

HERS-2 and Measured Home Performance



California Energy Commission

DOCKETED
12-EBP-1

TN # 67700

OCT. 12 2012

Has HERS-2 met its goals, and does it accurately model Home Performance?

Mike MacFarland, Energy Docs
2012 Forum on Dry Climate Home Performance

California Energy Commission

- CEC is required by Public Resources Code Section 25942 to establish criteria for a statewide home energy rating program for residential dwellings



Statewide Home Energy Program

- “The goal of the program is to create a **consistent, accurate, and uniform** rating system based on a single statewide rating scale that can serve to differentiate the energy efficiency levels between California homes and to **prioritize the investment in cost-effective** home energy efficiency measures.”

<http://www.energy.ca.gov/HERS/> (emphasis added)

History

HERS came into existence in the 1990's and:

- Became officially effective on June 17, 1999
- Established the requirements for Field Verification and Diagnostic Testing services of Title 24, Part 6; Building Energy Efficiency Standards.
- 2009 update included the requirements for California Whole-House Home Energy Ratings

Home Performance Case Study: Redding, CA



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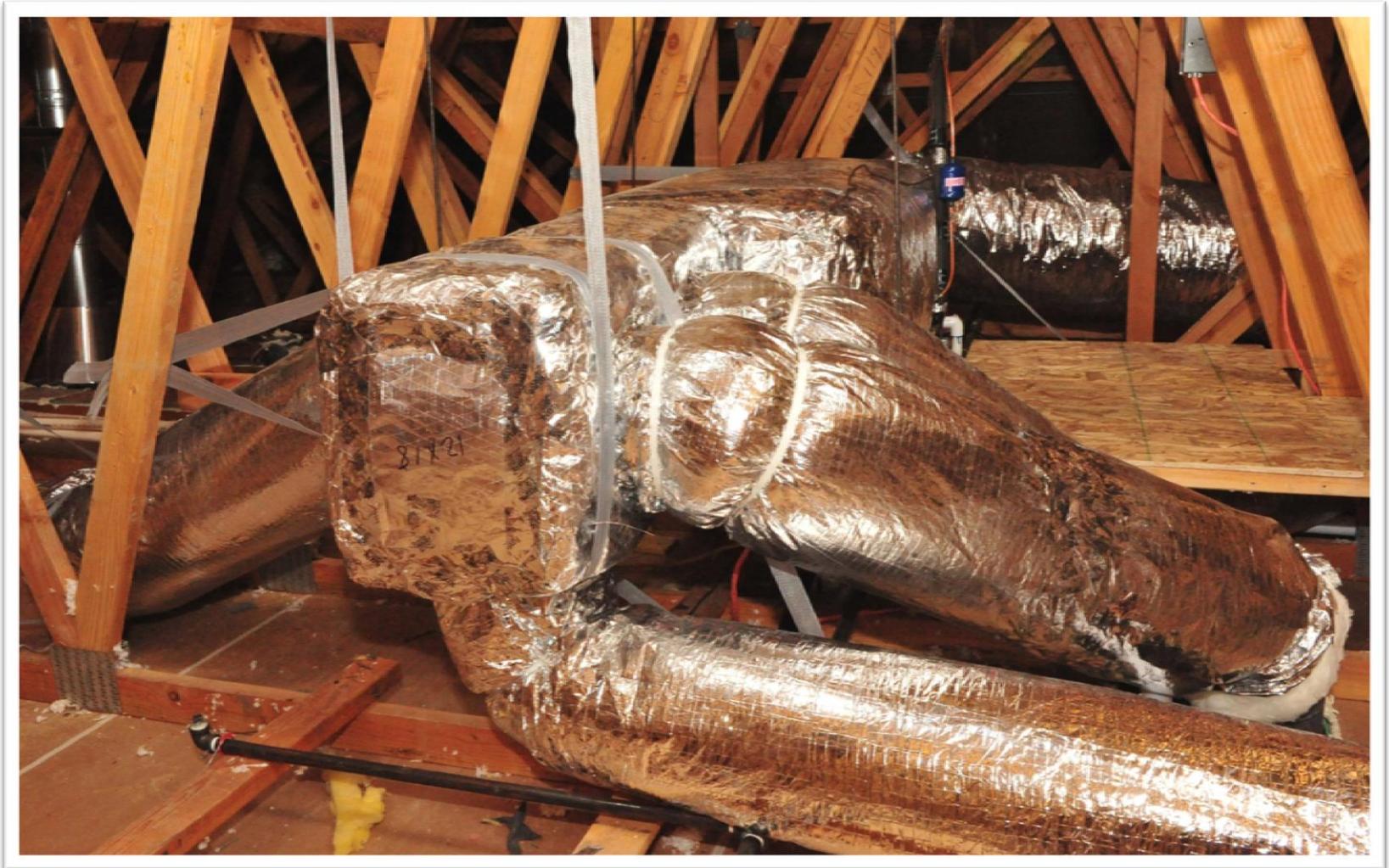
HP Case Study: Before Retrofit



Case Study: Before Retrofit



Case Study: New Heat Pump installed to Home Performance Best Practices- Before Insulation



Case Study: New Heat Pump installed to Home Performance Best Practices- Before Insulation



Project Details

- 2,973 SF Executive Home
- 10' ceilings, architectural details
- 4 Bedroom
- 2.5 Baths
- Pool with water feature
- Built in 2004 under 2001 UBC
- 2 occupants, 1 stay at home

List of Improvements

- Attic air sealing from 2630 CFM50 down to 1250 CFM50
- Replacement of 6.5 tons A/C and 140,000 Btu Furnaces with (2) 1.5 ton heat pumps (3 tons total)
- Replacement of R-8 duct systems @ 90 CFM25 and 180 CFM25 with new deep buried, no leakage radial design
- New Panasonic motion exhaust fans (4) set to meet BAS
- Removal of ~R-19 blown Fiberglass in attic. Install R-60 blown Cellulose in attic and cover all low ducts.
- Install Pentair 011012 Variable Speed Pool Pumps (2)
- CFL interior lighting retrofit (and some exterior)

History

- Home Purchased in October 2010
- Retrofit completed and occupied in Nov. 2010
- Post-retrofit utility bills full year Jan-Dec, 2011
- Post-retrofit, home was always occupied and kept at 68 night-73 days Winter, 73-75F Summer.
- Pre-retrofit, home used setbacks days and nights*
- Post-retrofit, Costs for year:
 - 13 cents/SF Heating, 7 cents/SF cooling
 - 46 cents/SF Baseload. Total \$ 0.66/SF Annually

Usage History Provided at Time of Sale

kWh by Month Display Billed Usage Yes No

*** Meter Consumption Comparison ***

2010	Jul	2823.00	2009	Jul	2992.00	2008	Jul	3034.00
	Jun	1988.00		Jun	1943.00		Jun	2173.00
	May	1520.00		May	1500.00		May	1629.00
	Apr	1416.00		Apr	1362.00		Apr	1402.00
	Mar	1471.00		Mar	1417.00		Mar	1596.00
	Feb	1567.00		Feb	1717.00		Feb	2013.00
2010	Jan	1908.00	2009	Jan	1813.00	2008	Jan	2220.00
	Dec	1992.00		Dec	1951.00		Dec	1917.00
	Nov	1563.00		Nov	1721.00		Nov	1570.00
	Oct	1563.00		Oct	1877.00		Oct	1550.00
	Sep	2422.00		Sep	2767.00		Sep	532.00
2009	Aug	2799.00	2008	Aug	2862.00	2007	Aug	.00
Total ==>		23032.00	Total ==>		23922.00	Total ==>		19636.00

** Mother-in-law stayed* 

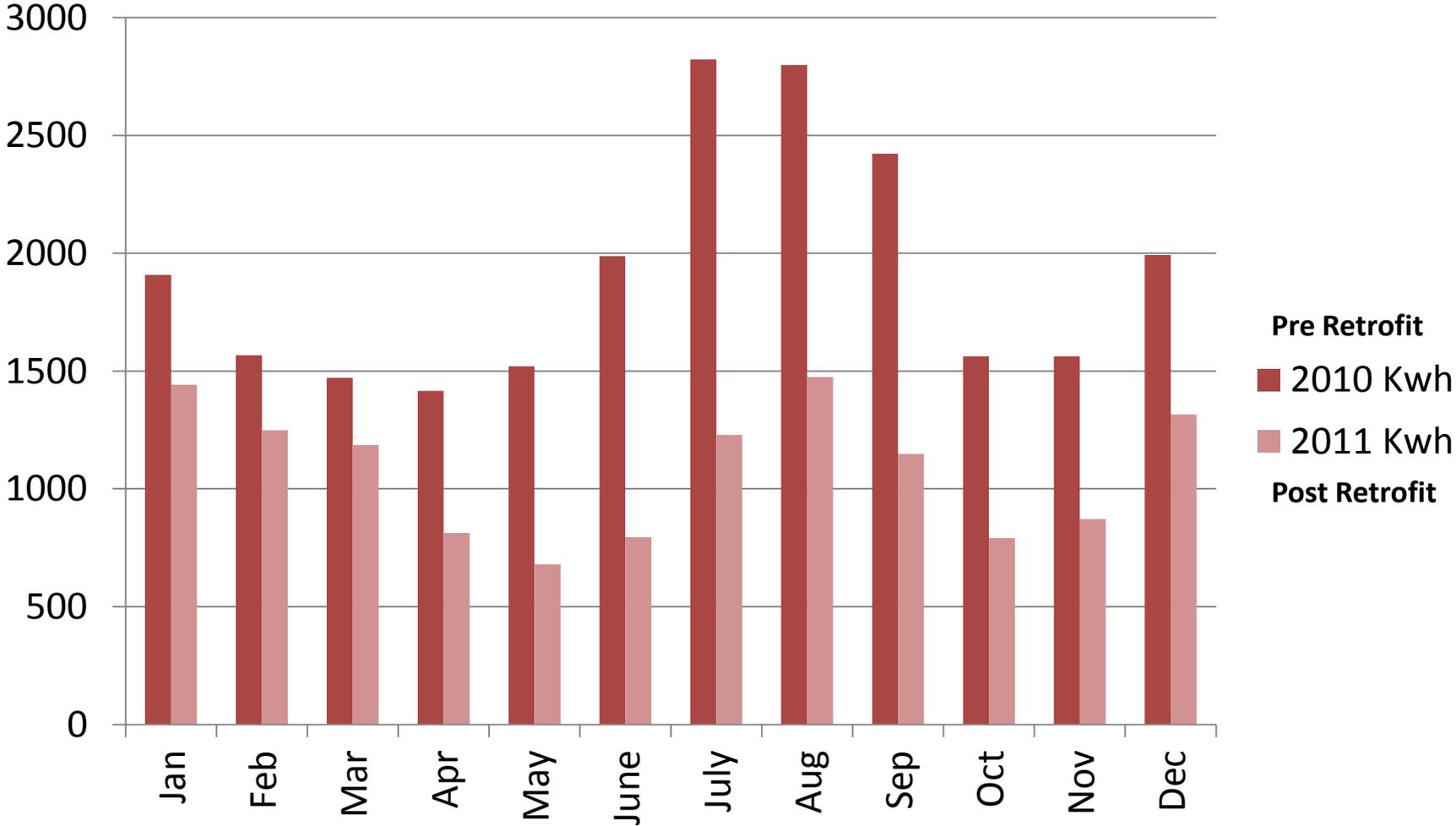
* Sellers offered an unsolicited explanation for high usage months

