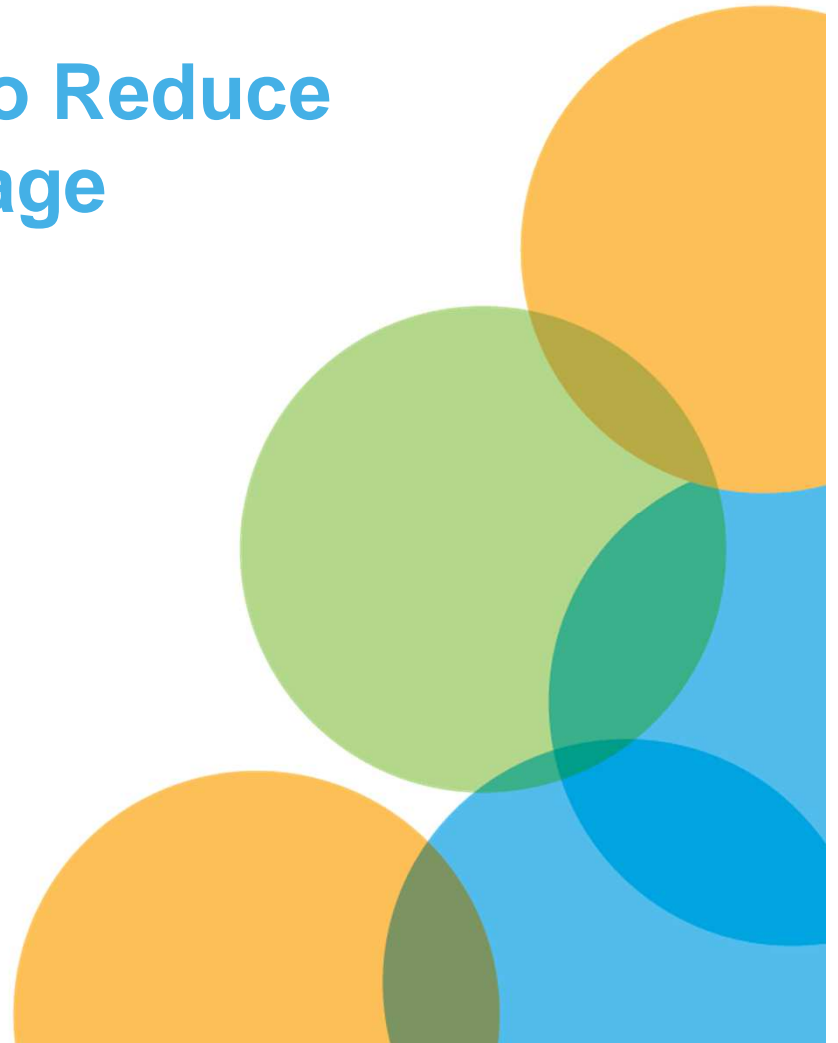


# Using an Aerosol Sealant to Reduce Multifamily Envelope Leakage

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UC Davis Western Cooling Efficiency Center

**2016 ACEEE Summer Study**





## Project Team & Funding

- Center for Energy and Environment
  - Ben Schoenbauer
  - Jim Fitzgerald
  - Kirk Kolehma
  - Megan Hoye
- UC Davis Western Cooling Efficiency Center
  - Mark Modera
  - Jose Garcia
- The Energy Conservatory



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# Multifamily Envelope Sealing: Opportunities and Challenges

- **Existing buildings.**

- Thousands of units of leaky units do not meet current standards.
- No/difficult/costly access to distributed air leaks. 10% to 25% reduction is challenging.

- **New Construction.**

- New code (low rise: 3 ACH50) and EPA ENERGY STAR high rise (0.3 cfm50/sf) requirements
- Single family approaches only recently starting to carry over to multifamily buildings. How can we do this more effectively for both exterior leakage and compartmentalization?

# Aerosol Sealing Benefits:

- Reduced air infiltration energy costs & cold drafts
- Improved IAQ from reduced odor & contaminant transfer
- Reduced noise transmission
- Simultaneous air leakage testing documents results
- Potential savings for avoided conventional air sealing (?)



# How does it do that?

## No, really?

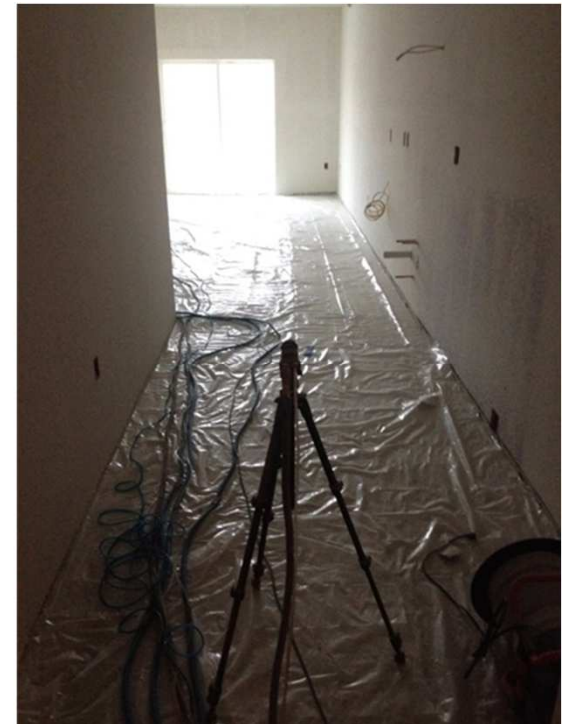
(animation video here)

The sealant is GREEN Guard Gold Certified  
for use in California school and health care facilities.

