Pacific Northwest
NATIONAL LABORATORY

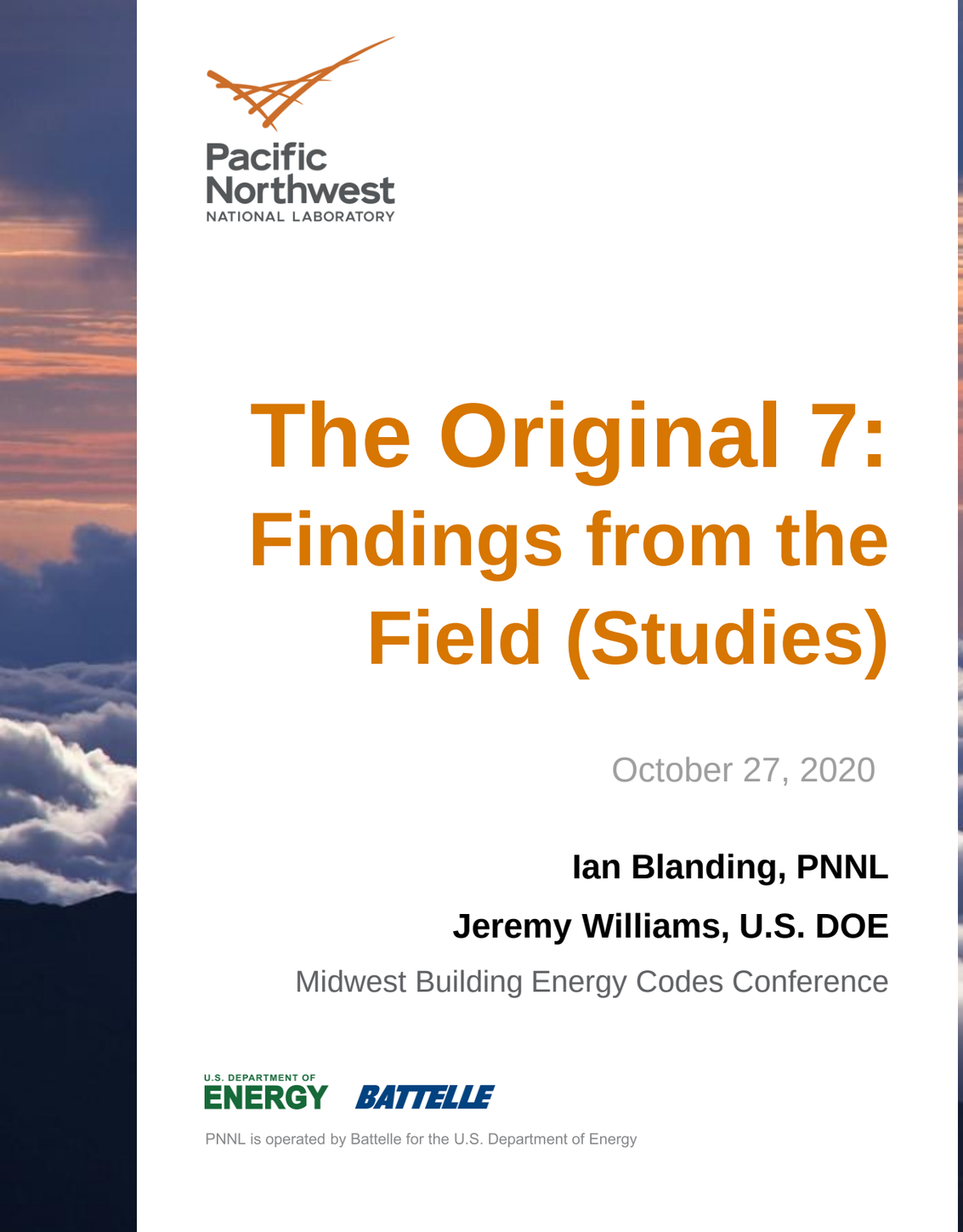
The Original 7:
Findings from the Field (Studies)

