# Is It All Hot Air: Ventilating Homes, Why? How Much? How?


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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

# Learning Objectives

1. Understand health benefits of ventilation, and describe health benefits of ASHRAE 62.2-2010 vs. the older 62-1989

2. Understand three core single family home ventilation system approaches (exhaust only, supply only, balanced)

3. Describe pros and cons of various ventilation approaches

4. Describe energy consequences of alternative ventilation strategies

# Health and Environmental Aspects Linked to Home Ventilation (HEALTH-V Study)

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The Health-V Study received UIC Internal Review Board approval for research involving human subjects, including written participant consent, protocol #2011-0813 “Health and Environmental Aspects Linked to Home Ventilation (HEALTH-V)”

# Purpose of study

WHO concluded there is insufficient evidence on ventilation and health outcomes

Look at impacts on health & IAQ associated w/ ASHRAE 62.2-2010 relative to ASHRAE 62-1989 for weatherization in low-income housing.

# Two protocols

ASHRAE 62-1989: 15 cfm fresh air/ occupant;

"Building Tightness Limit" (BTL) for infiltration derived from blower door test at 50 Pa depressurization.

If infiltration is enough, no mechanical or additional ventilation needed. In practice, many agencies use(d) BTL as air seal limit guide to avoid mechanical ventilation.

ASHRAE 62.2-2010:

Target is 7.5 cfm fresh air/ occupant **plus** 1 cfm/ 100 $ft^2$ floor area.

Usually mechanical ventilation needed. Effective "BTL" much leakier than with 62-1989.

# Purpose of study

Test two hypotheses:

1) Using a ventilation protocol in weatherization improves health & indoor environment conditions; and

2) Adopting ASHRAE 62.2-2010 results in significant health & indoor environment improvements compared with ASHRAE 62-1989.

# Methods & materials

- Participants recruited through low-income home weatherization programs in Illinois and Indiana, approximately 84 homes total (n=84).
- Environmental samples collected for 1-week (range 4-7 days) intervals before and after weatherization.
- Health interviews collected at baseline & approximately 6 months after weatherization

# Methods & materials

- 1-week interval air sample tests, pre- & post weatherization:
  - Passive air samples for
    - formaldehyde
    - total volatile organics (TVOCs)
    - Radon in both 1st flr LR & basement
  - Passive time-series loggers
    - Carbon monoxide
    - Carbon dioxide
    - Moisture


Collar Clip
DNPH-treated tape (contained behind diffusion barrier)
Diffusion barrier exposed
Sample blank/correction (contained in separate compartment in housing)
Sliding cover in open or sampling position


Collar clip
Desorption solvent chamber
Screen
Sorbent
Filling ports
Cover
Diffusion barrier


TELAIRE


EL-USB-CO

# Leakiness (cfm50)

| | **Pre-Wx** | **Post-Wx** |
|---|---|---|
| ASHRAE 62-1989 | 3,009 | 2,153 |
| ASHRAE 62.2-2010 | 3,021 | 2,141 |

# House ventilation

- No homes hade automated mechanical ventilation pre-Wx
- No 62-1989 homes received mechanical ventilation
- All 62.2-2010 homes received mechanical ventilation, average 60 cfm – ALL EXHAUST

# Results

## Formaldehyde

| Formaldehyde | Number (n) | Mean (ppb) | Geo-mean (ppb) | T-test p-value |
|---|---|---|---|---|
| **Pre-Wx all** | 71 | 31 | 28 | **0.002** |
| **Post-Wx all** | | 25 | 23 | |
| **Pre-Wx 62-1989** | 30 | 34 | 31 | **0.019** |
| **Post-Wx 62-1989** | | 27 | 25 | |
| **Pre-Wx 62.2-2010** | 41 | 29 | 26 | **0.041** |
| **Post-Wx 62.2-2010** | | 24 | 21 | |

Yellow indicates statistical significance

# Results

## TVOC

| TVOC | Number (n) | Mean (ppb) | Geo-mean (ppb) | T-test p-value |
|---|---|---|---|---|
| **Pre-Wx all** | 68 | 290 | 163 | **0.180** |
| **Post-Wx all** | | 203 | 134 | |
| **Pre-Wx 62-1989** | 31 | 242 | 124 | **0.989** |
| **Post-Wx 62-1989** | | 200 | 124 | |
| **Pre-Wx 62.2-2010** | 37 | 330 | 204 | **0.041** |
| **Post-Wx 62.2-2010** | | 205 | 142 | |

Yellow indicates statistical significance

# Results

## Radon, 1st floor

| Radon | Number (n) | Mean (pCi/l) | Geo-mean (pCi/l) | T-test p-value |
|---|---|---|---|---|
| **Pre-Wx all** | 46 | 2.7 | 1.8 | **0.143** |
| **Post-Wx all** | | 2.6 | 1.4 | |
| **Pre-Wx 62-1989** | 21 | 2.4 | 1.7 | **0.824** |
| **Post-Wx 62-1989** | | 2.8 | 1.6 | |
| **Pre-Wx 62.2-2010** | 25 | 3.0 | 1.9 | **0.067** |
| **Post-Wx 62.2-2010** | | 2.4 | 1.3 | |

Green indicates statistical significance at $p < 0.10$

# Preliminary results

## Radon, basement

| TVOC | Number (n) | Mean (pCi/l) | Geo-mean (pCi/l) | T-test p-value |
|---|---|---|---|---|
| **Pre-Wx all** | 51 | 5.1 | 2.6 | **0.330** |
| **Post-Wx all** | | 6.0 | 3.0 | |
| **Pre-Wx 62-1989** | 23 | 6.3 | 3.0 | **0.888** |
| **Post-Wx 62-1989** | | 6.7 | 2.9 | |
| **Pre-Wx 62.2-2010** | 28 | 4.2 | 2.4 | **0.073** |
| **Post-Wx 62.2-2010** | | 5.4 | 3.1 | |

Green indicates statistical significance at $p < 0.10$

# Results

## Carbon dioxide ($CO_2$)

| TVOC | Number (n) | Mean (ppm) | Geo-mean (ppm) | T-test p-value |
|---|---|---|---|---|
| **Pre-Wx all** | 66 | 985 | 914 | **0.005** |
| **Post-Wx all** | | 839 | 797 | |
| **Pre-Wx 62-1989** | 29 | 970 | 888 | **0.266** |
| **Post-Wx 62-1989** | | 849 | 810 | |
| **Pre-Wx 62.2-2010** | 37 | 996 | 936 | **0.004** |
| **Post-Wx 62.2-2010** | | 830 | 787 | |

Yellow indicates statistical significance

# Health Outcomes

- Children experienced fewer headaches
  - Statistically-significantly fewer in 62.2-2010 homes
- Fewer respiratory ailments in children, not statistically significant
- Reductions in eczema and skin allergies in children in both groups, difference between groups not statistically significant

# Health Outcomes

- Adults had less psychological distress
  - Difference between groups not statistically significant
- Statistically-significant improvement in reported overweight adults in 62.2-2010 homes relative to 62-1989 homes

# Conclusions

- 62.2-2010 homes had statistically-significant reductions of formaldehyde, TVOCs, and carbon dioxide ($p < 0.05$)
- 62.2-2010 homes had near-statistically-significant increases of basement radon and decreased of first floor radon ($p < 0.1$)
- 62-1989 had nothing statistically-significant except for formaldehyde reductions

# Conclusions

- No contaminants showed statistically-significant contaminant differences between groups
- Except for basement radon, 62.2-2010 homes showed greater reductions that 62-1989 for all contaminants
- Lack of statistical significance MAY be real, or may be insufficient sample size

# Conclusions

- Few health changes were statistically significant, some indication of greater improvement with 62.2-2010 relative to 62-1989

# Selecting Ventilation Systems for Homes

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# Types of Mech. Ventilation

Local Exhaust:

# Whole-Building Ventilation

"Whole-building ventilation is intended to dilute the unavoidable contaminant emissions from people, from materials, and from background processes."

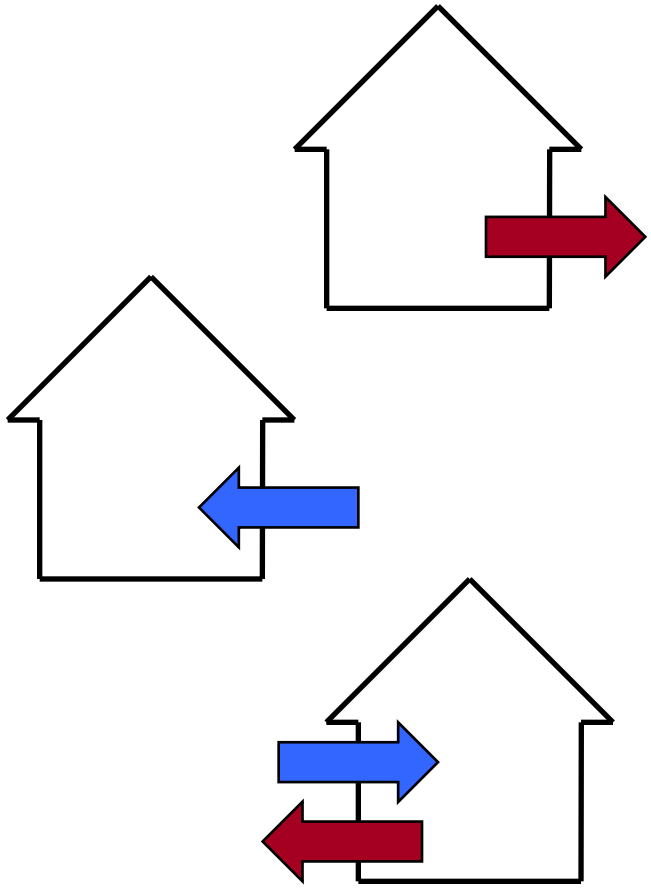
(ASHRAE 62.2-2013)

Contaminants don't just come from bathrooms and kitchens.

