

**REBUILD HAWAII CONSORTIUM MEETING**

**July 19, 2005**

# **Retro-Commissioning Buildings for Energy Efficiency**

**Making buildings work. *Better.***

**Don Davenport, P.E.  
E M C Engineers, Inc.**

## Poor Building Performance

Building commissioning is an important aspect of *new* construction projects as a process of ensuring that new buildings and their systems perform as designed.

**Unfortunately, most buildings have never gone through any type of commissioning or quality assurance process and are therefore performing well below their potential.**

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## “Quick Fix” Solutions

- Maintenance staff try to correct problems
- Severe time constraints
- Poor documentation
- Makeshift solutions
- Can lead to other problems
- Cause invisible, costly results



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## Beyond Quick-fix

- Retro-commissioning (Retro-Cx) goes beyond quick fix
- Determine root causes of problems
- Optimize building systems
- Control sequences that are optimized for efficient and effective operation
- Often reduces or eliminates need for capital improvements



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## Why Retro-Cx Anything?

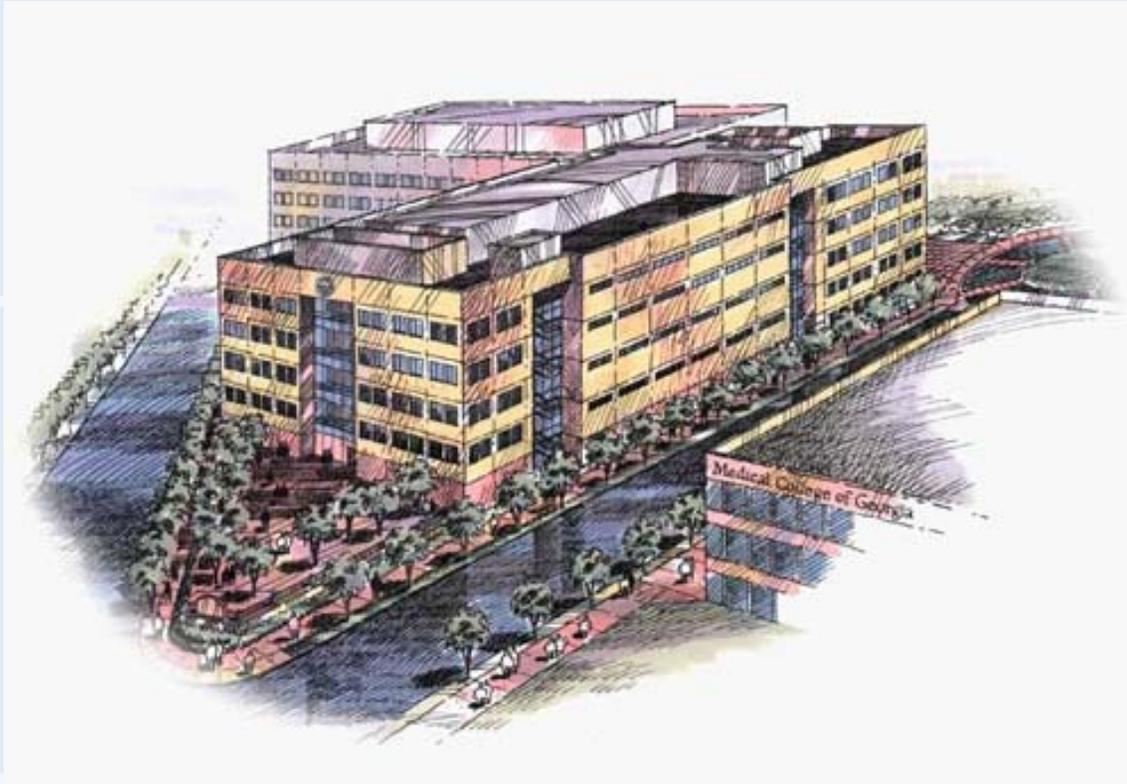
- Energy savings
- Space complaints – temperature, IAQ, etc.
- Room changed from original intent
- Modifications made to system components
- Changes to controls sequences, set points
- Building is not operating efficiently against benchmarks



**THINK ABOUT IT AS A BUILDING**

**“TUNE-UP!!”**

# *Commissioning Definitions*



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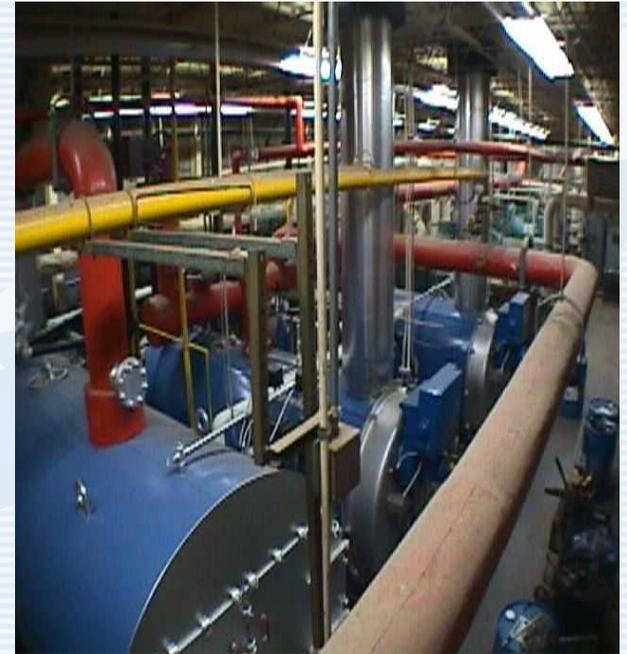
## “Flavors” of Commissioning

- Building commissioning (Cx)
- Recommissioning (ReCx)
- Continuous commissioning (CC)
- Retro-commissioning (Retro-Cx)

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## Commissioning

**Total building commissioning (Cx)** is the systematic **process** of assuring by test verification and documentation, from the design phase to a minimum of one year after construction, that all facility systems perform interactively in accordance with the design documentation and intent, and in accordance with the owner's operational needs.



