

GOING BEYOND A RESNET CERTIFICATION FOR CODE-COMPLIANT SIMULATIONS: A COMPARISON OF DETAILED RESULTS OF THREE RESNET-CERTIFIED, CODE-COMPLIANT RESIDENTIAL SIMULATION PROGRAMS

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ABSTRACT

In many states building code officials rely on certified, code-compliant simulations to determine whether or not a residence satisfies the energy code requirements using a performance-path analysis. In the United States, certification of residential code-complaint software is performed by the Residential Energy Services Network (RESNET). Unfortunately, significant differences in results can exist when one compares the ratings from one certified software program to the next. This paper explores some of these differences for an analysis of a code-complaint residence in Texas, and provides additional comparisons that may help identify possible reasons for these differences.

INTRODUCTION

In many states building code officials rely on certified, code-compliant simulations to determine whether or not a residence satisfies the energy code requirements using the performance-path of the International Energy Conservation Code (IECC) (IECC 2000, 2001). A performance path analysis requires a building energy simulation to determine whether or not the total annual energy use of a proposed design consumes less energy than a code-compliant reference house.

In order to ensure the accuracy and comparability of IECC performance path calculation tools, the RESNET Software Verification Committee has defined a suite of software tests for use in verifying IECC performance compliance software tool accuracy and comparability (Residential Energy Services Network, Inc., 2007). The RESNET Board of Directors has adopted this test suite as the verification tests that shall be used by RESNET to accredit computerized IECC performance compliance tools. The RESNET software verification test suite includes the following tests: Tier one of the HERS BESTEST (Judkoff and Neymark, 1995), IECC Code Reference Home auto-generation tests, HVAC tests, duct distribution system efficiency tests, and hot water system performance tests. Three programs are currently posted on RESNET's National Registry of

Accredited IECC Performance Verification Software Tools¹, including Energy Gauge® USA version 2.8, the International Code Compliance Calculator (IC3) version 3.3², and REM/Rate REM/Design version 12.7.

IC3, developed by the Energy Systems Laboratory (ESL) of the Texas A&M University System, is a RESNET-certified web-based, code-compliance software to demonstrate the performance of proposed single family residences according to the Texas Building Energy Performance Standards (TBEPS). The IC3 software has also been approved by the U.S. Environmental Protection Agency (EPA) and Texas Commission on Environmental Quality (TCEQ) in determining above-code compliance for credits toward NOx emissions reductions.

EnergyGauge® was developed by the Florida Solar Energy Center (FSEC). This software allows a performance-based analysis of building energy use and includes an economic analysis of proposed energy improvements (EnergyGauge USA, 2010). REM/Rate™ is a residential energy analysis, code compliance and HERS rating software developed by the Architectural Energy Corporation (AEC) specifically for the needs of Home Energy Raters (HERS) providers (REM/Rate, 2009).

Although all three programs have been certified by RESNET, significant differences in results still remain when one compares the ratings from one software to the next. Unfortunately, this can cause confusion and frustration with code officials and homeowners when even small differences can make the difference between a house passing code or not. This paper compares these three software tools using the same proposed house in

¹ Website for National Registry of Accredited IECC Performance Verification Software Tools
http://www.natresnet.org/programs/iecc_software/directory.aspx,
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² Input file for this IC3 version is ver. 4.01.05.

two locations in Texas using the 2000 IECC³ as the energy code for the performance approach. Differences in the code-compliance results using the 2000 IECC for all three programs are presented and analyzed to identify possible reasons for the differences.

DESCRIPTION OF THE PROPOSED HOUSE AND STANDARD REFERENCE HOUSE

The proposed house used in this analysis is a 2,500 sq. ft., square-shaped, single-story, single-family, detached house facing N, S (front door), E, W, with a floor-to-ceiling height of 8 feet. The house has a vented attic with a gabled roof pitched at 23 degrees facing the front of the house, which contains the HVAC system and ductwork. The wall construction is a light-weight wood frame with 2x4" studs at 16" on center with a slab-on-grade-floor, which is consistent with an average household determined from builder's surveys by the Texas National Association of Home Builders.

