FLORIDA SOLAR ENERGY CENTER®

CONTRACT REPORT

Effectiveness of Florida's Residential Energy Code: 1979 – 2007

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Final Report
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1 Background

More than 30 years ago, the 1973 oil embargo fundamentally changed the way we view energy resources. The 1973 Florida Legislature established the first Florida Energy Commission and the following year, at its recommendation, the Florida Solar Energy Center was established by the legislature. In 1978, the State Energy Office under the Department of Administration issued Florida's first statewide building energy efficiency code. Modeled after ASHRAE Standard 90-75, this code became effective in 1979 and from that point forward, Florida has successfully managed a statewide residential energy efficiency code, which consistently receives high marks in U.S. Department of Energy national code studies.

In 2006, the retail price of gasoline and the wholesale price of natural gas increased dramatically, at one point exceeded $3.00 per gallon and $13.75 per million Btu, respectively. Energy resources are now "top of mind" once again. Prices have declined, but not that much and retail gasoline prices are again pushing $3.00 per gallon.

As a result, there is renewed interest in energy efficiency and renewable energy resources. More than 50% of Florida's electricity is used in our 8 million residences and Florida's residential energy Code is a key tool in achieving statewide increases in energy efficiency.

2 Executive Summary

This study was commissioned by the Florida Department of Community Affair's Codes & Standards Section to determine the impacts of Florida's Energy Efficiency Code over time and recommend possible changes that would increase residential efficiency. It examines each of the 14 residential energy code cycles that have occurred during the 28 year period and determines the relative change in code stringency and its impact on energy use and energy cost throughout the period. The study also examines Florida's proposed 2007 Code[1] to determine how its requirements compare with the requirements

[1] Mod 2327, Florida Building Commission, 2007 Code-Cycle proposed modification recommended to the Commission by the Energy Technical Advisory Committee.

of Section 404 of the 2006 International Energy Conservation Code (IECC). Florida's proposed new energy code compliance software, EnergyGauge® USA,[2] is used to conduct annual, hourly simulations and analysis of 180 different home configurations. These results are combined with Florida's historical energy cost data and new home construction data to determine statewide energy use and cost changes across each code cycle and across all years since 1979. The change in median home size over the 28-year period is also considered by the analysis.

The major findings of the study are:

- Florida has had considerable success using its residential Energy Efficiency Code since 1979, increasing efficiency requirements by about 60% and cumulatively saving Floridians more than 34 billion kWh of electricity – enough to power more than 3 million new Florida homes[3] for a year. The cost savings have also been significant, estimated at almost $3.9 billion, cumulatively. Compared to the 1979 Code, the 150,000 new 2007 Code homes estimated to be built during 2007 will produce annual cost savings of more than $190 million per year.

- Florida's proposed 2007 Code will likely result in new homes that are about 4% more efficient than homes built to the standards of the 2006 IECC.

- Significant opportunities exist to cost-effectively increase residential energy efficiency, especially in new Florida homes. The American Council for an Energy Efficient Economy (ACEEE) recently completed a report on Florida's energy use showing a significant potential to cost-effectively construct homes that are at least 30% more efficient than Florida's proposed 2007 Code.[4]

- "Other" residential energy uses, which have not been considered by Florida's Energy Efficiency Code,[5] constituted 28% of total home energy use in 1979. In 2007, the share of these "other" home energy uses has increased significantly to 53% of the total home energy use.

- Home sizes have consistently increased over time, from a median of 1736 ft^2 in 1979 to a median of 2308 ft^2 in 2006,[6] taking back about 20% of the whole-home energy savings that would have been otherwise achieved.

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[2] Version 2.6.02

[3] Compliant with the proposed 2007 Florida Code.

[4] Elliot, N., et.al, 2007. "Potential for Energy Efficiency and Renewable Energy to Meet Florida's Growing Energy Demands." ACEEE Report E072, American Council for an Energy Efficient Economy, Washington, DC.

[5] Florida's Energy Efficiency Code considers only heating, cooling and hot water energy uses.

[6] Data derived from Florida Housing Data Clearing House, Shimberg Center, University of Florida, website: http://www.flhousingdata.shimberg.ufl.edu/

3 Methods

At its heart, Florida's Energy Efficiency Code for Building Construction is performance-based. In other words, it constructs a geometrically similar home with specified component performances (the Baseline Home) and uses that home to establish an "energy budget" which can not be exceeded by the proposed home (the As-Built Home). Thus, there is a specification (a "rule set") as to how the Baseline Home must be configured relative to the As-Built Home.

These rule sets are used in this analysis to configure a group of 6 homes, two for each of Florida's 3 main climate zones, to match the "energy budget" requirements for homes in each of the 14 energy code "cycles" (when the Codes changed). Two full sets of homes were created: one where home size varied from year to year to match Florida data on new home construction, and a second set where home size was held constant at its 1979 value. A fifteenth set of these 6 homes was created to match the minimum requirements of the 2006 IECC Baseline (Standard Reference Design Home) to examine the proposed 2007 Florida Code with respect to the 2006 IECC.

Unlike most code analysis, each of these homes is configured with a set of standard lighting and appliances in accordance with the *2006 Mortgage Industry National Home Energy Rating Standards* (the RESNET Standards).[7] These Standards are in widespread national use, forming a national basis for the following: home energy ratings run in all 50 states; qualification for the ENERGY STAR® new homes program run by the U.S. Environmental Protection Agency; a performance metric for the *Building America* program run by the U.S. Department of Energy; and qualification for the EPAct 2005 income tax credit on highly-efficient new homes.

These "other" energy uses are carefully specified by the RESNET Standards, with their total value calculated as a function of the home size. Thus, for this study, as home size increases so do these lighting and appliance energy uses, forming some of the house size "take back" reported here. While these uses do not directly affect the code energy uses of heating, cooling and hot water, they do indirectly impact these uses by altering the internal gains of the simulated homes.

Of these "other" energy uses, refrigerators deserve special mention. We have seen, due to significant improvements in the minimum standards for refrigerators, a substantial decline in refrigerator energy use over recent years, [8] going from 1335 kWh per year in 1979 to 613 kWh per year in 2007.[9]

The building, equipment and appliance configuration for each of the 14 code cycles are given in Table A.

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[7] RESNET, 2006. *Mortgage Industry National Home Energy Rating Standards*; online at: http://resnet.us/

[8] Harowitz, N., C. Calwell and T. Reeder, November 2001. "Out With the Old, In With the New: Why Refrigerator and Room Air Conditioning Programs Should Target Replacement to Maximize Energy Savings." National Resource Defense Council, Washington DC.

