

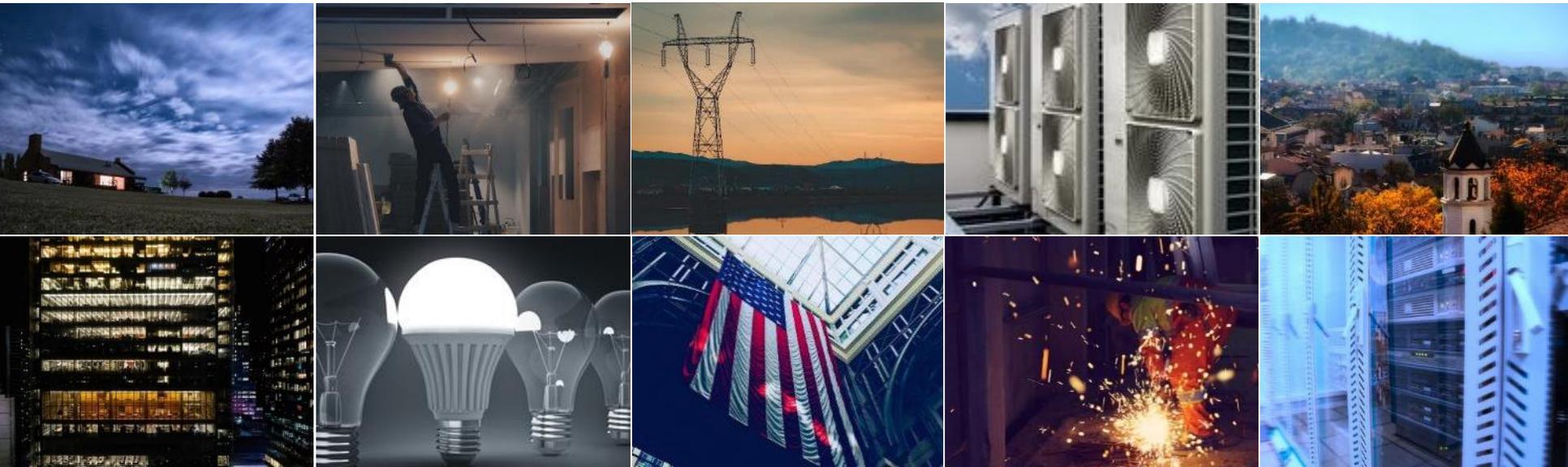
U.S. DEPARTMENT OF
ENERGY

Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

Single-family Residential Field Study: Phase III Data and Findings

2019 National Energy Codes Conference

JEREMY WILLIAMS Building Technologies Office



SUMMARY

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

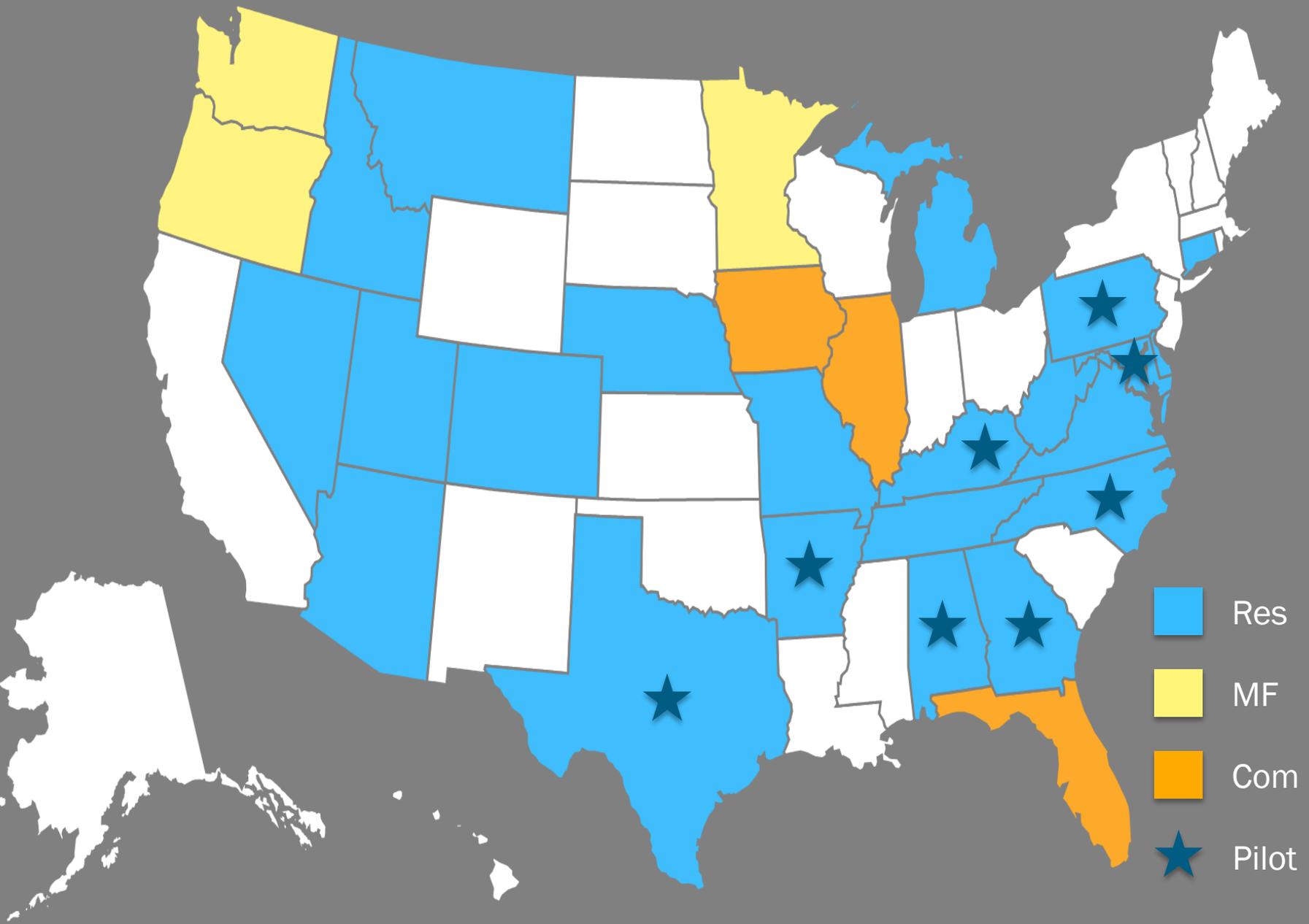


- **Background (Phases I & II)**
- **Phase III Results**
 - Key Item Comparisons
 - Measure Level Savings
 - Energy Use Intensity (EUI)
- **Conclusions**

METHODOLOGY SF RESIDENTIAL

HIGHLIGHTS

- **Field-based approach** to measuring state energy code implementation—status, challenges, opportunities
- Based on **key items** with greatest impact on energy efficiency
- **Metrics:** Statewide average energy use; measure savings ‘left on table’
- **Three-phases:** Baseline, education/training, re-measure
- A primary objective is to **inform training and education**—create business case for ongoing training programs
- Targeted **63 observations** of each key item
- To date, over **4500 homes visited** to date across **25 state studies**
- Focus today is on 7 states included in original DOE pilot study