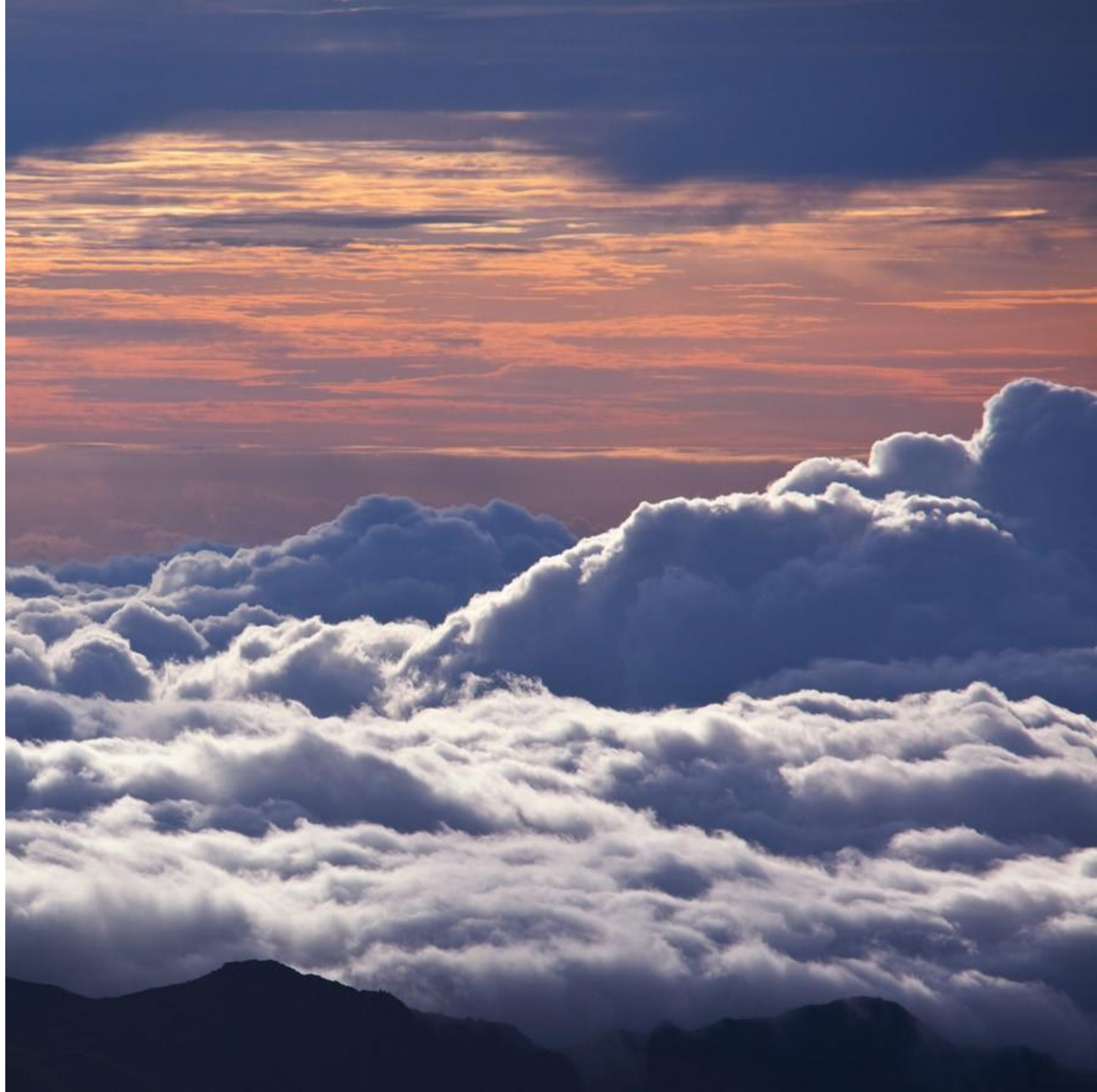
October 27, 2020

Ian Blanding, PNNL

Jeremy Williams, U.S. DOE

Midwest Building Energy Codes Conference

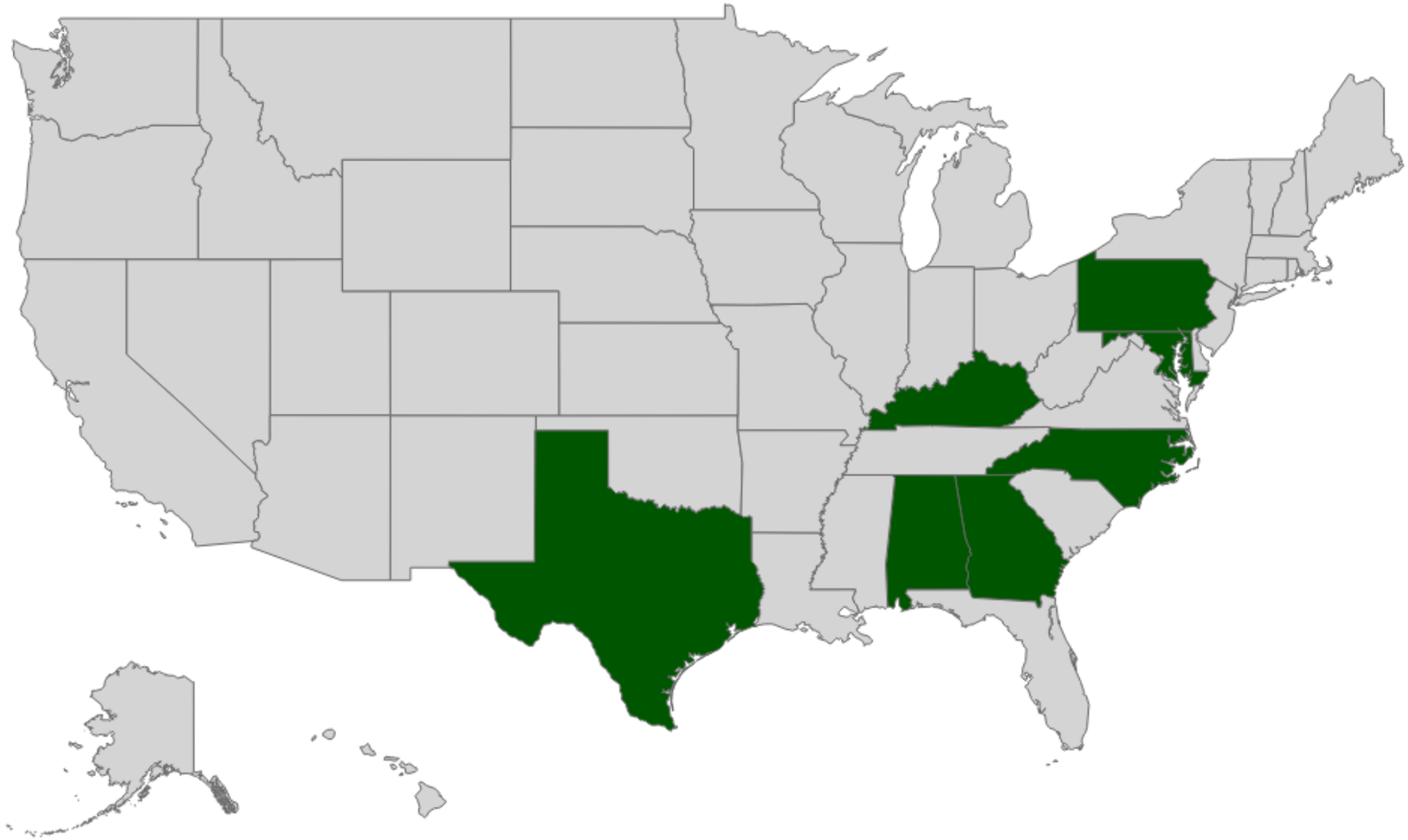




U.S. DEPARTMENT OF ENERGY BATTELLE

PNNL is operated by Battelle for the U.S. Department of Energy

The Original 7
Single-Family Energy Efficiency Field Studies



Methodology

1. **Pre-Study**: A baseline study to:
   a) identify the energy use in typical single-family residential buildings in a given state
   b) opportunities for improving energy efficiency

2. **Education & Training**: Education & training activities targeting issues identified through the baseline study

3. **Post-Study**: A second study to identify the change in energy use following the education & training activities

Study Goals and Objectives

Goal: Determine whether investments in energy code education & training programs can produce a significant, measurable change in energy savings.

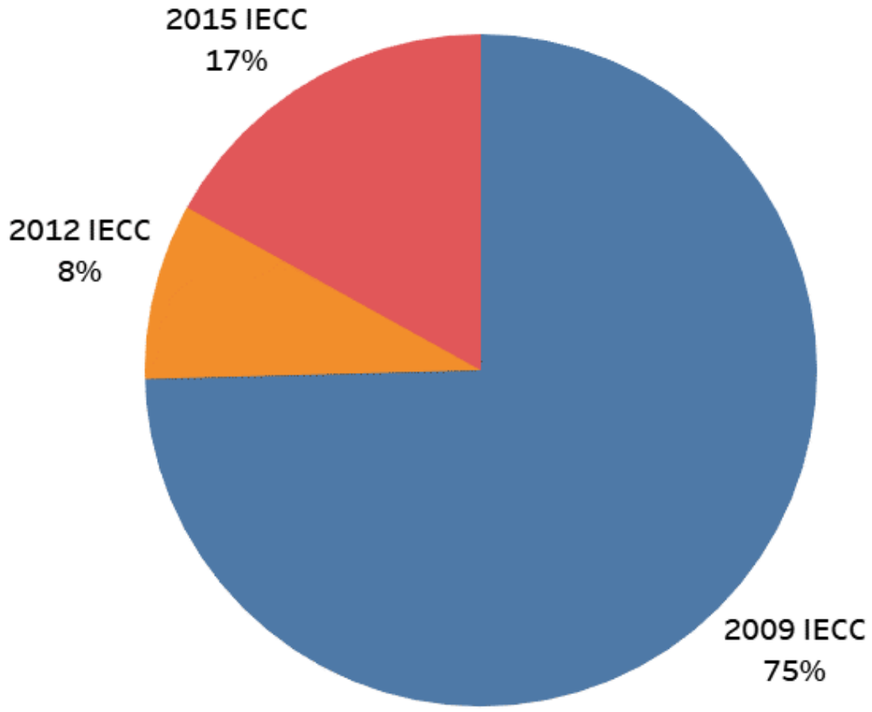
Purpose: Assist states in measuring energy code compliance and to identify areas of focus for workforce education & training initiatives.

