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Moving Toward Continuing Building Commissioning

Mark Nunnelly and Ray Prosis

Intent of Presentation

Understand guidelines for continuous building commissioning that can provide facility managers with optimized building performance in accordance with ASHRAE Guideline 1.1-2007

Objectives of Presentation

1. What is Commissioning?
2. What Does ASHRAE 1.1-2007 Provide?
3. Why Commission?
4. Commissioning Types
5. Commissioning Process
6. Cost of Efficiency

“Commissioning 101” Review

“The Commissioning Process is a quality-oriented process for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meets defined objectives and criteria.”

(ASHRAE Guideline 0-2005)

Or translated into English ... **TO FIND PROBLEMS THAT SHOULD HAVE BEEN FIXED OR DONE PROPERLY THE FIRST TIME!**

Many Organizations Available for Continuous Building Commissioning (Cx) Certification and/or Guidelines

- American Society of Heating, Refrigerating and Air-Conditioning Engineers - [ASHRAE](#)
- Association of Energy Engineers - [AEE](#)
- AABC Commissioning Group - [ACG](#)
- Building Commissioning Association - [BCA](#)
- National Environmental Balancing Bureau - [NEBB](#)

Summary of Guideline 0-2005

The Commissioning Process

- This guideline is a general Commissioning Process guideline. It does not focus on any specific system or assembly.
- It is also an integral part of the National Institute of Building Sciences (NIBS) total building commissioning guideline series.

The NIBS Total Building Commissioning Guidelines Series

- Guideline 1 – ASHRAE, HVAC & R Systems
- Guideline 2 – ASCE, Structural Systems
- Guideline 3 – BETEC, Exterior Envelope Systems
- Guideline 4 – NRCA, Roofing Systems
- Guideline 5 – AWCI, Interior Systems
- Guideline 6 – NEII, Elevator Systems
- Guideline 7 – ASPE, Plumbing Systems

The NIBS Total Building Commissioning Guidelines Series

Continued ...

- Guideline 8 – IES, Lighting Systems
- Guideline 9 – IEEE, Electrical Systems
- Guideline 10 – NFPA, Fire Protection Systems
- Guideline 11 – TIA, Telecommunications Systems
- Others developing

ASHRAE Guideline 1.1-2007

HVAC&R Technical

- This is a technical guideline to address specifically the HVAC&R systems of a building, new or existing.
- This guideline is supplemental to the commissioning approach detailed in ASHRAE 0-2005. This guideline must be used in conjunction with Guideline 0-2005; it is not intended to be a stand-alone document.

ASHRAE Guideline 1.1-2007 HVAC&R Technical (Continued)

The Commissioning Process of Guideline 1.1-2007 has been structured to coincide with the phases of a generic project with Pre-Design, Design, Construction, and Occupancy & Operations phases.

Importance of the OPR

Emphasis is placed on documentation of the *Owner's Project Requirements* at the inception of the project and the proper transfer of this documentation from one party to the next.

For an existing building, this same emphasis is placed on the *Current Facilities Requirements* (CFR) for a satisfactory retro-commissioning project.

Developing the Owner's Project Requirements (OPR)

The Owner's Project Requirements are the heart of the commissioning process. If the Owner does not have an OPR, it can be developed in a comprehensive workshop that might include the Owner, facility users, maintenance personnel, design team, commissioning authority, and other participants as necessary.

Poorly Defined OPR

- “Just design it like the typical office building.”
- “We just need for the building to be comfortable for our employees and guests.”
- “The HVAC system needs to be low maintenance because we have limited maintenance staff, and limited technical skills.”

Better Defined OPR

- “Keep the temperature and the humidity within the ASHRAE-defined summer and winter human comfort zones.”
- “Provide sufficient ventilation air in the building.”
(Satisfy the ASHRAE 62.1-2007 Ventilation for Acceptable Indoor Air Quality (IAQ))

Well Defined OPR (for HVAC Systems)

- All project documents (e.g., submittals, I, O & M manuals, troubleshooting guides, etc.) are to be in electronic format and tailored to this specific project.
- Use [X] manufacturer – all existing facilities on base utilize this manufacturer and all technicians are familiar with this system.
- Use only a screw chiller – good part load performance is desired due to highly variable loads and partial occupancy.

Well Defined OPR (for HVAC Systems)

(continued)

- Do not use interior duct lining – Owner wants to minimize the potential for IAQ problems.
- Do not use fan powered terminal units – Concerned over fan inefficiencies and system energy use.
- The HVAC system must provide consistent and individually controllable temperature, humidity, and airflow during occupied periods.
- Provide efficient and adequate work space around systems to facilitate the operations of the building.

Well Defined OPR (for HVAC Systems)

(continued)

- Concern over appearance and noise within the community (e.g., location of cooling towers, CUs, exhaust fans, etc.)
- Temperature within the space shall not vary more than +/- 2°F from setpoint from head to foot, and from space to space.
- Humidity control in the space will be an active system, not a passive system. Relative humidity shall not exceed 60% RH, occupied or unoccupied.

Well Defined OPR (for HVAC Systems)

(continued)

- The HVAC&R system efficiency goal is to be 15% higher than ASHRAE Standard 90.1 requirements.
- Environmental goals – No use of CFCs or HCFCs. Use 10% of recycled content in all metal products.
- ETC.....

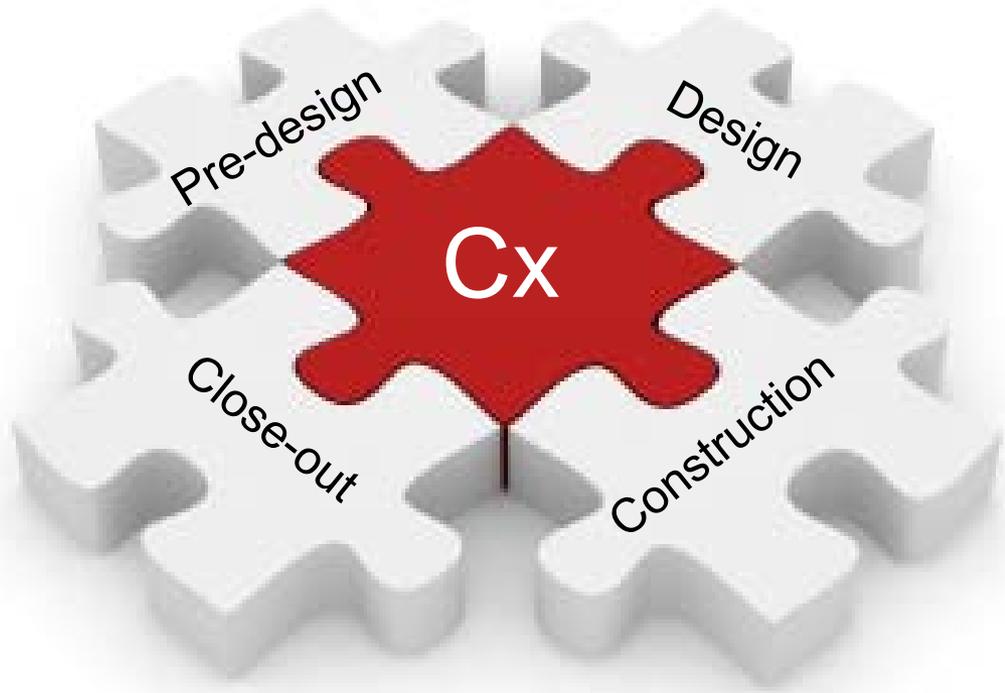
Detailed Commissioning Specs

- Avoid words that are ambiguous, unless you also include definitions (i.e., sustainable, sustainability, comfortable, etc.)
- Poor specification: "HVAC and Domestic Water Heating systems shall be commissioned".
- Better specification might be as described in MASTERSPEC Section 23 0800 – Commissioning of HVAC which is included in the ASHRAE Guideline 1.1-2007



Why Commission ?