The ceiling insulation is R-30 and wall insulation is R-13. The building has an exterior wall absorptance of 0.55 and roof absorptance of 0.75. The total window area is 12.8% of the total conditioned floor area, equally distributed on all four sides of the house. The windows have no exterior shading, a U-value of 0.47 Btu/hr-sq.ft.°F and solar heat gain coefficient (SHGC) of 0.4. The space temperature set points are 68°F for heating, 78°F for cooling, with a six hour 5°F set-back/set-up for winter and summer, respectively. The total internal heat gain is assumed to be fixed at a constant 0.88 kW (3,000 Btu/hr). No occupants are assumed in the simulated house. The air exchange rate of this proposed house is set to a specific leakage area of 0.00057, which was obtained by converting the normalized leakage of 0.57 as proposed in Section 402.1.3.10 of the 2000 IECC⁴. The heating and cooling system efficiency is set to the minimum Federal standards, which are SEER 13 for the air conditioner

and an AFUE of 0.78 for the gas furnace. An energy factor of 0.544 was used for the domestic water heater (40 gallon). The size of the DHW was determined by the number of bedrooms and bathrooms based on the information from ASHRAE Applications Handbook⁵.

Table 1 provides a detailed listing of the IC3 inputs for the proposed house (located in Houston) and comparable inputs for Software-2 and Software-1. Where one software did not have the same option as the others, the closest values in these programs were used. For example, in order to simplify the input for the user, IC3 does not require the input on the floor finish. The IC3 default for this is 20% tile and 80% carpet, which matches the inputs used in Software-2. In Software-1, "Carpet" was input because the choice of using a combination of floor covering is not available in the program. During this analysis, it was possible to set most of the IC3 parameters to be the same as the inputs required for the Software-2 because it provides a detailed summary of all the parameters used in the simulation. Unfortunately, this was not as straight forward an exercise with Software-1. For example, in this analysis the wall solar absorptance was set to 0.55 in both IC3 and Software-2, but this input is not directly available in Software-1. Instead, the color of the exterior wall is required. Therefore, in this analysis, a "Medium color" was chosen as an alternative to match the input in the other programs.

Several input parameters for the proposed house were found differently for all three programs, including the number of bedrooms, the Heating Degree Days (HDD), and ceiling and the wall insulation equivalent U-values. For the IC3 and Software-1, the proposed house has four bedrooms while there are no bedrooms in the proposed house in Software-2. The proposed house used in the IC3 analysis assumes no people in the house, which is required in Section 402.1.3.6 of the 2000 IECC. Since Software-2 assumes that the number of bedrooms is equal to the number of people in the house, the field for the input of the total number of bedrooms in Software-2 was entered as zero to match the internal gain settings between the three programs for the proposed house. In addition, in the 2000 IECC, Heating Degree Days – base 65 F (HDD₆₅) are used to determine the required insulation levels in the building envelope. In Software-2 and Software-1, if the user selects the location, the corresponding HDD₆₅ are automatically displayed. Unfortunately, in the analysis for the Houston and Dallas locations, the HDD₆₅ values

³ In the analysis, 2000 IECC was used in the standard reference house simulations for the three programs. In the 2000 IECC there is no specific mandatory requirement for duct insulation in Chapter 4 of the 2000 IECC. Therefore, a supply duct insulation of R8 and return duct insulation of R4 were used in the standard reference house simulation as required by the 2001 Supplement in IC3. Software-1 has a choice of either the 2000 IECC and 2001 IECC. However, the simulation results on Software-1 standard reference house were exactly the same when using these two codes. In Software-2, R6 was used for both supply and return duct insulation in the standard reference house.

⁴ Specific leakage area (SLA) = L/CFA, where CFA is the conditioned floor area in ft² and Leakage Area (L) is defined in accordance with Section 5.1 of ASHRAE 119 as the leakage area of the space (ft²) and can be calculated using the following equation: $L_n = 1000 * (L/A) * (H/H_0)^{0.3}$, where, L_n = normalized leakage (0.57), H_0 = height of a single story (8ft), H = height of the building (ft), A = floor area of the space (ft²).

⁵ This includes information from the 2003 ASHRAE Applications Handbook, p.49.9. Supplemented by Hendron, R., 2008, Building America Research Benchmark Definition, Updated December 19, 2008.

displayed were slightly different for each program (Table 1)⁶. This may be because different references were used in the three programs. There were also differences in the displayed equivalent U-values of the ceilings and walls, although the same cavity insulation values and framing factor of the walls and ceilings were entered into all three programs. This appears to be because the material used in the layers of the wall and ceilings were defined slightly differently in the three programs.

