



## Results and Insights from the Largest Existing Building Commissioning Effort Yet

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# What We'll Cover

- Overview of the programs included
  - Key design considerations
- Analysis of program results
  - Costs and savings
  - Biggest energy saving measures
- Lessons learned
  - Program challenges
  - Issues for providers
- Technical Issues with top measures



# Existing Building Commissioning Defined (EBCx)

- Also called Retrocommissioning or Recommissioning (RCx)
- A systematic process for improving building performance by identifying and implementing **operational improvements**
- Process focuses on the **operation** of mechanical equipment, lighting, and related controls and is intended to optimize how equipment operates as an integrated system



# What can EBCx accomplish?

- Optimize system and equipment operations and controls
  - Verify equipment controls and sequences
  - Ensure system operations are integrated
- Achieve significant energy cost savings
  - **5-20% savings** with modest capital expense
  - Overall project paybacks of **< 2 years** are common
- Train building operating staff and improve building documentation
  - Ensure changes are maintained
- Non-energy benefits
  - Extended equipment life
  - Reliability of systems
  - Occupant comfort



# Existing Building Commissioning Efforts in California

## California

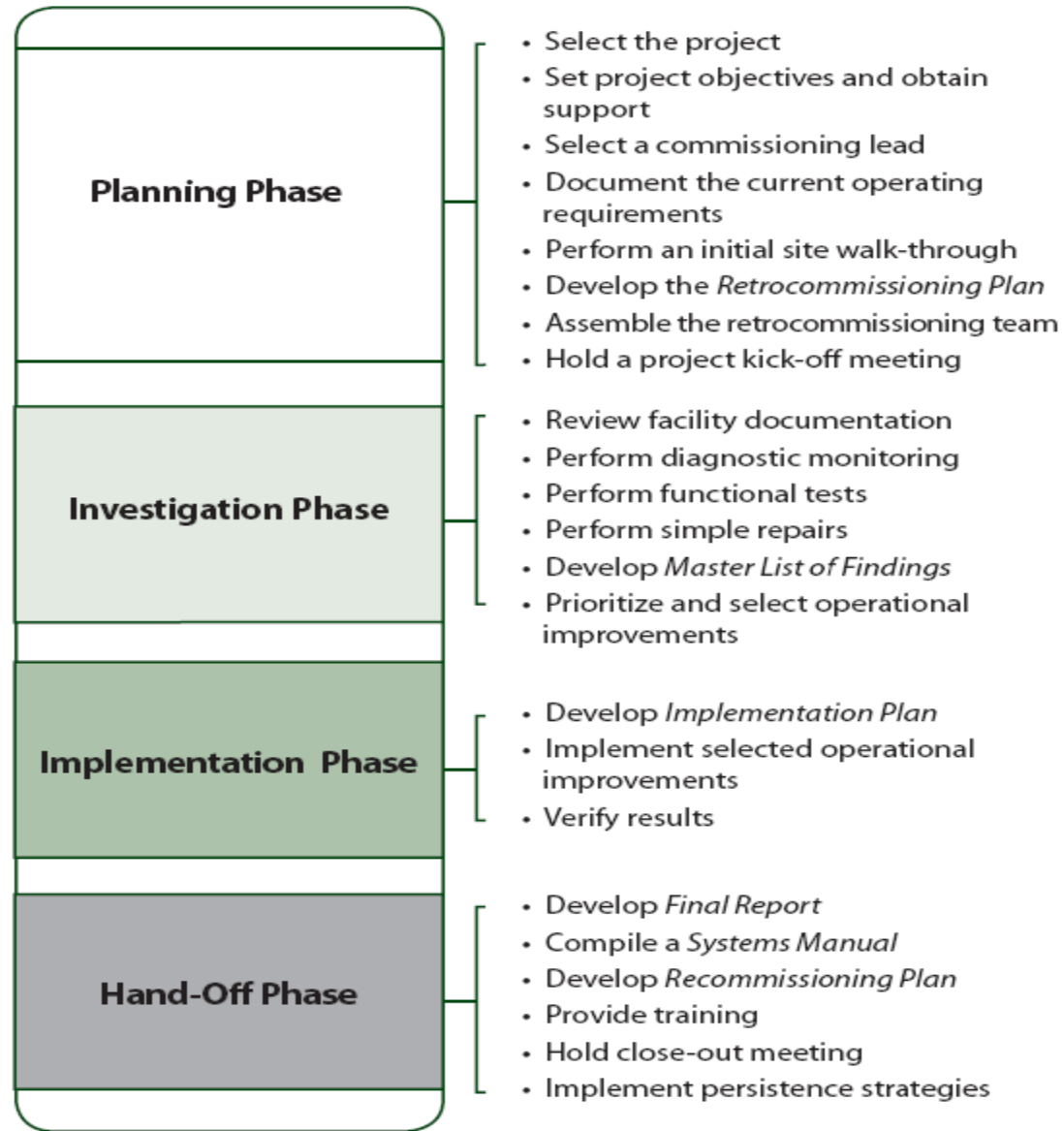
- Significant IOU support of RCx Programs in 2006-08 program cycle
  - Ten EBCx based programs
  - 250% increase from 2004-05 cycle
- Programs currently offered in SDG&E, SCE, PG&E & SMUD
  - Over \$10 million from 2006-2008
- Retrocommissioning programs for State buildings
  - Department of General Services
  - Statewide UC/CSU/IOU Partnership: MBCx



# Typical RCx Process

- Planning
- Investigation
- Implementation
- Hand-Off

## Retrocommissioning Process Overview



# Retrocommissioning Programs Included

- Programs within this common framework:
  - Southern California Edison (SCE)
  - San Diego Gas & Electric (SDG&E)
  - Pacific Gas & Electric (PG&E)
  - Sacramento Municipal Utility District (SMUD)
- SCE and SDG&E:
  - Mid 2006 to end of 2008
- PG&E:
  - Start 2007 to end of 2008
- SMUD
  - Start 2008 to 2009



# Program Design Considerations

- Incorporate diverse means of recruiting customers
  - Field Energy Analysts, utility account managers
  - Marketing tools, information sessions
- Streamline program process
  - Scoping study replaced with building screening process
- Standardize protocols for program deliverables and reviews
- Requirements designed to meet utility EM&V reviews
  - Metered baseline and post-installation data required
  - Suggested / prescribed verification activities
  - Standard review process



# Program Design Considerations, Cont.

- Adapt to financial decision makers needs
  - Fully funded engineering studies
  - Owner Program Agreement
  - Implementation Incentive Offer
  - Phased installations
- Provide customer support in implementing measures
  - Field Energy Analysts
  - Line item in ECM costs for additional provider support
  - Some funding for implementation assistance from utility
- Persistence activities require funding
  - Only for a sample of projects due to costs



# Overview of Program Policies

- Buildings over 100,000 sq ft
- Customer incentives on kWh saved
- Rigorous screening of buildings prior to participation
  - Screening scorecard
    - Energy Utilization Index (kWh/Sq Ft)
    - ENERGY STAR® Benchmark Score
    - Types of Controls & HVAC systems, O&M practices
- Standardized templates for reports and submittals
  - Master list of findings workbook
  - Technical review template
- Service providers are approved based on qualifications of individuals
  - Over 100 individuals qualified
  - 14 firms participating
- Legally binding agreement for owner
  - Must implement measures <1 year payback
  - Written incentive offer



