# Evaluation of EnergyGauge USA®, a Residential Energy Design Software, Against Monitored Data

Brian S. Fuehrlein, Subrato Chandra, David Beal, Danny S. Parker, Robin K. Vieira, Florida Solar Energy Center (FSEC)

# ABSTRACT

A new software, *EnergyGauge USA*® (http://www.fsec.ucf.edu/ratings/software/), is being developed for calculation of energy use in residential buildings. A simplified user interface allows buildings to be quickly defined and evaluated. Utilization of the DOE-2.1E energy simulation engine brings the computing power of hourly simulation to designers and raters. The software has enhancements to better simulate duct systems, air infiltration, attic and foundation thermal performance, heat pump part load characteristics and internal moisture capacitance.

A recurring question with building energy software, regardless of the calculation rigor, is the relative accuracy of the estimates, particularly for cooling loads. To address this question, the software was used to estimate the hourly air conditioning electrical demand in three homes extensively monitored in Apopka, Florida. Each of the homes were unoccupied, and were identical in layout and orientation, yet contained different efficiency measures. A conventional concrete block home served as the project control house while a second had better insulated walls (autoclaved aerated concrete) and double-glazed windows. The third home, constructed with wood frame walls, had solar-control windows and an attic radiant barrier.

Building geometry, construction and features were entered into the software with measured values being used for critical inputs. Monitored meteorological data was used to create weather files for the simulation and measured interior temperatures were input for each building. The resulting hourly simulation predictions for air conditioning power were then compared to the monitored values for September 1998. Analysis showed excellent correspondence between the simulated and actual data. Average error was less than 4 percent for average hourly and less than 6 percent for peak hour air conditioning usage. Maximum errors were about 10 percent.

## Introduction

A new software, *EnergyGauge USA*® (http://www.fsec.ucf.edu/ratings/software/), is being developed for calculation of energy use in residential buildings. A simplified user interface allows buildings to be quickly defined and evaluated. Utilization of the DOE-2.1E energy simulation engine brings the computing power of hourly simulation to designers and raters. The software has enhancements to better simulate duct systems, air infiltration, attic and foundation thermal performance, heat pump part load characteristics and internal moisture capacitance.

A recurring question with building energy software, regardless of the calculation rigor, is the relative accuracy of the estimates, particularly for cooling loads. To address this

question, the software was used to estimate the hourly air conditioning electrical demand in three homes extensively monitored in Apopka, Florida.

# The Entry Level Homes



**Figure 1. The Entry Level Homes** 

In August 1998 three side-by-side homes were completed near Orlando, FL (Figure 1). All homes have identical floor plans of 1187 square feet (Figure 2), similar roof and wall colors, air handler in conditioned space, and all homes face east. The first house, the Block house, was a base case home constructed of conventional concrete block. Its only modification was an upgraded AC unit (20% better than minimum code). The second home, built from

autoclaved aerated concrete (AAC), demonstrated excellent indoor air quality (IAQ). The third house was the energy-efficient home, built from 2x4 wood frame walls. Table 1 summarizes the details of the three homes.

In the AAC home a 4" diameter duct delivers fresh outside air to the home through the return air plenum whenever the air handling system operates. The FanRecycler<sup>TM</sup> is a

control device that turned on the air handler fan periodically, even when there was no need for heating or cooling. Coupling this with the outside air duct ensured fresh air ventilation in the home throughout the year. The other homes rely on cracks and crevices or open windows for ventilation. The installed radiant barrier in the Frame house was a paper backed aluminum foil stapled to underside of the roof deck and inside of the roof gable ends.

The homes were completed in August and monitored under unoccupied 1998 conditions between August 29 and September 29, 1998. During this month air conditioning inside, outside energy use, and attic temperatures, relative humidities and solar radiation were monitored. The home and duct air tightness and ventilation rates were In addition, volatile organic measured. compound (VOC) and formaldehyde levels were tested to compare the IAQ of the homes (Chandra et. al., 1999).



