BUILDING ENERGY CODES PROGRAM

U.S. Department of Energy

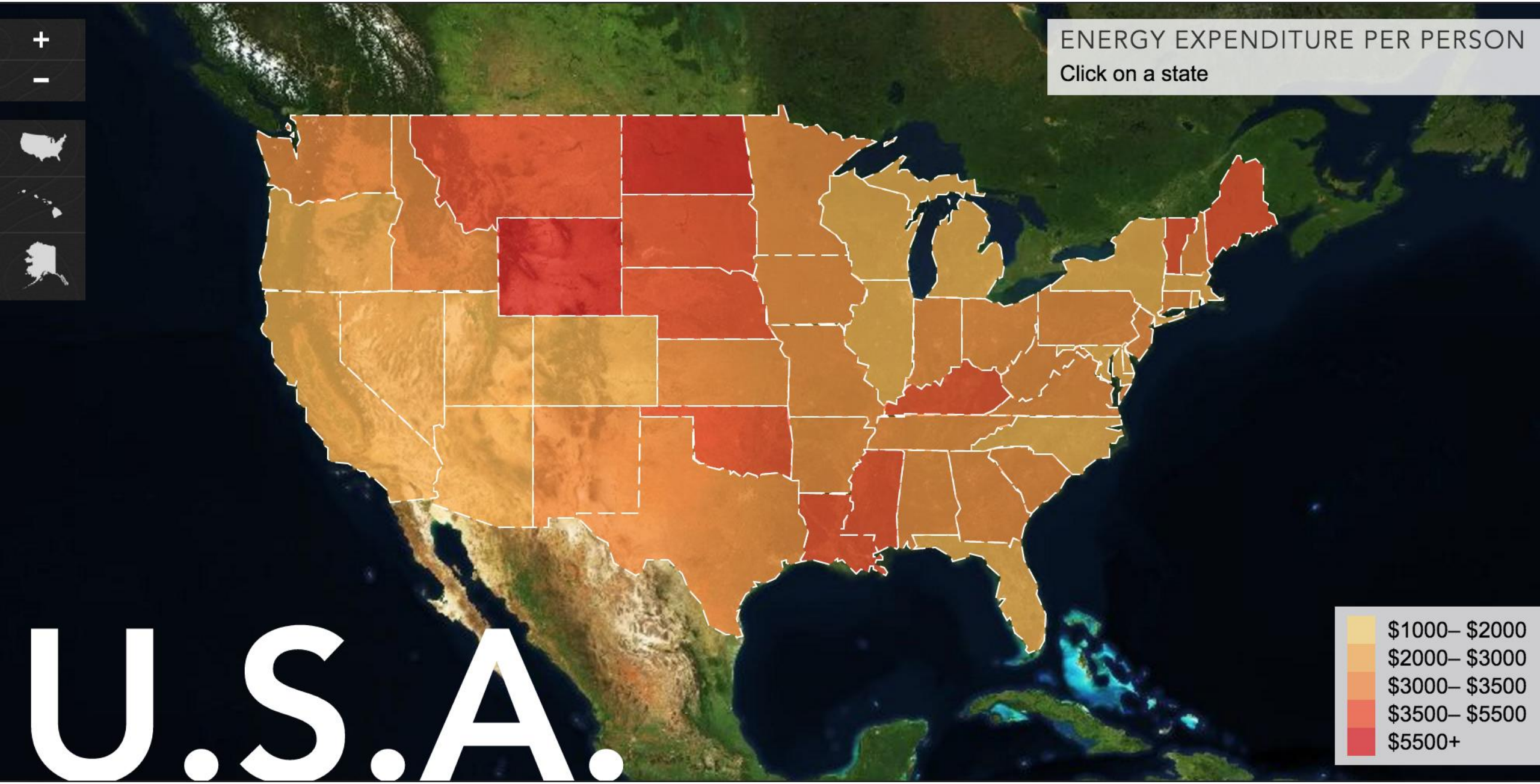
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Midwest Energy Codes Conference

Jeremy Williams

Summary

+ Energy Code Field Studies:
  - Residential [SF]
  - Commercial [MF + Com]
+ Compliance Resources
+ Program Updates
+ Q+A


+
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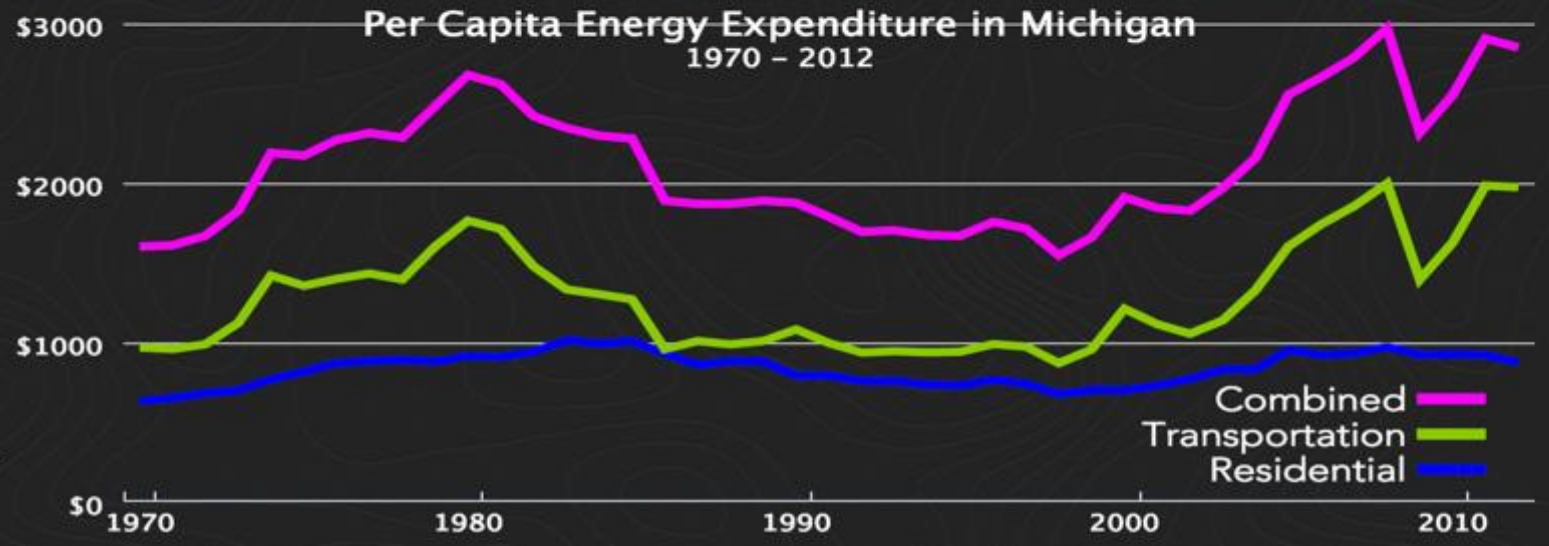
ENERGY EXPENDITURE PER PERSON
Click on a state
$1000– $2000
$2000– $3000
$3000– $3500
$3500– $5500
$5500+
U.S.A.

