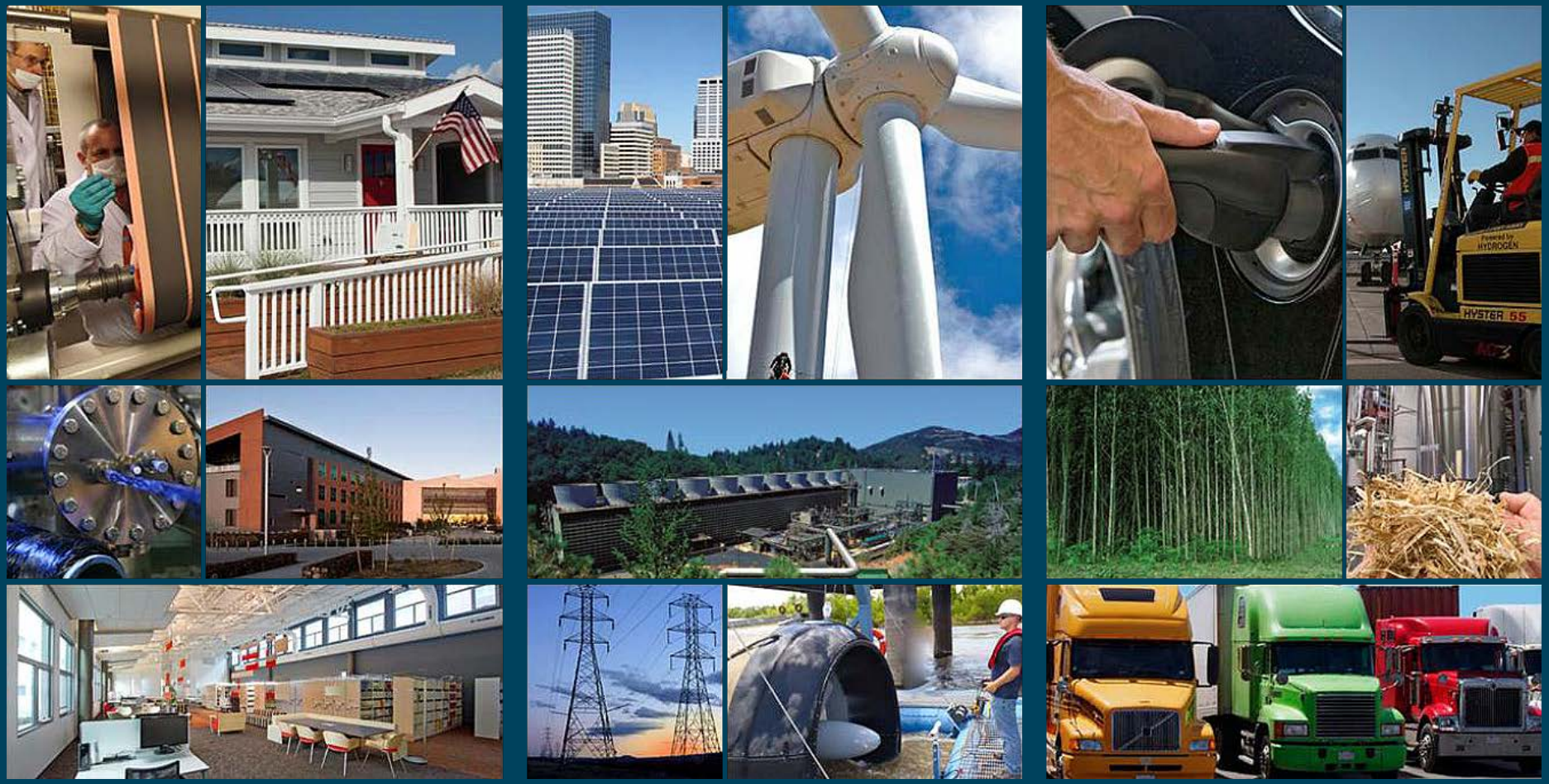
# Building Energy Codes Program

## Residential Energy Code Field Study



U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

**2016 BTO Peer Review**

April 6, 2016

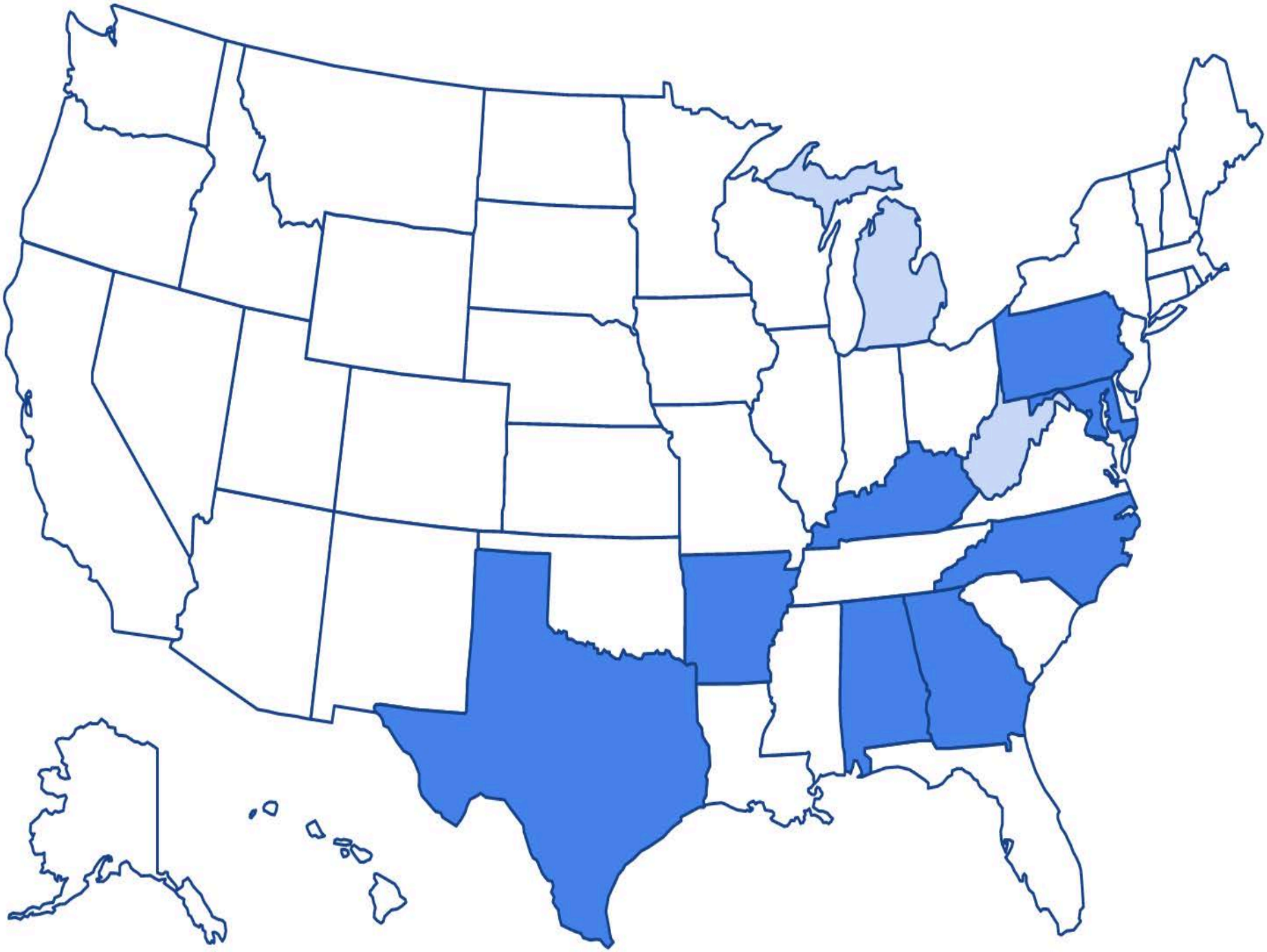
# BACKGROUND

# Residential Energy Code Field Study

**Purpose:** Maximize code-intended savings and provoke additional investments in energy code programs

**Objectives:**

+ Develop a **methodology** that equates to *energy*
+ Build an **empirical data** set based on observations made in the field
+ Establish the **business case** for private investment to increase savings through energy codes



| STATE | PROJECT LEAD | CZ | HOMES |
|---|---|---|---|
| AL | Institute for Market Transformation | 2A, 3A | 134 |
| AR | Southeast Energy Efficiency Alliance | 3A, 4A | 226 |
| GA | Southeast Energy Efficiency Alliance | 2A, 3A, 4A | 253 |
| KY | Midwest Energy Efficiency Alliance | 4A | 140 |
