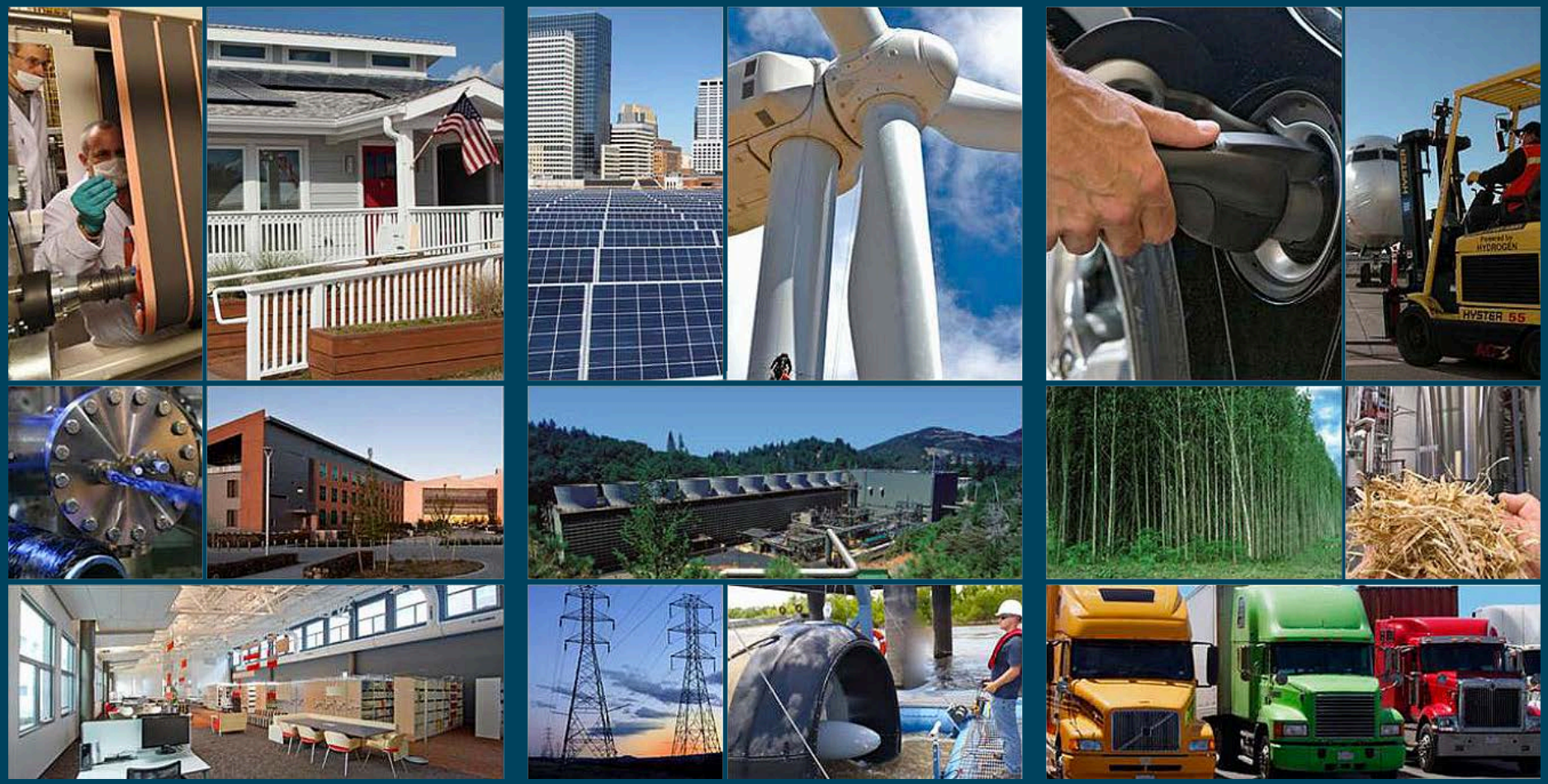
Building Energy Codes Program

Residential Energy Code Field Study



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2016 National Energy Codes Conference

March 22, 2016
Tucson, AZ

BACKGROUND

Residential Energy Code Field Study

Why the federal interest?

+ *Compliance is key* to ensuring savings
+ Largely unknown—issues with past studies

Compliance ≠ Energy Savings

Research Project:

+ Issued $6M FOA directed at this problem
+ Resulted in projects across 8 states
+ Additional states have initiated studies

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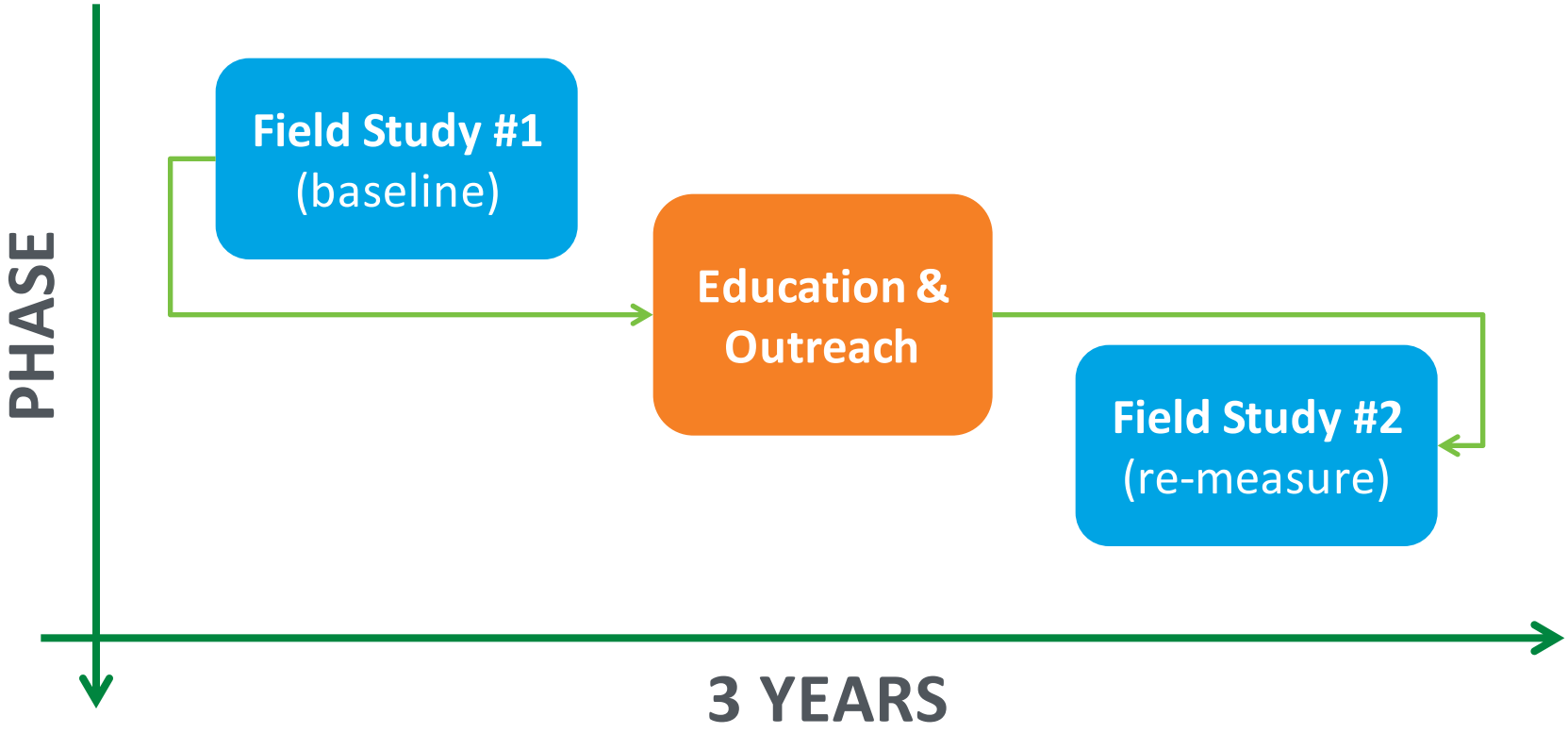
Residential Energy Code Field Study

