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Creating Energy Independence

Relationship between the Home Energy Score (HES) and the Home Energy Rating System (HERS)

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Executive Summary

Residential Energy Services Network (RESNET) commissioned the Florida Solar Energy Center (FSEC) and the Dillon Group, Inc. to conduct a study and analysis of the methodology and scoring systems related to the DOE Home Energy Score (HES) and the RESNET Home Energy Rating System (HERS) Index. The intent of the study is to determine if a reasonable correlation between the two methods of scoring the energy efficiency of homes can be established and if a reasonable correlation between HES and IECC code compliance can be achieved.

A significant cohort of approximately 2,900 registered home energy ratings are subjected to statistical analysis by the Dillon Group, Inc. The statistical analysis determines the distribution of HES results as a function of home energy efficiency as measured by the minimum standards of the 2009 IECC and by EPA's ENERGY STAR program. In addition, a parametric simulation analysis is conducted by the Florida Solar Energy Center using EnergyGauge® USA version 5.0, a RESNET-accredited HERS software tool, to determine the relationship between HES scores and the HERS Index.

The principle findings from the study clearly show the fundamental difference between HES and HERS – HES is a measure of only home energy use while HERS is a measure of home energy efficiency and relative performance. HES does not account for home size, the number of home occupants or energy use for lighting and appliances. As a result, there is no relationship between HES and accepted building energy codes or high-performance home programs like EPA's ENERGY STAR homes program or DOE's Zero Energy Ready Homes program, all of which focus on home energy efficiency and relative energy performance rather than absolute energy consumption. Because the HES methodology focuses solely on home energy use without consideration of home energy efficiency, larger homes of the same energy efficiency achieve substantially poorer HES score results than do smaller homes.

The HERS Index measures the energy efficiency and relative performance of homes, accounting for home size, the number of occupants and lighting and appliance energy uses. HERS is well correlated with accepted building energy codes because it measures energy efficiency performance against a standardized reference home case that is equivalent to the minimum energy efficiency code requirements of the 2006 International Energy Conservation Code (IECC).

Findings from the study are fully consistent with the fact that HES is a measure of absolute home energy use while the HERS Index, building energy codes and federal high-performance home programs are a measure of home energy efficiency or relative home energy performance.

Background

The U.S. Department of Energy's (DOE) Home Energy Score (HES) is a source energy use metric for residential space heating, space cooling and service hot water. HES comprises an absolute residential energy use scale without regard to home size, number of occupants or energy uses for lighting and appliances. HES is based on an energy use scale employing home energy use bins established for the DOE by Lawrence Berkeley National Laboratories (LBNL) in 997 weather locations across the United States.[1] The energy use bins for each weather location are established such that the smallest 12% of the estimated full range of home energy use for any given weather location is awarded a score of "10" (the least energy intensive homes) and the largest 20% of the estimated full range of home energy use for that weather location is awarded a score of "1" (the most energy intensive homes) with the energy use bins between "10" and "1" equally divided.[2, 3]

The Residential Energy Services Network's (RESNET) Home Energy Rating System (HERS) Index is a home energy efficiency performance metric established in accordance with ANSI/RESNET/ICC Standard 301-2014. The HERS Index is determined with respect to a reference home that is minimally compliant with the 2006 IECC and 2006 NEACA standards based on all home energy uses, including lighting and appliances. The reference home is of the same size and number of bedrooms (a surrogate for occupants) as the rated home. The reference home is assigned a HERS Index of "100" and a home that uses zero net purchased conventional energy achieves a HERS Index of "0." Thus, the HES scoring scale and the HERS Index scoring scale are 'inverse' to one another with larger values on the HES scale representing lesser energy use while larger values on the HERS Index scale represent greater energy use.

Abstract

A significant cohort of approximately 2,900 registered home energy ratings using the REM/Rate HERS software tool, as reported to RESNET, are subjected to statistical analysis by the Dillon Group, Inc. The statistical analysis determines the distribution of HES results as a function of home energy efficiency as measured by the minimum standards of the 2009 IECC and by EPA's ENERGY STAR program.

In addition, a parametric simulation analysis is conducted by the Florida Solar Energy Center using EnergyGauge® USA version 5.0, a RESNET-accredited HERS software tool, to determine the relationship between HES scores and the HERS Index. The parametric analysis uses a series of three archetypical homes, each configured to represent the 2006 IECC *standard reference design* (the HERS Reference), the 2012/2015 IECC prescriptive standard and the 2015 IECC Section R406 Energy Rating Index (ERI) standard. Each of the archetypical homes is configured using two fuel options: 1) all electric space and water heating equipment and 2) natural gas space and water heating equipment. The parametric analysis is conducted in three diverse climates (Chicago, Atlanta and San Diego) to examine the relationship between the HES score and the HERS Index.

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[1] http://hes-documentation.lbl.gov/home-energy-scoring-tool/scoring-methodology, retrieved January 5, 2015.
[2] http://energy.gov/eere/buildings/home-energy-score-research-and-background, retrieved January 9, 2016.
[3] Home Energy Score uses the 2009 Residential Energy Consumption Survey (RECS) dataset to determine the end points of its scale. RECS as well as the Commercial Building Energy Consumption Survey (CBECS) – conducted by the U.S. Energy Information Administration – are widely used data sources and serve as benchmarks for a number of national tools including the U.S. Environmental Protection Agency's Home Energy Yardstick and ENERGY STAR Portfolio Manager.

