EAB

Three Strategies to Manage Energy Costs of New and Existing Infrastructure

Building a Total Cost of Ownership Mindset, Part III

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Facilities Forum

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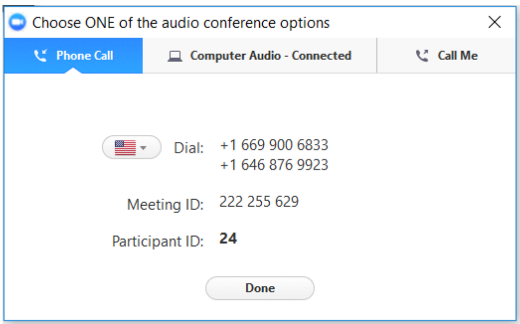

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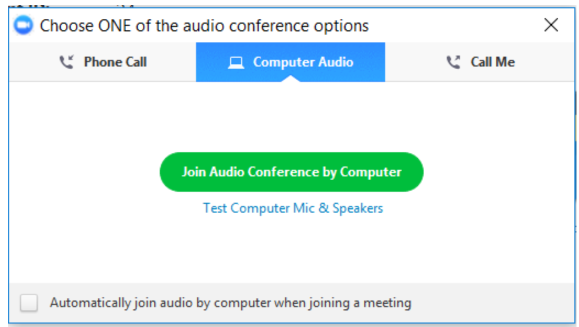

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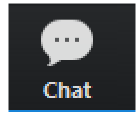


Building a Total Cost of Ownership Mindset

A Webinar Series in Three Parts

Part 1: Three Guardrails to Enforce Better Capital Project Decisions

Thursday, August 15th, 2019

Tactic 1: Maintain Accessible and Enforceable Design Guidelines That Balance Manufacturer Specifications and Performance Criteria

Tactic 2: Document Design and Construction "Lessons Learned" to Avoid Common TCO Missteps and Secure Easy Wins

Tactic 3: Advocate for Board-Backed Capital Project Policies That Look Beyond First Costs to Total Costs

Part 2: Three Pre-Occupancy Interventions to Lower Recurring Costs of Projects

Tuesday, October 8th, 2019

Tactic 4: Amplify the O&M[1] Perspective in Project Design (as an Antidote to "Value Engineering")

Tactic 5: Pull Forward Commissioning to Minimize Early-Occupancy O&M Costs

Tactic 6: Establish Building Handoff Expectations that Simplify O&M Activities in Early Occupancy

Part 3: Three Strategies to Manage Energy Costs of New and Existing Infrastructure

Tuesday, December 3rd, 2019

Tactic 7: Correct for Inevitable Energy Drift with Targeted Recommissioning

Tactic 8: Invest in Energy Retrofits to Secure Greater Utilities Savings and Reset Building Efficiency

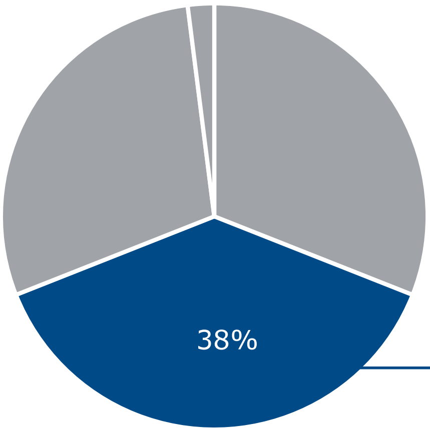
Tactic 9: Scale Up Investments in Continuous Commissioning Teams and Technologies

Source: EAB interviews and analysis.

You're in the Building…Now What?

Energy a Major Driver of Post-Occupancy Costs

EAB's Total Cost of Ownership Model



Recurring Operations and Maintenance

EAB Research on Maintenance Topics

- Addressing Increasingly Complex Deferred Maintenance Decisions
- Addressing Your Maintenance Backlog
- Shifting the Balance from Reactive to Preventive Maintenance

Energy and Utilities—Biggest Cost Category Under Operations

$14 Billion

Total spent on energy each year in the higher ed sector

Source: Energy Star, "Higher Education: An Overview of Energy Use and Energy Efficiency Opportunities"; EAB interviews and analysis.