# Preliminary Program Results

The 3 programs are ~50% complete:

- 77 Projects completed Investigation
- 27 Million Square Feet
- 32,000,000 kWh
- 300,000 therms
- 3,000 kW
- \$3.5 million annual energy cost savings



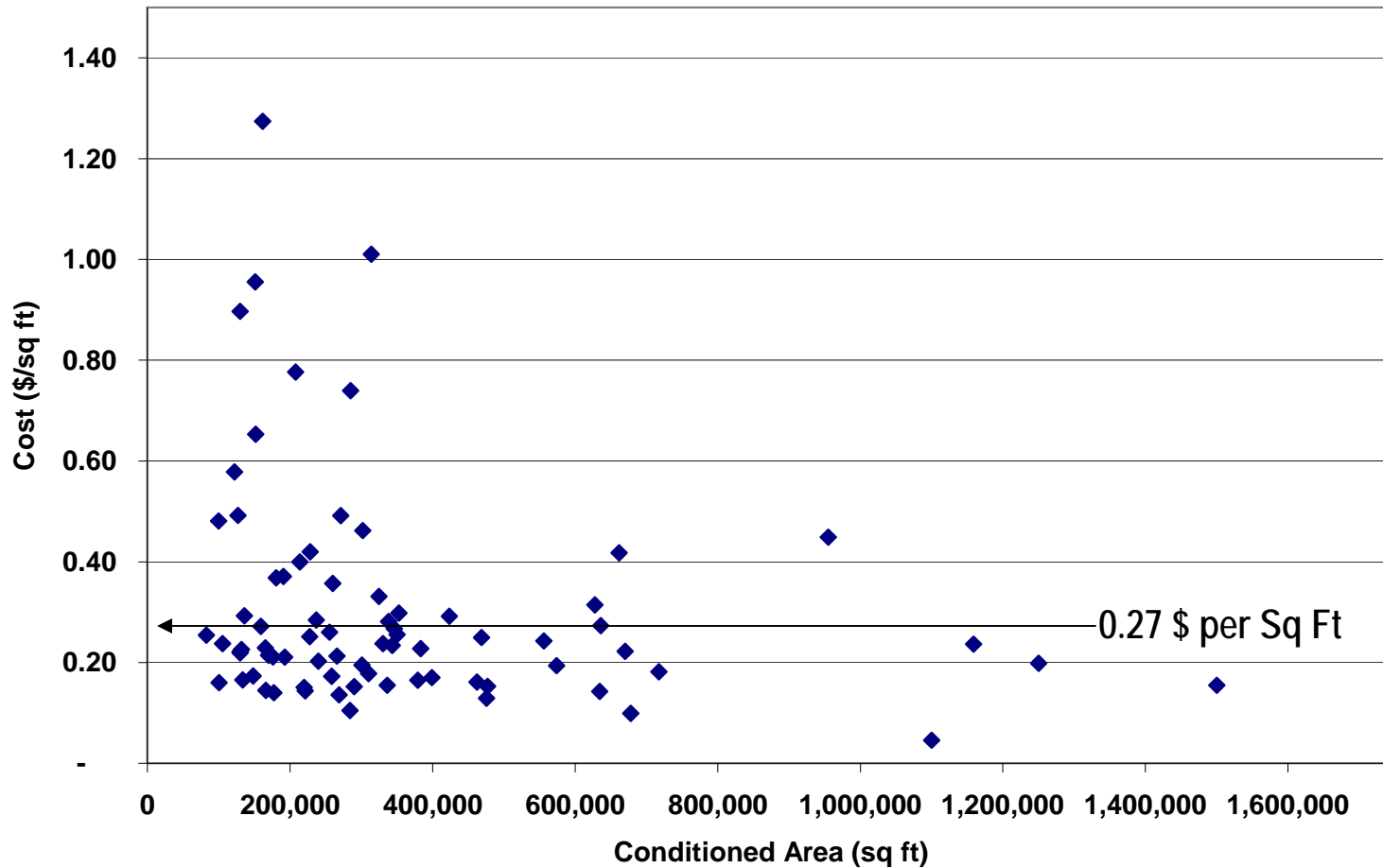
# Key Findings: Total Costs

- Per project Costs
  - Total: \$16,000 to \$460,000
  - Cost/sq ft: \$0.05 / sq ft to 1.25 / sq ft (\$2.90/sq ft)
  - Mean \$/sq ft = \$0.27
- ~50% of total cost is for RCx provider fees
- Project Payback
  - Mean = 2.8 years
    - includes all costs and all measures
- Costs scale downward with increased floor area, dropping considerably for buildings > 500,000 sq ft



# Project Costs per Square Foot

Total Project Cost by Building Size



# What factors are driving the costs?

- \$0.05 to \$1.25 per square foot for the RCx process depending on:
  - Number of systems
  - System complexity
  - Data logger requirements
  - Owner's requirements
  - Subcontractor requirements
  - Implementation involvement
  - Building size
  - Implementation costs include VFDs





# Indirect Costs: Staff time and resources

- **Typical tasks include:**
  - Provide initial list of opportunities
  - Gather documentation
  - Assist with trending or data logging
  - Perform repairs or improvements
  - Ongoing monitoring of implemented measures
- **Benefits include:**
  - Leverage first-hand knowledge of the building / help to streamline the process
  - On-the-job training
  - Helps persistence of implemented measures



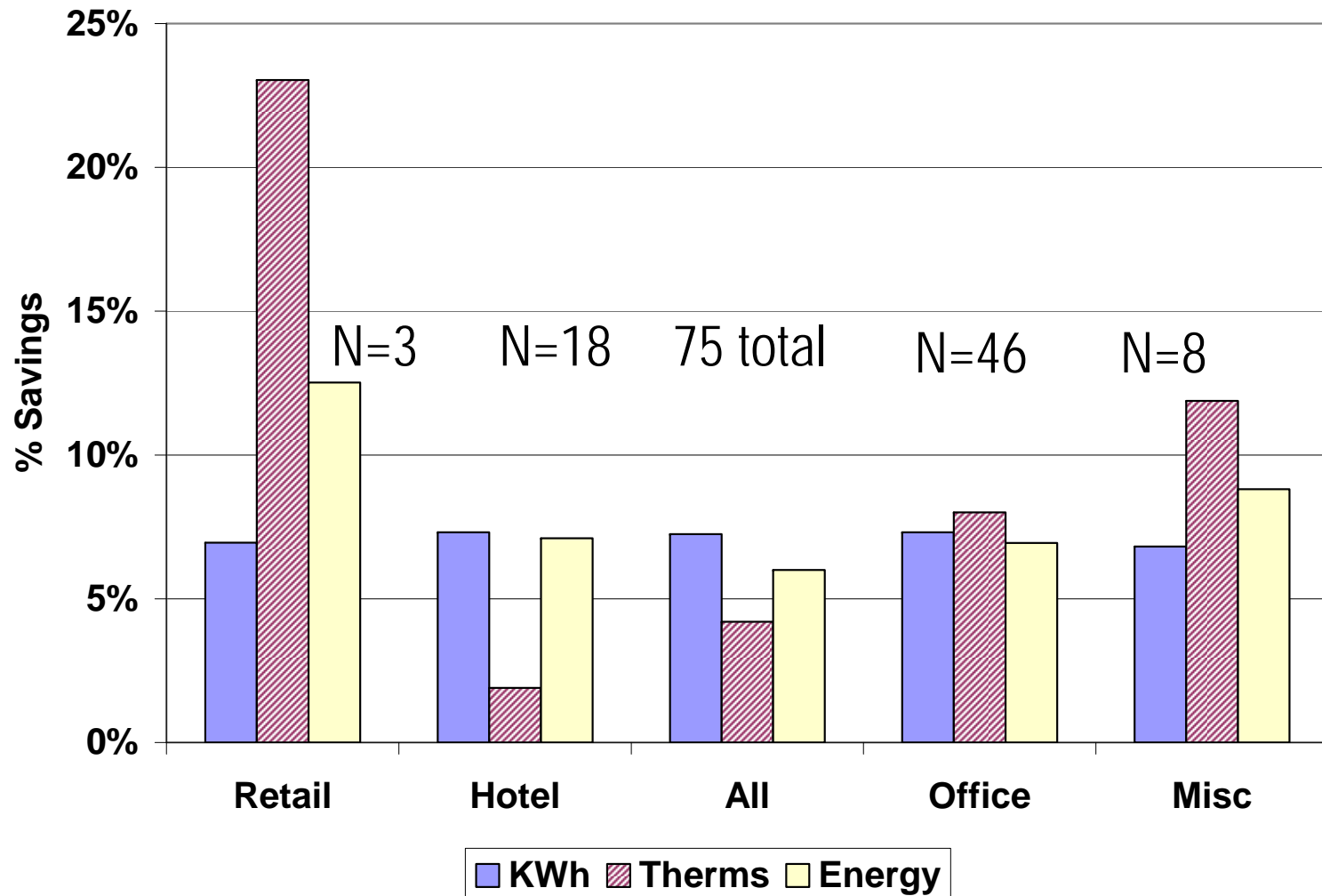
# How much are we saving?