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

Compliance is *Key*



DOE Residential Energy Code Field Study:
https://www.energycodes.gov/compliance/residential-energy-code-field-study

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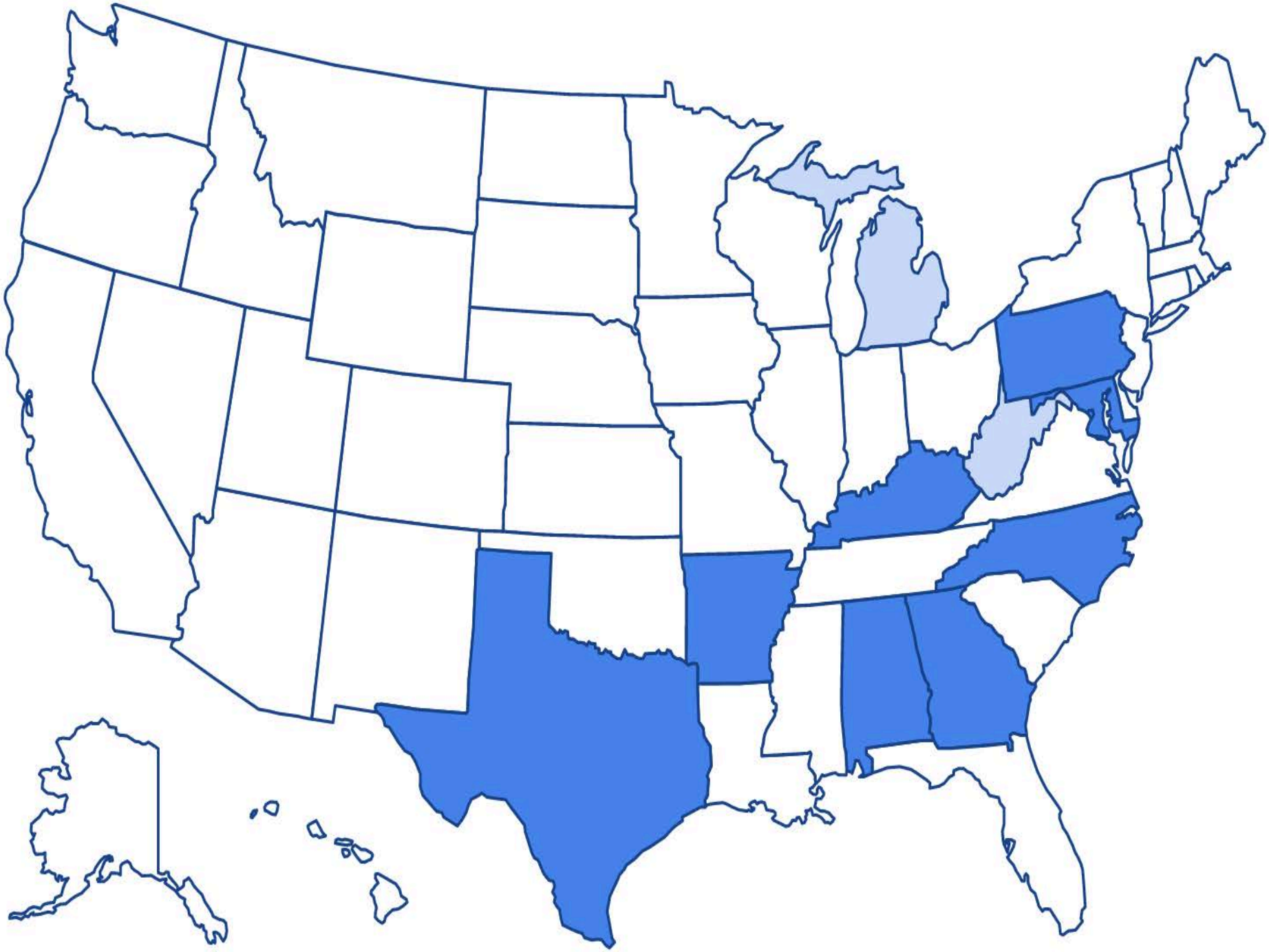

STATE	LEAD	BASE CODE	STATUS
AL	Institute for Market Transformation	2015 Alabama State Energy Code (2009 IECC w/ amendments)	Complete
AR	Southeast Energy Efficiency Alliance	2014 Arkansas State Energy Code (2009 IECC w/ amendments)	Complete
GA	Southeast Energy Efficiency Alliance	GA State Energy Code (2009 IECC w/ amendments)	*Pending*
KY	Midwest Energy Efficiency Alliance	2009 IECC	Complete
MD	Maryland Energy Administration	2015 IECC	Complete
*MI	Navigant	2015 Michigan State Energy Code (2015 IECC w/ amendments)	Complete
NC	Appalachian State University	2012 North Carolina State Energy Code (2009 IECC w/ amendments)	Complete
PA	Performance Systems Development	2009 IECC (2009 IRC)	Complete
TX	National Association of State Energy Officials	2015 IECC	Complete
*WV	Appalachian Residential Consortium for EE	2009 IECC	*Pending*

