

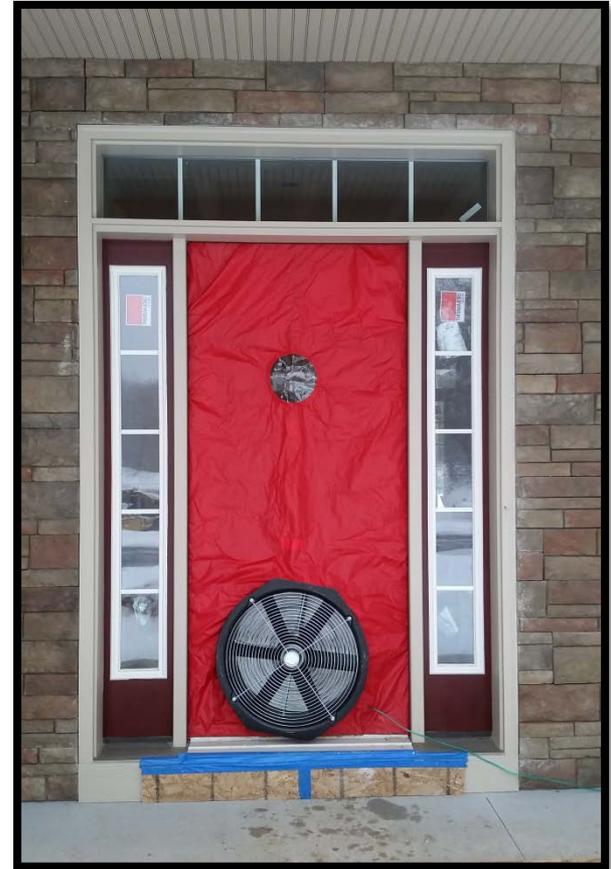
# **Energy Codes: Building Air Tightness and Ventilation**

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# What We'll Cover

- Why Build Tight?
- Why Ventilate?
- Ventilation Requirements of Code  
*...and how to get around them!*



# Why Build Tight?

- Water and moisture management
  - Durability
  - Structural integrity

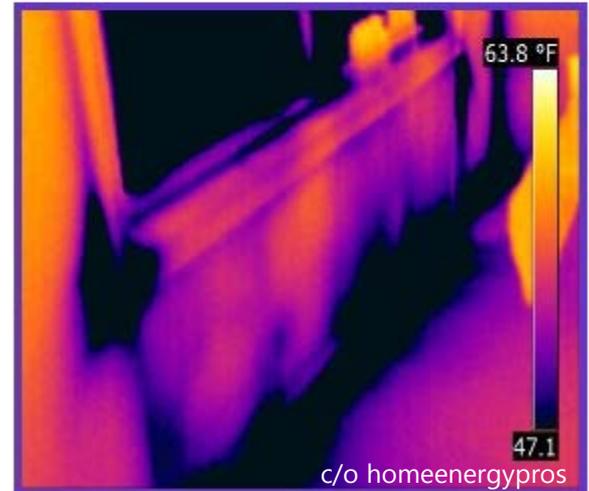


# Why Build Tight?

- Energy Performance
  - Significant and cost effective savings:

*U.S. DOE: "much of the energy savings attributed to the 2012 IECC results from (air sealing) improvement."\**

- Comfort
  - Less drafty
  - Quieter



# Why Ventilate?

- Control:
  - Odors
  - Moisture
  - Pollutants
- Promote: Health and Life Safety



Acrolein

PM2.5

CO

Formaldehyde

CO<sub>2</sub>

H<sub>2</sub>O

Odors

NO<sub>2</sub>

# Where Should We Ventilate?

- Local exhaust: kitchens and baths
- Whole-house



# ASHRAE 62.2: Ventilation Requirements



ANSI/ASHRAE Standard 62.2-2013  
(Supersedes ANSI/ASHRAE Standard 62.2-2010)  
Includes ANSI/ASHRAE addenda listed in Appendix C

## Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings

- Mandatory mechanical ventilation
  - Bathrooms, kitchens, whole-house
- Whole-House MV
  - Required for new construction regardless of tightness
  - May be exhaust, supply, or combination
  - May be intermittent or continuous

# ASHRAE 62.2:

## Whole-House Ventilation Rate

- **2010:** Whole-house ventilation rate assumes a building leakage of 0.02 cfm/ft<sup>2</sup>.