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PHASE ONE BASELINE STUDIES



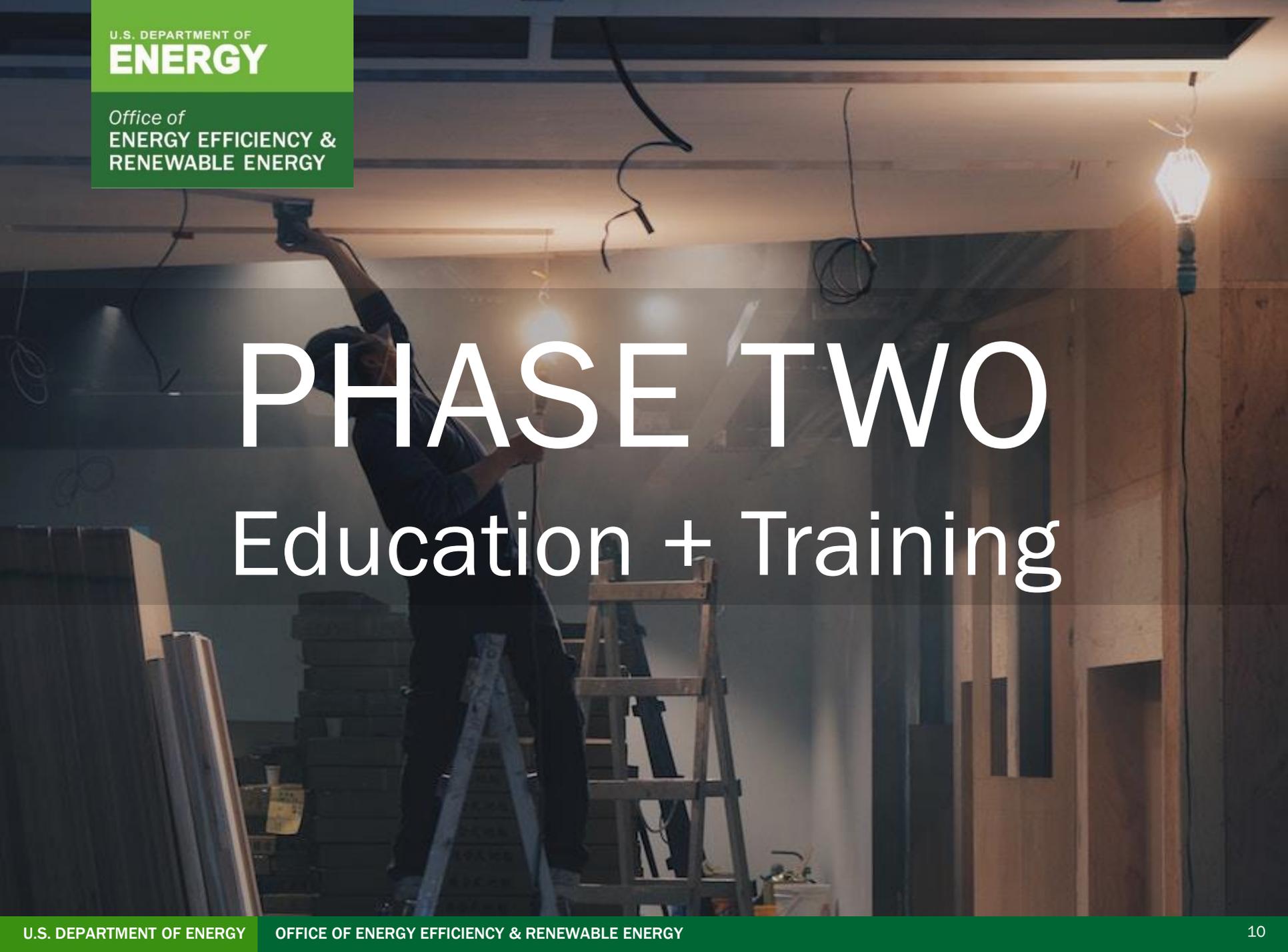
State	Current State Code	Expected EUI (kBtu/ft ²)	Observed EUI (kBtu/ft ²)	Differential (%)
AL	2009 IECC	22.40	19.67	12.8%
AR	2014 AR Energy Code (amended 2009 IECC)	33.12	28.21	14.8%
GA	Georgia Energy Code (amended 2009 IECC)	28.52	26.52	7.0%
KY	2009 IECC	33.98	31.31	7.9%
MD	2015 IECC	27.56	30.49	-10.6%
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%

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

KEY TAKEAWAYS (phase I)

- + 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 (e.g., windows)
- + But, still significant 'Savings left on the table' by focusing programs on target measures (millions of dollars)

Onward to phases II and III...

A construction worker is shown from the side, standing on a wooden step ladder and reaching up to work on the ceiling. The room is under renovation, with exposed wooden studs, hanging wires, and a single light bulb hanging from the ceiling. The lighting is warm and focused on the worker.

