Extreme Makeover – Lab Edition

A Case Study of Recommissioning and Revitalization of Existing Controls

Presented by B2Q Associates, Inc.

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A Woman's Business Enterprise (WBE)

UMass Amherst – Engineering Laboratory II

Learning Objectives

- Increase understanding of typical lab HVAC and hood controls, and where opportunities exist to optimize and update
- Understand energy, performance and safety impacts of lab controls, particularly failed or “out of spec” controls, and strategies for tuning these up and updating them
- Be able to identify candidates for lab controls re-commissioning and how to prioritize which controls software and hardware changes to make to get the best bang for your buck
- Improve the ability to understand and promote the benefits of lab controls re-commissioning – making the most of what exists

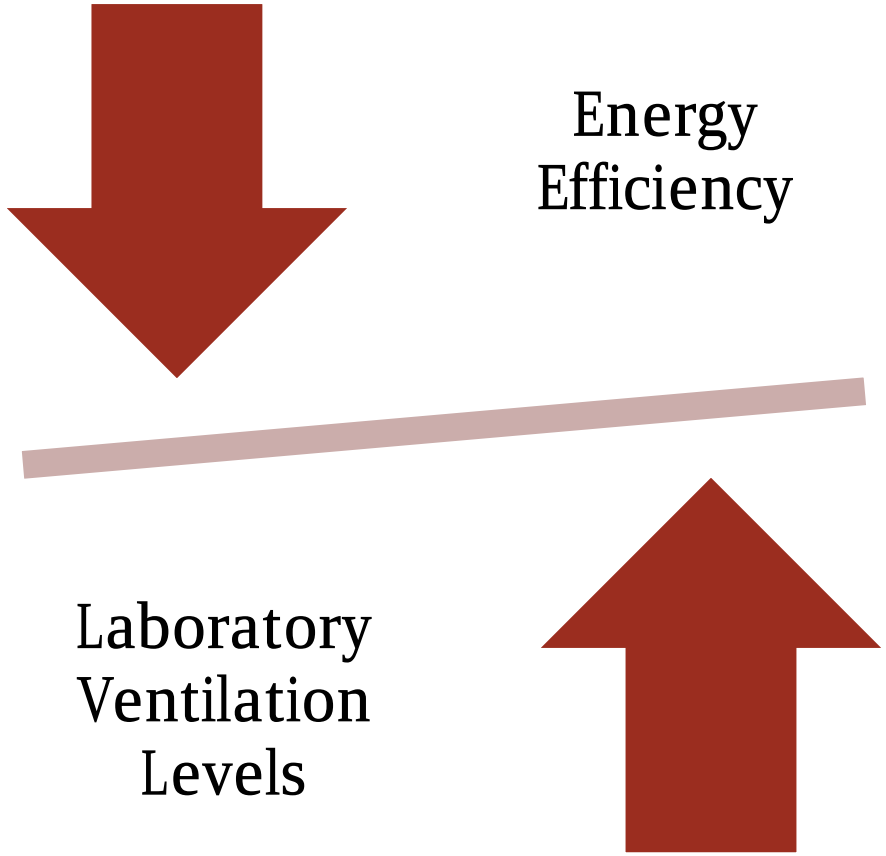
Why Are Lab Ventilation Controls Important?

Labs have *recommended* ventilation rates (ACH) set by ASHRAE 62.1

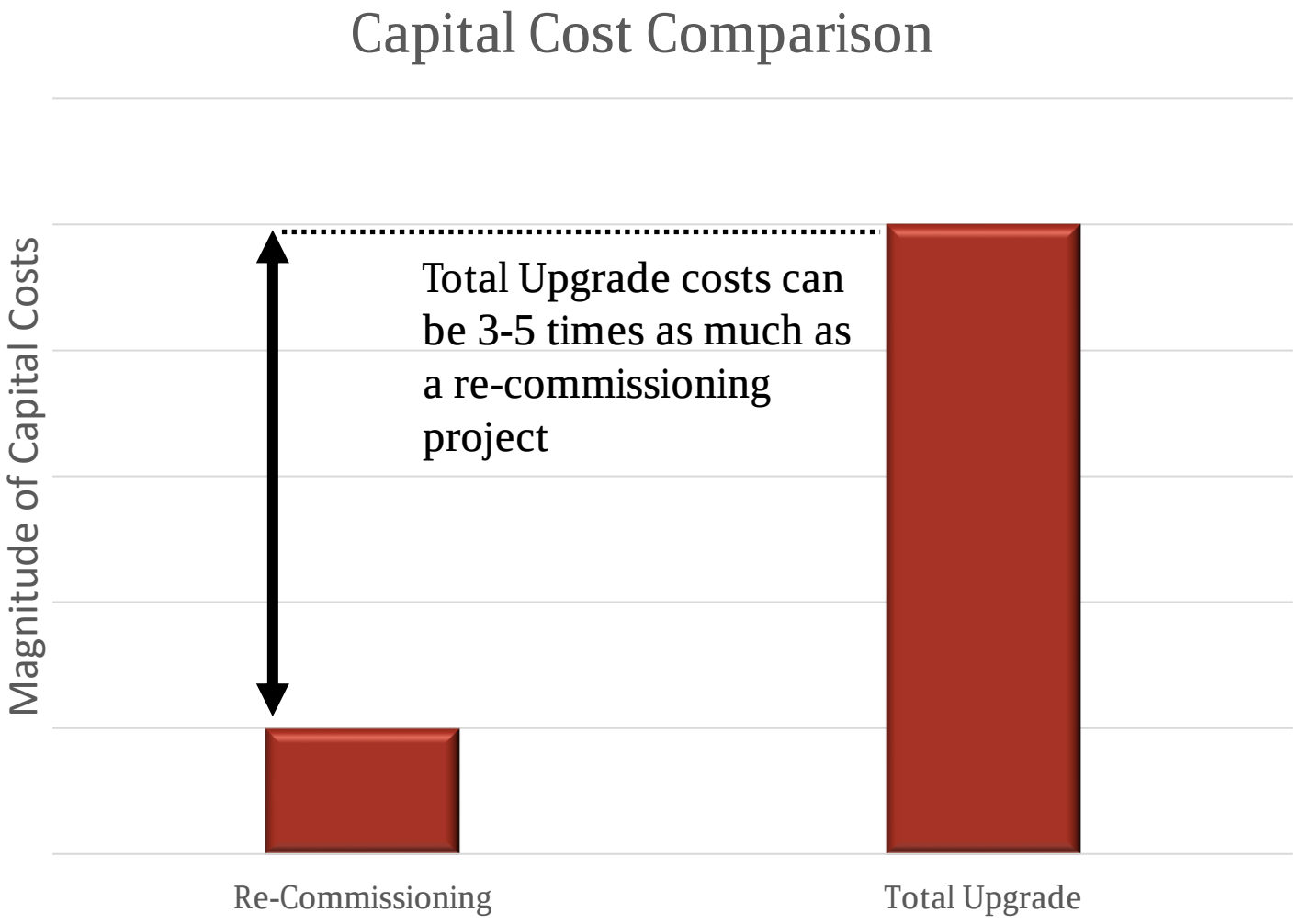
- Intent – Provide a safe environment for study and use of harmful chemicals
- The intent is achieved by continuously exhausting and introducing fresh air in the laboratory, preventing the accumulation of chemicals in the air, especially the effective breathing zone
- Laboratories require greater volume of ventilation than typical office/classroom spaces due to the use of chemicals
- Fume hoods have their own requirements for providing continuous ventilation from *ANSI Z9.5 2012*