Energy Inefficiencies Begin at Move-In

Berkeley Lab Research Indicates 10-30% Drift Possible Over Two Years

Common Causes of Post-Occupancy Building Drift

Causes	Resulting Inefficiencies
Band-aid fixes in response to customer complaints	Heating and air conditioning systems running simultaneously
Building programmed for 100% use at all times	Fans overrun and lights stay on unnecessarily
Building designed to now-outdated regulations	Extra air changes expend additional energy
Building occupants override equipment settings	Energy-efficient temperatures, settings disrupted

1.5-2.5x more energy consumption by new buildings than original design

Source: Cylon, "Is Building Performance Drift Driving Your Energy Bills & Maintenance Costs Up?"; Dexma, "Closing the Building Energy Performance Gap"; C Neagle, "Catching the (Building) Drift," *Facilities Net*, September 15, 2017; EAB interviews and analysis.

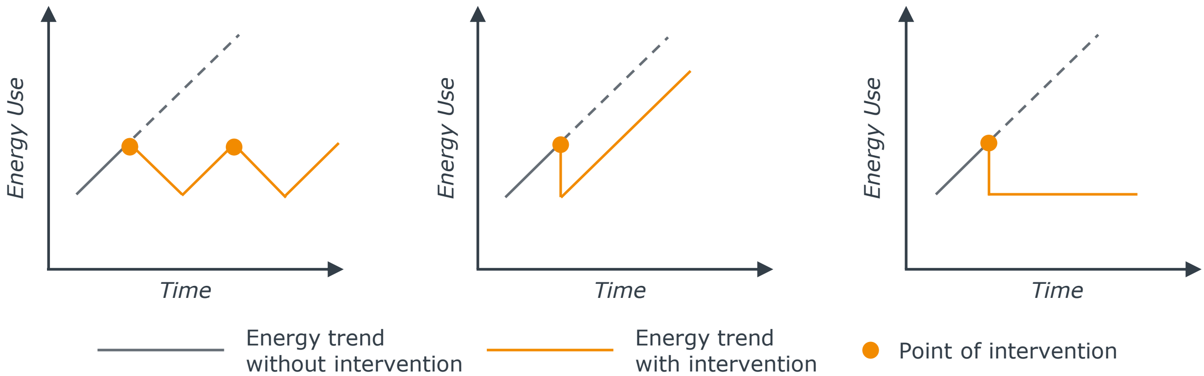
It’s Not Easy Being Green

Institutions Must Pursue Lifetime of Interventions to Correct for Building Drift

Energy Drift With and Without Recommissioning

Energy Drift With and Without Retrofits

Energy Drift With and Without Continuous Commissioning



Three Strategies to Manage Energy Consumption and Lower TCO

Tactic 7: Correct for Inevitable Energy Drift with Targeted Recommissioning

Tactic 8: Invest in Energy Retrofits to Secure Greater Utilities Savings and Reset Building Efficiency

Tactic 9: Scale Up Investments in Continuous Commissioning Teams and Technologies

Source: EAB interviews and analysis.

Tactic 7: Correct for Inevitable Energy Drift With Targeted Recommissioning

University of Pennsylvania Realizes Ongoing Savings Via Recommissioning (RCx) Program

FY07

Facilities partners with the School of Design to **pilot RCx on two buildings**, showing two-year payback and uncovering millions in potential savings

FY07

SFO launches RCx program staffed with **existing technicians**, targeting eight buildings per year

FY08-FY16

Facilities funds additional RCx from **utility budget surpluses**, tapping into third-party staff and expanding to 15 buildings per year

FY19

Penn recommissions 144 buildings in just over a decade, **saving 255 million kBTUs** and **cutting annual utilities spend by 5%**

Across Sectors, Recommissioning Delivers Proven Value

$0.29 Median cost savings per square foot every year after RCx

16% Median whole-building RCx energy savings

1.1 Average payback in years for whole-building RCx

Source: Lawrence Berkeley National Lab, "Building Commissioning," 2009; L Biemiller, "Don't Let Energy Costs Devour Your Budget," *The Chronicle of Higher Education,* 2017; University of Pennsylvania, Philadelphia, PA; EAB interviews and analysis.

