Building Optimization: Understanding the Value of Commissioning
2013 NAREIM Architectural & Engineering Council Meeting

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EnerNOC
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Agenda

• About EnerNOC
• Commissioning & Energy Services
• Applying Technology to Commissioning
• The Strategic Energy Plan
EnerNOC’s mission is to change the way the world uses energy

By helping companies make intelligent energy decisions
About EnerNOC

World-Class Team and Resources

• 750 employees and growing fast
• Publicly traded on the U.S. NASDAQ (ENOC)
• Over $79M in cash on balance sheet
• 5,600 customers across 13,500 sites with 8,300 MW’s in North America, Europe, Australia, and New Zealand

Full Value and Technology Offering

• Energy management application platform addresses demand and supply-side
• Combine technology, managed services, and market access
• More than $160M invested to date in technology
• 24/7/365 Network Operations Center, real-time metering and web-based monitoring

For up to date statistics visit http://www.enernoc.com
The EnerNOC’s Three Main Products

- DemandSmart
- EfficiencySmart
- SupplySmart

Earn Payments

Optimize Consumption

Optimize Pricing
Demand Response
Proven Success in Helping Curtail Demand

Acme Manufacturing Plant

Performing as Expected
Delivering 460 of 400kW (100%)

Energy Reduction Plan
To reduce your energy consumption during an event:
- Transfer load to backup generator
- Shut down all HVAC
- Shut down heating exhaust fans
Since 1995, energy prices have become much more volatile. Future prices are uncertain, creating both risk and opportunity.

**US Natural Gas Prices (1985 to Present)**
## EnerNOC’s Suite of Energy Efficiency Services

Energy and Commissioning services provided by EnerNOC's team of Energy Professionals

<table>
<thead>
<tr>
<th>Energy Services</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PLAN</strong></td>
<td>Enterprise-level energy planning and roadmap for integrating energy management into organization process and behavior</td>
</tr>
<tr>
<td><strong>AUDIT</strong></td>
<td>Level I, II, or III ASHRAE audit for commercial customers or facility energy survey for industrial customers that deliver prioritized EEMs</td>
</tr>
<tr>
<td><strong>ASSESSMENT</strong></td>
<td>Equipment, process, or system-specific analysis and savings recommendations</td>
</tr>
<tr>
<td><strong>COMMISSIONING</strong></td>
<td>New Building Commissioning – Retro-Commissioning – Continuous-Commissioning Services</td>
</tr>
</tbody>
</table>
| **MANAGE**      | Implementation support
Advise on EE options |
Energy Management Checklist
How has your company approached energy management? What’s working for you?

Does your organization...

☑ Track utility bills and spend...
   In a centralized, easy to manage location?
   Across facilities and utility regions?

☑ Use energy services...
   To identify priorities with audits and assessments?
   On a defined commissioning schedule?

☑ Participate in Demand Response...
   To generate revenue?
   To fund energy efficiency investments?

☑ Procure 3rd Party Supply?
   To manage risk and volatility effectively?
   In conjunction with EE to optimize supply strategies?

☑ Analyze energy use...
   At the business unit or facility level?
   With monthly or interval data? Periodically or in real-time?

☑ Have energy or carbon reduction goals?
   Have a plan in place to meet them?
   Integrate supply, demand and generation to meet your goals?
Pop Quiz: What’s Going On in This Photo?
Buildings Are Complex Systems

Many buildings have mechanical and operational issues. As modern buildings increase in complexity and engineering resources shrink, this challenge is compounded.
...Built by Complex Teams

Lack of coordination and consistent communication from the initial stages of design through to operation creates opportunities for errors and waste.

Gaps between disciplines resulting in:
- Poor coordination
- Lost details
- Costly change orders
- Delays in schedule
Energy Audits: Levels I, II, III Summary

**Figure 1 — Relationships of ASHRAE Energy Audit Levels 1, 2, and 3**

**Level 1: Walk-through**
- Rough Costs and Savings for EEMs
- Identify Capital Projects

**Level 2: Energy Survey & Analysis**
- End-use Breakdown
- Detailed Analysis
- Cost & Savings for EEMs
- O&M Changes

**Level 3: Detailed Survey & Analysis**
- Refined analysis
- Additional Measurements
- Hourly Simulation
Energy Audits: Levels I, II, III Summary