PHASE TWO

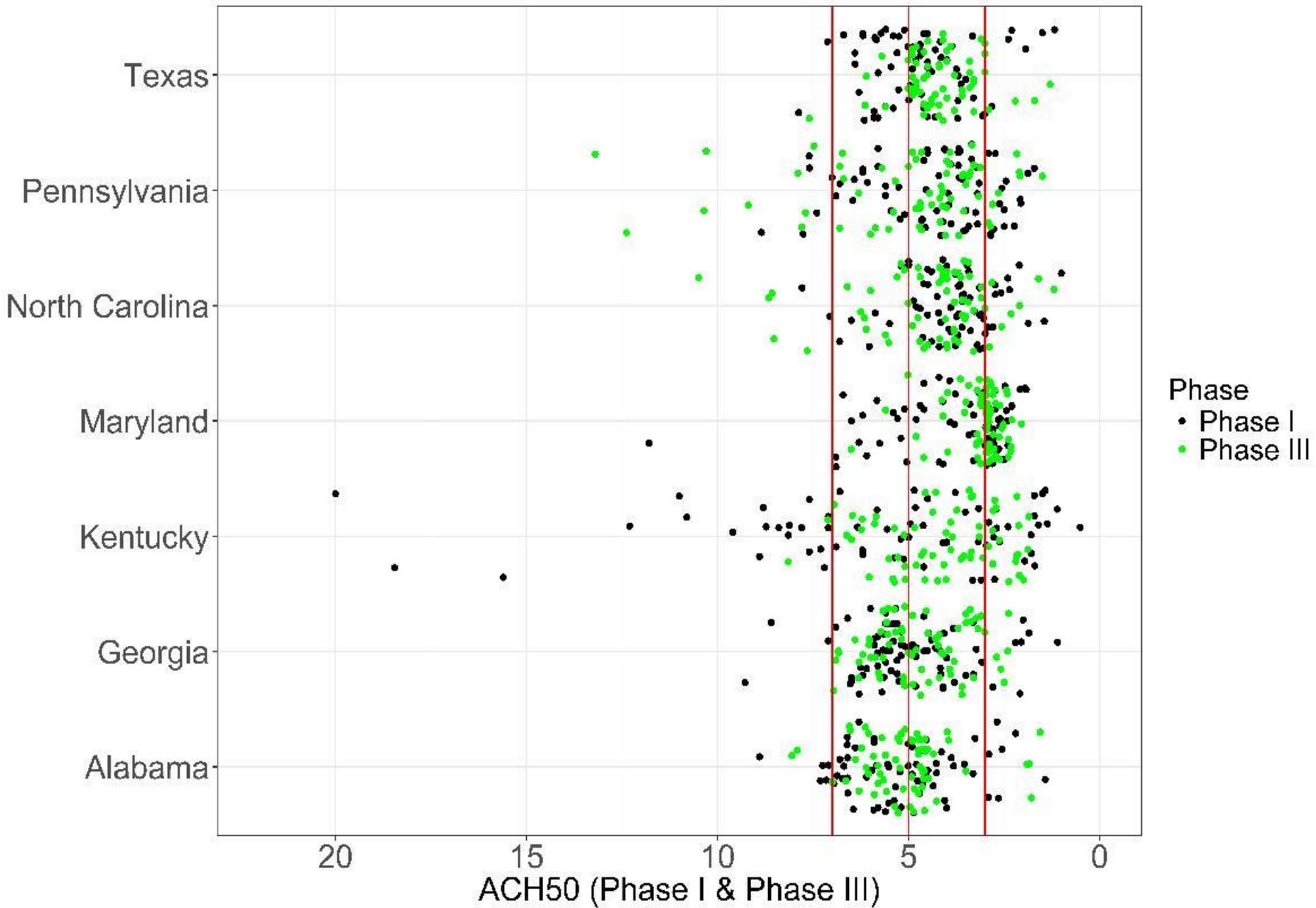
Education + Training

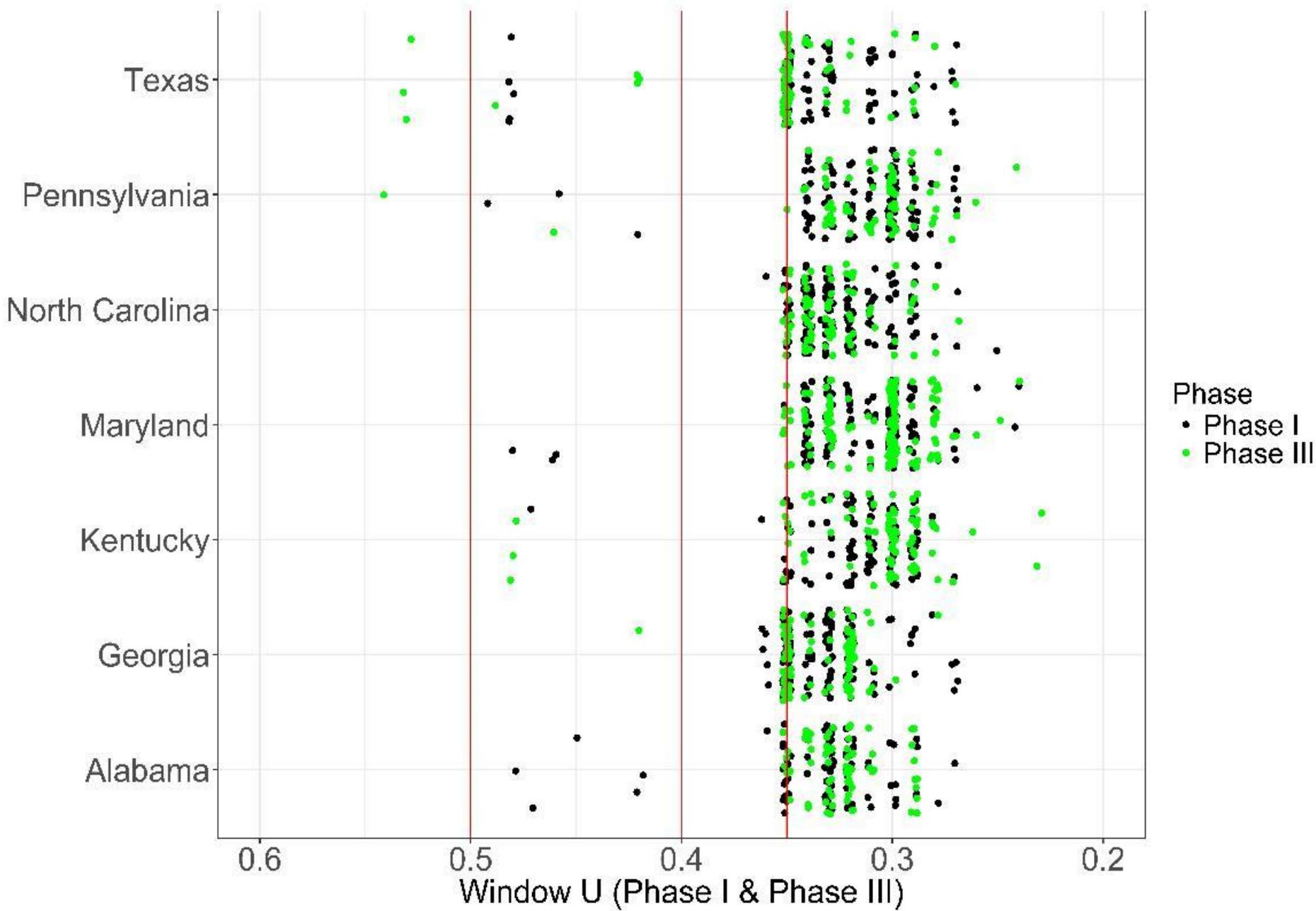
STRATEGIES EMPLOYED BY STATES

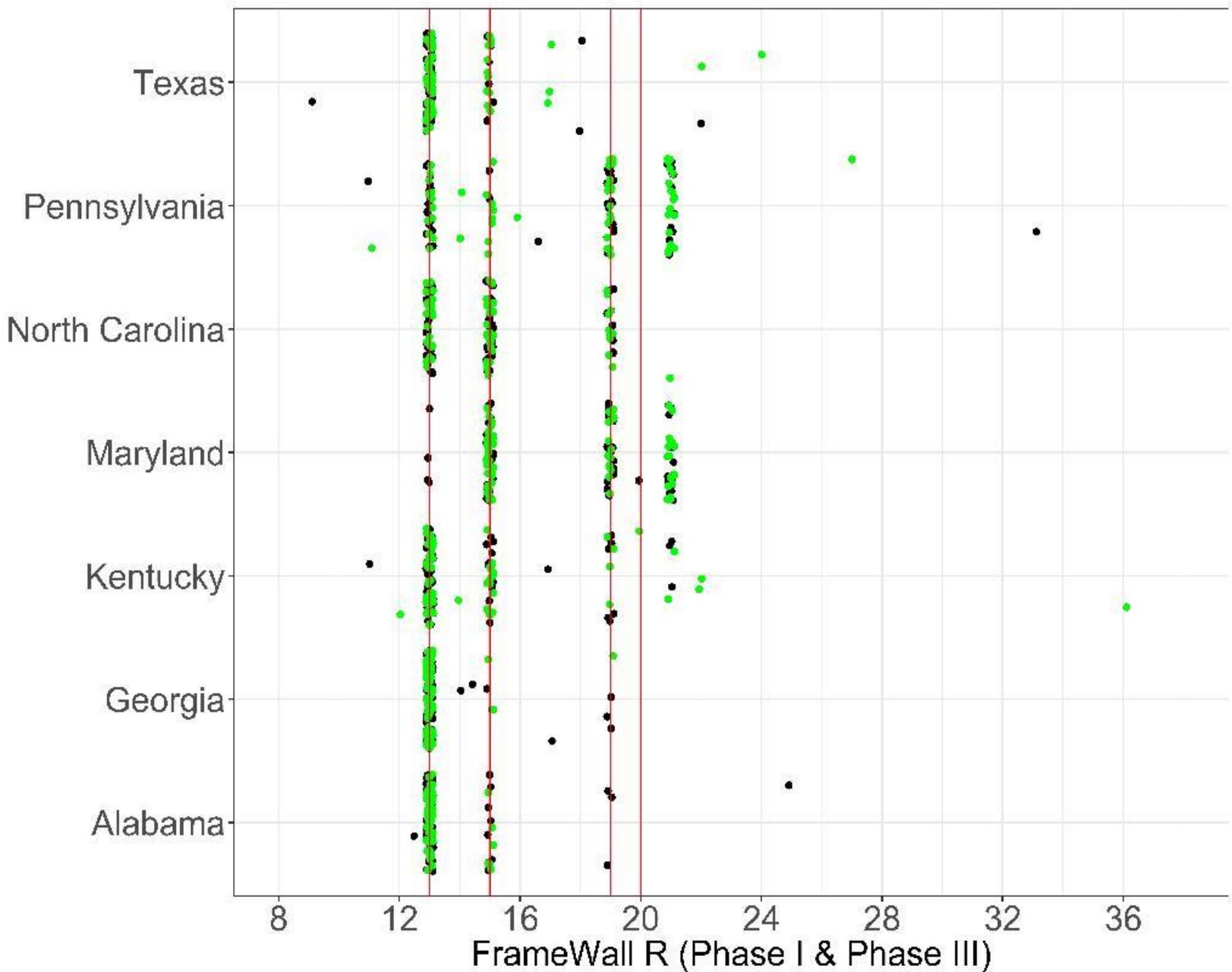
- + Individual states and project teams chose best strategies for each state
- + Mix of strategies—ranged from traditional classroom-based training to more advanced online or onsite methods
- + A few illustrative examples:
 - **AL:** Curriculum partnership with community college
 - **KY:** Emphasis circuit rider
 - **PA:** Tablets and apps in partnership with home energy raters
 - **NC:** Multimedia snippets combined with onsite training
 - **TX:** Mix of industry marketing/outreach and training events
- + Partnerships amongst broad range of stakeholders— state agencies, regional and trade organizations, academia, etc.