**Figure 2. Floor Plan** 

Building         New, 31, 1181 ff., 9, 524 ft, 10067f3         New, 31, 1181 ff., 9, 524 ft, 10067f3         New, 31, 1181 ff., 9, 524 ft, 10067f3           TMY Weather Data         User Defined         User Defined         User Defined           Building (12, 36, 10, N)         Building (12, 36, 10, N)         Building (12, 36, 10, S)           Shade Tree (20, 20, 5, SW)         Shade Tree (20, 20, 5, SW)           Slab on Grade, 0, 1181, 159, 4, 8, 2         159, 4, 8, 2           Ceiling         Cable, Shingle, Full After, Dark, 92, 0, Yee, 0056, 24.5         Dark, 92, 0, No, 0033, 24.5           Dors         Wood, 17.8, Algacent         Wood, 17.8, Algacent         Wood, 17.8, Algacent           Wood, 20.0, Exterior         Wood, 20.0, Exterior         Wood, 20.0, Exterior         Wood, 20.0, Exterior           Wood, 17.8, Algacent         Wood, 20.0, Exterior         Wood, 20.0, Exterior         Wood, 20.0, Exterior           Wood, 17.8, Algacent         Wood, 17.8, Algacent         Wood, 20.0, Exterior         Wood, 20.0, Exterior           Wood, 17.8, Algacent         Wood, 17.8, Algacent         Wood, 20.0, Exterior         Wood, 20.0, Exterior           Wood, 17.8, Algacent         Wood, 17.8, Algacent         Wood, 20.0, Exterior         Wood, 20.0, Exterior           Wood, 17.8, Algacent         Wood, 17.8, Algacent         Wood, 17.8, Algacent         Wood, 17.8, Algacent		Frame	AAC	Block		
B         8.524 ft 10067ft3         8.524 ft 10067ft3           SUrroundings         User Defined         User Defined         User Defined           Building (12,36,10, N)         Building (12,36,10, N)         Building (12,36,10, S)           Building (12,36,10, N)         Building (12,36,10, N)         Building (12,36,10, S)           Building (12,248,10, S)         Building (12,36,10, N)         Building (12,36,10, S)           Shade Tree (2,0,0,6,SW)         Stab on Grade, 0, 1181,         Stab on Grade, 0, 1181,           Stab on Grade, 0, 1181,         Stab on Grade, 0, 1181,         Stab on Grade, 0, 1181,           Stab on Grade, 0, 1181,         Stab on Grade, 0, 1181,         Stab on Grade, 0, 1181,           Stab on Grade, 0, 1181,         Stab on Grade, 0, 1181,         Stab on Grade, 0, 1181,           Ceiting         Under Attic, 30, 1180, 1, Wood         Under Attic, 30, 1180, 1, Wood           Deors         Wood, 120, Edentor         Wood, 200, Extentor         Wood, 200, Extentor           Wood 200, Edentor         Wood, 200, Extentor         Wood, 200, Extentor         Wood, 200, Extentor           Windows         S, Double, SC=41,         W, Double, Clear,         W, Single, Clear,         W, Single, Clear,           Wind, 012, 1057         Metal, 40.12, 1057         Metal, 43, 12, 1057         Metal, 42, 21, 155	Building	New, 3 1, 1181 ft.	New, 3, 1, 1181 ft,	New, 3, 1, 1181 ff,		
TMY Weather Data         User Defined         User Defined         User Defined           Surroundings         Building (12,36,10, 8)         Building (12,36,10, 8)         Building (12,36,10, 8)           Floor         Shade Tree (20, 20, 6, 54%)         Salab on Grade, 0, 1181,         1584, 8, 2         1584, 8, 2           Root         Gable, Shingle, Full Attic,         Hip, Shingle, Full Attic,         Hip, Shingle, Full Attic,         Hip, Shingle, Full Attic,           Dark, 92, 0, Ves, 0086, 24.5         Dark, 92, 0, No, 0033, 24.5         Dark, 92, 0, No, 0033, 24.5         Dark, 92, 0, No, 0033, 24.5           Ceilling         Dorss         Wood, 178, Adjacent         Wood, 178, Adjacent         Wood, 20.0, Exterior         Wood, 20.0, Exterior           Wood, 17, 8, Adjacent         Wood, 20.0, Exterior         Wood, 20.0, Exterior         Wood, 20.0, Exterior         Wood, 20.0, Exterior           Windows         S, Double, SC= 41,         W, Double, SC= 41,         W, Double, SC= 41,         W, Single, Clear,         W, Single, Clear,           Vimy, 40, 21, 1x0         Metal, 63, 21, 1x5         Metal, 32, 37, 21, 1x5         Metal, 37, 91, 21, 1x5           Windows         S, Double, SC= 41,         W, Double, Clear,         W, Single, Clear,         W, Single, Clear,           Vimy, 40, 12, 1x10         Metal, 63, 12, 1x5         Metal, 37, 91, 2, 1x5	0	8.524 ft. 10067ft3	8.524 ft, 10067ft3	8.524 ft, 10067ft3		
Surroundings         Building (12,36,10, N)         Building (12,36,10, S)         Building (12,36,10, S)           Building (12,36,10, N)         Building (12,36,10, S)         Building (12,36,10, S)         Stab on Grade, 0, 1181, Stab on Grade, 0, 1181, Stab on Grade, 0, 1181, 158,4, 8, 2         158,4, 8, 2         158,4, 8, 2         158,4, 8, 2         158,4, 8, 2         158,4, 8, 2         158,4, 8, 2         158,4, 8, 2         158,4, 8, 2         158,4, 8, 2         158,4, 8, 2         158,4, 8, 2         158,4, 8, 2         158,4, 8, 2         158,4, 8, 2         158,4, 8, 2         158,4, 8, 2         158,4, 8, 2         158,4, 8, 2         158,4, 8, 2         158,4, 8, 2         158,4, 8, 2	TMY Weather Data	User Defined	User Defined	User Defined		
Building (12,46,10, 8)         Building (12,36,10, 8)           Shade Tree (20, 20, 6, 5W)         Stabe on Grade, 0, 1181, 1584, 8, 2         Stabe on Grade, 0, 1181, 1584, 8, 2         Stabe on Grade, 0, 1181, 1584, 8, 2           Rooff         Gable, Shingle, Full Attic, Dark, 32, 0, Yes, 0086, 24.5         Dark, 32, 0, No, 0033, 24.5         Dark, 92, 0, No, 0033, 24.5           Ceiling Doors         Wond, 17.8, Adjacent         Wood, 17.8, Adjacent         Wood, 17.8, Adjacent         Wood, 20.0, Exterior           Windows         No Duble, SC= 41, Vmm, 6.12, 1x10         Metal, 8.9.12, 1x3         Metal, 4.8.12, 1x3           Windows         N, Double, SC= 41, Vmm, 6.12, 1x10         Metal, 8.9.2, 1x3         Metal, 4.8.12, 1x3           Windows         V. Double, SC= 41, Vmm, 6.12, 1x10         Metal, 8.9.12, 1x3         Metal, 4.8.12, 1x3           Windows         V. Double, SC= 41, Vmm, 4.012, 1bA7         Metal, 4.21, 21, 23         Metal, 4.8.12, 1x3           W Double, SC= 41, Vim, 4.012, 1bA7         Metal, 4.21, 1x3         Metal, 4.8.12, 1x5           N Double, SC= 41, Vim, 4.012, 1bA7         Metal, 4.2, 1x3         Metal, 4.2.8, 12, 1x5           Weild US, SC= 41, Vim, 4.012, 1bA         Metal, 4.2, 1x3         Metal, 4.8, 12, 1x5           N Double, SC= 41, Vim, 4.012, 1bC         Metal, 4.8, 12, 1x3         Metal, 4.8, 12, 1x5           Keingle, SC= 41, Vim, 9.12, 986         Metal	Surroundings	Building (12,36,10, N)	Building (12,36,10, N)	Building (12,36,10, S)		
Fior         Shade Tree (20, 20, 5 SW)         Stab on Grade, 0, 1181, 1584, 8, 2         Stab on Grade, 0, 1181, 159, 4, 8, 2         Stab on Grade, 0, 1181, 159, 4, 8, 2         Stab on Grade, 0, 1181, 159, 4, 8, 2           Root         Gable, Shingle, Full Attic, Dark, 92, 0, No, 0033, 24, 5         Dark, 92, 0, No, 0033, 24, 5         Dark, 92, 0, No, 0033, 24, 5           Deors         Wood, 17, 8, Adjacent         Wood, 17, 8, Adjacent         Wood, 17, 8, Adjacent         Wood, 17, 8, Adjacent           Windows         S, Double, SC=41, Vood, 17, 8, Adjacent         Wood, 17, 8, Adjacent         Wood, 20, Exterior           Windows         S, Double, SC=41, Vinyl, 612, 1x10         Metal, 612, 1x3         Metal, 4, 812, 1x3           W, Double, SC=41, Vinyl, 612, 1x10         Metal, 612, 1x3         Metal, 18, 12, 1x5         Metal, 18, 12, 1x5           W, Double, SC=41, W, Double, SC=41,         W, Double, Clear, W, Double, SC=41,         N, Double, Clear, W, Double, SC=41,         N, Single, Clear, W, Single, Clear,           W, Double, SC=41,         W, Double, Clear,         N, Single, Clear,         N, Single, Clear,           Winyl, 612, 1x10         Metal, 412, 21, 1x5         Metal, 418, 22, 12, 1x5         Metal, 418, 22, 12, 1x5           Walls         E, Double, SC=41,         N, Double, Clear,         N, Single, Clear,           Vinyl, 612, 1x10         Metal, 612, 92, 13,         Metal, 1012, 62, 72, 13	-	Building (12,48,10, S)	Building (12,36,10, S)			
