



FLORIDA SOLAR ENERGY CENTER\*

*Creating Energy Independence*

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

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DILLON GROUP

*A Research Institute of the University of Central Florida*



# Objectives

- The Dillon Group
  - Using statistical analysis of a large sample set of Rated Homes, determine the relationship between DOE's Home Energy Score (HES), 2009 IECC compliance and ENERGY STAR qualification
- Florida Solar Energy Center (FSEC)
  - Using parametric simulation analysis, determine the relationship between HES and the HERS Index scores.



# Methods

- Statistical analysis of a large sample of Rated Homes across the nation (The Dillon Group)
  - Rated Homes from 42 states
  - Final sample set of 2,621 Rated Homes
- Parametric simulation analysis of 54 home configurations (FSEC)
  - 3 homes sizes (1200, 2400, 4800 sf)
  - 3 home building code configurations (2006, 2012, ERI)
  - 3 representative climates (Chicago, Atlanta, San Diego)
  - 2 fuels (electric and gas space and water heating)



# From DOE's HES Website

*“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.”*



# HES Score Scale

Source energy use for heating, cooling and hot water  
Range includes all homes in any given weather location  
(Home size and number of occupants not considered)

10	9	8	7	6	5	4	3	2	1
10%	9.4%	9.4%	9.4%	9.4%	9.4%	9.4%	9.4%	9.4%	15%

Least  
Energy  
Intense



Most  
Energy  
Intense

Source energy use bins in 997 weather locations estimated for DOE by LBNL



# LBNL Source Energy Bin Example

Source Energy Use for Heating, Cooling and Hot Water

Location	10	9	8	7	6	5	4	3	2	1
	< MBtu	<= MBtu	<= MBtu	<= MBtu	<= MBtu	<= MBtu	<= MBtu	<= MBtu	<= MBtu	> MBtu
Anchorage, Alaska	77	92	108	123	139	154	178	201	225	225
Los Angeles, California	29	35	40	46	52	57	66	75	84	84
Denver, Colorado	51	61	72	82	92	102	118	134	150	150

Source: <http://hes-documentation.lbl.gov/home-energy-scoring-tool/scoring-methodology>