Objectives:

- Document typical construction practices across states (empirical data)
- Target specific areas for improvement—high-impact measures (“key items”)
- Quantify related savings potential (e.g., E, $, CO2)
- Support a business case for additional investments (e.g., utility programs)
- Encourage and streamline future states studies and training programs

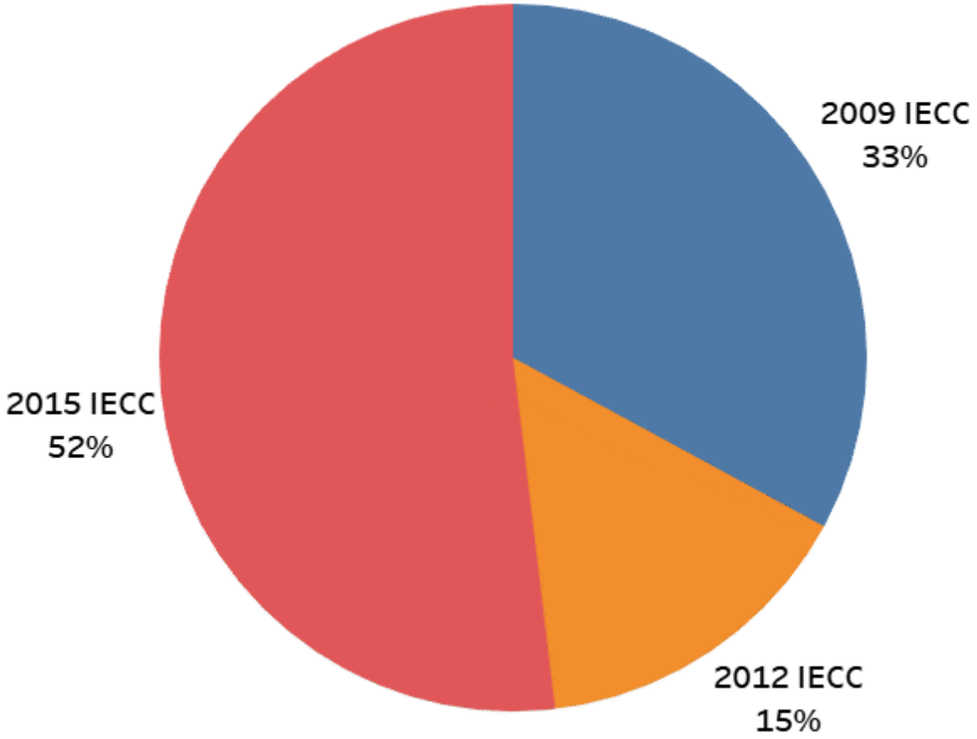
Energy Code Used
Phase I vs Phase III (All States)

Phase I



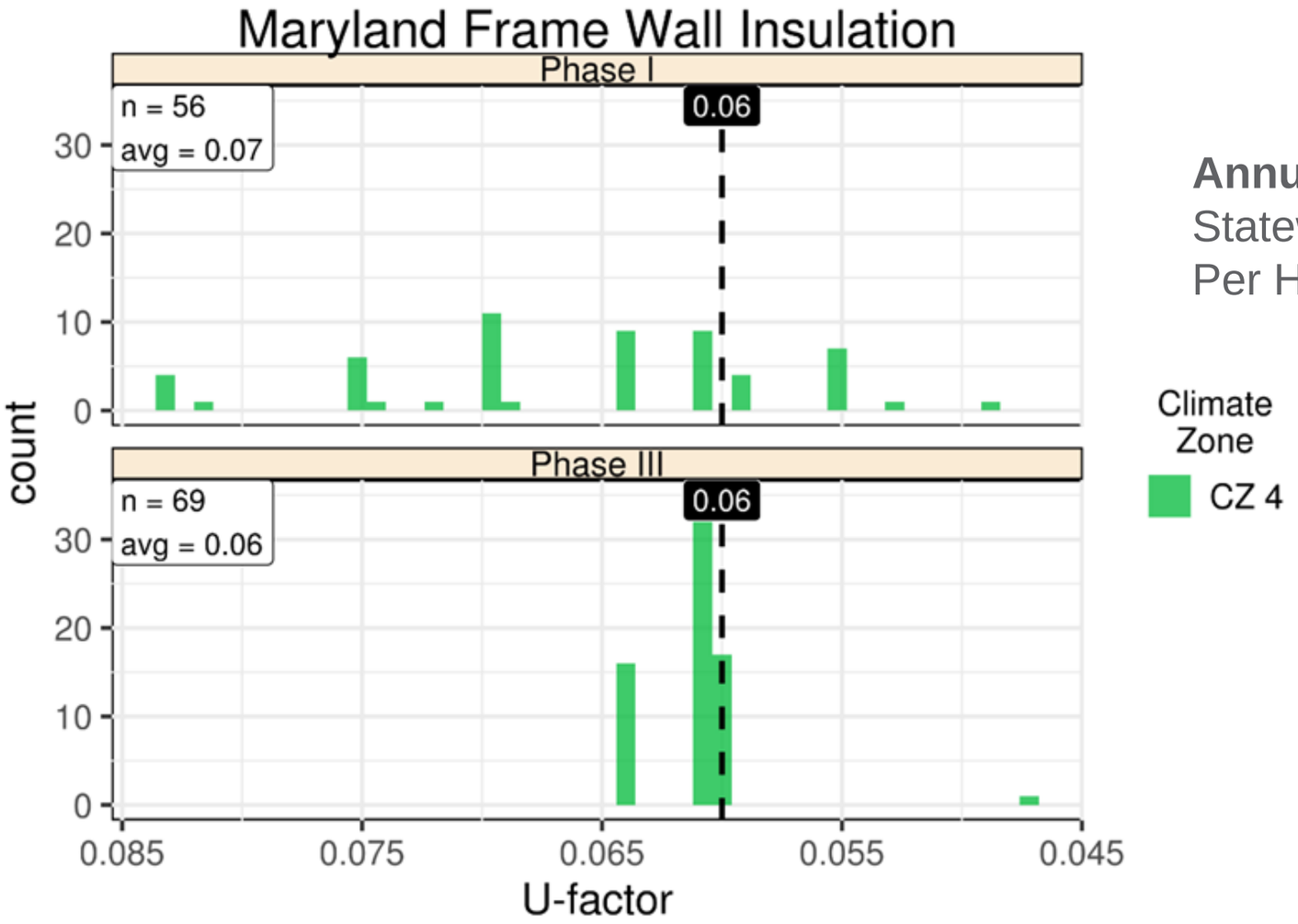
n=779

Phase III



n=869

Wall Insulation
Phase I vs III (MD)