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

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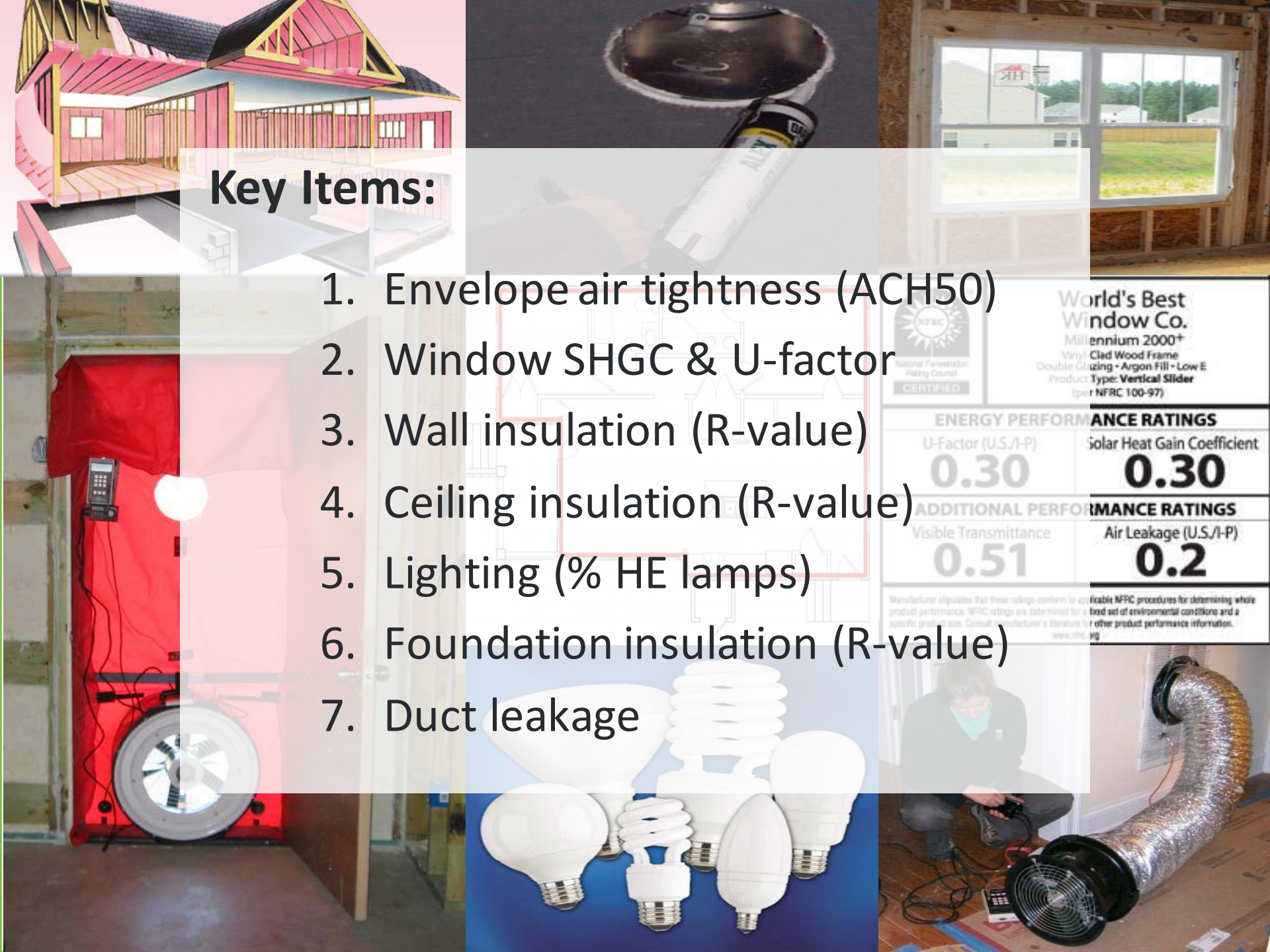

Key Items:

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)

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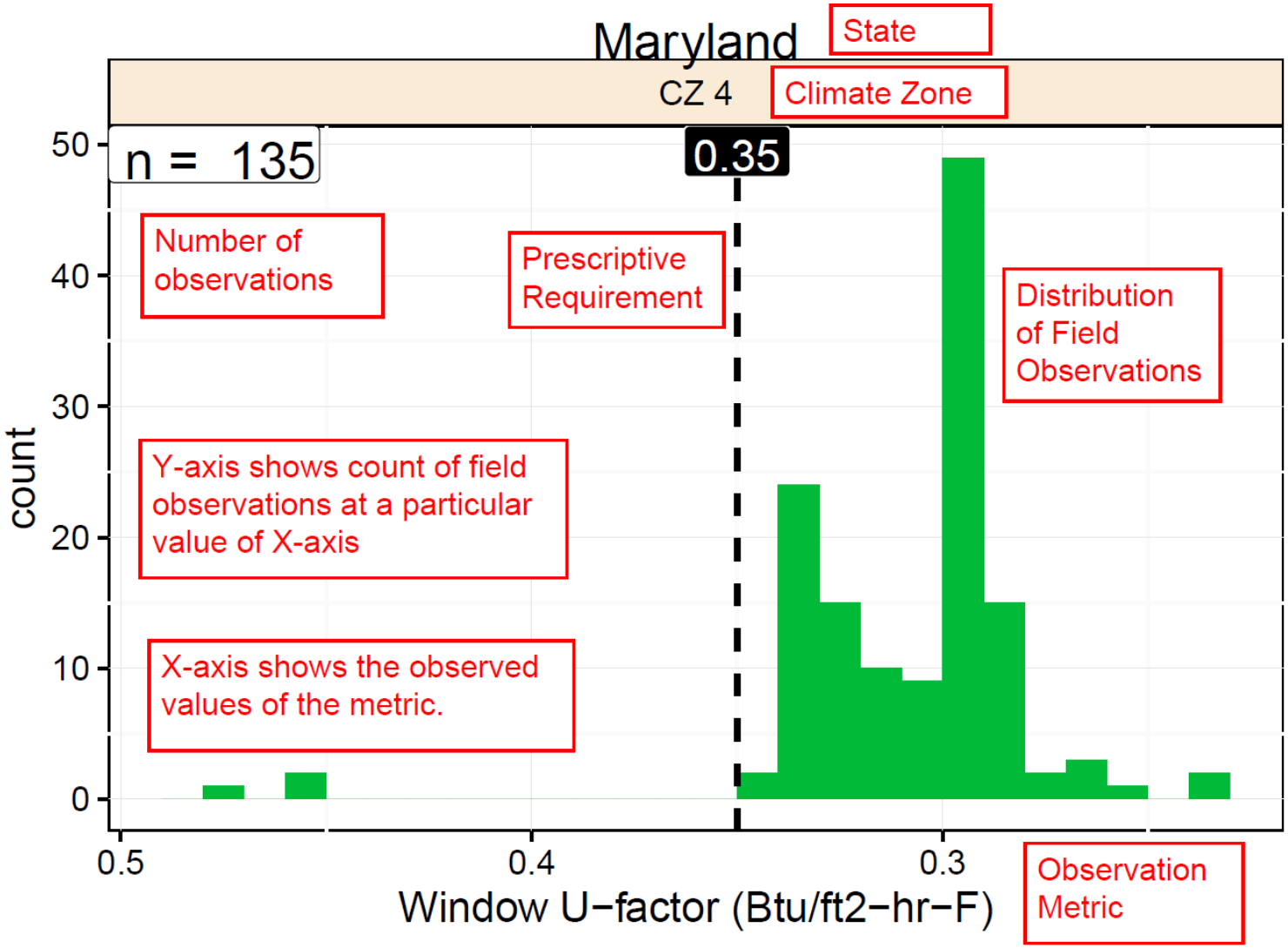
Key Measure (sample)