| MD | Maryland Energy Administration | 4A | 207 |
| MI | Navigant | 5A, 6A, 7A | 124 |
| NC | Appalachian State University | 3A, 4A | 249 |
| PA | Performance Systems Development | 4A, 5A | 171 |
| TX | National Association of State Energy Officials | 2A | 133 |

# METHODOLOGY

# Highlights

+ Results based on an **energy metric** and reported at the **state level**
+ Focus on **individual measures** within **new single-family homes**
+ **Data confidentiality** built into the experiment—no personal data will be shared
+ Designed around a **single site visit** prioritizing **key items**
+ Designed for **statistically significant results**

# Sampling

PNNL identified **individual building components** with **largest energy impact**:

+ Code items with *direct* energy impact
+ Expected distribution of field observations
+ Modeled affect on energy consumption

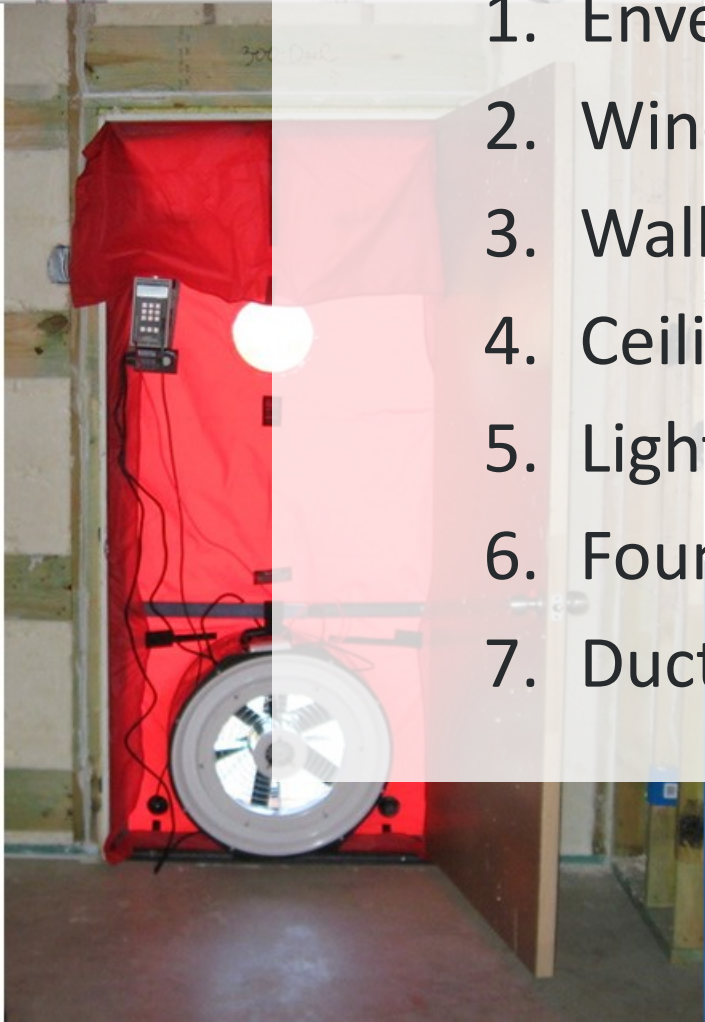
Sample size of **63 observations for each key item**:

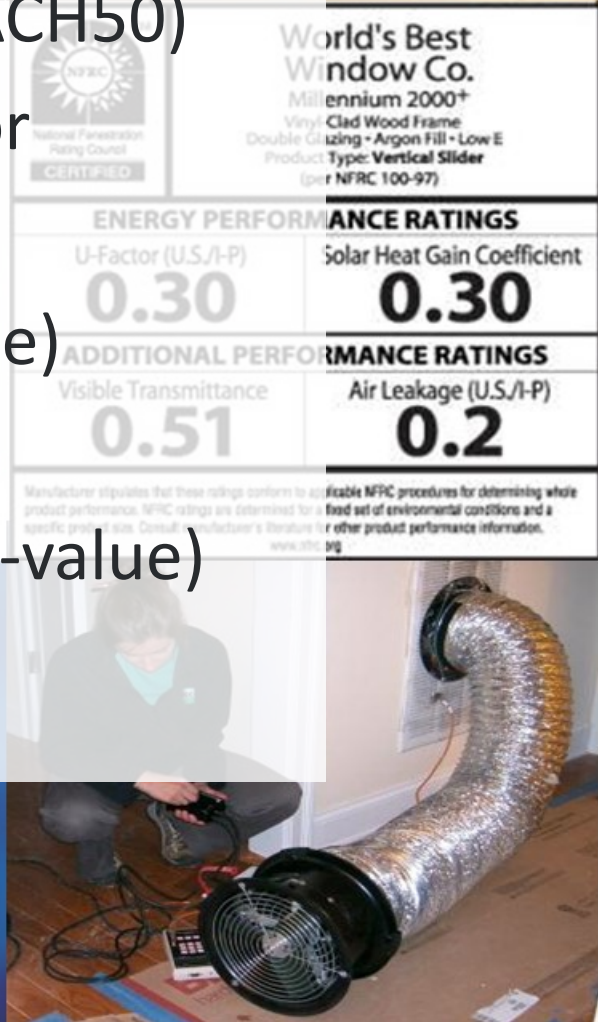
+ Detect statistically significant differences in pre- & post-studies
+ Enable statewide sampling plan & energy metric

## Key Items:

1. Envelope air tightness (ACH50)
2. Window SHGC & U-factor
3. Wall insulation (R-value)
4. Ceiling insulation (R-value)
5. Lighting (% HE lamps)
6. Foundation insulation (R-value)
7. Duct leakage