# Whole-House Ventilation

Three main types

- Exhaust only
- Supply only
- Balanced



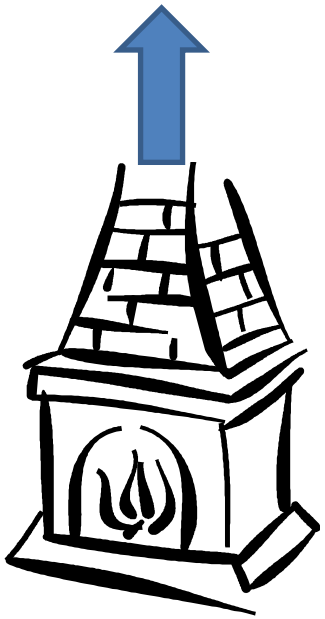
# Exhaust Only Ventilation

Efficient bath exhaust fan(s) running continuously or on timer


Major concern with Exhaust Only:

Where does make-up air come from?

# Potential Make-Up Air Problems



# Exhaust Only Cons

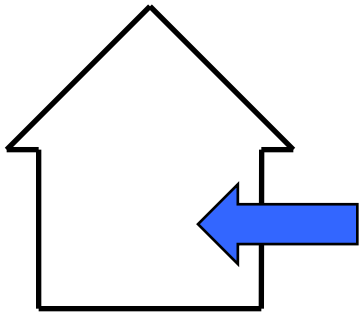
- Source of makeup air
- Lack of distribution/mixing

# Exhaust Only Pro's

- Simple!
- Easy installation
- Low cost
- Low maintenance
- Low power
  - (best fans 6-12 Watts)

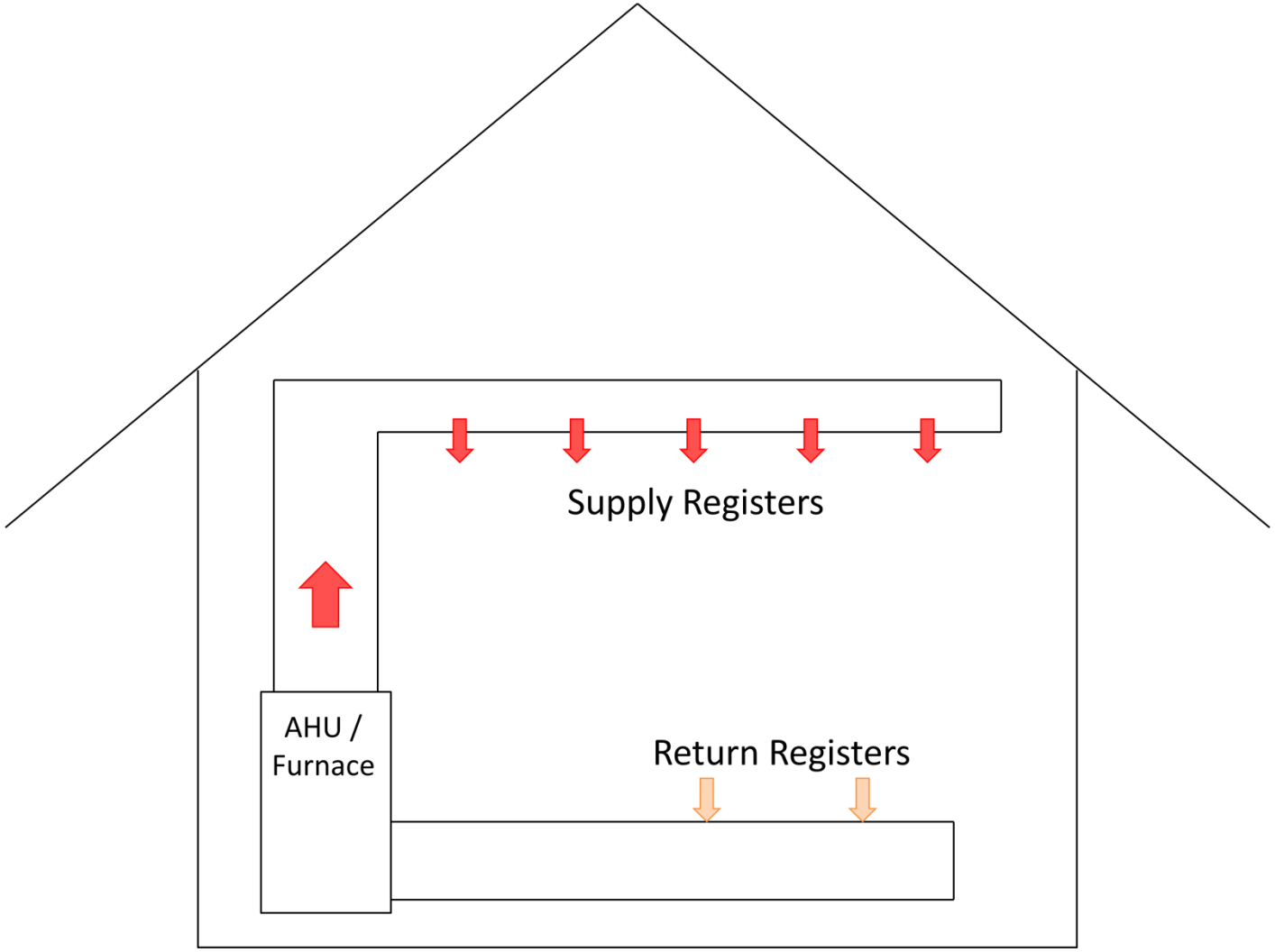
# Supply Only Ventilation

Comfort!