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## Recommissioning

### Recommissioning (ReCx)

applies only to buildings that have previously been commissioned or retro-commissioned. The original commissioning process documented that the building systems performed as intended at one point in time. The **intent of recommissioning** is to help ensure that the benefits of the initial commissioning process endure.



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## Continuous Commissioning

**Continuous-commissioning (CC)** is an “on-going process” to resolve operating problems, improve comfort, optimize energy use and identify energy and operational retrofits for existing buildings.



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## Retro-Commissioning

**Retro-commissioning (Retro-Cx)** is a systematic process for improving the current conditions and operations of an existing building, to ensure the functionality of equipment and systems and also to optimize how they operate together in order to reduce energy waste and improve building operation and comfort – applies to buildings that have never been commissioned.



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## What is Retro-Commissioning (R-Cx)?

- Typically focuses on:
  - HVAC Systems & Controls (mostly)
  - Lighting Controls
- Evaluates the condition of building's systems and optimizes the operation and performance to meet current operational needs.
- Typically focused on reducing electrical consumption and demand reduction.

## Retro-Commissioning Benefits

- Corrections are typically low cost measures to implement
- Savings are realized in energy cost, O&M costs, avoided capital—typically 5% to 20% in energy costs alone
- Paybacks typically 6 mo to 2 years – 50% to 200% ROI
- Training O&M staff to sustain ongoing building performance improvement

# *Retro-Commissioning Process*



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## Retro-Commissioning Phases

### *Planning Phase*

Asses BAS capabilities, potential building opportunities, and Investigation approach.

### *Investigation*

Determine how systems are supposed to operate, measure and monitor how they operate, and prepare a prioritized list of the operating opportunities.

### *Implementation*

Implement opportunities and verify proper operation

### *Operating Phase*

Report operating improvements made and train the building operator how to sustain efficient operation – implement capital improvements



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## Planning Phase

### *Planning Phase*

Asses BAS capabilities, potential building opportunities, and investigation approach.

*Investigation*

*Implementation*

*Operating Phase*

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## Planning Phase

- Kick-off meeting
- Obtain building data
- Benchmark performance (EUI calculations)
- Review building operational issues
- Quantify range of potential savings
- Develop RCx Plan

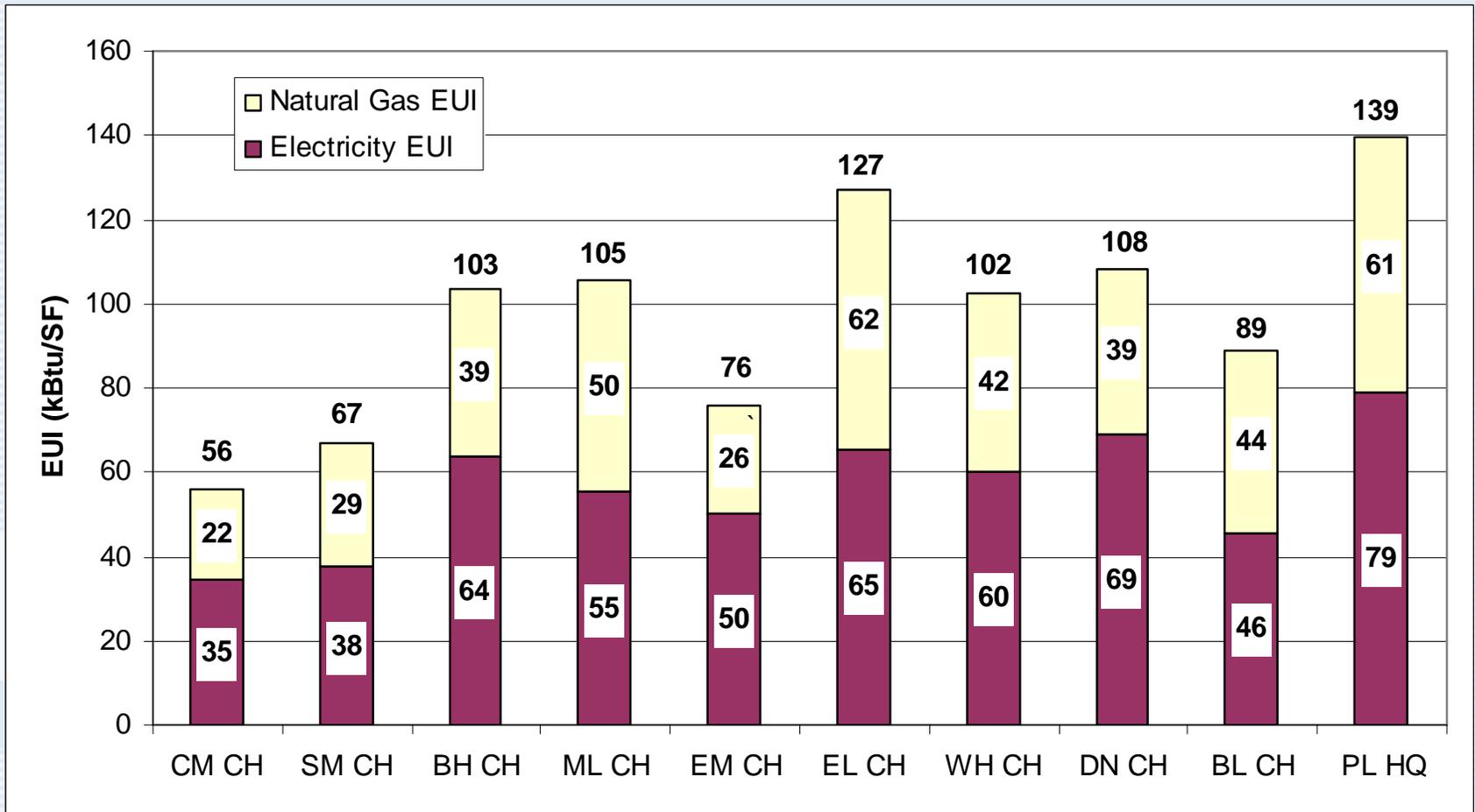


## Benchmarking Process

- Building Based:
  - Annual Utility Consumption from Billing
  - Calculate Energy Use Index (EUI) per SF
  - Compare to databases available: SIC, NAICS, CalArch, EIA, others
- Use EUI to identify best candidates for Retro-Cx opportunities
- Focus on any unique differences in your building systems or equipment as compared to the benchmarks

