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Building Energy Codes
U.S. DEPARTMENT OF ENERGY

Pacific Northwest
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Residential Energy Code Field Studies: Insights from the Field

2022 National Energy Codes Conference

Summer Seminar Series

Ian Blanding

Research Analyst

9/22/22

U.S. DEPARTMENT OF ENERGY BATTELLE

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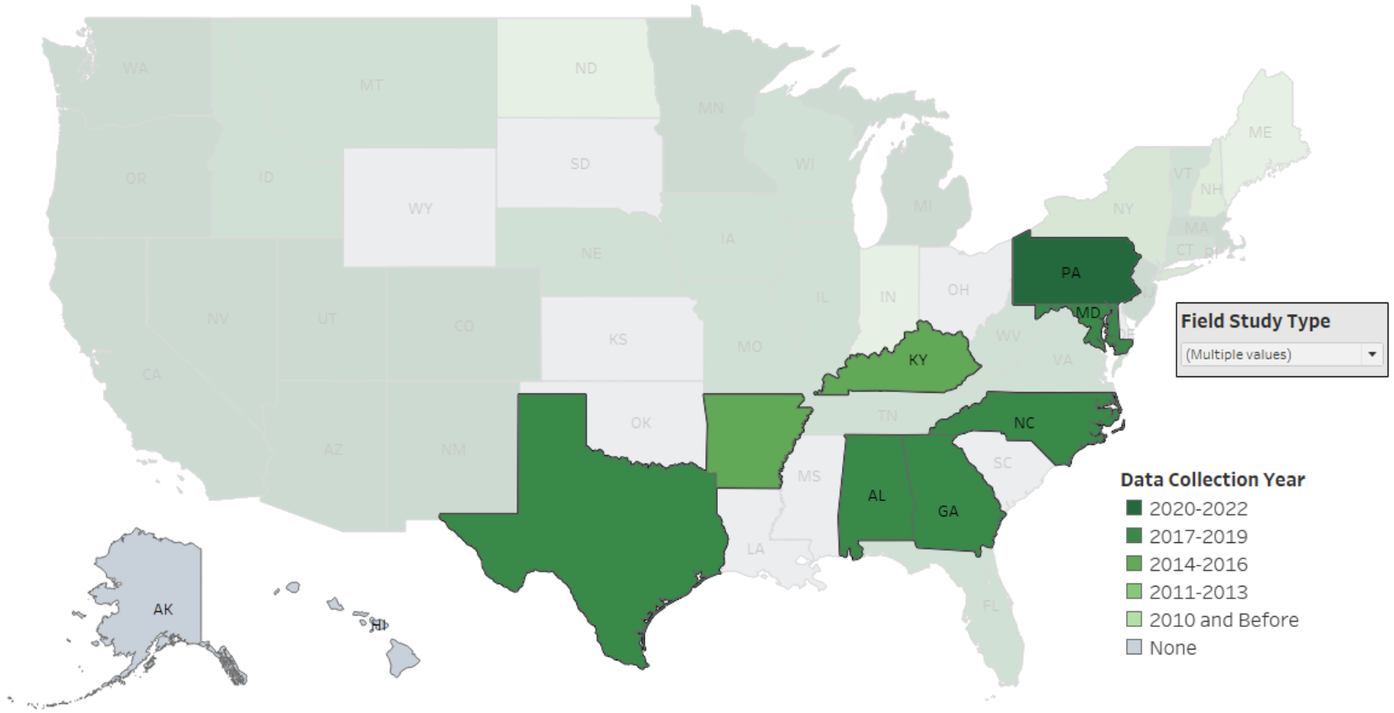
History of the Program

- As part of ARRA, code compliance was a critical metric to assess energy code impacts, resulting in several states conducting studies.
- In 2014, DOE funded 8 states to utilize a new methodology to assess the impacts of energy code compliance in residential single-family homes.
- To date, over 25 states have conducted field studies using a DOE methodology.



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Why conduct a field study?

1. Understand typical construction practices across states (e.g., foundation type, air leakage rates, insulation levels, etc.)
2. Calculate rates of non-compliance and identify specific measures to target education and training programs
3. Help validate expected savings from energy code adoption (e.g., E, $, CO2)
4. Support a business case for additional investments (e.g., utility programs)

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Key Measures

1. Foundation R-value and insulation installation quality (IIQ)
2. Wall R-value and IIQ
3. Ceiling/Attic R-value and IIQ
4. Window U-factor
5. Window SHGC
6. Envelope air tightness (ACH50)
7. Duct tightness (CFM25/100 ft2)
8. Percentage of high-efficacy lighting

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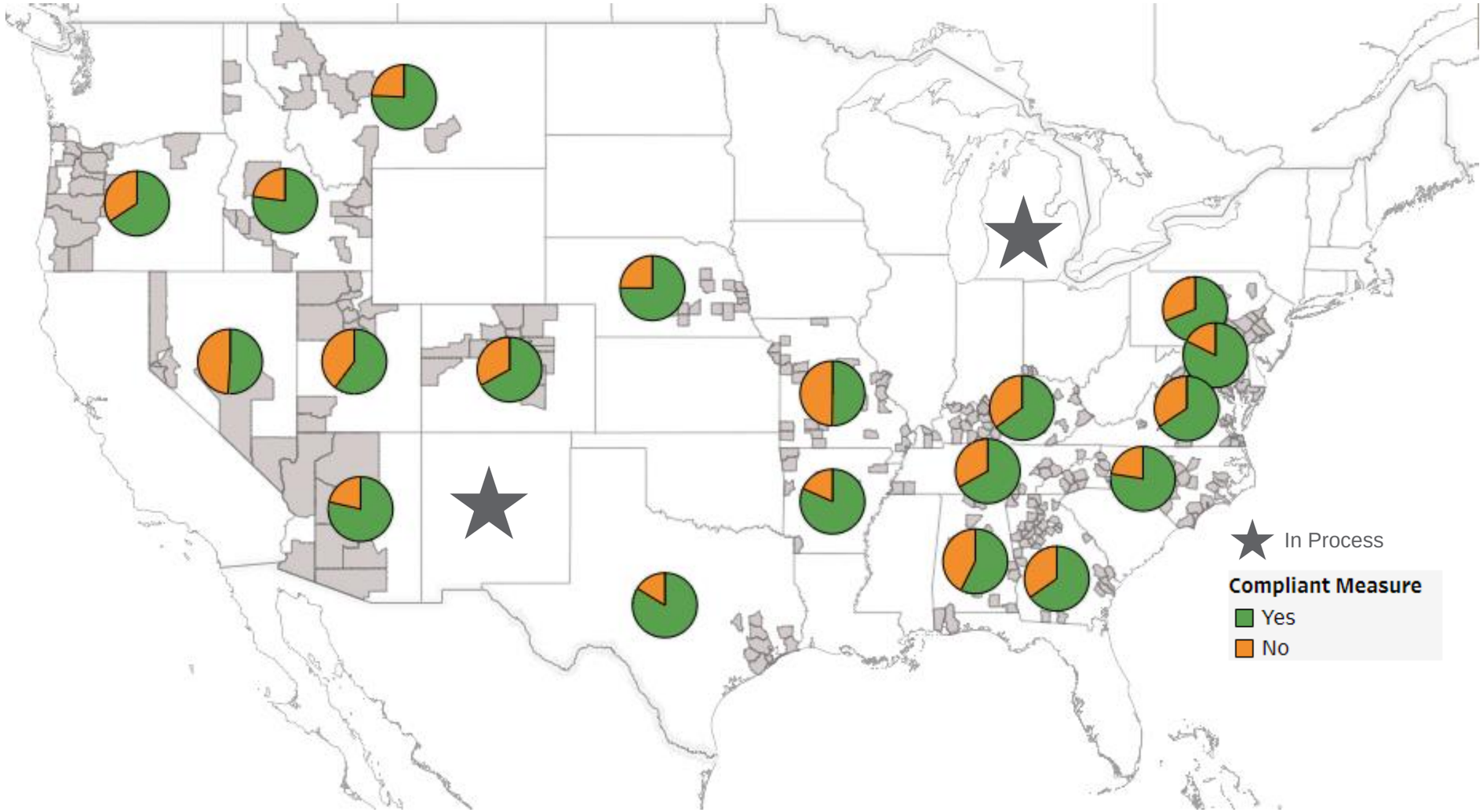
Results from Initial Studies

State	Annual Potential Savings		Statewide Savings Achieved from Phase II (Phase I – Phase III)	
	Phase I	Phase III	Annual Energy Cost Savings	% Change
Texas	$4,847,797	$1,243,958	$3,603,839	74.3%
Georgia	$4,516,678	$1,751,143	$2,765,535	61.2%
Maryland	$1,542,788	$311,414	$1,231,374	79.8%
Alabama	$1,299,382	$978,585	$320,797	24.7%
Kentucky	$1,219,856	$928,586	$291,270	23.9%
Pennsylvania	$3,198,846	$3,013,497	$185,349	5.8%
North Carolina	$2,025,958	$2,368,044	-$342,086	-16.9%
Total	$18,651,305	$10,595,227	$8,056,078	43.2%

So, where are we now?