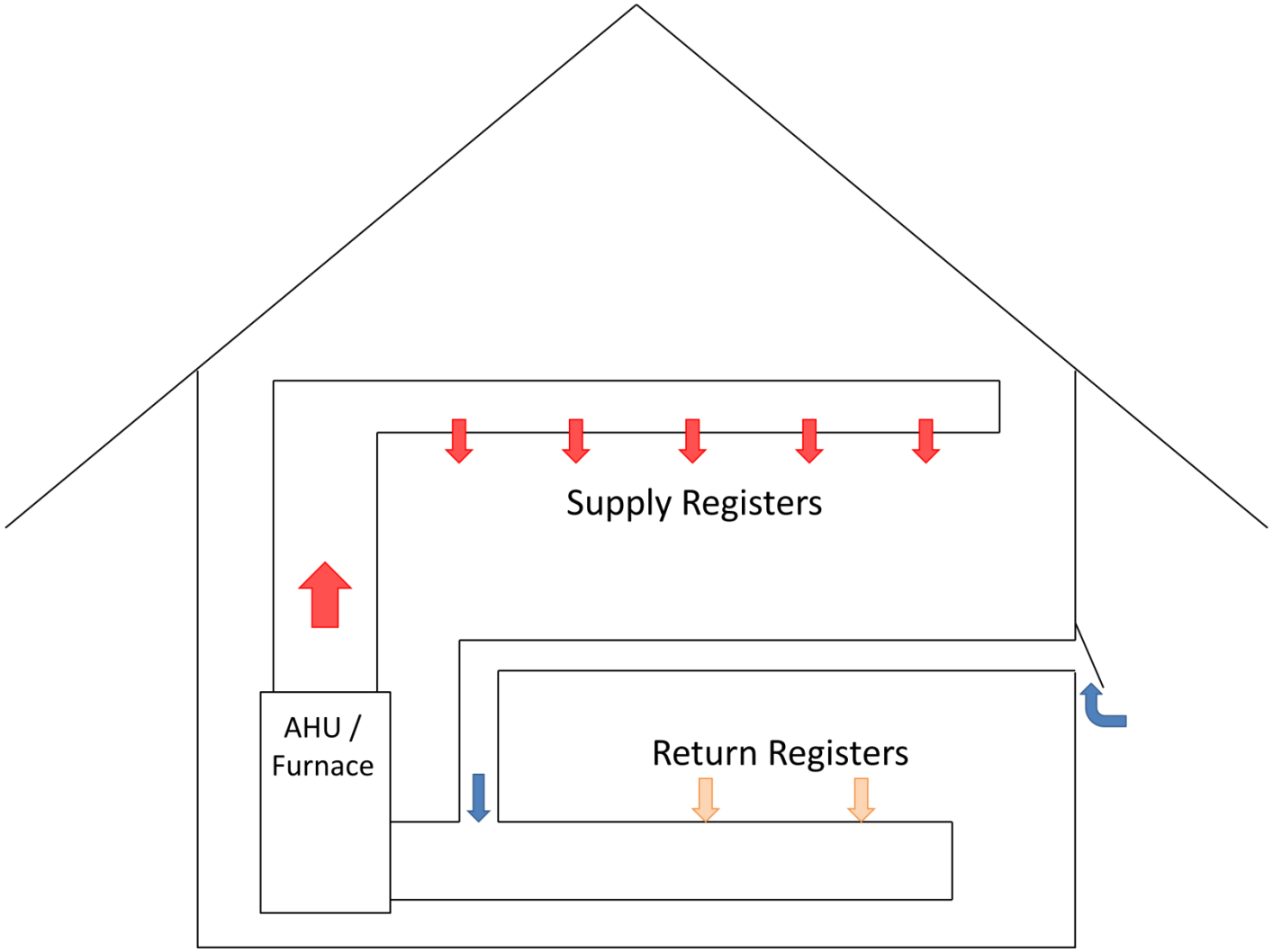


Central Fan Integrated Supply (CFIS) Ventilation

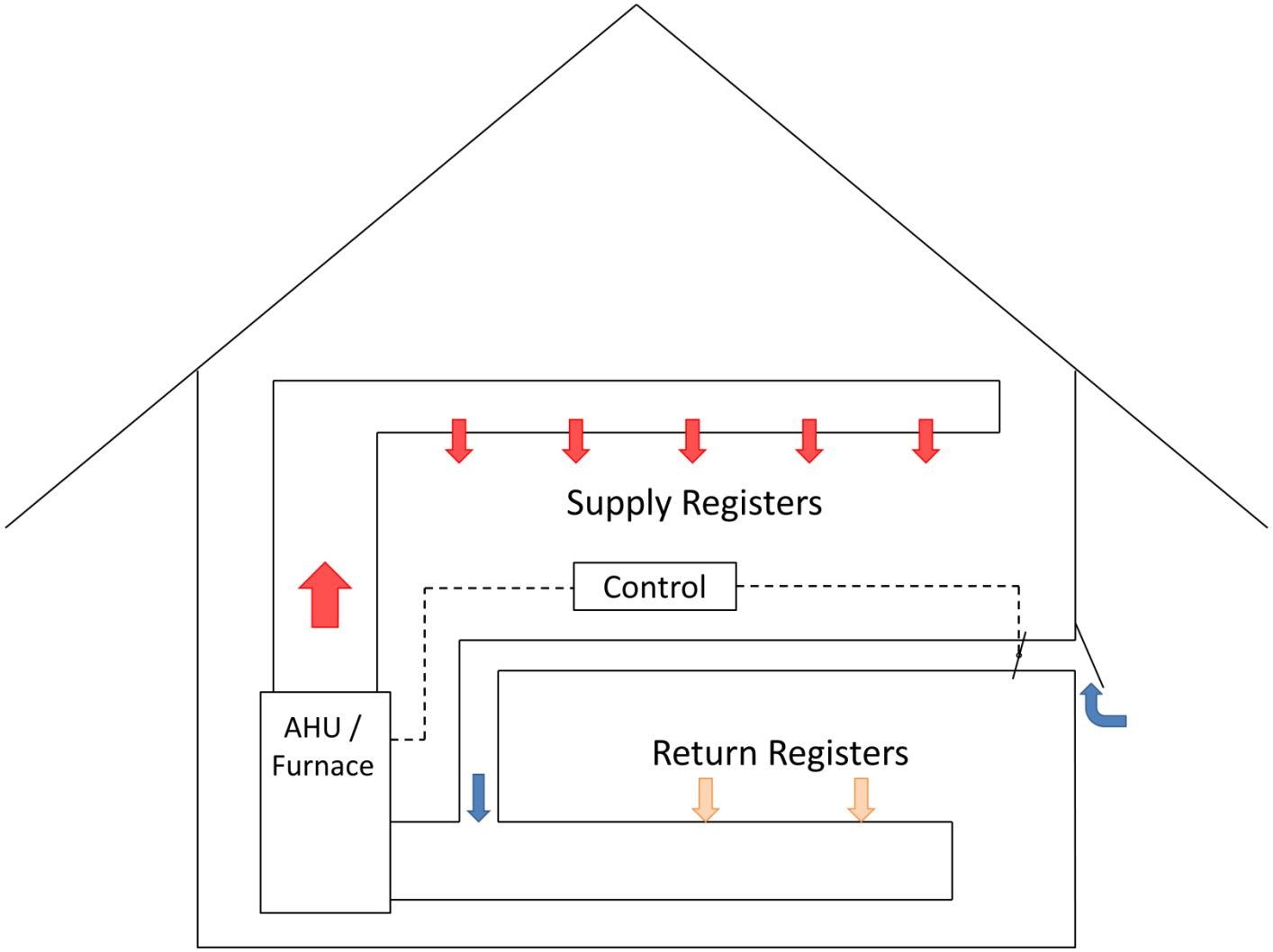
# Supply Only Ventilation



# Supply Only Ventilation



# Supply Only Ventilation



# CFIS

Advantages:

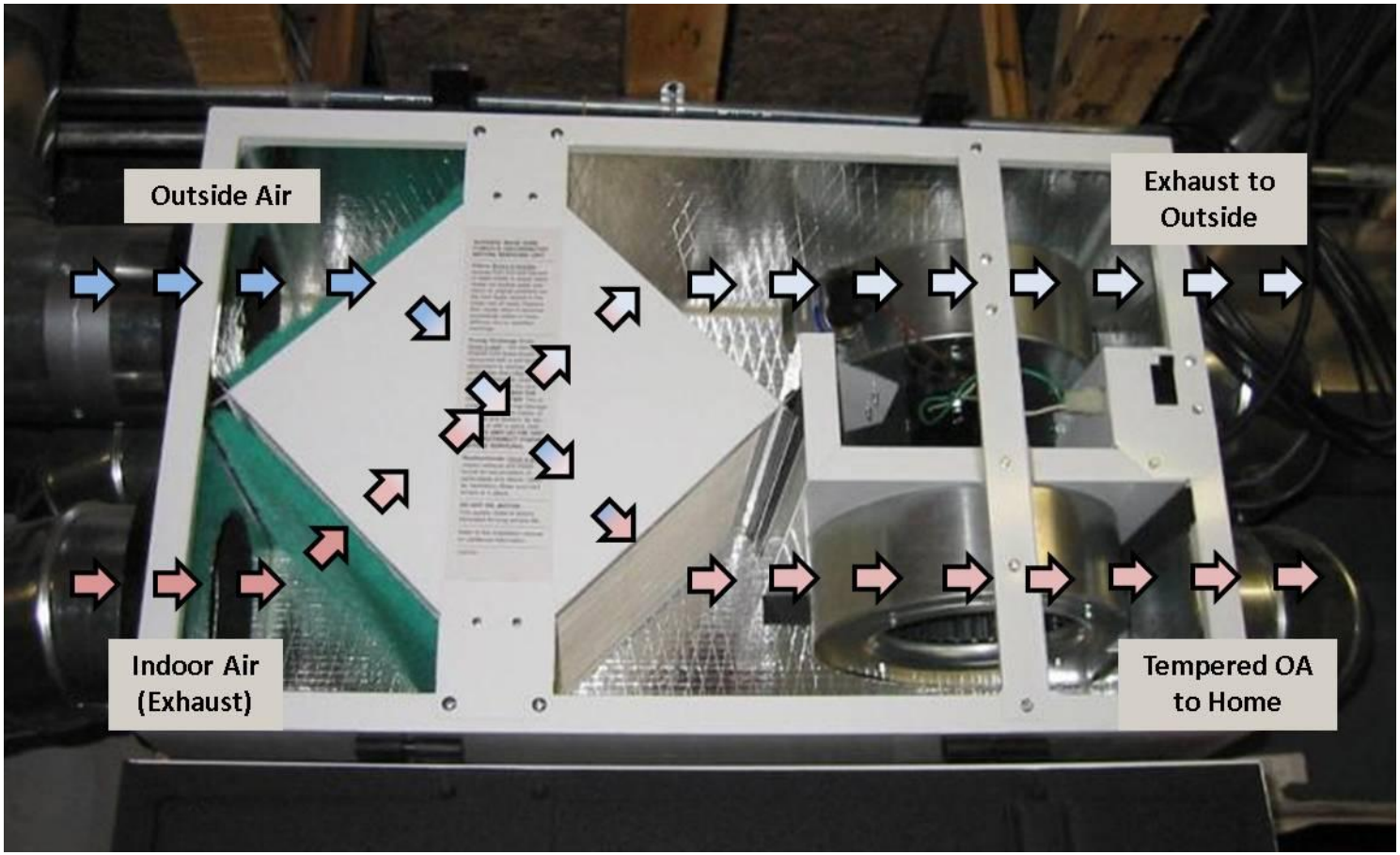
- Good distribution
- Relatively low first cost
- Modest maintenance

Disadvantages:

- Electricity use of AHU (200 – 1100 Watts)
- Duct losses

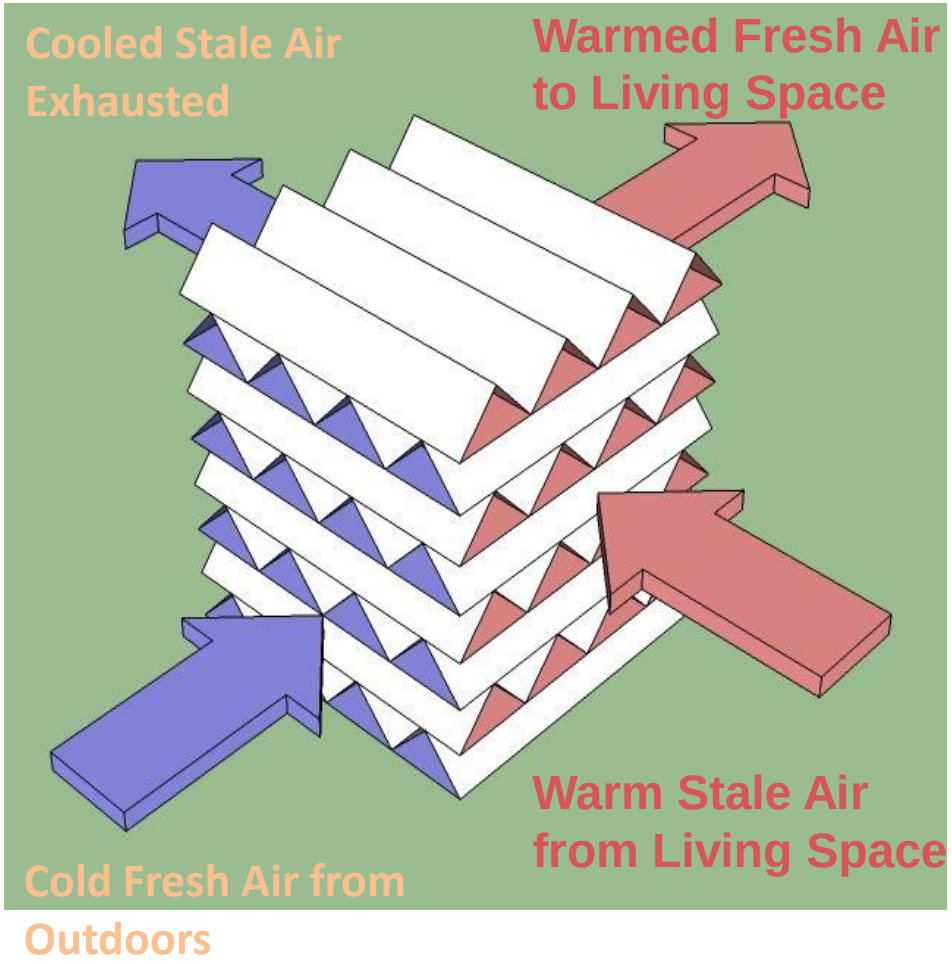
# Balanced Ventilation

## ERV / HRV

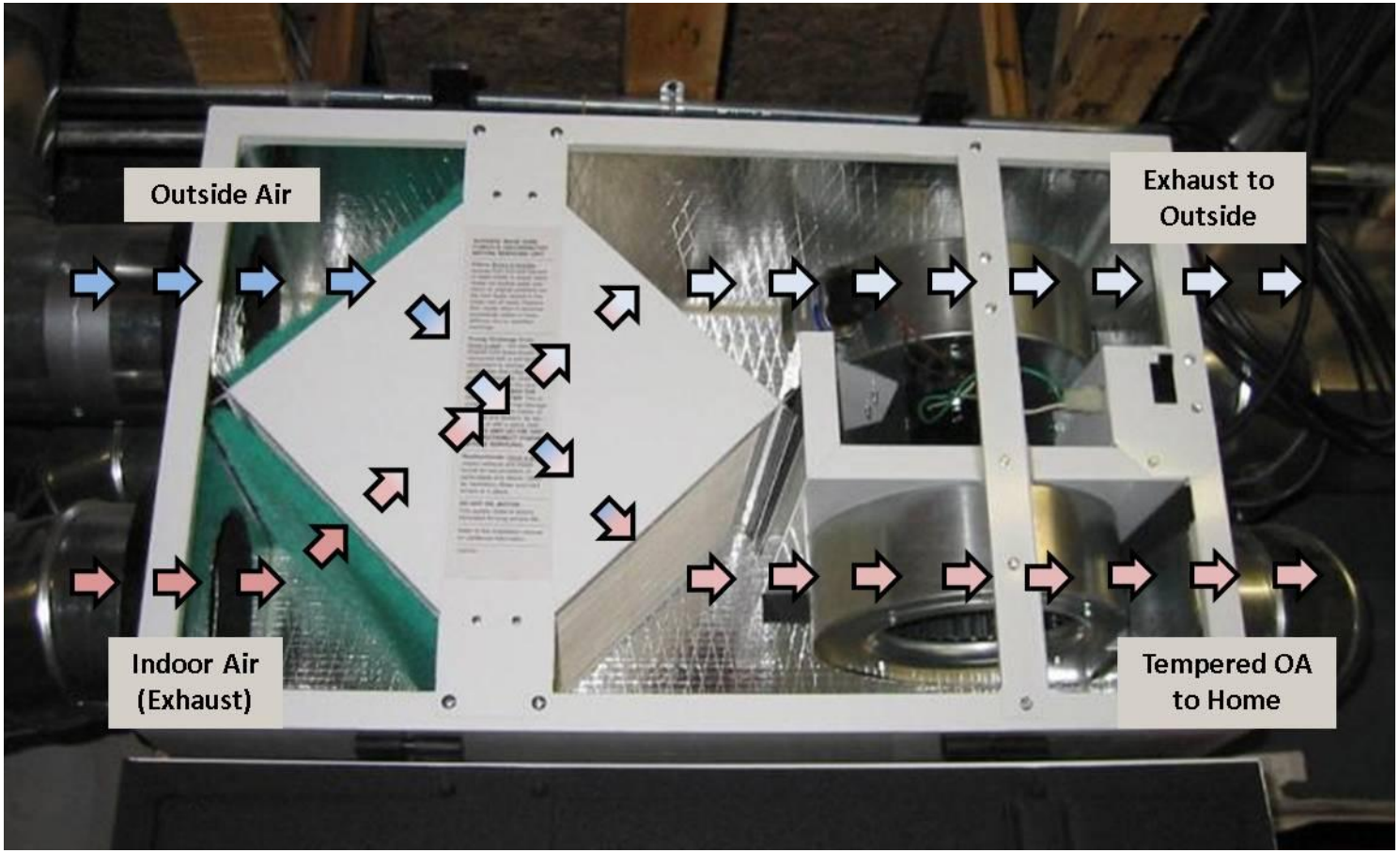


# Two Main Types

## Cross-Flow HX



# Cross-Flow HRV



# ERV Wheels

# ERV / HRV

Heat Recovery Ventilator (HRV)

- Sensible heat only (temperature)

Energy Recovery Ventilator (ERV)

- Sensible heat (temperature)
- Latent heat (humidity)

# HRV vs. ERV

ERVs transfer moisture,

but they are **NOT DEHUMIDIFIERS!**

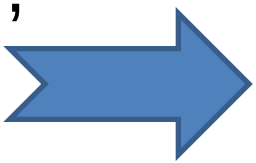
ERV will keep more moisture out

# ERV in Cold Weather

ERV will keep more moisture **IN**

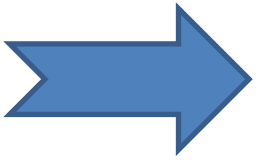
# ERV/HRV in Cold Climates

Large home, low density, not much activity or moisture generation…



ERV ?

Small apartment, high occupancy, lots of activity, moisture…

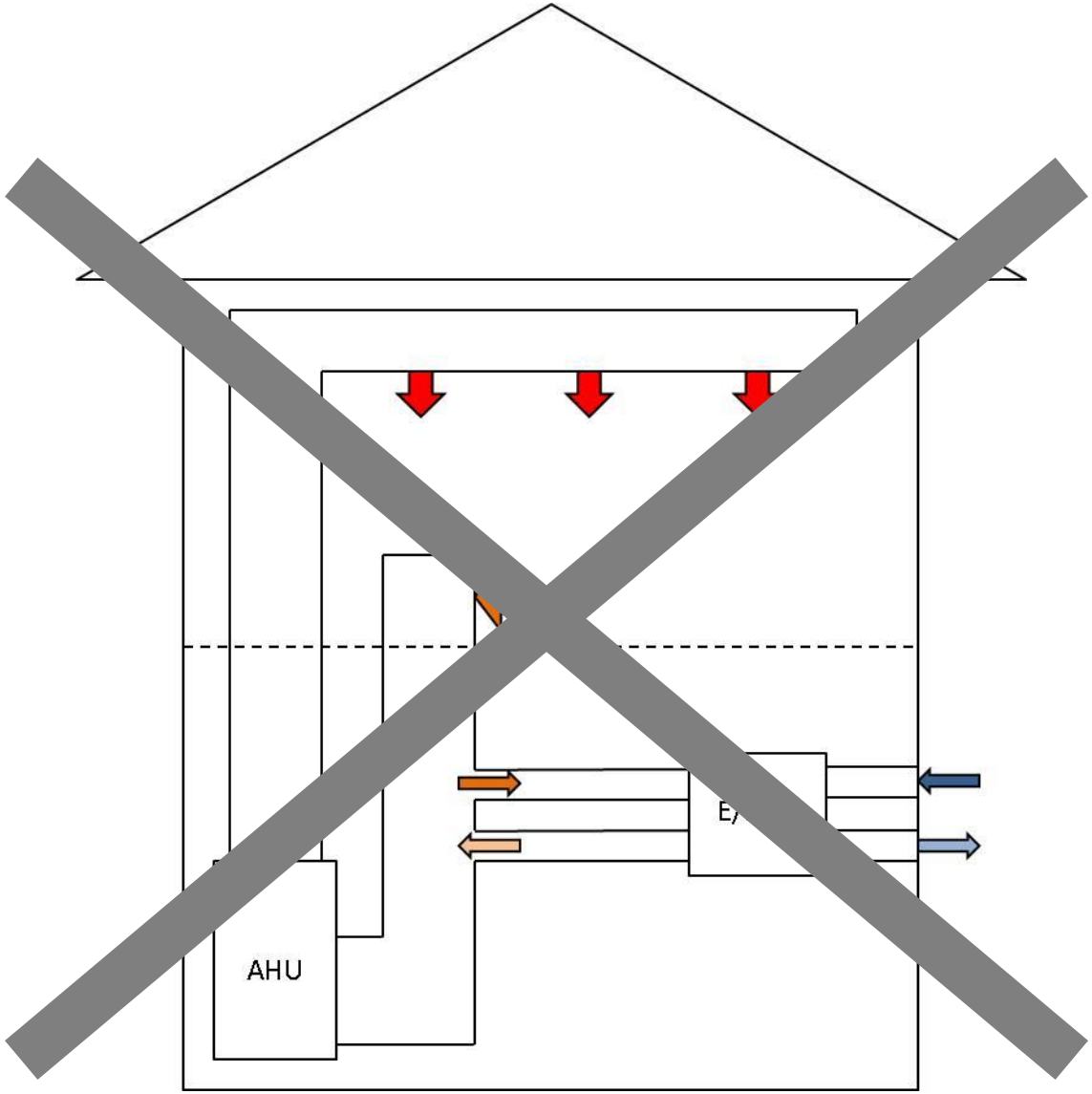


HRV ?