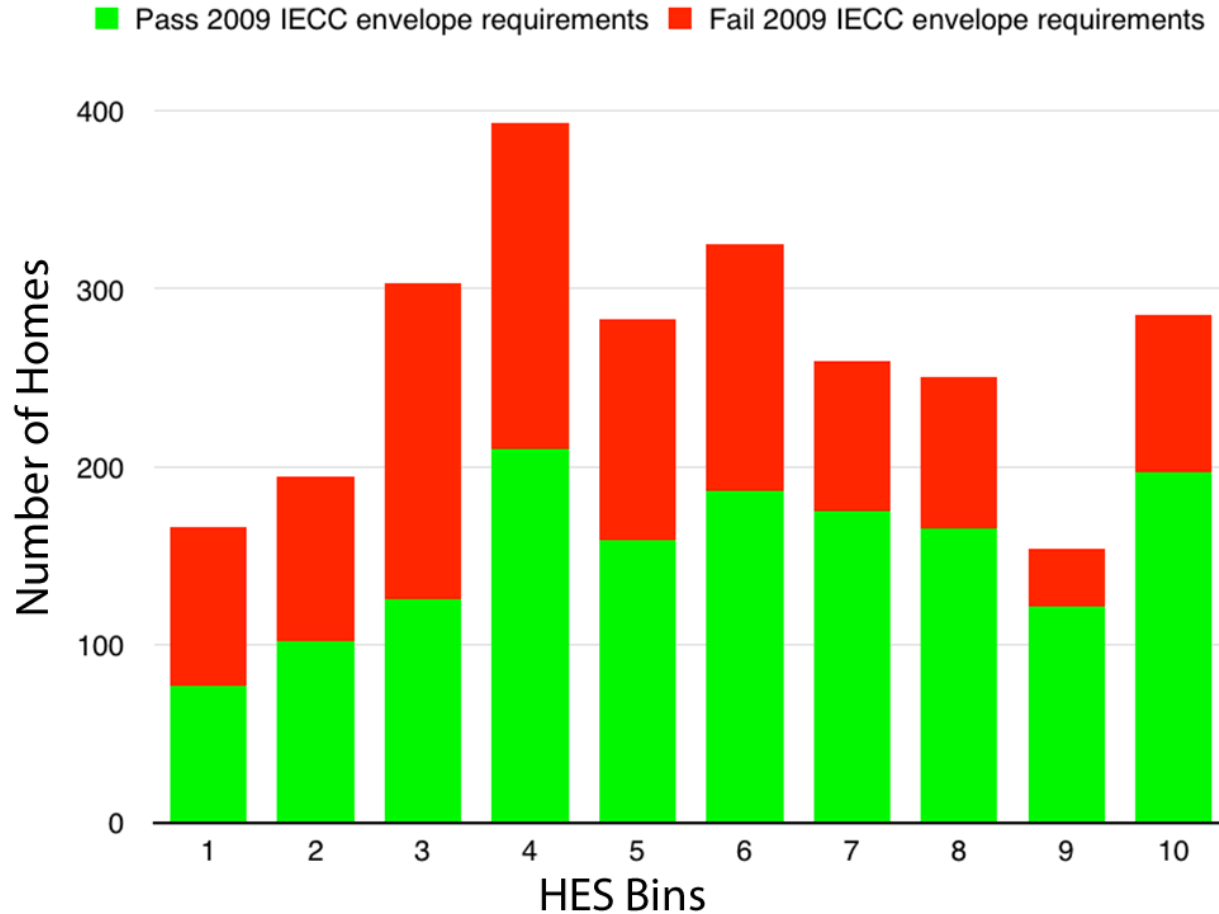


# Statistical Analysis

- 2900 home sample set culled to remove weather locations without corresponding HES bin weather locations leaving 2,621 homes
- Heating, cooling and hot water source energy use summed for each home
- LBNL 2015 source energy use bin data used to determine HES
- HES scores compared against 2009 IECC compliant homes
- HES scores compared against version 3 ENERGY STAR qualified homes