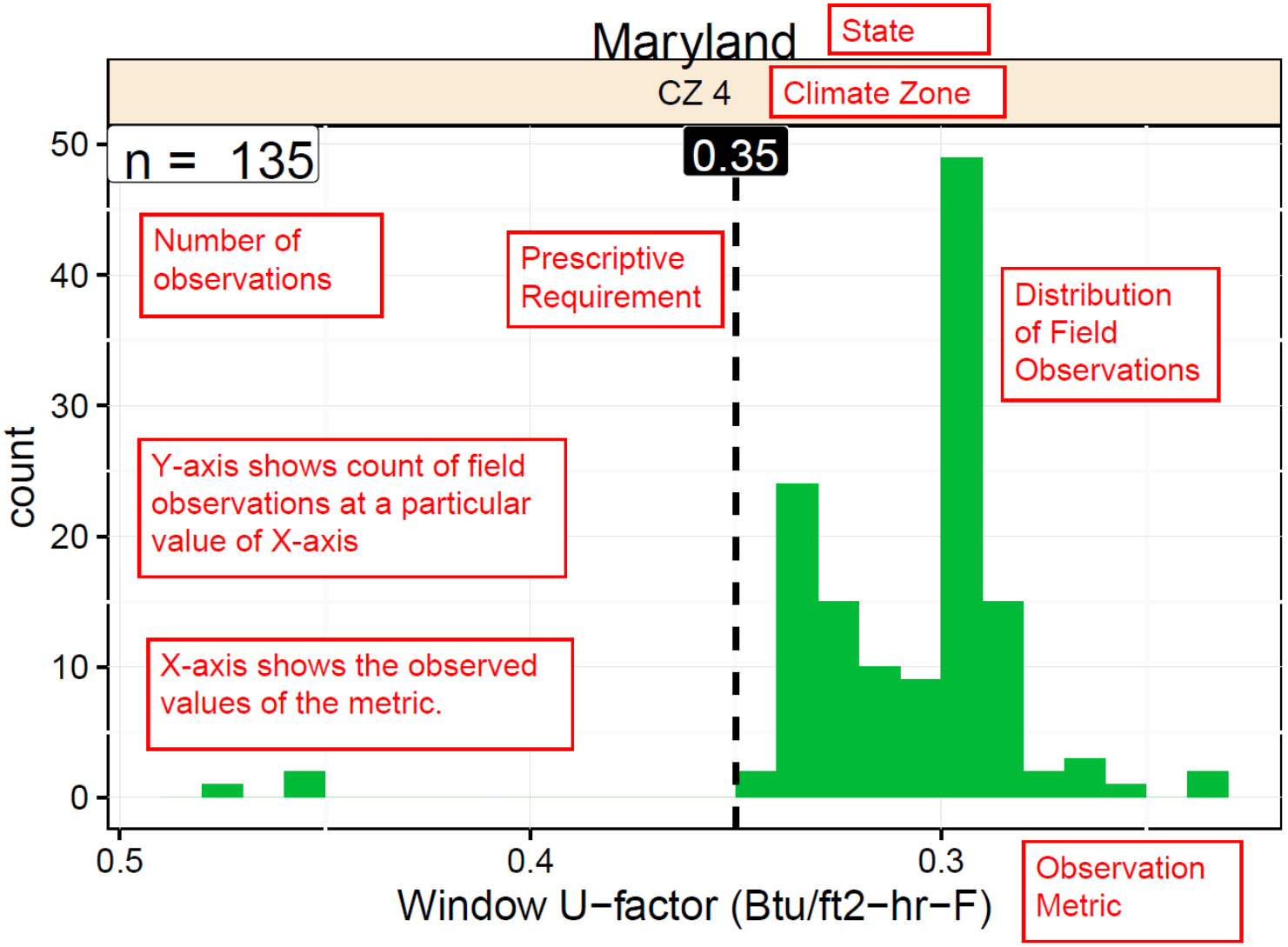
# FINDINGS

# PNNL Analysis

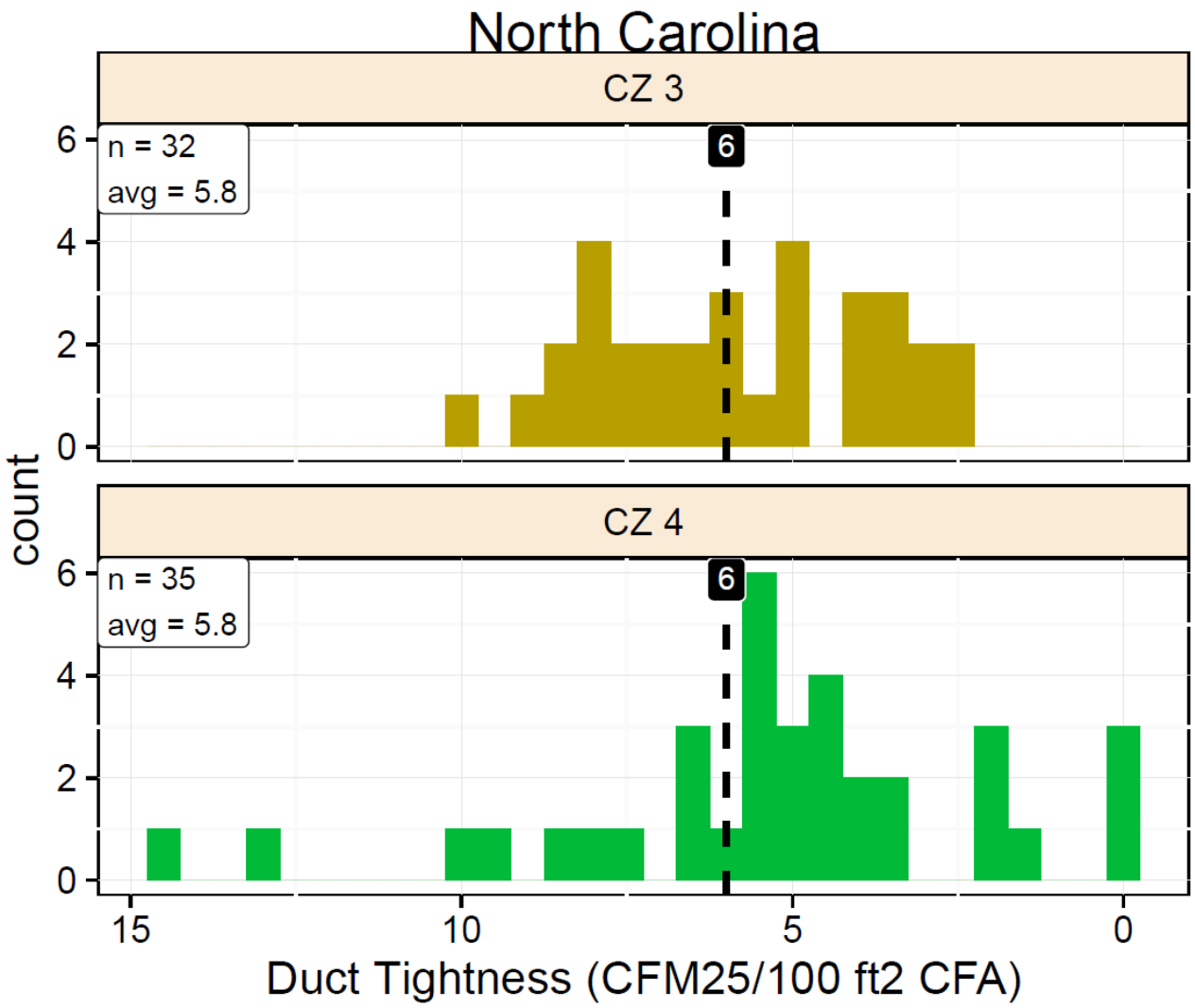
*Three types:*

1. Distribution of **Key Measures** (histograms)
2. Average statewide **EUI** (kBtu/ft$^2$)
3. **Savings** (energy, $, $CO_2$)