The corresponding settings generated by the three software programs for the standard reference house are shown in the Table 1. In this table, the RED font is used for the standard reference house settings which are different from the proposed house. In order to produce an “above code” condition, the window area in the proposed and standard reference house was different. In this analysis the standard reference house has a window area equal to 18% of the conditioned floor area. It was noted that the standard reference house summary information is not shown in Software-1. Therefore, no settings from Software-1 are listed in the table. In Table 1, it can be seen that the different programs simulate the standard reference house differently in several of the important features of the house, including the shape of the house, the framing factor, the window frame, the HVAC system size, the ducts, the internal gains, etc. Unfortunately, these differences lead to large variation in the results of the code-compliance analysis. For example, IC3 contains a duct model, which is based on ASHRAE Standard 152-2004 (Kim, 2006). In IC3, the duct leakage, duct insulation, duct location, etc. are used to calculate the duct distribution efficiency for the HVAC system for both the standard reference house and the proposed house. Software-2 also simulated the ducts in the attic using its own duct model in the proposed house. For the standard reference house, a fixed duct distribution efficiency of 0.80 was used and the ducts were assumed to be located in the interior. In addition, in the proposed house Software-2 assumed to have a constant 0.88 kW internal gain, while the reference house had a variable internal gain schedule. In IC3, a constant internal gain schedule of 0.88 kW was applied to both the proposed house and reference house. Other less significant differences in the inputs can be found in Table 1.

COMPARISON OF SIMULATION RESULTS

Based on the values listed in Table 1, two locations were simulated in this analysis, Houston and Dallas. All simulations used the TMY2 hourly weather data. Figure

1 and Table 2 shows the total energy use and a breakdown of the end use for the proposed house and 2000 IECC standard reference house, as well as the results displayed as the percentage above code from the three programs.

The Proposed House in Houston:

For the proposed house in Houston, IC3 calculated the total annual site energy use to be 74.5 MMBtu, which is almost exactly the same as the Software-2 result of 74.6 MMBtu/yr. The result from Software-1 was 84.3 MMBtu/yr, which is 13% higher than the total annual energy use of IC3 and Software-2.

A breakdown of the different end uses shows that IC3 had a very good agreement with Software-2 on percentage of the cooling, heating, DHW, and lighting/appliance, while Software-1 shows a good agreement only on cooling and DHW, but large differences on heating and lighting/appliance when compared to IC3 and Software-2.

Standard Reference House in Houston:

Large differences were found in the standard reference house simulation results from the three performance calculators. The IC3 calculated total annual energy use was 77.7 MMBtu, which is similar to the Software-2 total of 71.7 MMBtu (i.e., a difference of 8%). The result from Software-1 was 90.9 MMBtu/yr, which is 17% higher than IC3 and 27% higher than Software-2.

Upon further investigation, the unexpected low energy use of the standard reference house using Software-2 was due to an adjustment in the bedroom input. As previously described, in order to match the internal gain settings among the three calculators for the proposed house, the number of bedrooms in Software-2 was forced to be zero, which did not impact the proposed house simulation, but apparently led to other changes in the calculations to determine other parameters in the standard reference house simulation. For example, the daily hot water usage in the standard reference house in Software-2 was calculated to be 30 gallon per day, which is much less than that of the proposed house and the standard reference house in IC3 and Software-1 (i.e., 70 gallon/day). In Table 2, if adjusting the DHW energy use back to the 70 gallon/day level, that is, 18 MMBtu/yr, the total energy use of the standard reference house increases to 80.2 MMBtu/yr. However, since the DHW heaters may or may not be thermally connected to the conditioned space, the implications on the cooling and heating energy use from this adjustment was not resolved. Therefore, a more detailed understanding of the Software-2 simulation programs is needed to accomplish the comparison with IC3 or Software-1 on the standard reference house.

⁶ The HDD₆₅ value in IC3 was obtained from ASHRAE 90.1 -2007.

Code Compliance Results for the Proposed House in Houston:

It is important to note although big difference existed in the energy use of the proposed house and standard reference between Software-1 and Software-2, quite surprisingly the two programs showed very close code-compliance results. The above-code analysis shows the proposed house exceeds the 2000 IECC by 7.3% in Software-1. After adjusting only the DHW energy use in Software-2, the results showed that the proposed house passes the 2000 IECC by 7.0%. In IC3, the proposed house exceeds the 2000 IECC by 4.0%.

