



# Practical M&V for Recommissioning Projects

Russ Chitwood



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# Overview

- Role of M&V in Recommissioning
- Case Study
- RCx Projects
- M&V Methods
- M&V Results
- Conclusions



# Role of M&V in Recommissioning

- Recommissioning is an increasingly popular energy conservation measure
  - Low implementation costs
  - Reduces energy & demand costs
  - Reduces O&M costs
- Short simple paybacks allow for Measurement & Verification (M&V) costs to be incorporated into RCx projects
- M&V:
  - Verifies savings by
    - Defining the baseline
    - Comparing to as-built conditions
  - Reduces risk to customer and RCx provider



## Case Study – Building 500

- 1940's-era military hospital in Aurora, CO (next to Denver)
- Part of former Fitzsimmons AFB, now University of Colorado Health Sciences Center
- Historic 7-story building now remodeled for a variety of uses
- Participated in Xcel Energy's DSM Recommissioning Program
  - RCx projects bought down to 1 year payback with rebates
- Colorado Governor's Office of Energy Management and Conservation provided additional funding to research methods, values and costs of M&V



# Building HVAC System

- Served by central chiller plant cooling loop and steam plant heating loop
- Several AHUs – mix of constant and variable air volume
- Multiple building automation systems for AHUs – no inter-communication
- In some cases, no control – 24/7 operation



# RCx Projects Investigated

- Optimize air-side economizers (8 AHUs)
- Reduce minimum outside air (7 AHUs)
- Adjust AHU schedules (6 AHUs)
- Reducing air flow for CV AHUs – resheaving fans (9 AHUs)

## Investigation Report

<b>Measure</b>	<b>Cost Savings</b>	<b>Implementation Cost</b>	<b>SPB (yrs)</b>
Adj min OSA and Econo total	\$ 8,170	\$ 2,000	0.5
Schedule AHU totals	\$ 22,530	\$ 1,700	0.1
Reduce fan speeds total	\$ 17,983	\$ 9,000	0.7
<b>Grand total</b>	<b>\$ 48,683</b>	<b>\$ 12,700</b>	<b>0.3</b>



# M&V Methods

- Option 1 – Calculation and visual inspection
  - Not a true IPMVP M&V option
  - Measure savings calculated during investigation phase
  - Pros: easily implemented, low cost
  - Cons: calculated savings can be significantly off due to inaccurate assumptions, initial measurement errors, and persistence issues.
  
- Option 2 – Partially Measured Retrofit Isolation
  - Savings determined by partial field measurements, other criteria stipulated
  - Meets IPMVP Option A requirements
  - Pros: increases accuracy and decreases risk
  - Cons: unmeasured assumptions still being made



# M&V Methods

## ■ Option 3 – Retrofit Isolation

- Savings verified by field measurements and calculated from the measured results
- Meets IPMVP Option B requirements
- Pros: accurate savings calculation method specific to the measure, less risk
- Cons: high M&V costs because continuous monitoring required

## ■ Option 4 – Whole Facility

- Utility bill analysis with baseline adjustments
- Meets IPMVP Option C requirements

## ■ Option 5 – Calibrated Simulation

- Building energy modeling, usually with DOE2-based software
- Meets IPMVP Option D requirements