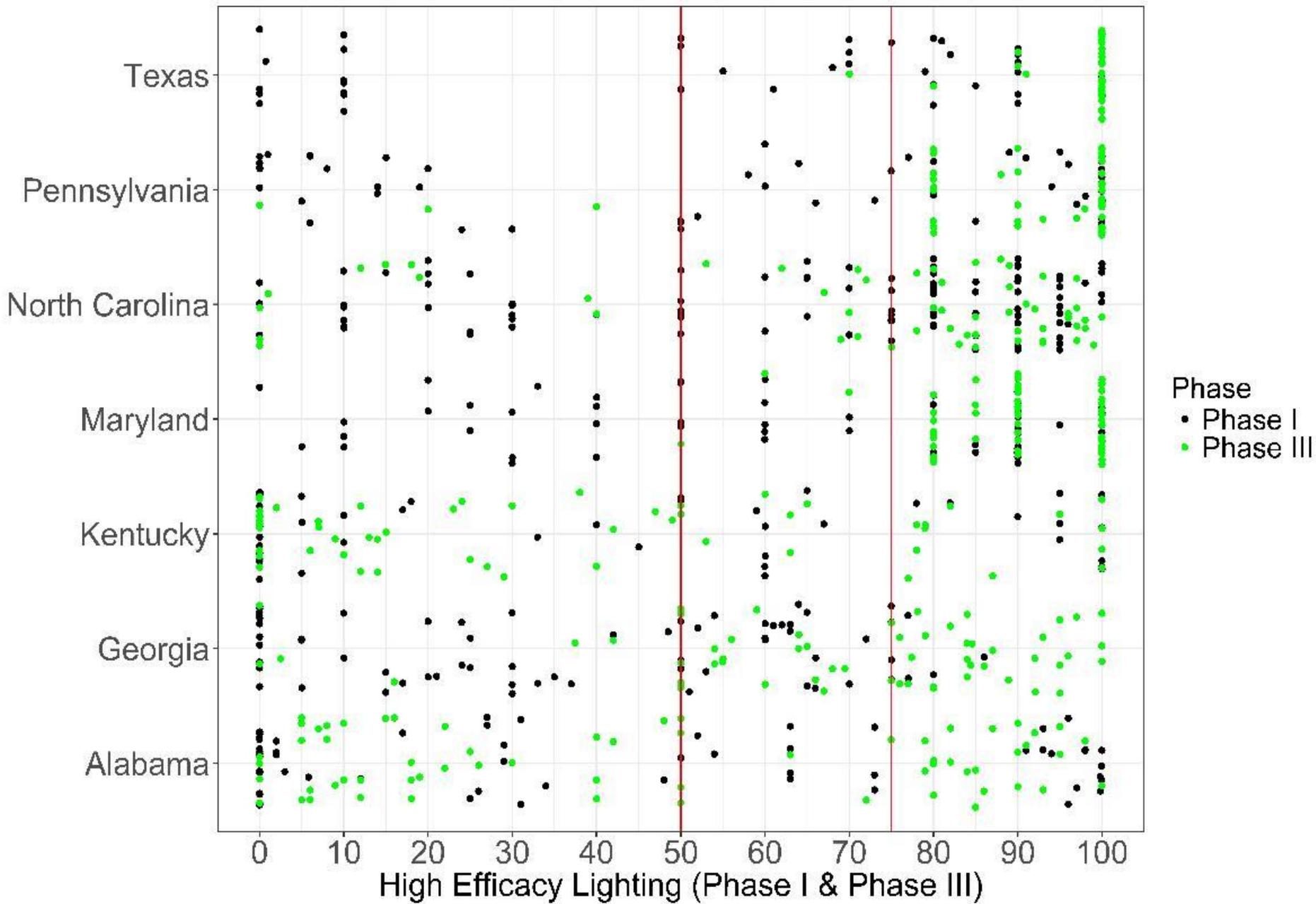
PHASE THREE

REMEASURE vs PHASE ONE





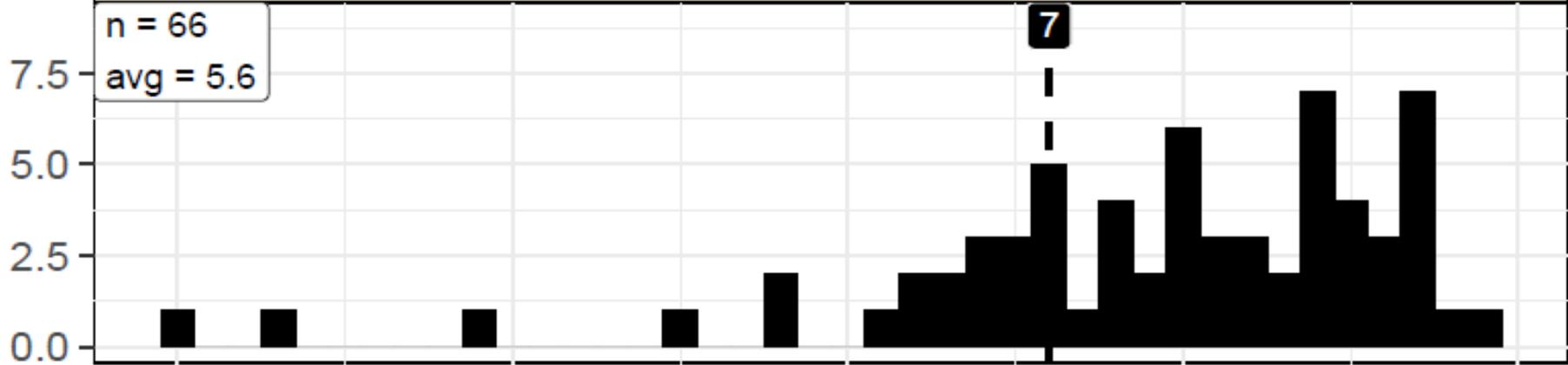




Kentucky

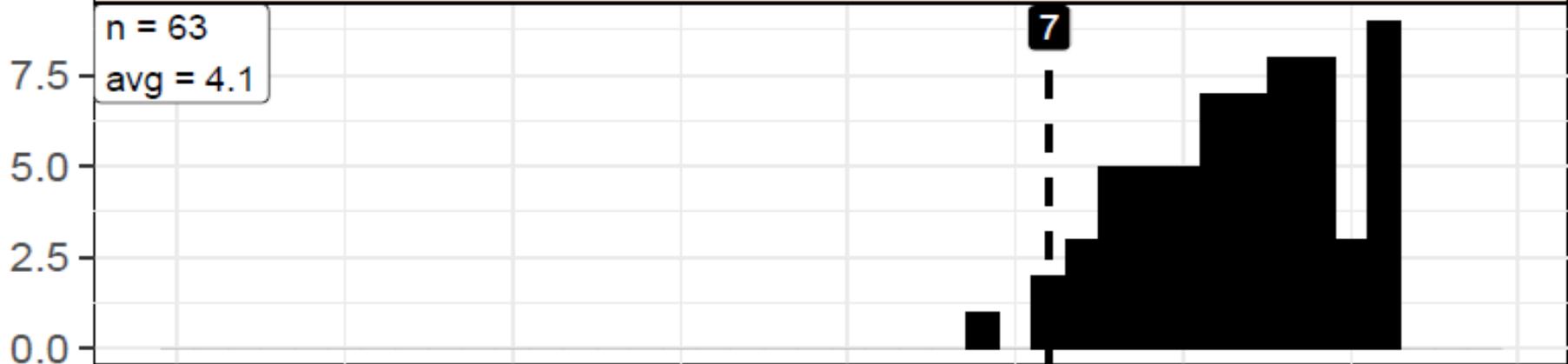
Phase I

n = 66