- Risk Reduction for new construction
- Verify equipment and system(s) operate
- Reduce energy consumption
- Mitigate Indoor Air Quality problems
- Increase asset value
- Reduce tenant complaints
- Identify failing components to prevent emergency replacement
- LEED Certification



Is Commissioning Really Necessary?

Purpose?

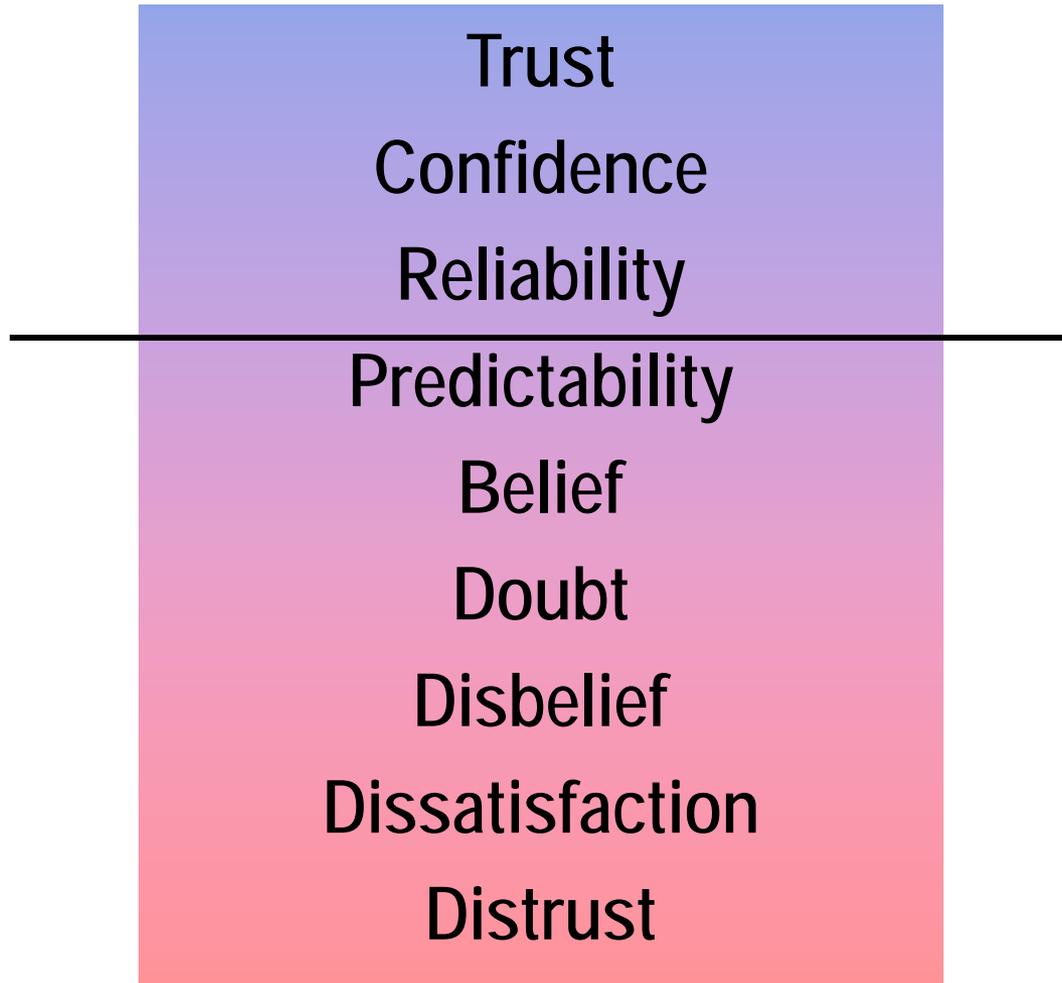
Increase confidence in reliable AND predictable component AND system performance.

Isn't it just about documentation?

Commissioning creates a snapshot to **assure the installed systems worked** as designed and intended at one time.

Commissioning documentation provides a **baseline for operational performance** to allow a reasonable comparison when eventual performance deviates from intended performance.

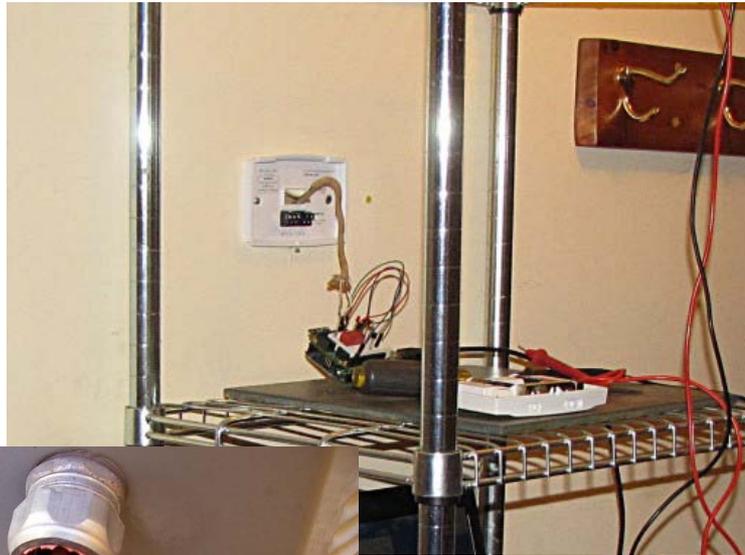
Perception of Performance



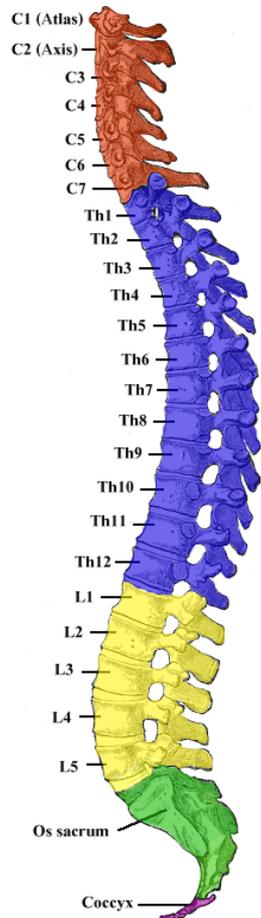
Didn't quite meet the Owner's Project Requirements!



Didn't quite meet the Owner's Project Requirements!