# Key Measure (sample)

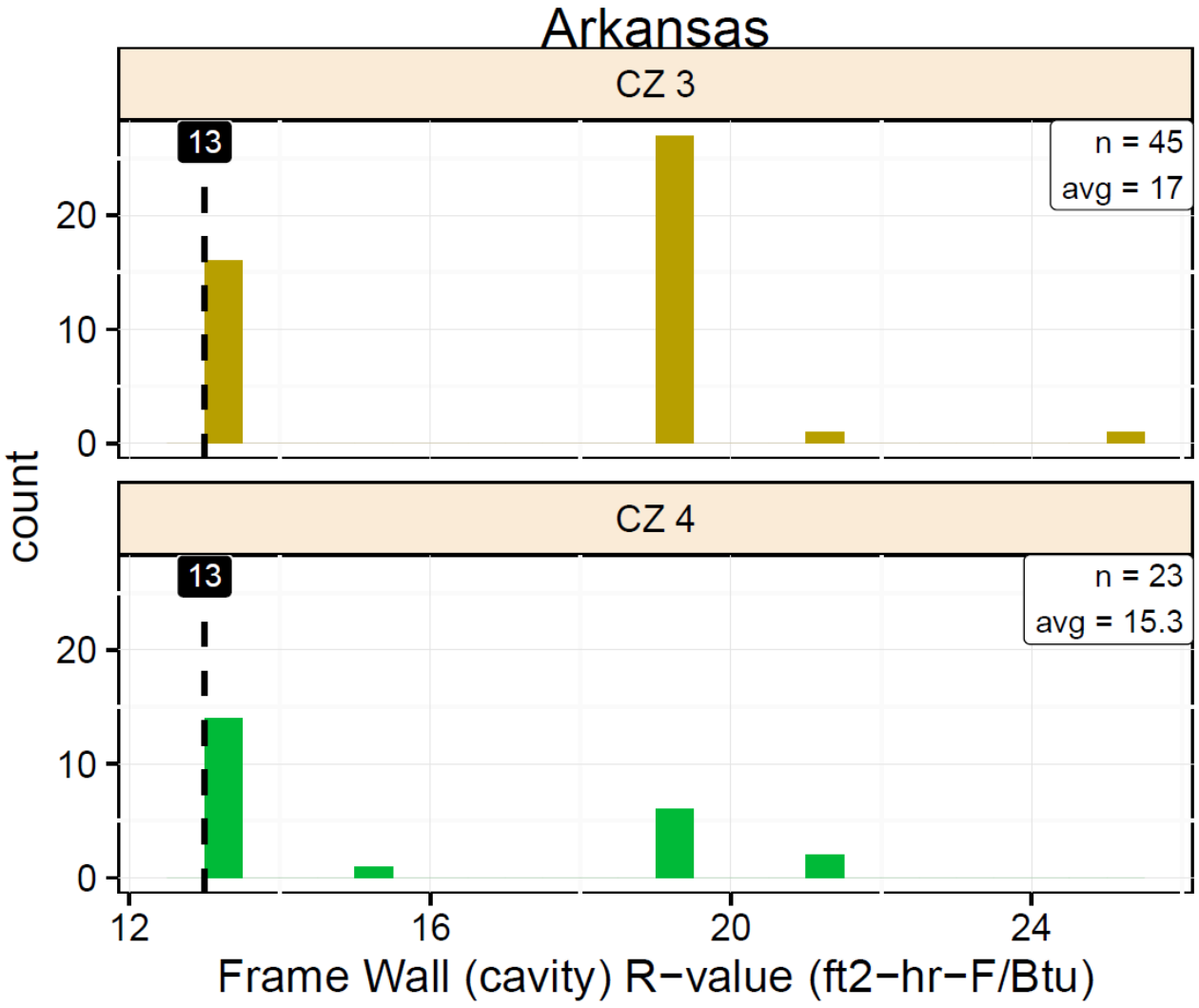


# Duct Tightness




Vertical black line = 2012 North Carolina State Code Requirement

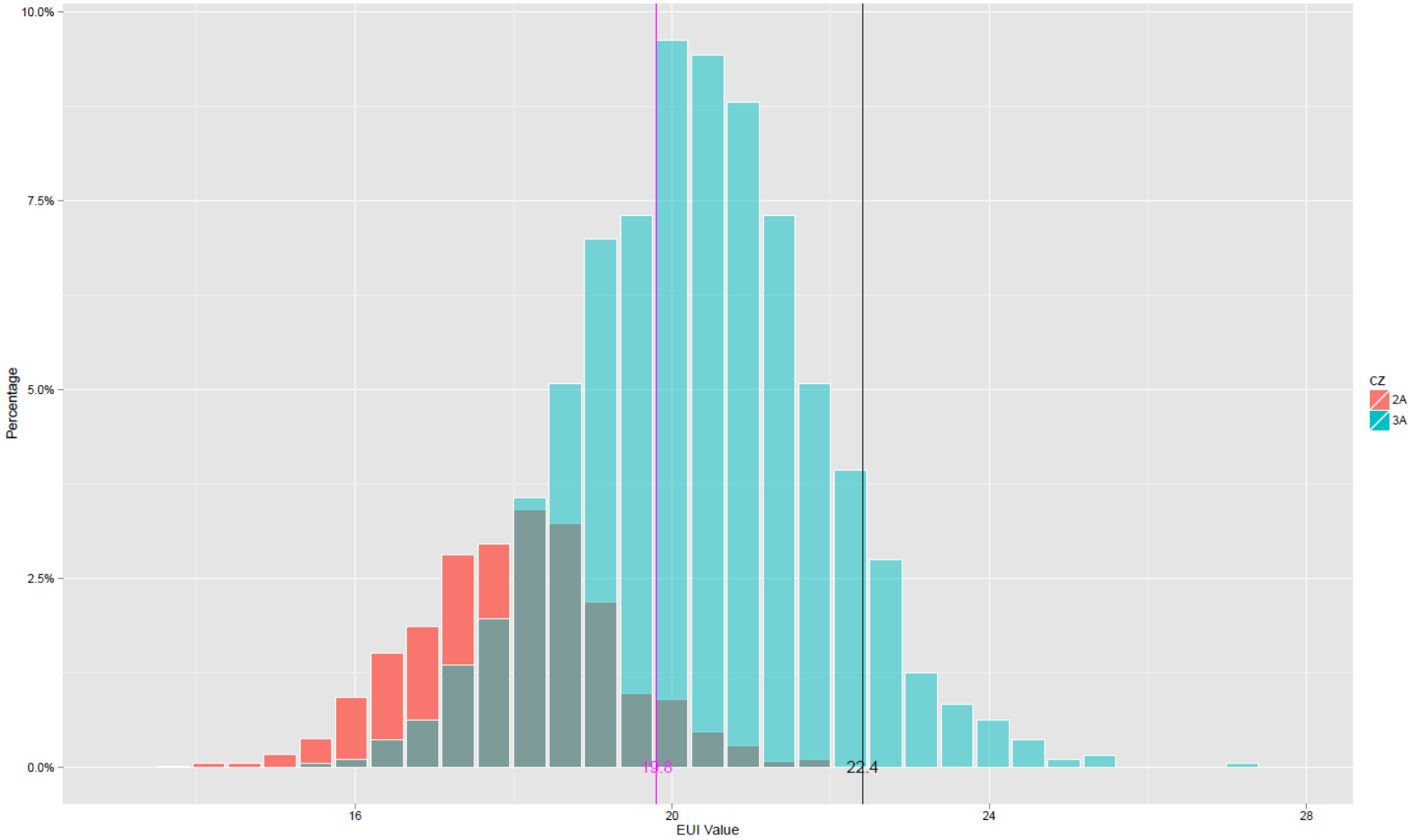
# Frame Wall (Cavity)




Vertical black line = 2009 IECC and 2014 Arkansas State Code Requirement

# Alabama State Simulated EUI vs. 2009 IECC Code-Compliant EUI

Vertical magenta line indicates the weighted average EUI of all simulated models based on observed data.
Vertical black line indicates the weighted average EUI for a 2009 IECC prescriptive code-compliant model.