Findings from the study and analysis show that a correlation between HERS Index scores and HES scores is not achievable. Further, results show that there is no relationship between HES scores and home energy efficiency as measured by either IECC building code standards or EPA's ENERGY STAR new homes program. The findings are fully consistent with the fact that HES is a measure of absolute home energy use while the HERS Index and building energy codes are measures of home energy efficiency or relative home energy performance.

Methodology

Statistical Analysis of Rated Home Sample Set

The statistical analysis conducted by the Dillon Group, Inc. relied on a sample set of more than 2,900 REM/Rate HERS ratings blindly selected from 42 different states across the nation. This initial sample set was then scrubbed to remove homes in locations that did not comport with the 997 weather stations for which the 2015 HES scoring bins are provided by Lawrence Berkeley National Laboratory (LBNL). This resulted in a sample set consisting of 2,621 HERS ratings. For each of the homes in the final sample set, the source energy use for space heating, space cooling and service hot water was summed. The resulting total source energy use for heating, cooling and hot water was then used to determine the HES score for each home using the 2015 HES scoring bin data provided by LBNL.

The sample set was then analyzed to determine the relationship between HES scores and the 2009 IECC envelope efficiency requirements. An additional analysis was performed to determine the relationship between HES score and ENERGY STAR home certification for the sample set.

Parametric Simulation Analysis

The simulation analysis conducted by the Florida Solar Energy Center uses EnergyGauge USA version 5.0 to parametrically examine the relationship between HES scores and HERS Index scores. It is important to point out that EnergyGauge USA 5.0 is fully compliant with the ANSI/RESNET/ICC 301-2014 Standard and thus uses a HERS Reference Home that aligns with the 2006 IECC *standard reference design*. Further, EnergyGauge USA 5.0 implements the DOE-2.1E hourly simulation engine, which is the same hourly simulation engine used in the HES simulation tool.

Three home archetypes were studied by the simulation analysis:

- 1,200 ft^2, 1-story, 3-bedroom, frame home on a vented crawlspace
- 2,400 ft^2, 2-story, 3-bedroom, frame home on a vented crawlspace
- 4,800 ft^2, 2-story, 5-bedroom, frame home on a vented crawlspace

Each of the three archetypes was configured to meet three levels of energy efficiency:

- 2006 IECC *standard reference design* (HERS Reference Home)
- 2012/2015 IECC prescriptive requirements
- 2015 IECC Section R406 Energy Rating Index (ERI) requirements

Each archetype was configured with a *best-case* window orientation with 35% of the total window area facing north and 35% facing south and with 15% facing east and 15% facing west. Additionally, each archetype was configured to simulate both electric space heating and water heating and natural gas space heating and water heating for a total of 18 configurations. Each of these 18 configurations is evaluated in Chicago, IL, Atlanta, GA, and in San Diego, CA, for a total of 54 cases.

Tables 1 provides the envelope characteristics for the 2006 IECC *standard reference design* (and the HERS Reference Home) used for the simulation analysis. Table 2 provides the prescriptive envelope characteristics for the 2012/2015 IECC prescriptive envelope characteristics used for the simulation analysis. It should be pointed out that there is no difference between the prescriptive envelope requirements of the 2012 IECC and the 2015 IECC.

Table 1: 2006 IECC Standard Reference Design Values

LOCATION	**IECC CZ**	Ceiling U-Factor	Wall U-Factor	Found. type	Floor U-Factor	Fen U-Factor	Fen SHGC
Atlanta, GA	3A	0.035	0.082	Crawl	0.047	0.65	0.40
San Diego, CA	3A	0.035	0.082	Crawl	0.047	0.65	0.40
Chicago, IL	5A	0.030	0.060	Crawl	0.033	0.35	0.40

Table 2: 2012/2015 IECC Prescriptive Insulation Values

LOCATION	**IECC CZ**	Ceiling R-value	Wall R-value	Found. type	Floor R-value	Fen U-Factor	Fen SHGC
Atlanta, GA	3A	38	13+5	Crawl	19	0.35	0.25
San Diego, CA	3A	38	13+5	Crawl	19	0.35	0.25
Chicago, IL	5A	49	13+5	Crawl	30	0.32	0.40

Table 3 provides additional IECC simulation characteristics used in the analysis.

Table 3: Additional IECC Simulation Characteristics

Item	**2006 IECC**	**2012/2015 IECC**
Envelope Leakage	SLA = 0.00036	3 ach50
Distribution System Efficiency (DSE)	DSE = 0.80	DSE = 0.88
Programmable Thermostat	No	Yes
High Efficiency Lighting	10%	75%
Hot Water Pipe Insulation	No	Yes
Max Window/Floor Area Ratio	18%	15%
Mechanical Ventilation	None	ASHRAE 62.2-2013
Sealed Air Handlers	No	Yes

Table 4 provides the electric and gas equipment efficiencies for the 2006 and 2012/2015 IECC simulations. For the 2015 ERI analysis, these equipment efficiencies are improved so as to achieve the ERI scores required for Section R406 compliance.