Lab Ventilation Impacts

- Laboratory ventilation comes with a tradeoff:
  - Greater levels of ventilation increase the energy consumption of the building
  - However, just adding ventilation doesn't necessarily increase the safety of the lab environment
  - Optimizing ventilation for energy efficiency
    - Ventilation effectiveness testing
      - Chemicals – types, amounts, locations, housekeeping
      - Airflow distribution
  - Meet minimum acceptable air change rates



Possible Laboratory Ventilation Control Projects



RCx project:

- TAB & Functional testing of each device
- Replace only failed or "out of scope" devices
- ~$500 per valve card (28)
- ~$200 per poppet valve (6)

Capital Upgrade:

- Upgrade of **ALL** valve cards, actuators, & fume hood monitors
- New lab-level controller for **EVERY ZONE**
- Reprogramming of every controller
- ~$1,000 per valve (136)
- ~$1,000 per controller (22)
- ~$400 per fume hood monitor (46)
- New wiring
- More labor intensive than RCx project

Case Study – Engineering Lab II - Summary

Baseline Condition	Post-Implementation Condition
Mean of 10 ACH in labs	• Achieved EH&S recommended minimum ACH • 8 ACH first floor, 6 ACH second and third floor
Continuous ventilation designed for occupied space	• Installed occupancy sensors to detect occupants • Reduced ventilation to 4 ACH during unoccupied
Fume hoods are often unused & left closed	• Reduced the minimum fume hood airflow • Allows supply airflow to reduce proportionally
Degrading control devices provide imprecise control	• Repairing/replacing devices regained control of sequences, offsets, & ACH
Over-ventilation caused poor temperature control	• Regaining precise control uncovered additional issues to be fixed to improve temperature control

Achieving Successful Re-Commissioning

Scoping

Properly Vet the Laboratory

Ensure ventilation will enable energy savings

Investment Grade

Perform a detailed study on labs

Account for each terminal device, identify rough quantity of failures, identify device minimums

Sample TAB to verify BAS readings

Begin re-engineering of laboratories and identify accurate potential for energy savings

Implementation

Perform Ventilation Effectiveness Testing

Gather multidisciplinary team

Final Verification of new ACH, offsets, Fume hood flows by EH&S

Test each device, replacing or recalibrating/repairing devices unable to provide adequate precision

Commissioning

Perform During & After Implementation

Testing of all devices for sequences and TAB

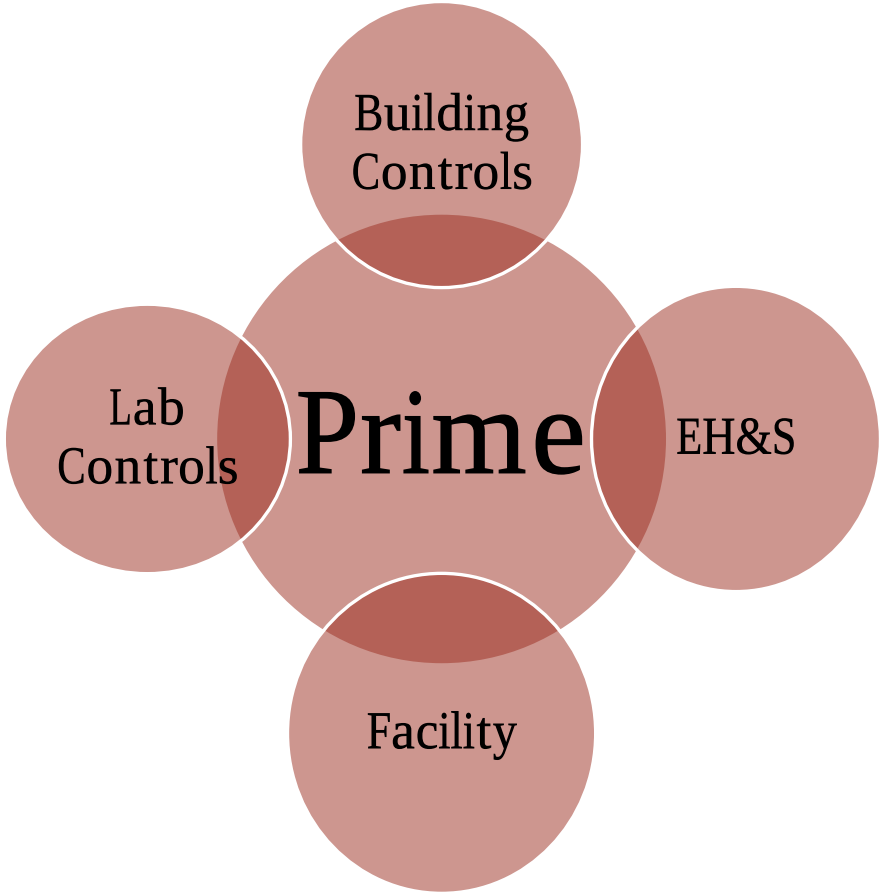
Verify all ACHs & Offsets

Measurement and Verification of Building Level Energy Savings

Provide Training & Closeout Documentation

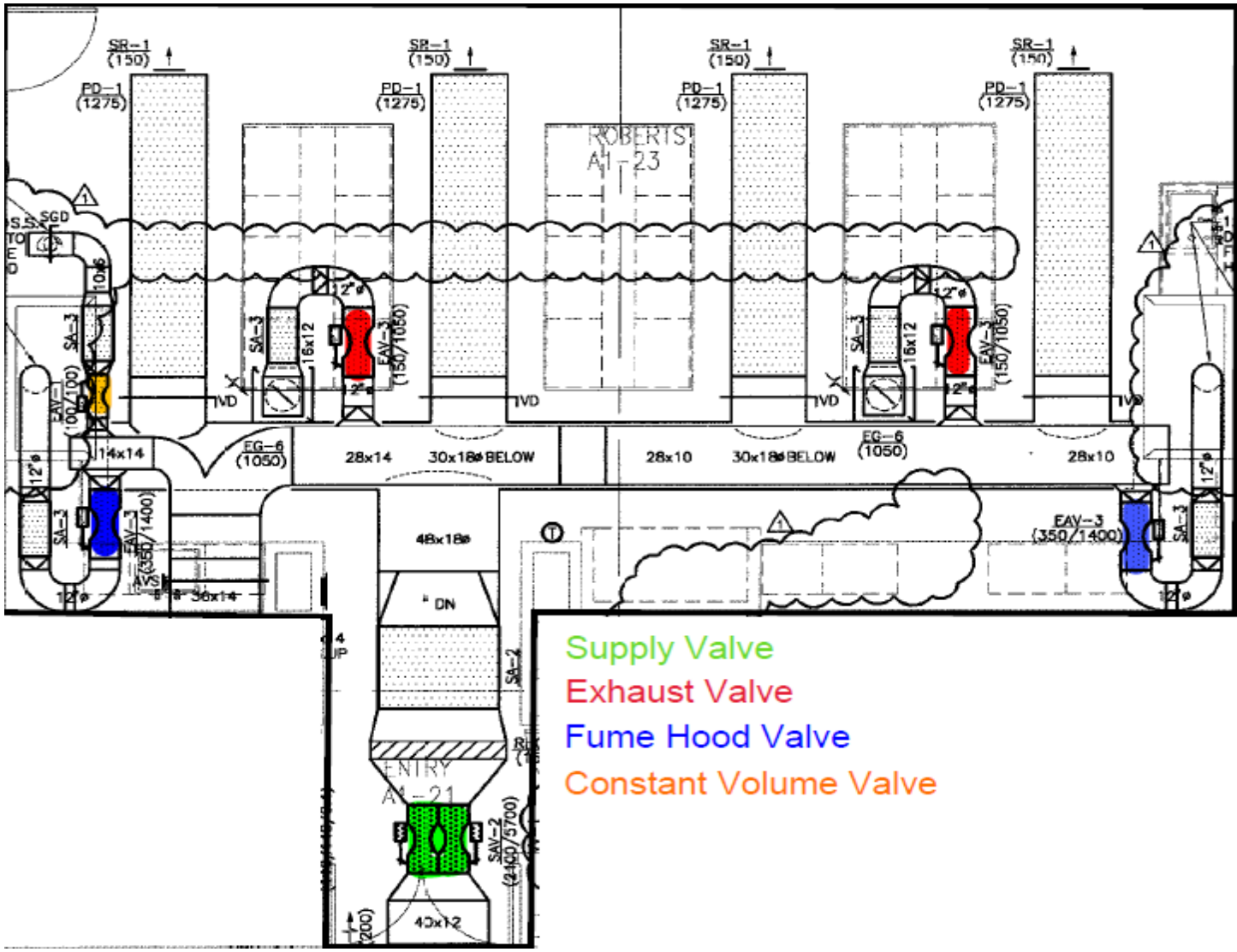
Establish & Maintain Communicative Relationships