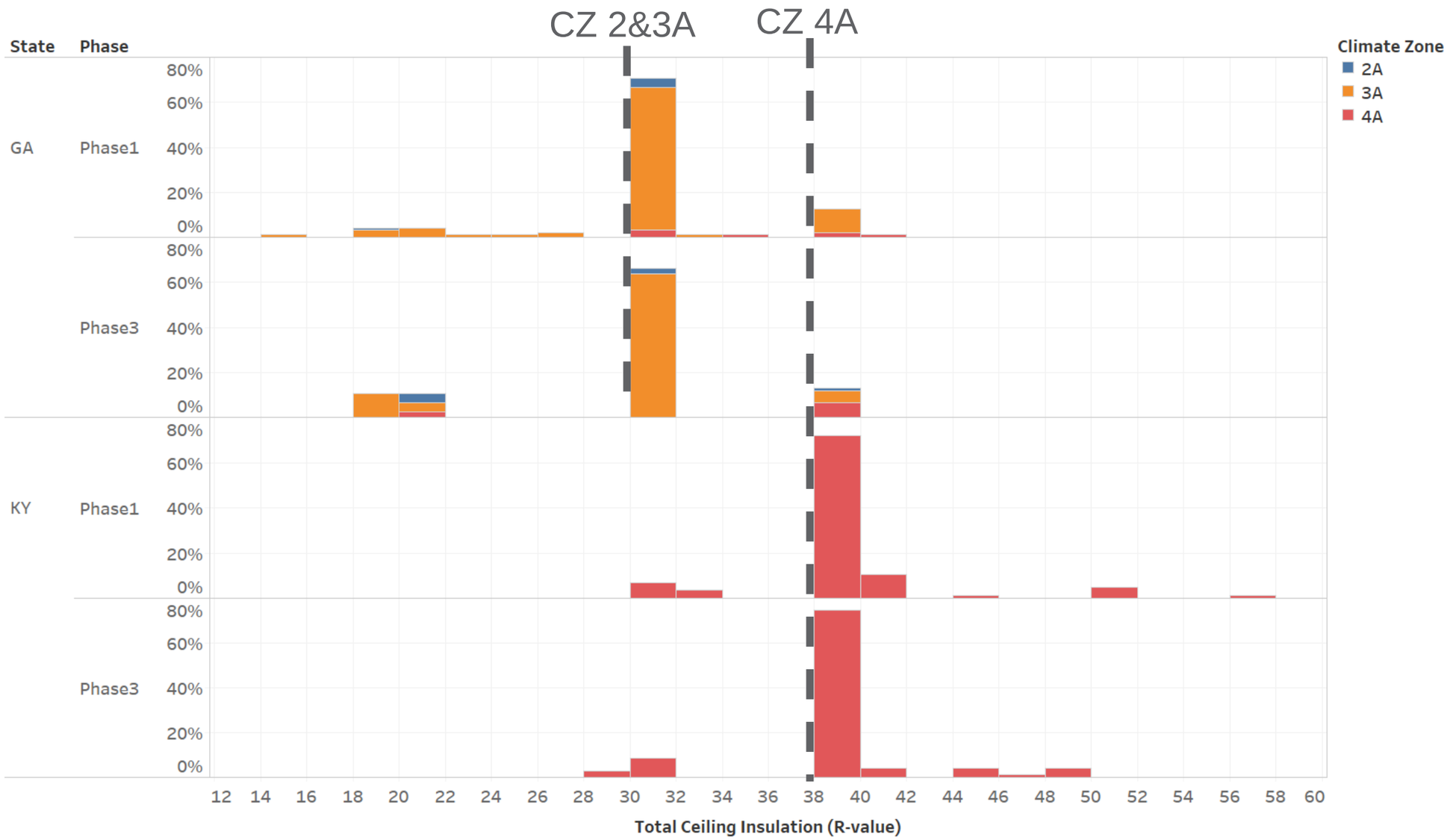


Annual Savings: Phase I to III

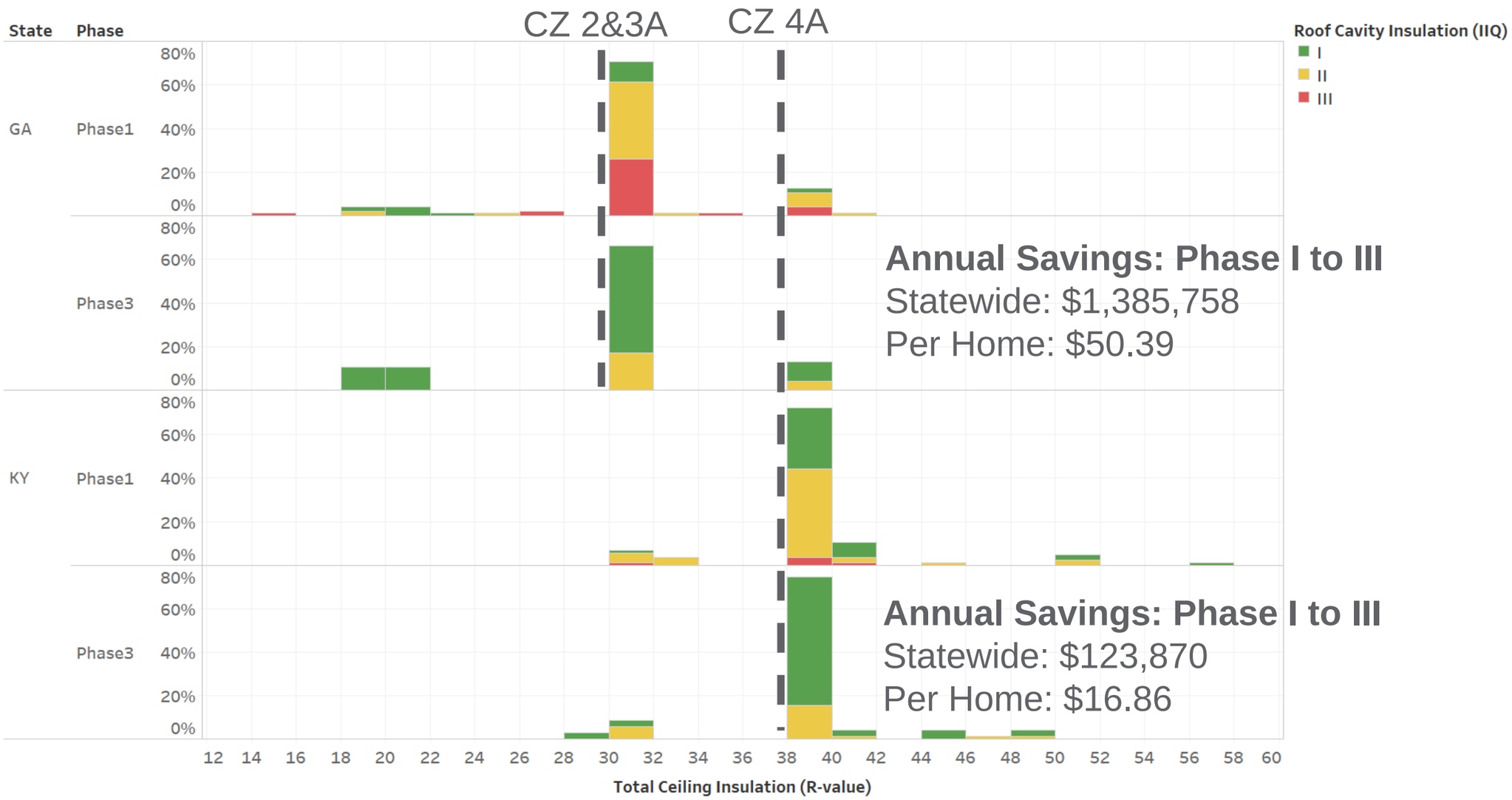
Statewide: $327,982

Per Home: $31.11

Ceiling Insulation
Phase I vs III (GA & KY)