Energy Expenditure

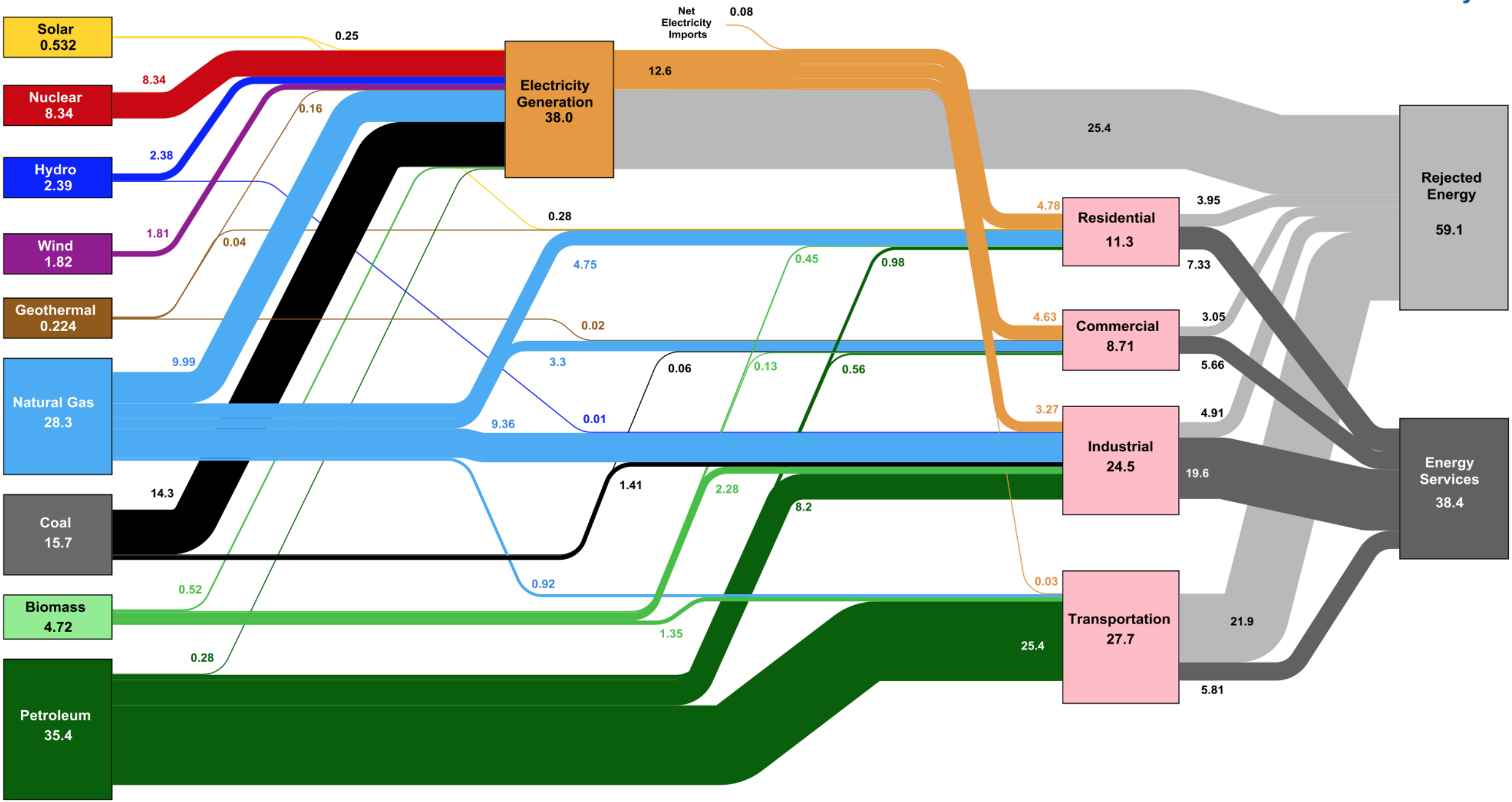
$2849

per person in 2012



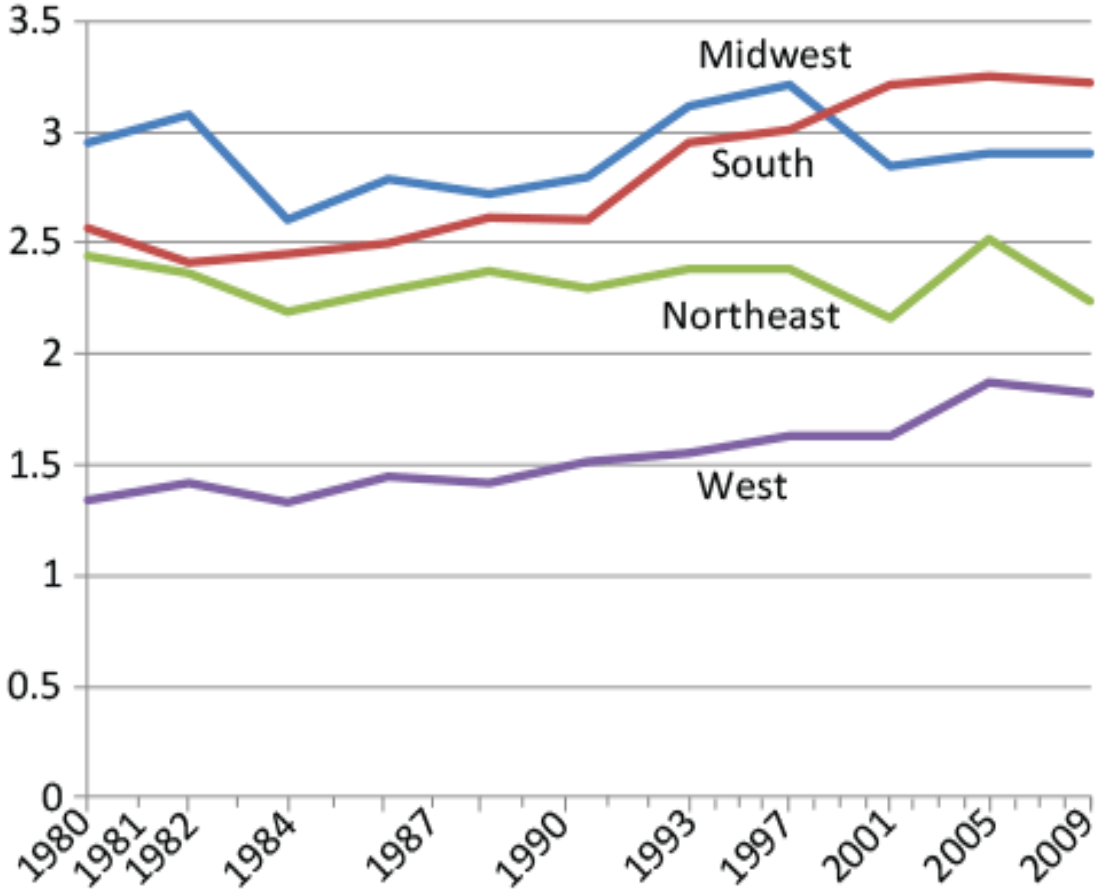
Estimated U.S. Energy Consumption in 2015: 97.5 Quads