Code Compliance Results for the Proposed House in Dallas:

For the next analysis the same proposed house was then entered in the three software programs using Dallas, Texas as the building location. Figure 2 and Table 3 presents the comparison in the energy use in proposed house and standard reference house, the percentage of each energy end-use, and the percentage above-code. Similar to the house located to Houston, IC3 (86.8 MMBtu/yr) and Software-2 (87.3 MMBtu/yr) had very good agreement in simulating the energy use of the proposed house. Software-1 (100.6 MMBtu/yr) showed a significant difference in the total energy use for the proposed house, about 13 MMBtu/yr or 15% more than IC3 and Software-2. This is mainly due to the larger heating energy use, which was about 40% to 45% higher than that of IC3 and Software-2, respectively.

When comparing the code-compliance results for Dallas, the proposed house passes the 2000 IECC by 1% in IC3 and 6.6% in Software-1. In IC3, the heating energy in the standard reference house is 24.5 MMBtu/yr, which is 1.7 MMBtu less than the proposed house (26.2 MMBtu/yr) due to 130 sq. ft. more window area and the winter-time passive solar impact. However, in Software-1, the heating energy in the standard reference house increased to 42.2 MMBtu/yr, which is 3.7 MMBtu/yr more than the proposed house (38.5 MMBtu/yr). This contributed to the differences in code-compliance values in IC3 (1%) and Software-1 (6.6%). In Software-2 simulation, the hot water usage for the standard reference house was also adjusted for Dallas. The proposed house exceeds the 2000 IECC by 4%, which is between the Software-1 and IC3 simulation results.

SUMMARY

This paper reports on an effort to compare three RESNET accredited IECC Performance Verification

Software Tools. In this analysis, the same proposed house was entered into IC3, Software-2 and Software-1, for Houston and Dallas locations, respectively. Due to the different software inputs and output reports, selected input settings had to be adjusted in order to create a simple, comparative test suite.

The results show that significant differences can exist between these tools when testing the same proposed house. Although the proposed house simulation showed very close results for two of the program, it did not assure consistent code-compliance ratings between the three programs, due to the difference in interpreting the 2000 IECC code, the auto-generation mechanism between the proposed house and standard reference house, and other unknown assumptions for the other softwares. Therefore, it is recommended that additional analysis, including sensitivity tests on important parameters for each program, may be needed to help identify possible reasons for these differences.

REFERENCE

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Table 1. Input for the Proposed and Standard Reference House in Three Software