# HES versus 2009 IECC



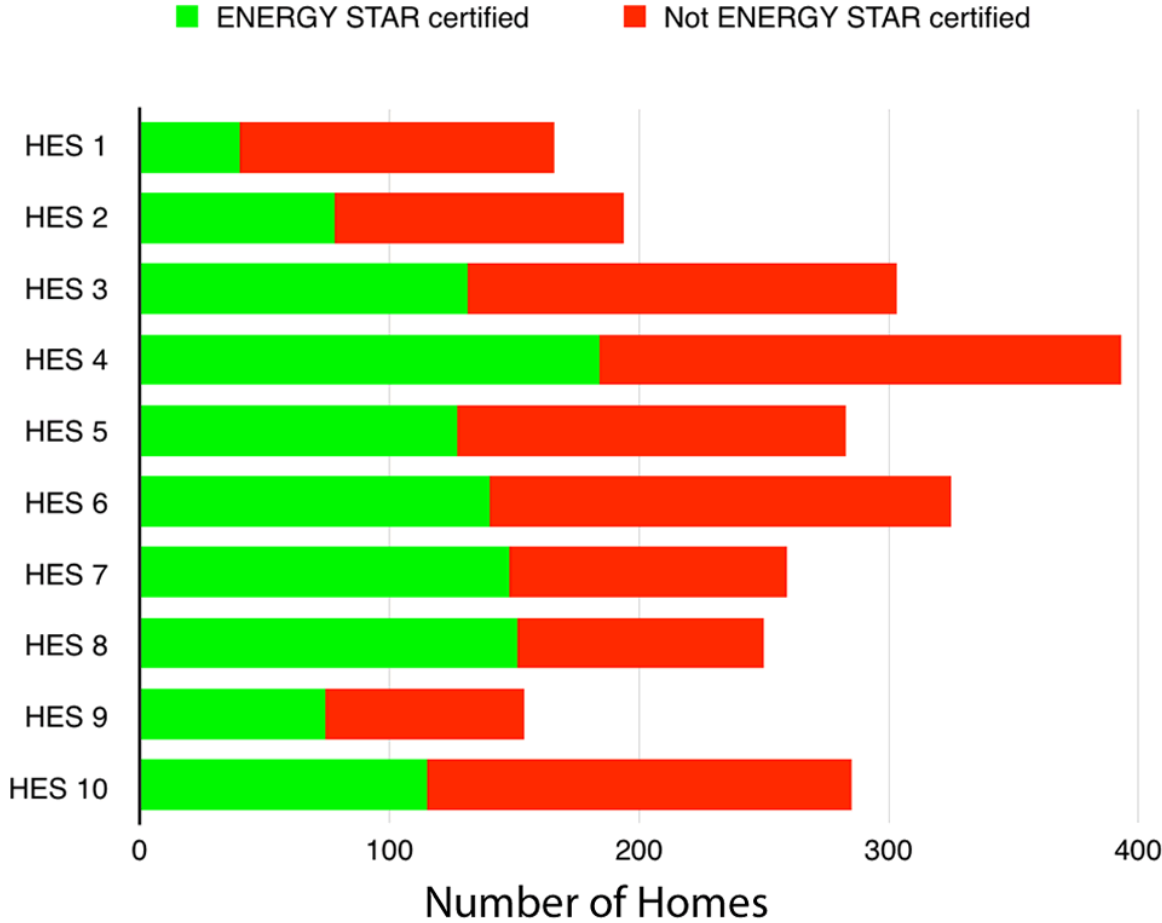


# 2009 IECC HES Statistics

- 31% of homes with HES of '10' did not meet the 2009 IECC envelope requirements
- 46% of homes with HES of '1' met the 2009 IECC envelope requirements
- Based on cost-effectiveness analysis, 27% of the homes with HES of '10' cost the homebuyer more than a home built to 2009 IECC envelope requirements.



# HES versus ENERGY STAR (v.3)

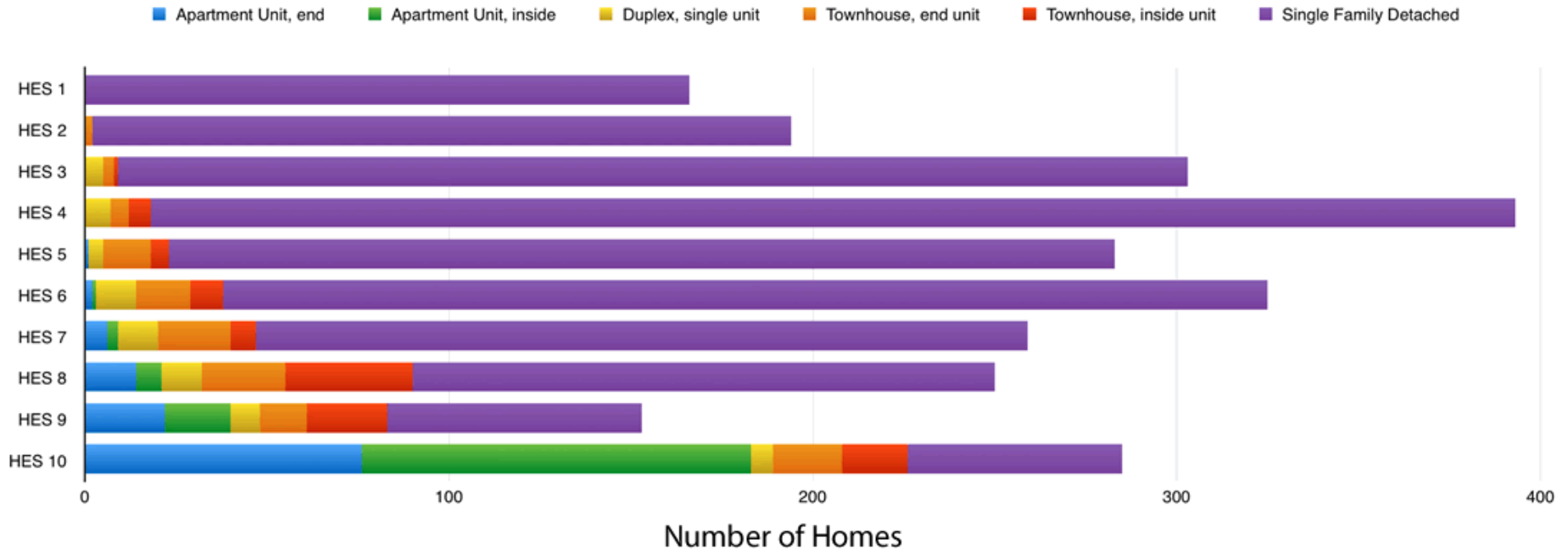


# ENERGY STAR HES Statistics

- 90% of ENERGY STAR homes scored HES less than '10'
- 24% of homes with HES of '1' were ENERGY STAR qualified
- Only 10% of ENERGY STAR homes scored HES of '10'
- Lion's share of homes scoring HES of '10' were multifamily homes.