The Commissioning Framework & Purpose Under the ASHRAE 1.1-2007 Guide



- Presents Commissioning Profile for Integrated systems and other Building Components
- Provides Templates for Users
- Assists to Define Desired Performance Criteria
- Collect Actual Performance Data
- Distill Results Into Useful Information
- Strategize Optimal Performance
- Sets Action Plan to Make Adjustments

Types of Commissioning

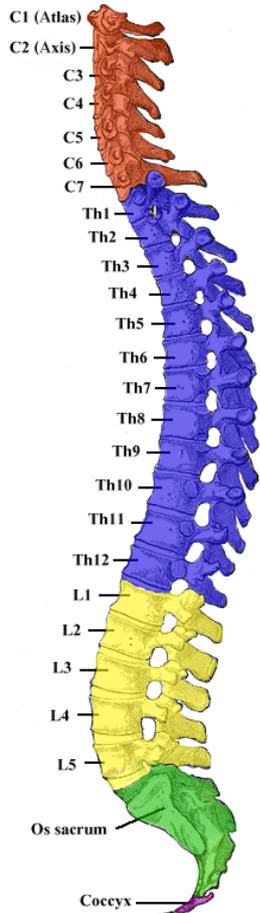
- Commissioning (Cx)
- Re-commissioning (ReCx)
- Retro-commissioning (RCx)
- Continuous/Monitored Commissioning (MBCx)

Types of Commissioning: New Construction

Begins with planning and can be applied throughout the life of the defined project

- concept
- design
- construction
- start up
- acceptance
- Training
- CULTURE

The Commissioning Framework



Pre-functional

Design Review

Create testing forms (ASHRAE Templates)

Confirm component installation

Functional

Test Integrated Systems

Acceptance

Issue Resolution (It's in THEIR scope)

Documentation

Performance (Remember Seasons)

Trend log review

Measurement & Verification (M&V)

“Quality-based” Sample Rates – Example for New Construction:

# New Construction Checklist	Overall Sample Rate	Component Sample Rate
1 - 10	100%	70 - 100%
11 - 20	80%	50 - 70%
21 - 50	50%	30 - 50%
51 - 100	30%	15 - 30%
>100	2 - 20%	2 -10%

“This is not meant to be used directly for your project due to the many variables in determining acceptable sample rates and owner input.”
(ASHRAE Addendum d to Guideline 0-2005)

Commissioning Authority, CxA

- Hired directly by Owner (typical)
- Creates commissioning schedule
- Creates Integrated Commissioning Plan and Coordinates
- Reports to Owner
- Provides technical review
- Performs all functional tests
- Reviews TAB reports
- Confirms control sequence operation (remember seasons)
- Verifies component and system function
- Provides final commissioning report to Owner

Operational Intent: Desires and Expectations

Clarifying Owner expectations

- Performance Requirements
- Schedule
- Budget
- Expectations
- Performance Strategies (Integration and Energy Savings)
- Performance Metrics
 - Metering, Cultural Checks, Systems Trending

Commissioning Documentation

- Commissioning team develops technical specifications containing:
 - Project team roles and responsibilities
 - Pre-functional test plans
 - Functional Test plans
 - Acceptance Test plans
 - Long-term Performance Test plan

Types of Commissioning: **Re-Commissioning**

Application of previously executed commissioning tests to restore system functionality to the original design intent.

Re-Commissioning Program Coverage

Areas Affected

- Energy Savings
- Carbon Foot Print Reduction
- Reliability of Proper Implementation and Performance
- Functionality for Customer Comfort

Major Components Included

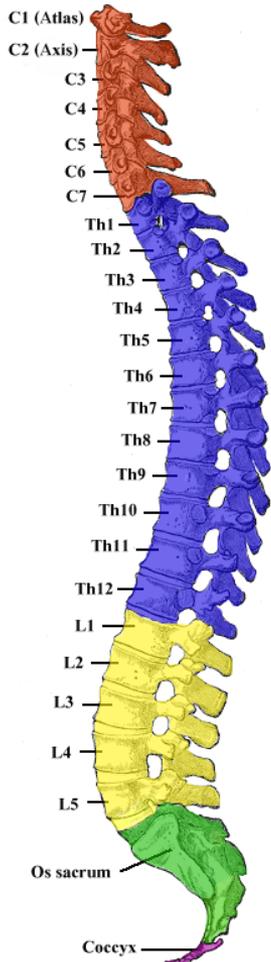
- Structure (envelope when implemented)
- HVAC Plant (energy supply)
- Distribution System
- Power systems

Types of Commissioning: **Retro-Commissioning**

A systematic investigation process for improving and optimizing operation and maintenance focused on recovering energy costs.

This commissioning applies to buildings not previously commissioned.

The Retro-Commissioning Framework



- Test and verify current equipment operation
- Verify system sustainability
 - “Work arounds”?
 - Operator confidence in system performance
- Changes in building use?
- Spot check current building TAB against last available report
- Verify controls viability (Recommissioning)
 - Sequences
 - Controllers
 - Sensor accuracy
 - Schedules
 - Setpoints

Reasons to Consider Retro-Commissioning (RCx)

- It addresses the gap between a building that does not work as intended and an already overburdened maintenance and engineering staff
- The building is not providing an adequate work environment
- There are indoor air quality issues
- If mold is present in the building
- The building's energy costs are too high compared with similar buildings
- Equipment and systems are sustaining damage from the indoor environment
- LEED EB prerequisite

Indication that HVAC System is not operating effectively and/or efficiently ...

Ambient Conditions:
93.9Fdb/70Fdp/46%RH

29% of Barracks have
windows open and
100% Cooling ON



You never know what you will find above the ceilings ...



Small items that had been overlooked for years ...



Retro-commissioned Buildings ...