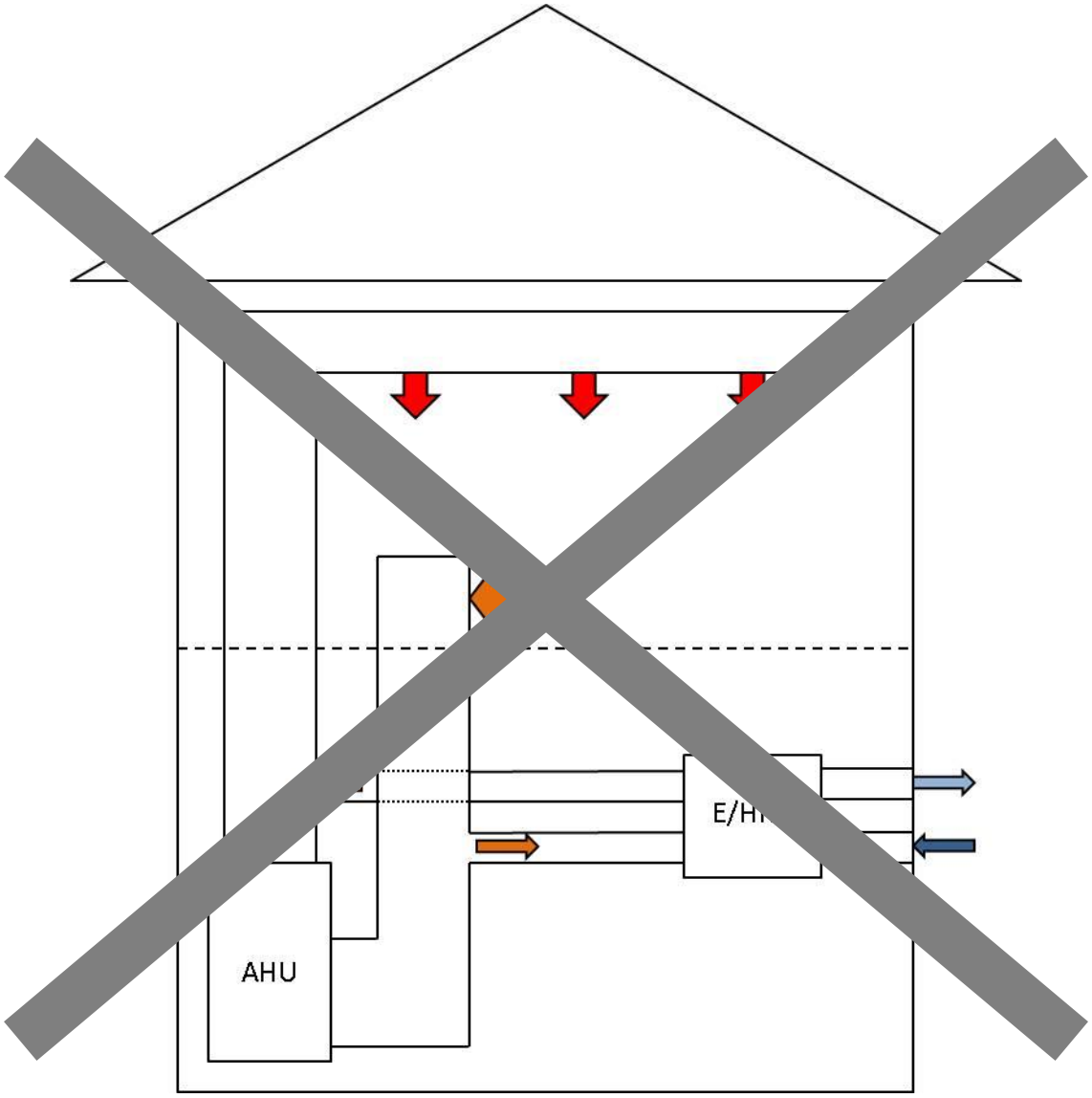
# HRV & ERV Integration

- Exhaust from bathrooms?
- Dedicated duct system?
- Integrate with central duct system?

# E/HRVs with Central AHUs

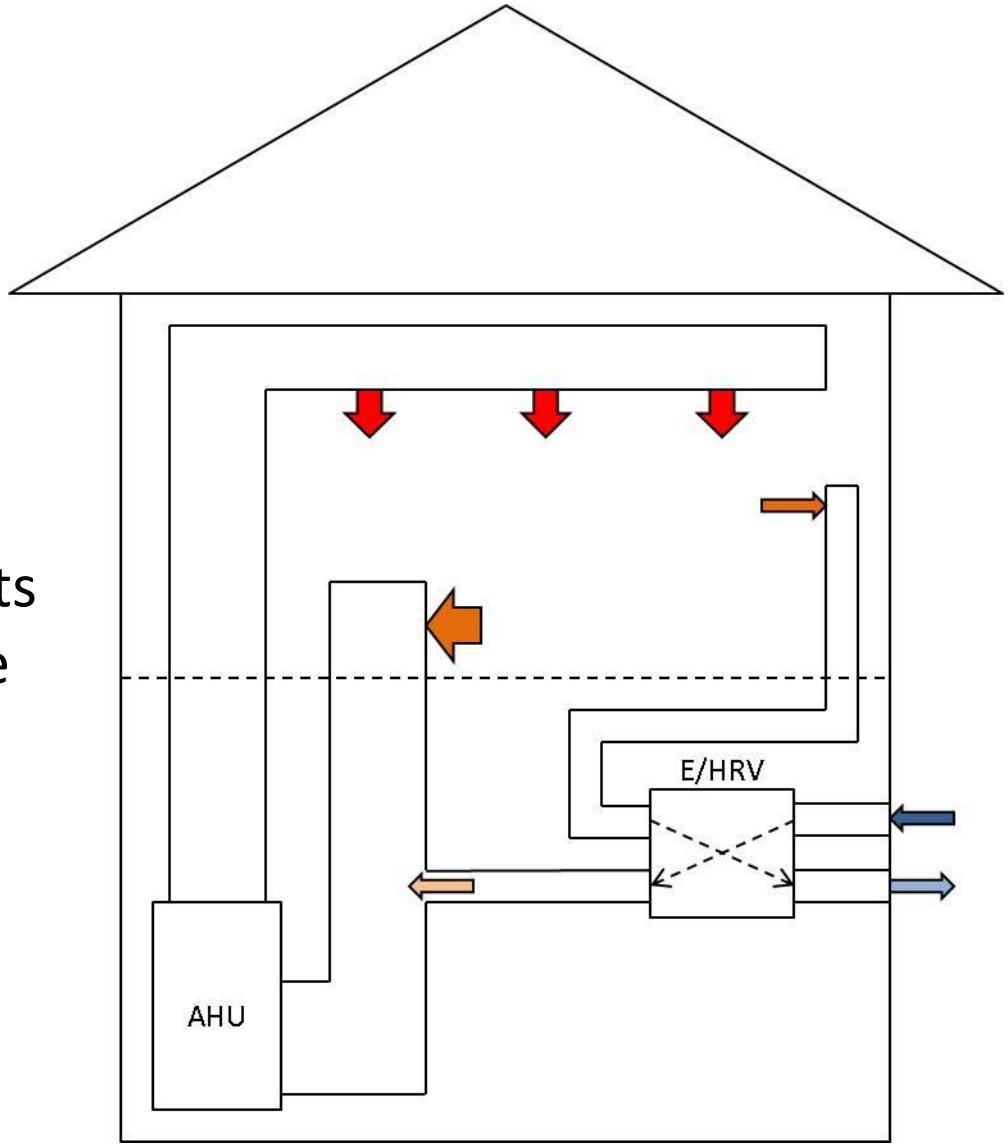


# E/HRVs with central AHUs



# E/HRVs with central AHUs

Dedicated ducts for at least one side (supply or exhaust)



# HRV's & ERV's

Benefits:

- Heat recovery
- Balanced ventilation
- Distributed fresh air (often)
- Known source of outdoor air

Disadvantages:

- First cost
- Maintenance
- Integration issues
- Elec. use (35 – 150 W)

# ERV Maintenance

Monitoring ERVs in new Homes:

- Growing power consumption
- Lower flow rates

Intakes blocked in 6-8 months

Maintenance is key!

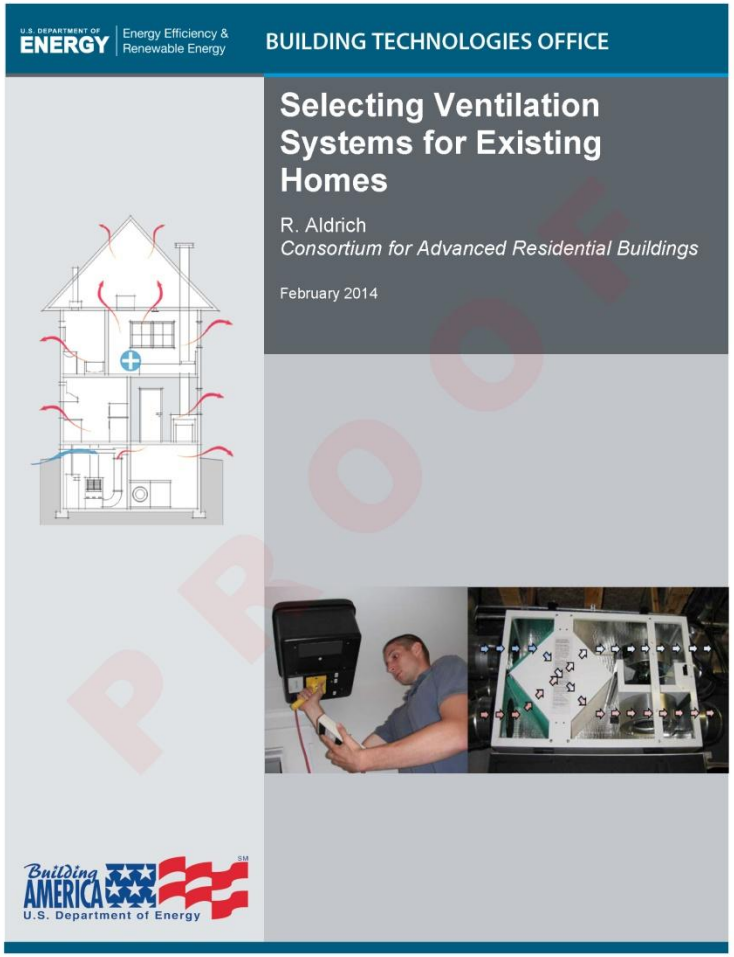
# BA Guidelines

Guidelines:

www.buildingamerica.gov

"Publications"

http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/measure_guide_ventilation_systems.pdf



# Questions?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# Make-Up Air

# Make-Up Air

Problem: Makeup air required for kitchen hoods > 400 CFM

Solution: Do you really need a kitchen hood with flow > 400 CFM?