# HES and Home Type



# Home Type HES Statistics

- 100% of the homes scoring HES of '1' were single family detached homes
- 79% of the homes in the sample set that scored HES of '10' were apartments, condominiums or townhomes



# Parametric Simulations

- EnergyGauge<sup>®</sup> USA v.5.0 used for analysis
- Three home sizes:
  - 1,200 ft<sup>2</sup>, 1-story, 3-br, frame on vented crawl
  - 2,400 ft<sup>2</sup>, 2-story, 3-br, frame on vented crawl
  - 4,800 ft<sup>2</sup>, 2-story, 5-br, frame on vented crawl
- Configured to meet three efficiency levels:
  - 2006 IECC *std. reference design* (HERS Reference)
  - 2012/2015 IECC prescriptive requirements
  - 2015 IECC Section 406 Energy Rating Index (ERI)



# Three Climates Types

- Chicago, IL
  - O'Hare International Airport TMY3 weather
  - Cold dry climate (CZ 5)
- Atlanta, GA
  - Hartsfield international Airport TMY3 weather
  - Mixed dry climate (CZ 3)
- San Diego, CA
  - Lindbergh Field TMY3 weather
  - Mild marine climate (CZ 3)



# Envelope Configurations

## 2006 IECC Standard Reference Design Values

LOCATION	IECC CZ	Ceiling	Wall	Found.	Floor	Fen	Fen
		U-Factor	U-Factor	type	U-Factor	U-Factor	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

## 2012/2015 IECC Prescriptive Envelope Values

LOCATION	IECC CZ	Ceiling	Wall	Found.	Floor	Fen	Fen
		R-value	R-value	type	R-value	U-Factor	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





# Additional IECC 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



# 2006 & 2012/2015 IECC Equipment

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



# HES Source Energy Use Bins

Location	HES Bins									
	10	9	8	7	6	5	4	3	2	1
Chicago Ohare	<62	62	76	88	101	114	126	145	164	>183
Atlanta Heartsfield	<43	43	53	61	70	78	87	100	113	>126
San Diego Lindbergh	<31	31	38	44	51	57	63	73	82	>91



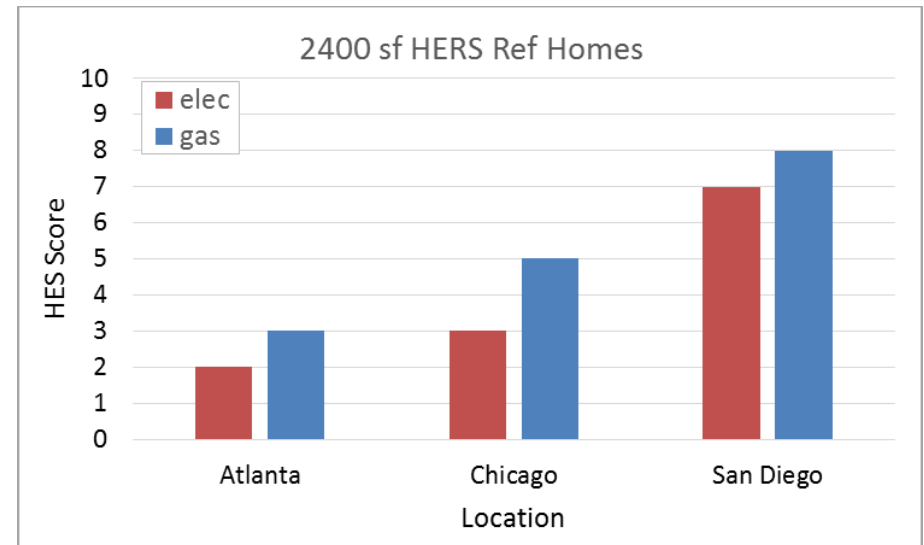
# Example HER Reference Results

Natural Gas Homes:							
Chicago Homes	heat therms	heat kWh	cool kWh	HW therms	Source MBtu	HERS Index	HES
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