Table 4: 2006 and 2012/2015 IECC Equipment Efficiencies

LOCATION	**IECC CZ**	Heating System		Cooling System		Water Heater	
		Fuel	Eff	Fuel	SEER	Fuel	EF
Atlanta, GA	3A	elec	7.7	elec	13	elec (40)	0.92
Atlanta, GA	3A	gas	78%	elec	13	gas (40)	0.59
San Diego, CA	3A	elec	7.7	elec	13	elec (40)	0.92
San Diego, CA	3A	gas	78%	elec	13	gas (40)	0.59
Chicago, IL	5A	elec	7.7	elec	13	elec (40)	0.92
Chicago, IL	5A	gas	78%	elec	13	gas(40)	0.59

Thermostat set point temperatures for all simulations are maintained at the 2006 IECC values of 78F for cooling and 68F for heating.

Findings

Statistical Analysis of Rated Home Sample Set Findings

The statistical analysis of the 2,621 homes in the rated home sample set strongly indicates that the Home Energy Score has no relationship with energy code compliance. Of the homes in the dataset that scored a "10" on the HES scale, 31% do not meet the building envelope performance requirements of the 2009 International Energy Conservation Code. Based on a cost effectiveness analysis, 27% of the homes that scored a "10" on the Home Energy Score scale actually cost the homebuyers more than a home built to the minimum requirements of the 2009 IECC. Further, 46% of the homes in the "1" HES bracket met or exceeded the requirements of the 2009 IECC.

The lion's share of homes in the dataset that scored a "10" on the Home Energy Score scale were multi-family homes such as apartments, condos, and townhouses.

Surprisingly, most of the homes that were ENERGY STAR version 3 qualified never made it into the "10" bracket on the Home Energy Score scale. In fact, 90% of the ENERGY STAR homes in the dataset were not a "10" and some were a "1", the so-called energy hogs on the HES scale.

Figure 1 provides a stacked bar chart of the distribution of HES scores for the sample set of homes in the analysis. Homes that pass the 2009 IECC envelope requirements are shown in green at the bottom of each bar and those that fail the 2009 IECC envelope requirements are shown in red at the top of each bar.

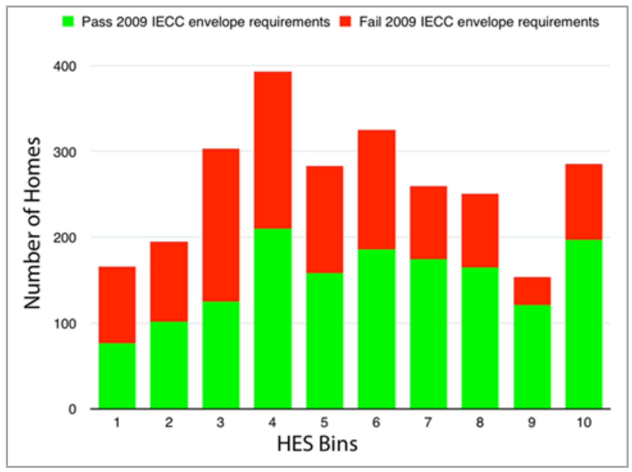

Figure 1: Histogram of HES scores and 2009 IECC envelope compliance for sample set of 2,621 rated homes.

It is clear from Figure 1 that any relationship between HES scores and compliance with the envelope provisions of the 2009 IECC is non-existent.

A similar analysis was conducted to examine the relationship between HES scores and ENERGY STAR v3.0 qualified homes. Figure 2 presents results from this analysis. ENERGY STAR certified homes are distributed across all the scores on the Home Energy Score scale. For the homes in the 2,621 home sample set that scored a "1" (the worst energy consumers according to the HES system), 24% were qualified to earn the ENERGY STAR label.

In fact, 90% of the homes in the sample set that were qualified for ENERGY STAR v3.0 fall somewhere on the HES scale between 1 and 9. Only 10% of the ENERGY STAR homes in the sample score a "10" on the Home Energy Score scale.

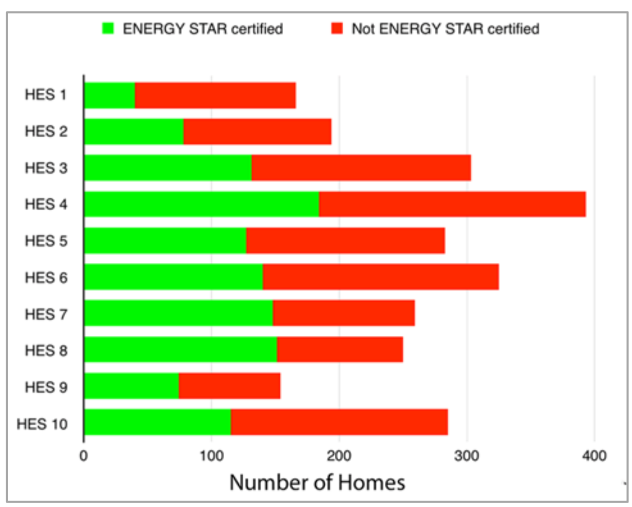

Figure 2: Histogram of HES scores and ENERGY STAR certification of sample set of 2,621 rated homes.