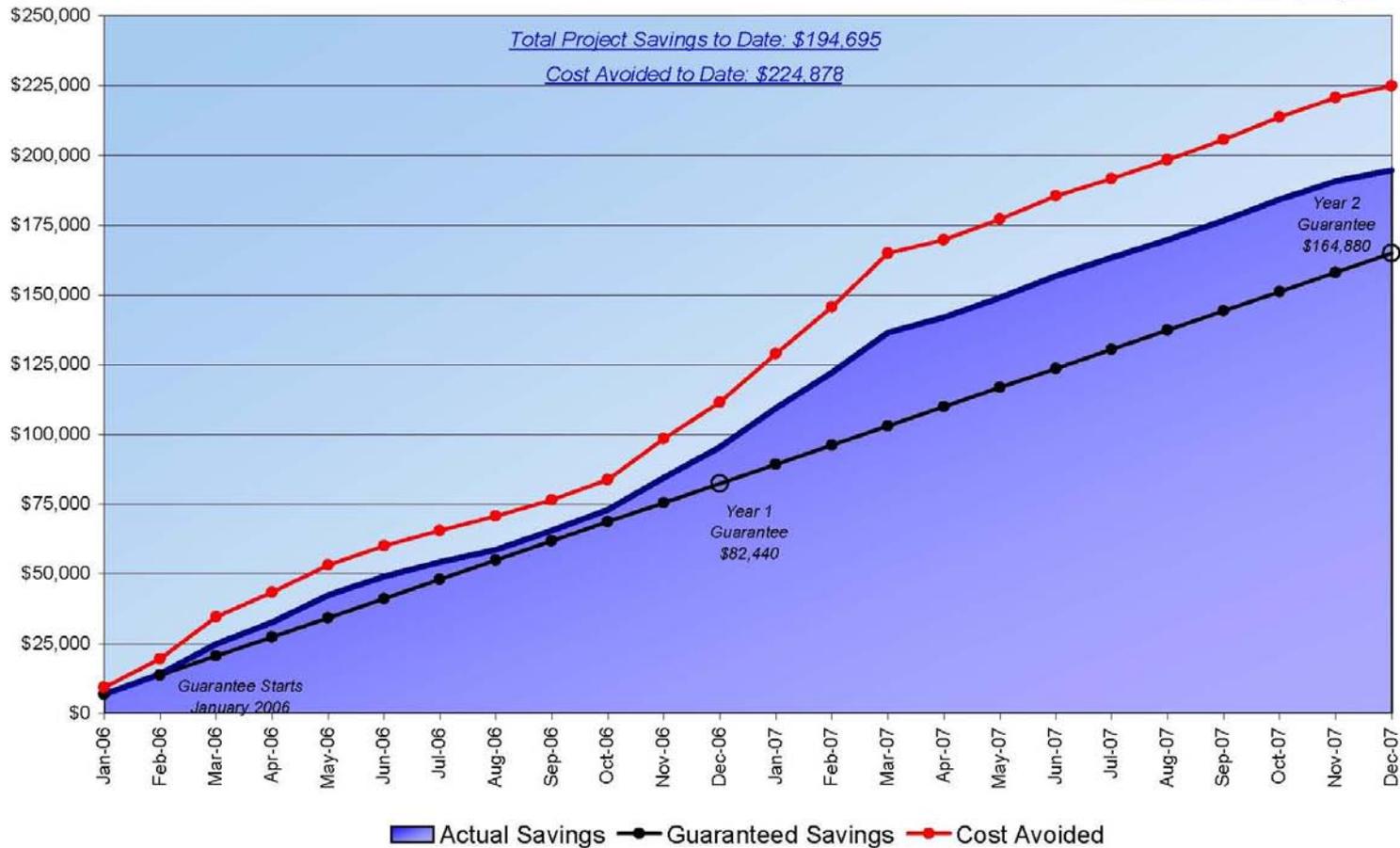
- The *Building Commissioning Association* (BCA) claims that existing buildings can improve energy performance by 13%.
- According to the *Department of Energy*, Commissioning has proven itself time and again. In existing buildings, whole-building energy savings average about 15%.
- *Portland Energy Conservation Inc.* (PECI) studies indicate that on average the cost of operating a commissioned building ranges from 8% to 20% below that of a non-commissioned building.
- *Building Owners and Managers Association* (BOMA) cost data for the office buildings suggest that commissioning can save energy from 20% to 50% and additional maintenance savings from 15% to 35%.

Continuous Monitored Commissioning

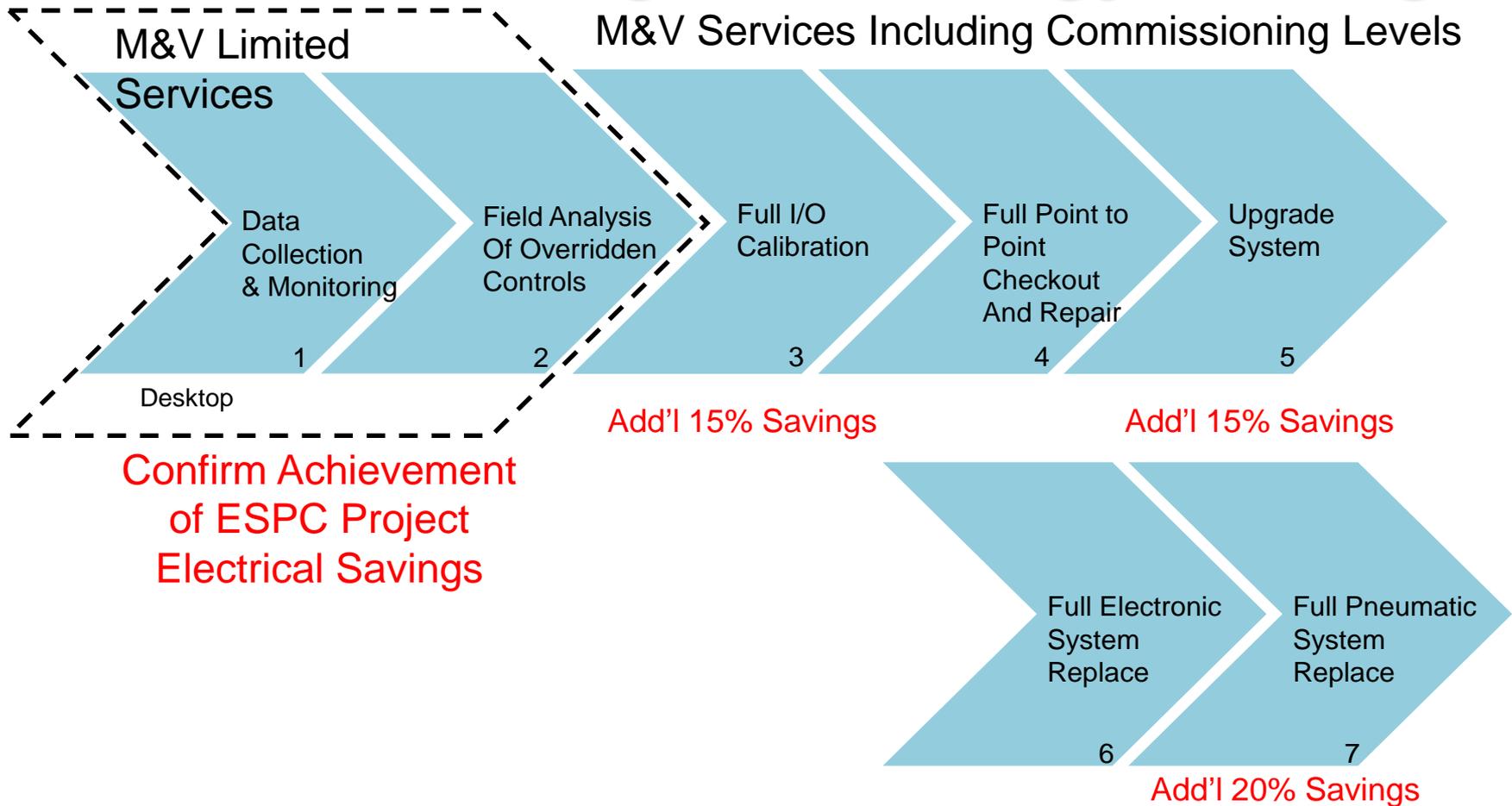
Process of continuously ensuring systems are operated and maintained to sustain intended performance.

