



# Compliant and Unhealthy: When an Older Code Meets Contemporary Construction Methods

ACEEE Conference on Health,  
Environment, and Energy

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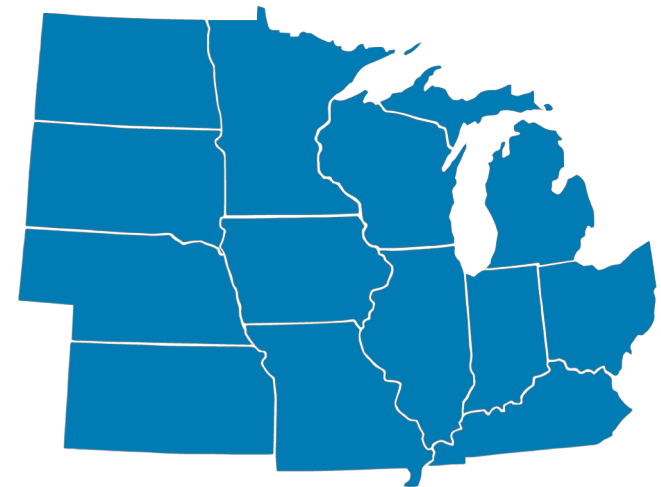
# About MEEA

## *The Trusted Source on Energy Efficiency*

We are a nonprofit membership organization with **160+ members**, including:

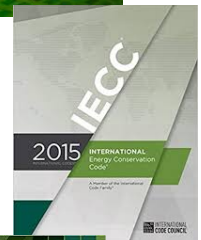
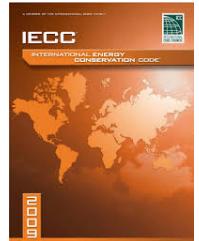
- Utilities
- Research institutions and advocacy organizations
- State and local governments
- Energy efficiency-related businesses

As the key resource and champion for energy efficiency in the Midwest, MEEA helps a diverse range of stakeholders understand and implement cost-effective energy efficiency strategies that provide economic and environmental benefits.