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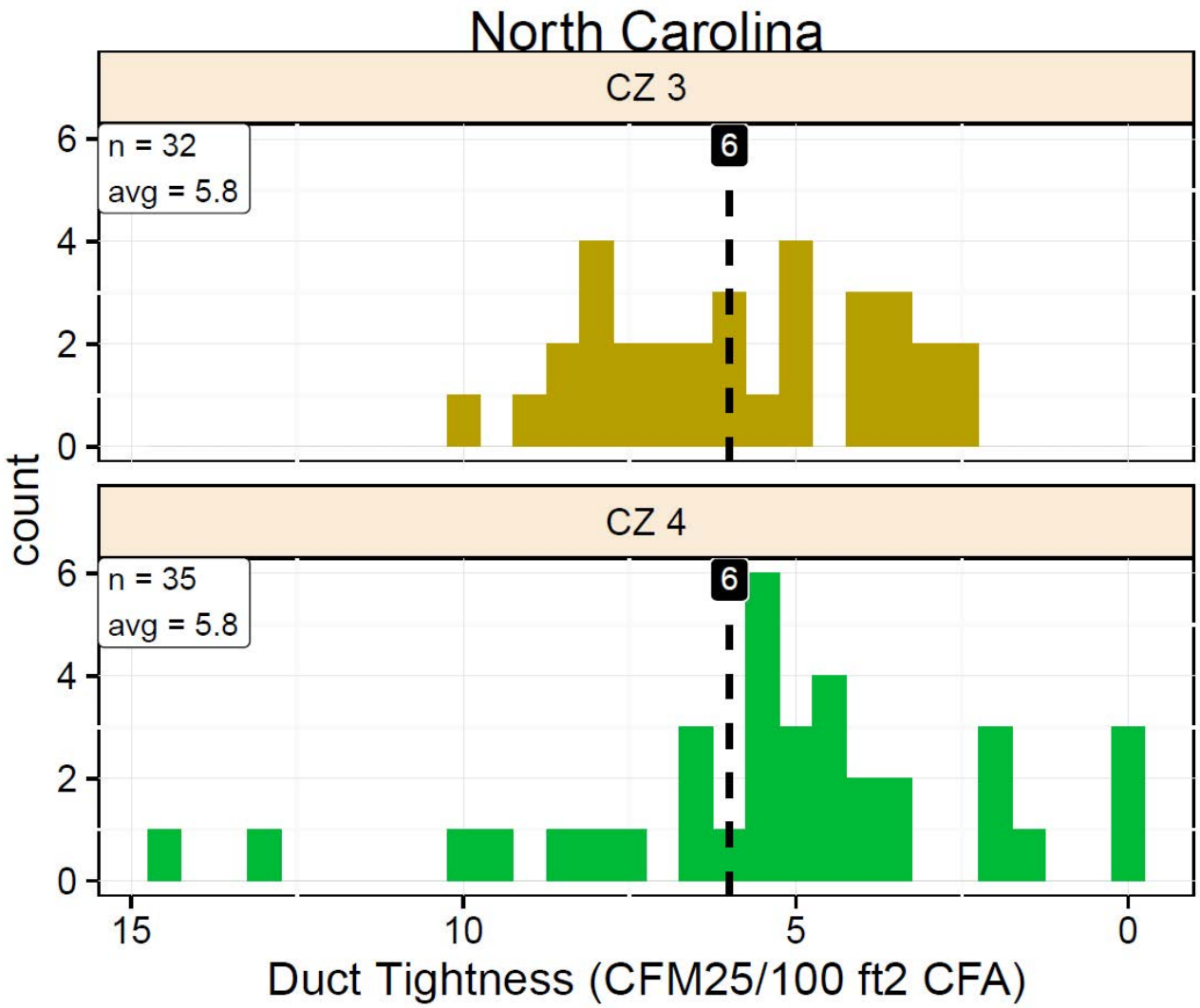
Duct Tightness



Vertical black line = 2012 North Carolina State Code Requirement

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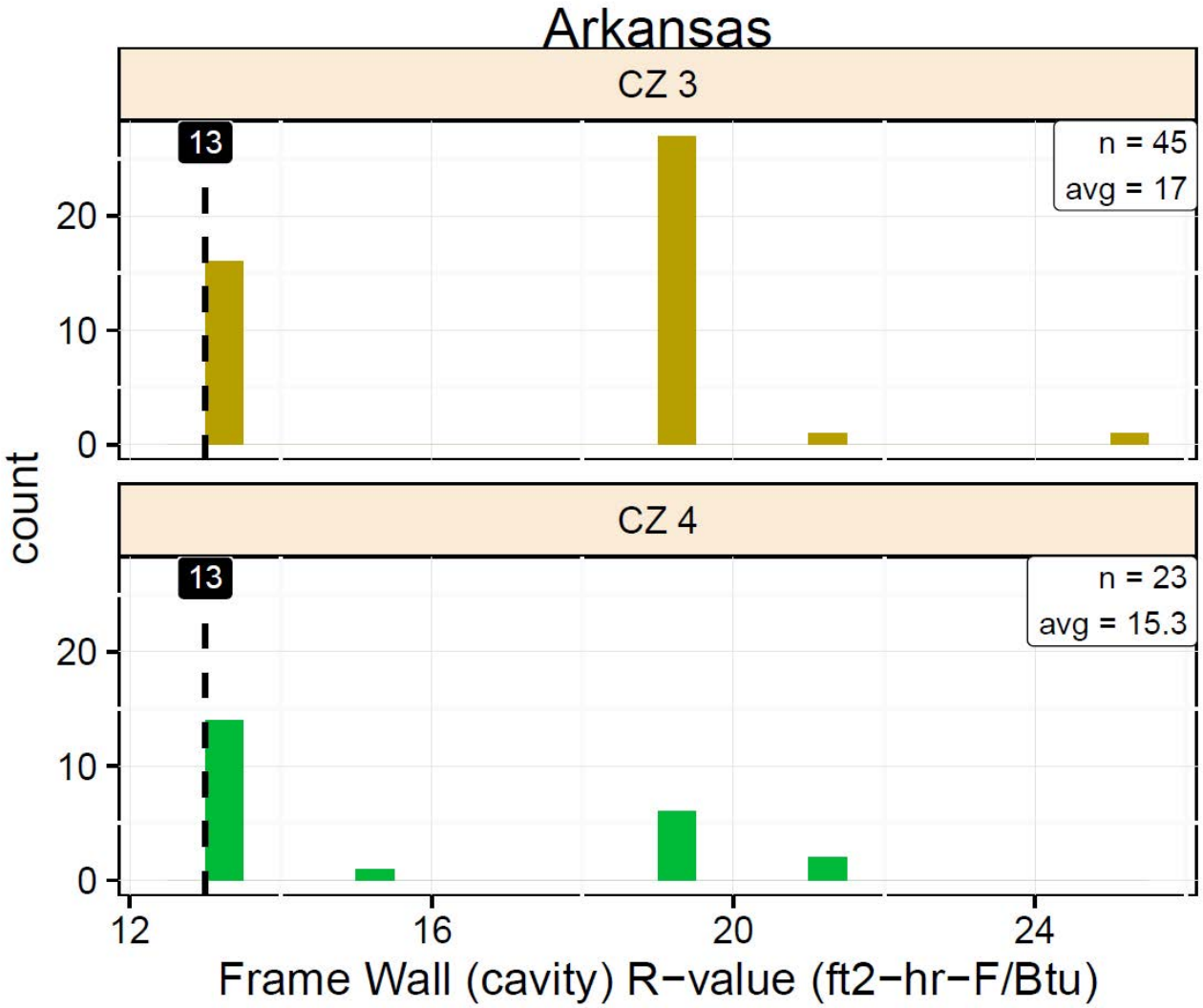
Frame Wall (Cavity)