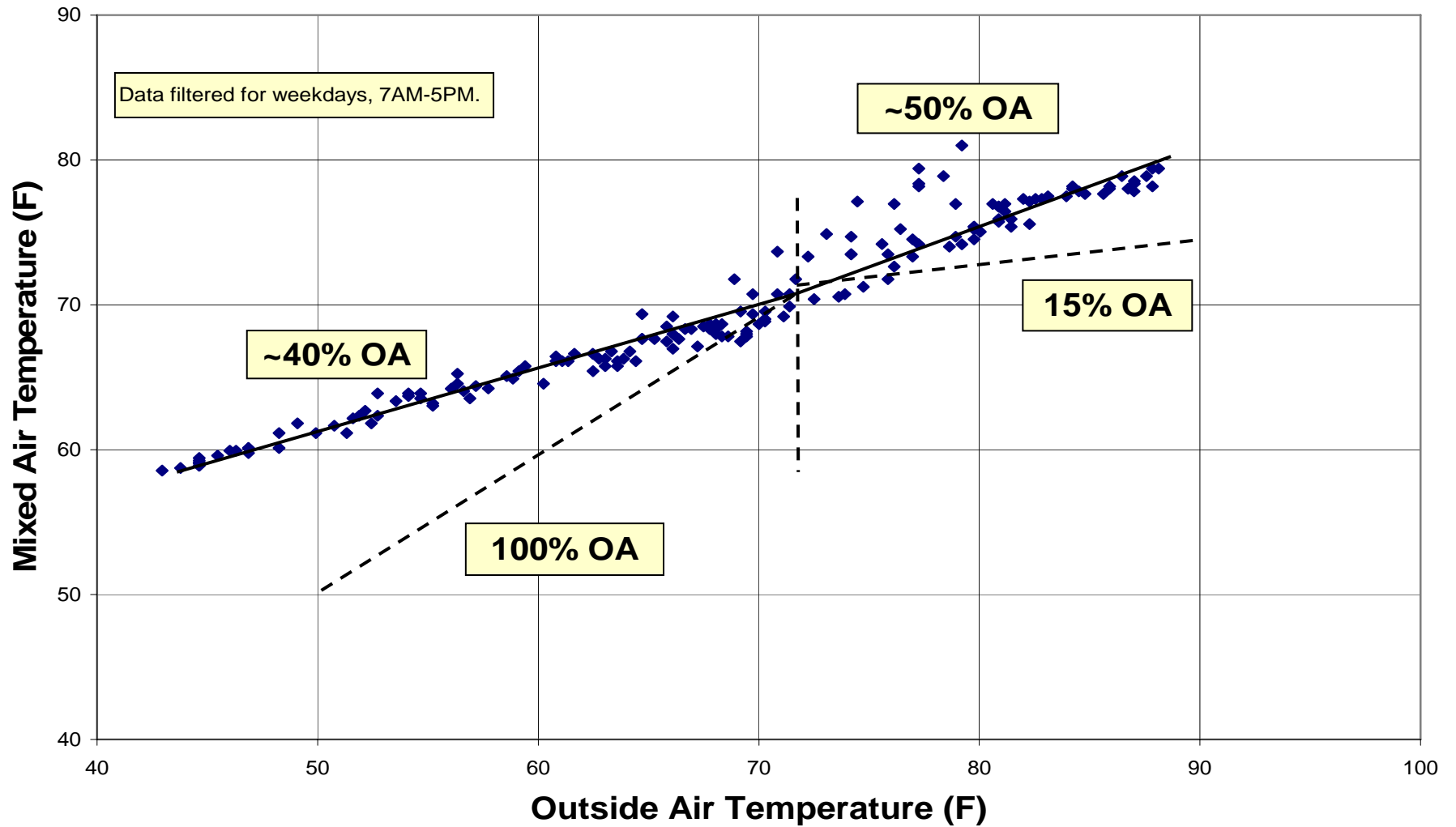


## Baseline Data Collected

- Spot power measurements of constant volume supply and return fan motors
- Temperature data monitored – outside air, return air, mixed air, and supply air – via EMS and data loggers
- AHU start/stop monitored
- Damper positions, nameplate motor data inspected

# Sample: Pre-Retrofit Economizer

## AHU-2N MAT vs OAT





## M&V Results – Economizer & Minimum OSA

### ■ Option 1: Calculation & Inspection

- Stipulate CFM, %OSA, SAT, RAT, schedule, weather, chiller plant efficiency
- Assumes controls to be fully functional after retrofit – no change to savings