# • Aerosol Sealing Process

- Pressurize apartment
- Spray air sealing fog
- Sealant particles build up on gaps as they flow through the leaks

Similar to  
process  
used for  
aerosol  
duct  
sealing





## Study Objectives

### **Demonstrate sealing capability and evaluate commercialization**

- Refine sealing technique – measure leakage and noise transmission reduction & identify sealing locations
  - How to incorporate into sealing strategy – preseal “large” leaks and protect horizontal surfaces as necessary
  - Time estimates
  - Model energy savings and ventilation/inter-apt flows
1. Sealed 18 units in 3 new construction buildings
  2. Sealed 9 units in 3 existing buildings



# Site Work Prep: pre-seal wide gaps

1 to 2 person-hours



Sprinkler head



Duct penetration



Low voltage wiring



Range electric line



AC Line set



Plumbing penetration



# • Site Work Prep: temporary sealing

For openings  
that need to  
remain open

Exhaust fan ducts



Combustion vents



Exterior doors



Plumbing penetrations



Shower handles

Fill traps or cover waste line openings

# Site Work Prep: cover horizontal surfaces

Ideal: drywall mud/tape, no finished materials/surfaces, and bare floor



Not ideal: ready for occupancy

Temporary seals & covers:  
3 to 7 person-hours



# Site Work Prep: cover horizontal surfaces



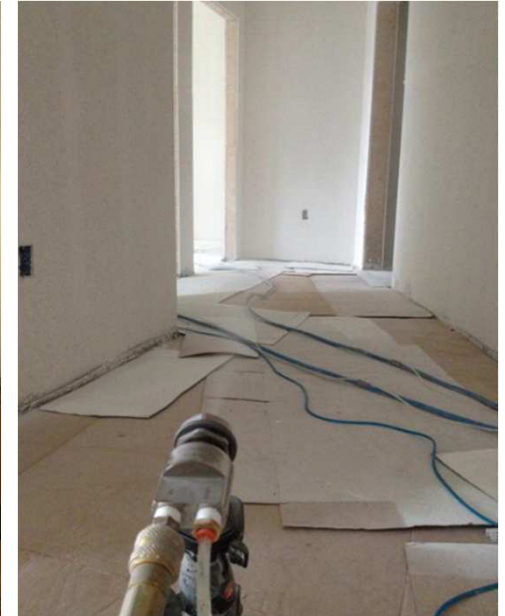


# Site Work

## Set-up, Seal & Breakdown

- Blower door and nozzles
- Pressurization
- Spray sealant
- Open windows & purge