Types of Commissioning: Continuous

Annual Guarantee: \$82,440
 Guarantee to Date: \$164,880



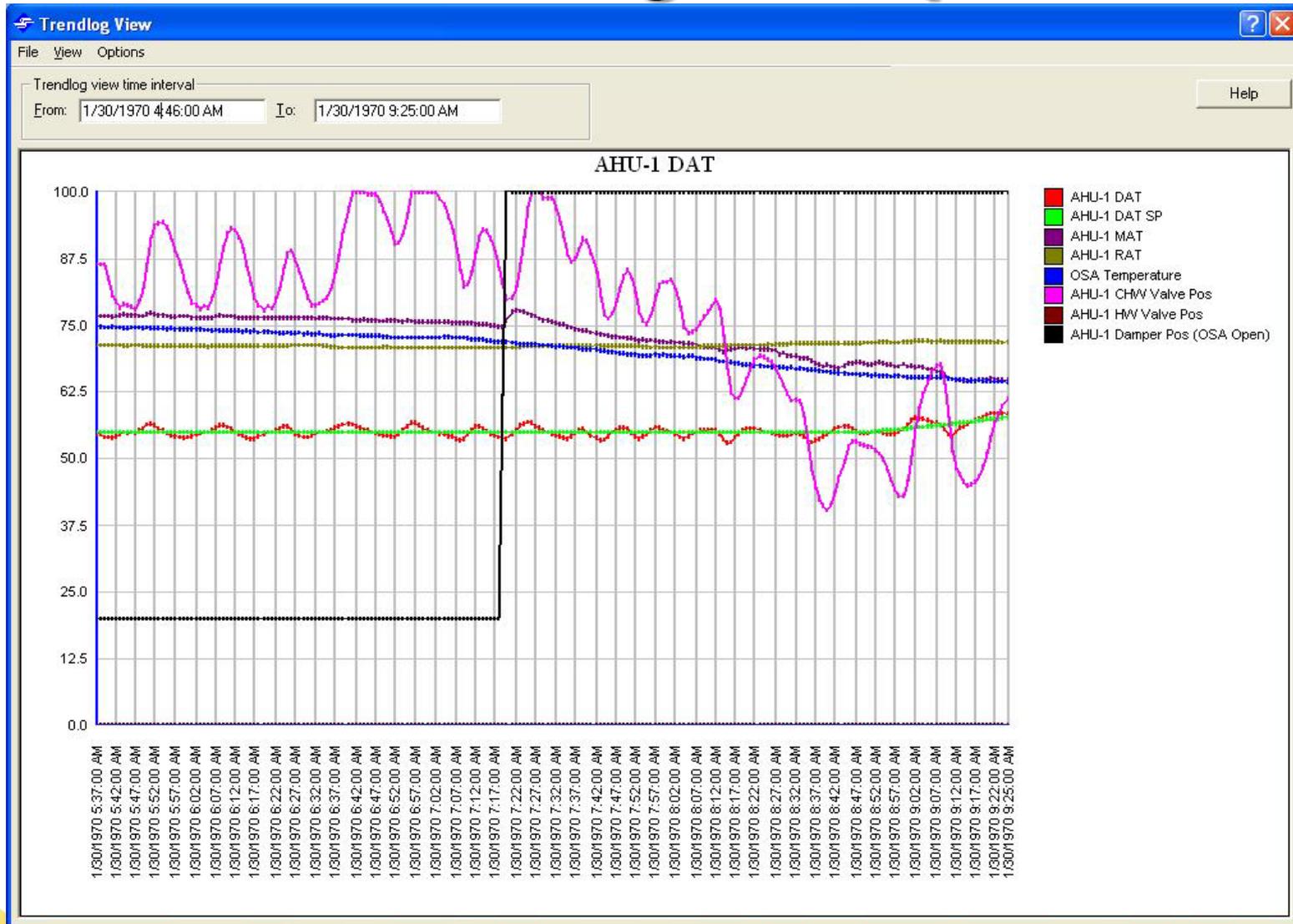
Understanding Levels of Commissioning and Energy Savings



Trend Logs

- Reviewing system performance in **Real Time or Recorded**
- Establishing **relevant** trend logs
- Concurrent trends useful for troubleshooting
- An MRI scan of system performance
- Learn to read the scan
 - Analyze
 - Diagnose
 - Prescribe

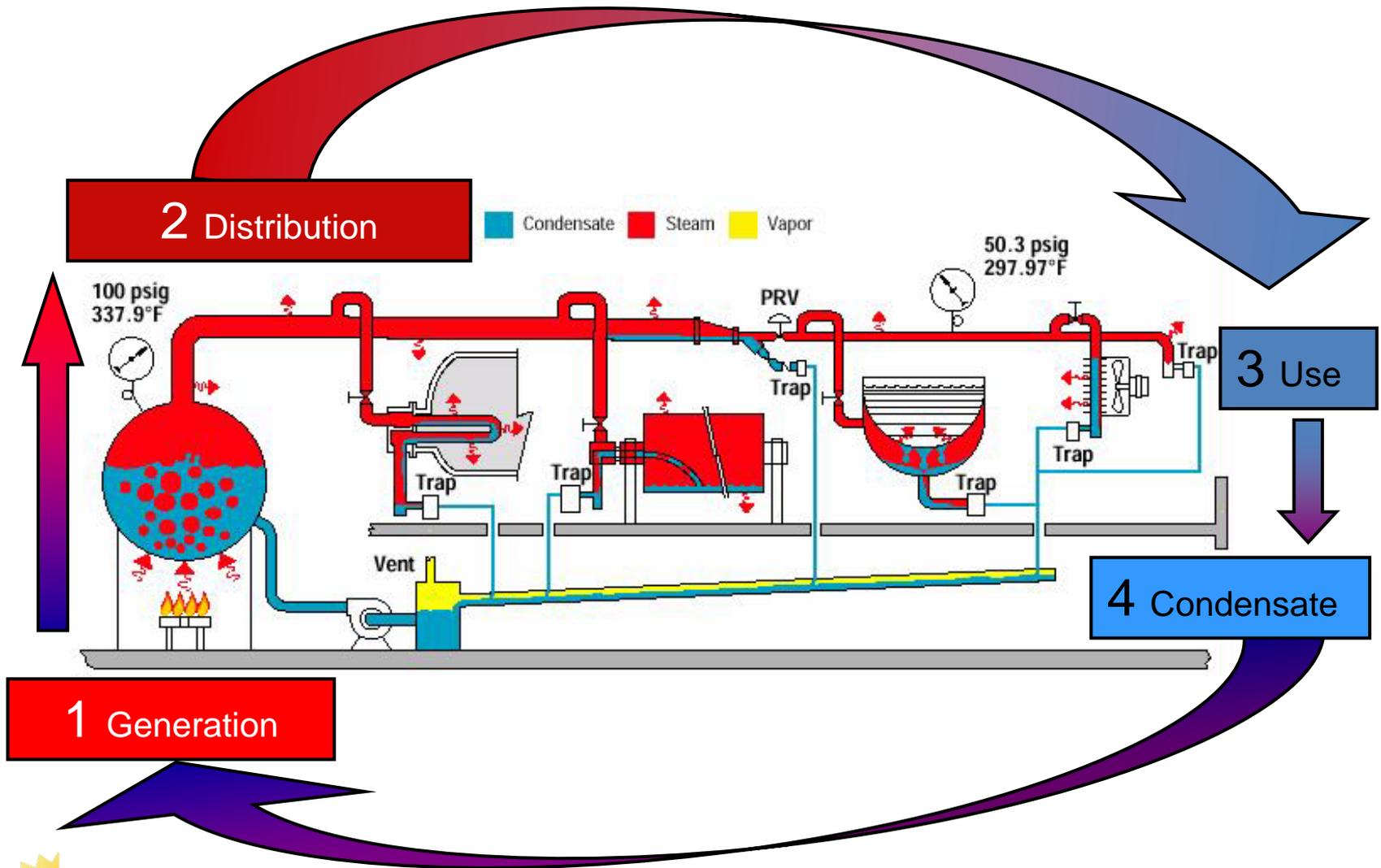
Trend Log Example



Alarms and Messaging

- Setup On/Off Alarming on Systems
 - HVAC
 - Lighting (security, janitorial)
- Temperature Setpoint Deadbands
- Temperature Alarming values
- Simultaneous Heating and Cooling Alarms
- Management Acknowledge of Messages
- CULTURE

Why do Trending and Alarms Matter?