Preliminary Audits (ASHRAE Level 1)

- **Brief site survey**, identifies potential EEMs (typically HVAC, lighting, controls)
- Financial evaluation limited to potential savings and order-of-magnitude costs
- Meets LEED EB O&M – Energy & Atmosphere Pre-requisite

ASHRAE Level 2 Audits

- More detailed survey than Level 1 audit
- Identifies all appropriate EEMs (typically HVAC, lighting, controls)
- **Energy savings calculations rely on field measurements** and design drawings
- Financial analysis includes measure-by-measure calculation of energy savings, potential utility incentive, cost estimate and simple payback period or NPV/ROI
- Detailed energy spreadsheets or eQUEST models
- Worth **2 points for LEED EB O&M** - Energy & Atmosphere Credit 2.1

Investment Grade Audits (ASHRAE Level 3)

- Savings calculations rely on detailed measurements
- Often includes some **preliminary design with subcontractor cost estimates**
- Intended for budget-level funding
How Much Do Audits Cost?

Due Diligence: Audits Could be Level I with Meter analytics to point out potential operational issues.

Due Diligence security provided with Level I

The range of audit costs are estimated based on market research and previous estimates by the California Energy Commission (2000)

Figure 2.2. Audit Cost and Quality
Commissioning

A full building tune-up to ensure your buildings are running at maximum efficiency. Detailed review of systems and equipment performance

- **New Building Commissioning**
  - The process of assuring that new buildings are designed and constructed to meet the Owner’s Project Requirements

- **Existing Building Commissioning (EBCx), or Retro-Commissioning (RCx):**
  - The commissioning of an existing building not previously commissioned

- **Re-commissioning**
  - Commissioning tune-up of a previously commissioned building

- **Continuous or Monitoring-Based Commissioning (MBCx)**
  - A form of Cx or RCx where building energy usage and/or its systems are monitored on an on-going basis to indicate when systems need attention
Industry Best Practice: Retro-Commissioning

Full-building tune-up that:

• Helps your building perform optimally
• Targets energy savings opportunities with a systematic evaluation
• Focuses on implementation of no-cost and low-cost energy-saving improvements.
• Saves 15 percent of energy cost *
• Recommended every 4-5 years, usually precipitated by noticeable degradation in performance

Retro-Commissioning Goals

Energy savings *and* happy and productive tenants are key to long-term success

- **Decrease Operations and Maintenance effort and costs**
  - Facilitate *ongoing recommissioning* of systems to ensure persistence of savings.
  - Identify *root causes* of poor system performance.
  - *Extend the operation lifecycles* of equipment and systems.

- **Increase indoor environmental quality and occupant comfort**
  - Verify that adequate air flows and proper space temperatures are being maintained in occupant spaces.

- **Realize immediate and long-term energy savings and peak demand savings**
  - Optimize how the building’s energy using systems are operated and maintained.
  - Identify previously unrecognized inefficiencies in building and plant system operations.
  - Measure and document energy savings from resulting operational improvements.
How Much Does Retro-Commissioning Cost?

There many variables; It’s a function equipment, complexity, building size and Retro-Commissioning Phases.

<table>
<thead>
<tr>
<th>Ft 2</th>
<th>Simple 2 phase</th>
<th>Price per ft²</th>
<th>Full 5 phase</th>
<th>Price per ft²</th>
</tr>
</thead>
<tbody>
<tr>
<td>100,000</td>
<td>$30,000</td>
<td>0.30</td>
<td>$50,000</td>
<td>0.50</td>
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<tr>
<td>250,000</td>
<td>$38,000</td>
<td>0.15</td>
<td>$57,000</td>
<td>0.23</td>
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<tr>
<td>500,000</td>
<td>$45,000</td>
<td>0.09</td>
<td>$65,000</td>
<td>0.13</td>
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<tr>
<td>1,000,000</td>
<td>$50,000</td>
<td>0.05</td>
<td>$75,000</td>
<td>0.08</td>
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</table>

**Commerical**

<table>
<thead>
<tr>
<th>Description</th>
<th>No. of Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td># Number of AHUs</td>
<td>15</td>
</tr>
<tr>
<td># Number of Packaged RTUs</td>
<td>5</td>
</tr>
<tr>
<td># Number of Chillers</td>
<td>2</td>
</tr>
<tr>
<td># Number of Boiler Plants</td>
<td>1</td>
</tr>
<tr>
<td># Number of Chiller Plants</td>
<td>0</td>
</tr>
</tbody>
</table>
Opportunities to Leverage Utility Funding