avg = 5.6



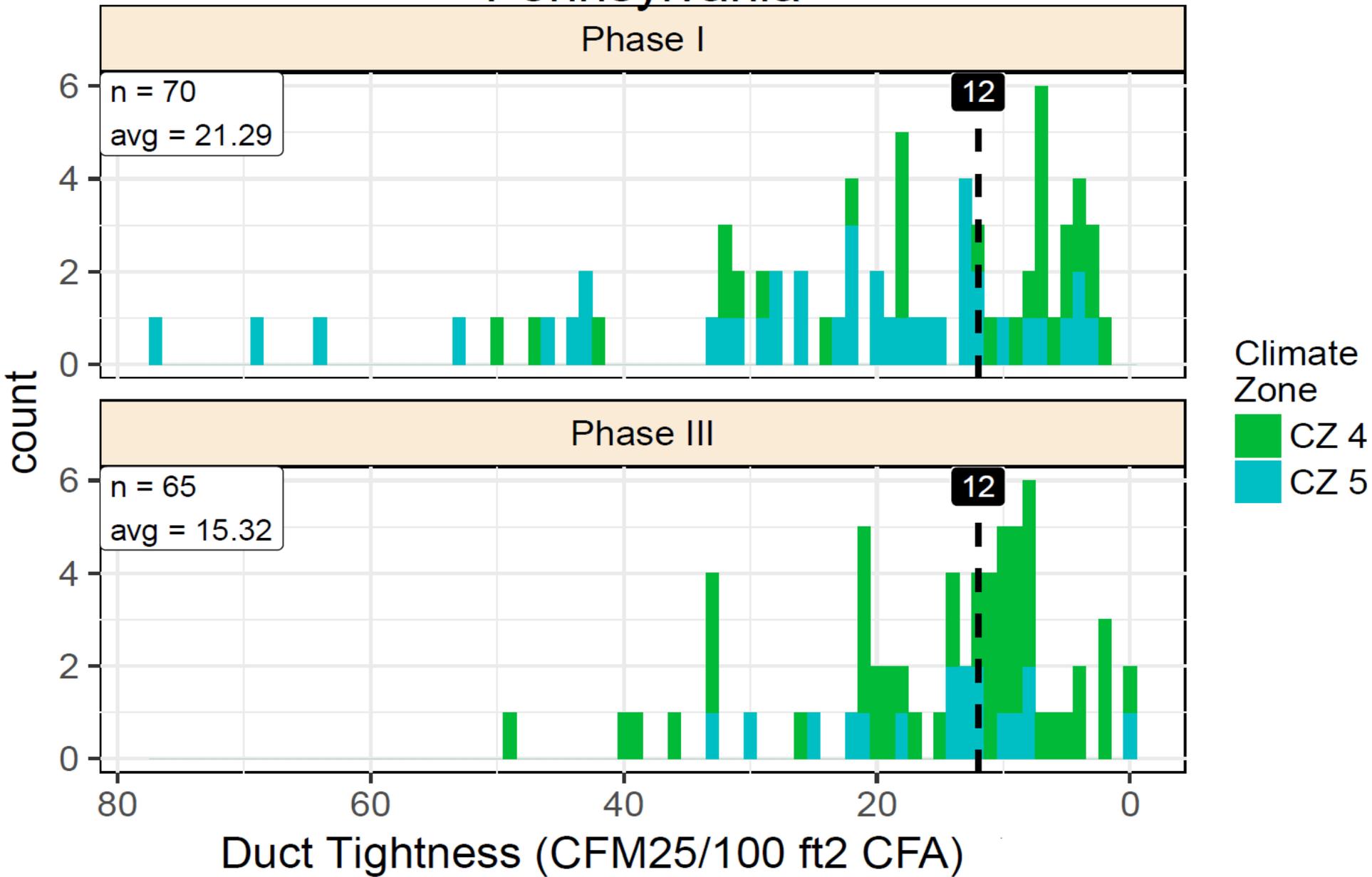
Phase III

n = 63
avg = 4.1



Envelope Tightness (ACH50)

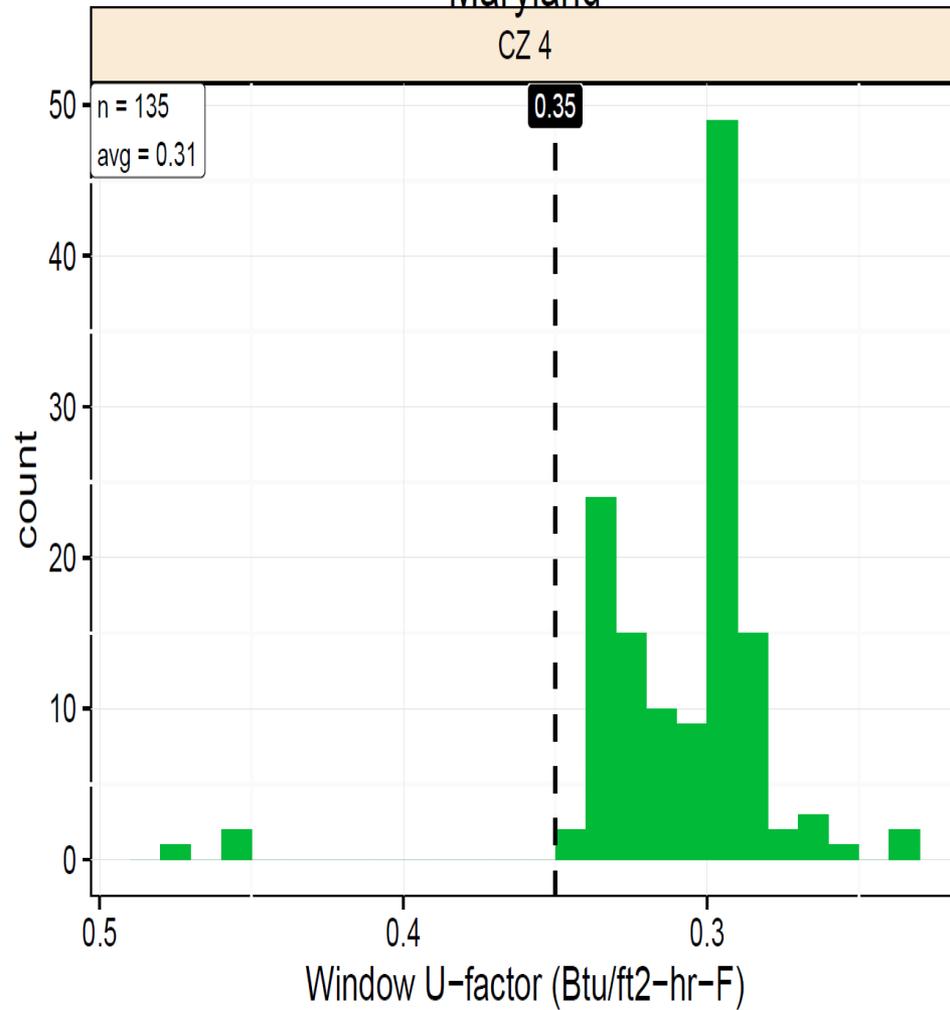
Pennsylvania



WINDOWS (u-factor)

