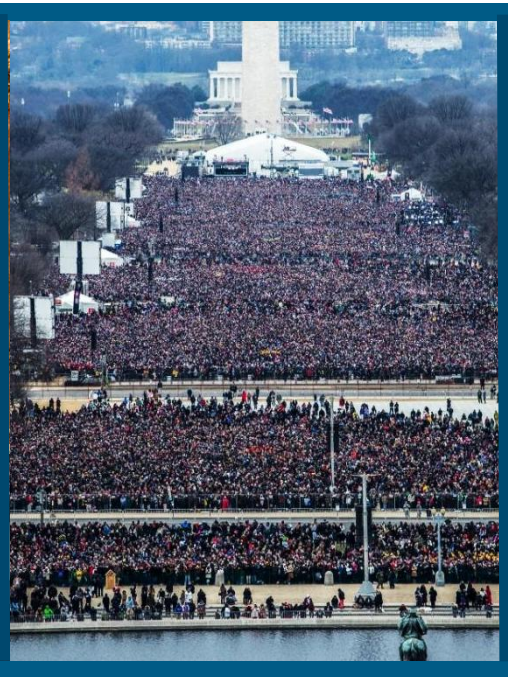
AOC's Commissioning Efforts
Successes and Lessons Learned

March 14, 2013

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ARCHITECT OF THE CAPITOL

Agenda

About the Architect of the Capitol

- Sustainability and Energy
- Alignment with AOC's Strategic Vision
- Energy Reduction Progress

Commissioning at AOC

- AOC's Commissioning Efforts
- Policies, Timeline and Documents
- Examples of Issues
- Other Related Efforts
- Benefits and Lessons Learned

Data Analytics and Performance Monitoring

- Examples
- Utility Metering Enterprise System
- Move to Performance Monitoring

Wrap-up

- Looking Ahead
- Building Automation System
- Information Sources

About the Architect of the Capitol

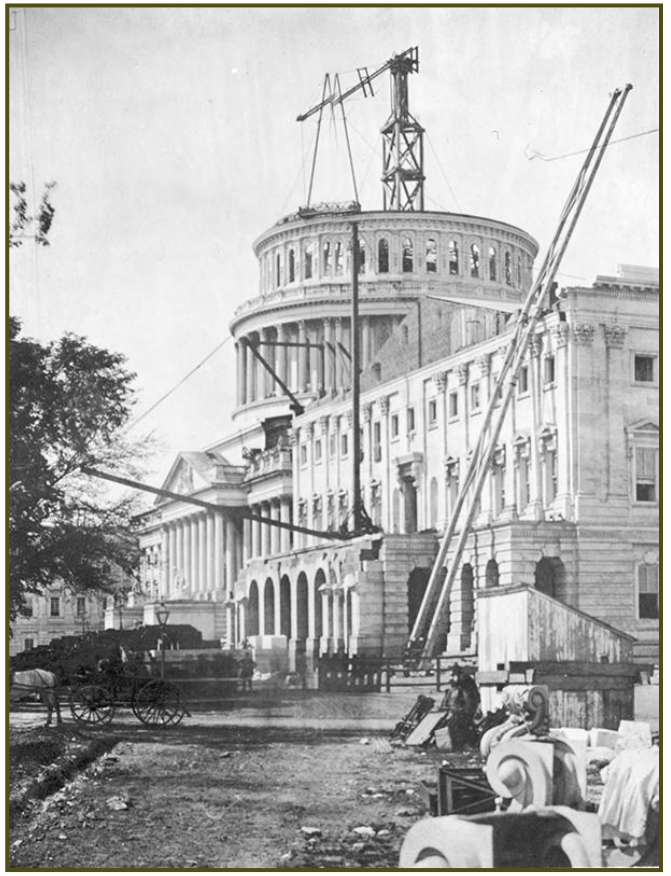
"Provide Congress and the public a wide range of professional expertise and services to preserve and enhance the Capitol complex and related facilities."

- **17.4 million square feet of facilities and 550 acres of historic buildings and grounds**
- **Includes U.S. Capitol, Senate and House Office Buildings, Library of Congress, Supreme Court, Botanic Garden and others**
- **Production and distribution of steam and chilled water to more than 25 buildings**
- **Assets entrusted to our care must continue to meet Legislative, Judicial, and public needs while maintaining historical preservation focus**

Capitol Complex

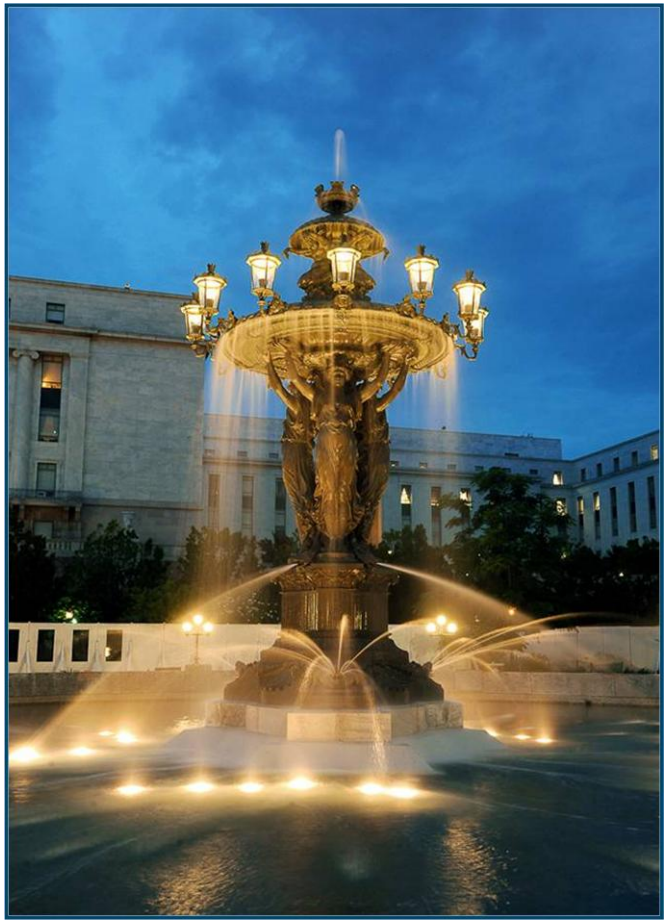
Office of Sustainability, Energy and Water Conservation

- The Architect of the Capitol's Legacy of Sustainability began in 1793.
- Energy and sustainability previously existed as a compilation of initiatives.
- Today, these issues are housed within a well-developed and formal program.
  - Office established in August 2011
- Biggest challenges - preserving iconic elements while making them as energy efficient as possible.



Sustainability and Energy

- Office of Sustainability, Energy and Water Conservation
- Benchmarking
- Major focus areas
  - Buildings
  - Infrastructure
  - People
- Sustainability
  - Adoption of OMB type scorecard
  - Sustainability tracking database



Policies and Initiatives

Federal

- Energy Policy Act of 2005
- Energy Independence and Security Act of 2007
- Executive Orders do NOT apply to the Legislative Branch
- Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings (shadowing)

Architect of the Capitol

- FY12-FY16 Strategic Vision
- Building and Project Sustainability Scorecards
- Commissioning Policy

AOC Guidance

- Sustainability, Energy and Water Management Plan (overall)
- Energy Management Plan (jurisdiction and building specific)
- Building Automation System Master Plan with specifications
- Design Guidelines

Alignment with AOC's Strategic Vision

One Team, One Mission

- Cultivate an organization of learning, sharing, and support
- Utilize AOC resources efficiently

Innovative and Empowered Workforce

- Increase employee involvement and engagement
- Build a culture of transparency, ownership and accountability

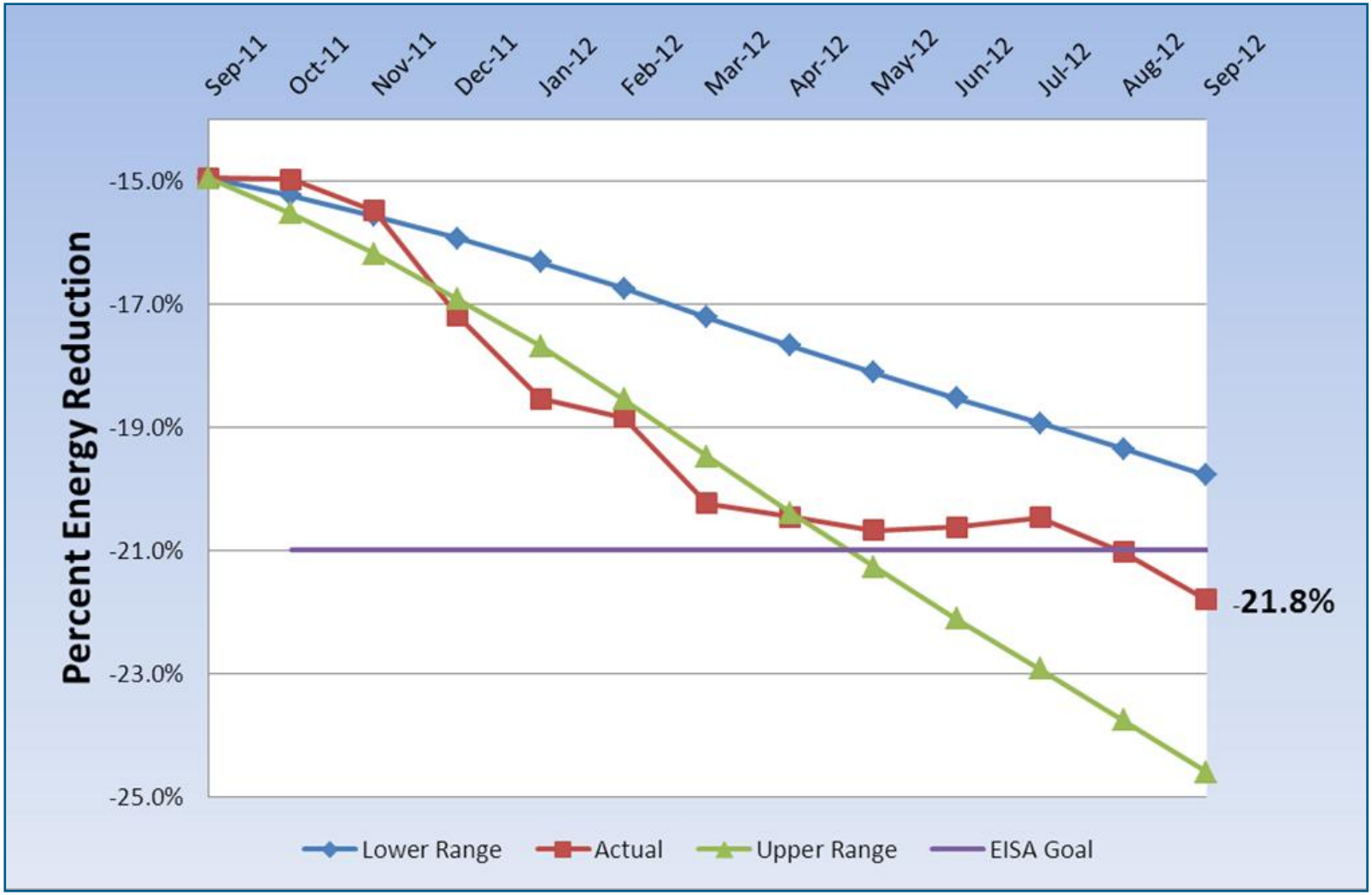
Extraordinary Services

- Provide extraordinary client services

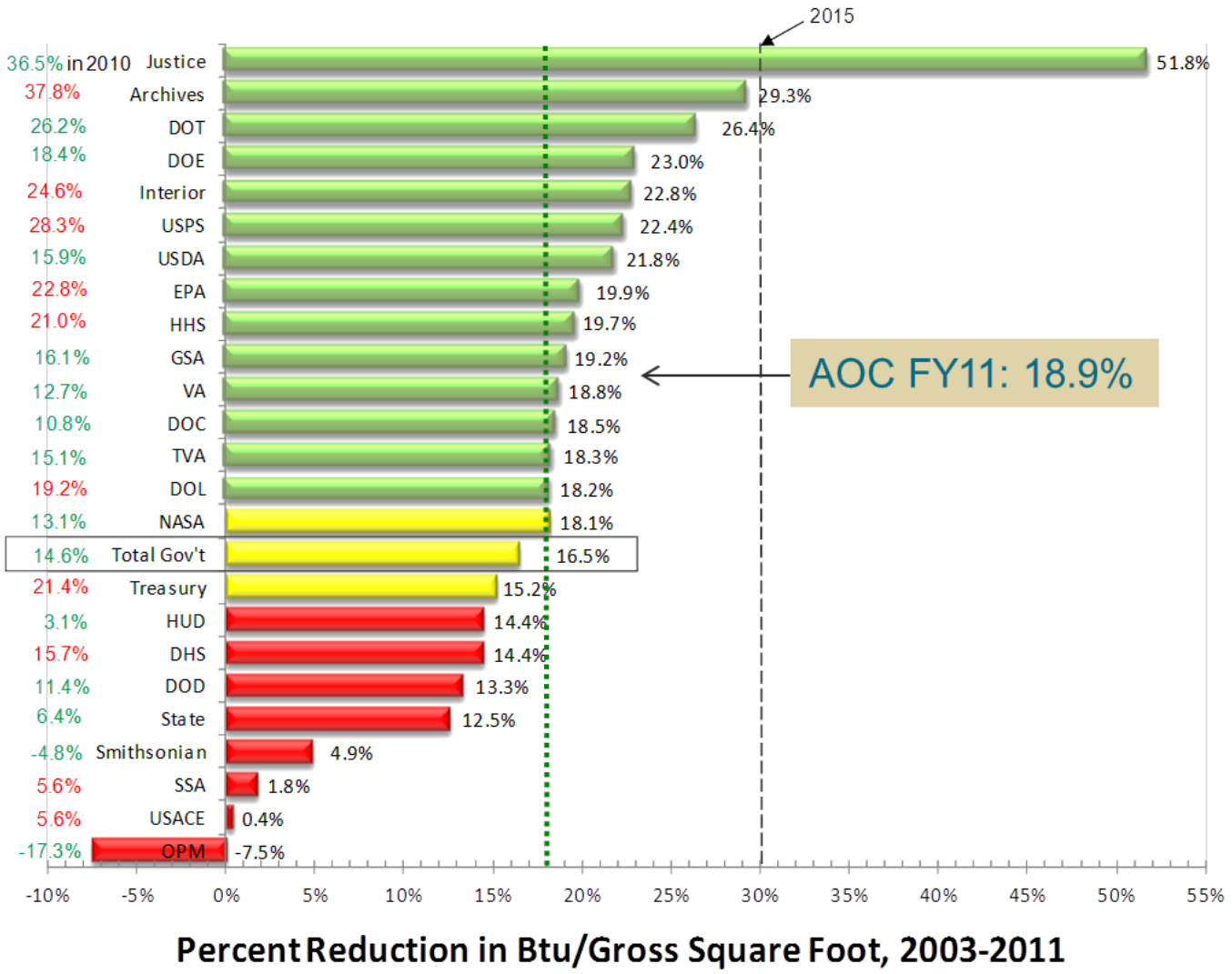
Awe-Inspiring Facilities

- Preserve, enhance, and protect our facilities and landscapes
- Strengthen our facilities through asset lifecycle management
- Promote a culture of resource conservation

