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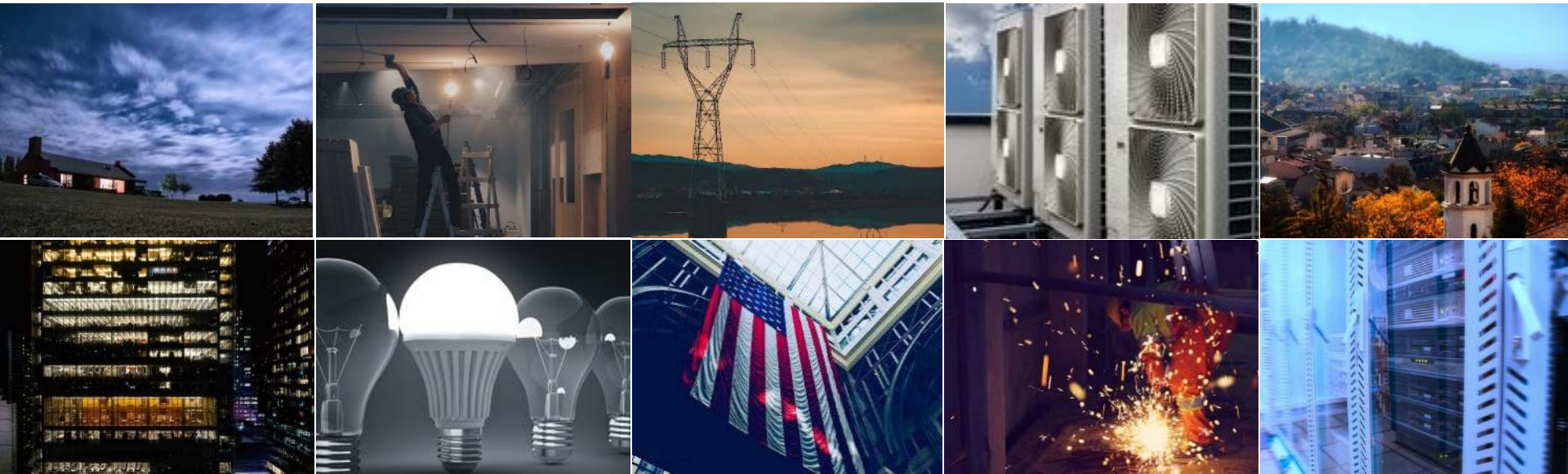
ENERGY CODE COMPLIANCE META-ANALYSIS:

A Multi-state Field Study Initiative in the U.S.

EBC Building Energy Codes Working Group

JEREMY WILLIAMS U.S. Department of Energy



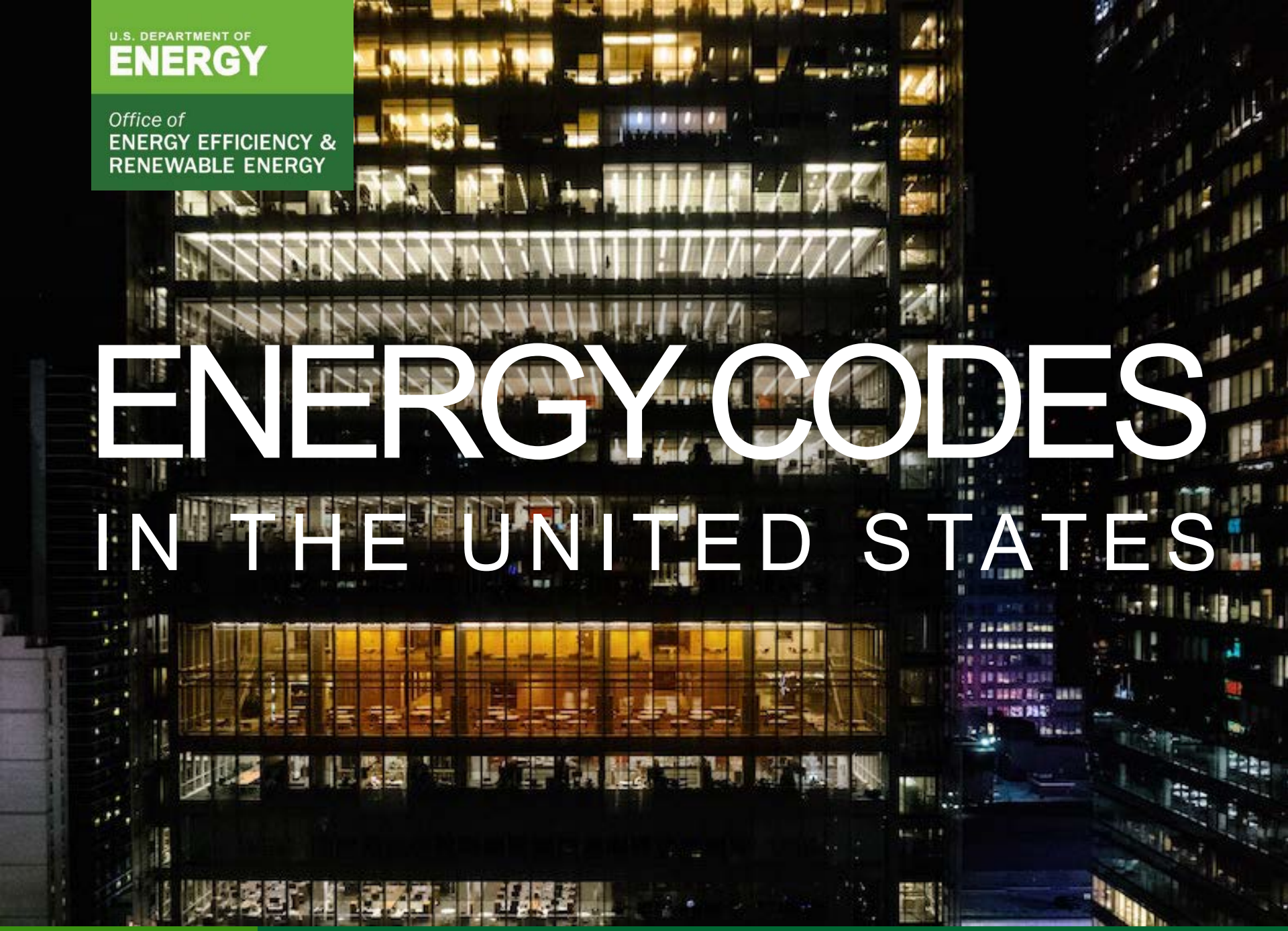
INTRODUCTION

BACKGROUND: Building Energy Codes in the U.S.

META-ANALYSIS STUDY:

+ Objectives
+ Methodology
+ Key Takeaways

> Q+A and DISCUSSION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ENERGY CODES
IN THE UNITED STATES

Energy Codes in the United States

DEVELOPMENT:

+ Model codes are developed at the national level:
  - International Energy Conservation Code (IECC)
  - ANSI/ASHRAE/IES Standard 90.1

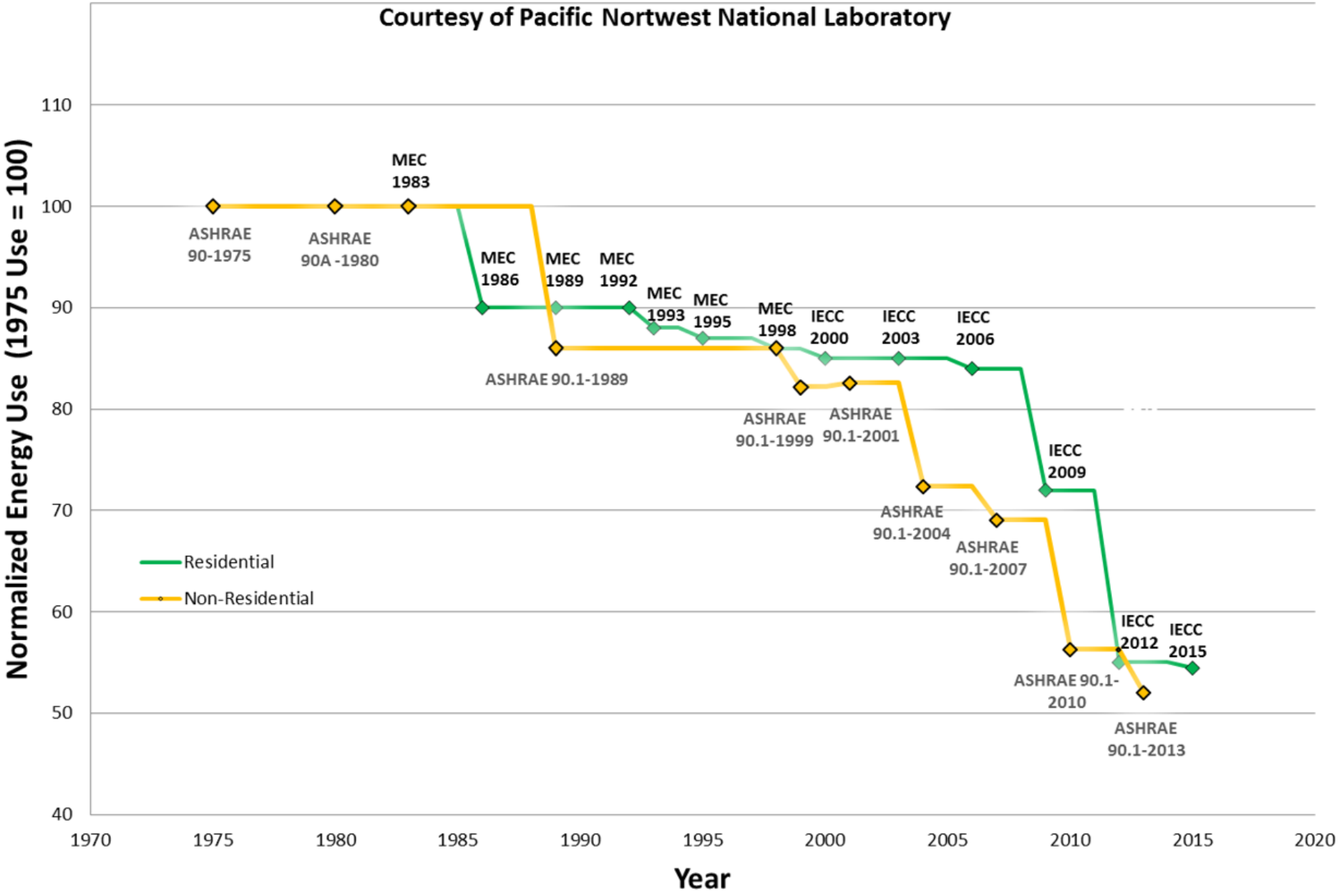
ADOPTION:

+ Codes are adopted into law at the state and local level
+ Typically via administrative or legislative processes

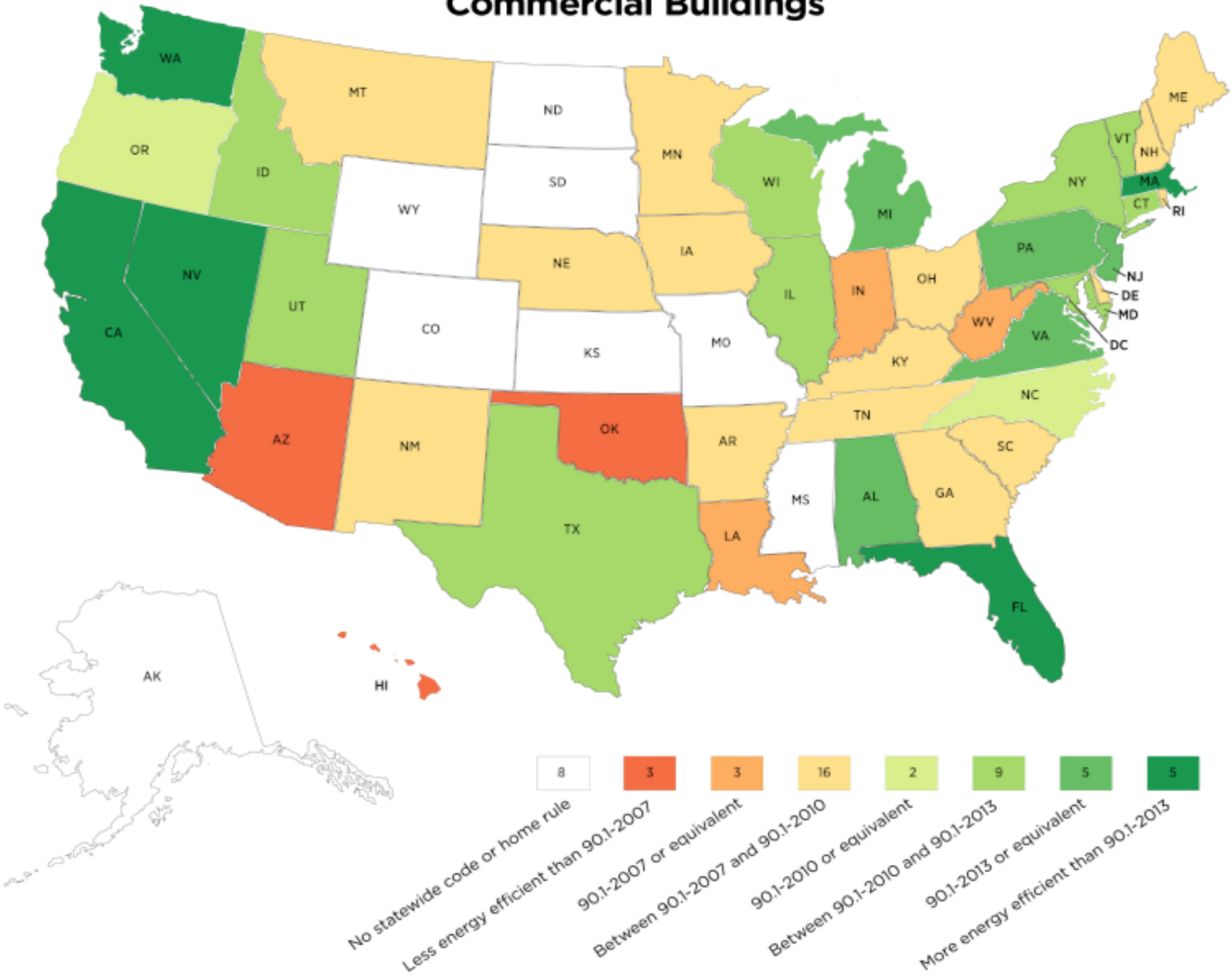
COMPLIANCE:

+ Complied with at the local level by a range of stakeholders (e.g., architects, engineers, builders, trades, etc.)
+ Enforced by local building departments (building officials)—via a combination of plan review and field inspection(s)

Improvement in Residential and Non-Residential Model Energy Codes (Year 1975-2015)



Commercial Buildings



How does one track code *compliance*?

There are several challenges…

+ Compliance is dissociated—depends on a huge number of local actors and happens across a wide geographic region
+ Checklist-based approaches don't tell the whole story—percentages don't equate directly with *energy*
+ Past studies have yielded an inconsistent range of results

Yet, *compliance is critical* to ensuring the benefits promised by energy codes are realized by home and business owner

> Series of State Energy Efficiency Field Studies

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SF RESIDENTIAL FIELD STUDY

OBJECTIVES

Q: Can targeted energy code education & training influence a measurable change in statewide energy consumption?

+ Develop a consistent, adaptable and replicable methodology:
  + Ability to assess and track compliance on a large scale
  + Based on an *energy* metric
+ Construct an empirical data set—the largest publicly available set of its kind
+ Seek a case for increased education and training—increase ROI through more targeted E&T programs
+ Demonstrate the broad impacts of codes—average energy use, savings and environmental impacts

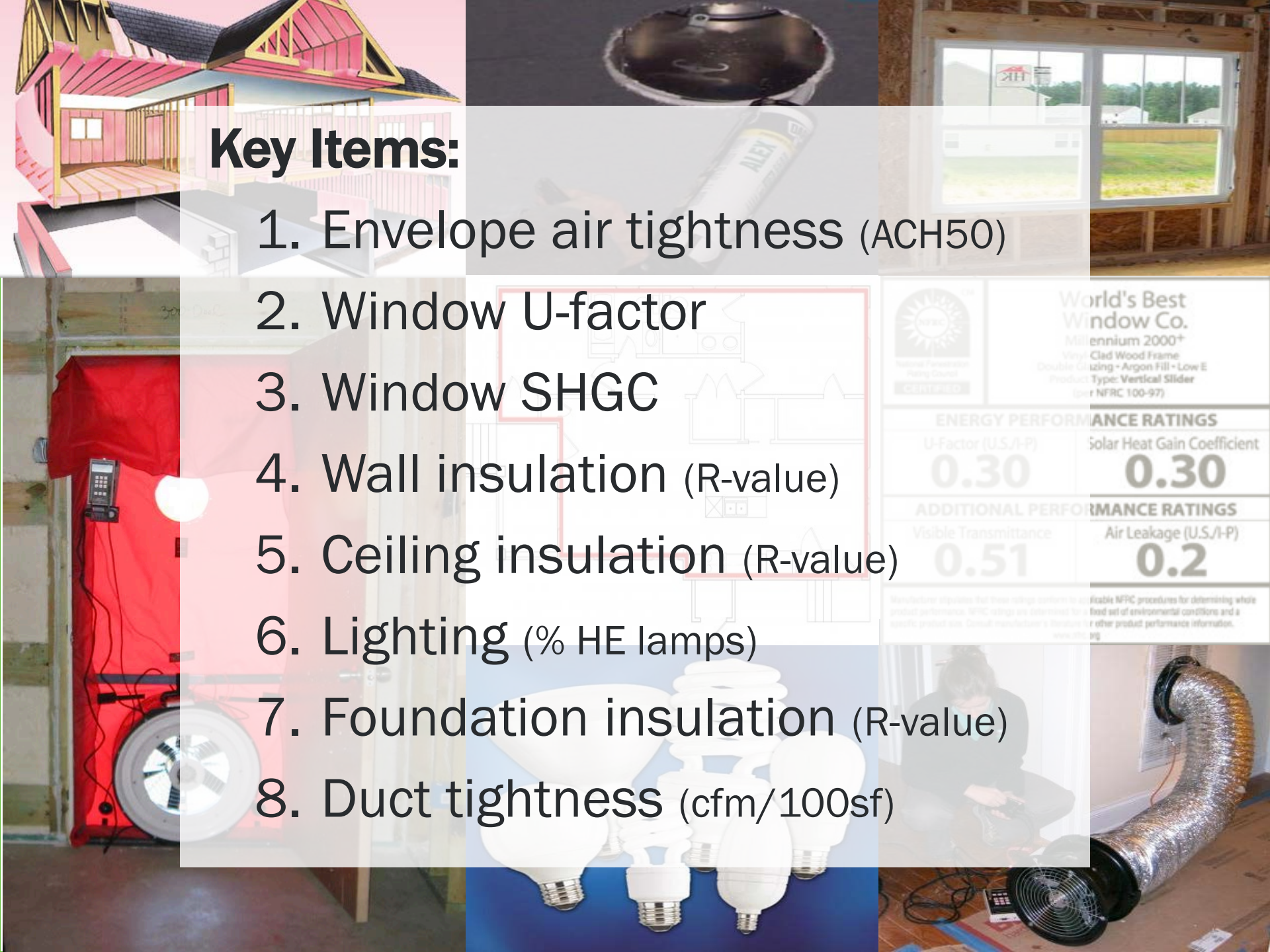
METHODOLOGY

Highlights:

+ **Field-based approach** to measuring state energy code implementation—status, challenges, opportunities
+ Based on **key items** with greatest impact on energy efficiency
+ Targeted **63 observations of each** key item
+ **3 Metrics**: (1) Measure distributions; (2) Measure-level Savings Potential (or 'savings left on the table"); (3) Statewide average energy use
+ To date, over **4500 homes visited** across **25 state studies**