Figure 3 provides the distribution of housing types across the HES scale. Most of the homes in the sample that score a "10" are multifamily units such as apartments, condos, and townhouses. This reflects a bias in Home Energy Score against larger homes such as single family detached. Two homes from Akron, OH, score 55's on the HERS Index— yet one home is a "9" on the HES scale, the other a "4". The "9" is a 1,474 square foot, single story apartment with two bedrooms, while the "4" is a 4,891 square foot, two story single family detached home with five bedrooms.

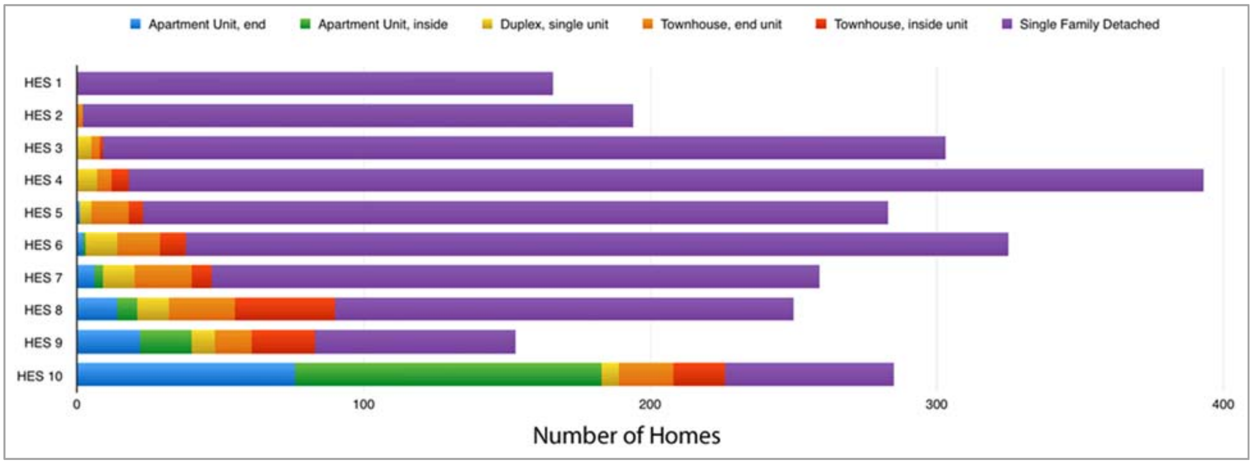

Figure 3: Histogram of HES scores showing distribution of home types for sample set of 2,621 rated homes.

Parametric Simulation Analysis Findings

Findings from the parametric simulation analysis show trends similar to the statistical analysis of rated homes. However, parametric analysis is more controlled where confounding characteristics can be eliminated and the relationship between HES and HERS can be more closely examined.

Lawrence Berkeley National Laboratory (LBNL) developed HES source energy use bins for 997 specific weather locations across the Nation. The 2015 LBNL data tables for these source energy use bins are available online. Table 5 provides the source energy use bins taken from this source for the three weather locations used for the parametric analysis. The energy end uses comprising these source energy use bins are space heating, space cooling and service hot water.

Table 5: HES source energy use bins for three locations used in simulation analysis[4]

Location	**HES Scoring Bins**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Chicago O'Hare	>183	164 183	145 163	126 144	114 125	101 113	88 100	76 87	62 75	<62
Atlanta Hartsfield	>126	113 126	100 112	87 99	78 86	70 77	61 69	53 60	43 52	<43
San Diego Lindbergh	>91	82 91	73 81	63 72	57 62	51 56	44 50	38 43	31 37	<31

As shown by the scoring bin values in Table 5, the three climates selected for parametric analysis represent a range of expected source energy uses. It is also important to point out that a HES score of "10" represents the 12% smallest source energy use in the range and a HES score of "1"

4 http://hes-documentation.lbl.gov/home-energy-scoring-tool/scoring-methodology, retrieved January 5, 2016

represents the 20% largest source energy use in the range, with the bins between "10" and "1" equally divided.

Tables 6 through 8 present results from the parametric simulation analysis. The individual space heating, space cooling and service hot water site energy uses (kWh or therms) are shown along with the total source energy use (MBtu), the HERS Index score and the HES score. Source energy use values are calculated from site energy use values using site-to-source multipliers of 3.14 and 1.05 for electricity and natural gas, respectively.

Table 6: Parametric Analysis Results for Chicago Homes

Chicago Homes	**heat therms**	**heat kWh***	**cool kWh**	**HW kWh**	**HW therms**	**Source MBtu**	**HERS Index**	**HES (2015)**
Natural Gas Homes:								
HERSref - 1200sf	410	340	945		204	78	100	8
HERSref - 2400sf	726	583	1786		204	123	100	5
HERSref - 4800sf	1305	1049	3249		257	210	100	1
2012IECC - 1200sf	321	251	546		193	63	81	9
2012IECC - 2400sf	507	400	941		193	88	75	7
2012IECC - 4800sf	860	682	1661		228	139	71	4
2015ERI - 1200sf	236	219	462		92	42	55	10
2015ERI - 2400sf	388	263	712		124	64	55	9
2015ERI - 4800sf	645	444	1345		162	104	55	6
All Electric Homes:								
HERSref - 1200sf		5478	865	3418		105	100	6
HERSref - 2400sf		9422	1572	3418		154	100	3
HERSref - 4800sf		16785	2845	4623		260	100	1
2012IECC - 1200sf		4194	612	3247		86	82	8
2012IECC - 2400sf		6623	1120	3247		118	77	7
2012IECC - 4800sf		11171	1998	4104		185	74	4
2015ERI - 1200sf		2679	412	1448		49	55	10
2015ERI - 2400sf		4424	839	1448		72	55	9
2015ERI - 4800sf		7488	1548	1644		114	55	5