IC3			Software 2			Software 1		
	Proposed House	2000 IECC		Proposed House	2000 IECC		Proposed House	2000 IECC
PROJECT			PROJECT			PROJECT		
# Bedrooms	4	4	# Bedrooms	0	0	# Bedrooms	4	
# Bathrooms			# Bathrooms	2	2	# Bathrooms		
# Stories	1	1	# Stories	1	1	# Stories	1	
Building Azimuth	0	0	Rotate Building	0	0			
Conditioned Area	2500	2500	Occupancy	Single Family	Single Family	Housing Type	Sng.fam. detached	
Average Wall Height	8	8	Conditioned Area	2500	2500	Conditioned Area	2500	
CLIMATE			CLIMATE			CLIMATE		
Location	Houston	Houston	Location	Houston	Houston	Location	Houston	
Weather File	TMY2	TMY2	Weather File	TMY2	TMY2	Weather File	TMY2	
HDD	1500	1500	HDD	1434	1434	HDD	1548	
SURROUNDINGS			SURROUNDINGS			SURROUNDINGS		
Shade Trees	None	None	Shade Trees	None	None	Shade Trees	None	
Adjacent Buildings	None	None	Adjacent Buildings	None	None	Adjacent Buildings	None	
FLOORS			FLOORS			FLOORS		
Type	Slab-on-Grade	Slab-on-Grade	Type	Slab-on-Grade	Slab-on-Grade	Type	Slab	
R-value	0	0	R-value	0	0	R-value	0	
Area	2500	2500	Equiv. U-value	0.518	0.518	Area	2500	
Perimeter	200'	200'	Area	2500	2500	Perimeter	200'	
Floor Finish	20% Tile, 80% Carpet	20% Tile, 80% Carpet	Perimeter	200'	200'	Floor Covering	Carpet	
ROOF			ROOF			ROOF		
Configuration	Gable	Gable	Configuration	Gable	Gable	Configuration		
Attic Description	Full Attic	Full Attic	Attic Description	Full Attic	Full Attic	Attic Description		
Roofing Material	Asphalt shingles	Asphalt shingles	Roofing Material	Composition shingles	Composition shingles	Roofing Material		
Roof emissivity	0.9	0.9	Roof Color	Light	White	Roof Color	Light	
Absorptance	0.75	0.75	Solar Absorptance	0.75	0.75	Solar Absorptance		
Roof Ins. R-value	0	0	Roof Deck Ins. Level	0	0	Roof Deck Ins. Level		
Roof Framing Factor	7%	7%	Roof Framing Factor	7%	10%	Roof Framing Factor		
Ceiling Area	2500	2500	Ceiling Area	2500	2500	Ceiling Area		
Slope	23 deg.	23 deg.	Slope	5.1/12, 23 deg	5.1/12, 23 deg	Slope		
Attic Ventilation Ratio	0.0033	0.0033	Attic Ventilation Ratio	0.0033	0.0033	Attic Ventilation Ratio		
CEILING			CEILING			CEILING		
Type	Under Attic	Under Attic	Type	Under Attic	Under Attic	Type	Blown, Attic	
Area	2500	2500	Area	2500	2500	Gross Area	2500	
R-value	30	30	R-value	30	19.68	R-value	30	
Equivalent U-value	0.033	0.033	Equivalent U-value	0.03	0.042	Equivalent U-value	0.034	0.041
Framing Fraction	7%	7%	Framing Fraction	7%	0%	Framing Fraction	7%	
Trusses	Wood	Wood	Trusses	Wood	Wood	Trusses		
Radiant Barrier	No	No	Radiant Barrier	No	-	Radiant Barrier	No	
WALLS			WALLS			WALLS		
Type	Frame-Wood	Frame-Wood	Type	Frame-Wood	Frame-Wood	Type	Frame-Wood	
Cavity Ins. R-value	13	11	Cavity Ins. R-value	13	9.42	Cavity Ins. R-value	13	
Equivalent U-value	0.078	0.085	Equivalent U-value	0.086	0.085	Equivalent U-value	0.099 (Total: 0.206)	Total: 0.212
Framing Fraction	25%	25%	Framing Fraction	25%	0%	Framing Fraction	25%	
Sheathing R-value	0	0	Sheathing R-value	0	0	Sheathing R-value	0	
Solar Absorptance	0.55	0.55	Solar Absorptance	0.55	0.5	Exterior Color	Medium	
Width x Height	(50 x 8)x4	(50 x 8)x4	Width x Height	(50 x 8)x4	(25 x 8)x8	Gross Area	1600	
DOORS			DOORS			DOORS		
Orientation	South, North	South, North	Orientation	South, North	Eight	Orientation		
Width x Height	3' x 6.67'	3' x 6.67'	Width x Height	3' x 6.67'	(0.75 x 6.67)x8	Width x Height	20'x2	
			Type	Insulated	Insulated	Opaque Area	20'x2	
U-value	0.2	0.2	Storm Door Type	None	None	Storm Door Type	None	
WINDOWS			WINDOWS			WINDOWS		
U-value	0.47	0.47	Winter U-value	0.2	0.2	U-value	0.47	
SHGC	0.4	0.4	NFRC U-value	0.47	0.47	SHGC	0.4	0.4
No. of panes	1 (default)	1 (default)	NFRC SHGC	0.4	0.4			
Frame	Aluminum w/o break	Aluminum w/o break	Type	Single (Clear)	Low-E Double			
Overhang Depth	0	0	Frame	Metal	Vinyl			
Overhang Separation	0	0	Overhang Depth	0	0			
Width x Height	(16' x 5' = 80)x4	(22.5' x 5' = 112.5)x4	Overhang Separation	0	0			
Internal Shade	0.9, 0.7	0.9, 0.7	Width x Height	(16' x 5' = 80)x4	(14.06'x4' = 56.25)x8	Area	80x4	
			Internal Shade	IECC	Drapes/Blinds	Interior Shading	0.9, 0.7	
			Screening	None	-			
INFILTRATION			INFILTRATION			INFILTRATION		
Input	SLA = 0.00057	SLA = 0.00057	Input	SLA = 0.00057	nL = 0.57	Input	SLA = 0.00057	
Terrain Parameter	Suburban	Suburban	Equivalent Value	0.00057	0.00057			
Shielding Coefficient	Suburban	Suburban	Terrain Parameter	Suburban	Suburban			
			Shielding Coefficient	Suburban	Suburban			
			Ventilation Air	None	None	Cooling Season Vent.	None	