These states have Turn-key Programs and/or Utility Funding Opportunities.Outlined states have active DR Programs as well.
5 Phase RCx Process Overview

**Planning Phase**
- Develop RCx Plan
- Develop Findings Log Template
- Kick-off Meeting
- Initial Site Survey
- Develop M&V Plan

**Pre-Investigation Phase**
- Evaluate/Calibrate Existing Monitoring System
- Recommend Additional Monitoring Systems
- Setup Sample Trends/Collect Sample Data
- Assess Data Quality
- Populate Findings Log

**Investigation Phase**
- Collect Baseline Data
- Establish Baseline
- Conduct Pre-Functional Tests
- Update Findings Log
- Support Client with Implementing PFT Improvements
- Conduct Functional Testing
- Update Findings Log

**Implementation Phase**
- Support Client with Implementing FT Improvements
- Verify Improved Operation
- Update Findings Log
- Develop RCx Report

**Handoff Phase**
- Develop Ongoing Diagnostics
- Complete Training
- Develop RCx Systems Manual
Planning Phase – Key Actions

• Obtain Building Mechanical and Electrical Construction Documents
• Develop Team Approach
• Develop Measurement and Verification (M&V) Plan
  • Usually follows IPMVP (International Performance Measurement and Verification Protocol)
  • M&V Plan must be effective yet not-over-burdensome
Pre-Investigation Phase – Key Actions

• Install/calibrate building electric and BTU meters
• Ensure EMCS can collect trend data
  • Run sample trends
  • Test data storage
• Obtain or determine Sequences of Operation
  • From Construction Documents or Controls Submittals
  • Monitor equipment directly
• Identify opportunities to improve control
Investigation Phase - Pre-functional Tests

• Conduct Point-to-Point Tests
  • Calibrate Analog Inputs
    • Temperature sensors, DP transducers, etc.
  • Test change of state for Binary Outputs
    • Start/stop, on/off
• Test change of state for Binary Inputs
  • Current switches, DP switch, etc.
• Test range of control for Analog Outputs
  • Actuators for valves, dampers, etc.
• Correct Issues identified during Pre-functional Tests
Investigation Phase - Pre-functional Tests

• Develop Energy Baseline

• Perform Installation Verification
  • Verify proper equipment installed
  • Verify equipment installed properly
Investigation Phase - Field-based Functional Tests

• Test the sequences of operation

• Custom field tests designed to observe functional performance

• Calibrate sample of VAV terminals
Investigation Phase - Typical Findings and Measures

• Typical Findings
  • Failed Control Components (Valves, Relays, EP Transducers, Sensors)
  • Leaking Valves
  • Dirty Coils
  • Rogue Zones Control SAT Setpoints
  • Pump Performance Deterioration

• Potential Measures
  • Pump Staging
  • Night Setbacks
  • OAT Lockouts and Scheduling
  • Differential Pressure Setpoint Reset
  • ACH Reduction
Optimizing the Sequences of Operations

- Static Pressure Reset
- VAV Minimum Position adjustments
- Optimize Start-up
- Coasting
- Optimize Economizer Operation
- Boiler OA Resets
Optimizing the Sequences of Operations
Often 50-100 Observations and Recommendations

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Existing</th>
<th>Observed Using Data / Site Visit</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start / Stop Operating Schedule</td>
<td>As per user defined building occupancy schedule.</td>
<td>Mon-Sun: 5am - 10pm all year round including holidays. (Alternate schedule is also available on BMS which is - Mon-Sat: 6am - 10pm and Sun: 7am - 10pm. This is not used right now, no dates are selected for this schedule)</td>
<td>Consider updating the existing building schedule, seasonally it should be: Mon-Thu: 5:30am-1:00pm during summer Mon - Fri.</td>
</tr>
<tr>
<td>Start-up</td>
<td>No start-up sequence as per original sequences of operation.</td>
<td>Whenever the unit is in an open position. Once the actual occupancy, mode requirements or economics are considered, the start-up sequence should be updated.</td>
<td>Consider reducing minimum OA control ventilation. Add make up air to the VAV box dampers as the VAV box dampers continue to increase, move conditioned area to make up air closer to the VAV box dampers.</td>
</tr>
<tr>
<td>Minimum OA control</td>
<td>Economizer control with set value for minimum outside air (12000 CFM for AHU-1 &amp; -2 design minimum).</td>
<td>Based on trend data and energy balance calculations, minimum OA appears to be roughly around 27 to 30%.</td>
<td></td>
</tr>
</tbody>
</table>

