The tricky part is measuring energy code compliance

NASEO Annual Meeting
Manhattan Beach, CA
September 17, 2019
Ed Carley, Senior Buildings Program Manager

Notes from the field – Texas code study

- In 2014, NASEO was awarded a DOE Grant to conduct an energy code field study in Texas. Later narrowed to 30 counties around Houston.
- Methodology developed by DOE and PNNL
- Three phases
  1. Baseline field study
  2. Education, training and outreach
  3. Final field study

- Project partners: Texas State Energy Conservation Office, South-central Partnership for Energy Efficiency as a Resource (SPEER), Britt-Makela Group (now Cadmus), Pacific Northwest National Laboratory

Part of a nationwide effort

- 4500 homes visited across 25 states
- DOE funded studies have been conducted in:
  - Alabama
  - Arkansas
  - Georgia
  - Kentucky
  - Maryland
  - North Carolina
  - Pennsylvania
  - Texas
- Next cohort:
  - Colorado (NASEO)
  - Nevada (NASEO)
  - Arizona
  - Utah
- Addition studies conducted in:
  - Connecticut
  - Delaware
  - Idaho
  - Illinois
  - Michigan
  - Montana
  - Nebraska
  - Tennessee
  - Virginia
  - West Virginia

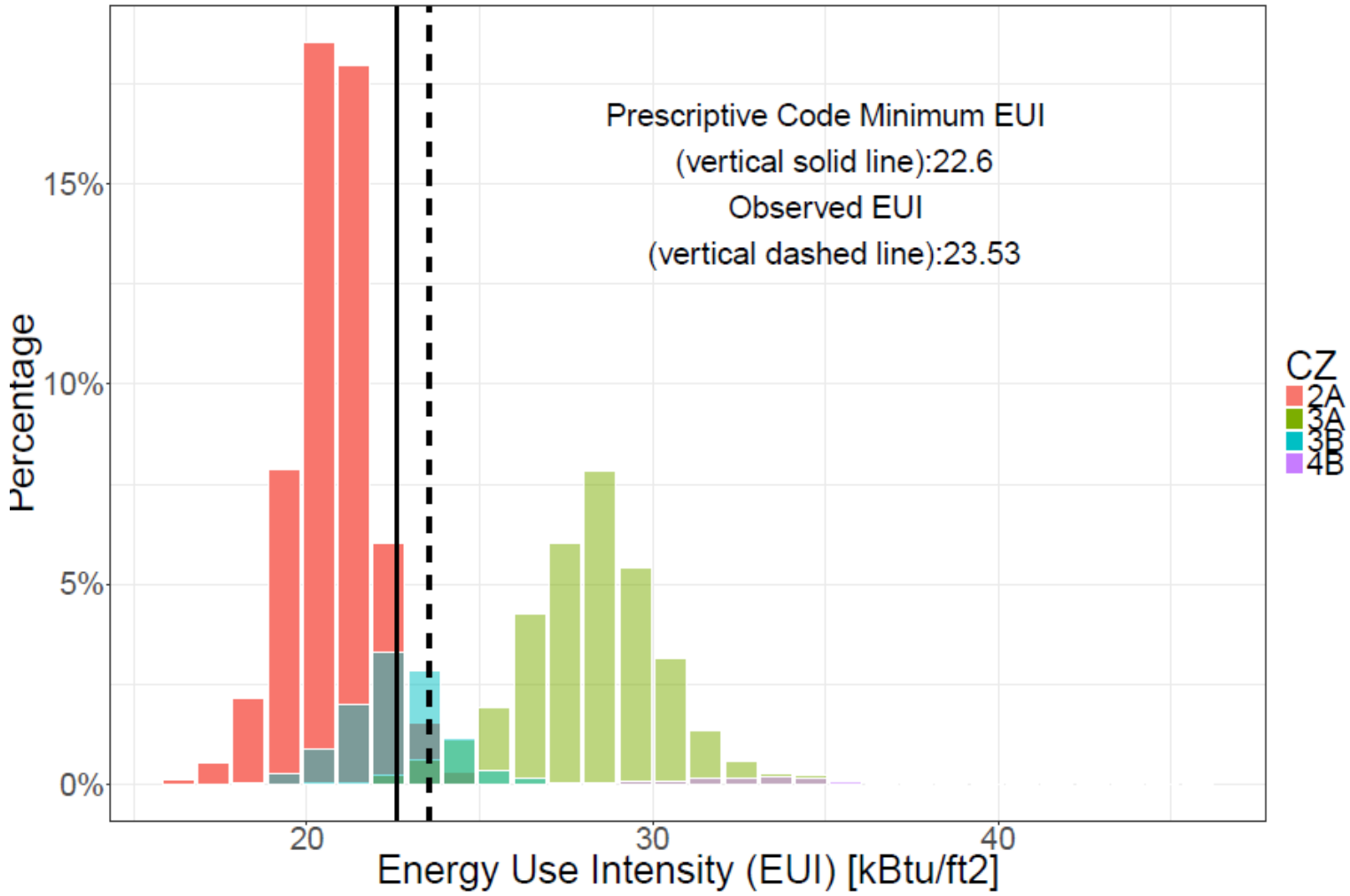
Methodology

Highlights

- Results to be based on an energy metric and reported at the state-level
- Focuses on individual code requirements within new single-family homes
- Data confidentially built into the experiment-no personal data will be shared
- Designed around a single site-visit prioritizing key items
- Designed with statistically significant results in mind

Methodology available at https://www.energycodes.gov/compliance/energy-code-field-studies.

Phase III


Prescriptive Code Minimum EUI
(vertical solid line):22.6
Observed EUI
(vertical dashed line):23.53
15%
10%
5%
0%
Percentage
20
30
40
Energy Use Intensity (EUI) [kBtu/ft2]
CZ
2A
3A
3B
4B

Key measures

1. Envelope tightness (ACH at 50 Pascals)
2. Window SHGC
3. Window U-factor
4. Exterior wall insulation (assembly U-factor)
5. Ceiling insulation (R-value)
6. Lighting (% high-efficacy)
7. Foundation insulation (R-value)2
8. Duct tightness (expressed in cfm per 100 ft2 of conditioned floor area at 25 Pascals)

Additional information gathered:

Square feet, number of stories, wall profile, builder profile (number of homes built/yr., envelope data, HVAC equipment profiles, location of ducts, water heaters, ventilation systems

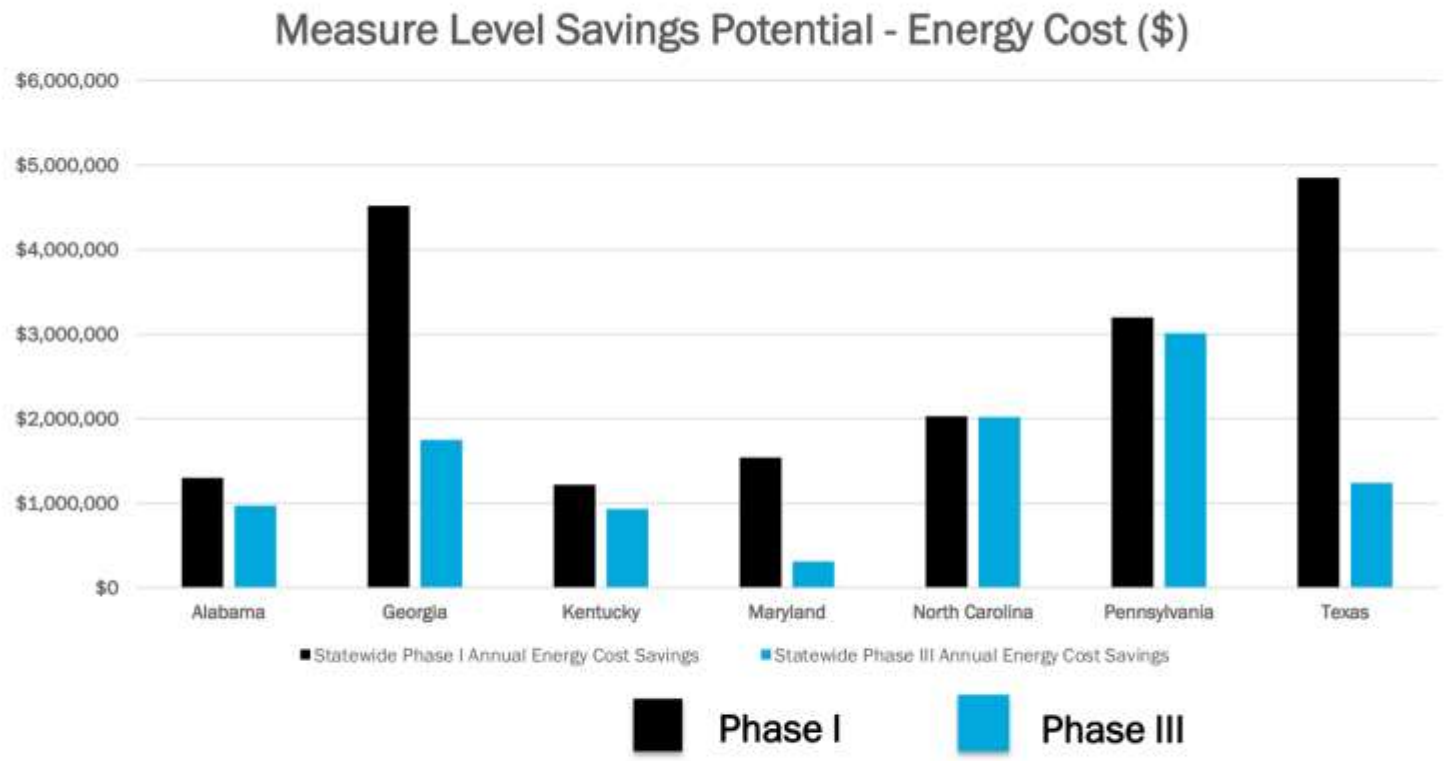
SUCESSES + ACCOMPLISHMENTS

- 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

MEASURE LEVEL SAVINGS



RESULT: 7 of 7 states reduced their measure savings potential

Source- Jeremy Williams, U.S. DOE presentation- National Energy Codes Conference 2019

Key findings

- The buildings 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' focusing programs on target measures (millions of dollars)

Source- Jeremy Williams, U.S. DOE presentation- National Energy Codes Conference 2019

Notes from the Future

- In 2019, NASEO was awarded a grant to conduct field studies in Nevada and Colorado
- Two phases
  1. Baseline Field Study
  2. Education training and outreach

- Project partners: Nevada Governors Office of Energy, Colorado Energy Office, South West Energy Efficiency Partnerships (SWEEP), PNNL

Why conduct field studies?