$$Q_{fan} = 0.01A_{floor} + 7.5(N_{br} + 1)$$

- **2013 and 2016:** Removed leakage assumption. Result: Fan rate increases for tight homes.

$$Q_{tot} = 0.03A_{floor} + 7.5(N_{br} + 1)$$

$$Q_{fan} = Q_{tot} - Q_{inf}$$

# I-Codes:

## Ventilation Requirements

- **IECC R403.6**
  - Mandatory air-tightness: 3 or 5 ACH<sub>50</sub>
  - Mandatory mechanical ventilation (implied: local exhaust and whole-house)
  - Fan efficacy requirements
- **IRC and IMC Whole-House MV**
  - R303.4, 403.1: Required if ACH<sub>50</sub> ≤ 5
  - M1507, 403.3.2: May be exhaust, supply, or combination
  - M1507, 403.3.2: May be intermittent or continuous

Rates based on ASHRAE 62.2-2010;  
 $Q_{fan} = 0.01 * CFA + 7.5(Nbr + 1)$

TABLE M1507.3.3(1)

DWELLING UNIT FLOOR AREA (square feet)	BEDROOMS	
	2 – 3	4 – 5
	Airflow in CFM	
< 1,500	45	60
1,501 – 3,000	60	75
3,001 – 4,500	75	90
4,501 – 6,000	90	105
6,001 – 7,500	105	120
> 7,500	120	135

# I Don't Get It...

Let's run some simulations!

- BeOpt/EnergyPlus
- Climate Zone 5
- Single Family Detached Home (~2650 ft<sup>2</sup>, 3 bedrooms)
- 2015 IECC Prescriptive Path Compliant

**Build tight AND ventilate???**



# Survey

## How frequently do you want to have acceptable indoor air quality?

- Annually
- Quarterly
- Monthly
- Daily
- Hourly
- All the time!

# Build Tight and Ventilate Right



ACH<sub>50</sub> = 0

ASHRAE 62.2-2013/2016 rate

Daily Average Fresh Air Changes Per Hour

## Results:

- Consistent fresh air rate: ~0.3 ACH
- "Acceptable" IAQ based on ANSI standard

Daily Average Fresh Air Changes Per Hour



- 0 ACH<sub>50</sub>; Q=0.03\*CFA+ 7.5(Nbr+1)