FY12 Energy Reduction Progress



AOC/Agency-Wide Comparison

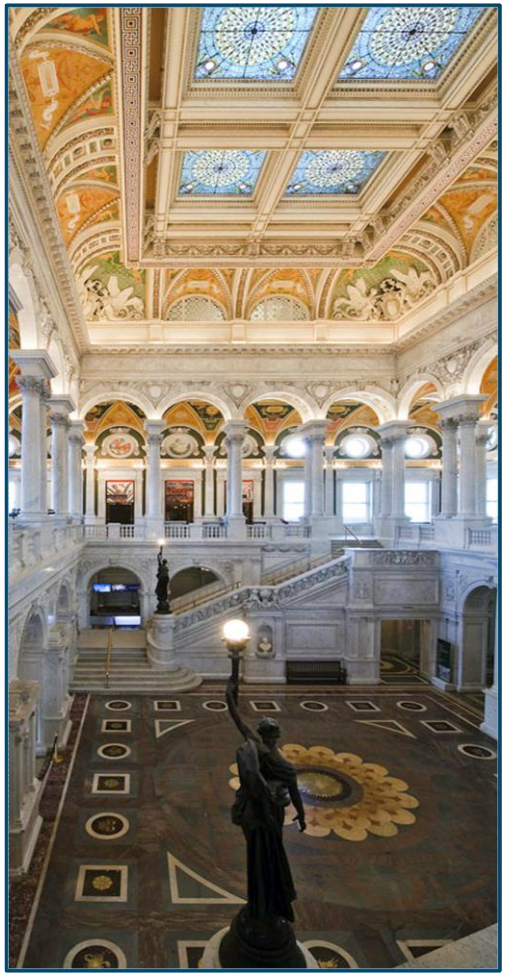


Percent Reduction in Btu/Gross Square Foot, 2003-2011

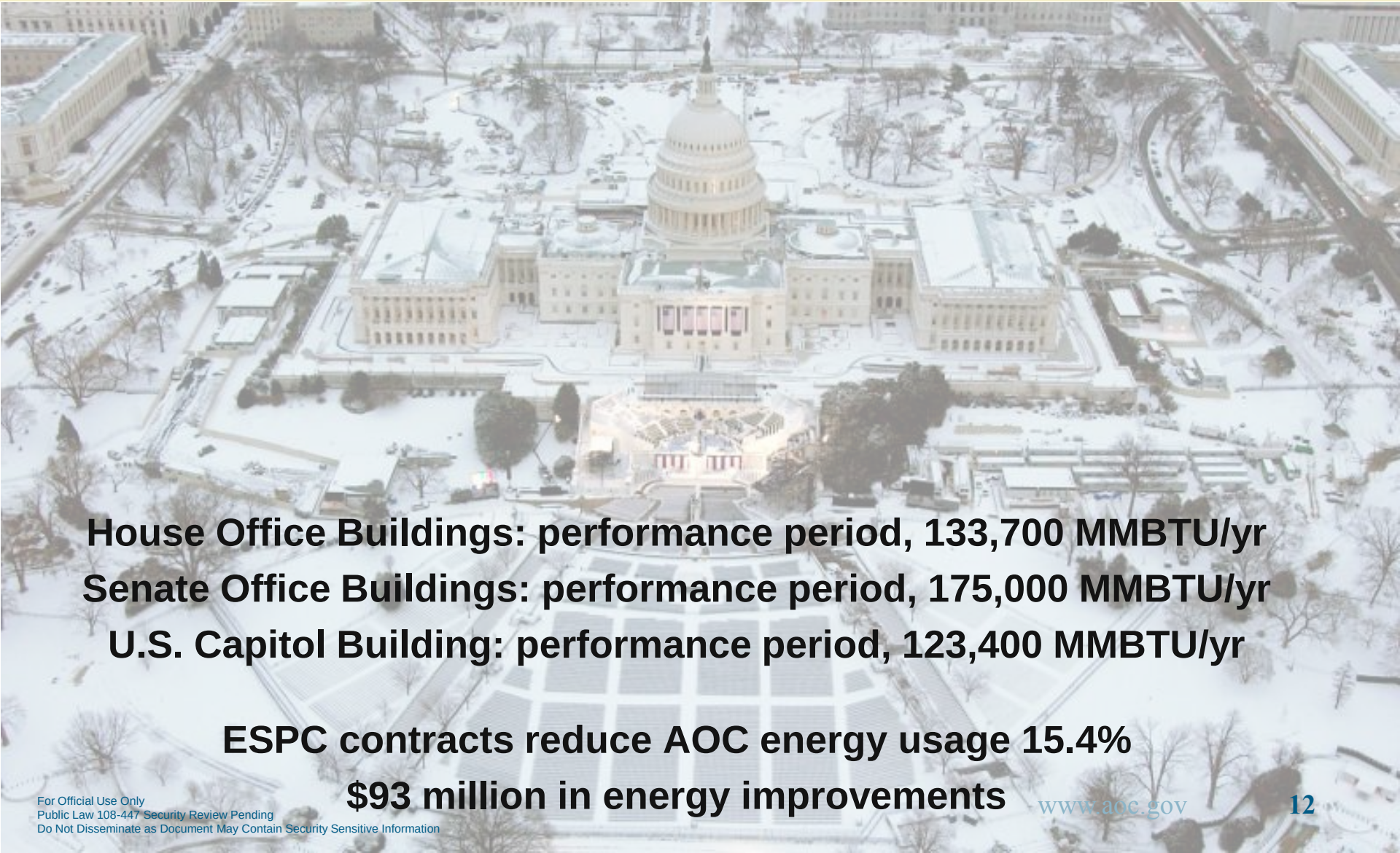
Source: Federal Energy Management Program

Energy Initiatives

- Ongoing ESPC work on lighting and HVAC systems
- Utility infrastructure upgrades
- Conversion of legacy pneumatic control systems to direct digital control
- Lighting and lighting control retrofits
- Increased use of control strategies – scheduling, VFD control, economizers
- Ongoing retro-commissioning and water balancing
- Operation and Maintenance personnel training
- Metering and Enterprise System



ESCP Contracts



House Office Buildings: performance period, 133,700 MMBTU/yr

Senate Office Buildings: performance period, 175,000 MMBTU/yr

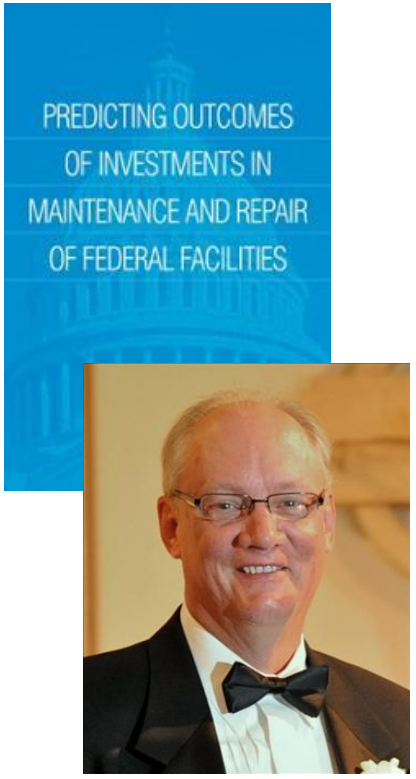
U.S. Capitol Building: performance period, 123,400 MMBTU/yr

ESPC contracts reduce AOC energy usage 15.4%

$93 million in energy improvements

NRC Report on Predicting Outcomes

Title: Predicting Outcomes of Investments in Maintenance and Repair (M&R) of Federal Facilities



Related Recommendations

- Strategic approach for investments (identify/set priorities, measure /analyze performance, fiscal transparency)
- Improve communication – delivery/notifications methods, accuracy, transparency and acknowledge uncertainties
- Collaborate to develop and refine government-wide measures for outcomes, investments and standardized practices
- Maximize use of existing data when developing performance metrics; clearly defined benefit to offset data collection and maintenance
- Take advantage of enhanced data collection and analytic methods and devices

Commissioning at AOC

Exploring Types of Commissioning

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Commissioning (Cx)

- Performed on new buildings or systems
- Performed after start-up and TAB

Re-commissioning

- Performed on existing buildings or systems that have been already been commissioned
- Cyclical and/or recurring; 3-4 year cycle
- Potential for eroding performance without monitoring

Retro-commissioning (RCx)

- Existing buildings or systems that were never commissioned
- Majority of deficiencies cited have less than a 3-year payback

Performance Monitoring

- Continuous monitoring of critical sensors and performance indicators

In general, all commissioning will save energy, resolve operational issues, extend equipment life-cycle, and improve occupant comfort.

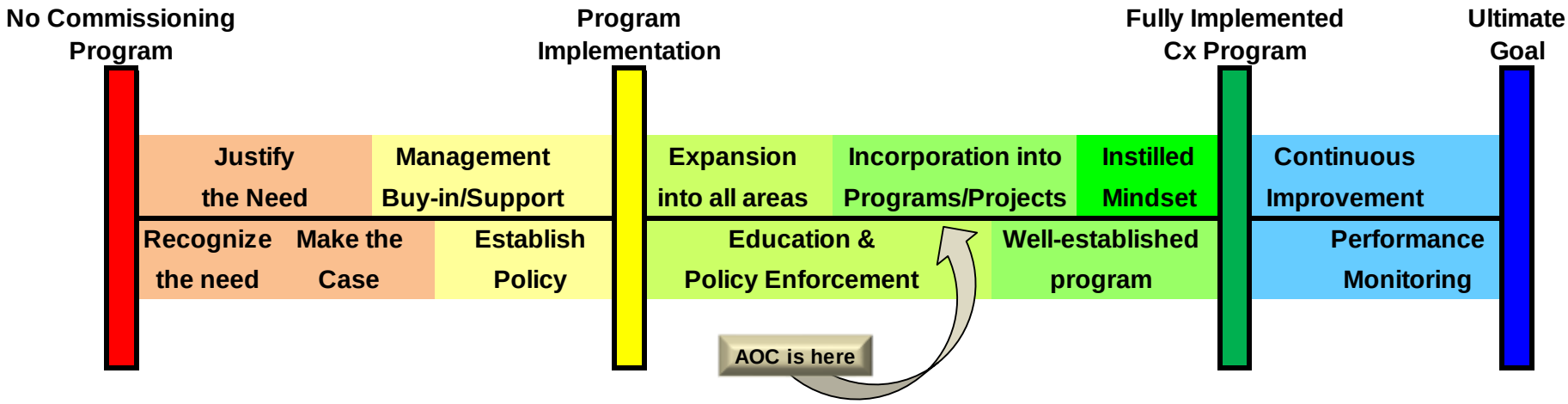
AOC's Commissioning Efforts

- Main focus area is HVAC and building automation (controls)
- Implemented retro-commissioning program in FY09
  - Completed 4 buildings, totaling almost 3,000,000 SF
- Established formal commissioning policy in FY10
- Dedicated, in-house commissioning manager
- Completed two ESPC projects in the House Office Buildings and U.S. Capitol that included commissioning of new HVAC equipment and controls
  - Included 5 buildings, totaling over 6 MSF
- One ongoing ESPC for Senate Office Buildings that includes commissioning of similar measures
  - Includes 3 buildings, totaling almost 2.5 MSF
- Other efforts include water balancing, technical analysis, performance monitoring of buildings with direct digital controls

AOC Commissioning Policy

- **Established September, 2010 as official AOC policy to implement guidelines for commissioning of construction projects**
- **System considered include complex and critical systems, mechanical, electrical, plumbing, envelope, building automation, transportation systems, lighting, emergency power**
- **In-house or third party Commissioning Authority (CxA) based on scope, expertise and availability**
- **Three levels of Commissioning:**
  - **Low – functionality testing of equipment, limited documentation and less complex; normally done in-house**
  - **Mid-level – brief Cx Plan covering testing and verification of systems with few inter-relationships; in-house or third party based on complexity**
  - **Full scale – exhaustive testing with detailed Cx Plan and using a CxA; high level of complexity and inter-relationships**
- **Includes Commissioning System Selection Matrix, Roles and Responsibility Matrix and CxA Requirements**