[9] E-Source, Residential Appliances, 1995, pp 4.4.1 - 4.5.2

Table A. Characteristics of Florida Code "Baseline" Homes by Code Vintage

Code Component:	Code Year													
	1979	**1980**	**1982**	**1984**	**1986**	**1989**	**1991**	**1991R**	**1993**	**1997**	**2001**	**2004**	**2004R**	**2007**
House type	Wood frame; 3 bedroom; square; slab-on-grade													
Floor area	1736	1749	1767	1784	1851	1929	1976	2007	2053	2141	2225	2273	2308	2308
Slab edge	1979	1980	1982	1984	1986	1989	1991	1991R	1993	1997	2001	2004	2004R	2007
North	R=3.4	R=3.4	R=0	R=0	R=3.5	R=3.5	R=3.5	R=3.5	R=3.5	R=3.5	R=3.5	R=3.5	R=3.5	R=0
Central	R=3.4	R=3.4	R=0	R=0	R=3.5	R=3.5	R=3.5	R=3.5	R=3.5	R=3.5	R=3.5	R=3.5	R=3.5	R=0
South	R=3.4	R=3.4	R=0	R=0	R=0	R=0	R=0	R=0	R=0	R=0	R=0	R=0	R=0	R=0
Walls	1979	1980	1982	1984	1986	1989	1991	1991R	1993	1997	2001	2004	2004R	2007
North	R=0	R=0	R=11	R=11	R=19	R=19	R=19	R=19	R=19	R=11	R=11	R=11	R=11	R=13
Central	R=0	R=0	R=11	R=11	R=19	R=19	R=19	R=19	R=19	R=11	R=11	R=11	R=11	R=13
South	R=0	R=0	R=11	R=11	R=19	R=19	R=19	R=19	R=19	R=11	R=11	R=11	R=11	R=13
Ceilings	1979	1980	1982	1984	1986	1989	1991	1991R	1993	1997	2001	2004	2004R	2007
North	R=17.2	R=17.2	R=19	R=19	R=30	R=30	R=30	R=30	R=30	R=30	R=30	R=30	R=30	R=30
Central	R=17.2	R=17.2	R=19	R=19	R=30	R=30	R=30	R=30	R=30	R=30	R=30	R=30	R=30	R=30
South	R=17.2	R=17.2	R=19	R=19	R=30	R=30	R=30	R=30	R=30	R=30	R=30	R=30	R=30	R=30
Roof/attic	Composition shingle on felt on plywood on trusses with vented attic													
Doors (north)	R=2	R=2	R=2	R=2	R=5	R=5	R=5	R=5	R=5	R=5	R=5	R=5	R=5	U=0.75
Windows:	1979	1980	1982	1984	1986	1989	1991	1991R	1993	1997	2001	2004	2004R	2007
% WFA	15%	15%	15%	15%	15%	15%	15%	15%	15%	18%	18%	18%	18%	18%
Area (sq.ft.)	260	262	265	268	278	289	296	301	308	385	400	409	415	415
U-factor:	1979	1980	1982	1984	1986	1989	1991	1991R	1993	1997	2001	2004	2004R	2007
North	1.30	1.30	1.30	0.87	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.75	0.75
Central	1.30	1.30	1.30	1.30	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.75	0.75
South	1.30	1.30	1.30	1.30	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.75	0.75
SHGC:	1979	1980	1982	1984	1986	1989	1991	1991R	1993	1997	2001	2004	2004R	2007
North	0.75	0.75	0.75	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.40	0.40	0.40	0.40
Central	0.75	0.75	0.75	0.75	0.66	0.66	0.66	0.66	0.66	0.66	0.40	0.40	0.40	0.40
South	0.75	0.75	0.75	0.75	0.66	0.66	0.66	0.66	0.66	0.66	0.40	0.40	0.40	0.40
Envelop leakage	1979	1980	1982	1984	1986	1989	1991	1991R	1993	1997	2001	2004	2004R	2007
ach50	12.4	11.8	10.8	9.9	9.0	7.9	7.3	7.1	6.8	6.1	5.7	5.6	5.6	5.6
Heating System	1979	1980	1982	1984	1986	1989	1991	1991R	1993	1997	2001	2004	2004R	2007
Type:														
North	Strip	Strip	Strip	Strip	HP	HP	HP	HP	HP	HP	HP	HP	HP	HP
Central	Strip	Strip	Strip	Strip	Strip	Strip	Strip	Strip	Strip	Strip	HP	HP	HP	HP
South	Strip	Strip	Strip	Strip	Strip	Strip	Strip	Strip	Strip	Strip	HP	HP	HP	HP
HSPF:	1979	1980	1982	1984	1986	1989	1991	1991R	1993	1997	2001	2004	2004R	2007
North	COP=1	COP=1	COP=1	COP=1	6.6	6.6	6.5	6.8	6.8	6.8	6.8	6.8	7.7	7.7
Central	COP=1	COP=1	COP=1	COP=1	COP=1	COP=1	COP=1	COP=1	COP=1	COP=1	6.8	6.8	7.7	7.7
South	COP=1	COP=1	COP=1	COP=1	COP=1	COP=1	COP=1	COP=1	COP=1	COP=1	6.8	6.8	7.7	7.7
Cooling System	1979	1980	1982	1984	1986	1989	1991	1991R	1993	1997	2001	2004	2004R	2007
SEER														

Code Component:	Code Year													
	1979	1980	1982	1984	1986	1989	1991	1991R	1993	1997	2001	2004	2004R	2007
North	6.1	6.8	8.0	7.8	8.5	8.5	8.9	10.0	10.0	10.0	10.0	10.0	13.0	13.0
Central	6.1	6.8	8.0	7.8	9.0	9.0	8.9	10.0	10.0	10.0	10.0	10.0	13.0	13.0
South	6.1	6.8	8.0	7.8	9.0	9.0	8.9	10.0	10.0	10.0	10.0	10.0	13.0	13.0
HW System EF	1979	1980	1982	1984	1986	1989	1991	1991R	1993	1997	2001	2004	2004R	2007
EF	0.81	0.81	0.81	0.83	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.92	0.92	0.92
Tank (gal)	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Ducts	1979	1980	1982	1984	1986	1989	1991	1991R	1993	1997	2001	2004	2004R	2007
Leaks (Qn)	0.12	0.12	0.12	0.12	0.12	0.12	0.10	0.10	0.08	0.08	0.08	0.06	0.06	0.05
R-value	4.2	4.2	4.2	4.2	4.2	4.2	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Location	Attic	Attic	Interior	Interior	Attic	Attic	Attic	Attic	Attic	Attic	Attic	Attic	Attic	Attic
AHU	Garage	Garage	Garage	Garage	Garage	Garage	Garage	Garage	Garage	Garage	Garage	Garage	Garage	Garage
Other (kWh/yr)	1979	1980	1982	1984	1986	1989	1991	1991R	1993	1997	2001	2004	2004R	2007
Miscellaneous	2159	2185	2219	2252	2382	2534	2625	2685	2774	2945	3108	3201	3269	3269
Lighting	1844	1854	1868	1882	1936	1998	2036	2061	2097	2168	2235	2273	2301	2301
Refrigerator	1335	1335	1335	1211	1211	1033	969	969	749	749	607	610	610	613
Dryer	891	891	891	891	891	891	891	891	891	891	891	891	891	891
Range	447	447	447	447	447	447	447	447	447	447	447	447	447	447
Dishwasher	145	145	145	145	145	145	145	145	145	145	145	145	145	145
Cloths washer	105	105	105	105	105	105	105	105	105	105	105	105	105	105
Pool pump	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceiling fans	Vary by climate zone													
North	382	382	382	382	382	382	382	382	382	382	382	382	382	382
Central	491	491	491	491	491	491	491	491	491	491	491	491	491	491
South	652	652	652	652	652	652	652	652	652	652	652	652	652	652

Sources

1979: Section 502.2, "Model Energy Efficiency Building Code." Florida Department of Administration, State Energy Office, November, 1978.

1980: Section 502.2, "Model Energy Efficiency Code for Building Construction." Florida Department of Community Affairs, Bureau of Codes and Standards, October 1, 1980

1982: Section 903.11, "Model Energy Efficiency Code fo Building Construction." Florida Department of Community Affairs, Codes and Standards Section, September, 1982.

1984: Section 1002.1, "Energy Efficiency Code for Building Construction." Florida Department of Community Affairs Energy Code Program, April 1984.

1986: Form 900-A-84, "Energy Efficiency Code for Building Construction 1986." Florida Department of Community Affairs Energy Code Program, Revised January 1987.

1989: Form 900-A-89, "Energy Efficiency Code for Building Construction 1989." Florida Department of Community Affairs Energy Code Program, 1989.

1991: Form 900-A-91, "Energy Efficiency Code for Building Construction 1991." Florida Department of Community Affairs Energy Code Program, 1991.

1993: Form 600A-93, "1993 Energy Efficiency Code for Building Construction." Florida Department of Community Affairs Energy Code Program, 1993.

1997: Form 600A-97, "Energy Efficiency Code for Building Construction, 1997 Edition." Florida Department of Community Affairs, Building Codes and Standards Office, 1997.

2001: Form 600A-01, "Florida Building Code 2001, Chapter 13, Florida Energy Efficiency for Building Construction."