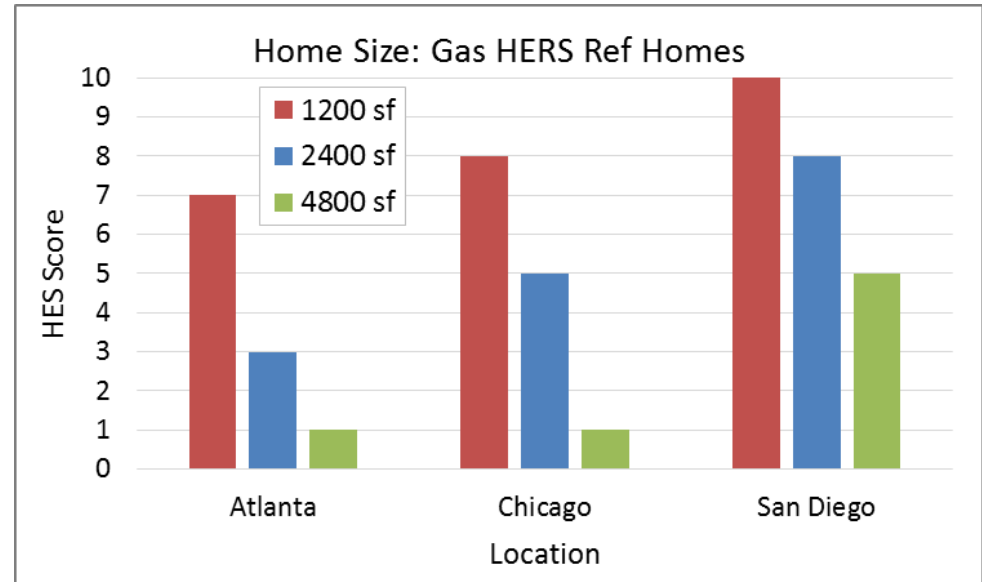
# 2006 IECC (HERS Reference)

- HERS Reference Home (2006 IECC) HES scores are weather sensitive (HES 2-3 in Atlanta, 3-5 in Chicago and 7-8 in San Diego)
- Gas homes score at least 1 HES point better than electric homes in all climates and 2 HES points better in Chicago.



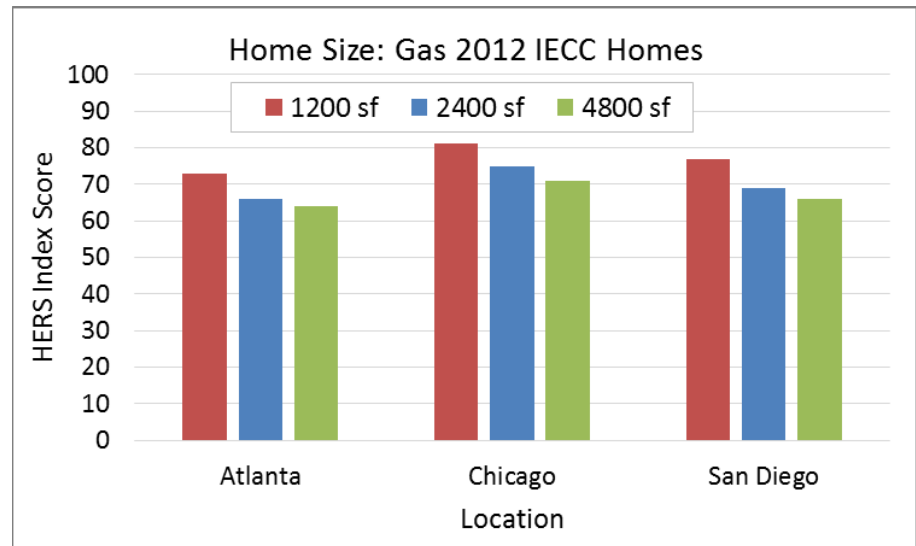
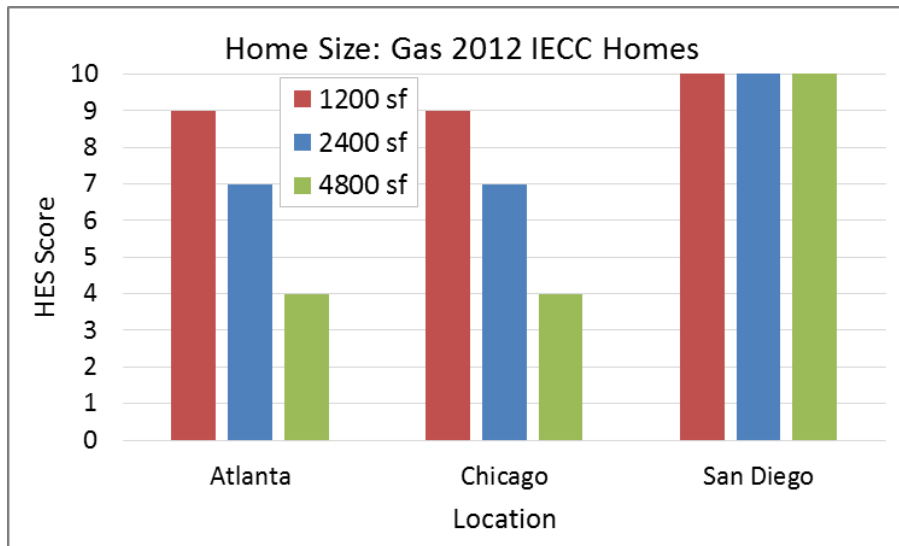
# IECC 2006 HES Home Size Results