Winter	Spring	Summer	Fall	Annual
0.31	0.31	0.31	0.31	0.31

# How to Avoid Ventilation:

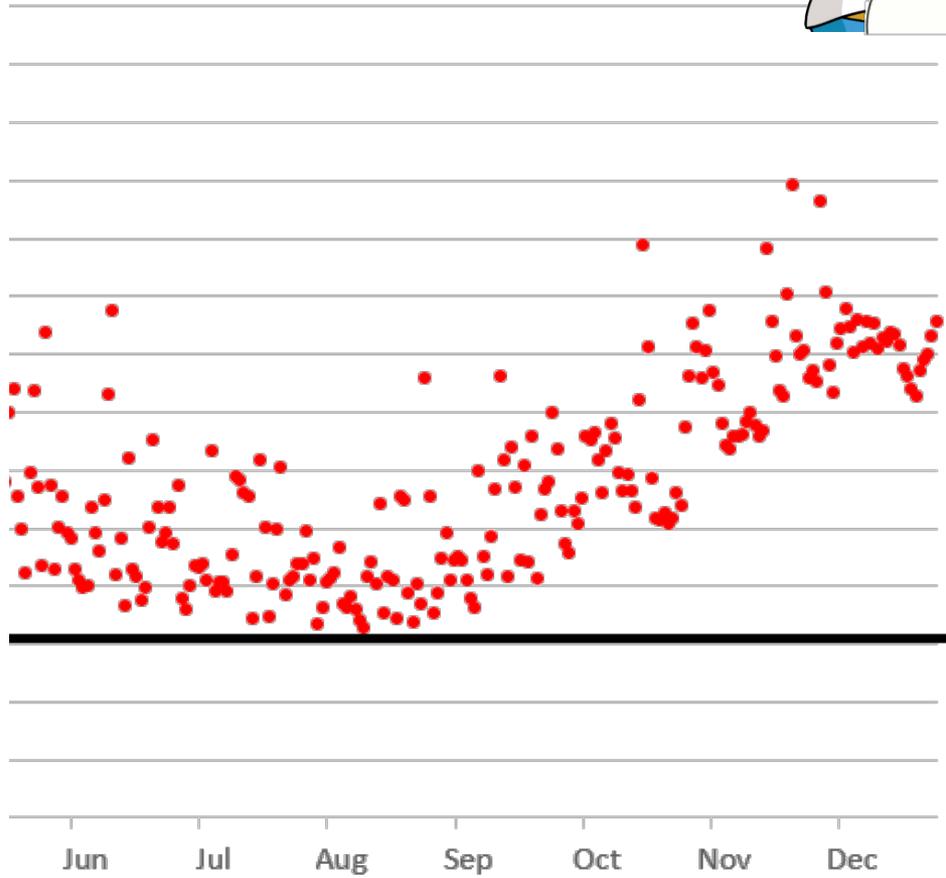
## #1: Build Really Leaky

Daily Average Fresh Air Changes Per Hour



### Results:

- Need  $\geq 14 \text{ ACH}_{50}$  for *daily* average infiltration to always meet or exceed Build Tight/Ventilate Right scenario
- 60% increase in HVAC energy use vs. 62.2 Built Tight/Ventilate Right scenario
- Severe over-infiltration; diminished comfort



Average Fresh Air Changes Per Hour

Winter	Spring	Summer	Fall	Annual
0.31	0.31	0.31	0.31	0.31
0.81	0.58	0.47	0.73	0.65

• 14 ACH50; No Mech Vent

# How to Avoid Ventilation

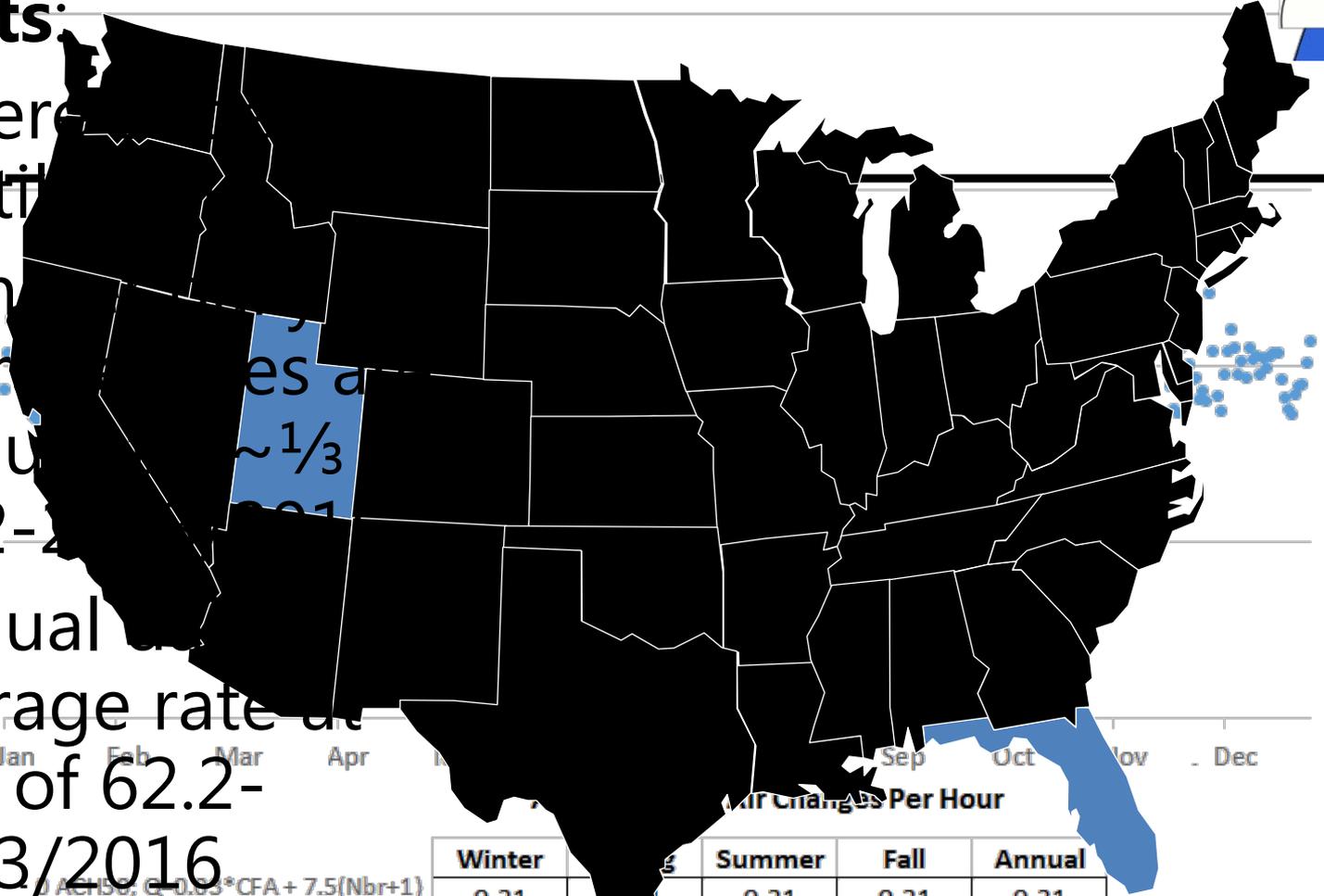
## #2: Move Ventilation Requirement to 3 ACH<sub>50</sub>