2004: Form 600A-04, "Florida Building Code 2004, Chapter 13, Florida Energy Efficiency for Building Construction."

2007: Section 13-613, Proposed Modification No. 2367, "Florida Building Code 2007, Chapter 13, Florida Energy Efficiency for Building Construction."

Individual cells of Table A are highlighted in light yellow to identify the transitions from code cycle to code cycle. The sources at the bottom of Table A give the specific Code provision that were used for each code cycle to configure the homes in this analysis. Also note from the pool pump entries in Table A that pools, which consume considerable power in Florida, are not considered by this analysis.

Following the simulations, the results from the two homes in each climate zone are averaged to obtain average energy use for each of the three climate zones. Following this climate averaging, a statewide weighted average energy use is determined using the 1993 utility residential customer base for each climate.[10]

The building energy analysis tool used to accomplish the analysis is EnergyGauge USA. EnergyGauge USA is accredited by RESNET for use in determining home energy ratings (HERS Index) and is accredited by the IRS for use in determining qualification for the federal income tax credit for highly-efficient new homes.[11] EnergyGauge USA is available online as a free 15-day trial download or for purchase of a one-year user's license at a moderate price.[12]

While EnergyGauge has not been available for each of the code cycles in question, it was important that it be used in this analysis for at least three reasons:

1. It is very important that the same energy analysis be used for every code cycle or we have no confidence that the results are comparable,
2. EnergyGauge is the proposed compliance software tool for Florida's 2007 Code,
3. EnergyGauge is a nationally accredited, detailed, hourly building analysis tool based the highly-respected DOE-2.1E building simulation engine.

Florida's Code also contains distinguishing features tailored to Florida's hot, humid climates. For many years, Florida's code has provided specification for limiting the infiltration of humid, outdoor air, as it contributes significantly to our ability to control relative humidity in Florida homes. Likewise, Florida has led national efforts to curb duct leakage, which leads to depressurization and moisture control problems in its residential construction.

Evidence from field studies of Florida homes between 1989 and 2006 show that Florida's Code, along with its research and educational efforts have been successful in these regards. The data show that measured envelope leakage in new Florida homes has consistently declined from an ach50[13] of more than 12 in 1979 to ach50 of about 5.6 in 2006.[14,15,16,17]

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[10] Rose, Matthew, Craig McDonald, Peter Shaw, and Steve Offutt. 1993. *Electricity Conservation and Energy Efficiency in Florida: Appendix C-D Technical and Achievable Potential Data Inputs.* SRC Report No. 7777-R8. Bala Cynwyd, Penn.: Synergic Research Corporation.

[11] http://www.resnet.us/programs/taxcredit_software/directory.aspx

[12] http://www.energygauge.com/usares/trial.htm

[13] ach50 is a measure of envelope leakiness. It is equal to the number of building air changes per hour (ach) measured while the building is under a pressure with respect to the outdoors of 50 Pascal.

[14] Cummings, J., J. Tooley and N. Moyer, 1990. "Radon Pressure Differential Project, Phase I." Report No. FSEC-CR-344-90, Florida Solar Energy Center, Cocoa, FL.

Likewise, these same studies show that measured duct leakage has also significantly decreased since the late 80's when it was first identified (Cummings, 1991) as a significant energy waste factor in Florida homes. As these scientific findings have come forth over the years, Florida's Energy Efficiency Code has been modified, seeking to significantly reduce duct leakage. The recent field studies (Cummings, 2002 and Swami, 2006) show that normalized duct leakage to outdoors ('Qn' in Table A)[18] in new homes has decreased significantly from a value of about 0.12 in 1979 to a value of about 0.05 in 2007.

For the analysis conducted here, these values for envelope tightness and duct leakage are expressly evaluated across the code cycles as shown in Table A, above.

4 Results

4.1 Changes in Code Stringency Over Time

The initial question to be answered by the analysis is how much did code stringency change over the past 28 years? This is answered by comparing the "energy budgets" for each code cycle to those of the previous code cycle and to that of the 1979 code cycle. Although the code did not have a designated Baseline prior to 1986, it had an effective Baseline in its prescriptive Code in overall compliance. Figure 1 presents the results from this analysis

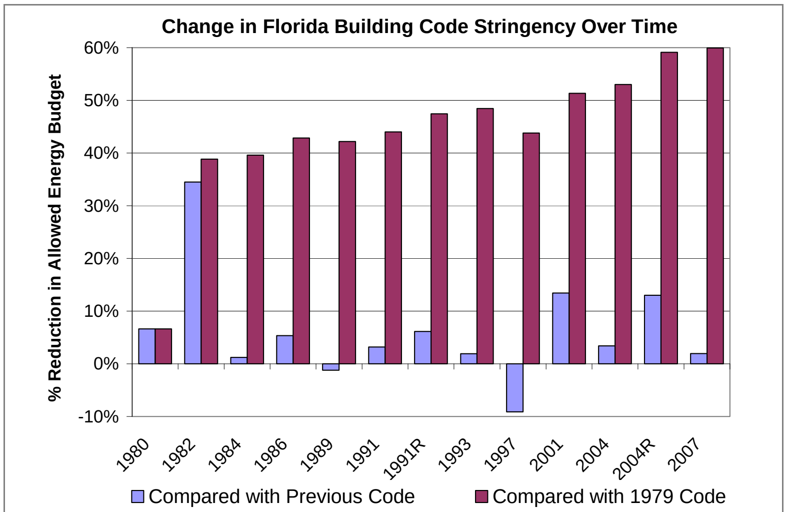

Figure 1 Comparison of Code cycle stringency from 1979 - 2007.

Figure 1 shows that, while the overall reduction in energy budget over the years has been significant at 60%, the reduction has occurred in spurts. First, in 1982 there was a

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[15] Cummings, J., J. Tooley and N. Moyer, 1991. "Investigation of Air Distribution System Leakage and Its Impact in Central Florida Homes." Report No. FSEC-CR-397-91, Florida Solar Energy Center, Cocoa, FL.

[16] Cummings, J., C. Withers, L. Gu, J. Mcilvaine, J. Sonne, P. Fairey, M. Lombardi, 2002. "Field Testing and Computer Modeling to Characterize the Energy Impacts of Air Handler Leakage." Report No. FSEC-CR-1357-02, Florida Solar Energy Center, Cocoa, FL.

[17] Swami, M. V. et.al., 2006. "Florida Building Code - Enhance Florida's Building to Next-Generation Energy & Mechanical Codes and Energy Compliance." Report No. FSEC-CR-1678-06, Florida Solar Energy Center, Cocoa, FL

[18] Normalized duct leakage (Qn) is equal to the measure duct leakage (in cfm) to outdoor at a 25 Pascal pressure difference divided by the conditioned floor area of the home.

substantial increase in code stringency caused by the fact that duct were placed in the interior of the home to arrive at the energy budget for that year. This provision also existed in the 1984 code cycle but has not been used since. The 1989 code cycle shows a slight increase in energy budget, however, this entire increase is due to the increase in house size between the two code cycles.

In 1997, there was a 9.9% increase in the allowed energy budget. This is due to two things that occurred during the 1997 code cycle changes. First, the method of calculating the energy use attributable to windows in homes was made much more accurate, eliminating a significant winter credit for windows. Second, to compensate for this substantial change in the impact of windows, two other Baseline Home characteristics changed significantly in 1997. The percentage of windows as a function of the conditioned floor area was increased from 15% to 18% and the value of the wall insulation was decreased from R-19 to R-11. These code changes combined to make Florida's 1997 Code less stringent than its 1993 Code.

This reduction in stringency was overcome plus some in the 2001 code cycle, when the Baseline heating system was changed from strip heat to a heat pump in both central and south Florida. There is one additional jump in code stringency that occurred in code-cycle 2004R, when the 2004 Code was revised to account for the January 2006 federal revision of the minimum NAECA standards for air conditioners and heat pumps.