- HES results are sensitive to climate at all home sizes
- HES is more sensitive to home size than it is to climate
- In Chicago, there is a 7 point drop in HES between 1,200 ft<sup>2</sup> and 4,800 ft<sup>2</sup> home (85%)



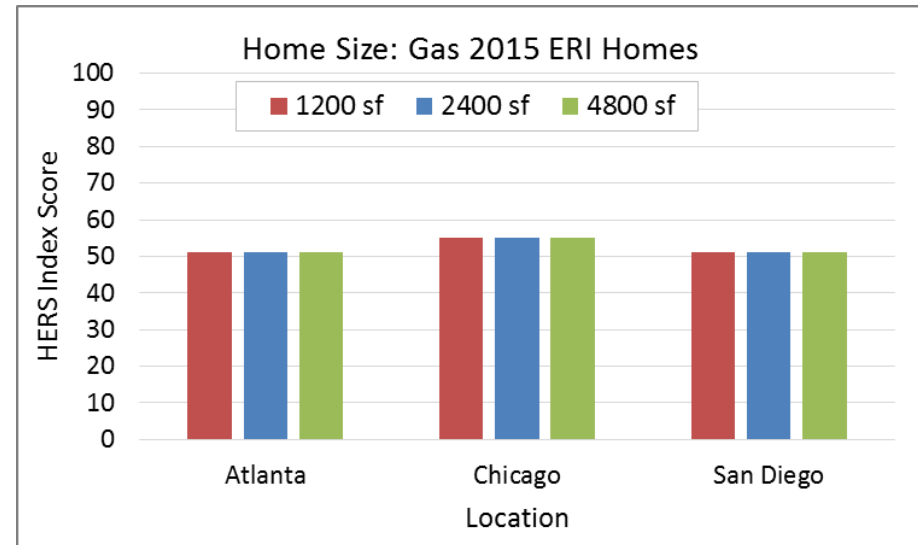
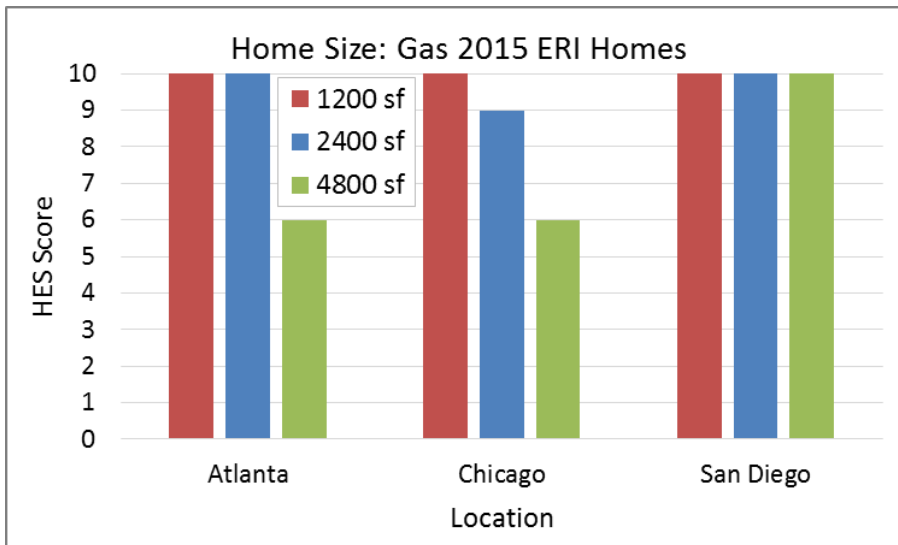
# 2012/2015 IECC Home Results

- Atlanta and Chicago homes:
  - 22% average HES decline between the 1,200 ft<sup>2</sup> and 2400 ft<sup>2</sup>
  - 43% average HES decline between 2,400 ft<sup>2</sup> and 4,800 ft<sup>2</sup>
- All three home sizes in San Diego achieve HES of '10'