Maryland

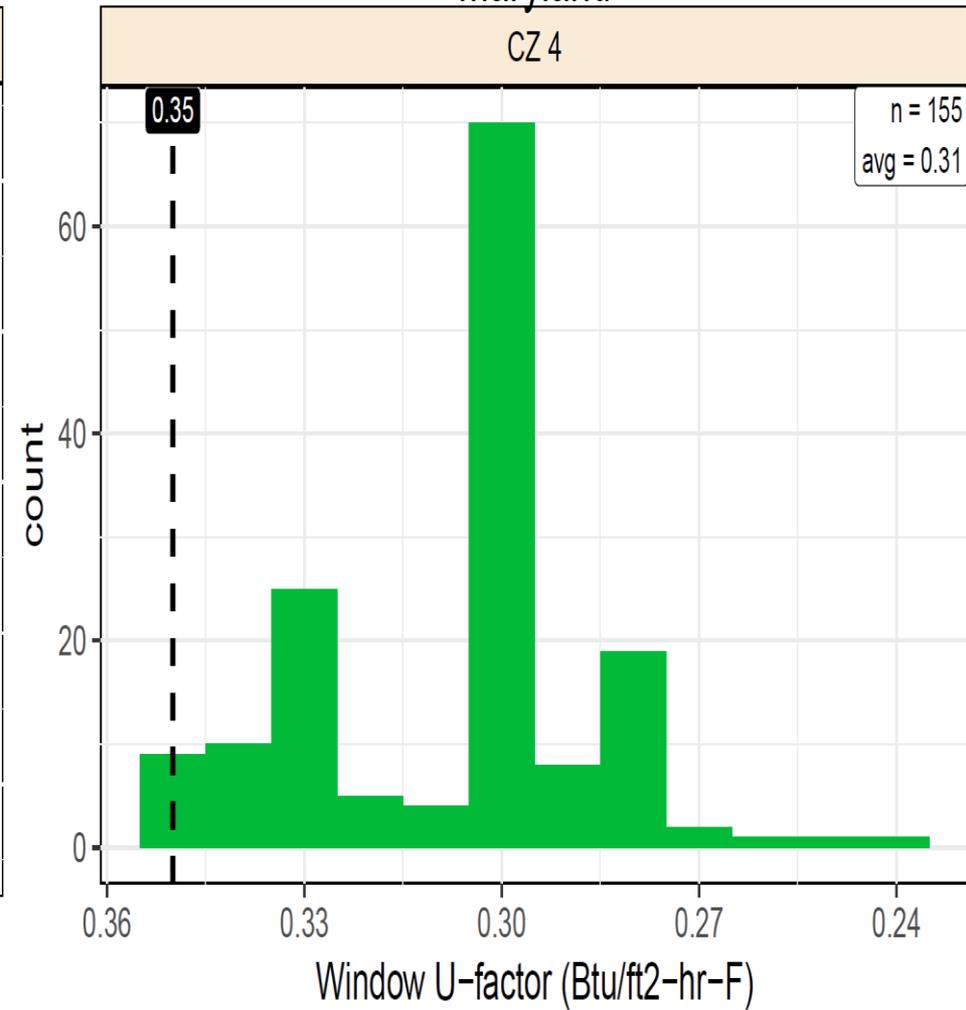
CZ 4



Phase I

Maryland

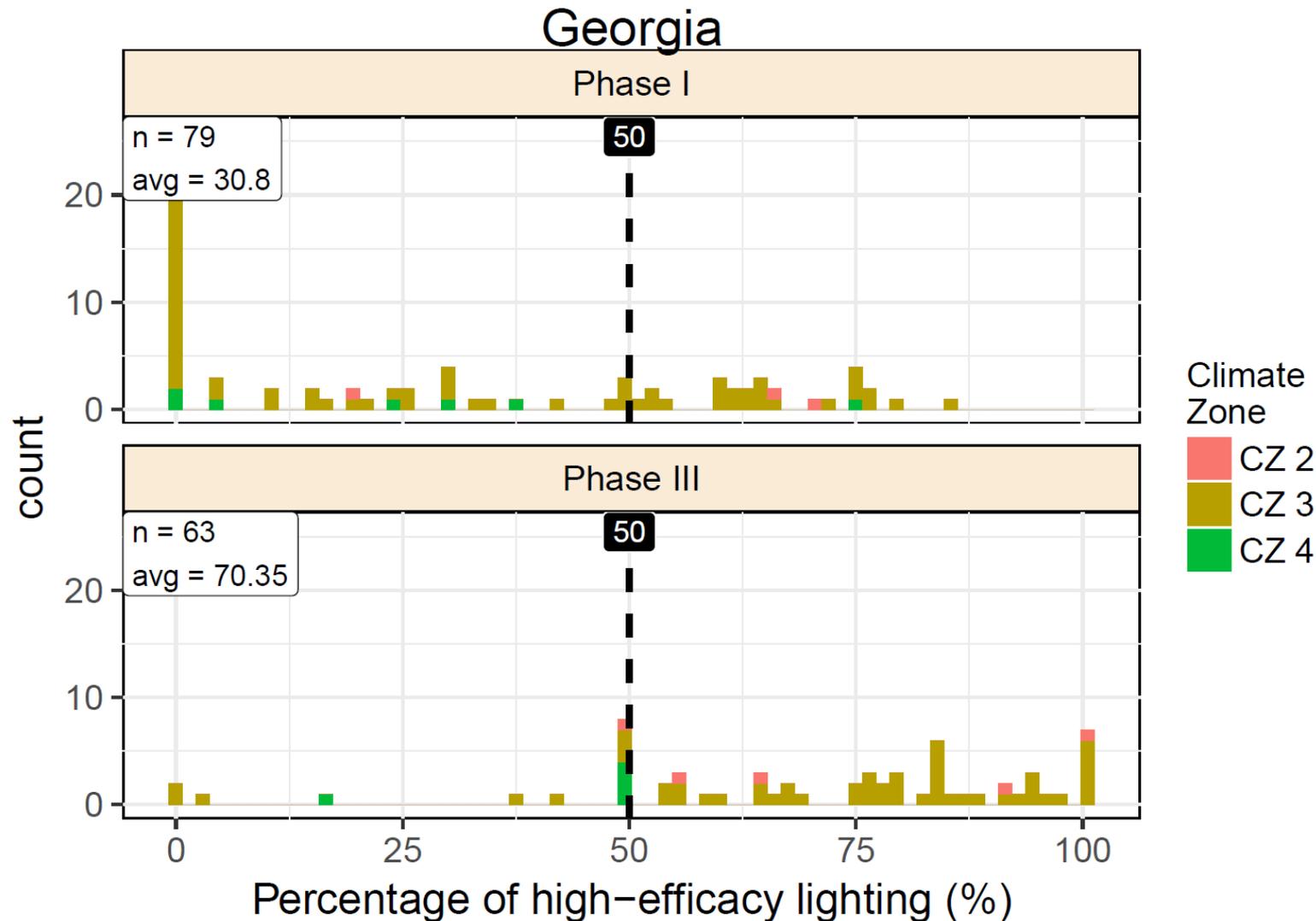
CZ 4



Phase III

STATE-SPECIFIC COMPARISONS – HIGH EFFICACY LAMPS (%)

Lighting got much better in Phase III



STATEWIDE ENERGY USE

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

How do we measure success?

Success = Change in average statewide EUI of at least **1.25 kBtu/ft²** (Phase III vs I)

- + Did average energy use change (better or worse)?
- + Did it change enough to be *significant*?

<https://www.energycodes.gov/compliance/energy-code-field-studies>

STATEWIDE ENERGY USE

Good

Observed Phase III EUI is lower than Observed Phase I EUI and difference is statistically significant

{GA, KY, MD, and TX}

Trending in Wrong Way

Observed Phase III EUI greater than Observed Phase I EUI, but difference is not statistically significant

{NC}

Trending in Right Way

Observed Phase III EUI is lower than Observed Phase I EUI, but difference is not statistically significant

{AL}

Bad

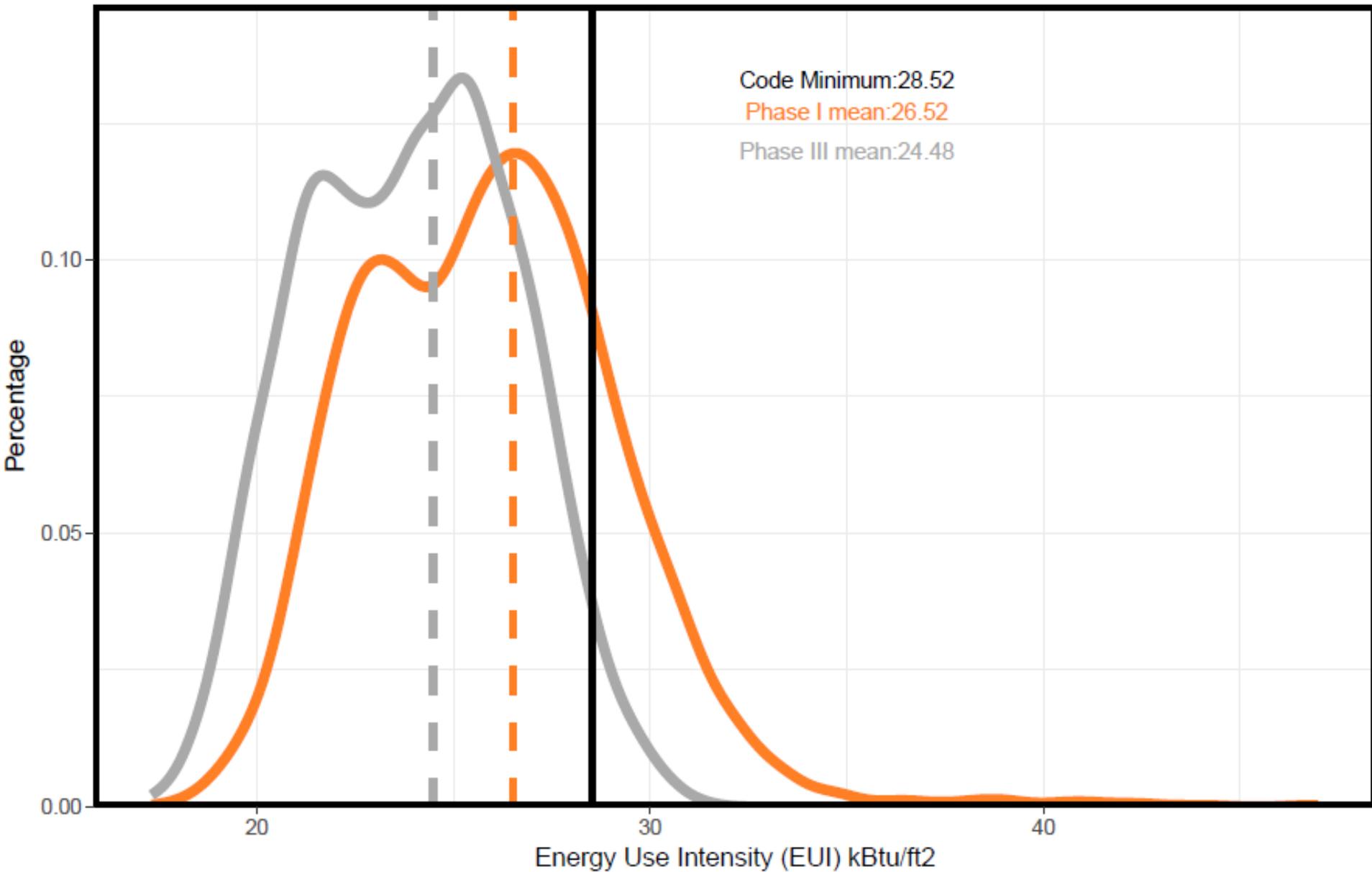
Observed Phase III EUI greater than Observed Phase I EUI and difference is statistically significant