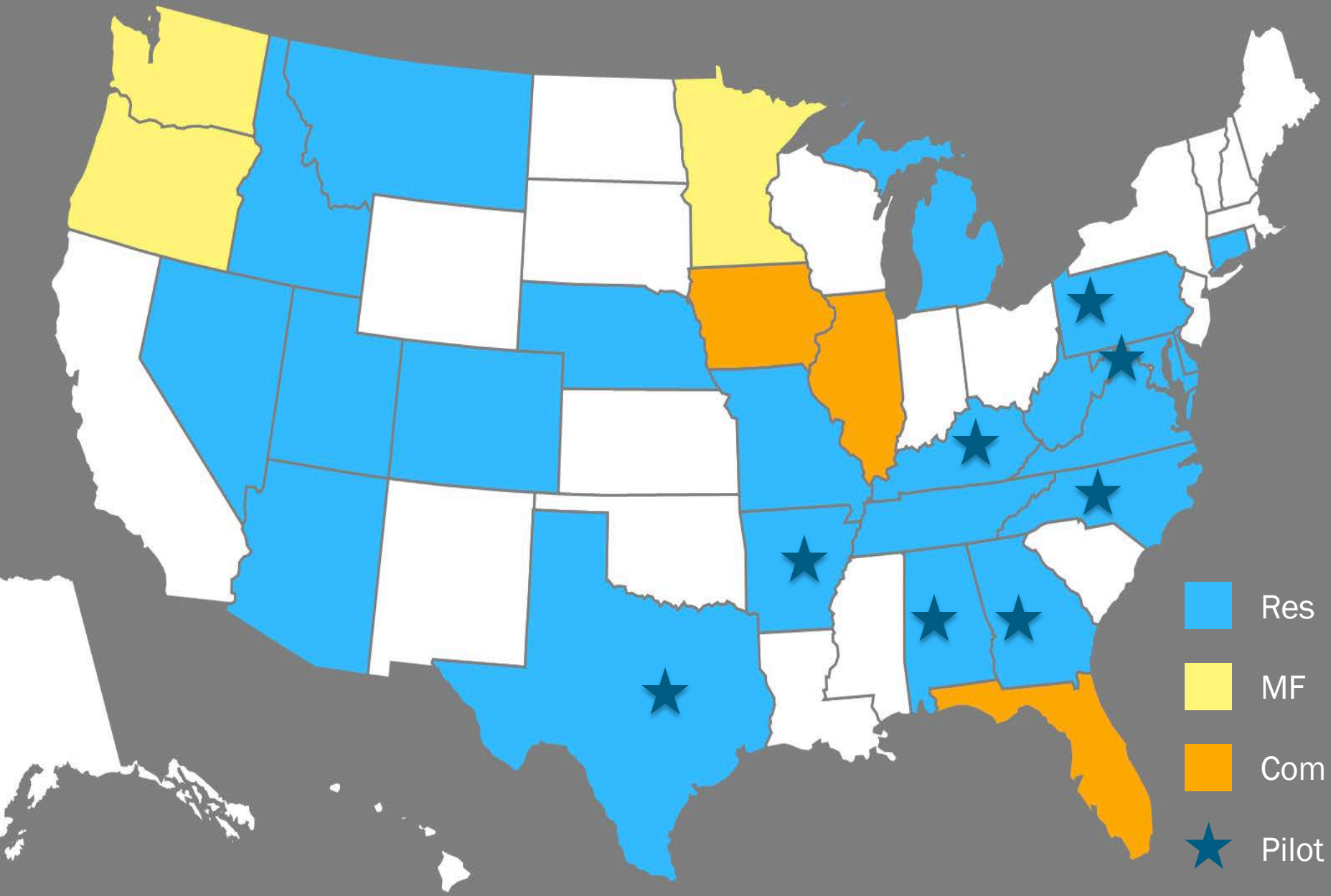
Focus today: 7 states included in original pilot study

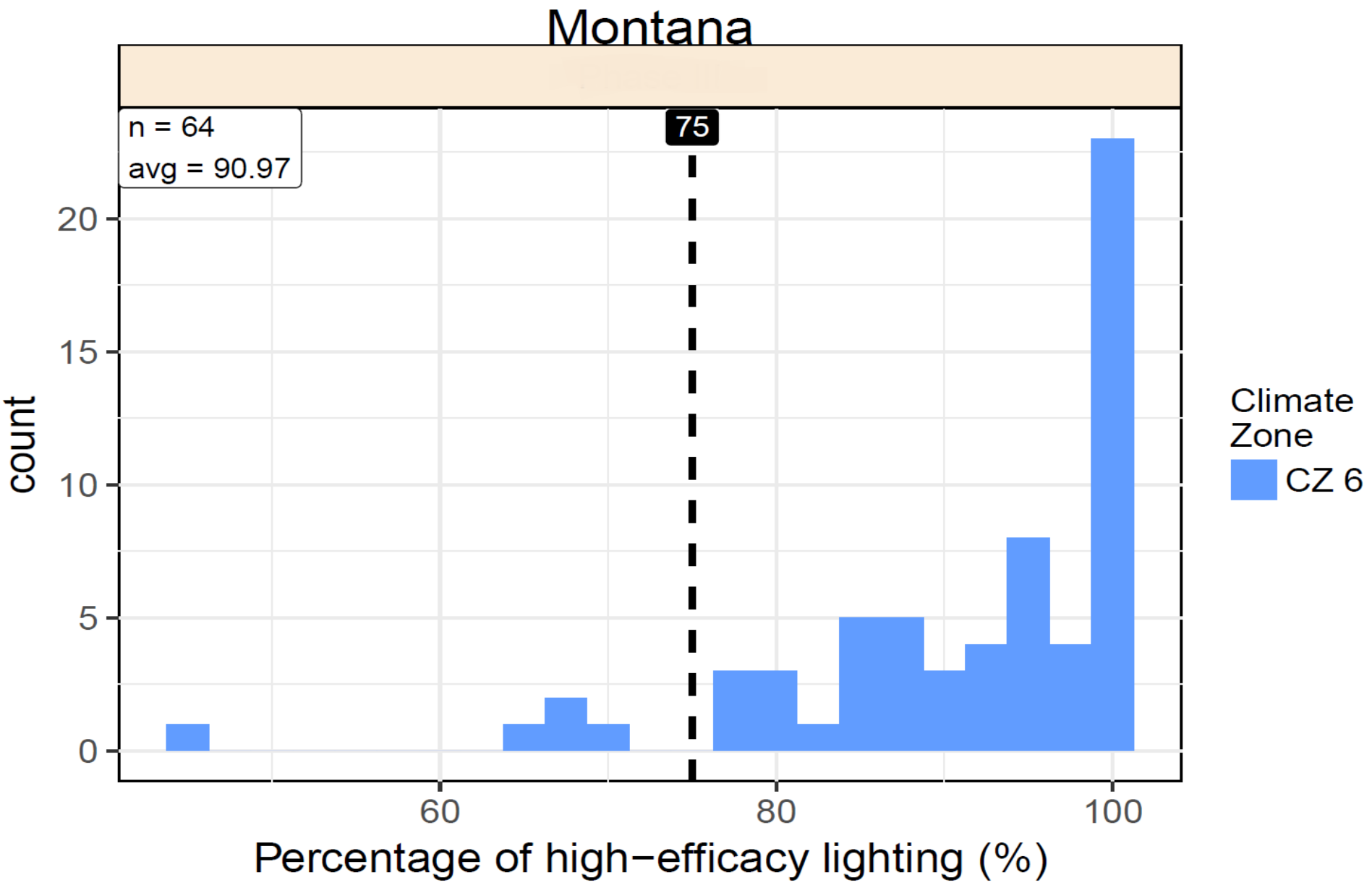
Phases: (1) Baseline > (2) Education + Training > (3) Re-measure