- Prime contractor establishes and maintains communications between all parties of the project including coordinating and supervising all work.
- EH&S has final say in all ventilation setpoints, air changes, anything regarding health and safety of lab occupants
- Facilities staff has final approval of any controls changes, and is responsible for coordinating access with the Prime
- Lab and Building Controls are responsible for making hardware replacements, programming adjustments, etc.



Typical HVAC Layout – Engineering Lab II

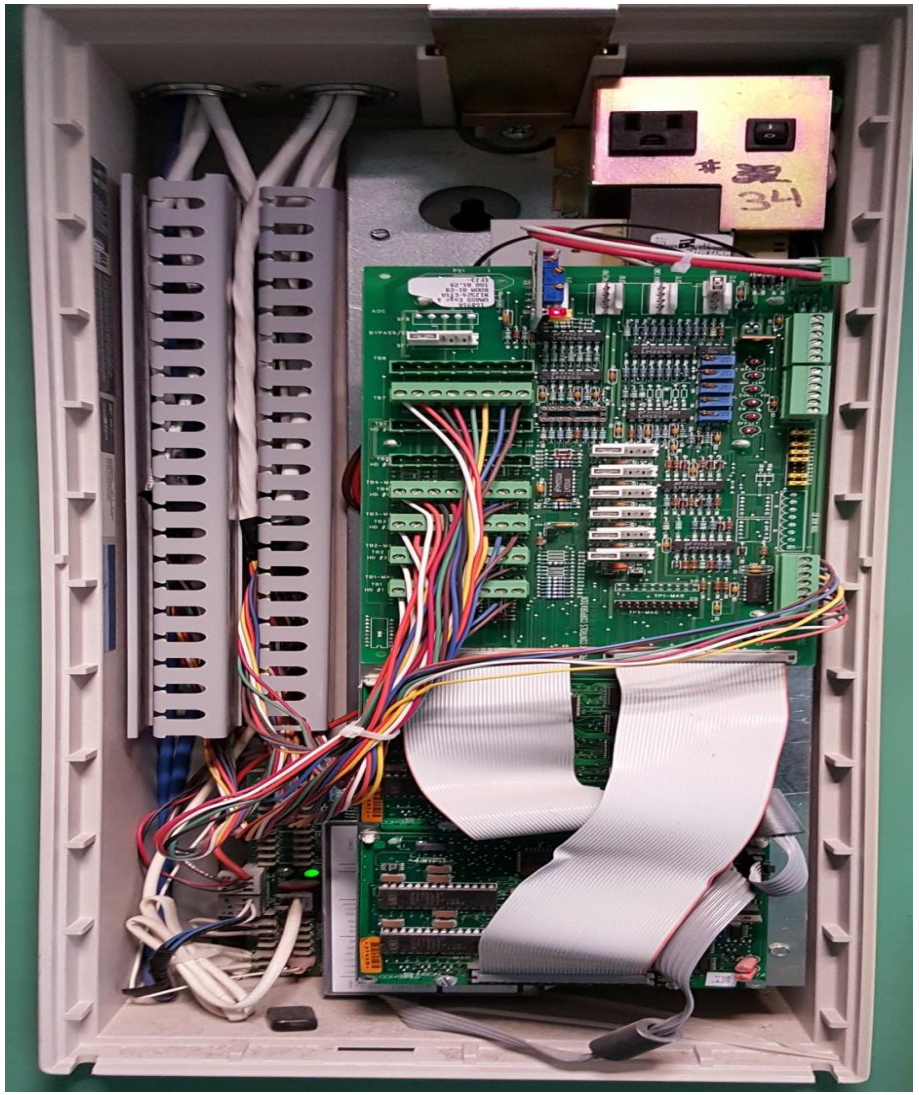
- Terminal Devices control the volume of supply and exhaust air into and out of the lab
- Airflow varies to meet the demands of the space, such as temperature or occupancy levels
- Every terminal device must be accounted for and work together to create safe offsets
- Laboratory offsets are typically negative to prevent contamination of adjacent spaces, although there are exceptions



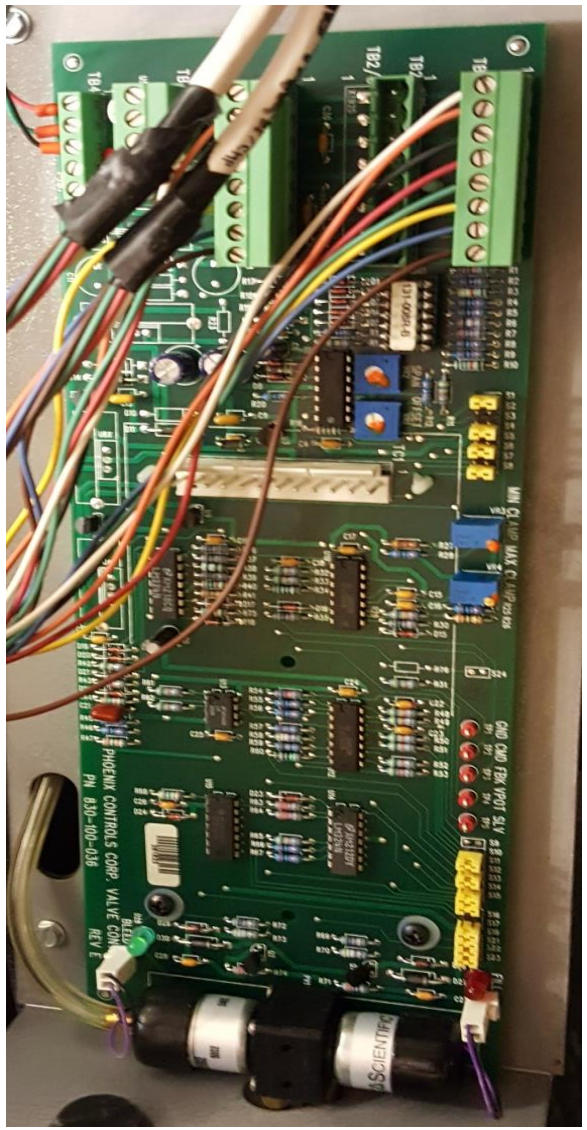
ELab II – Laboratory Ventilation Control System