- DOE has established an “off the shelf” resource – the Field Study Methodology document available on the Building Energy Code Program web site.
- The data collected can be used to focus training of building officials, home builders.
- Energy codes save energy and money for every occupant of a home for the life of the structure. Field studies provide information on the building practices in your state and identify areas where performance may be improved.

Why conduct field studies?

- Results can be taken and used by stakeholders in your state- state energy office, utilities, REEOs, others
- Results may show that current codes are being exceeded in some areas, while leaving savings on the table in others.

IECC 2021- Residential

- Committee Action Hearings took place in Albuquerque, NM in April & May
- No major gains in residential energy efficiency, no roll backs either.
- EV ready was proposed for IECC 2021 residential, disapproved by committee
- Gains in water heating efficiency have both energy and water saving benefits

IECC 2021- Commercial

- Transparency requirements- certificates for commercial buildings describing envelope, HVAC, and other systems.
- Energy recovery ventilation required in multifamily buildings.
- Lighting power density (LPD) in line with ASHRAE 90.1-2019.
- Plug load- 50% of receptacles in certain occupancies must be controlled

IECC 2021- Stay tuned

- Next step- Public Comment Hearings in Las Vegas in late October, early November
- NASEO has convened an Energy Code Task Force of states a couple of affiliates to work together to prepare for the code development process.

Thank you

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PNNL Final Analysis

	Phase I				Phase III		
Measure	Total Energy Savings (MMBtu)	Total Energy Cost Savings ($)	Total State Emissions Reduction (MT CO2e)		Total Energy Savings (MMBtu)	Total Energy Cost Savings ($)	Total State Emissions Reduction (MT CO2e)
Envelope Air Leakage	27,182	484,314	3,092		581	10,321	65
Ceiling Insulation	11,372	215,656	1,080		4,835	91,786	595
Exterior Wall Insulation	9,277	171,044	1,102		8243	151,974	976
Foundation Insulation	6,800	108,156	668		11,676	178,905	1,075
Lighting	5,742	197,544	1,427		4,454	153,383	1,130
Duct Leakage	2,135	43,142	284		17,151	342,217	2,251
TOTAL	62,508	$1,219,856	7,653		46,941	$928,585	6,093
Savings					**25%**	**24%**	**20%**

Source: Ian Blanding, MEEA

MEEA
MIDWEST ENERGY EFFICIENCY ALLIANCE

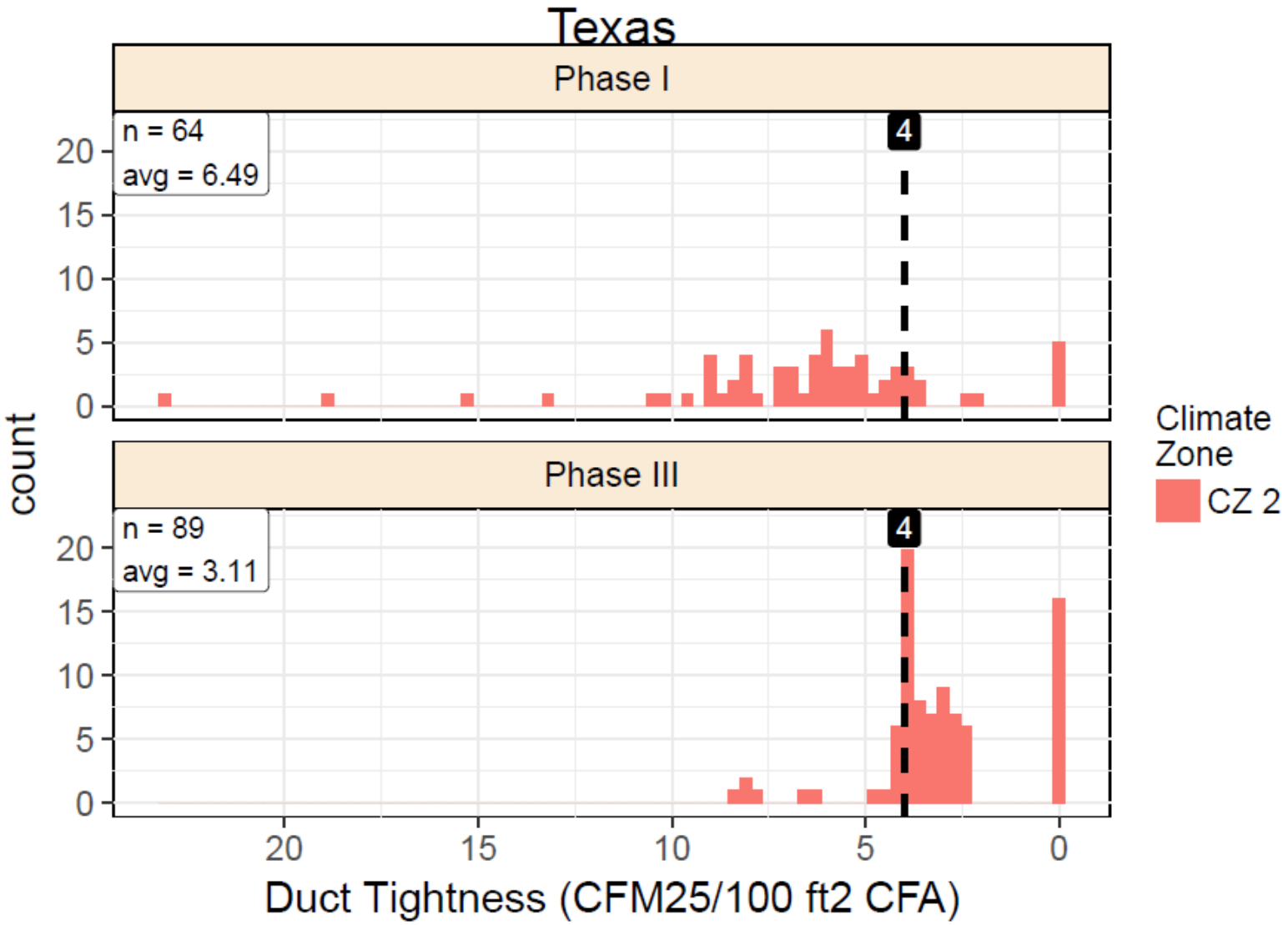
Phase I

Measure	Climate Zone	Electricity Savings (kWh/ home)	Natural Gas Savings (therms/ home)	Total Savings (kBtu/ home)	Number of Homes	Total Energy Savings (MMBtu)	Total Energy Cost Savings ($)	Total State Emissions Reduction (MT CO2e)
Duct Leakage	2A	330	4	1,539	2,053	3,160	88,351	512
	3A	307	5	1,511	7,453	11,258	306,577	1,759
	State Total	312	5	1,517	9,506	14,420	395,063	2,272
Lighting	2A	396	-1	1,237	2,053	2,540	88,164	548
	3A	374	-2	1,119	7,453	8,343	297,068	1,859
	State Total	379	-1	1,146	9,506	10,891	385,451	2,408
Envelope Air Leakage	2A	143	5	946	2,053	1943	46,517	253
	3A	178	6	1,246	7,453	9,286	217,033	1,166
	State Total	170	6	1,179	9,506	11,207	263,089	1,417
Exterior Wall Insulation	2A	121	3	679	2,053	1,395	35,824	201
	3A	149	4	891	7,453	6642	165,622	917
	State Total	143	4	844	9,506	8,022	201,105	1,116
Window SHGC	2A	67	-0.4	182	2,053	375	14,166	90
	3A	57	-0.7	124	7,453	930	40,403	265
	State Total	59	-0.6	138	9,506	1,309	54,674	356
TOTAL		1,064	12	4,823	9,506	45,849	1,299,382	7,569