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## Example Benchmark – Energy Use Index



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## Investigation Phase

*Planning Phase*

*Operating Phase*

*Implementation*

### ***Investigation***

Determine how systems are supposed to operate, measure and monitor how they operate, and prepare a prioritized list of the operating opportunities.

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## Investigation Phase

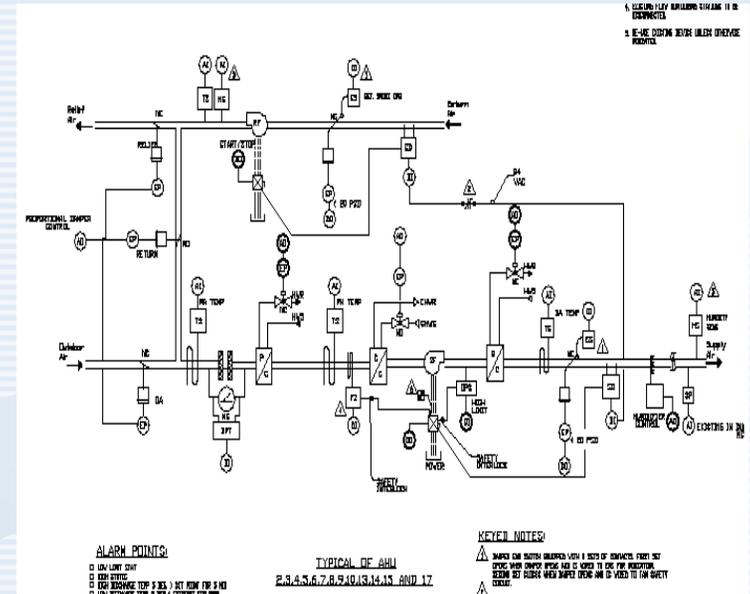
- Inspect, assess, test, measure, document
- Identify inoperable subsystems and equipment – repair if needed for testing
- Perform updated HVAC load study
- Identify improvements for implementation



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## Investigation Phase

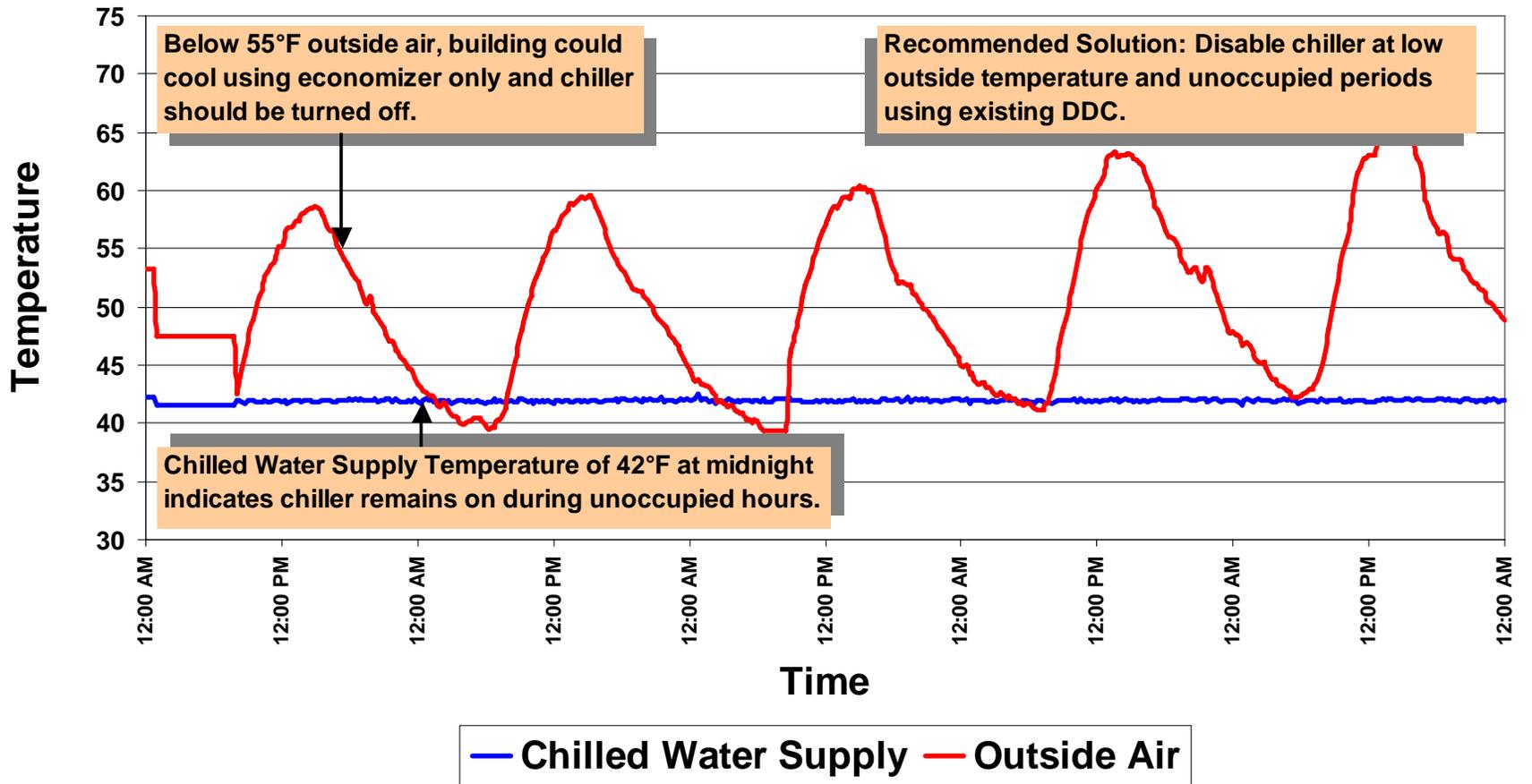
- Validate the direct digital control (DDC) system
- What is the equipment actually doing?
- Trend system points
- Identify changes to setpoints, schedules, & sequences and cost/benefits
- Document conditions