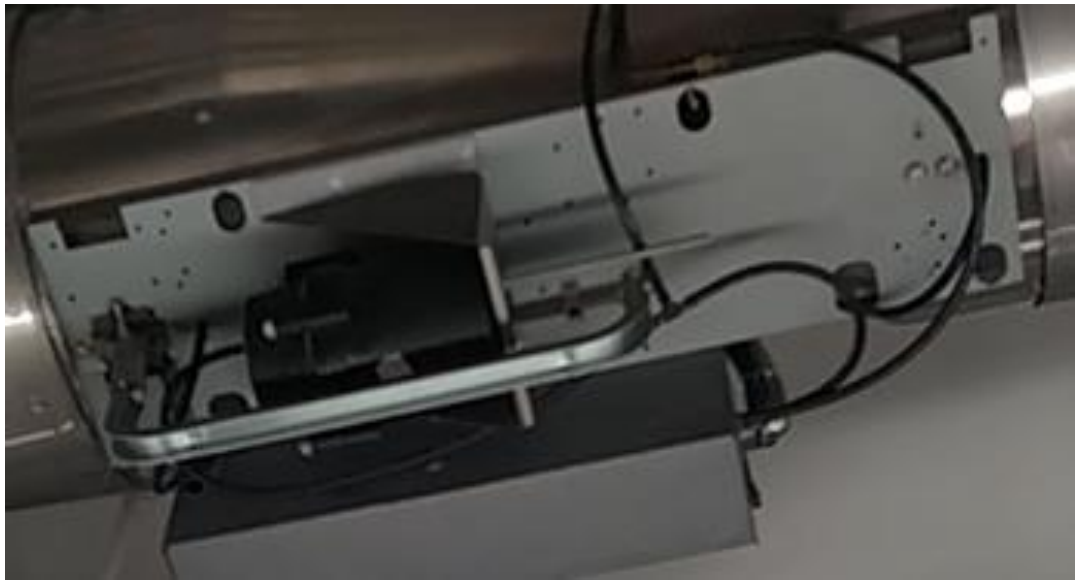
ANALOG-ELECTRIC INTEGRATION

- Phoenix terminal devices are pneumatically controlled with a DDC overlay
- Analyze system and determine if re-commissioning is appropriate
  - Are devices salvageable?
    - TAB sample
    - Voltage Testing
    - Quantify device issues
- MIJ Panel would be removed in upgrade & replaced with lab/BAS field controller



