

Midwest Trends: *Using Big (HERS) Data to Understand Residential Construction*

2019 RESNET Conference
Ian Blanding



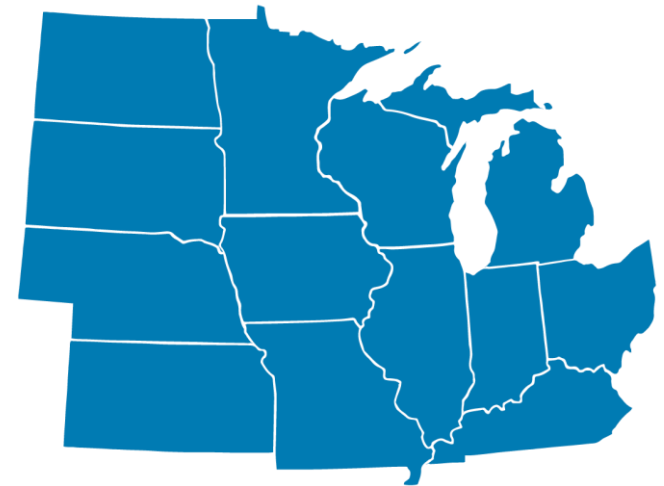
About MEEA

The Trusted Source on Energy Efficiency

We are a nonprofit membership organization with **160+ members**, including:

- Utilities
- Research institutions and advocacy organizations
- State and local governments
- Energy efficiency-related businesses

As the key resource and champion for energy efficiency in the Midwest, MEEA helps a diverse range of stakeholders understand and implement cost-effective energy efficiency strategies that provide economic and environmental benefits.



Goal

- Analyze HERS data from high level to local level
- Highlight key similarities and differences between locations
- Overlap state, local and utility policy and public datasets to complement the HERS data and gather a more complete understanding of key drivers for HERS homes and the industry

Agenda

- HERS data background
- Midwest Building Policies & Programs
- Midwest HERS Overview
 - Trends by Climate Zone
- Utilizing the data
 - Energy Code Adoption
 - Impact of Energy Codes/Compliance
 - Utility Programs
 - HERS Homes vs Code Homes
- Key Takeaways
- Questions

HERS Dataset

Background

Midwest HERS Data Set

Background

- MEEA received a dataset for all **HERS rated homes in the Midwest** from RESNET which spans **2014 - 2016**
- Dataset includes **HERS scores**, plus most features that impact building efficiency (**minimum rated features**)
- Although dataset includes single, duplex and low-rise multifamily – **the analysis only focuses on new single family**

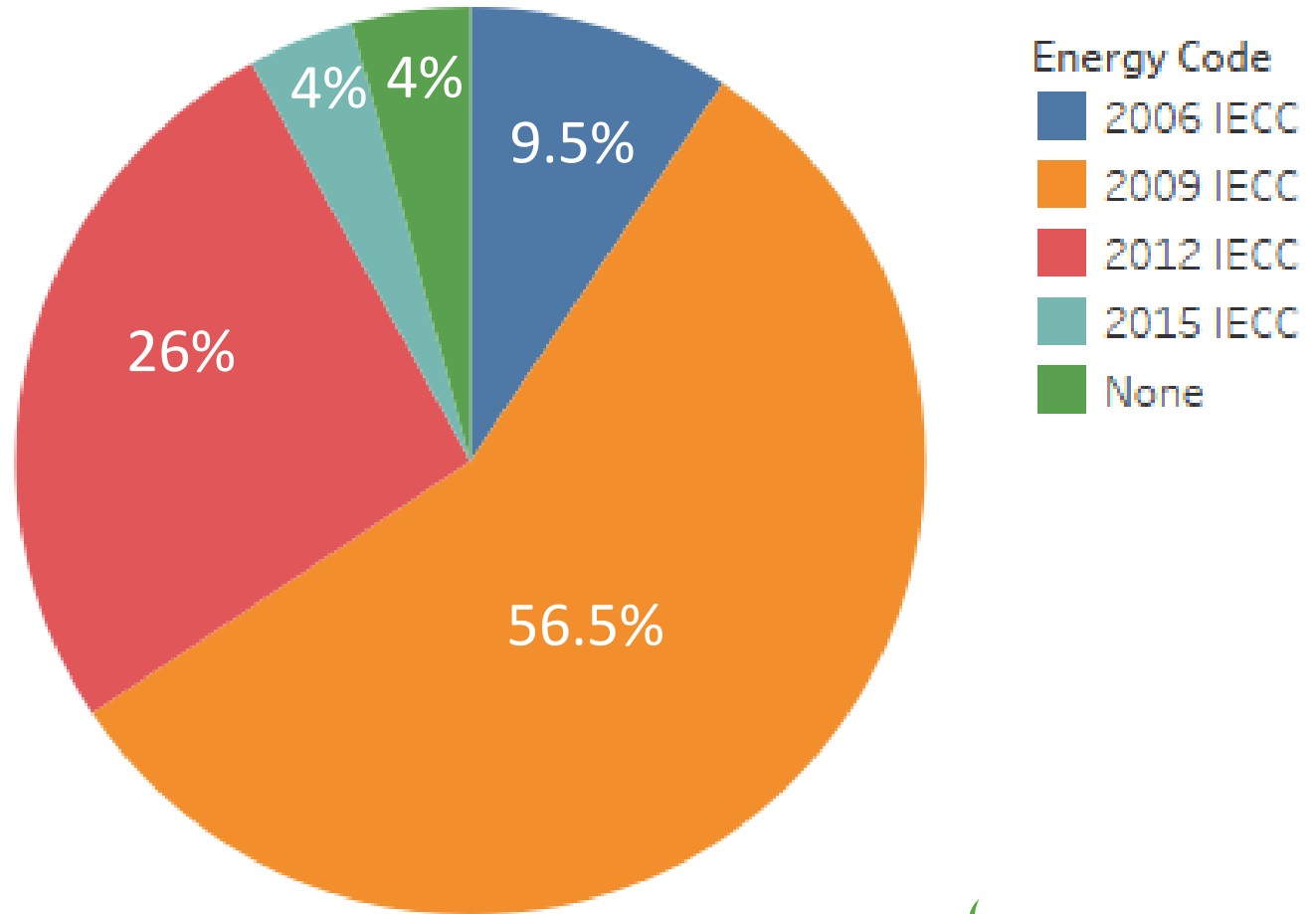
Midwest HERS Data Set

Background

- New Construction (2014 – 2016)
- Single Family
- # of homes analyzed: 78,000
- Confirmed Ratings
- Software: REM/Rate < v.15
- HERS Rated vs. 1-family permits in Midwest
 - 2014: 24%
 - 2015: 25%
 - 2016: 22%

Energy Code

Breakdown by HERS Home



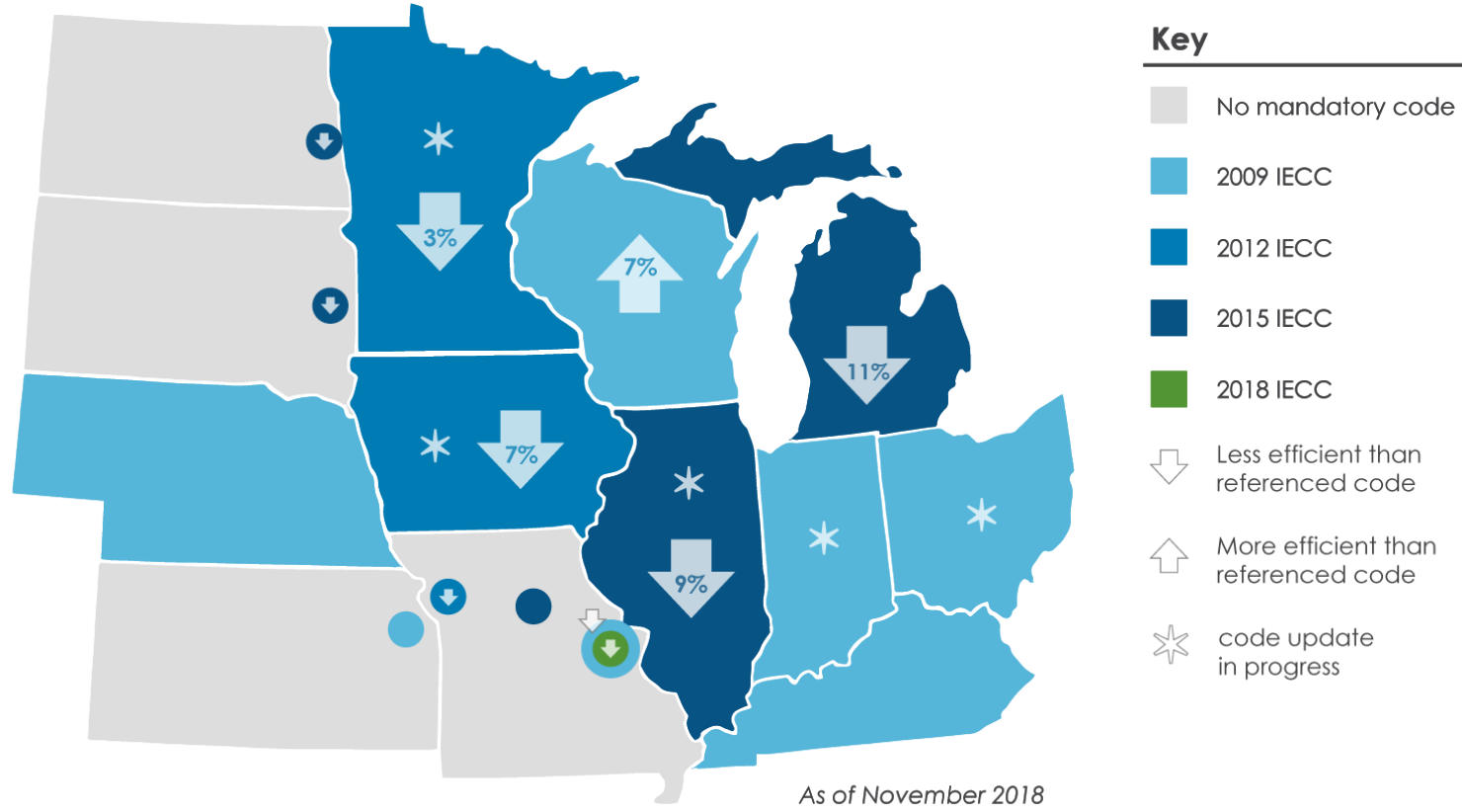
Midwest Residential Policies

Codes and Utility Program



Residential Code

Amend Codes Update Referenced Codes

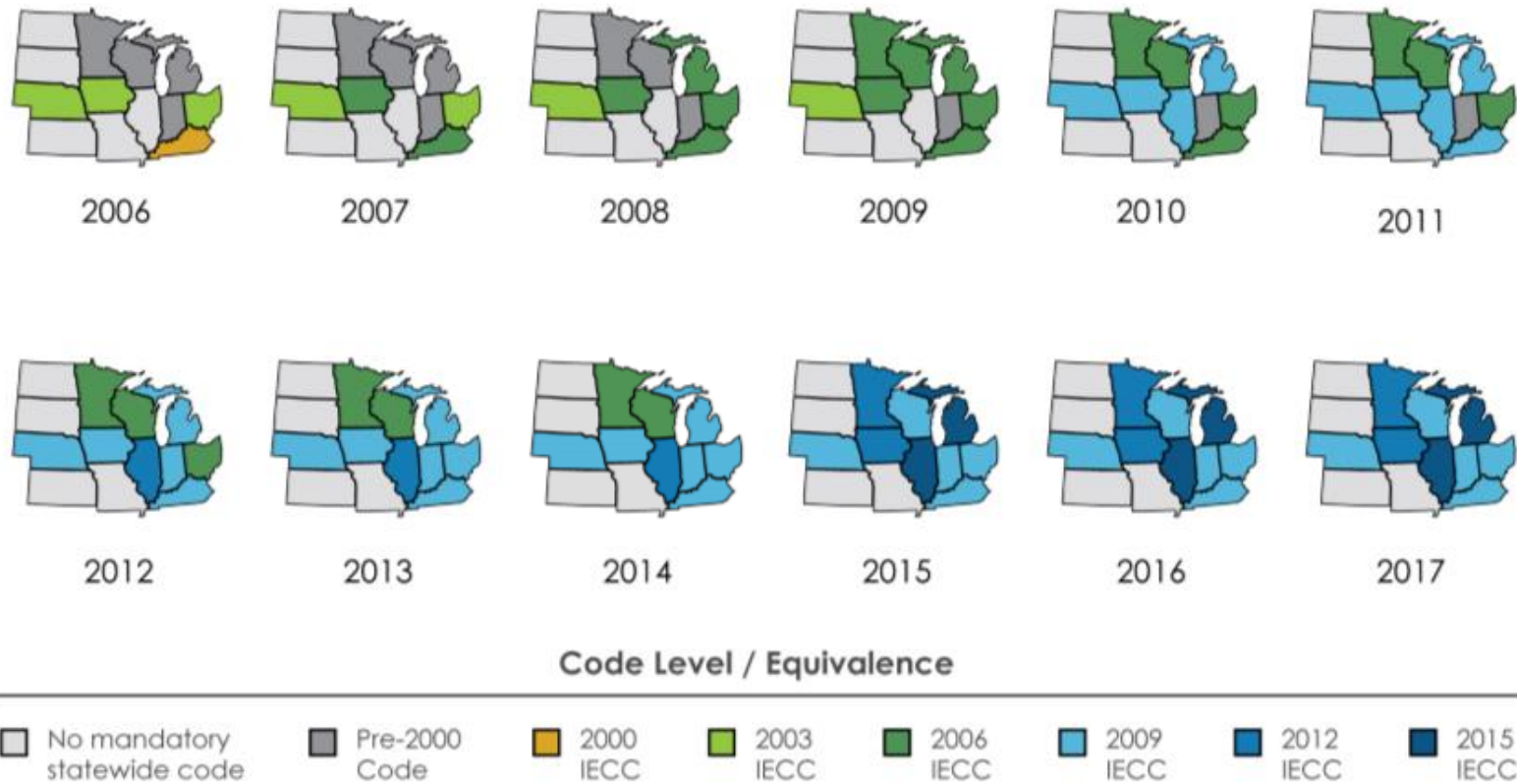


As of November 2018

Percentage change is based on EUI of adopted code

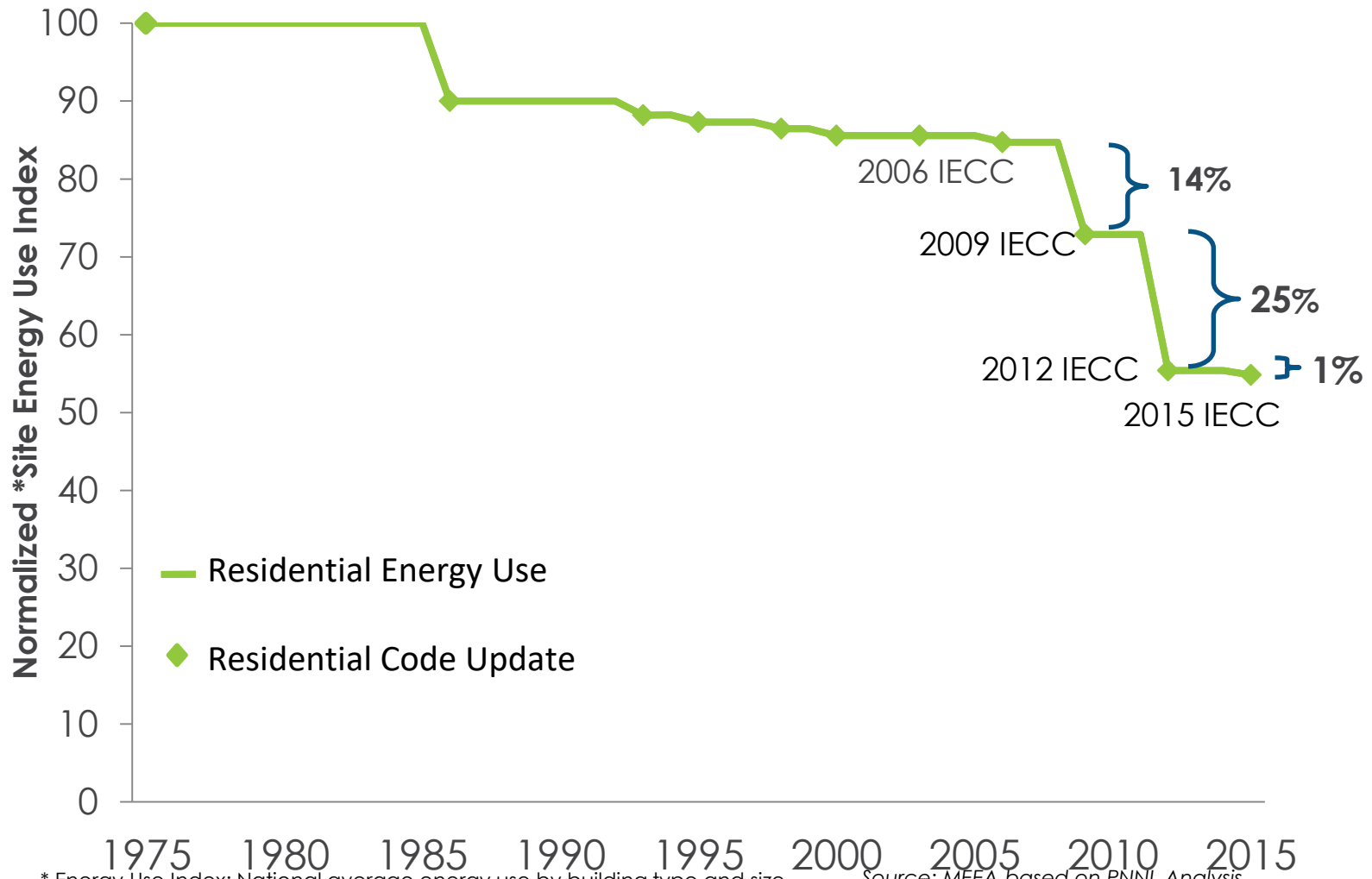
Residential Building Energy Codes

Adoption Timeline



Residential Building Energy Code

Energy Use as Code Improves (1975-2016)

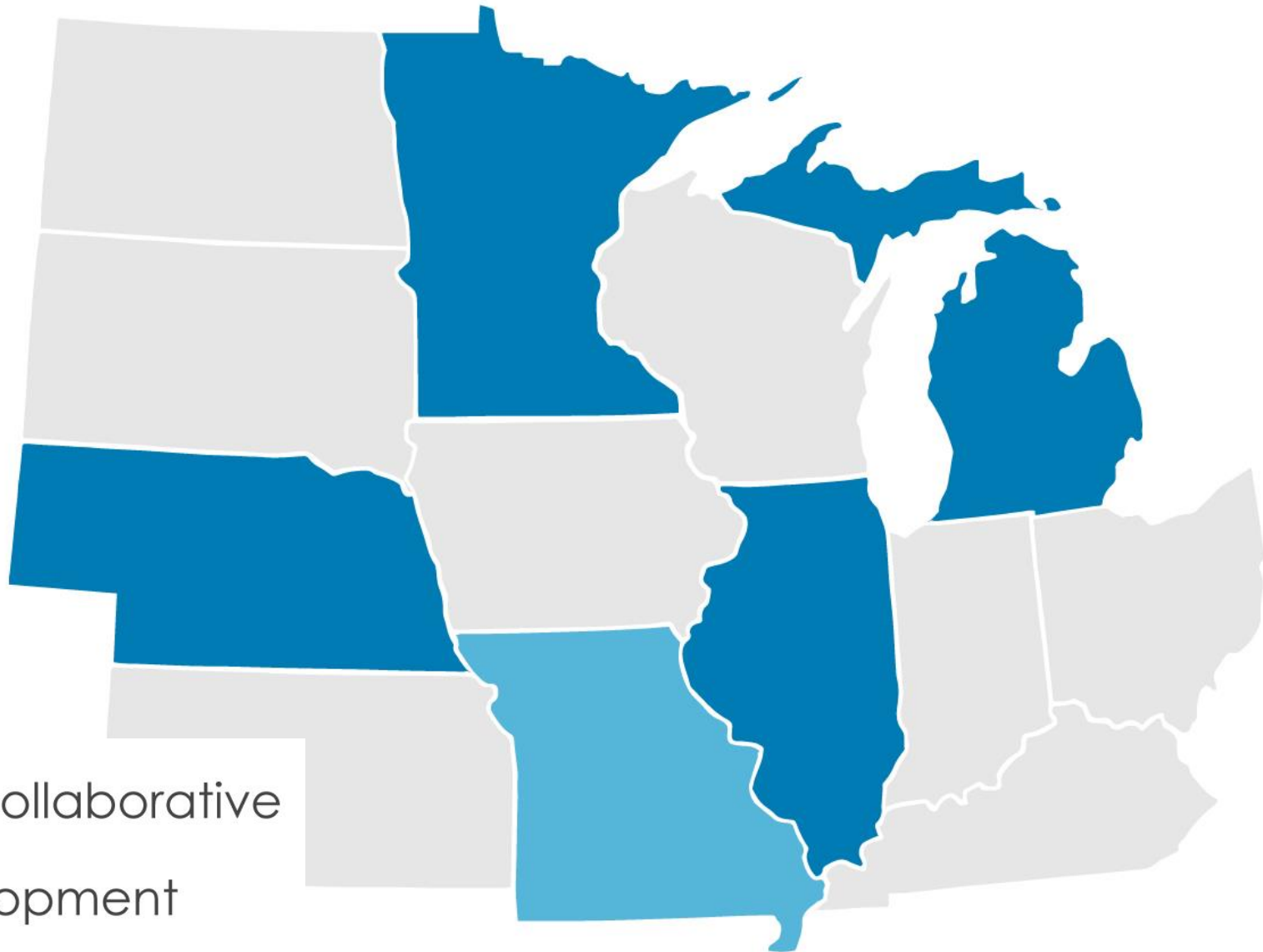


* Energy Use Index: National average energy use by building type and size.

Source: MEEA based on PNNL Analysis

Code Collaboratives

Compliance



■ Active collaborative

■ In development

Code Compliance Studies

Map of US



Field Studies

US DOE

DOE Residential Field Study

Program Design

1. Residential Baseline Study
 - Basis for measuring improvement
 - Identifies specific compliance improvement opportunities
2. Integrated Compliance Support Program
 - Develop a suite of programs targeted at identified compliance improvement opportunities
3. Post Program Study
 - Positive results from Kentucky

Code Compliance Programs

Utility

- Utilities have shown interest in funding code compliance programs
- New residential home construction
- Ameren, MO Residential Energy Code Support Program
 - Code Collaborative
 - Circuit Rider
 - In Person Training

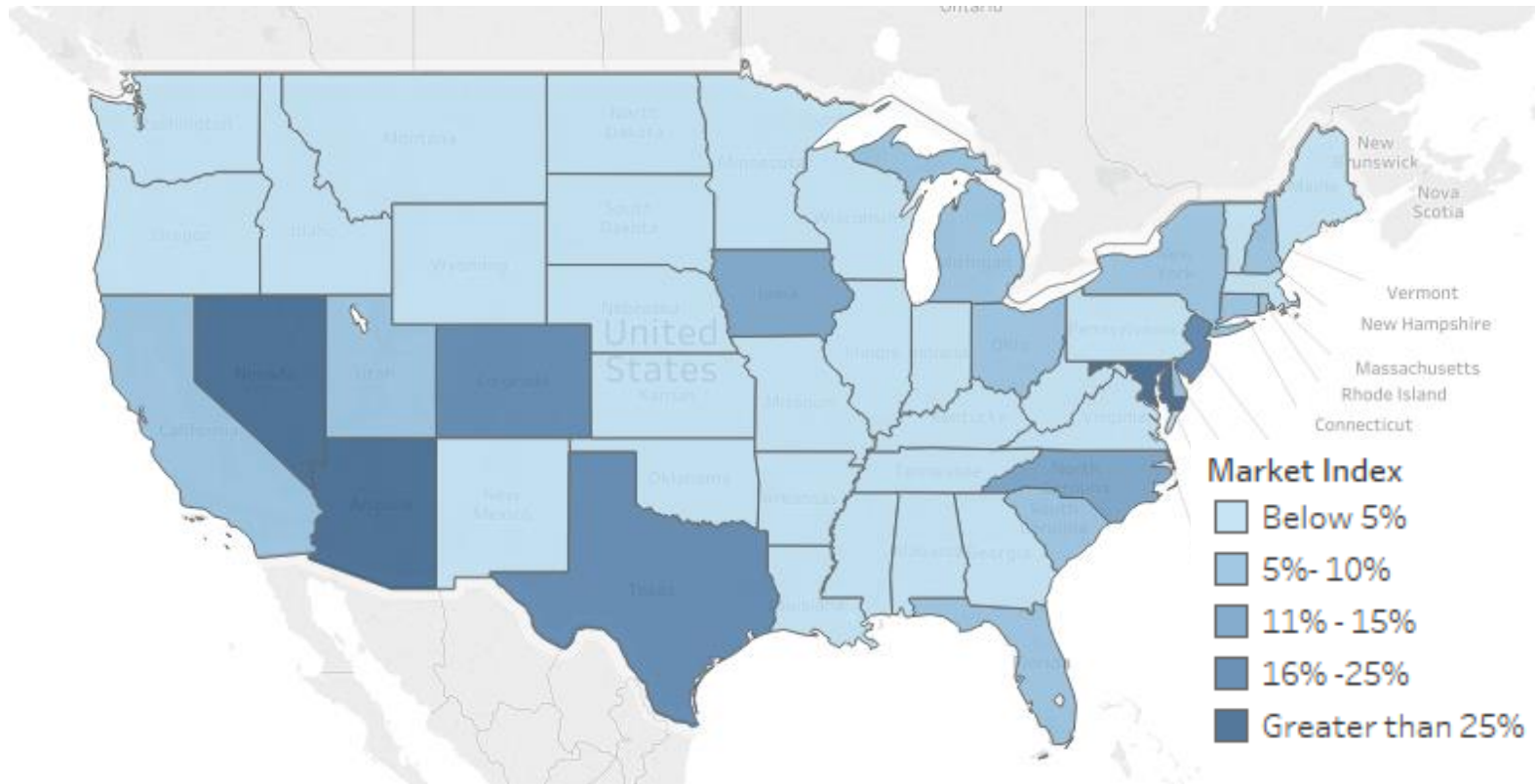
New Construction Program

Utility

State	Utility	Requirements
IA	Mid Am/Alliant	≤ 57
IL	ComEd/Nicor	20-30% ^ Code
IN	Vectren	≤ 63
MI	Consumers	Energy Star
MN	Xcel/Centerpoint	10-50% ^ Code
MO	Ameren/Columbia	≤ 65
NE	OPPD	≤ 60
OH	Columbia Gas	≤ 70
WI	Focus	Energy Star