# 2015 ERI Results

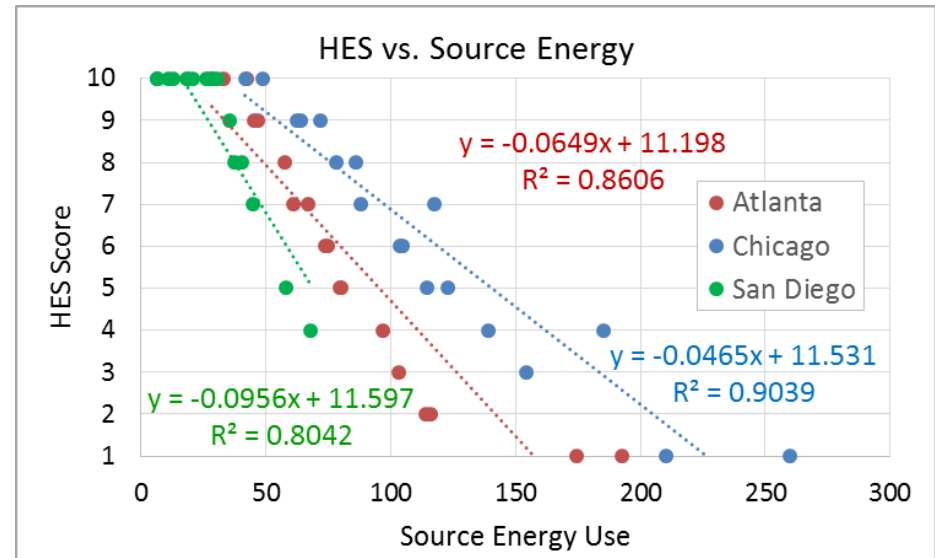
- Two Atlanta homes, one Chicago home and all San Diego homes achieve HES of '10'
- No HES improvement "head room" for homes 2,400 ft<sup>2</sup> or less.
- HERS Index as required by 2015 IECC leaves substantial "head room" below HERS Index for home improvement





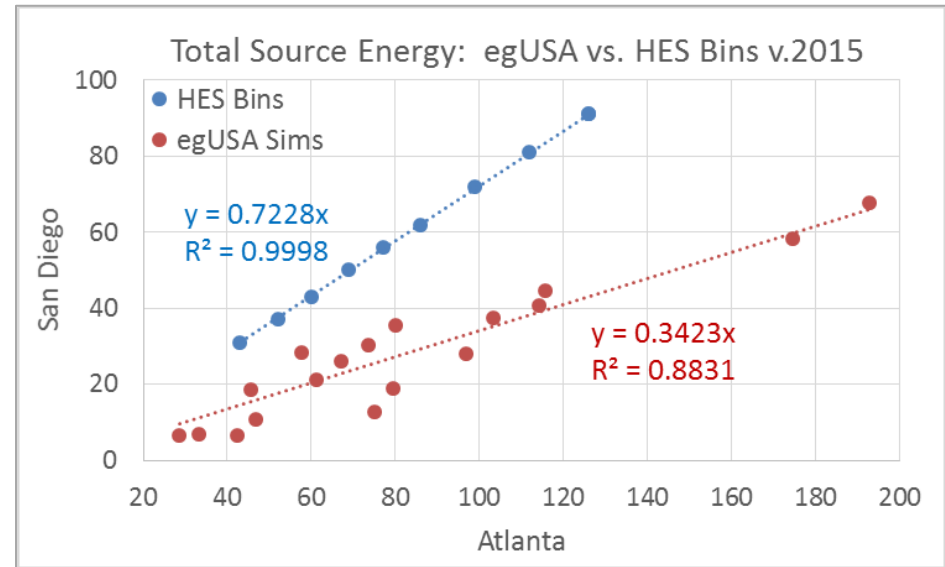
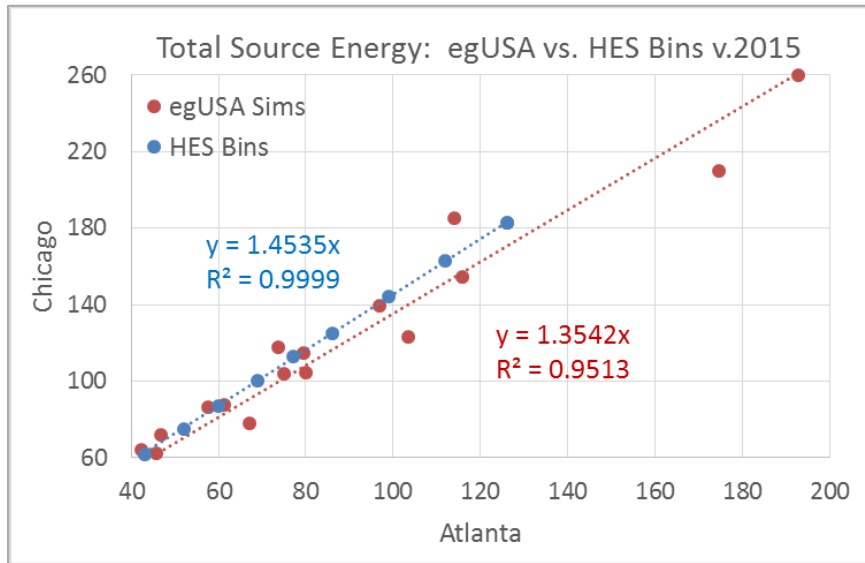
# HES versus Source Energy Use