Unit Name: AHU-1 to AHU-4
Building: York
Serves / Type of Unit: Multiple Levels / Variable Air Volume (VAV) unit with VAV terminal units (most include reheat coils). AHU-1 / AHU-2: Law Library AHU-3 / AHU-4: Judd - Jodrey
## ABC Law Library - Findings Log (Sep 2013)

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Equip. Name / System Type</th>
<th>Issue Description</th>
<th>Recommended Action</th>
<th>Measure Type</th>
<th>Savings Potential (Short-term / Long-term)</th>
<th>Savings Calcs required (Y/N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>AHU 1</td>
<td>It was observed that one of the outside air dampers on AHU 1 is not actuating and is currently 50% open at all times</td>
<td>Repair or replace malfunctioning actuator, adjust the damper linkages and blades as necessary and restore BMS operation</td>
<td>Repair</td>
<td>Short</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>AHU 2</td>
<td>Return fan VFD is running in hand mode</td>
<td>Repair or replace the VFD and restore system to normal BMS operation mode</td>
<td>Repair</td>
<td>Short</td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
<td>AHU 2</td>
<td>It was observed that one of the return air dampers did not open fully</td>
<td>Repair the malfunctioning actuator or adjust the damper linkage so that field readings match BMS conditions</td>
<td>Repair</td>
<td>Short</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Trend Analysis
Can provide numerous building operational assessments including Load Profiles

RSC 8019 - Load Profiles - 9/1/12 to 12/31/12

- Average Weekday
- Average Weekend Day
- Peak Day - 12/30/12
RCx Process Review

Full Scope of Retro-Commissioning

**Planning Phase**
- RCx Plan
- Kickoff Meeting
- Site Assessment
- Collect Facility Documentation
- M&V Plan

**Pre-Investigation Phase**
- Establish Baseline
- Setup and Collect Trends

**Investigation Phase**
- Pre-Functional Testing/ Sensor Calibration
- Update Findings Log
- Functional Performance Testing
- Update Findings Log

**Implementation Phase**
- Support Implementation
- Verify Implementation
- Update Findings Log
- Near Warranty

**Verification Phase**
- End Review
- Assemble System Manual
- Conduct Training
New Building Commissioning

Cx Definition: ASHRAE Guideline 0

• 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.

• The process focuses upon *verifying and documenting* that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the owner’s project requirements.
The BCA defines the basic purpose of commissioning as:

"The **basic purpose of building commissioning** is to provide documented confirmation that building systems function in compliance with criteria set forth in the project contract documents to **satisfy the owner's operational needs**. Commissioning of existing systems may require the development of new functional criteria in order to address the owner's current systems performance requirements."
What is New Construction Commissioning?

New Construction Commissioning Process

- Quality assurance
- Process to **optimize** new building performance
  - **Establishes** building and subsystem operations **requirements**
  - **Verifies** expected systems performance
  - **Documents** sequence of operations
  - Typically starts in **design phase** and continues **12 – 18 months after C.O.**
  - Commissioning authority works closely with design and construction teams
  - Typical fees range from **0.1%** to **1%** of the construction costs

- **Design**
  - Review and define owner’s project requirements
  - Review design documents to ensure compliance with functional objectives
  - Develop commissioning specs and plan

- **Construction**
  - Review of submittal documents
  - On-going site inspections
  - Witness contractor performed system start-up procedures

- **Acceptance**
  - Final installation and inspection report
  - Systems functional testing
  - Operations and maintenance training and documents review

- **Post Occupancy**
  - Seasonal testing
  - Near warranty end review
  - Final commissioning report
  - Develop manual systems
Why New Construction Commissioning?