Nuisance Alarm “Overridden”

- A Repetitive alarm on a failed \$100 low water sensor and controller became a distraction and forgotten about.



Turned into a Remodeling and Equipment replacement project.



Continuous Building Commissioning Best Practices

- Conduct visual inspections
- Perform all maintenance per manufacturer requirements.
- Report any anomalies *immediately*
- **AND**

correct a *small* problem before . . .

... it compromises performance.



Integration Systems Focus

- Building Envelope
- Fire Systems
- Security & Access Controls
- Lighting
 - Ample Lighting, Controlled OFF and Stay OFF (Guard Tour, Janitor, Late Nighters)
- Electrical Equipment
 - Serviced, Personal Equipment
- Mechanical Systems
 - Chemical Treatment, Maintenance Program, Temperature (HVAC) Controls
- HVAC Controls
 - Overridden, Control Parameter Changes

Integration Systems Degradation

–Sustainability is Major Problem

- Degrade with Maintenance
- Degrade with Operations
- Degrade with Policy

–Processes limit success

- Training on turnover
- Maintenance nonexistent
- Diagnostics not part process
- QC is not existent

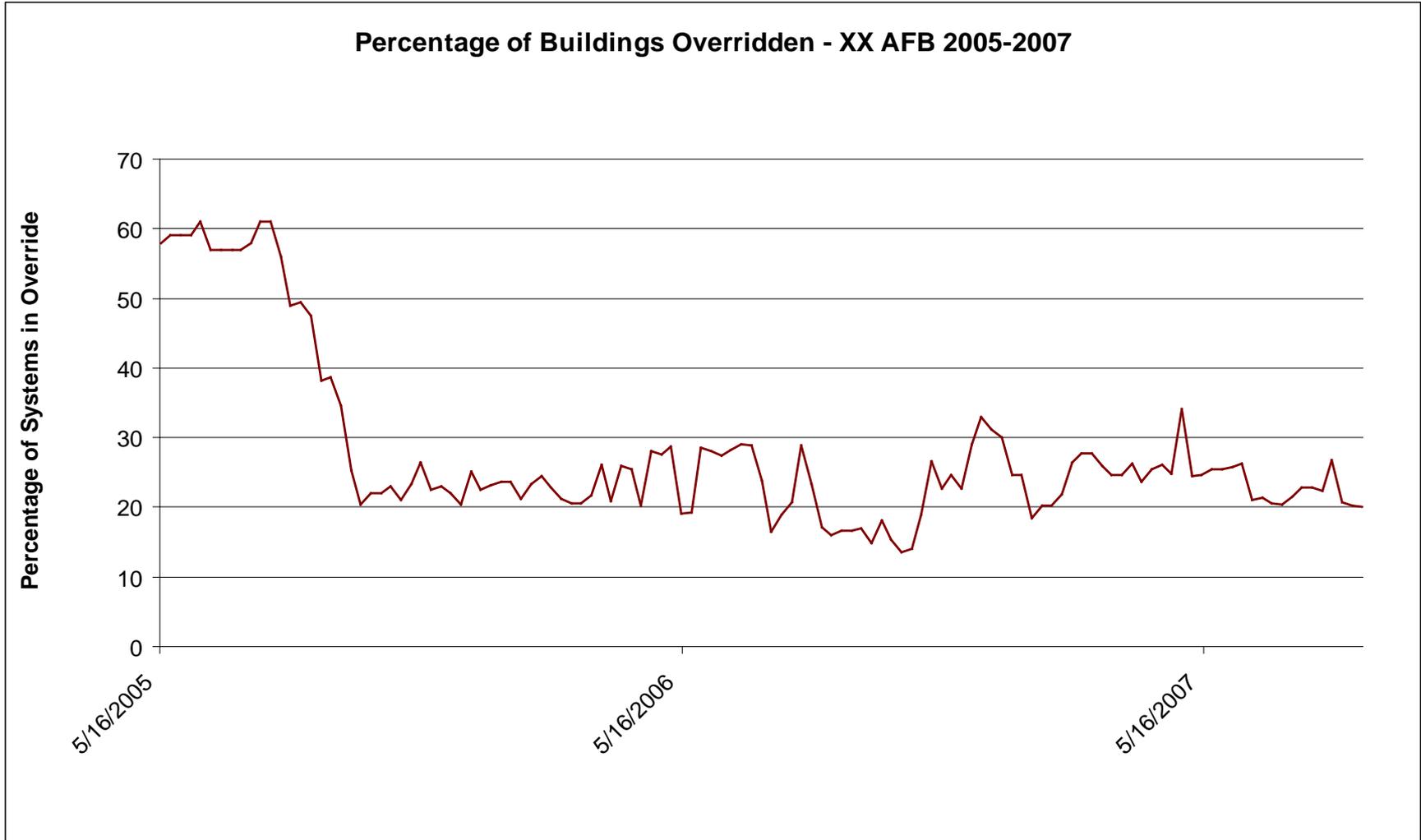
Controls Systems Issues

Extremes

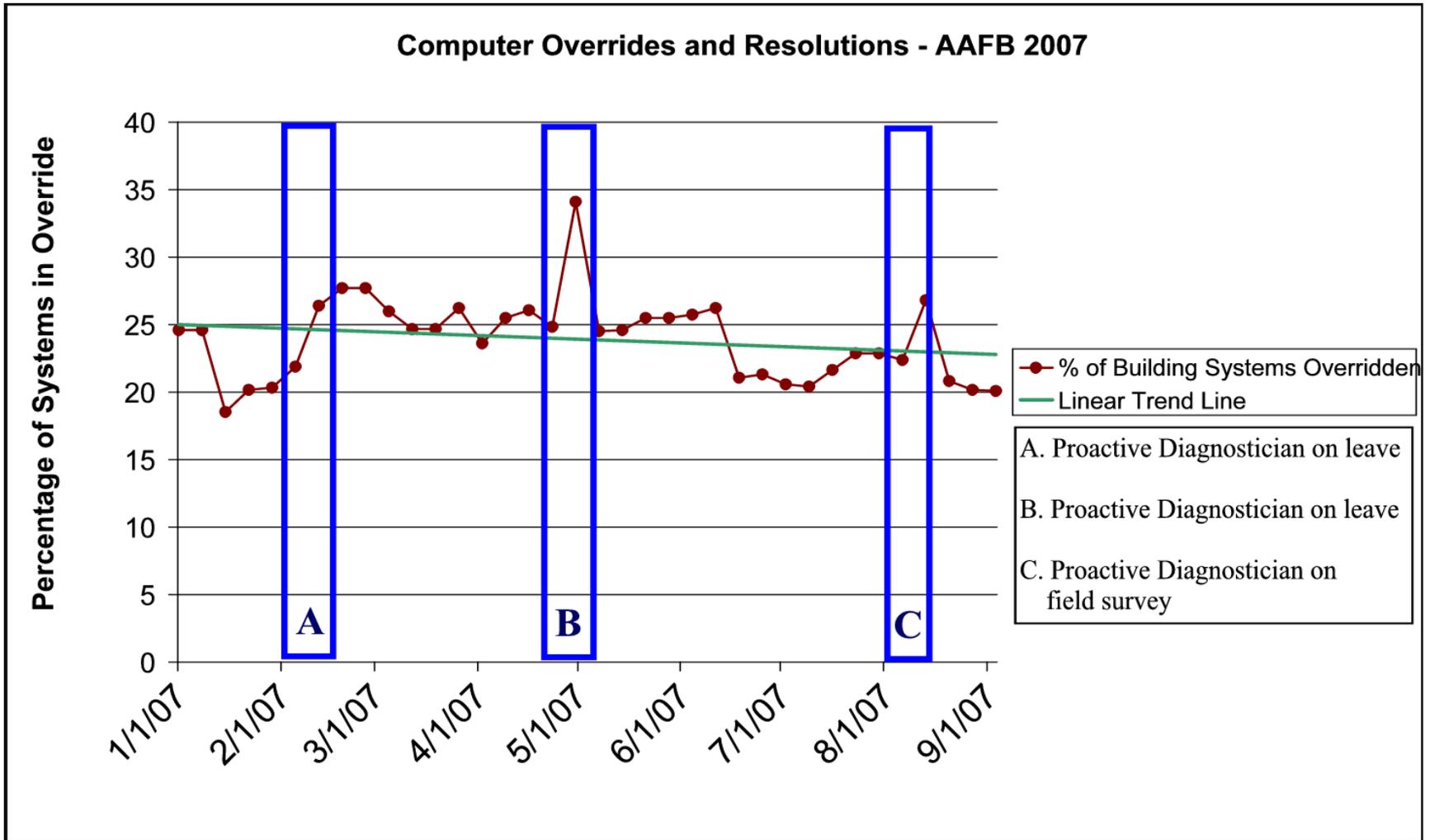
- Poor Maintenance Program
 - 90% systems overridden
 - Two years - 2% points overridden
 - Equates to Approximately 15% systems
- Outsourced Maintenance – Good program
 - 9% points overridden
 - Points affect vary on system but generally affects the energy use negatively

Project Example

Percentage of Buildings Overridden - XX AFB 2005-2007



Degradation Without Oversight



Top Ten List Of Controls Issues

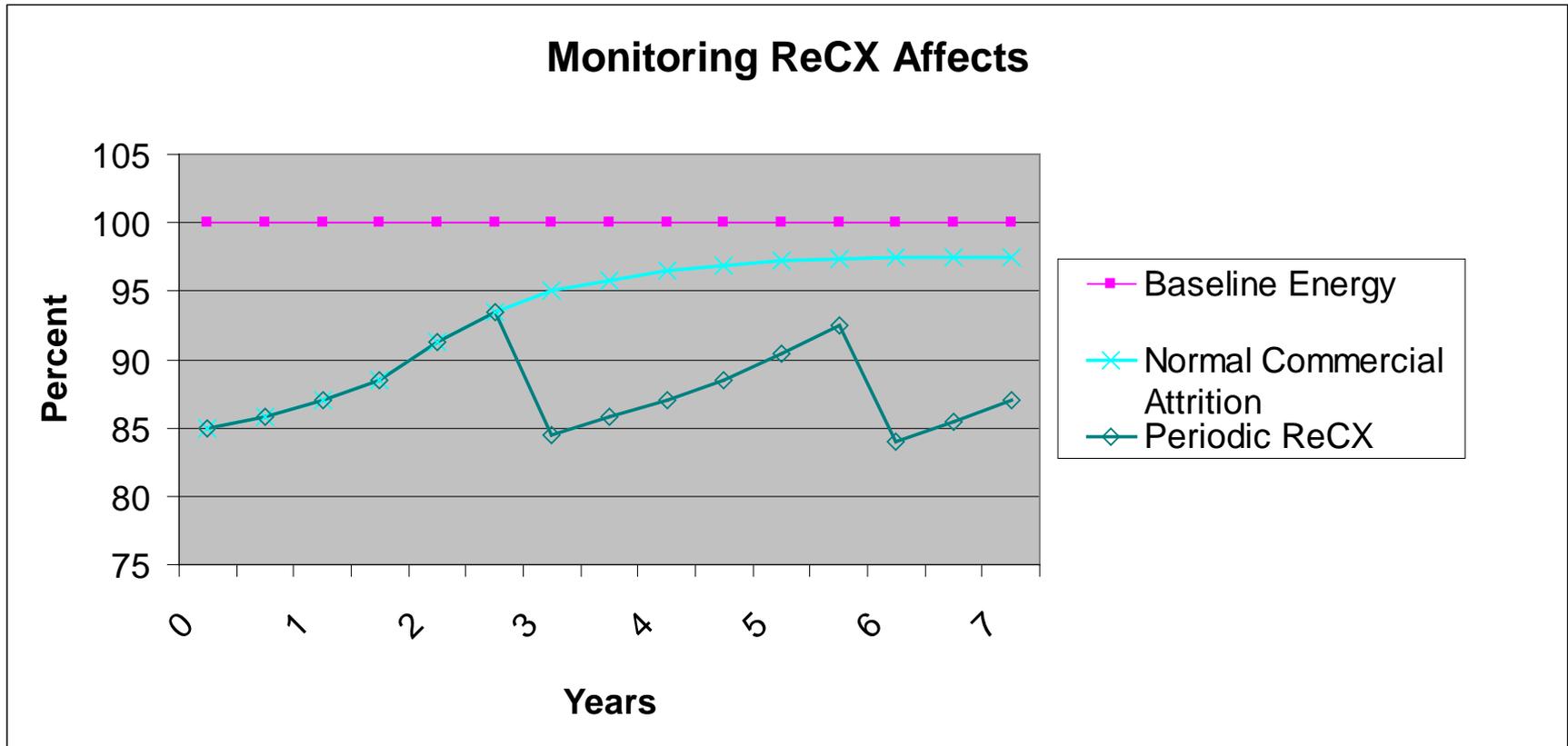
1. HOA in Hand Mode
2. Main Panel Overrides
3. Sub-Panel Overrides
4. Switch Overrides
5. Poor or Improper Maintenance
6. Broken and Failed Parts
7. Linkage Disconnected
8. Equipment Incorrectly Installed
9. Incorrect Equipment Design
10. Incorrect or Modified Controller Program

Observation: Diagnostics

- Without a continuous diagnostics approach, energy usage will be **20% to 40% higher** than required to provide a comfortable and healthful indoor environment.