Overall, these Florida Code changes have resulted in significant energy savings. It is informative to examine where these savings have occurred. Figure 2 presents an analysis of the achieved savings by end use. Clearly, the largest savings have occurred in space cooling, with significant improvements in both envelope efficiency requirements and air conditioning equipment efficiency over time. Florida has also seen savings, albeit not nearly as pronounced, in space heating for much the same reason. There have been small reductions in hot water energy use and an increase in energy use for all "other" energy uses. In 1979 the other energy uses represented only 28% of total energy use, while, for the proposed 2007 Code, they represent more than 52% of total home energy use.

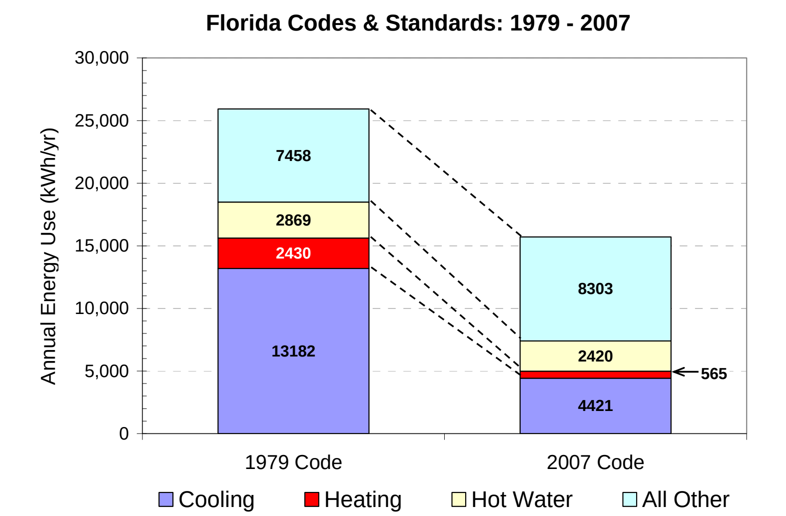

Figure 2 Average Florida home savings resulting from Florida Code implementation.

4.2 Cumulative Energy Savings Over Time

To determine how these increases in code stringency have impacted statewide energy use in Florida, it is necessary to know how many new homes were constructed during each of the 14 code cycles. The raw data for permits and new home construction starts are collected from the *Florida Statistical Abstracts*, maintained by the Bureau of Economic and Business Development at the University of Florida and from the *Statistical Abstracts of the United States*, maintained by the U.S. Census Bureau. The resulting data are presented in Table B.

Table B. Florida New Home Starts 1980-2007 [19]

Year	Permits	Starts	Year	Permits	Starts
1980	174,451	167,836	1994	128,602	131,000
1981	146,557	141,000	1995	122,903	123,400
1982	103,813	100,100	1996	125,020	140,100
1983	189,440	180,400	1997	133,990	145,100
1984	204,925	196,700	1998	148,603	138,100
1985	202,615	193,800	1999	164,722	152,800
1986	195,525	193,000	2000	155,269	147,900
1987	178,764	193,900	2001	167,035	161,200
1988	170,597	185,100	2002	185,431	177,000
1989	164,985	165,400	2003	213,567	197,300
1990	126,347	126,800	2004	255,893	185,700
1991	95,308	102,100	2005	287,250	173,600
1992	102,022	116,200	2006	N/A	165,400
1993	115,103	115,100	2007*	N/A	150,000

* Value for 2007 Starts is an estimate by the author

Table B presents both permit activity and new construction start data. The permit data are not used in the analysis but were collected as a reasonableness check on the new start data.

The effective dates of the code cycles do not necessarily line up with the beginning and end of calendar years so it is necessary to modify the data in Table B to line up with the various code cycles. This is done by linearly proportioning the housing starts for the periods of the calendar years that cross code cycles, resulting in the data given in Table C.

[19] Sources: Bureau of Economic and Business Research, *Florida Statistical Abstract*, various years, (21st, 32nd and 40th Editions). University Presses of Florida, Gainesville, FL; U.S. Bureau of the Census, *Statistical Abstract of the United States*: various years (106th, 107th, 110th, 111th and 113th Editions.) Washington, DC, 1986.

Table C. Code Cycle Housing Starts

Code Effective Dates			Housing Starts		
Vintage	Begin	End	Year	%Starts	#Starts
1979	1/1/1980	5/1/1980	1979	33.06%	55,487
1980	5/1/1980	1/1/1981	1980	67.12%	112,657
	1/1/1981	1/1/1982	1981	100.00%	141,000
	1/1/1982	8/31/1982	1982	66.30%	66,368
1982	9/1/1982	1/1/1983	1982	33.42%	33,458
	1/1/1983	1/1/1984	1983	100.00%	180,400
	1/1/1984	4/1/1984	1984	24.86%	48,906
1984	4/1/1984	1/1/1985	1984	75.34%	148,199
	1/1/1985	1/1/1986	1985	100.00%	193,800
1986	1/1/1986	1/1/1987	1986	100.00%	193,000
	1/1/1987	1/1/1988	1987	100.00%	193,900
	1/1/1988	1/1/1989	1988	100.00%	185,100
1989	1/1/1989	1/1/1990	1989	100.00%	165,400
	1/1/1990	1/1/1991	1990	100.00%	126,800
1991	1/1/1991	1/1/1992	1991	100.00%	102,100
1991R	1/1/1992	1/1/1993	1992	100.00%	116,200
1993	1/1/1993	1/1/1994	1993	100.00%	115,100
	1/1/1994	1/1/1995	1994	100.00%	131,000
	1/1/1995	1/1/1996	1995	100.00%	123,400
	1/1/1996	1/1/1997	1996	100.00%	140,100
	1/1/1997	11/1/1997	1987	83.29%	120,850
1997	11/1/1997	1/1/1998	1997	16.71%	24,250
	1/1/1998	1/1/1999	1998	100.00%	138,100
	1/1/1999	1/1/2000	1999	100.00%	152,800
	1/1/2000	1/1/2001	2000	100.00%	147,900
	1/1/2001	1/1/2002	2001	100.00%	161,200
	1/1/2002	3/1/2002	2002	16.16%	28,611
2001	3/1/2002	1/1/2003	2002	83.84%	148,389
	1/1/2003	1/1/2004	2003	100.00%	197,300
	1/1/2004	1/1/2005	2004	100.00%	185,700
	1/1/2005	10/1/2005	2005	74.79%	129,843
2004	10/1/2005	1/1/2006	2005	25.21%	43,757
	1/1/2006	12/8/2006	2006	93.42%	154,524
2004R	12/8/2006	1/1/2007	2006	6.58%	10,876
	1/1/2007	1/1/2008	2007	100.00%	150,000

From the data presented in Table C, it is possible to determine the cumulative statewide energy savings that have been achieved by increases in stringency of Florida's code cycles. The results are presented in Figure 3.

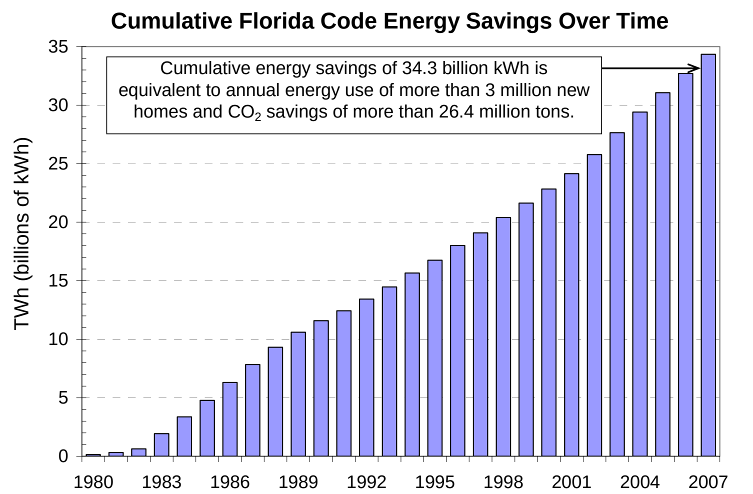

Figure 3 Cumulative Florida Residential Energy Code Savings over time.