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

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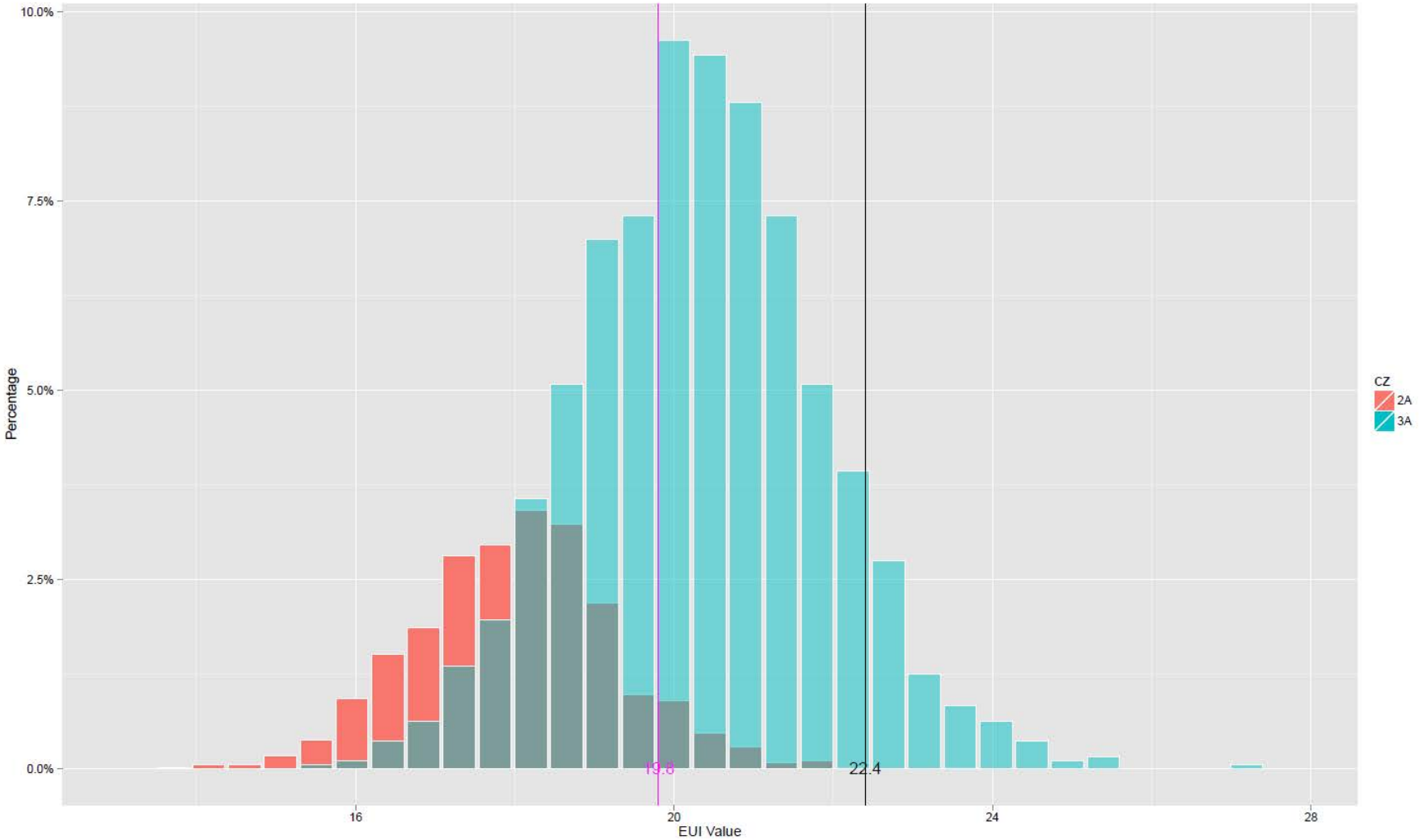
Alabama State Simulated EUI vs. 2009 IECC Code-Compliant EUI

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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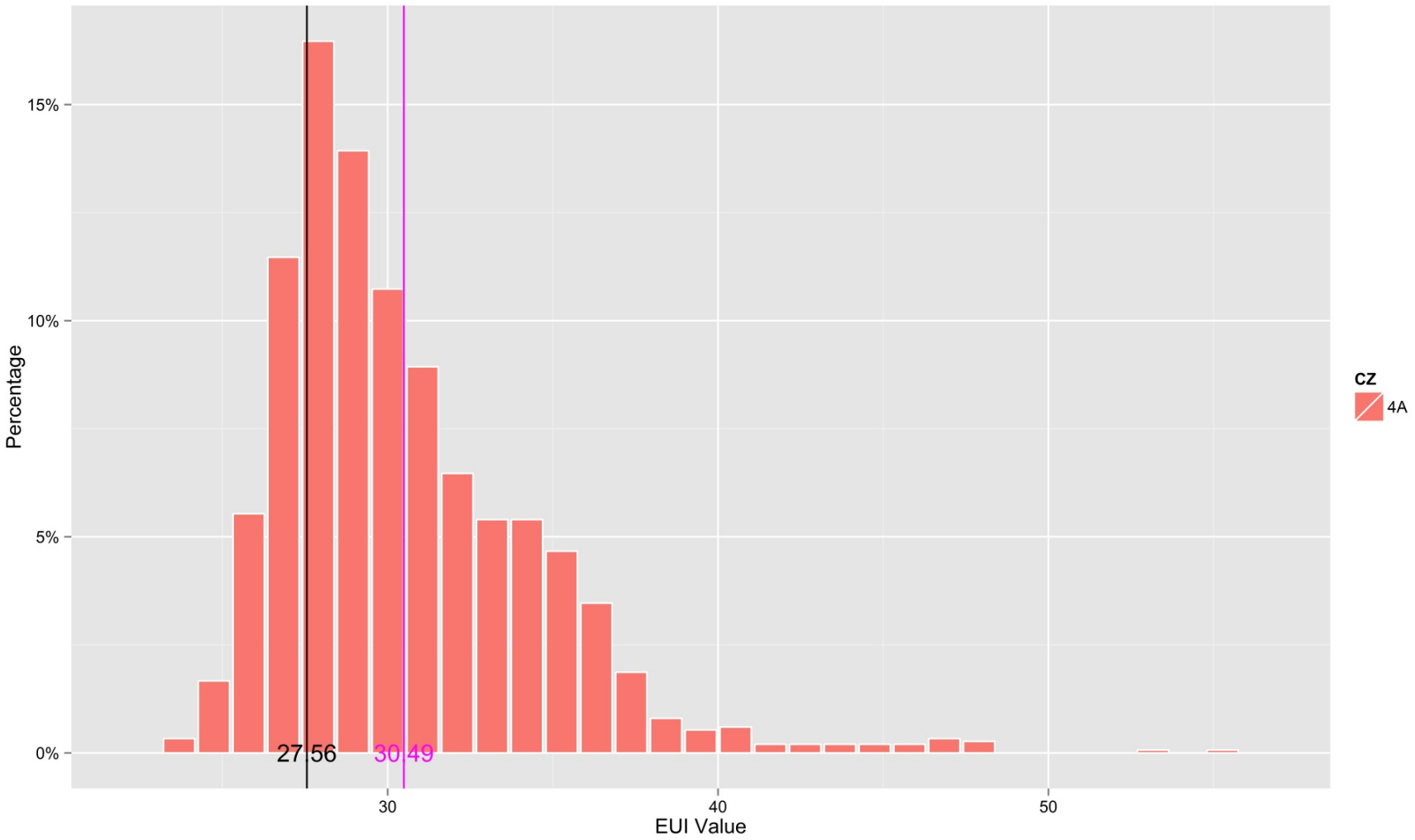
Maryland State Simulated EUI vs. 2015 IECC Code Compliant EUI