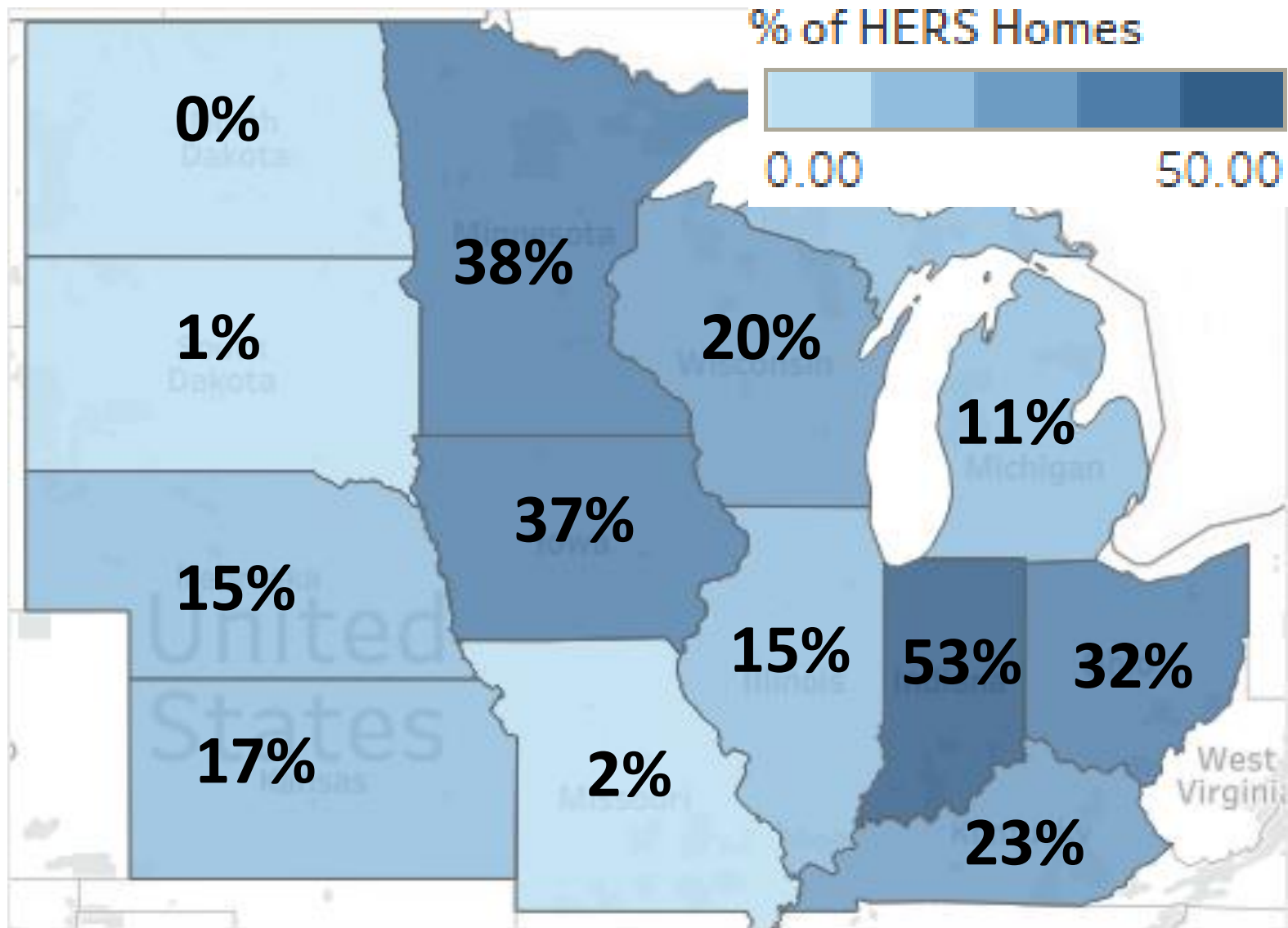
Energy Star Homes

2017 Market Share



Source: EnergyStar.gov

Percentage of HERS Homes Based on Census New Construction



HERS Comparison

Policies and Programs

State	% of HERS homes	Avg. HERS Score	Primary CZ	State IECC	State IMC	Utility Program
IN	53%	66.0	5	2009	2012 IMC	Y
MN	38%	52.0	6	2012+	2012 IMC	Y
IA	37%	55.0	5	2012+	2015 IMC	Y
OH	32%	59.0	5	2009	2015 IMC	Y
KY	23%	65.0	4	2009	2012 IMC	Y
WI	20%	55.0	6	2009	2015 IMC	Y
KS	17%	70.0	4	None	None	N
NE	15%	52.5	5	2009	None	Y
IL	15%	55.0	5	2012+	None	Y
MI	11%	55.0	5	2009	2015 IMC	Y
MO	2%	62.5	4	None	None	Y
SD*	1%	51.5	6	None	None	N
ND*	0%	58.5	6	None	None	N

Midwest HERS Homes

High Level Overview

Home Features

Average in Midwest

- HERS Score: 59
- Home Size: 3,500 sq. ft.
- Bedrooms: 3.5
- Foundation:
 - 83% basements/crawl
 - Avg. R- 3+5
- Walls
 - 13% w/ ext. insulation
 - Avg. R – 17 + .5
- Windows
 - U-.30
 - SHGC - .29
- Ceiling
 - R-42

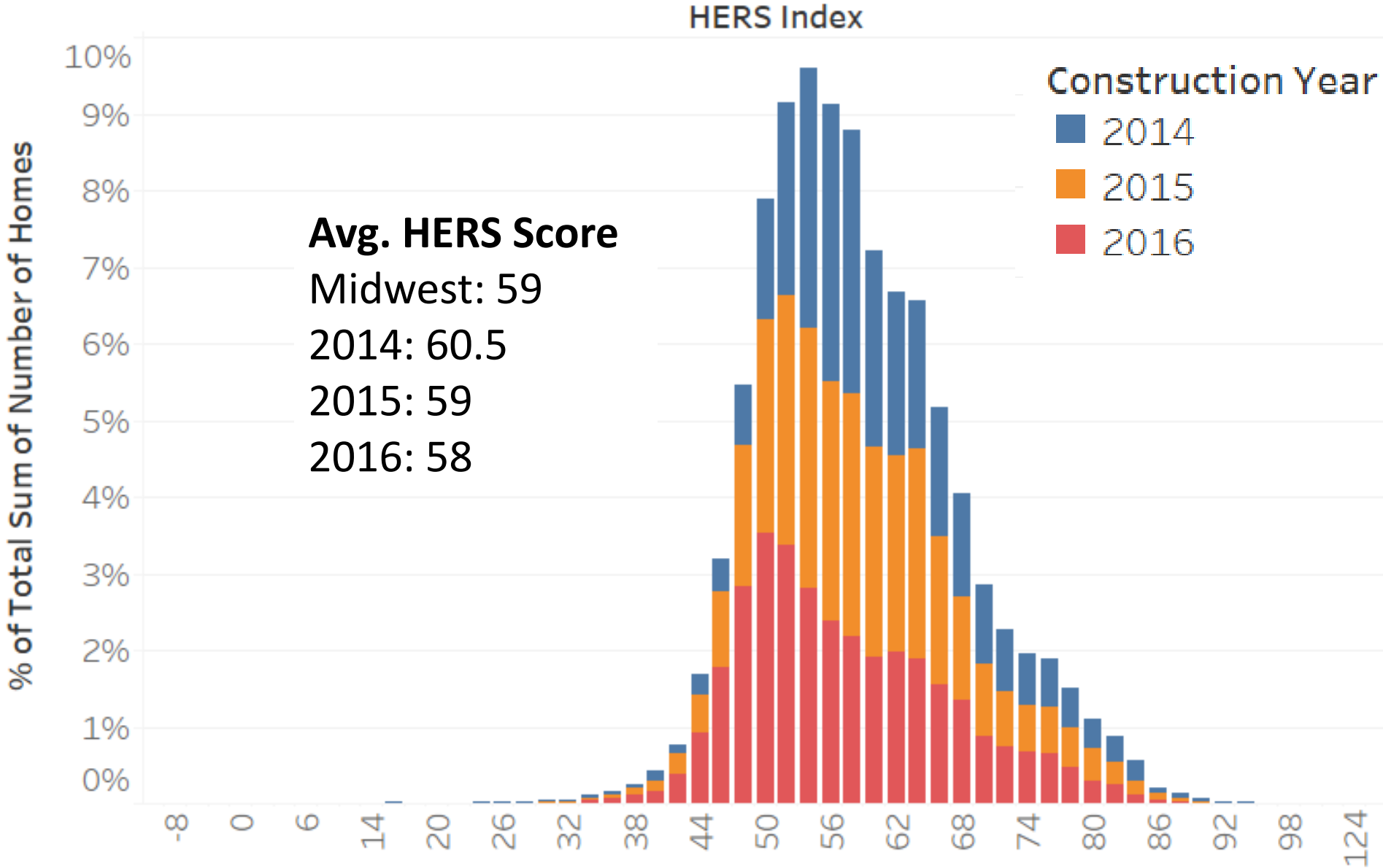
Home Features

Average in Midwest

- ACH50: 2.7
- Duct Leakage: 2% outside
- High Efficacy Lights: 57%
- HVAC
 - Furnace/AC - 88%
 - AFUE: 93.5
 - SEER: 13.5
- Water Heating
 - 94% Conventional
 - Capacity: 50 Gallons
 - EF: .79

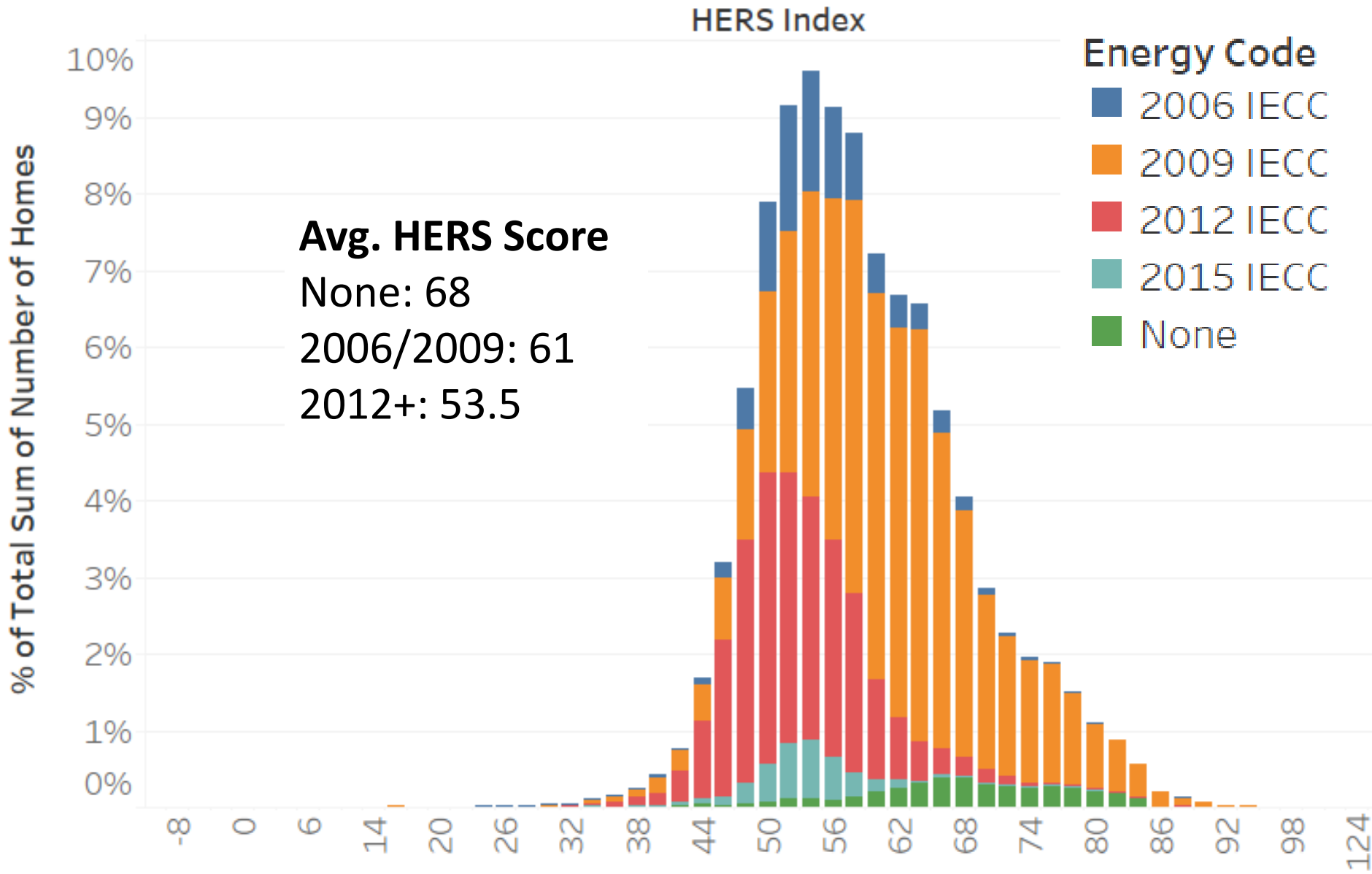
HERS Score by Year

All Midwest



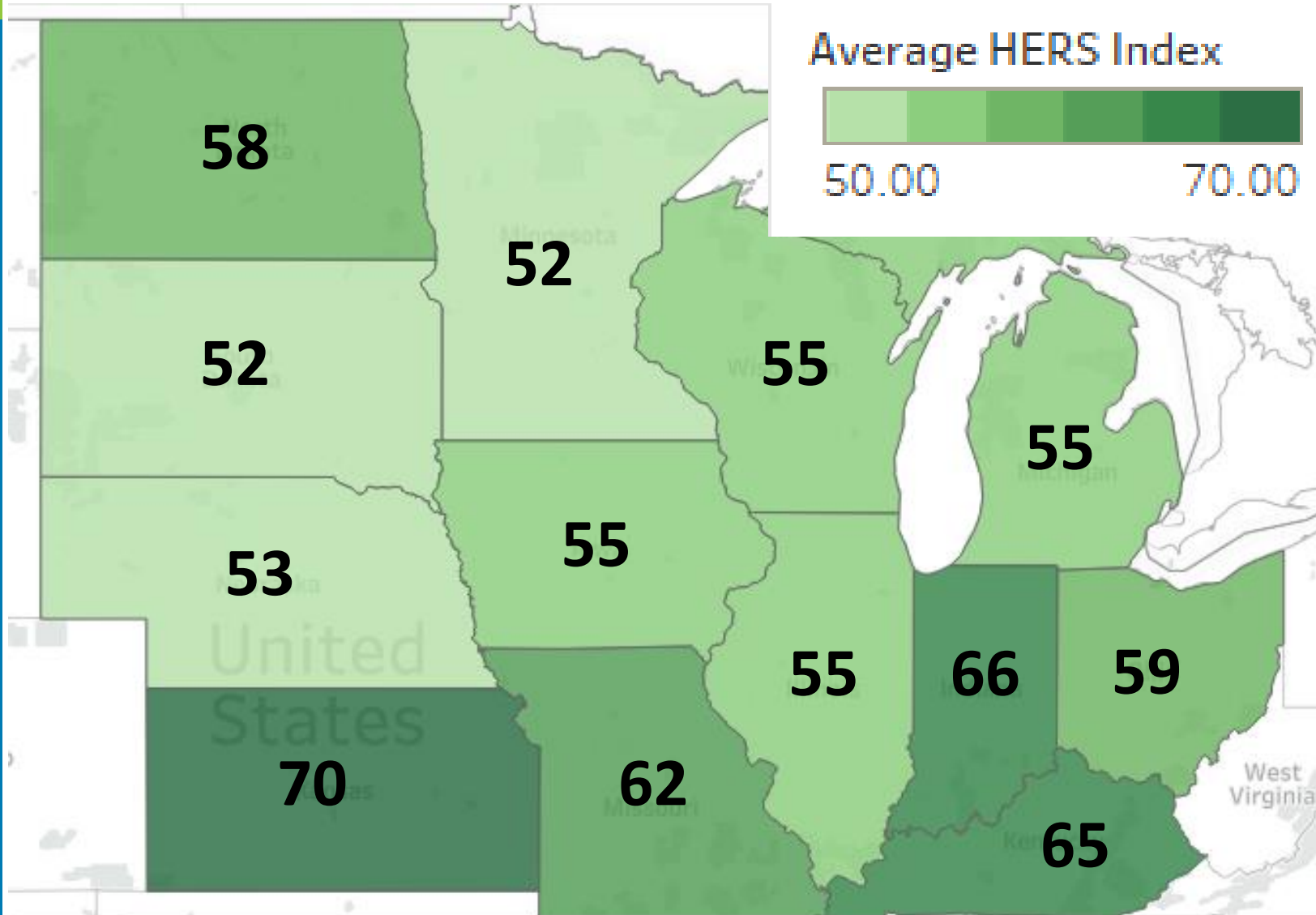
HERS Score by Energy Code

All Midwest



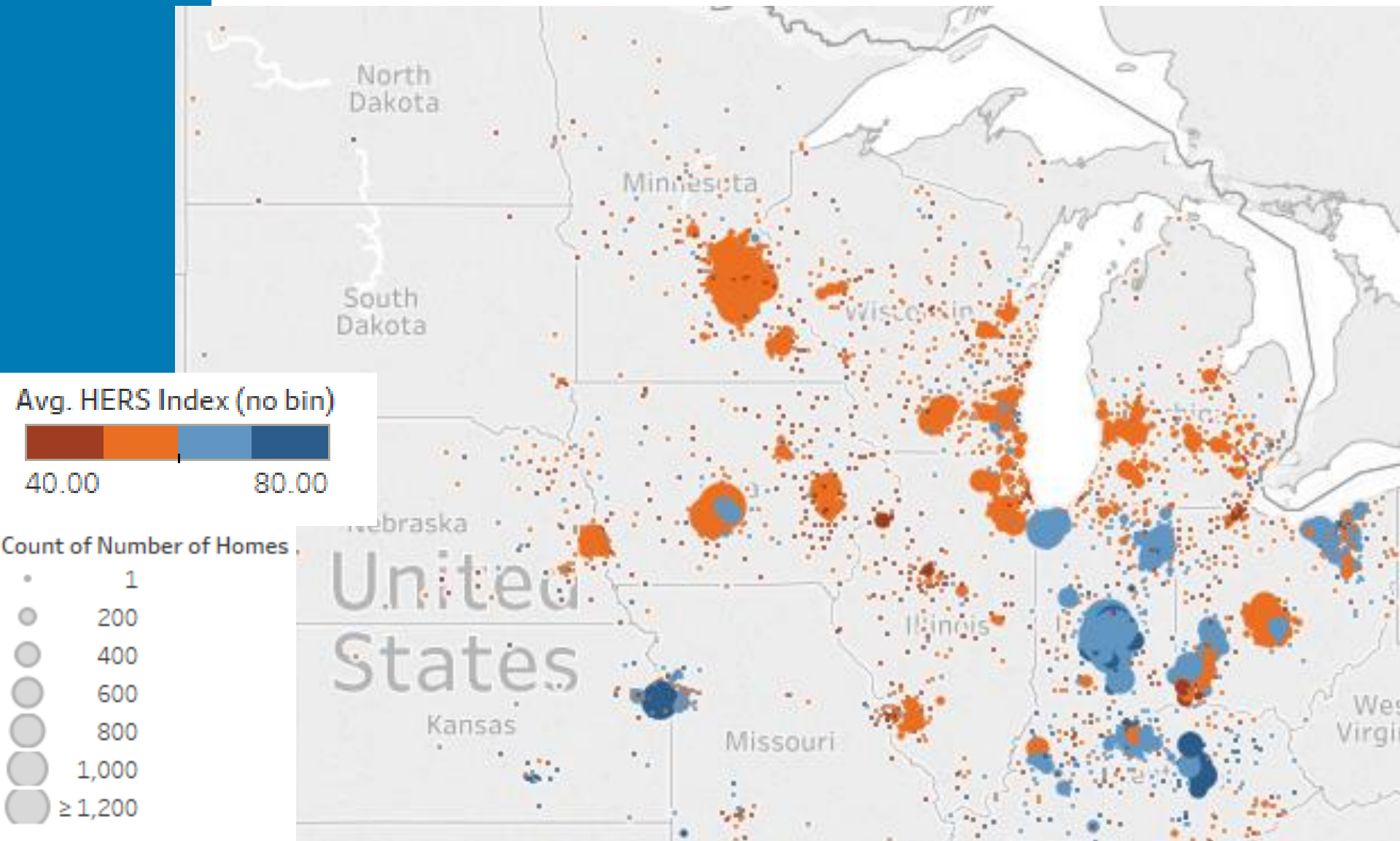
Average HERS score

By State



Map of HERS Homes

Number and Score of homes by Zip

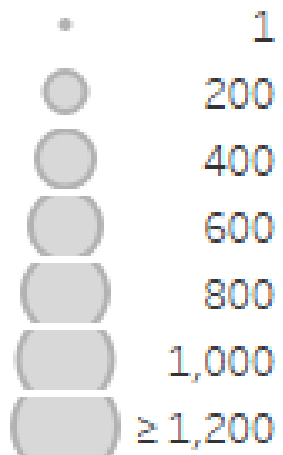


Above Grade (R-Value)

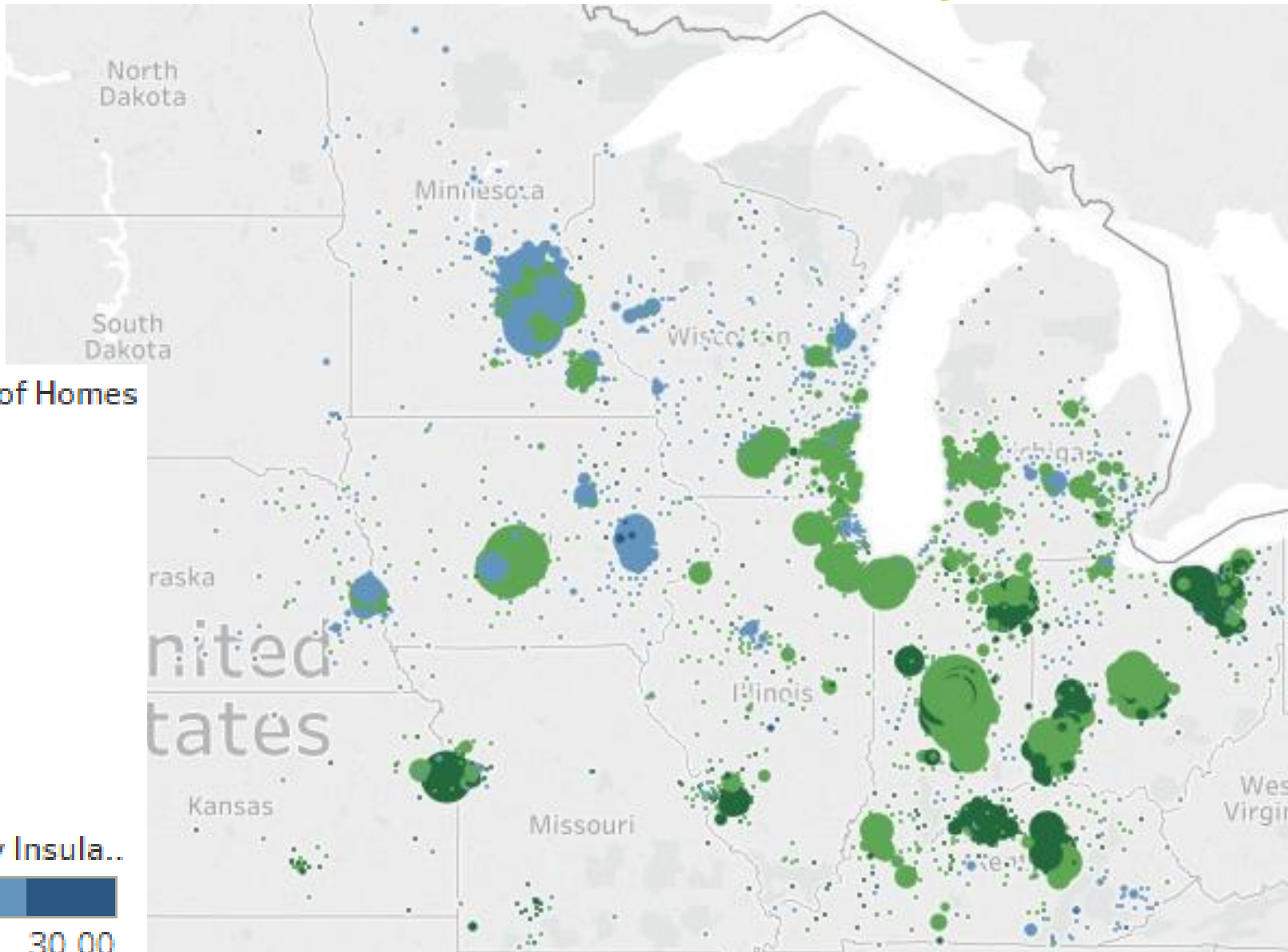
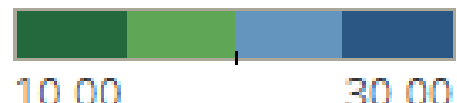
Average by Zip



Sum of Number of Homes



Avg. AGW Cavity Insula..

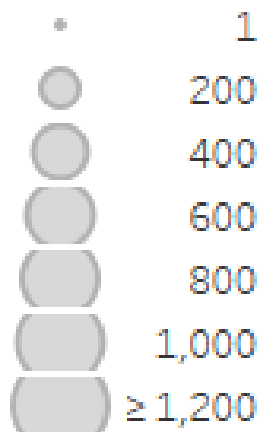


AGW Insulation Installation

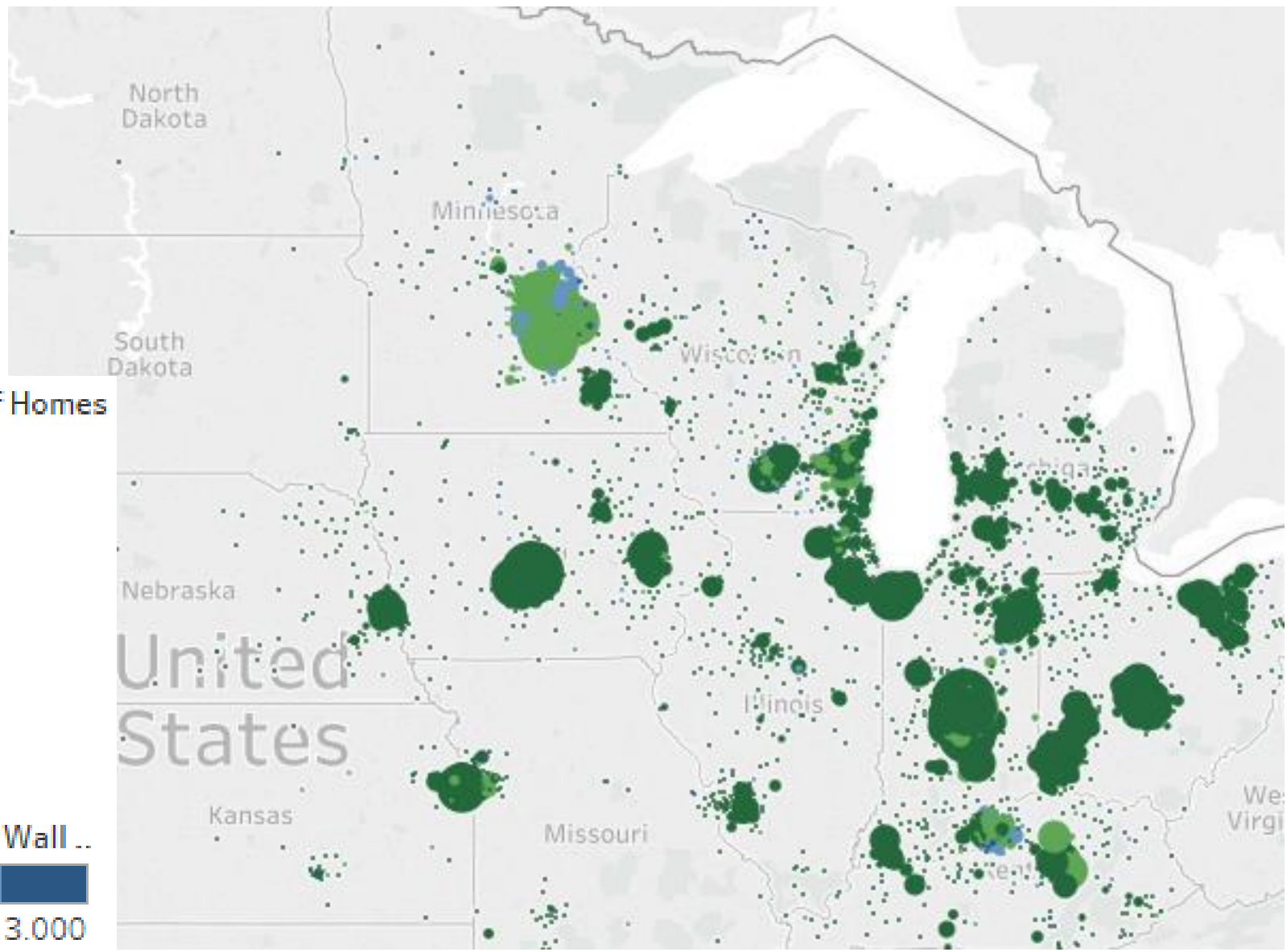
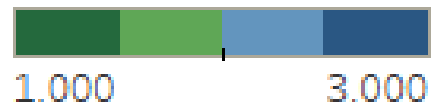
Average by Zip



Sum of Number of Homes



Avg. Above Grade Wall ...