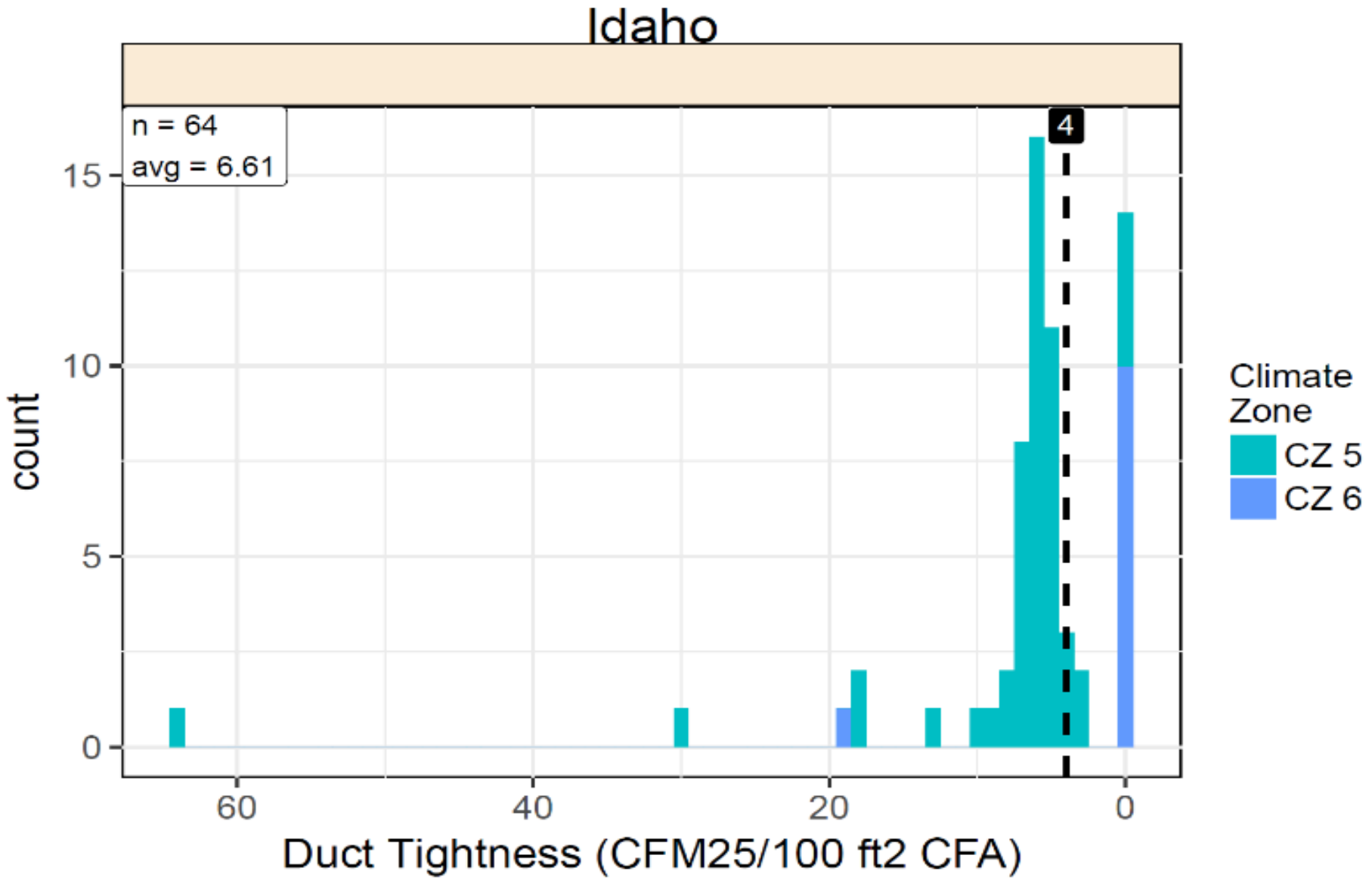


Key Items:

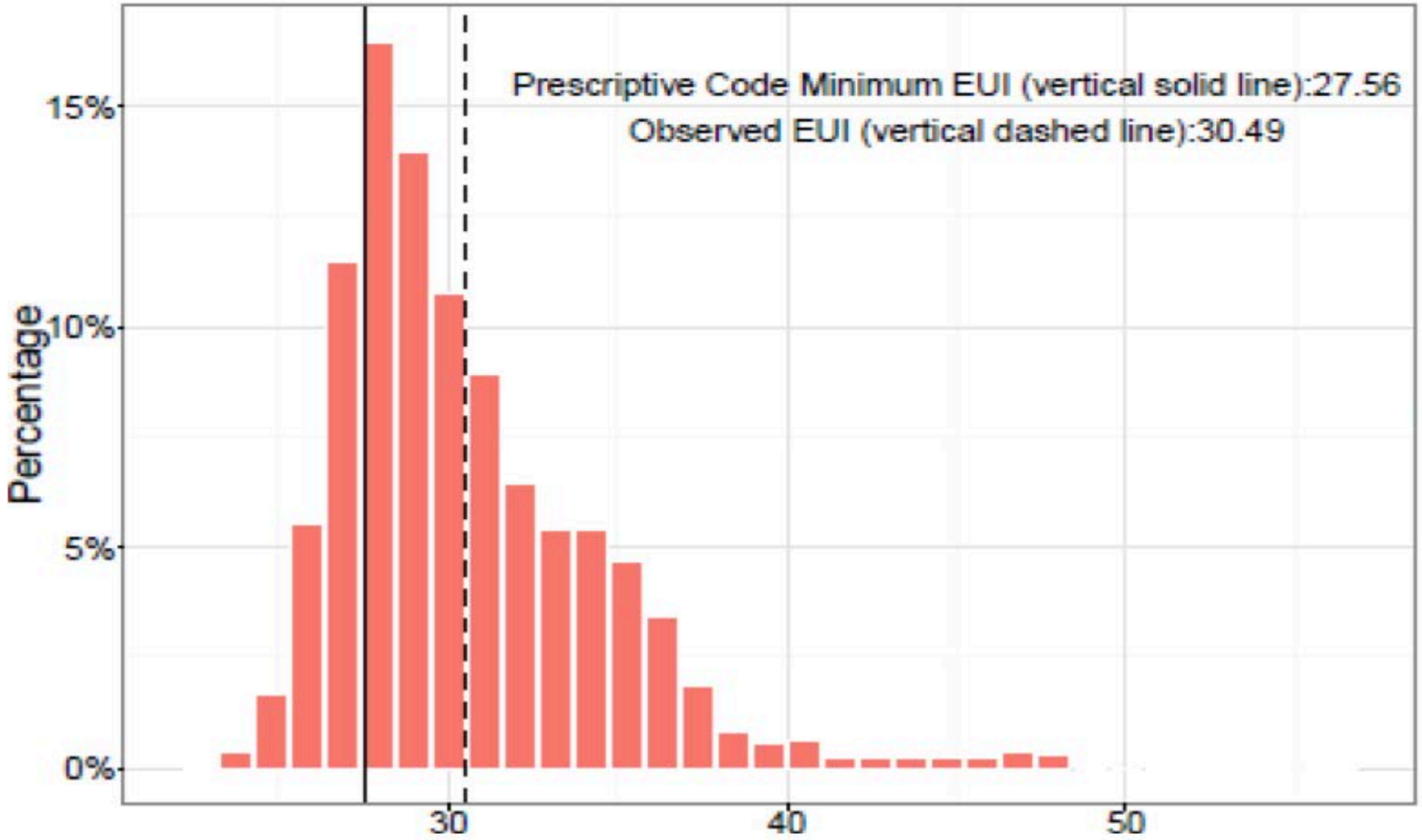
1. Envelope air tightness (ACH50)
2. Window U-factor
3. Window SHGC
4. Wall insulation (R-value)
5. Ceiling insulation (R-value)
6. Lighting (% HE lamps)
7. Foundation insulation (R-value)
8. Duct tightness (cfm/100sf)


Res
MF
Com
Pilot


Montana
n = 64
avg = 90.97
75
20
15
10
5
0
count
60
80
100
Percentage of high−efficacy lighting (%)
Climate Zone
CZ 6


Idaho
n = 64
avg = 6.61
4
15
10
5
0
count
60
40
20
0
Duct Tightness (CFM25/100 ft2 CFA)
Climate Zone
CZ 5
CZ 6

State	Envelope Tightness	Duct Tightness	Wall Insulation	Lighting
AL	$263,089	$395,063	$201,105	$385,451
AR	$104,022	$110,524	$74,792	-
GA	-	$685,683	$1,151,262	$799,065
KY	$9,558	$327,731	$223,954	$137,883
MD	$754,946	$146,619	$401,480	$195,378
NC	$211,315	$334,527	$390,827	$520,839
PA	-	$1,360,493	$798,031	$365,254
TX	$4,656,869	$3,582,893	$5,029,864	$2,774,421
Total	**$5,999,799**	**$6,943,533**	**$8,271,315**	**$5,178,291**


Prescriptive Code Minimum EUI (vertical solid line):27.56
Observed EUI (vertical dashed line):30.49
Percentage
15%
10%
5%
0%
30
40
50

MD Phase I

State	Current State Code	Expected EUI (kBtu/ft^2)	Observed EUI (kBtu/ft^2)	Differential (%)
AL	2009 IECC	22.40	19.67	-12.8%
AR	2014 AR Energy Code (amended 2009 IECC)	33.12	28.21	-14.8%
GA	Georgia Energy Code (amended 2009 IECC)	28.52	26.52	-7.0%
KY	2009 IECC	33.98	31.31	-7.9%
MD	2015 IECC	27.56	30.49	+10.6%
NC	2012 NC Energy Code (amended 2009 IECC)	23.79	22.96	-3.5%
PA	2009 IECC (2009 IRC)	45.48	40.73	-10.4%
TX	2009 IECC	25.94	20.95	-19.2%