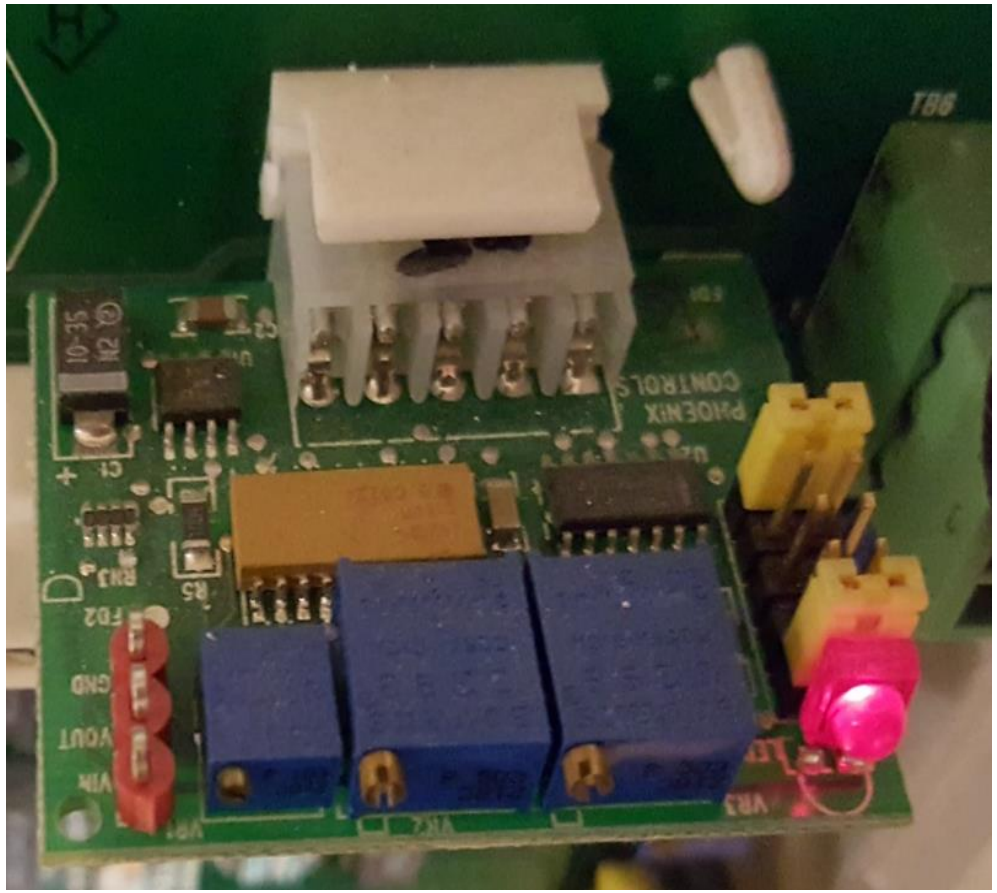
Typical Phoenix Air Valve Card

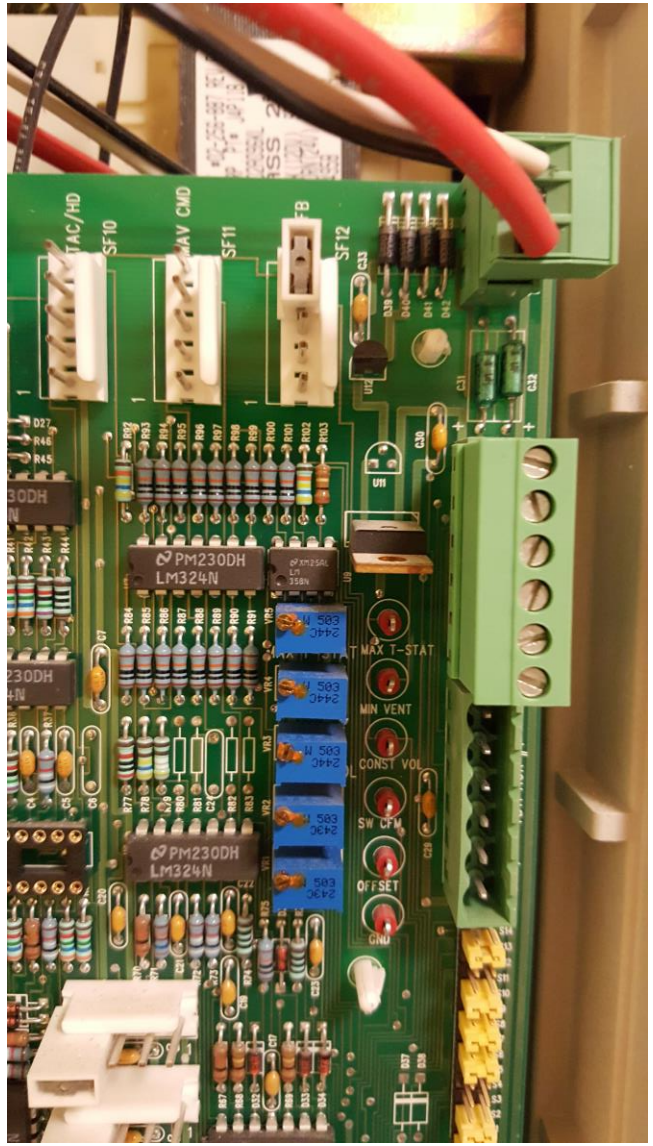




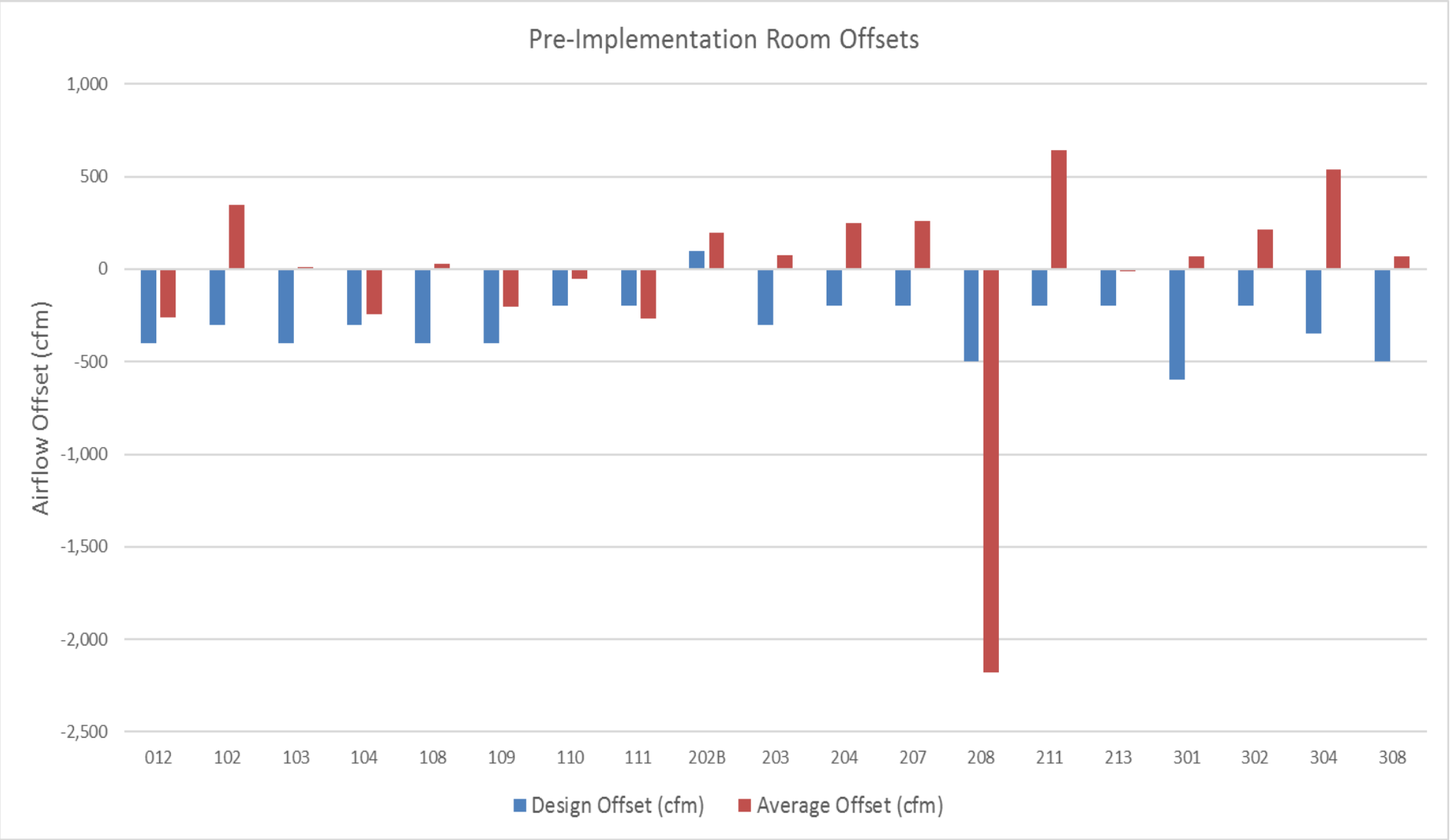
- Air Valve card (left)
  - Solenoid poppet valve modulates valve position to maintain airflow setpoint
- Valve card may begin to fail if voltage at feedback and command points deviate
- Poppet valve may fail while the rest of the device works properly
  - Always check pneumatic tubing connections before replacing

Phoenix – MIJ Panel





Degradation of Terminal Device Control



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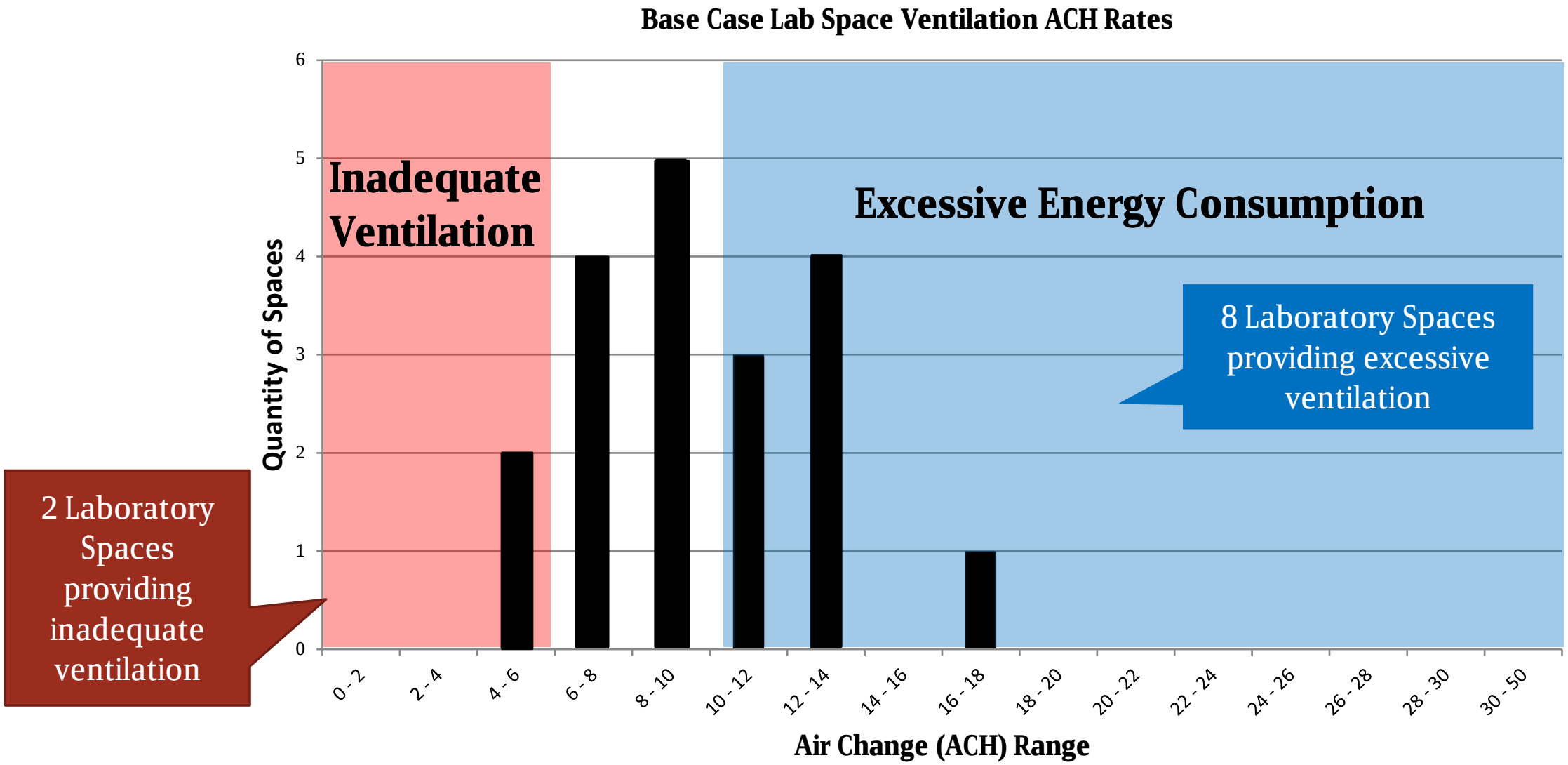


Implementation Investigation

Exhaust ductwork abandoned and driving air change rates.