OK Can

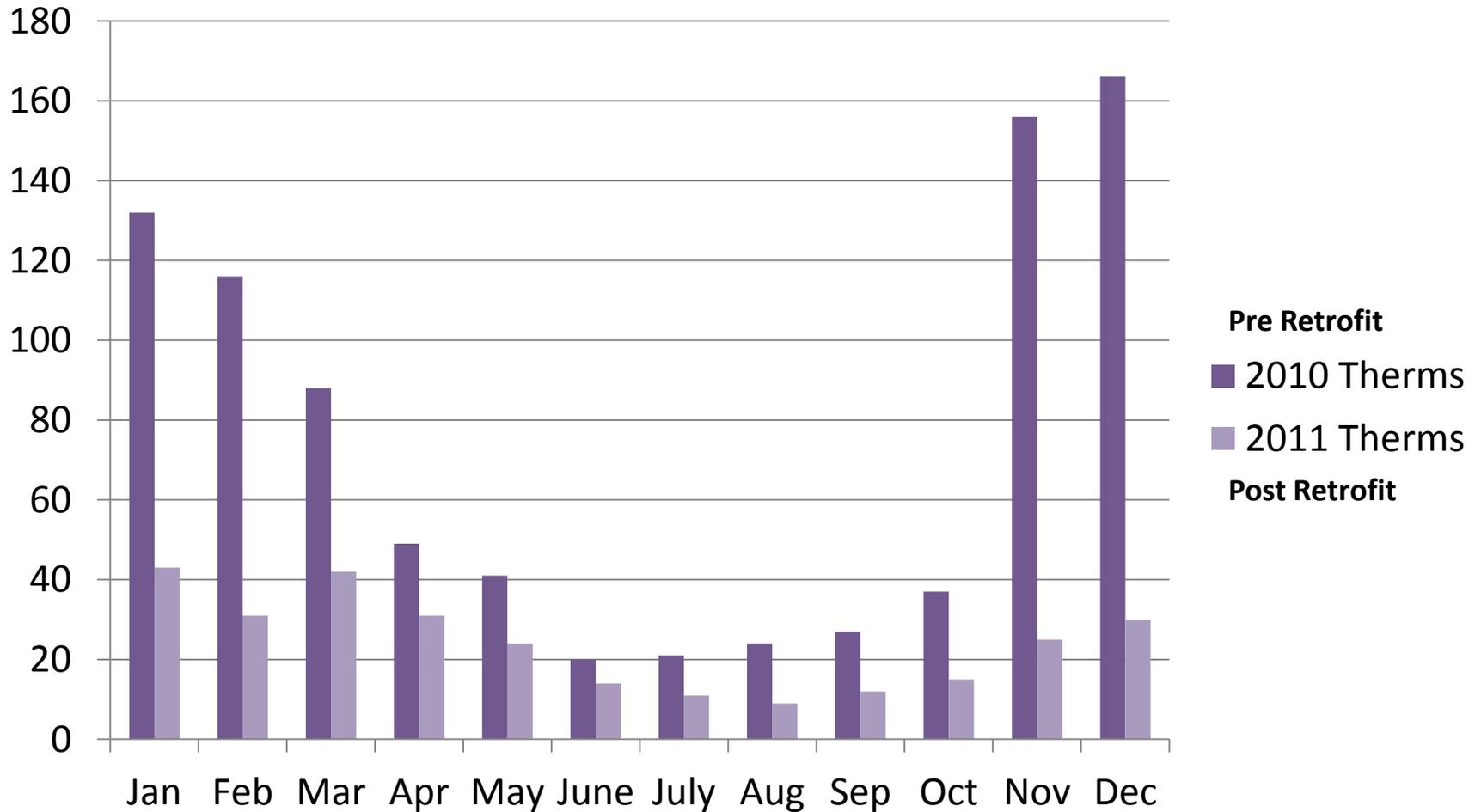
HP Project Savings- Post Retrofit

Monthly Savings From Retrofit 2011	kWh Saved	Therms Saved	Total Energy Units Saved	Total \$ Saved	% Kwh Saved	% Therms Saved	% Total Energy Saved
Jan	466	89	10.5	\$167.72	24.4%	67.4%	53.2%
Feb	318	85	9.6	\$144.30	20.3%	73.3%	56.6%
Mar	285	46	5.6	\$92.21	19.4%	52.3%	40.3%
Apr	603	18	3.9	\$97.52	42.6%	36.7%	39.6%
May	840	17	4.6	\$125.91	55.3%	41.5%	49.2%
June	1193	6	4.7	\$156.51	60.0%	30.0%	53.2%
July	1594	10	6.4	\$211.55	56.5%	47.6%	54.9%
Aug	1324	15	6.0	\$183.95	47.3%	62.5%	50.4%
Sep	1274	15	5.8	\$177.70	52.6%	55.6%	53.3%
Oct	772	22	4.8	\$123.56	49.4%	59.5%	53.5%
Nov	691	131	15.5	\$247.51	44.2%	84.0%	73.8%
Dec	676	136	15.9	\$251.78	33.9%	81.9%	68.0%
Total Savings	10,036	590	93.2	\$1,980.20	43.6%	67.3%	56.1%
Square Footage	2973						
Heating Cost per SF	\$0.13						
Cooling Cost per SF	\$0.07						

HP Project Electricity Savings



HP Project Gas Savings



Investment Breakdown

- Project Cost: \$ 35,000.
- Annual Savings: \$ 1,980.
- Utility Rate Expected Increases:
7.84% Electric, 3-5% Gas
- Approximately 12 year “payback”

So what is the HERS-2 Score ?

The HERS-2 Score= 99



Seriously, only a [99]? After all of that hard work?
And after the owners spent \$35 thousand of their retirement?

The HERS-2 Score= 99



But this home uses 56% less total energy than it did before!

Let's Find Out:

1. Are the modeling assumptions accurate?
2. Do the predictions of energy use match the actual usage from utility bills?
3. Was it an Energy Pig? If not, then has the 2008 code improved the efficiency of new homes by 50% or more over 2001 code homes?

Are the Modeling Assumptions Accurate?


Official Home Energy Audit
 in conformance with the
 requirements of the
 California Energy
 Commission
 www.energy.ca.gov

Site Information
Address
 4556 Yellowstone Dr
 Redding, CA 96002

General Information
 Conditioned Floor Area 2,977 ft²
 Conditioned Volume 29,770 ft³
 Bedrooms 4
 House Type Single Family
 Foundation Type Slab on Grade

Energy Efficiency Features

Insulation
 Ceiling R-49 EXT = R-2
 Wall R-13 EXT = R-4
 Floor Over Crawlspace None
 Slab Edge 0

Windows
 SHGC 0.4, 0.63
 U-Factor 0.4, 1.04

Heating System
 Electric Heat Pump 8.6 HSPF
 Electric Heat Pump 8.6 HSPF

Cooling System
 Split A/C 15.25 SEER
 Split A/C 15.25 SEER

Ventilation System
 25 Watts
 25 Watts

Water Heating System
 1 - 50 Gal GasFired (0.57 EF)

OPAQUE SURFACE DETAILS											
Surface Type	Area	U-Factor	Insulation				Azm	Tilt	Status	Joint Appendix 4	Location/Comments
			Cavity	Exterior	Frame	Interior					
Wall	655	0.072	13				90	90	Existing	4.3.1-A3	Zone 1
Wall	633	0.072	13				0	90	Existing	4.3.1-A3	Zone 1
Wall	655	0.072	13				270	90	Existing	4.3.1-A3	Zone 1
Wall	673	0.072	13				180	90	Existing	4.3.1-A3	Zone 1
Roof	2977	0.018	49				270	18	Existing	4.2.1-A23	Zone 1
Slab	2977	0.73	0				0	0	Existing	4.4.7-A1	Zone 1
Wall	30	0.072	13				315	90	Existing	4.3.1-A3	Zone 1
Wall	30	0.072	13				135	90	Existing	4.3.1-A3	Zone 1

FENESTRATION SURFACE DETAILS											
ID	Type	Area	U-Factor ¹	SHGC ²	Azm	Status	Glazing Type	Location/Comments Type			
1	Window	24	0.4	0.4	90	Existing	U=0.4 SHGC=0.4	Zone 1			
2	Window	8	0.4	0.4	90	Existing	U=0.4 SHGC=0.4	Zone 1			
3	Window	40	1.04	0.63	90	Existing	U=1.04 SHGC=0.63	Zone 1			
4	Window	28	0.4	0.4	90	Existing	U=0.4 SHGC=0.4	Zone 1			
5	Window	57.5	0.4	0.4	0	Existing	U=0.4 SHGC=0.4	Zone 1			
6	Window	182	0.4	0.4	270	Existing	U=0.4 SHGC=0.4	Zone 1			
7	Window	25	0.4	0.4	270	Existing	U=0.4 SHGC=0.4	Zone 1			
8	Window	81	0.4	0.4	180	Existing	U=0.4 SHGC=0.4	Zone 1			
9	Window	24	0.4	0.4	180	Existing	U=0.4 SHGC=0.4	Zone 1			
10	Window	12	0.4	0.4	315	Existing	U=0.4 SHGC=0.4	Zone 1			
11	Window	12	0.4	0.4	135	Existing	U=0.4 SHGC=0.4	Zone 1			
			(1) U-Factor Type: 116-A = Default Table from Standards, NFRC = Labeled Value								
			(2) SHGC Type: 116-B = Default Table from Standards, NFRC = Labeled Value								

Yes, they all appear to be accurate.