Floor         Stab on Grade, 0, 1181, 1594, 8, 2         Stab on Grade, 0, 1181, 1594, 8, 2         Stab on Grade, 0, 1181, 1594, 8, 2           Roof         Gable, Shingle, Full Attic, Dark, 92, 0, Ves, 0066, 24.5         Dark, 92, 0, No, 0033, 24.5         Dark, 92, 0, No, 0033, 24.5           Ceiling         Under Attic, 30, 1190, 1, Wood         Under Attic, 30, 1190, 1, Wood         Under Attic, 30, 1190, 1, Wood           Wood, 17.8, Adjacent         Wood, 17.8, Adjacent         Wood, 20.0, Exterior         Wood, 20.0, Exterior           Wood, 20.0, Exterior         Wood, 20.0, Exterior         Wood, 20.0, Exterior         Wood, 20.0, Exterior           Windows         S, Double, SC= 41,         S, Double, Clear,         W, Single, Clear,         Virnyl, 612, 113           W, Double, SC= 41,         W, Double, Clear,         W, Single, Clear,         W, Single, Clear,         W, Single, Clear,           Virnyl, 40.12, 10x7         Metal, 48.12, 13.5         Metal, 28.12, 13.5         Metal, 28.12, 13.5           W, Double, SC= 41,         W, Double, Clear,         W, Single, Clear,         W, Single, Clear,           Virnyl, 40.12, 10x7         Metal, 48.12, 13.3         Metal, 48.12, 13.3         Metal, 48.12, 13.3           W, Double, SC= 41,         W, Double, Clear,         W, Single, Clear,         W, Single, Clear,           Virnyl, 40.12, 10x7         Metal, 48.12, 13.3	-	Shade Tree (20, 20, 5, SW)				
Root         159.4, 8, 2         159.4, 8, 2         159.4, 8, 2           Gable, Shingle, Full Aftic, Dark, 92, 0, Yes, 0066, 24.5         Dark, 92, 0, No, 0033, 24.5         Dark, 92, 0, No, 0033, 24.5           Doors         Wood, 17.8, Adjacent         Wood, 17.8, Adjacent         Wood, 17.8, Adjacent           Wood, 20.0, Edenor         Wood, 20.0, Edenor         Wood, 20.0, Edenor         Wood, 20.0, Edenor           Windows         S, Double, SC=.41,         S, Double, Clear,         S, Single, Clear,         S, Single, Clear,           Windows         Virw, 6 ft2, 1x10         Metal, 6.9 ft2, 1x3         Metal, 4.8 ft2, 1x3         Metal, 4.8 ft2, 1x3           W, Double, SC=.41,         W, Double, Clear,         W, Single, Clear,         W, Single, Clear,         Virw, 4.0 ft2, 1x5           W, Double, SC=.41,         W, Double, Clear,         W, Single, Clear,         W, Single, Clear,         Virw, 4.0 ft2, 1x5           W, Double, SC=.41,         W, Double, Clear,         W, Single, Clear,         Virw, 5.6 ft2, 1x5         Metal, 4.8 ft2, 1x3           W, Double, SC=.41,         N, Double, Clear,         W, Single, Clear,         Virw, 5.6 ft2, 1x10         Metal, 5.9 ft2, 1x5         Metal, 5.8 ft2, 1x5           Walls         E, Double, SC=.41,         N, Double, Clear,         N, Single, Clear,         Virw, 9.7 ft2, 2x5         Metal, 15.8 ft2, 1x3	Floor	Slab on Grade, 0, 1181,	Slab on Grade, 0, 1181,	Slab on Grade, 0, 1181,		
Roof         Gable, Shingle, Full Attic, Dark, 92,0, No., 0033, 24.5         Hip, Shingle, Full Attic, Dark, 92,0, No., 0033, 24.5         Dark, 92,0, No., 0033, 24.5           Windows         Wood, 17.8, Adjacent         Wood, 17.8, Adjacent         Wood, 17.8, Adjacent         Wood, 20.0, Exterior           Windows         S, Double, SC=41,         Wood, 20.0, Exterior         Wood, 20.0, Exterior         Wood, 20.0, Exterior           Windows         S, Double, SC=41,         W, Double, Clear,         S, Single, Clear,         W, Single, Clear,           Windows         W, Double, SC=41,         W, Double, Clear,         W, Single, Clear,         W, Single, Clear,           Windows         W, Double, SC=41,         W, Double, Clear,         W, Single, Clear,         W, Single, Clear,           W, Double, SC=41,         W, Double, Clear,         W, Single, Clear,         W, Single, Clear,           W, Double, SC=41,         W, Double, Clear,         W, Single, Clear,         W, Single, Clear,           Vinyl, 40 ft2, 1bx7         Metal, 40 ft2, 1bx7         Metal, 22.8 ft2, 1x5           N, Double, SC=41,         E, Double, Clear,         W, Single, Clear,           Vinyl, 9 ft2, 1x10         Metal, 16.2 ft2, 1x5         Metal, 21.8 ft2, 1x3           E, Double, SC=41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 9 ft2, 864		159.4, .8, .2	159.4, .8, .2	159.4, .8, .2		
Dark, 92, 0, Yes, 0066, 24.5         Dark, 92, 0, No, 0033, 24.5         Dark, 92, 0, No, 0033, 24.5           Obors         Wood, 17.8, Adjacent         Wood, 17.8, Adjacent         Wood, 17.8, Adjacent           Wood, 20.0, Exterior         Wood, 20.0, Exterior         Wood, 20.0, Exterior         Wood, 20.0, Exterior           Windows         S, Double, SC= 41,         S, Double, Clear,         S, Single, Clear,         W, Single, Clear,           Wind, 17.5, ft2, 1x5         Metal, 6.9, ft2, 1x3         Metal, 4.8, ft2, 1x3           W, Double, SC= 41,         W, Double, Clear,         W, Single, Clear,           Vinyl, 6 ft2, 1x10         Metal, 16.2, ft2, 1x5         Metal, 15.8, ft2, 1x5           W Double, SC= 41,         W, Double, Clear,         W, Single, Clear,           Vinyl, 40 ft2, 10x7         Metal, 4.2, ft3, 10x7           W, Double, SC= 41,         W, Double, Clear,         W, Single, Clear,           Vinyl, 6172, 1x5         Metal, 15.2, ft2, 1x5         Metal, 4.2, ft3, 10x7           Weils, SC= 41,         W, Double, Clear,         W, Single, Clear,           Vinyl, 6172, 1x10         Metal, 15.2, ft2, 1x3         Metal, 4.8, ft2, 1x5           Watts         E, Double, SC= 41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 912, 9x6         Metal, 15.2, ft2, 1x5         Metal, 10.72, 8x7<	Roof	Gable, Shingle, Full Attic,	Hip, Shingle, Full Attic,	Hip, Shingle, Full Attic,		
Ceiling Doors         Under Attic, 30, 1190, 1, Wood         Under Attic, 30, 1190, 1, Wood         Under Attic, 30, 1190, 1, Wood           Wood, 718, Adjacent         Wood, 718, Adjacent         Wood, 78, Adjacent         Wood, 20.0, Exterior         Wood, 20.0, Exterior           Windows         S, Double, SC=.41,         S, Double, S12, 1x3         Metal, 4.8 ft2, 1x3           W, Double, SC=.41,         W, Double, Clear,         W, Single, Clear,           Windows         W, Double, SC=.41,         W, Double, Clear,         W, Single, Clear,           W, Double, SC=.41,         W, Double, Clear,         W, Single, Clear,           W, Double, SC=.41,         W, Double, Clear,         W, Single, Clear,           W, Double, SC=.41,         W, Double, Clear,         W, Single, Clear,           W, Double, SC=.41,         W, Double, Clear,         W, Single, Clear,           Vim, 40 ft2, 1x5         Metal, 40 ft2, 1x5         Metal, 42.8 ft2, 1x5           N, Double, SC=.41,         W, Double, Clear,         W, Single, Clear,           Vimy, 9 ft2, 9x6         Metal, 512, 1x5         Metal, 42.8 ft2, 1x5           Walls         Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           Walls         Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           Yimy, 9 ft2, 9x6		Dark, .92, 0, Yes, .0066, 24.5	Dark, .92, 0, No, .0033, 24.5	Dark, .92, 0, No, .0033, 24.5		
Deors         Wood, 17.8, Adjacent         Wood, 17.8, Adjacent         Wood, 20.0, Exterior         Wood, 20.0, Exterior           Windows         S, Double, SC= 41,         S, Double, Clear,         S, Single, Clear,           Vinyl, 6 ft2, 1x10         Metal, 6.9 ft2, 1x3         Metal, 4.8 ft2, 1x3           W, Double, SC= 41,         W, Double, Clear,         W, Single, Clear,           Vinyl, 17.5 ft2, 1x5         Metal, 40 ft2, 1x5         Metal, 15.2 ft2, 1x5           W, Double, SC= 41,         W, Double, Clear,         W, Single, Clear,           Vinyl, 40 ft2, 10x7         Metal, 40 ft2, 1x5         Metal, 2.1 x5           W, Double, SC=.41,         W, Double, Clear,         W, Single, Clear,           Vinyl, 0 ft2, 1x5         Metal, 2.8 ft2, 1x5         Metal, 4.2 gt2, 1x5           N, Double, SC=.41,         W, Double, Clear,         M, Single, Clear,           Vinyl, 6 ft2, 1x10         Metal, 6.2 ft2, 1x3         Metal, 4.8 ft2, 1x5           E, Double, SC=.41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 17.5 ft2, 2x5         Metal, 16.2 ft2, 1x5         Metal, 10.72, 8x7           Walls         Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           Unityl, 9 ft2, 9x6         Metal, 9 ft2, 9x7         Metal, 10 ft2, 4.2, Exterior           Vin	Ceiling	Under Attic, 30, 1190, .1, Wood	Under Attic, 30, 1190, .1, Wood	Under Attic, 30, 1190, .1, Wood		