Ceiling Insulation
Phase I vs III (GA & KY)



Insulation Installation
Phase I vs Phase III (All States)

Wall Insulation (IIQ) (n=934)

Wall Cavity Insulation (IIQ)	Phase1	Phase3
I	36%	41%
II	51%	52%
III	13%	6%

Ceiling Insulation (IIQ) (n=1,143)

Roof Cavity Insulation (IIQ)	Phase1	Phase3
I	60%	78%
II	32%	20%
III	8%	2%

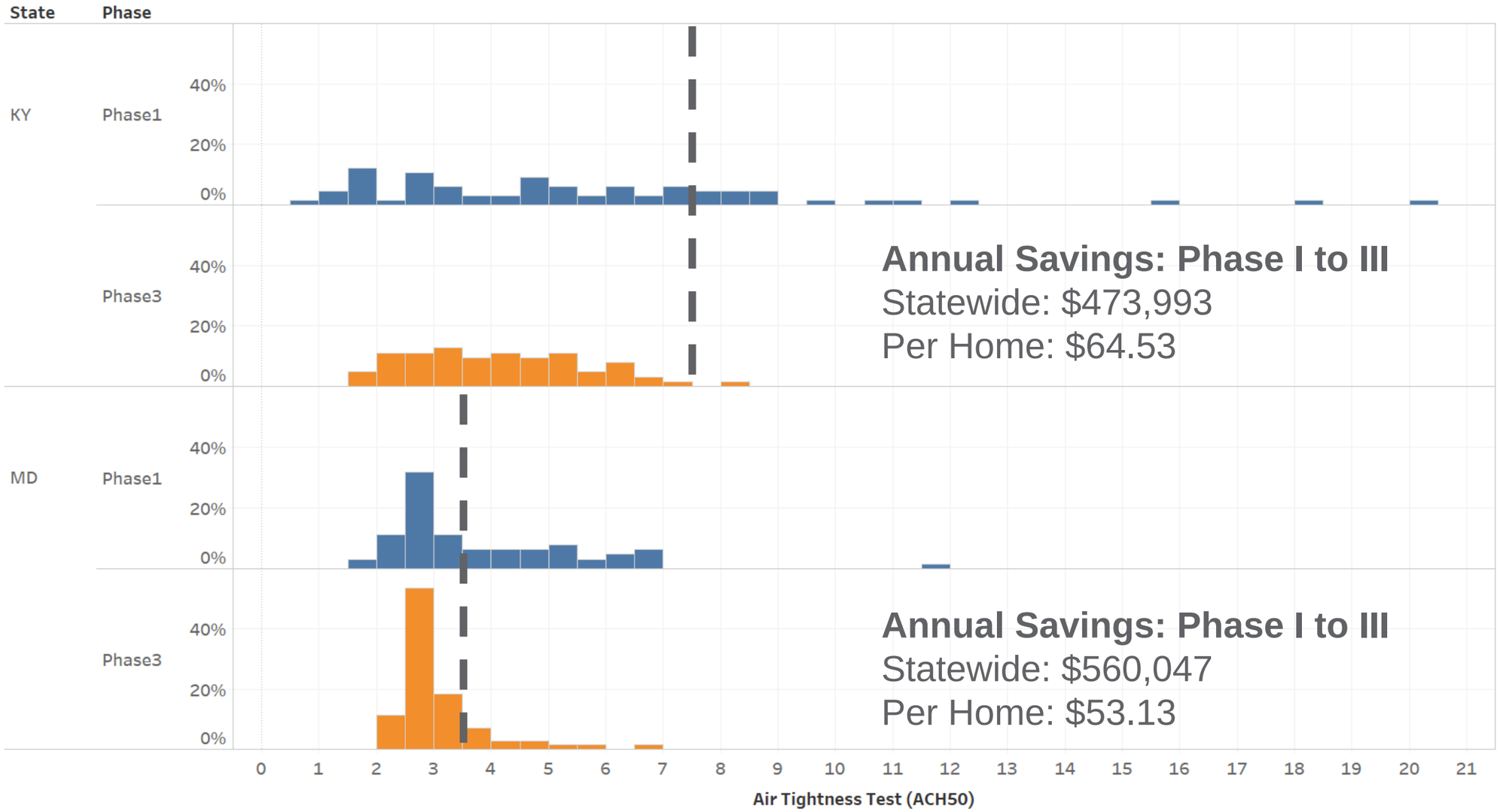
Basement Insulation (IIQ) (n=308)

Basement Cavity Insulation (IIQ)	Phase1	Phase3
I	56%	37%
II	38%	60%
III	6%	3%

Floor Insulation (IIQ) (n=355)

Floor Insulation (IIQ)	Phase1	Phase3
I	47%	28%
II	36%	53%
III	17%	19%

Air Tightness
Phase I vs III (KY & MD)

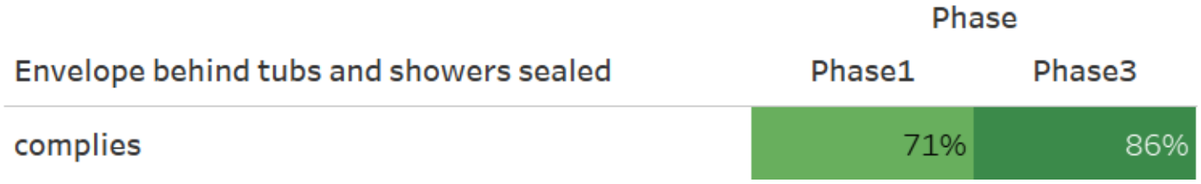


Air Sealing Items
Phase I vs Phase III (All States)

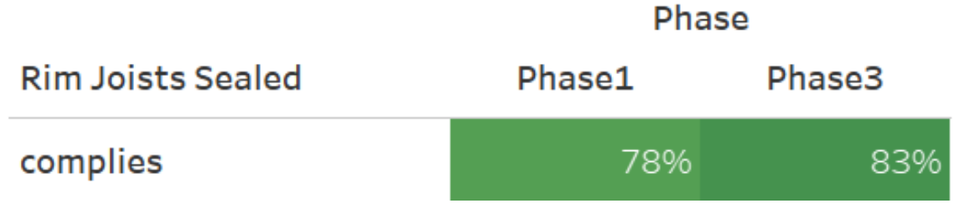
Utility Penetrations Sealed (n=878)

Garage Walls & Ceilings Sealed (n=689)

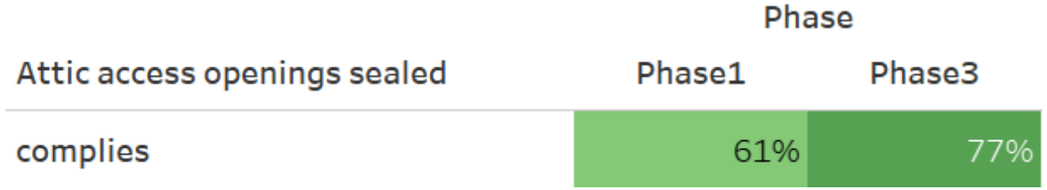
Behind Tub & Shower Sealed (n=707)