* includes kWh for gas furnace fan

Table 7: Parametric Analysis Results for Atlanta Homes

Atlanta Homes	**heat therms**	**heat kWh***	**cool kWh**	**HW kWh**	**HW therms**	**Source MBtu**	**HERS Index**	**HES (2015)**
Natural Gas Homes:								
HERSref - 1200sf	240	200	2139		161	67	100	7
HERSref - 2400sf	413	336	3694		161	103	100	3
HERSref - 4800sf	734	597	6540		201	175	100	1
2012IECC - 1200sf	136	110	1326		152	46	73	9
2012IECC - 2400sf	210	169	2003		152	61	66	7
2012IECC - 4800sf	367	296	3390		179	97	64	4
2015ERI - 1200sf	101	71	752		87	29	51	10
2015ERI - 2400sf	164	109	1294		96	42	51	10

Atlanta Homes	heat therms	heat kWh*	cool kWh	HW kWh	HW therms	Source MBtu	HERS Index	HES (2015)
2015ERI - 4800sf	316	226	2478		122	75	51	6
All Electric Homes:								
HERSref - 1200sf		2692	2137	2637		80	100	5
HERSref - 2400sf		4475	3696	2638		116	100	2
HERSref - 4800sf		7879	6553	3559		193	100	1
2012IECC - 1200sf		1561	1324	2496		58	73	8
2012IECC - 2400sf		2374	2002	2496		74	67	6
2012IECC - 4800sf		4089	3409	3149		114	64	2
2015ERI - 1200sf		1286	798	1010		33	51	10
2015ERI - 2400sf		2008	1335	1021		47	51	9
2015ERI - 4800sf		3768	2461	1196		80	51	5

* includes kWh for gas furnace fan

Table 8: Parametric Analysis Results for San Diego Homes

San Diego Homes	heat therms	heat kWh*	cool kWh	HW kWh	HW therms	Source MBtu	HERS Index	HES (2015)
Natural Gas Homes:								
HERSref - 1200sf	41	38	483		155	26	100	10
HERSref - 2400sf	95	82	979		155	38	100	8
HERSref - 4800sf	168	146	1749		193	58	100	5
2012IECC - 1200sf	12	10	180		145	19	77	10
2012IECC - 2400sf	25	20	273		146	21	69	10
2012IECC - 4800sf	45	36	454		171	28	66	10
2015ERI - 1200sf	12	9	128		38	7	51	10
2015ERI - 2400sf	19	13	155		26	7	51	10
2015ERI - 4800sf	38	28	289		52	13	51	10
All Electric Homes:								
HERSref - 1200sf		304	482	2523		35	100	9
HERSref - 2400sf		667	978	2523		45	100	7
HERSref - 4800sf		1175	1748	3400		68	100	4
2012IECC - 1200sf		94	179	2385		28	77	10
2012IECC - 2400sf		184	272	2386		30	69	10
2012IECC - 4800sf		325	453	3010		41	66	8
2015ERI - 1200sf		99	128	411		7	51	10
2015ERI - 2400sf		164	182	672		11	51	10
2015ERI - 4800sf		307	335	1116		19	51	10

* includes kWh for gas furnace fan

Results from the parametric analysis show a significant sensitivity to weather location. The HES results for the 2,400 ft^2 HERS Reference Homes for each weather location are examined first. It is important to note that the HERS Reference Homes evaluated in this analysis comply with the requirements of the ANSI/RESNET/ICC 301-2014 Standard, where the envelope features of the HERS Reference Home align with those of the 2006 IECC. In addition, the equipment efficiencies are those compliant with the minimum NAECA standards in 2006. Thus, these HERS Reference Home results comport well with the minimum efficiency requirements of the 2006 IECC.

As shown in Figure 4, HES scores are not consistent from climate to climate, with the HERS Reference Home (2006 IECC) scoring 2-3 in Atlanta, 3-5 in Chicago and 7-8 in San Diego. One expects more consistency across climate locations for identical homes that are all minimally compliant with the 2006 IECC. In addition, there is a consistent bias toward gas heating equipment with gas heating systems in Chicago scoring 2 full HES points more than electric heating systems. Since these home configurations are for the HERS Reference Home, the HERS Index scores are, by definition, 100 in each weather location and for both fuel types.

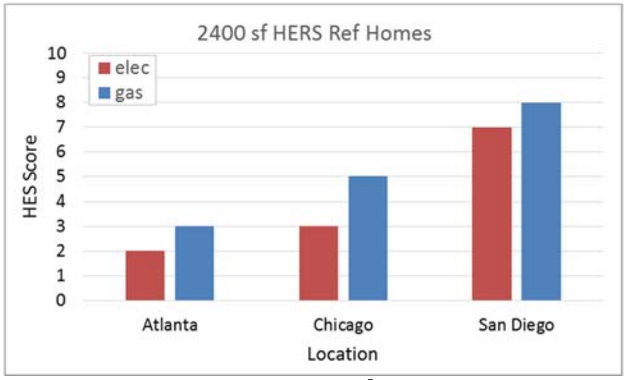

Figure 4: HES scores for 2400 ft^2 HERS Reference Homes (2006 IECC) in three weather locations.