Figure 3 is relatively unremarkable except for the magnitude of the energy savings that have been achieved by Florida's Energy Code. Total electricity savings of more than 34 billion kWh are sufficient to power more than 3 million new Florida homes for a year and avoid more than 26 million tons of CO_2 emissions.

In order to determine the cost impacts of the energy savings given in Figure 3, it is necessary to determine the statewide retail cost of electricity for each of the years shown in Figure 3. This is done in terms of the revenue-based retail cost of electricity.[20,21] The revenue-based cost is calculated as the total annual statewide residential revenue collected divided by the total annual statewide electricity provided. Thus, it includes all costs paid by the retail customer for electricity.

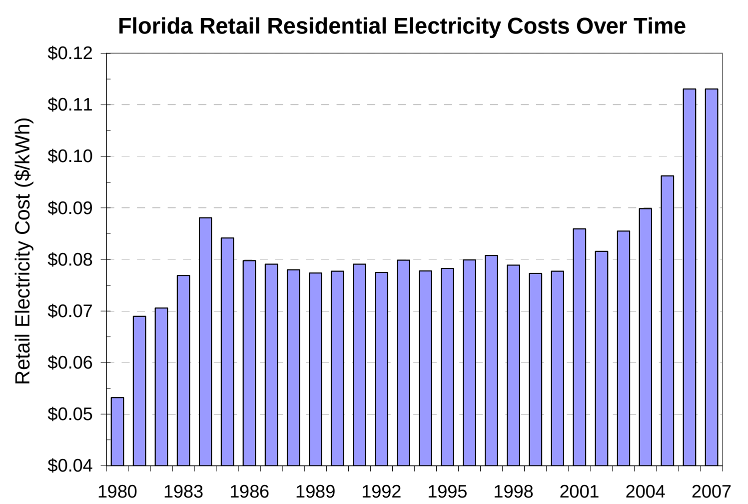

Figure 4 Florida's retail residential electricity cost from 1980 - 2007.

Figure 4 presents the statewide average revenue-based Florida retail electricity costs from 1980 -2007. This figure shows that Florida's retail residential costs remained relatively constant across the period until about 2004 when a distinct trend in price increases began that has persisted up through the present. Given the

[20] Shoemyen, A., et.al., various years. *Florida Statistical Abstracts*, 20th and 24th Editions. Bureau of Economic and Business Research, College of Business Administration, University of Florida, Gainesville, FL.
[21] U.S. EIA: http://www.eia.doe.gov/cneaf/electricity/epa/epa_sprdshts.html

national and international trends in fuel costs, there is no logical reason to predict that Florida's retail residential electricity prices will moderate in the future.

In 1986, when Florida adopted its first Baseline Home performance-based approach to Code compliance, natural gas energy use was modified to account for the customer-weighted price difference between electricity and natural gas. This "cost-based" approach to the treatment of natural gas and electricity remains in Florida's Residential Code until the proposed 2007 Residential Code becomes effective. However, residential natural gas use is not considered in this study for two reasons:

- The proposed 2007 Code does not use a cost-based compliance approach but instead uses a normalized, modified loads approach as is used by RESNET Home Energy Rating Standards, and
- Natural gas use represents only 1.3% of residential primary energy use in Florida due to the small heating loads encountered by Florida residences.[22]

Combining the data from Figures 3 and 4, the cumulative cost savings from the Florida Residential Energy Efficiency Code may be obtained. Figure 5 presents these results, clearly illustrating the impact of recent increases in retail residential electricity price. The cumulative cost savings are significant at a total of almost $4 billion. The annual savings from the estimated 150,000 new homes that will be constructed in Florida in 2007 is more than $190 million.

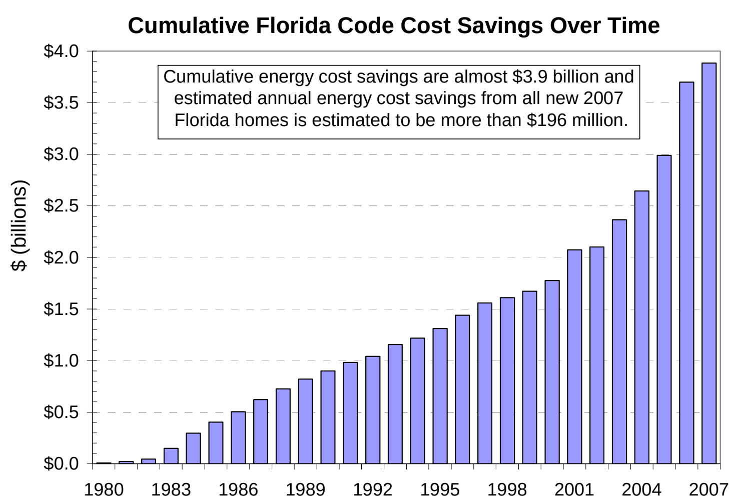

Figure 5 Cumulative cost savings from Florida Residential Energy Efficiency Code for Building Construction.

4.3 Impacts of Florida House Size Increase Over Time

So far the values that have been presented include the impacts of the increases of house size that have occurred over the past 28 years. However, two full sets of analysis were accomplished; one that increased house size from code cycle to code cycle and one that held house size constant at its 1979 value for the entire period. The difference between these two sets of simulations represents the "takeback" resulting from the increases in house size over the years. In other words, if house size had not increased over time, the savings would have been even greater.

[22] EIA: http://www.eia.doe.gov/emeu/states/sep_sum/html/sum_btu_res.html

Figure 6 illustrates this impact. It is important to point out that the data for Figure 6 includes whole-home energy use rather than just the code energy uses of heating, cooling and hot water. These "other" energy uses are quite important because they increase as house size increases. The result is that the house size "takeback" effect has a 20% impact on whole-house energy use.

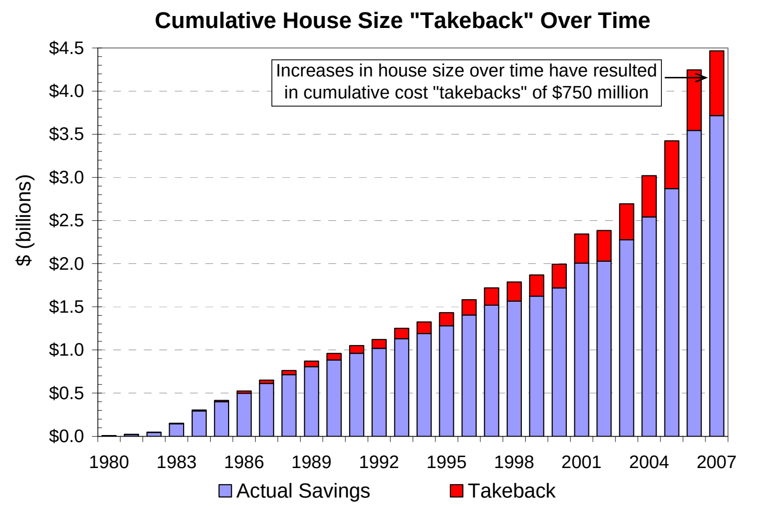

Figure 6 Impacts of house size "takeback" on Florida's Energy Code savings.

4.4 Florida's Code as Compared with the 2006 IECC

The analysis also compared Florida's proposed 2007 Residential Code with the requirements of the 2006 IECC. For this analysis, the 2007 Florida Code home was compared with the IECC, Section 404 "Standard Reference Design Home." The Standard Reference Design Home has the same meaning as the Florida Baseline Home in that it establishes the energy budget that can not be exceeded by a proposed home seeking compliance with the IECC.