AOC Commissioning Timeline



Cx Activities & Responsibility Matrices

Master Cx Guideline and Specification

Reference Number	M = Mandatory R = Recommended O = Optional	Project Size			HVAC						Plumbing		Electrical								Fire/Life Safety						Special Systems
		Small	Medium	Large	Air Handling Systems	Exhaust Systems	Heating Hot Water Systems	Chilled Water Systems	Steam Systems	VAV Terminal Units	Domestic Hot Water	Central Chilled Drinking Water	Normal Power Distribution System	Emergency Power Distribution System	Lighting Controls System	Lightning Protection System	UPS Systems	Special Call Circuits	Bird Proofing	Power Monitoring	Control System	Fire Alarm Detection	Fire Sprinklers/Fire Pumps	Stairwell Pressurization	Smoke Management/Control	Fire Alarm Annunciation	Fire Damper	Egress Devices	Congressional Clock System
Construction Phase																											
System Specific Activities																											
C4	Equipment & System Submittal Reviews	M	M	M	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
C7	Equipment O&M Manual Review	M	M	M	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
C8	Equipment Training Planning	O	R	M	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
C9	Systems O&M Manual Development	O	R	M	X	X	X	X	X	X	X	X	X	X	X						X			X	X				
C10	Systems Training Plan	O	R	M	X	X	X	X	X	X	X	X	X	X	X						X			X	X				X
C11	Electrical Test Agency Plan Review	O	O	R									X	X			X			X									
C12	Test, Adjust & Balance Execution Plan Review	O	R	M	X	X	X	X		X														X	X				
C13	Final Contractor Test Report Forms Development	O	O	R			X	X	X		X	X											X						
C14	Final Equipment Startup Report Forms Development	O	O	R	X		X	X	X			X	X	X							X		X						
C15	Final System Readiness Checklist Development	R	M	M	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
C16	Final Functional Performance Test Procedure Development	M	M	M	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Responsible and Participating CX Team Members																
AOC Project Manager	Superintendent Office	AOC Architect	AOC Engineering	- AOC Mechanical	- AOC Electrical	- AOC Fire Protection	- AOC Safety	- AOC Fire Marshal	- AOC Elevator Division	- AOC Electronic Division	AOC Construction Manager	Design Professional	Installing Contractors	Commissioning Professional	Final User Representative(S)
Construction Phase															
= Responsible														S = small, M = medium, L = large, A = all	

Cx Process Flowchart

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Pre-Design

- Form Cx Team
- Develop OPR
- Develop Initial Cx Plan

Design

- Develop Cx requirements for construction documents
- Update and verify OPR and BOD
- CxA reviews design documentation and provides feedback to A/E
- CxA updates Cx Plan and Cx specs

Construction / Installation

- Update Cx Team
- Verify Submittals
- CxA develops all test forms and checklists
- Update OPR and BOD
- Maintain Cx Issues Log
- CxA verifies start-up and perform verification checks

Acceptance

CxA performs functional performance tests
Resolves outstanding Cx Issues Log
Retest systems and equipment
CxA reviews and verifies O&M manuals

Occupancy & Operations / Warranty

Maintain OPR, BOD, record drawings
CxA conducts site visit at 10 months
Deferred ad/or seasonal testing is performed
CxA prepares Final Cx Report
Annual Benchmarking

Retro-Commissioning Scope of Work

Contractor qualifications

- Similar scope projects in last five years
- Years of relevant energy management experience
- Current professional certification and specific controls experience
- Maintain competency levels for duration

Systems

- Heating, ventilation, air conditioning
- Domestic hot water
- Associated controls

Tasks

- Regular progress meetings and meeting minutes preparation
- Review of existing systems, documentation and strategies
- Calibration, functional testing, monitoring and analysis, formulation of energy conservation measures (ECMs)

Deliverables

- Retro-commissioning plan
- Mid-point report and review, final report
- Review and lessons learned workshop

Other Related Efforts

Air Handling Studies

Four evaluations were performed on newer fan technologies and filtering; one more is planned.

Water Balancing

Performed in several problematic buildings, either alone or with RCx.

Thermal Meter Checks

As part of RCx effort, steam and CHW meter accuracy are verified.

Performance Monitoring

Currently being performed on four buildings with DDC systems that have been in place for a few years.

Integration

Currently being performed on a newer, +700,000 SF facility that was never tied into to our campus-wide system; balancing, RCx and performance monitoring to follow.

RCx: Calibration & Maintenance Template

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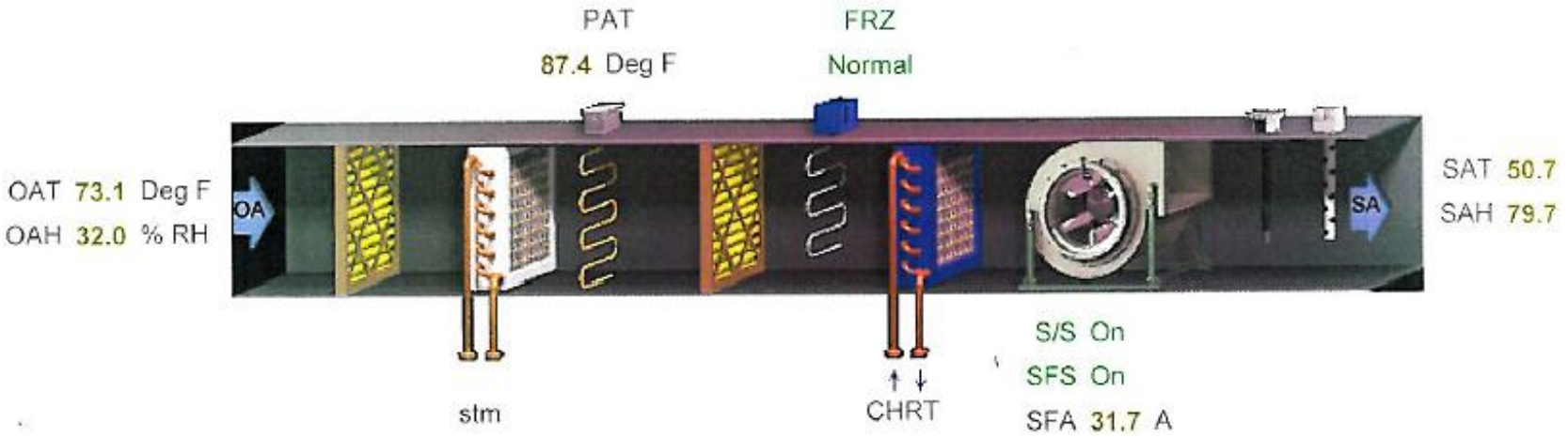
2. Calibration Checklist:

a. ☑ Review manufacture's product documentation on calibration processes for sensing and control equipment.

b. ☑ Verify calibrations can be performed without damage to equipment / personnel or disruption of services.

c. ☑ Perform calibration on associated input and output components using the table below.

Component: Sensor/ Actuator	Model/ Mfr.:	System:	Local Pre-Calib. Values:	BAS Pre-Calib. Values:	Measured Pre-Calib. Values:	Calib. Values:	Comments:
OAT		A.L.	n/a	60.2	81.6		MONITOR ONLY
OAH		A.L.	n/a	56.8	48.7		MONITOR ONLY
PAT		A.L.	n/a	90.5			MONITOR ONLY
CHRT		A.L.	60.0	55.7			MONITOR ONLY
SFA		A.L.	37.8	31.2			MONITOR ONLY
SAT-1		A.L.		53.7	53.9	53.7	OK
SAH		A.L.		82.7	78.9	78.9	OK
SAT-2		PNEUM	54.0		53.9		OK
CHW-VLV		PNEUM	0/50/100				* MANUALLY SET - ACTUATOR
STM-VLV		PNEUM	0/50/100				* MANUALLY SET - ACTUATOR
OA DAMPERS		PNEUM	0/100				OK



RCx: Functional Performance Testing

4. Sensor Calibration Checks. The sensors listed below are to be checked for calibration and adequate location.

Sensor	Location OK[1]	BAS Value	Measured Value	Pass Y/N
Outside Air Temperature °F	Yes	80.2	81.6	Yes
Outside Air Relative Humidity, %	Yes	56.8	48.7	Yes
Discharge Air Temperature °F	Yes	53.2	53.9	Yes
Discharge Air Relative Humidity, %	Yes	82.7	79.8	Yes
Chilled Water Return Temperature, °F	Yes	55.7	60	Yes

[1] *Sensor location is appropriate and away from causes of erratic operation.*

Comments:

5. Device Calibration Checks. The actuators or devices listed below are to be checked for proper operation and/or calibration.

Device or Actuator	Procedure / State	BAS Value	Site Observation	Pr Y
Outside Air Damper	Closed	n/a	n/a	Y
	Midpoint	n/a	n/a	Y
	Open	n/a	n/a	Y
Pre-Heat Steam Coil Valve %	1. 0% closed	0%	0%	Y
	2. 50% open	50%	50%	Yes
	3. 100% open	100%	100%	Yes
ChW Coil Valve %	1. 0% closed	0%	0%	Yes
	2. 50% open	50%	50%	Yes
	3. 100% open	100%	100%	Yes
Supply Fan VFD speed	1. 0 Hz	0 Hz	0 Hz	Yes
	2. 40 Hz	40 Hz	40 Hz	Yes
	3. 60 Hz	60 Hz	60 Hz	Yes

7. Functional Testing Record

Seq. ID	Mode ID	Test Procedure (including special conditions)	Expected Response	Pass Y/N	Notes
1	UNOCCUPIED MODE: System OFF	1. Using the BAS system, command the unit to the unoccupied / shutdown mode. 2. Using the mode selection switch command the unit to the off mode. 3. Restore parameters to their original values	1. The supply fan will shutdown. The OA and DA dampers shall close. 2. Supply fan off, outside air damper closed 3. The unit returns to normal operation.	YES	1. There is not unoccupied mode for the unit. The unit operated 24/7 2. As expected 3. As expected
2	OCCUPIED MODE: System enable	1. With the unit in the occupied mode / enable mode, observe the operation of the unit.	1. The supply air fan operated at the manually set VFD frequency (60Hz), the discharge air temperature is controlled by the reset schedule: OAT 40°F – DAT 68°F OAT 80°F – DAT 48°F	YES	As expected Note: The written sequence of operation was not provided

RCx: Commissioning Issues Log

AHU Humidifier control loop is modulating open even though humidity is 30% greater than setpoint.
Replace supply air temperature sensor. Sensor is reading 5.0 deg F higher than certified measured reading
Replace mixed air temperature sensor. Sensor is reading 4.9 deg F higher than certified measured reading
Repair low pressure steam leak on preheat coil inlet flange.
Repair low pressure steam leak on preheat coil tab valve above inlet flange.
Replace chilled water control valve. Valve operates, but has significant corrosion.
OA damper command is not controlled by AHU-31 command.
OA damper command is not controlled by AHU-31 Freezestat command
AHU Humidifier control loop is modulating open even though humidity is 30% greater than setpoint.
Repair ourdoor air damper linkage. OA Dampers leaks-by when commanded close.
Replace chilled water control valve. Valve operates, but has significant corrosion.

Our RCx Issues Logs also include priority, project number, status and energy impact.

- ✓**Valves**
- ✓**Dampers**
- ✓**Sensors**
- ✓**Actuators**
- ✓**Control logic**

V-3 ChW valve is showing signs of corrosion. Consider repair / replace
V-4B V-4B valves are showing signs of corrosion. Consider repair / replace
Local pneumatic Outdoor air sensors are tracking more than 30 deg F incorrectly. This effects simultaneous heating and cooling activities. Consider replacement / upgrade
MPS steam control valve is isolated due to failure. MPS control valve to be replaced.
Main Steam isolation valve is showing signs of corrosion. Consider repair / replace
Secondary water control valve does not open fully. Verify flow at FCU coil.
No zone thermostat for FCU control
Secondary water valve remains at 100% open
No zone thermostat for FCU control
Secondary water valve remains at 100% open
No zone thermostat for FCU control