Launch Recommissioning Program with Existing Staff

Tried and True Programs Affirm Additional FTEs Not Necessary to Begin

Sample Higher Ed Recommissioning Program Structures

Institution	Initial Staff Investment	Reporting Unit	Buildings RCx/Year
University of Minnesota	Three FTEs (two engineers and one technician)	Energy Management	4-5
Iowa State University	Three FTEs (one engineer and two HVAC mechanics)	Facilities Services (O&M)	3-5
Texas A&M University	Two FTEs (one energy manager and one engineer)	Utilities & Energy Services, which also contracts with the university's Energy Systems Lab	8

Download Iowa State's **RCx job descriptions** here.

Source: Iowa State University, Ames, IA; Texas A&M University, College Station, TX; University of Minnesota, Minneapolis, MN; EAB interviews and analysis.

Sure-Fire Wins for Recommissioning

Focus on Buildings with Highest Savings Opportunity or Strategic Importance

Common Targets for Early Recommissioning Programs

University of Minnesota

Top Energy Consumers

Around 90% of RCx efforts at the University of Minnesota are driven by energy use, based on an energy use index (BTU/GSF)

Emory University

Customer Complaints

Emory University focuses RCx on buildings with the highest volume of customer complaints, which largely stem from HVAC issues

University of Virginia

Changes in Regulations

University of Virginia uses ASHRAE's[1] "risk banding" to identify low-risk labs that quality for ventilation optimization

The University of North Carolina at Chapel Hill

New Buildings

UNC Chapel Hill recommissions new buildings after their first few years of occupancy to account for changes in energy use from the original design

1) American Society of Heating, Refrigerating and Air-Conditioning Engineers.

Source: Emory University, Atlanta, GA; University of North Carolina at Chapel Hill, Chapel Hill, NC; University of Minnesota, Saint Paul, MN; University of Virginia, Charlottesville, VA; EAB interviews and analysis.

Within the Facilities Wheelhouse

Texas A&M University Sees Success With Standard RCx Process

TEXAS A&M UNIVERSITY

Texas A&M's Playbook for Recommissioning Efforts

1. **Research**
   Two FTEs review asset mechanical and control drawings, air- and water-balance reports, and control program
2. **Tour**
   Tour building with HVAC mechanics to tap into first-hand knowledge of building operations
3. **Verify**
   Verify key mechanical operations to ensure functionality
4. **Compare**
   Compare each air handler's performance with design specifications
5. **Repair**
   Bring systems back into alignment with original design parameters
6. **Repeat**
   Repeat steps on all HVAC parts; periodically return to building and repeat as necessary

Early Impact of Recommissioning

22% Average energy reduction per building

$3.5M Average annual energy savings

Source: R Gryzkewicz, "Texas A&M-sized Savings," *facilitiesnet*, 2004; Texas A&M University, College Station, TX; EAB interviews and analysis.

Tactic 8: Invest in Energy Retrofits to Secure Greater Utilities Savings and Reset Building Efficiency

The Empire State Building Strikes Back

In 2009, Empire State Building owner begins exploring options to decrease utilities costs and greenhouse gas emissions

Hires Jones Lang Lasalle, Johnson Controls, and nonprofits to complete a deep energy retrofit, including:

- Replacing 6,514 windows with energy-efficient "**superwindows**"
- Renovating the old **chiller plant**
- **Reducing lighting power density** in tenant spaces
- Upgrading building controls from **pneumatic to digital**

Implementation success supported by:

- Life-Cycle Cost Analysis
- Piggybacking energy upgrades on planned improvements
- Energy modeling
- Building occupant energy reduction measures