Windows         Wood, 20.0, Exterior         Wood, 20.0, Exterior         Wood, 20.0, Exterior           Windows         S, Double, SC=41,         S, Double, Clear,         S, Single, Clear,           Windows         W, Double, SC=41,         W, Double, Clear,         W, Single, Clear,           W, Double, SC=41,         W, Double, Clear,         W, Single, Clear,           W, Double, SC=41,         W, Double, Clear,         W, Single, Clear,           W, Double, SC=41,         W, Double, Clear,         W, Single, Clear,           W, Double, SC=41,         W, Double, Clear,         W, Single, Clear,           W, Double, SC=41,         W, Double, Clear,         W, Single, Clear,           Vinyl, 20 ft2, 1x5         Metal, 22.8 ft2, 1x5         Metal, 22.8 ft2, 1x5           N, Double, SC=41,         N, Double, Clear,         N, Single, Clear,           Vinyl, 6 ft2, 1x10         Metal, 6.9 ft2, 1x3         Metal, 4.8 ft2, 1x3           E, Double, SC=41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 9 ft2, 2x6         Metal, 16.2 ft2, 1x5         Metal, 15.8 ft2, 1x5           Walls         Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           Yinyl, 9 ft2, 9x6         Metal, 9 ft2, 8x6         Metal, 10 ft2, 6x7           Frame-Wood,         LW Concret	Doors	Wood, 17.8, Adjacent	Wood, 17.8, Adjacent	Wood, 17.8, Adjacent		
Windows         S, Double, SC=.41,         S, Double, B.912, 1x3         Metal, 4.812, 1x3           W, Double, SC=.41,         W, Double, Clear,         W, Single, Clear,         W, Single, Clear,           Vinyl, 17, 512, 1x5         Metal, 4.012, 1x5         Metal, 4.012, 1x5         Metal, 4.012, 1x5           W, Double, SC=.41,         W, Double, Clear,         W, Single, Clear,         W, Single, Clear,           Vinyl, 40 f2, 1b07         Metal, 4.012, 1bx7         Metal, 3.9, 12, 1bx7           W, Double, SC=.41,         W, Double, Clear,         W, Single, Clear,           Vinyl, 20 f12, 1x5         Metal, 22.8 f12, 1x5         Metal, 2.1, 21, 1bx7           W, Double, SC=.41,         N, Double, Clear,         N, Single, Clear,           Vinyl, 6 f12, 1x10         Metal, 5.9 f12, 1x3         Metal, 4.8 f12, 1x3           E, Double, SC=.41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 9 f12, 9x6         Metal, 9 f12, 9x6         Metal, 10.12, 8x7           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           Vinyl, 9 f12, 9x6         Metal, 9 f12, 7, Exterior         282 f12, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           417 f12, 11, Exterior         242 f12, 7, Exterior         242 f12, 4.2, Exterior		Wood, 20.0, Exterior	Wood, 20.0, Exterior	Wood, 20.0, Exterior		
Vinyl, 6 ff2, 1x10         Metal, 0, 9 ff2, 1x3         Metal, 4, 8 ff2, 1x3           W Double, SC=41,         W, Double, Clear,         W, Single, Clear,           Vinyl, 17, 5 ff2, 1x5         Metal, 16, 2 ff2, 1x5         Metal, 15, 8 ff2, 1x5           W, Double, SC=41,         W, Double, Clear,         W, Single, Clear,           Vinyl, 40 ff2, 1b07         Metal, 40 ff2, 10x7         Metal, 37, 9 ff2, 10x7           Webal, 50, 50, 50, 50, 50, 50, 50, 50, 50, 50	Windows	S, Double, SC=.41,	S, Double, Clear,	S, Single, Clear,		
W, Double, SC=.41,         W, Double, 16.2 ft2, 1x5         Metal, 15.8 ft2, 1x5           Winyl, 47.5 ft2, 1x5         Metal, 16.2 ft2, 1x5         Metal, 15.8 ft2, 1x5           W, Double, SC=.41,         W, Double, Clear,         W, Single, Clear,           W, Double, SC=.41,         W, Double, Clear,         W, Single, Clear,           W, Double, SC=.41,         W, Double, Clear,         W, Single, Clear,           Vinyl, 20 ft2, 1x5         Metal, 22.8 ft2, 1x5         Metal, 22.8 ft2, 1x5           N, Double, SC=.41,         N, Double, Clear,         N, Single, Clear,           Vinyl, 6 ft2, 1x10         Metal, 6.9 ft2, 1x3         Metal, 4.8 ft2, 1x3           E, Double, SC=.41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 9 ft2, 9x6         Metal, 9 ft2, ftx6         Metal, 16.2 ft2, 1x5           Walls         Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           Vinyl, 9 ft2, 9x6         Metal, 9 ft2, 7, Exterior         242.5 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           38.6 ft2, 11, Exterior         209.3 ft2, 7, Exterior         242.5 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           38.6 ft2, 11, Adjacent         209.3 ft2, 7, Exterior		Vinyi, 6 ft2, 1x10	Metal, 6.9 ft2, 1x3	Metal, 4.8 ft2, 1x3		
Winyl, 17, 5 ft2, 1x5         Metal, 12, 12, 12, 12         Metal, 15, 8ft2, 1x5           W, Double, SC=-41,         W, Double, Clear,         W, Single, Clear,           Vinyl, 40 ft2, 10x7         Metal, 40 ft2, 10x7         Metal, 37.9 ft2, 10x7           W, Double, SC=-41,         W, Double, Clear,         W, Single, Clear,           Vinyl, 20 ft2, 1x5         Metal, 22.8 ft2, 1x5         Metal, 22.8 ft2, 1x5           N, Double, SC=-41,         N, Double, Clear,         N, Single, Clear,           Vinyl, 6 ft2, 1x10         Metal, 6.9 ft2, 1x3         Metal, 4.8 ft2, 1x3           E, Double, SC=-41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 17, 5 ft2, 2x5         Metal, 15.2 ft2, 1x5         Metal, 15.8 ft2, 1x5           E, Double, SC=-41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 9 ft2, 9x6         Metal, 9 ft2, 8x6         Metal, 10 ft2, 8x7           E, Double, SC=-41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 9 ft2, 9x6         Metal, 9 ft2, 8x6         Metal, 10 ft2, 8x7           Walls         Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           242.5 ft2, 11, Exterior         282 ft2, 7, Exterior         292 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int		W, Double, SC=.41,	W, Double, Clear,	W, Single, Clear,		
W, Double, SC=.41,         W, Double, Clear,         W, Single, Clear,           Winy, 40 ft2, 10x7         Metal, 40 ft2, 10x7         Metal, 37.9 ft2, 10x7           W, Double, SC=.41,         W, Double, Clear,         W, Single, Clear,           Vinyl, 20 ft2, 1x5         Metal, 22.8 ft2, 1x5         Metal, 22.8 ft2, 1x5           N, Double, SC=.41,         N, Double, Clear,         N, Single, Clear,           Vinyl, 6ft2, 1x10         Metal, 6.9 ft2, 1x3         Metal, 4.8 ft2, 1x3           E, Double, SC=.41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 17,5 ft2, 2x5         Metal, 612 ft2, 1x5         Metal, 15.8 ft2, 1x5           E, Double, SC=.41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 9 ft2, 9x6         Metal, 9 ft2, 9x6         Metal, 10 ft2, 6x7           E, Double, SC=.41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 9 ft2, 9x6         Metal, 9 ft2, 9x6         Metal, 10 ft2, 6x7           Walls         Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           417 ft2, 11, Exterior         245 ft2, 7, Exterior         242.5 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           338 6 ft2, 11, Exterior         107 ft2, 7, Exterior         102.5 ft2, 4.2, E		Vinyl, 17.5 ft2, 1x5	Metal, 16.2 ft2, 1x5	Metal, 15.8 ft2, 1x5		
Winy, 40 ft2, 10x/         Metal, 40 ft2, 10x/         Metal, 37.9 ft2, 10x/           W, Double, SC=.41,         W, Double, Clear,         W, Single, Clear,           Vinyl, 20 ft2, 1x5         Metal, 22.8 ft2, 1x5         Metal, 22.8 ft2, 1x5           N, Double, SC=.41,         N, Double, Clear,         N, Single, Clear,           Vinyl, 6 ft2, 1x10         Metal, 6.9 ft2, 1x3         Metal, 4.8 ft2, 1x3           Walls         E, Double, SC=.41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 6 ft2, 1x10         Metal, 16.2 ft2, 1x5         Metal, 4.8 ft2, 1x3           Walls         E, Double, SC=.41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 9 ft2, 9x6         Metal, 9 ft2, 8x6         Metal, 10 ft2, 8x7           E, Double, SC=.41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 9 ft2, 9x6         Metal, 9 ft2, 8x6         Metal, 10 ft2, 8x7           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           417 ft2, 11, Exterior         242 ft2, 7, Exterior         242 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           242.5 ft2, 11, Exterior         209.3 ft2, 7, Exterior         105 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,		W, Double, SC=.41,	W, Double, Clear,	W, Single, Clear,		