- Electric savings
  - 6.75% overall electrical consumption
    - Ranges from <1% to 24%
- Gas savings
  - 4.2% overall gas consumption (portion w/ data)
    - Ranges from -0.1% to 50%

\* Median values shown



# Percent Annual Energy Savings By Building Type

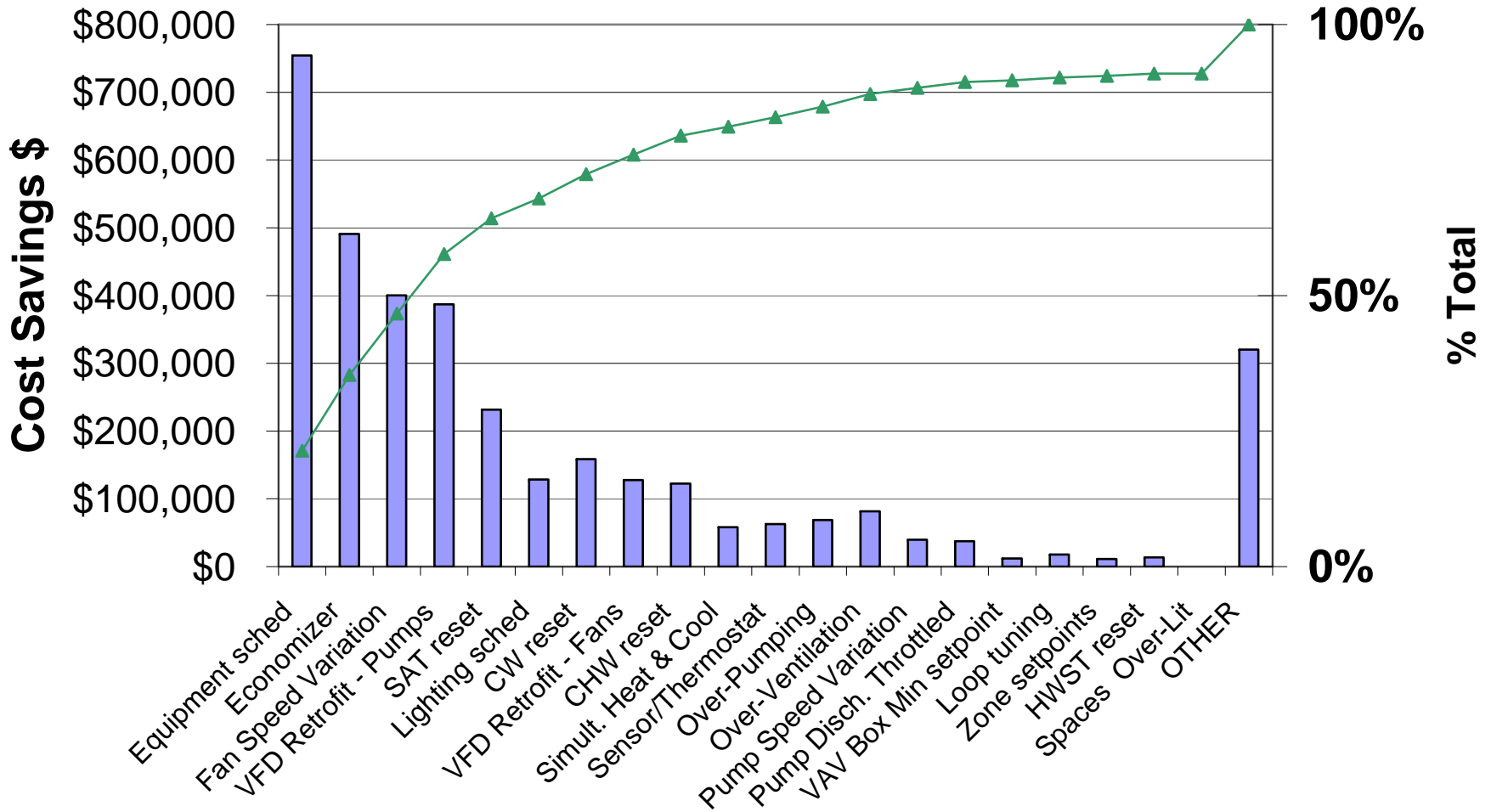


# Not all identified measures will be implemented

- 16% of measures were not selected for implementation
  - Only 79 of 485 measures
  - 12% of kWh savings found
  - 5% of therms found
  - Average cost and payback of unselected measures 2X those selected