All abandoned ductwork was capped, no longer pulling exhaust

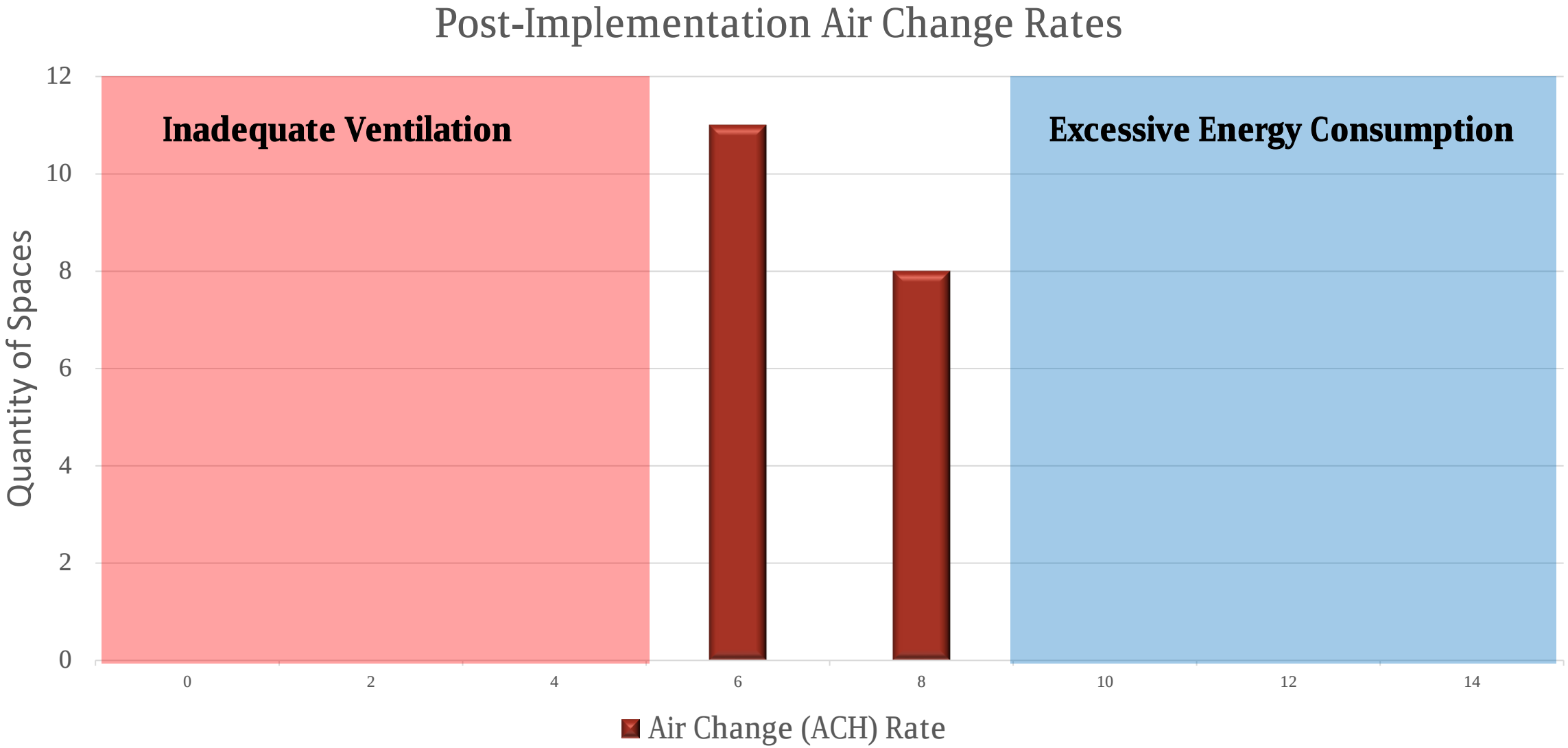
Implementation Investigation Issues

On-going commissioning during implementation can save time and money; look for the following issues:

- Labs suddenly have difficulty maintaining temperature
  - Decreasing airflow to the air valve and reheat coil uncovered ~5 valves that were constantly leaking by
- Labs not triggering occupancy
  - Check that all labs are mapped to the correct point
  - Ex: lab 204N & 204S share a single occupancy status. Be sure both software points are tied to the binary output that the sensors are wired to
- Ensure lab airflow offsets are accurate
  - It is easy to accidentally make a lab airflow positive instead of negative, if a single jumper is out of place