Big Building, Big Results

$4.4M Annual energy savings

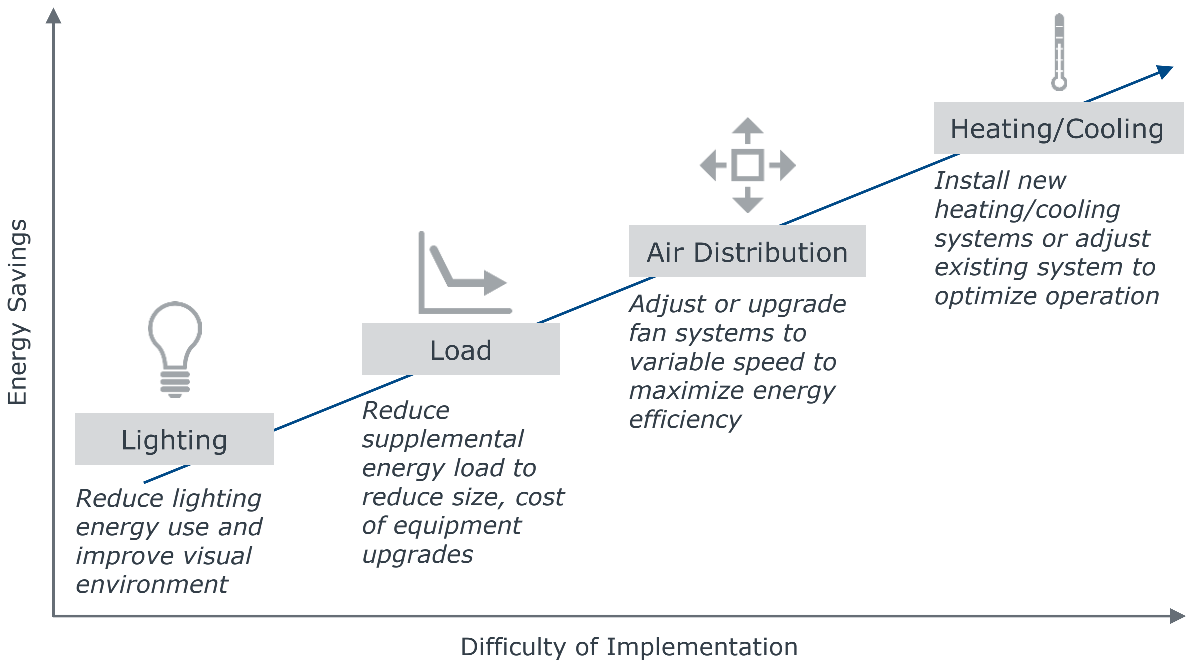
38% Overall building energy reduction

3.1 Years to pay back retrofits

Source: Clinton Foundation, "How the Empire State Building is Redefining Sustainability and supporting the Economy in New York City;" E Harrington and C Carmichael, "Project Case Study: Empire State Building," *RMI,* 2009; K Vaughn, "Empire State Building Retrofit Surpasses Energy Savings Expectations," *RMI,* 2012; EAB interviews and analysis.

Order of Operations for Staged Retrofits

Department of Energy-Endorsed Implementation Plan for Staged Energy Retrofits



Source: ENERGY STAR Building Manual; EAB interviews and analysis.

You Can Go Your Own Way…

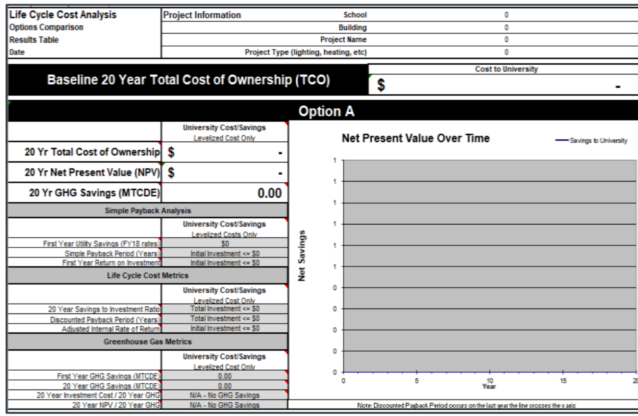
Life-Cycle Cost Analysis (LCCA)—Proven Method to Assess Retrofit Options

University of Virginia

UVA's Life-Cycle Cost Calculator

- LCCA model predicts future expenses and savings for capital projects and energy conservation measures
- Calculator prompts comparison of lowest first-cost option with two alternatives
- Standardized approach provides common language, process, and standards for investment decisions

Download UVA's **LCCA calculator** here.



Source: B Weigel, "Life Cycle Costing for Building Investments," *Cx Associates*, February 26, 2014; Harvard University, "Life Cycle Costing"; University of Virginia, Charlottesville, VA; EAB interviews and analysis.