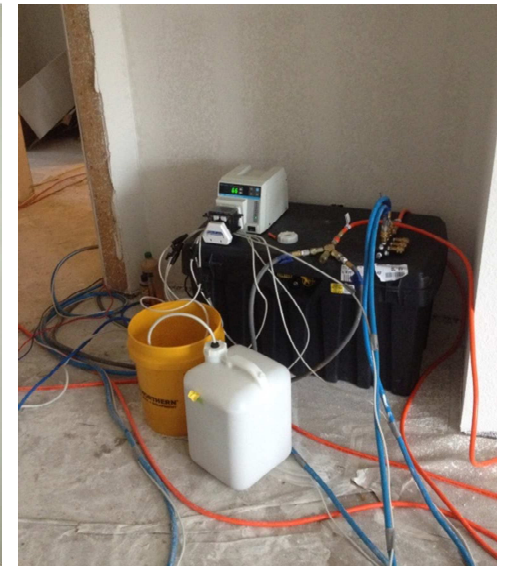
6 to 7 person-hours



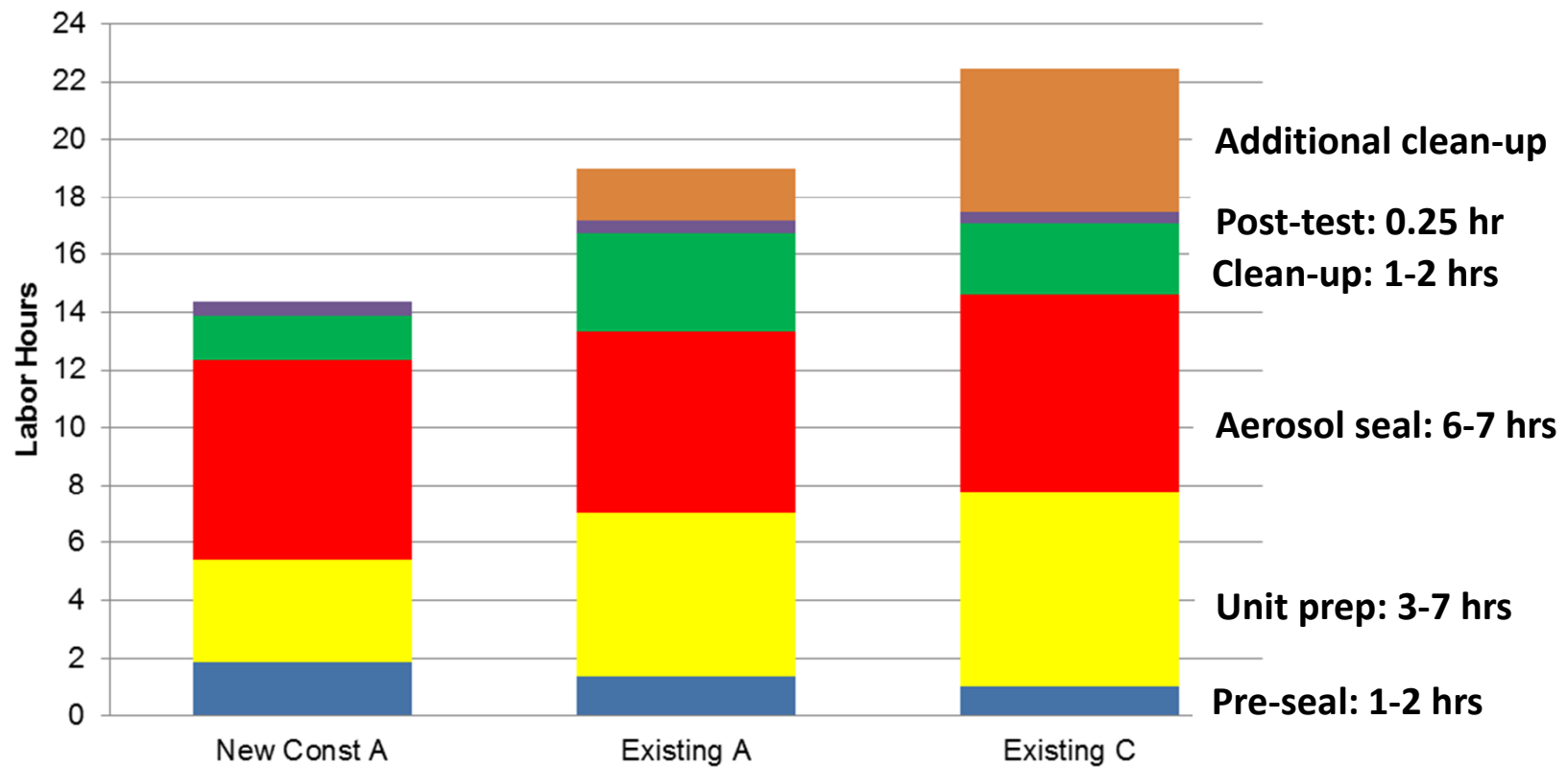
## Remove Covers & Pack-up

- Care to not disturb seals
- Minimal clean-up

1.5 to 3.5 person-hours



## ●●● Sealing work: how long does it take?



14 to 22 person-hours: still learning

## Sealed Penetrations

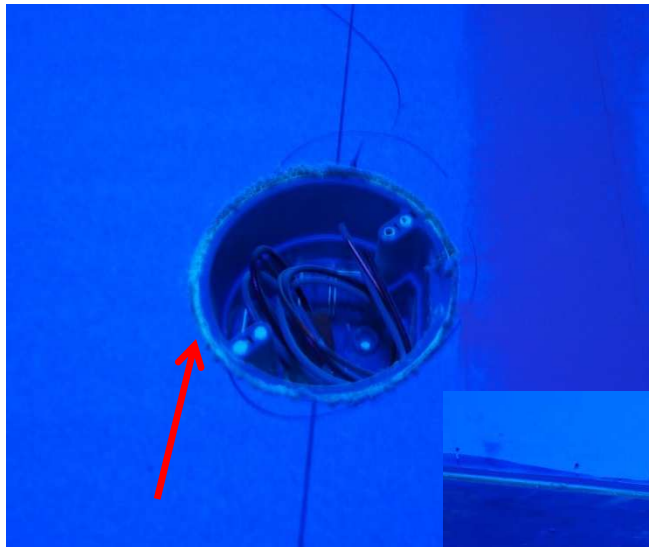