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## Evaluate Trend Data

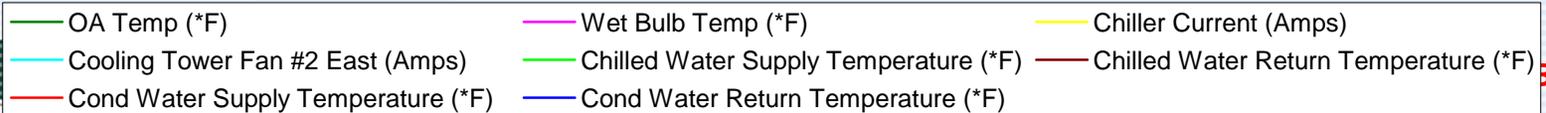
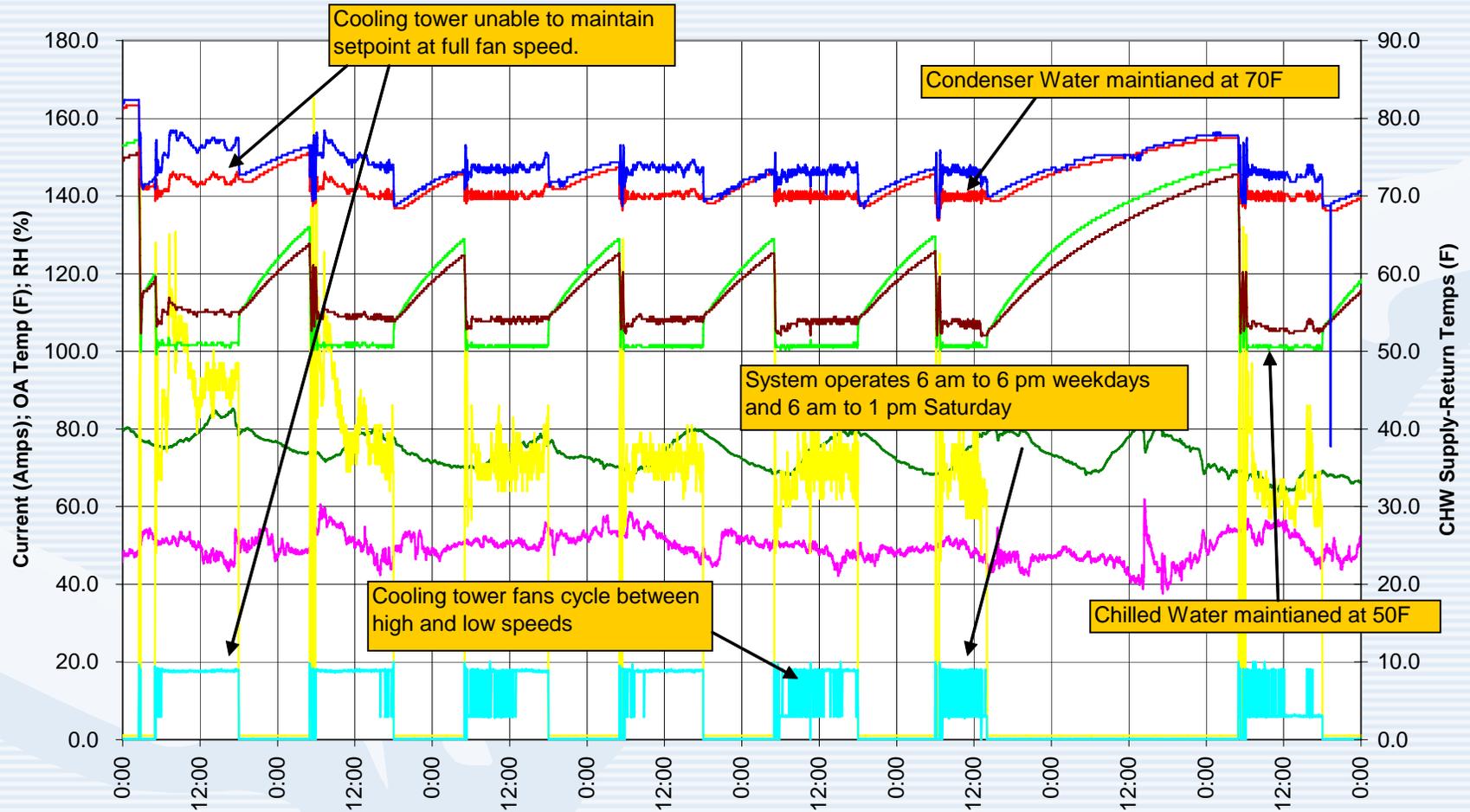
**Problem: Chiller Operates During Low Outside Temperatures and Unoccupied Periods**