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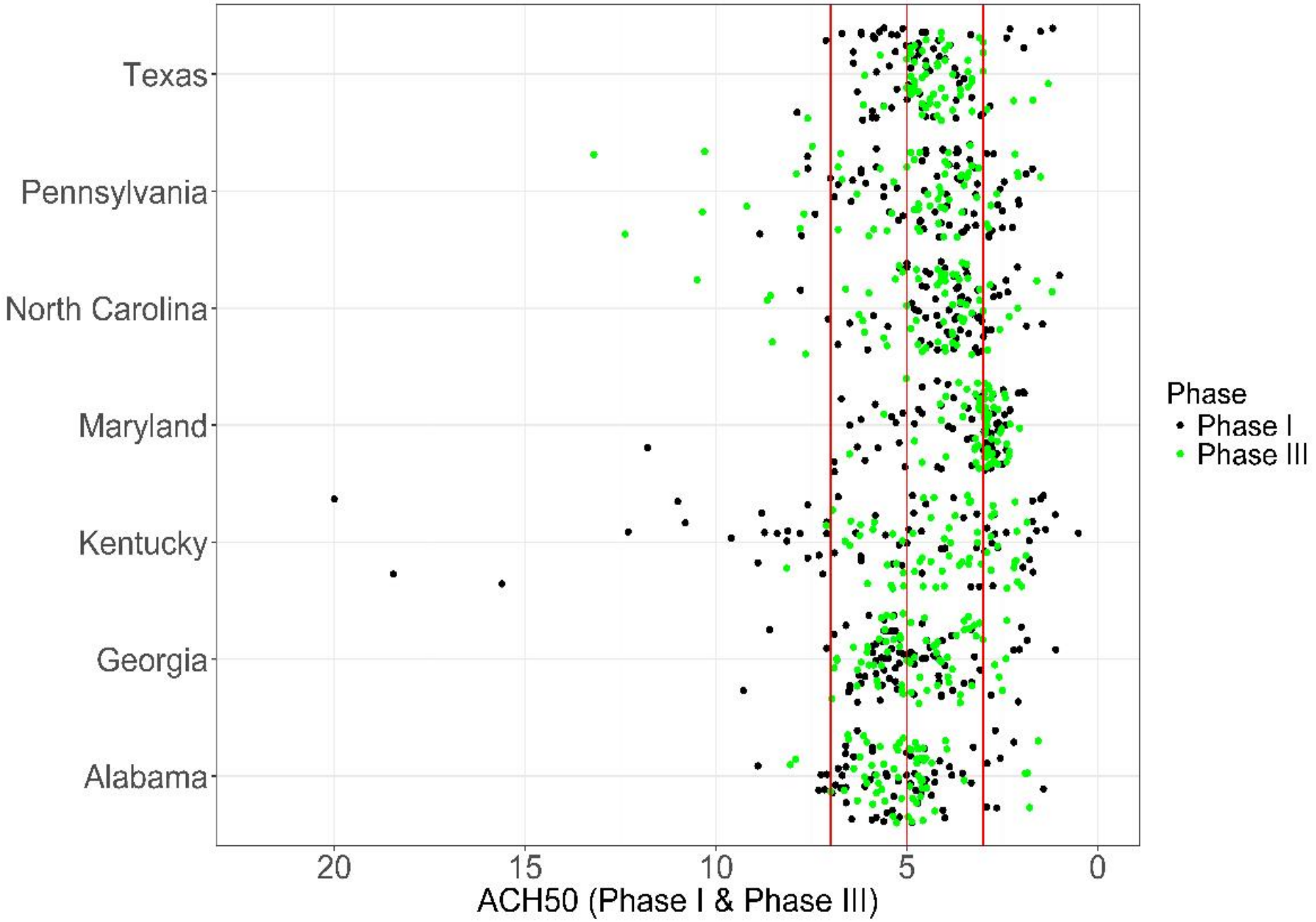
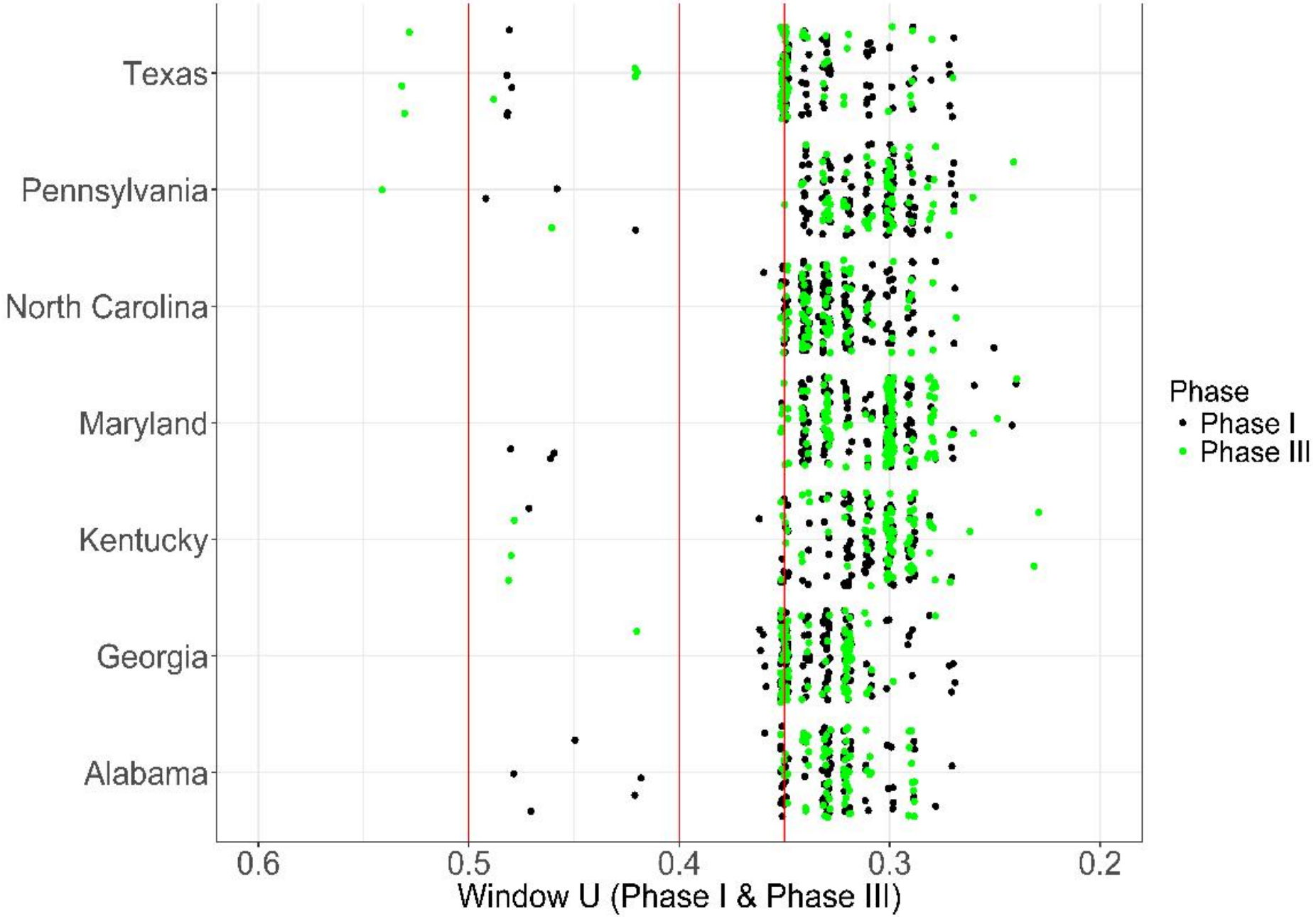
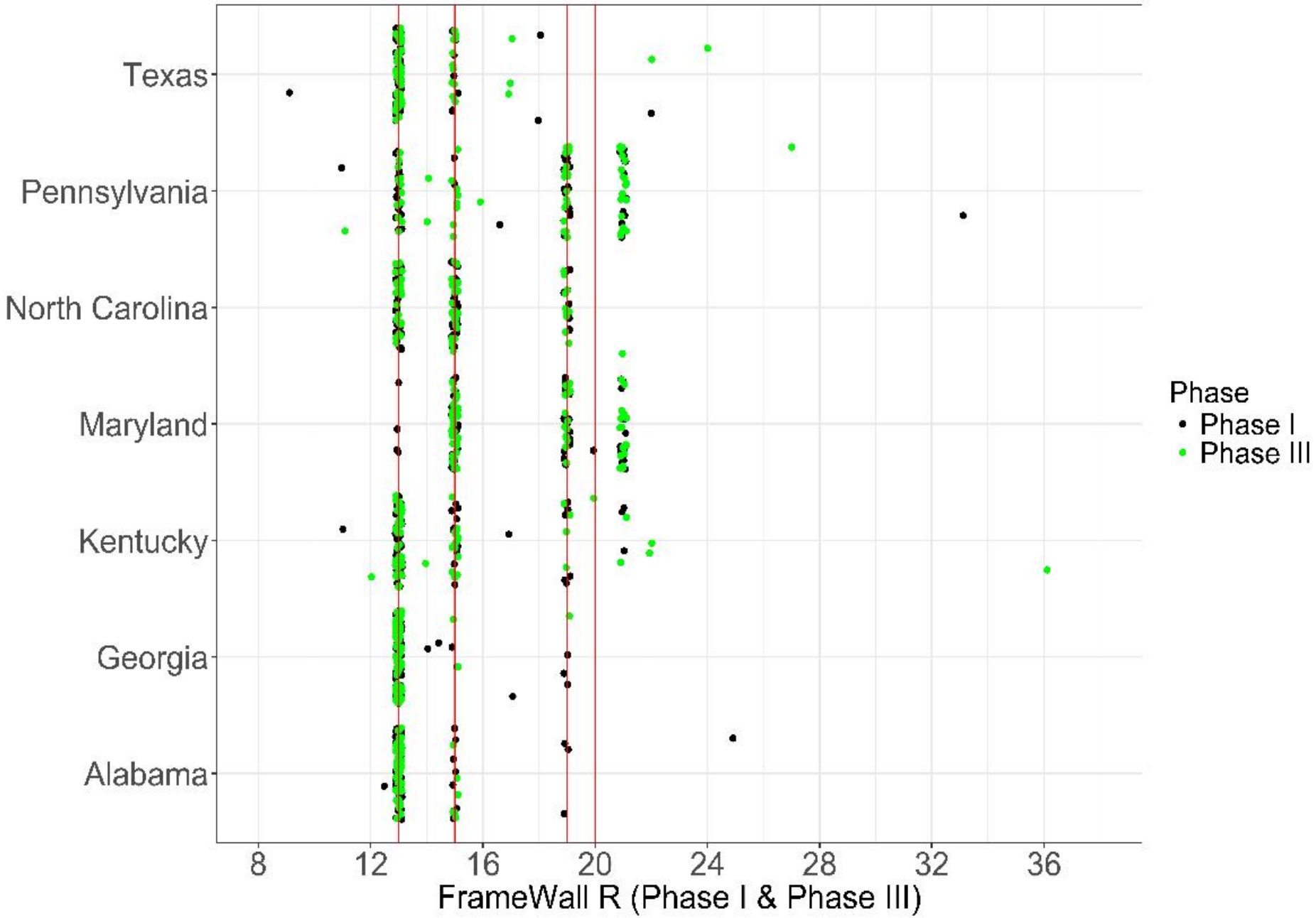
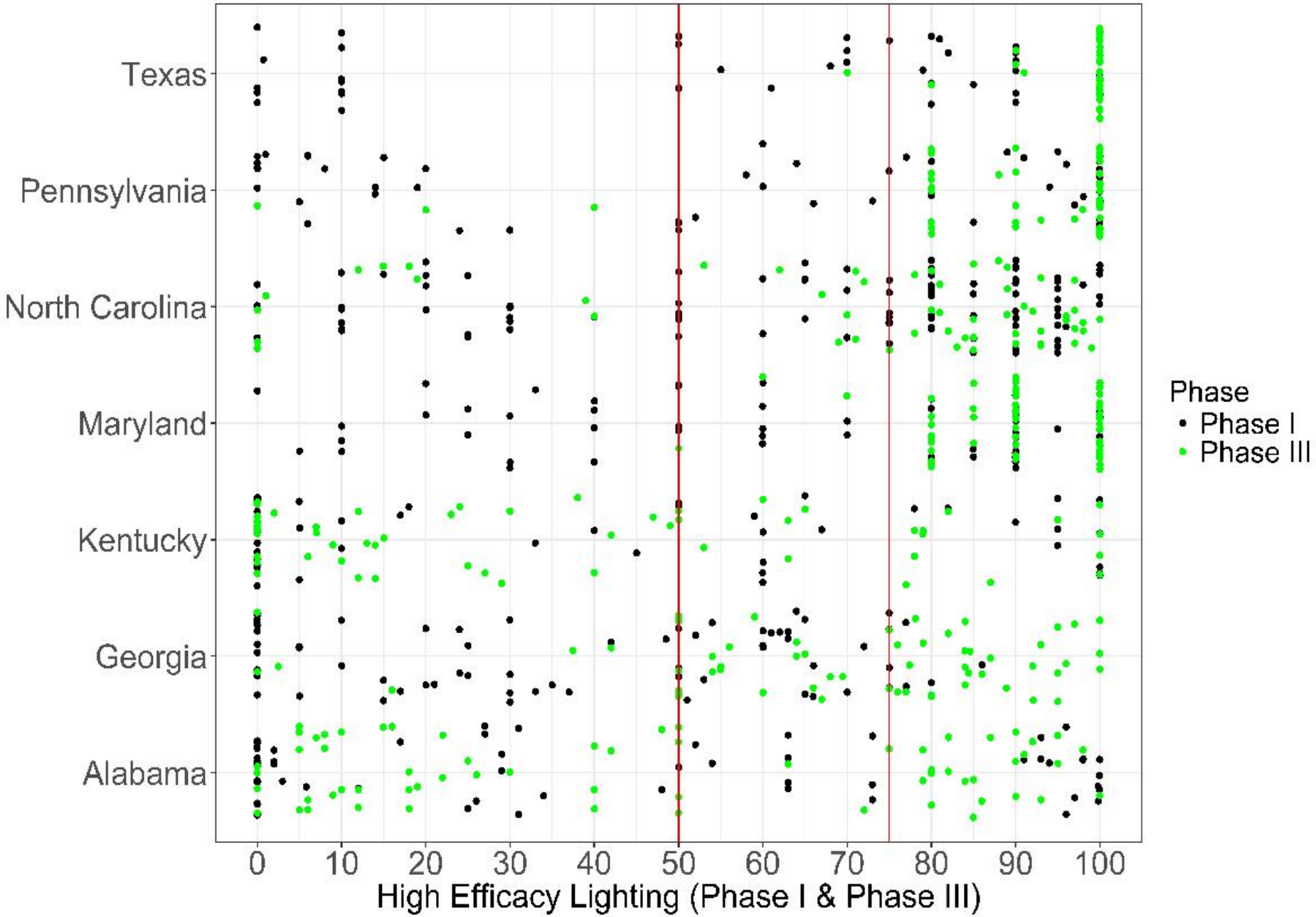
KEY FINDINGS