RCx: Energy Conservation Measures

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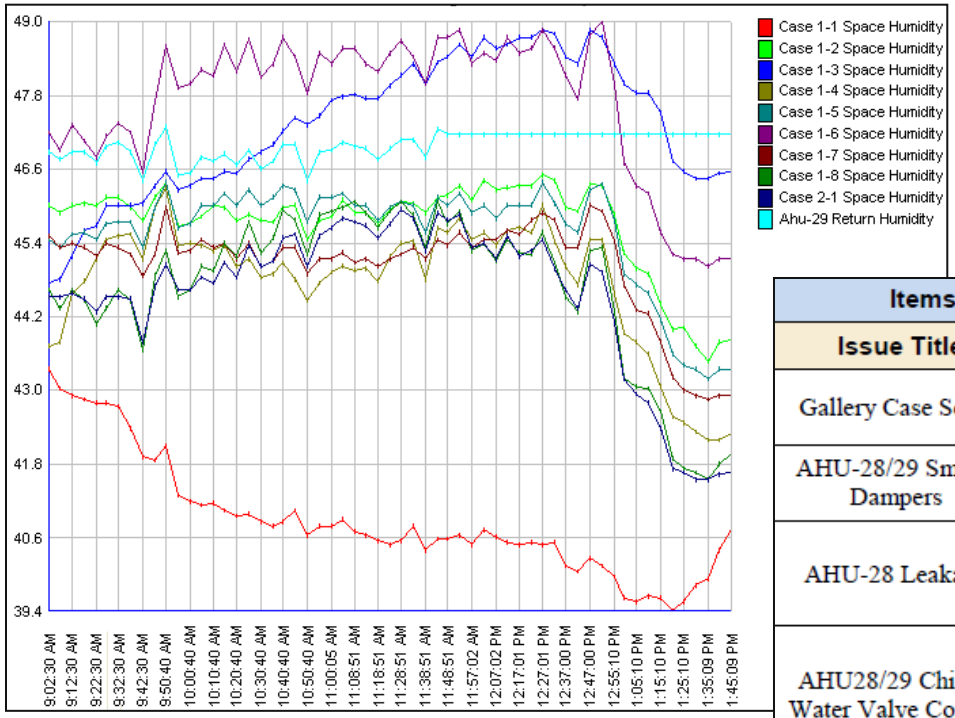
ECO/ Opportunity Strategy	Measure Type*	Electric Energy Savings kWh /Yr	Chilled Water Savings MMBtu /Yr	Steam Savings MMBtu /Yr	Total Energy Savings MMBtu /Yr	Total Energy Savings $/Yr	Total Cost to Implement ($)	Payback (Years)
ECO 1/ 40-50 HP AHU Unoccupied Schedule (4 AHUs)	RC	252,216	5,904	1,186	7,951	$100,893	$46,286	.5
ECO 2 /20-25 HP AHU Unoccu Schedule (9 AHUs)						5,440	$77,188	1.4
ECO 3 /OAT Supply Fan Frequ Reset (5 AHUs)						7,849	$52,662	1.9
ECO 4 /25-50 HP AHU RAT-Based Supply Fan Frequency Reset (4 AHUs)	RC	85,854	700	318	1,311	$21,540	$52,491	2.4
ECO 5 /Actual Occupancy Supply Fan Frequency Reset (AHU-16)	RC	58,900	655	82	938	$14,150	$28,562	2.0

13 ECOs Identified

Total Energy Savings: $413,876/year
Implementation Cost: $584,434

Average Payback: 1.4 years

Example: Archival Display Cases



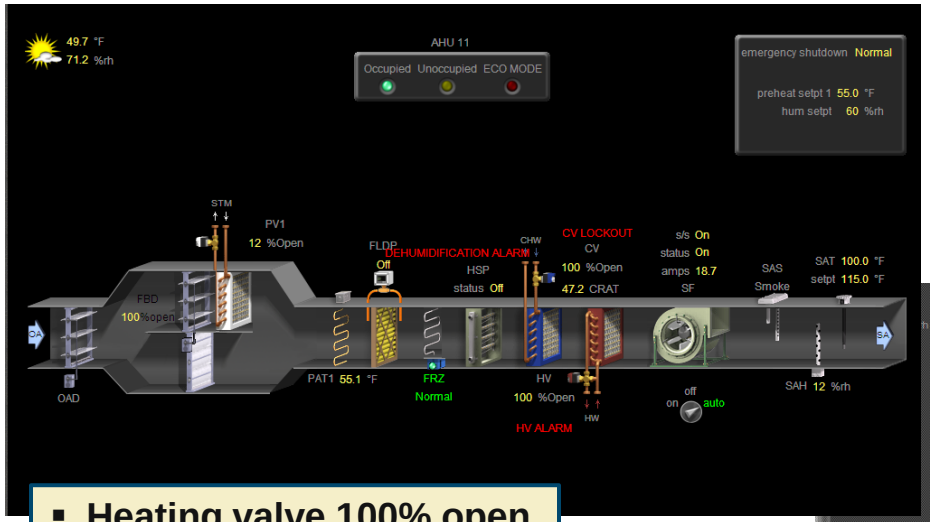
Post-trending indicated temperature and humidity stability.

Temperature and Humidity Variance

Items Added to Corrective Actions Matrix (CAM)	
Issue Title	**Description**
Gallery Case Seals	Only one rubber seal is provided. Recommend an additional seal be installed to enhance the case performance.
AHU-28/29 Smoke Dampers	Smoke dampers are not installed per Drawing M21.
AHU-28 Leakage	There were minor air leaks observed near the supply connection from the main branch to the individual case supply ducts for Cases 1-5 and 1-6. It is recommended these air leaks be resolved.
AHU28/29 Chilled Water Valve Control	When the chilled water valve is fully open, the leaving air temperature is not able to meet the dehumidification mode setpoint of 45 degF. The air temperature remained at 49.8 degF.
AHU-28/29 Humidifier Control	The humidifier currently controls to maintain the return air humidity, not the case humidity, per 21.0. Recommend design intent be clarified.
Gallery Case Humidity	The humidity in each case is slightly low of setpoint. Recommend this be investigated.

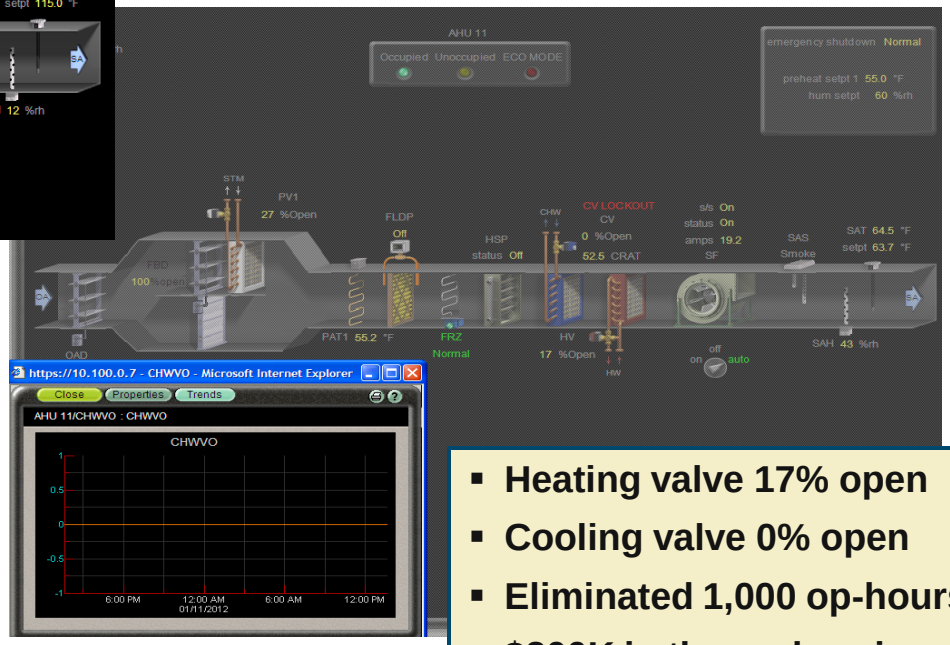
Example: 100% Outside Air Units

BEFORE LOOP TUNING



- Heating valve 100% open
- Cooling valve 100% open
- 4 AHUs, 120,000 CFM

AFTER LOOP TUNING

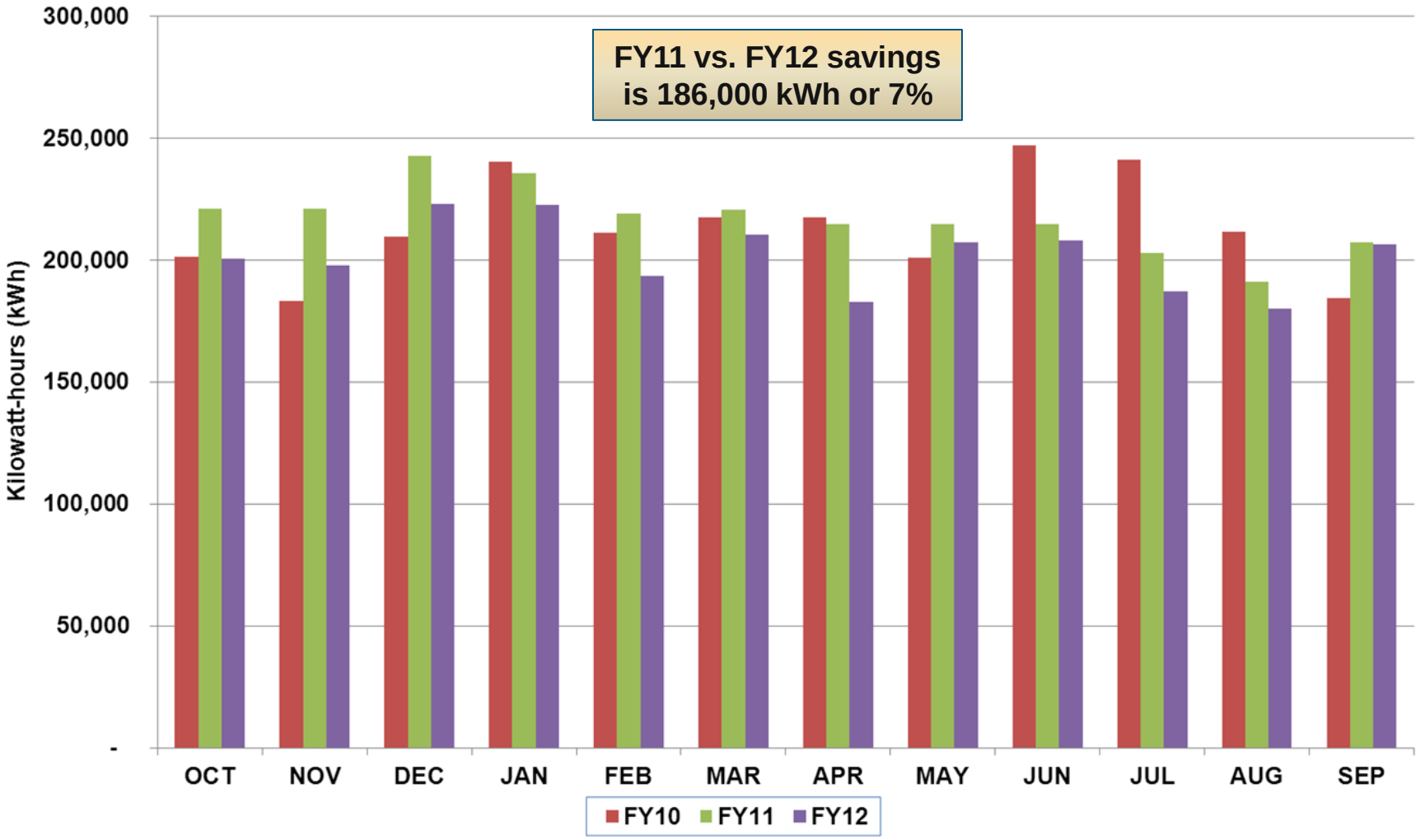


- Heating valve 17% open
- Cooling valve 0% open
- Eliminated 1,000 op-hours
- $200K in thermal savings

Example: Building Pressurization

- Scope of Work included RCx of HVAC, air balancing, formulating energy conservation opportunities and some limited project design review.
- Functional Performance Test (FPT) was conducted by our RCx contractor, with AOC personnel participation.
- By reducing fan speed by 22%, the 12 kW electrical savings would result in $12,000 of annual cost avoidance.
- Other air handler issues identified:
  - Broken OA damper actuator
  - Malfunctioning/missing building pressure sensors
  - Simultaneous heating/cooling
  - Leaking heating valve
- Further savings will be realized once the other building issues are addressed in upcoming upgrade project.

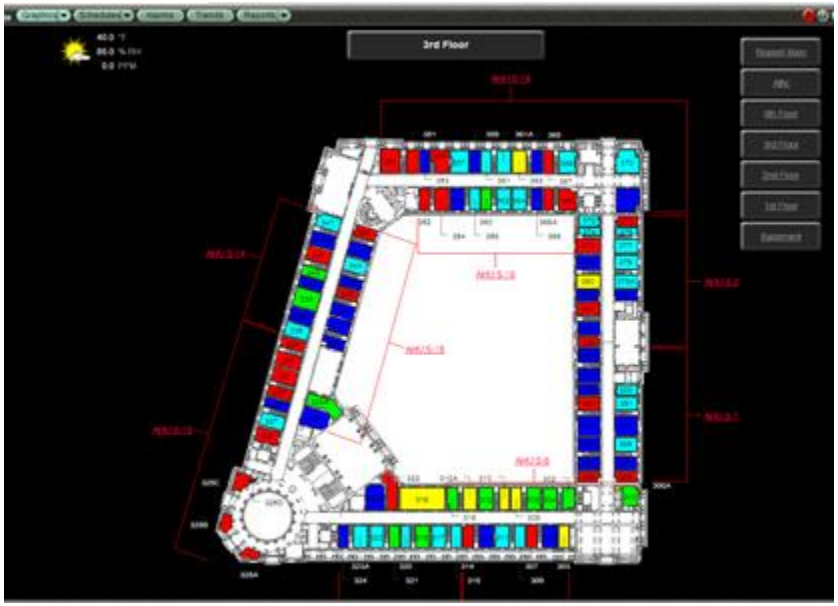
Building Pressurization Electrical Savings



Building Automation Thermographics

- When initially clipped over on 12/17/12
- Red blocks indicating spaces with potential hot/cold calls.