An additional attribute that is examined by the parametric analysis is the impact of home size. The analysis considers three different home size configurations:

- 1200 ft^2, 1-story, 3-bedroom homes
- 2400 ft^2, 2-story, 3-bedroom homes
- 4800 ft^2, 2-story, 5-bedroom homes

Results of the analysis show a strong HES sensitivity to home size. Figure 5 shows data for the HERS Reference Home (2006 IECC) for three homes sizes in three weather locations. The same weather location sensitivity that we see in Figure 4 is observed in Figure 5 but the HES home size sensitivity is even larger than the climate sensitivity. In Chicago, a HES difference of 7 points (from 8 to 1) is observed between the 1200 ft^2 and the 4800 ft^2 homes. This constitutes an 85% reduction in HES score. Both of these homes have identical envelope and equipment features equal to the minimum requirements of the 2006 IECC. If the HES score is intended to represent home energy efficiency relative to some building energy standard, one would not expect see these large differences as a function of home size. Again, since the homes shown in Figure 5 are HERS Reference Home configurations, which is the same as the 2006 IECC minimum standards, the HERS Index score is 100 for all home sizes in each weather location.

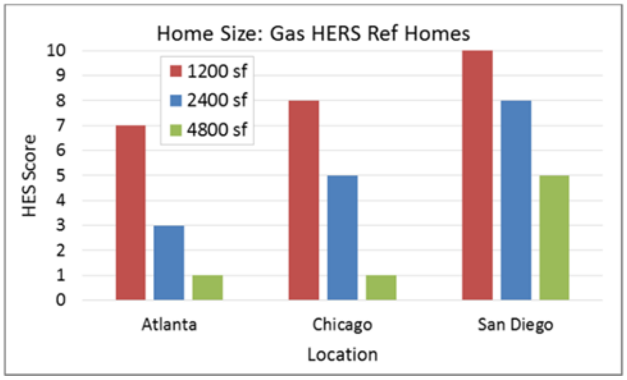

Figure 5: HES score sensitivity to homes size showing impact for gas-equipped homes

The analysis also includes homes that are configured to comply with the 2012 IECC prescriptive standard (see also Tables 2 and 3). These homes are significantly more energy efficient than the 2006 IECC (HERS Reference Home). As a result, these data provide a more meaningful mechanism to compare HES scores and HERS Index scores.

To avoid confusion, it is important to again point out that the HES score scale and the HERS Index score scales run in opposite directions. On the HES scale, a "10" is designed to represent the best 12% of the housing stock and a "1" is designed to represent the poorest 20% of the housing stock. On the other hand, the HERS Index scale goes in the opposite direction with "0" representing a home that uses no net purchased conventional energy and "100" representing the energy use of the HERS Reference Home (2006 IECC minimum compliance).

Figures 6 and 7 provide resulting data from the 2012 IECC home simulations showing HES score results in Figure 6 alongside HERS Index score results in Figure 7.

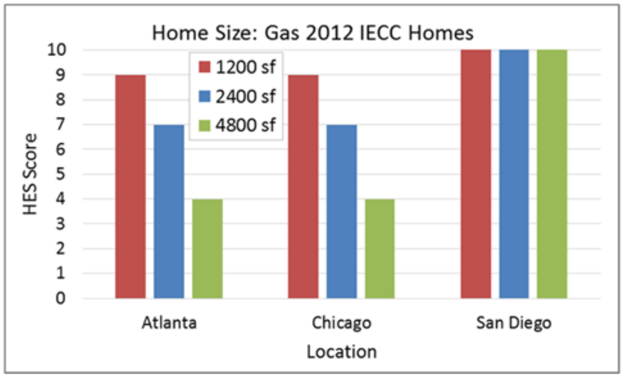

Figure 6: HES scores by home size for 2012 IECC gas homes.

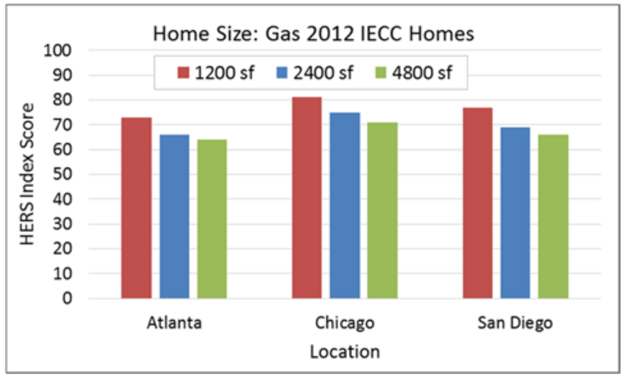

Figure 7: HERS Index scores by home size for 2012 IECC gas homes.