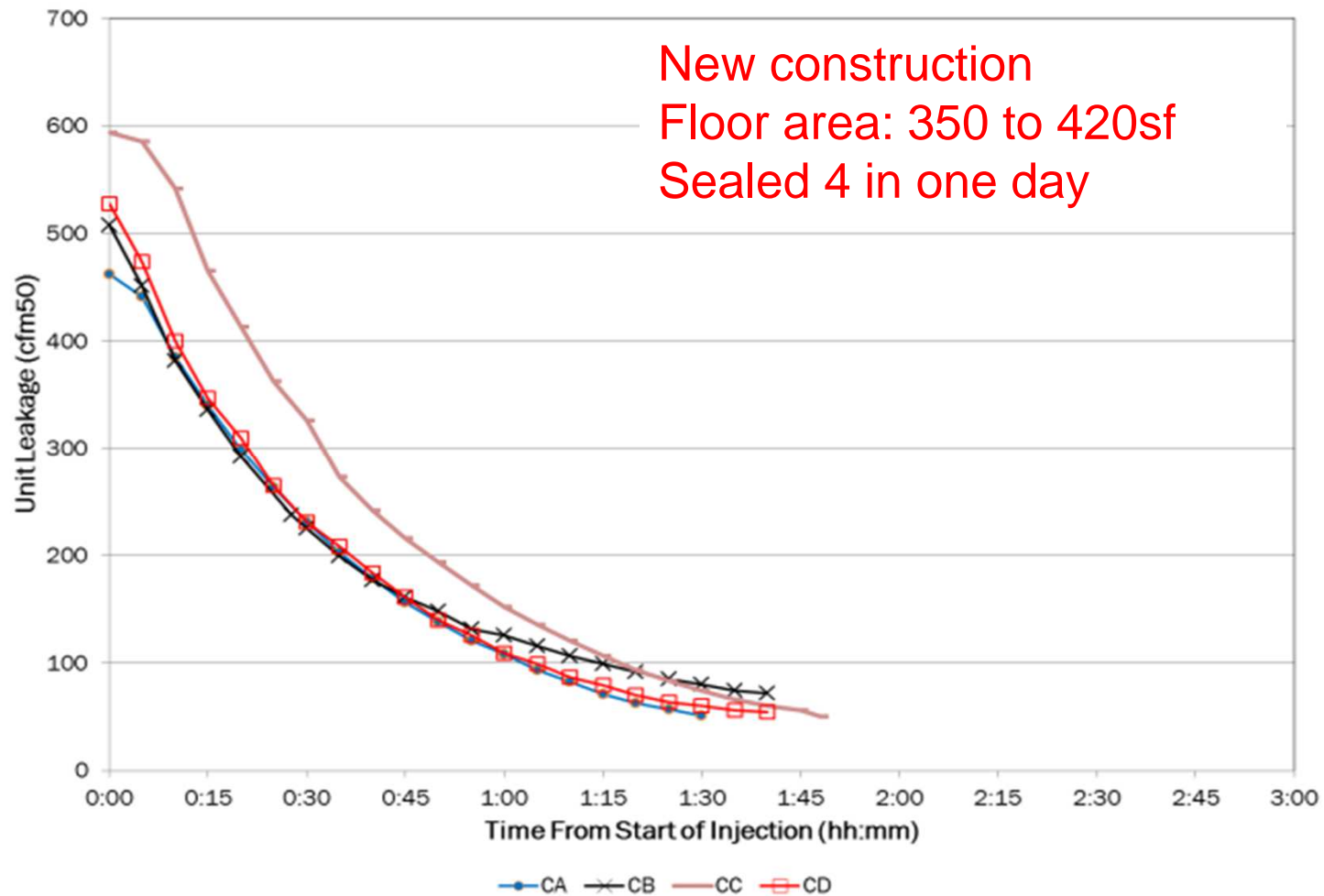
## Sealed Penetrations



## Sealed penetrations- black light photos

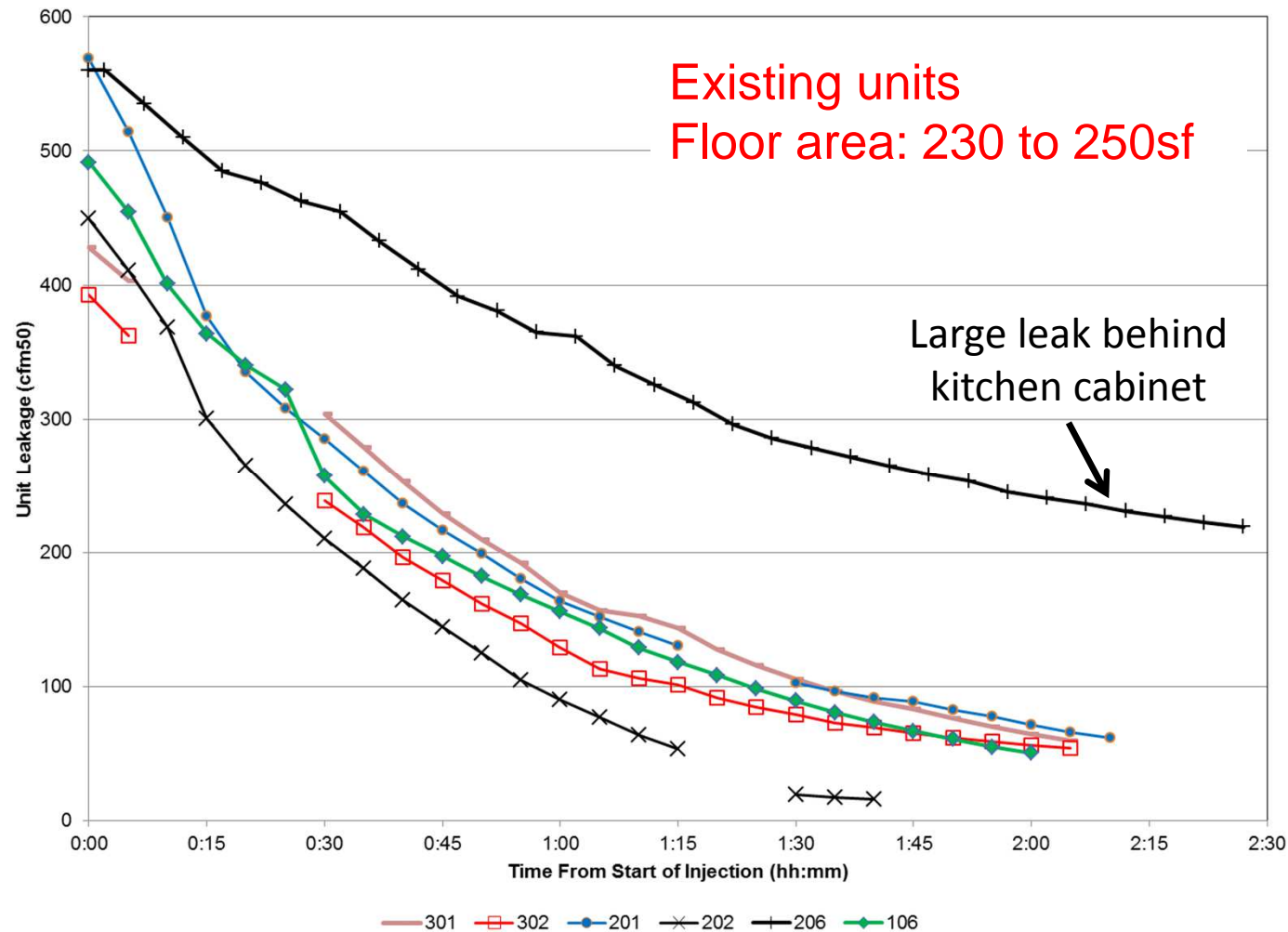


# Leakage Reduced Over Injection Period



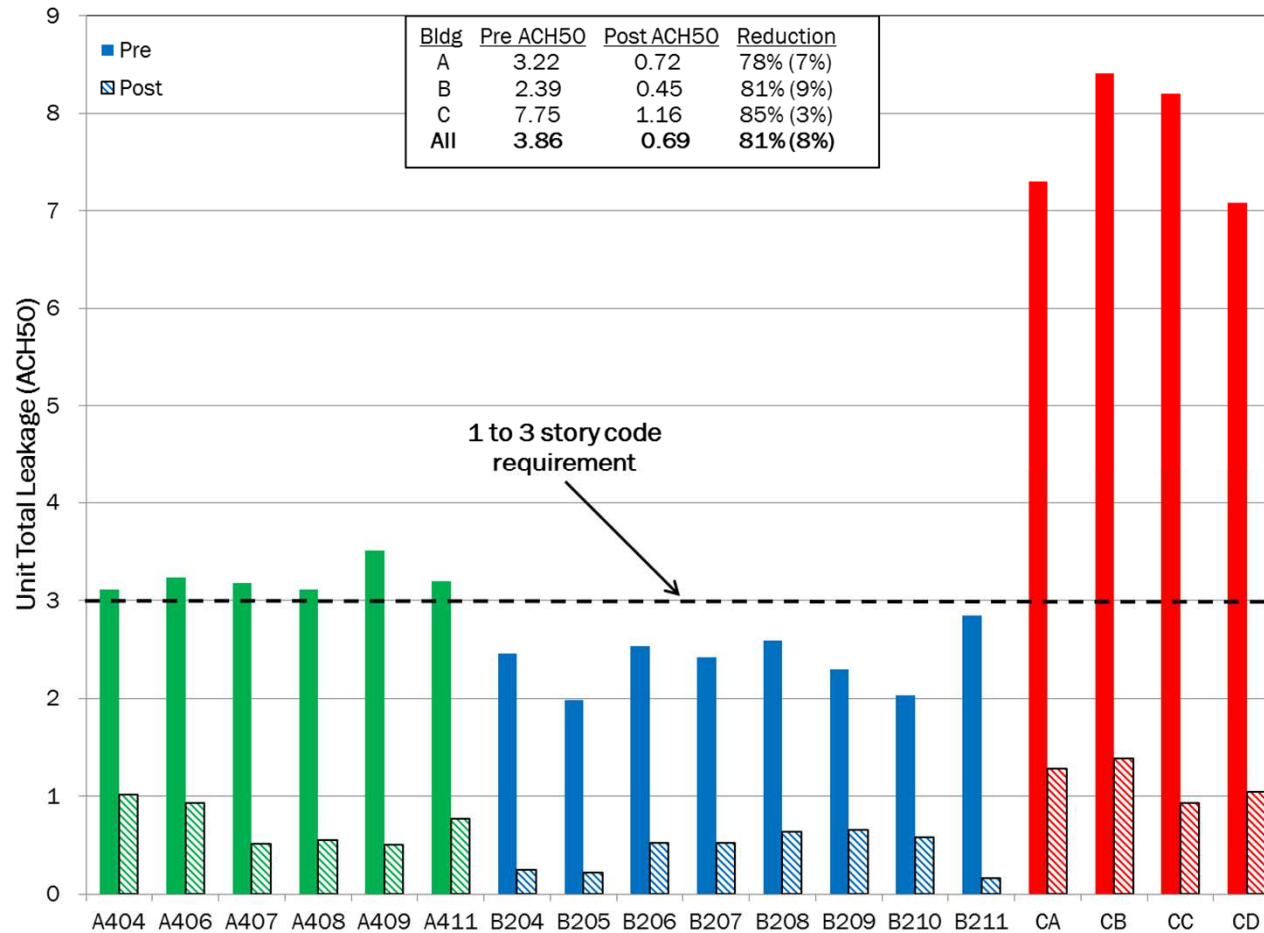
Pre: 7.1 – 8.4 ACH50, Post: 0.9 – 1.4 ACH50  
82% to 89% reduction