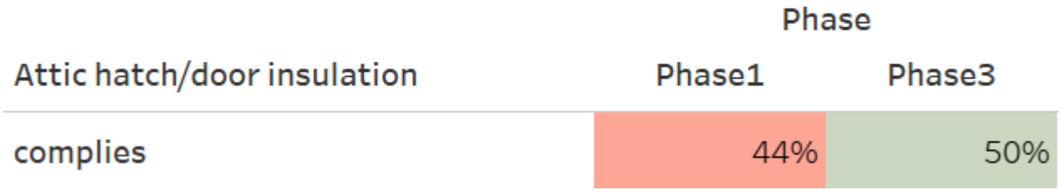
Rim Joists Sealed (n=618)



Attic Access Sealed (n=632)



Attic Hatch Insulated (n=609)

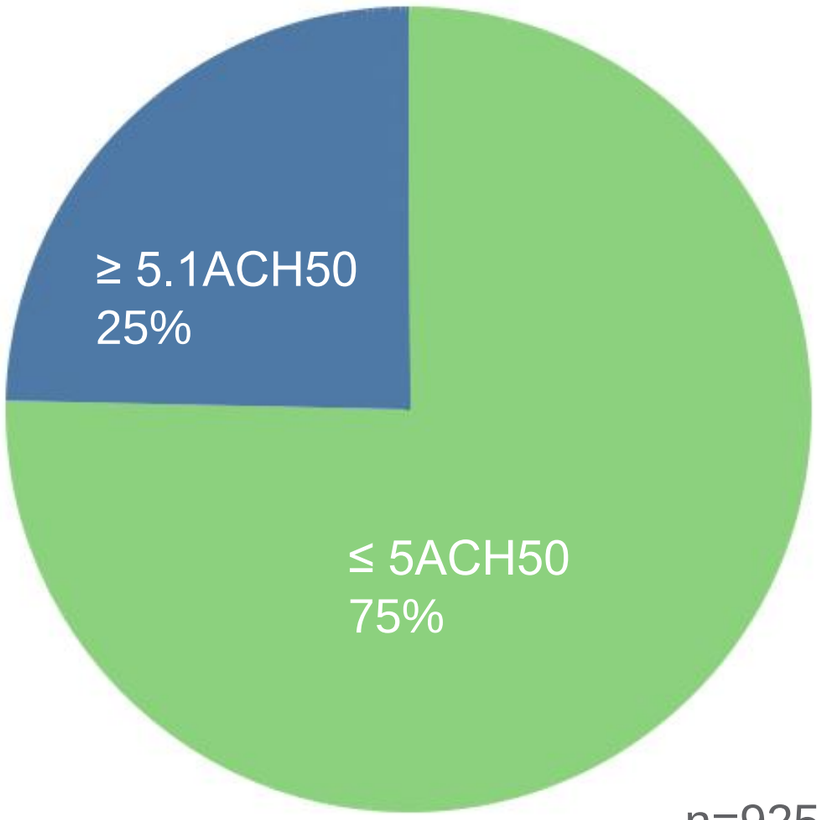


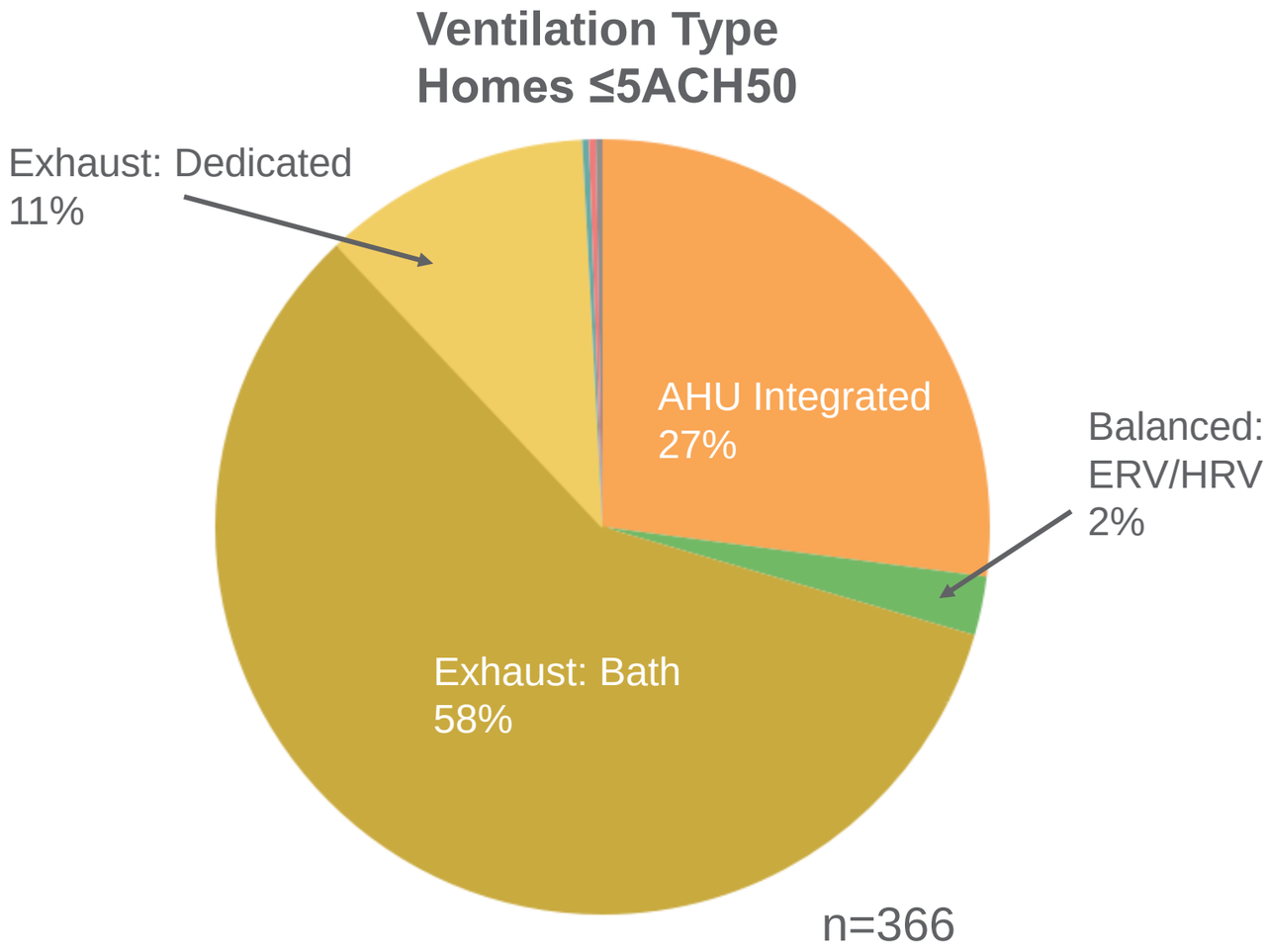
Air Tightness and Visual Inspections
Key Findings (All States+)

Code Requirement	Compliance Rate based on Visual Inspection	Compliance Rate based on Blower Door Test
All Homes	78.7%	84.9%
5 ACH50 and below	81.9%	74.7%
4 ACH50 and below	86.9%	62.6%