{PA}

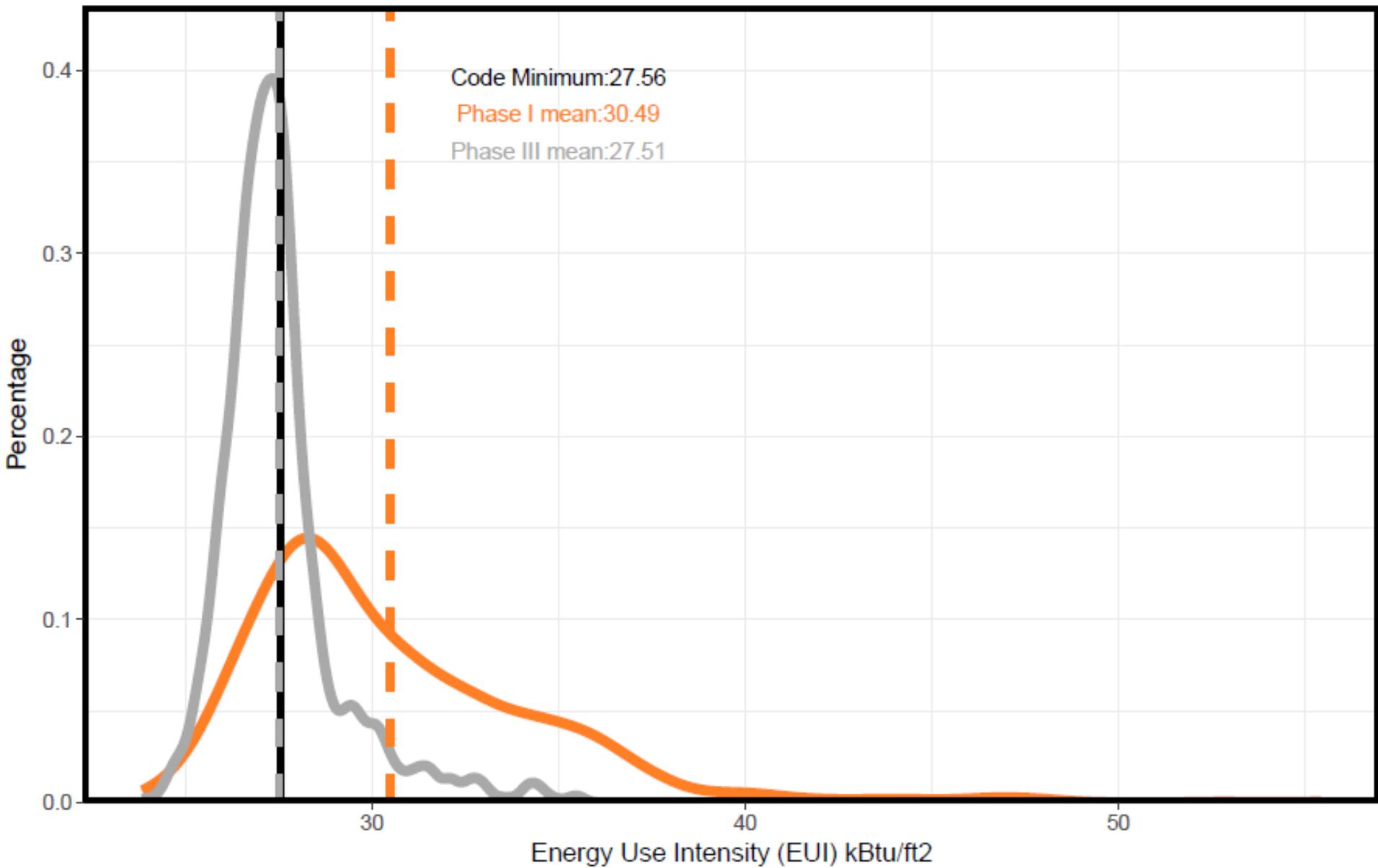
RESULT: 5 of 7 states reduced their statewide EUIs

STATE	PHASE I EUI	PHASE III EUI	Δ	%
AL	19.81	19.04	0.77	4%
GA	26.52	24.48	2.04	8%
KY	31.31	29.49	1.82	6%
MD	30.49	27.51	2.98	10%
NC	22.96	23.21	+0.25	+1%
PA	40.73	43.70	+2.97	+7%
TX	22.57	20.74	1.84	8%

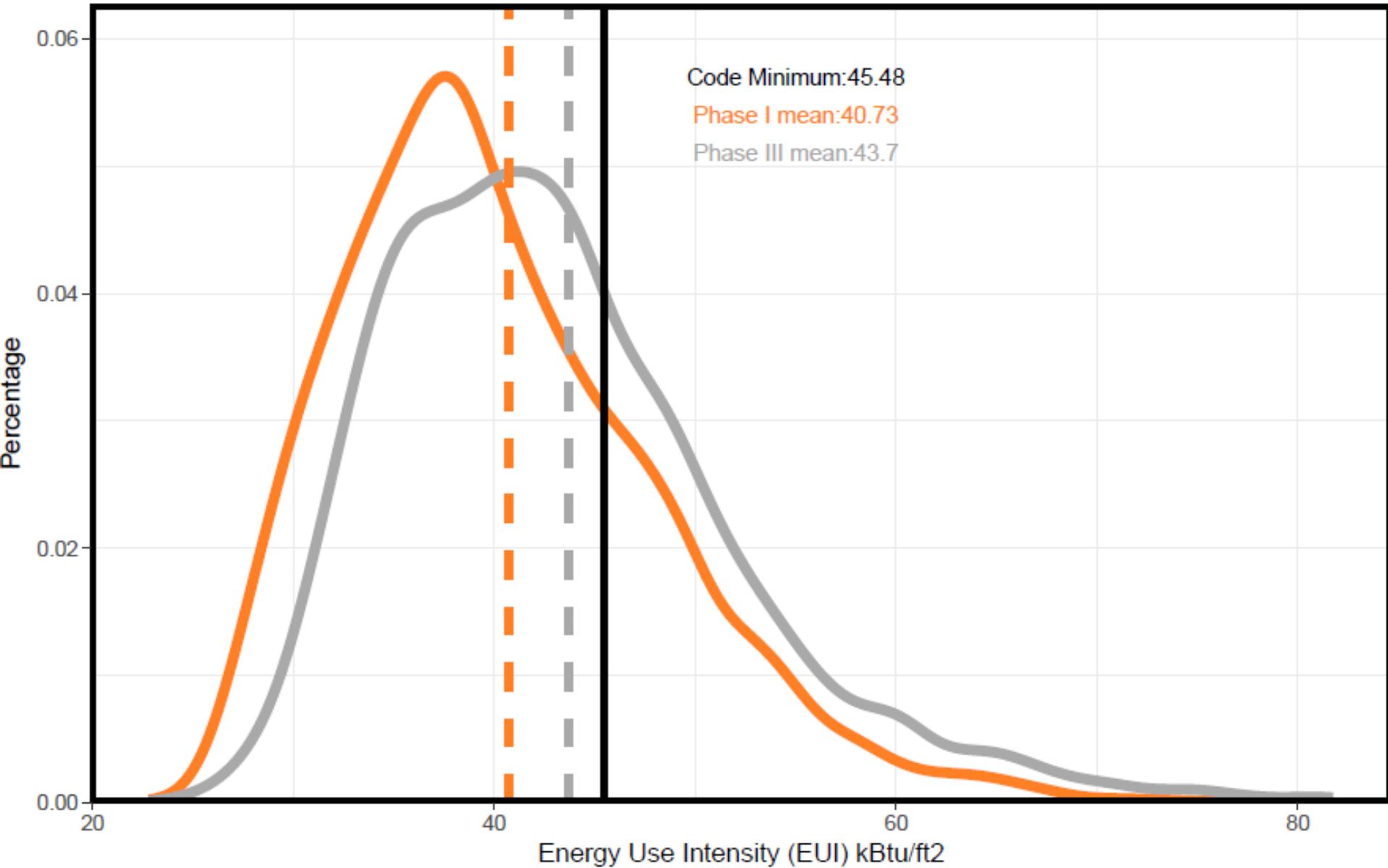
Georgia Phase I and Phase III EUI Comparison