A number of observations can be made based on the results shown in Figures 6 and 7. First, the strong sensitivity of the HES score to home size is apparent in Atlanta and Chicago with a 22% drop in HES score between the 1,200 ft^2 and the 2,400 ft^2 homes and a further drop of 43% between the 2,400 ft^2 and 4,800 ft^2 homes. On the other hand, in San Diego all three home sizes achieve a HES score of "10" – the best score available on the HES scale. This indicates that the HES score bins for San Diego are calibrated in a different manner than for Atlanta and Chicago.

For the corresponding HERS Index scores shown in Figure 7, there is also a decline in HERS Index by home size. However, the HERS Index and HES scales are inverse to one another, with lower HERS Index scores indicating lower relative energy use rather than greater energy use as is the case for the HES scale. For the HERS Index scores, the average reduction in HERS Index is 9% going from 1,200 ft^2 to 2,400 ft^2 homes and 4% going from 2,400 ft^2 to 4,800 ft^2 homes. Since the HERS Index is relative to the energy use of a standard reference home tied to the 2006 IECC, there is also greater consistency across climates for the HERS Index scores, with San Diego showing HERS index values between those of Chicago and Atlanta.

Figures 8 and 9 present HES and HERS Index data for homes complying with Section R406 provisions of the 2015 IECC using the Energy Rating Index (ERI). By definition, minimum compliance for these 2015 provisions require that the homes achieve the same maximum HERS Index regardless of size. However, there are climatic differences such that the Atlanta and San Diego homes need to achieve an ERI of 51 while Chicago homes need to achieve an ERI of 55.

Figure 8 shows the tendency for the HES scale to "max out" at home energy efficiencies that comply with minimum national codes. The 1,200 ft^2 homes achieve a HES score of "10" in all three climates and the 2,400 ft^2 homes achieve a HES score of "10' in two of the three climates. In contrast, the HERS Index scores shown in Figure 12 provide significant "head room" for home efficiency improvement below the 51-55 HERS Index values represented by the 2015 ERI homes.

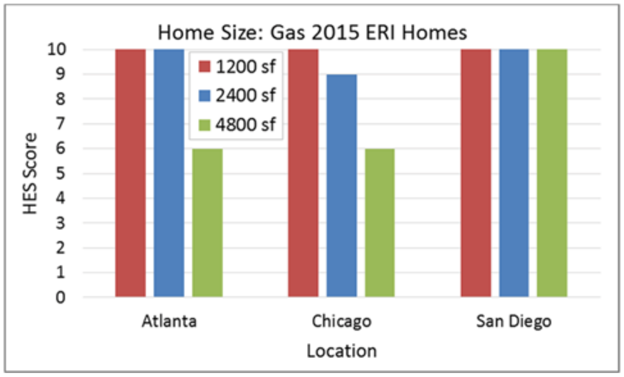

Figure 8: HES scores by home size for 2015 ERI compliant gas homes.

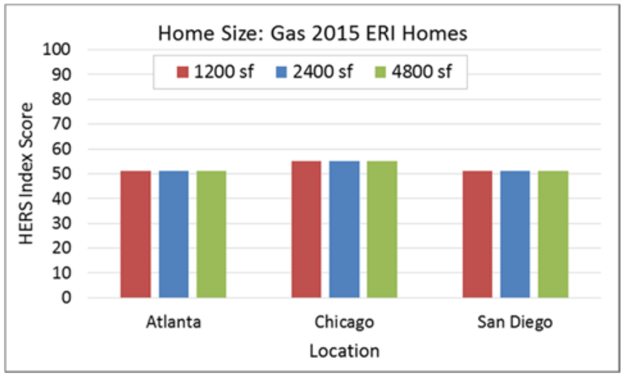

Figure 9: HERS Index scores by home size for 2015 ERI compliant gas homes.

To examine the fact that the HES bins for San Diego do not appear consistent with Atlanta and Chicago, the HES scores for all 18 configurations are plotted against the total source energy use for the configurations in the three climates. Figure 10 provides the results of this analysis. The results show that Atlanta and Chicago homes have HES scores spanning the full range from 1 to 10. However, for the same home configurations in San Diego, fully two-thirds (12 of the 18) of the home configurations achieve HES scores of 10. Only two Chicago home configurations and three Atlanta home configurations achieve HES scores of 10. The median HES scores in the three weather locations are 6.0 in Atlanta, 6.5 in Chicago and 10.0 in San Diego.

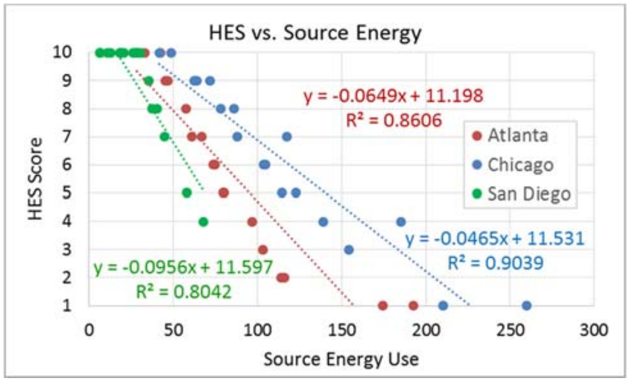

Figure 10: HES scores versus predicted source energy use for three weather locations

Further analysis is conducted to examine the correspondence between HES scores and source energy use predictions across the three weather locations. Figures 11 and 12 present results from this analysis.