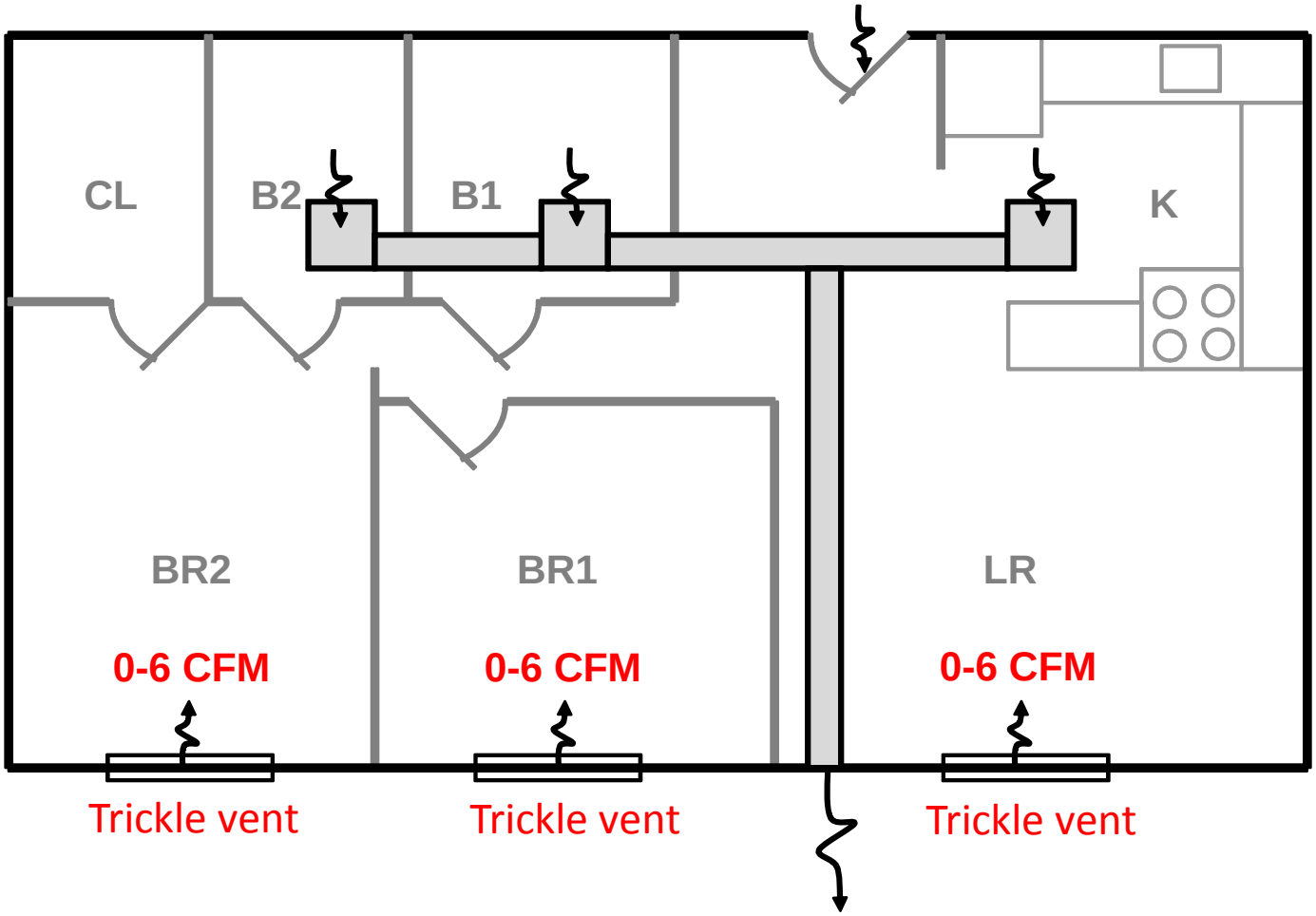
- Motorized damper (passive)
- Motorized damper + fan
- … + resistance heat

# Passive Vents

## Trickle Vents

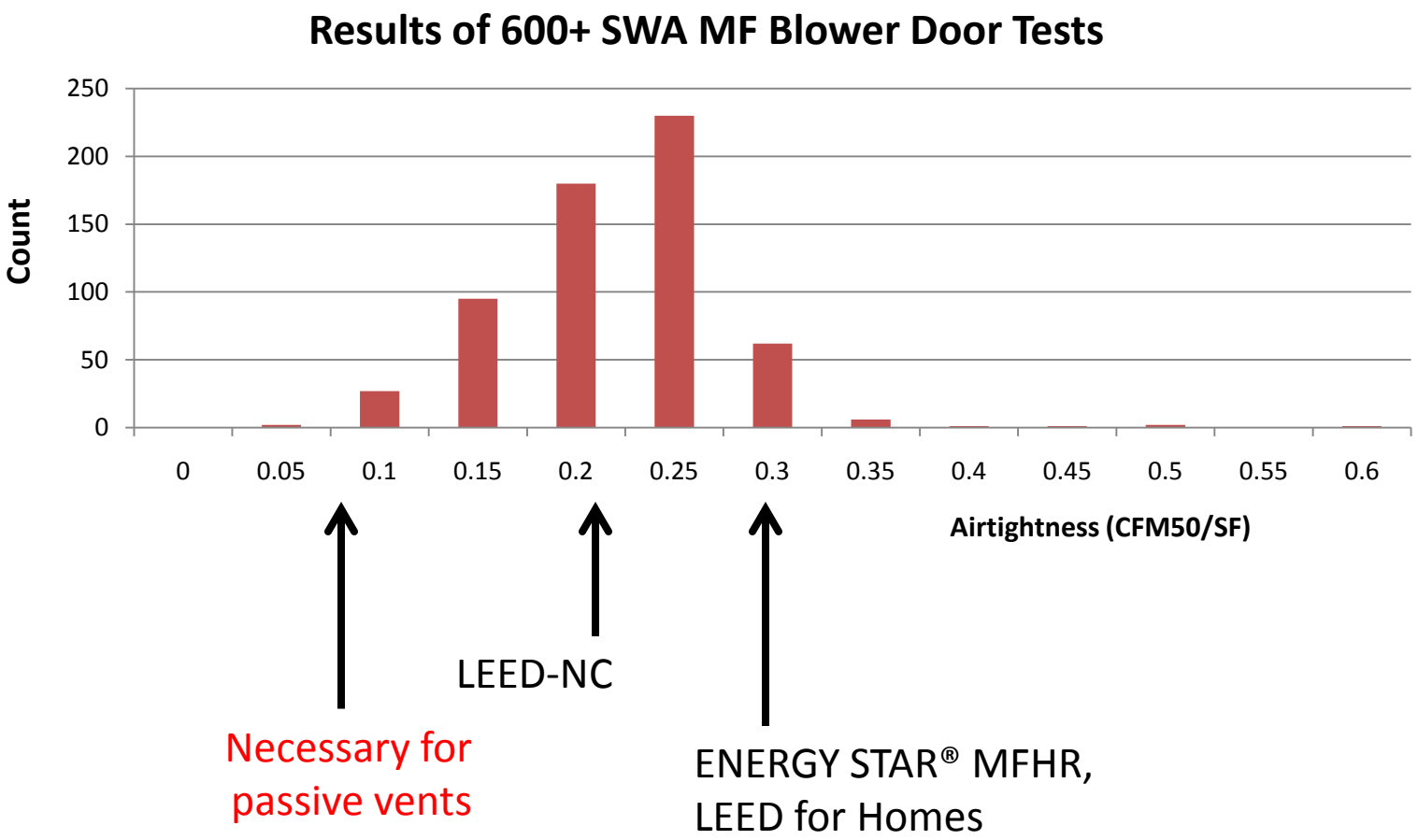
## Wall Vents

# Trickle Vent Example



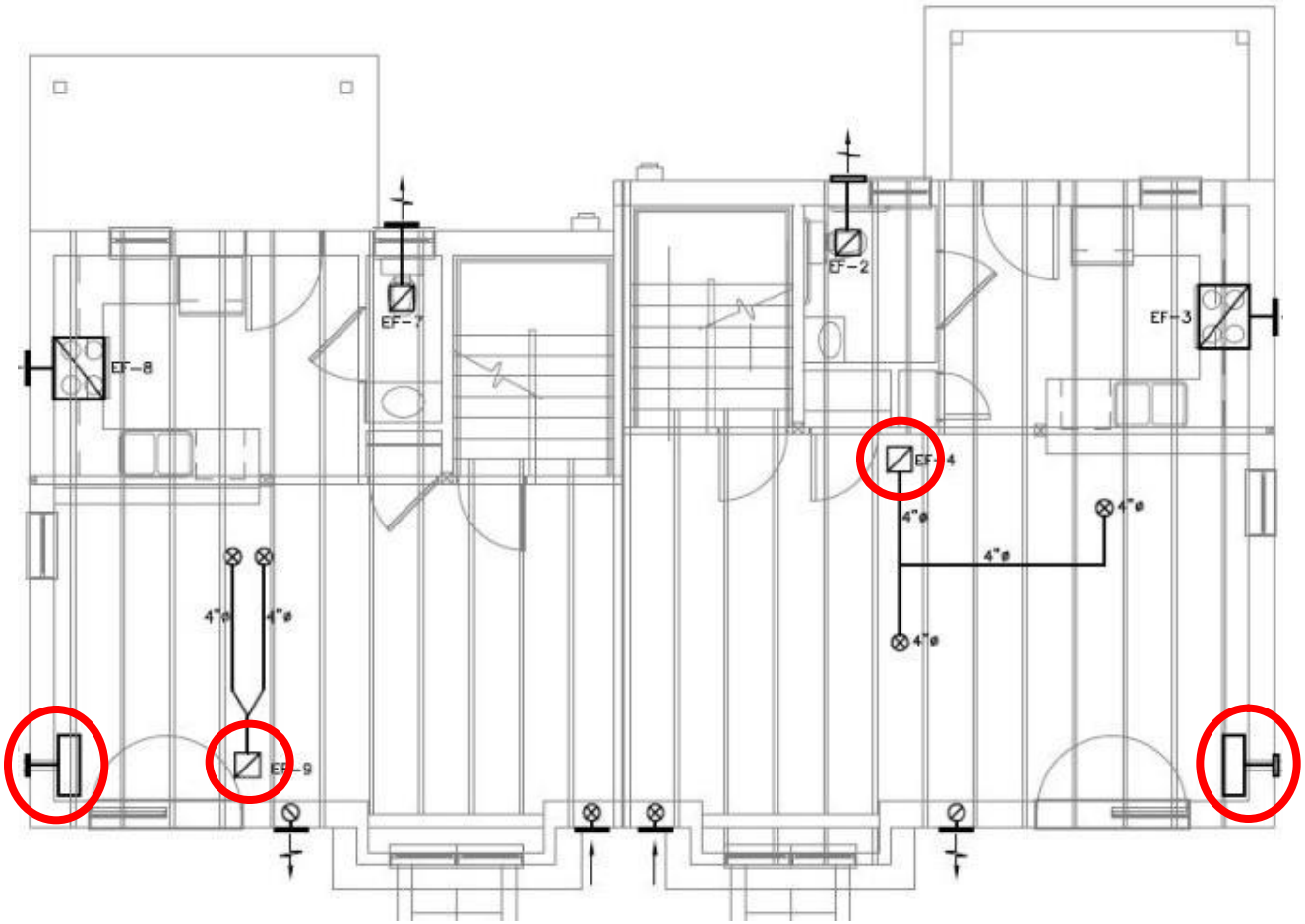

Building America study:
http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/ventilation_multifamily_buildings.pdf