Residential Energy Code Field Study Dashboard



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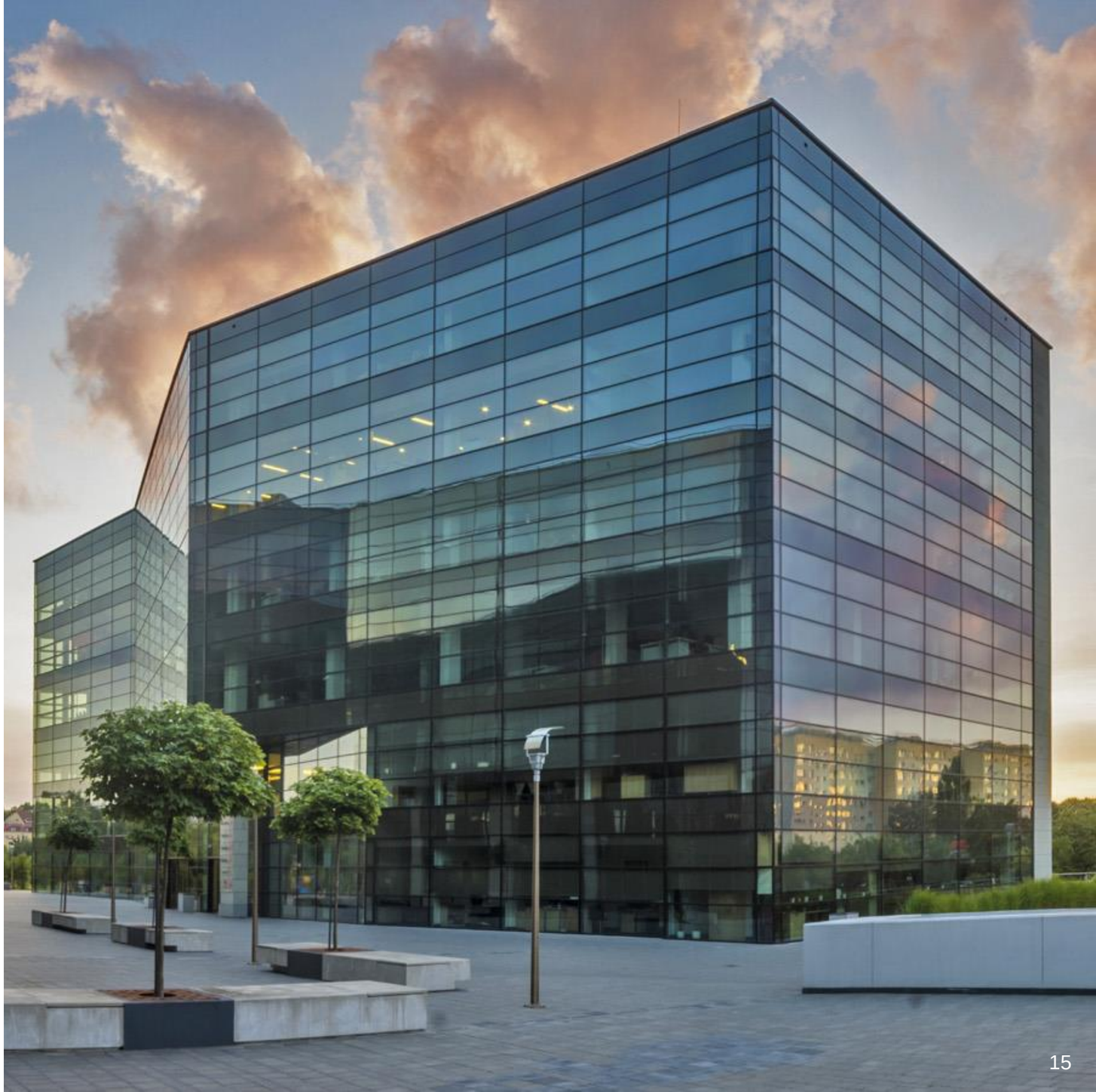
Thank you



Market Driven Residential Energy Codes: Comparing Performance in a Changing Technological Environment

Rob Vieira, Director, Buildings Research Division

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- **Christina Volpi, Jeremy Williams, Chris Perry, and Basu Kalpita**
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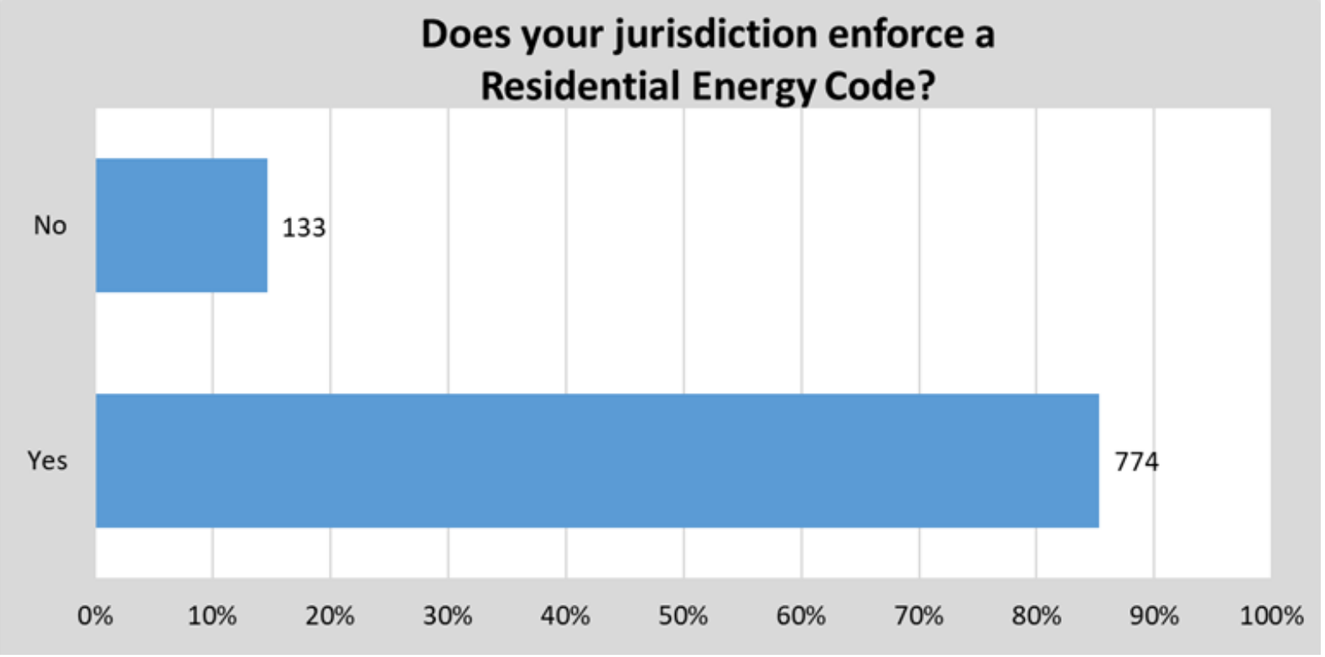
- A number of cooperating Utilities
- Southwest Energy Efficiency Project

Introduction

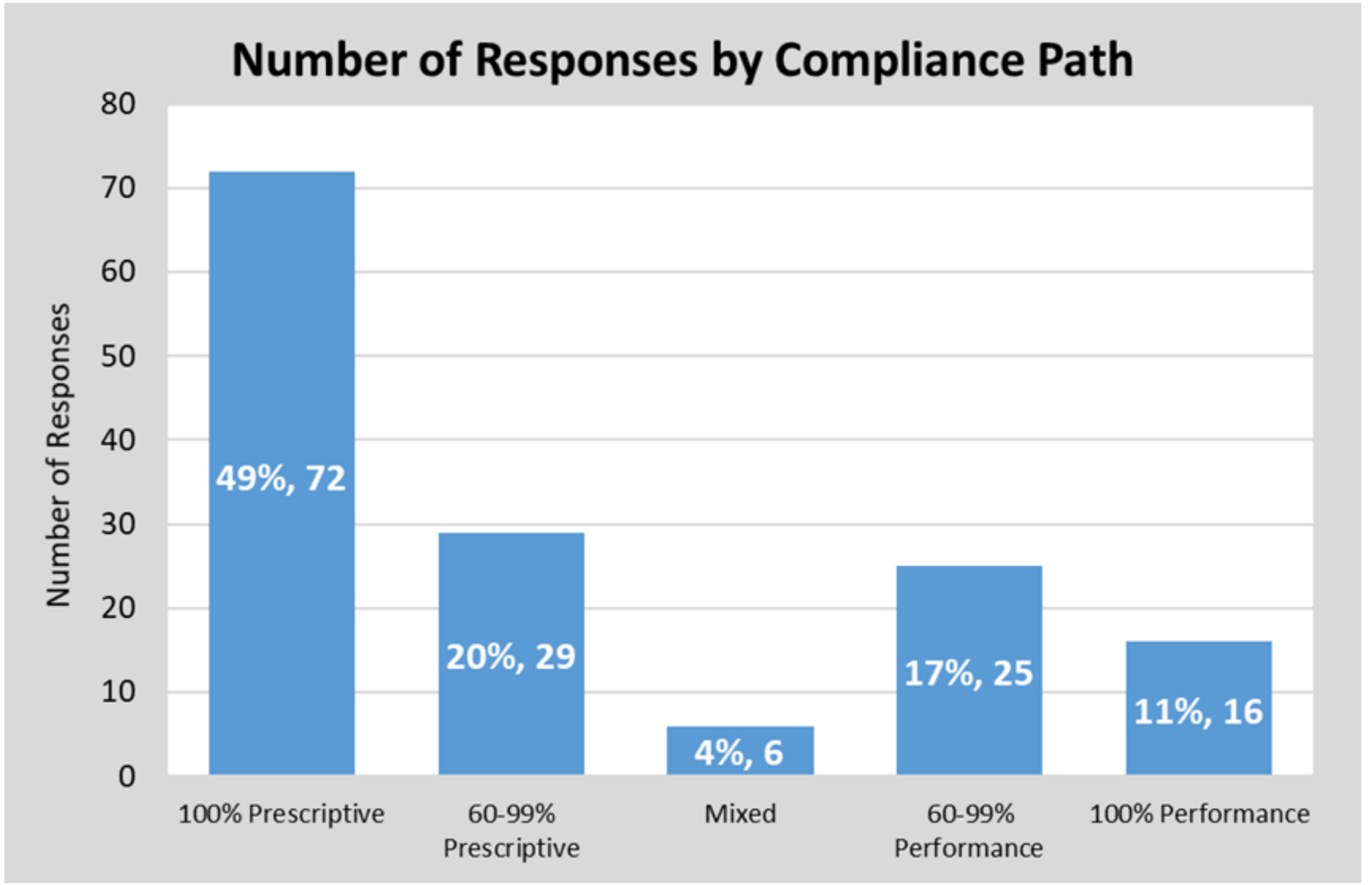
- Evaluate relative energy impacts for International Energy Conservation Code® (IECC®) compliant homes
  - Differentiating between prescriptive- and performance-based residential compliance methods
- Two research investigations in this presentation:
  - Survey of Building Officials' perception of performance differences, conducted February 18 to March 20, 2020
  - Utility data comparison in 2 locations where prescriptive and performance methods are used for comparable codes