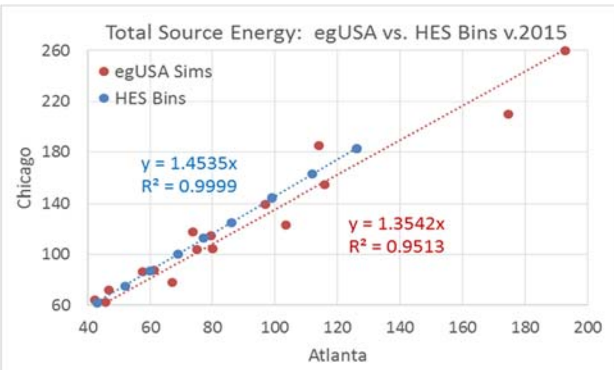

Figure 11: Comparison of Atlanta and Chicago HES bins and simulation results.

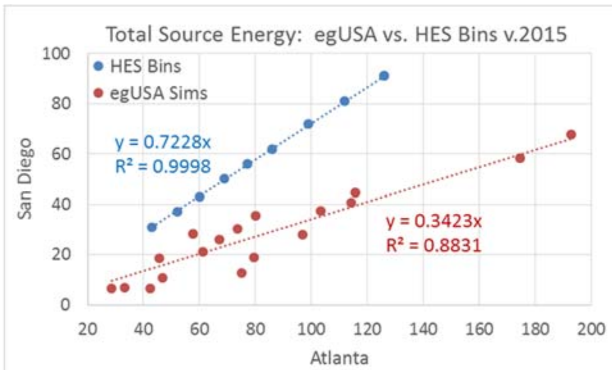

Figure 12: Comparison of Atlanta and San Diego HES bins and simulation results.

Figure 11 shows that HES bins predict that estimated source energy use in Chicago is about 145% of HES bin estimated source energy use in Atlanta. The simulation results show that predicted source energy use in Chicago at about 135% of predicted source energy use in Atlanta. These results could be considered reasonably consistent. The comparison of Atlanta and San Diego shown in Figure 12, however, is quite different. The HES bins predict source energy use in San Diego is 72% of source energy use in Atlanta. On the other hand, the parametric simulation results show that source energy use in San Diego is only 34% of source energy use in Atlanta – only half of what the HES bin data predict. Thus, it appears there is a disconnection between the San Diego HES bin data estimates and predicted source energy use in this weather location.

As previously noted, a principle goal of the parametric simulation analysis is to determine if a reasonable correlation can be established between the HES and HERS Index scoring methodologies. The three energy code configurations modeled in the study are used to make this assessment. Figure 13 presents results of this analysis.

The analysis for the HERS Reference Home configuration, which is equal to the minimum home efficiency standards established by the 2006 IECC, shows no correlation between HES scores and HERS Index scores. For the 2012/2015 prescriptive IECC compliance home configurations, the analysis shows that about 13% of the data variance can be explained by the best fit correlation, meaning that 87% of the data variance remains unexplained. And for the 2015 ERI home configurations, the best fit correlation explains only about 7% of the data variance, leaving more than 93% unexplained. These correlations are extremely week, resulting in the conclusion that there is no reasonable correlation between HES and energy code compliance or between HES and HERS Index scores.

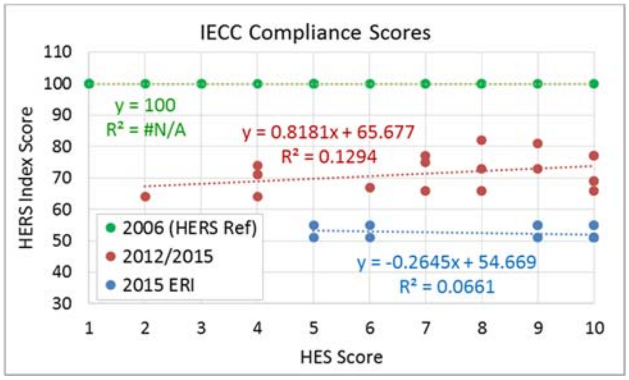

Figure 13: Correlation between HES and HERS Index scores for three home configurations representing different levels of code compliance.

Conclusions

Based on the findings of both the statistical analysis of 2,621 home energy ratings and the parametric simulation analysis of 18 building archetypes in three weather locations, the following conclusions are drawn.

- Findings from the study are fully consistent with the fact that HES is a measure of absolute home energy use while the HERS Index and building energy codes are a measure of home energy efficiency or relative home energy performance.
- Small homes and multifamily home types typically achieve "higher" HES scores and standard-sized and single-family detached homes typically achieve "lower" HES scores.
- Because it is based on an absolute source energy use scale, the HES score is not able to reasonably represent either 2009 IECC code compliance or ENERGY STAR certification within a large cohort of 2,621 home energy ratings conducted across the nation.
- Results from parametric simulation analysis indicate that the source energy use bins used for HES scoring are inconsistent with DOE-2 based simulations in one of the three climates examined in this study. The San Diego HES scoring bins do not comport well with reasonable expectations.
- No evidence is found that would support any correlation between HES and HERS Index scores or that would support any correlation between HES scores and any level of IECC code compliance.

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