# What level is realistic?

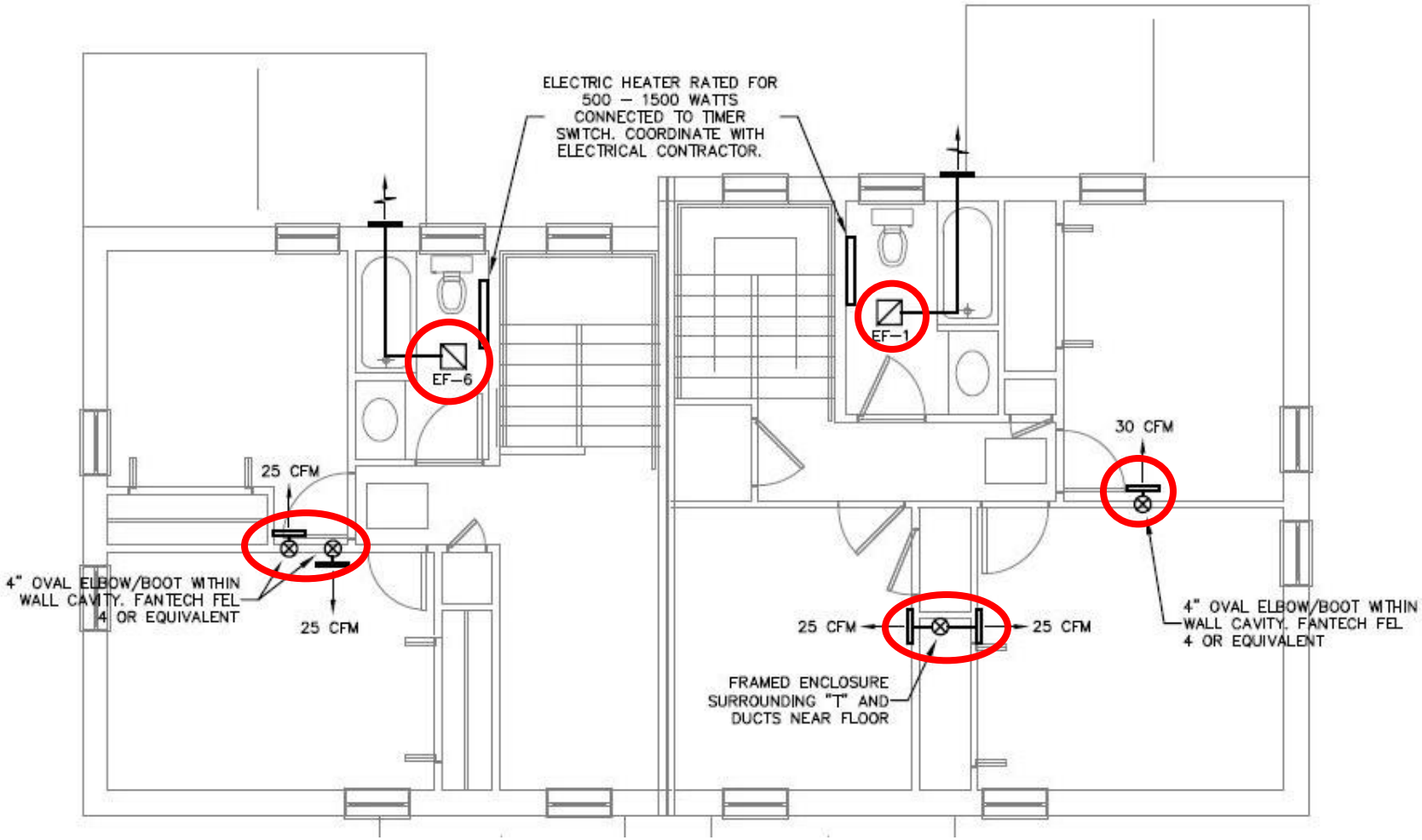


# Distribution example: Greenfield, MA

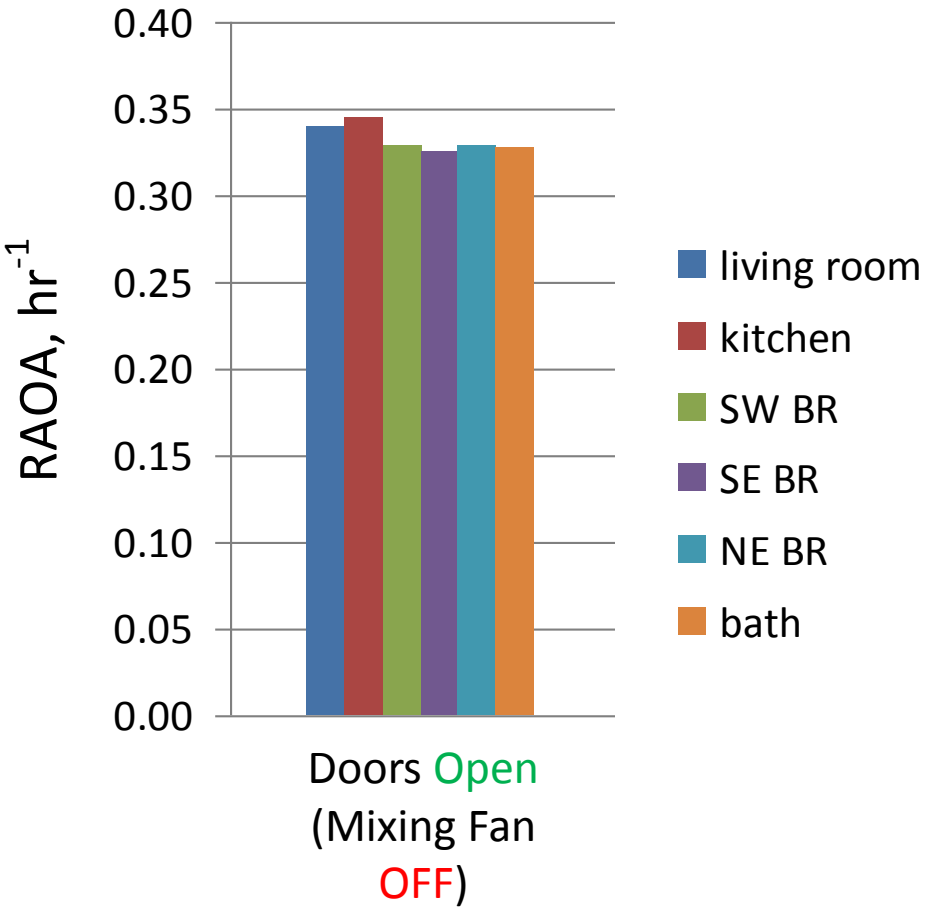
# Heating System – First Floor



# Heating System – Second Floor



# Tracer Gas Testing



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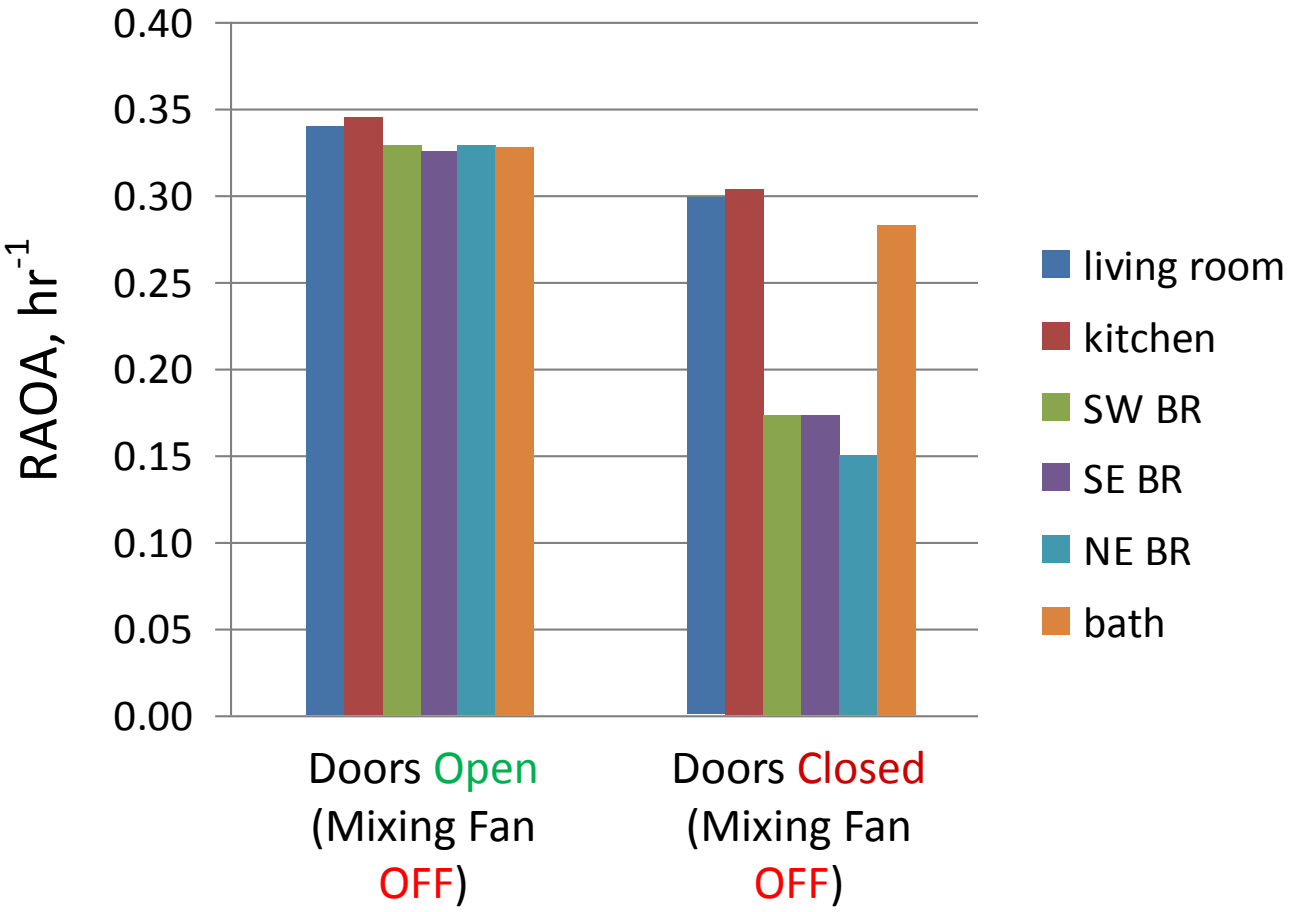