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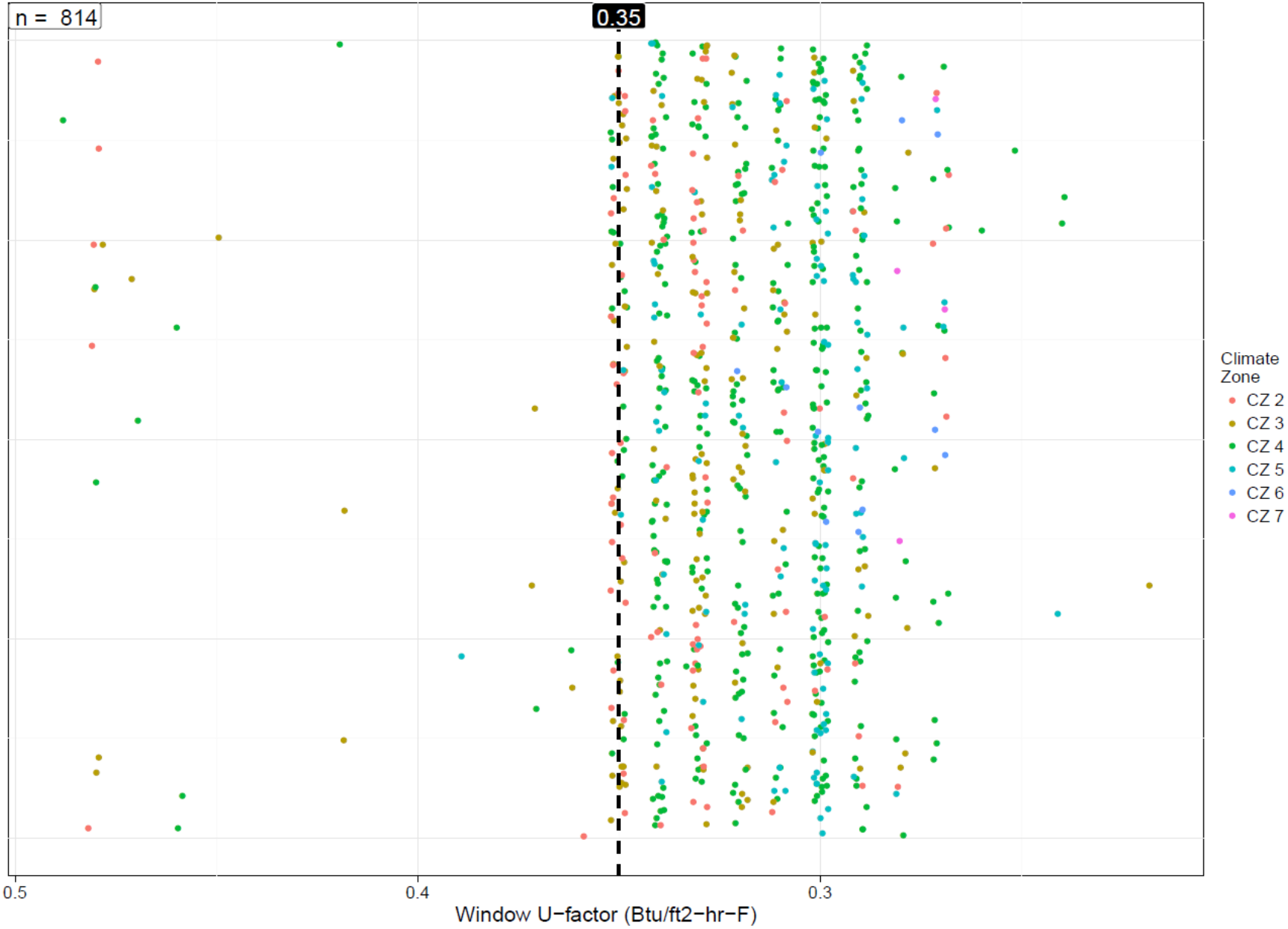