Do the Predictions Appear Accurate?

Official Home Energy Audit in conformance with the requirements of the California Energy Commission
www.energy.ca.gov

Site Information

Address
4556 Yellowstone Dr
Redding, CA 96002

General Information

Conditioned Floor Area	2,977 ft ²
Conditioned Volume	29,770 ft ³
Bedrooms	4
House Type	SingleFamily
Foundation Type	Slab on Grade

Energy Efficiency Features

Insulation

Ceiling	R-49 EXT = R-2
Wall	R-13 EXT = R-4
Floor Over Crawlspace	None
Slab Edge	0

Windows

SHGC	0.4, 0.63
U-Factor	0.4, 1.04

Heating System

Electric Heat Pump	8.6 HSPF
Electric Heat Pump	8.6 HSPF

Cooling System

Split A/C	15.25 SEER
Split A/C	15.25 SEER

Ventilation System

	25 Watts
	25 Watts

Water Heating System

1 - 50 Gal GasFired (0.57 EF)

Annual Results End Use	Electricity (kWh)		
	Existing	Improved	Savings
Space Heating	5,670		
Space Cooling	1,070		
Fans	497		
Pumps	234		
Domestic Hot Water	0		
Indoor Lighting	1,420		
Outdoor Lighting	239		
Appliances	4,403		
Ancillary	2,698		
Renewables	0		
TOTAL	16,230		

Fossil Fuel (therms)	Fossil Fuel (therms)		
	Existing	Improved	Savings
	0		
	0		
	0		
	0		
	359		
	0		
	0		
	66		
	0		
	0		
TOTAL	425		

CO ₂ (lbs/year)	Existing	Improved	Savings
Electricity	11,199		
Fossil Fuel	4,950		
TOTAL	16,149		

Climate Zone:	11
Floor Area:	2,977
Type:	SingleFamily

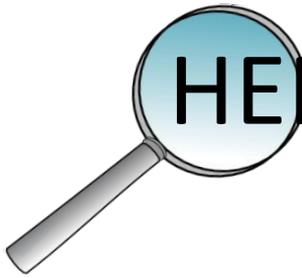
Average Demand (kW)	3.9		
TDV Energy (kBtu/ft²-yr)	105.73		
Energy Cost	\$2,535		

TDV % Savings:	
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The estimated operating costs shown in this report are dependent upon many factors. The construction and conservation features of the home clearly are important. Equally important is the thermostat setting. How the thermostat is used, appliance use, and occupant interaction all influence the annual operating cost. The estimates provided in this report are based on typical conditions; your actual usage will vary. For investor owned utility rebate purposes, the site converted BTU % savings are N/A.

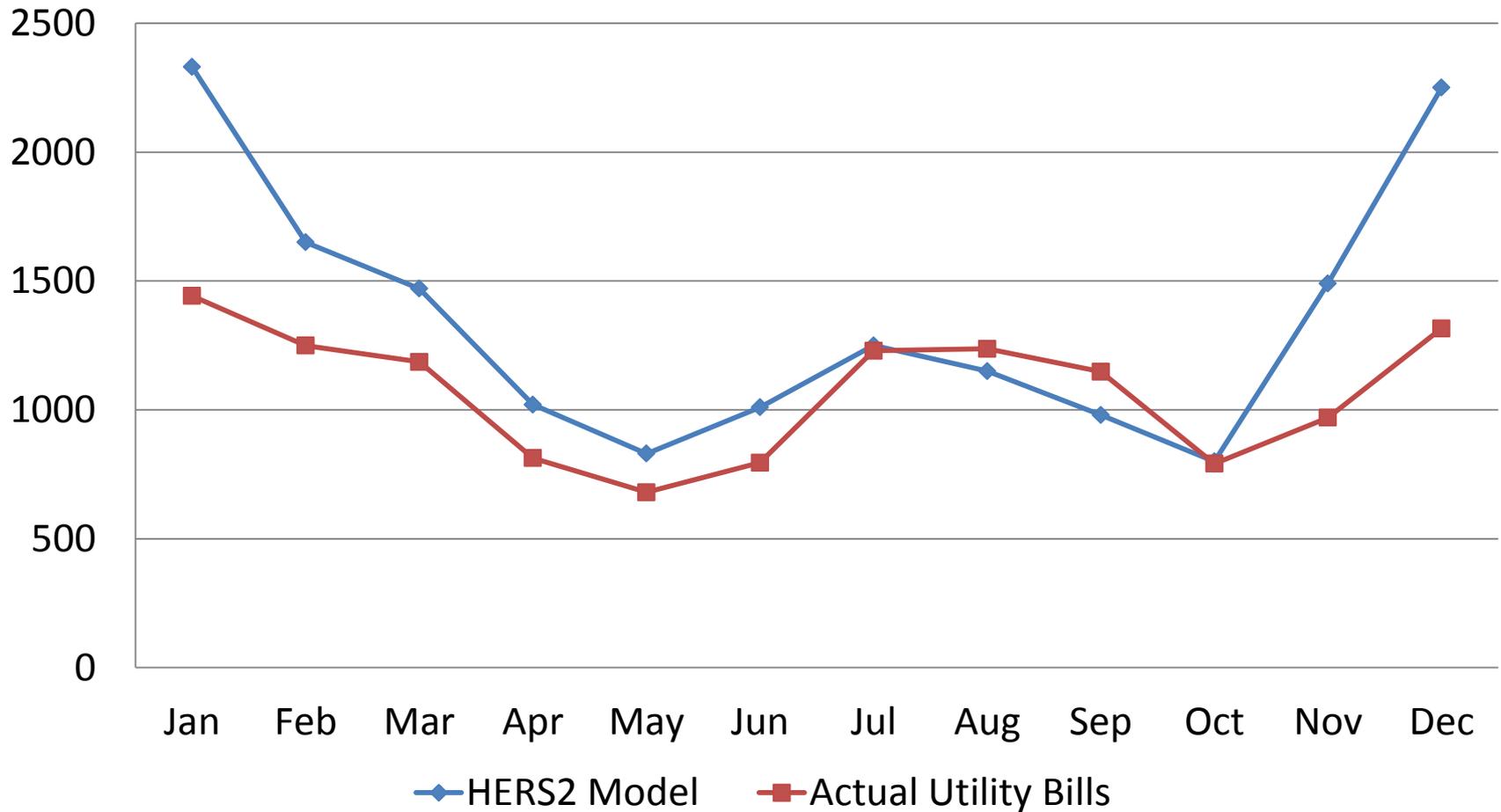


Let's take a look at the data:



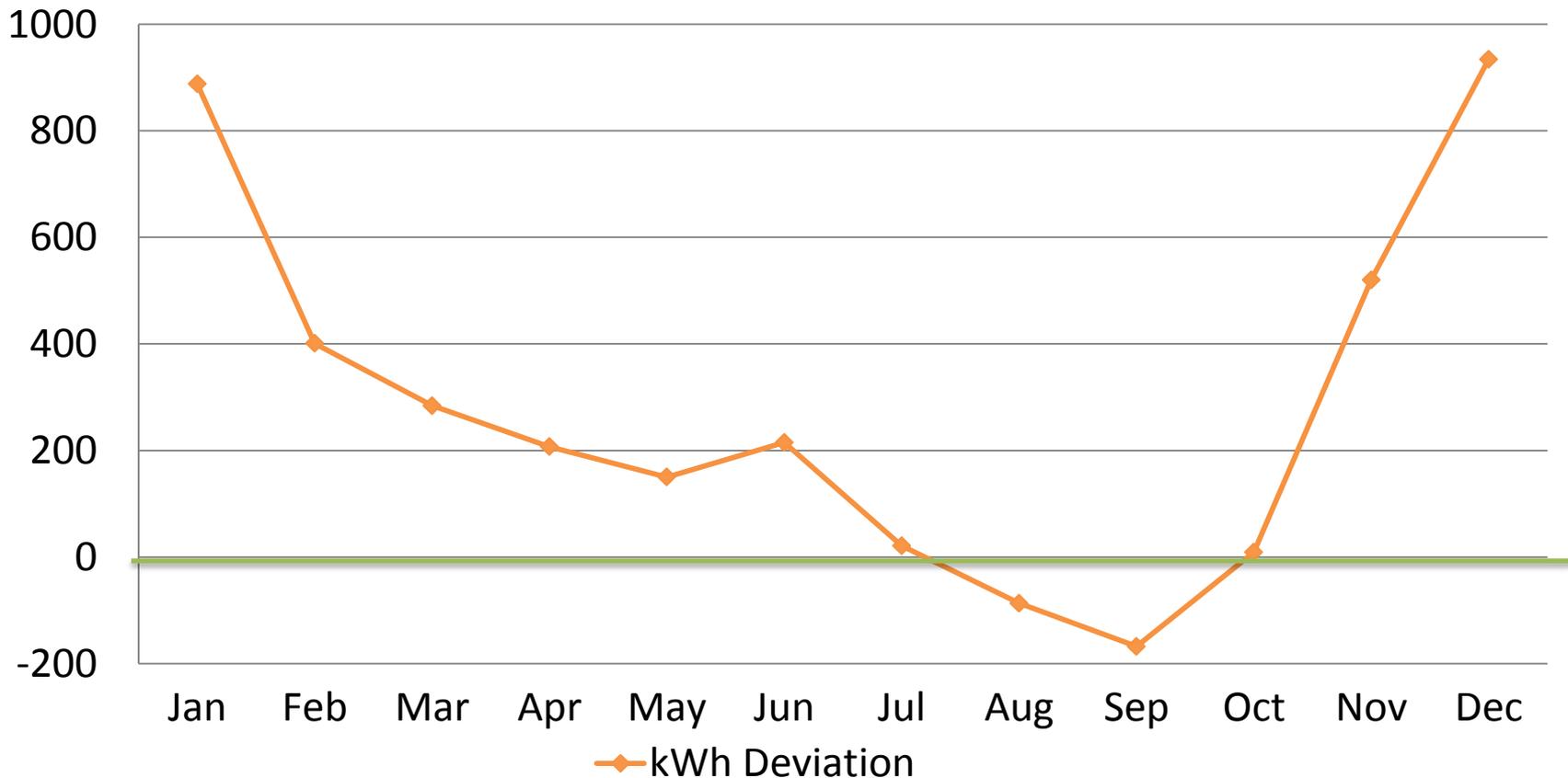
HERS-2 Model Versus Electric Bills

HERS2 Versus Actual Use: kWh



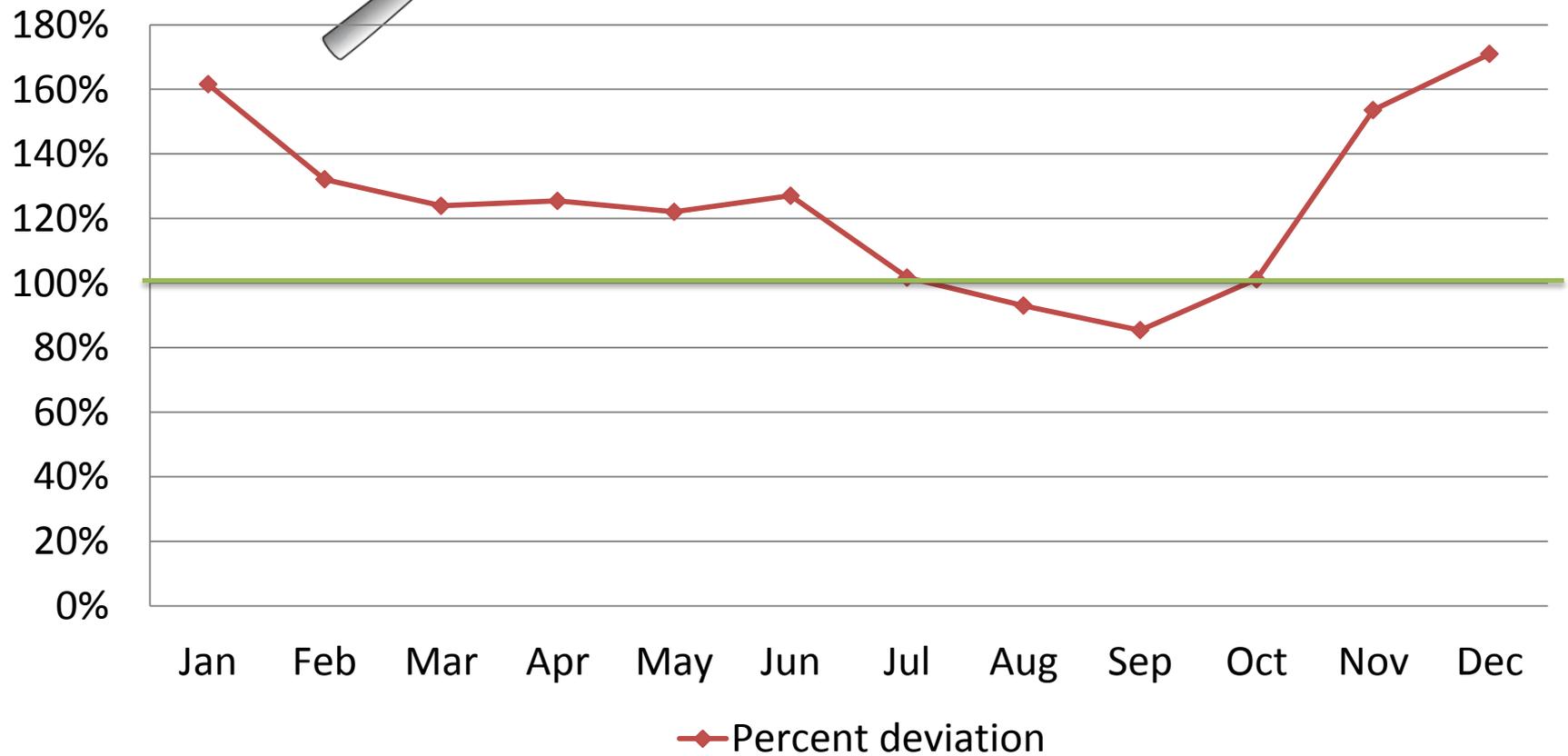
Electricity Prediction by Month Compared to Actual Home Use

HERS2 Monthly Deviation from Actual



HERS-2 Prediction Accuracy

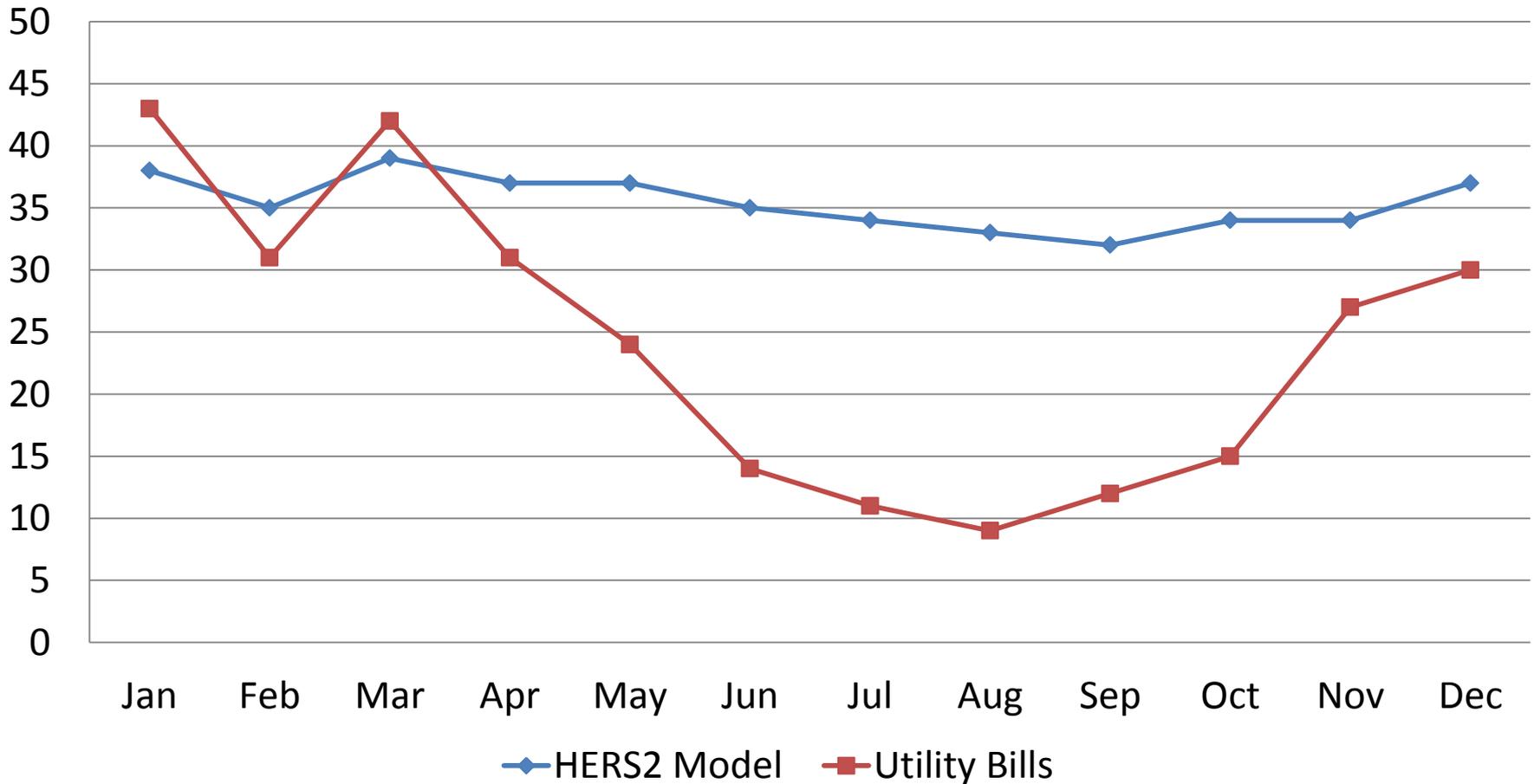
Monthly Deviation %:
HERS2 compared to Electric Bill