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## Evaluate Trend Data

Mountain America Credit Union



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## Investigation Phase

- Validate and re-balance the air and hydronic systems of the HVAC systems – if needed
- Redistribute air and water to meet loads
- Calibrate & test terminals
- Test building pressurization
- Verify indoor air quality and ventilation air levels



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## Investigation Phase

- Investigation report documents the retro-commissioning effort
  - As-found conditions
  - Adjustments or repairs made to systems (if any)
  - Results of evaluation and implementation plan
  - Implementation costs and savings estimated
  - Remaining issues that could not be resolved without upgrade-repair-replacement project
- Identify any capital projects to address current operational needs or correct problems
- Provide budget cost estimate for more capital intensive projects

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## Implementation Phase

*Planning Phase*

*Investigation*

**Implementation**

Implement opportunities and verify proper operation

*Operating Phase*

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## Implementation Phase

- Implement operational improvements to correct deficiencies & improve system operation to achieve improved efficiencies
- Test changes and validate improved performance
- Typically takes less time than investigation



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## Operating Phase

*Planning Phase*

*Investigation*

*Implementation*

**Operating Phase**

Report operating improvements made and train the building operators how to sustain efficient operation – implement capital improvements



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## Operational Phase

- Provide on-site training – “how is the building suppose to operate” – to sustain improvements
- Update O&M data
- Document setpoints and settings for systems – on-going benchmarking



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## Sustaining Improvements

- Continuous Commissioning-
  - Staff availability
  - Staff capability
  - System benchmarking tools and data
- Re-Commissioning
  - Annual or Bi-annual revisit of systems
  - EUI assessments
  - Re-adjustments

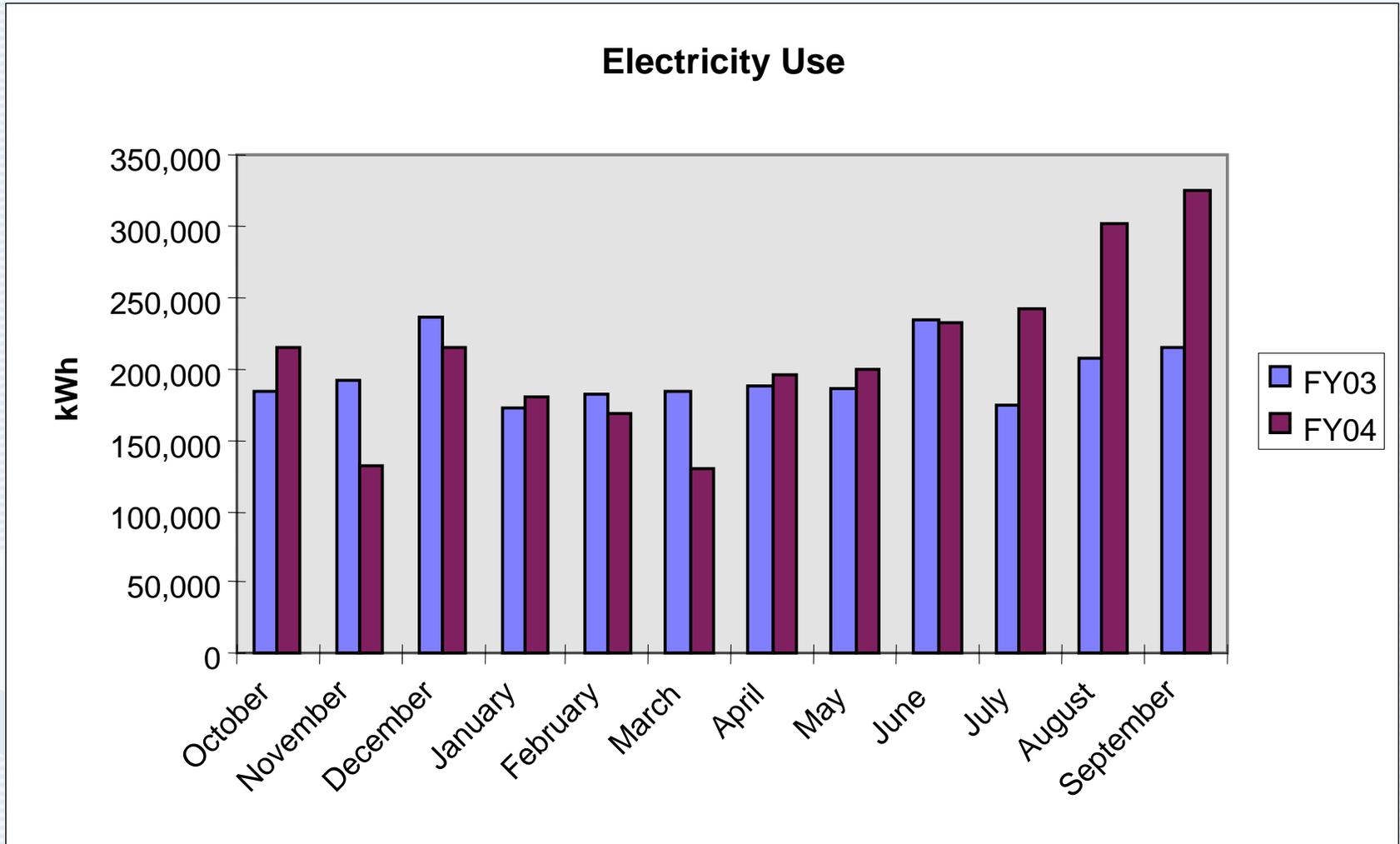
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## Sustaining Improvements

- Track monthly building energy use
- Track sub-metered electrical use
- Verify operation of energy conservation strategies