With Double, SC=.41,         With Double, Clear,         With Single, Clear,           Vinyl, 20 ft2, 1x5         Metal, 22.8 ft2, 1x5         Metal, 22.8 ft2, 1x5           N, Double, SC=.41,         N, Double, Clear,         N, Single, Clear,           Vinyl, 5 ft2, 1x10         Metal, 6.9 ft2, 1x3         Metal, 4.8 ft2, 1x3           E, Double, SC=.41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 17.5 ft2, 2x5         Metal, 16.2 ft2, 1x5         Metal, 15.2 ft2, 1x5           E, Double, SC=.41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 9 ft2, 9x6         Metal, 9 ft2, 8x6         Metal, 10 ft2, 8x7           E, Double, SC=.41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 9 ft2, 9x6         Metal, 9 ft2, 8x6         Metal, 10 ft2, 8x7           E, Double, SC=.41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 9 ft2, 9x6         Metal, 9 ft2, 8x6         Metal, 10 ft2, 8x7           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           17 ft2, 11, Exterior         282 ft2, 7, Exterior         282 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           338.6 ft2, 11, Exterior         102 ft2, 7, Exterior         102 ft2, ft2, 4.2, Exterior <th></th> <th></th> <th>Metal, 40 ft2, 10x/</th> <th></th>			Metal, 40 ft2, 10x/			
Vinyl, 2012, 1x5         Metal, 22.8 ft2, 1x5         Metal, 22.8 ft2, 1x5           N, Double, SC=-41,         N, Double, Clear,         N, Single, Clear,           Vinyl, 6 ft2, 1x10         Metal, 6.9 ft2, 1x3         Metal, 4.8 ft2, 1x3           E, Double, SC=-41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 17.5 ft2, 2x5         Metal, 16.2 ft2, 1x5         Metal, 15.8 ft2, 1x5           E, Double, SC=-41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 9 ft2, 9x6         Metal, 9 ft2, 8x6         Metal, 10 ft2, 8x7           E, Double, SC=-41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 9 ft2, 9x6         Metal, 9 ft2, 8x6         Metal, 10 ft2, 8x7           E, Double, SC=-41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 9 ft2, 9x6         Metal, 9 ft2, 8x6         Metal, 10 ft2, 8x7           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           417 ft2, 11, Exterior         282 ft2, 7, Exterior         242.5 ft2, 12, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           388 6 ft2, 11, Exterior         209.3 ft2, 7, Exterior         154 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,      <		W, DOUBLE, SC=.41,	W, Double, Clear,	W, Single, Clear,		
Winyl, 612, 1x10         Netal, 6.9 ft2, 1x3         Metal, 4.8 ft2, 1x3           Vinyl, 612, 1x10         Metal, 6.9 ft2, 1x3         Metal, 4.8 ft2, 1x3           E, Double, SC=.41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 17.5 ft2, 2x5         Metal, 16.2 ft2, 1x5         Metal, 15.8 ft2, 1x5           Walls         E, Double, SC=.41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 9 ft2, 9x6         Metal, 9 ft2, 8x6         Metal, 10 ft2, 8x7           E, Double, SC=.41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 9 ft2, 9x6         Metal, 9 ft2, 8x6         Metal, 10 ft2, 8x7           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           417 ft2, 11, Exterior         282 ft2, 7, Exterior         282 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           242.5 ft2, 11, Exterior         209.3 ft2, 7, Exterior         104.4, 10, 42, 42, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           338.6 ft2, 11, Adjacent         201.3 ft2, 17, Exterior         102.5 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           105.2 ft2, 11, Exterior         107 ft2, 7, Exterior         <	-		Metal, 22.8 It2, 185	Metal, 22.8 ft2, 185		
Vinit, bitz, 1x10         Metal, 0.912, 1x3         Metal, 1.912, 1x3           E, Double, SC= 41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 17.5 ft2, 2x5         Metal, 16.2 ft2, 1x5         Metal, 15.8 ft2, 1x5           E, Double, SC= 41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 9 ft2, 9x6         Metal, 9 ft2, 8x6         Metal, 10 ft2, 8x7           E, Double, SC= 41,         E, Double, Clear,         E, Single, Clear,           Vinyl, 9 ft2, 9x6         Metal, 9 ft2, 8x6         Metal, 10 ft2, 8x7           Walls         Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           417 ft2, 11, Exterior         282 ft2, 7, Exterior         282 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           242.5 ft2, 11, Exterior         203 ft2, 7, Exterior         242.5 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           338.6 ft2, 11, Exterior         107 ft2, 7, Exterior         105 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           105.2 ft2, 11, Exterior         107 ft2, 7, Exterior         102.5 ft3, 4.2, Exterior           Frame-Wood,         Frame-Wood,         Frame-Wood,		N, DUUDIE, SC=.41,	N, DUUDIE, Clear, Motol 6.0.62.1v2	N, Single, Clear, Motol 4.9.62 1v2		
Image: Sec. 41,	-		E Double Clear	E Single Clear		
Infiltration         Notes         Notes         Notes         Notes         Notes           Walls         E, Double, SC=.41, Vinyl, 9 ft2, 9x6         Metal, 9 ft2, 8x6         Metal, 10 ft2, 8x7           Walls         E, Double, SC=.41, Vinyl, 9 ft2, 9x6         Metal, 9 ft2, 8x6         Metal, 10 ft2, 8x7           Walls         Frame-Wood, 417 ft2, 11, Exterior         282 ft2, 7, Exterior         282 ft2, 42, Exterior           Frame-Wood,         LW Concrete-Int Insul, 417 ft2, 11, Exterior         282 ft2, 7, Exterior         242.5 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul, 242.5 ft2, 11, Exterior         209.3 ft2, 7, Exterior         154 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul, 338.6 ft2, 11, Exterior         209.3 ft2, 7, Exterior         154 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul, 338.6 ft2, 11, Exterior         Block-Int Insul, 105.2 ft2, 11, Exterior         102 ft2, 12, Exterior           Frame-Wood,         Frame-Wood, 105 ft2, 11, Exterior         Frame-Wood, 107 ft2, 7, Exterior         Frame-Wood, 105 ft2, 4.2, Exterior           Mech Ventilation         None         None         None         None           Garage         Mote Ventilation         None         None         No           Guing data         Garage         19 ft, 425 ft <sup>+</sup> 419		Vinul 17.5 ft7 2v5	Motol 16.2 ft2 1v5	Motal 15.8 ft7 1v5		
Walls         L, botsof, interpretation         L, botsof, interpretation         L, botsof, interpretation           Walls         Vinyl, 9 ft2, 9x6         Metal, 9 ft2, 8x6         Metal, 10 ft2, 8x7           Walls         E, Double, SC=.41, Vinyl, 9 ft2, 9x6         Metal, 9 ft2, 8x6         Metal, 10 ft2, 8x7           Walls         Frame-Wood, 417 ft2, 11, Exterior         282 ft2, 7, Exterior         282 ft2, 4.2, Exterior           Frame-Wood, 242.5 ft2, 11, Exterior         245 ft2, 7, Exterior         242.5 ft2, 4.2, Exterior           Frame-Wood, 338.6 ft2, 11, Exterior         209.3 ft2, 7, Exterior         154 ft2, 4.2, Exterior           Frame-Wood, 245 ft2, 11, Exterior         107 ft2, 7, Exterior         154 ft2, 4.2, Exterior           Frame-Wood, 208.6 ft2, 11, Adjacent         201.3 ft2, 11, Adjacent         208.6 ft2, 11, Adjacent           105.2 ft2, 11, Exterior         107 ft2, 7, Exterior         102.5 ft2, 4.2, Exterior           Frame-Wood, 208.6 ft2, 11, Adjacent         201.3 ft2, 11, Adjacent         208.6 ft2, 11, Adjacent           125 ACH, 21 CFM, 50, .25, 1         16 ACH, 27 CFM, 45, 45, 1         .065 ACH, 10.5 CFM, 61, .63, 1           Mech Ventilation Garage Sunspace         Non         None         None           No         No         No         No         No           Central Unit, 24, 800, 12, .75         Central Un		E Double SC= 41	E Double Clear	E Single Clear		