Daily Average Fresh Air Changes Per Hour

### Results:

- Severe ventilation
- Summer average fresh air changes are frequently ~1/3 of 62.2-2001
- Annual average rate at ~1/2 of 62.2-2013/2016

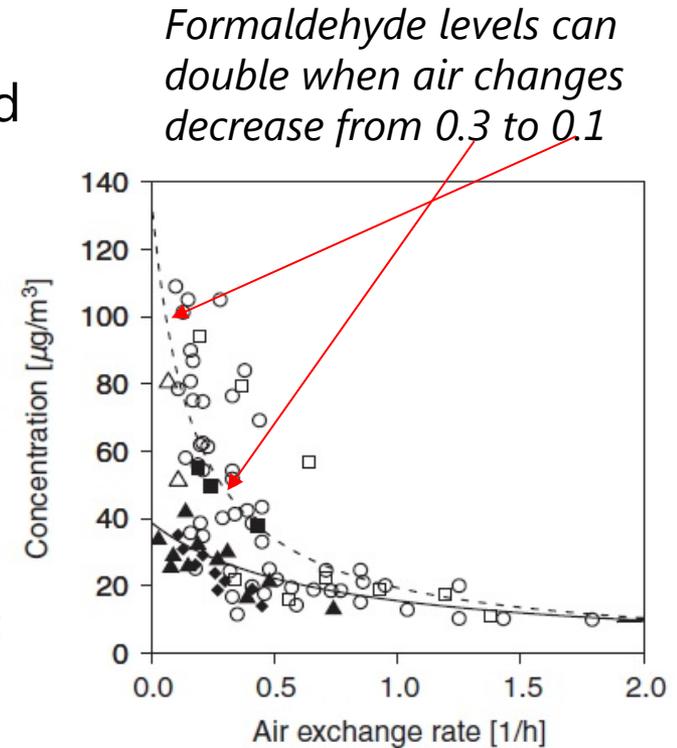


Winter	Spring	Summer	Fall	Annual
0.31	0.14	0.31	0.31	0.31
0.19	0.14	0.12	0.18	0.16

● 3 ACH 50; No Mech Vent

# What's Wrong with Under-Ventilating?

- Significantly increases exposure to pollutants
- Annual average cost of health effects associated with poor residential IAQ are ~\$500/person\*
- Symptoms:
  - Impaired cognition
  - Headaches
  - Fatigue
  - Trouble concentrating
  - Irritation of the eyes, nose, throat and lungs
  - Cancer
  - Respiratory disease
  - Heart disease



Source: Hult et al.

\*See reference slide. Assumes poor IAQ accounts for 0.01 disability adjusted life years (DALYs) per person, and that the value of a DALY is \$50,000. This value is at the low end of epidemiological studies that estimate the value of a DALY between \$50k - \$200k.