Table 1. Inputs for the Proposed and Standard Reference House in Three Software (Continued)

IC3			Software 2			Software 1		
	Proposed House	2000 IECC		Proposed House	2000 IECC		Proposed House	2000 IECC
COOLING			COOLING			COOLING		
Type	Central Unit	Central Unit	Type	Central Unit	Central Unit	Type	Central Unit	
SHR (SV-A)	0.623	0.623	SHR	0.623	0.623	SHR	0.623	
SEER	13	13	SEER	13	13	SEER	13	13
Capacity kBtu/hr	60	60	Capacity kBtu/hr	60	45.5	Capacity kBtu/hr	60	
Supply CFM	1800	1800	Tested Coil Air Flow CFM	1800	1365			
Autosizing option	No	No	Autosizing option	-	-			
HEATING			HEATING			HEATING		
Type	Gas Furnace	Gas Furnace	Type	Gas Furnace	Gas Furnace	Type	Gas Furnace	
Efficiency	0.78 AFUE	0.78 AFUE	Efficiency	0.78 AFUE	0.78 AFUE	Efficiency	0.78 AFUE	
Capacity kBtu/hr	60	60	Capacity kBtu/hr	60	35.4	Capacity kBtu/hr	60	
Autosizing option	No	No	Autosizing option	-	-			
DUCTS			DUCTS			DUCTS		
R-value (S, R)	8, 4	8, 4	R-value (S, R)	8, 4	6, 6	R-value (S, R)	8, 4	8, 4
Supply Duct Area	675	675	Supply Duct Area	675	675	Supply Duct Area	675	
Return Duct Area	125	125	Return Duct Area	125	125	Return Duct Area	125	
# Returns	1	1	# Returns	1	1	# Returns	1	
Supply Duct Location			Supply Duct Location			Supply Duct Location		
Return Duct Location	Attic	Attic	Return Duct Location	Attic	Interior	Return Duct Location	Attic	
Air Handler Location			Air Handler Location			Air Handler Location		
Duct Air Leakage			Duct Air Leakage	20%	-	Duct Air Leakage	20%	
Return Leak Fraction	10%+10%	10%+10%	Return Leak Fraction	0.5	0	Return Leak Fraction	0.5	
Dist. Eff. due to leaks	NA	NA	Dist. Eff. due to leaks	=> Qn = 0.144	80%			
HOT WATER			HOT WATER			HOT WATER		
Type	Natural Gas	Natural Gas	Type	Natural Gas	Natural Gas	Type	Natural Gas	
Capacity	40	40	Location	Interior	Interior	Location	Interior	
Gallons per Day	70	70	Capacity	40	40	Capacity	40	
EF/Recov. Eff.	0.544 EF, 0.78 RE	0.544 EF, 0.78 RE	Gallons per Day	70	30	Gallons per Day	70	
Set Temperature	120	120	EF	0.54	0.59	EF/Recov. Eff.	0.54 EF, 0.78 RE	
			Set Temperature	120	120			
TEMPERATURES			TEMPERATURES			TEMPERATURES		
			Thermostat Schedule	IECC 1998/2000	IECC 1998/2000			
Cooling	78F (5F Setup)	78F (5F Setup)	Cooling	78F (5F Setup)	78F (5F Setup)	Cooling	78F	
Heating	68F (5F Setback)	68F (5F Setback)	Heating	68F (5F Setback)	68F (5F Setback)	Heating	68F	
Thermostat	Programmable	Programmable	Thermostat	Programmable	Programmable	Thermostat	Programmable	
Seasonal Sch.: Heat	Always	Always	Seasonal Sch.: Heat	Always	Always			
Seasonal Sch.: Cool	Always	Always	Seasonal Sch.: Cool	Always	Always			
			Seasonal Sch.: Vent	No	Always			
APPL. + LIGHTS			APPL. + LIGHTS			APPL. + LIGHTS		
			Appliance Schedule	IC3 (User Created)	IECC 1998/2000			
LIGHTING			LIGHTING			LIGHTING		
Scheduled	Constant	Constant	Scheduled	Constant		Scheduled	Constant	
Released	100%	100%	Released	100%		Released		
kWh/yr	3854	3854	kWh/yr	3854		kWh/yr	3854	
Peak W	440	440	Peak W	440		Peak W	440	
MISCELLANEOUS			MISCELLANEOUS			MISCELLANEOUS		
Scheduled	Constant	Constant	Scheduled	Constant	Yes	Scheduled	Constant	
Released	100%	100%	Released	100%	90%			
kWh/yr	3854	3854	kWh/yr	3854	8555.5	kWh/yr	3854	
Peak W	440	440	Peak W	440	1568.9	Peak W	440	