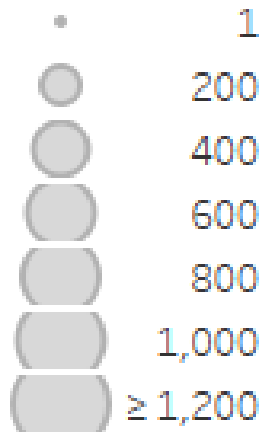


Ceiling Insulation (R-Value)

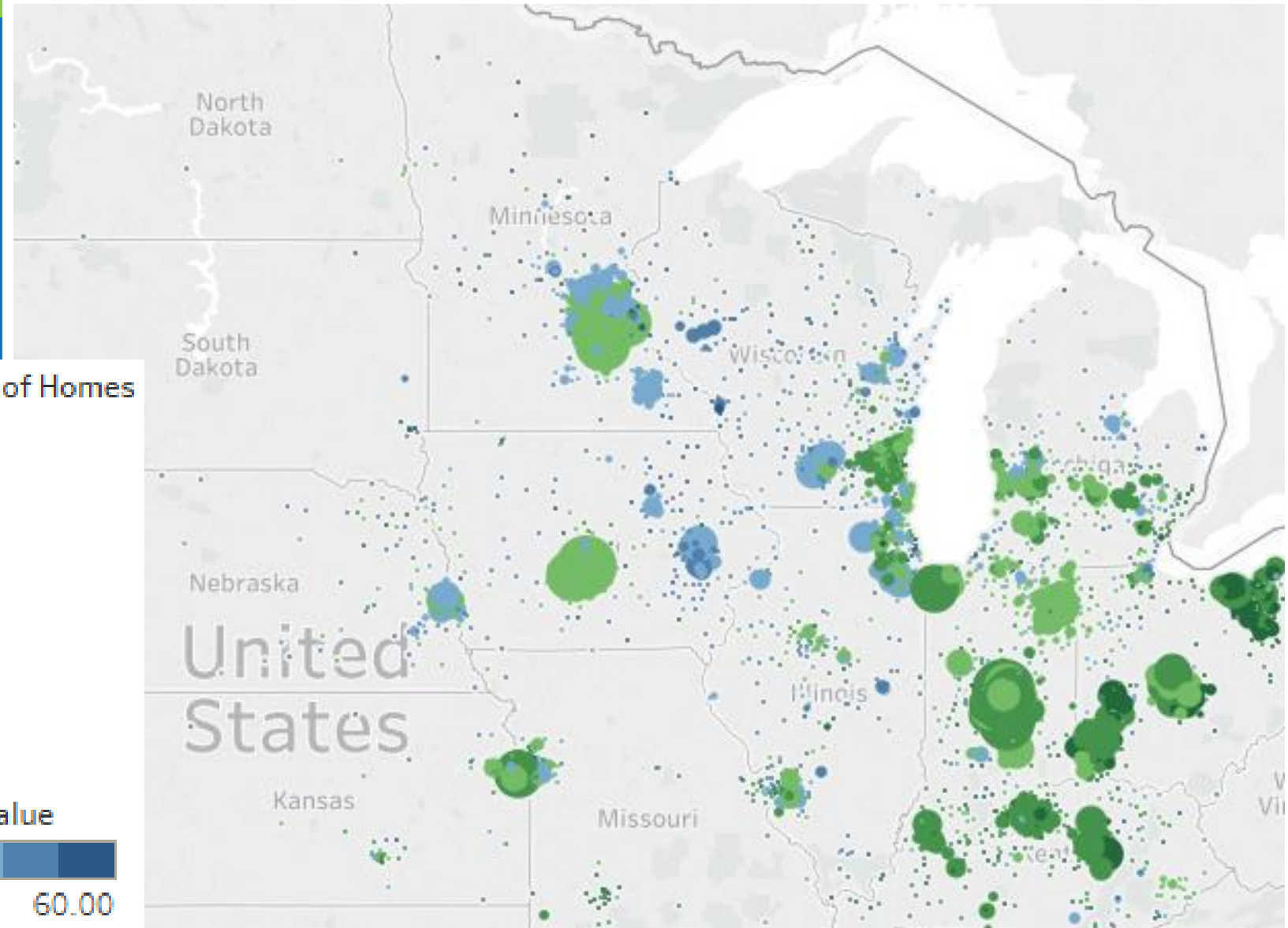
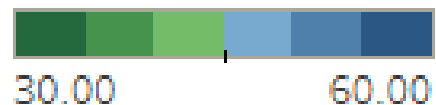
Average by Zip



Sum of Number of Homes



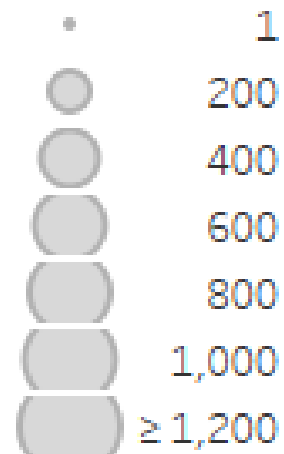
Avg. Ceiling R Value



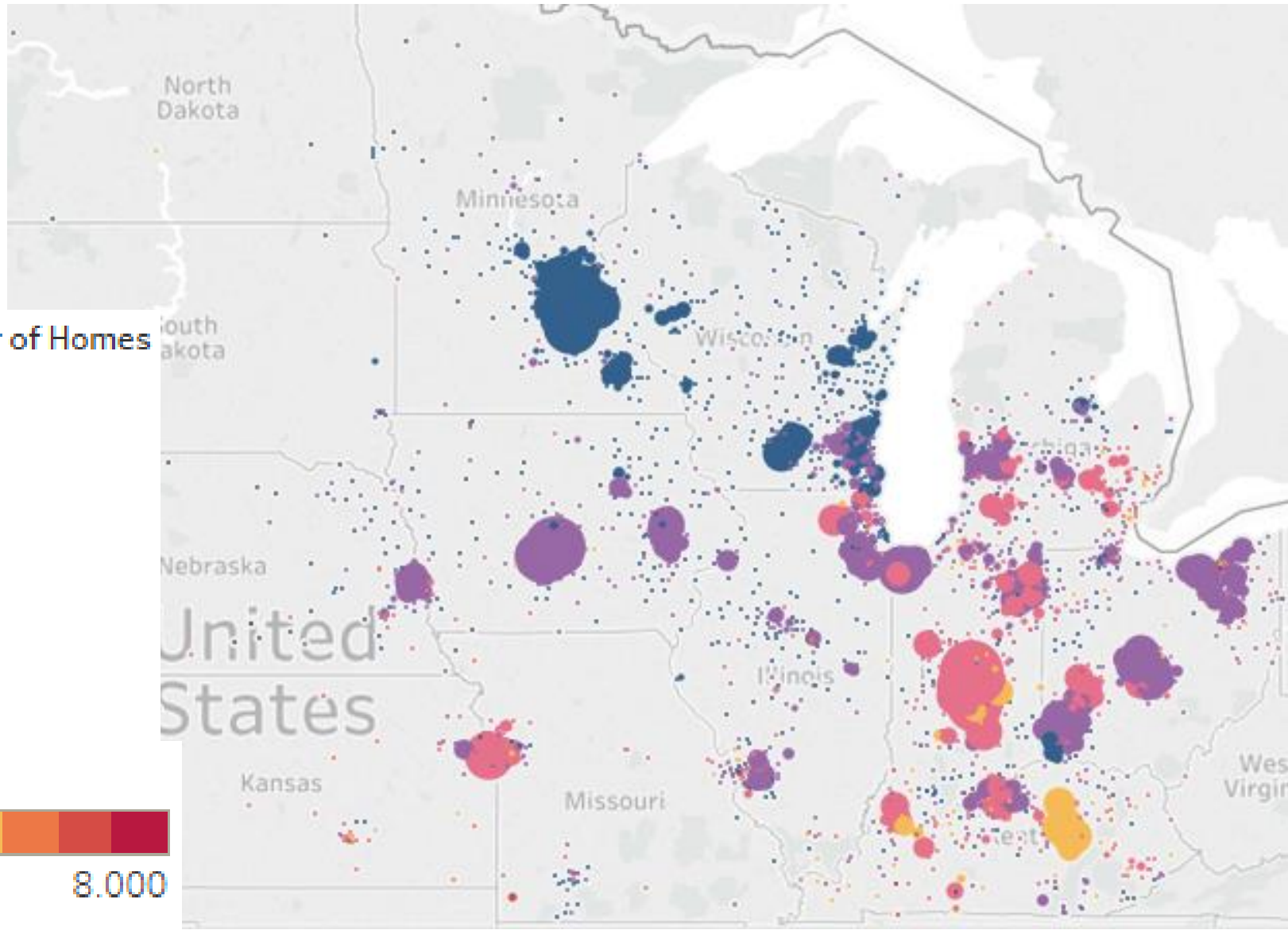
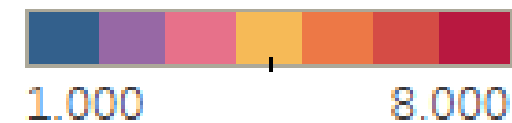
Air Sealing (ACH50) *Average by Zip*



Sum of Number of Homes



Avg. ACH50

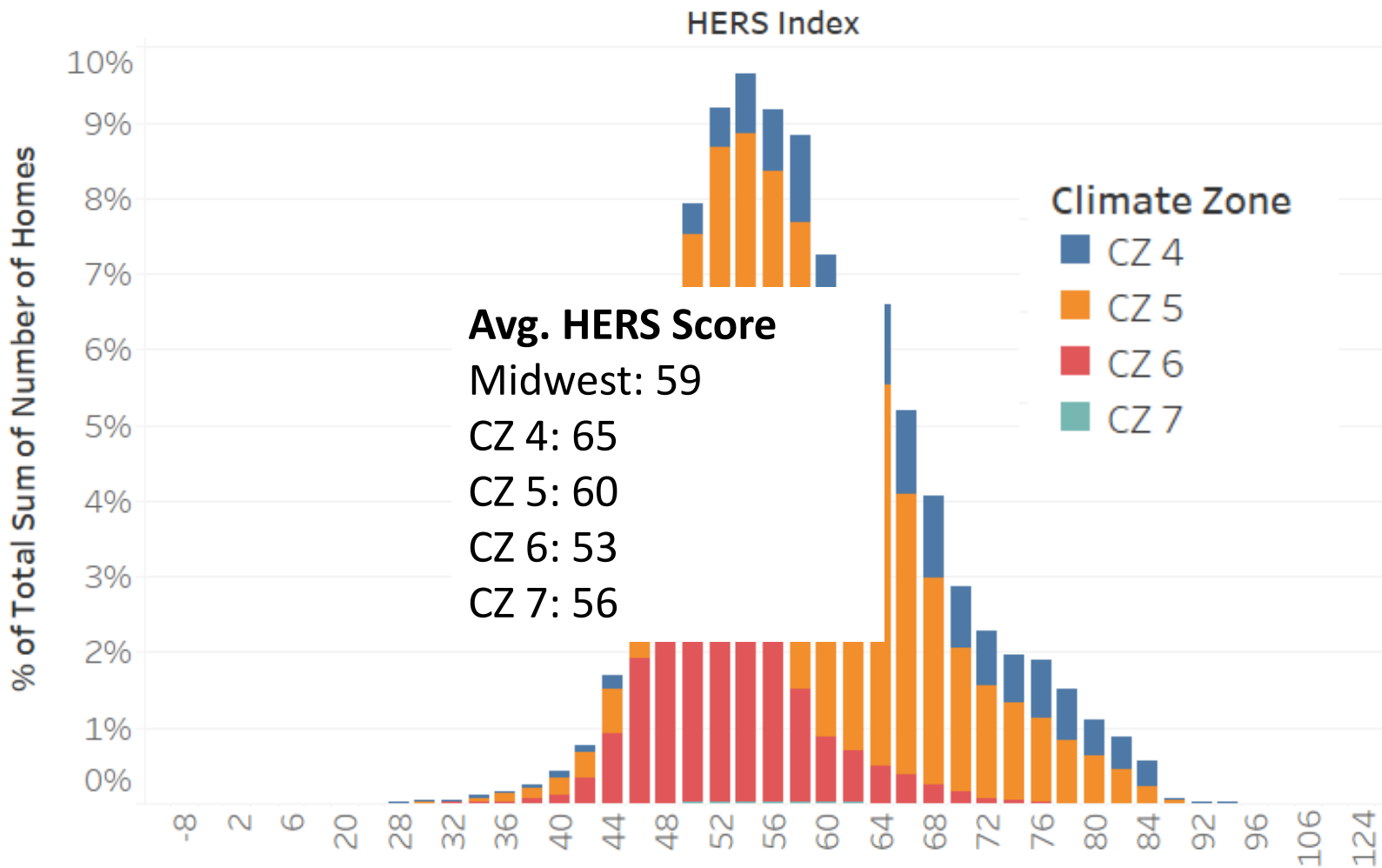


Climate Zone

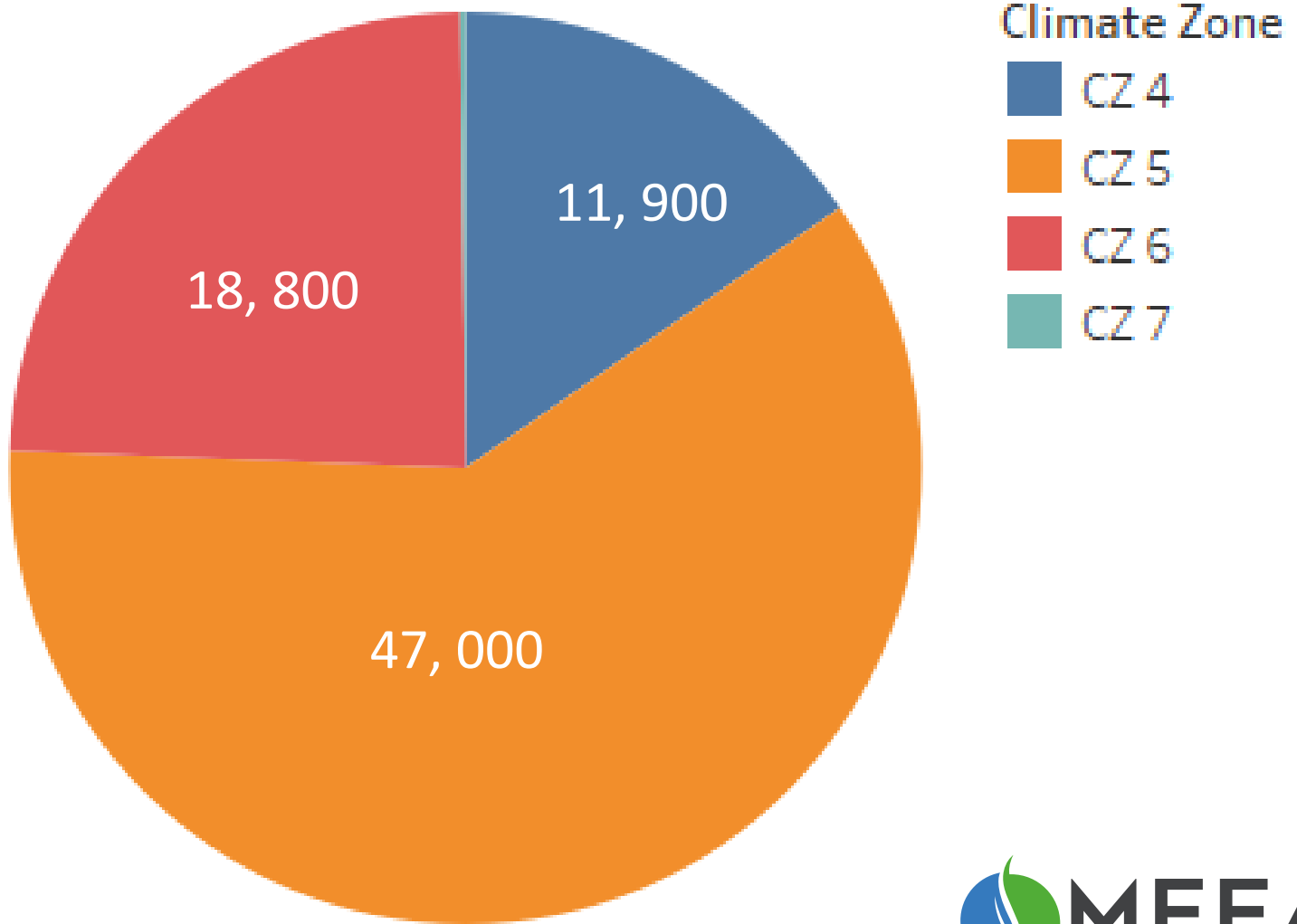
Detailed Analysis

HERS score

Breakdown in Midwest by CZ



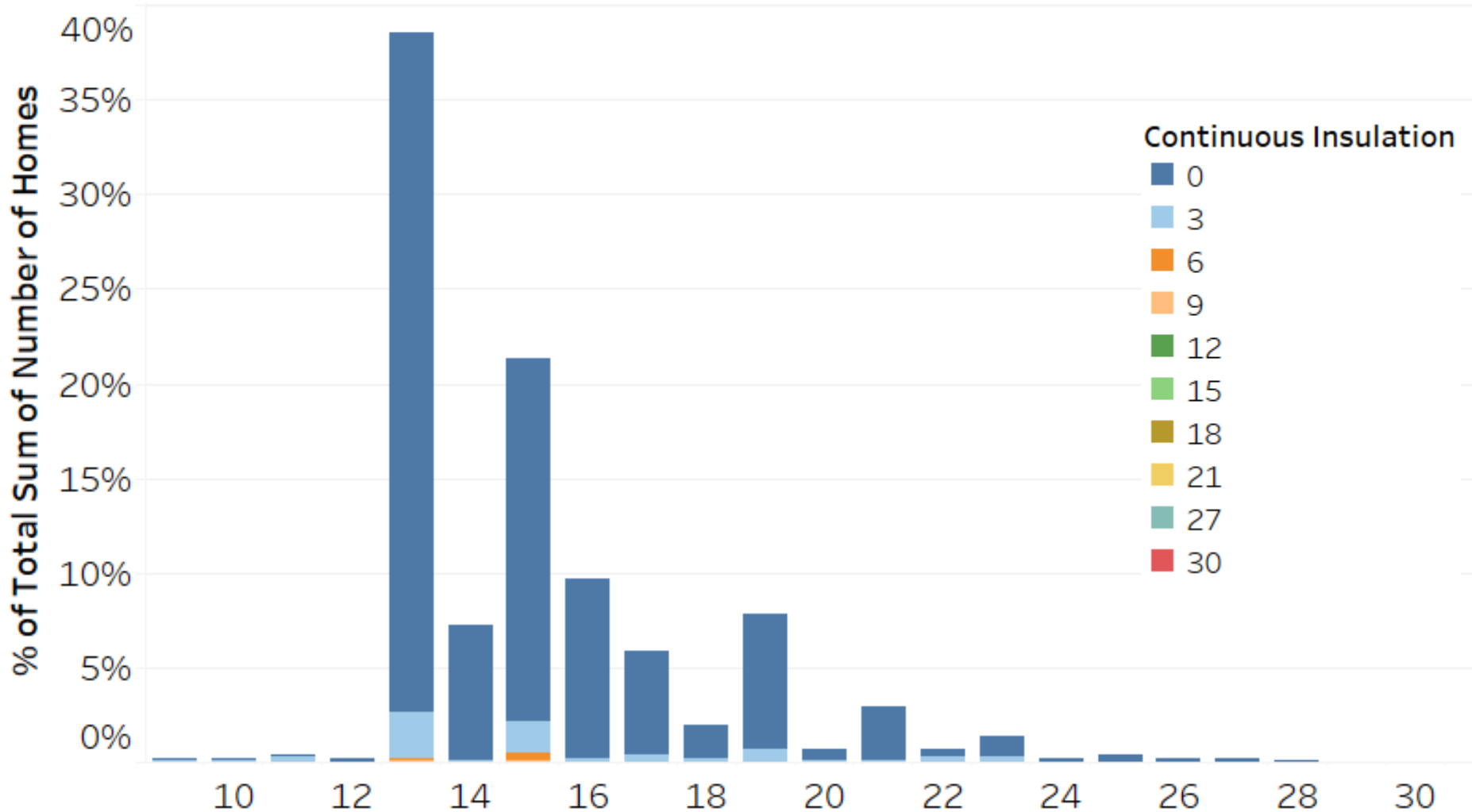
Number of Homes *Breakdown in Midwest by CZ*



Above Grade Wall Insulation

Graph: CZ 4

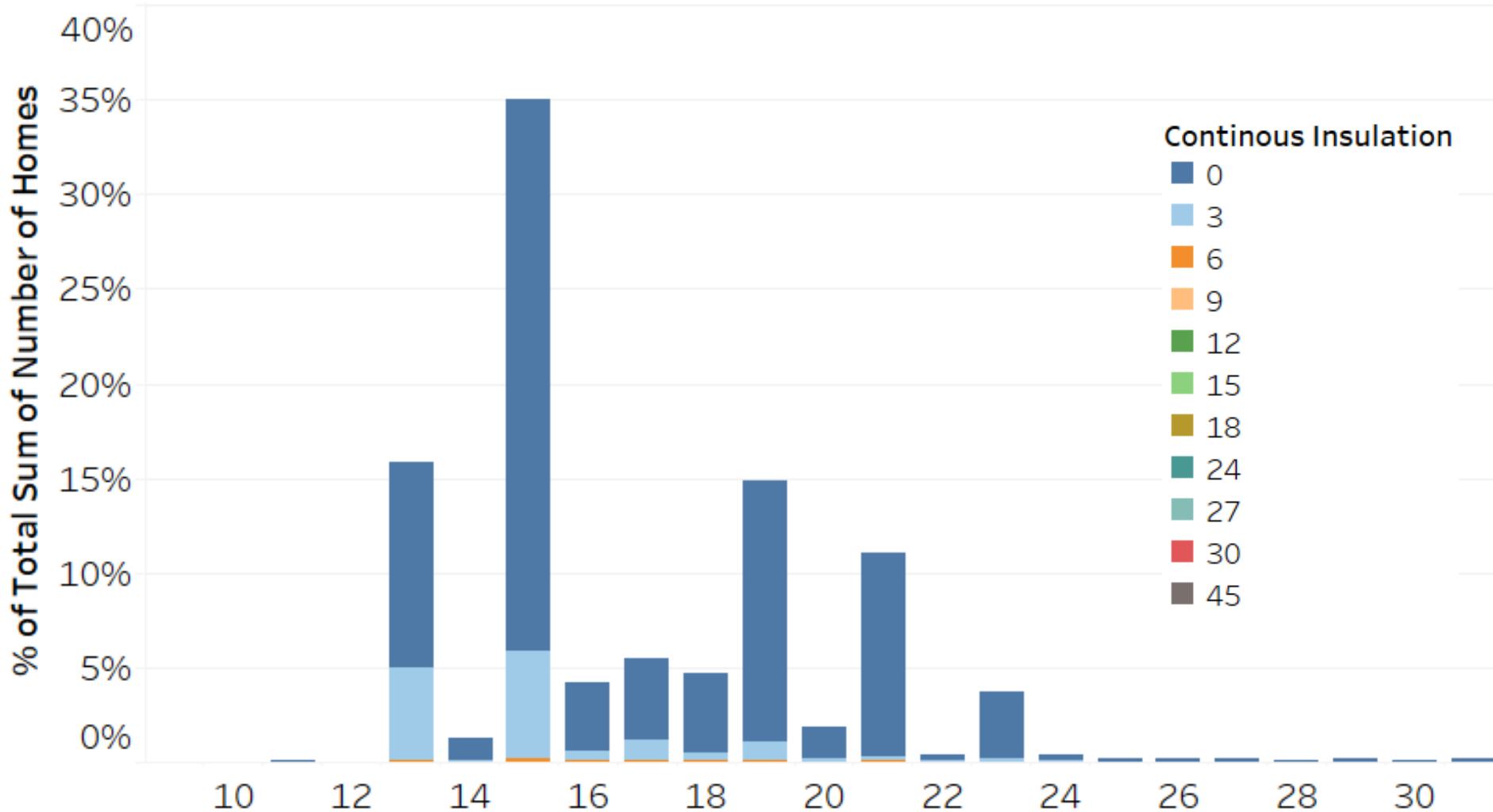
AGW Cavity Insulation (R-Value)



Above Grade Wall Insulation

Graph: CZ 5

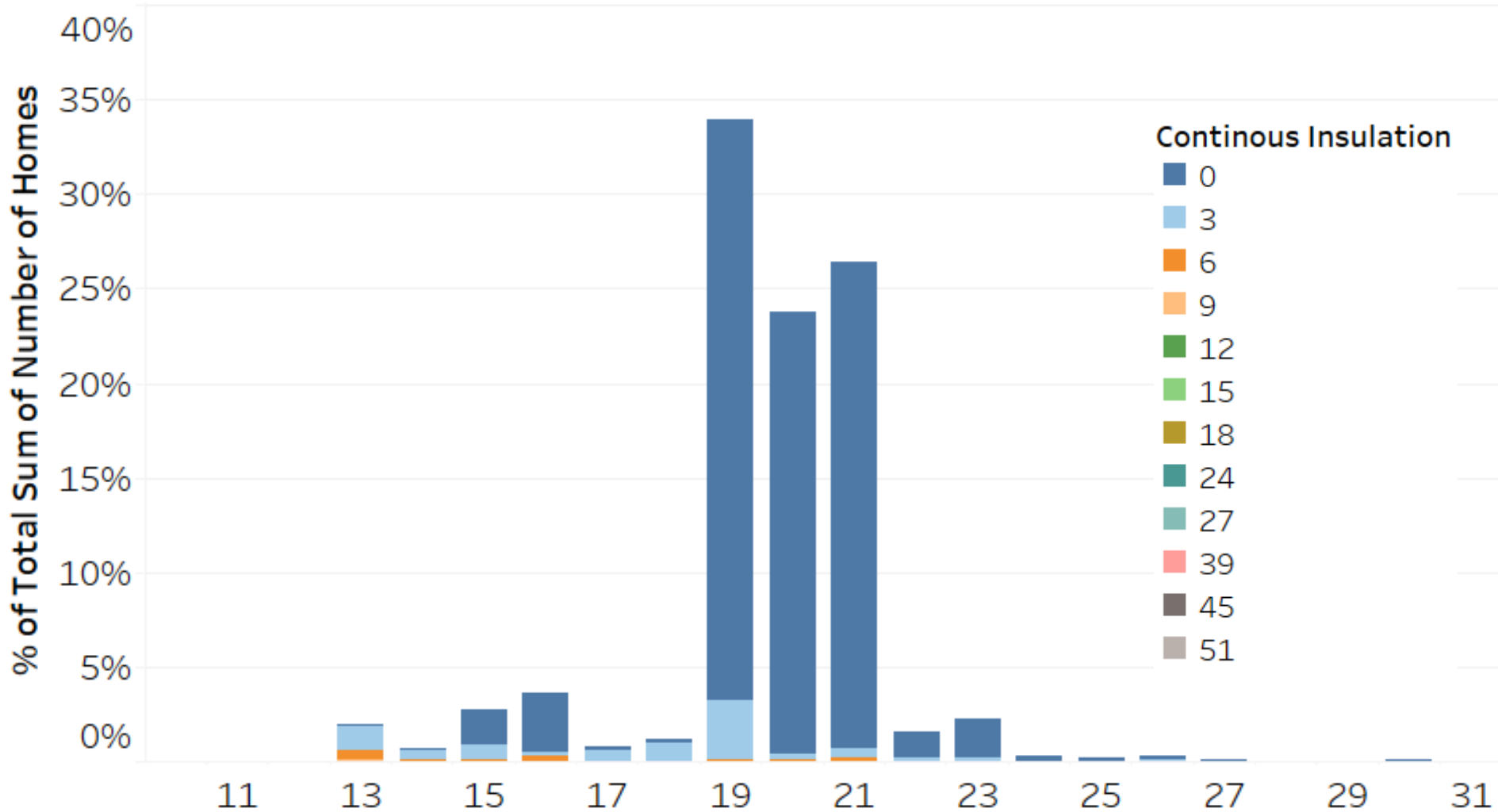
AGW Cavity Insulation (R-Value)