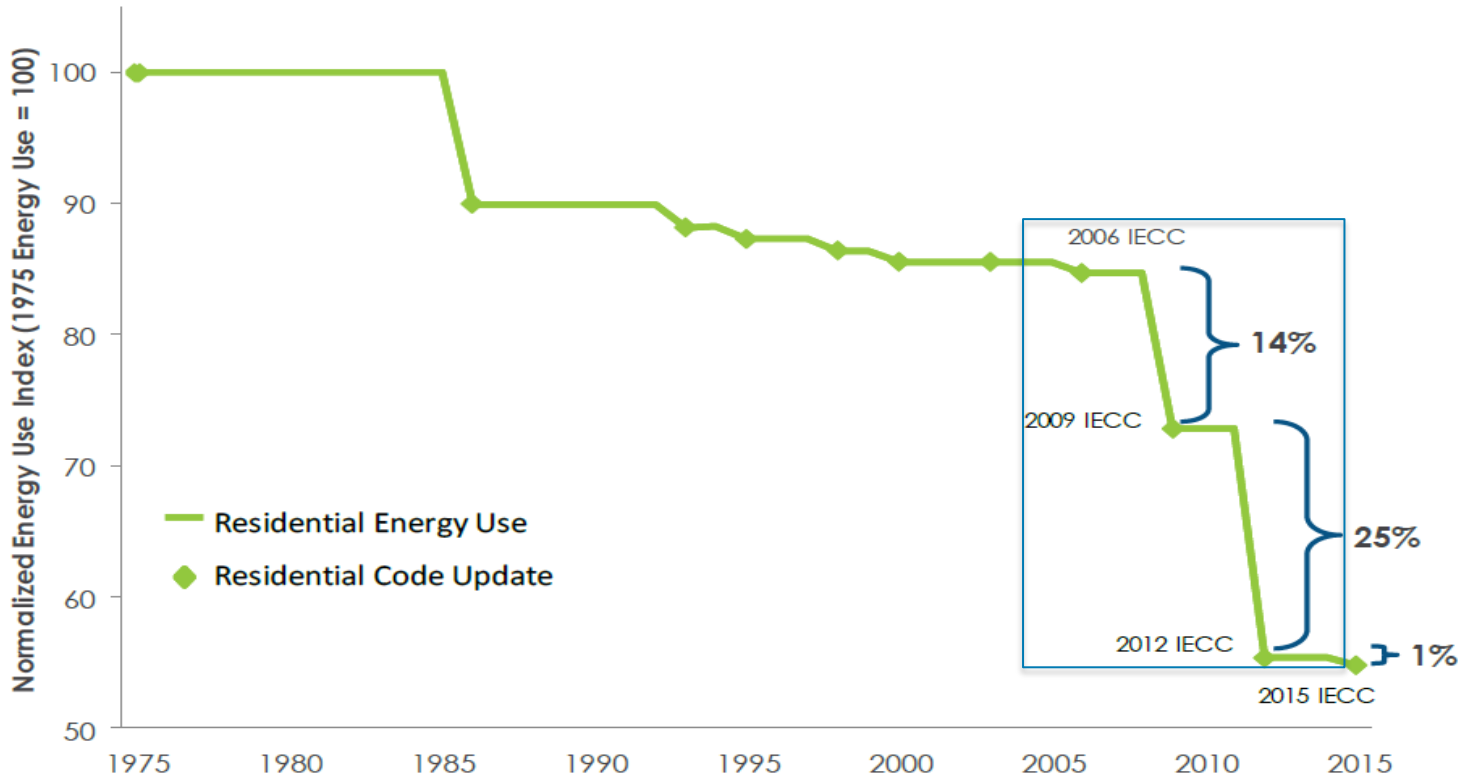
# Energy Codes Overview

- National model codes are published every three years
  - Adopted and enforced by state or local jurisdictions
  - Most recent code is 2018 International Energy Conservation Code (IECC)
- Energy codes, like all building codes, establish minimum life-safety requirements
  - Air Sealing
    - **Blower door test**
  - Ventilation
  - Windows and Doors
  - Insulation



# Energy Codes

## *Improving Efficiency*



\* Energy Use Index: National average energy use by building type and size.

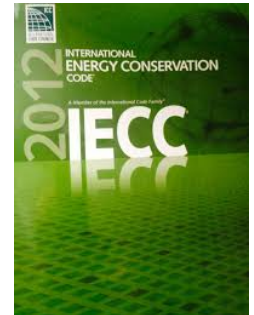
Source: PNNL Analysis

Envelope air sealing is a major driver in improved efficiency

# Energy Codes

## *Envelope Tightness*

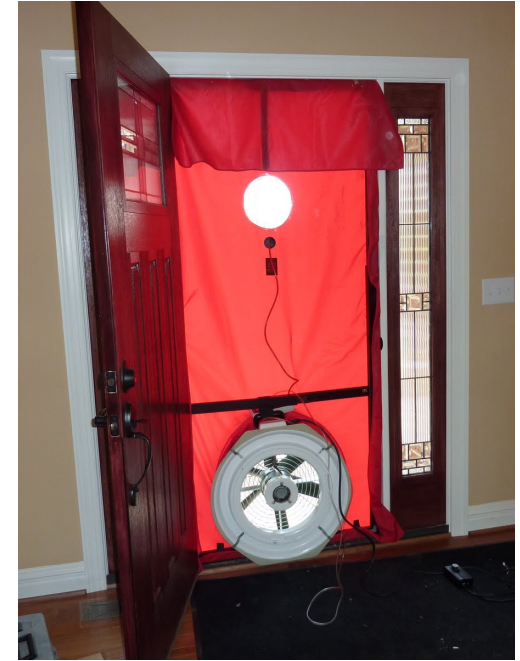
- Older codes ( $\leq 2009$ ) relied on a leaky envelope to provide fresh air (visual inspections)
  - Location of “fresh air” intake is unknown
  - It could even be across dead (or undead) racoon in the crawl space?
- Newer codes ( $\geq 2012$ ) require testing (blower door) to verify building tightness
  - Mechanical ventilation required below specified air leakage
  - Fresh air intake is from a know source/location



# Energy Codes

## *Blower Door Test*

- Blower door tests determine envelope leakage
  - ANSI/RESNET/ICC 380
- Pressurizes (or depressurizes) home to 50 pascals (~20 mph wind)
- Code limits maximum Air Changes Per Hour (ACH50)
  - 2009 IECC, 7 ACH50
  - 2012 IECC, 3 ACH50\*



\* 5 ACH50 in climate zones 1 and 2

# Questions

## *Known Unknowns*

- Since 2010, **nearly 3 million homes** have been constructed where visual air sealing inspection is allowed
- How do you know when mechanical ventilation is needed in a visually inspected home?
  - What is the envelope tightness of a visually inspected home?
  - Is proper ventilation installed in “tight” visually inspected homes?