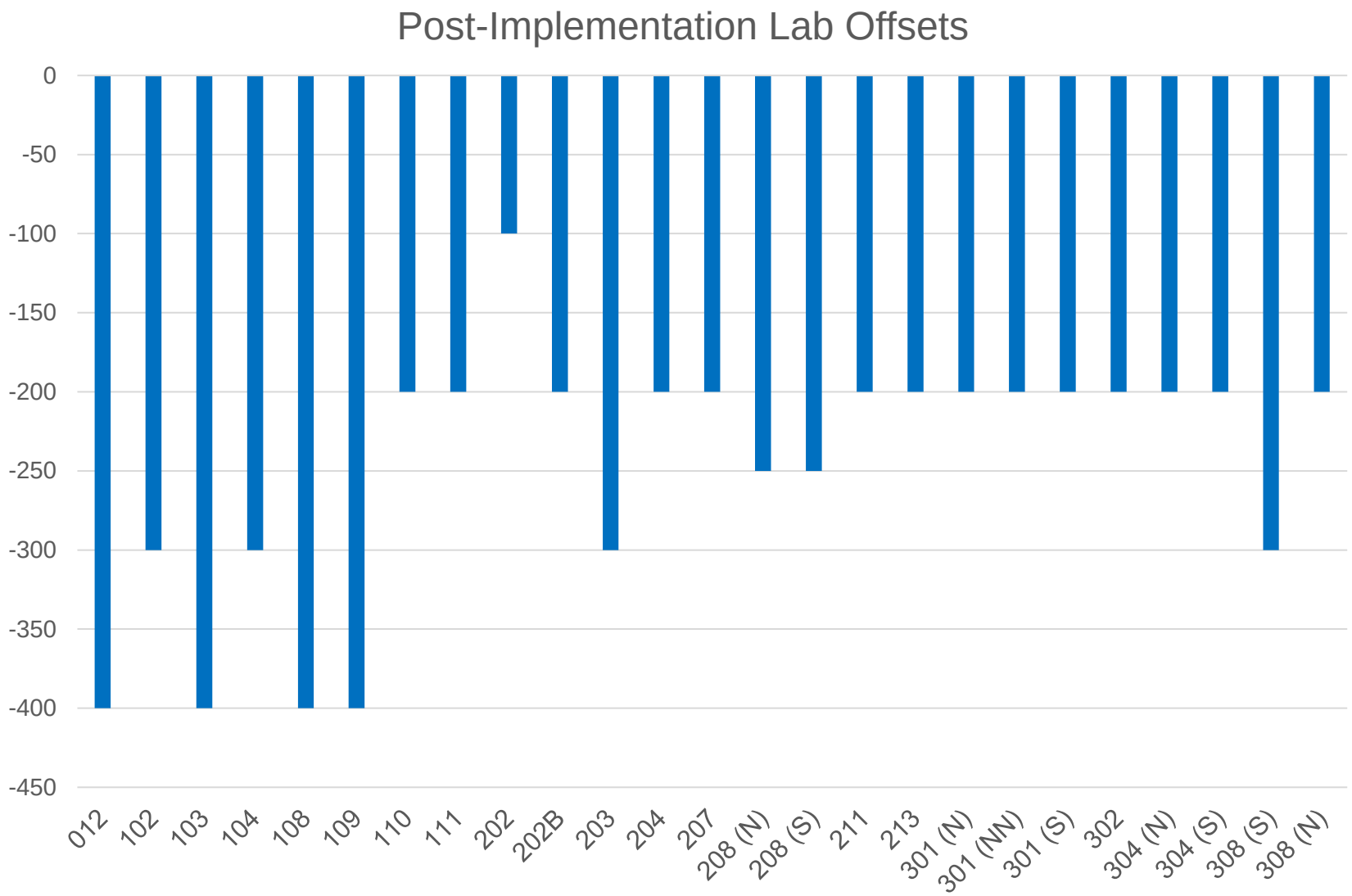
Typical Reheat Valve

Re-Commissioning ACH Rates



Re-Commissioning Laboratory Offsets

- All lab offsets control as designed
- Offsets are equal to original design
  - Exception is 202 which has become a physical laboratory with no chemical use



Case Study Economics

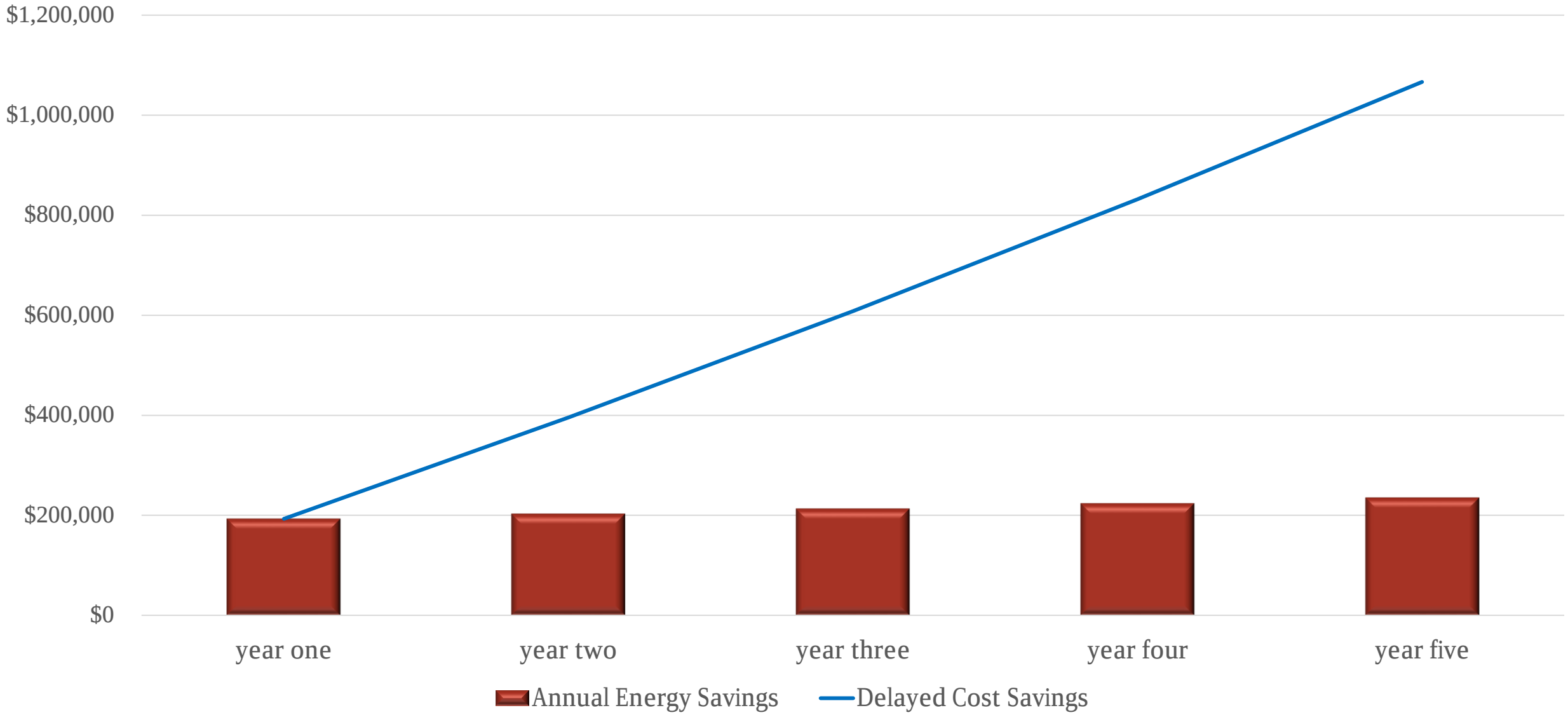
- Great Payback!
- Combined many Projects
- >60% of terminal Devices remain acceptable
- Regain Control of Ventilation within 3 months
- Decrease Building Energy Consumption by >30%

UMass Engineering Lab II - Implementation Project		
Annual Electric Energy Savings	670,113	kWh/year
Annual Electric Cost Savings	$67,011	$/year
Annual Steam Savings	6,312	Mlbs/year
Annual Gas Cost Savings	$126,240	$/year
Total Cost Savings	$193,251	$/year
Incentive Amount	$95,942	$
Net Implementation Cost	$352,965	$
Simple Payback	1.8	years

Project List:

- Air Handler & Exhaust Fan:
- Simultaneous heating and cooling
- Lockout Cooling Valve
- Replace Exhaust Static Pressure Sensors
- Reprogram exhaust fan bypass dampers
- Reprogram exhaust fan VFD control
- Reduce Non-lab Airflow
- Add building dP sensors
- Add graphics to BAS
- Recommissioning of laboratory devices
- Re-engineering & reprogramming of laboratory setpoints
- Install occupancy sensors
- Replace supervisor BAS controllers