Above Grade Wall Insulation

Graph: CZ 6+7

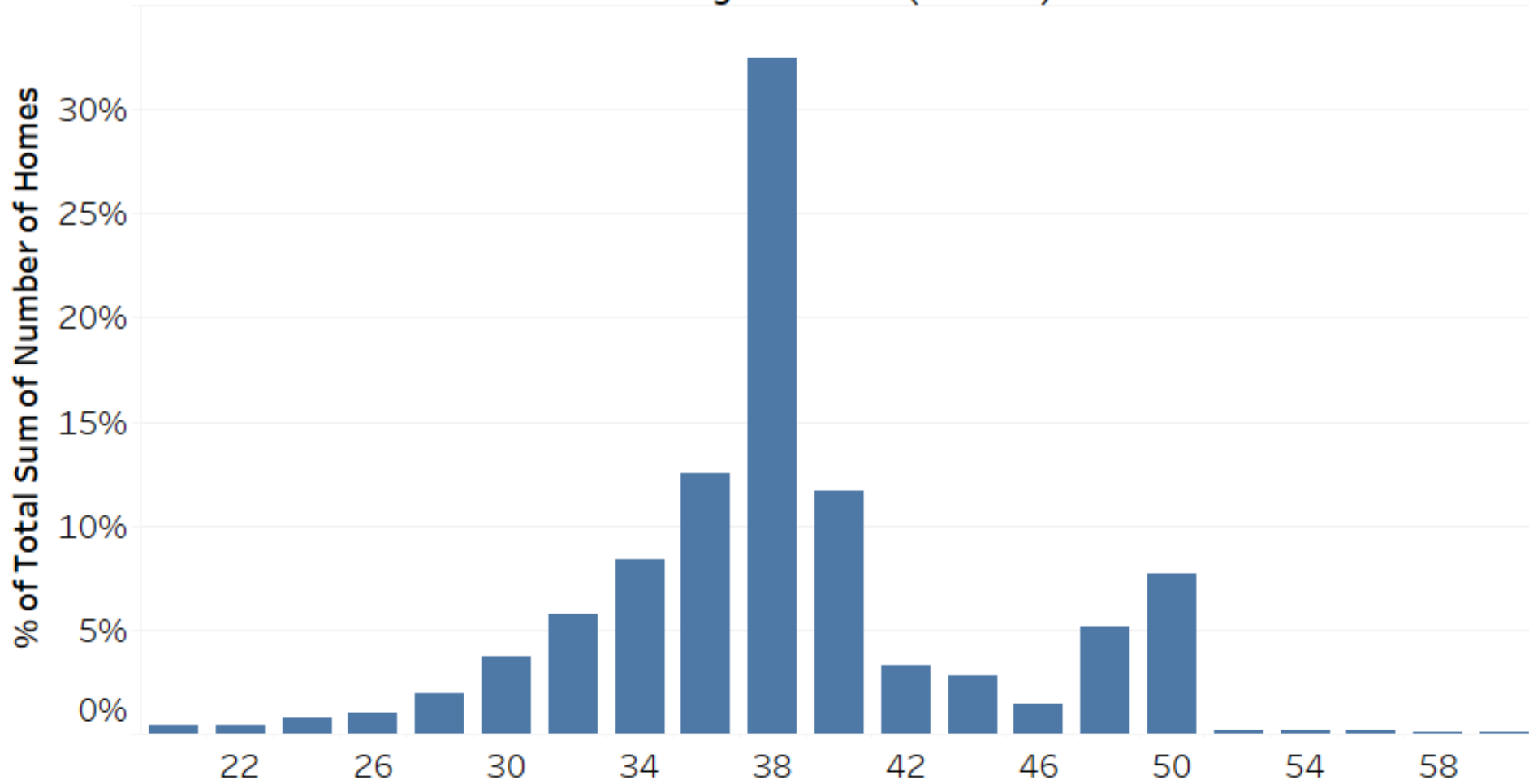
AGW Cavity Insulation (R-Value)



Ceiling Insulation

Graph: CZ 4

Ceiling Insulation (R-Value)

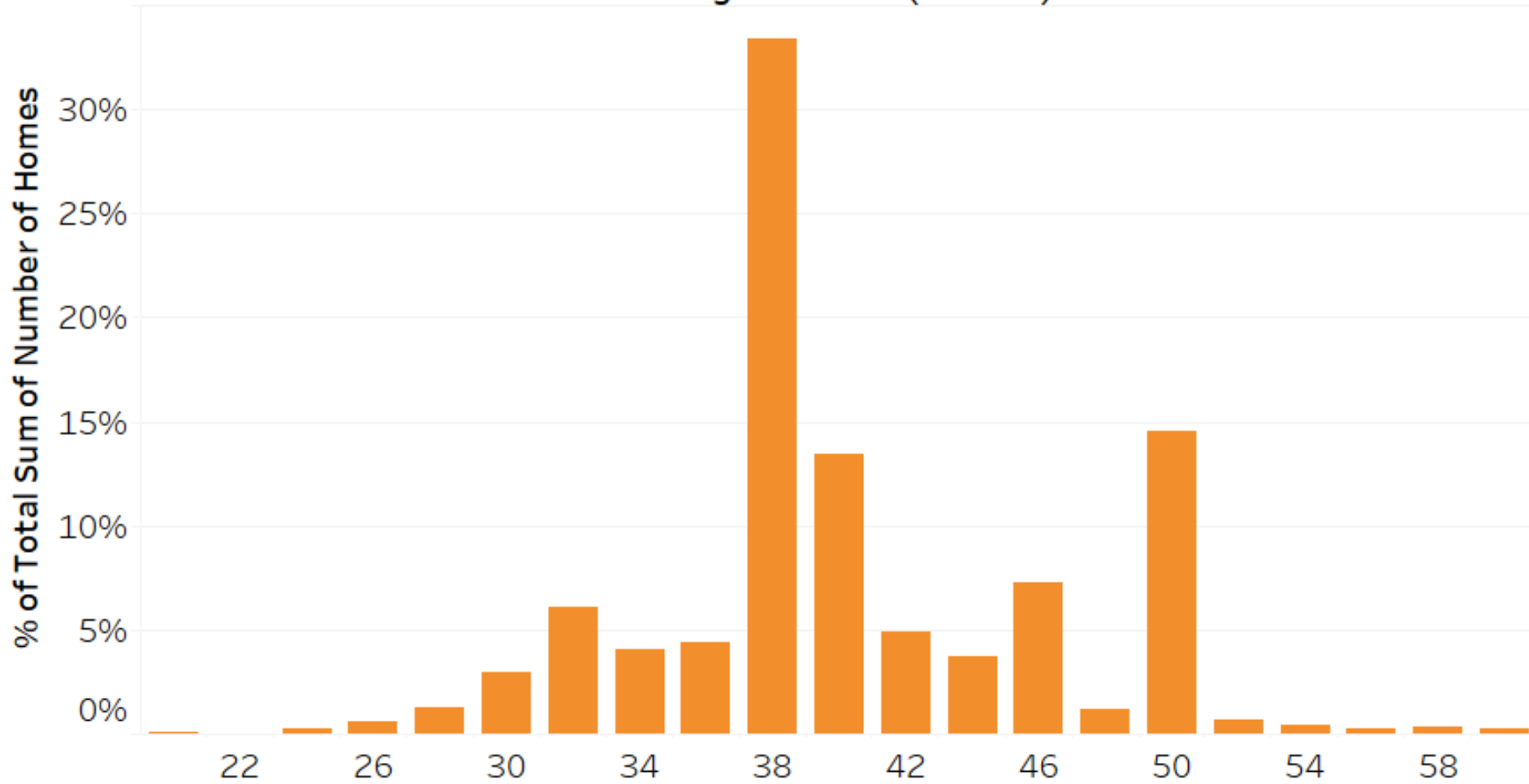


Ceiling Insulation

Graph: CZ 5



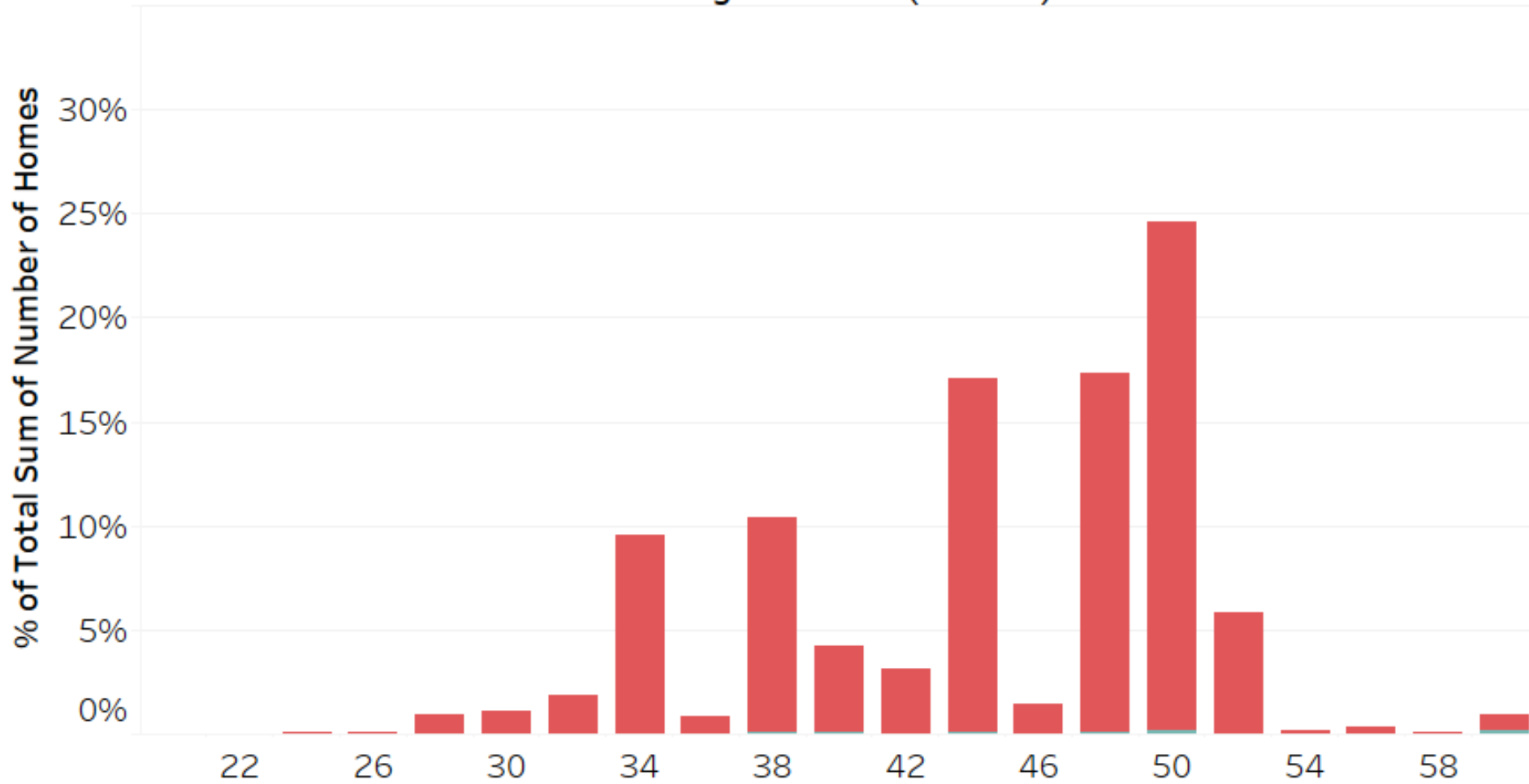
Ceiling Insulation (R-Value)



Ceiling Insulation

Graph: CZ 6+7

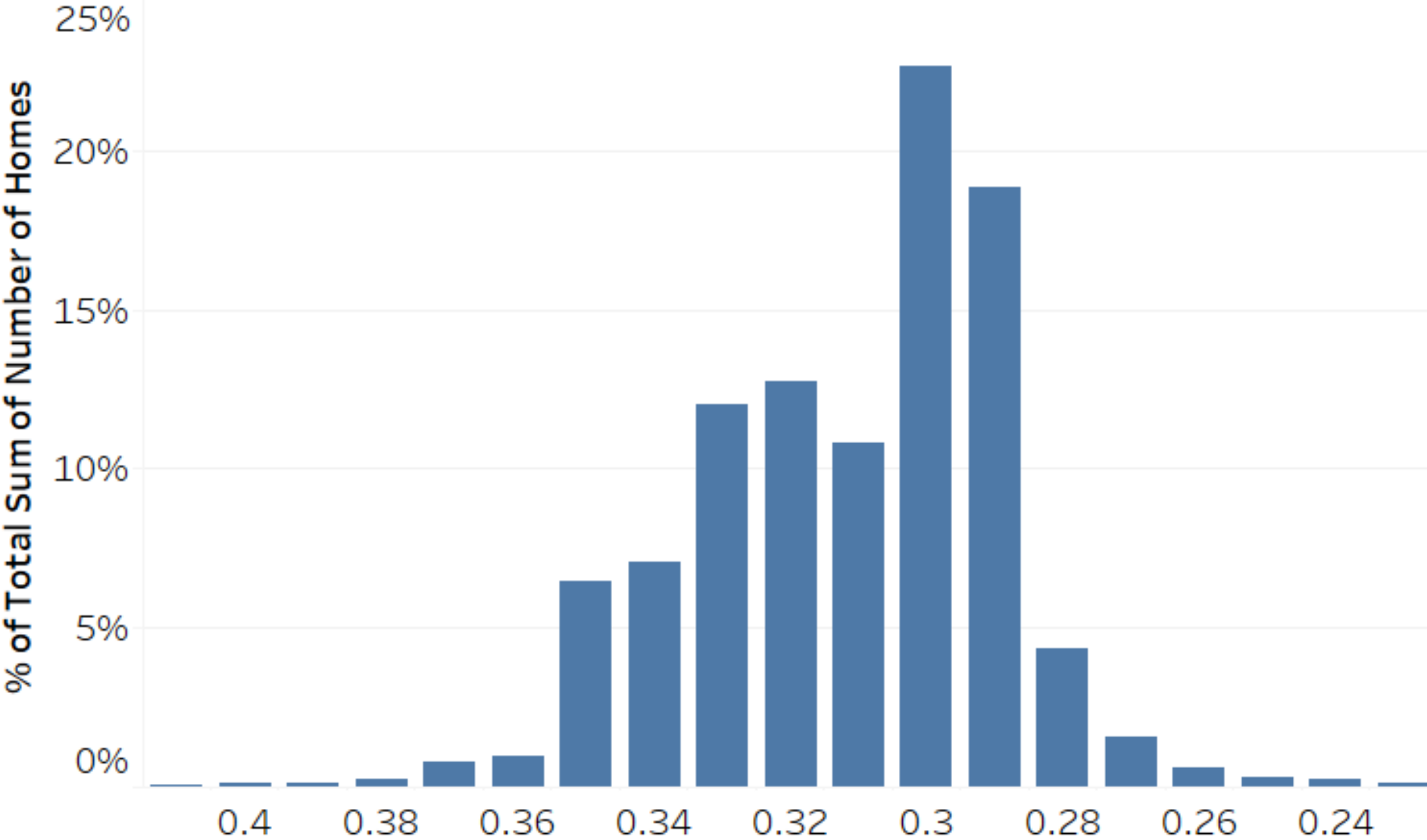
Ceiling Insulation (R-Value)



Window U-Factor

Graph: CZ 4

Window Efficiency (U-Factor)

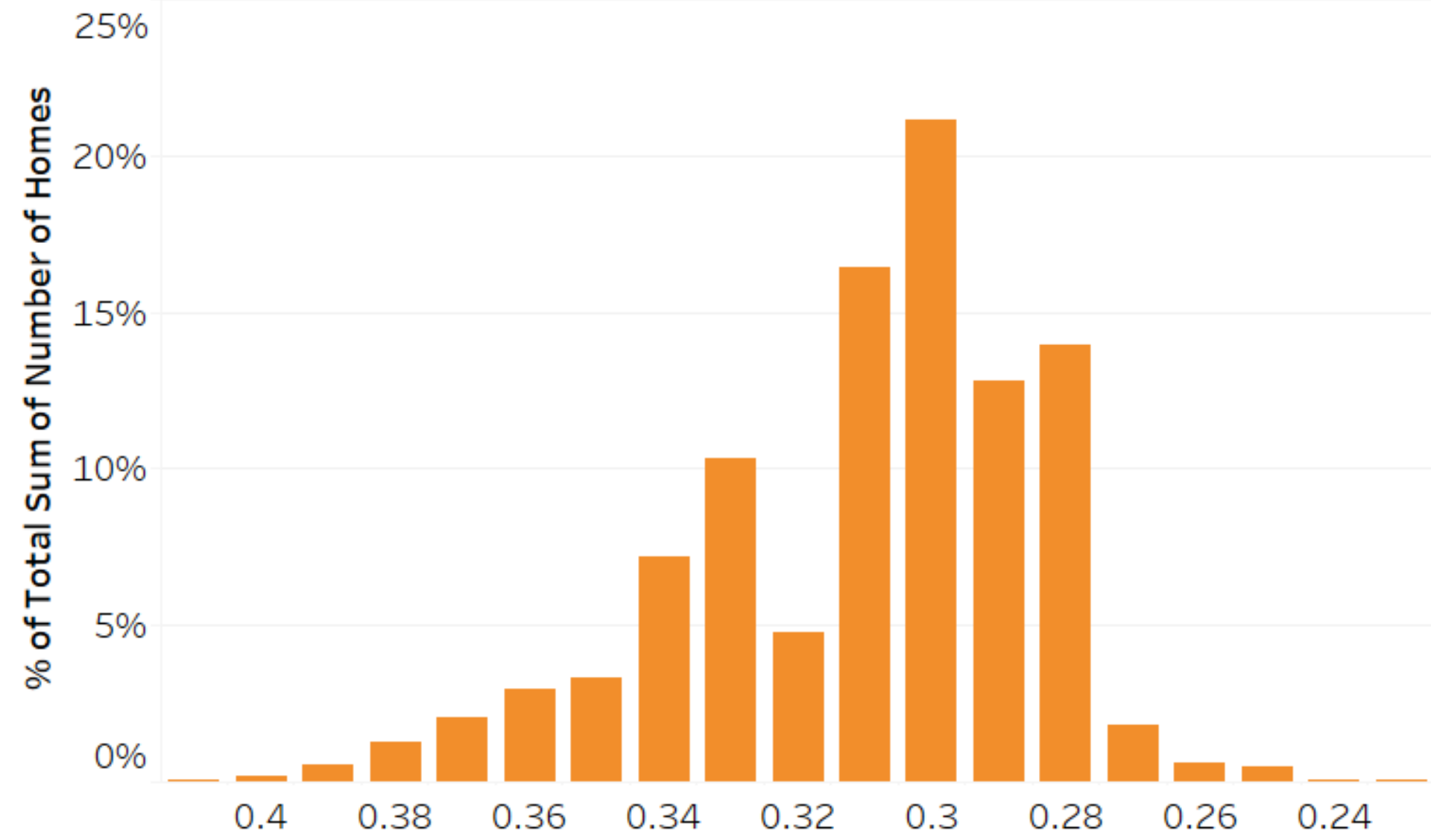




Window U-Factor

Graph: CZ 5

Window Efficiency (U-Factor)

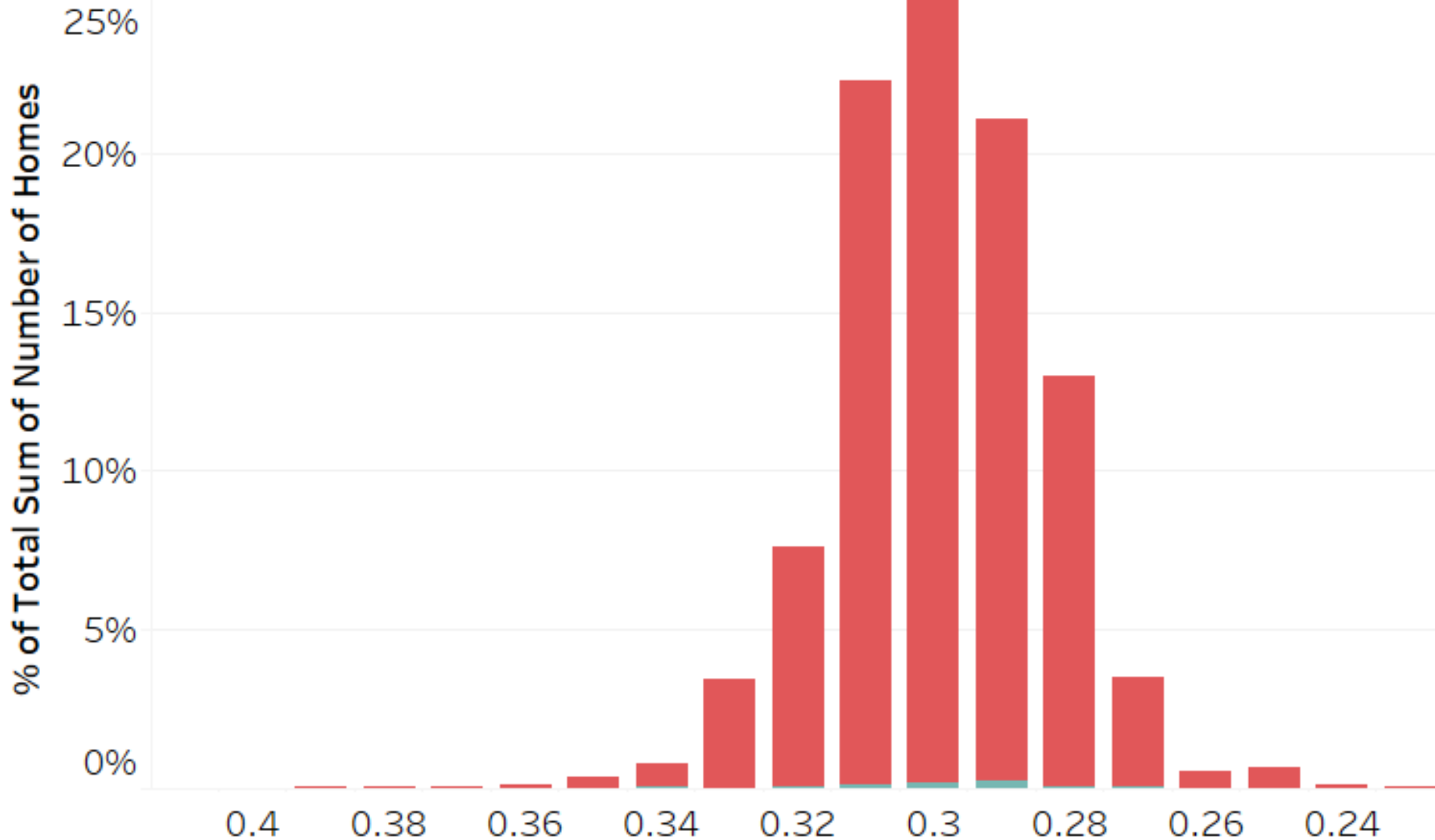




Window U-Factor

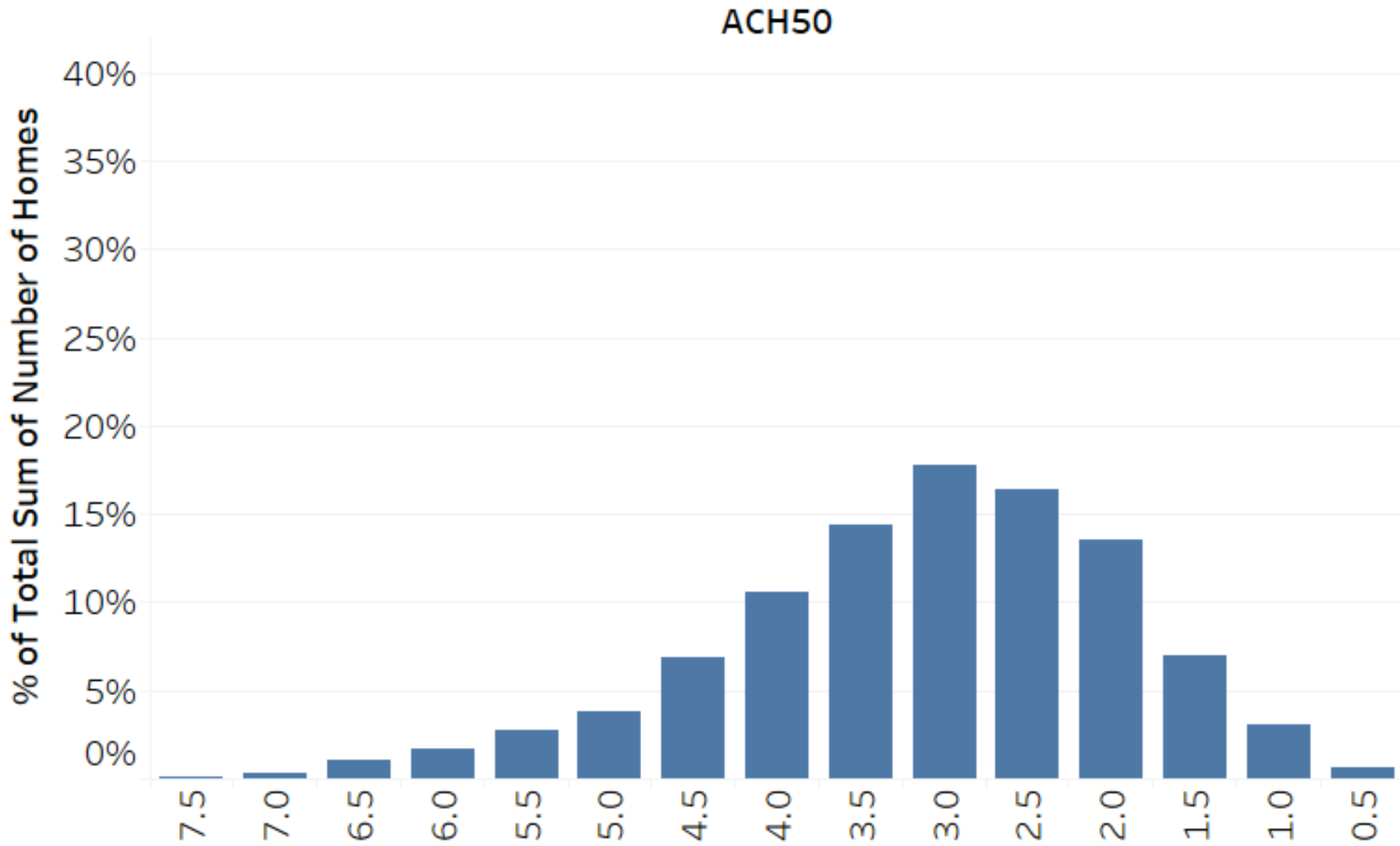
Graph: CZ 6+7

Window Efficiency (U-Factor)