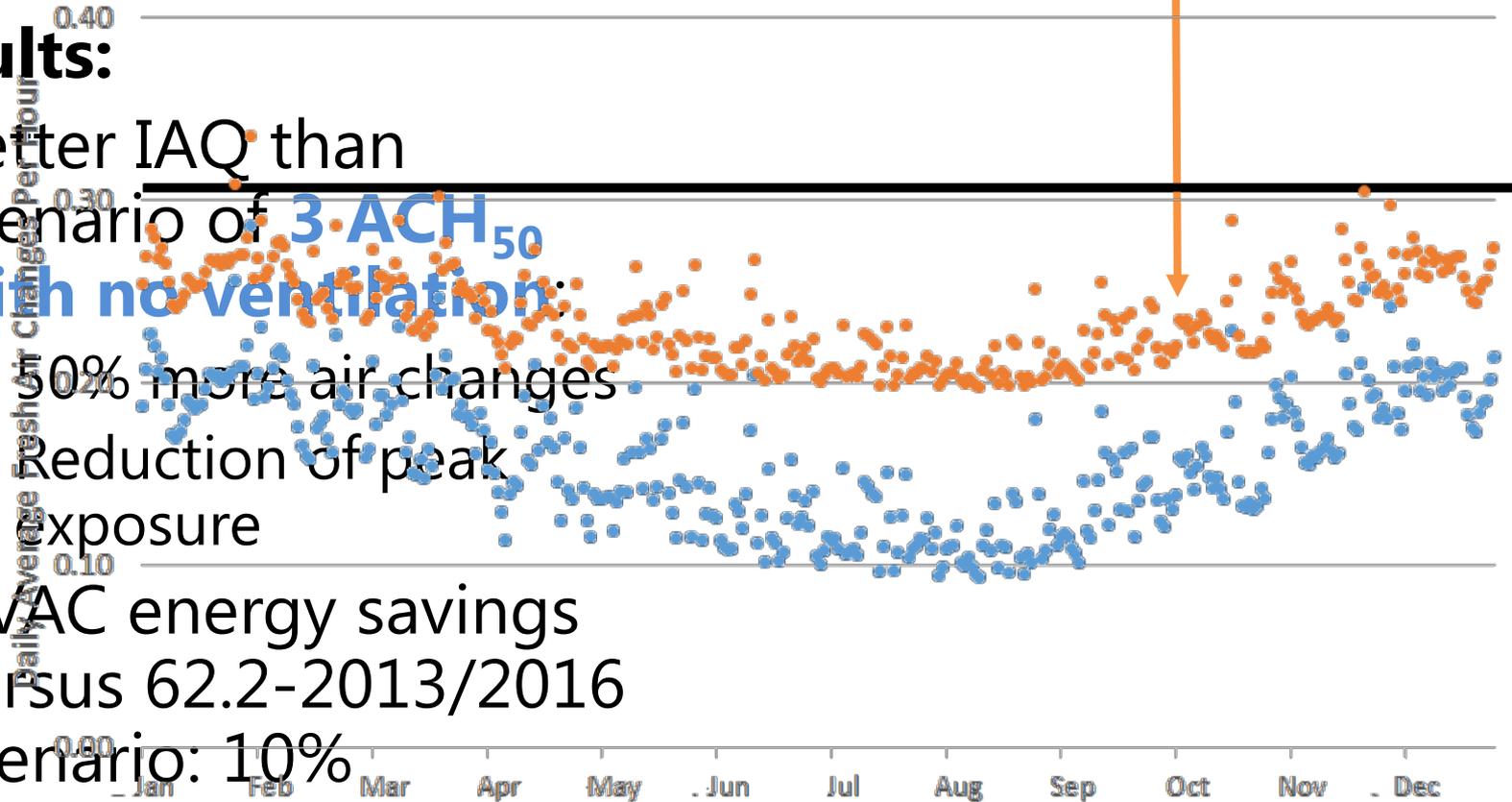
# Code as Compromise:

## 3 ACH50; $Q=0.01 * CFA + 7.5(Nbr + 1)$

Daily Average Fresh Air Changes Per Hour

### Results:

- Better IAQ than scenario of **3 ACH<sub>50</sub> with no ventilation**:
  - 50% more air changes
  - Reduction of peak exposure
- HVAC energy savings versus 62.2-2013/2016 scenario: 10%



Average Fresh Air Changes Per Hour

	Winter	Spring	Summer	Fall	Annual
• 0 ACH50; $Q=0.03 * CFA + 7.5(Nbr + 1)$	0.31	0.31	0.31	0.31	0.31
• 3 ACH50; No Mech Vent	0.19	0.14	0.12	0.18	0.16
• 3 ACH50; $Q=0.01 * CFA + 7.5(Nbr + 1)$	0.26	0.23	0.21	0.25	0.24

# Recommendations

- Build tight, AND
- Ventilate
  - At a minimum, retain ICC ventilation requirements, or
  - As an alternative, reference ASHRAE 62.2-2013 or 62.2-2016 ventilation requirements, or
  - Require compliance with 62.2-2013 or 62.2-2016
- Benefits
  - Energy savings
  - Acceptable IAQ
  - Comfort
  - Improved durability
  - Improved public health

# References

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# Thank You

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