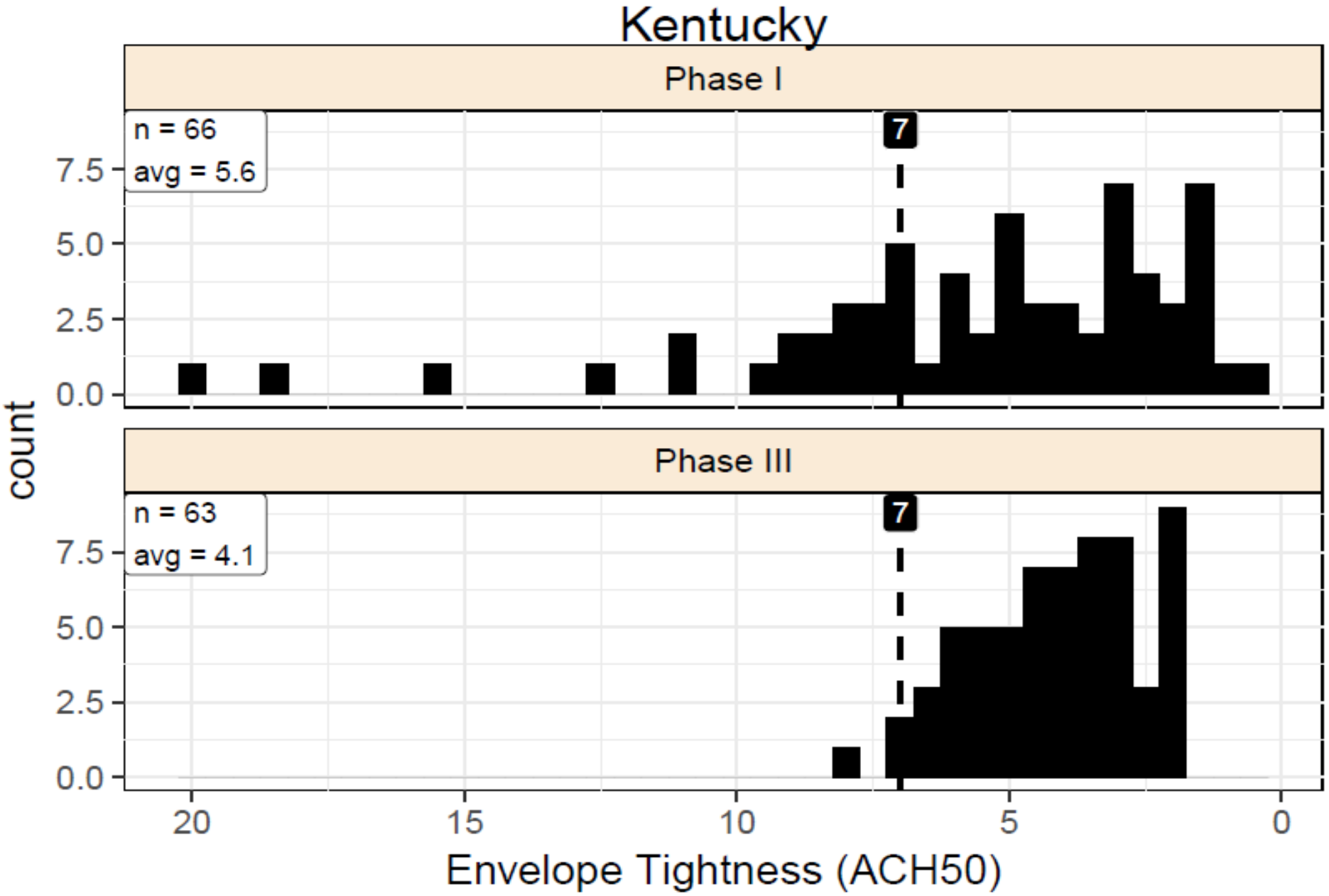
PHASE I + III DATA


Texas
Pennsylvania
North Carolina
Maryland
Kentucky
Georgia
Alabama
20
15
10
5
0
ACH50 (Phase I & Phase III)
Phase
Phase I
Phase III


Texas
Pennsylvania
North Carolina
Maryland
Kentucky
Georgia
Alabama
0.6
0.5
0.4
0.3
0.2
Window U (Phase I & Phase III)
Phase
Phase I
Phase III

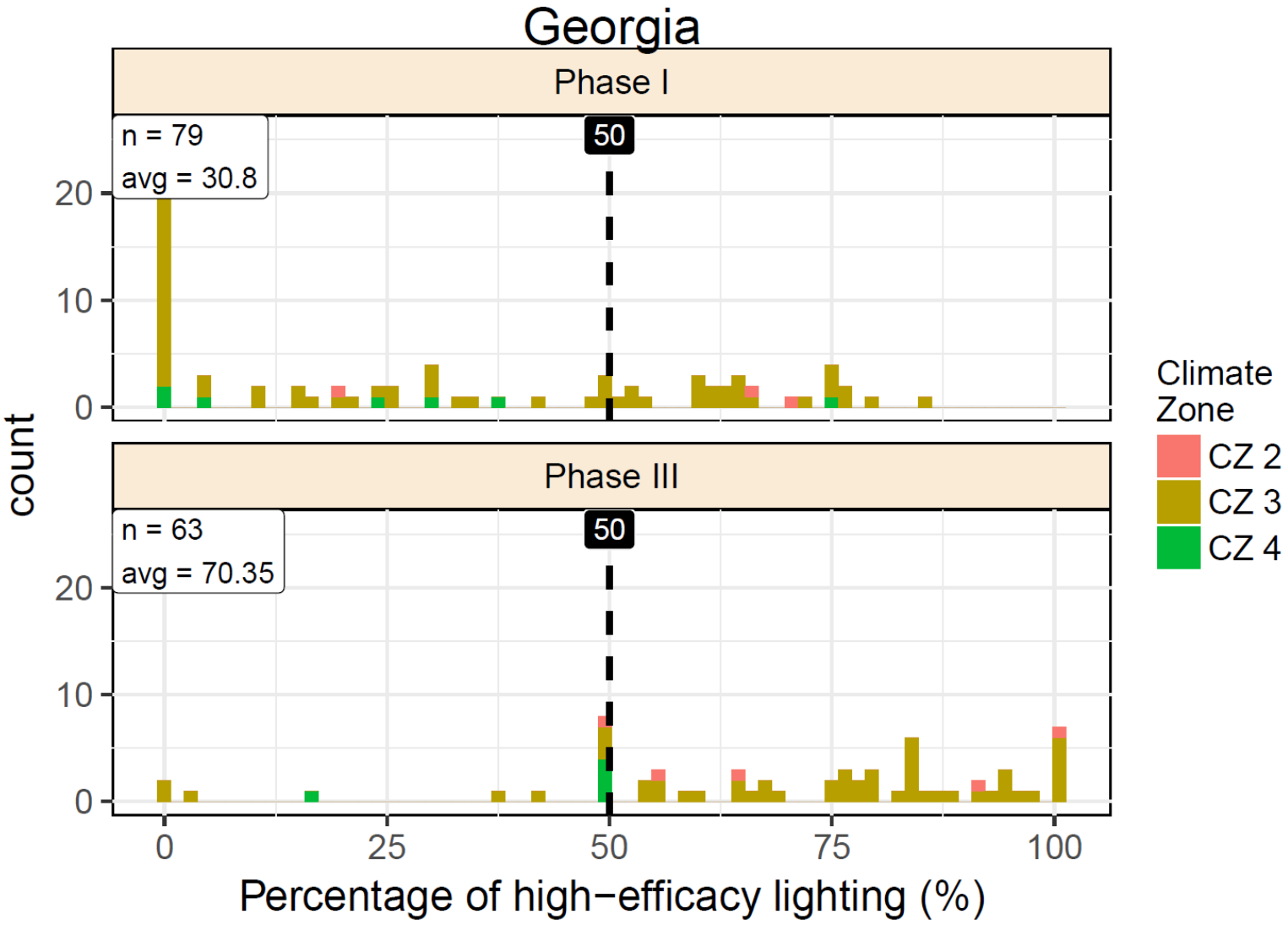

Texas
Pennsylvania
North Carolina
Maryland
Kentucky
Georgia
Alabama
8
12
16
20
24
28
32
36
FrameWall R (Phase I & Phase III)
Phase
Phase I
Phase III