- After control logic revisions
- This will now be much more useful for AOC to enhance operations and/or troubleshoot



Typical Retro-commissioning Savings

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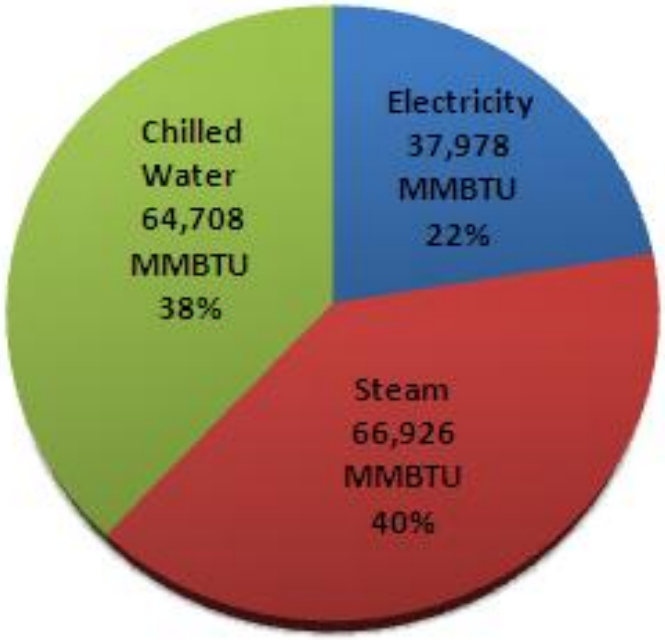
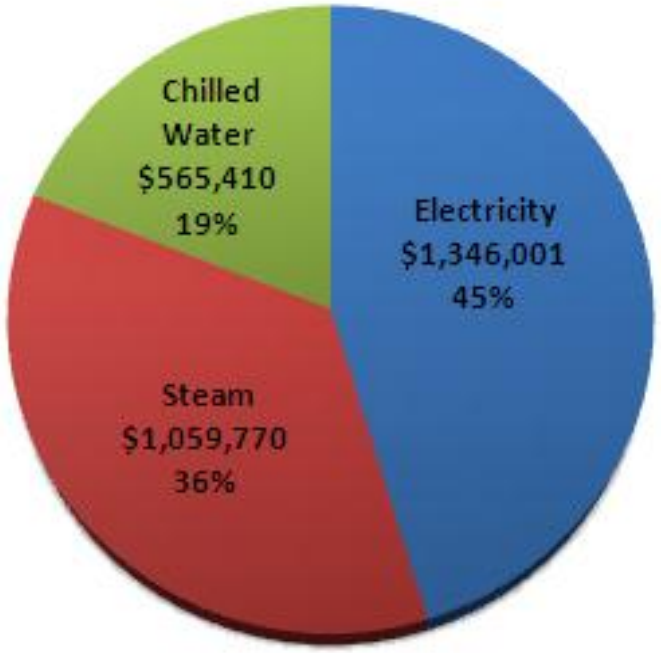
Consumption:
169,612



Cost:
$2,971,181



Fiscal Year Energy Usage and Cost Summary
(620,000 GSF with an EUI 104 kBTU/SF)

Not an AOC Facility

Buildings to Central Utility Plant

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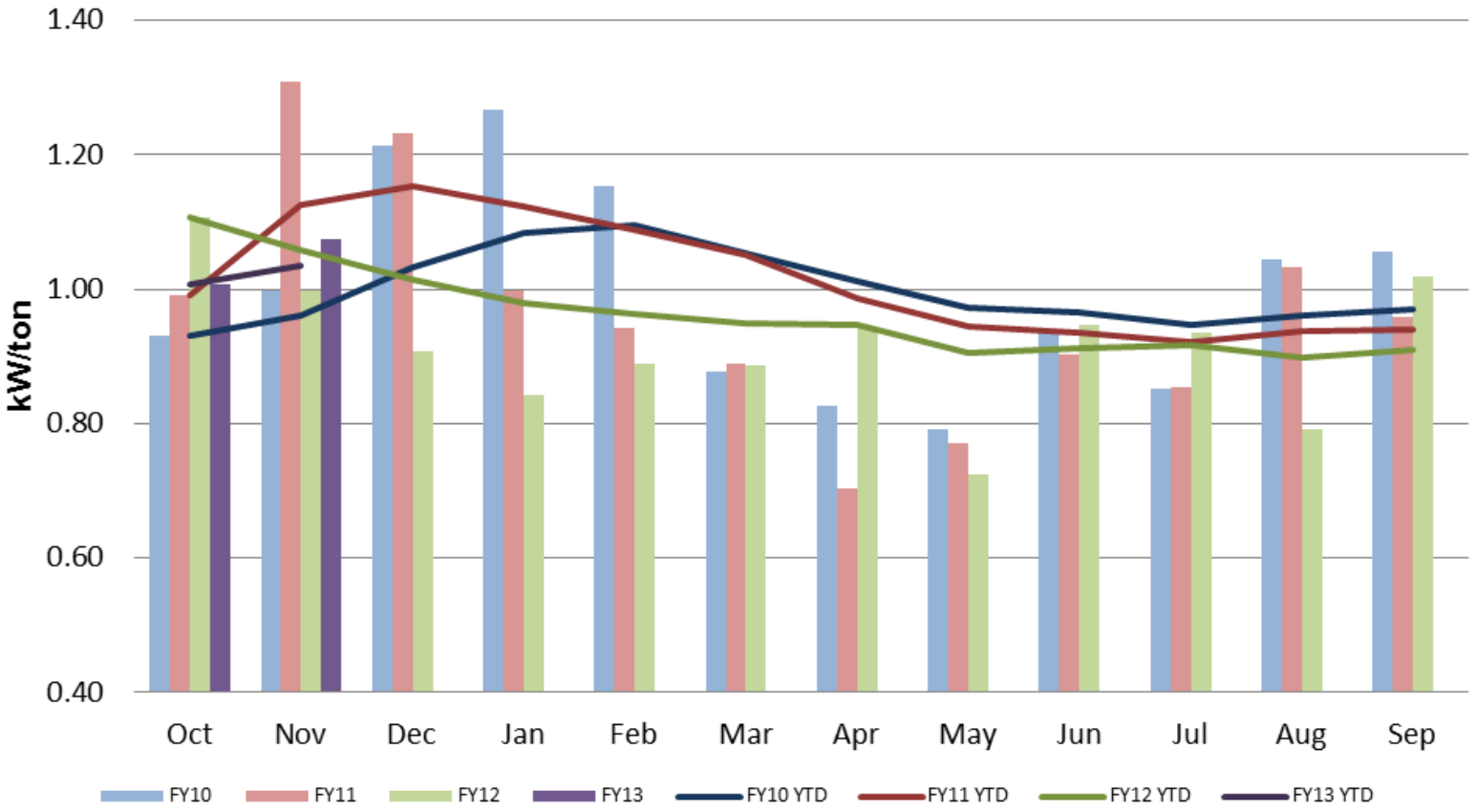
Energy saving efforts and commissioning in our buildings is helping the performance of our Central Utility Plant



Other Benefits of Cx Program

Office of Security Programs

- Corrective action being taken on building pressurization issues
- Incorporating remaining 170+ items in pneumatic to DDC conversion project
- TAB Survey drawings served as valuable resource for redesigning and correcting HVAC issues identified

Thurgood Marshall Federal Judiciary Building

- Used Cx Issues Log (376 items) to assess O&M contractor performance
- The RCx process and the deficiencies identified facilitated the change from a paper-based PMS to a CMMS, restoring operation status and avoiding recurrence
- Incorporating remaining items in major DDC upgrade project

Library of Congress

- Quantified chilled water flow for large data center
- Follow-up review and self-Cx for steam and chilled water valves and logic
- Incorporating remaining items and ECMs in small/large DDC upgrade projects and using the findings for potential ESPC (184 items total)

House Office Buildings

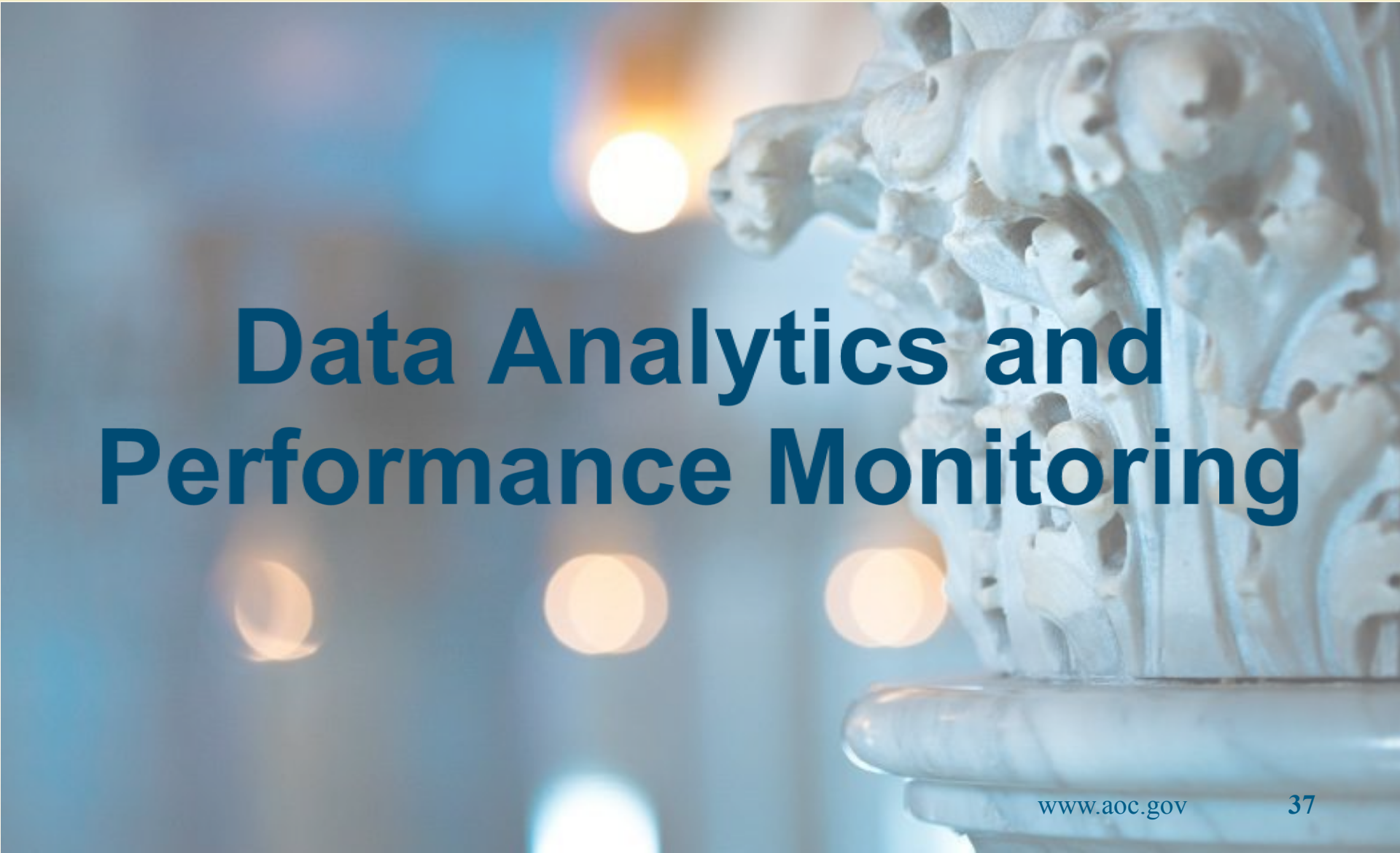
- Decreased summer hot calls in locations that have been challenging in the past

Lessons Learned at AOC

- **Beneficial timing with other projects (timing and scope)**
  - **Before – address deficiencies identified in the Cx Issues Log in project scope, perform minor repairs in house, document existing conditions**
  - **After – follow-up on energy strategies, ensures persistence of savings; identifies other potential improvements**
- **Coordination with other assessment efforts**
  - **Many times, the CxA has the same or better skill sets to perform a detailed energy audit**
  - **You will probably get a better HVAC energy conservation measure analysis from the CxA than from an energy auditor**
- **Build a good team; by respectful and mindful of building operations and maintenance staff and recognize their efforts**
  - **In-house maintenance and contract maintenance forces require slightly different approaches, both in execution and follow-up**