# Leakage Reduced Over Injection Period



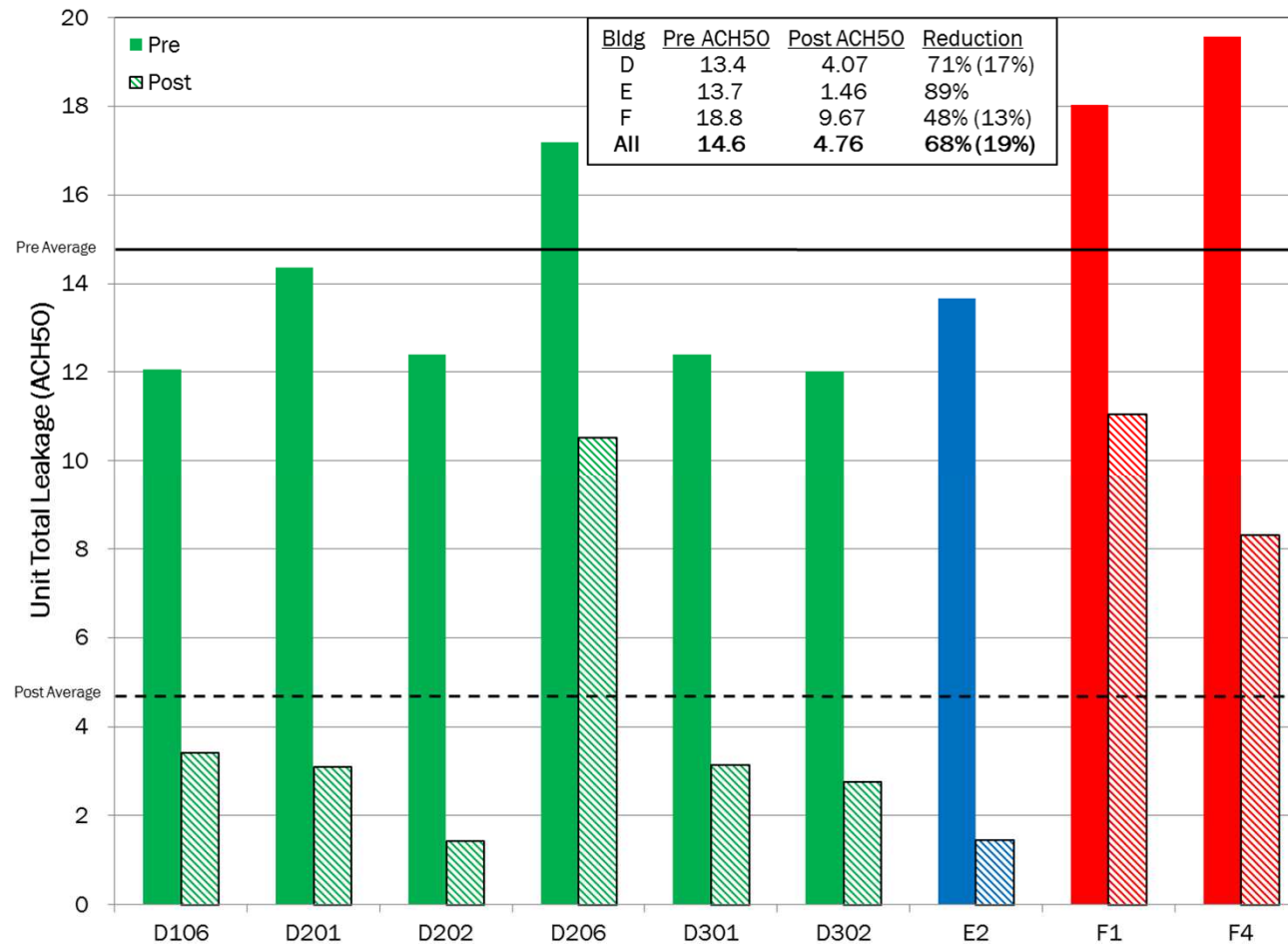
Pre: 12.0 – 17.2 ACH50, Post: 1.4 – 10.5 ACH50  
39% to 88% reduction

## Leakage Results: 18 New Construction Units



Average leakage: pre= 3.9 ACH50, post= 0.7 ACH50  
 54% to 95% below code requirement, average= 77%

## Leakage Results: 9 Existing Units



Average leakage: pre= 14.6 ACH50, post= 4.8 ACH50  
 6 of 9 within 15% of new construction code requirement