# DOE Residential Field Studies

## *Data Collection*

- In 2014 DOE funded three-year, three-phase residential baseline studies in 8 states
  - <https://www.energycodes.gov/compliance/energy-code-field-studies>
- Phase 1 – Baseline study
- Phase 2 – Training and education
- Phase 3 – Redo baseline study



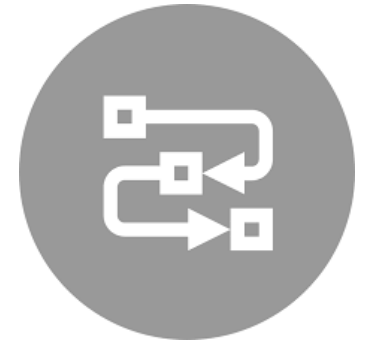
# DOE Residential Field Studies

## *Data Collection*

- Study was designed to give statistically significant results on new homes
  - Statewide random selection of homes
  - Including air sealing and ventilation data
- MEEA led the study in Kentucky
  - KY code (2009 IECC) allows visual inspection
- MEEA collected ~25,000 data points on new homes in KY

# Phase 1 Data Methodology Overview

- Assume homes only get blower door tests for a HERS rating
  - HERS is a standardized rating of home energy consumption
- Determine % of KY HERS rated homes (2016)
  - 28% of homes rated
- Randomly remove HERS % of homes from dataset
- Determine % of remaining homes requiring mechanical ventilation (<5 ACH50)
- Determine if required ventilation was installed



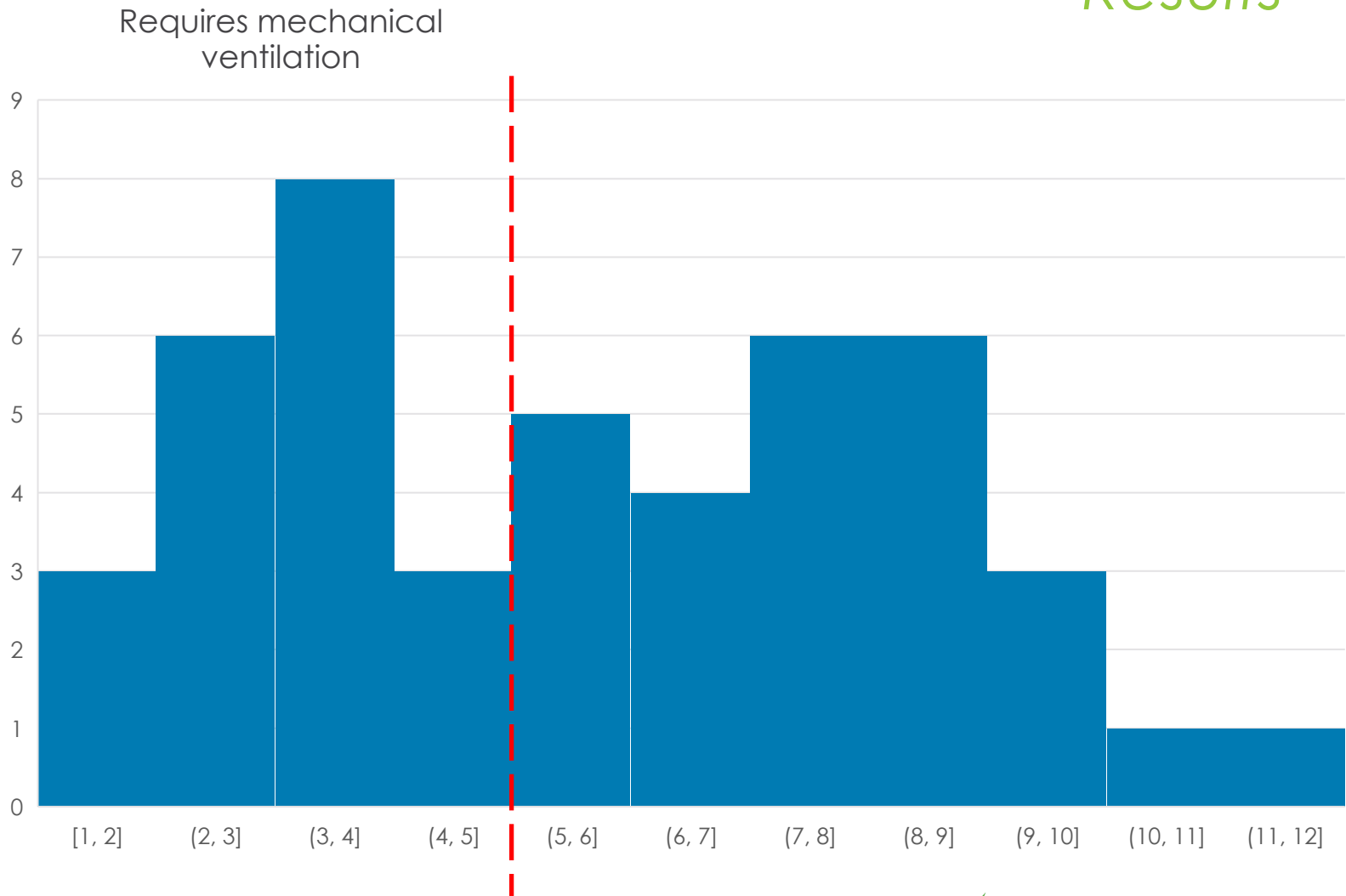
# Phase 1 Data (KY)