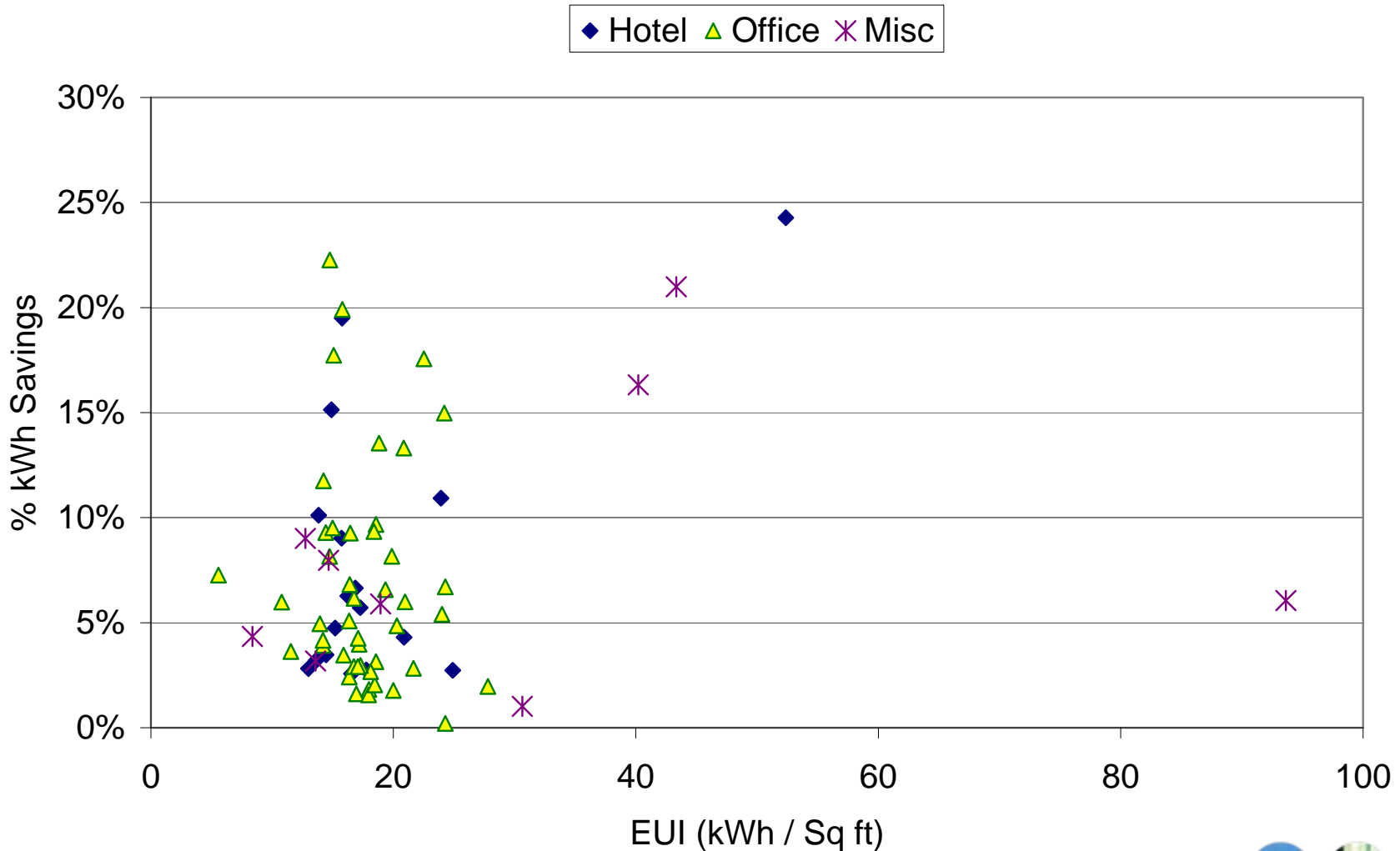


# Cost Savings by Measure



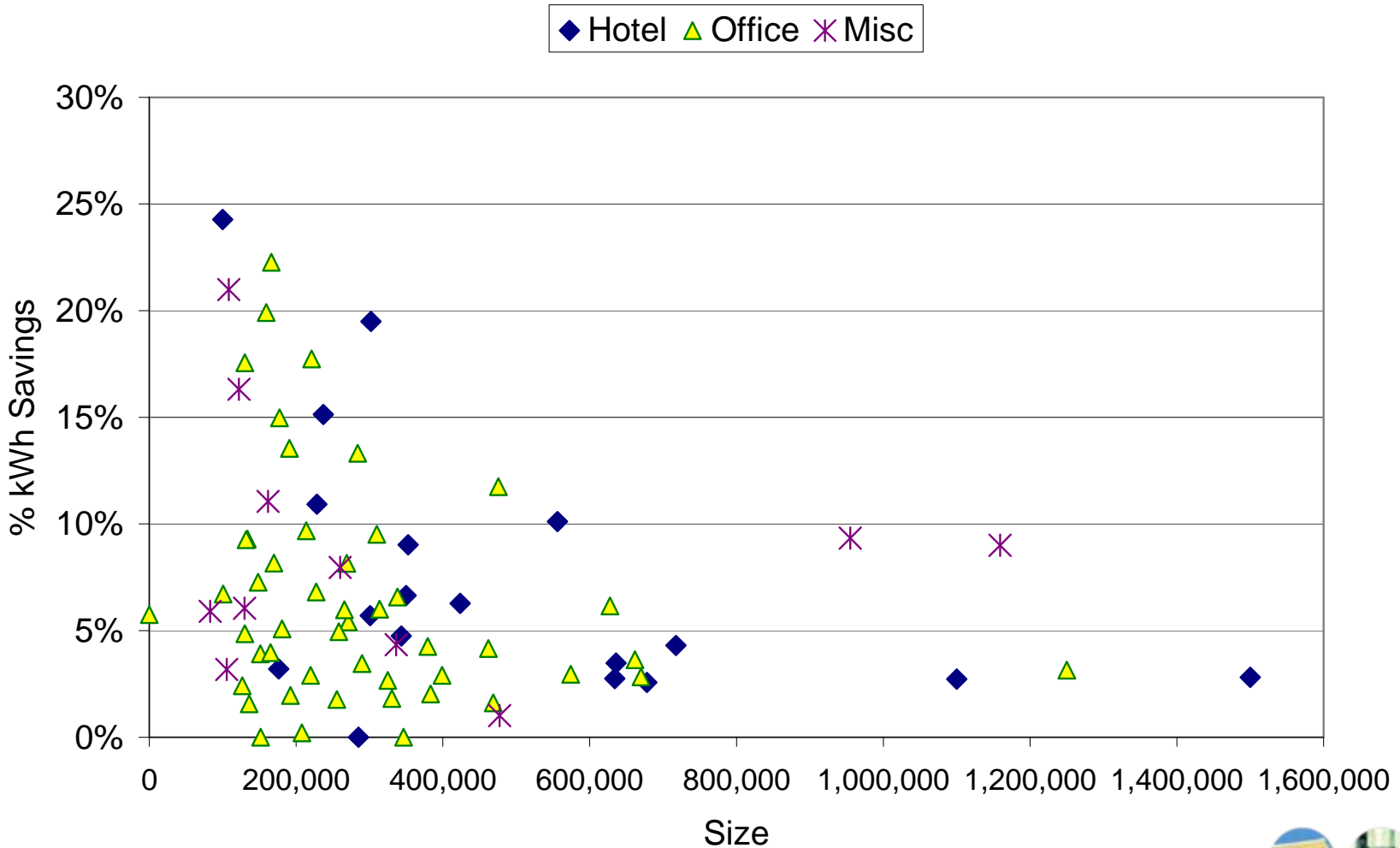
# Savings by pre-project EUI

EUI vs Percentage Electric Savings



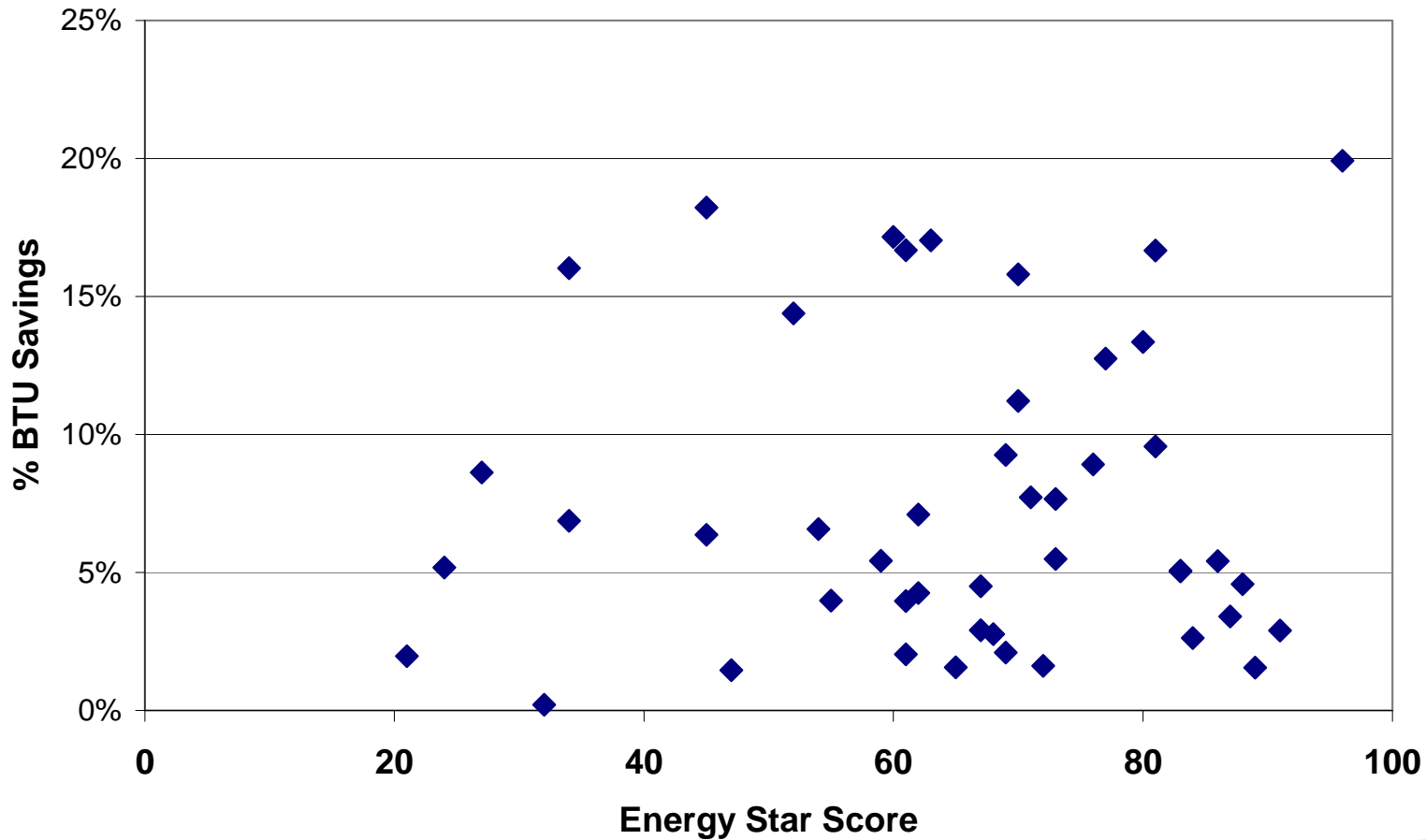
# Savings by building size

Electric Savings by Building Size

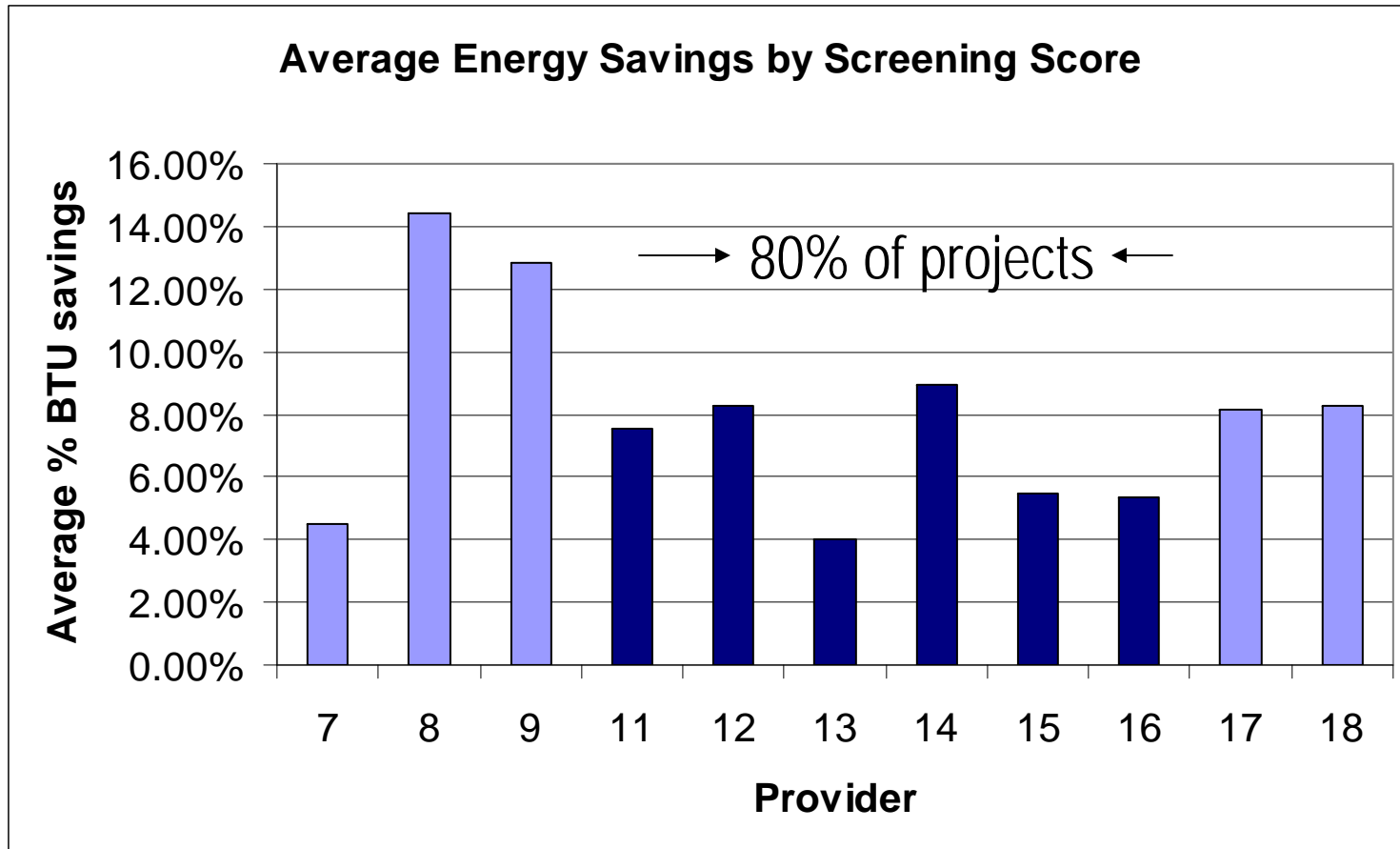


# Savings by Energy Star score

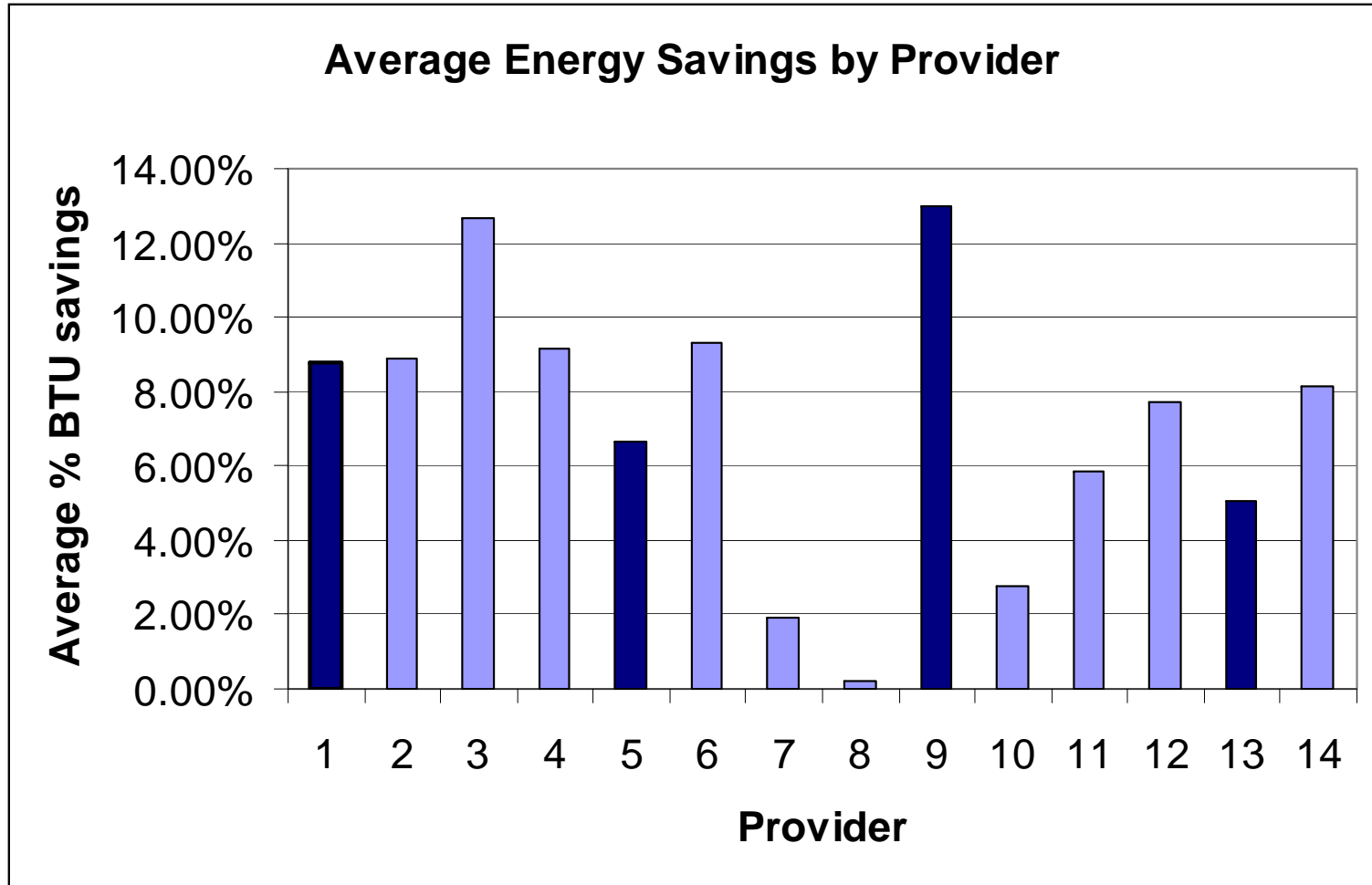
## Energy Savings vs % BTU Saved



# Savings by screening score



# Savings by service provider



# Program Challenges

- EBCx is a long-term endeavor
  - Requires an internal champion or momentum for the project
- EBCx entails operational changes
  - Requires buy-in from various levels of an organization
- Without persistence strategies in place, some measures can be easily (even inadvertently) undone