- Ensures design and construction of building will satisfy owners’ **functional requirements**
- **Reduces overall project costs**
- Delivers an average of **13%** in operational energy savings (LBNL)
- LEED Certification
  - Basic commissioning scope **prerequisite** for new building certification
  - Enhanced scope can lead to “**enhanced commissioning**” credit and yield additional energy savings
- Enhances **occupant comfort and productivity**
- Reduces likelihood of future maintenance issues

**Typical Commissioning Scope**

- **HVAC Systems**
- **Building Operations & Design**
- **Domestic Water Heat Generation**
- **Building Energy Management & Control System**
- **Electrical Metering**
- **Lighting Controls (interior and exterior)**
LEED Prerequisite

• Review the Owner’s Project Requirements (OPR), AE’s Basis of Design (BOD) and other design development documents as provided by the AE

• Develop and provide all commissioning related specifications

• Provide a complete Commissioning Process Plan

• Schedule, organize and coordinate an initial commissioning coordination meeting

• Conduct installation reviews

• Perform and document a final installation review

• Document all issues and assign for resolution.

• Verify the completion of system start-up and testing routines

• Review contractor provided Operations and Maintenance

• Assemble and produce the Final Commissioning Report
LEED Enhanced Cx

• Review contractor submittals.

• Complete a design document review at a point where the construction bid documents are approximately 50% complete.

• Develop and provide a Systems Manual

• Verify training of Operations Personnel

• Conduct a near-warranty-end review of the commissioned systems
Construction Phase – System Readiness Process (Prefunctional Testing)

• System Readiness Plan
  • EnerNOC Prepares System Readiness Checklists (SRCs)
  • Contractor adds Copies of Blank start up Forms
• Installation occurs contractors complete SRCs
• System Start-ups occur and forms completed
• Contractor Submits System Readiness Manual
Sequences of Operations – Year 1
(Looks good, but has this AHU been commissioned?)

- Sequences of Operations (SOO) are design engineer’s written instructions of how systems are to be controlled

- A good SOO allows systems to provide occupant comfort at low energy cost

- Energy Management and Control System (EMCS) programmer converts written SOOs into executable program code

- EMCS controls equipment (hopefully) to achieve designer’s control intent
Construction Phase - Site Observation

• Walk the construction site observing the work in progress:
  • Identify potential issues EARLY in the construction process to prevent the typical “rush” at project completion
  • Minimize costs and time delays from corrective actions
  • Helps to prevent repetition of incorrectly installed equipment
• Summarize Findings in Site Observation Report
Construction Phase - Start-up Activities

• Witness piping and duct Pressure Tests and Flushing
• Witness flushing of piping
• Verify duct cleaning as required
• Witness sample of TAB measurements
  • Setpoint Determination, e.g. DP and minimum outdoor air damper position
Commissioning Process Review

Full Scope of Commissioning

**Design Phase**
- Owner’s Project Requirements (OPR)
- Basis of Design Review
- Project Design Documents Review
- Develop and Provide Commissioning Specs
- Develop and Provide Commissioning Plan

**Construction Phase**
- Submittal Documents Review
- On-Going Construction Site Inspections
- Witnessing Contractor Performed System Start-Up Procedures

**Acceptance Phase**
- Final Installation Inspection & Report
- Systems Functional Testing
- O&M Documents & Training Review

**Post-Occupancy Phase**
- Final Commissioning Report
- Develop Systems Manual
- Seasonal Testing
- Near Warranty End Review
Big Data is Changing How We Commission and Optimize Buildings

30-Day Electric Usage

- Refrigerator: 6.2%
- Livingroom: 13.3%
- Oil Boiler: 3.5%
- Dishwasher: 2.5%
- Mudro + Sink Lt: 13.3%
- Clothes Dryer: 9.5%
- Cooking Range: 6%
- Well Pump: 2.4%
- Bathrm + Mudrm: 1.1%
- Sewer Pump: 0.2%
- Kids BR + Basement: 19.5%
- Bathrm Htr + Light: 0.9%
- Clothes Washer: 3.9%
- Home Office: 20%

BIG DATA ANALYTICS
Key to Unlocking Big Energy Savings

Energy data from thousands of Nuvias users tells an amazing story. Representing over $100 million per year of potential energy bill savings, users are taking advantage of Novias Energy’s free energy analytics platform.

5600 Million
- 1.2 Trillion
- 1.8 Million
- 1.5 Million
- 27.9 Million
- 30 Thousand

See inside.