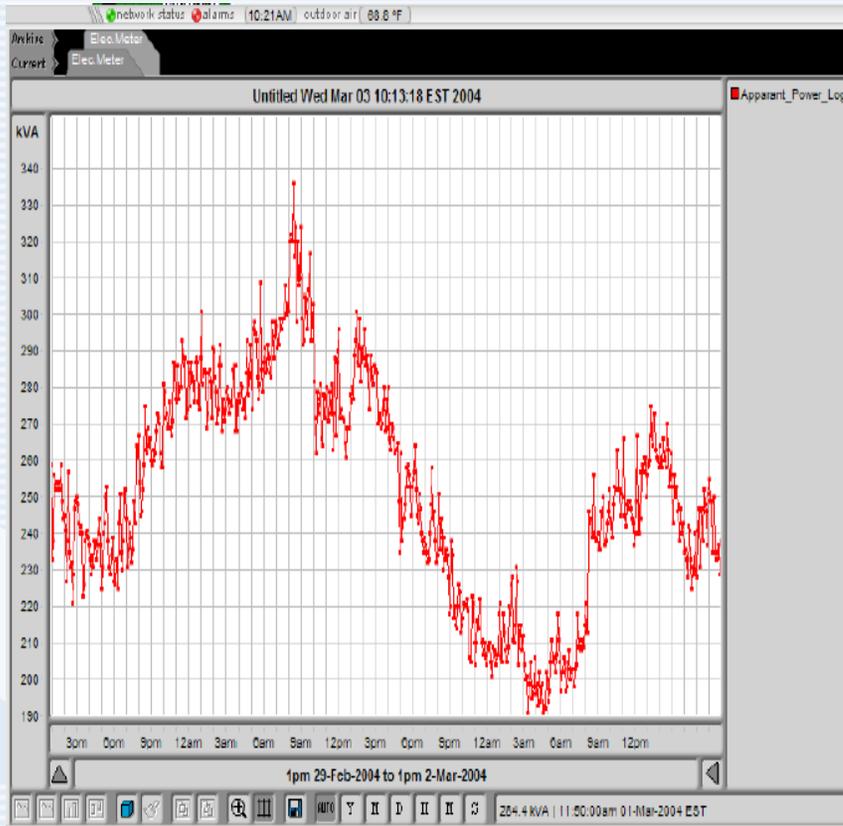
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## Track Monthly Energy Use



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## On-Going Benchmarking



- Set system benchmarks for ongoing performance
  - Daily, weekly, monthly, annually based on metered data
  - Setpoints & environmental conditions
  - System operation points (example: motor speed)
  - Boiler & chiller requirements

# *Retro-Commissioning Case Studies*



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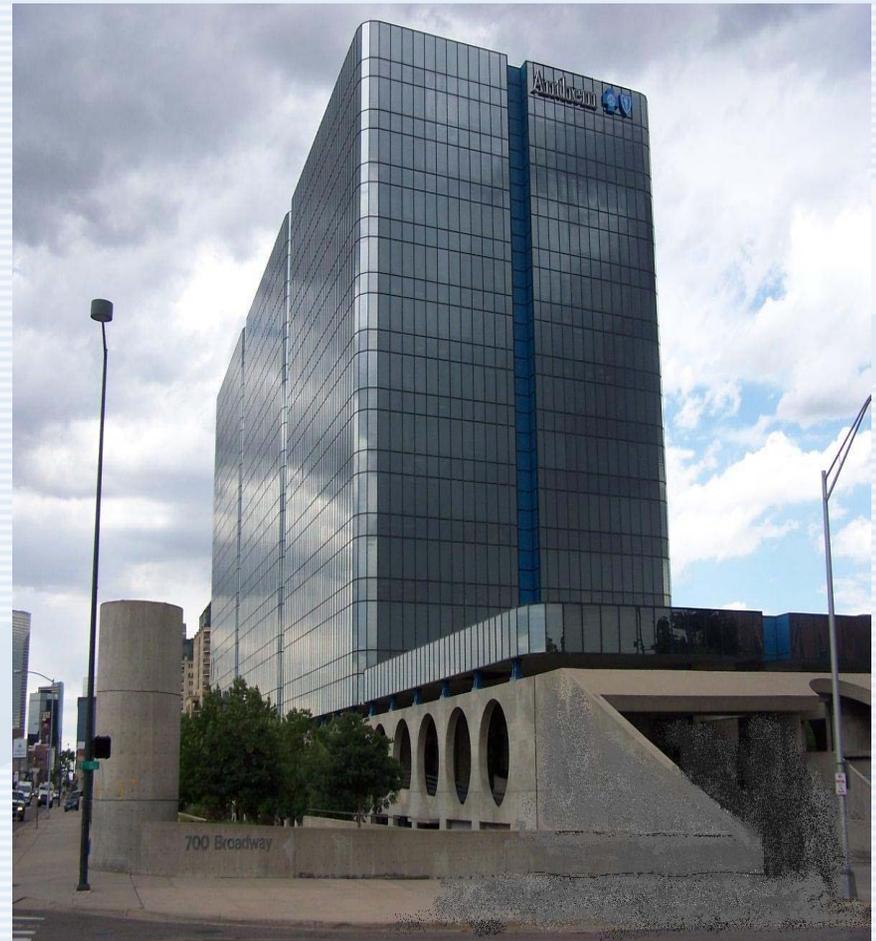
## “Top 10” Opportunities Found

- 10. Reduce reheat for dehumidification/optimize controls
- 9. Reset supply air static pressure setpoints
- 8. Terminal unit tune-ups – dampers & valves
- 7. Return VFDs to variable speed operation
- 6. Improve clg. tower sequencing/lower cond. wtr. temps
- 5. Improve chiller sequencing
- 4. Ensure proper ventilation airflow rate
- 3. Optimize/restore economizer operation
- 2. Eliminate simultaneous heating and cooling
- 1. Turn off equipment when not needed (Scheduled S/S)

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## Case Study 1 (R-Cx / Energy)