Interference         Interference         Interference           Walls         E, Double, SC=.41, Vinyl, 9 ft2, 9x6         Metal, 9 ft2, 8x6         Metal, 10 ft2, 8x7           Walls         Frame-Wood, 417 ft2, 11, Exterior         282 ft2, 7, Exterior         282 ft2, 4.2, Exterior           Frame-Wood, 417 ft2, 11, Exterior         282 ft2, 7, Exterior         282 ft2, 4.2, Exterior           Frame-Wood, 417 ft2, 11, Exterior         245 ft2, 7, Exterior         242.5 ft2, 4.2, Exterior           Frame-Wood, 338 6 ft2, 11, Exterior         245 ft2, 7, Exterior         242.5 ft2, 4.2, Exterior           Frame-Wood, 54 ft2, 11, Exterior         209.3 ft2, 7, Exterior         154 ft2, 4.2, Exterior           Frame-Wood, 338 6 ft2, 11, Exterior         209.3 ft2, 7, Exterior         154 ft2, 4.2, Exterior           Frame-Wood, 55 ft2, 11, Exterior         107 ft2, 7, Exterior         102.5 ft2, 4.2, Exterior           Infiltration         105.2 ft2, 11, Exterior         107 ft2, 7, Exterior         102.5 ft2, 4.2, Exterior           Frame-Wood, 208.6 ft2, 11, Adjacent         201.3 ft2, 11, Adjacent         208.6 ft2, 11, Adjacent         208.6 ft2, 11, Adjacent           Infiltration         125 ACH, 21 CFM, 50, 25, 1         16 ACH, 27 CFM, 45, 45, 1         .065 ACH, 10.5 CFM, 61, 63, 1           Mech Ventilation         None         None         None         None		Vinvl 9 ft2 9x6	Metai 9 ft2 8x6	Metal 10 ft2 8x7		
Walls         Vinyl, 9 ft2, 9x6         Metal, 9 ft2, 9x6         Metal, 10 ft2, 8x7           Walls         Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           417 ft2, 11, Exterior         282 ft2, 7, Exterior         282 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           417 ft2, 11, Exterior         245 ft2, 7, Exterior         282 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           338.6 ft2, 11, Exterior         209.3 ft2, 7, Exterior         154 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           338.6 ft2, 11, Exterior         107 ft2, 7, Exterior         154 ft2, 4.2, Exterior           Frame-Wood,         Exterior         107 ft2, 7, Exterior         102.5 ft2, 4.2, Exterior           Infiltration         State ft2, 11, Adjacent         201.3 ft2, 11, Adjacent         208.6 ft2, 11, Adjacent           125 ACH, 21 CFM, 50, 25, 1         16 ACH, 27 CFM, 45, 45, 1         .065 ACH, 10.5 CFM, 61, .63, 1           Mech Ventilation         None         None         None           Garage         Sunspace         No         No         No           Cooling         Central Unit, 24, 800, 12, .75         Central Unit,		E Double SC= 41	E. Double, Clear,	E. Single, Clear.		
WallsFrame-Wood, 417 ft2, 11, ExteriorLW Concrete-Int Insul, 282 ft2, 7, ExteriorBlock-Int Insul, 282 ft2, 4.2, ExteriorFrame-Wood, 242.5 ft2, 11, ExteriorLW Concrete-Int Insul, 242.5 ft2, 11, ExteriorBlock-Int Insul, 242.5 ft2, 4.2, ExteriorFrame-Wood, 338.6 ft2, 11, ExteriorLW Concrete-Int Insul, 209.3 ft2, 7, ExteriorBlock-Int Insul, 242.5 ft2, 4.2, ExteriorFrame-Wood, 338.6 ft2, 11, ExteriorLW Concrete-Int Insul, 209.3 ft2, 7, ExteriorBlock-Int Insul, 154 ft2, 4.2, ExteriorFrame-Wood, 105.2 ft2, 11, ExteriorLW Concrete-Int Insul, 209.3 ft2, 7, ExteriorBlock-Int Insul, 102.5 ft2, 4.2, ExteriorInfiltration Mech Ventilation Garage Sunspace Cooling Heating Duct SystemNoneNoneInfiltration G. 295.5, 60, 5.419%, 6, 295.25, 60, 7.113%,NoneNone		Vinyl, 9 ft2, 9x6	Metal, 9 ft2, 8x6	Metal, 10 ft2, 8x7		
417 ft2, 11, Exterior         282 ft2, 7, Exterior         282 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           242.5 ft2, 11, Exterior         245 ft2, 7, Exterior         242.5 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           338.6 ft2, 11, Exterior         209 3 ft2, 7, Exterior         154 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           338.6 ft2, 11, Exterior         209 3 ft2, 7, Exterior         154 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           105.2 ft2, 11, Exterior         107 ft2, 7, Exterior         102.5 ft2, 4.2, Exterior           Frame-Wood,         Frame-Wood,         Frame-Wood,         Frame-Wood,           Stream-Wood,         Exterior         102.5 ft2, 4.2, Exterior         102.6 ft2, 4.2, Exterior           Infiltration         Stream-Wood,         Frame-Wood,         Frame-Wood,         Frame-Wood,           125 ACH, 21 CFM, 50, 25, 1         16 ACH, 27 CFM, 45, 45, 1         .065 ACH, 10.5 CFM, 61, .63, 1           None         None         None         None           Garage         Sunspace         No         No         No	Walls	Frame-Wood,	LW Concrete-Int Insul,	Block-Int Insul,		
Frame-Wood, 242.5 ft2, 11, Exterior         LW Concrete-Int Insul, 245 ft2, 7, Exterior         Block-Int Insul, 242.5 ft2, 4.2, Exterior           Frame-Wood, 338.6 ft2, 11, Exterior         LW Concrete-Int Insul, 209.3 ft2, 7, Exterior         Block-Int Insul, 154 ft2, 4.2, Exterior           Frame-Wood, 105.2 ft2, 11, Exterior         209.3 ft2, 7, Exterior         154 ft2, 4.2, Exterior           Frame-Wood, 105.2 ft2, 11, Exterior         107 ft2, 7, Exterior         154 ft2, 4.2, Exterior           Frame-Wood, 105.2 ft2, 11, Exterior         107 ft2, 7, Exterior         102.5 ft2, 4.2, Exterior           Frame-Wood, 105.2 ft2, 11, Exterior         107 ft2, 7, Exterior         102.5 ft2, 4.2, Exterior           Frame-Wood, 208.6 ft2, 11, Adjacent         201.3 ft2, 11, Adjacent         208.6 ft2, 11, Adjacent           208.6 ft2, 11, Adjacent         201.3 ft2, 11, Adjacent         208.6 ft2, 11, Adjacent           .125 ACH, 21 CFM, 50, .25, 1         .16 ACH, 27 CFM, 45, .45, 1         .065 ACH, 10.5 CFM, 61, .63, 1           None         None         None         None           Sunspace         No         No         No           No         No         No         No           Cooling         Electric Heat Pump, 24, 7.5         Electric Heat Pump, 24, 7.5         Electric Heat Pump, 24, 7.5           Electric Heat Pump, 24, 7.5         Electric Heat Pump, 24, 7.5 <td< th=""><th></th><th>417 ft2, 11, Exterior</th><th>282 ft2, 7, Exterior</th><th>282 ft2, 4.2, Exterior</th></td<>		417 ft2, 11, Exterior	282 ft2, 7, Exterior	282 ft2, 4.2, Exterior		
242.5 ft2, 11, Exterior         245 ft2, 7, Exterior         242.5 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           338.6 ft2, 11, Exterior         209.3 ft2, 7, Exterior         154 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           105.2 ft2, 11, Exterior         107 ft2, 7, Exterior         154 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           105.2 ft2, 11, Exterior         107 ft2, 7, Exterior         102.5 ft2, 4.2, Exterior           Frame-Wood,         Exterior         102.5 ft2, 4.2, Exterior           Infiltration         State         105.2 ft2, 11, Adjacent         201.3 ft2, 11, Adjacent           208.6 ft2, 11, Adjacent         201.3 ft2, 11, Adjacent         208.6 ft2, 11, Adjacent         208.6 ft2, 11, Adjacent           .125 ACH, 21 CFM, 50, .25, 1         16 ACH, 27 CFM, 45, .45, 1         .065 ACH, 10.5 CFM, 61, .63, 1         .63, 1           None         None         None         None         None           Sunspace         No         No         No         No           Cooling         Central Unit, 24, 800, 12, .75         Central Unit, 24, 800, 12, .75         Central Unit, 24, 800, 12, .75         Electric Heat Pump, 24, 7.5         <		Frame-Wood,	LW Concrete-Int Insul,	Block-Int Insul,		
Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           338.6 ft2, 11, Exterior         209.3 ft2, 7, Exterior         154 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           105.2 ft2, 11, Exterior         107 ft2, 7, Exterior         102.5 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           105.2 ft2, 11, Exterior         107 ft2, 7, Exterior         102.5 ft2, 4.2, Exterior           Frame-Wood,         Frame-Wood,         Frame-Wood,           208.6 ft2, 11, Adjacent         201.3 ft2, 11, Adjacent         208.6 ft2, 11, Adjacent           208.6 ft2, 11, Adjacent         201.3 ft2, 11, Adjacent         208.6 ft2, 11, Adjacent           .125 ACH, 21 CFM, 50, .25, 1         .16 ACH, 27 CFM, 45, .45, 1         .065 ACH, 10.5 CFM, 61, .63, 1           None         None         None         None           Sunspace         No         No         No           Cooling         419 ft <sup>+</sup> , 425 ft <sup>+</sup> 419 ft <sup>+</sup> , 425 ft <sup>+</sup> 419 ft <sup>+</sup> , 425 ft <sup>+</sup> Heating         Electric Heat Pump, 24, 7.5         Electric Heat Pump, 24, 7.5         Electric Heat Pump, 24, 7.5           Buct System         6, 295.5, 60, 5.419%,         6, 295.25, 60, 0.1.838%,         6, 295.25, 60, 7.113%,		242.5 ft2, 11, Exterior	245 ft2, 7, Exterior	242.5 ft2, 4.2, Exterior		