Lessons Learned at AOC

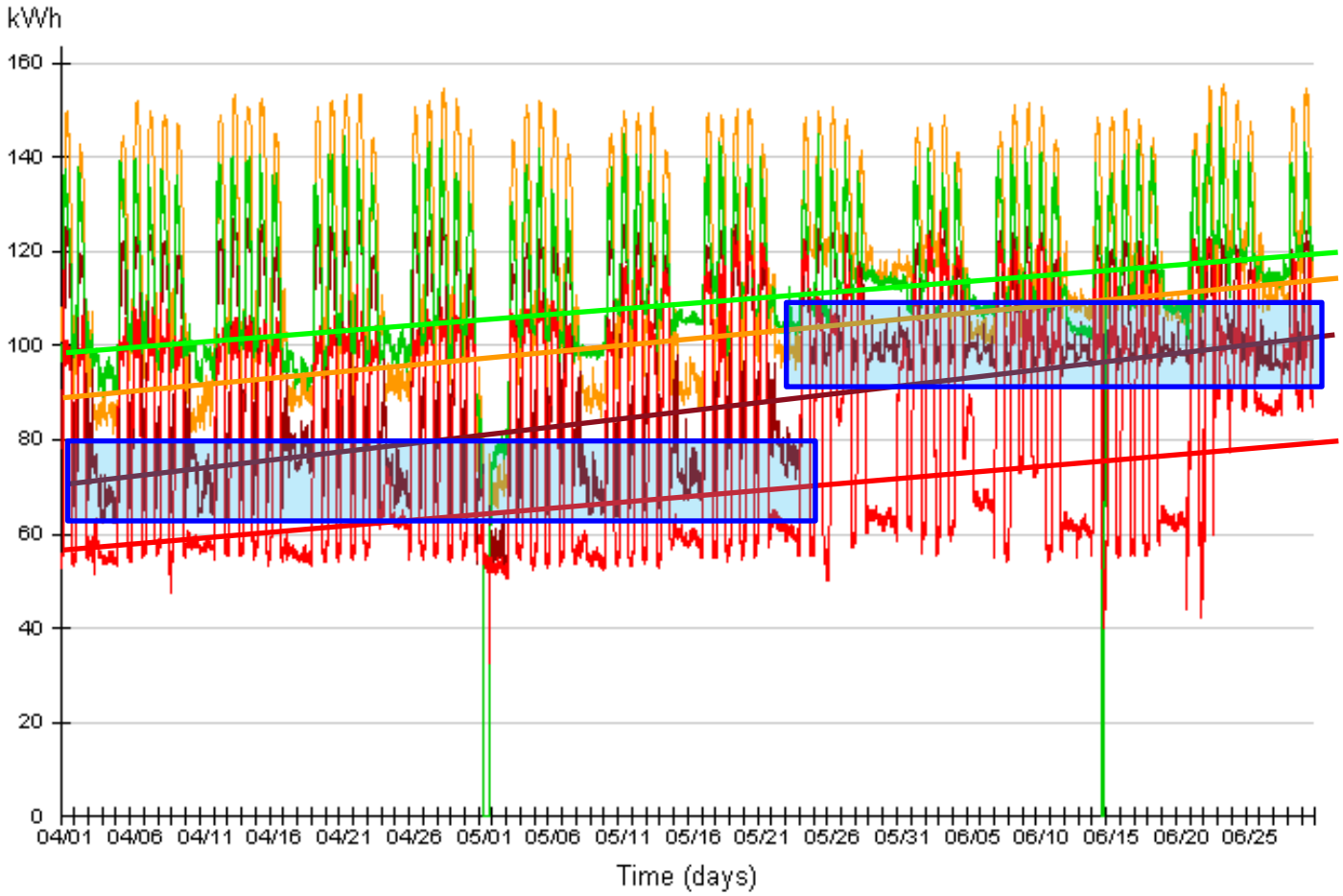
- **It is very difficult to effectively RCx a non-DDC building – lack of data collection capability, persistence of savings.**
  - **It is also difficult if the building lacks metering**
- **In general, the majority of real, impactful energy savings involve operational or equipment improvements to the HVAC system.**
- **Link Commissioning Issues Log deficiencies with work order system for in-house repairs to track efforts.**
- **Assist jurisdiction with formulation of smaller or larger scale projects.**
- **Always have a lessons learned discussion at close-out.**
- **Annual follow-up on open Cx Issues Log items and energy conservation measures.**


Data Analytics and
Performance Monitoring

Data Analytics Example: Energy Increase Mystery

ARCHITECT OF THE CAPITOL

DRILLING DOWN INTO IDR (INTERVAL DATA RECORDER) DATA FOR APR-JUN 2010

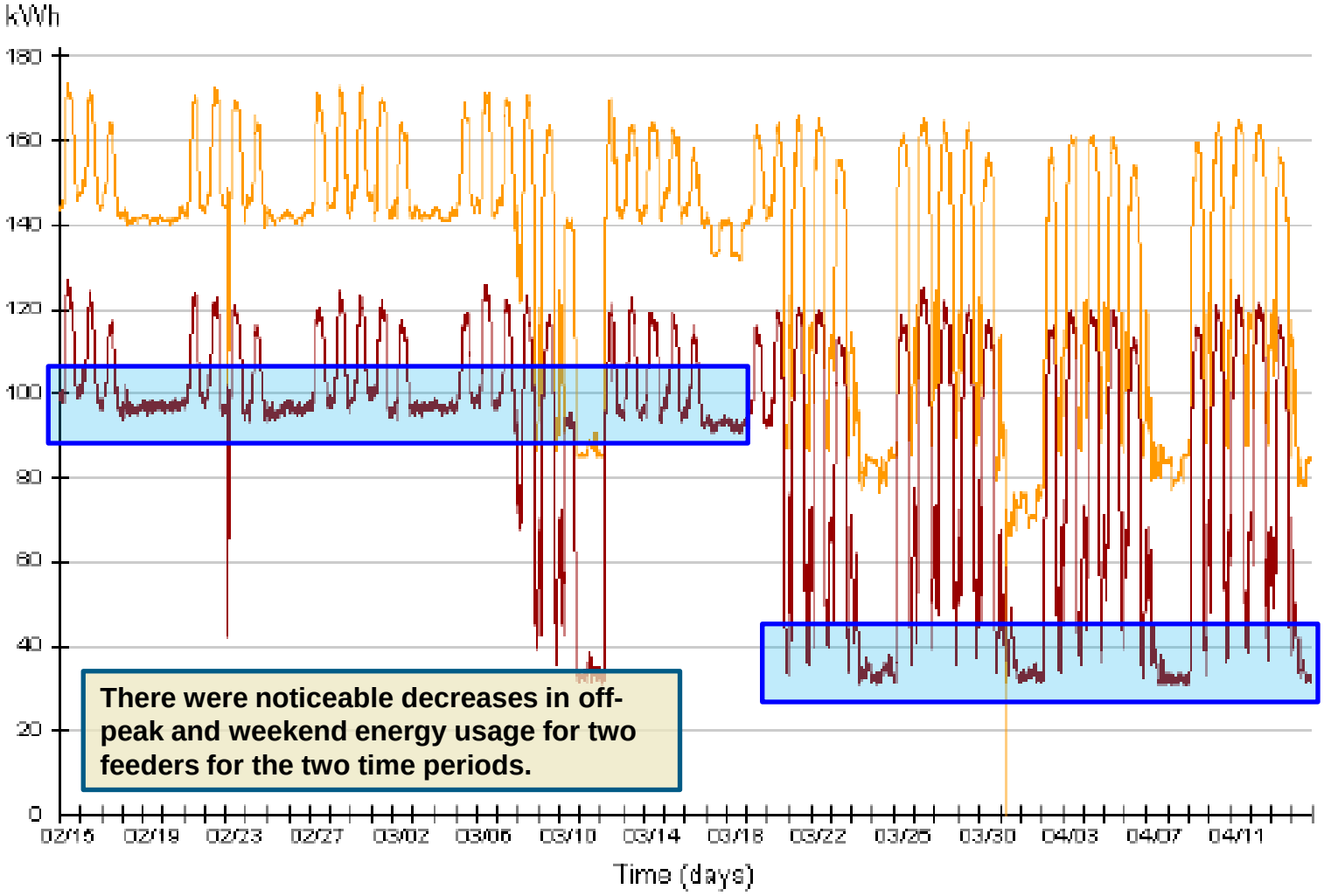


- Four building feeders
- Peak daily usage remains consistent
- Steady upward creep in non-peak base during off-hours
- Trends Indicate decay in setbacks or scheduling of electrical equipment
- Drastic 30 kWh change in one feeder

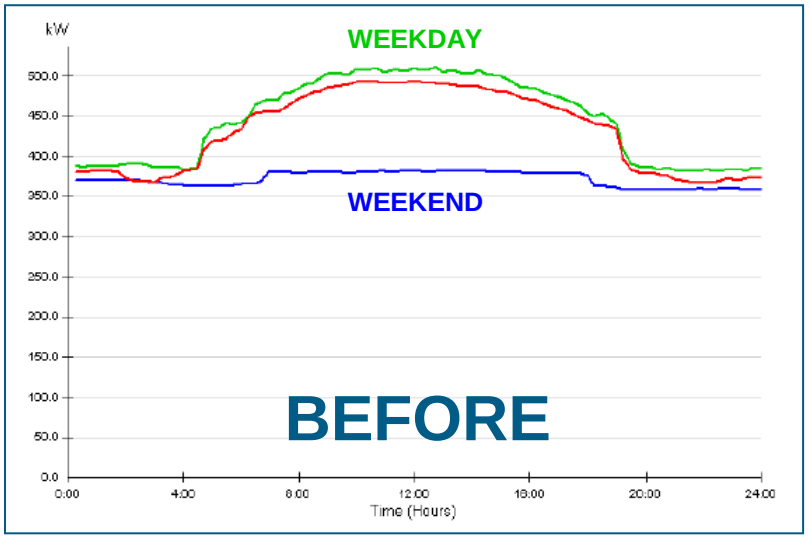
Data Analytics Example: The After Snapshot

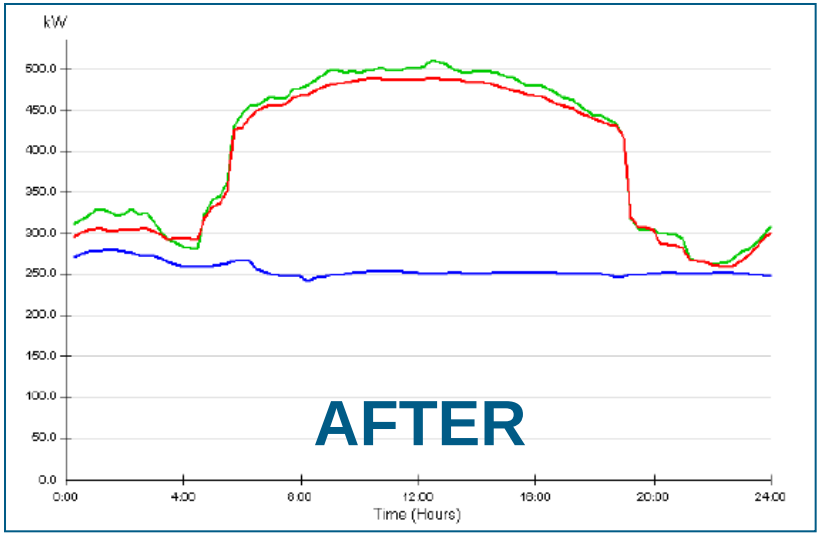
ARCHITECT OF THE CAPITOL

DRILLING DOWN INTO IDR (INTERVAL DATA RECORDER) DATA FOR FEB-APR 2012



Data Analytics Example: Energy Savings

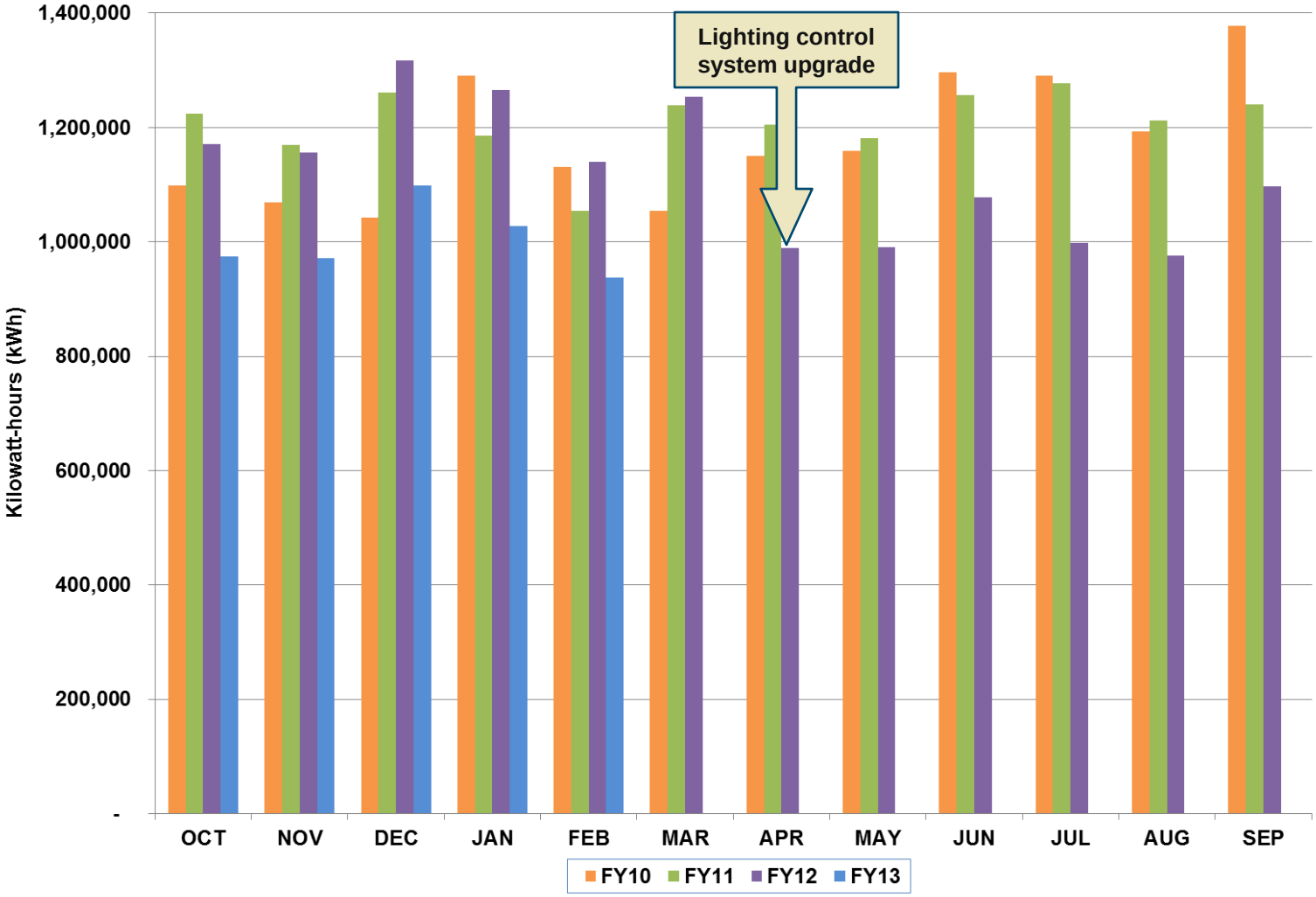




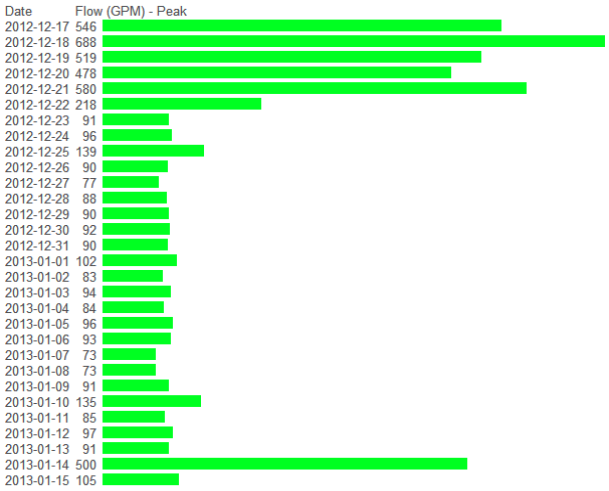
- **Average Weekends went from 375 kW to 250 kW, a 33% reduction**
- **Average Weekdays went from 375 kW to 275 kW during unoccupied times, a 27% reduction**
- **Comparing utility bills:**
  - **3/20-4/21/11 30 days 1,205,613 kWh = 40,187 kWh/day**
  - **3/20-4/16/12 28 days 988,473 kWh = 35,303 kWh/day**