Building Official Energy Code Officials Survey

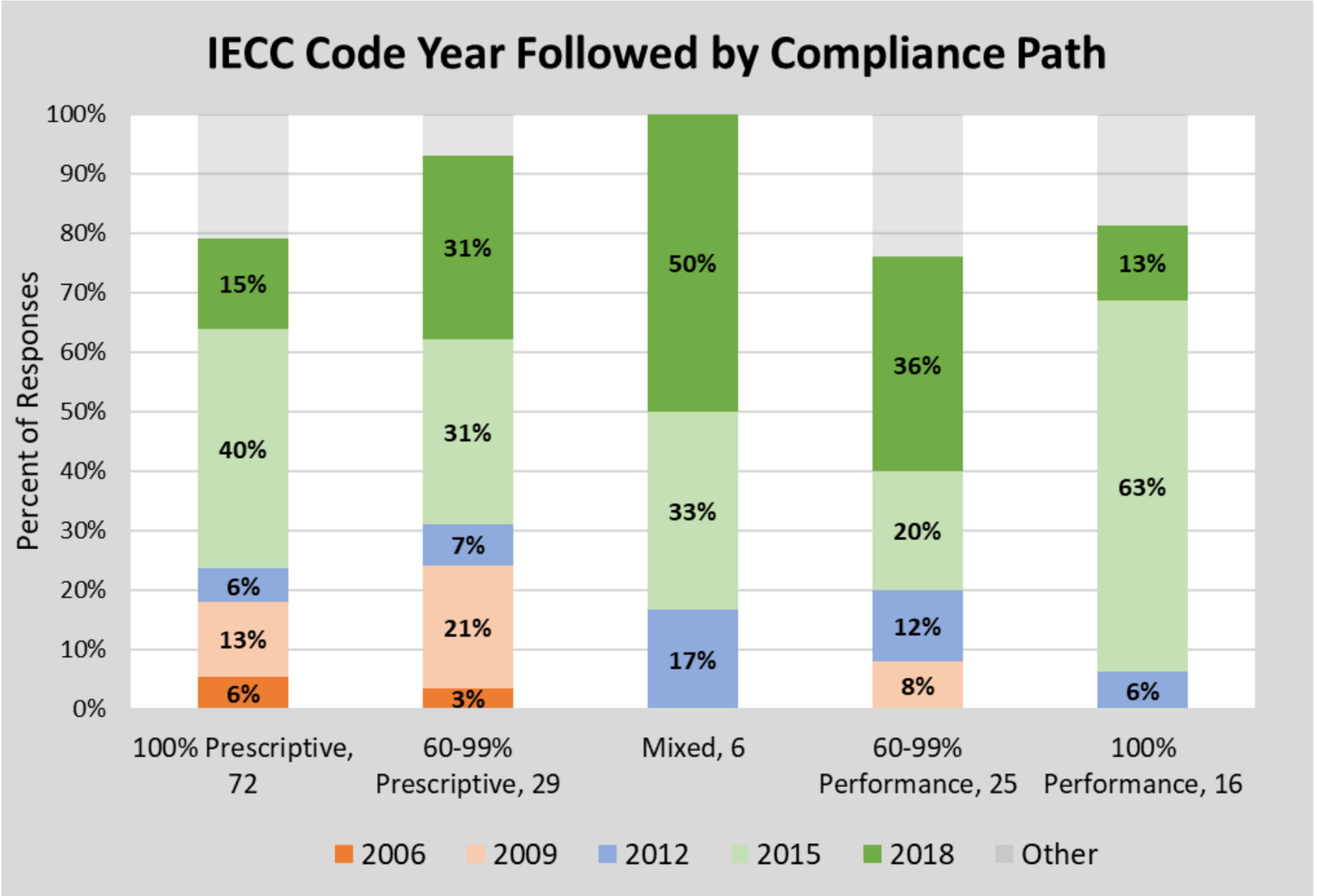
- 15% of respondents were from jurisdictions that do not enforce the Residential Energy Code (of 907 responses)
- 2015 International Energy Conservation Code (IECC) was most common (36%), 2018 IECC was second-most (26%) (of 640 responses)



Number of projects by compliance path:



Jurisdictions Following Older Code Followed the Prescriptive Path Most or All of the Time.



Code Official Opinions

- Why do builders choose the prescriptive path?

  Prescriptive is easier

- How much time spent at design, on-site, and follow-up?

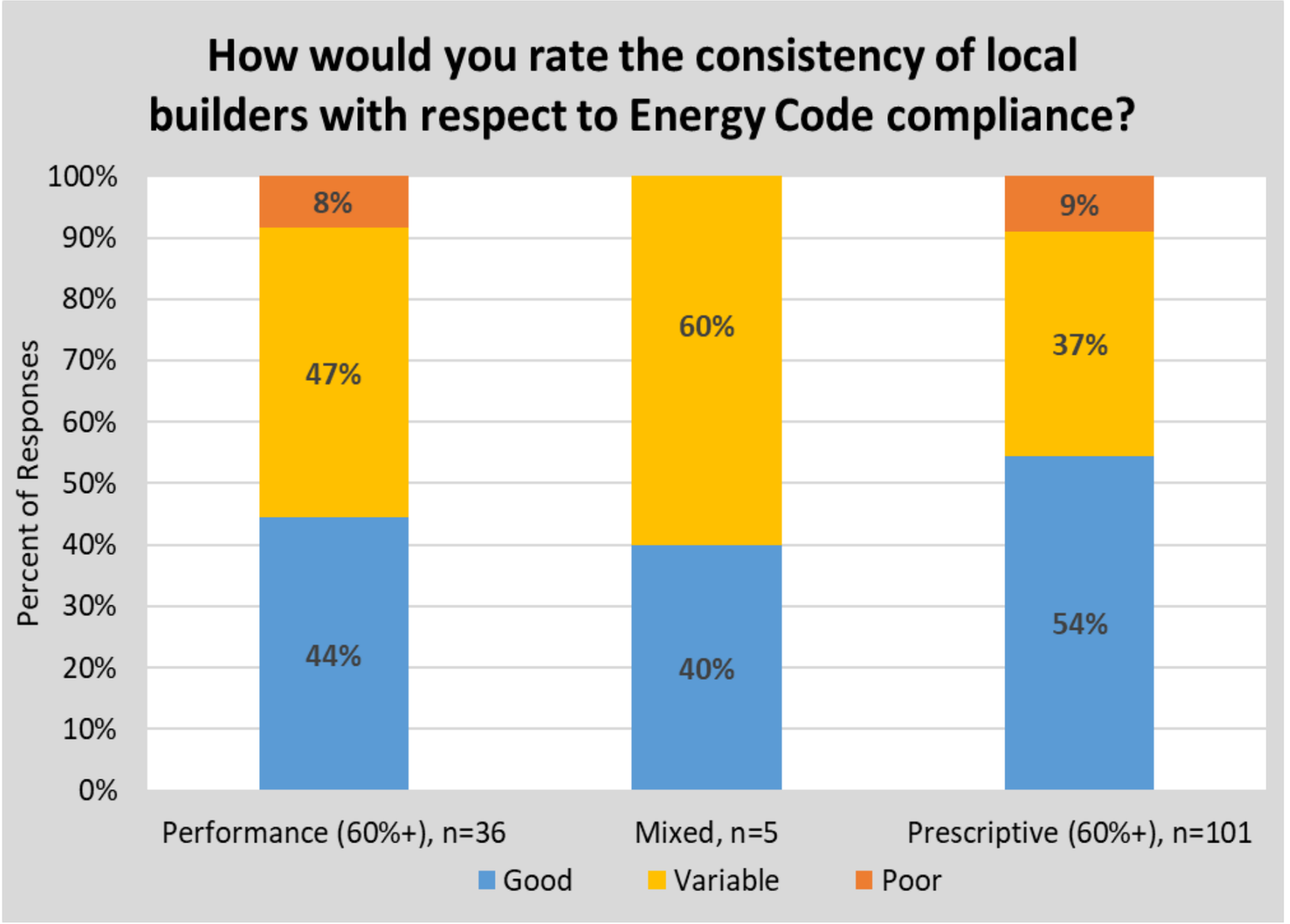
  Prescriptive total about 2 hours

  Performance total about 3 hours

- Which compliance method takes longer to verify?

  Mixed, but the most popular answer was that performance takes longer (44%)

Officials Opinions of Builder Consistency



Utility Bill Comparison

- Utility bill evaluation of two locations in climate zone 5 with both performance and prescriptive compliance methods:
  Fort Collins, Colorado and Iowa
- Data collection limitations due to restrictions to protect homeowner identification
  - Colorado
    - State-level data release restrictions required ‘binning’ of homes into 15+
  - Iowa
    - Utility required binning homes into 5+

3 Cohorts of Compliance in Fort Collins

- Homes achieved energy code compliance via:
  - **Prescriptive, R-Value** – meeting or exceeding specific energy code minimums, such as R-values and U values in Sections R401 through R404 of the IECC.
  - **Prescriptive, REScheck** – demonstrating compliance per the Total UA Alternative (Section R402.1.5) methods using RES*check*™ software.
  - **Performance** – using a computer simulation tool to model the annual energy cost of the proposed design for comparison to a code-compliant reference building's energy cost by Section R405 Simulated Performance Alternative (Performance) or Section R406 Energy Rating Index (ERI) Compliance Alternative.