- 11-story (386,000 sq ft) Medical Administration building constructed in 1973
- Radiant heating and cooling system
  - High energy use
  - High electrical demand
  - Inadequate cooling capacity



## Case Study 1 (R-Cx / Energy)

- Flow imbalance in chilled water system limited available cooling
- Reduce ventilation fan speed to save electrical demand
- Provide economizer control on ventilation fans
- Optimize chiller/flat plate free cooling control
- Reset heating and chilled water temperatures supplied to radiant panels

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## Case Study 1 (R-Cx / Energy)

### Savings & Payback

Electric Peak Demand Savings	289.2 kW
Annual Electric Energy Savings	1,698,781 kWh
Annual Energy Cost Savings	\$133,830
Simple Economic Payback	0.9 years

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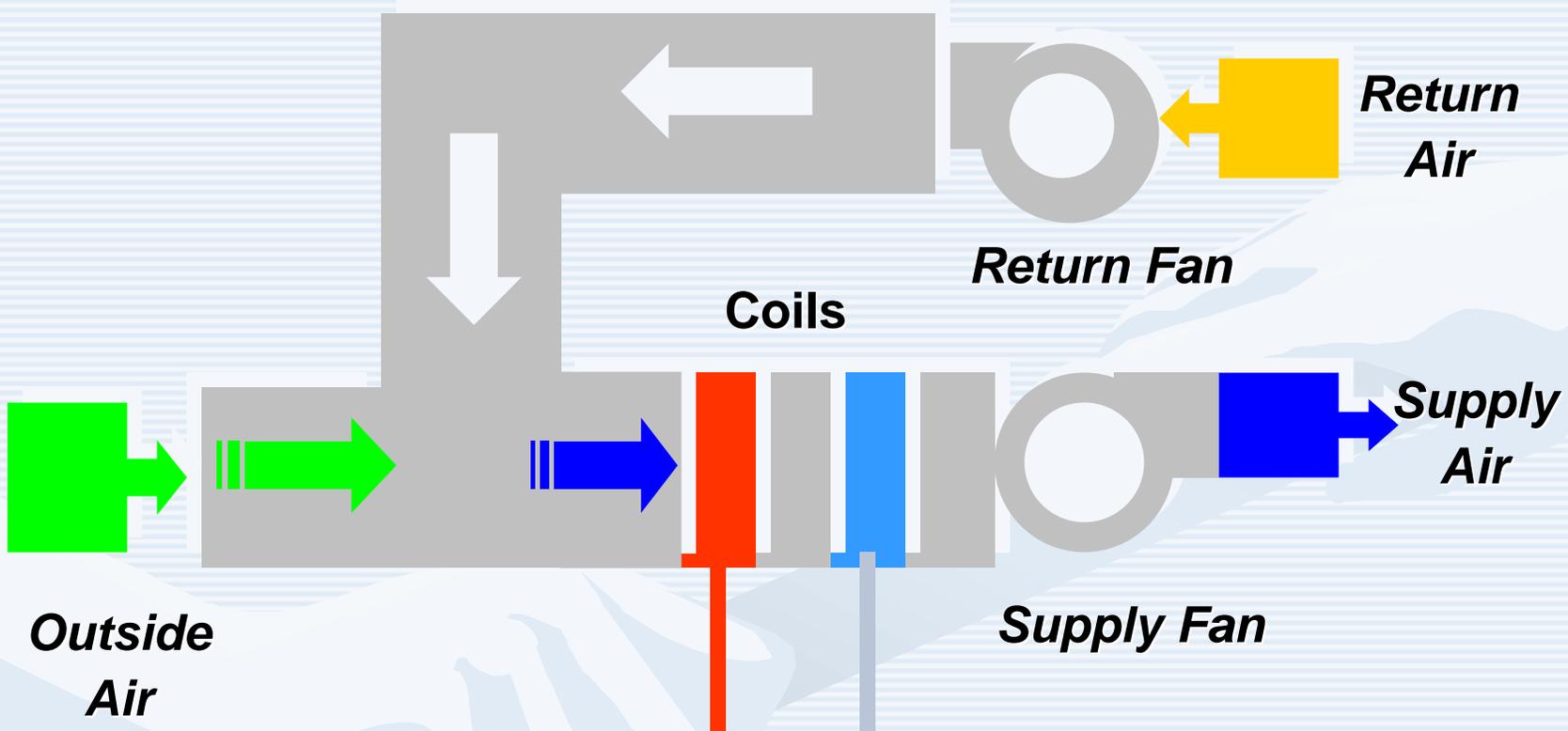
## Case Study 2 - Health Care Clinic

- Retro-Cx AHU-3 to correct airflow & improve control
- Constant volume reheat AHU system
- Was operating rooms – now administrative offices
- As-found measured - 1927 cfm
- Design required - 861 cfm