# Program Challenges, Cont.

- Program timelines are prescribed, challenging for projects starting later in program cycle
  - Long sales cycle; long program cycle
- Cost of investigation typically a big hurdle
  - Benefit of programs that can help cover the upfront cost
- Binding financial commitment from Owner
- Supporting customer through implementation phase
- Persistence activities not within cost-effectiveness requirements
- All providers do not provide equal results



# Program Challenges , Cont.

- Customer recruitment
  - Portfolio holders were cautious
  - Established relationships opened doors
- Multiple RCx programs on similar time frames = stretched resources of providers
  - RCx provider opportunity in CA
- Maintaining quality while maximizing participation
- Sufficient documentation for EM&V takes a lot of resources that could be used to otherwise maximize savings



# Provider Challenges

- Operating staff may not be enthusiastic about RCx
- Limited budget and time frame for scope of work
  - Digging deep can be challenging on some projects
- Meeting program documentation and review requirements
- Having sufficiently skilled engineers and staff to:
  - Identify complex controls measures and
  - Conduct energy analysis



# Provider Challenges...

- Collecting data trends from control systems
  - Limited memory
  - Setting up trends
  - Availability of points
- Utilizing data loggers
- Getting complete synchronized data sets
  - not missing that one point!
- Using data with unaligned time stamps or intervals
  - Universal Translator
- Working with pneumatic or “hybrid” control systems
  - Limits EMCS data, system control options