Results from this analysis, as illustrated by Figure 7, show that Florida's proposed 2007 Code "meets or exceeds" the requirements of the 2006 IECC in all Florida climates examined in this analysis. Overall, Florida's proposed 2007 Code provides about 4% energy savings compared to the 2006 IECC Standard Reference Design Home.

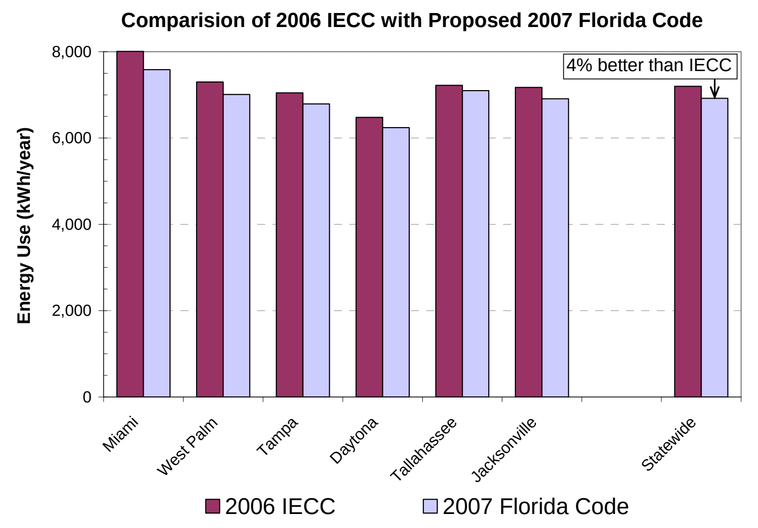

Figure 7 Comparison of 2006 IECC requirements with proposed 2007 Florida Code.

These additional savings occur primarily because Florida's Code directly addresses important ancillary issues related to duct system and envelope leakage that are not explicitly codified in the 2006 IECC.

These home attributes are critically important in Florida where the hot, humid climate requires that outdoor air exchange, whether caused by duct leakage, envelope tightness or their combination be limited to control relative humidity in homes. Recent field research on these items (Cummings, 2004 and Swami, 2006) has shown that Florida's efforts to codify requirements for envelope and duct system sealing have been beneficial over time. In the earlier field research studies (Cummings, 1990 and 1991) both envelope leakage and duct system leakage were measured to be significantly greater than they are today (see also Table A).

The 2006 IECC also contains mandatory requirements that are not contained in Florida's performance-based Code. The first of these IECC mandatory requirements is for R-8 duct insulation. Florida has found that this requirement is not cost effective in Florida, saving only a few dollars per year compared to Florida's R-6 Baseline and costing the industry significant quantities to retool to accommodate such a requirement. Additionally, the codification of duct sealing in Florida's Code is of significantly greater value from a cost-effectiveness basis than the small increase in required R-value.

The 2006 IECC also contains a mandatory requirement for window SHGC, whereby the area-weighted average SHGC may not exceed 0.50. Since Florida's Code Baseline home incorporates windows with SHGC=0.40, this mandatory IECC requirement does not result in an increase in Code stringency but rather only imposes an industry-based requirement that produces no gain in overall home energy efficiency. For this reason, Florida has chosen to not include this IECC mandatory requirement in the Florida Code.

4.5 Beyond Florida's Proposed 2007 Code

A number of national and state programs exist that have the goal of exceeding minimum Florida Energy Efficiency Code requirements. These programs are often referred to as "beyond code" programs. The U.S. Environmental Protection Agency (EPA) administers an ENERGY STAR® new homes program[23] that requires homes to be about 15% better than Florida's Code requirements to qualify. The U.S. Department of Energy (DOE) administers the *Building America* program[24] that requires new homes to be about 20% better than Florida's Code requirements, and some Florida utilities administer new home programs that include incentives for homes that exceed Florida's Code requirements.[25,26] Additionally, the U.S. Department of Treasury (IRS) offers a $2,000 income tax credit to builders of highly efficient new homes with projected heating and cooling energy use that is 50% less than the national model code minimum requirements.[27]

Probably the most successful of the market programs nationwide is the EPA ENERGY STAR program. It has very high name recognition among consumers and is responsible for the construction of more than 188,000 ENERGY STAR new homes nationwide in

[23] http://www.energystar.gov/index.cfm?c=new_homes.hm_index
[24] http://www.eere.energy.gov/buildings/building_america/
[25] http://www.fpl.com/residential/buildsmart/contents/buildsmart_home_buyer_information.shtml
[26] http://www.progress-energy.com/custservice/flares/builders/efficient/index.asp
[27] http://www.irs.gov/businesses/small/industries/article/0,,id=155445,00.html

2006. According to U.S. Census data, this amounts to 12% of the new single-family home starts during 2006.[28] EPA data show that Florida's market penetration of ENERGY STAR new homes is significantly below the national average at only 2% of new single-family home starts, while Nevada has an astounding ENERGY STAR market penetration of 71% of new single-family home starts.

According to the Residential Energy Services Network (RESNET), approximately 8,776 homes qualified for the federal tax credit for highly efficient new homes during 2006.[29] Participation in this program is expected to rise for a number of reasons: 1) the program was not implemented for the entire year during 2006 due to requirements for IRS to develop rules on qualification, 2) the software qualification structure was not available until spring of 2006, and 3) builder awareness of the program was not high during the initial year of the tax credit availability. Of the 8,776 homes certified nationally for tax credits, only 167 of them (1.9%) were constructed in Florida.

Between November 2006 and February 2007, the American Council for an Energy Efficient Economy (ACEEE), in collaboration with the Florida Solar Energy Center, undertook a study of Florida's potential to use energy efficiency and renewable energy technology to displace forecast future energy demands in Florida.[30]

Among other things, this study found that significant cost-effective energy savings are available for energy efficiency and renewable energy (EERE) relative to Florida's proposed 2007 Energy Efficiency Code. Figure 8 presents one set of economic analysis results from this study. The levelized cost of conserved energy (CCE)[31] for a large number of these building improvements is less than 12 cents per kWh – the current average retail cost of residential electricity in Florida.

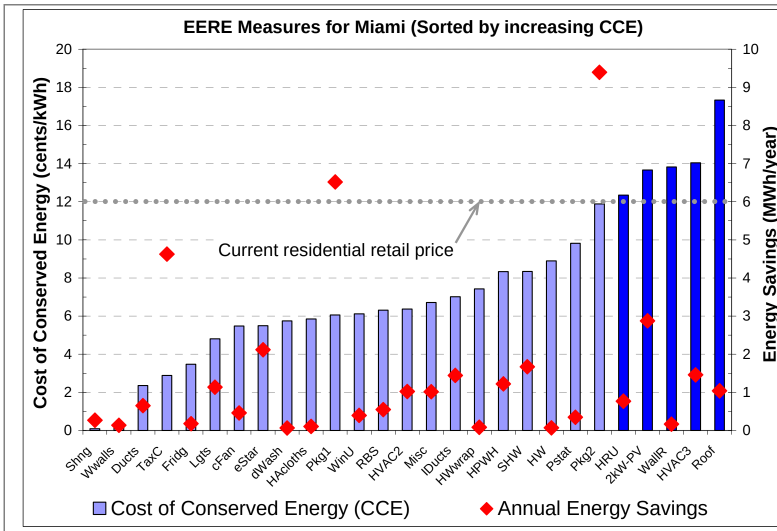

Figure 8 Cost of Conserved Energy (CCE) for an array of home improvements relative to Florida's proposed 2007 Code.

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[28] http://www.census.gov/const/C40/Table2/tb2u2006.txt
[29] Personnel communication with Steve Baden, Executive Director of RESNET.
[30] Elliot, et.al., 2007. "Potential for Energy Efficiency and Renewable Energy to Meet Florida's Growing Energy Demands." ACEEE Report E072, American Council for an Energy Efficient Economy, Washington, DC.
[31] Meier, A., J. Wright and A.H. Rosenfeld. 1983. *Supplying Energy Through Greater Efficiency*, pp 19-21. Berkeley, CA: University of California Press.