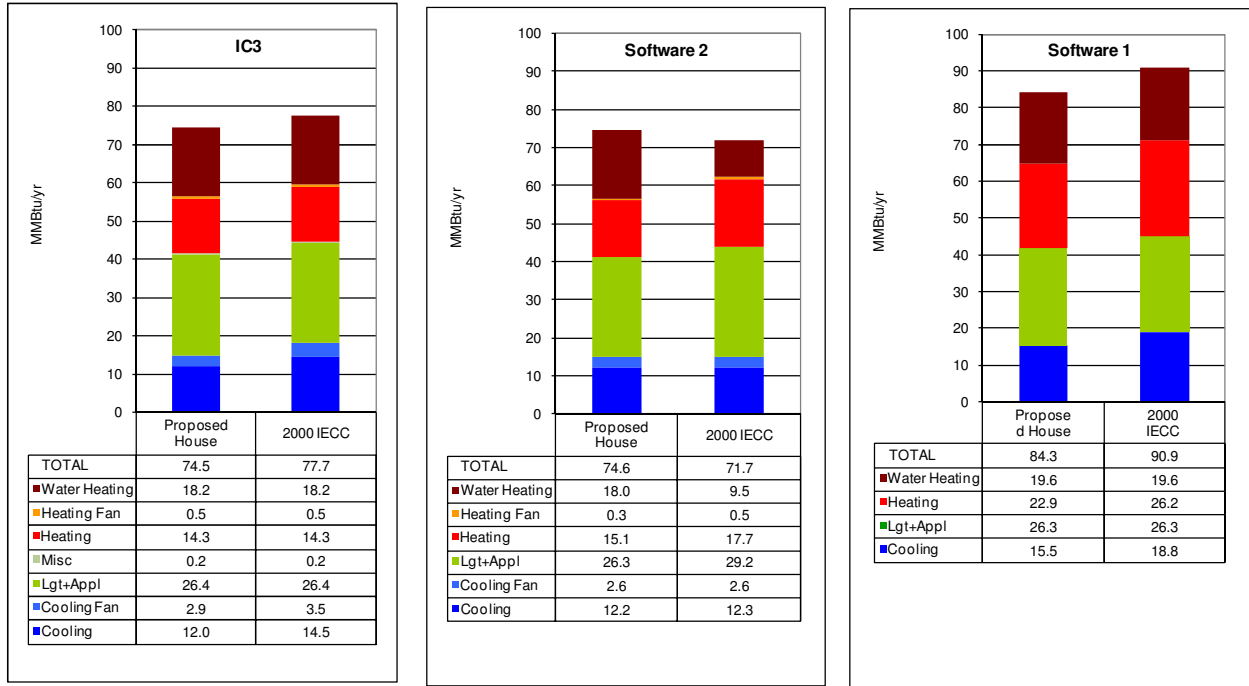


Figure 1. Simulation Results from Three Code Compliance Software (Houston)

Table 2. Simulation Results from Three Code Compliance Software (Houston)

% of Total (IC3 4.01.05)			% of Total (Software 2)			% of Total (Software 1)		
Houston, TX	Proposed House	Standard Reference House	Houston, TX	Proposed House	Standard Reference House	Houston, TX	Proposed House	Standard Reference House
Cooling	20.0%	23.2%	Cooling	20.0%	20.7%	Cooling	18.4%	20.7%
Lgt+Appl	35.4%	34.0%	Lgt+Appl	35.3%	40.7%	Lgt+Appl	31.2%	28.9%
Heating	20.2%	19.4%	Heating	20.7%	25.3%	Heating	27.2%	28.8%
DHW	24.4%	23.4%	DHW	24.1%	13.2%	DHW	23.3%	21.6%
% Above-code	4.0%	Code	% Above-code	-4.0%	Code	% Above-code	7.3%	Code
ENERGY USE (MMBtu/yr): Software 2								
	Proposed House	Standard Reference House						
Cooling	12.2	12.3						
Cooling Fan	2.6	2.6						
Lgt+Appl	26.3	29.2						
Heating	15.1	17.7						
Heating Fan	0.3	0.5						
Water Heating	18.0	18.0						
TOTAL	74.6	80.2						
Adjusted % Above-code	7.0%							