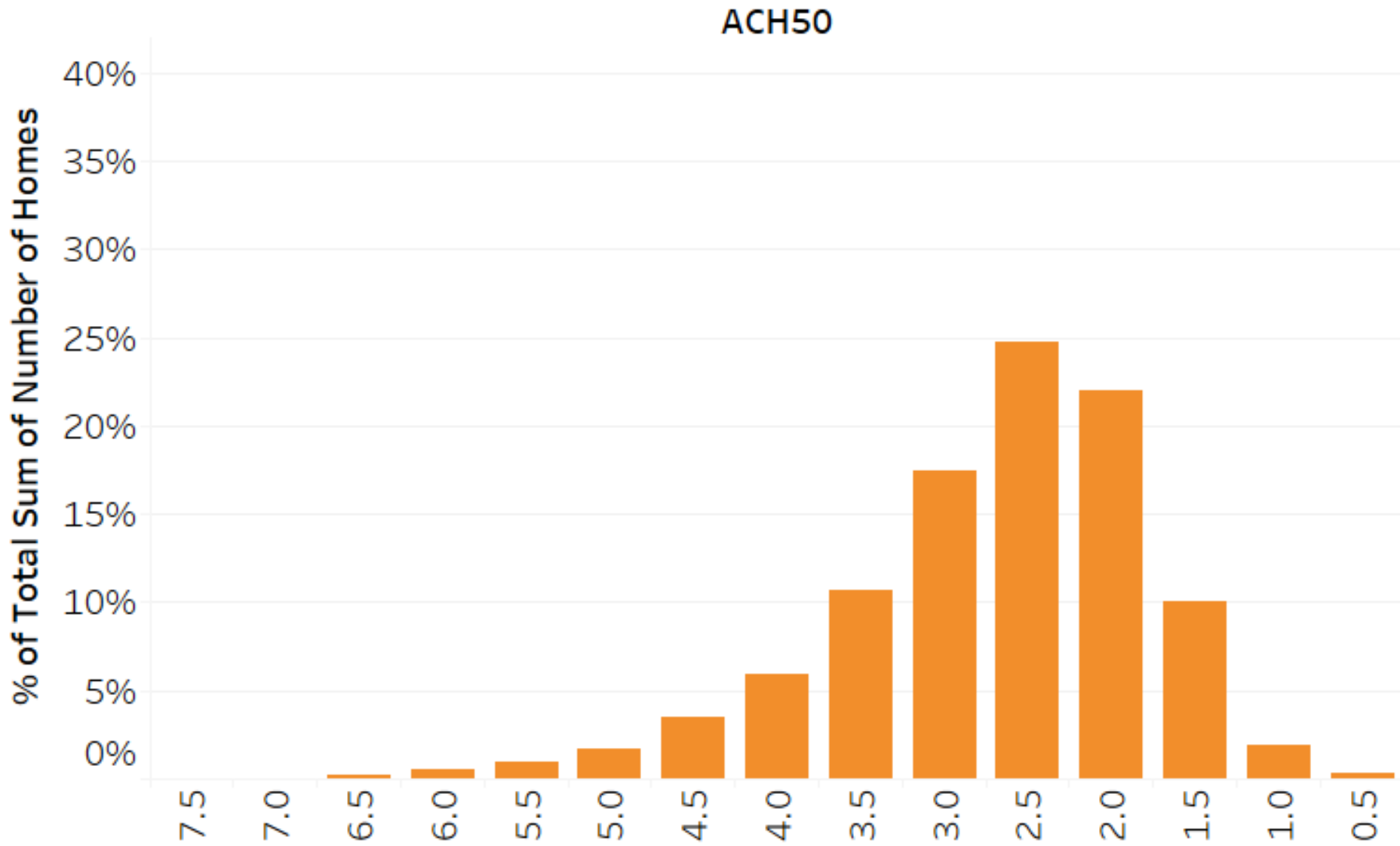
ACH50

Graph: CZ 4



ACH50

Graph: CZ 5

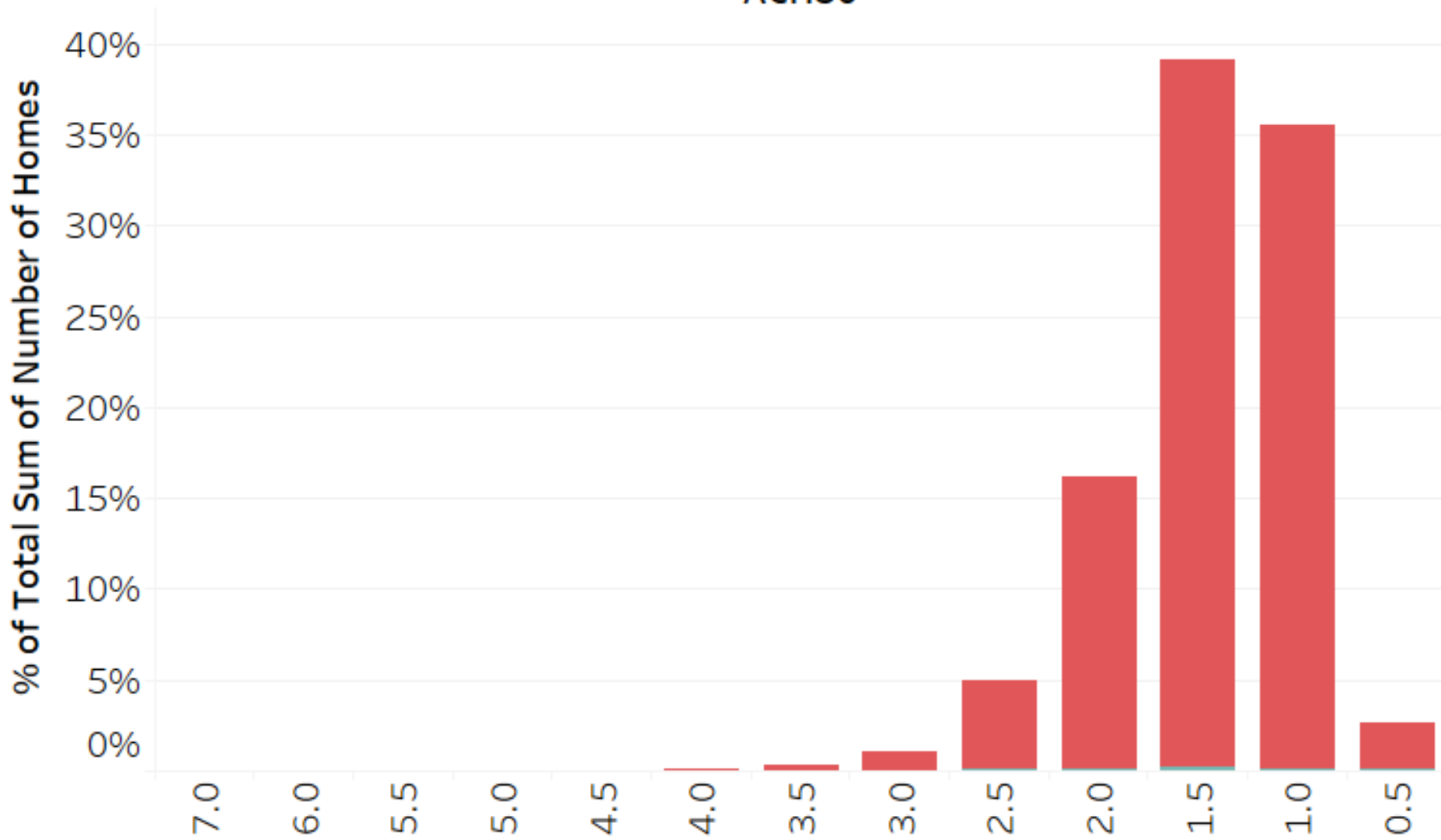




ACH50

Graph: CZ 6+7

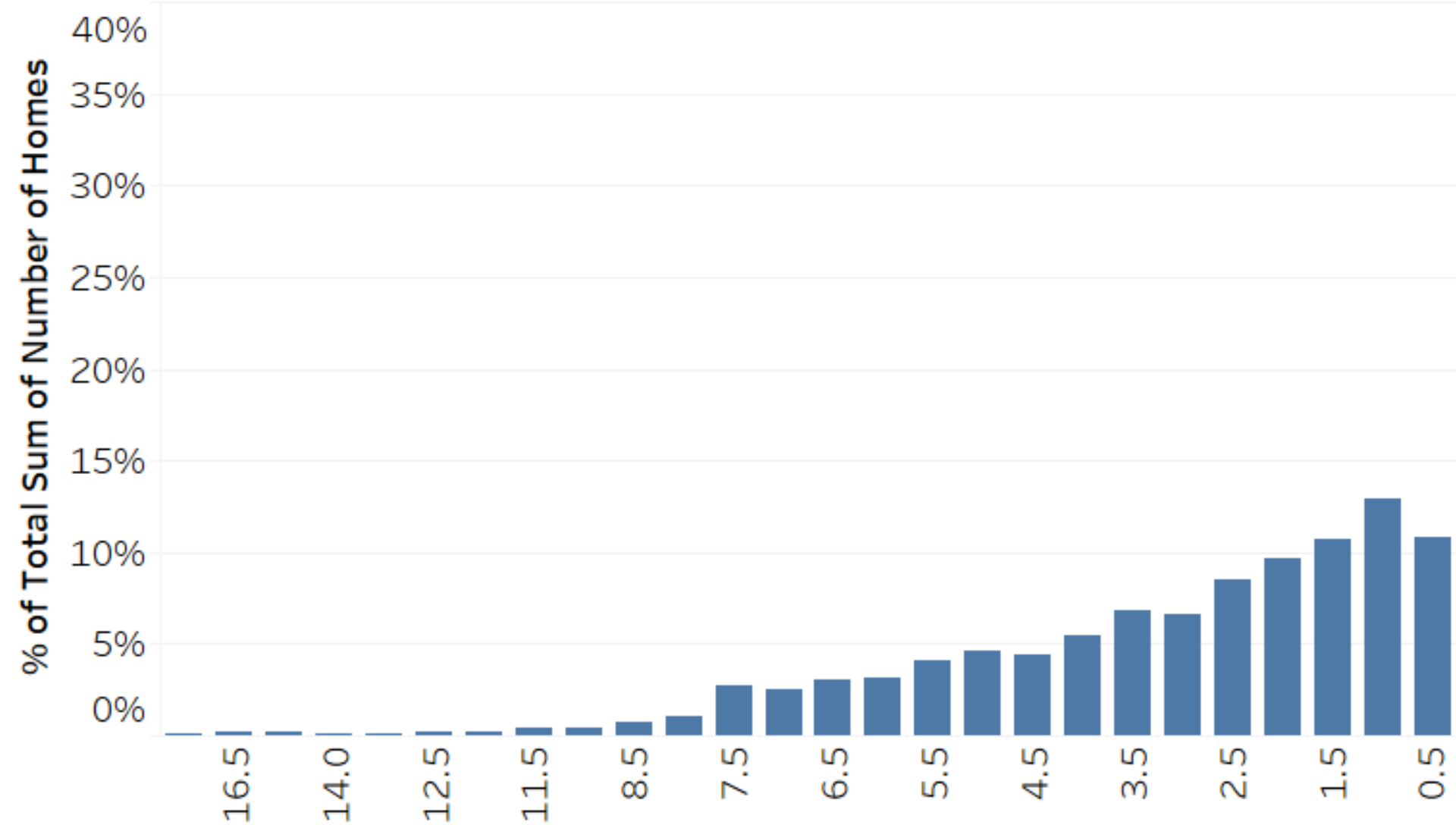
ACH50



Duct Leakage (Unconditioned)

Graph: CZ 4

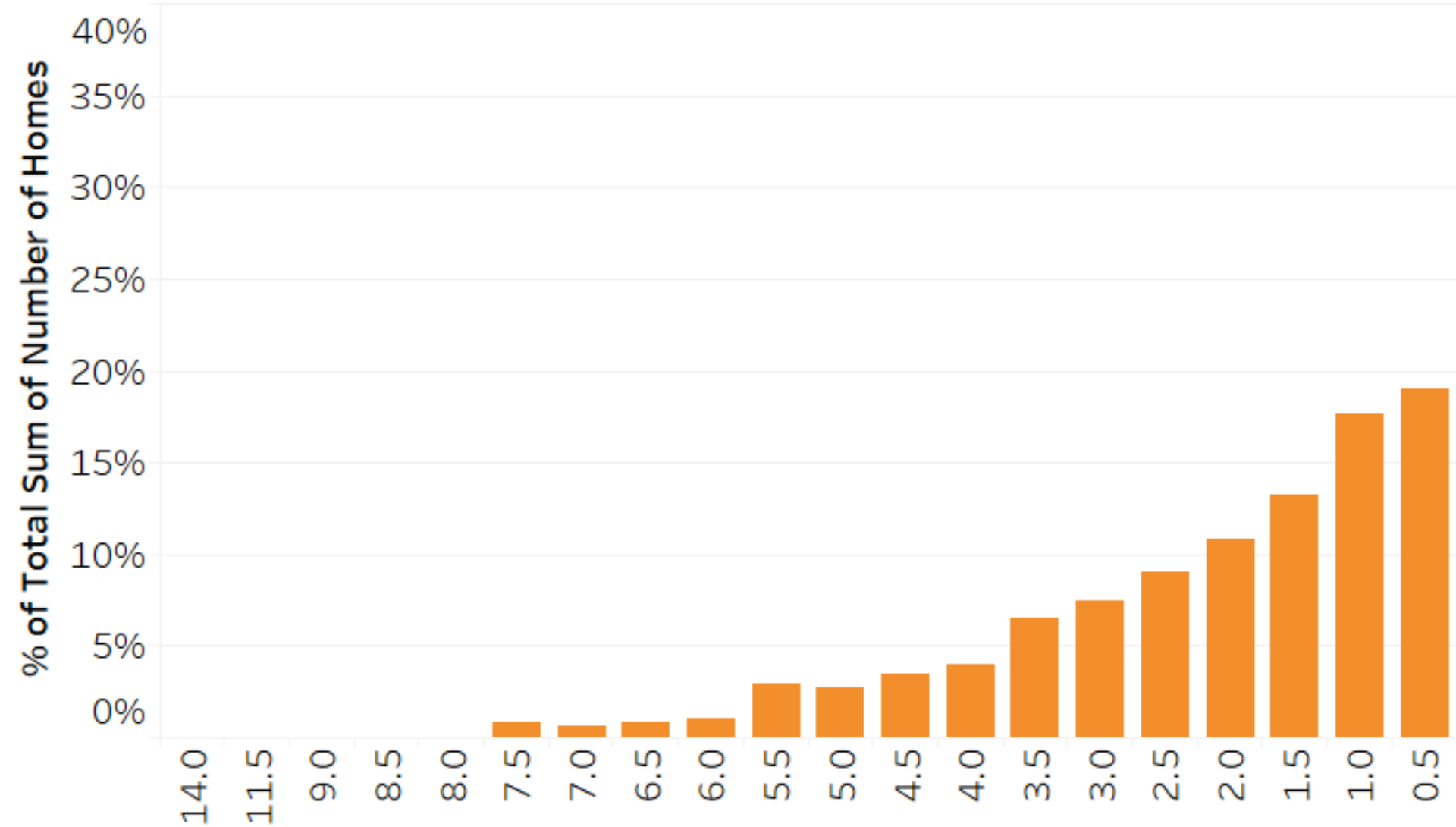
Duct Leakage - Unconditioned Space (%)



Duct Leakage (Unconditioned)

Graph: CZ 5

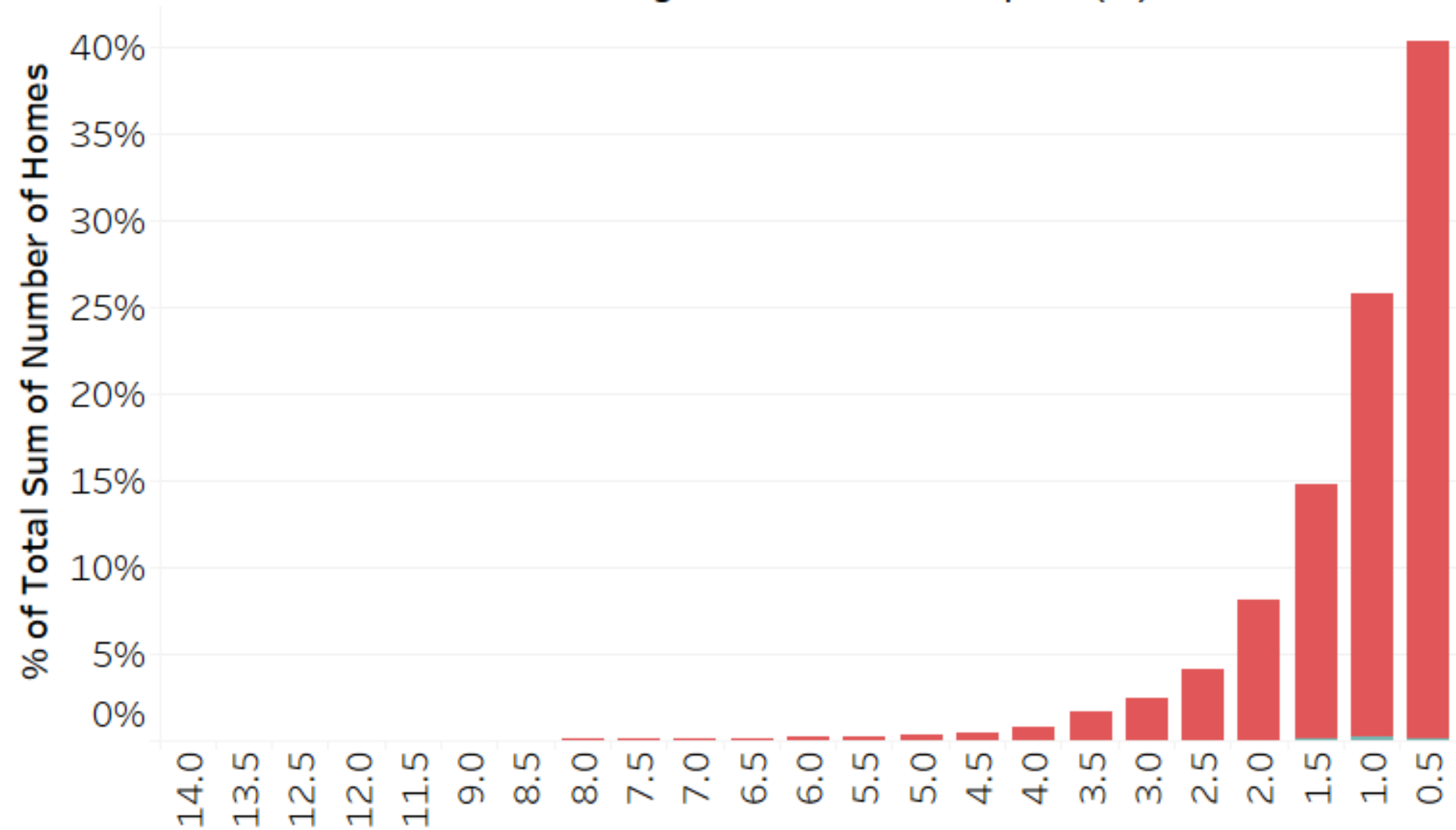
Duct Leakage - Unconditioned Space (%)



Duct Leakage (Unconditioned)

Graph: CZ 6+7

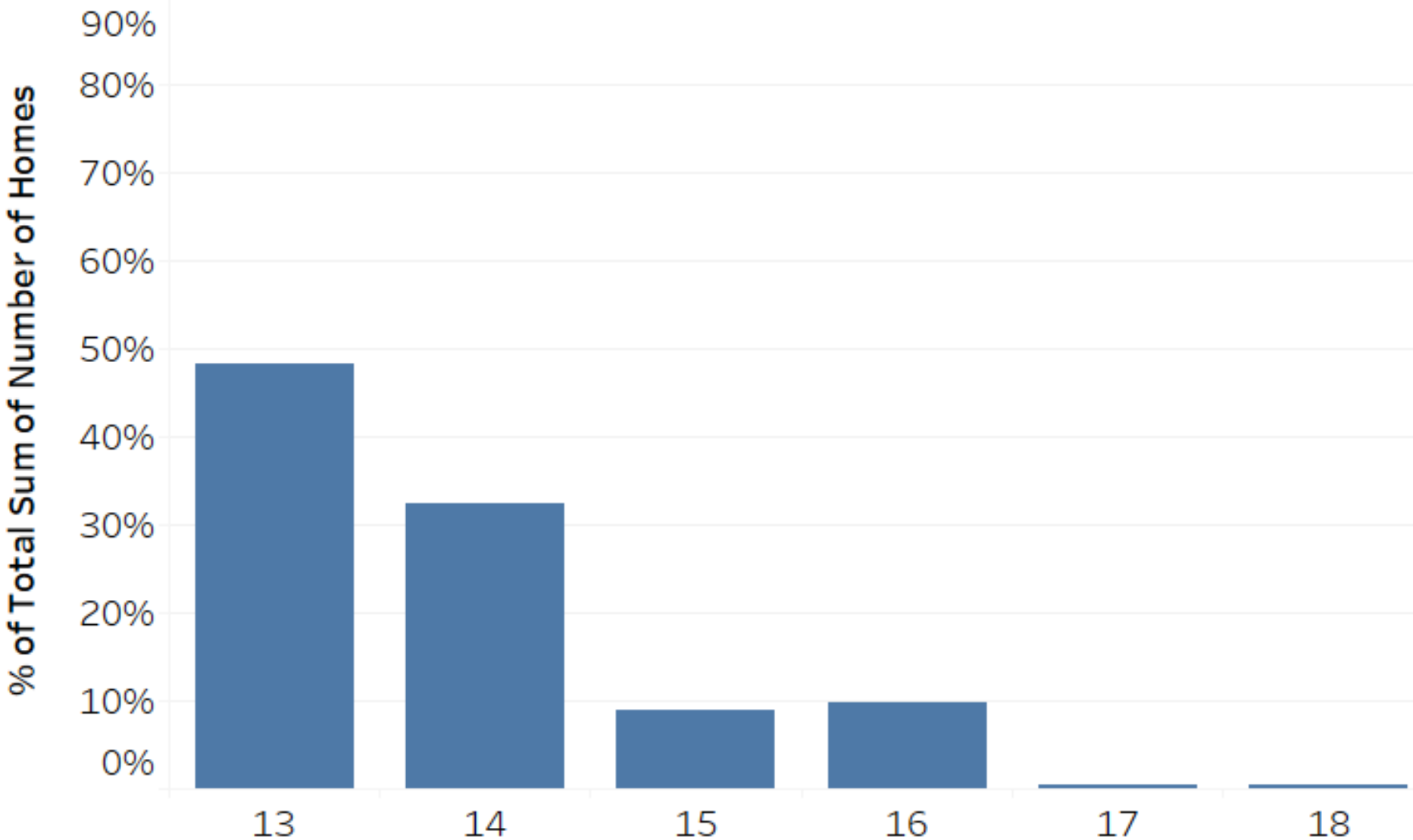
Duct Leakage - Unconditioned Space (%)



AC Efficiency

Graph: CZ 4

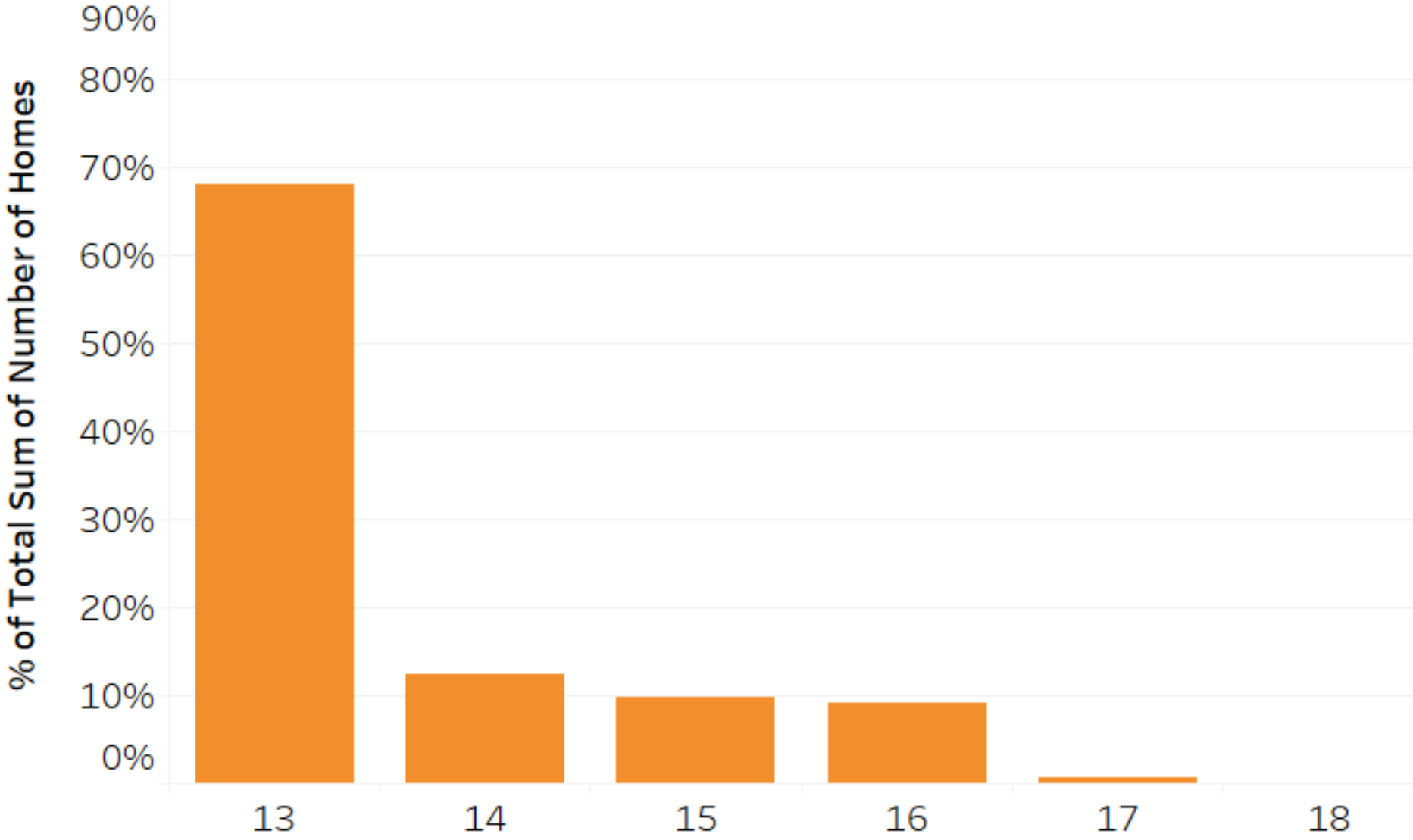
AC Efficiency (SEER)



AC Efficiency

Graph: CZ 5

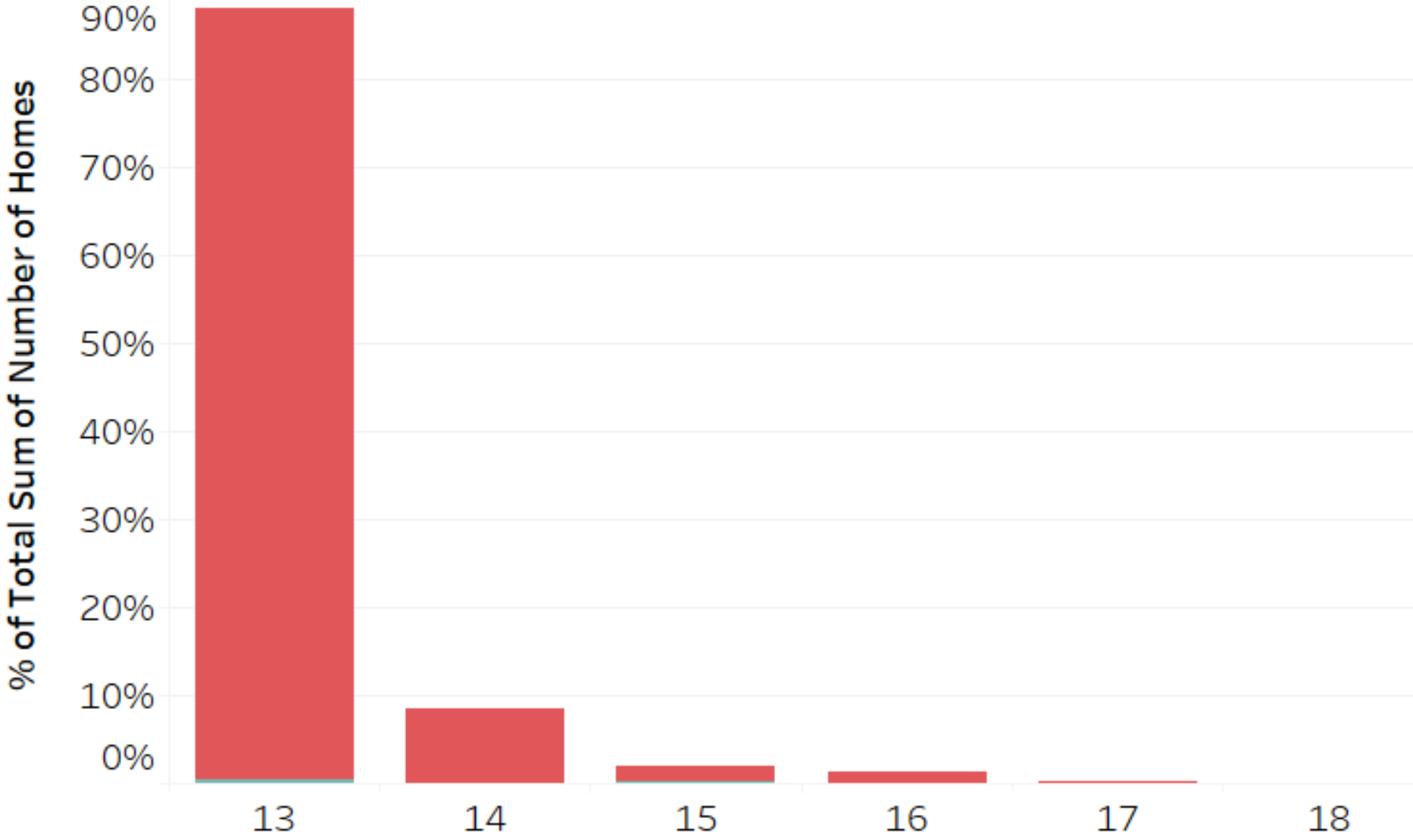
AC Efficiency (SEER)



AC Efficiency

Graph: CZ 6+7

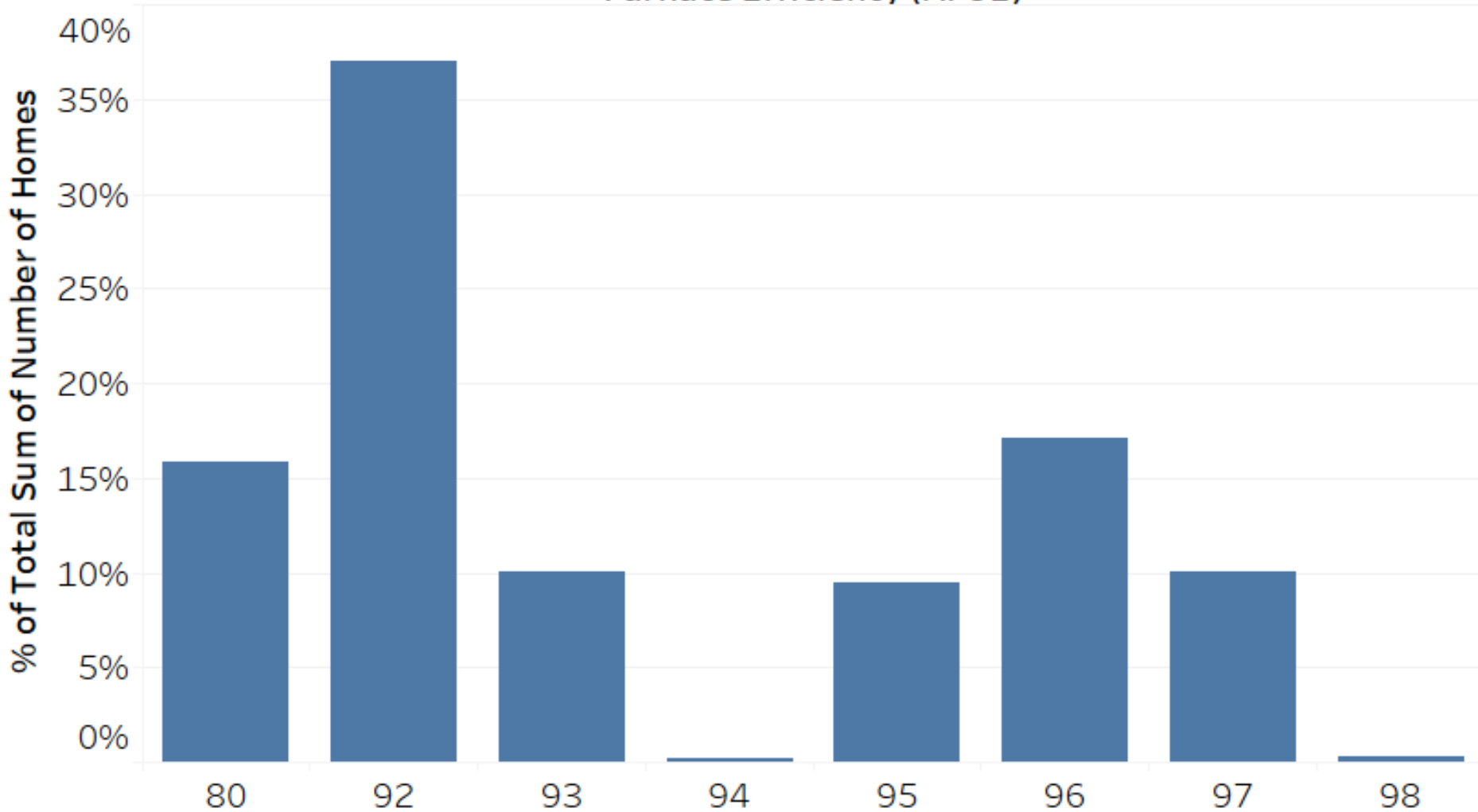
AC Efficiency (SEER)



