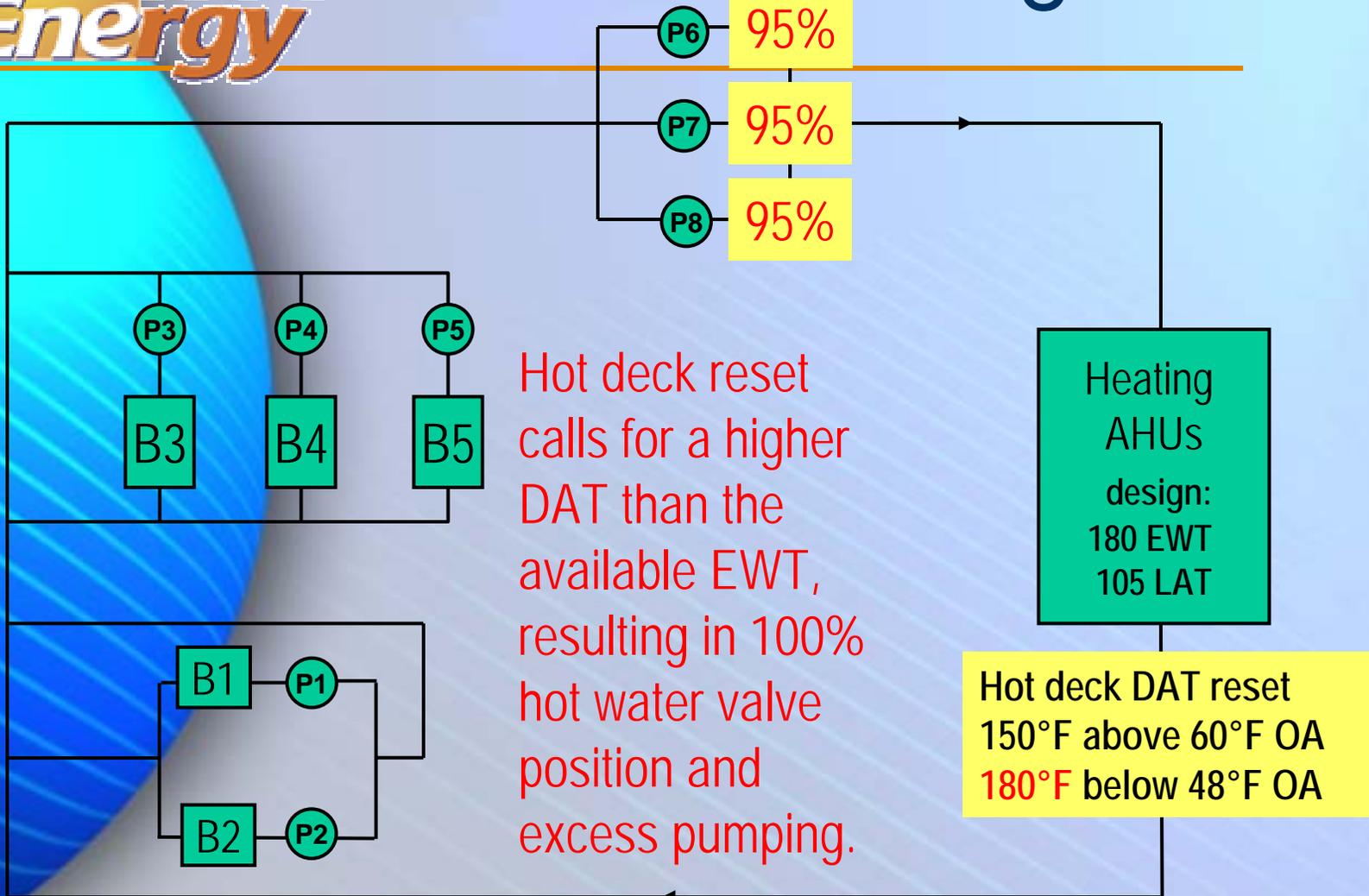
- ❖ Discharge air temperature reset not matched with hot water temperature reset
- ❖ Differential pressure setpoint across the distribution pumps set too high