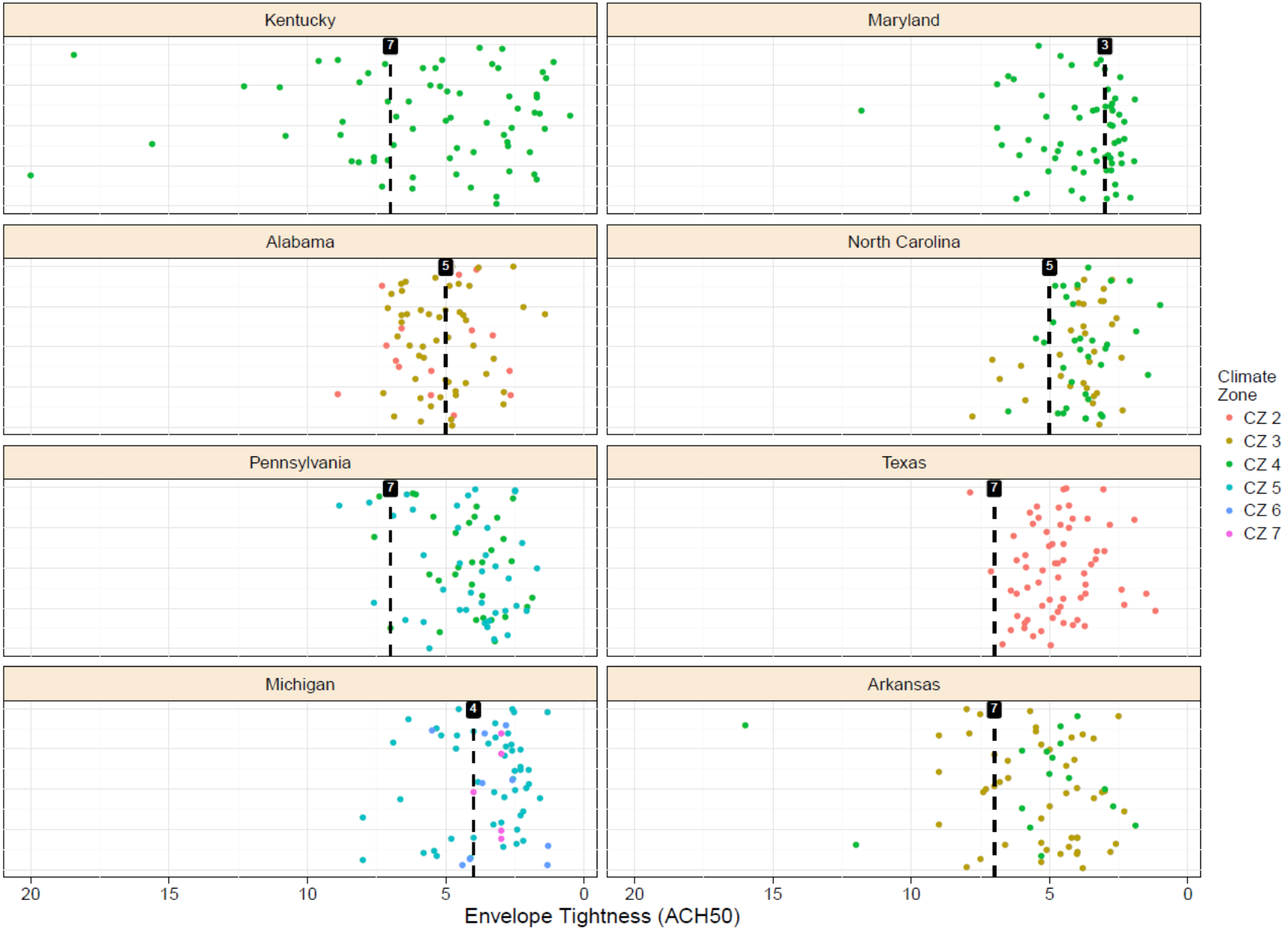
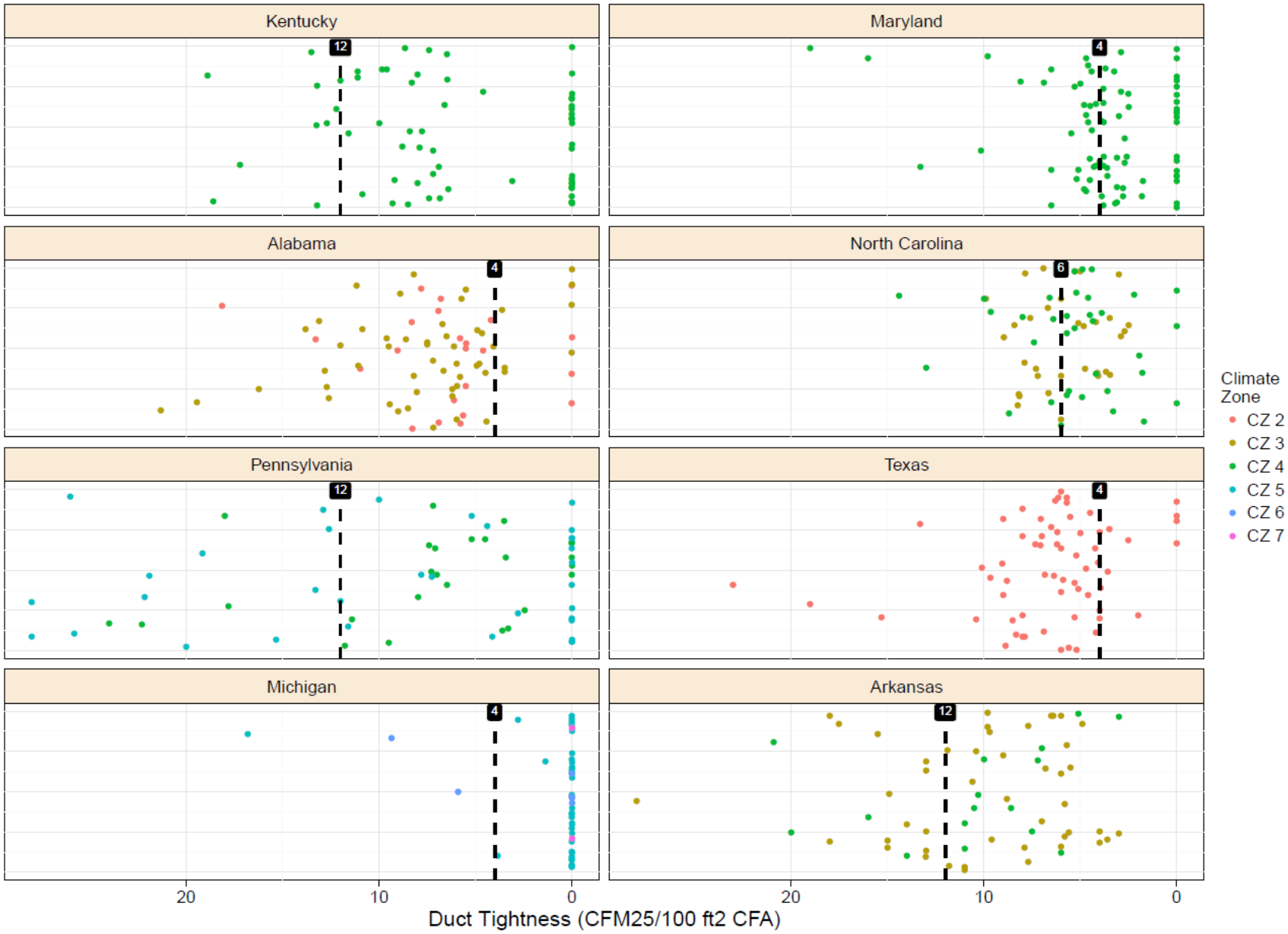
# Window U-Factor