Source: Reiner et al., *Code to Classroom, 2020* ACEEE Summer Study

Air Tightness and Ventilation
Phase I & III (All States)





Duct Leakage Conditioned vs Unconditioned
Key Findings (All States+)

Code requirement (cfm /100 ft)	Sample size (n)	Average duct tightness (cfm / 100 ft)	
		Unconditioned space	100% Conditioned space
4	451	6.4	17.8
12	469	12.2	20.7

Source: Reiner et al., *Code to Classroom, 2020* ACEEE Summer Study

Duct Sealing Items
Phase I vs Phase III (All States)

Cavities Not Use as Ducts (n=934)

Building Cavities Not Used as Ducts	Phase1	Phase3
complies	97%	97%

HVAC Filter Boxes Sealed (n=1,276)

Filter Boxes Sealed	Phase1	Phase3
complies	78%	91%

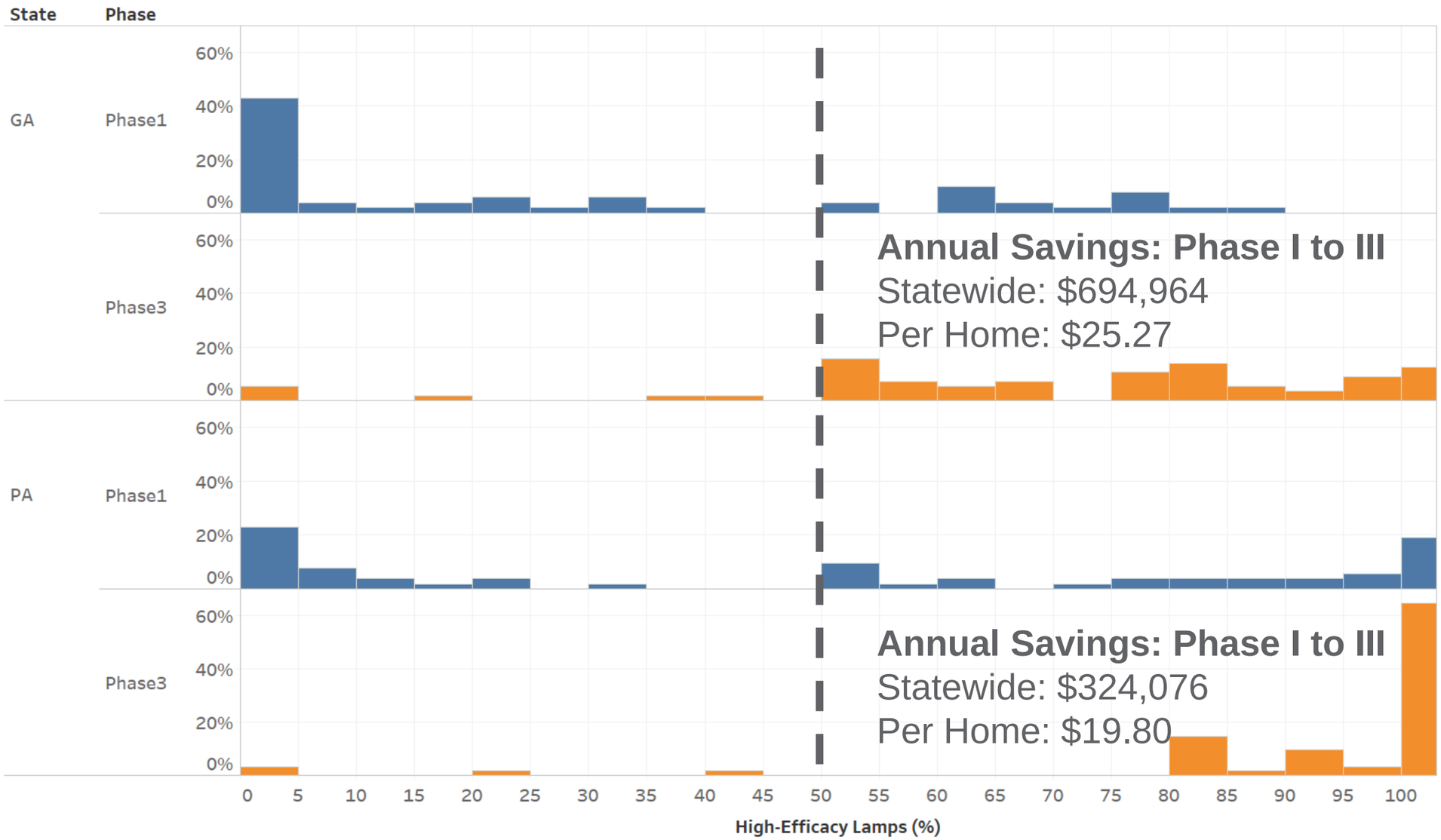
HVAC Register Boots Sealed (n=850)

HVAC register boots per Table 402.4.2	Phase1	Phase3
complies	63%	69%

HVAC Air Handler Sealed (n=1,393)

Air Handlers Sealed	Phase1	Phase3
complies	84%	94%

Lighting
Phase I vs III (PA & GA)