- ❖ Information from DOE FEMP
- ❖ Berkley June 2009 Commissioning Study

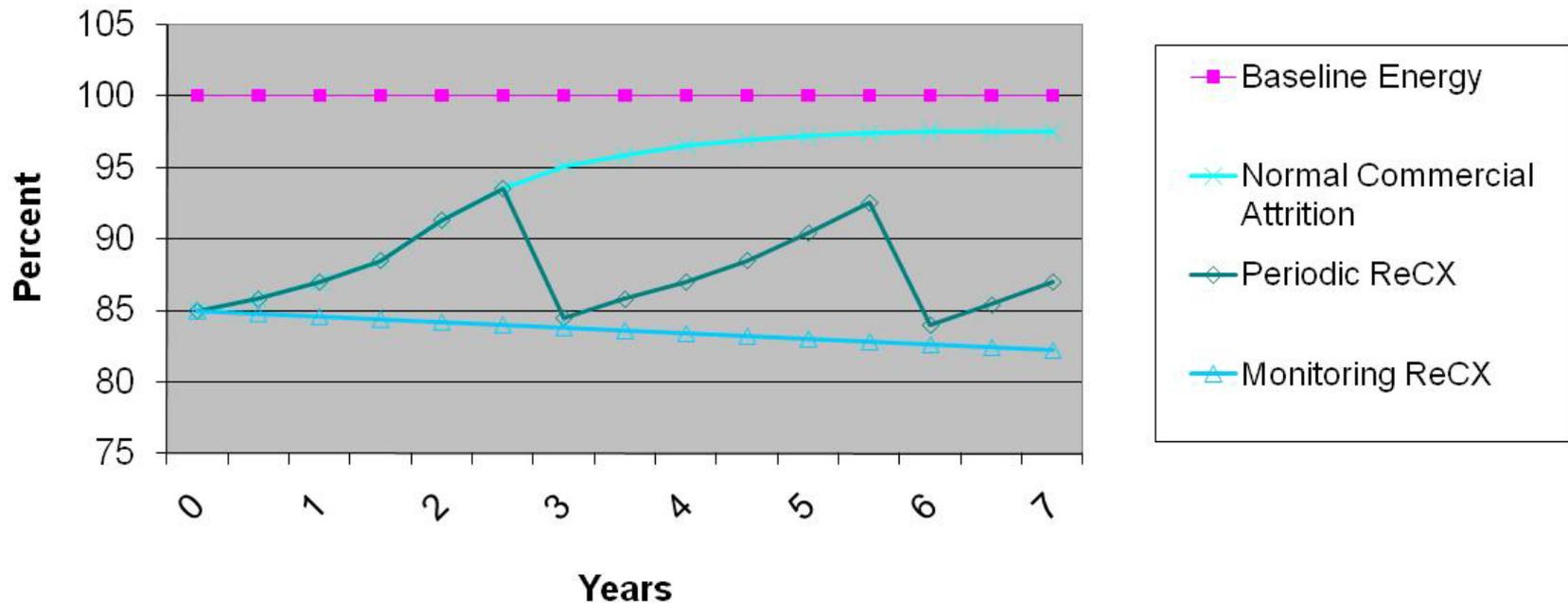
Baseline with Periodic Recommissioning Affects



- ❖ Information from DOE FEMP
- ❖ Berkley June 2009 Commissioning Study

Baseline with Commercial Average

Monitoring ReCX Affects



- ❖ Information from DOE FEMP
- ❖ Berkley June 2009 Commissioning

The Cost of Commissioning ...

Where are the Savings?

Table 5. Standard efficiency rates for central plant utilities

Central Plant Utility	Efficiency
Chilled Water	1.0 kW/ton
Steam	80%
Hot water	80%
Condenser water	0.4 kW/ton

Table 6. Overall performance of MBCx phase -1 projects

Savings/Cost Metric	MBCx Phase-1 projects	Cx Meta-analysis ⁵	Cx Meta-analysis ⁵ CA/OR/WA Only ⁶
	median/proj avg/ aggregate	median/proj avg	median/proj avg
Total source energy savings %	10% / 9% / 10% (N=24/24/22) ¹	13% / 16% (N=46)	8% / 9% (N=24)
Total site energy savings %	11% / 11% / 11% (N=24/24/22) ¹	15% / 19% (N=46)	8% / 9% (N=24)
Simple Payback Period	2.2 / N/A / 2.1 (N=21/24) ^{2,3}	1.0 / 2.1 (N=98)	1.5 / 2.7 (N=36)
Electricity savings %	9% / 8% / 9% (N=24/24/22) ¹	9% / 11% (N=46)	
Peak electricity savings %	5% / 6% / 6% (N=23/23/21) ¹	2% / 7% (N= 3)	
Fuel savings %	9% / 15% / 13% (N=24/24/22) ¹	6% / 13% (N=19)	
Chilled water savings %	17% / N/A / 22% (N=10) ⁴		
Hot water/Steam savings %	12% / 23% / 18% (N=13)		
Total Thermal		36% / 37% (N=16)	

Average Cost of Commissioning

- ReCx \$.27/sqft to \$1.26/sqft
 - Payback <2yrs
- MBCx \$.37/sqft to \$1.62/sqft
 - Payback <2.5yrs

- ❖ Information from DOE FEMP
- ❖ Berkley June 2009 Commissioning Study

Can I LEED?

- Absolutely!
- LEED Possible Pts. 35
 - Prerequisites
 - Optimized Energy Performance
 - Cx Investigation and Analysis
 - BAS Performance Measurements Implemented
 - System Level Metering
 - Enhanced Refrigeration Management
 - Emissions Reporting
 - Renewable Energy Implementation and Metering

The Cost of LEED-ing?

- Energy Savings 7-20%
- \$0.50 - \$1.50 cost/sqft
- Simple payback 2.5yrs
- Include M&V for extra pts.

US Green Building Council

Strategy for Solution: Awareness

- Admit you have a problem
- Desire to find a solution
- Realize you need Outside Support
- Act to correct, implement the solution

Culture

- Main Focus is Client Comfort
- Oblivious to Actual Problem
- Problem recognized, excuses made
- No strategy
- No accountability
- No quality control program

Fixing the Culture

- Public Kiosks
 - Energy Dashboards
 - Provide Individual Responsibilities
- Create Departmental Awards for best Performance or Ideas
- Client Comfort
 - Fix the problem
- Change Processes
 - Guard Tour (lighting)
 - Janitorial (lighting, Space Setpoints)

Putting It All Together



Tools Going Forward

- Address Cultural Changes Immediately
- Metering for Performance and Baselines
- Change Those Things You Can Immediately
 - Overridden Controls (Mechanical Systems, Lighting)
 - Proper Space Temperature Setpoints
- Eliminate Improperly Placed Equipment
 - Copiers, Workstations, Space Heaters, Mini-Refrigerators

Summary of Guideline 1.1-2007

- HVAC&R Systems Fully Cover Commissioning Process of Guideline 0-2005 (Integration)
- Verification During Each Commissioning Phase
- Documentation and Acceptance During Each Phase
- "Systems" Manuals Specific Requirements
- Training on All Systems and Integrated Operations
- Commissioning Templates

It isn't commissioned until you hand over the keys!



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