A Systems approach is needed to solve the complex comfort problems

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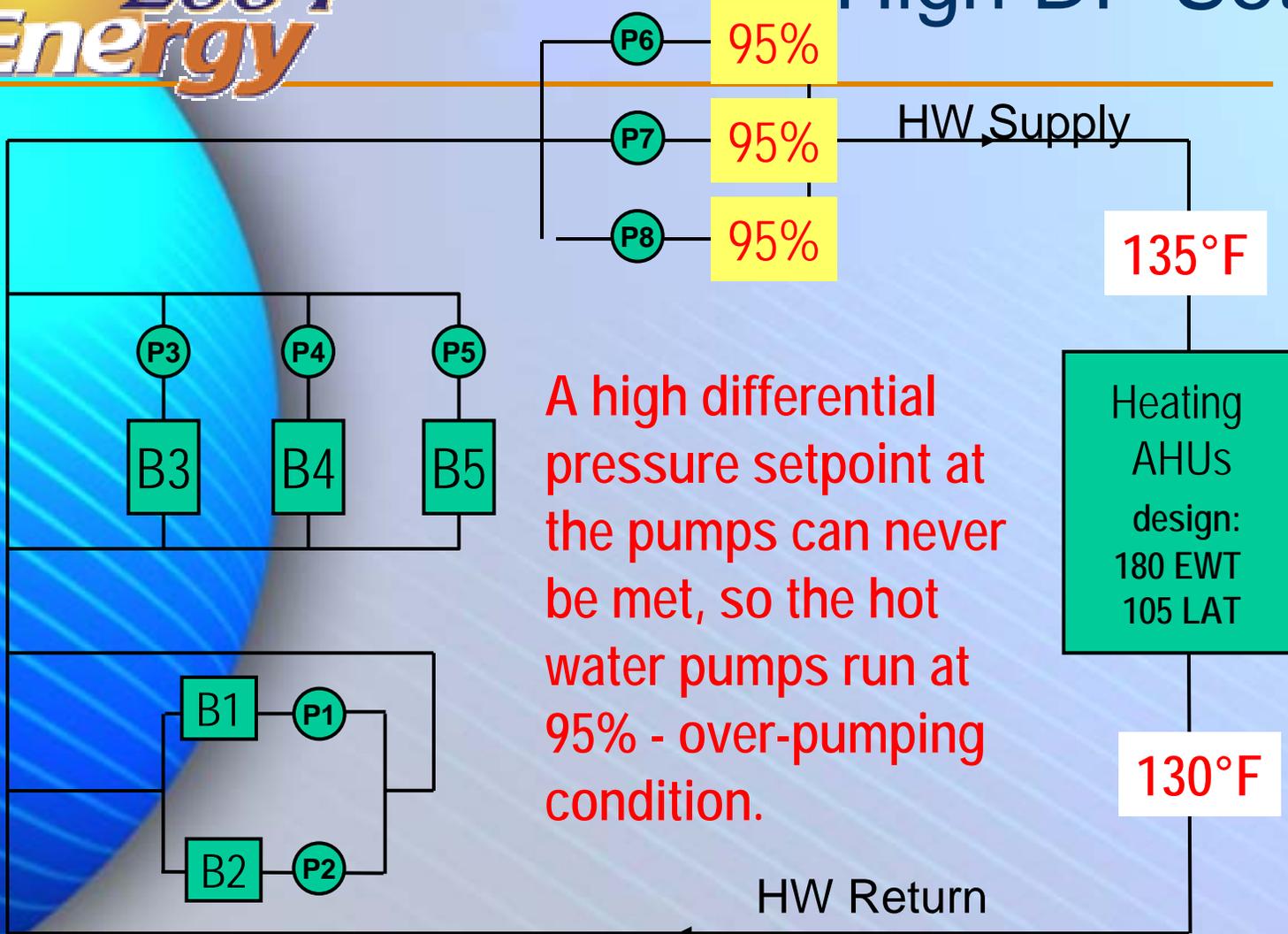
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Heating Water Control: Discharge Air Reset