…Or Find a Partner

Energy Savings Performance Contracts Put Low-Risk Solutions Within Reach

Third-Party Consultant

Colorado School of Mines
Partner: McKinstry

- Mines partnered with McKinstry on a $7.6 million-retrofit over two phases
- McKinstry oversaw a retrofit program that included updating lights, building controls, and installing a new central irrigation control system and air handler energy recovery coils

Three-Year Savings on Phase One:

46M gals of water

4.2M kWh of electricity

30M lbs of steam

$1M utilities savings

Energy Provider

Kutztown University

Partner: NORESCO

- Kutztown worked with ESCO partner NORESCO on a $6.6 million-retrofit
- NORESCO's energy retrofits included new lighting and controls, low-flow plumbing fixtures, window systems, and variable frequency drives on heat and chilled water pumps

Program Highlights:

$718K annual savings

15 year contract

Source: NORESCO, "Kutztown University"; "Sustainable Operations at Mines," Colorado School of Mines; Colorado School of Mines, Golden, CO; Kutztown University, Kutztown, PA; EAB interviews and analysis.

Options to Fund Retrofit Programs

Risk Tolerance, Timeline, and Upfront Capital Shape Funding Strategies

External Funding Sources

Third-Party Performance Contracting

- For cash-strapped universities, one of the only ways to fund large-scale retrofits
- Contractor services not always in alignment with university needs

Grants

- Foundations offering grants for efficiency projects
- Applications time-consuming and grant renewal not guaranteed

Utility Rebates

- Refunds available for retrofits; rebates can be reinvested into future projects
- May not match university priorities, and amounts vary

Internal Funding Sources

Students: Green Fees

- Small student "tax" can create meaningful fungible funds
- Pressure to apply funds to "trendy" green projects, not those with ROI

Fuel Budget: In-House Performance Contracting

- Some campus borrowing from energy budget to fund retrofits
- Difficult to make the case to senior leaders; payback can be complex

Administration: Green Loan Funds

- Borrowing rates are typically lower than traditional sources and banks
- While the ROI is clear, revolving funds can be difficult to operationalize

Access the U.S. Department of Energy's Better Buildings **Funding Navigator** here.

Source: EAB interviews and analysis.

"Send in the Delta Force"

UVA's Retrofit Team Breaks Through Efficiency Stall Points

University of Virginia

Delta Force Program

- *Who:* Interdisciplinary team of Office of Sustainability staff, Facilities staff, and external professionals
- *What:* Retrofitting and recommissioning task force operating through a green revolving fund model
- *Results:* **$20 million** in avoided energy costs since 2007
- *How:* Staged approach to retrofits

1. **Free energy audit** of building
2. Current bulbs **replaced with LEDs**
3. **HVAC and other retrofits implemented**, funded by the unit plus 25% interest to replenish fund

Delta Force Takes on Clark Hall

Retrofits of academic/lab building included:

- Converting all lighting to LEDs
- Installing low-flow toilets and sink aerators
- Upgrading HVAC controls
- Repairing the energy recovery system
- Scaling back airflow rates in labs

Results: 67% drop in energy costs; carbon emissions lowered by 3,000+ tons annually

Before

After

Source: "Delta Force Program," *Sustainability UVA;* M Kelly, "Delta Force Trims Clark Hall Costs by Nearly Two-thirds," *UVA Today,* 2018; University of Virginia, Charlottesville, VA; EAB interviews and analysis.

Show Me the Money

TAMU Deploys Incentives to Engage Occupants in Efficiency Efforts

TEXAS A&M UNIVERSITY

Texas A&M's Energy Performance Improvement (EPI) Pilot Program

1 Energy Hogs Selected

- TAMU's Utilities and Energy Services launches the EPI program in 2017
- Four biggest energy hogs on campus chosen for pilot

2 Buildings Updated and Retooled

EPI retrofits buildings, including: modifying lighting controls, reducing air changes, installing occupancy and humidity sensors, repairing fume hoods, and addressing occupant comfort concerns

3 Occupants Educated as Energy Efficiency Partners

- In parallel, EPI staff hold monthly meetings with building occupants to review energy use via interactive dashboard
- Relationships with occupants allow EPI staff to adapt retrofits to occupant needs and use

4 Units Rewarded for Sustained Improvements

- Via gainsharing agreement, EPI returns 75% of energy savings to building occupants
- **$500K savings in the first year**
- **Ten more buildings slated to join EPI in 2019**

Source: "Energy Performance Improvement (EPI)," Texas A&M Utilities & Energy Services; Texas A&M University, College Station, TX; EAB interviews and analysis.