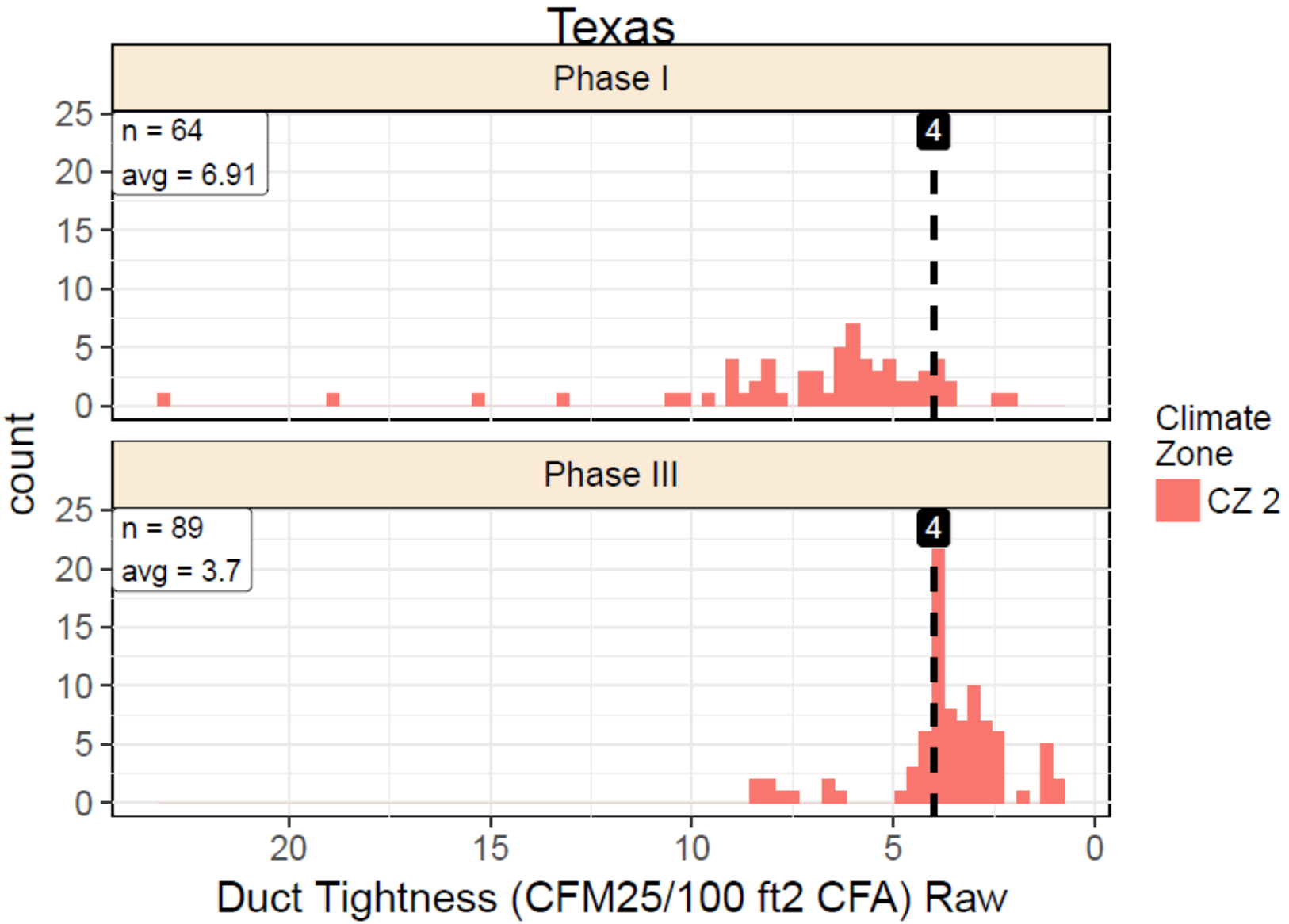
Phase III

Measure	Climate Zone	Electricity Savings (kWh/ home)	Natural Gas Savings (therms/ home)	Total Savings (kBtu/ home)	Number of Homes	Total Energy Savings (MMBtu)	Total Energy Cost Savings ($)	Total State Emissions Reduction (MT CO2e)
Duct Leakage	2A	272	3	1,267	2,053	2,600	72,745	425
	3A	251	4	1,232	7,453	9,185	250,493	1,449
	State Total	255	4	1,240	9,506	11,785	323,238	1,874
Lighting	2A	298	-1	932	2,053	1,914	66,494	420
	3A	282	-1	844	7,453	6,289	224,155	1,427
	State Total	286	-1	864	9,506	8,203	290,649	1,847
Envelope Air Leakage	2A	101	3	664	2,053	1,363	32,666	178
	3A	125	4	875	7,453	6,520	152,418	819
	State Total	119	4	828	9,506	7,883	185,084	996
Exterior Wall Insulation	2A	105	2	590	2,053	1,211	31,106	175
	3A	129	3	774	7,453	5,772	143,974	799
	State Total	124	3	733	9,506	6,983	175,080	975
Window SHGC	2A	NA*	NA*	NA*	NA*	NA*	NA*	NA*
	3A	NA*	NA*	NA*	NA*	NA*	NA*	NA*
	State Total	NA*	NA*	NA*	NA*	NA*	NA*	NA*
TOTAL		785	10	3,665	9,506	34,855	974,051	5,693
		26%	16%	24%		24%	25%	25%

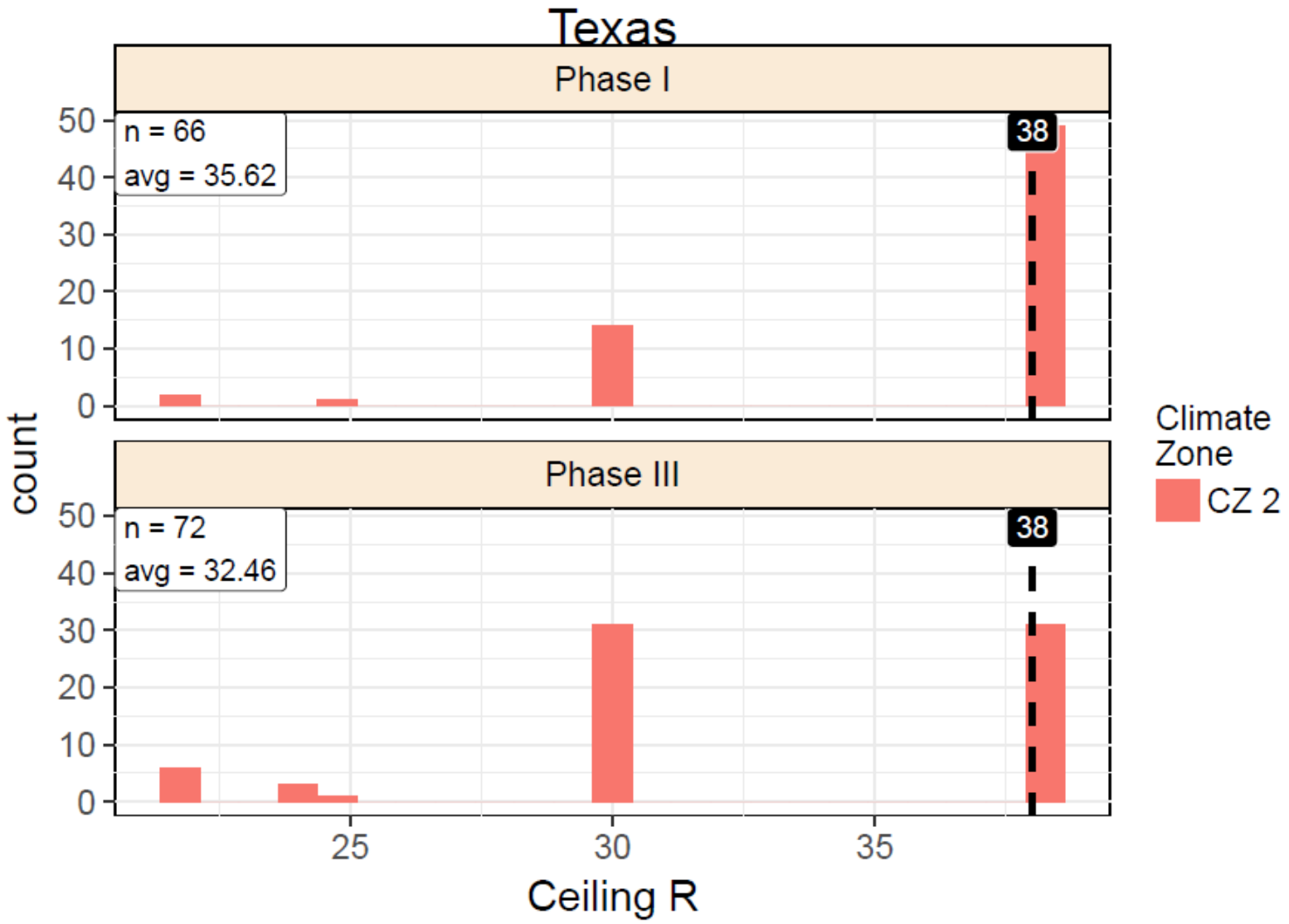
Duct Tightness (CFM25/100 ft^2 CFA) – Adjusted