Three packages of improvements are particularly interesting with respect to the previous discussion. As shown in Table D (taken from the cited report), ENERGY STAR new homes, Tax Credit new homes and a new home that saves 40% of whole home energy use with respect to Florida's proposed 2007 Code are all shown to be cost-effective from the perspective of the levelized cost of conserved energy (CCE).

Table D. Projected Cost-Effective Residential Energy Savings Potential for Florida

New Home Efficiency	kWh Saved per Home per Year (Statewide Average)	2023 Statewide Savings (GWh)	Economic Savings Potential (% of Total Residential Electricity Potential)	Cost per kWh Saved
Energy Star Home (15% savings)	*2,021*	*5,764*	*11%*	*$ 0.06*
Tax Credit Eligible Home (25% savings)[a]	*1,857*	*2,715*	*5%*	*$ 0.03*
40% Savings Home[b]	*1,998*	*584*	*1%*	*$ 0.07*
Total Savings (GWh)		**53,054**	**100%**	**$ 0.049**
% Savings (% of 2023 Projected Sales)		**34%**		

[a] Savings are incremental to Energy Star Homes.
[b] Savings are incremental to Tax Credit Eligible Homes.

These data clearly show that there are significant savings that can be cost-effectively achieved beyond Florida's proposed 2007 Code. Note from Figure 1 that the last time Florida had a substantial increase in its Code stringency was in 1982, shortly after the cost of oil was at an all time high in 1981. That high, in constant dollars, was not exceeded until the 2006 oil price spike to almost $80 per barrel.

5 Recommendations

The primary recommendation from this study is that the stringency of Florida's Residential Energy Efficiency Code for Building Construction be increased. The amount of this increase is a matter that will require the deliberation of the Florida Building Commission, its Technical Advisory Committees and Florida's stakeholders but the data indicate that an increase of at least 15-20% would likely be quite cost effective. There are at least two strategies for accomplishing an overall increase in Florida's Code's stringency.

5.1 <u>Make Florida's Energy Code Comprehensive.</u>

Include all home energy uses in Florida's Code as is currently done in national Home Energy Rating Systems. The data from this study show that the home energy uses that are not covered by Florida's Code now account for more than 50% of home energy use. In 1979 these "other" energy uses accounted for only 28% of total energy use. By virtue of the fact that Florida's Energy Efficiency Code has consistently addressed the energy uses of heating, cooling and hot water, these uses have been substantially moderated. On the other hand, these "other" energy uses have not been substantially addressed and have increased over time as home size has increased.

Increasing numbers of these "other" energy uses have both a standard level of energy use and a method to determine the efficacy of alternative, more efficient means of providing these energy services. Lighting is a prime example, where new compact fluorescent technology using standard "Edison" sockets makes it possible to achieve significant energy savings compared to the standard incandescent bulb. In Florida, where air conditioning requirements are large, increases in lighting efficiency have a synergistic impact, whereby the total energy savings that accrue from lighting savings are about 125% of the lighting savings alone.

A number of household appliances, including refrigerators, dishwashers, clothes washers and ceiling fans are now "rated" for energy performance, either through the national appliance labeling program of the Federal Trade Commission or through the EPA. Through the Residential Energy Services Network (RESNET), the Home Energy Rating System (HERS) industry has promulgated national consensus standards that include the efficiency of these devices in whole-house energy performance analysis.[32]

These national standards are in widespread use across all 50 states and serve as the qualification basis for EPA's ENERGY STAR new homes program and many other "beyond code" programs across the nation.

RESNET Ratings provide a relative energy use index called the HERS Index – a HERS Index of 100 represents the energy use of the "American Standard Home" and an Index of 0 (zero) indicates that the Proposed Home uses no net purchased energy (a Zero Energy Home). A set of rater recommendations for cost-effective improvements that can be achieved by the Rated Home is also produced.

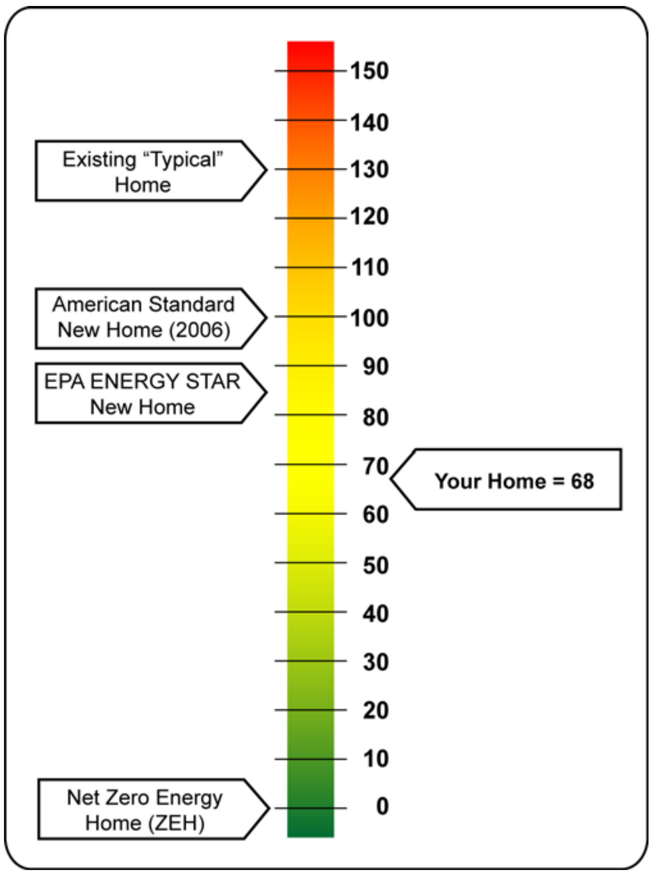

Figure 9 RESNET's HERS Index scale.

The American Standard New Home depicted on the HERS Index scale in Figure 9 is comprised of the minimum Code requirements of the 2006 IECC for the building envelope and its heating, cooling and hot water equipment, augmented by RESNET's standards for the additional lighting and appliances energy uses that are standard in American homes.

[32] Chapter 3, *2006 National Mortgage Industry Home Energy Rating System Standards.* Residential Energy Services Network, Oceanside, CA (online: http://www.resnet.us/standards/mortgage/default.htm).

As depicted on this scale, EPA's ENERGY STAR new home qualification requires a HERS Index of 85 in Florida, meaning that on a whole-home basis, ENERGY STAR new homes use approximately 15% less energy than the American Standard Home.

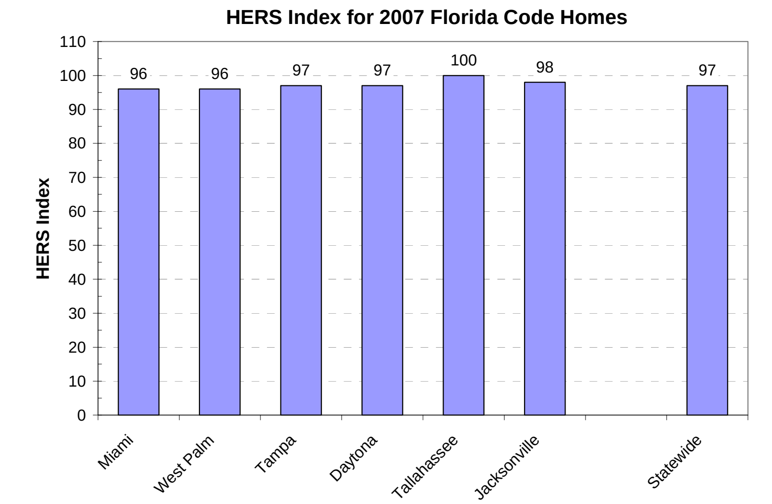

Figure 10 HERS Indices for 2007 Florida Code homes located in six Florida climates.