- Atlanta and Chicago have HES scores across full range from '1' to '10'
- San Diego values range from '4' to '10'
- Two Chicago homes and three Atlanta homes score '10'
- However, two-thirds (12 out of 18) San Diego home configurations score '10.'



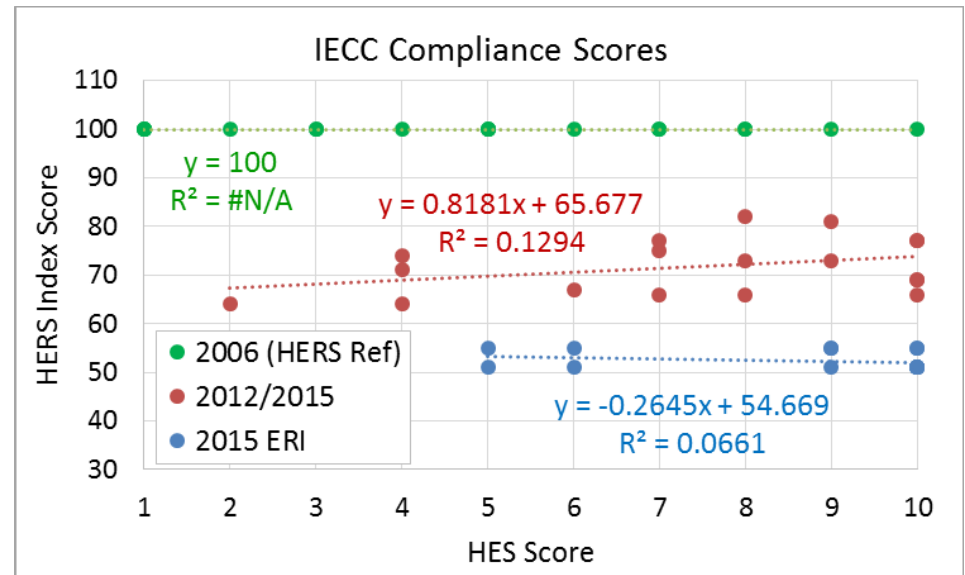
# HES Bins and Simulations

- Chicago's HES Bins are 145% of Atlanta's and Chicago's simulations are 135% of Atlanta's (reasonable)
- San Diego's HES Bins are 72% of Atlanta's but San Diego's simulations are only 34% of Atlanta's (not reasonable)



# HES/HERS Correlations

- Data regression shows no correlation between HERS Reference (2006 IECC) and HES
- Correlation between 2012/2015 IECC and HES is weak, leaving 87% of data variance unexplained by regression equation
- Correlation between 2015 ERI and HES equally weak, leaving 93% of variance unexplained by regression equation.



# Conclusions

- General findings are consistent:
  - HES is a measure of absolute source energy use for heating, cooling and hot water
  - HERS Index is a measure of home energy efficiency or relative energy performance for all home energy uses
- HES Scores are very sensitive to home size
  - Small and multifamily homes typically achieve “higher” HES scores
  - Standard sized and single-family homes achieve “lower” HES scores
- No evidence was found to support any correlation between HES and HERS Index scores or between HES and any level of building code compliance.



# For Further Information

Full report to RESNET is posted online:

<http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-2014-16.pdf>

Any Questions?