Furnace Efficiency

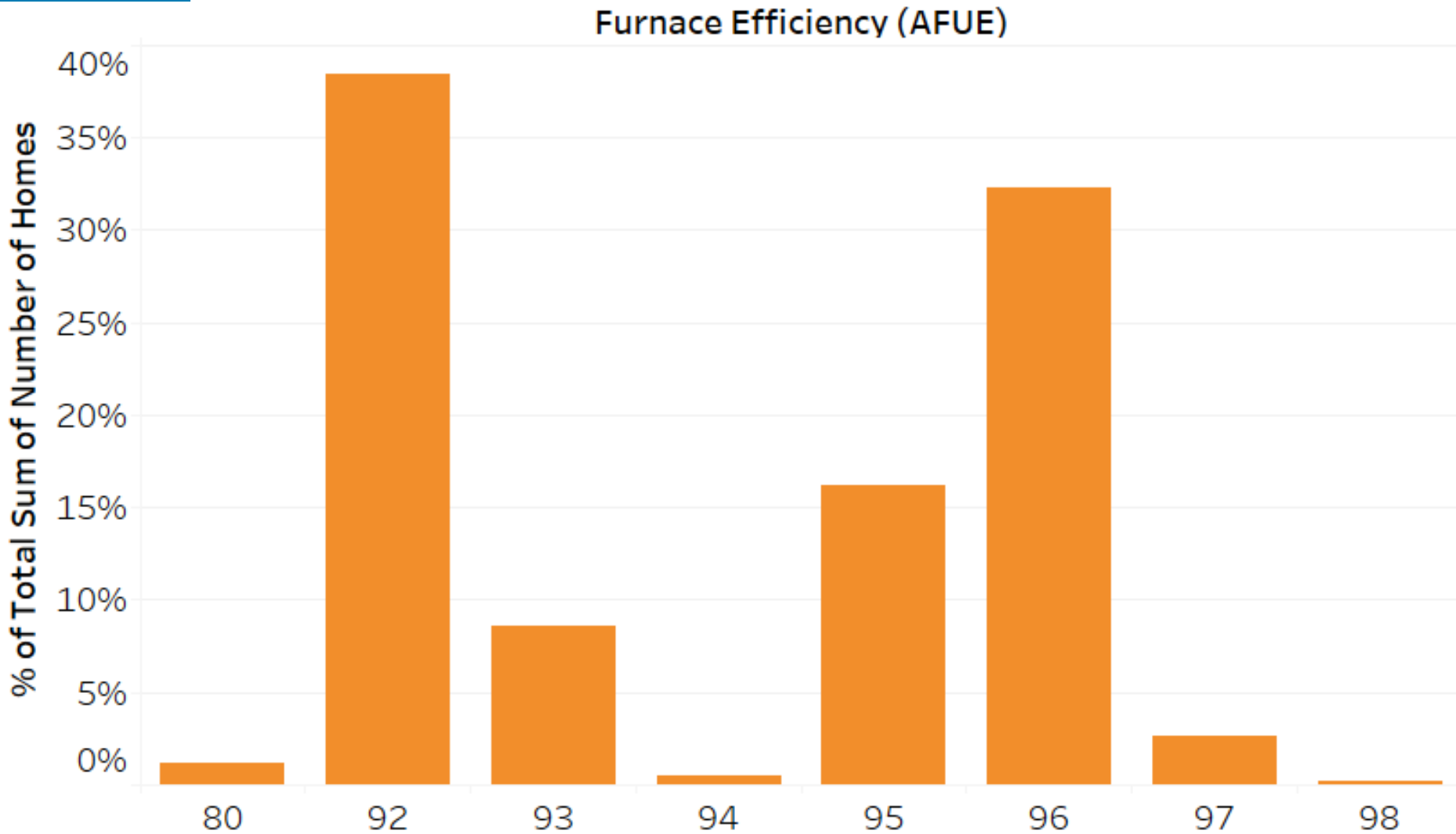
Graph: CZ 4

Furnace Efficiency (AFUE)



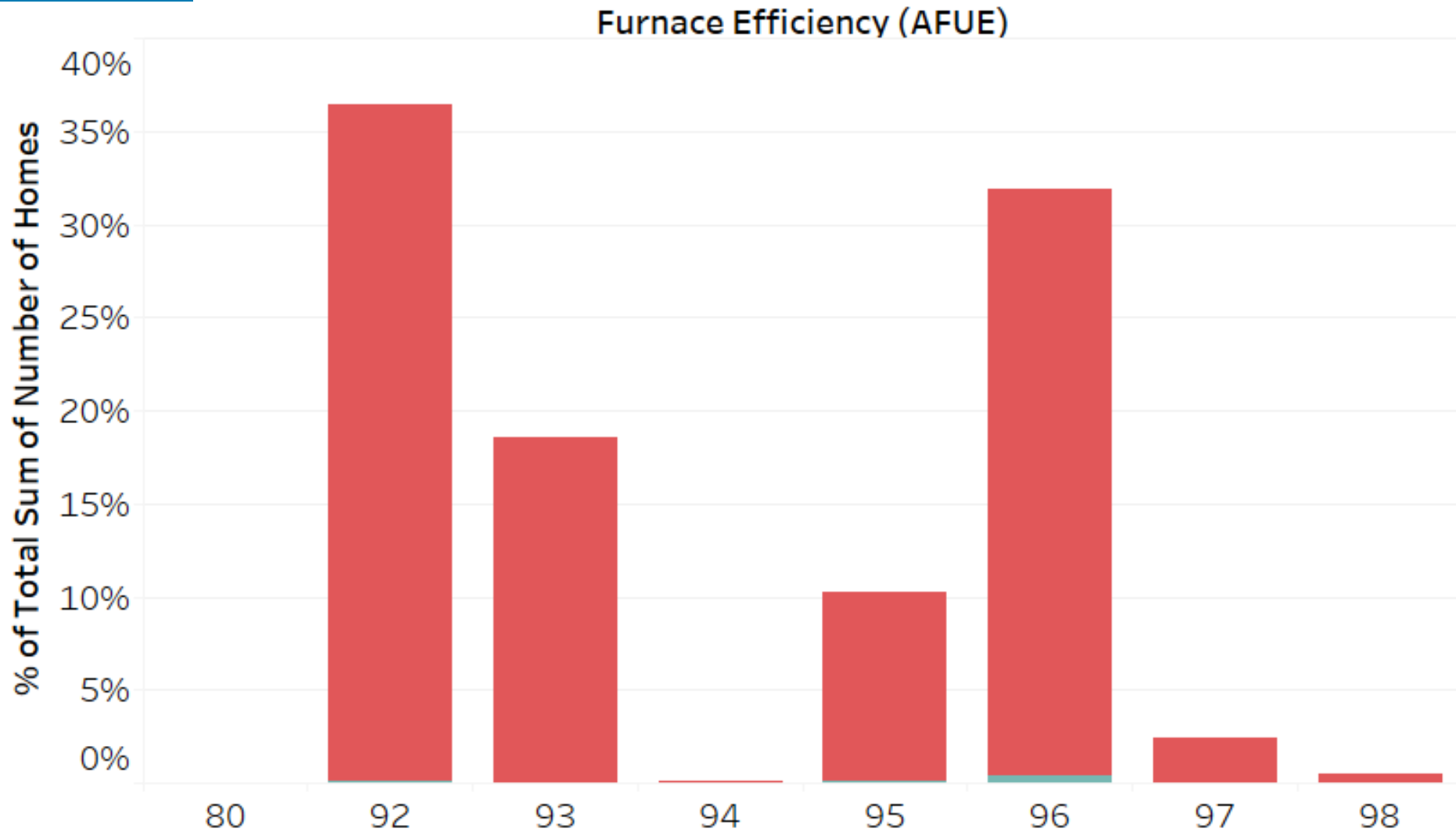
Furnace Efficiency

Graph: CZ 5



Furnace Efficiency

Graph: CZ 6+7



Using the Data

Informing Programs & Policy

Using the Data

Policy and Program Improvements

- **State**
 - Understand code compliance
 - Inform state energy code update
 - Targeted training or educational campaign
- **Jurisdictions**
 - Understand construction practices
 - Benchmark for building efficiency
 - Inform future policies
- **Utility/Builder**
 - Understand program penetration
 - Determine how builders meet a HERS target
 - Inform future programs

State Energy Code Adoption

Ohio Example

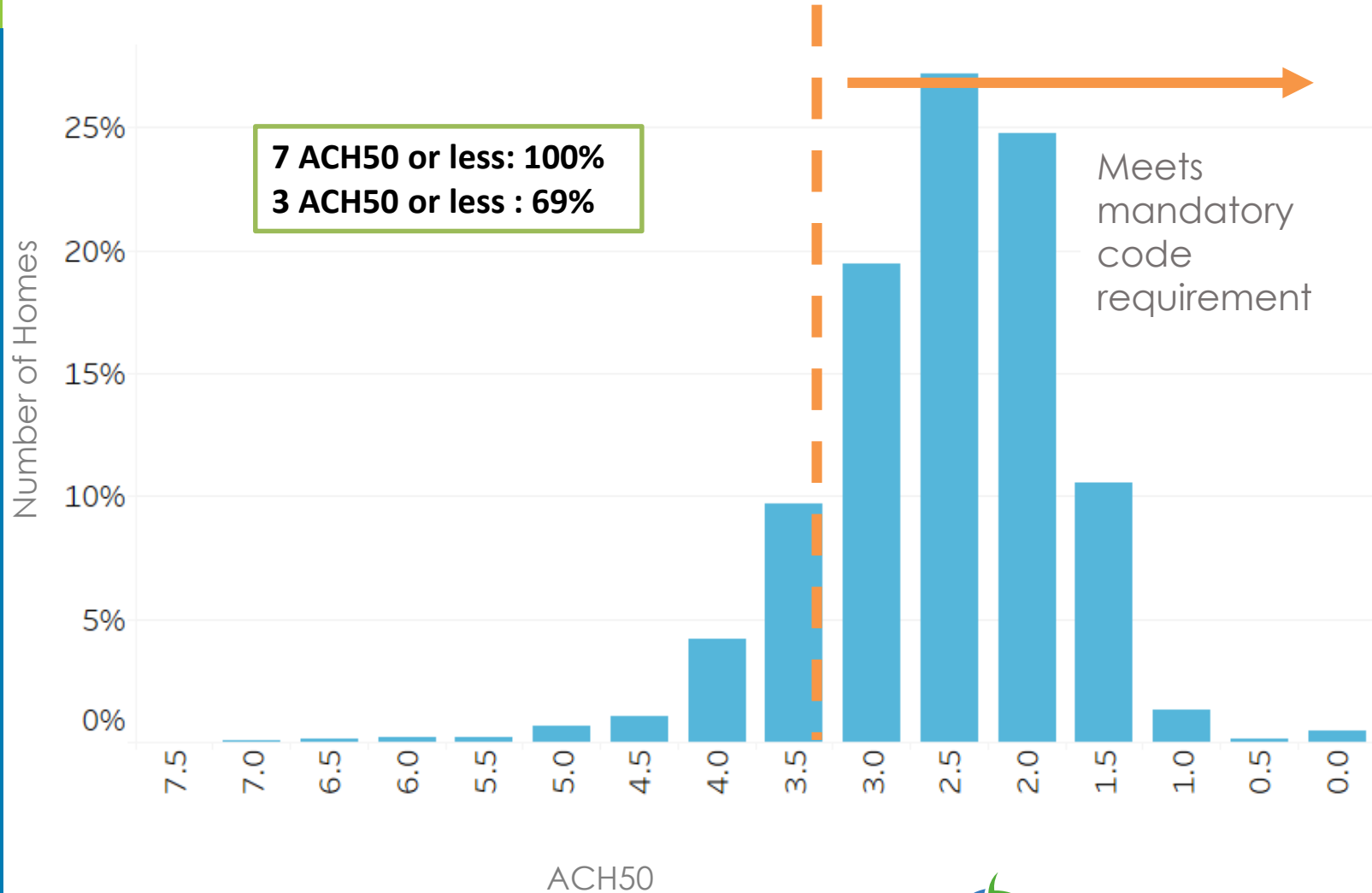
Ohio Residential Energy Code

Adoption Example

- Ohio updated residential energy code from 2009 to amended 2018 IECC
- 32% HERS market penetration
- HERS data played an important role in understanding construction practices and how to meet HERS/ERI scores
- Moved stakeholders from not wanting to update to being open to some improvement

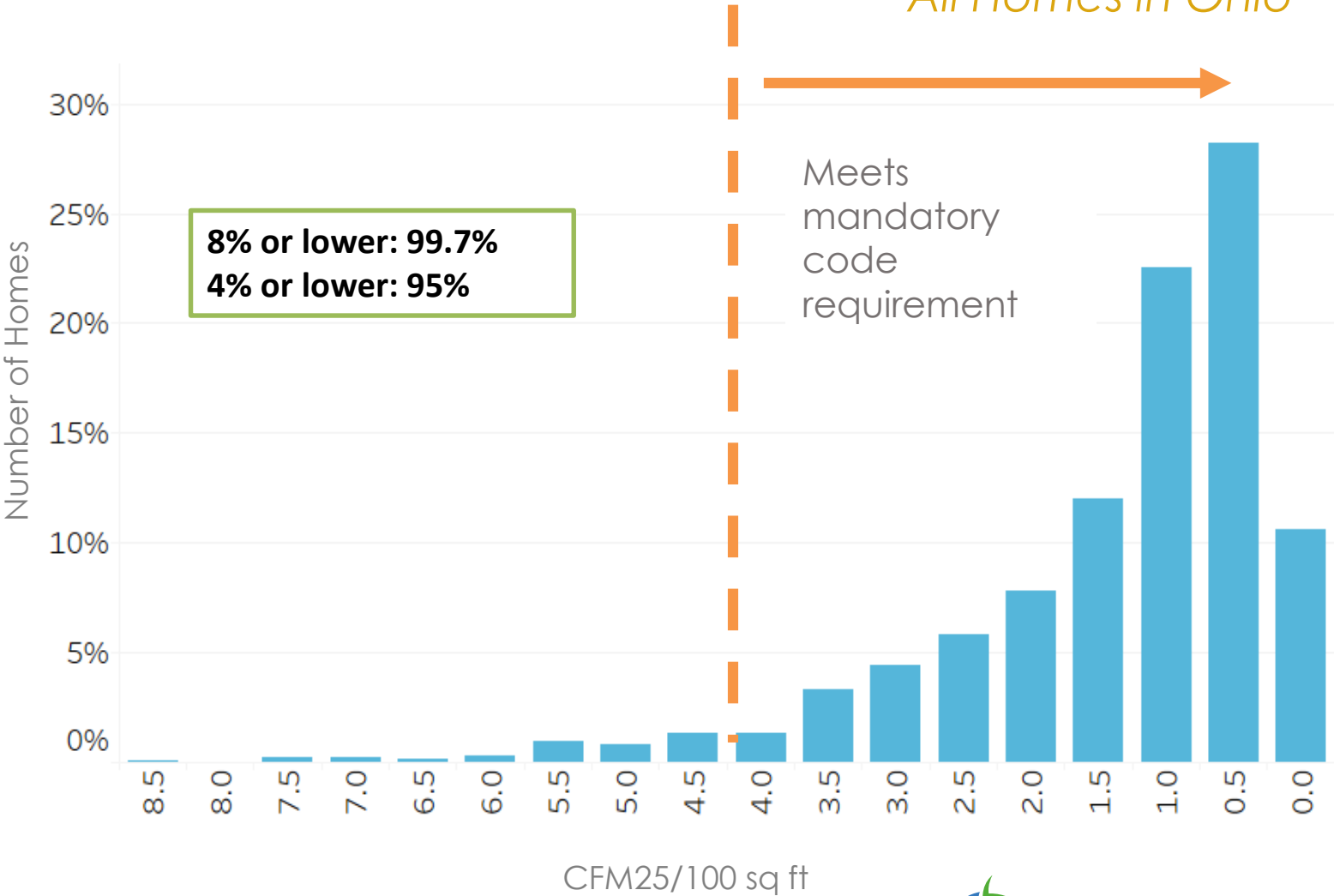
Air Leakage (ACH50)

All Homes in Ohio



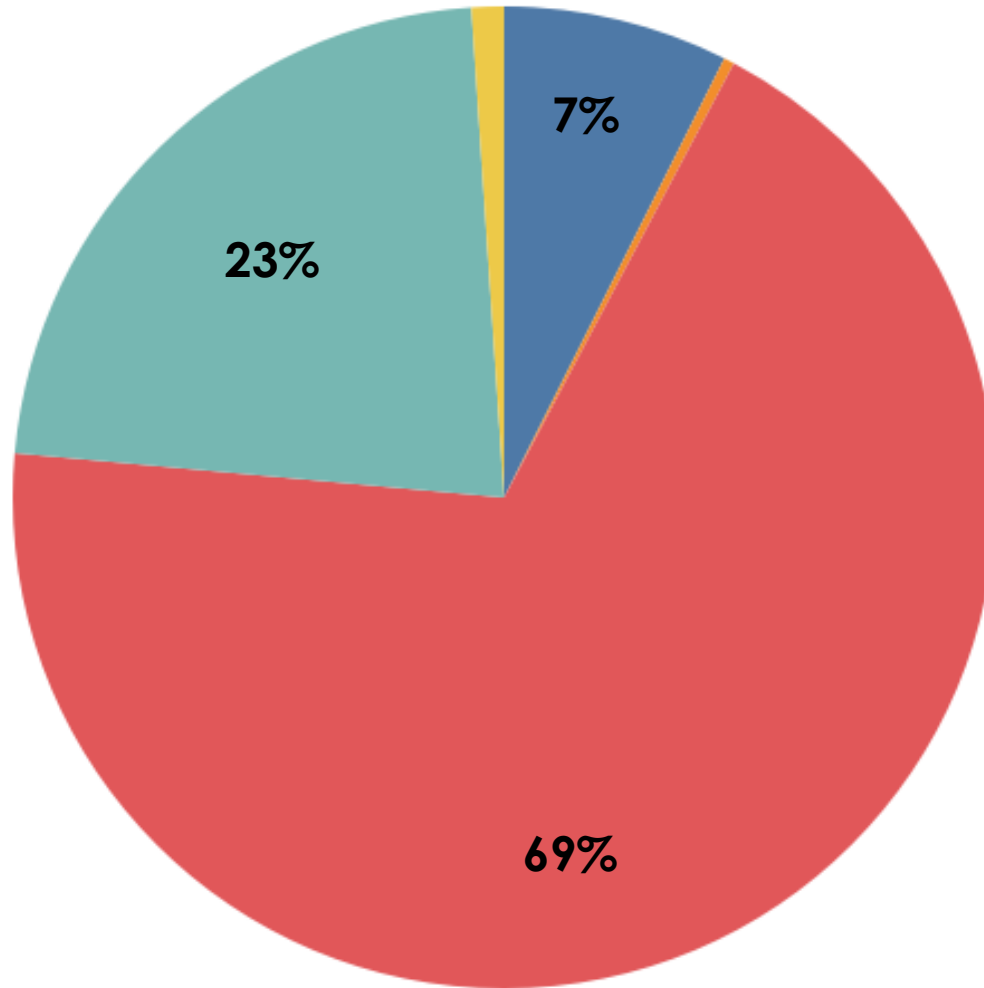
Duct Leakage to Outside - Unconditioned

All Homes in Ohio



Ventilation Type

All Homes in Ohio

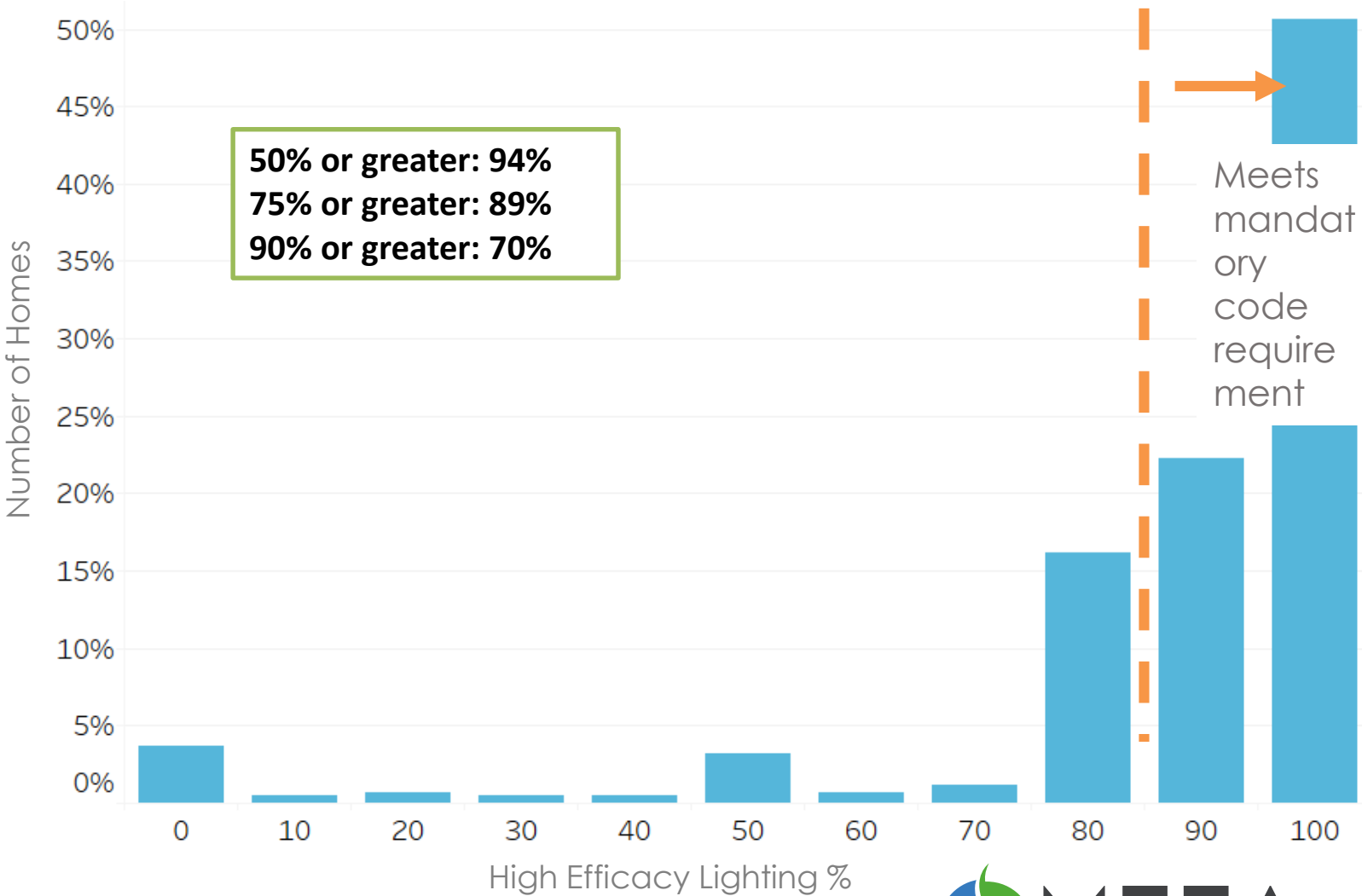


Ventilation Type

- Air Cyclers
- Balanced
- Exhaust Only
- None
- Supply Only

High Efficacy Lighting (%)

All Homes in Ohio



Example Homes

HERS 59 - 61

Home	1	2	3	4	5	6	2009 IECC	2018 IECC
HERS Score	59	59	60	60	61	61	NA	61
Cond. Area (sq. ft.)	3141	4808	3860	4494	3770	5234		
BSMT: Cont.	11	5.5	7	10	8	7	10 or	15 or
BSMT: Batt			4			4	13	19
AGW: Cont.					3		13+5 or	13+5 or
AGW: Batt	19	13	19	15	11	16	20	20
Ceiling: Blown	38	39	41	27	39	39	38	49
Window: U-Factor	.33	.35	.33	.36	.34	.34	.35	.30
HEL: %	75	0	75	95	80	100	50	90
Air Leakage	2.5	2.7	4.9	2.2	2.9	2.3	7	3
Duct Leakage	1.5	1.5	Cond.	Cond.	3.2	2.2	8 or Cond.	4 or Cond.
AC (SEER)	13	13	13	13	13	13	13	13
Furnace (AFUE)	92	92	92	92	92	92	80	80

Average Home Features

HERS 59-61; 42-45

HERS 59-61 – 2634 Homes

Building Envelope

- AGW – R-15 or 15+3
- Ceiling – R-37
- Windows – U-.33
- Air Leakage – 2.8 ACH50

Lighting/Equipment

- Duct Leakage – 1.4%*
- Lighting – 83%
- AC Eff. – 13.5 SEER
- Furnace Eff. – 94 AFUE

Conditioned Area– 3700 Sq. Ft.

* Or in conditioned space

HERS 45-47 – 226 Homes

Building Envelope

- AGW – R-19 or 17+5
- Ceiling – R-42
- Windows – U-.31
- Air Leakage – 2.2 ACH50

Lighting/Equipment

- Duct Leakage – 1.3%*
- Lighting – 83%
- AC Eff. – 14 SEER**
- Furnace Eff. – 95.5 AFUE**

Conditioned Area– 4880 Sq. Ft.