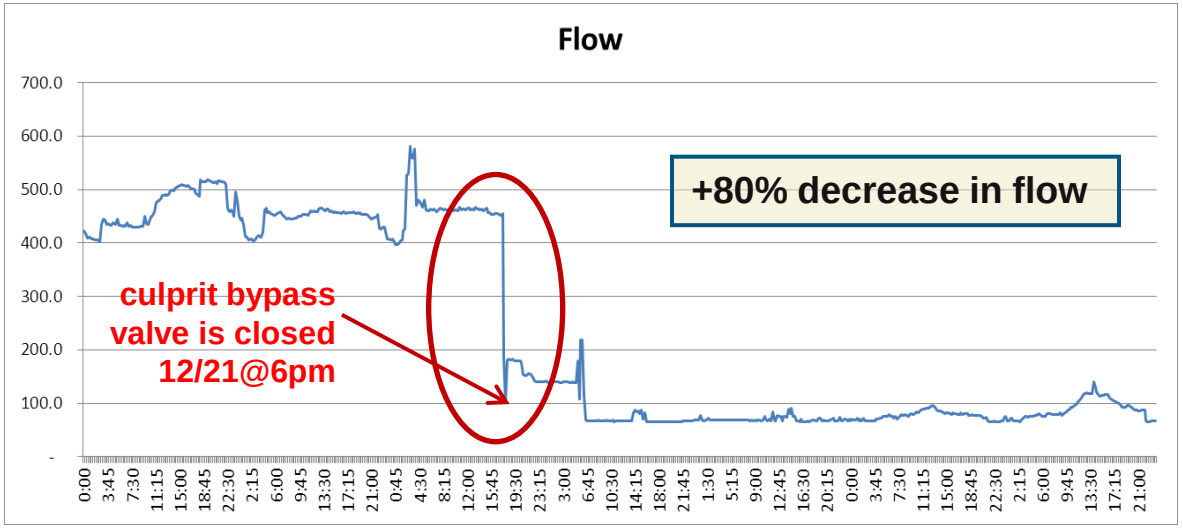
SINCE APRIL 2012, TOTAL ELECTRIC USAGE HAS BEEN REDUCED BY 2.3 MWh OR 17%, WHICH EQUATES TO $30K COST AVOIDANCE ANNUALLY

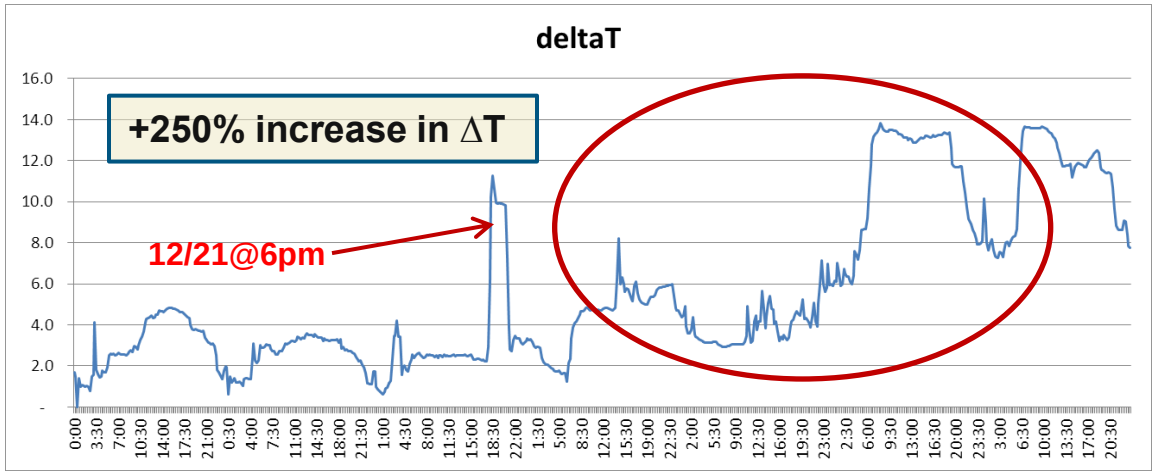
Data Analytics Example: Continued Savings