# Modeling Ventilation in Multifamily Buildings

*2016 ACEEE Summer Study*

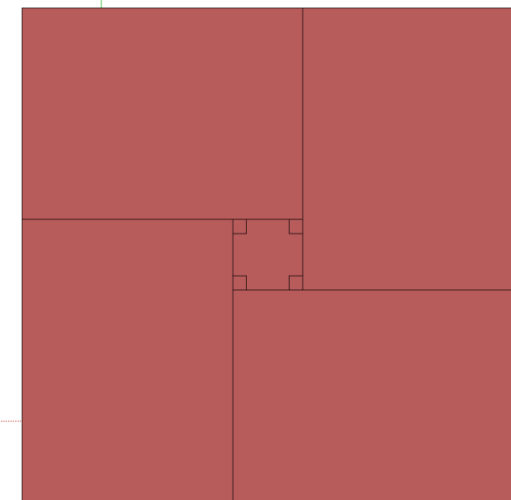
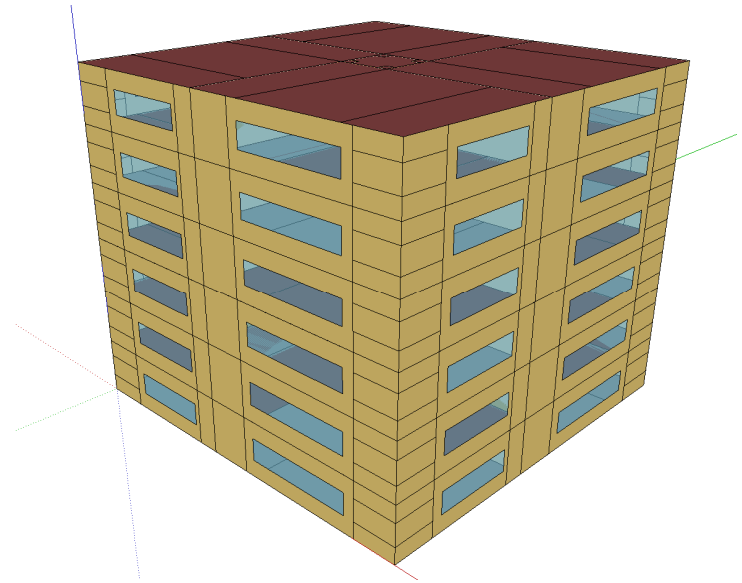
Curtis Harrington  
UC Davis, Western Cooling Efficiency Center

# Model

- **EnergyPlus**
- **Ventilation model:** Airflow network
  - Calculates inter-zone flows
  - Accounts for wind and stack effects
- **HVAC Equipment:**
  - Based on MN multifamily building stock
    - Heating provided by baseboard radiant heaters
    - Cooling provided by window air conditioners

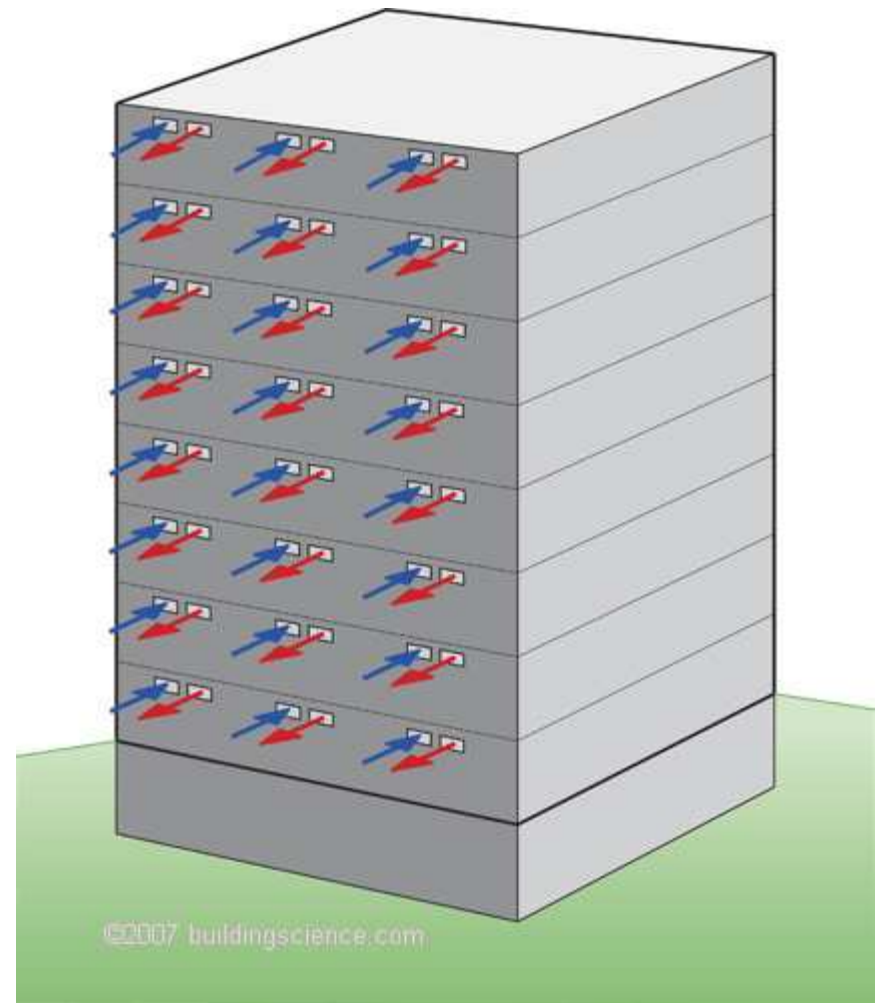
# Model - Construction

- 6-Story building model
- Floor plan:
  - 4 Units per floor
  - 1 Elevator shaft
- Construction:
  - DOE reference model construction
  - Window to wall ratio: 20%



# Model – Ventilation Method

- Four ventilation strategies investigated
  - Exhaust only
  - Exhaust with some supply
  - Balanced
  - No ventilation
- Individual unit exhaust fans and balanced ventilators