Lawrence Livermore National Laboratory



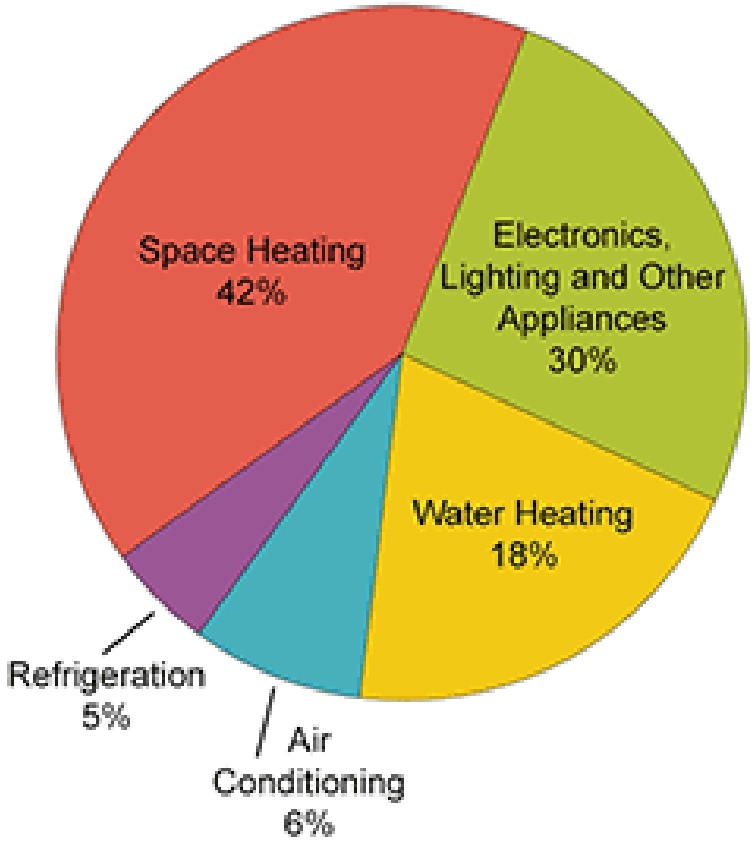
Total Home Energy Use By Region, 1980-2009

quadrillion Btu



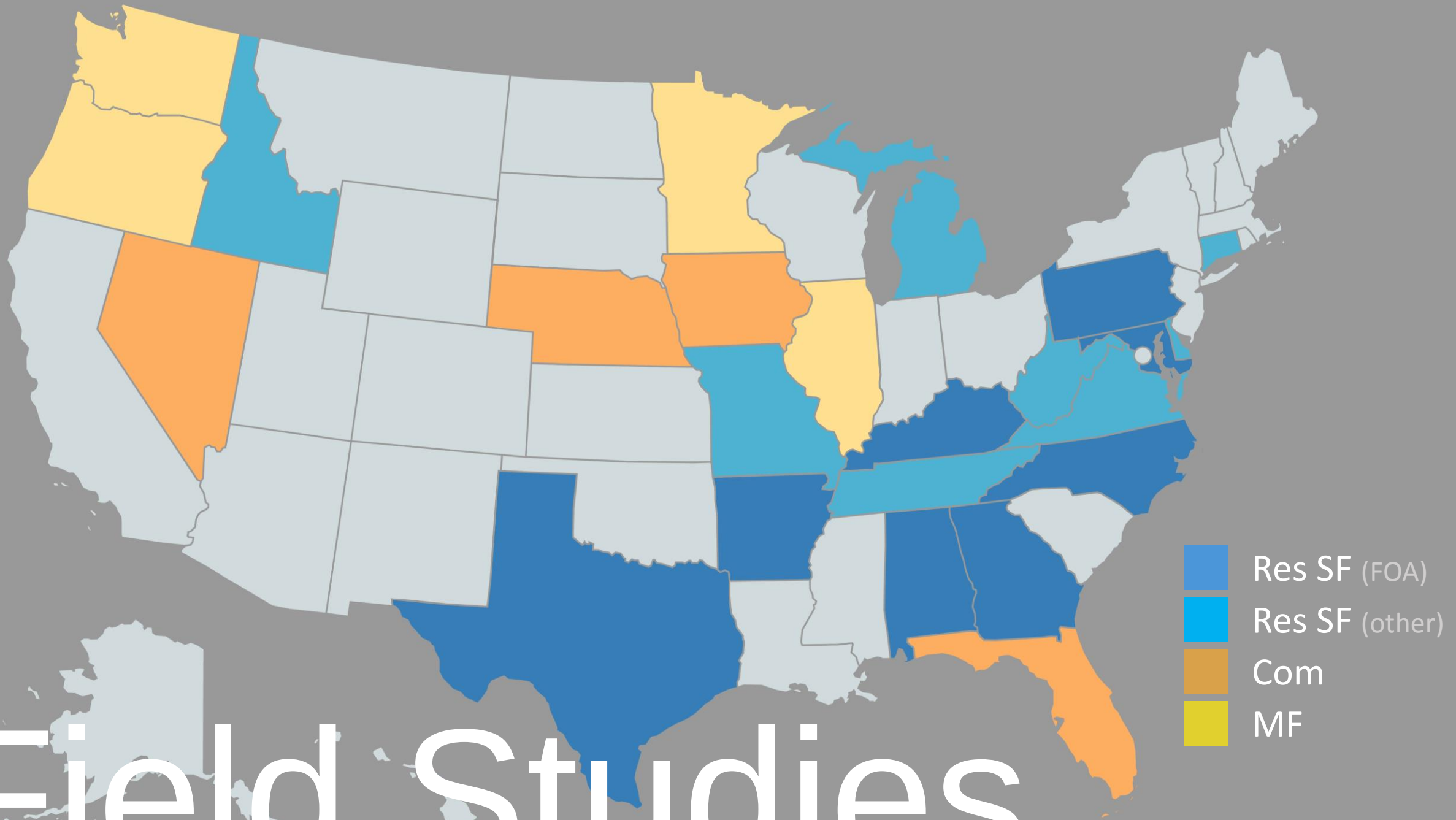
Source: U.S. Energy Information Administration, *Residential Energy Consumption Survey (RECS)* 1980-2009.

How Energy Is Used in Homes (2009)*



* 2009 is the most recent year for which data are available.

Source: U.S. Energy Information Administration, *Residential Energy Consumption Survey (RECS) 2009*.



Field Studies

FIELD STUDIES
[RESIDENTIAL]

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Project Goals

1. Develop a **methodology** equating to *energy*
2. Establish a set of **empirical data** based on observations made in the field
3. Highlight the **business case** for investment to increase code savings

STATE	CZ	BASE CODE	HOMES
AL	2A, 3A	2015 Alabama State Energy Code (2009 IECC w/ amendments)	134
AR	3A, 4A	2014 Arkansas State Energy Code (2009 IECC w/ amendments)	226
GA	2A, 3A, 4A	GA State Energy Code (2009 IECC w/ amendments)	218
KY	4A	2009 IECC	140
MD	4A	2015 IECC	207
*MI	5A, 6A, 7A	2015 Michigan State Energy Code (2015 IECC w/ amendments)	124
NC	3A, 4A	2012 North Carolina State Energy Code (2009 IECC w/ amendments)	249
PA	4A, 5A	2009 IECC (2009 IRC)	171
TX	2A	2015 IECC	133
		TOTAL	**1600 +**

Trends Across States [phase one]

Envelope & Duct Tightness: Similar ranges regardless of requirement—envelope results better than some predicted (e.g. 3-5 ACH)

Wall & Ceiling Insulation: Typically meet label R-values—generally weaker installation quality

Windows: Almost all observations exceed requirement—most better than U-factor=0.35 regardless of CZ (similar trend for SHGC)

Lighting: No consistent trend—surprisingly low compliance

Key Items	TX**	AL	GA	AR	NC	KY	MD**	PA	Heat Map
									Red=bad Green=good
Climate Zone***	2	2,3	2,3,4	3,4	3,4	4	4	4,5	
Exterior wall insulation*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	1.00
Duct tightness	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	1.00
Lighting	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	1.00
Envelope tightness	Yes	Yes	None	Yes	Yes	Yes	Yes	None	0.75
Ceiling insulation*	Yes	None	Yes	None	None	None	Yes	None	0.38
Foundation Insulation*	None	None	None	None	Yes	Yes	None	Yes	0.38
Window SHGC	None	Yes	None	Yes	None	None	None	None	0.25
Window U-factor	None	None	None	None	None	None	None	None	0.00
No. of Key Items with Savings	5	5	4	4	5	5	5	4	0.58