** Or GSHP



Ohio Code Outcome

Proposed Changes

- Updated
 - Mandatory Testing and Ventilation
 - Air Leakage from 7 to 5 ACH50
 - Duct Leakage from 12 to 6% leakage to the outside
 - Efficient Lighting from 50 to 90%
 - Adopted ERI as written
- Did not update
 - Insulation levels from 2009 IECC
 - Kept multiple compliance options

Change in Energy Code

Minnesota Example

Minnesota *Code Update*

- Minnesota updated its energy code in 2015 from the 2006 to 2012 IECC
- Significant update - 27% efficiency improvement in baseline
- Would expect to see changes in construction practices, particularly with respect to mandatory energy code changes and utility programs
- Comparison between 2014 to 2016

Minnesota

Code Update – Key Changes

- Mandatory
 - Blower Door
 - 7 ACH50 – 3 ACH50
 - Duct Blaster
 - 8% to outside to 4% total leakage
 - Efficient Lighting
 - 0% to 75%
- Prescriptive
 - Wall insulation: R-19 to R-20
 - Window U-Factor: .35 to .32

Utility Program

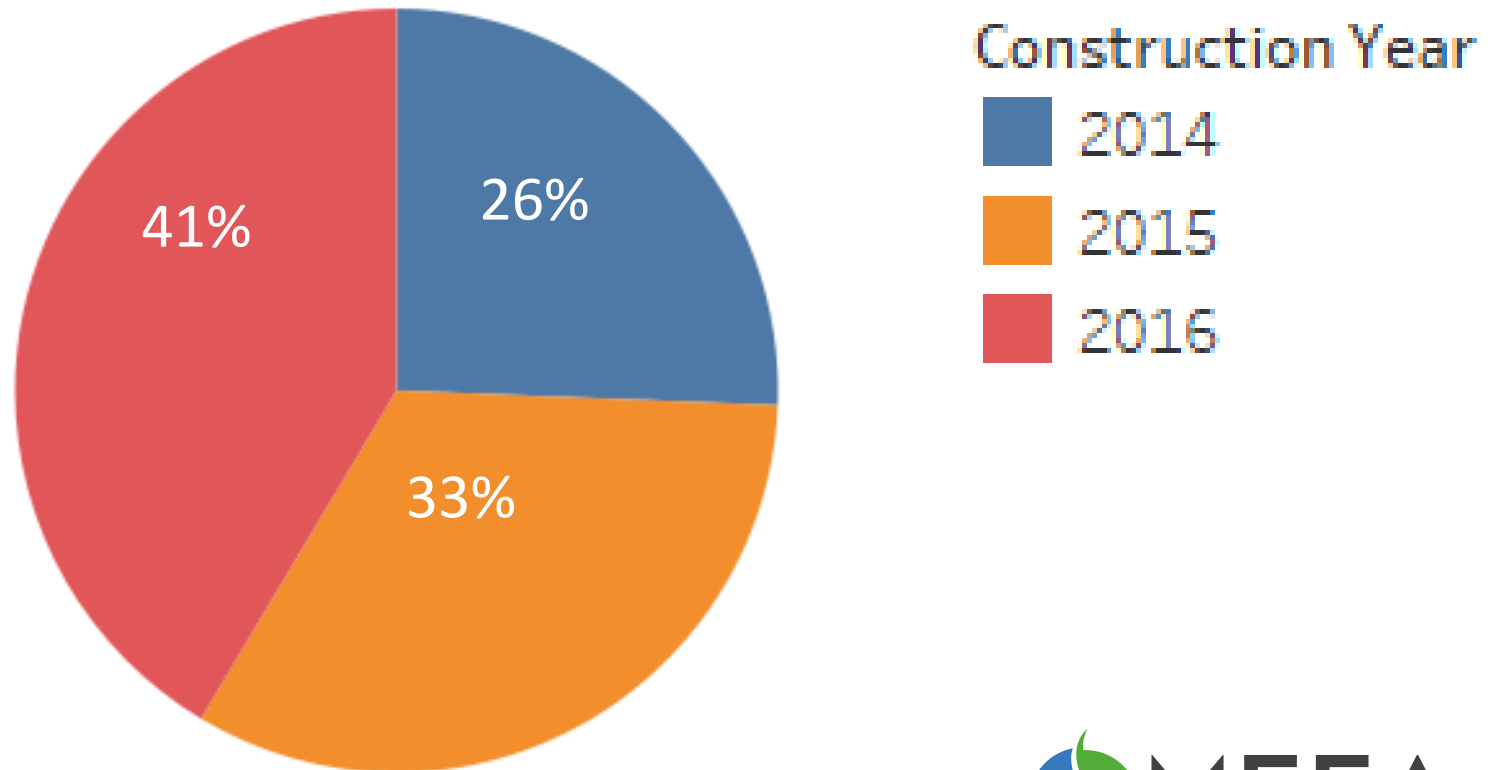
Xcel/ Centerpoint/ Green Path

- Strong Utility and Green Programs
 - Xcel Energy's High Efficiency New Homes Program – Since 2012
 - Centerpoint Energy High Efficiency Homes Program – Since 2013
 - Above code – 10 – 50% above code
 - BATC MN Green Path – Since 2011
 - 1st Tier – HERS Rating
 - 2nd Tier – HERS < 55 + 25 additional points
 - 3rd Tier – HERS < 50 + 50 additional points

Increase in HERS Homes

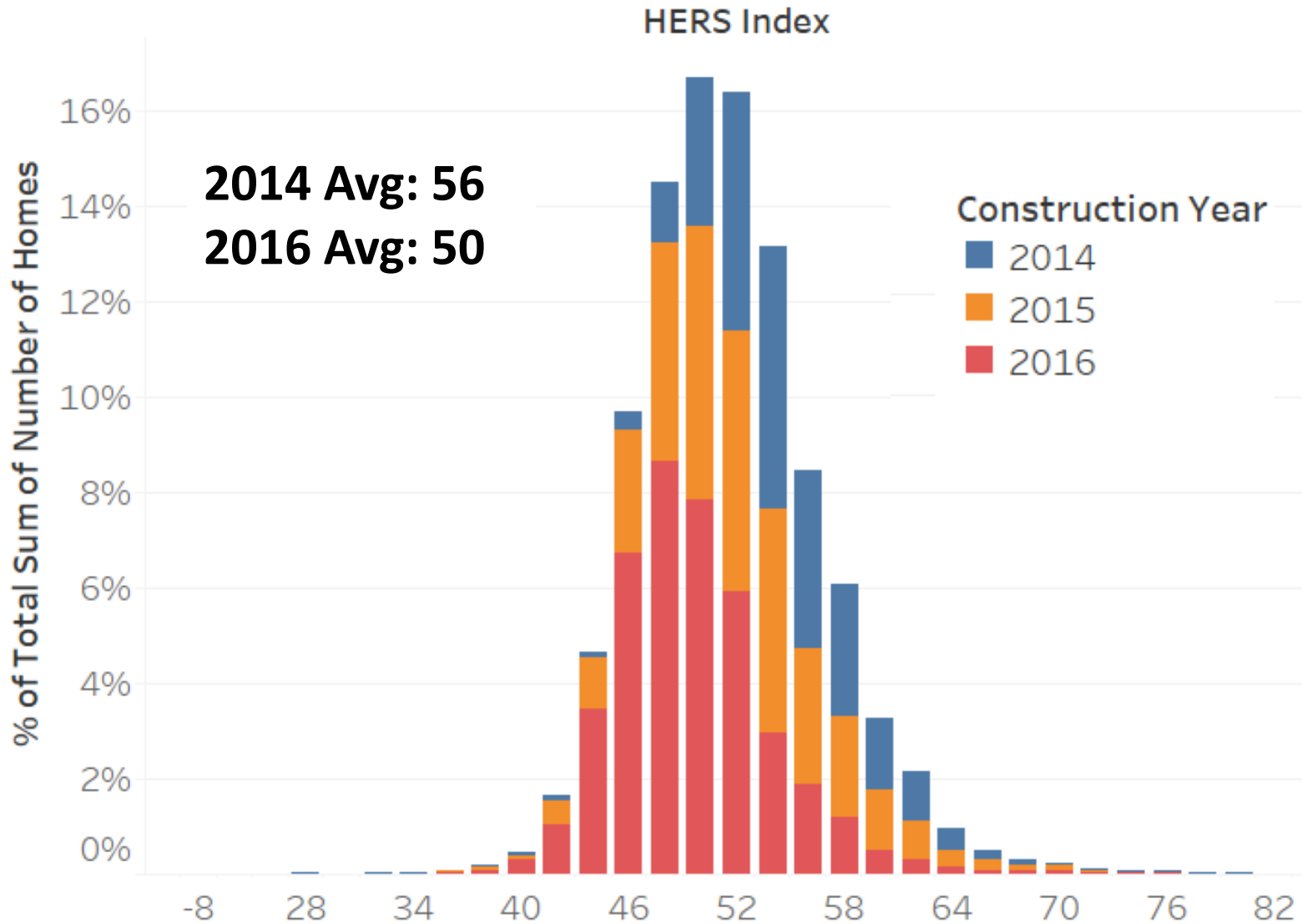
MN: 2014 - 2016

- Nearly 2,000 more HERS homes in 2016 than 2014



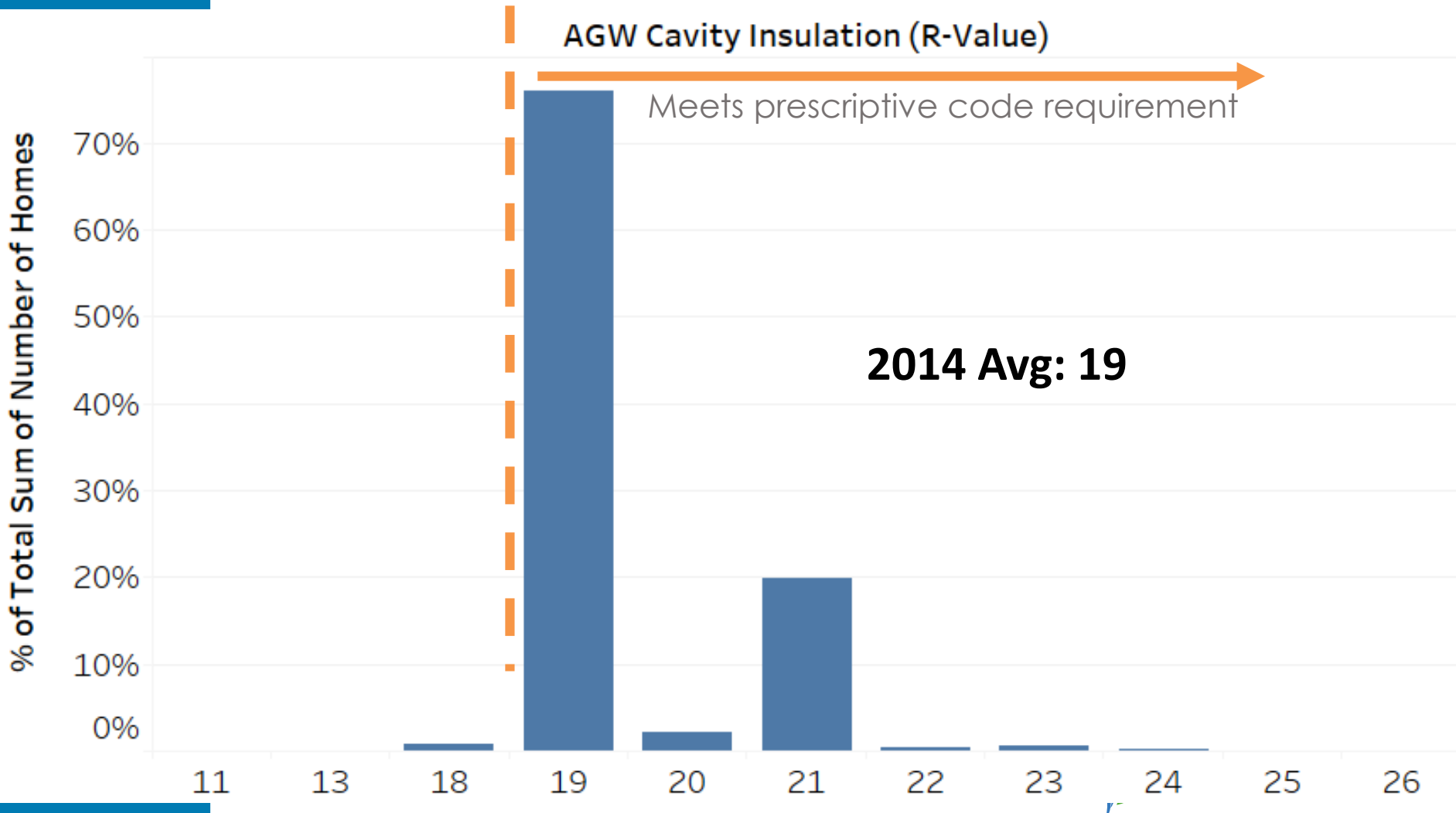
Change in HERS Index

MN: 2014 - 2016



AGW Efficiency

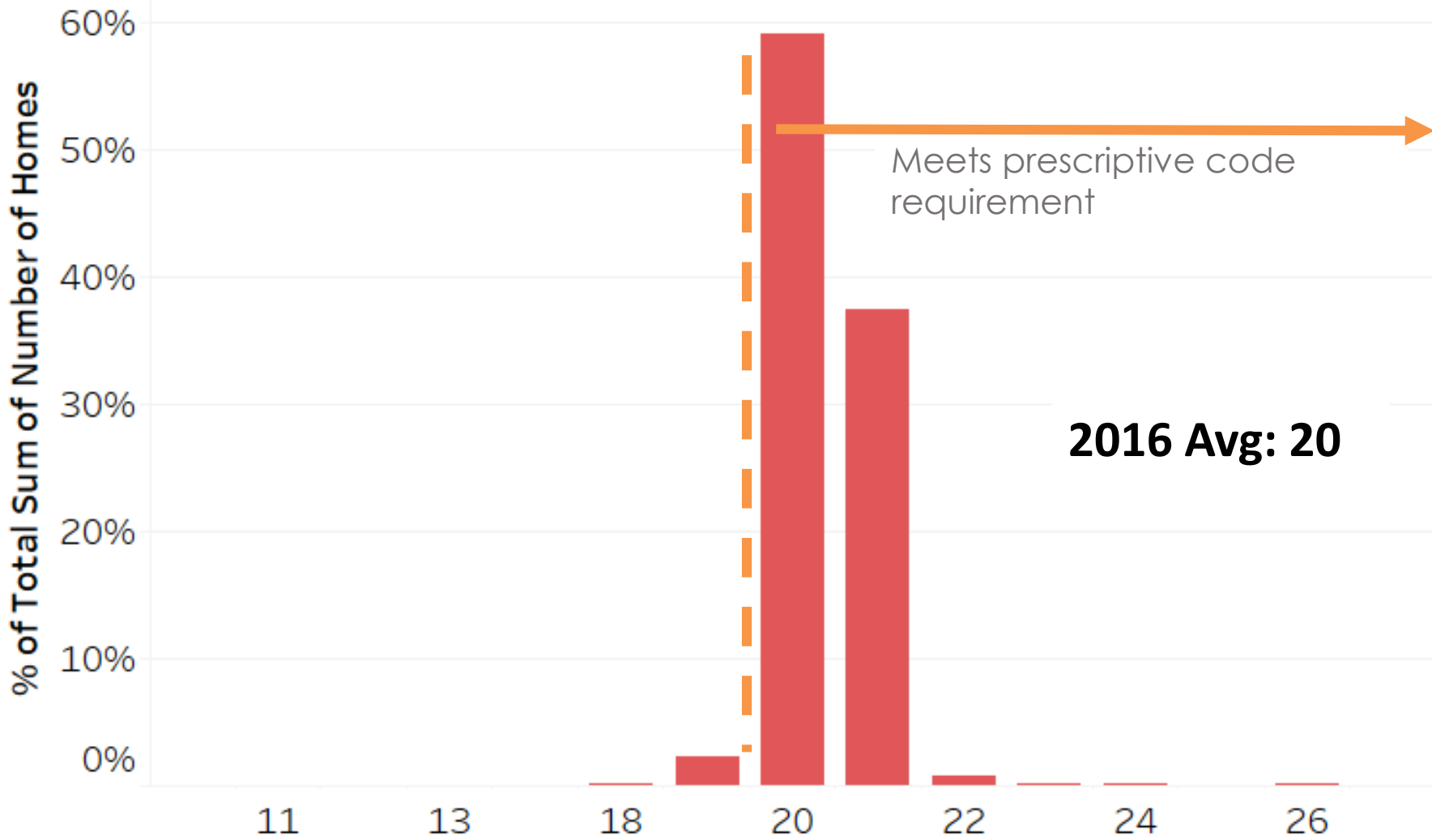
MN: 2014



AGW Efficiency

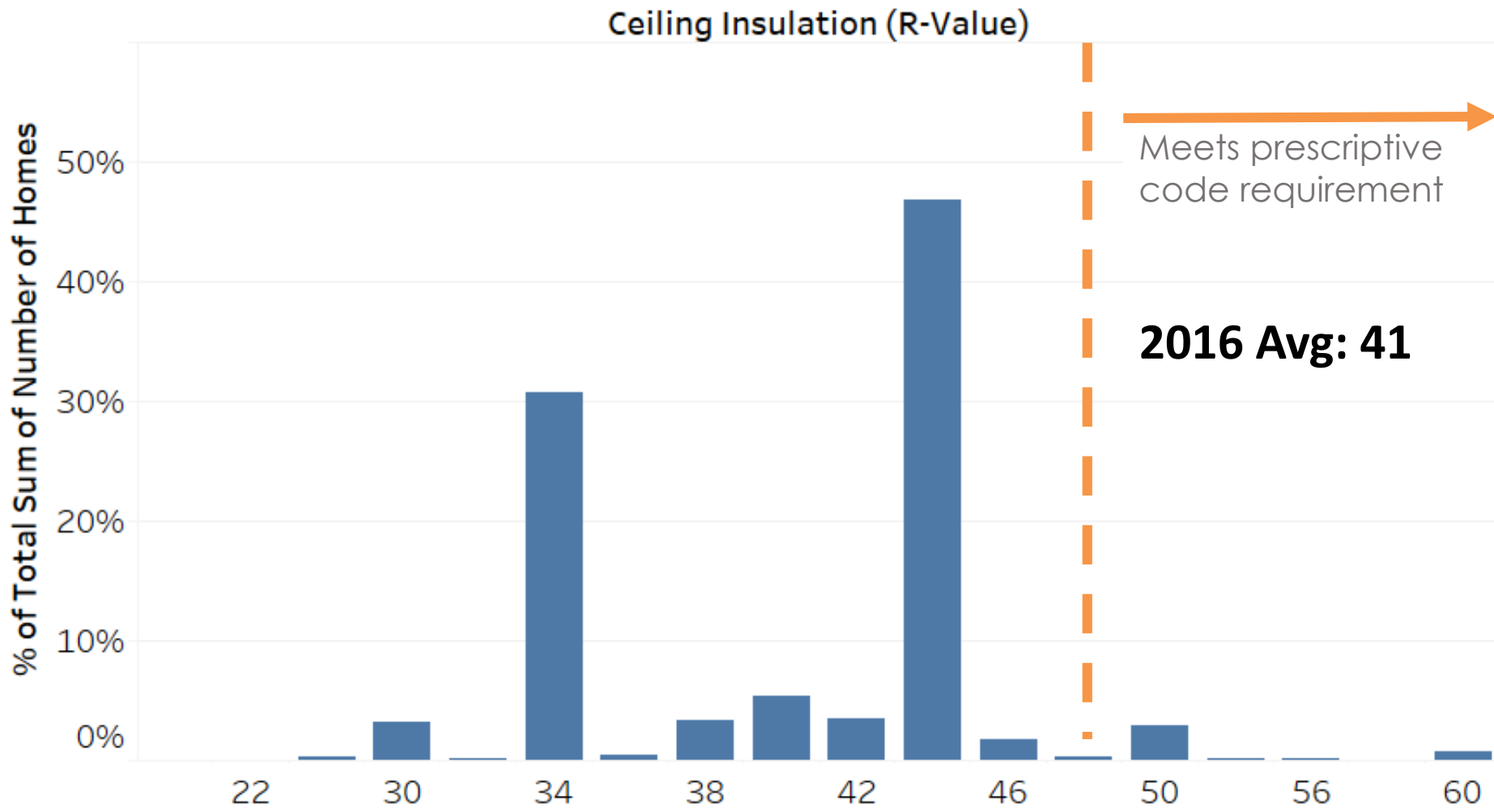
MN: 2016

AGW Cavity Insulation (R-Value)



Ceiling Efficiency

MN: 2014



Meets prescriptive code requirement

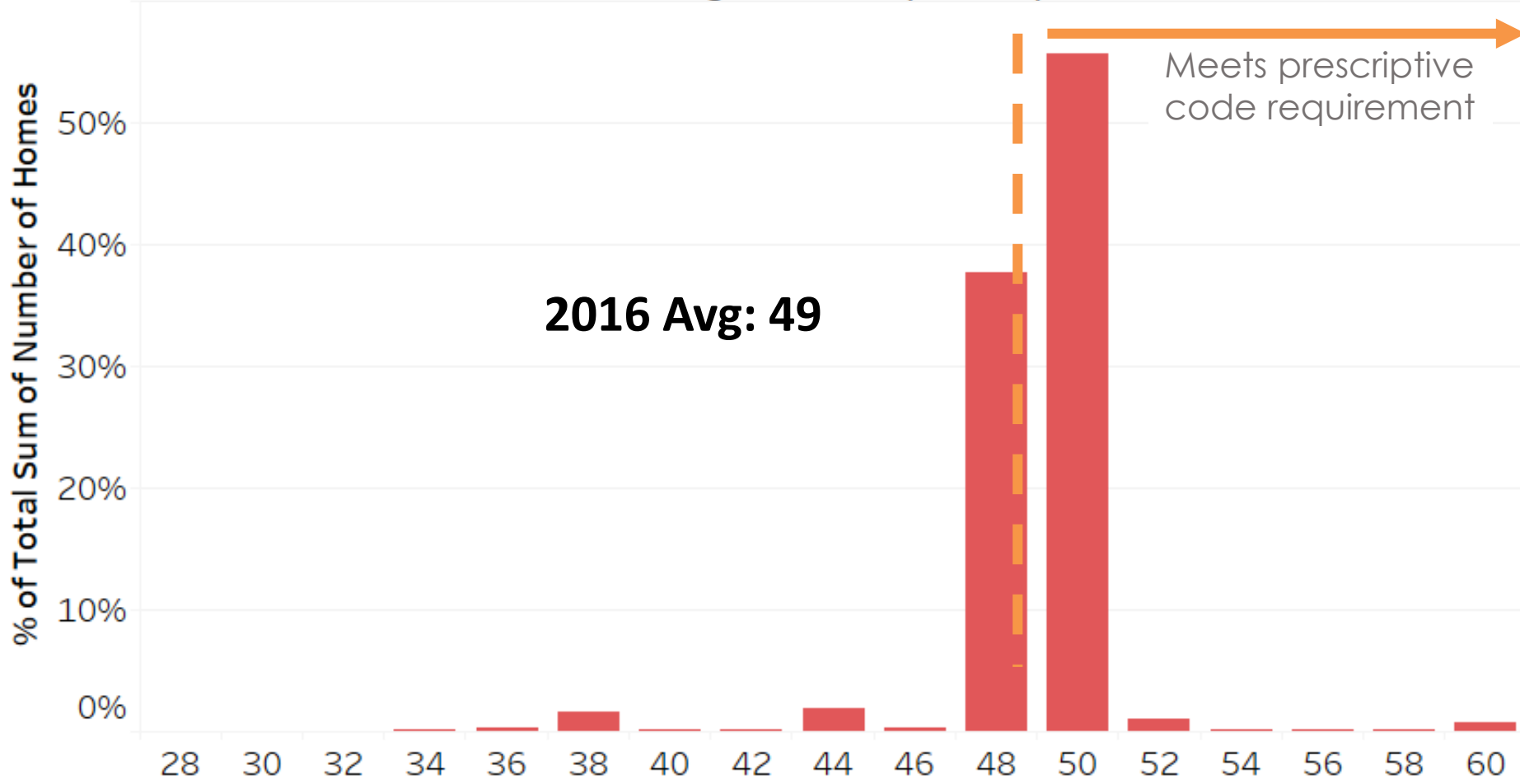
2016 Avg: 41

Ceiling Efficiency

MN: 2016

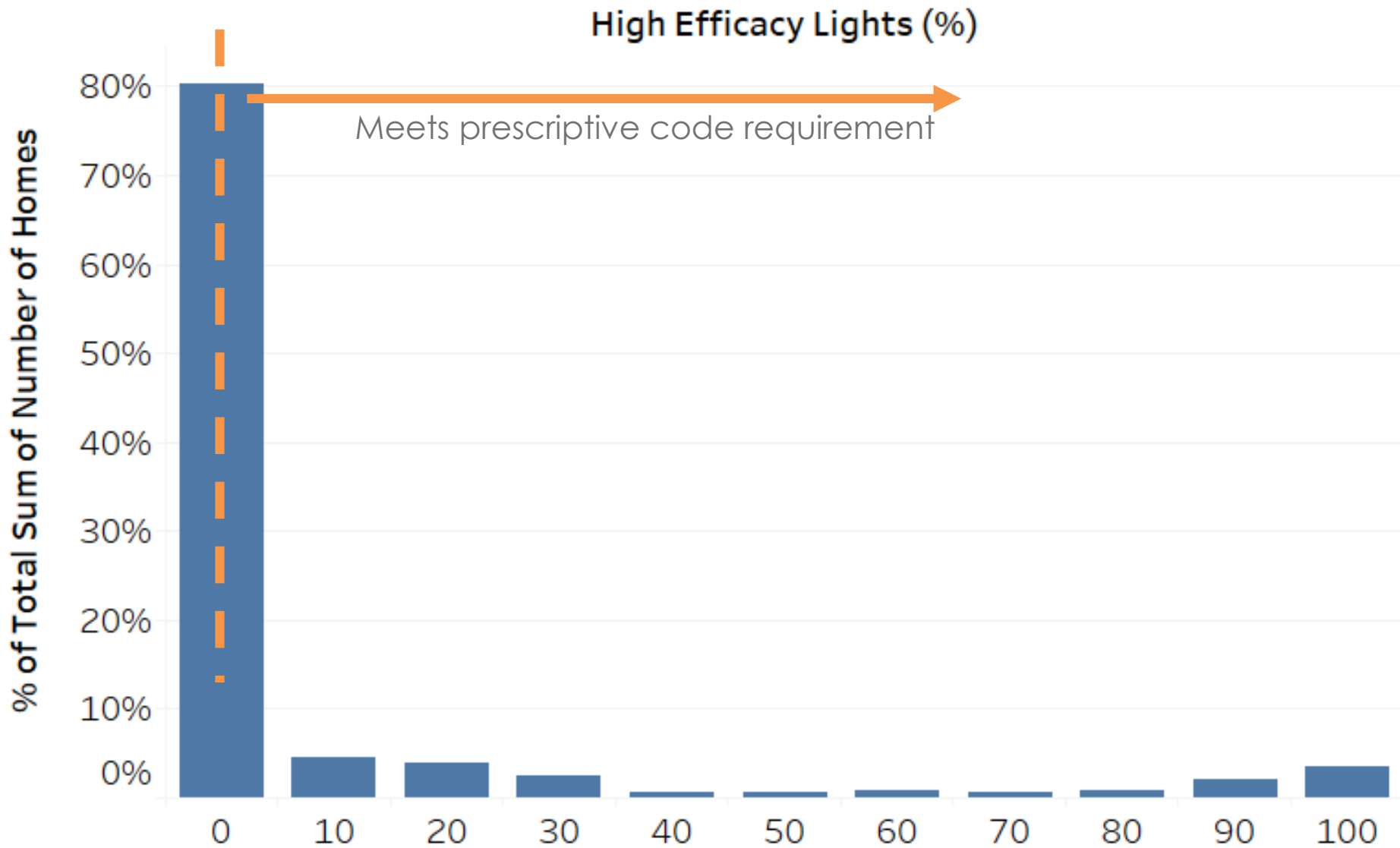


Ceiling Insulation (R-Value)