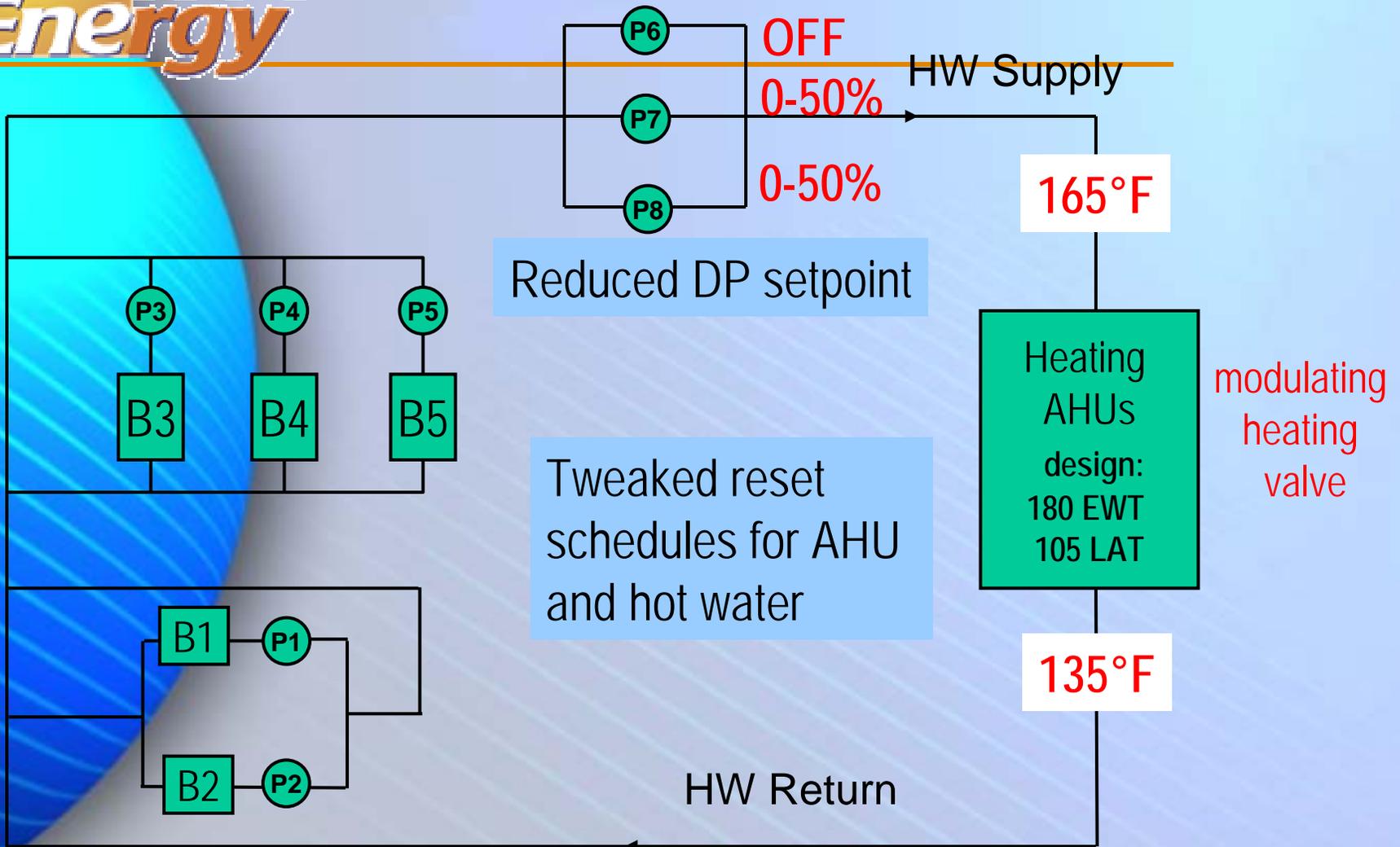
Hot deck reset calls for a higher DAT than the available EWT, resulting in 100% hot water valve position and excess pumping.

Heating Water Control: High DP Setpoint



A high differential pressure setpoint at the pumps can never be met, so the hot water pumps run at 95% - over-pumping condition.

Heating Water Pump Control – Modified





Lighting Sweep Disabled

- ❖ 5 floors lighting 24/7: over \$14,000/year waste
- ❖ Who can break into the janitor's closet?
- ❖ Give control back to occupants by adding accessible override switches for common areas
- ❖ Reinitiate lighting sweeps for offices with correct programming
- ❖ Buy-in from tenants for schedules

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Public Programs & Collaboratives

- ❖ US DOE/FEMP, <http://www.eere.energy.gov/femp/>
 - RCx in Energy Savings Performance Contracts (ESPC)
 - Rebuild America
 - Oak Ridge National Laboratories
- ❖ US EPA Energy Star Buildings Program, www.energystar.gov
- ❖ California Commissioning Collaborative, www.cacx.org
- ❖ Collaborative for High Performance Schools, www.chps.net

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Active RCx Programs

❖ New York:

- NY State Energy Research & Development Authority (NYSERDA) RCx Initiative, www.nyserda.org/commissioning.html