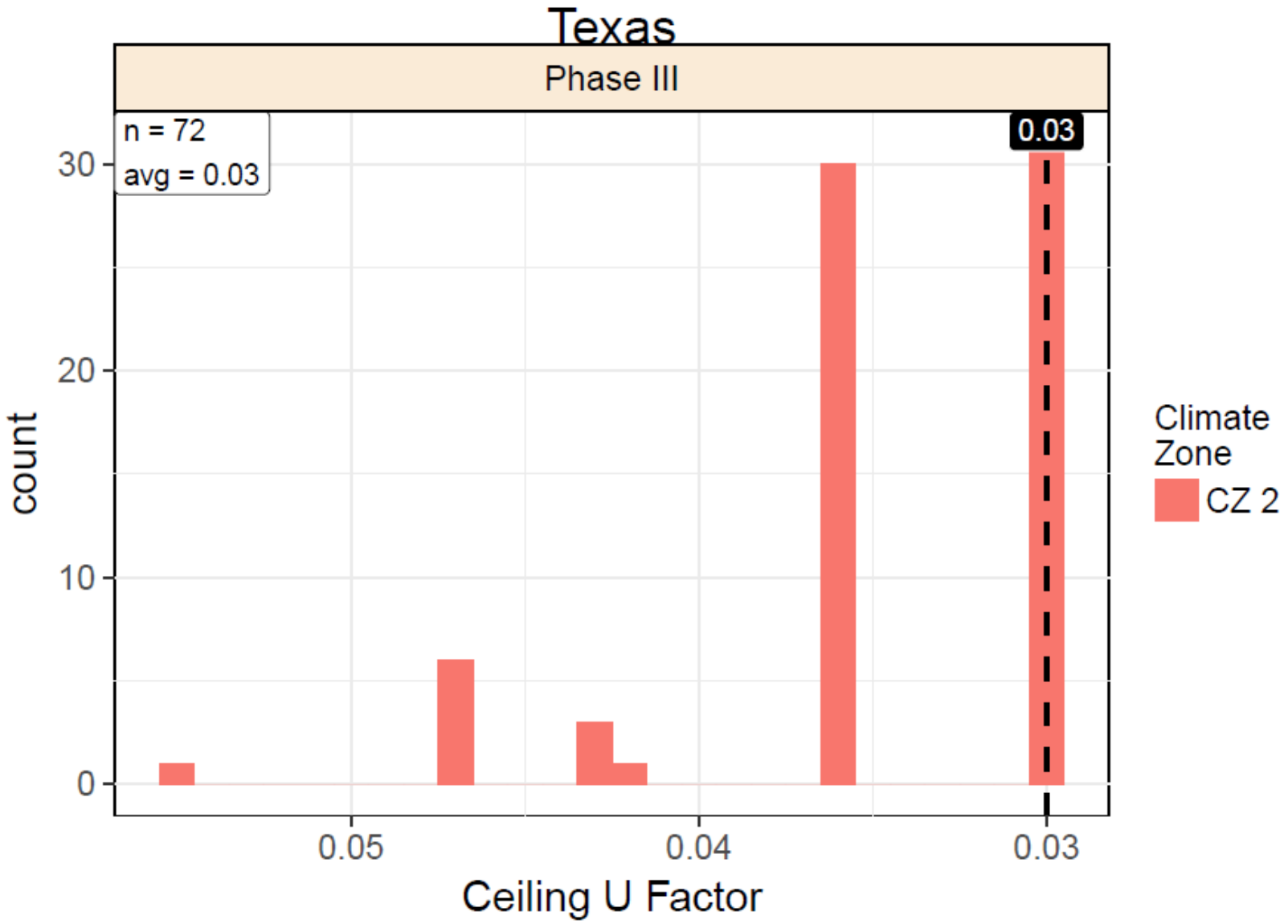
Duct Tightness (CFM25/100 ft^2 CFA) - Unadjusted