Fort Collins Data Groups

- Bins differentiated by compliance method, code year, and residence type
  - 2015 IECC Code year, attached
  - 2015 IECC Code year, detached
  - 2018 IECC Code year, attached
  - 2018 IECC Code year, detached

Fort Collins Bins

- Ultimately, monthly energy use data for 39 bins were received, each bin comprises similarly sized homes, representing 731 homes

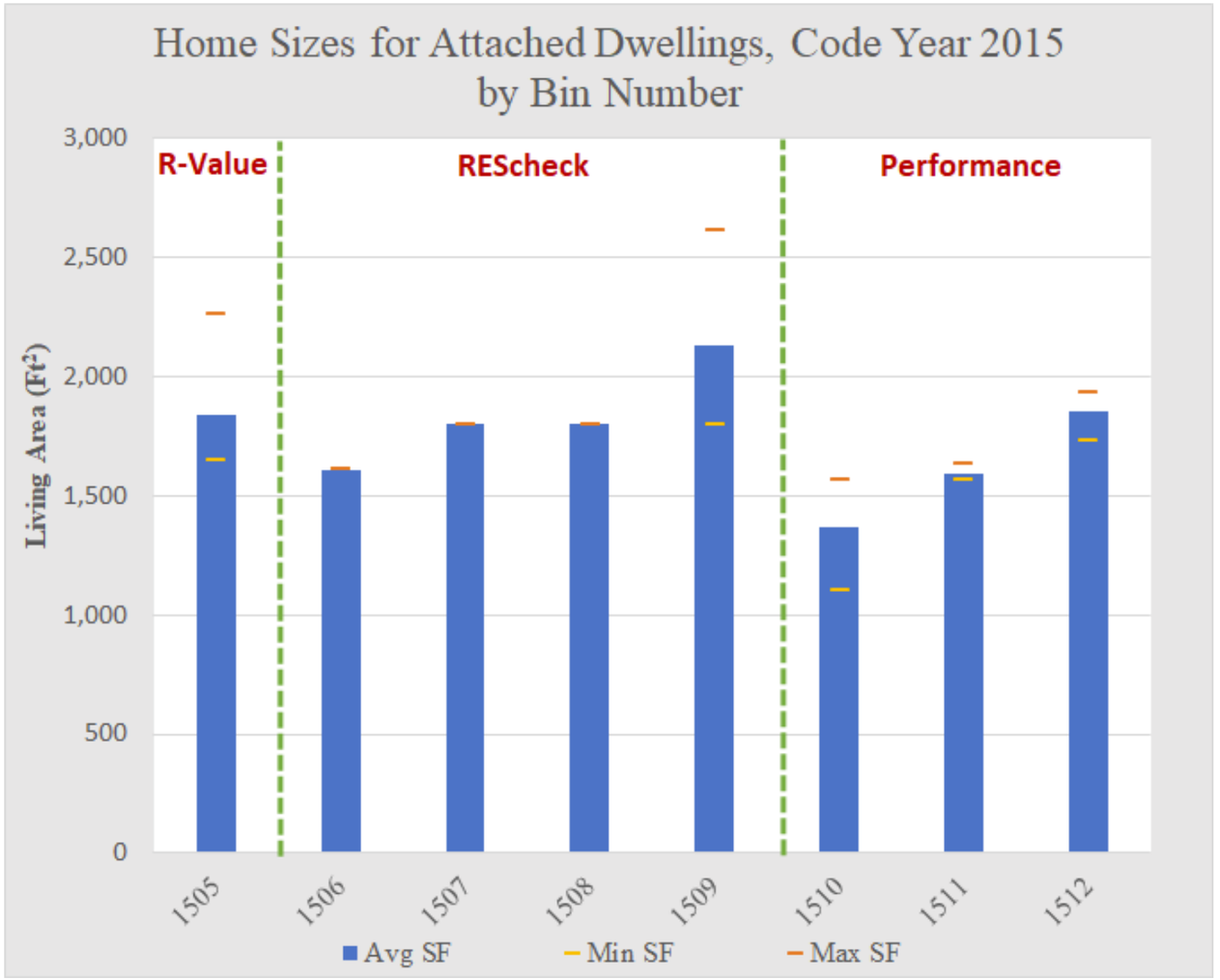
Breakdown of Bins

Type of Home	Performance	Prescriptive, R-Value	Prescriptive, REScheck	Total
Code Year 2015				
Attached	3	1	4	8
Detached	8	3	10	21
Code Year 2018				
Attached	2	0	2	4
Detached	3	0	3	6
Total	16	4	19	39

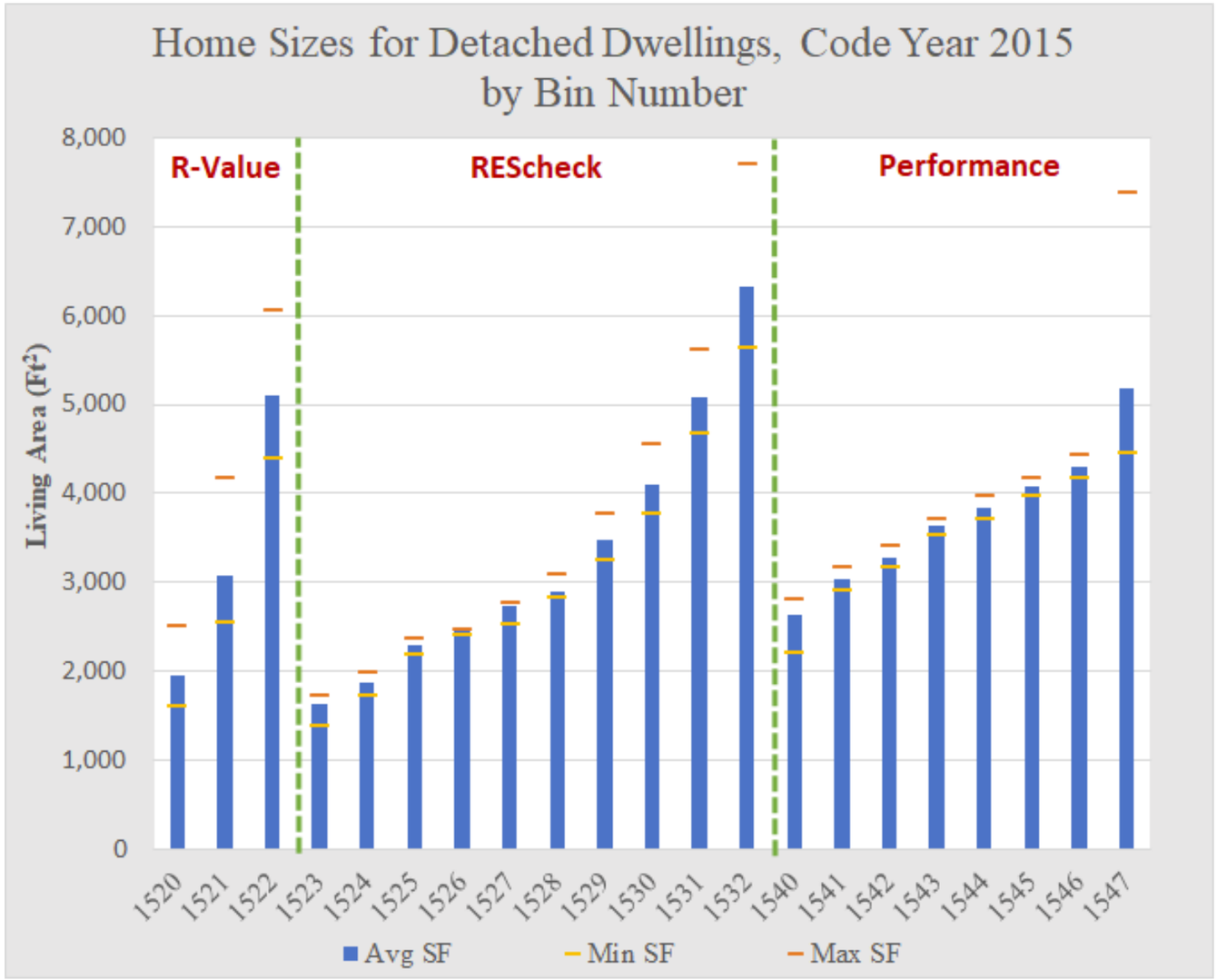
Monthly Data

- Utilities normalized data by calendar month
- Provided number of homes in bin for each month
- Provided standard deviation, minimum and maximum usage for each bin each month
- Provided monthly average usage for each bin