HERS Model Versus Gas Bills

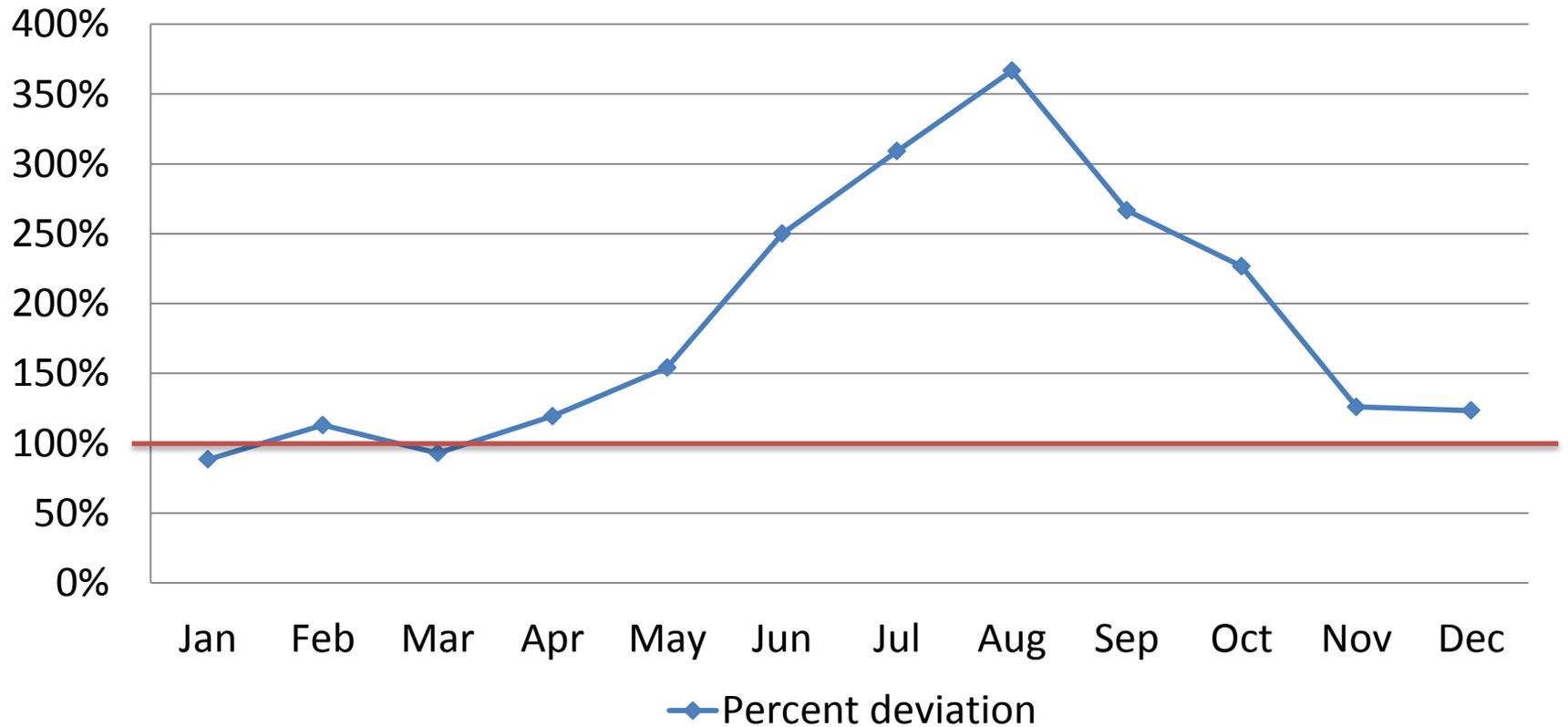


HERS2 Versus Actual Use: Therms



HERS Gas Prediction Accuracy

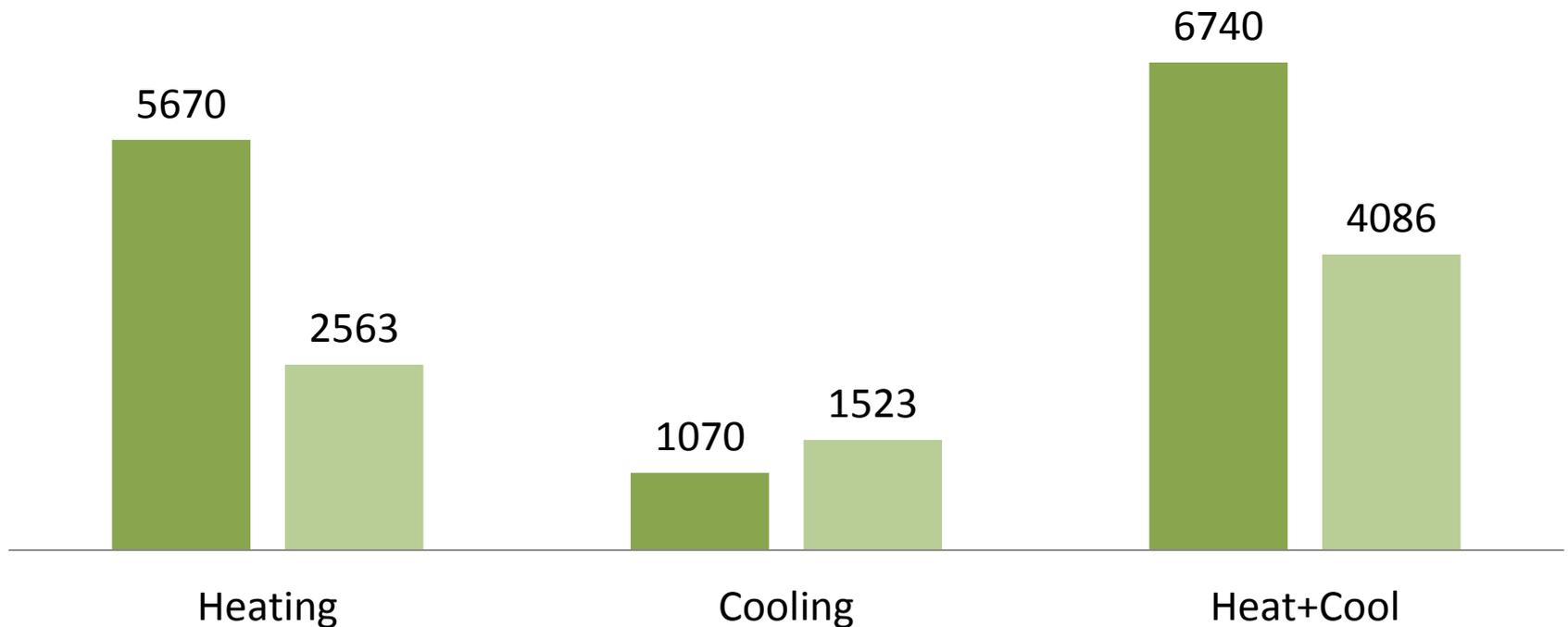
**Monthly Deviation %:
HERS2 compared to Gas Bill**



Heating and Cooling Predicted Versus Actual Electricity Use

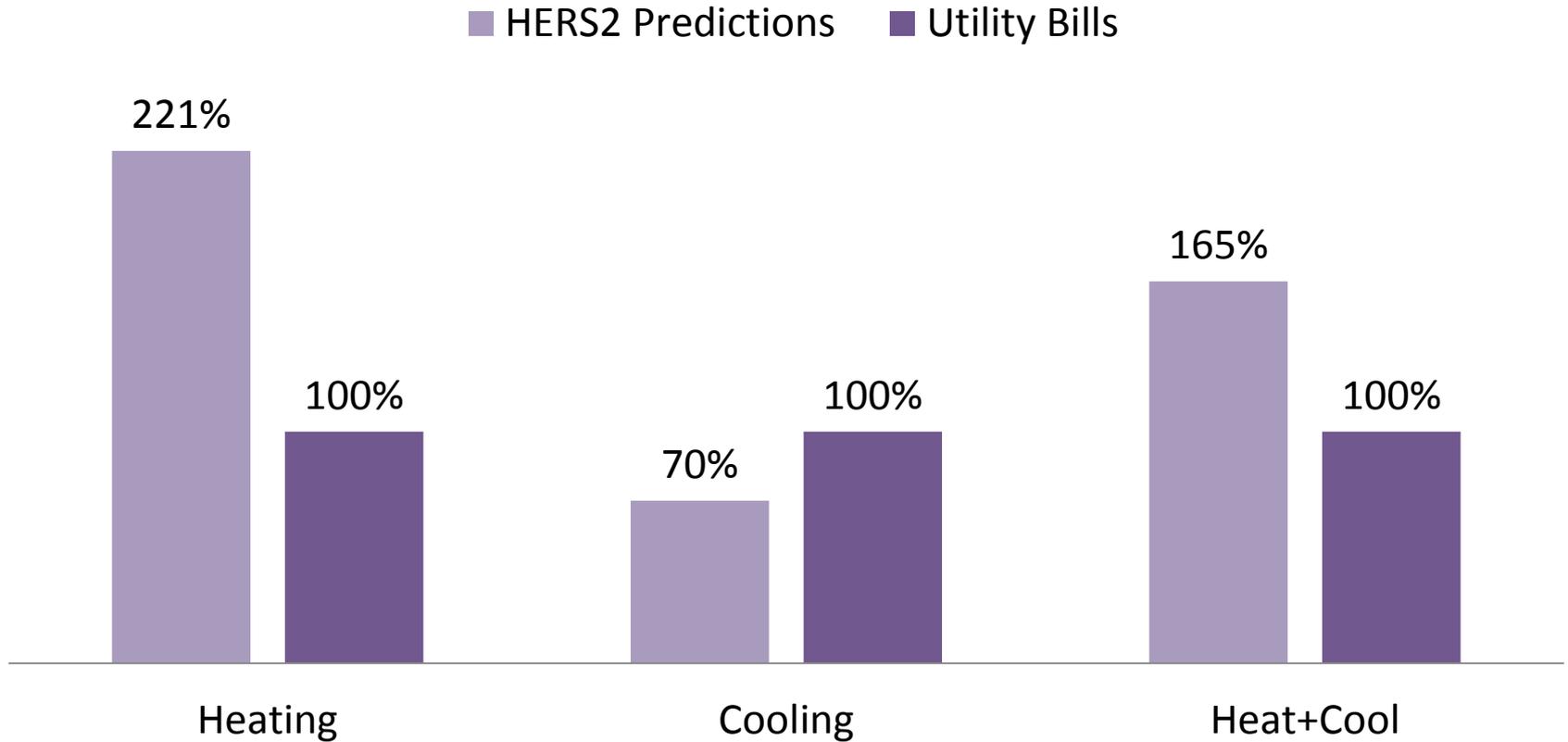
HERS2 Magnitude of Error For Heating and Cooling kWh