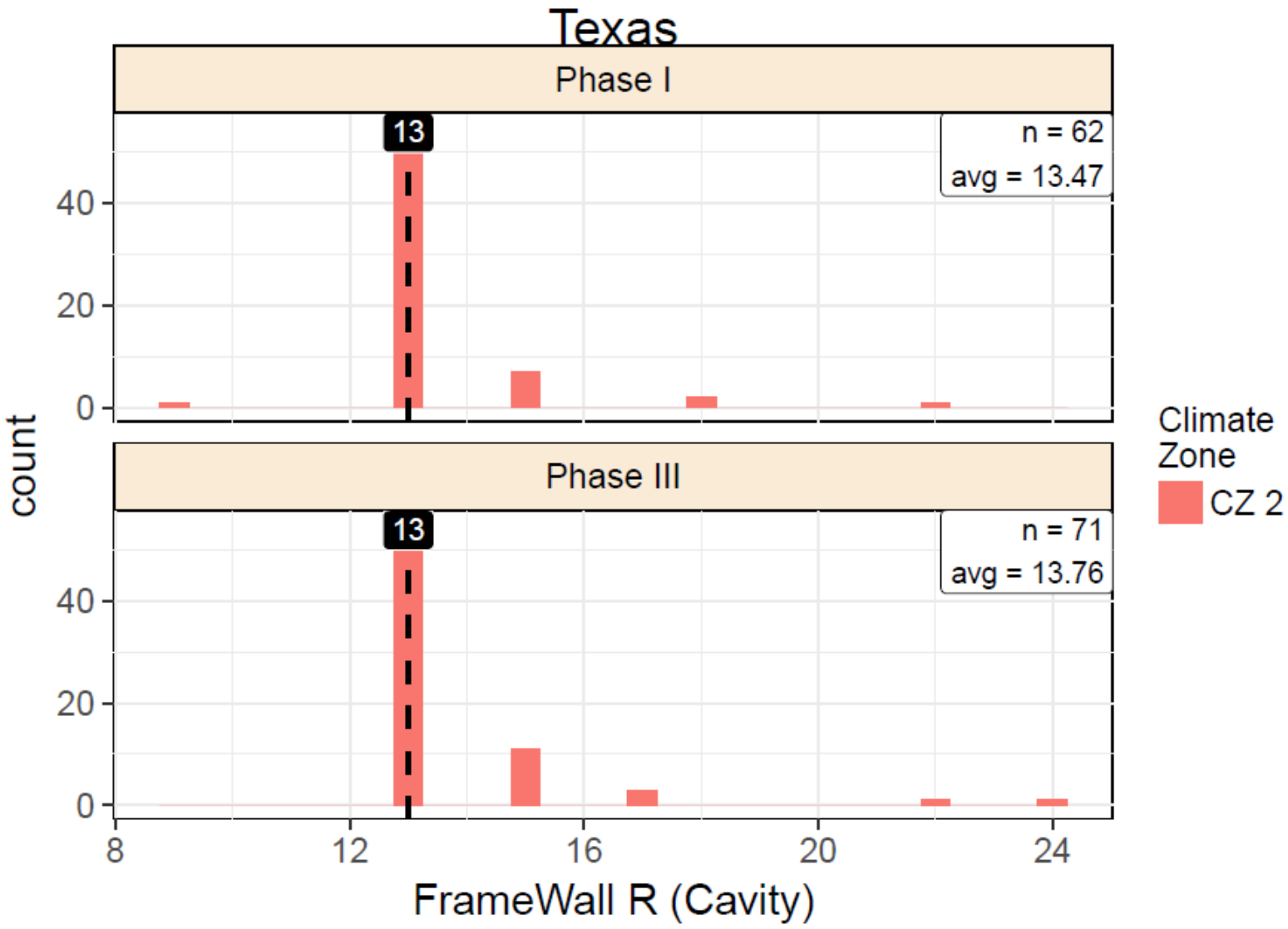
Ceiling R-Value



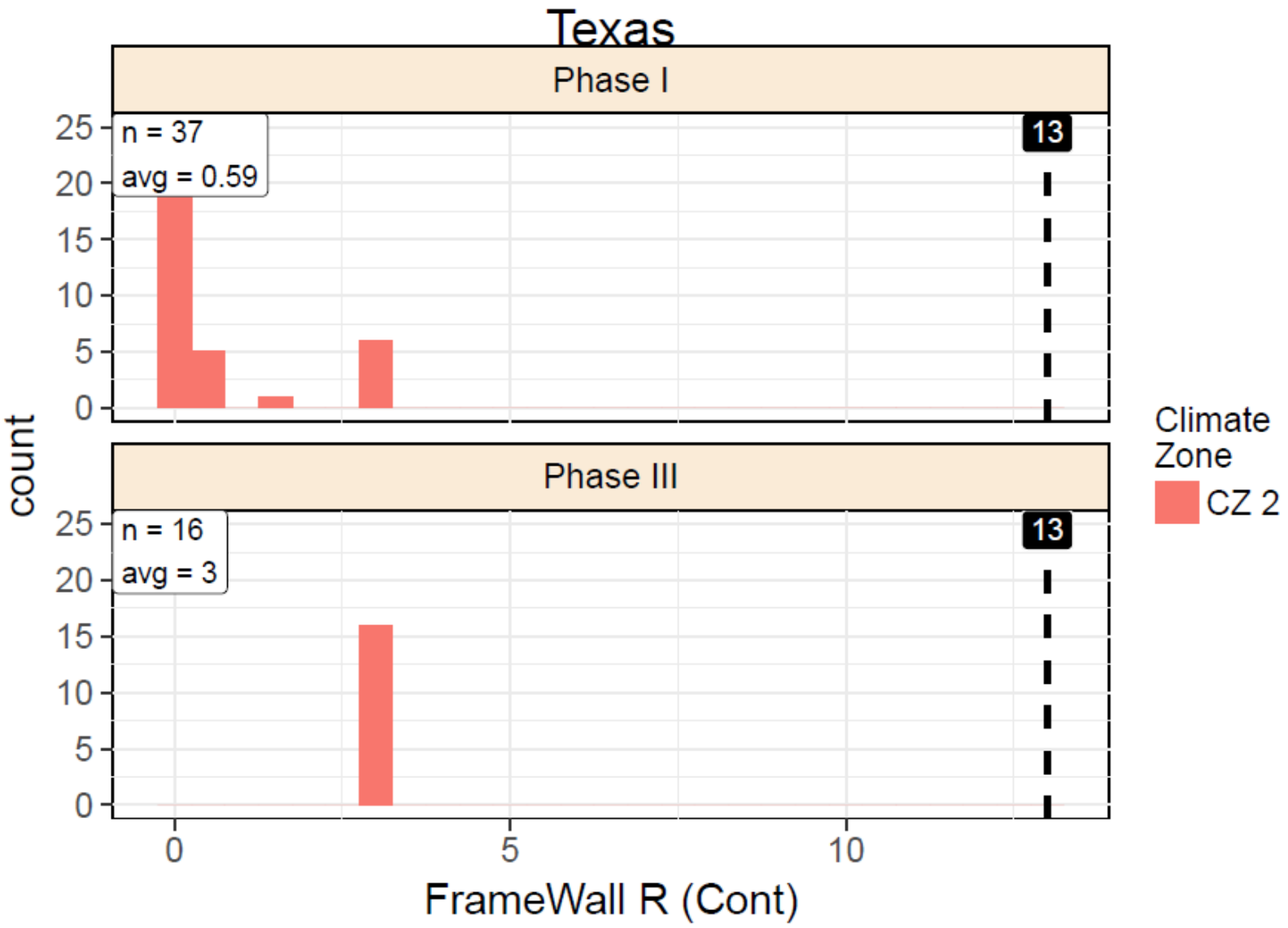
Ceiling U-Factor



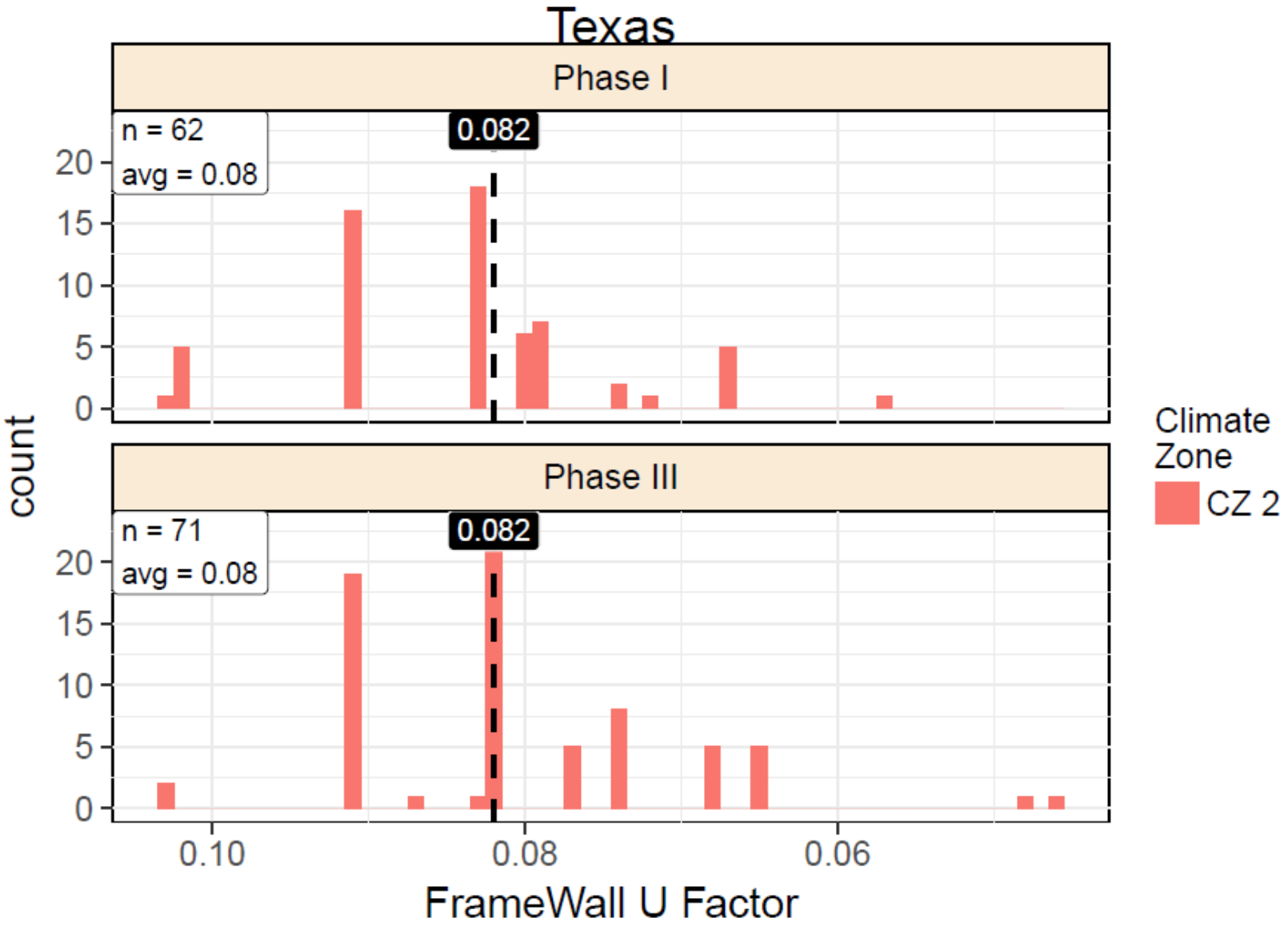
Frame Wall R-Value (Cavity)



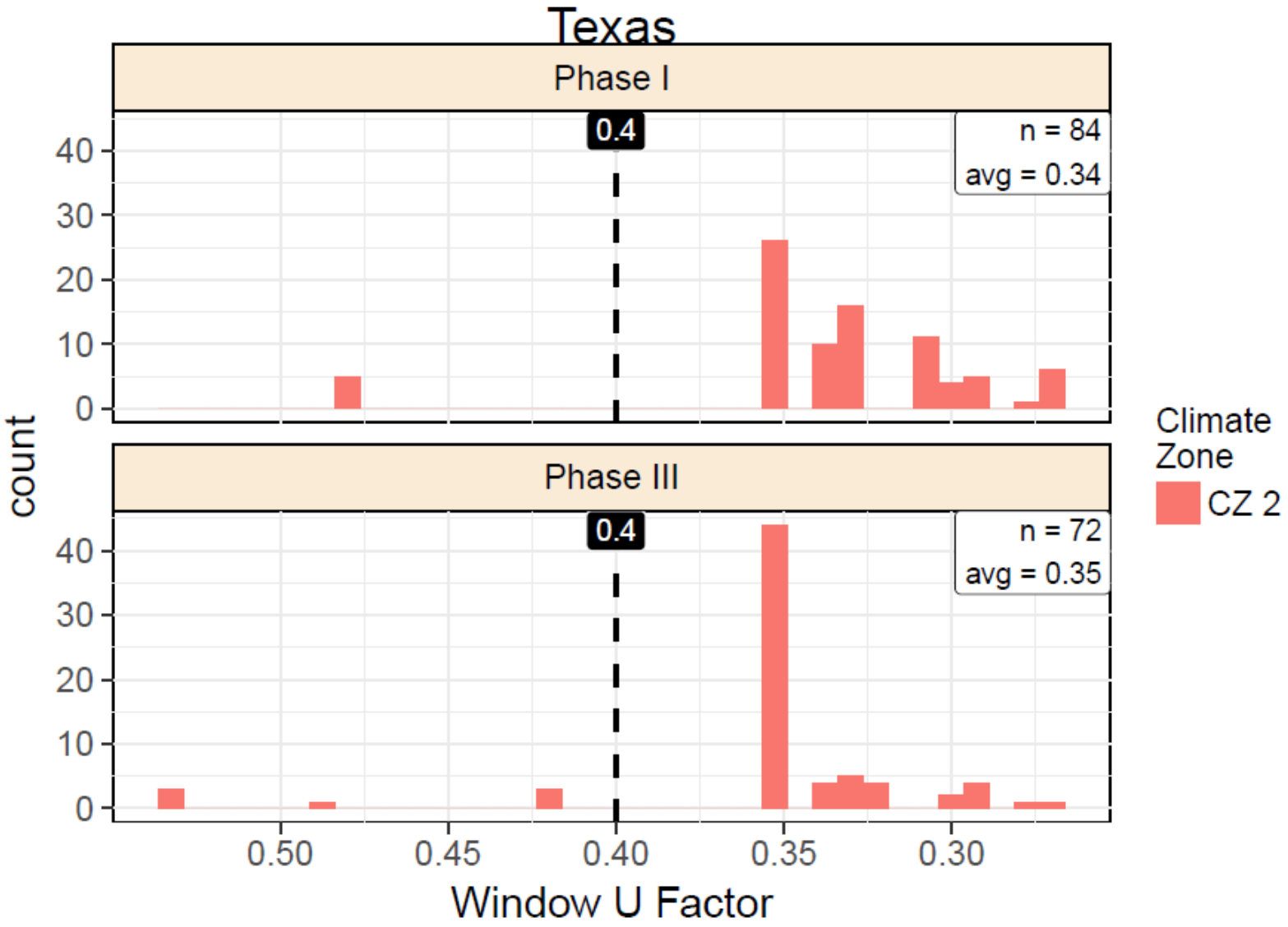
Frame Wall R-Value (Cont)