## Results

### ACH50 of Visually Inspected Homes

Median	5.3
Average	5.7
Range	19.5
Maximum	20
Minimum	0.51
Standard Deviation	3.7
Sample Size	48
Number of homes < 5 ACH50	25
<b>% Sample Size &lt;5 ACH50</b>	<b>52%</b>
<b>% Sample Size &lt;5 ACH50 with Only Bath Fan Ventilation</b>	<b>82%</b>

# Phase 1 Data (KY) Results



# Phase 1 Data

## Other States

State	AR	NC	PA	MO
<b>Energy Code</b>	2009 IECC	2012 IECC (amended out blower door testing)	2009 IECC	Home Rule (no statewide code)
<b>% of homes &lt;5 ACH50</b>	43.86%	86.96%	72.73%	61.67%
<b>% HERS rated homes</b>	10.48%	30.67%	21.75%	5.53%

# Phase 1 Data

## *Average Results from 5 States*

- Average % of homes with < 5 ACH50: **66.1%**
- Average % of HERS rated homes in states studies: **19.22%**
- Average % of bath fan only ventilation: **88.1%** (KY and MO)



# Phase 3 Data (KY)

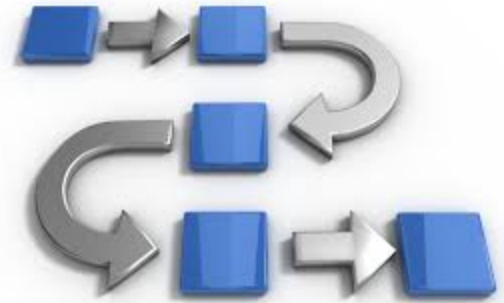
## Overview

- Phase 3 presented an **opportunity** to directly compare visual inspection and blower door results
- **Second baseline study** was conducted after completion of two year compliance improvement program (Phase 2)
- Same energy items surveyed on a **new random set** of homes
- New home efficiency **markedly improved** (25%) compared to Phase 1 homes

# Phase 3 Data (KY)

## Methodology Overview

- Blower door tests were performed on all study homes
- *Builders were asked if compliance was via visual inspection or blower door test*
- Correlate visual inspection with blower door test results
- Determine % of homes requiring mechanical ventilation (<5 ACH50)
- Determine if required ventilation was installed