### ■ Option 2: Partially Measured Retrofit Isolation

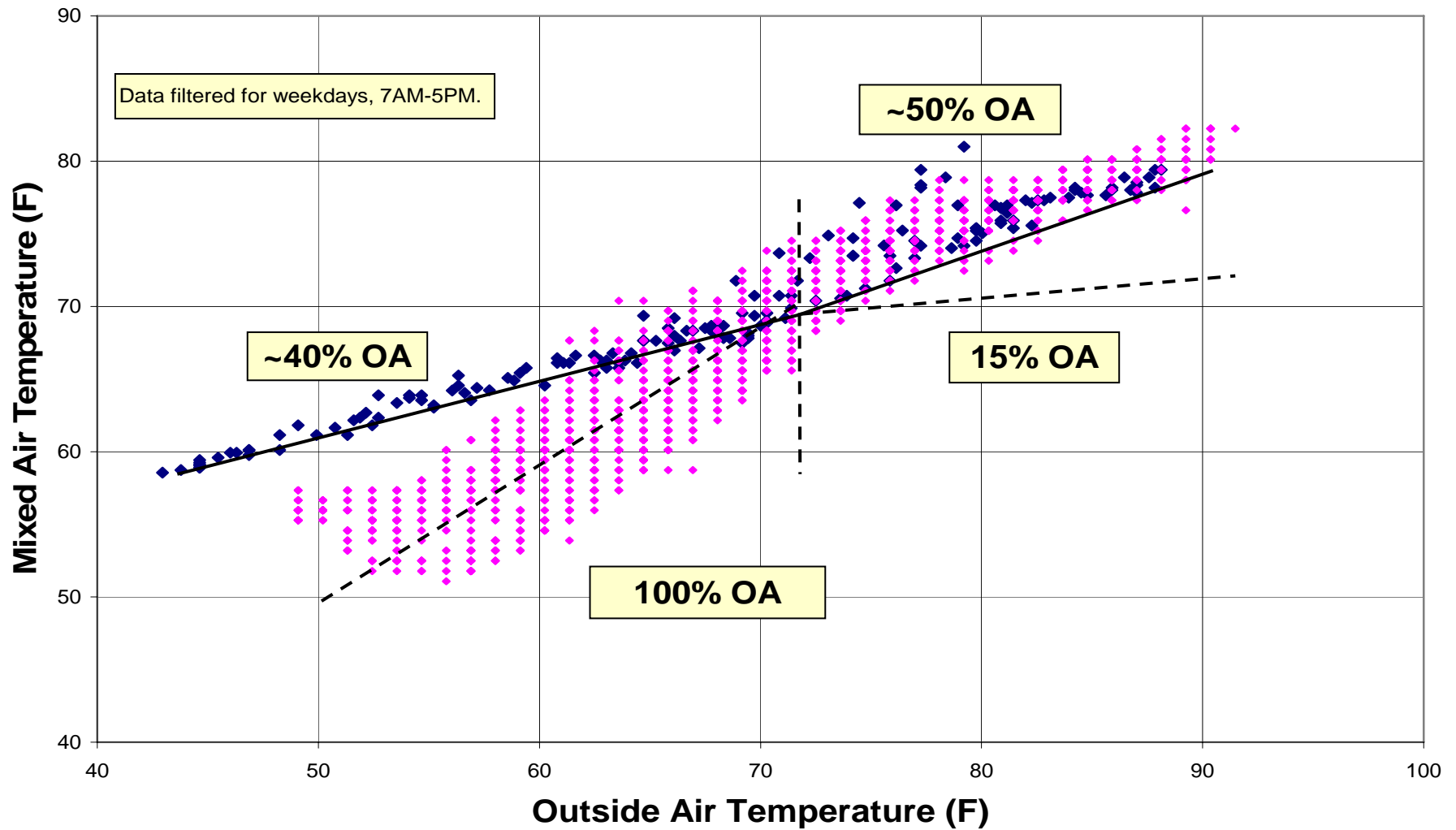
- Spot CFM measurements; stipulated schedule
- Monitoring of OSA, RAT, MAT, SAT
- Found that economizers were working during mild temperatures (100% OSA), but not during hottest OSA temperatures (min. OSA) – due to mainly to old actuators
- Annual cost savings dropped by 45%

### ■ Option 3: Retrofit Isolation

- Added schedule monitoring – no savings change

# Sample: Post-Retrofit Economizer

## AHU-2N MAT vs OAT





## M&V Results – Scheduling

### ■ Option 1: Calculation & Inspection

- Stipulate post-retrofit SF & RF kW, MAT, SAT, RAT, schedule, weather
- On inspection, 1 AHU had a 24 hour cooling load –savings down by 13%

### ■ Option 2: Partially Measured Retrofit Isolation

- Post-retrofit SF & RF kW spot measurements (constant volume)
- Monitoring of schedule; stipulation of temperatures
- Another AHU found to have 24 hour operation – savings down by 33%