■ HERS2 Prediction ■ Utility Bills



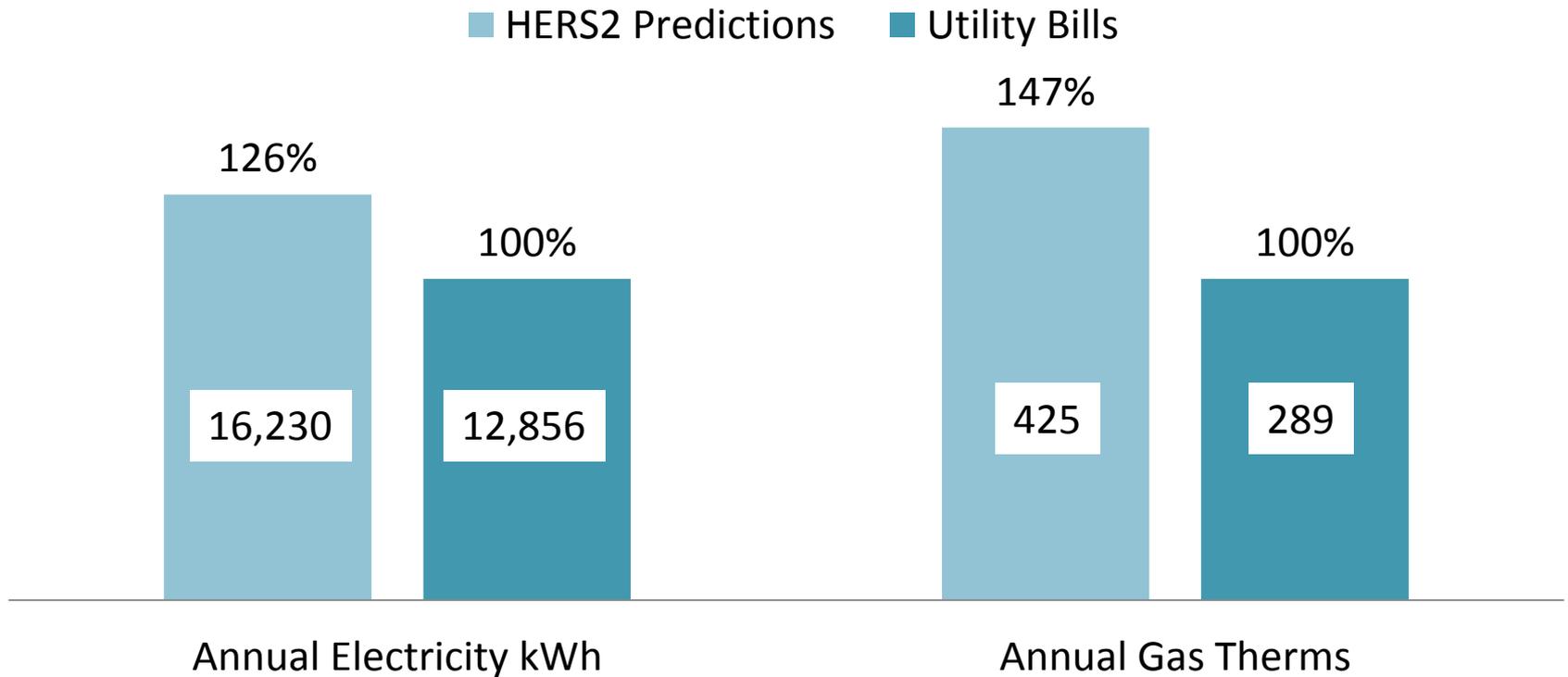
Heating and Cooling Prediction Accuracy

HERS2 Prediction Accuracy For Heating and Cooling



Total Prediction Accuracy

HERS2 Prediction Accuracy For Total Annual Gas and Electric Use



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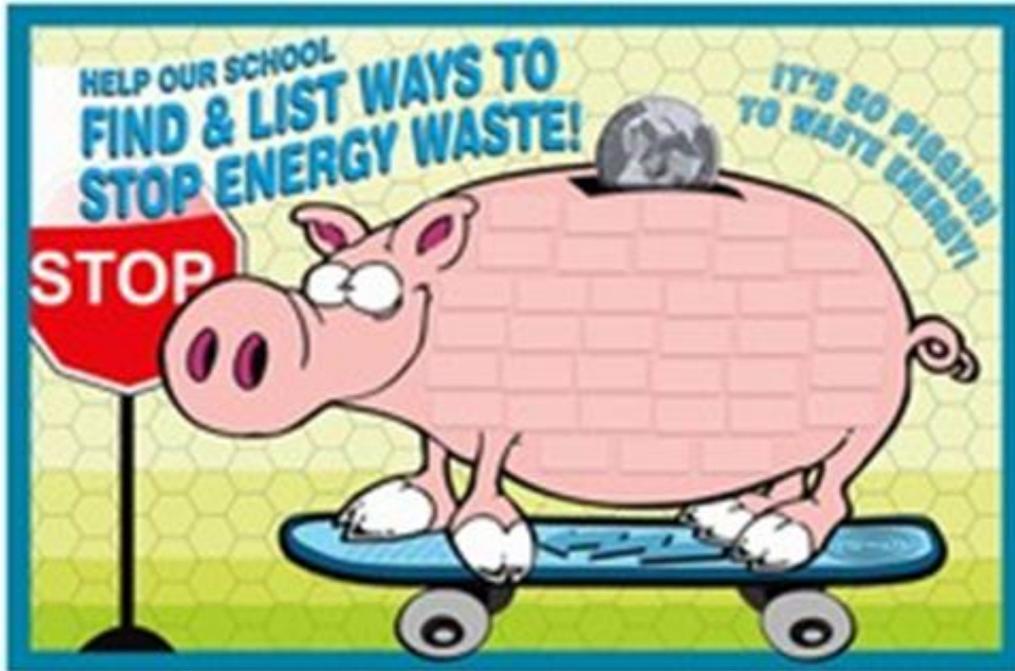
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No, the predictions are not accurate

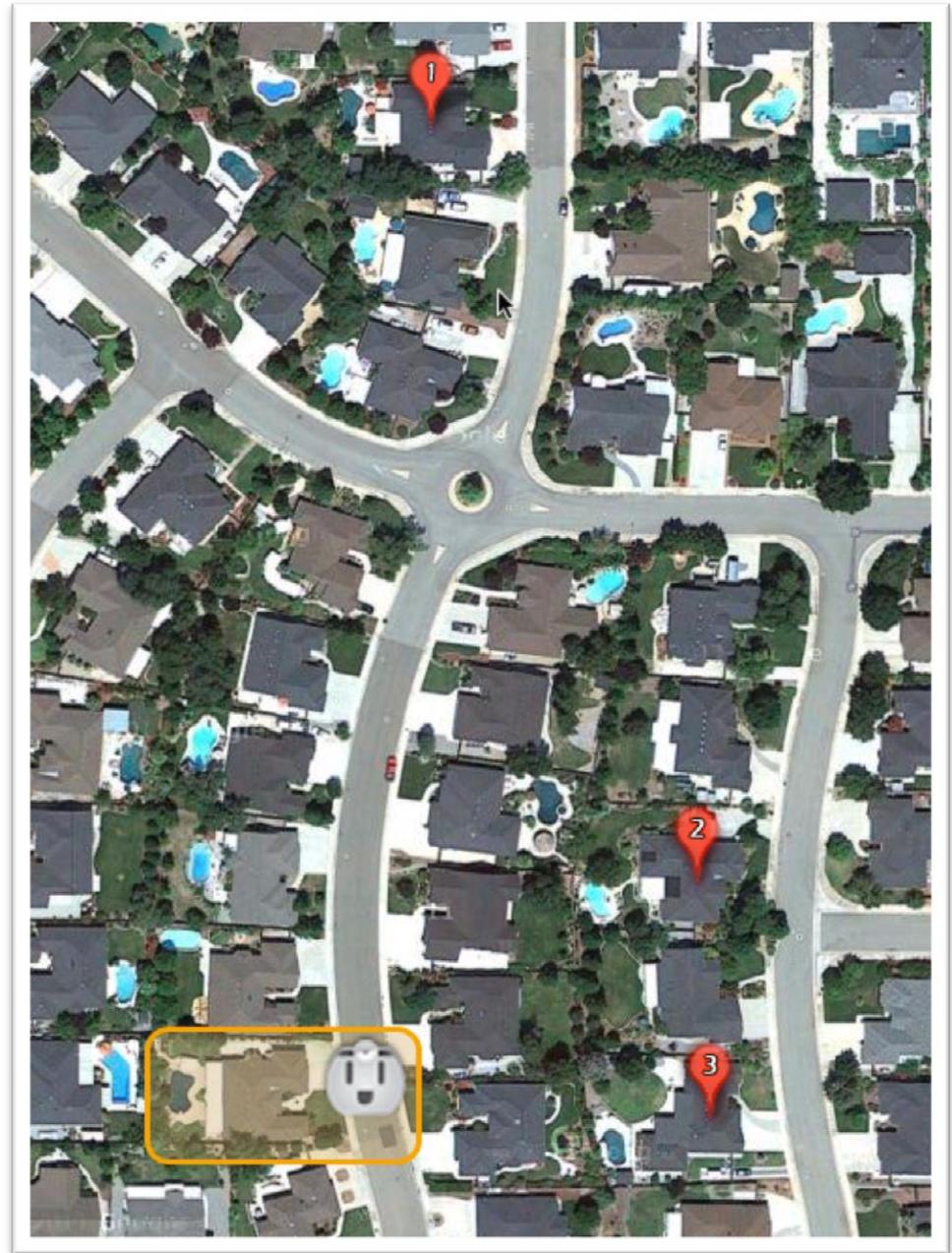
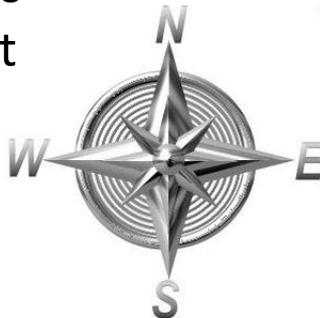
Was the Case Study Just an Energy Pig?