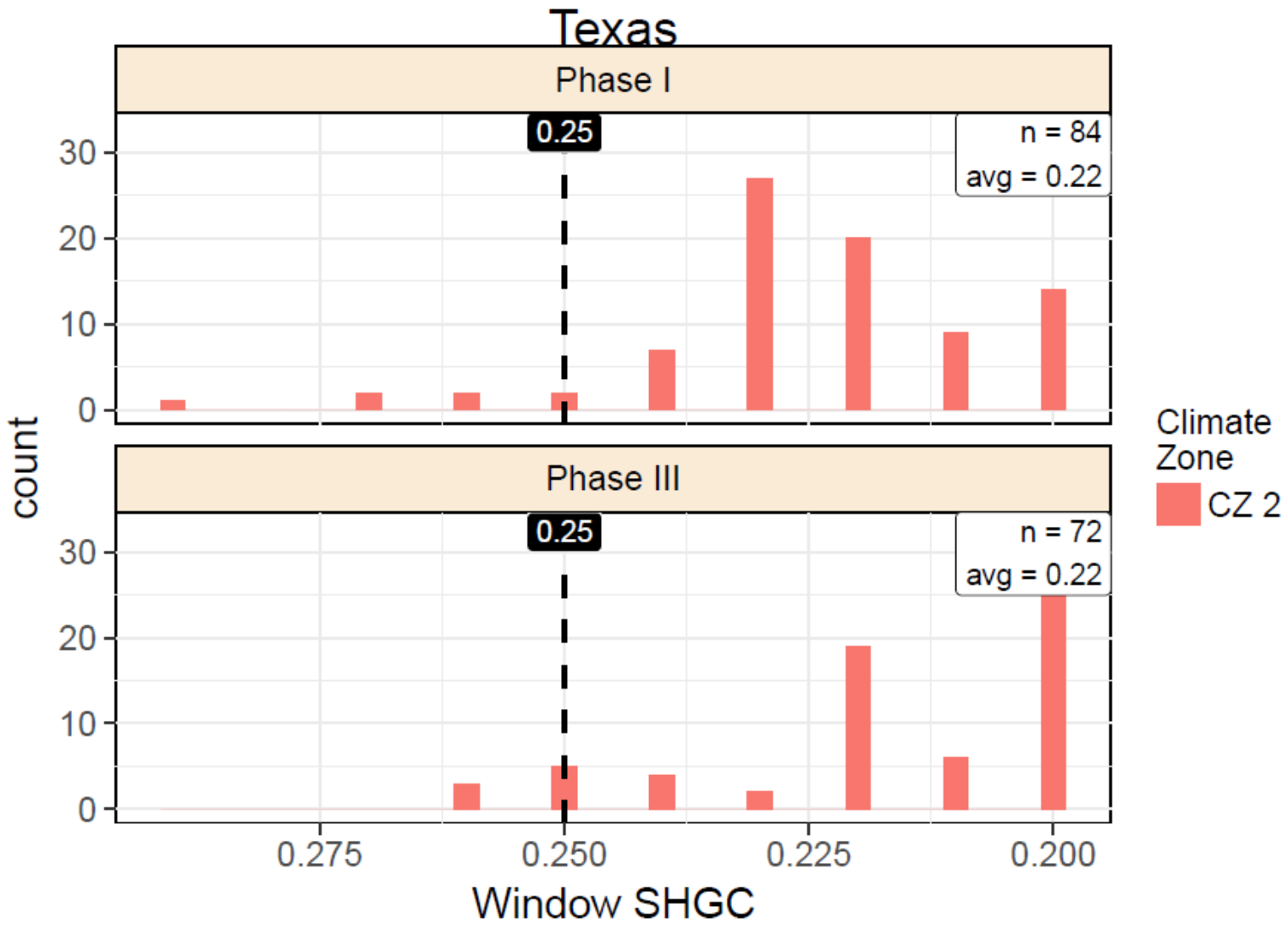
Frame Wall U-Factor



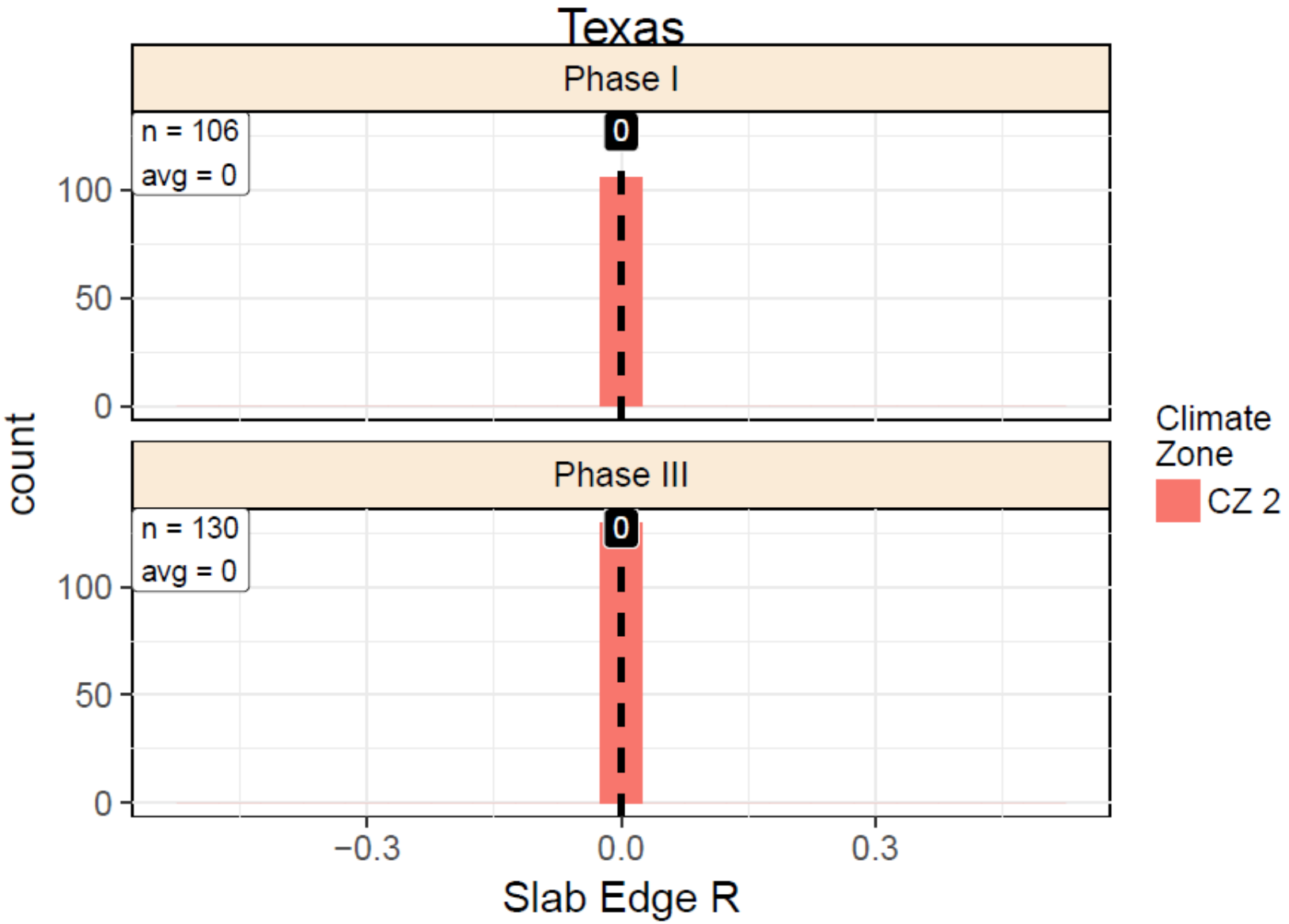
Window U-Factor



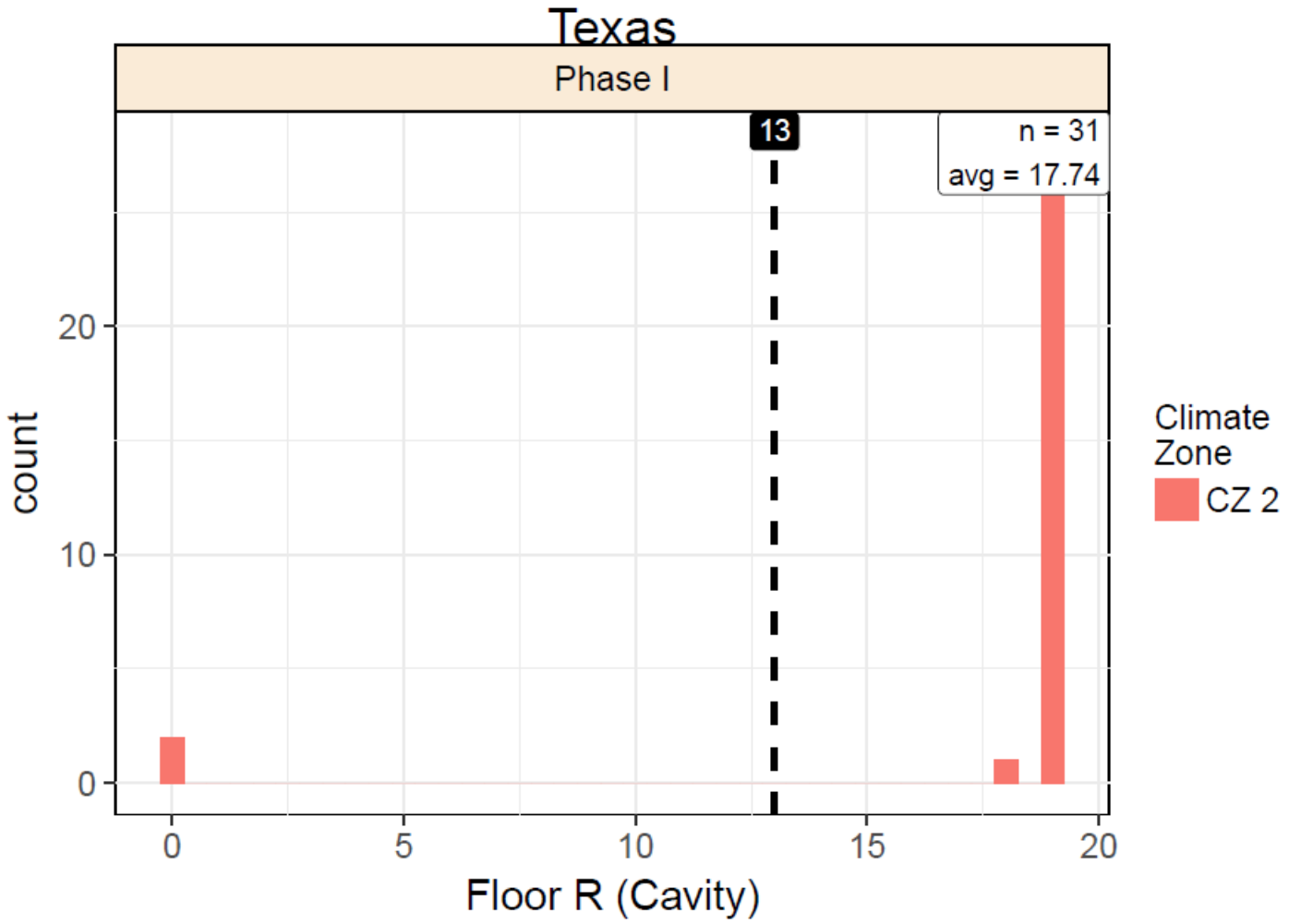
Window SHGC


Texas
Phase I
0.25
n = 84
avg = 0.22
Phase III
0.25
n = 72
avg = 0.22
count
30
20
10
0
0.275
0.250
0.225
0.200
Window SHGC
Climate Zone
CZ 2