Tactic 9: Scale Up Investments in Continuous Commissioning Teams and Technologies

Inefficiencies Fester Without Continuous Commissioning[1] (CCx)

"Every day a malfunction goes undetected, we lose money. Returning to check on a building every five years was a good start. Now with fault detection and diagnostics tools, we can check on system performance every five minutes."

SFO, Public Research University

Continuous Commissioning Proves Its Value in Short Order

$600K — **University of Iowa**'s energy savings in the first six months of CCx

$400K — **Texas A&M's** yearly energy savings from CCx in just one building

3K — Tons of GHG[2] emissions reduced annually via CCx at **University of Connecticut**

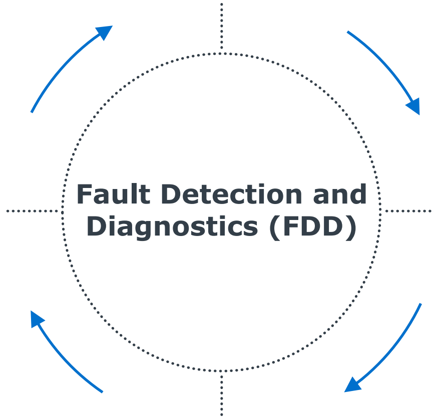
1) Continuous Commissioning® is a registered trademark of the Texas A&M Engineering Experiment Station.
2) Greenhouse gas.

Source: Texas A&M University, "Energy Systems Laboratory's Continuous Commissioning Process Helps Save More Than $100 Million;" Emory University, Atlanta, GA; University of Connecticut, Mansfield, CT; University of Iowa, Iowa City, IA; EAB interviews and analysis.

Fault Detection and Diagnostics in Action

Analyze Data

- FDD software continually assesses building systems data across hundreds of points
- *Example: FDD tracks heating valve operating status, position, and coil temperature changes*



Evaluate Alerts

- FDD team establishes fault priority based on cost and risk
- *Example: Heating valve is on and closed, but Delta T is 10°, far above the preferred threshold of 3°*

Diagnose Problem

- FDD team compares ideal asset status to current data; brainstorms possible causes
- *Example: Valve error expends additional $200/day and is a high priority; possibly caused by improper sealing or sensor error*

Mobilize Team

- FDD team creates response plan and goes out into the field to fix asset equipped with proper tools and resources
- *Example: FDD team fixes valve within 24 hours of fault detection*

Source: University of Iowa, Iowa City, IA; EAB interviews and analysis.

Moving to Continuous Commissioning

Iowa's Successful Pilot Program Leads to Broader Rollout

THE UNIVERSITY OF IOWA

Evolution of Iowa's Fault Detection and Diagnostics (FDD) Program

2014

Pilot

- Large lab building chosen for two-year pilot
- Facilities works with Microsoft and Iconics to design FDD pilot; all components developed and maintained in-house

$780K *Energy savings in first year*

2015-17

Scale Up Tech and Team

- KGS Clockworks chosen as new FDD vendor: customizable, but less manual effort
- CCx team assembled from qualified HVAC techs, analytics and controls staff across campus

20 *Buildings added to CCx program*

2016-Present

Track and Highlight Savings

- CCx team meets four mornings/week to review previous day's reports and coordinate responses
- KPIs track ratio of predictive to reactive work orders, total HVAC work orders

1:3 *PM:RM[1] ratio, up from 1:9*

2018-Present

Expand Investment

- Additional 29 buildings equipped with FDD software
- Next steps: using FDD to improve warranty management for new capital projects

49 *Buildings currently in CCx program*

1) Preventive maintenance to reactive maintenance.

Source: "University of Iowa Fault Detection and Diagnostics Program," Facilities Management; University of Iowa, Iowa City, IA; EAB interviews and analysis.

Range of Options for CCx Tech Investment

Best-Fit Approach Balances Cost Intensity and Staff Capacity

Off the Shelf

- With two FTEs managing the whole CCx program, Gonzaga needed an FDD software that was simple to install and manage
- CopperTree (formerly BuildPulse) supplemented Gonzaga's BAS
- New FDD able to generate standardized error reports and get to root of problems

3 weeks to install in 14 buildings

Hybrid

- Iowa began its CCx pilot with a blank-slate FDD with manual programming
- Leaders used lessons learned from pilot program to articulate expectations of FDD software
- FDD syncs with CMMS and can be programmed to Iowa's specifications

3 months to install in 20 buildings

Homegrown

- Emory's engineering team knew the FDD analyses to track and developed a homegrown system
- Tech-savvy Sustainable Performance Engineer hired from Johnson Controls to oversee programming
- Later added supplementary monitoring software

6 months to earn payback on new FTE's salary

Download EAB's **FDD Software Guide for Higher Education** here.