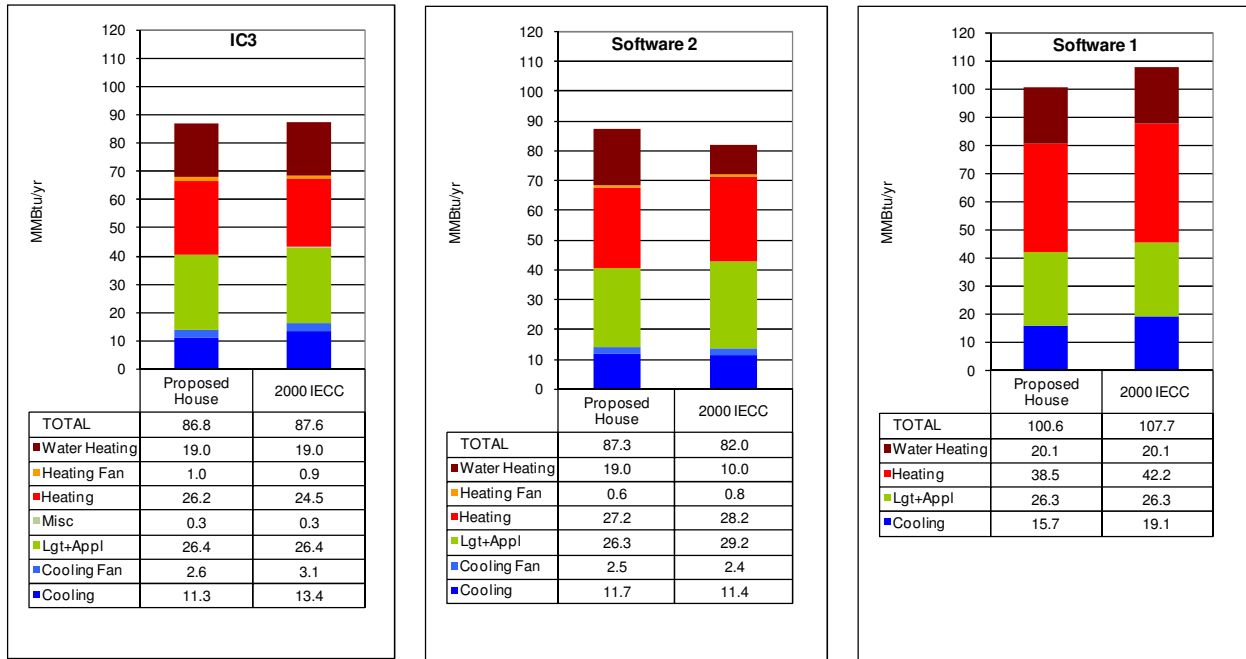


Figure 2. Simulation Results from Three Code Compliance Software (Dallas)

Table 3. Simulation Results from Three Code Compliance Software (Dallas)

% of Total (IC3 4.01.05)		
Dallas, TX	Proposed House	Standard Reference House
Cooling	16.0%	18.8%
Lgt+Appl	30.4%	30.1%
Heating	31.7%	29.4%
DHW	21.9%	21.7%
% Above-code	1.0%	Code

% of Total (Software 2)		
Dallas, TX	Proposed House	Standard Reference House
Cooling	16.3%	16.9%
Lgt+Appl	30.1%	35.6%
Heating	31.8%	35.3%
DHW	21.8%	12.2%
% Above-code	-6.5%	Code

% of Total (Software 1)		
Dallas, TX	Proposed House	Standard Reference House
Cooling	15.6%	17.7%
Lgt+Appl	26.1%	24.4%
Heating	38.3%	39.2%
DHW	20.0%	18.7%
% Above-code	6.6%	Code

ENERGY USE (MMBtu/yr): Software 2		
	User	Code
Cooling	11.7	11.4
Cooling Fan	2.5	2.4
Lgt+Appl	26.3	29.2
Heating	27.2	28.2
Heating Fan	0.6	0.8
Water Heating	19.0	19.0
TOTAL	87.3	91.0
Adjusted % Above Code	4.0%	