Education and Training
Approach by State

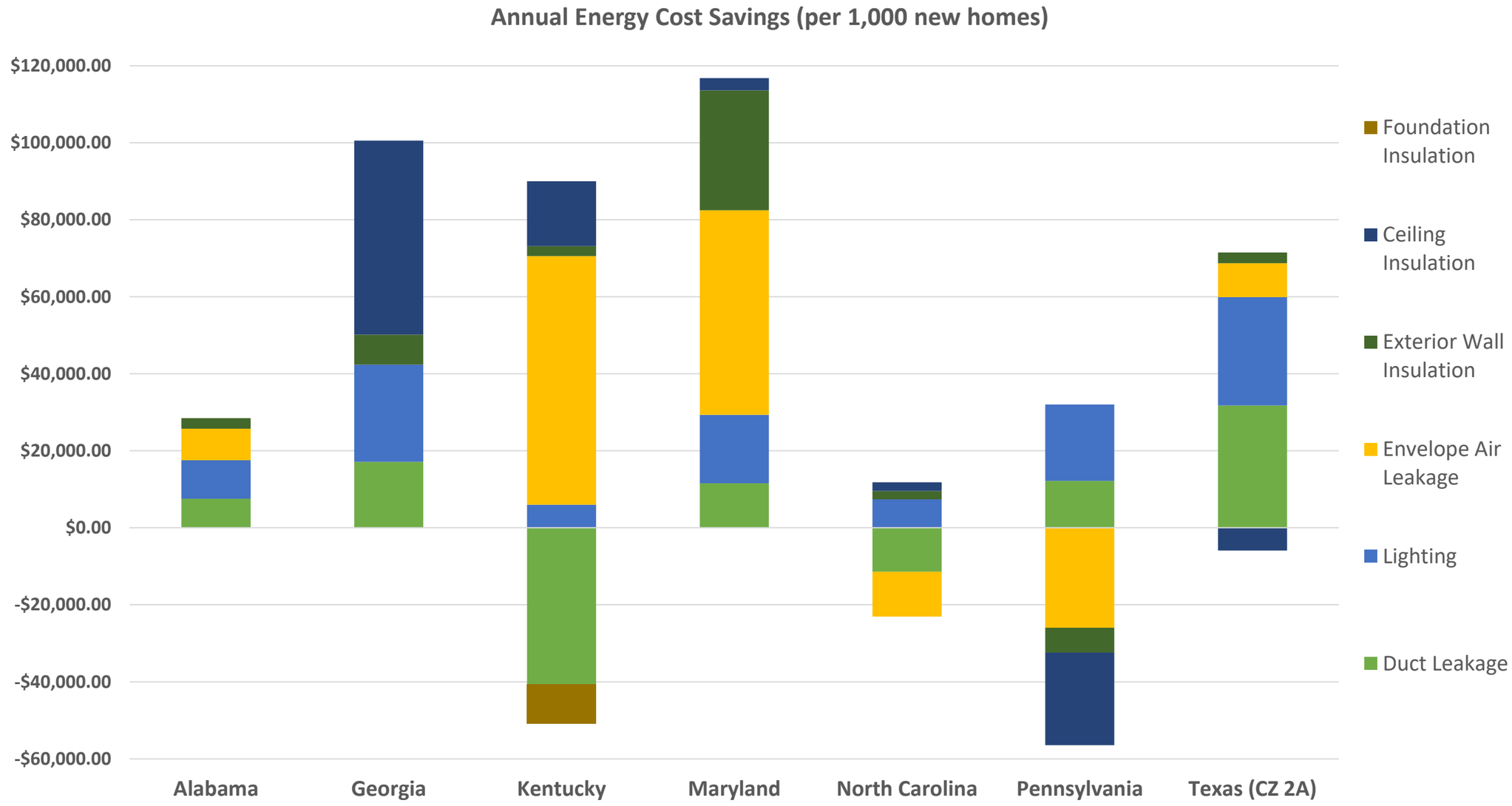
State	Classroom Training	Online Training	Circuit Rider	Hotline	Technical Resources
Alabama	x	x			x
Georgia	x	x	x	x	x
Kentucky	x	x	x	x	x
Maryland	x		x	x	x
North Carolina	x				x
Pennsylvania	x	x	x		x
Texas	x	x			x

Success
Targeted Measure-level Training

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%)

Source: Jeremy Williams, DOE, NECC Field Study Presentation

Annual Energy Cost Savings
Phase I to Phase III by State



Source: Reiner et al., *Code to Classroom, 2020* ACEEE Summer Study

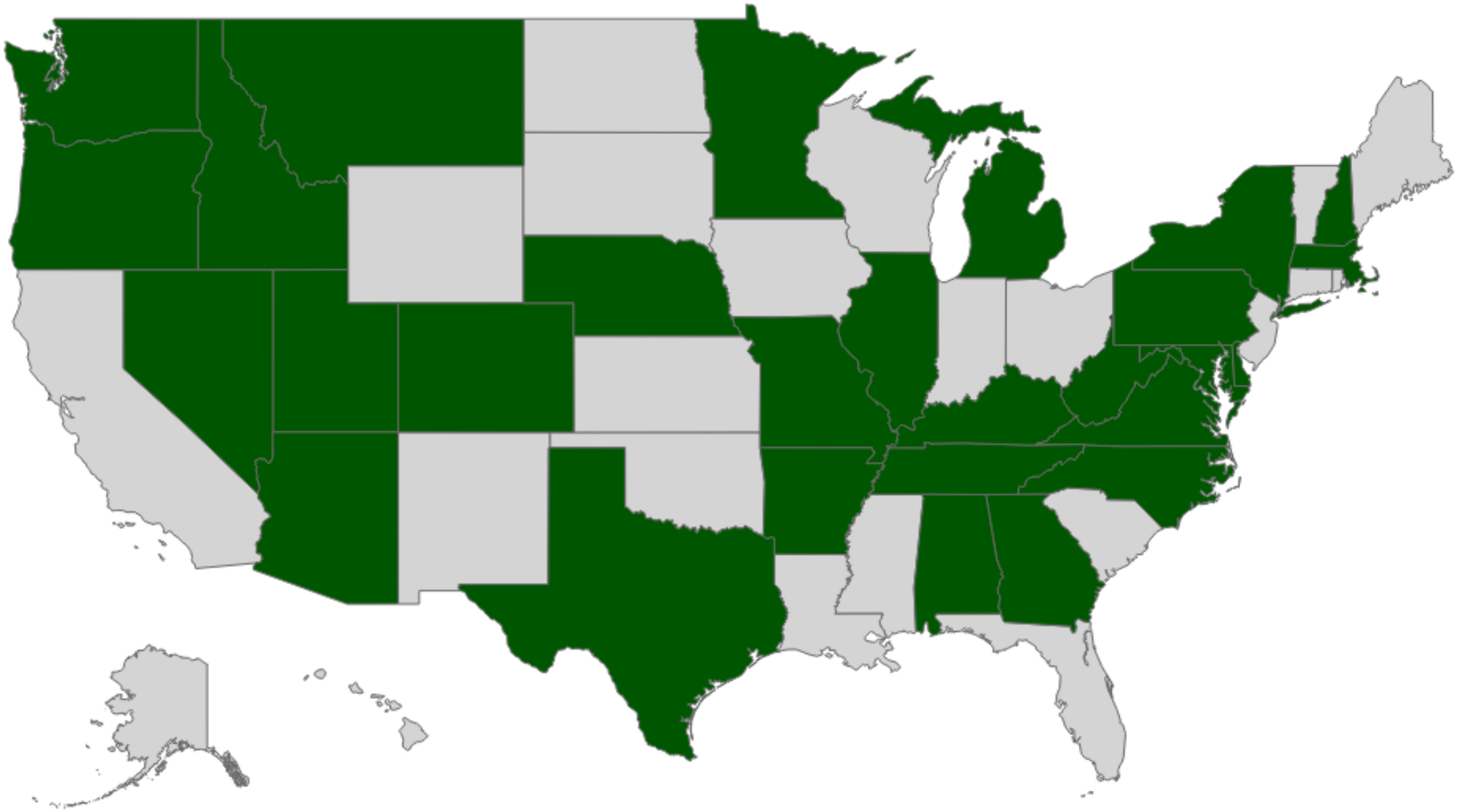
Cost-Benefit Analysis
Program Cost vs Energy Cost Savings

State	Estimated Program Cost (Phase II)	Annual Cost Savings (Statewide)	Annual Cost Savings (Per Home)	Annual Energy Savings (MMBtu)	BCR (1-year)	BCR (20-year)
Alabama	$ 323,000	$ 270,657	$28.47	10,994	0.8	9.6
Georgia	$ 800,000	$ 2,765,535	$100.55	88,276	3.5	39.7
Kentucky	$ 519,000	$ 291,271	$39.66	15,567	0.6	6.4
Maryland	$ 310,000	$ 1,231,375	$116.82	72,748	4.0	45.6
Texas (CZ 2A)	$ 898,000	$ 3,603,839	$ 65.60	142,392	4.0	46.0

Source: Reiner et al., *Code to Classroom, 2020* ACEEE Summer Study

Residential Buildings

State Energy Code Field Studies



Pacific Northwest
NATIONAL LABORATORY

Thank you