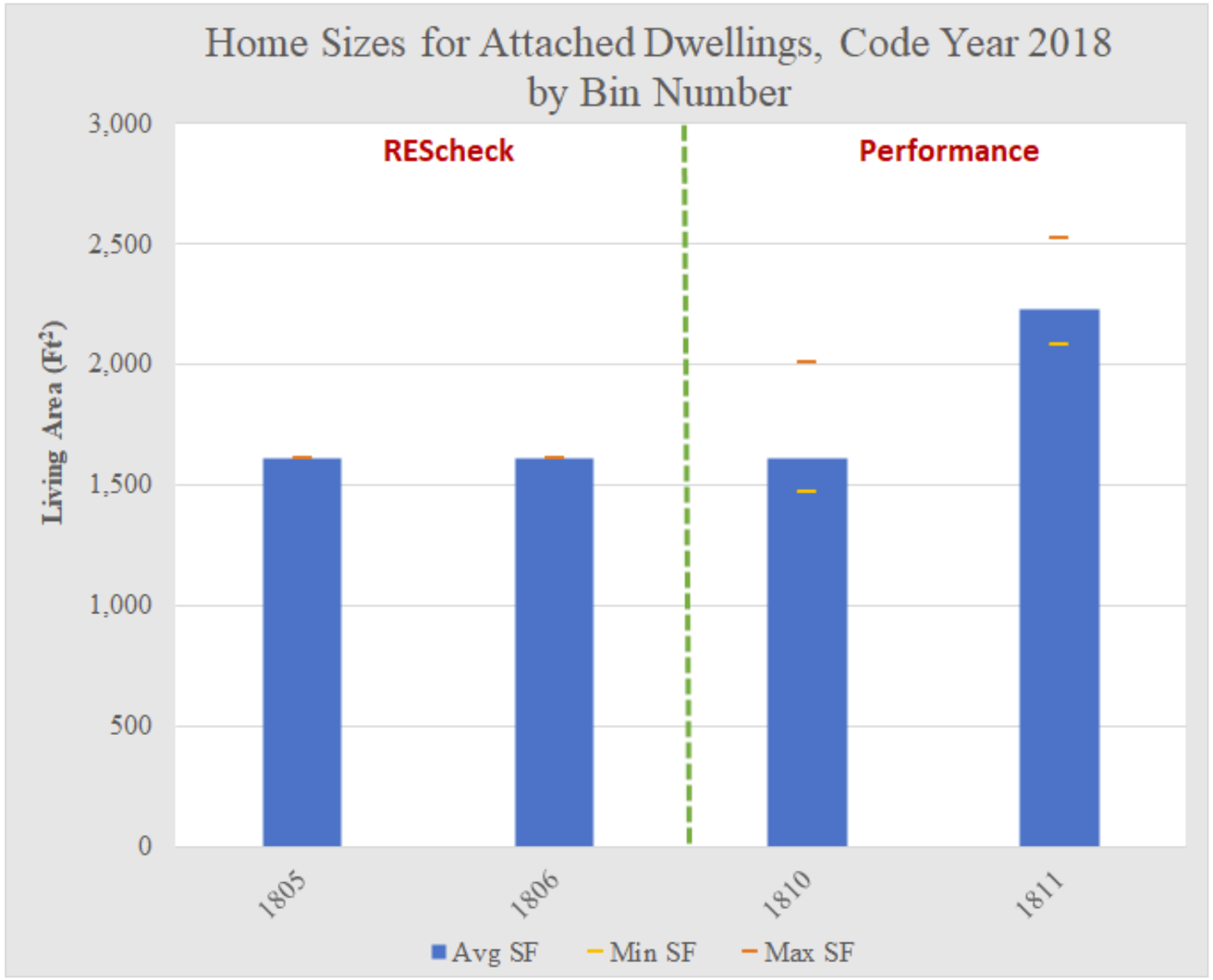
2015 IECC Attached Bins by House Size



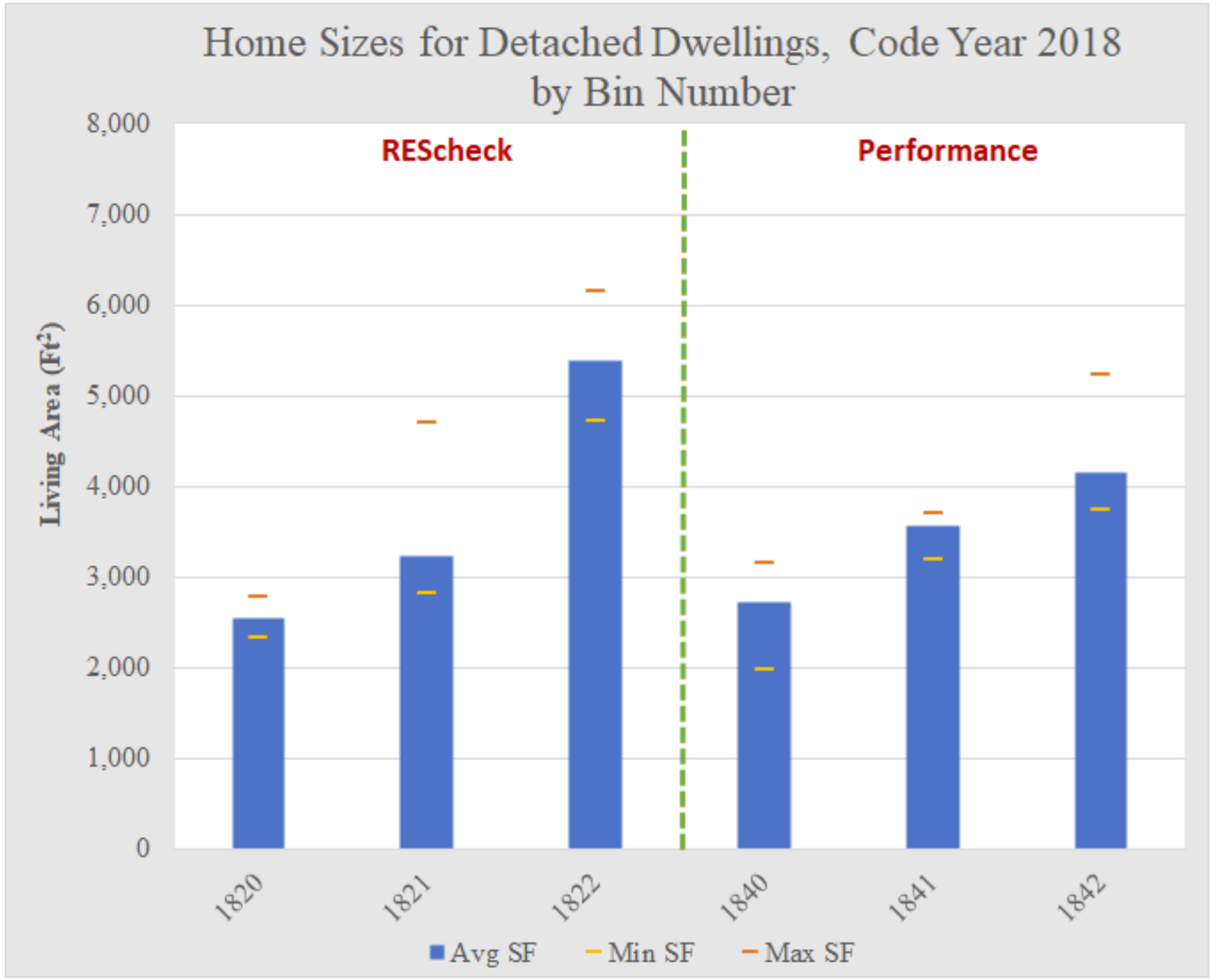
2015 IECC Detached Bins by House Size



2018 IECC Attached Bins by House Size

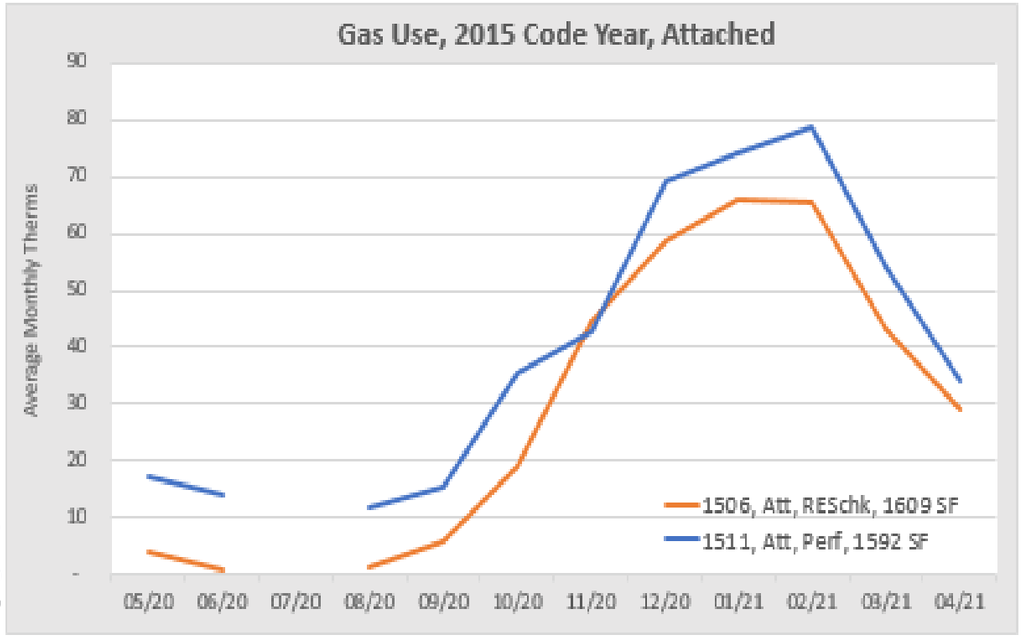


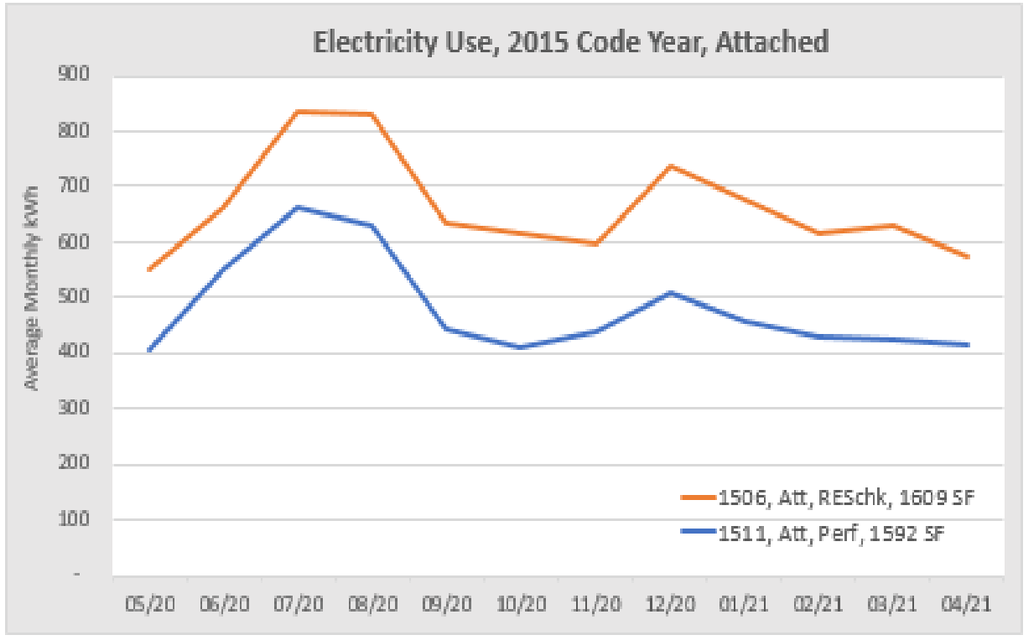
2018 IECC Detached Bins by House Size