Source: Emory University, Atlanta, GA; Gonzaga University, Spokane, WA; University of Iowa, Iowa City, IA; EAB interviews and analysis.

Continuous Commissioning Dream Team

Dedicated CCx Staff Defend Against Spiraling Total Costs

Ideal CCx Team Roster

- HVAC Experts
- Engineer(s)
- Controls Technician
- Planning and Energy Analytics Expert

Download Emory's **CCx Specialist job description** here.

Implementation Guidance

- Distinguish FDD responses from regular work orders to prevent staff from mis-prioritizing urgency
- If using manual FDD software, ensure Facilities has appropriate data expertise to interpret reports
- Secure IT support, especially at program initiation, to address any implementation hiccups
- Look for opportunities to bridge O&M and CCx activities to prevent culture of territorialism

Source: Emory University, Atlanta, GA; EAB interviews and analysis.

Maintain the Gain

Sustained Cost Avoidance Requires Ongoing Advocacy for CCx Program

Energy Savings

Common Metrics

- Annual energy savings
- Percent change in greenhouse gas emissions
- Percent change in energy use

Talking Points

- "We cut our biggest non-labor cost by $X."
- "We reduced our carbon footprint by X%."
- "CCx has reduced *or* kept energy use steady compared to increases in non-FDD buildings."

Maintenance Efficiencies

Common Metrics

- Ratio of reactive to preventive maintenance in FDD buildings
- Total HVAC work orders in FDD buildings compared to non-FDD buildings
- Percent change in reactive or emergency work orders in FDD buildings

Talking Points

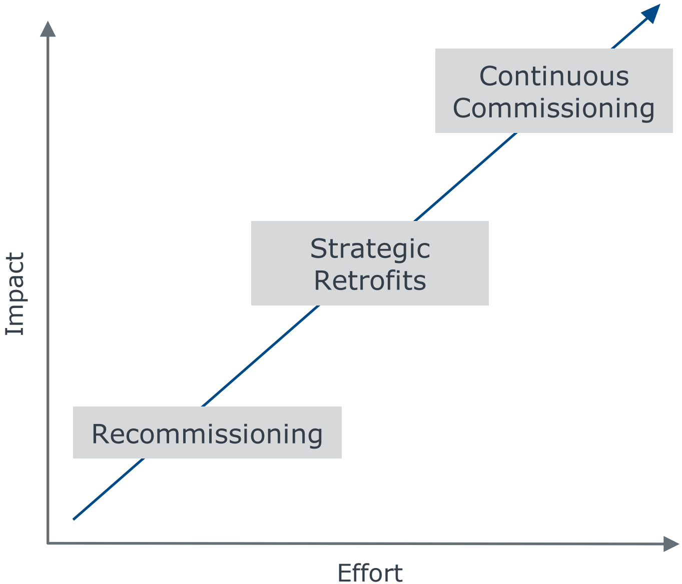
- "For every $1 we invest in preventive maintenance, we're saving nearly $3 in reactive needs."
- "Building occupants are experiencing less discomfort from HVAC issues."
- "We're spending less staff time responding to emergencies and more on preventing emergencies from happening."

Source: Sightlines, "The State of Facilities in Higher Education: An In-Depth Look at the 2015 Trends and Best Practices"; EAB interviews and analysis.

TCO-Driven Energy Strategies

Tactics Build on Each Other to Bend the Energy Cost Curve

Understanding the Link Between Energy Management and Total Cost of Ownership



Strategic Considerations for Facilities Leaders

1. Where have you succeeded in making energy interventions on campus? Where have you seen the greatest ROI?
2. What hurdles are preventing you from moving to the next stage of energy management?
3. Which strategies do you plan on pursuing across the next five years to reduce energy costs?

Source: EAB interviews and analysis.

Any Questions?

Contact Information

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Evaluating Today's Session

Please take a minute to provide your thoughts on today's presentation.

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