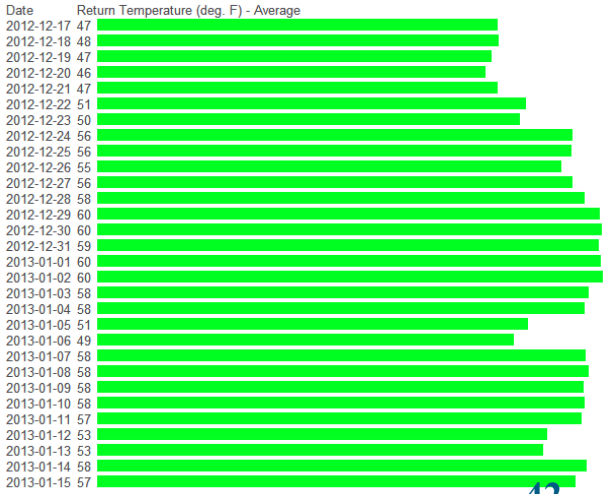


Chilled Water ΔT Issue



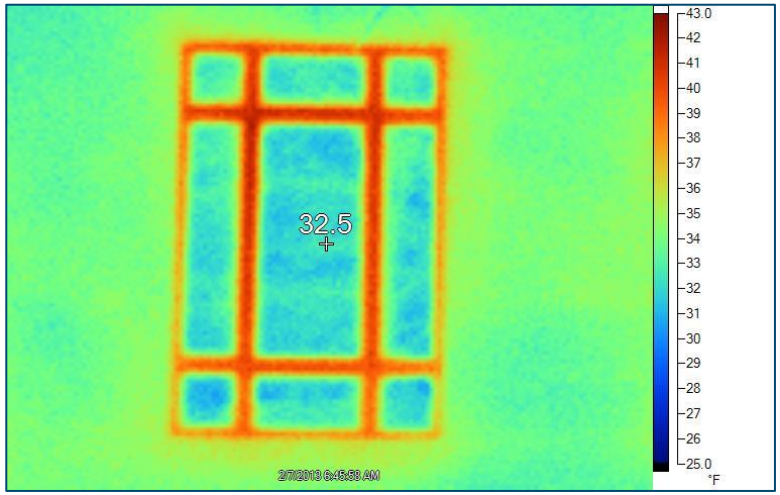


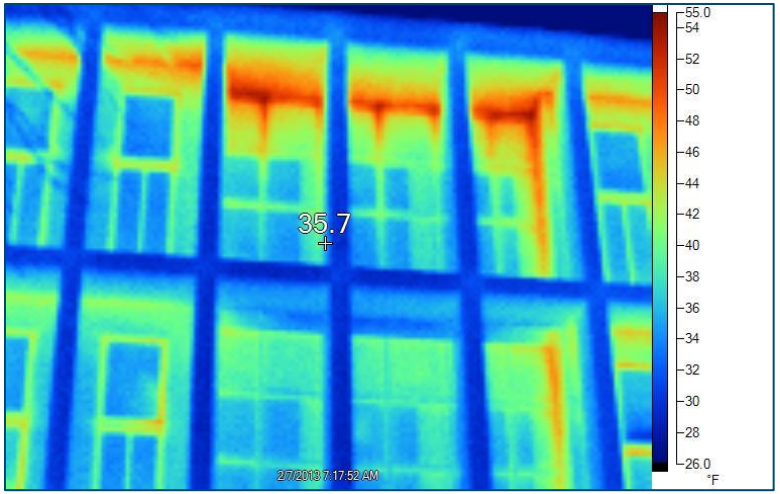


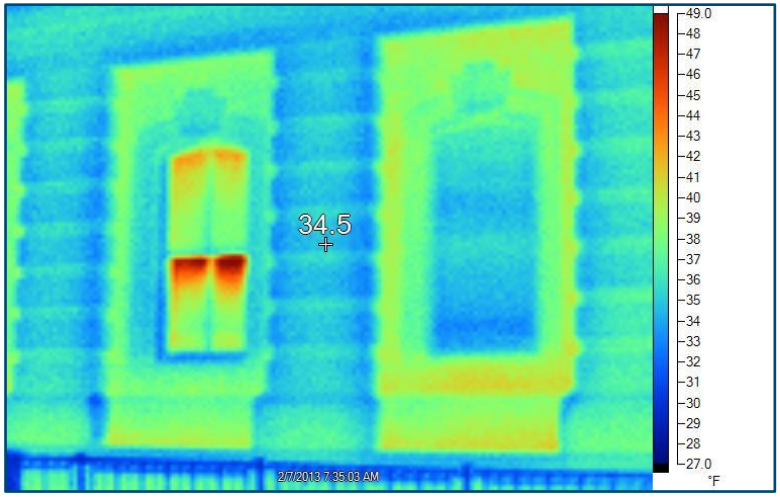


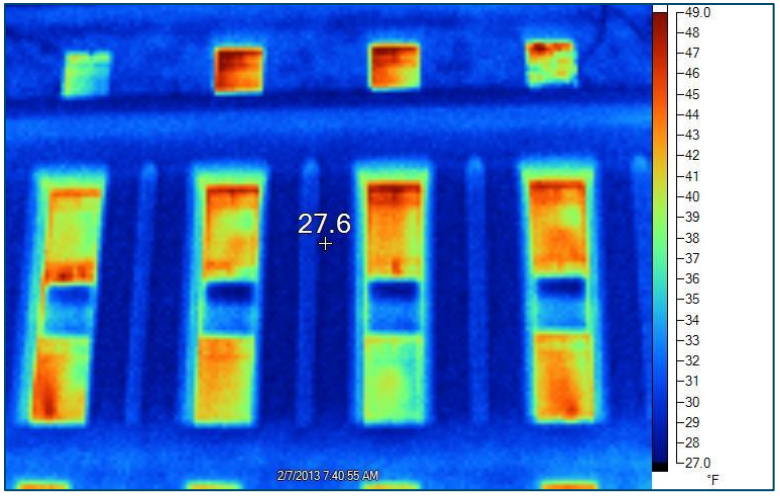
Infrared Analysis

Infrared Analysis - Windows

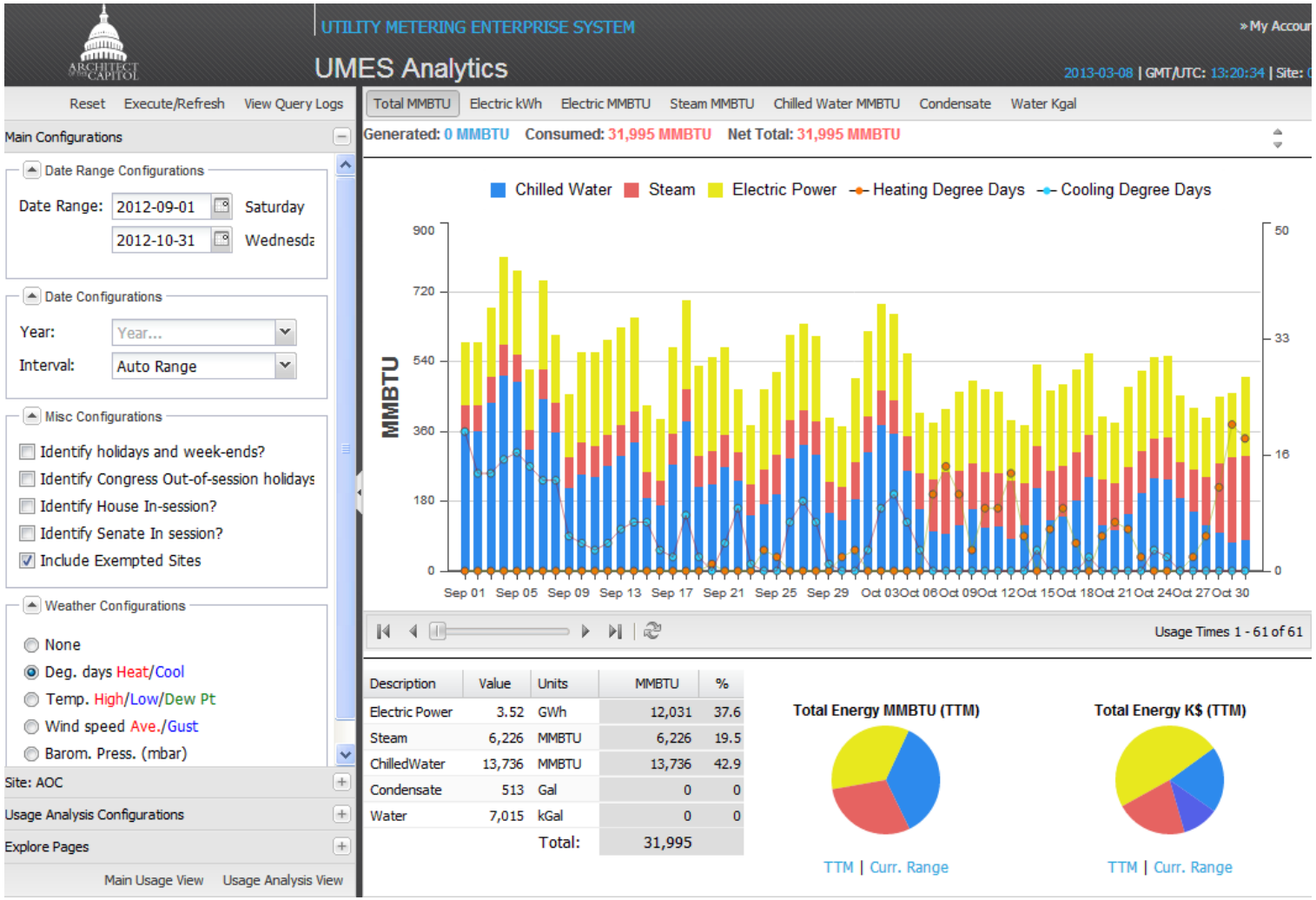






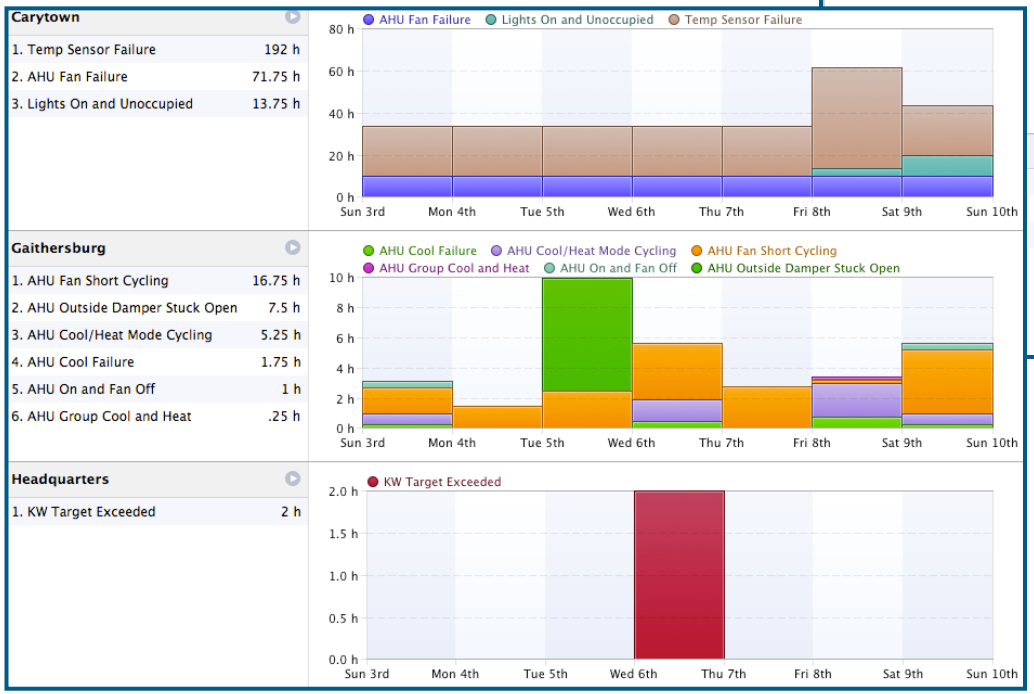


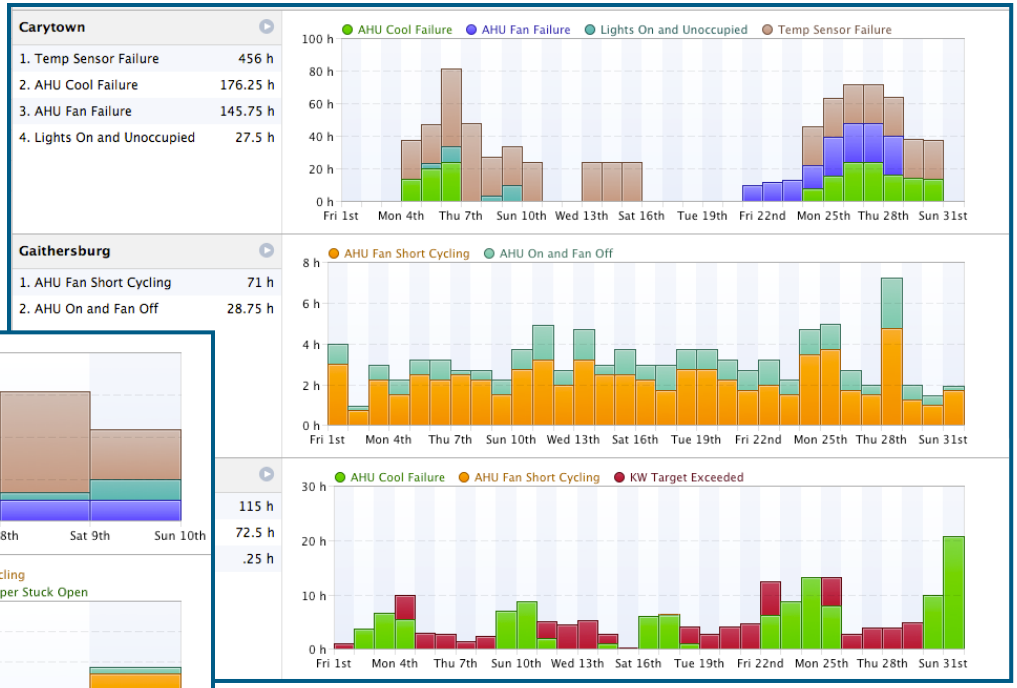
Utility Metering Enterprise System



The Move to Performance Monitoring

How do you process the many data streams from your building automation and metering systems?





Seeking out solutions to simplify building performance measurement – turning data into actionable graphics!

Wrap-up

Looking Ahead

ARCHITECT OF THE CAPITOL

Direct digital control conversions of legacy pneumatic systems

- One remaining building with legacy network infrastructure and several buildings with pneumatic control devices

Advanced data analytics through building automation add-ons or third party software

- Provide easy to use tools for the energy manager or maintenance technician
- Identify and correct deficiencies and document performance improvements

Improved coordination with new Facility Condition Assessments

Building Automation System Master Plan implementation

- Establish AOC BASnet User's Working Group
- Clarify Roles & Responsibilities, training, specifications

Metering and Utility Metering Enterprise System (UMES)

Leveraging enterprise data AOC

- Award contract this year for two large full-DDC buildings

Building Automation System (BASnet)

ESPC Contracts

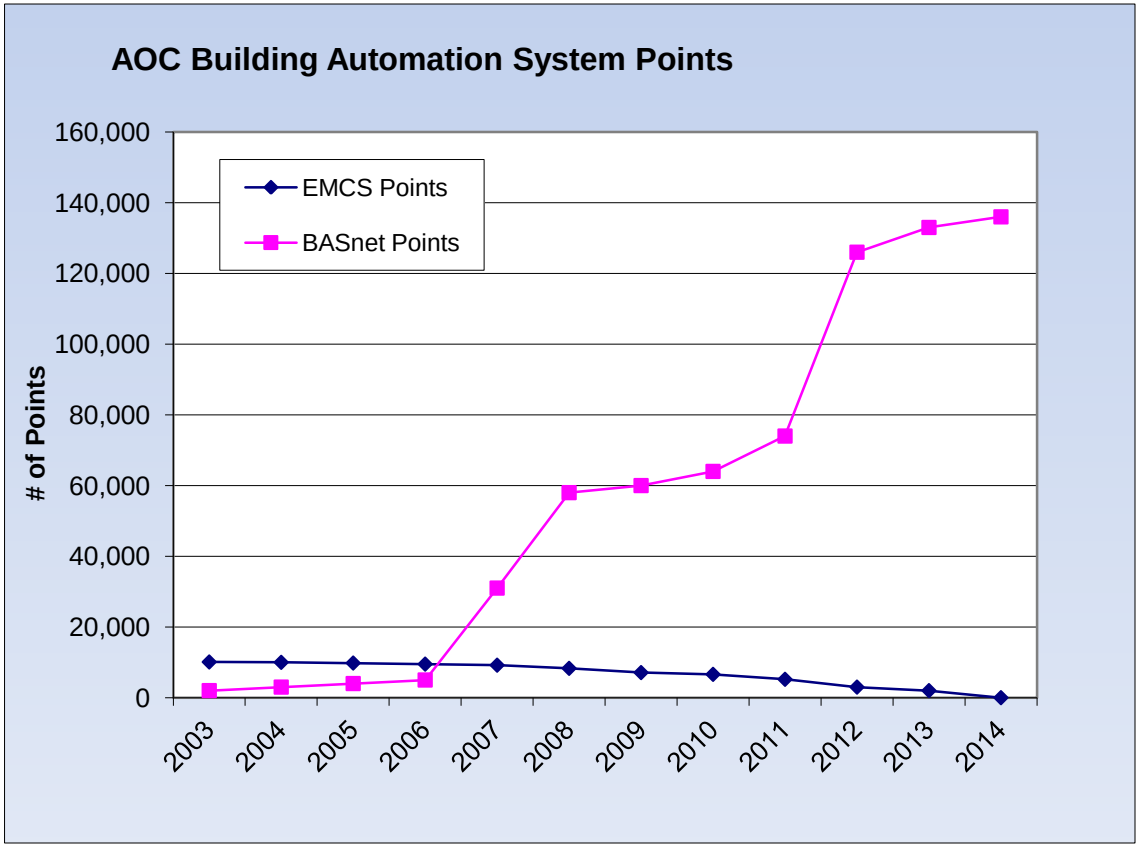
- Adding BAS control to air handlers
- Primary driver of energy savings

System growth

- EMCS STAEFA System being retired
- BAS System growing exponentially

BAS Master Plan

- Utilize new technology
- Help Jurisdictions with:
  - Training Requirements
  - Staffing Requirements
  - Expertise necessary
- Leverage experience from Power Plant Automation



BAS Training Matrix

Level	Course Title	Shop Foreman	Supervisor	Field Personnel	Energy Manager	EMCS	Energy Manager	Hrs	Provider	Frequency
HVAC Training										
I	Fundamentals of HVAC							20	UWis	Once
I	Understanding Building Mechanical Systems							14	UWis	Once
II	HVAC Operations and Troubleshooting							40	TEMPCON	Refresher every 2 years
II	HVAC Controls & Air Distribution							16	ATC	Once
II	HVAC Systems & Heat Transfer							16	ATC	Once
II	Variable Frequency Drives							16	ATC	Refresher every 3 years
II	Preventive Maintenance of HVAC (MEP) Systems and Equipment							16	UWis	Refresher every 2 years
II	Building Operator Certification							40+	BOC	Once
III	Balancing, Adjusting and Testing of HVAC and Air Systems							24	ATC	Once
III	Testing, Adjusting and Balancing (TAB)							36	UWis	Once
Direct Digital Controls Training										
I	DDC Systems – Basic and Advanced Courses							24	ATC	Once
I	Direct Digital Controls Systems							40	TEMPCON	Once
I	WebCTRL Operator Training							24	ALC	Refresher every 2 years
I	Envision for BACTalk Operator Course (BT-100)							40	Alerton	Refresher every 2 years
I	Envision for BACTalk Basics Course (BT-e100)							6	Alerton	Once (Online)
I	Reliable Training Course							16	Reliable	Refresher every 2 years
II	How to Read & Troubleshoot from the Logic Page							8	ALC	Once
II	Direct Digital Controls (DDC) Controls							36	UWis	Once
II	Engineering and Commissioning an Alerton Control System (BT-e230)							32	Alerton	Once (Online)
II	BACTalk System Engineering and Commissioning (BT-e230 Lab)							40	Alerton	Once
III	Advanced Direct Digital Control Systems							24	TEMPCON	Once
III	WebCTRL Advanced Engineering Training							24	ALC	Refresher every 2 years
III	BACtalk Systems DDC Programming Course (BT-400)							40	Alerton	Once (Online)
III	Alerton Advanced Course (BT-e500)							32	Alerton	Once (Online)
III	Alerton Advanced Course (BT-500 Lab)							40	Alerton	Once
III	Reliable Dealer Training							40	Reliable	Once
Commissioning										
III	HVAC Systems Commissioning/Re-Cx							40	TEMPCON	Once
III	Commissioning DDC/Pneumatic Controls for New and Existing Buildings							26	UWis	Once
Energy Training										
I	GovEnergy Conference							20	GSA/DOE	Every 2 years
I	World Energy Engineering Congress							20	AEE	Every 2 years
II	Fundamentals of Energy Auditing							40	UWis	Once
II	Improving Energy Efficiency in Existing Buildings							40	UWis	Once
II	Planning and Conducting Energy Audits							16	ATC	Once
II	Energy Manager Certification (CEM)							40	AEE	Refresher every 3 years

Some Great Information Sources