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 2015 IECC code-compliant model.



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Lighting

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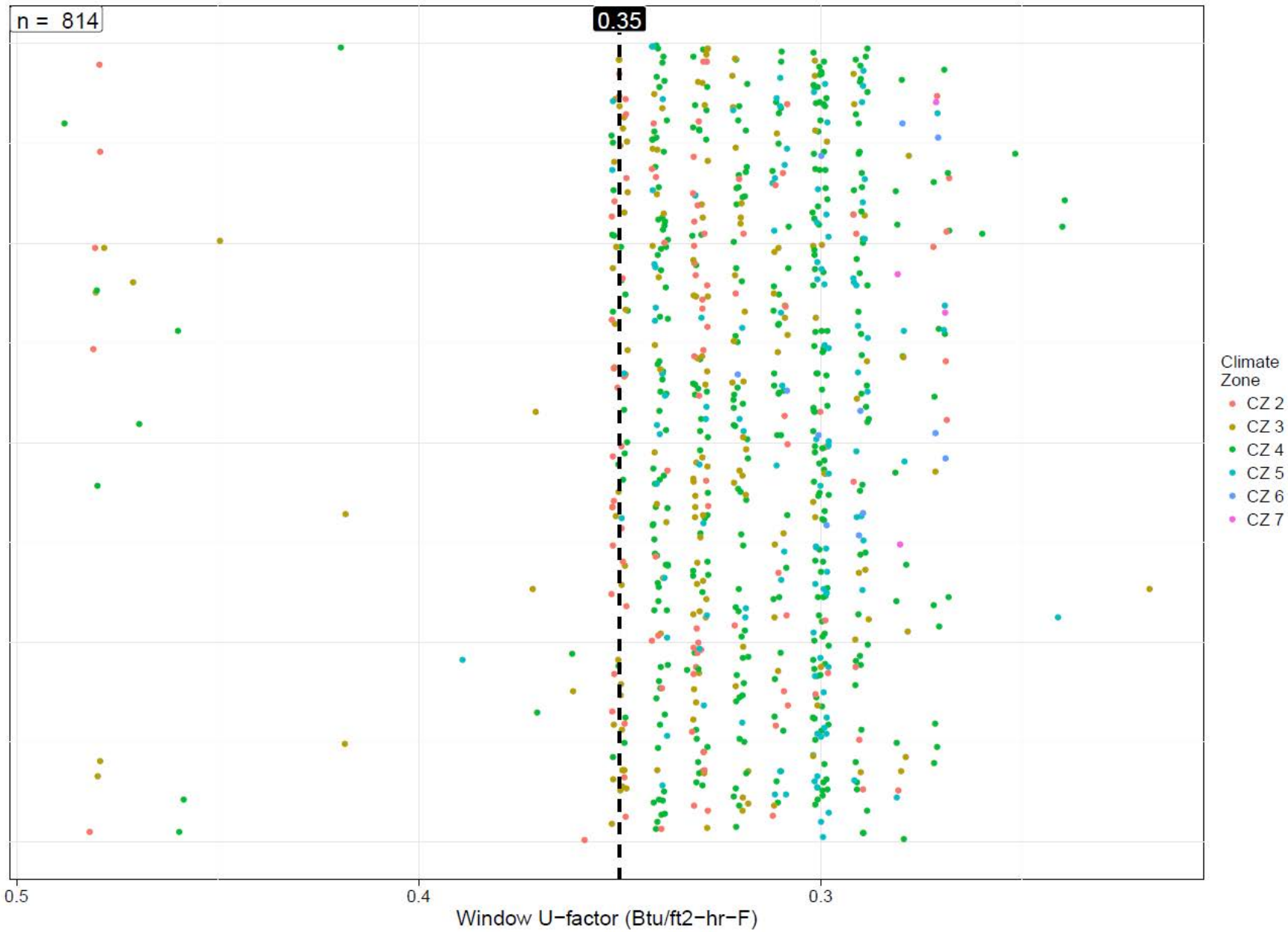
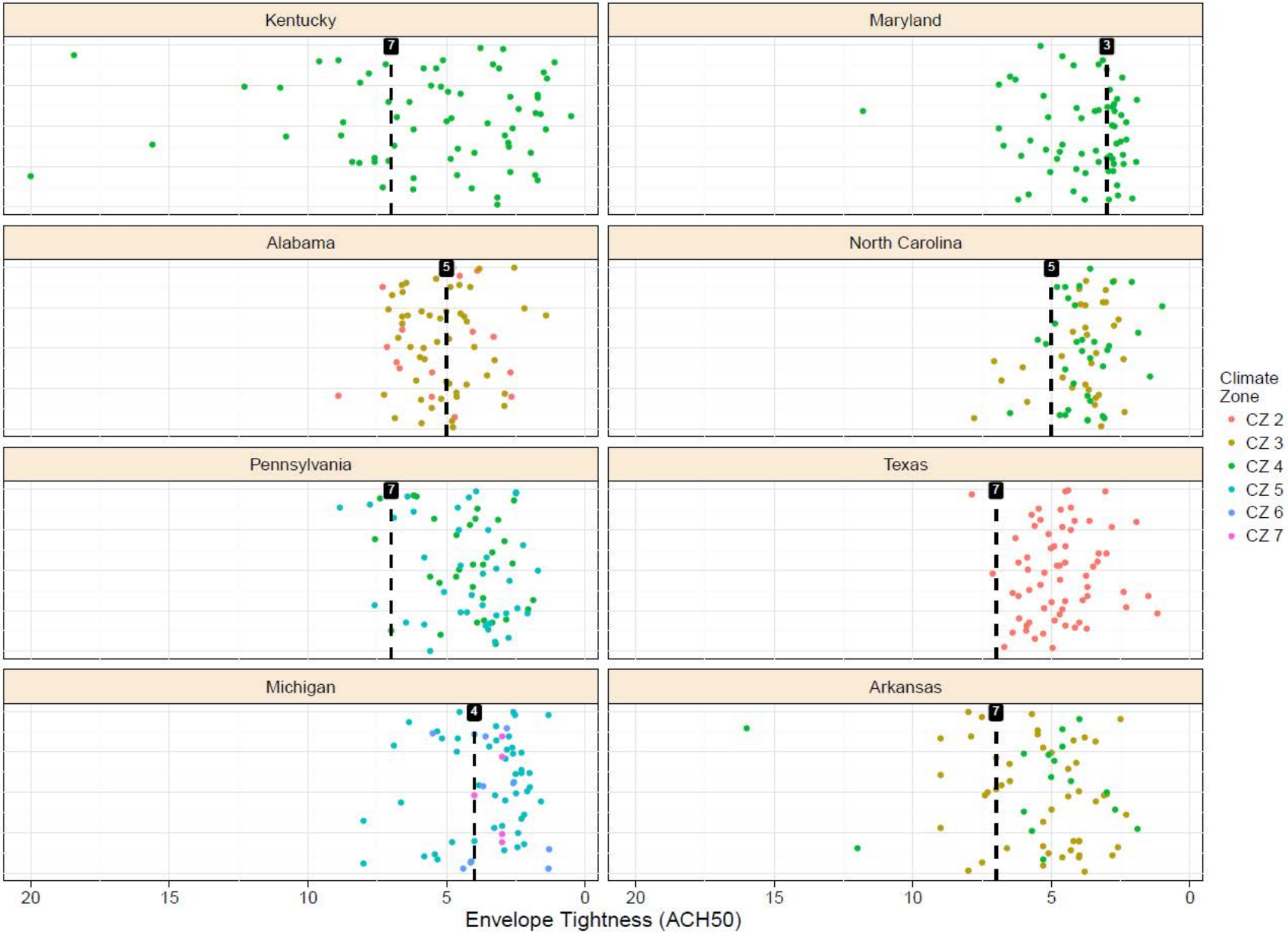
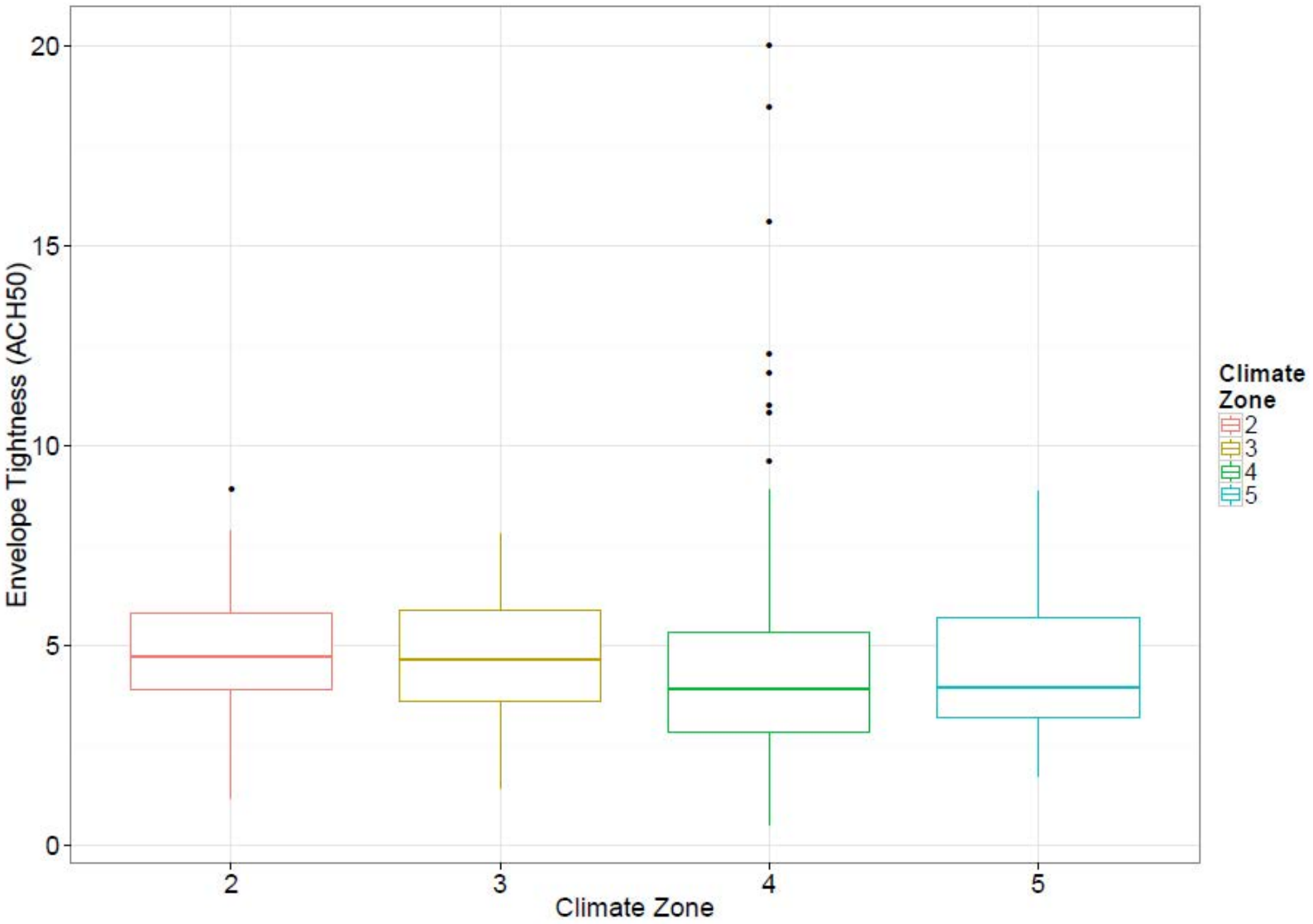
Window U-Factor