*Includes insulation installation quality

** 2015 IECC

***As sampled

State	CZ (state)	Code	EUI (Observed)	Target Measures (% Compliance)	Savings (Annual)
MI	**5A, 6A, 7A**	2015 IECC*	39.72	Lighting (34%)	$ 931,667
				Wall Insulation	$ 585,950
				Envelope Tightness	$ 488,334
NC	**3A, 4A**, 5A	2009 IECC*	22.99	Lighting (57%)	$ 607,598
				Duct Leakage (62%)	$ 386,073
				Envelope Tightness (88%)	$ 244,617
PA	**4A, 5A**, 6A	2009 IECC	41.34	Duct Leakage (42%)	$ 733,592
				Wall Insulation (69%)	$ 264,734
				Lighting (62%)	$ 188,283
TX	**2A**, 3A, 2B, 3B, 4B	2015 IECC	21.08	Wall Insulation	$ 5,029,864
				Envelope Tightness	$ 4,656,869
				Duct Leakage	$ 3,582,893
				Lighting (62%)	$ 2,774,421
				Ceiling Insulation	$ 443,058

Preliminary Conclusions [phase one]

- Builders and building officials are doing a good job meeting adopted codes and advancing requirements
- Many homes are using less energy than would be expected based on prescriptive codes (majority of states)
- Significant portions of savings can be addressed by continuing to focus compliance programs on target measures
- There is still significant savings potential from individual code requirements
- Phase 3: More data to come!
- Field studies are critical to understanding the patterns of compliance and their impact on energy

Next Steps

Now: Most projects finishing phase two (education, training & outreach)

Fall 2017: Shift to second field study (Phase 3)

- Re-measurement to assess the impact of Phase 2 activities
- Will take place through spring—results mid-2018

End of Project (2018):

- Update methodology
- Publish all final data
- Guidance to additional states

Planning a Study?

Budget: About $120,000 per study

PNNL services available to those following methodology (free of charge):

- Sample design
- Customized data forms
- Technical analysis

Commercial and multifamily methodologies pending (2018)

For more information:

- Webinar overview presentation
- Methodology guideline (coming soon)
- Analysis technical support document (coming soon)
- State project reports (now available)
- Raw field data
- Overall project report (following Phase III)

https://www.energycodes.gov/compliance/residential-energy-code-field-study

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FIELD STUDIES
[COMMERCIAL]

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Commercial Field Study

Goal: Develop and pilot a methodology to maximize energy & cost savings through increased compliance in commercial buildings.

Objectives:

+ Establish a methodology that can be replicated across states
+ Identify a sampling protocol that yields representative results
+ Develop field data collection instruments and recruitment protocols
+ Collect field data to fulfill the required sample
+ Develop educational resources and pilot training to address common issues

Commercial Field Study

Lead Organization: Institute for Market Transformation (Washington, DC)

Summary:

+ 4 states {NE, IA, FL, ~~NV,~~ IL?}
+ 3 years
+ $2.1M
+ Office & Retail (CZ 2A & 5A)

Project Team:

+ Cadmus Group
+ Florida Solar Energy Center (FSEC)
+ Colorado Code Consulting
+ Industry advisory committee

http://energy.gov/eere/buildings/articles/funding-opportunity-commercial-energy-codes-field-studies

Current Activities

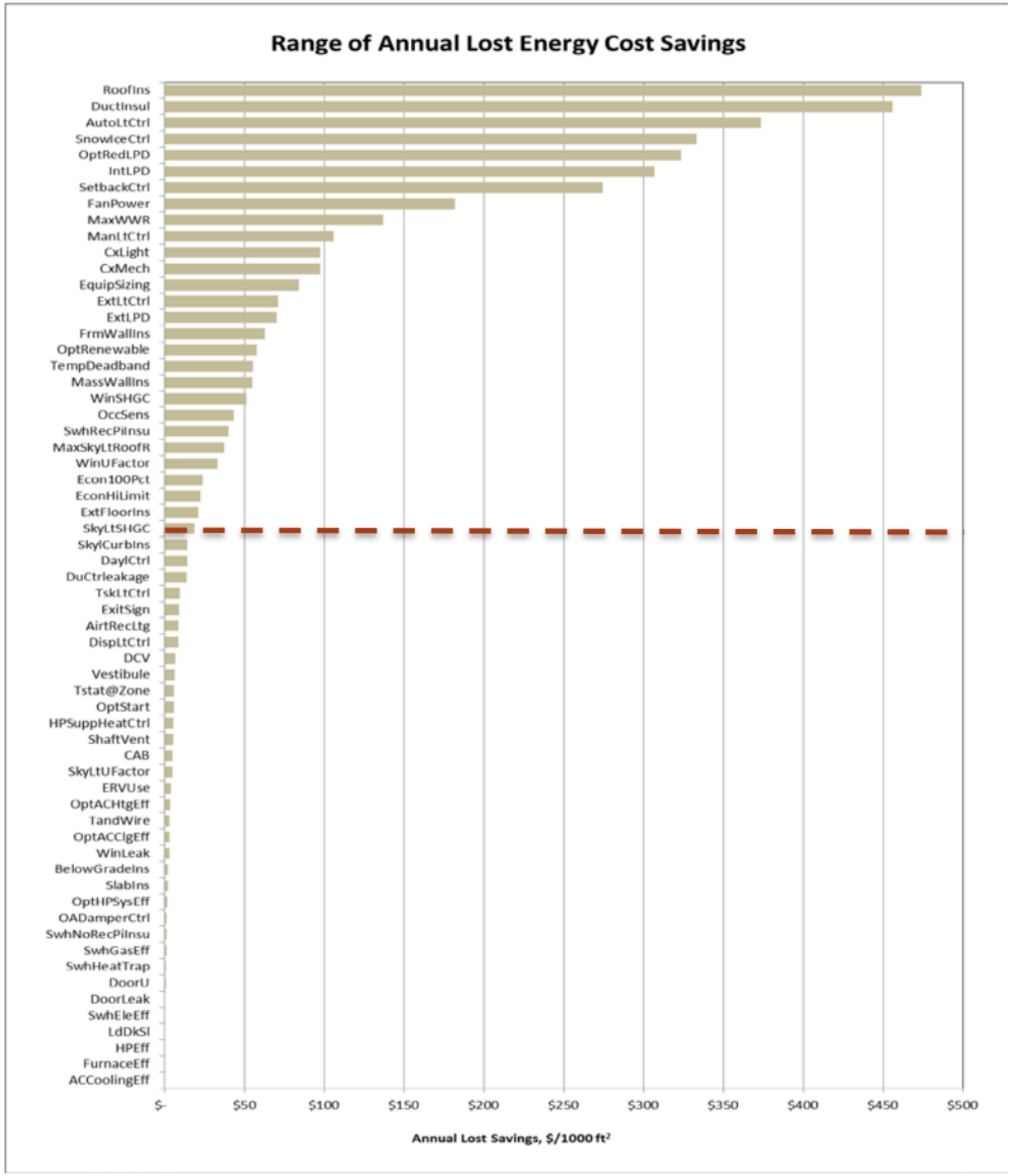
+ Methodology:
  - PNNL analysis to identify key measures and associated savings
  - Translation to needed inputs (from field data)
+ Field Instruments: Data Collection Form
+ Plans for sampling and recruiting