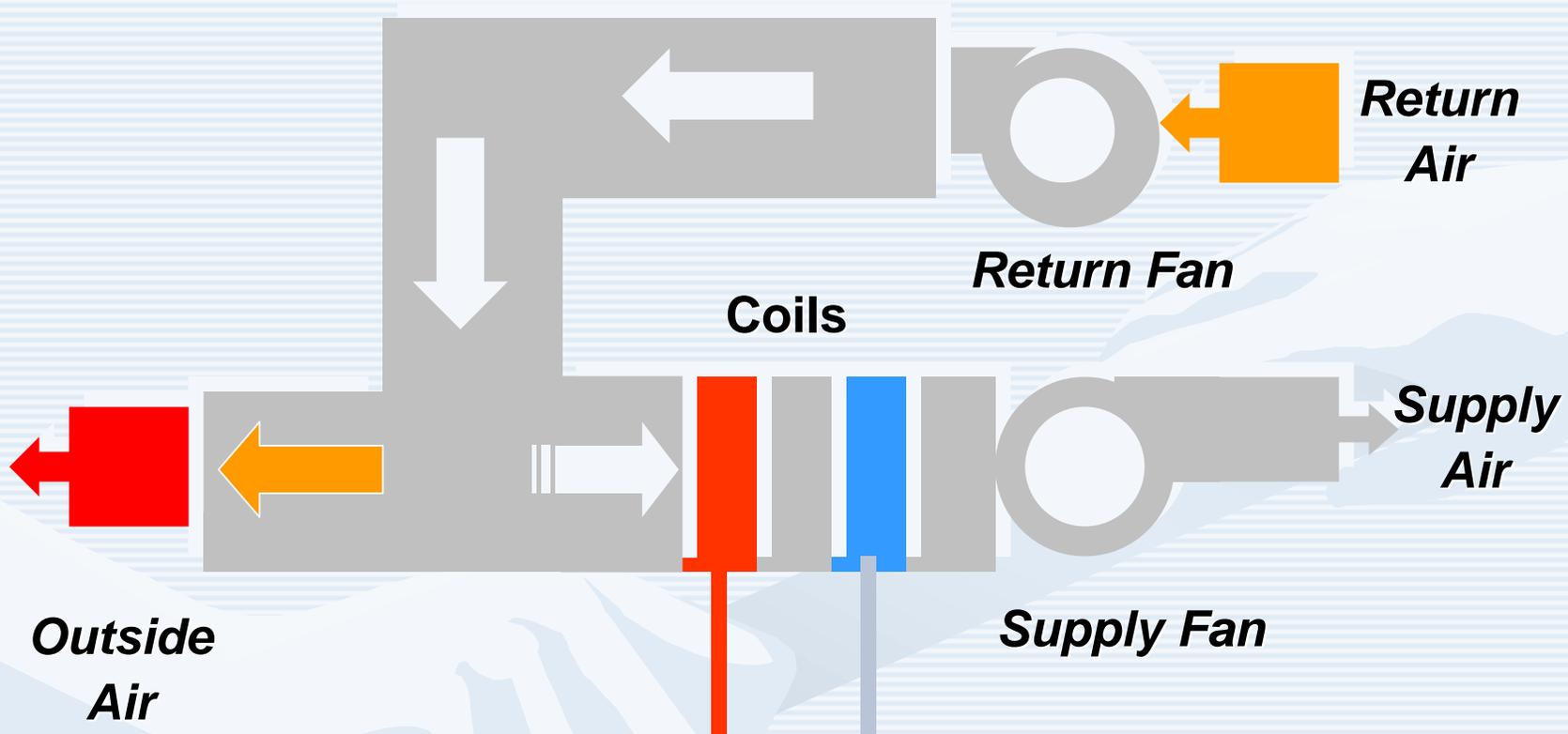
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## Normal Air Flow



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## OA Air – Exhausting – As Found



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## Case Study 2 - Health Care Clinic

- Results:
  - Reduced supply air flow 60%
  - Reduced sf fan amperage 20%
  - Turned off return fan
  - Improved space & zone conditions



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## Case Study 3 – Administration Bldg.

### Problem:

- **Photo A:** Static pressure actually measured at 2" W.C. with relief dampers open.
- **Photo B:** Insulation is blown against SF-2 backdraft dampers.
- Not shown: Insulation is torn at SF-2 discharge.

### Suspect:

- Both fans have been run at one time in order to generate enough static pressure to tear insulation.



**A**



**B**

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## Case Study 3 – Administration Bldg.

### Problem:

- **Photo A: Turning vanes at duct chase (main air shaft) are missing. Some turning vane mounts are broken.**

### Question:

- **Where are the turning vanes?**



## Case Study 3 – Administration Bldg.

### Answer:

- Bottom of the supply air duct chase, obstructing the basement floor ductwork.
- Static pressure past basement floor turning vanes = 1.65".  
Pressure drop from fan to basement duct is 0.6" W.C.



## Case Study 3 – Administration Bldg.

### Recommendations

- Remove debris from supply air chase.
- Replace turning vanes in duct chase.
- Replace backdraft dampers and actuators. Turn backdraft dampers around so failure mode is away from fans.
- Repair barometric relief dampers.
- Replace SF-2 fan belts.
- Install interlock so that fans cannot start unless backdraft damper serving active fan is open.
- Install safety interlock so that only one fan can operate at a time.
- Re-Verify air balance, especially on basement floor.

## Benefits of Cx/R-Cx

- Cost depends on systems selected, size of building, type of building
- Budgetary estimates:
  - RCx from \$0.40 to \$0.90 per SF depending on scope of services required, size & type of building
- ROI & Payback – Excellent (<1 yr typical)
- Energy savings typically 5 to 15%
- R-Cx - existing buildings account for over 95% of building SF – most are not operating efficiently nor very comfortably
- What is the cost of loss of comfort resulting in loss of productivity in poor building environment?

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## Example Resources

- Portland Energy Conservation Inc – [www.peci.org](http://www.peci.org)
- Building Commissioning Association, “[www.bcxa.org](http://www.bcxa.org)”
- “Practical Guide to Commissioning Existing Buildings,” Haasl & Sharp, 1999,  
[ateam.lbl.gov/mv/docs/RetroCommissioningGuide.pdf](http://ateam.lbl.gov/mv/docs/RetroCommissioningGuide.pdf)
- ASHRAE, Guideline 1-1996, “The HVAC Commissioning Process,” [www.ashrae.org](http://www.ashrae.org)
- “Continuous Commissioning Guidebook for Federal Energy Managers”  
[http://www.eere.energy.gov/femp/pdfs/ccg01\\_covers.pdf](http://www.eere.energy.gov/femp/pdfs/ccg01_covers.pdf)

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Retro-Commissioning  
Commissioning  
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# *Question & Answers*



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Thank You!