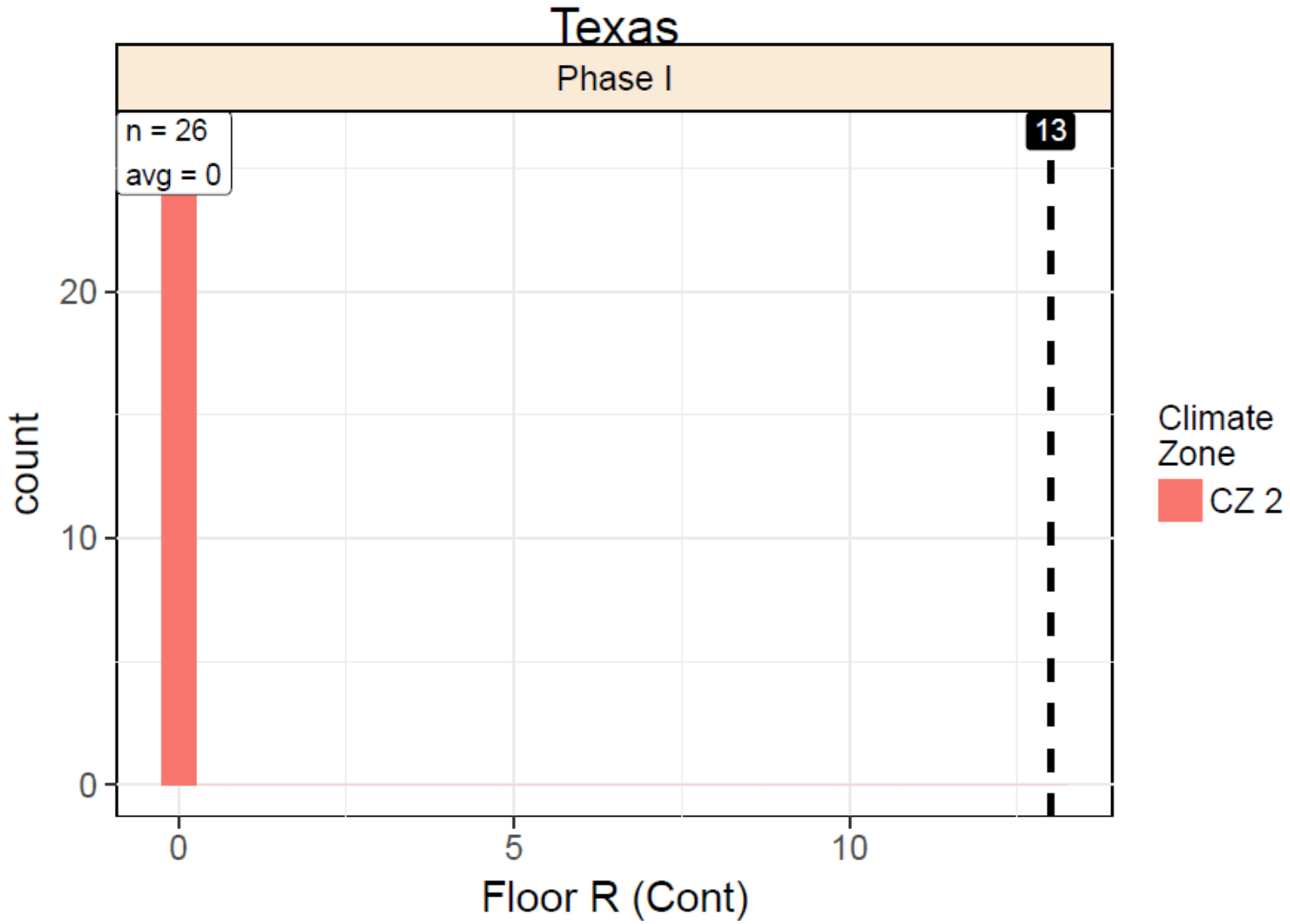
Slab R-Value


Texas
Phase I
n = 106
avg = 0
0
100
50
0
Phase III
n = 130
avg = 0
0
100
50
0
count
−0.3
0.0
0.3
Slab Edge R
Climate Zone
CZ 2

Floor R-Value (Cavity)

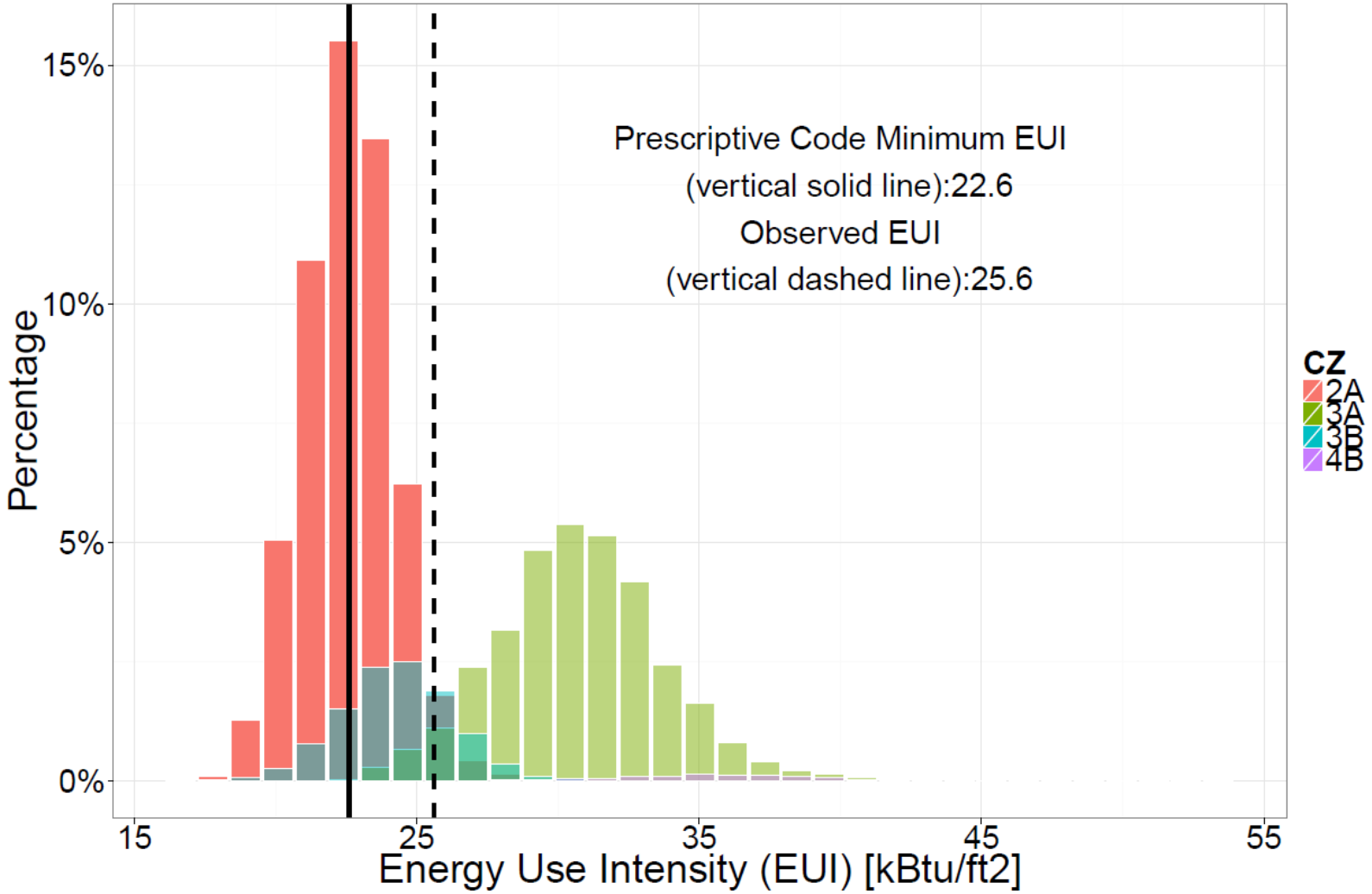


Floor R-Value (Cont)