Measures with Lost Savings	Sample Lost Savings Life-Cycle	Verification hours	Lost Saving $ / Hour
Mechanical systems commissioning requirement	$1,647	0.24	$6,741
Equipment sizing requirement	$13,054	3.41	$3,829
Building entrances shall be protected with an enclosed vestibule.	$1,758	0.87	$2,014
Thermostat setback and start/stop controls	$4,990	2.55	$1,953
Thermostat deadband requirement	$4,426	2.56	$1,726
Economizers have appropriate high-limit shutoff control and be integrated	$3,353	3.00	$1,118
Roofs shall be insulated to meet CZ requirements	$2,288	2.47	$926
Lighting commissioning requirement	$2,525	2.90	$871
Interior lighting power allowance	$3,705	4.44	$835
Window-to-wall ratio meets maximum limits.	$3,163	4.25	$744
Automatic time switch control	$280	0.55	$510
Economizer supplies 100% design supply air	$1,444	2.89	$499
Manual lighting control	$1,015	2.74	$370
Occupancy sensor control	$918	3.36	$273
Heat pump supplementary heat control	$356	1.38	$259
Slab-on-grade floors meet insulation requirements and are protected	$446	2.66	$167
Above grade frame walls shall be insulated to meet CZ requirements	$468	3.34	$140
Recessed lighting shall be sealed, rated and labeled.	$85	0.98	$87
Exit sign maximum power	$216	2.78	$78
SWH pipe insulation - non-recirculated	$64	1.08	$59
Daylight zone control	$121	2.73	$44
Duct insulation requirement	$76	2.39	$32
SWH heat trap	$25	2.11	$12
Water heater efficiency, electric	$5	2.93	$2
Damper control when space is unoccupied	$2	2.17	$1
Total for measures with below-code potential savings	$46,430	60.8	$764
Total for measures with no potential savings identified (met code)	$0	40.9	$0
Total for all applicable measures	$46,430	102	$455

- In this sample, 9 measures (14%) responsible for 81% for the savings

Summary of Measures and Instances in this Sample

Grouping by Lost Savings per Hour and Applicability	Measures #	Measures %	Applicable Instances #	Applicable Instances %	Life-Cycle Lost Savings	% Lost Life-Cycle Savings
High lost $/verification hour (>$750/hour)	9	14%	61	21%	$37,747	81%
Med lost $/verification hour ($750-$400 /hour)	3	5%	18	6%	$4,886	11%
Low lost $/verification hour (<$400/hour)	13	21%	90	31%	$3,797	8%
Compliant with code	19	30%	120	42%	$0	0%
Not applicable this sample	19	30%	0	0%	$0	0%
Total	63		289		$46,430	



- Worst case lost savings
- Simulation can lead to initial screening
- No need to look at measures that have no chance of being impactful

Challenges

+ Sampling: Limited availability in certain areas:
  - FL: Representative sample (statistical)
  - NE: Census (look at everything available)
  - States to CZ's?
+ Methodology:
  - Identifying key items—buildings or measures?
  - Number of site visits?
  - General complexity of commercial compared to residential
+ Cost of Studies: Testing different means of gathering data—teams tracking this information (e.g. incentives, students, etc.)

Next Steps

+ Finalization of field protocols for initial pilot test
+ Start gathering initial data
+ Buildings in 1-2 states expected by spring timeframe

Multifamily Field Study

Lead Organization: Ecotope (Seattle, WA)

Summary:

+ 4 states {OR, WA, MN, IL}
+ 3 years
+ $1.6M

Project Team:

+ Center for Energy & Environment (CEE)
+ Seventhwave
+ The Energy Conservatory

http://energy.gov/eere/buildings/articles/funding-opportunity-commercial-energy-codes-field-studies

Multifamily Field Study

Goal: Develop and pilot a methodology to maximize energy & cost savings through increased compliance in multifamily buildings.

Objectives:

+ Update the existing SF methodology to address low-rise MF buildings
+ Identify challenges and practices specific to multifamily buildings (taxonomy)
+ Identify a sampling protocol that yields representative statewide results
+ Conduct market research to inform future training (e.g. air leakage testing)

Table 1: Key Characteristics Targeted by the Study

Component	Data Collected	Code Reference†
	Building	
Exterior wall insulation	R-value	Tables R402.1.2, R402.1.4
Ceiling insulation	R-value	Tables R402.1.2, R402.1.4
Foundation insulation	R-value	Tables R402.1.2, R402.1.4
Window	U-factor	Tables R402.1.2, R402.1.4
Window	SHGC	Tables R402.1.2, R402.1.4
Exterior lighting	Wattage	Section C405.5
Central HVAC	**Efficiency rating**	**Section C403, (referenced by IECC section R403.8)**
Pipe insulation	**R-value**	**Section C403.2.10**
Central DHW	**Efficiency rating**	**Section C403**
Circulating system	**Pump controls**	**Section C404.6**
Envelope tightness	Air changes per hour (ACH)	Section R404.4.1.2
	Common Areas	
Lighting	Lighting power density	Section C405.4.2
Corridor ventilation	**Air flow (CFM/ft^2)**	**Table 403.3 (IMC)**
	Units	
Lighting	Percent high efficacy	Section R404.1
Ventilation	Flow rating	Section M1507 (IRC), (referenced by IECC section R403.6)
Envelope tightness	Air changes per hour (ACH)	Section R404.4.1.2

† - IECC reference. Individual state energy code references vary.

Challenges

+ Very similar to the commercial study
+ Sampling:
  - Limited availability in certain areas
  - Statistical sampling vs. census
+ Methodology:
  - Identifying key items
  - Number of site visits
  - Air leakage—uncertainty surrounding testing protocols

Next Steps

+ Finalization of field protocols for initial pilot test
+ Start gathering initial data
+ Buildings in 1-2 states expected by spring timeframe

RESOURCES

Residential Buildings

- c_s > 2012/2015 IECC
- c_s = 2012/2015 IECC
- 2009 < c_s < 2012 IECC
- c_s = 2009 IECC
- c_s < 2009 IECC
- No Statewide Code

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RES*check* & COM*check*™

Update:

+ New user interface currently under development
+ Modernized look and feel
+ Improved usability across various devices
+ Ability to share projects between users
+ *Will be seeking feedback in coming weeks!*

https://www.energycodes.gov/software-and-web-tools

Training Portal & Webinar Series

Presentations:

+ Codes 101: An Introduction to Building Energy Codes
+ Model code updates:
  - **IECC**: 2009, 2012, 2015
  - **90.1**: 2007, 2010, 2013
+ Series: Adoption, Compliance & Enforcement (ACE)

Energy Code Commentator Webinars:

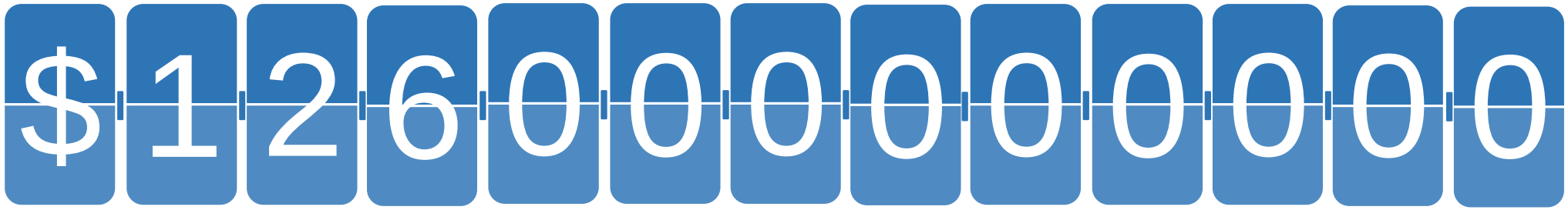
+ Energy Code Compliance Paths
+ Tight Residential Envelopes
+ REScheck & COMcheck Basics
+ Lighting Requirements of 90.1-2013
+ 2015 IECC Energy Rating Index (ERI)
+ Introduction to Commercial HVAC
+ Daylighting Controls
+ What's New in 90.1-2016?