Maryland Phase I and Phase III EUI Comparison

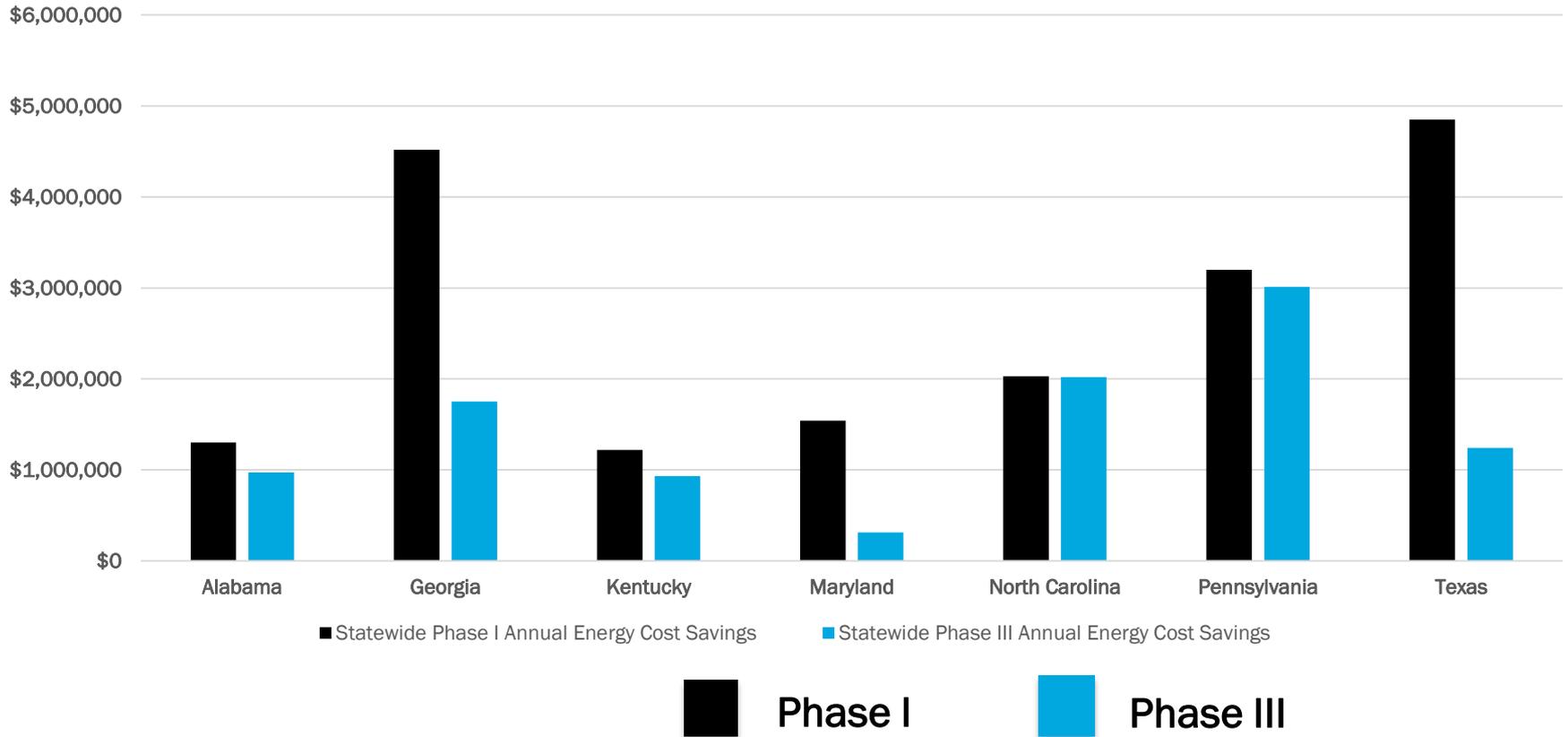


Pennsylvania Phase I and Phase III EUI Comparison



MEASURE LEVEL SAVINGS

Measure Level Savings Potential - Energy Cost (\$)



RESULT: 7 of 7 states reduced their measure savings potential

Was Targeted Measure-level Training Successful?

STATE	DUCT TIGHTNESS	LIGHTING	ENVELOPE TIGHTNESS	WALL INSULATION	CEILING INSULATION
AL	YES	YES	YES	YES	N/A
GA	YES	YES	N/A	YES	YES
KY	NO	YES	YES	YES	YES
MD	YES	YES	YES	YES	YES
NC	NO	YES	NO	YES	N/A
PA	YES	YES	N/A	NO	N/A
TX	YES	YES	YES	YES	NO
% of States Where Training Worked	5 of 7 (71%)	7 of 7 (100%)	4 of 5 (80%)	6 of 7 (86%)	3 of 4 (75%)

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

CONCLUSIONS

SF RESIDENTIAL PILOT

KEY TAKEAWAYS (phase 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

STATE	Δ EUI	\$ Δ
AL	4%	25.4%
GA	8%	61.2%
KY	6%	23.8%
MD	10%	79.9%
NC	+1%	0.50%
PA	+7%	5.9%
TX	8%	74.4%

CONCLUSION

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)
- + Mixed results in terms of statistical significance

SUCESSES + ACCOMPLISHMENTS

- + Established empirical data set representing typical construction practices across several states
- + New methodology moves past 90% compliance mentality and re-focused on *energy* metric
- + We have a much better grasp on key items and their impact
- + What's happening in the field appears much better than expected (on average)—significant improvement to code compliance estimates
- + Enabled existing education & training programs to focus on the most important (key) items and achieve greater bang-for-the-buck
- + Value in states performing regular studies—measure impacts and inform ongoing state education and training activities
- + Interest in expanding these types of studies to capture and track new and advancing technologies (market penetration)

SUCESSES + ACCOMPLISHMENTS (continued)

- + Results have influenced several state and national training efforts (e.g., insulation installation quality and grading)
- + States have elected to update their codes based on data and findings
- + IECC has been updated based on data and findings (e.g., windows, lighting, envelope air tightness, duct tightness, etc.)
- + Identified significant savings potential associated with key items—hundreds of millions over 30 years—through codes already in place
- + Reduced average statewide energy use and measure savings potential

What do we do about it?

- What would you like to see come of this work?
- Do your experiences reinforce the findings?
- What are logical next steps?
- What else should we be thinking about?

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