Envelope Tightness



Envelope Tightness



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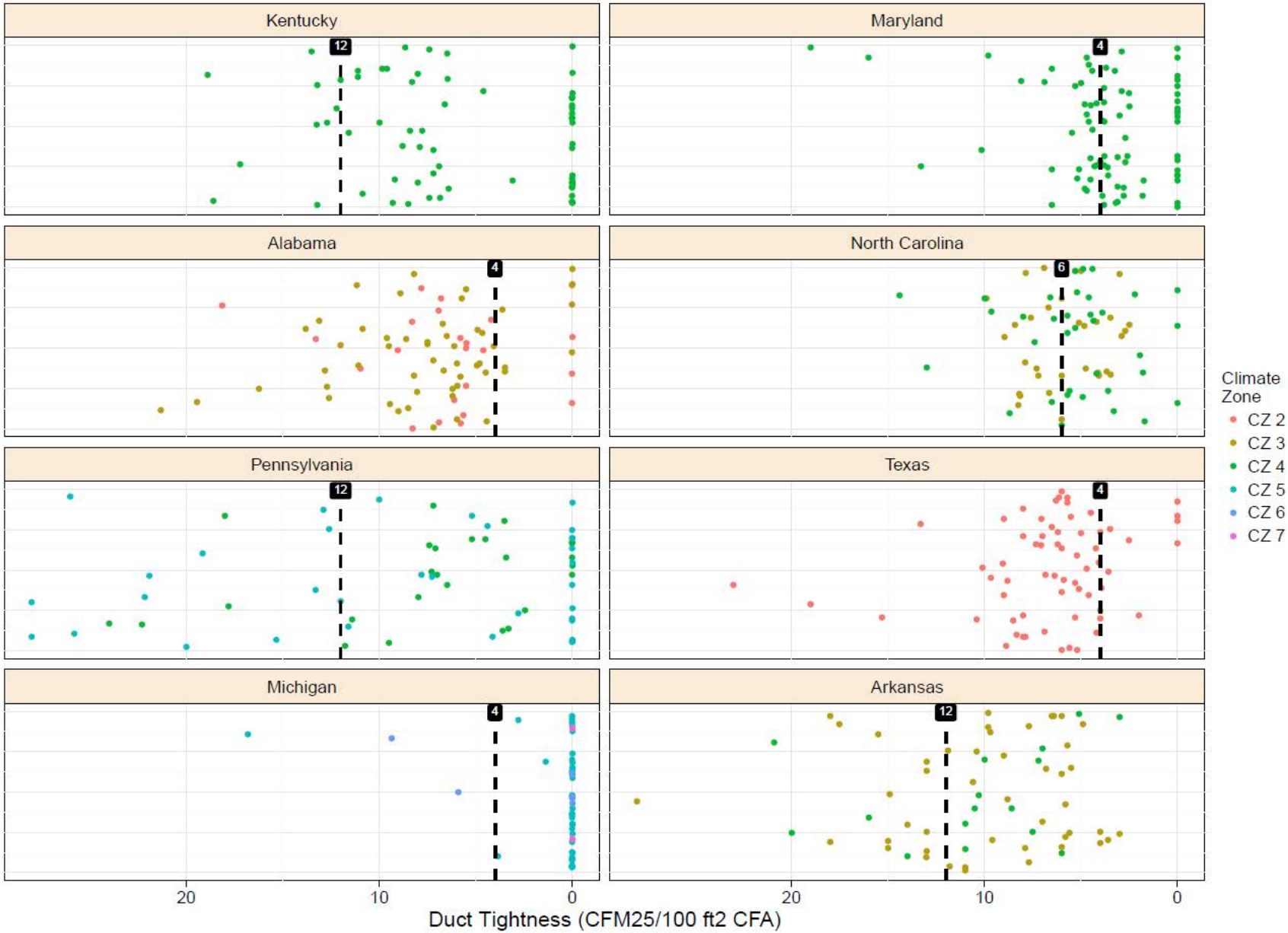
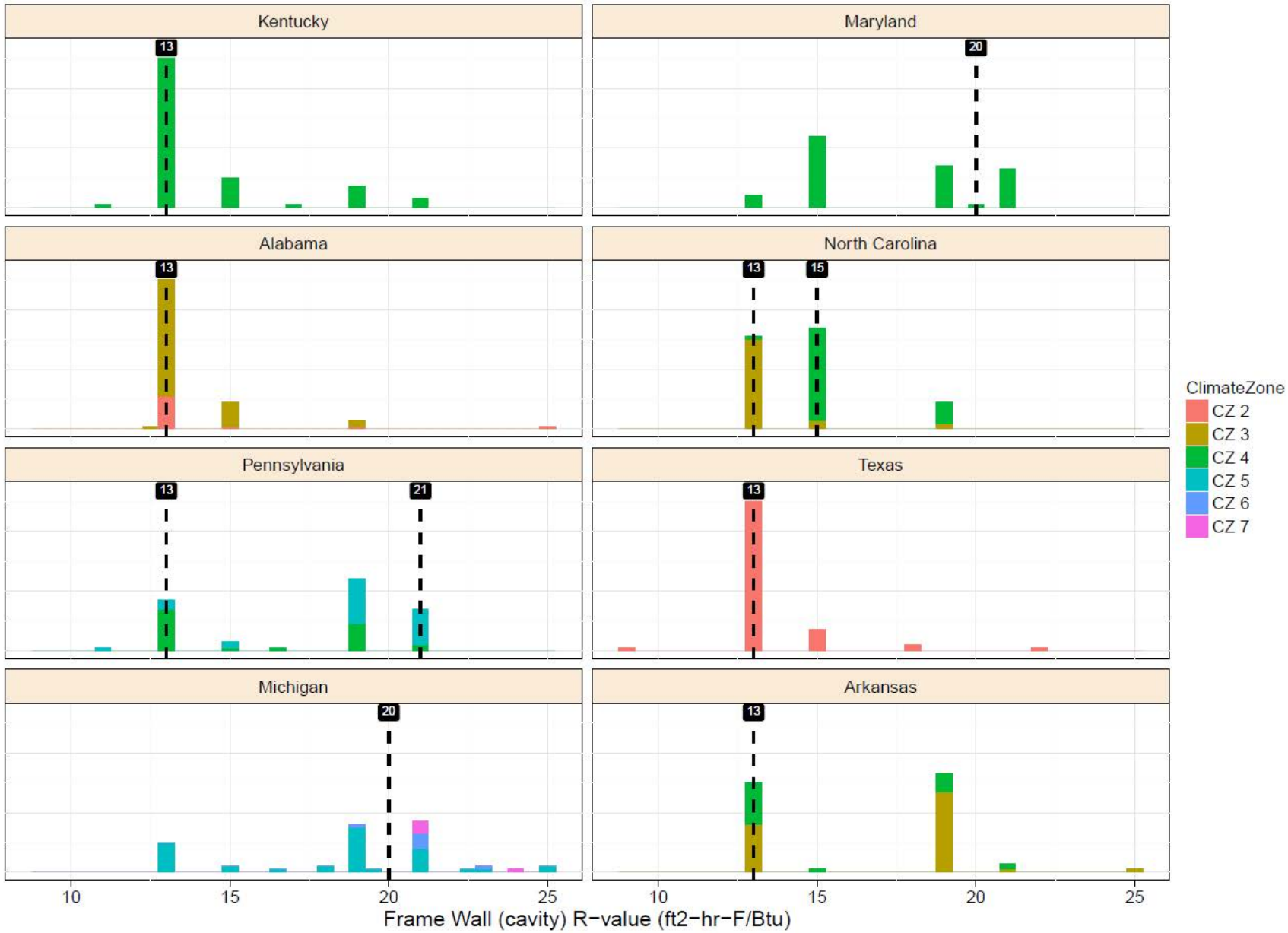
Duct Leakage (cfm/100 sf)



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

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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

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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

2016 National Codes Conference

March 21-24, 2016 | Tucson, AZ

The only national conference dedicated to all things energy codes!

Visit: www.energycodes.gov

Contact: Jeremy Williams, *Project Manager*
jeremy.williams@ee.doe.gov

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