Let's look at the electricity use of 3 other nearly identical homes in the neighborhood

Neighborhood Comparison Homes

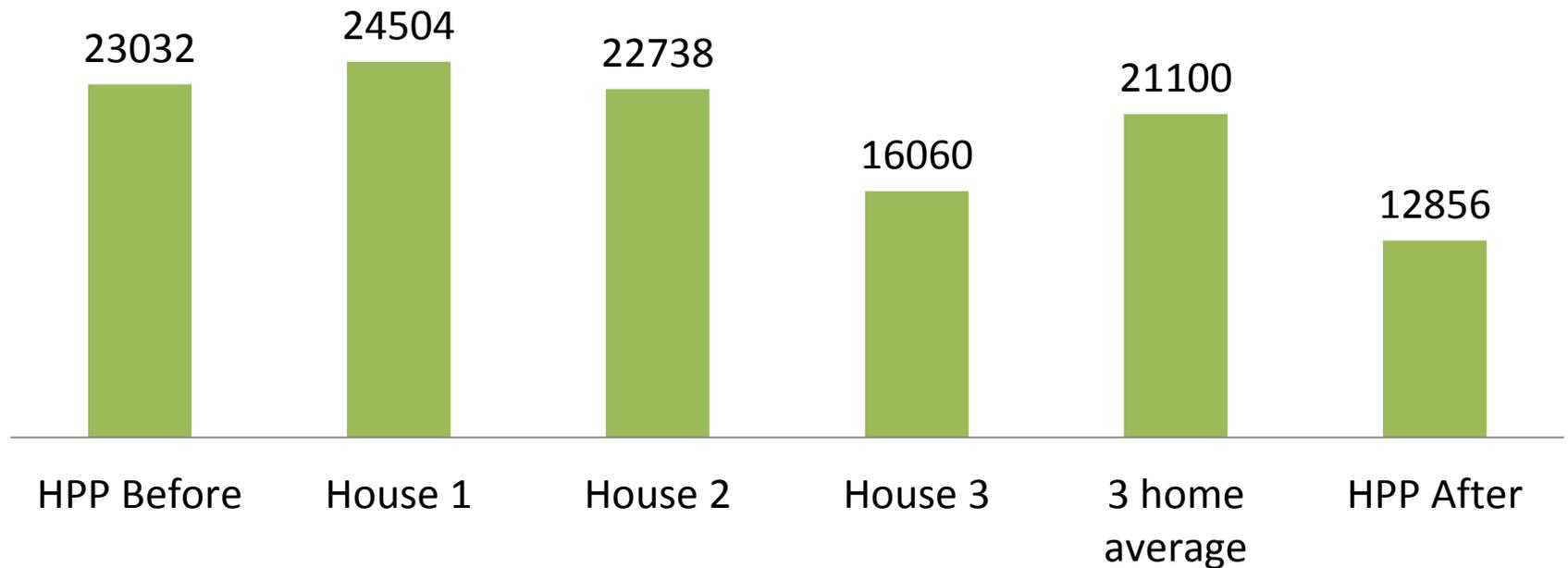
- All built by same Local Builder/Developer
- All same age and code (2003-2004)
- Same Subcontractors on all
- Three comparable homes
- All within 200SF of Reference
- Swimming Pools
- Front Faces East
- 4 Bedrooms



Comparison Homes Annual Average Electricity Use

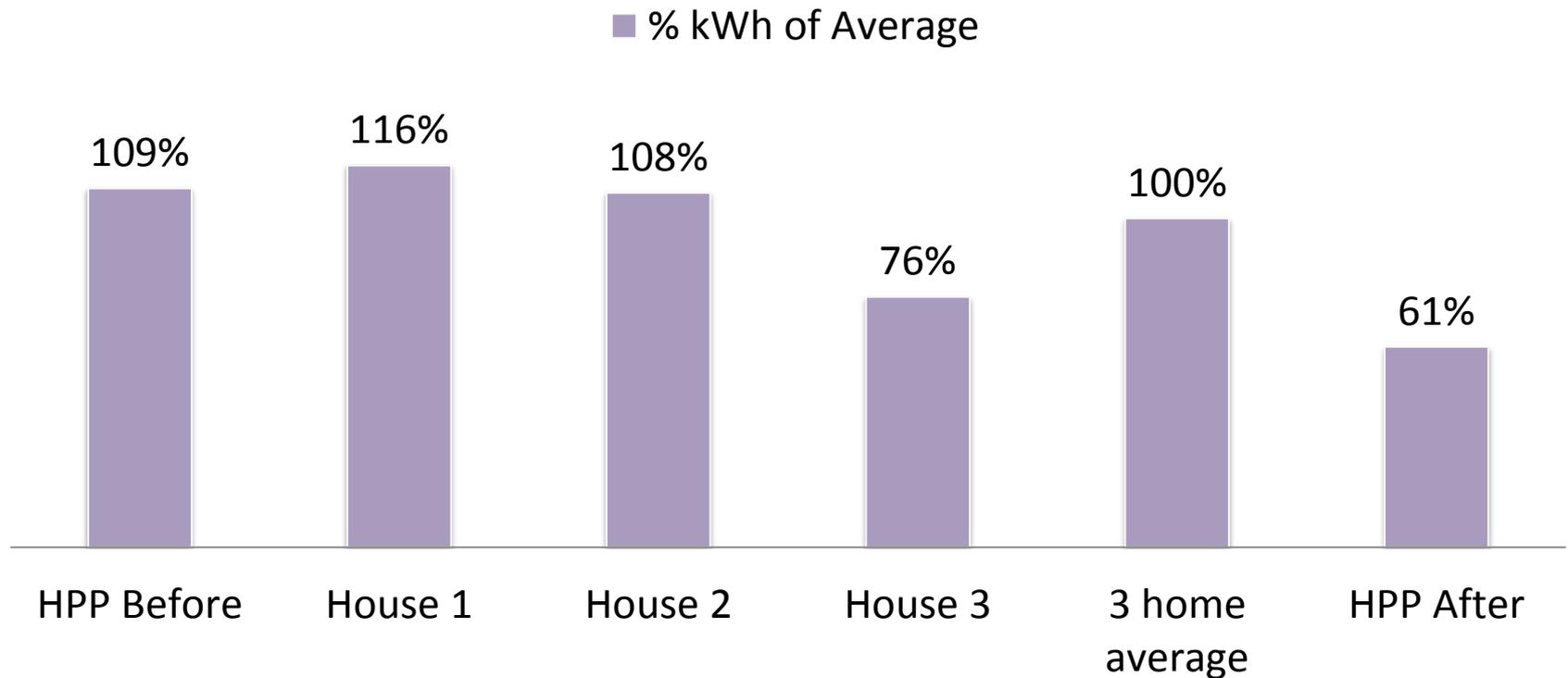
**Electricity Comparison in kWh/Yr.
(same builder, age, orientation, size, pools)**

■ 3 yr Utility Average kWh/Yr



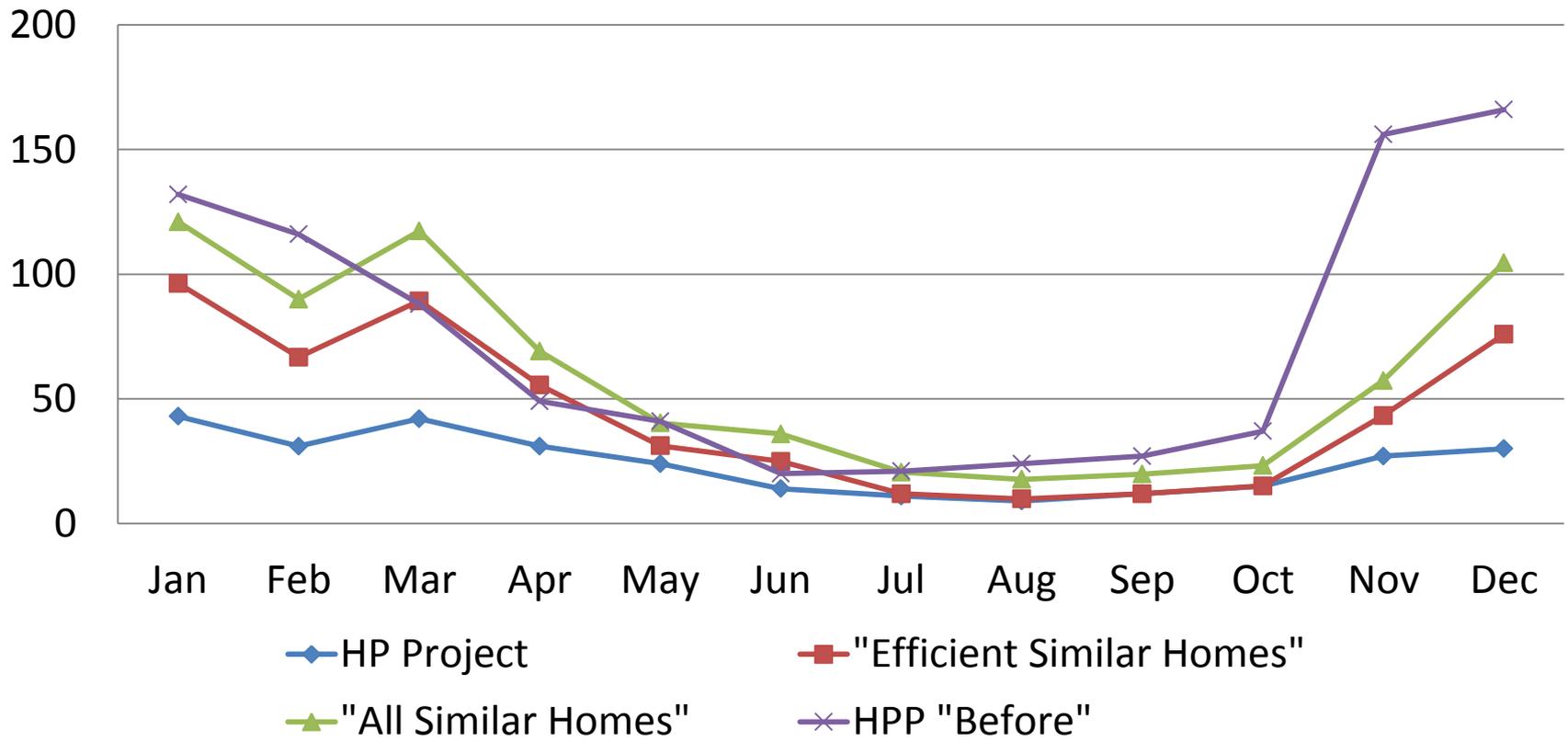
Electricity Use as Percent of Comparison Home Average