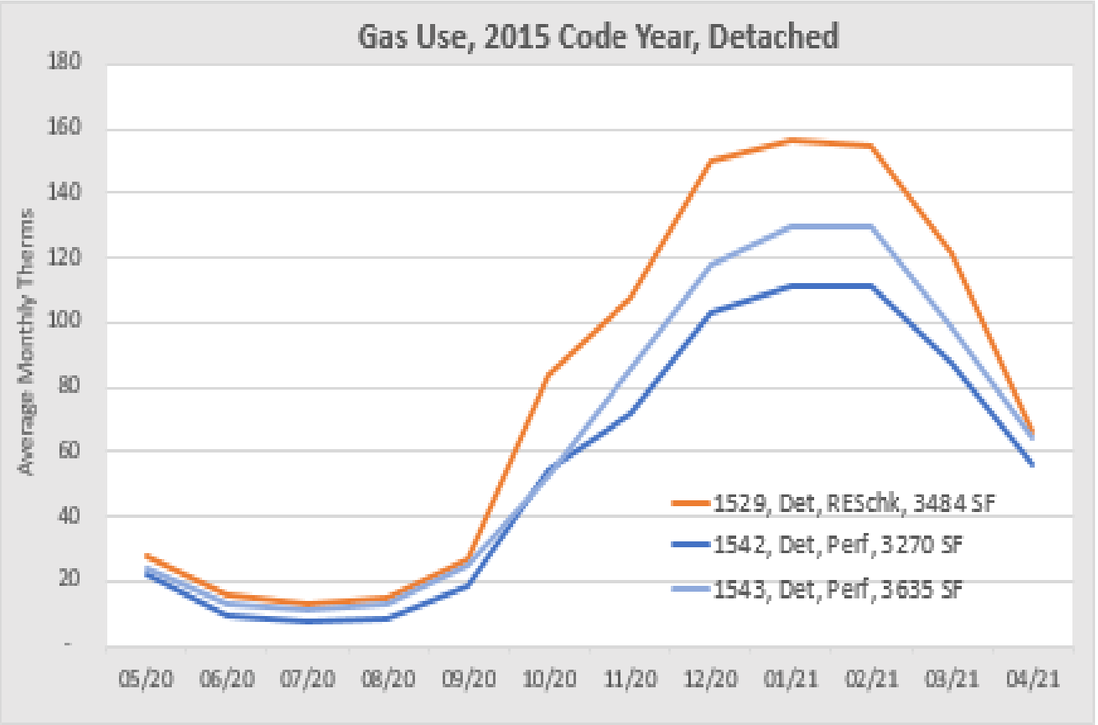
Attached Bin Comparison

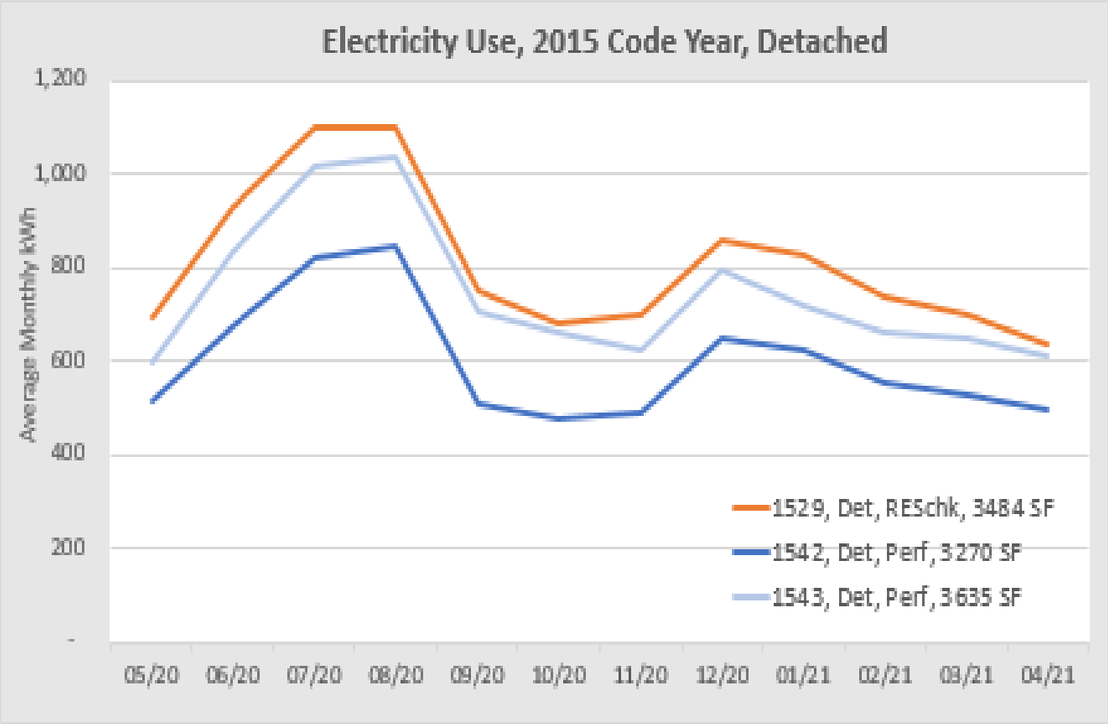
- Bins carefully selected to include homes of same type and similar size.
- Smaller attached homes example with Performance using more gas, but less electricity. However, Bin 1506 is known to comprise homes with electric water heating.