National & State Technical Analysis

Sample publications:

+ Energy & cost savings (national & state)
+ Cost-effectiveness (national & state)
+ Impact analysis (E, $, CO_2)
+ Specialized studies (e.g. HERS and the IECC)
+ Supporting methodologies
  (technical support documents)
+ State-level cost calculator (customizable)

Building energy codes are projected to save U.S. home and business owners (thru 2040)



Impact:

+ $126B (energy costs)
+ 841 MMT (avoided CO_2)
+ 12.82 quads* (primary energy)

Equivalency:

+ 177M passenger vehicles
+ 245 coal power plants
+ 89 million homes

* For perspective, the primary energy consumption of the entire U.S. commercial & residential sectors in 2015 was estimated at 38 quads

Building Energy Codes Program

How Much Do Energy Codes Save?

Energy codes will save U.S. home and business owners $126 billion through 2040. This equates to 841 million metric tons of avoided carbon emissions. ***Learn more...***

HIGHLIGHTS

- The Impact of Building Energy Codes
- DOE Proposals for the 2018 IECC

Popular Links

Tools

COMcheck REScheck

Technical Assistance

Help Desk

Status of State Energy Codes

Select a state

News

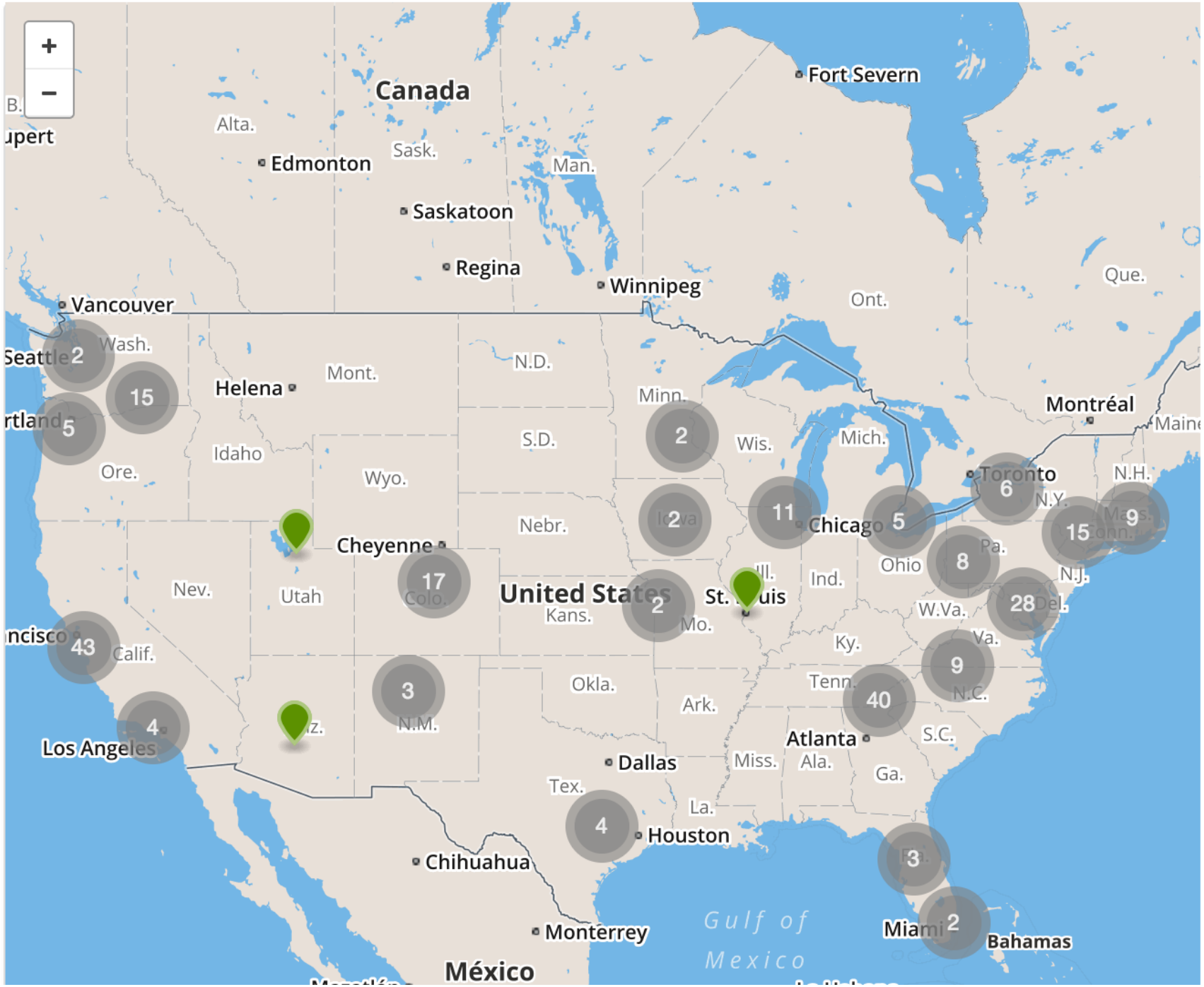
- Kathleen Hogan Awarded 2016 Sammie for Career Achievement
  Source: *Partnership for Public Service*
- A Modern, Integrated Power Grid: The Perfect Setting for Doing More and Using Less
  Source: *Alliance to Save Energy*, posted: 09.14.2016
- Guide to Understanding What Builders Want from HERS Raters
  Source: *Insulation Institute*, posted: 09.13.2016

PROGRAM

- [x] Appliance Standards Program
- [x] Emerging Technologies
- [x] Commercial Buildings Integration
- [x] Residential Buildings Integration
- [x] Building Energy Codes

ACTIVITY

- [ ] Code Compliance
- [ ] Code Development & Analysis
- [ ] Energy Data Analysis & Modeling Tools
- [ ] Energy Efficiency Guides & Program Models
- [ ] Market Engagement
- [ ] R&D - Advanced Lighting