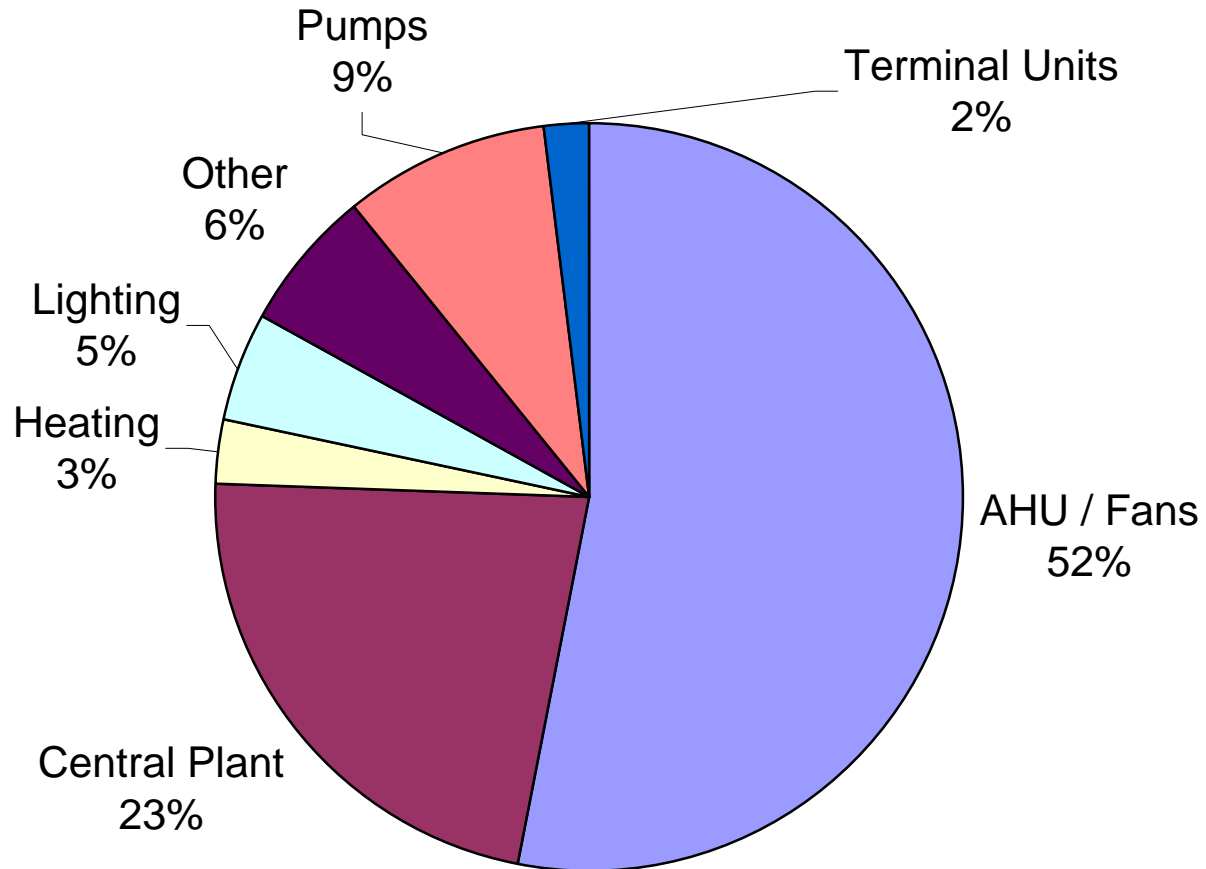
# Provider Challenges

- Limited calculation templates available
  - Experienced providers have examples
- Limiting measures to payback cap set by programs (4 years)
  - Excludes items the customer may want analyzed
- Program process does not match “BCA Best Practices”
  - Publicly funded programs
  - Focus of programs on energy savings
  - Cost effectiveness limited persistence activities
- Customer expects quick fix, and doesn’t understand EBCx is a process
  - Not a moment of brilliance



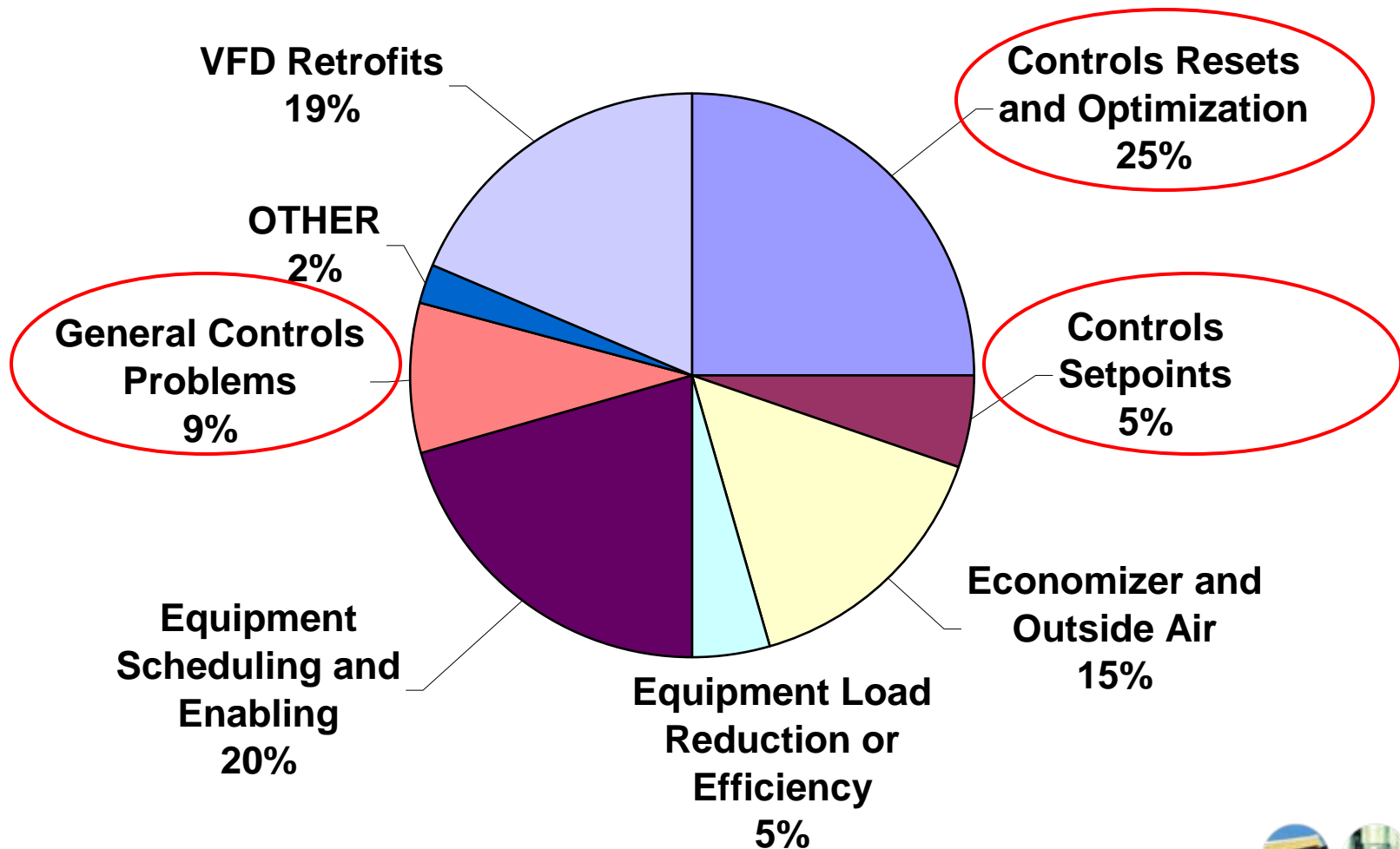
# \$ Savings by Building System

Results show most savings relate to air handlers and fans:



# Cost savings by Finding Type

Results show most savings relate to controls:



# Controls Issues responsible for >50% savings

- **Enhanced Sequences**
  - Setbacks, resets may not be in place
- **Sensor Calibration**
  - First step in investigation
  - Proper sequencing rely on key sensors
- **Integration Issues**
  - SAT Reset and duct static pressure reset
  - Building warm-up and outside air control
  - Chilled water setpoints with discharge air temperatures