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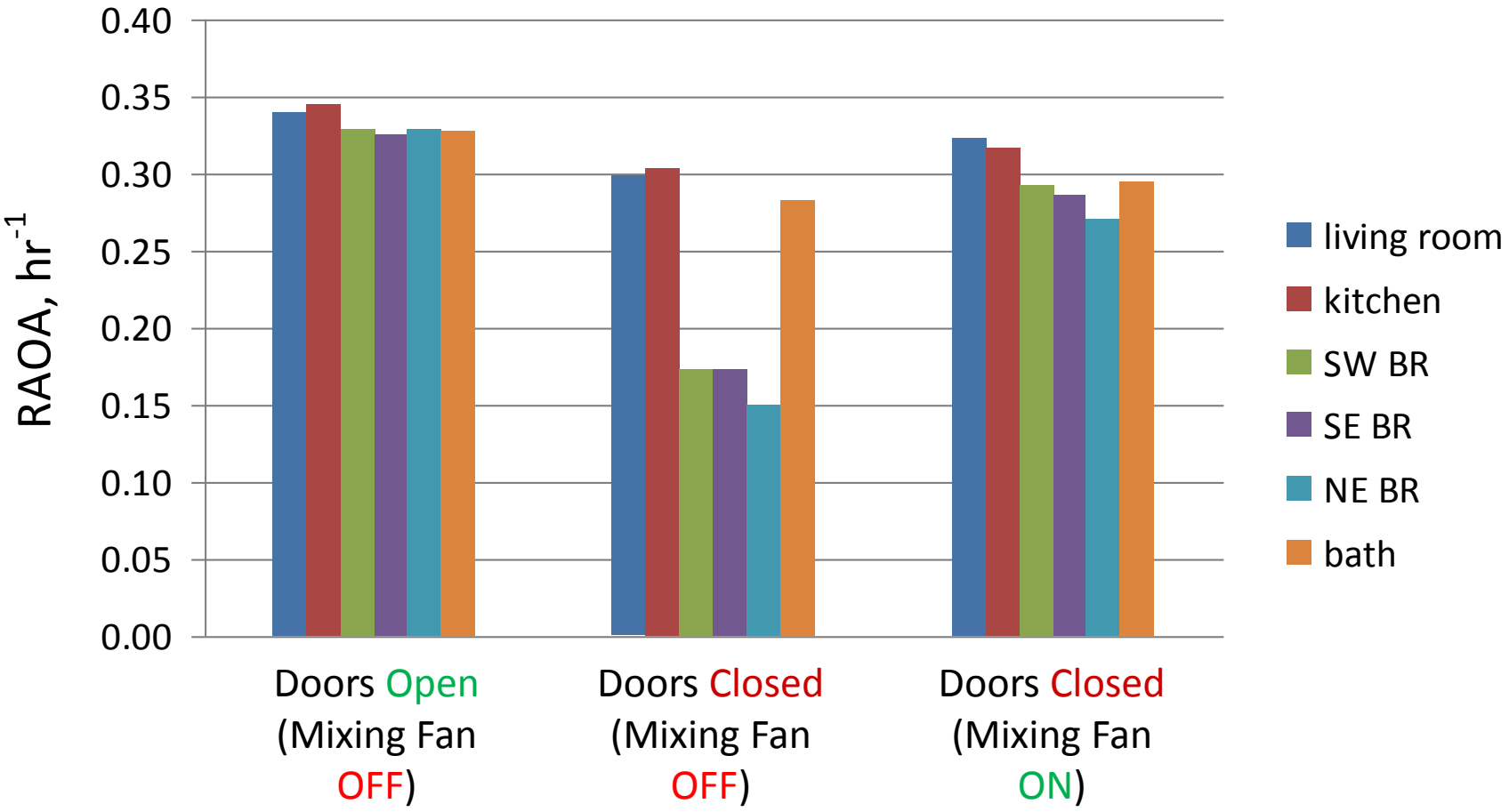


# Costs

# Cost Example

| System | Description |
|---|---|
| No Ventilation | NA |
| **Exhaust Only** | Single 10W fan, 60 CFM |
| **CFIS** | 250W AHU fan, 100 CFM, 14 h/d |
| **HRV** | 40W, 60 CFM, 24 h/d, 70% SRE |

- New home, Boston climate
- 60 CFM continuous or equivalent
- Condensing gas furnace (94% eff.)
- SEER 13 AC
- No duct leakage
- $0.20/kWh
- $1.50/therm

# Cost Example

| | Incremental Costs | | | |
|---|---|---|---|---|
| System | Equip. | Install | Total | Op. Cost |
| None | $0 | $0 | $0 | $0 |

# Cost Example

| System | Incremental Costs | | | Op. Cost |
|---|---|---|---|---|
| | Equip. | Install | Total | |
| None | $0 | $0 | $0 | $0 |
| **Exhaust** | $50 - $150 | NA | $100 | $79 |

# Cost Example

| System | Incremental Costs | | | Op. Cost |
|---|---|---|---|---|
| | Equip. | Install | Total | |
| None | $0 | $0 | $0 | $0 |
| **Exhaust** | $50 - $150 | NA | $100 | $79 |
| **CFIS** | $150 | $400 | $550 | $232 |

# Cost Example

| System | Incremental Costs | | | Op. Cost |
|---|---|---|---|---|
| | Equip. | Install | Total | |
| None | $0 | $0 | $0 | $0 |
| **Exhaust** | $50 - $150 | NA | $100 | $79 |
| **CFIS** | $150 | $400 | $550 | $232 |
| **HRV** | $700 - $2,500 | $1,500 | $2,500 | $104 |

**Example only!**
**Costs & systems vary tremendously.**

# Testing/Commissioning

# Ventilation Commissioning

Check that things work!

- Look at Systems.

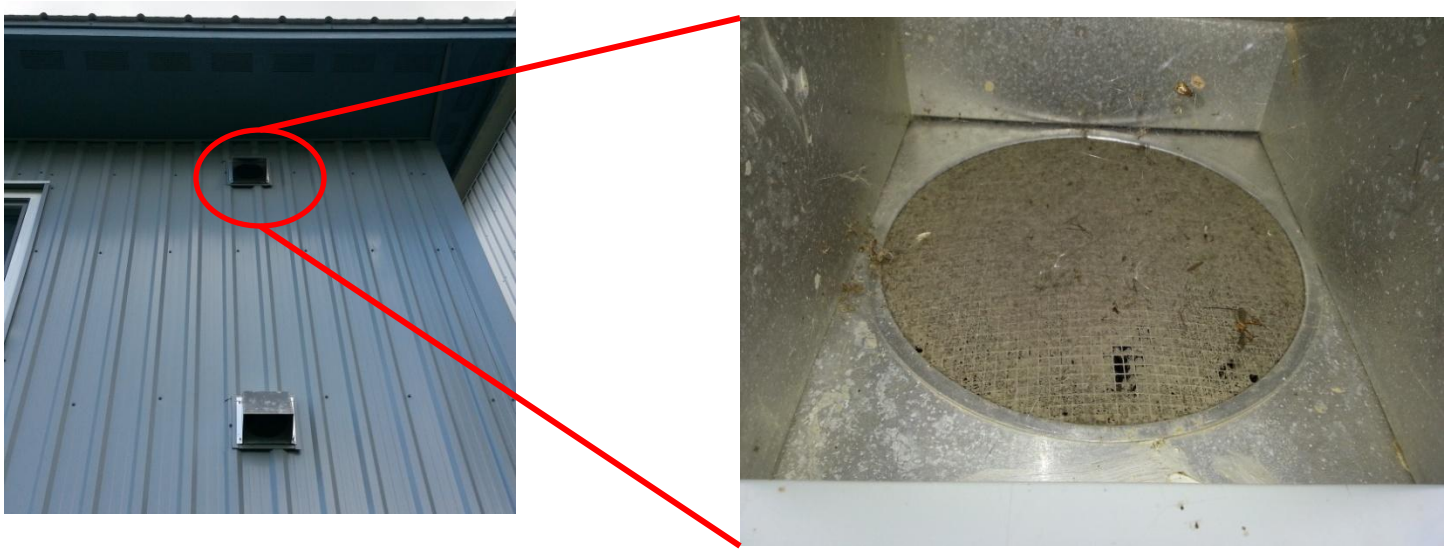
- Fans turn on, dampers open when they're supposed to.

# Ventilation Commissioning

Check that things work!

- Equipment, air intakes accessible for maintenance
- Measure Flow

# Maintenance!



- Clean air intakes (indoors and outdoors)
- Filters
- Dampers/motors
- Heat exchange media
- Manufacturer instructions