5600 Million
- per year of Presidential
- energy savings
- that users are:
- unlocking, thus
- saving 30% annually.

30 Thousand
- manufacturing
- is achieved, thus
- unlocking 20% annually.

1.2 Trillion
- is achieved, thus
- unlocking 10% annually.

1.8 Million
- is achieved, thus
- unlocking 5% annually.

1.5 Million
- is achieved, thus
- unlocking 2% annually.

27.9 Million
- is achieved, thus
- unlocking 1% annually.

30 Thousand
- is achieved, thus
- unlocking 0.4% annually.

45
“Meter and Sub-meter Analytics” Can Be Powerful

Today’s systems collect energy data, combine it with external variables such as weather and rate information with actionable energy efficiency measures and the ability to measure and verify the results.

#1 Real-time Metering:
Data collection and aggregation

#2 Energy Monitoring:
Web-based energy data visualization
Night Baseload Comparison

Fixing operational issues could be easy wins for a newly acquired building. It’s good to know if issues are Capex or Opex.
Example EE tool for reducing energy spend

Anomaly: Night & Weekend Setback

Savings Potential:
- 3600 kWh per week
- $288 per week
- 11% of electricity spend

Building did not enter typical night setback mode multiple times this week.

What was still running on Sunday?
Example EE tool for mitigating peaks

**Anomaly:** Morning Start-up Schedule

**Savings Potential:**
- 30 kW in peak demand
- $300 per month in demand charges, $3600 per year
- 3% of electricity spend

Morning start-up results in demand spike at least 30kw above daily peak demand.
Demand Side and Supply Side: DR and EE Are a Physical Hedge

Load factor, which measures the ratio of peak electricity usage to normal electricity usage, plays an important role in supply management because load factor determines your cost with suppliers.

\[
\text{Load Factor} = \frac{\text{Peak Demand} \times 8,760}{\text{Total kWh consumed}}
\]

Delta quantifies increased LF% and Decrease in rate per kWh

Peak Demand * 8,760 / Total kWh consumed = Load Factor %
Go beyond monitoring with a whole building AFD approach: collects BMS data, filter for faults and efficiency improvements, and get actionable energy efficiency measures with the ability to measure and verify the results.
Strategic Energy Management – what is it?

Goals

• Make energy as integral to business as safety, quality and security
• Stop waste and deliver a constant stream of savings

Basic Elements

• Executive commitment
• Plan with long-term and short-term goals
• Deep review of energy usage
• Energy team with accountability
• Metrics-driven
• Continuous Improvement ("Plan-Do-Check-Act")
• Widespread engagement (purchasing, retrofits, O&M, behavior)
Strategic Energy Management

Energy Management is Scattered in the Organization

The solution is a program that focuses efforts across the entire organization effectively & efficiently
Equipment – 100% of the focus, but 33% of the picture

Sustainability teams look at the whole spend, while facility teams look at equipment.
A systematic, common-sense approach

Avoid the traps!
Continuous Cycle of Success
Plan-Do-Check-Act

Plan and Prioritize
Get data. Benchmark against industry standards and company goals. Identify opportunities and define a plan of action.

Implement and Manage
Assign resources. Implement chosen tasks to manage risk and save energy.

Measure and Verify
Measure and validate that expected savings have been achieved. Implement sustaining elements.

Iterate
Build on Success with a Phased Engagement

Phase in the program based on location, division, or components of the plan
SEM Workflow

1. Energy Management Assessment
2. Strategic Planning
3. Energy Program Implementation
4. Monitoring & Support
Thank You!

Questions?

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Changing the Way the World Uses Energy....
Sequences of Operations - 10 years later…

- Sequences “temporarily” changed to troubleshoot problems
  - Control relays and actuators “temporarily” bypassed to fix system problems

- Control components fail:
  - Variable Frequency Drives (VFDs)
  - Sensors (temperature, pressure, current)
  - Relays

- Result: Equipment not being controlled efficiently which leads to higher costs
Investigation Phase - Pre-functional Tests

• Typical Issues found:
  • Damper linkages disconnected
  • Valve actuators stuck
  • Variable Frequency Drives (VFDs) in “Hand” or Manual
  • Sensors (temperature, pressure, current) inoperative or out of calibration
  • Relays bypassed or failed