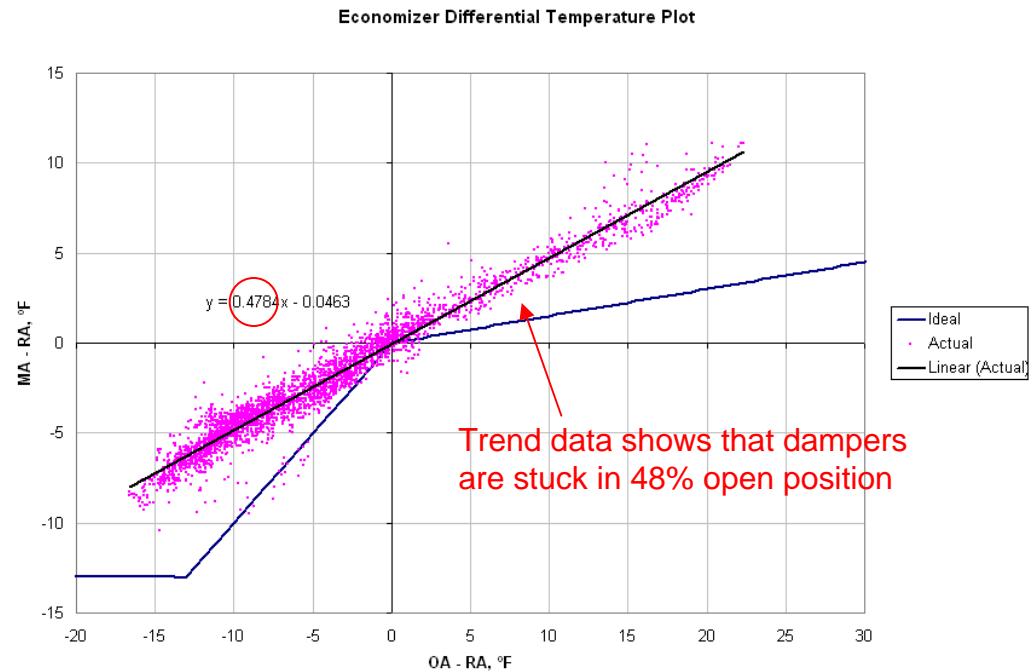
# Next Biggest Saver: Airside Economizers

- Reduce the need for mechanical cooling during mild or cold weather ( $< \sim 70^{\circ}\text{F}$  OA) by using up to 100% outdoor air
- Findings identified through:
  - Functional testing
  - Trend data analysis
  - Review of controls sequences
- Findings rarely identified through occupant complaints
- Average annual energy savings =  $\$0.032/\text{sq ft}$ 
  - $\$8,000$  / year for a 250,000 sq ft building!



# Methods for Identifying Economizer Operation

- Functional testing
- Trend data analysis
- Review of sequences



# Identifying Economizer Opportunities

## System analysis



Finding:

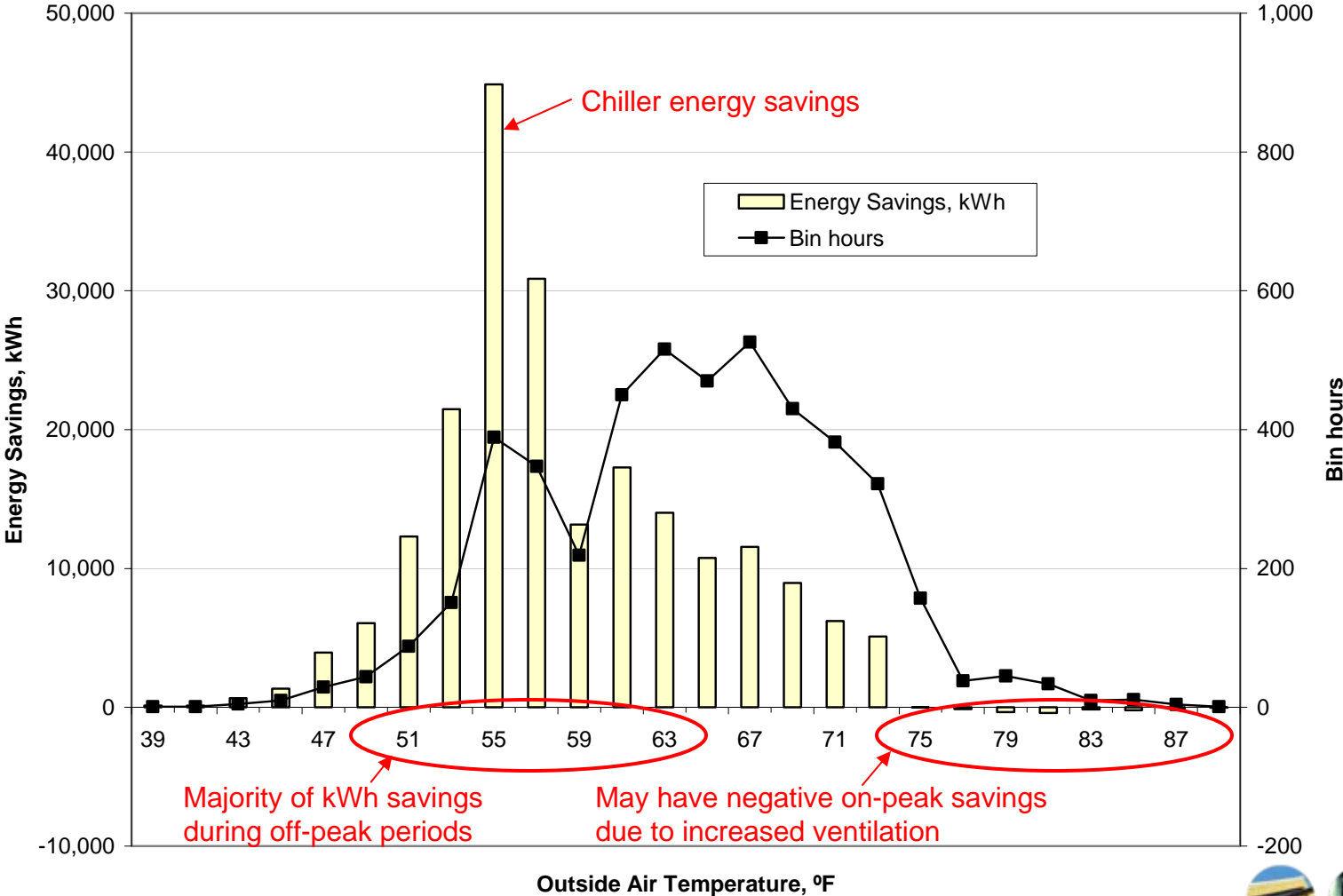
Return air dampers are oversized

Measure:

Shut off half for energy savings, better control



# Typical Economizer Savings Profile



# Other Biggest Saver: Fan Speed Variation

- Typically identified through trend data analysis
  - Trend fan speed and related points (duct or building pressure, outside air temperature)
- Can also be identified by site observation
  - The EMCS may not reflect how the system is actually operating.
  - E.g., Hand-Off-Auto switch in Hand position.
- Average annual energy savings = \$0.04/sq ft
  - \$9,250 / year for a 250,000 sq ft building!
- Biggest fans are typically biggest savers



# Fan Speed Variation Measures

- A variety of findings:
  - Failed VFD
  - VFD running in Hand mode instead of Auto (there's that H-O-A switch again)
  - Constant duct static pressure
  - Constant AND high duct static pressure
  - Building under negative pressure (return fan speed too high)



# Summary

- California is leading in organized EBCx efforts
  - Multiple well funded programs underway
- Preliminary program results show significant energy and cost savings:
  - 27 million Sq ft completed in this program cycle to date
  - Total 32 million kWh, 300,000 therm savings
  - Average project paybacks of ~ 2 years
- Majority of saving from a handful of measures & systems
  - Controls & Economizers
  - High level from fans / AHUs systems
- Cost-effectiveness varies by project:
  - Building type; EUI; Building size; Provider
- Under utility sponsored EBCx, providers and program managers face unique challenges
  - and abundant opportunity!



# Questions?

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