# Model – Leakage

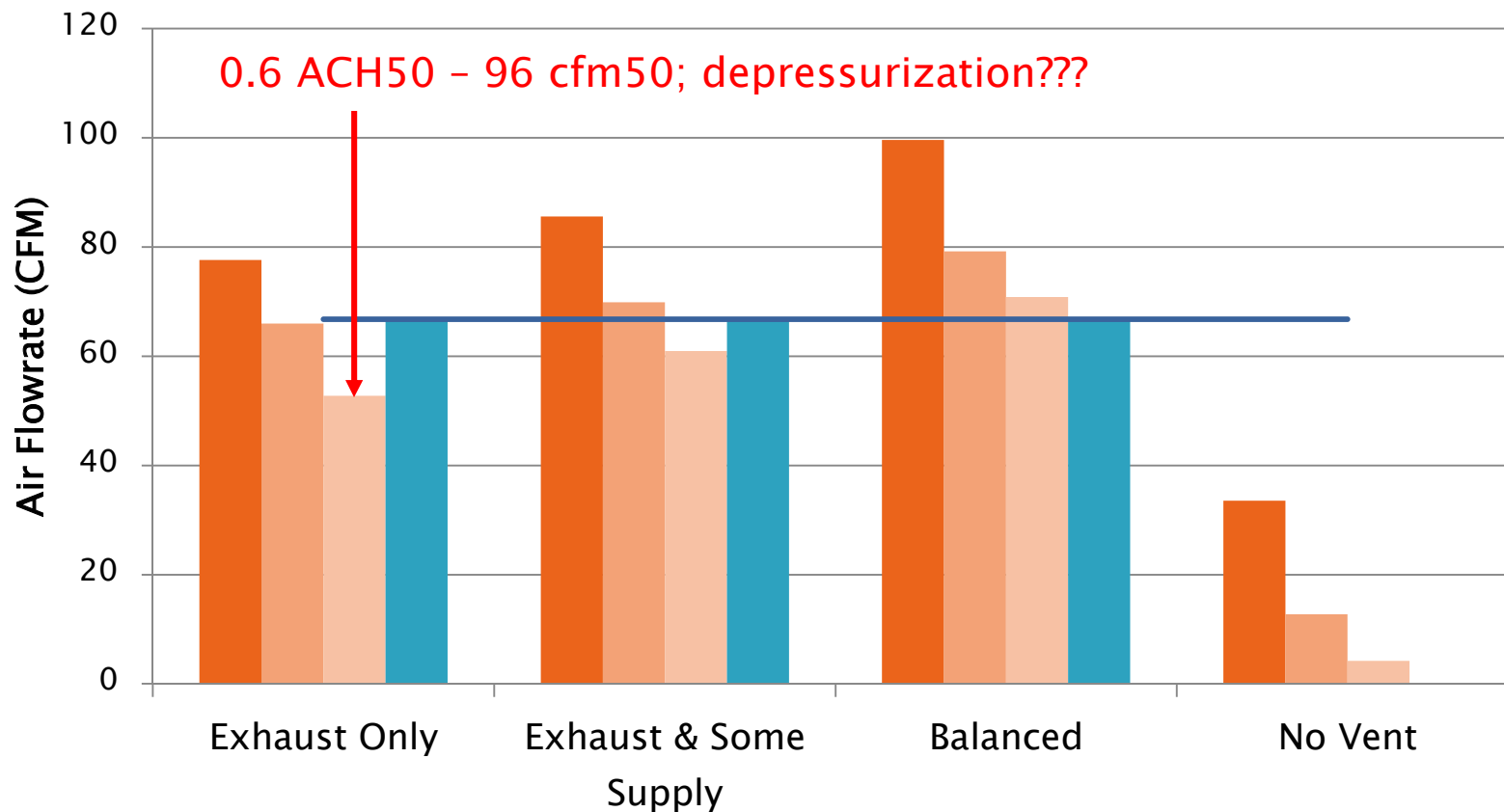
## Envelope leaks:

- Existing Building
  - Leaky: 9.5 ACH50 (existing data)
  - Sealed: 3 ACH50 (MN code?)
- New Building
  - Compliant: 3 ACH50 (MN code?)
  - Tight: 0.6 ACH50 (Passive House)

| ACH50 | Exterior | Interior | Floor/Ceiling | Door |
|-------|----------|----------|---------------|------|
| 9.5   | 43%      | 34%      | 13%           | 9%   |
| 3     | 47%      | 18%      | 5%            | 29%  |
| 0.6   | 47%      | 18%      | 5%            | 29%  |