To assess the relationship between the HERS Index and Florida's proposed 2007 Code, the 2007 Florida homes depicted by Table A are evaluated for their HERS Index. The results from this analysis are shown in Figure 10. Figure 10 shows that the 2007 Florida Code home will, on a statewide average, be approximately 3% more efficient than the HERS American Standard Home. Note that the values shown in Figure 10 correspond very well with the relationship shown in Figure 7 between the Florida Code home and the 2006 IECC. Thus, a HERS Index of 100 provides a close approximation of Florida's 2007 Energy Efficiency Code. The great difference is that "other" energy uses are fully considered in the HERS analysis.

Thus, the quickest, easiest and most straight forward way to address home energy use in a comprehensive manner is to adopt this national Home Energy Rating System and simply require a HERS Index less than 100 for Florida Code compliance, much like is done for ENERGY STAR qualification. In fact, based on the analysis presented in Section 4.5 and by the ACEEE Florida Report (see footnote 29), the ENERGY STAR level of home performance may be a very good point to start with increases to Florida's Code stringency.

There are additional advantages to this approach, as follows:

- It does not require any change to Florida's Code Baseline Home because RESNET's American Standard Home already aligns with Florida's Code Baseline Home for envelope features and heating, cooling and hot water equipment. Thus, no previously existing agreements on the configuration of the Florida Code Baseline Home need be renegotiated.
- It allows all energy efficiency technologies, not just heating, cooling, hot water and envelope measures to compete on an equal footing in achieving the most cost effective improvements in overall home energy efficiency.

- It makes Florida's Code system seamlessly compatible with virtually all national 'beyond code" programs, including ENERGY STAR and federal income tax credit qualification for highly efficient homes.
- The system can be used to provide "advanced warnings" to industry of code stringency increases, which they will understand intrinsically. Rather than changing Florida's Code Baseline Home requirements, the implications of which are difficult and complex to grasp and understand, industry can be given advanced notice that in some certain number of years the requirements for Code compliance will change from a HERS Index of 'x' to a HERS Index of 'y', a concept that will be easy to understand and evaluate using existing code compliance software.
- It allows opportunities to privatize Florida Energy Code enforcement system through an infrastructure of Home Energy Raters that already exist within the state and for which there is an existing infrastructure within Florida for training and certification and quality assurance based on national consensus standards.
- This HERS Index can be used as a measure of energy efficiency for green building and other "beyond code" programs.
- The HERS index incorporates the evaluation of renewable energy systems, including solar hot water and on-site PV power production.
- It provides a very simple means of measuring progress into the future.

5.2 Revise Florida's Code Baseline Home

An alternative means of strengthening Florida's Residential Code is to increase the efficiency of Florida's Code Baseline Home. Individual components that can be modified in the Code Baseline Home to accomplish an increase in Florida's Code stringency are as follows:

- Decrease the Baseline Home window area from 18% of the conditioned floor area to 12% of the conditioned floor area.
- Incorporate a solar hot water system with 75% solar fraction into the Baseline Home.
- Move the heating and air conditioning ducts and air handler system from the attic and garage into the conditioned space for the Baseline Home.
- Provide for substantially leak-free duct systems in the Baseline Home and require that all As-built homes be tested and shown to be substantially leak free.
- Increase ceiling insulation to R-38 and wall insulation to R-19 in the Baseline Home.
- Change the roof and wall solar absorptance in the Baseline Home from 0.75 to 0.40.
- Change the SHGC of the windows in the Baseline Home from 0.40 to 0.30.

- Require that the Baseline Home energy budget be determined using a programmable thermostat.

On incorporating the above changes in the Florida Code Baseline Home, substantial reductions in the energy budget for heating, cooling and hot water are achievable. Figure 11 illustrates, showing a 60% reduction in these code energy uses as compared with the proposed 2007 Code and an 84% reduction as compared with the 1979 Code. It should be pointed out that these reductions in the Baseline Home energy budget are achieved with minimum standard heating and cooling equipment. Since the federal standard for rating heating and cooling equipment is preemptive, it is not deemed wise to use increased heating and cooling equipment efficiency as a viable strategy for reducing the energy budget of the Baseline Home.

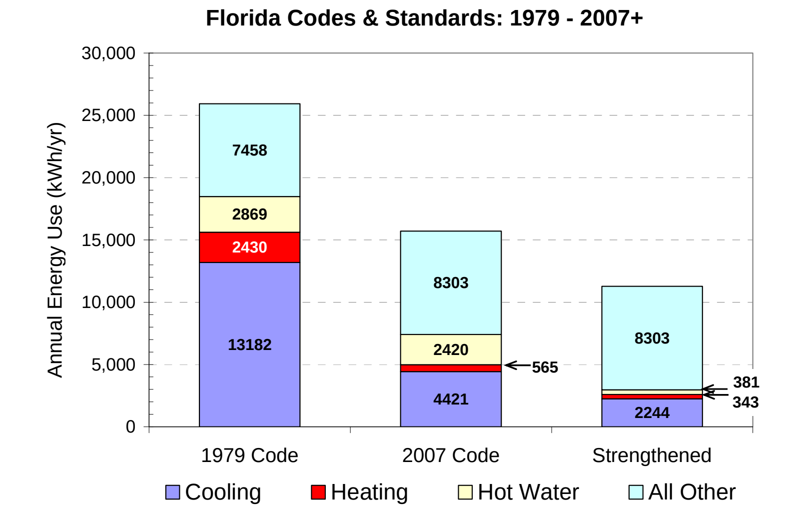

Figure 11 Changes in annual energy uses (and Code energy budgets) if Baseline Home specifications are substantially strengthened.

Note that, while Code savings shown in Figure 11 for the more stringent Baseline are almost 60%, the reduction in whole-home energy use is only about 28%. To illustrate this point, Figure 12 plots the HERS Index, which measures whole-home energy use, for the 2007 Code homes along side of this more stringent Baseline, showing a whole-home energy savings on the HERS Index of about 28%.

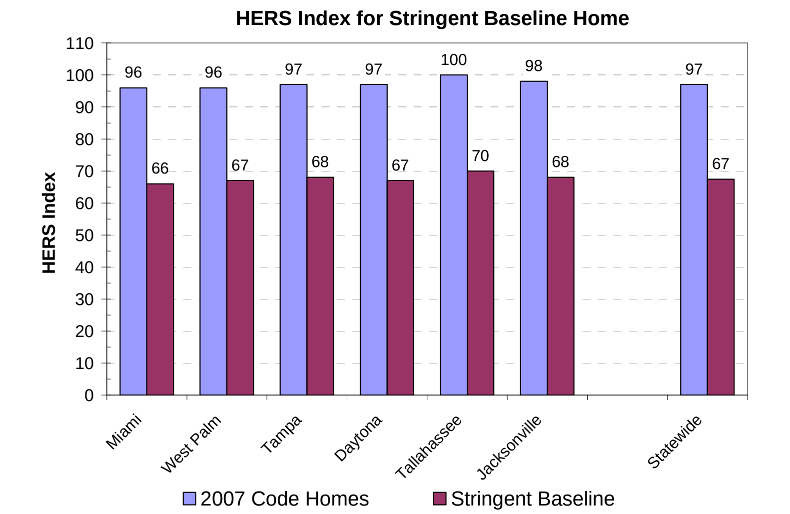

Figure 12 HERS Indices for 2007 Florida Code homes compared with HERS Indices for much more stringent Baseline Home.

Thus, it is even more apparent than ever that "other" home energy uses are dominating the energy use in the Baseline Home, with the "other" category consuming almost 74% of the total energy use for the strengthened Baseline Home in Figure 11. While it is quite possible to strengthen the Code Baseline Home by a considerable amount, this strategy may not be the most appropriate way to move forward due to its over emphasis on heating, cooling and hot water at the expense of the increasing energy uses in the "other" category. Of the two strategies for moving Florida's Code forward, the authors believe the comprehensive option described in Section 5.1 is the preferable way to proceed into the future.