### ■ Option 3: Retrofit Isolation

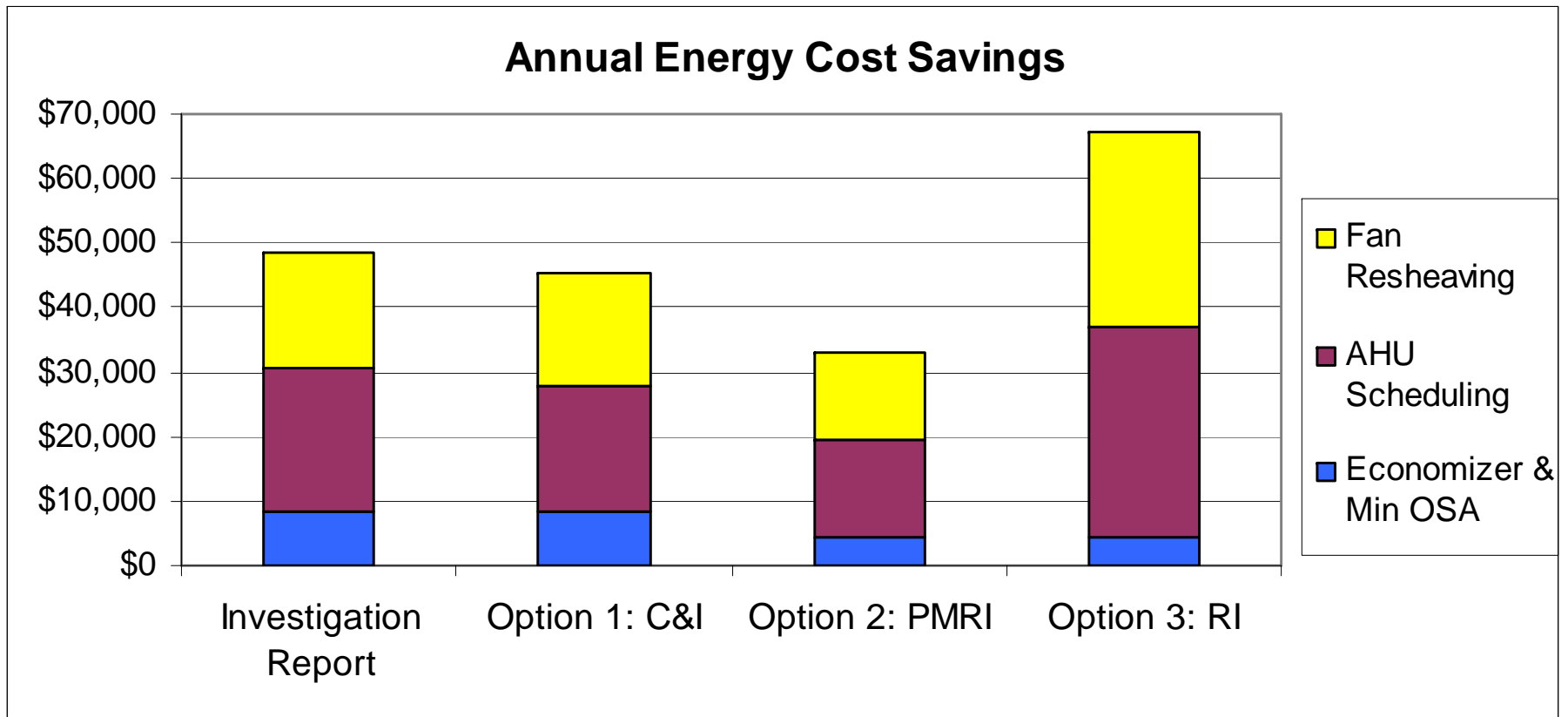
- Monitoring of OSA, MAT, SAT, RAT
- AHU from Option 2 found to have a leaking hot water coil, causing excess heating and a false cooling load
- Net savings after fix increased by 30%