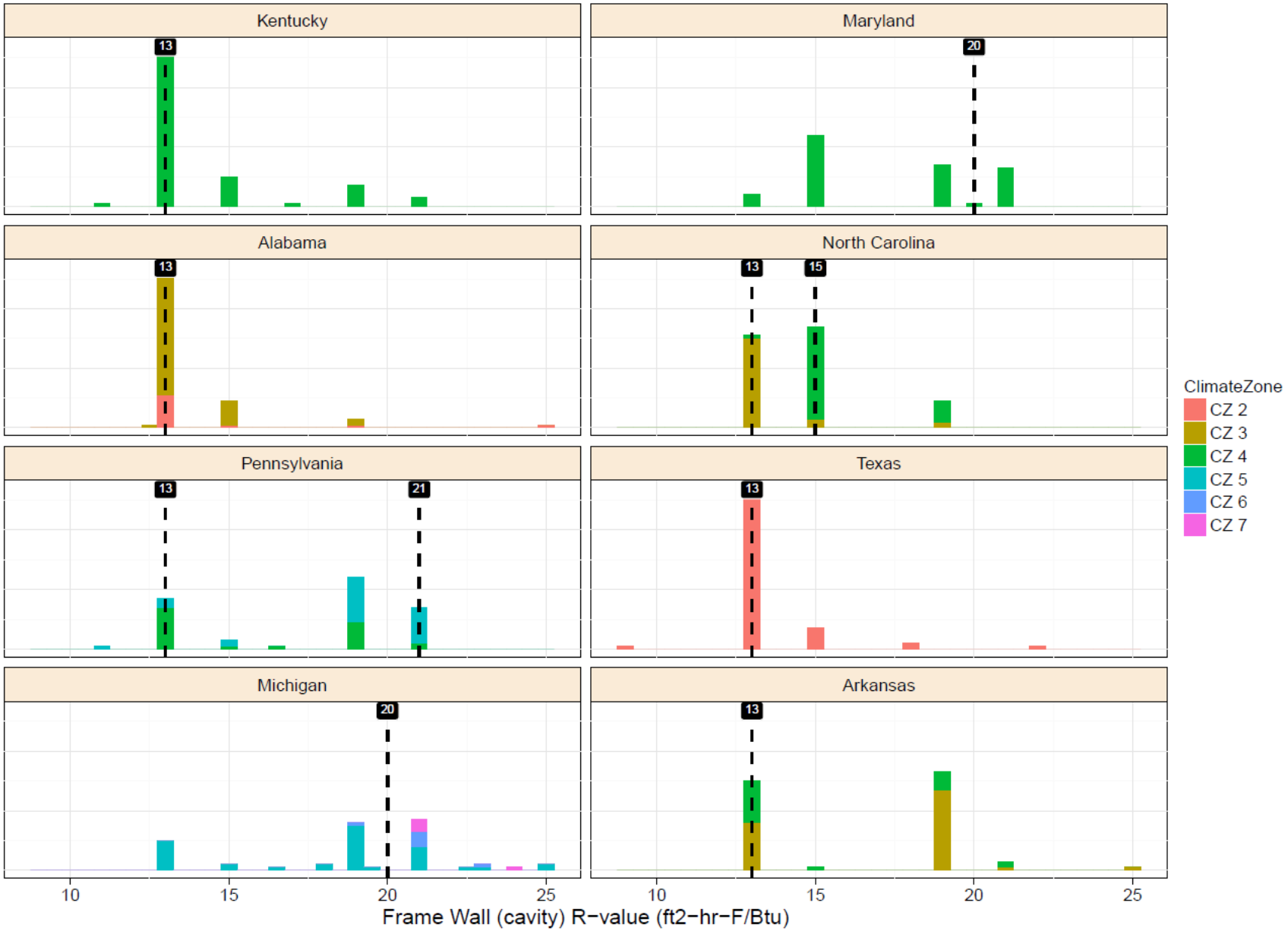
# Envelope Tightness



# Duct Leakage (cfm/100 sf)



# Wall Insulation (Cavity)



# Trends Across States

**Lighting:** No consistent trend—surprisingly low compliance

**Envelope Tightness:** Similar range regardless of requirement

**Duct Leakage:** Similar range regardless of code requirement

**Wall Insulation:** Typically meet label R-values:

+ Generally weak installation quality
+ Similar trend for ceiling insulation

**Windows:** Almost all observations exceed requirement:

+ U-factor *and* SHGC
+ Most better than U-factor=0.35 and SHGC=0.3

# SAVINGS

| State | CZ (state) | Code | EUI (Observed) | Target Measures (% Compliance) | Savings (Annual) |
|---|---|---|---|---|---|
| **AL** | **2A, 3A** | 2009 IECC* | 19.81 | Duct Leakage (88%) | $ 395,063 |
| | | | | Lighting (35%) | $ 385,451 |
| | | | | Envelope Tightness | $ 263,089 |
| | | | | Wall Insulation | $ 201,105 |
| | | | | Window SHGC | $ 54,674 |
| **AR** | **3A, 4A** | 2009 IECC* | 27.73 | Duct Leakage | $ 128,798 |
| | | | | Envelope Tightness | $ 104,022 |
| | | | | Wall Insulation | $ 57,863 |
| | | | | Window SHGC | $ 28,557 |
| **KY** | **4A** | 2009 IECC | 31.51 | Envelope Tightness (70%) | $ 484,314 |
| | | | | Lighting (30%) | $ 197,544 |
| | | | | Wall Insulation | $ 171,044 |
| | | | | Duct Leakage (72%) | $ 57,064 |
| **MD** | **4A** | 2015 IECC | 30.49 | Envelope Tightness (48%) | $ 754,946 |
| | | | | Wall Insulation (27%) | $ 401,480 |
| | | | | Lighting (61%) | $ 195,378 |
| | | | | Duct Leakage (49%) | $ 146,619 |
| | | | | Ceiling Insulation (72%) | $ 44,366 |

| State | CZ (state) | Code | EUI (Observed) | Target Measures (% Compliance) | Savings (Annual) |
|---|---|---|---|---|---|
| **MI** | **5A, 6A, 7A** | 2015 IECC* | 39.72 | Lighting (34%) | $ 931,667 |
| | | | | Wall Insulation | $ 585,950 |
| | | | | Envelope Tightness | $ 488,334 |
| **NC** | **3A, 4A**, 5A | 2009 IECC* | 22.99 | Lighting (57%) | $ 607,598 |
| | | | | Duct Leakage (62%) | $ 386,073 |
| | | | | Envelope Tightness (88%) | $ 244,617 |
| **PA** | **4A, 5A**, 6A | 2009 IECC | 41.34 | Duct Leakage (42%) | $ 733,592 |
| | | | | Wall Insulation (69%) | $ 264,734 |
| | | | | Lighting (62%) | $ 188,283 |
| **TX** | **2A**, 3A, 2B, 3B, 4B | 2015 IECC | 21.08 | Wall Insulation | $ 5,029,864 |
| | | | | Envelope Tightness | $ 4,656,869 |
| | | | | Duct Leakage | $ 3,582,893 |
| | | | | Lighting (62%) | $ 2,774,421 |
| | | | | Ceiling Insulation | $ 443,058 |

# CONCLUSIONS

# Preliminary Conclusions

+ Builders and building officials are doing a very good job meeting adopted codes
+ Many homes are using less energy than would be expected based on prescriptive codes (5 of 6 six states)
+ There is still significant savings potential from individual code requirements:
  - Some are consistently better than code (e.g. windows)
  - Some are inconsistent with code (e.g. lighting)
  - Some are virtually always exactly at code (e.g. walls)
  - Nothing is consistently worse than code
+ Similar studies underway—more data to come!
+ Field studies are critical to understanding the patterns of compliance and their impact on energy

# Planning a Study?

## Available Support:

+ Budgeted cost was $115,000 per baseline study
  - Adequate in almost all states
+ PNNL services available free to those following methodology:
  - Sample design
  - Customized data collection forms
  - Analysis
+ Commercial methodology under development (targeted late 2017)

# Available Resources

**For more information:**

- Spreadsheets containing all field data
- Webinar presentation
- Methodology guideline (coming soon)
- Technical support document (coming soon)
- State project reports (coming soon)
- Overall project report (following Phase III)

## Residential Energy Code Field Study:

https://www.energycodes.gov/residential-energy-code-field-study

www.energycodes.gov