Texas
Pennsylvania
North Carolina
Maryland
Kentucky
Georgia
Alabama
0
10
20
30
40
50
60
70
80
90
100
High Efficacy Lighting (Phase I & Phase III)
Phase
Phase I
Phase III

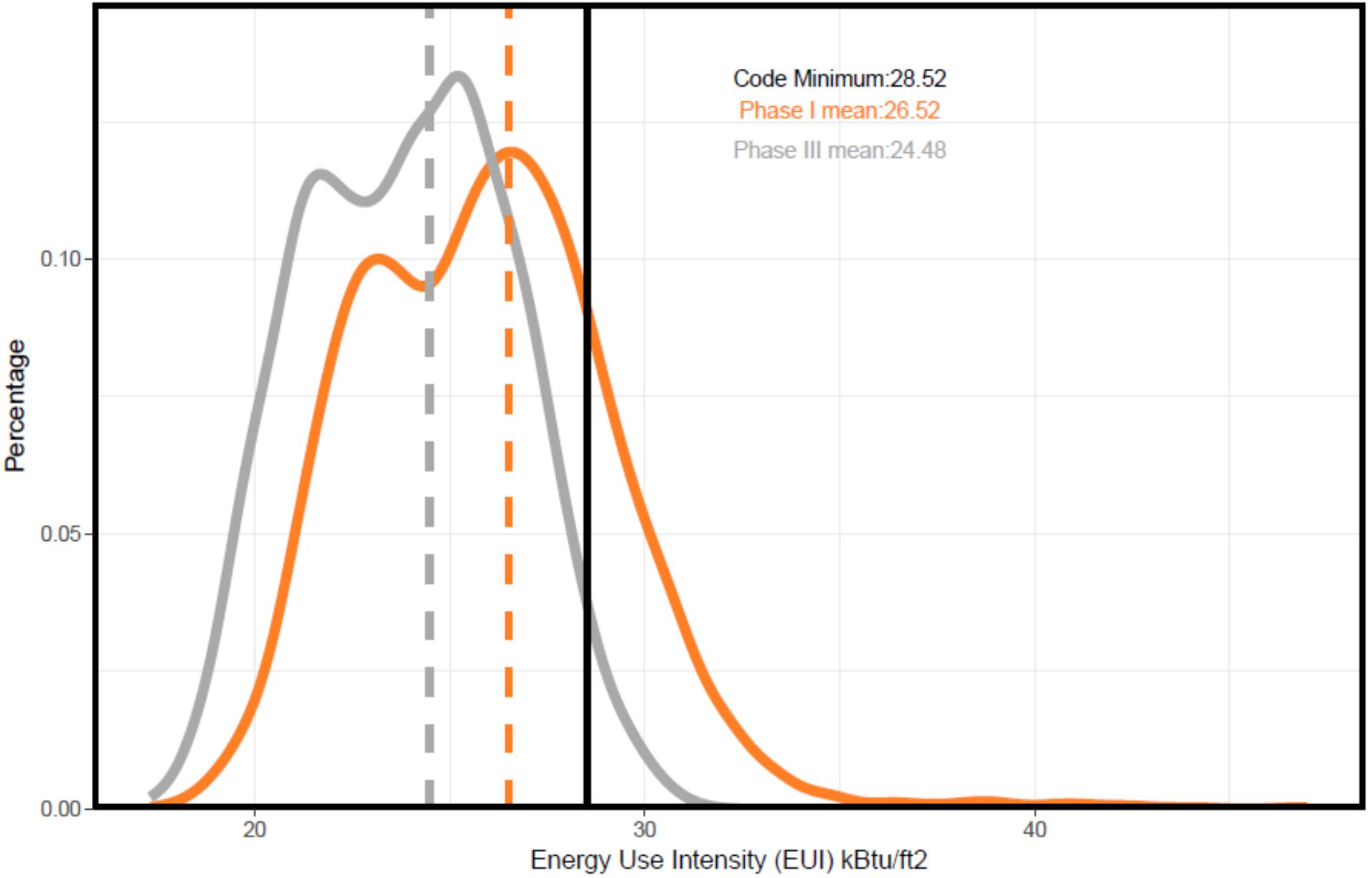

Kentucky
Phase I
n = 66
avg = 5.6
7
Phase III
n = 63
avg = 4.1
7
count
7.5
5.0
2.5
0.0
20
15
10
5
0
Envelope Tightness (ACH50)

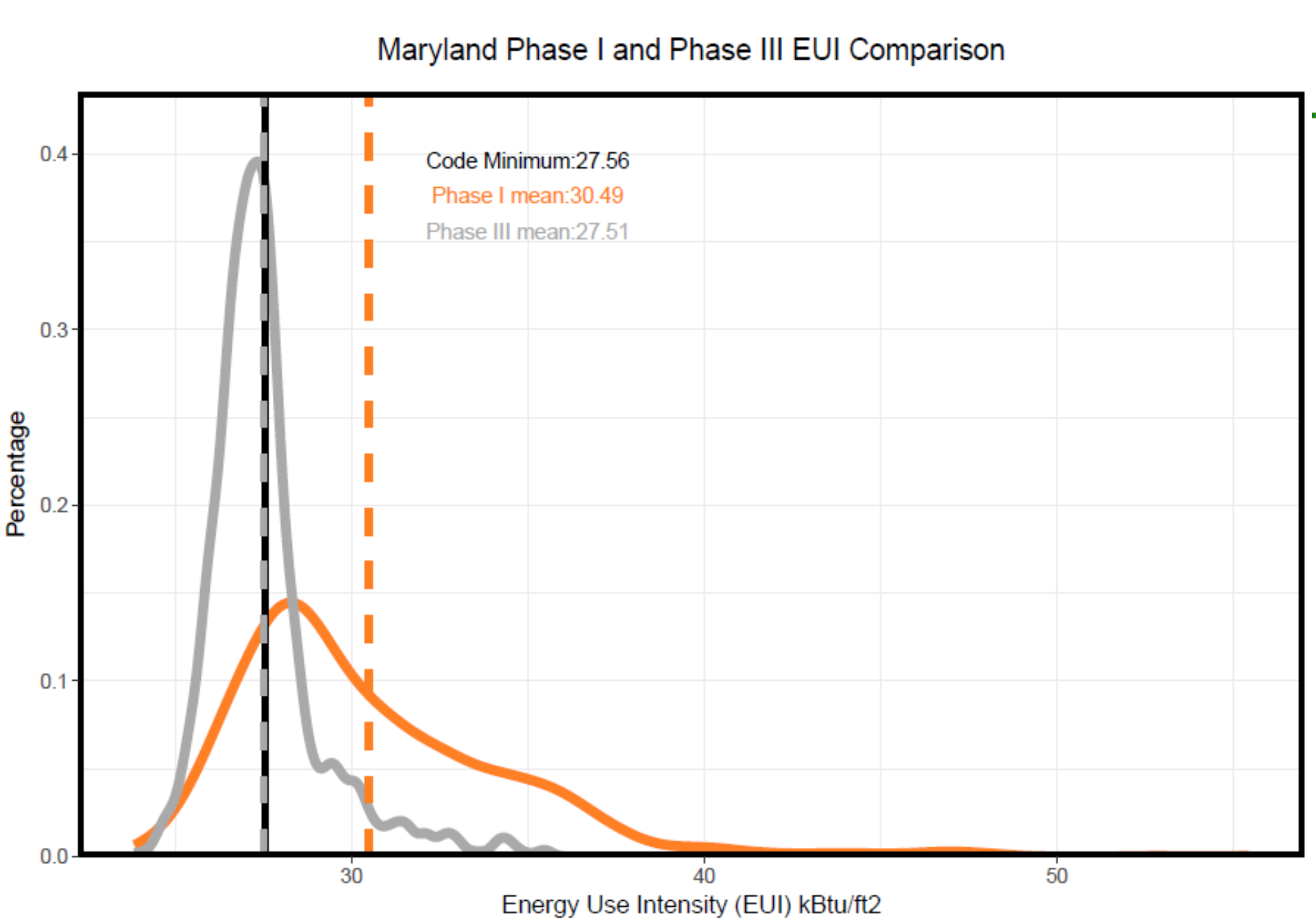
HIGH EFFICACY LAMPS (%)