Efficient Lighting

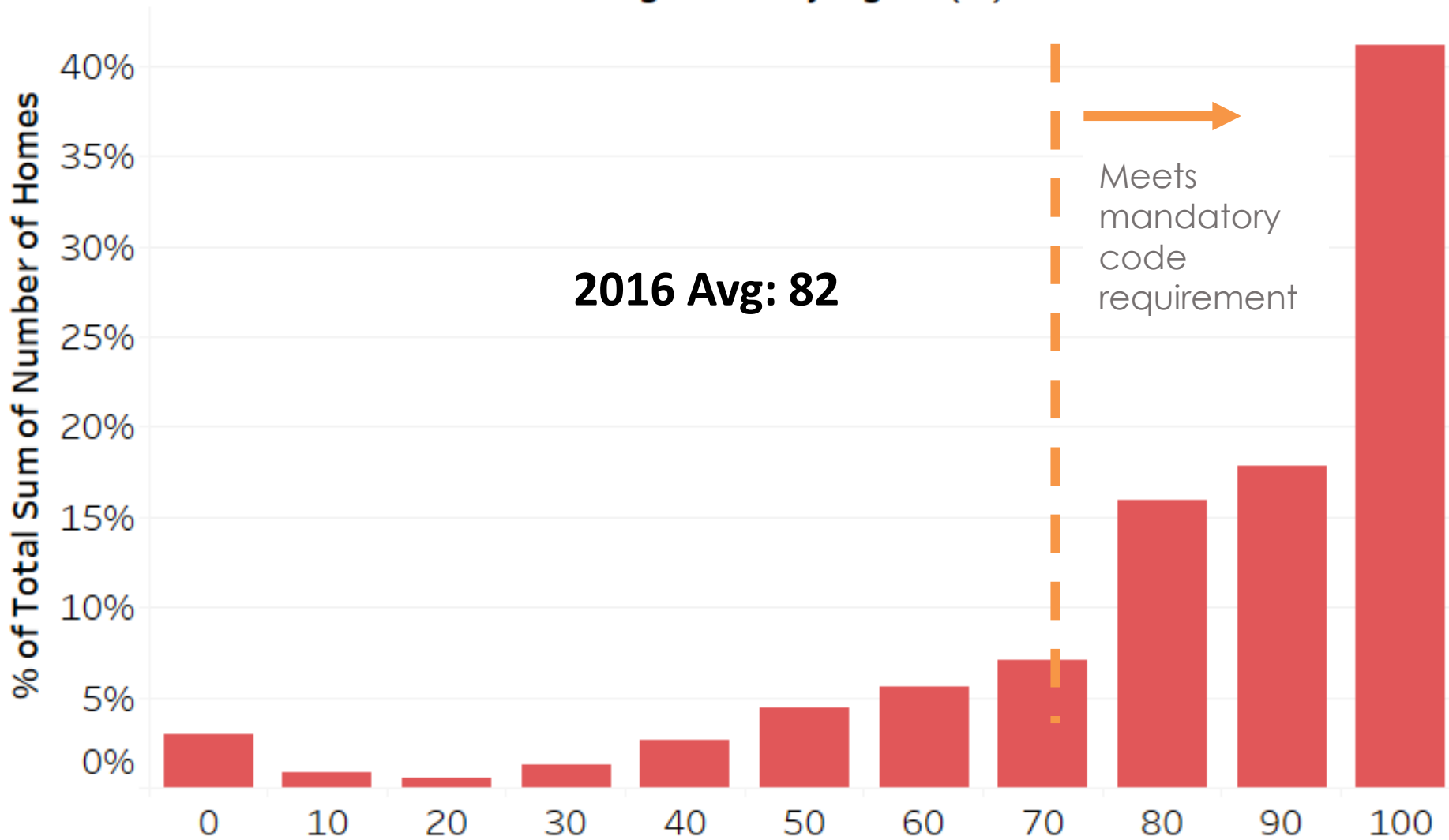
MN: 2014



Efficient Lighting

MN: 2016

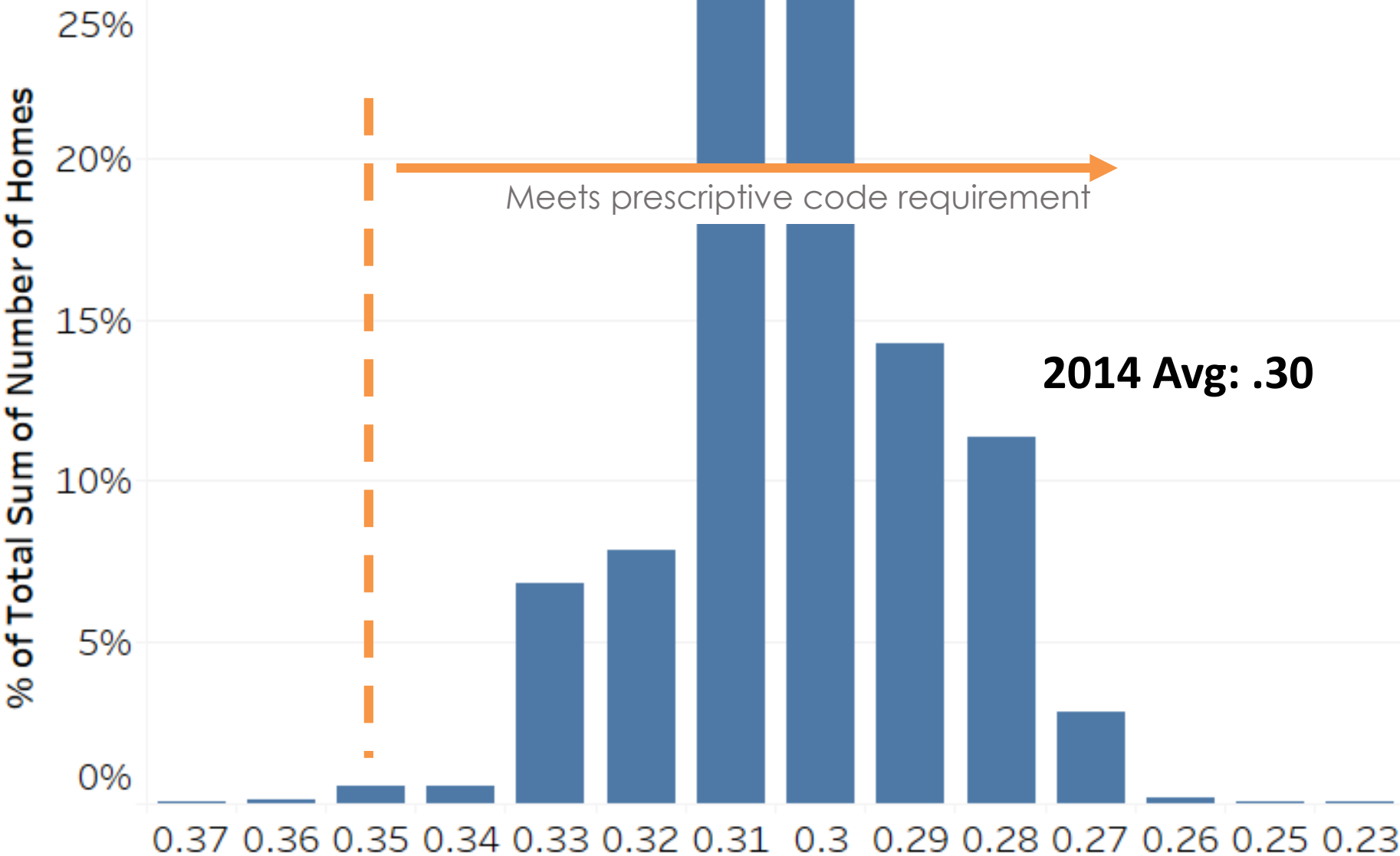
High Efficacy Lights (%)



Window U-Factor

MN: 2014

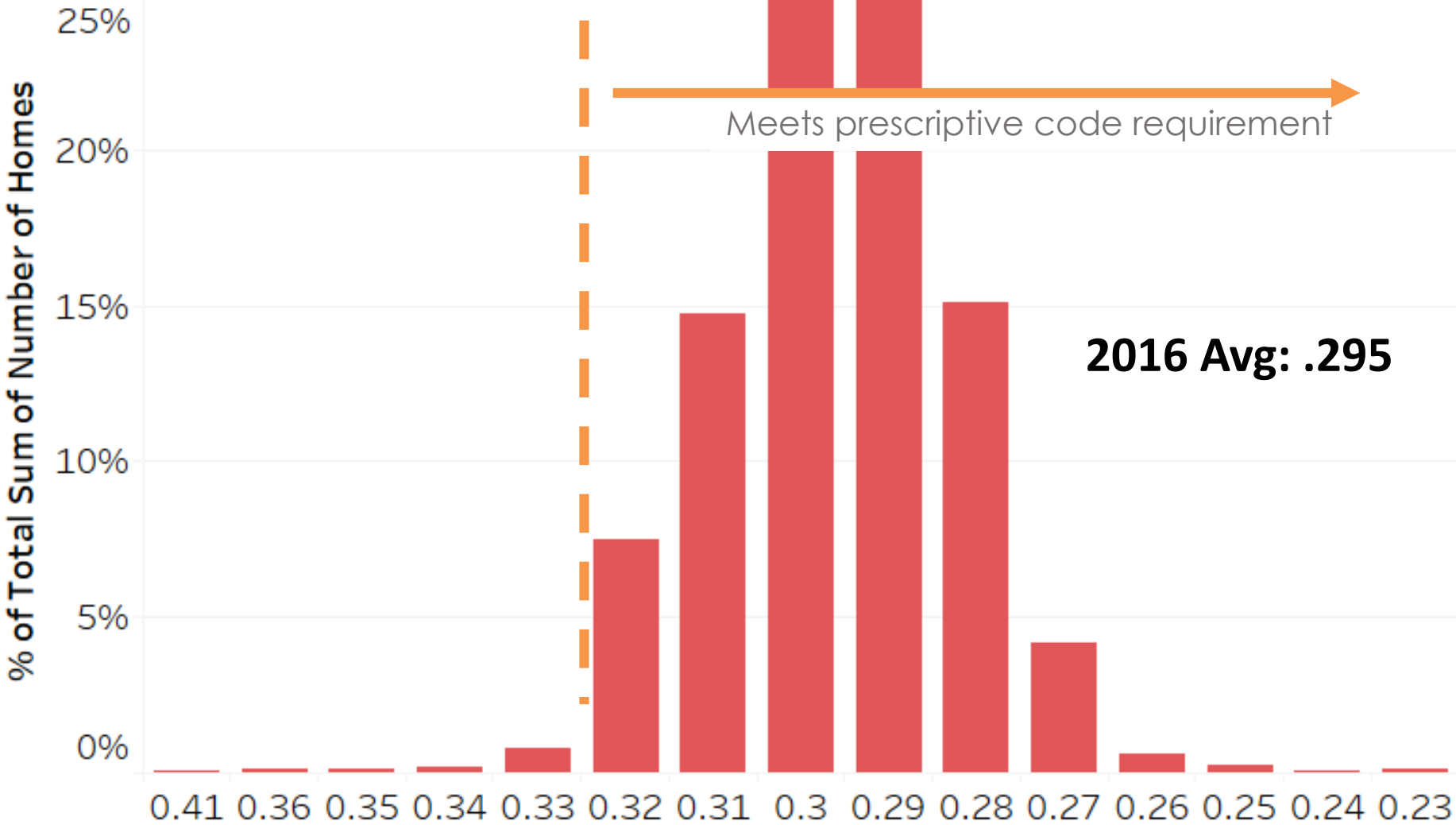
Window Efficiency (U-Factor)



Window U-Factor

MN: 2016

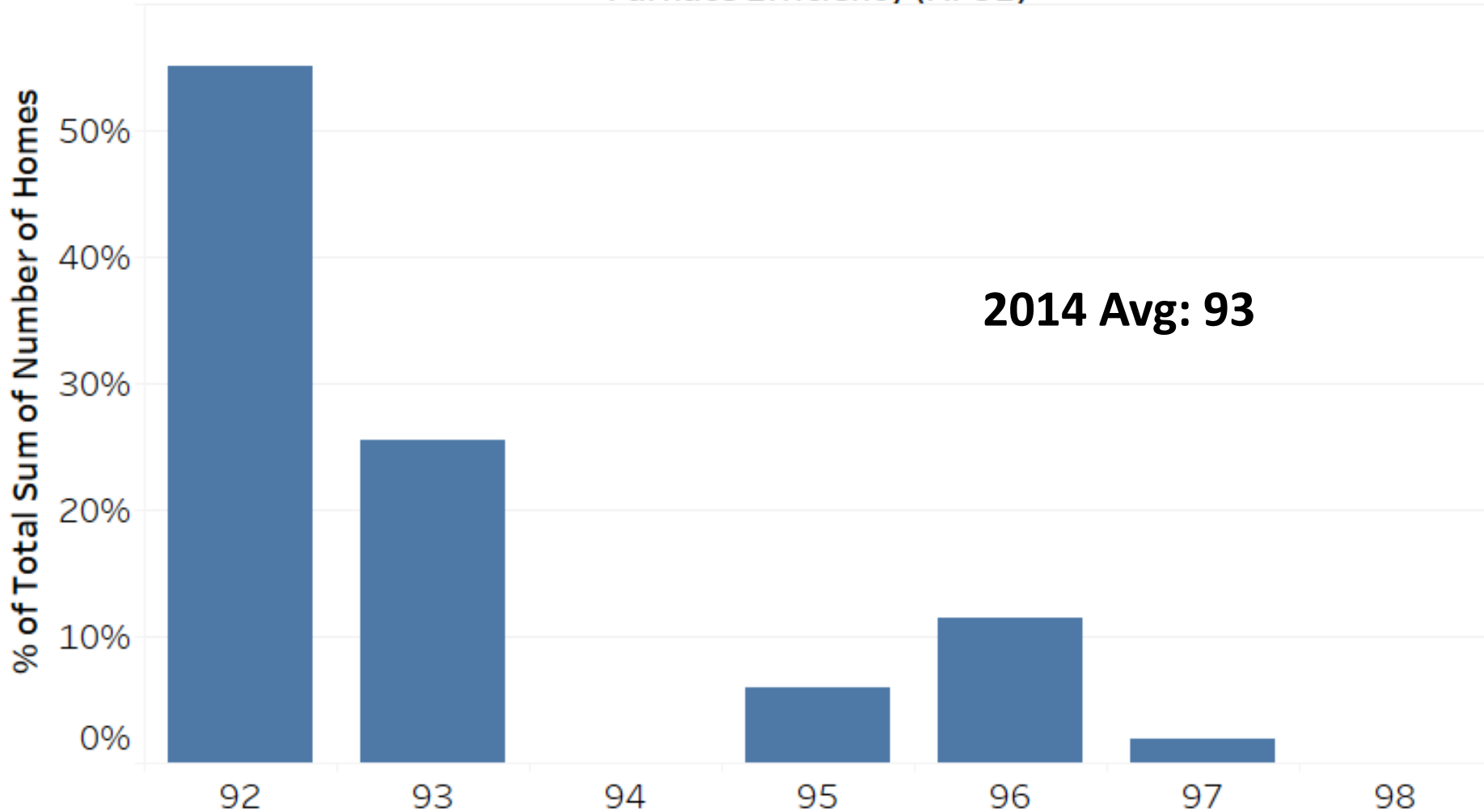
Window Efficiency (U-Factor)



Furnace Efficiency

MN: 2014

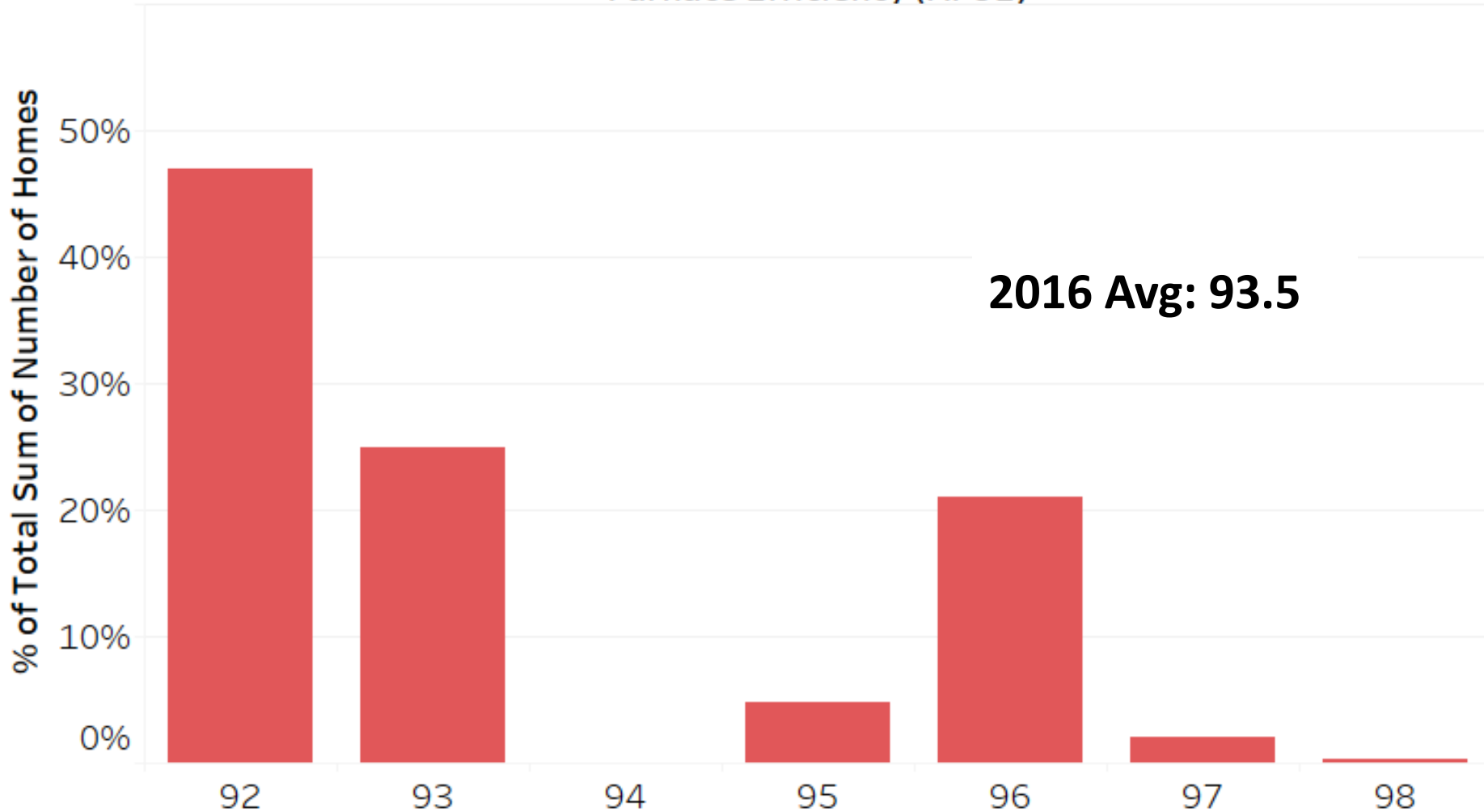
Furnace Efficiency (AFUE)



Furnace Efficiency

2016

Furnace Efficiency (AFUE)



2016 Avg: 93.5

Other Measures

Little to no change

Measure	2014 (Avg)	2016 (Avg)
Sq. Ft.	4,000	3,700
Bedrooms	4	4
Window U-Factor	U-.30	U-.295
ACH50	1.5	1.6
Duct Leakage	1.2	1.1
AC Efficiency	13.1	13.2
Furnace Efficiency	93	93.5
Energy Star	75%	72%

Utility Programs

Iowa

Iowa Utility Programs

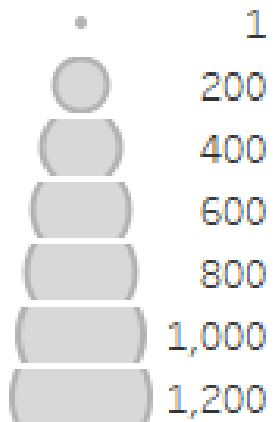
New Home Construction 14-16

- Alliant New Home Program
 - Builder Option Package
 - Reqs. Heating \geq 94 AFUE; Cooling \geq 15 SEER; SAVE
 - Advanced Performance
 - HERS 57 or lower; SAVE
 - High-Performance
 - HERS 52 or lower; SAVE
 - HERS Score Bonus
 - HERS 47, 42 or less
- Mid American New Home Program
 - Energy Star Certified
 - Advanced Building Option
 - HERS 57 or lower; 70 HVAC Save score

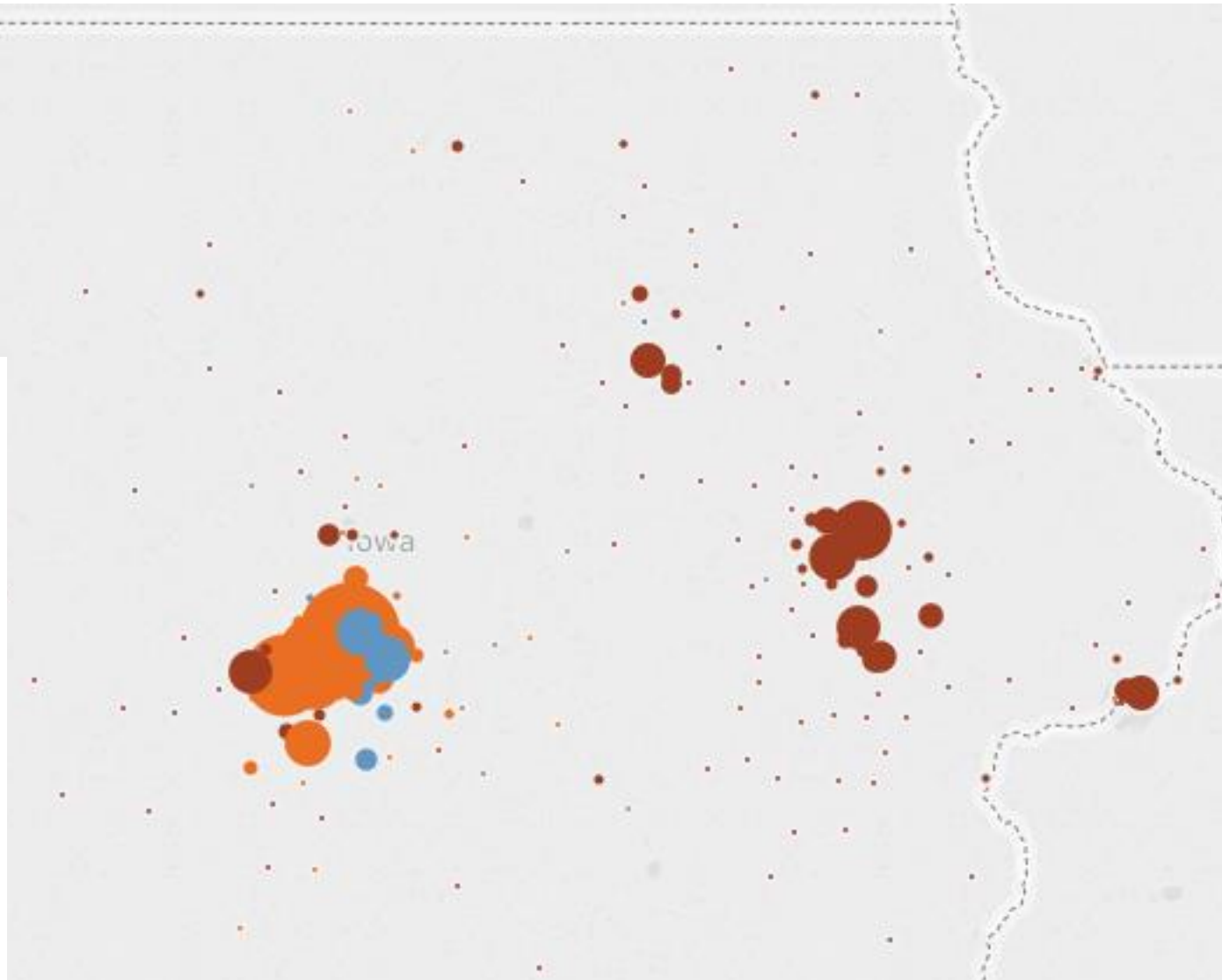
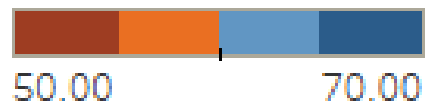
HERS Homes IA

Average Score by Zip

Count of Number of Homes

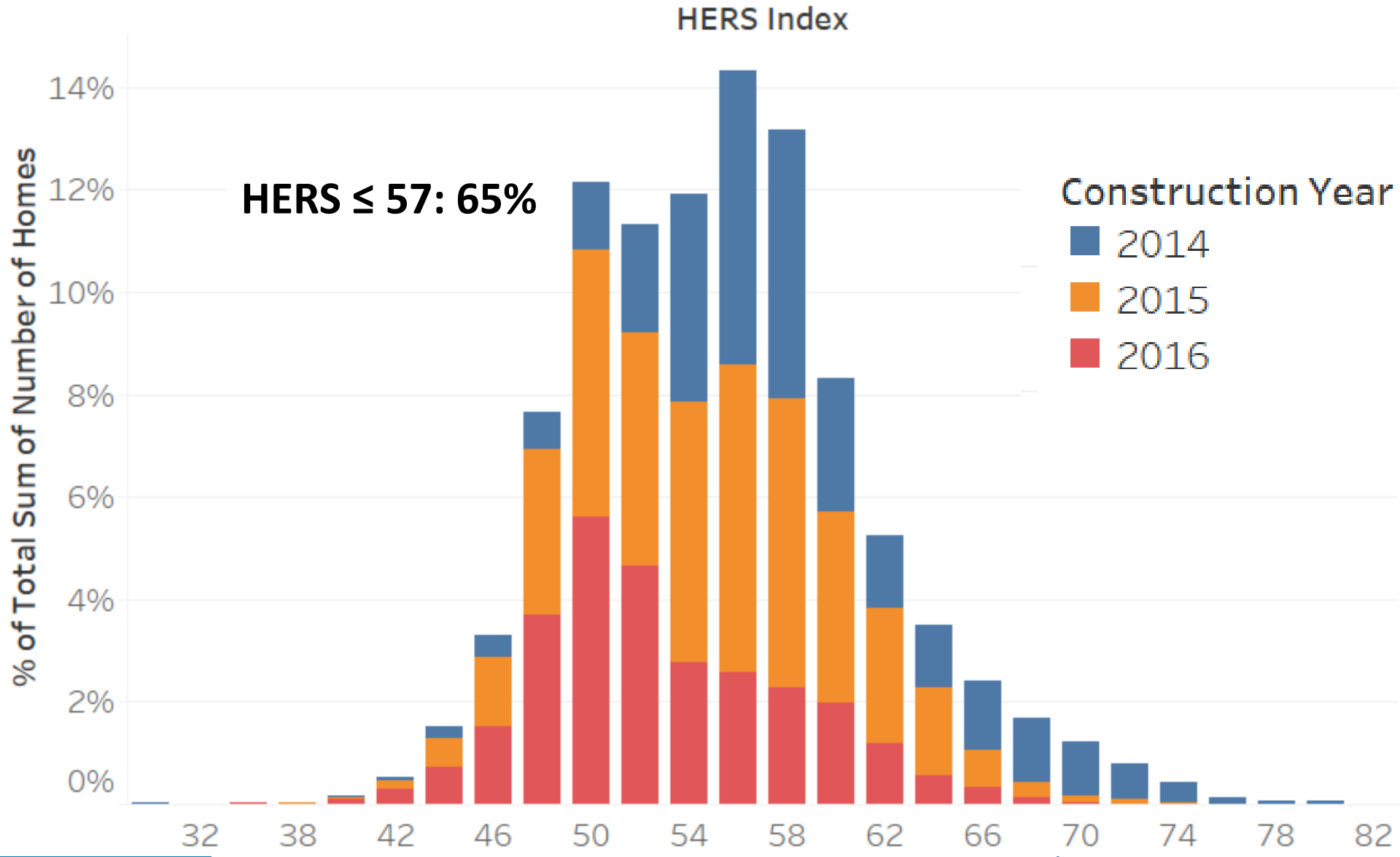


Avg. HERS Index (no bin)



HERS Index Iowa

Score by Year



Other Research

Comparing HERS to DOE study homes



What Makes a HERS Home
So Special, Anyway?

A Comparison of Field-Tested Homes

By Ian Blanding
October 2018



Comparing Field Tested Homes

HERS vs Baseline Study

- **Goal of Study:** Conduct an energy code component analysis of “typical” and HERS rated homes in Kentucky to determine:
 - Key similarities and differences
 - Level of efficiency by component
 - Comparison to the 2009 IECC (state code) prescriptive and mandatory measures

Background

KY - DOE Residential Field Study

- Single Family Homes
- Data collection started in 2015
- Multi-phase Compliance Study:
 - Phase I - Data Collection/Analysis
 - Phase II - Compliance Intervention
 - Phase III - Data Collection/Analysis
- Data collected by field technicians
- 8 key items+ – highest energy impact
- Visited 140 homes
 - Collected 63 complete datasets
- All used prescriptive path to comply

Background

KY - Home Energy Rating System Data

- RESNET provided consistent HERS data from 2014-2016 (*used 2015 data*)
- Single-Family
- Dataset includes home components that significantly affect energy use
- Data collected by certified raters
- Includes 8 key items +
- 1,616 HERS Homes ~ 24% of permitted homes in 2015

Home Characteristics

Averages: *Baseline vs HERS*

General Characteristic	Specific Characteristic	Baseline Homes	HERS Homes
Conditioned Size	Square Feet	2,433	2,881
Foundation Insulation	Cont. (R-Value)	3.9	5.1
	Cavity (R-Value)	8.5	1.8
Wall Insulation	Cont. (R-Value)	0.5	0.8
	Cavity (R-Value)	13.9	15.1
	Quality (1-3)	1.8	1.3
Ceiling Insulation	Cont. (R-Value)	37.7	37.2
	Quality (1-3)	1.6	1.1
Window	Efficiency (U-Factor)	0.32	0.31
	Glazing (SHGC)	0.26	0.27
Air Leakage	Leakage Rate (ACH50)	5.6	3.6
Duct Location	Conditioned (%)	27.3	51.4
Efficient Lights	HEL (%)	33	49
Equipment Efficiency	AC (SEER)	13.6	13.9
	Furnace (AFUE)	89.4	93.0

HERS compare to code homes?

Kentucky

- On average, HERS homes have more efficient components than Baseline homes
 - Insulation Grade, Air Sealing, Duct Location, and Furnace Efficiency demonstrate biggest distinctions
- HERS homes were larger on average
 - Using more resources/energy
- Ventilation is an area of concern in both homes

Conclusions

Conclusions

Key Takeaways

- States with highest HERS market penetration have utility program and state energy code
- Energy Codes, utility programs, local policies all impact HERS homes
- Data can be very useful to understand and inform these programs and policies

Conclusions

Next Steps

- Continue to collect and analyze data each year
- Use it to understand impacts from new energy codes and changes in programs
 - What will happen with changes in Iowa?
 - What about Pay for Performance programs?
- Dig deeper into what influences and grows the HERS industry and ratings

Questions?

Thank you!

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