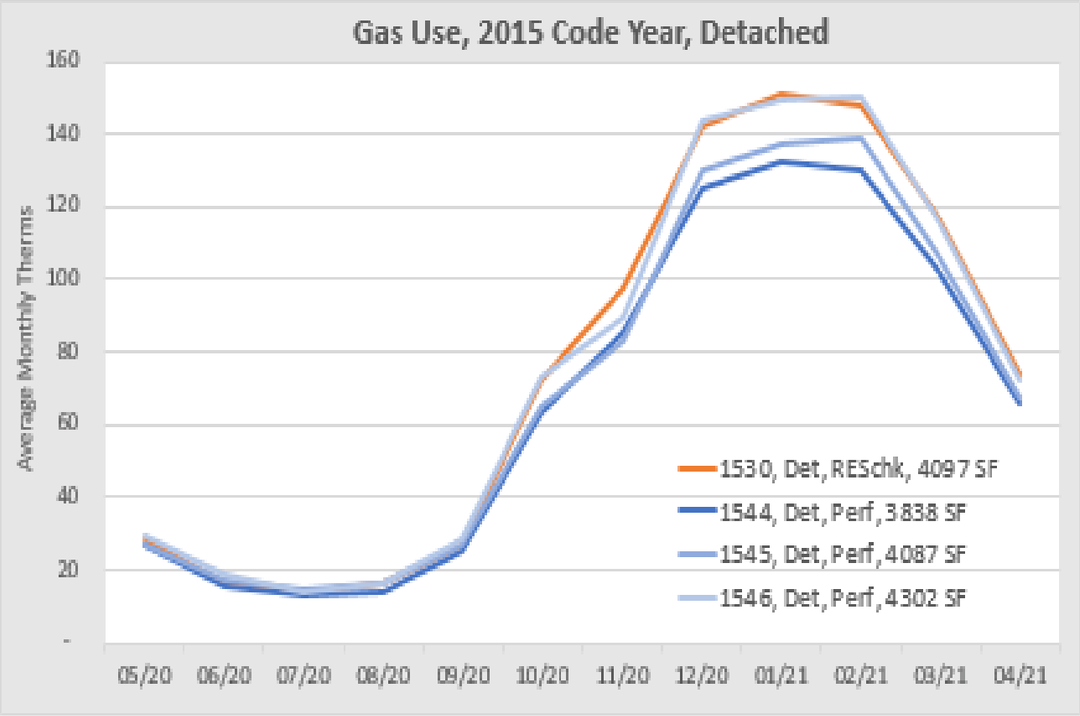


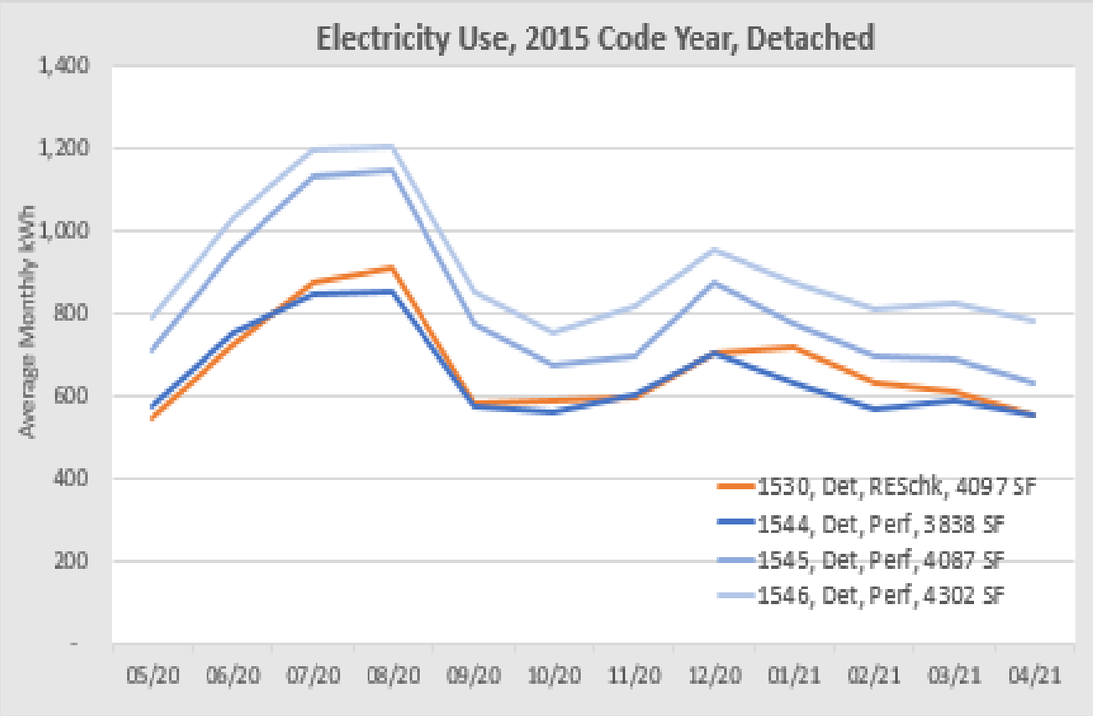
Comparing Detached Bins of ~ 3500 ft²



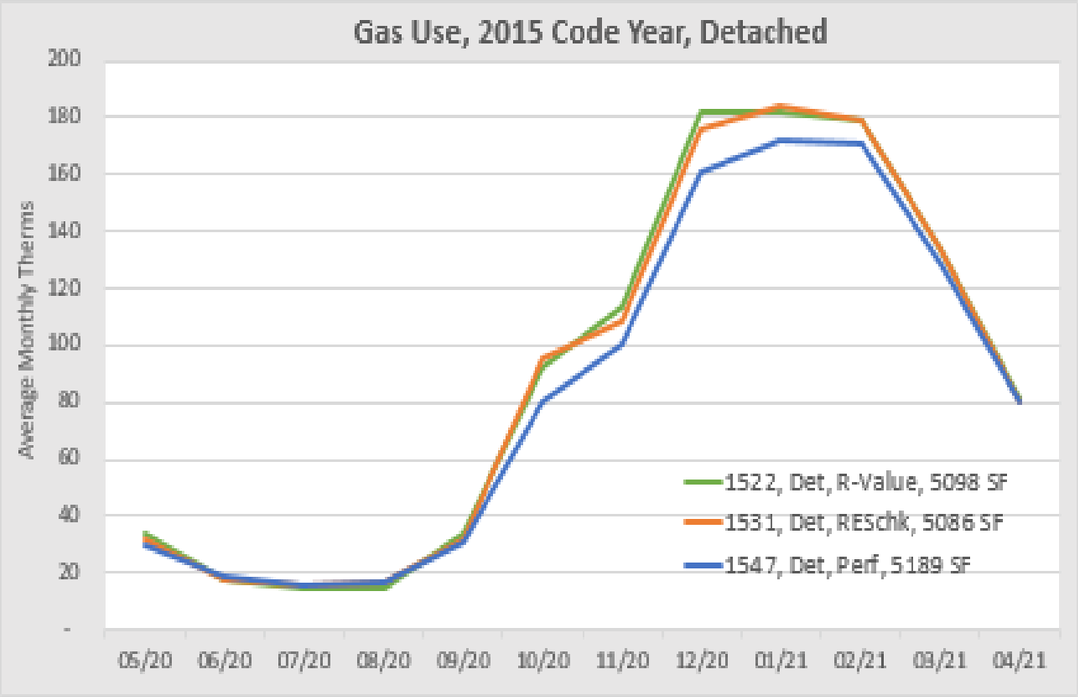


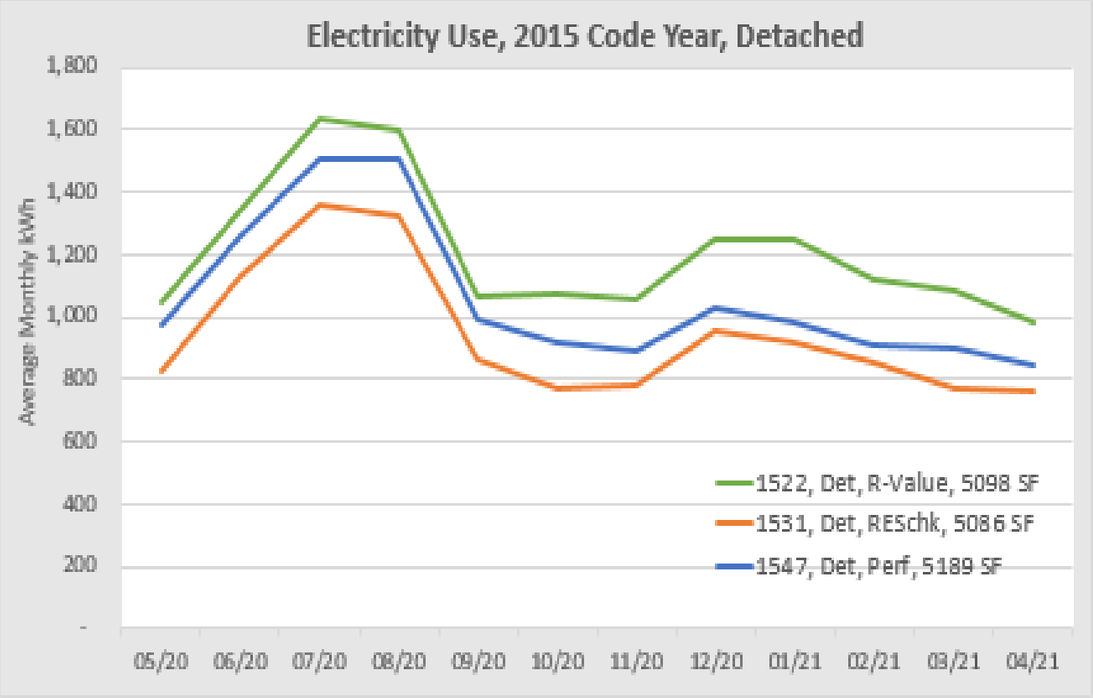
Comparing Detached Bins of ~4000 ft²





Comparing Detached Bins of ~5000 ft²





Regression Analysis Ft. Collins

GAS

	2015 IECC, Attached			2015 IECC, Detached			2018 IECC, Attached		2018 IECC, Detached	
	Performance	RES check	R-Value	Performance	RES check	R-Value	Performance	RES check	Performance	RES check
Relative to:										
Performance		-1			1	1				
REScheck	1			-1						
R-Value				-1						
% Gas DHW	1.00	0.75	1.00	1.00	0.53	1.00	1.00	-	1.00	0.55
Electrical Tape		x	x							

ELECTRIC

	2015 IECC, Attached			2015 IECC, Detached			2018 IECC, Attached		2018 IECC, Detached	
	Performance	RES check	R-Value	Performance	RES check	R-Value	Performance		Performance	
Relative to:										
Performance		0.5	-0.5			1				
REScheck	-0.5								-0.5	
R-Value	0.5			-1						
% Electric DHW	-	0.25	-	-	0.47	-	-	1.00	-	0.45
Electrical Tape		x	x							

	No significance
-0.5	Marginally significantly less
-1	Significantly less
0.5	Marginally significantly more
1	Significantly more

X ➔ Possible Electrical Tape on Condensate Line: ~5% of R-Value cohort
About 65% of the REScheck cohort

Home Size is Significant

- For both code years, larger detached homes used significantly more gas and electricity than smaller homes, with home size being more significantly related to gas use than electricity use. Home size was not statistically significant for the attached houses where the size range was small.

Model Projected 6 month Gas Use

Therms for Mean Home Size, Assuming 100% Gas DHW

Group	RValue to Perf.	Perf to RValue	RESChk to Perf.	Perf to RESChk	RValue toRESChk	ResChk to RValue
2015 Attached	No Sig. Difference	No Sig. Difference	264	384	No Sig. Difference	No Sig. Difference
2015 Detached	709	631	710	616	No Sig. Difference	No Sig. Difference

Model Projected Annual Electricity Use

kWh for Mean Home Size, Assuming 100% Gas DHW

Group	RValue to Perf.	Perf to RValue	RESChk to Perf.	Perf to RESChk	RValue to RESChk	ResChk to RValue
2015 Attached	6003	6846	9403	5955	No Sig. Difference	No Sig. Difference
2015 Detached	10414	8875	No Sig. Difference	No Sig. Difference	No Sig. Difference	No Sig. Difference
2018 Attached	No Sig. Difference	No Sig. Difference	No Sig. Difference	No Sig. Difference	No Sig. Difference	No Sig. Difference
2018 Detached	No Sig. Difference	No Sig. Difference	9353	8733	No Sig. Difference	No Sig. Difference

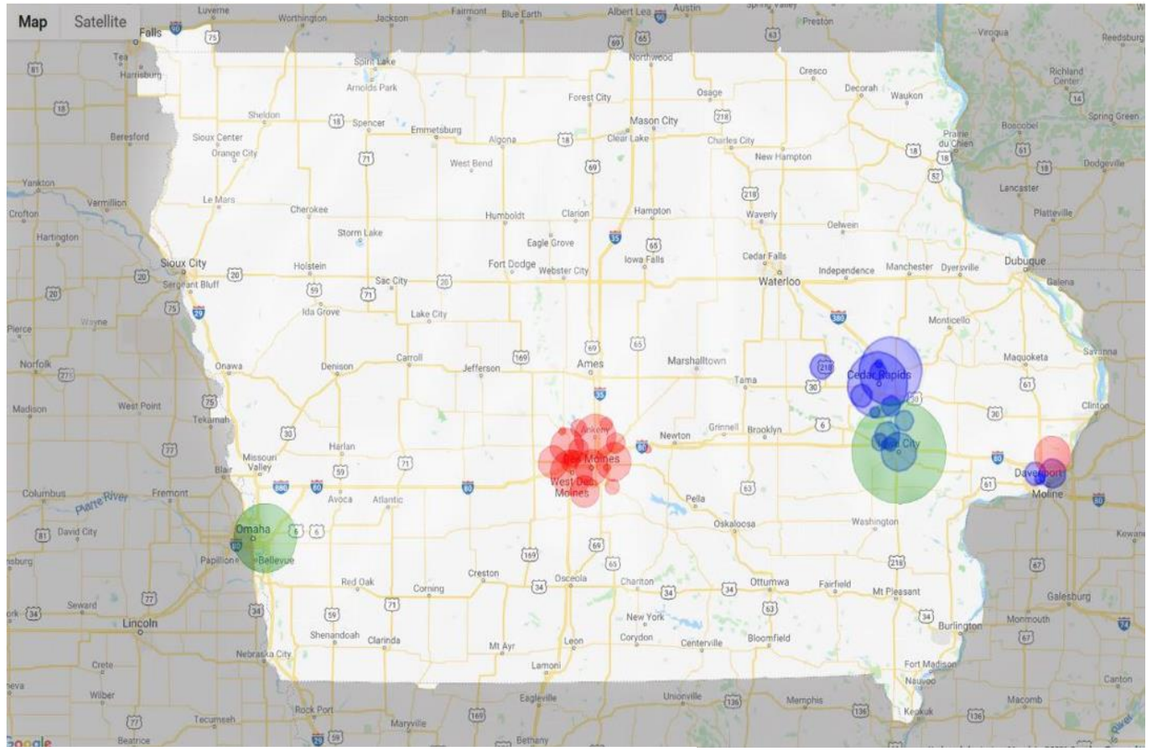
Conclusions from Ft. Collins Utility Data

- Bottom line: There is unlikely a huge prevalent difference in energy use based on compliance method. However, we cannot conclude that the methodologies are equal.

Iowa Utility Bill Compliance Cohorts

- Homes achieved energy code compliance via:
  - **Prescriptive** – meeting or exceeding specific Energy Code minimums using the R-value, U-factor Alternative or Total UA Alternative methods as required in Sections R401 through R404 of the 2012 IECC.
  - **HERS+ Prescriptive** – meeting compliance per the U-factor Alternative or the UA Tradeoff methods, and also including a Home Energy Rating System (HERS) index rating.
  - **Performance** – using a computer simulation tool to model the annual energy cost of the proposed design for comparison to a Code-compliant reference building's energy cost as required in Section R405 Simulated Performance Alternative (Performance).

Iowa Data



Legend:
Red is Performance, purple is HERS+ Prescriptive, green is Prescriptive

- Ultimately, monthly energy use data for 130 bins representing 754 homes were received.