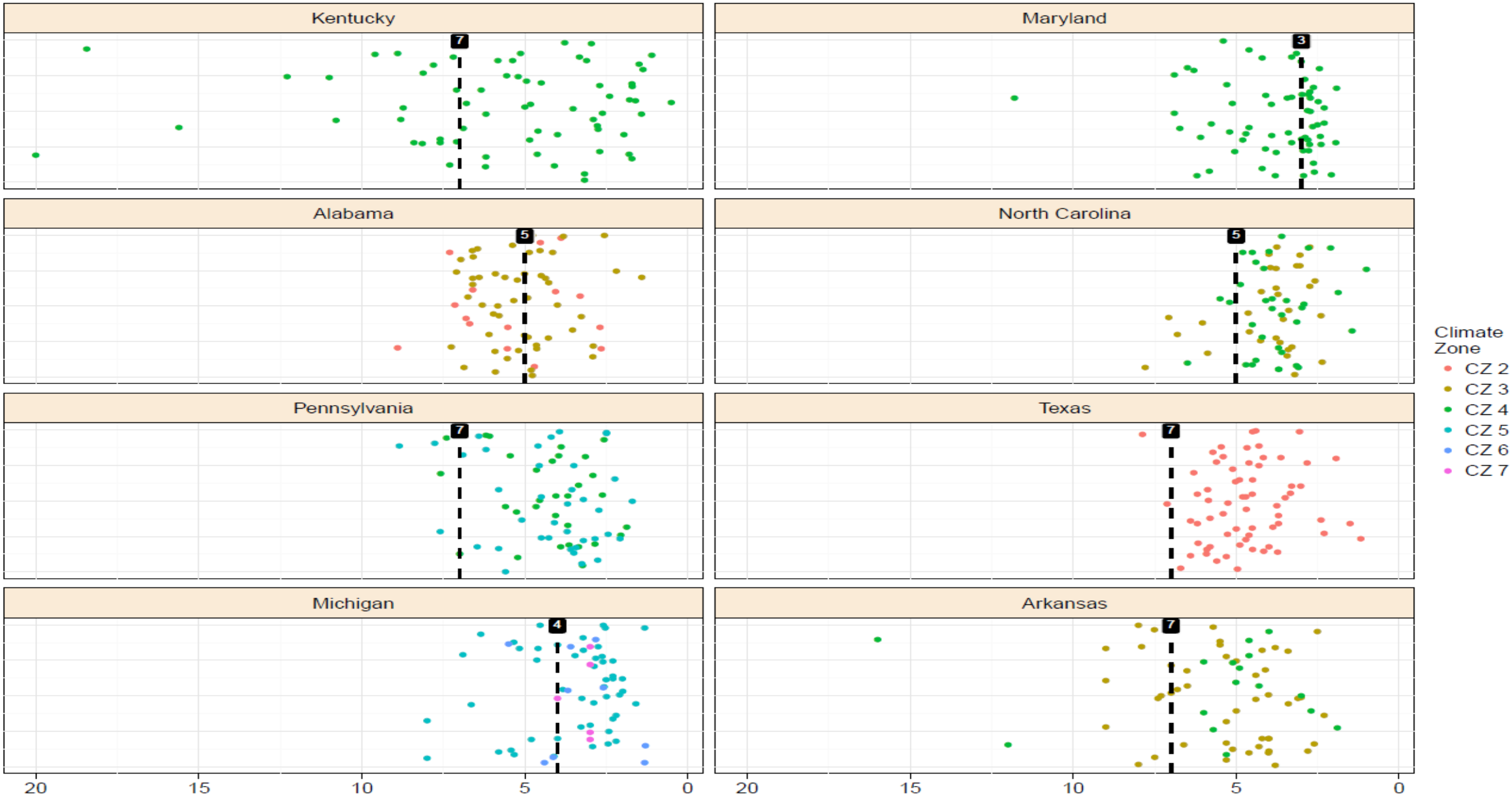
DOE Building Energy Codes Program

For more information:

Visit: energycodes.gov

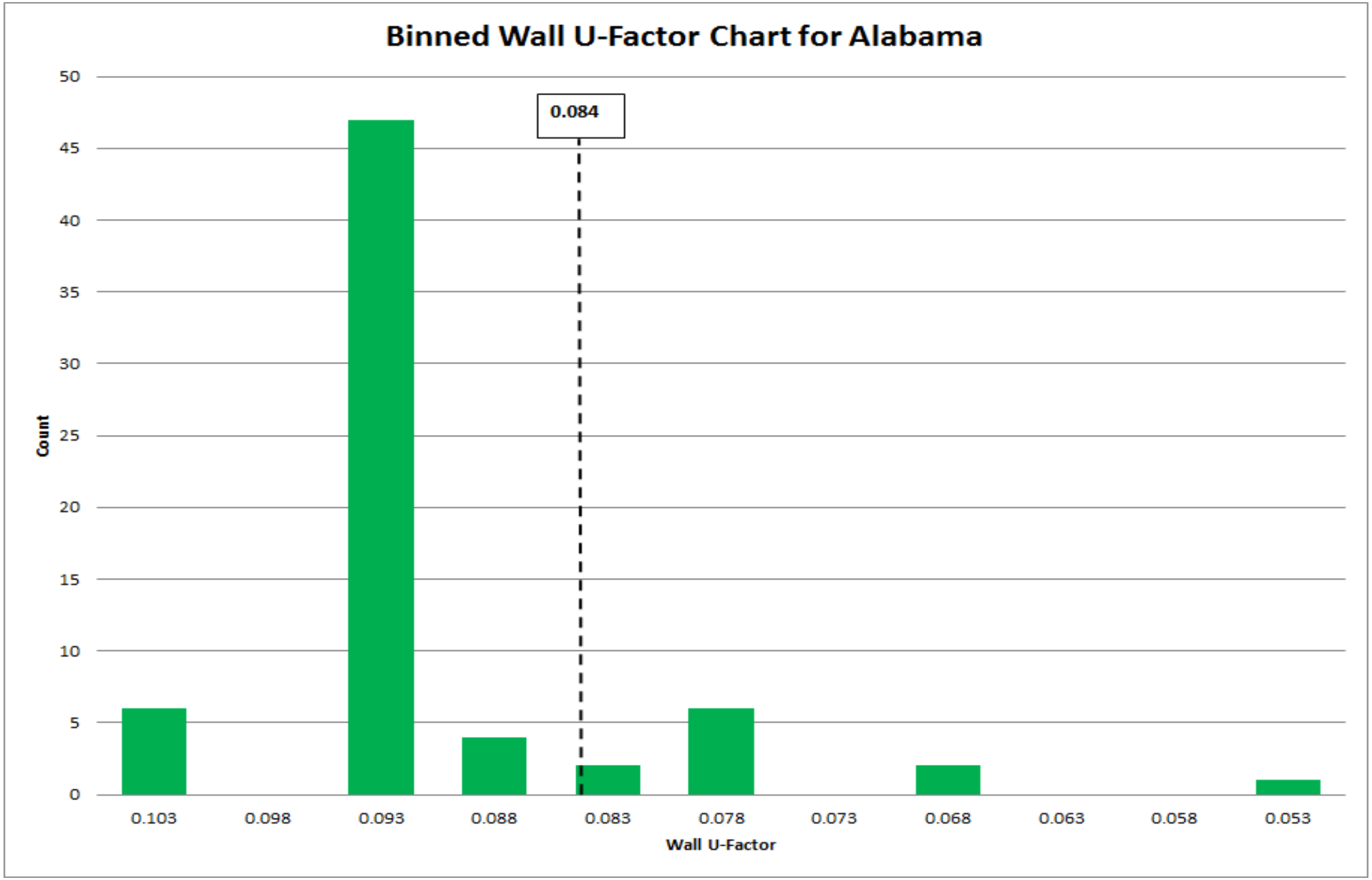
Contact: Jeremy Williams
jeremy.williams@ee.doe.gov