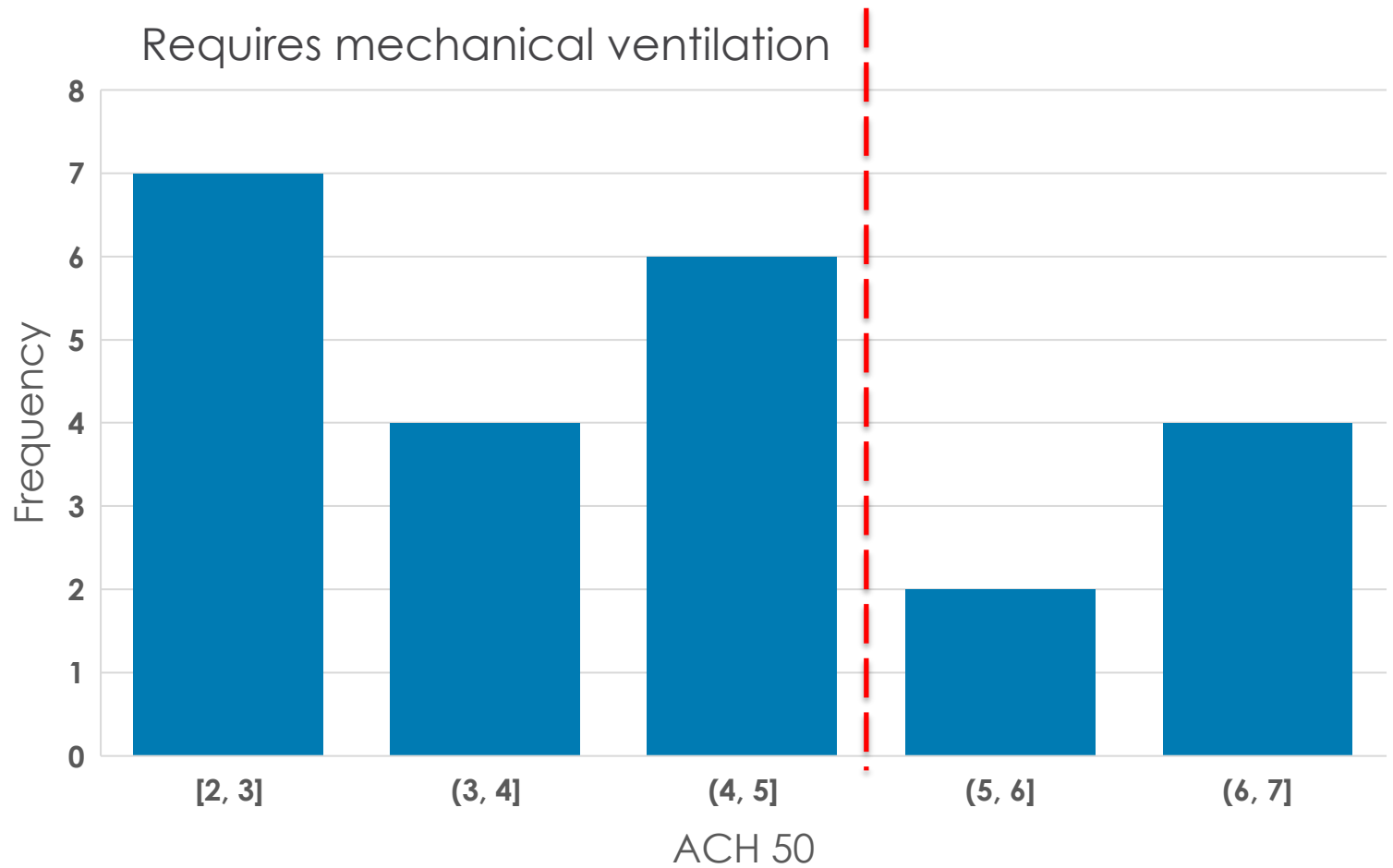
# Phase 3 Data (KY) Results

## ACH50 of Visually Inspected Homes

Median	4.3
Average	4.2
Range	5.0
Maximum	7.0
Minimum	2.0
Standard Deviation	1.6
Sample Size	23
Number of homes < 5 ACH50	17
<b>% Sample Size &lt;5 ACH50</b>	<b>74%</b>
<b>% Sample Size &lt;5 ACH50 with Only Bath Fan Ventilation*</b>	<b>90%</b>

\*While all homes met code air sealing requirements, the % of under-ventilated homes actually increased from 82% to 90%

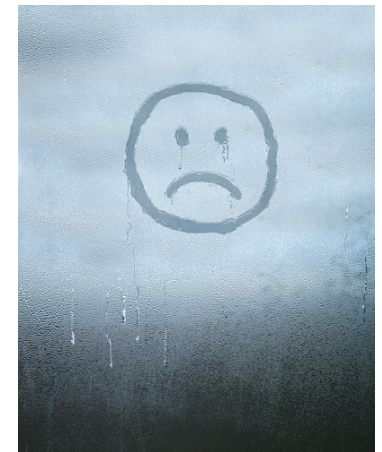
# Phase 3 Data (KY) Results



# Consequences

## Moisture

- Studies have found that improper ventilation causes increased moisture and mold in homes
  - Excess moisture can also damage structural components
- A separate MEEA study found that ~90% of new homes in KY and MO had oversized AC units (140% - 160%)
  - Oversized AC units meet cooling needs faster than they can remove moisture, called short cycling





# Conclusions

- This is potentially a (BIG) problem with significant health implications
  - Could affect 1.5 – 3 million homes nationwide
- Testing is important (and inexpensive)
  - The only way to know envelope tightness
- Build tight, ventilate right
  - As this study showed, ventilation impacts are often overlooked when making energy improvements



Thank you!

*Chris Burgess*  
*[cburgess@mwalliance.org](mailto:cburgess@mwalliance.org)*

*Nicole Westfall*  
*[nwestfall@mwalliance.org](mailto:nwestfall@mwalliance.org)*