338.6 ft2, 11, Exterior         209.3 ft2, 7, Exterior         154 ft2, 4.2, Exterior           Frame-Wood,         LW Concrete-Int Insul,         Block-Int Insul,           105.2 ft2, 11, Exterior         107 ft2, 7, Exterior         102.5 ft2, 4.2, Exterior           Frame-Wood,         Frame-Wood,         Frame-Wood,         Frame-Wood,           105.2 ft2, 11, Exterior         107 ft2, 7, Exterior         102.5 ft2, 4.2, Exterior           Frame-Wood,         Frame-Wood,         Frame-Wood,         Frame-Wood,           208.6 ft2, 11, Adjacent         201.3 ft2, 11, Adjacent         208.6 ft2, 11, Adjacent         208.6 ft2, 11, Adjacent           125 ACH, 21 CFM, 50, 25, 1         .16 ACH, 27 CFM, 45, 45, 1         .065 ACH, 10.5 CFM, 61, .63, 1         None           Mech Ventilation         None         None         None         None           Garage         419 ff', 425 ft'         419 ff', 425 ft'         419 ff', 425 ft'         419 ff', 425 ft'           Sunspace         No         No         No         No         No           Cooling         Central Unit, 24, 800, 12, .75         Central Unit, 24, 800, 12, .75         Central Unit, 24, 800, 12, .75         Electric Heat Pump, 24, 7.5         Electric Heat Pump, 24, 7.5           Buct System         6, 295.5, 60, 5.419%,         6, 295.25, 60, 10.838%, <td< th=""><th></th><th>Frame-Wood,</th><th>LW Concrete-Int Insul,</th><th>Block-Int Insul,</th></td<>		Frame-Wood,	LW Concrete-Int Insul,	Block-Int Insul,		
Frame-Wood, 105.2 ft2, 11, Exterior         LW Concrete-Int Insul, 107 ft2, 7, Exterior         Block-Int Insul, 102.5 ft2, 4.2, Exterior           Infiltration         Frame-Wood, 208.6 ft2, 11, Adjacent         201.3 ft2, 11, Adjacent         208.6 ft2, 11, Adjacent           Infiltration         .125 ACH, 21 CFM, 50, .25, 1         .16 ACH, 27 CFM, 45, .45, 1         .065 ACH, 10.5 CFM, 61, .63, 1           Mech Ventilation         None         None         None           Garage         419 ft, 425 ft         419 ft, 425 ft         419 ft, 425 ft           Sunspace         No         No         No           Cooling         Electric Heat Pump, 24, 7.5         Electric Heat Pump, 24, 7.5         Electric Heat Pump, 24, 7.5           Bickrine Heating         6, 295.25, 60, 5.419%,         6, 295.25, 60, 7.113%,         6, 295.25, 60, 7.113%,		338.6 ft2, 11, Exterior	209.3 ft2, 7, Exterior	154 ft2, 4.2, Exterior		
Infitration         105.2 ft2, 11, Exterior         107 ft2, 7, Exterior         102.5 ft2, 4.2, Exterior           Infitration         Frame-Wood,         Frame-Wood,         Frame-Wood,         Frame-Wood,           208.6 ft2, 11, Adjacent         201.3 ft2, 11, Adjacent         208.6 ft2, 11, Adjacent         208.6 ft2, 11, Adjacent           125 ACH, 21 CFM, 50, 25, 1         .16 ACH, 27 CFM, 45, 45, 1         .065 ACH, 10.5 CFM, 61, 63, 1           Mech Ventilation         None         None         None           Garage         419 ft, 425 ft         419 ft, 425 ft         419 ft, 425 ft           Sunspace         No         No         No           Cooling         Heating         Electric Heat Pump, 24, 7.5         Electric Heat Pump, 24, 7.5         Electric Heat Pump, 24, 7.5           Buct System         6, 295.5, 60, 5.419%,         6, 295.25, 60, 7.113%,         6, 295.25, 60, 7.113%,		Frame-Wood,	LW Concrete-Int Insul,	Block-Int Insul,		
Infiltration         Frame-Wood, 208.6 ft2, 11, Adjacent         Frame-Wood, 201.3 ft2, 11, Adjacent         Frame-Wood, 208.6 ft2, 11, Adjacent           Infiltration         .125 ACH, 21 CFM, 50, 25, 1         .16 ACH, 27 CFM, 45, 45, 1         .065 ACH, 10.5 CFM, 61, 63, 1           Mech Ventilation         None         None         None         None           Garage         419 ft', 425 ft'         419 ft', 425 ft'         419 ft', 425 ft'           Sunspace         No         No         No           Cooling         Central Unit, 24, 800, 12, .75         Central Unit, 24, 800, 12, .75         Central Unit, 24, 800, 12, .75           Heating         Electric Heat Pump, 24, 7.5         Electric Heat Pump, 24, 7.5         Electric Heat Pump, 24, 7.5           0, 295, 5, 60, 5, 419%,         6, 295, 25, 60, 10, 838%,         6, 295, 25, 60, 7, 113%,		105.2 ft2, 11, Exterior	107 ft2, 7, Exterior	102.5 ft2, 4.2, Exterior		
Infiltration         208.6 ft2, 11, Adjacent         201.3 ft2, 11, Adjacent         208.6 ft2, 11, Adjacent           Mech Ventilation         .125 ACH, 21 CFM, 50, .25, 1         .16 ACH, 27 CFM, 45, .45, 1         .065 ACH, 10.5 CFM, 61, .63, 1           Mech Ventilation         None         None         None         None           Garage         419 ft', 425 ft'         419 ft', 425 ft'         419 ft', 425 ft'           Sunspace         No         No         No           Cooling         Central Unit, 24, 800, 12, .75         Central Unit, 24, 800, 12, .75         Central Unit, 24, 800, 12, .75           Heating         Electric Heat Pump, 24, 7.5         Electric Heat Pump, 24, 7.5         Electric Heat Pump, 24, 7.5           0, 295.5, 60, 5.419%,         6, 295.25, 60, 10.838%,         6, 295.25, 60, 7.113%,		Frame-Wood,	Frame-Wood,	Frame-Wood,		
Infiltration         .125 ACH, 21 CFM, 50, 25, 1         .16 ACH, 27 CFM, 45, 45, 1         .065 ACH, 10.5 CFM, 61, 65, 1           Mech Ventilation         None         None         None         None           Garage         419 ff', 425 ff'         419 ff', 425 ff'         419 ff', 425 ff'         Mone         None           Sunspace         No         No         No         No         No           Cooling         Central Unit, 24, 800, 12, .75           Heating         Electric Heat Pump, 24, 7.5           Duct System         6, 295.5, 60, 5.419%,         6, 295.25, 60, 10.838%,         6, 295.25, 60, 7.113%,		208.6 ft2, 11, Adjacent	201.3 ft2, 11, Adjacent	208.6 ft2, 11, Adjacent		
None         None         None         None           Garage         419 ff*, 425 ff*         419 ff*, 425 ff*         419 ff*, 425 ff*         419 ff*, 425 ff*           Sunspace         No         No         No         No           Cooling         Central Unit, 24, 800, 12, .75           Heating         Electric Heat Pump, 24, 7.5           Duct System         6, 295.5, 60, 5.419%,         6, 295.25, 60, 10.838%,         6, 295.25, 60, 7.113%,		.125 ACH, 21 CFM, 50, .25, 1	.16 ACH, 27 CFM, 45, 45, 1	.005 ACH, 10.5 CFM, 01, .03, 1		
Garage         419 ft, 425 ft         419 ft, 425 ft         419 ft, 425 ft           Sunspace         No         No         No           Cooling         Central Unit, 24, 800, 12, .75         Central Unit, 24, 800, 12, .75         Central Unit, 24, 800, 12, .75           Heating         Electric Heat Pump, 24, 7.5         Electric Heat Pump, 24, 7.5         Electric Heat Pump, 24, 7.5           Duct System         6, 295.5, 60, 5.419%,         6, 295.25, 60, 10.838%,         6, 295.25, 60, 7.113%,				NUNE 410 # 435 #		
Cooling         Central Unit, 24, 800, 12, .75         Central Unit, 24, 800, 12, .75         Central Unit, 24, 800, 12, .75           Heating         Electric Heat Pump, 24, 7.5         Electric Heat Pump, 24, 7.5         Electric Heat Pump, 24, 7.5           Duct System         6, 295.5, 60, 5.419%,         6, 295.25, 60, 10.838%,         6, 295.25, 60, 7.113%,	Gunerage	4138,4238 No	413 x, 423 ll No	413 IL, 423 IL No		
Heating         Electric Heat Pump, 24, 7.5         Electric Heat Pump, 24, 7.5         Electric Heat Pump, 24, 7.5           Duct System         6, 295.5, 60, 5.419%,         6, 295.25, 60, 10.838%,         6, 295.25, 60, 7.113%,	Cooling	Control Unit 24 800 12 75	Central Linit 24 800 12 75	Control Unit 24 800 12 75		
Duct System         6, 295.5, 60, 5.419%,         6, 295.25, 60, 10.838%,         6, 295.25, 60, 7.113%,	Heating	Electric Heat Pump 24, 75	Flectric Heat Pump 24 7 5	Electric Heat Pump 24 75		
	Duct System	6 295 5 60 5 419%	6 295 25 60 10 838%	6 295 25 60 7 113%		
I Affic Interior I Affic Interior Interior Interior I Affic Interior	a and a parent	Attic Interior Interior	Affic Interior Interior	Attic Interior Interior		
Hot Water Electric 50, 01, 88, 130 Electric 50, 01, 88, 130 Electric 50, 01, 88, 130	Hot Water	Electric 50, 01, 88, 130	Electric 50, 01, 88, 130	Electric 50, 01, 88, 130		
Temperatures 79, 73.5, 72.5 78, 72, 71.5 78, 71.5 78, 71.5, 72	Temperatures	79.73.5.72.5	78,72,71.5	78, 71.5, 72		
Appliances Refrigerator Refrigerator Refrigerator	Appliances	Refrigerator	Refrigerator	Refrigerator		