APPENDIX

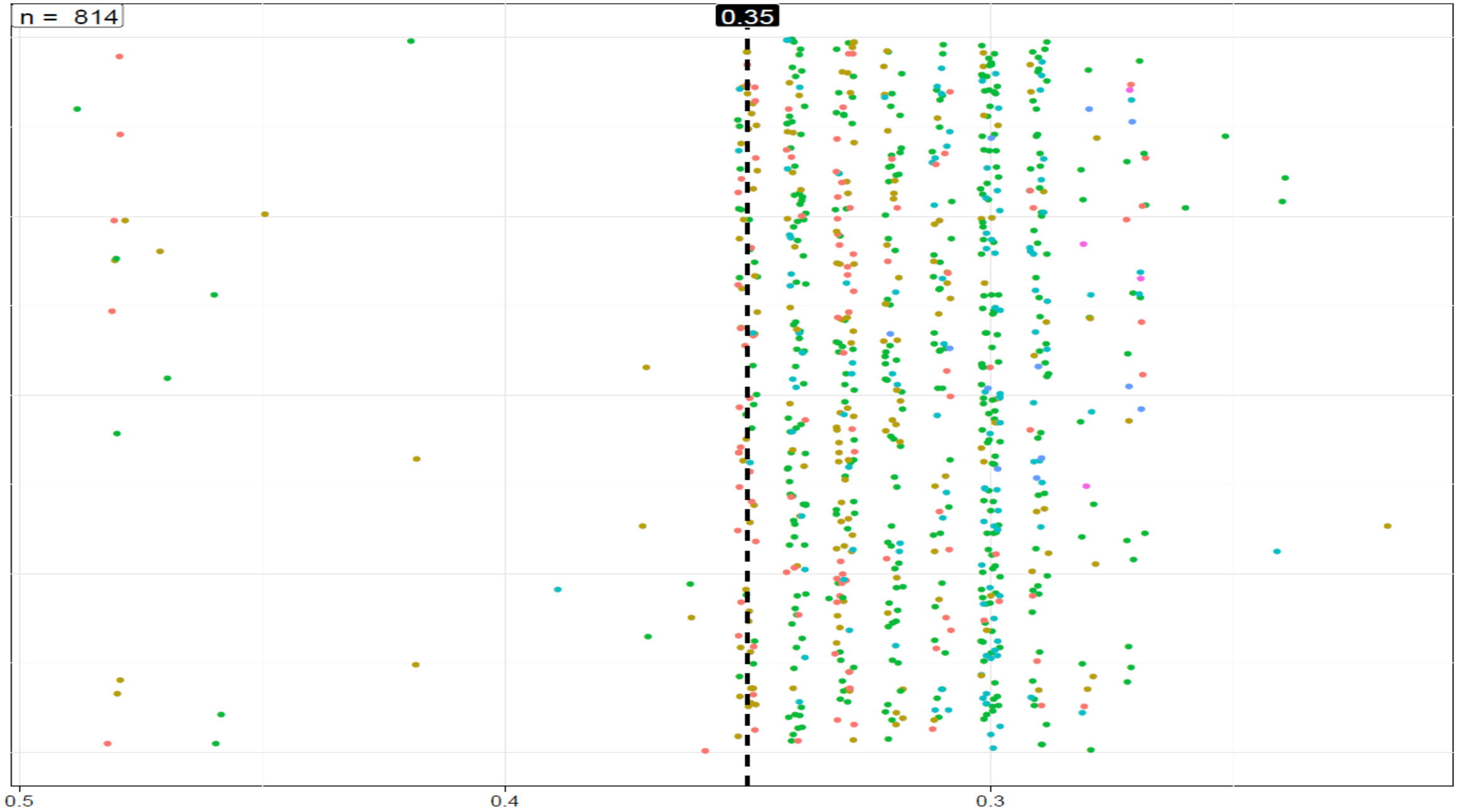


ENVELOPE TIGHTNESS

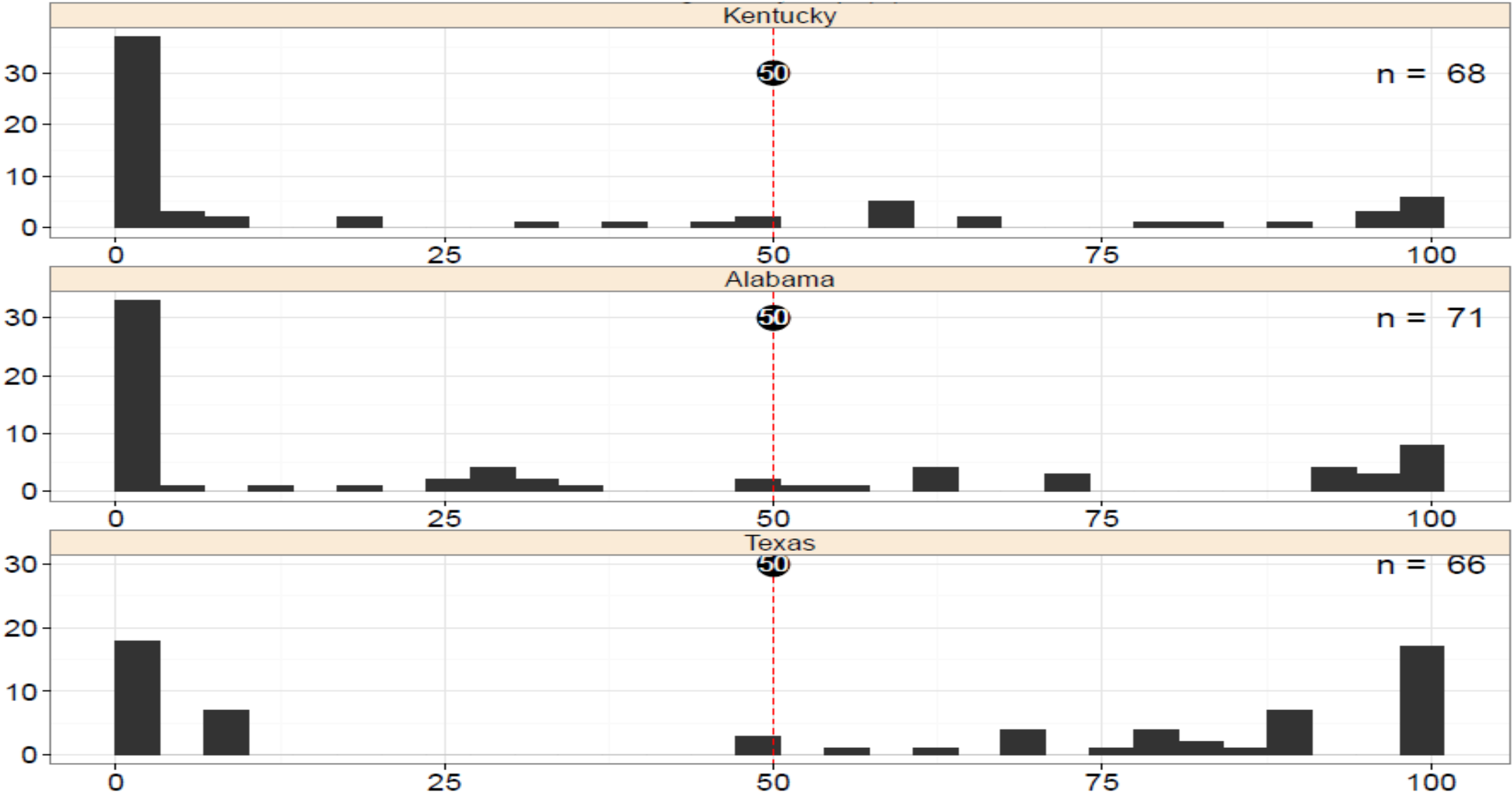
WALL INSULATION (cavity)



WALL INSULATION (assembly u-factor)



WINDOW (u-factor)



LIGHTING

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