**Home Performance Home Vs. Neighbors
(All comparison homes have natural gas furnaces)**



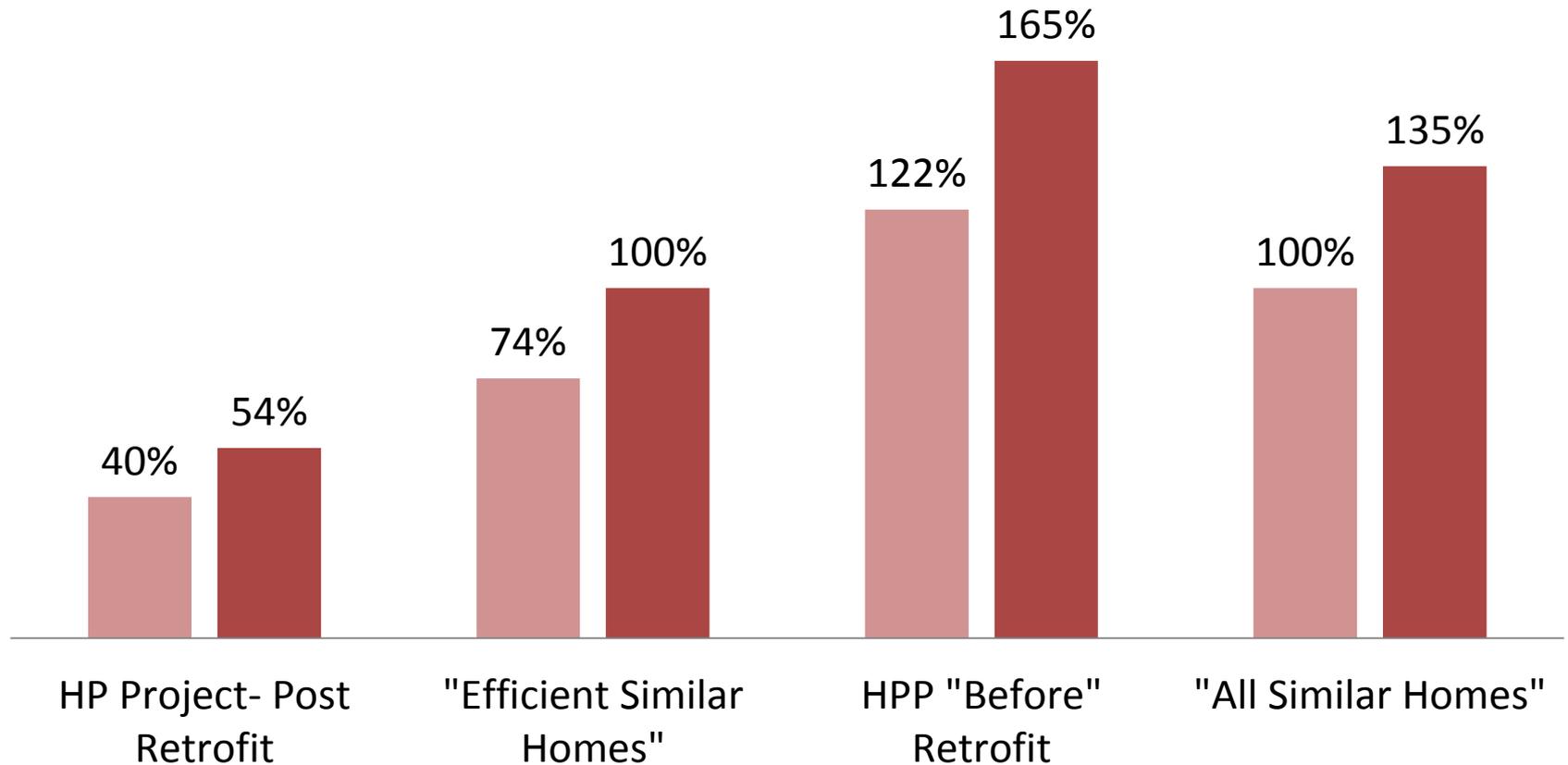
Gas Use Comparison to PG&E “Efficient Similar” and “All Similar” Homes

Natural Gas Monthly Therms Comparison

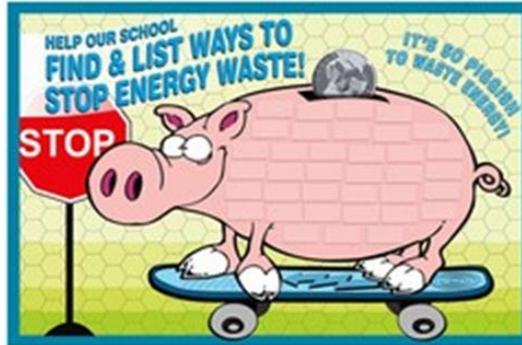


Percent Gas Comparison of HP Project to "Similar" and "Efficient" PG&E Homes

- % Therms Use of "All Similar Homes"
- % Therms Use of "Efficient Similar Homes"



So, Was the Case Study Just an Energy Pig?



CONCLUSIONS:

- The case study BEFORE retrofit was right in the middle of the **electricity** use for similar homes, using **less** than house #1, the **same** as #2, and **more** than #3.
- The case study compared to similar PG&E gas homes shows this home BEFORE retrofit used 22% more than “similar”, and 65% more than “efficient” homes (top 20%).

Title 24 Code Changes 2005 and 2008 Standards



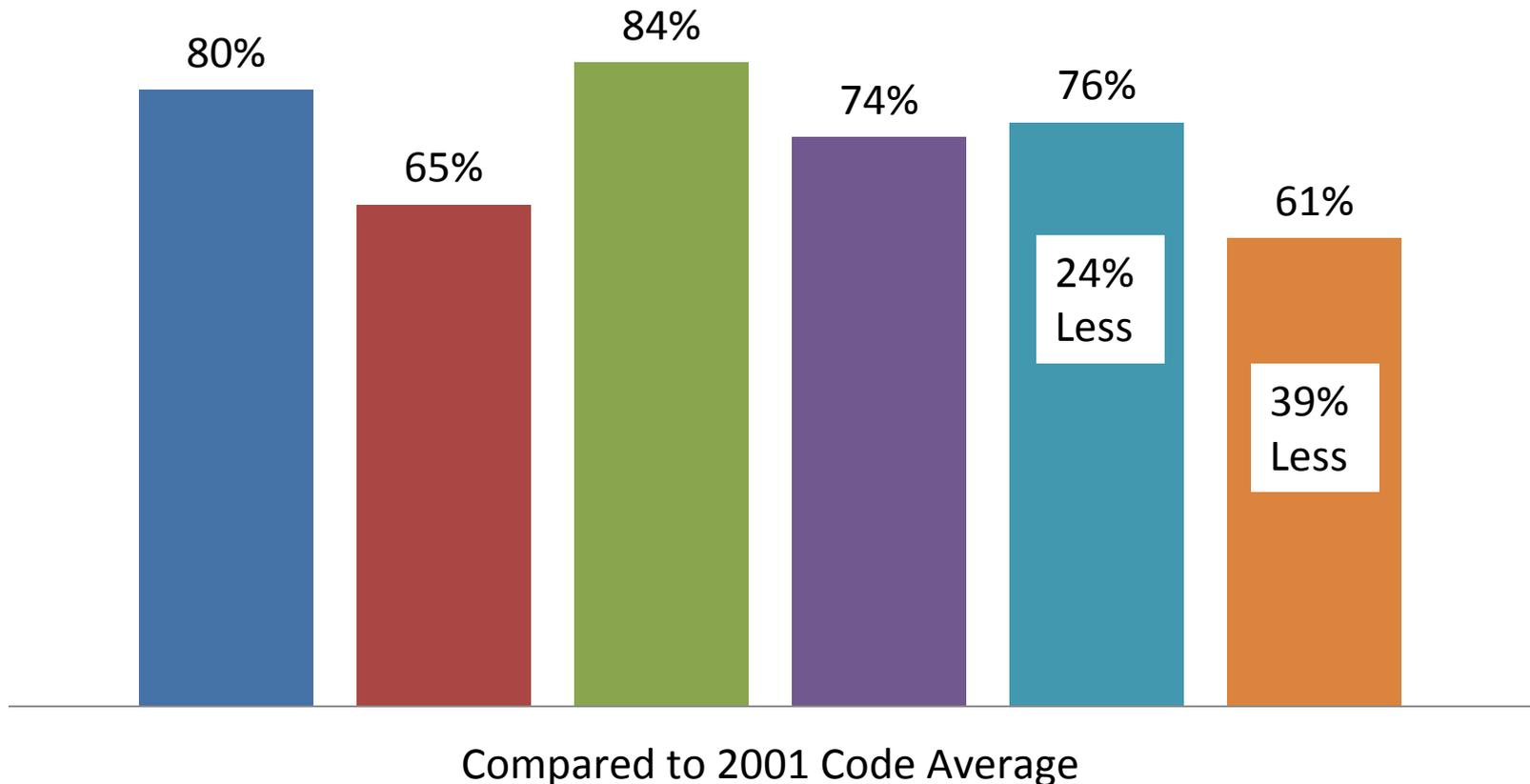
Since the HERS-2 score compares the home with an identical model version built to 2008 Standards:

- What percentage is possible that total energy use could have declined with the last two code changes?

An Electric Utility Review of (4) new Redding homes built to newest 2008 Code shows:

Comparison to (3) 2001 Code Redding Homes

■ House 1 ■ House 2 ■ House 3 ■ House 4 ■ 4 Home Average ■ HP Project



Comparison to 2008 Standards-Issues to Consider

- A 2009 Houston Texas Home Energy Efficiency study of 226,000 homes found that baseload energy use of homes increases with the age of the home. Homes built in 2003 increased in baseload energy use by 10% in five years of occupancy
- None of the 2008 code-built homes have pools, and an average was used.
- Due to the age of the new homes, most had incomplete annual data, and extrapolation of the annual use was used for these.
- No knowledge of the buildings other than valuation; Number of bedrooms, orientation, construction types, water heating, and heating and cooling equipment types, washers and dryers. Would new custom homes likely have all new energy efficient appliances?
- Does a new home start with all potential energy consuming feature installed? Do things like entertainment units, TV's, backyard landscaping, hot tubs and Garage refrigerators “start” in a new home?
- We don't have any gas usage information.
- Builder series HVAC equipment was used in subdivision development residences. Higher efficiency equipment would likely be used in the new homes surveyed- which, due to size, were predominantly custom homes.
- The “4 new home ave” is the same percentage as the older Ref. home #3.

Conclusions

- The Home Performance Project uses approximately 15% less electricity than the average of the newest 2008 code homes in Redding*
- The HPP uses 46% less Natural Gas than the top 20% most efficient PG&E “similar” homes.
- If a [100] HERS-2 Score represents an identical home built to 2008 standards, then shouldn't this home be something between [85] and [54]?
- At [99], it appears HERS-2 falls short of its goal to be:
consistent, accurate, and uniform

(*) Same approximate size, corrected for pool energy use.