Lighting got much better in Phase III

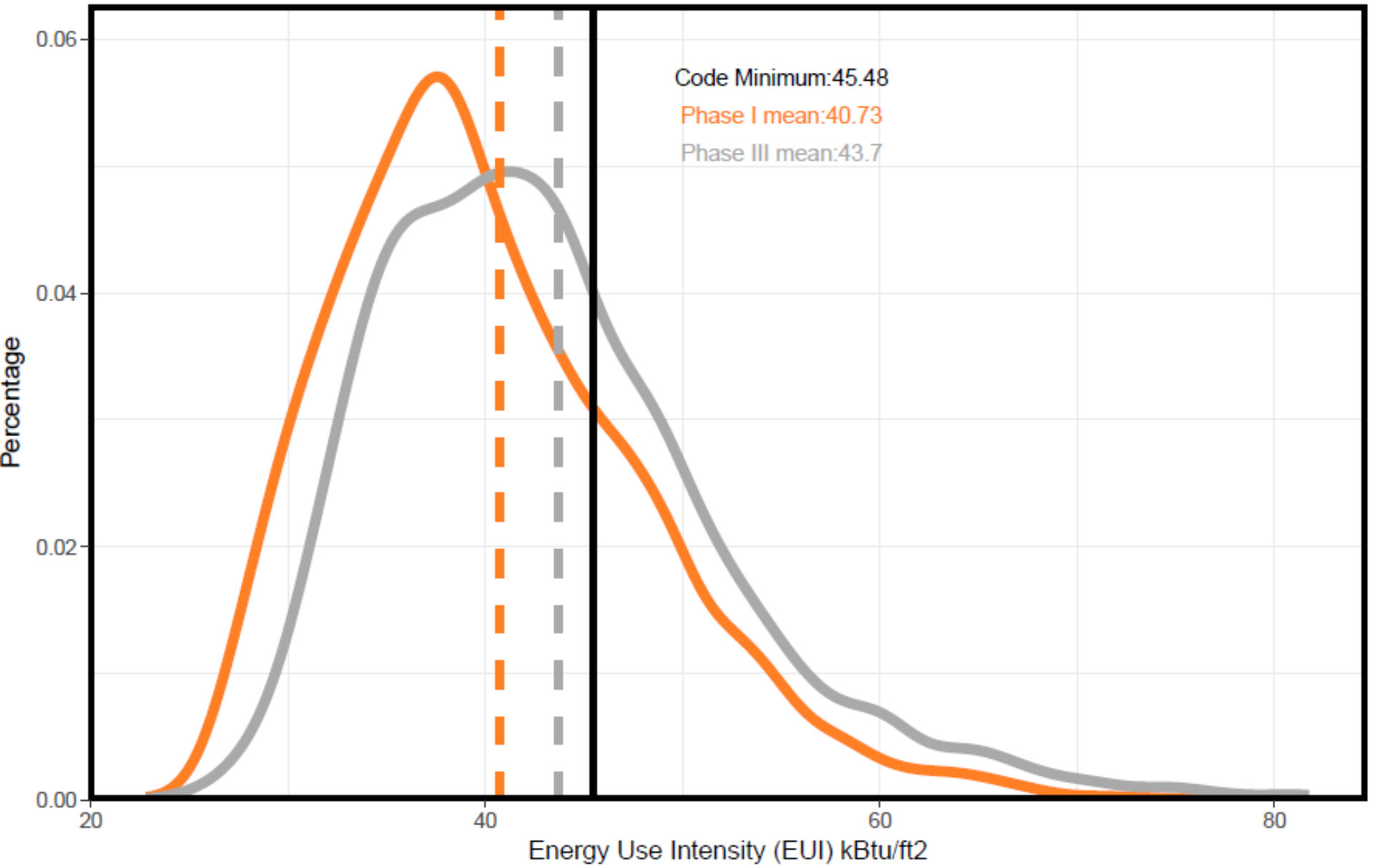


Georgia Phase I and Phase III EUI Comparison



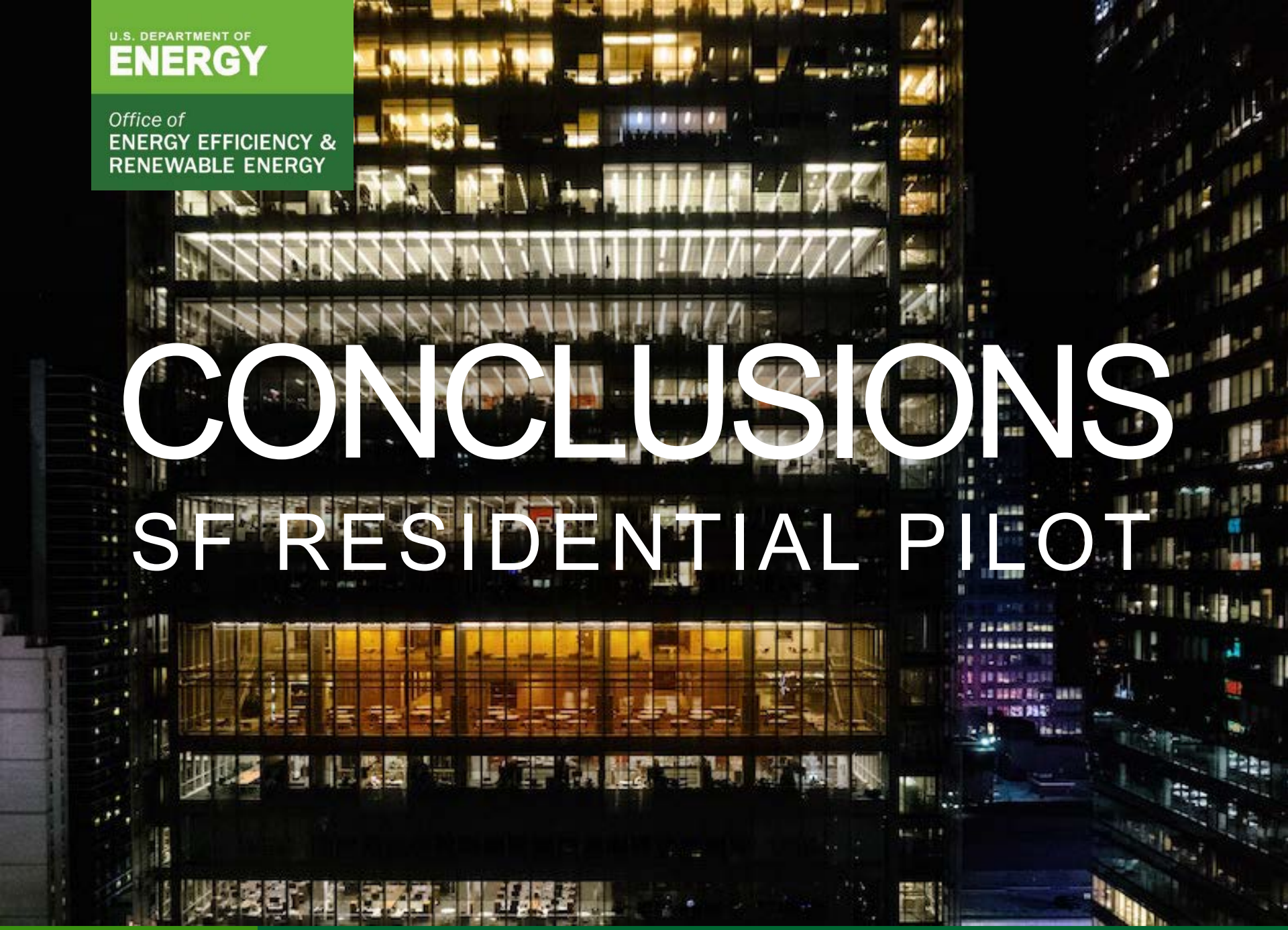

Maryland Phase I and Phase III EUI Comparison
Code Minimum:27.56
Phase I mean:30.49
Phase III mean:27.51
Percentage
0.0
0.1
0.2
0.3
0.4
30
40
50
Energy Use Intensity (EUI) kBtu/ft2

Pennsylvania Phase I and Phase III EUI Comparison



STATE	PHASE I Annual Energy Cost Savings Potential ($ millions)	PHASE III Annual Energy Cost Savings Potential ($ millions)	$Δ	%
AL	$1,300,000	$970,000	$330,000	25.4%
GA	$4,520,000	$1,750,000	$2,770,000	61.2%
KY	$1,220,000	$930,000	$290,000	23.8%
MD	$1,540,000	$310,000	$1,230,000	79.9%
NC	$2,030,000	$2,020,000	$10,000	0.50%
PA	$3,200,000	$3,010,000	$190,000	5.9%
TX	$4,850,000	$1,240,000	$3,610,000	74.4%

STATE	PHASE I Annual Savings (per home)	PHASE III Annual Savings (per home)	Δ (per home)
AL	$136.76	$102.04	$34.71
GA	$164.35	$63.63	$100.72
KY	$166.10	$126.62	$39.48
MD	$146.10	$29.41	$116.69
NC	$67.60	$67.27	$0.33
PA	$195.47	$183.86	$11.61
TX	$88.28	$22.57	$65.71



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CONCLUSIONS

SF RESIDENTIAL PILOT

CONCLUSIONS (phase I and III)

- The building industry is generally doing a good job implementing energy efficiency codes
- Homes using less energy on average than expected based on prescriptive measures (majority of states)
- Certain measures universally met code (windows)
- But, significant savings 'left on the table' (millions of dollars)
- These *can* be addressed via targeted education and training programs

CONCLUSIONS

Q: Can targeted energy code education & training influence a measurable change in statewide energy consumption?

A: Yes, they can! But, they didn't in all cases…

+ Most states showed improvement in statewide EUI (5 of 7)
+ All states improved measure savings potential (7 of 7)
+ But mixed results for some states (by statistical significance)

SUCESSES + ACCOMPLISHMENTS

+ Original Goals: New methodology moves past checklist-based mentality and re-focused on *energy* metric through empirical data

+ What's happening in the field appears much better than expected—comes with significant improvement to code compliance estimates

+ Model and state codes have been updated based on data and findings (e.g., windows, lighting, envelope air tightness, duct tightness, etc.)

+ States are refocusing their training efforts and reducing their energy use—hundreds of millions of dollars through codes already in place

+ Value in states performing regular studies—track impacts and inform ongoing state education and training activities

+ Interest in expanding these types of studies to capture and track new technologies in the market—renewables, grid, resilience and more…

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JEREMY WILLIAMS

Building Technologies Office

U.S. Department of Energy

jeremy.Williams@ee.doe.gov

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