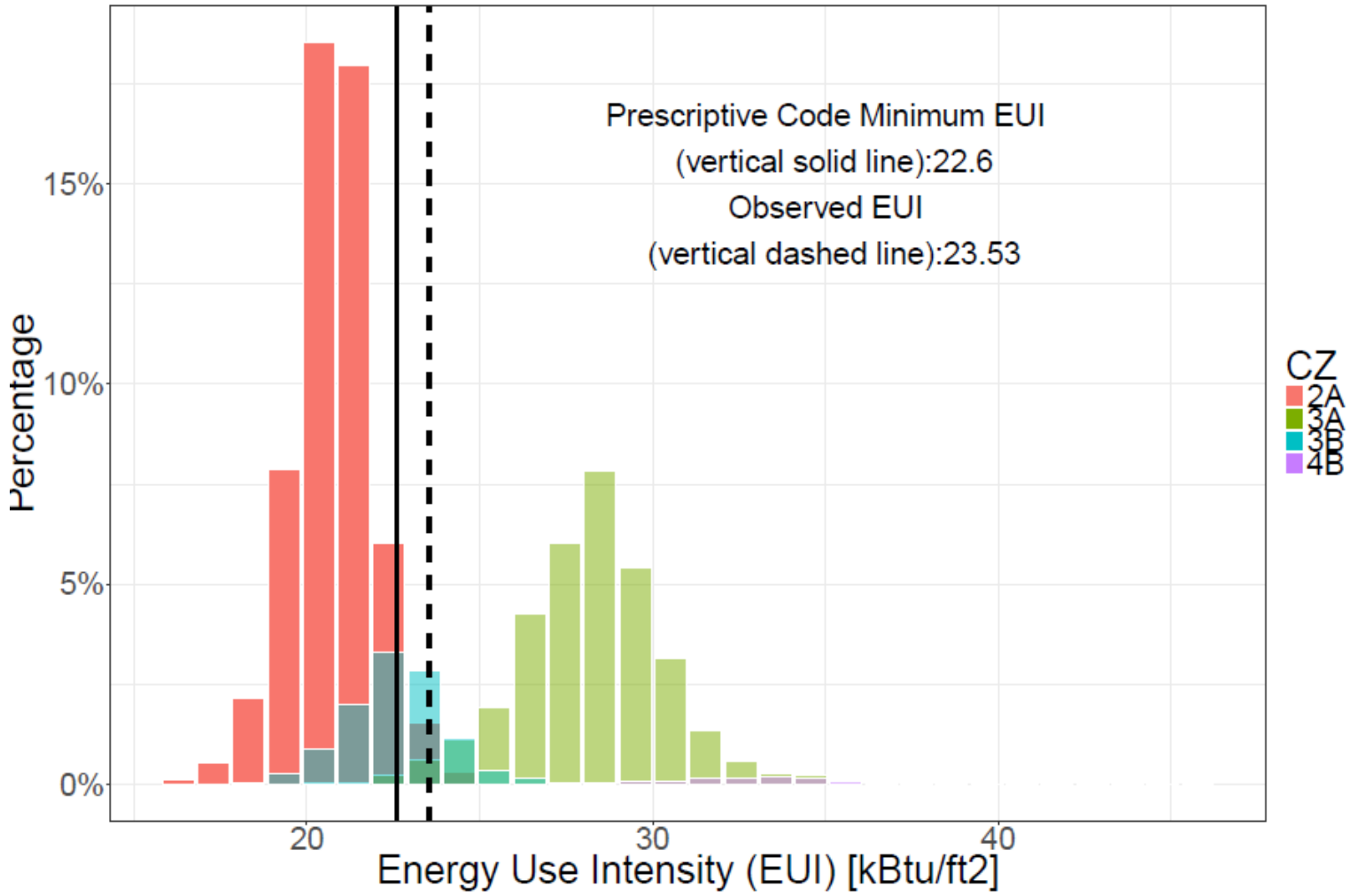


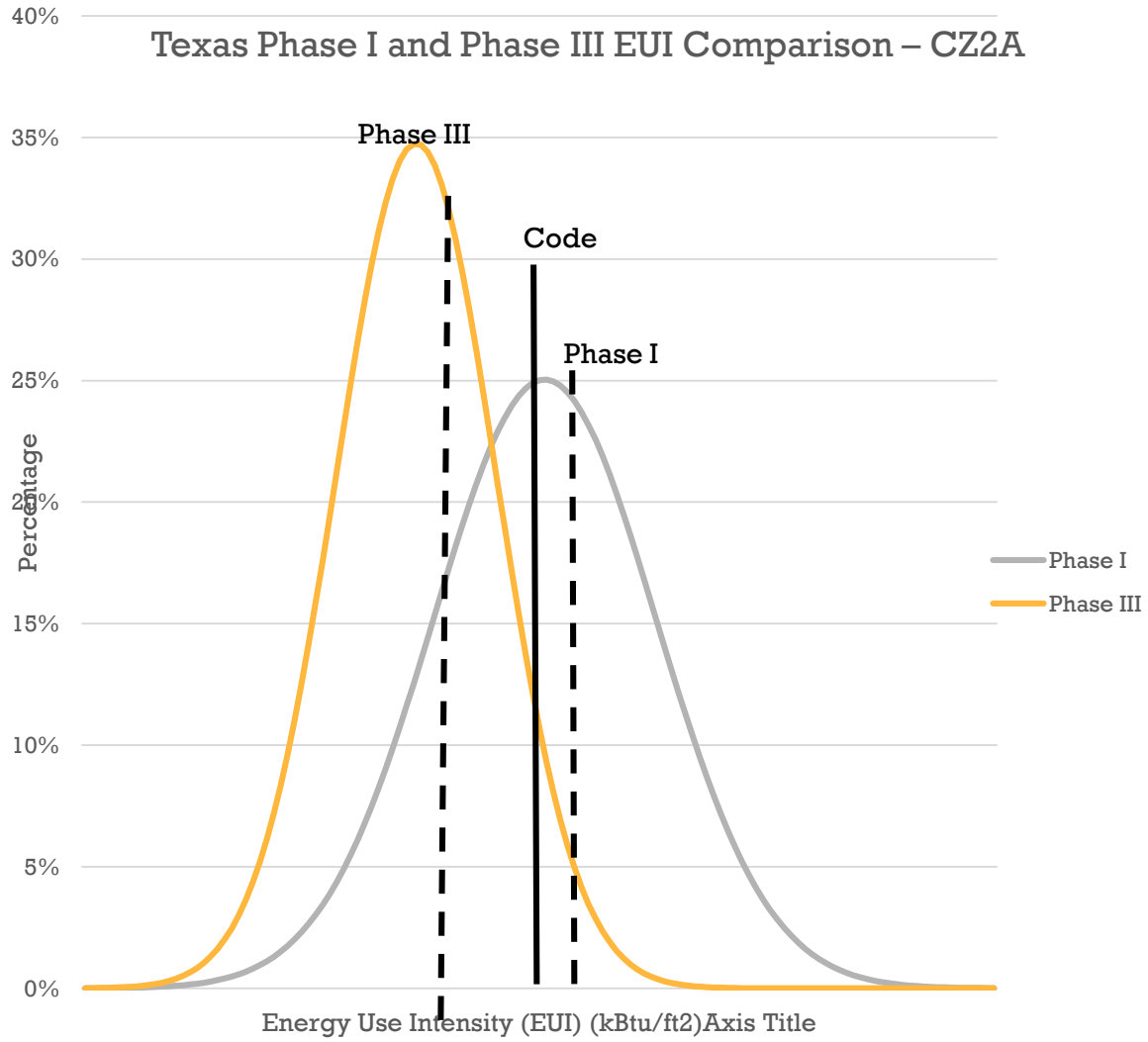
EUIs

Phase I


Prescriptive Code Minimum EUI
(vertical solid line):22.6
Observed EUI
(vertical dashed line):25.6
15%
10%
5%
0%
Percentage
15
25
35
45
55
Energy Use Intensity (EUI) [kBtu/ft2]
CZ
2A
3A
3B
4B

Phase III


Prescriptive Code Minimum EUI
(vertical solid line):22.6
Observed EUI
(vertical dashed line):23.53
15%
10%
5%
0%
Percentage
20
30
40
Energy Use Intensity (EUI) [kBtu/ft2]
CZ
2A
3A
3B
4B


Texas Phase I and Phase III EUI Comparison – CZ2A
40%
35%
30%
25%
20%
15%
10%
5%
0%
Percentage
Phase III
Code
Phase I
Phase I
Phase III
Energy Use Intensity (EUI) (kBtu/ft2)Axis Title

Statewide Measure Level Savings

Phase I

Measure	Electricity Savings (kWh/home)	Natural Gas Savings (therms/home)	Total Savings (kBtu/home)	Number of Homes	Total Energy Savings (MMBtu)	Total Energy Cost Savings ($)	Total State Emissions Reduction (MT CO2e)
Envelope Air Leakage	162	26	3130	100,608	314,889	4,656,869	88,045
Exterior Wall Insulation	241	21	2913	100,608	293,040	5,029,864	129,948
Duct Leakage	210	11	1801	100,608	181,188	3,582,893	112,965
Lighting	261	-2	701	100,608	70,571	2,774,421	139,105
Ceiling Insulation	24	2	235	100,608	23,677	443,058	13,027
TOTAL	898	58	8,780	100,608	883,365	16,487,105	483,090

Corrected Emissions

Phase III

Phase 3	Electricity Savings (kWh/ home)	Natural Gas Savings therms/ home)	Total Savings (kBtu/ home)	Number of Homes	Total Energy Savings (MMBtu)	Total Energy Cost Saving	Total State Emissions Reduction (MT CO2e)
Envelope Air Leakage	106	18	2,141	100,608	217,253	3,179,965	58,441
Exterior Wall Insulation	210	18	2,549	100,608	258,485	4,426,562	113,892
Duct Leakage	19	1	158	100,608	15,958	316,613	10,021
Lighting	1	0	2	100,608	183	7,249	364
Ceiling Insulation	60	4	577	100,608	58,222	1,090,432	32,095
Total	395	41	5,427	100,608	550,101	9,020,821	214,811

CZ2A Measure Level Savings

Phase I

Measure	Electricity Savings (kWh/	Natural Gas Savings (therms/	Total Savings (kBtu/	Number of Homes	Total Energy Savings (MMBtu)	Total Energy Cost Savings ($)	Total State Emissions Reduction (MT CO2e)
Envelope Air Leakage	54	5	719	54,937	39,493	654,623	15,910
Exterior Wall Insulation	52	3	493	54,937	27,090	511,748	15,239
Duct Leakage	226	9	1,621	54,937	89,058	1,914,867	66,132
Lighting	264	-2	737	54,937	40,483	1,550,412	76,960
Ceiling Insulation	23	1	199	54,937	10,942	216,147	6,806
TOTAL	619	17	3,769	54,937	207,065	4,847,797	181,047

Phase III

Measure	Electricity Savings (kWh/	Natural Gas Savings (therms/	Total Savings (kBtu/	Number of Homes	Total Energy Savings (MMBtu)	Total Energy Cost Savings ($)	Total State Emissions Reduction (MT CO2e)
Envelope Air Leakage	14	1	187	54,937	10,295	170,471	4,135
Exterior Wall Insulation	36	2	346	54,937	19,009	359,086	10,692
Duct Leakage	20	1	144	54,937	7,896	170,171	5,891
Lighting	1	0	2	54,937	105	4,050	202
Ceiling Insulation	58	3	498	54,937	27,367	540,180	16,994
TOTAL	129	7	1,178	54,937	64,673	1,243,958	37,913