Table 1: Leakage distribution used in models

# Results – Ventilation Flows



Annual building average fresh airflow per unit

9.5 ACH50

3 ACH50

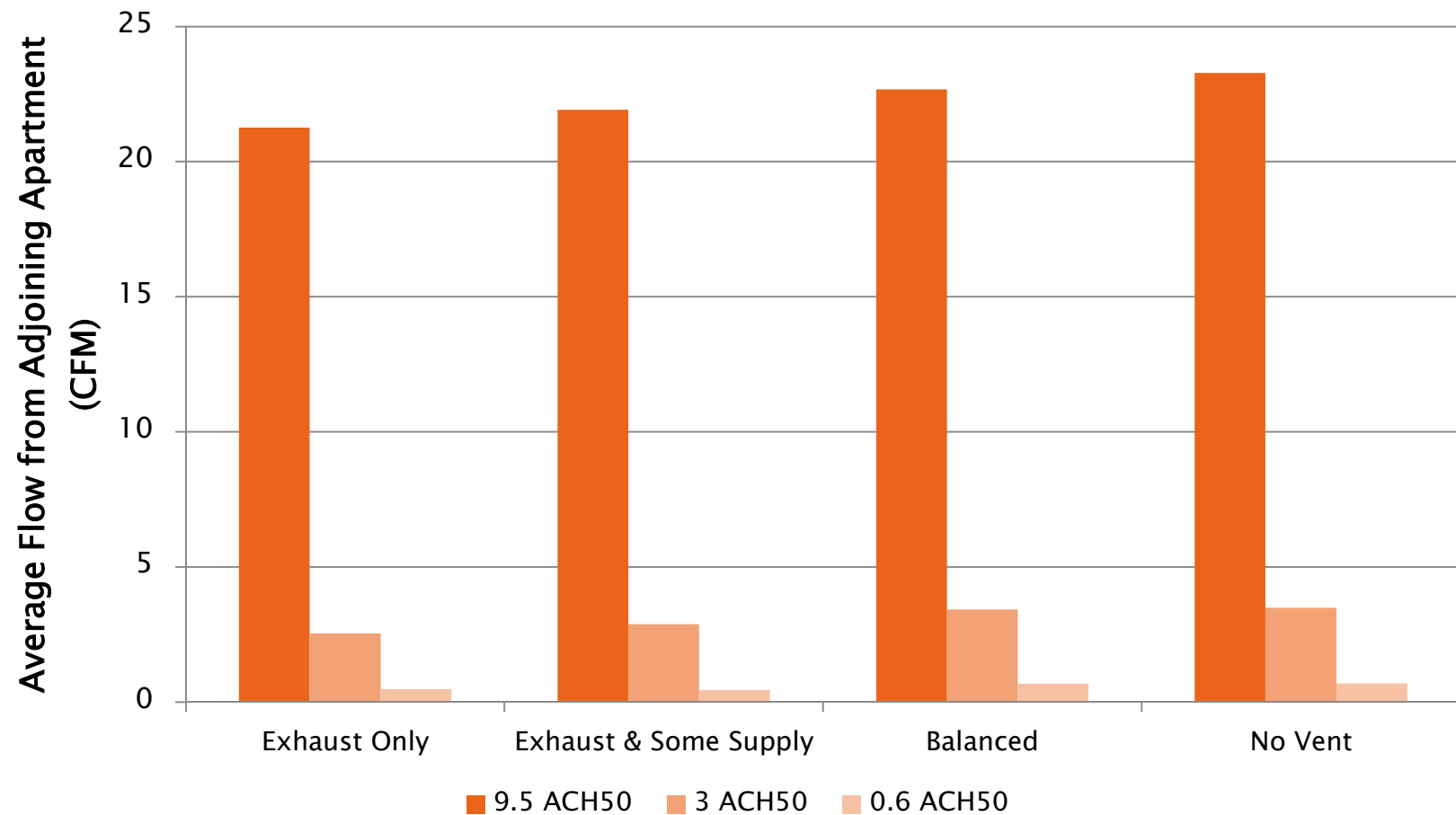
0.6 ACH50

Vent Fan Flow

MN Code Req't



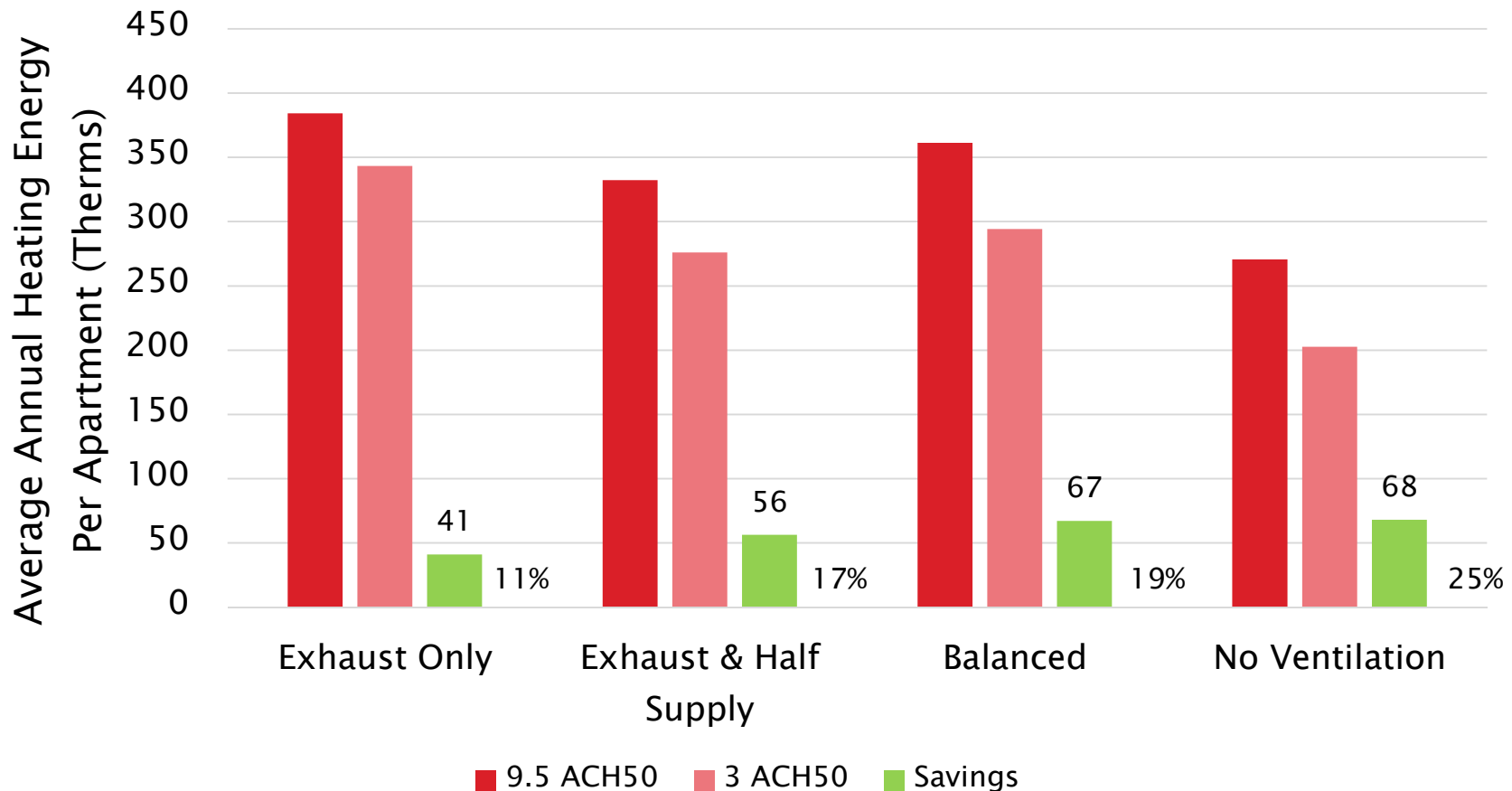
# Results – Interior Flows



# Results - Annual HVAC Energy Use (New Buildings)



# Results - Annual HVAC Energy Use (Existing Buildings)



# Results – Summary Table

- Impact of sealing air leaks in apartment buildings in Minneapolis

| Energy End Use         | New Buildings | Existing Buildings |
|------------------------|---------------|--------------------|
| Heating Savings        | 4–18%         | 11–25%             |
| Cooling Savings        | -4–1%         | -7–-1%             |
| Transfer Air Reduction | 81%           | 86%                |

# Conclusions

- When aerosol sealing can be applied
  - New construction
  - Rehab
  - Change in occupancy (higher cost)
- New construction
  - 81% reduction & 77% below code
  - Heating savings ~ 27 therms/yr
  - 81% reduction in flow from adjacent units
- Existing units
  - 68% reduction & 6 of 9 within 15% new code
  - Heating savings ~ 67 therms/yr
  - 86% reduction in flow from adjacent units
- Balanced ventilation is crucial for new construction, exhaust or supply OK for existing

# Future Work

## Large Building Sealing with Department of Defense

- Sealing existing commercial buildings on military bases
- Lab testing of seal strength and durability
- Modeling energy savings due to large-building sealing

## Building America

- Integrate sealing process into construction schedule
- Work with developers in CA and MN
- Test multiple options



# Questions?