Delayed Capital Funding



Building Level Optimization Results

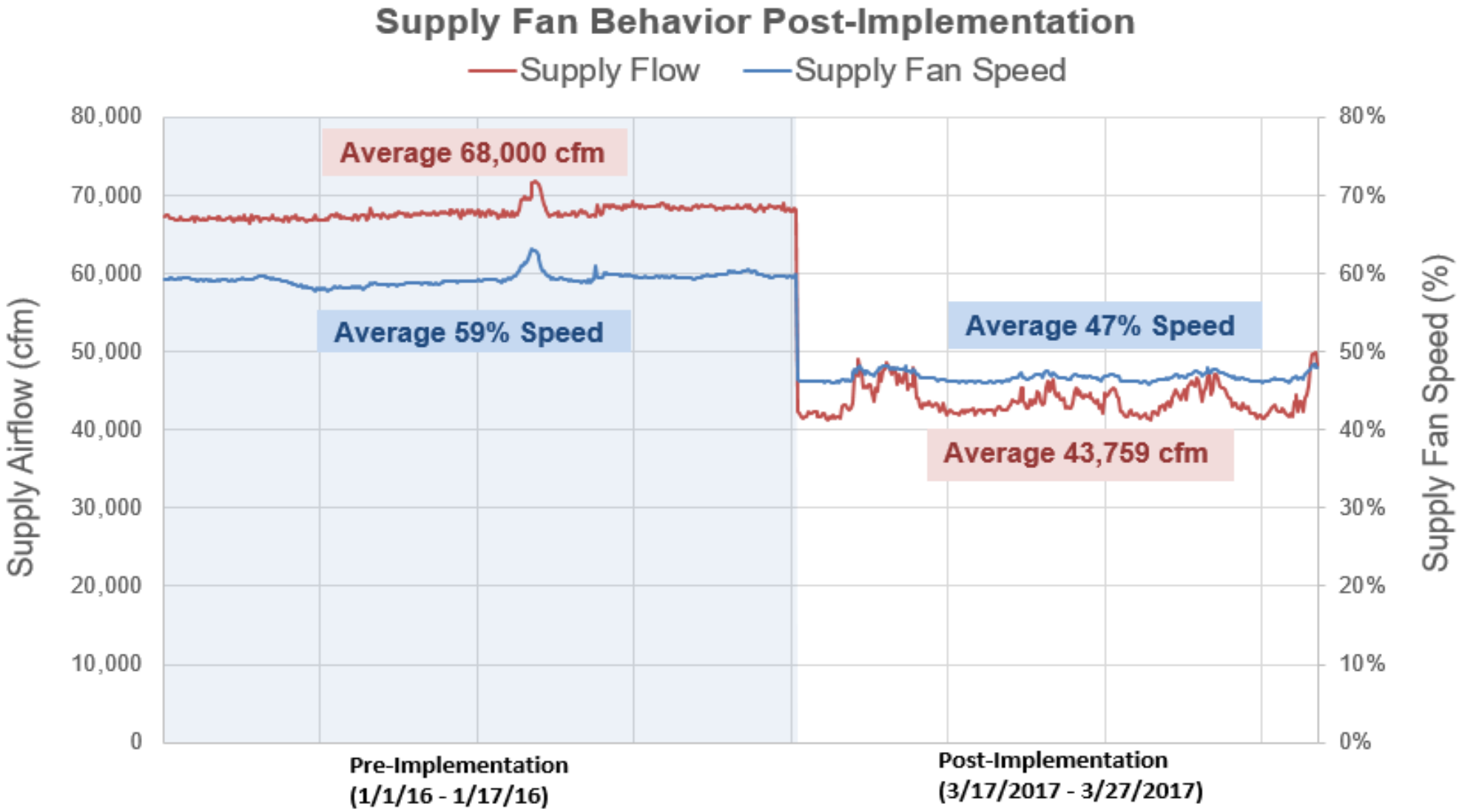
Space Level Optimization

- Space by Space Re-engineering of total building airflow balance
- 22 Laboratory controllers reprogrammed
- 136 Air Valves tested and “re-vitalized”
- Re-Engineered minimum airflows of 113 VAV terminal boxes
- 33 VAV controller sequences re-programmed for variable heating flow capability
- Contributes to AHU and EF airflow Reductions

AHU & EF Results

- 62 kW reduction in total fan load
- 23,000 cfm reduction in average supply air
- 13% reduction in average supply fan speed
- 23,000 cfm reduction in average exhaust air
- 26% reduction in average exhaust fan speed (2 fans)
- 549,000 kWh/year reduction in fan energy

Building Level Optimization Results



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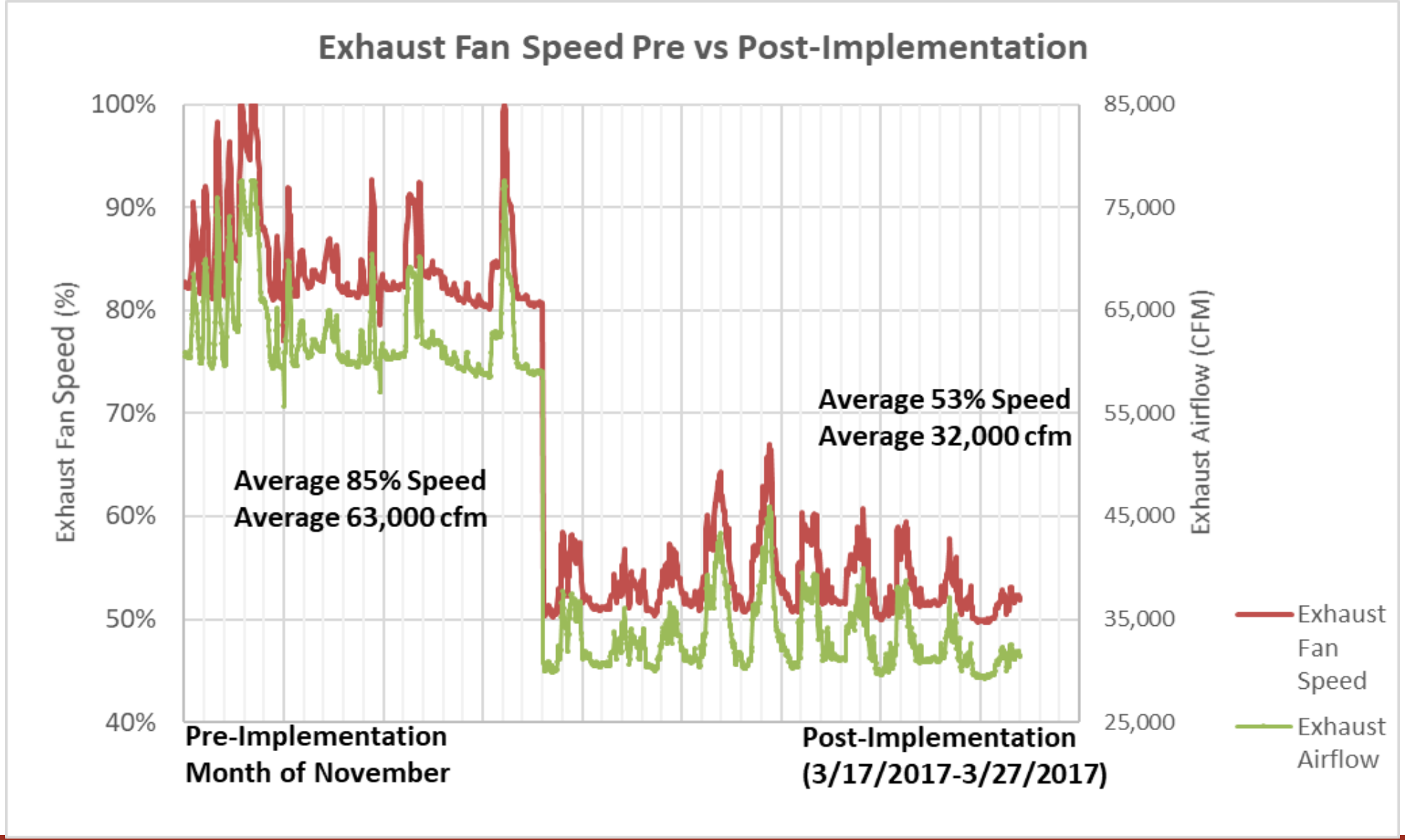

Final Remarks

- Laboratory Ventilation is critical to the health and safety of lab occupants
- Find the proper balance between providing enough lab ventilation to satisfy health and safety requirements while limiting the amount of energy consumption
- While a full controls upgrade will provide precise control with brand new devices, it comes with high costs and potentially delayed implementation
- Recommissioning efforts can provide immediate reduction in building energy use and immediate increase in the precision of the ventilation controls, at a much lower cost than a capital project

Questions?

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