❖ Colorado and Minnesota:

- Xcel Energy Re-commissioning Program, www.xcelenergy.com

❖ Texas:

- CenterPoint Energy RCx Program, <http://www.centerpointefficiency.com/recx>



Active RCx Programs

❖ California:

- Oakland Energy Partnership, Building Tune-up Program,
www.oaklandenergypartnership.com/tuneup/
- Sacramento Municipal Utility District, RCx Program, [email: jparks@smud.org](mailto:jparks@smud.org)
- San Diego Gas & Electric, RCx Program,
[email: apotter@peci.org](mailto:apotter@peci.org)
- Los Angeles County Energy Efficiency Partnership & IOU/UC-Cal State Partnership,
[email: piercera@sce.com](mailto:piercera@sce.com)

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Training Programs

- ❖ Association of Energy Engineers*, www.aeecenter.org
- ❖ Building Commissioning Association*, www.bcxa.org
- ❖ Building Operator Certification*, www.theBOC.info
- ❖ National Env'l Balancing Bureau*, www.nebb.org
- ❖ NYSERDA, www.nyserda.org/commissioning.html
- ❖ Pacific Energy Center,
http://www.pge.com/education_training/
- ❖ Univ. of Wisconsin – Madison*,
<http://epdweb.engr.wisc.edu/>

* Certification offered

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Tools of the Trade

❖ Commercially-available Tools

- Architectural Energy Corporation – ENFORMA®, www.archenergy.com
- Facility Dynamics - PACRAT, www.facilitydynamics.com

❖ Emerging Tools

- Chillery Systems, LLC – ChillerCheck, www.ChillerCheck.com
- Rogers & Associates, Inc - Virtual Facility Engineer, www.facilityengineer.com



Guides

- ❖ National Building Controls Information Program
 - DDC Online, www.ddc-online.org
- ❖ Lawrence Berkeley National Laboratory
 - Functional Test Guide, <http://buildings.lbl.gov/hpcbs/FTG>
- ❖ Federal Energy Management Program
 - Continuous Commissioning Guide
http://www.eere.energy.gov/femp/operations_maintenance/commissioning_guidebook.cfm

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Guidelines

- ❖ ASHRAE Guideline 1-1996: HVAC Cx Process, www.ashrae.org (order online)
- ❖ NYSERDA, RCx Guideline, <http://www.nysesda.org/retrocxhandbookfinal040704.pdf>
- ❖ Oak Ridge National Lab/PECI, Practical Guide for Commissioning Existing Buildings, <http://eber.ed.ornl.gov/commercialproducts/retrocx.htm>
- ❖ Oregon Office of Energy, www.energy.state.or.us/bus/comm/bldgcx.htm

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Guidelines, con't.

- ❖ Pacific Gas & Electric, Energy Design Resources, www.energydesignresources.com
- ❖ Rebuild America Guide Series, www.rebuild.org
- ❖ US DOE/FEMP, www.eere.doe.gov/femp
- ❖ US DOE/PECI, Model Commissioning Plan and Guide Commissioning Specifications, www.peci.org/cx/guides

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Annual Conference

- ❖ NYSERDA IS HOSTING THE 2005 National Conference on Building Commissioning, www.peci.org/ncbc
 - May 3-5, 2005, New York City

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NYSERDA's RCx Initiative

❖ Initiative Goals:

- Provide evidence that RCx works
- Develop a stream-lined procedure for taking buildings through an RCx process
- Develop network of qualified providers
- Transform the market so RCx becomes standard practice

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How Will NYSERDA Help Me Try Out RCx?

- ❖ Initial incentive for Scoping Study
 - Limited quantity of incentives available
 - Select buildings good for demonstration and most likely to provide best paybacks
- ❖ Technical Assistance Program
 - 50% cost share to help pay for full RCx evaluation

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NYSERDA's RCx Process:

- ❖ Screening
- ❖ Scoping Study
- ❖ Technical Assistance Program Application
- ❖ RCx Evaluation Takes Place
- ❖ Implementation of Recommendations

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NYSERDA Initiative Contact Information

- ❖ More Information:
 - Adam Hinge at HingeA@aol.com or (914) 631-9061
 - NYSERDA: Kim Schryer at kas@nyserda.org or (518) 862-1090 ext. 3410
 - NYSERDA Generally at
 - (866) NYSERDA or www.nyserda.org/commissioning.html

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