## M&V Results – Resheaving CV Fans

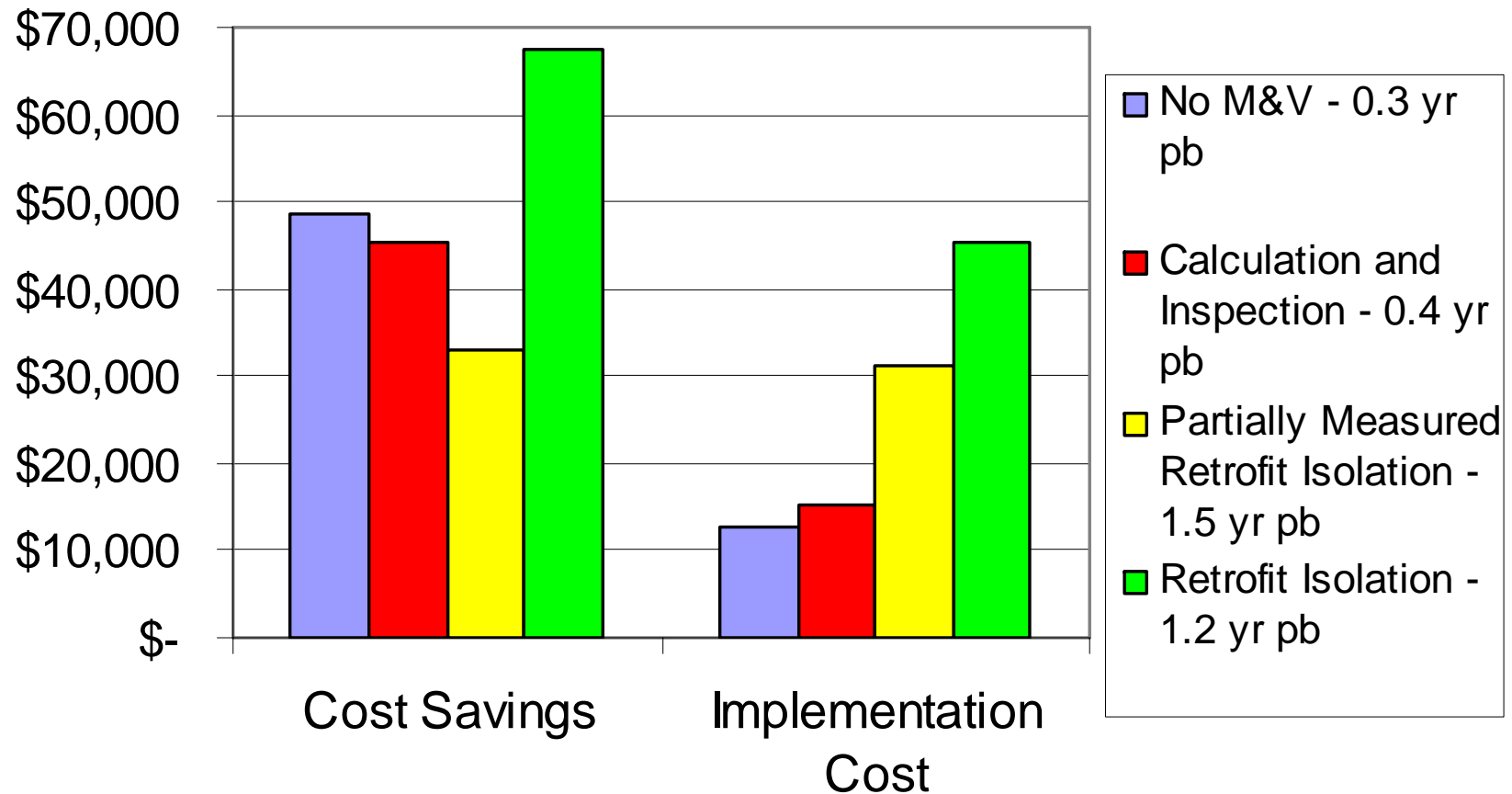
- Option 1: Calculation & Inspection
  - Stipulate pre- and post-retrofit SF & RF kW, SAT, and Schedule
- Option 2: Partially Measured Retrofit Isolation
  - Pre- and post-retrofit SF & RF kW spot measurements
  - Stipulate SAT and schedule
  - Calculations overstated savings via cubic relationship of CFM to kW
  - Spot-measured kW averaged 40% reduction for a 15-20% airflow reduction
  - Savings down by 25%
- Option 3: Retrofit Isolation
  - Monitor AHU schedules, SAT
  - SAT did not need to be reduced, space temperatures satisfied with lower airflow
  - Chiller plant energy raised net savings by 68%

# Results- Annual Savings



# Results - M&V Costs vs. Savings

## Annual Cost Savings vs. Implementation Costs





## Conclusions

- M&V is worth performing, because results will not match calculations
- When more measured data is gathered, the potential to identify additional RCx opportunities increases
- Utilizing the appropriate M&V method for each project type will reduce overall M&V costs while determining if savings goals are met
- M&V helps to create accurate and persistent measures and savings
- Paybacks are still good with M&V incorporated into the project



# Contact Information

**Russ Chitwood**

**Nexant, Inc.**

**1401 Walnut Street**

**Boulder, CO 80303**

**[rchitwood@nexant.com](mailto:rchitwood@nexant.com)**

**[www.nexant.com](http://www.nexant.com)**