Breakdown of Bins

	Performance	HERS+ Prescriptive	Prescriptive	Total
Bins with Electric Data	9	41	44	94
Bins with Gas Data	45	41	44	130
Bins having both Gas & Electric Data	9	41	44	94

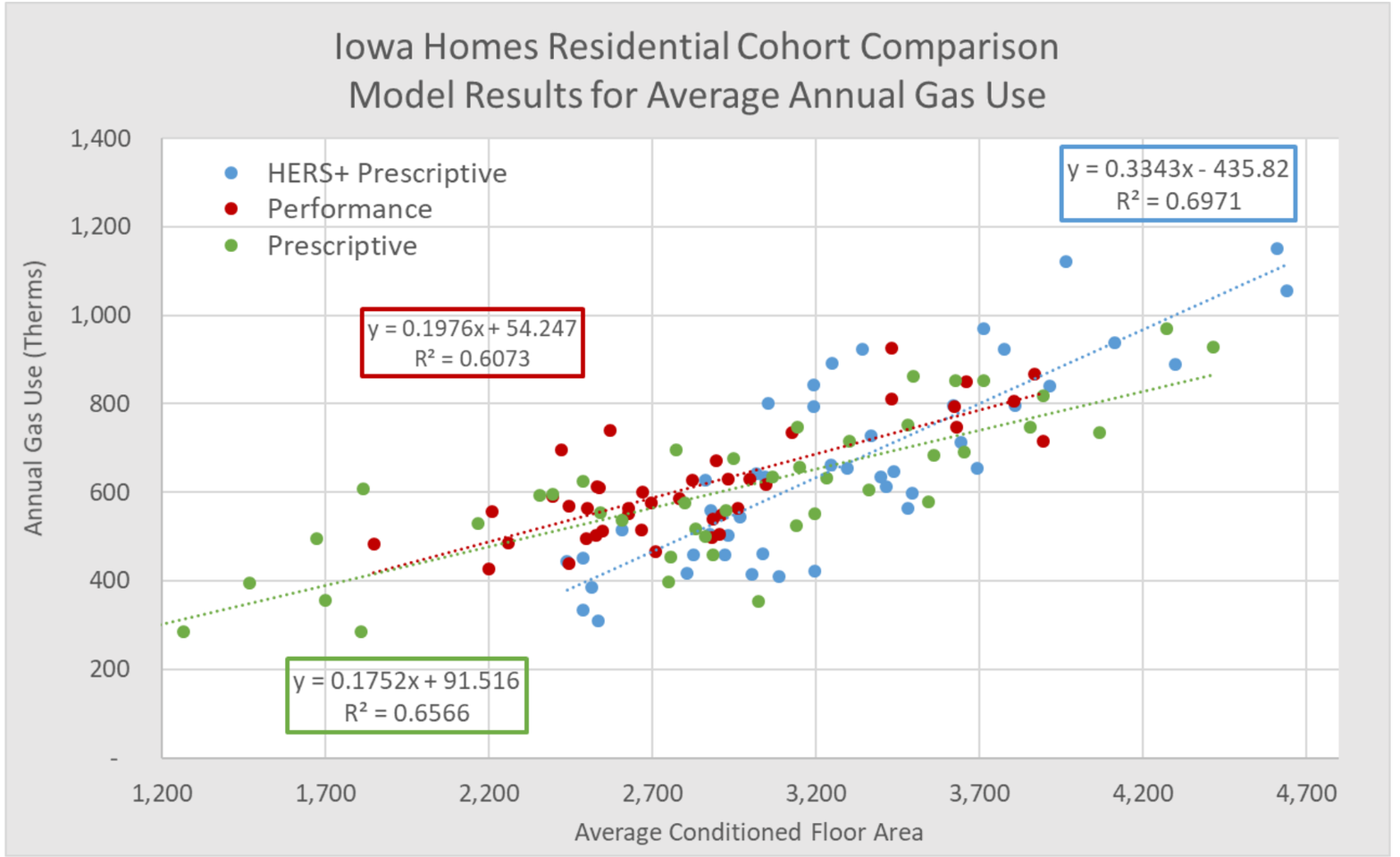
Iowa Home Characteristics

	Characteristic	HERS +	Performance	Prescriptive
	Average CFA (Ft^2)	3,288	2,846	2,898
	Min CF (Ft^2)	2,160	891	1,057
	Max CFA (Ft^2)	5,247	4,674	4,848
	Average Number of Stories	1.1	1.5	1.3
	Average Number of Bedrooms	3.6	3.4	4
Home Count with Foundation Type:	Conditioned Basement	261	221	222
	Slab on Grade		18	32
Home Count with Housing Type:	Single Family	219	193	254
	Townhouse Interior		11	
	Townhouse Exterior	42	10	
	Duplex		25	

Iowa Results by Fuel

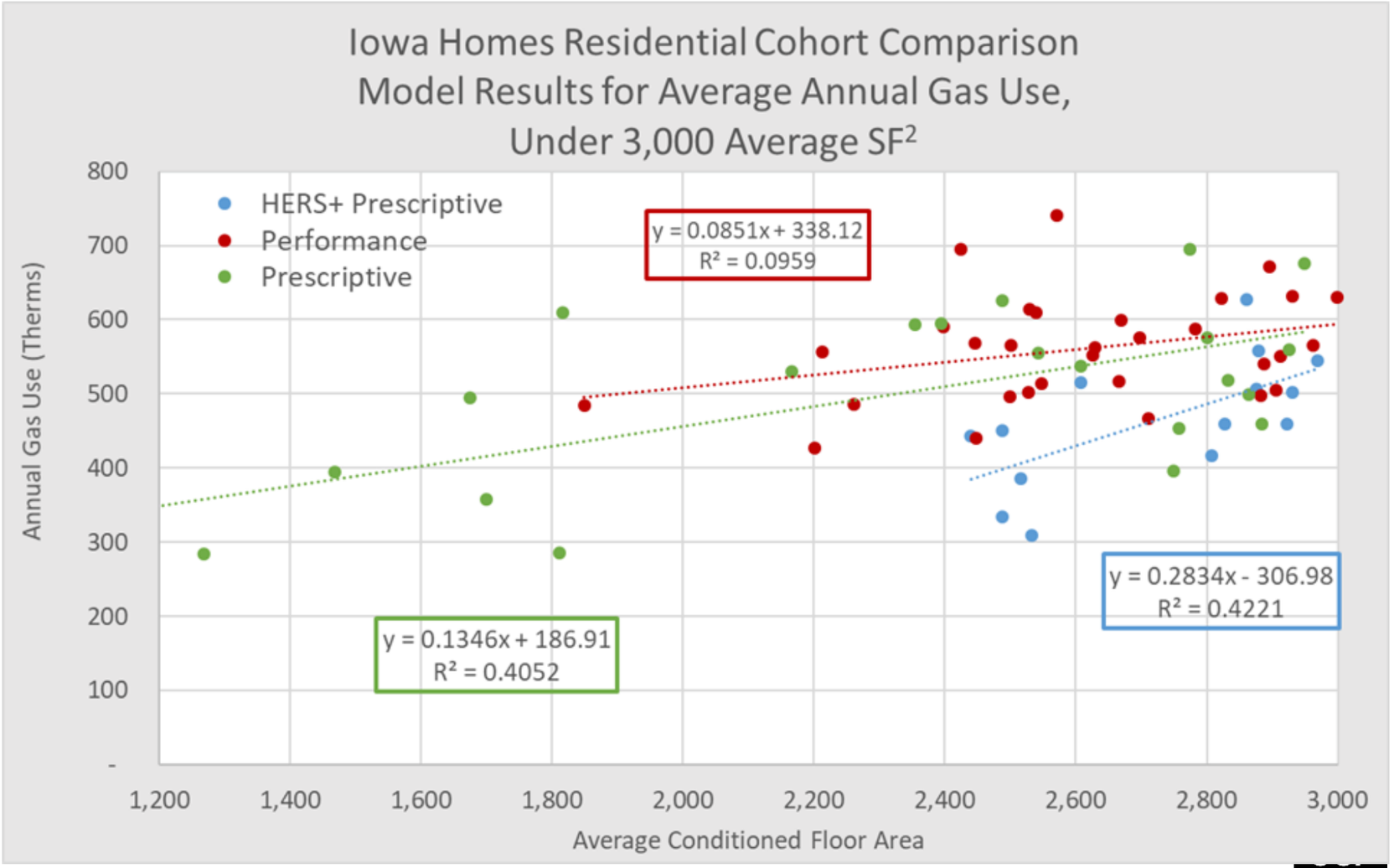
- The available characteristics were *very poor* at predicting *electricity* use.
- The model for predicting natural gas usage was moderately strong.
- And when electricity and gas energy use were translated into kBtu and combined per bin, prediction strength was much weaker than predicting gas use alone.
- Iowa analysis focuses on winter gas usage.

All Iowa Homes Gas by Path



Iowa Results of Homes < 3000 ft2

- Smaller home segment of bins had limited findings…



Iowa Smaller Home Results

- Cohorts of smaller homes (<3,000 Ft2) complying by the 2012 IECC
  - HERS+ path used statistically significantly less gas and electricity than Performance cohort. Caveat: Regression strength is weak
  - HERS+ path used marginally statistically significantly less gas than Prescriptive cohort.

Summary Page 1

- Compliance path in many jurisdictions is dominated by one method.
- In locations where there are multiple types, building jurisdiction personnel on average believe it takes more personnel time for performance relative to prescriptive.

Summary Page 2

- In two climate-zone-five regions studied, compliance path was not *consistently* significant in determining energy use of occupants.
- However, in some cases there were statistical significances.

Summary Page 3

- HERS+ path homes in Iowa used less gas than performance or prescriptive for homes under 3,000 square feet
- In Ft. Collins, detached homes complying by the Performance method used both less gas and electricity than the homes complying with REScheck or the R-value method when there was a statistical difference. Attached homes did not follow these results.

Future Study

- Different Climate Zones
- **Very large samples required due to binning**
- Utility cooperation required
- How to account for fact that each builder in an area typically complies using one method?
- Does exceeding code matter (lower UA total than required, lower ERI or Performance ratio)?

Reports

Available Project Reports
Market Driven Residential Energy Codes - Compliance Path Enforcement Costs [based on survey results]
Relative International Energy Conservation Code (IECC) Energy Impacts by Compliance Path [simulation]
Market Driven Residential Energy Codes: Comparing Performance in a Changing Technical Environment Code Official Survey Results [survey report]

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