Table 1. Summary of EnergyGauge USA inputs

## EnergyGauge USA

Figure 3 shows the EnergyGauge USA software. This software is PC based and uses the DOE-2.1E simulation engine to allow users to examine many different energy options based on the power of hourly simulation. The hourly-based simulation allows the user to input different thermostat settings, hour by hour, to analyze their impact on the peak cooling loads. For example, changing the thermostat to 72 from 78 degrees from 8 a.m. until 5 p.m. can create excessive cooling loads during peak summer months and the new simulation would be able to predict this, hour by hour. Also, since inside temperatures can be predicted, the software allows designers to examine how design features influence comfort conditions. Another feature, as the name would imply, allows homes to be modeled in 213 cities across the US. Typical Meteorological Year data is available for all 213 cities.

Title:	Block Hause		Datar Nome:	Prion Fuebriein	
owner:	FSEC		Rater Name. Builder:	Viking Builders	
Building New Building Rotate I Number Total Nu	Type	Worst Case         Yes         Purpose         Energy Calc.         Rating	Propert Ad	y Location dress Type Street Address 1224 Windwar	C Lot Information
Condition Area:	hed Average Conditioned Wall Height: Volume: 181 <sub>X</sub> 8.524 <sub>=</sub> 10066.844	Post Project	City: County:	Apopka Orange	State: FL Zip: 32703-0000

Figure 3. EnergyGauge USA

Other unique features of the new software are highlighted below:

- Simulate the interaction of duct air distribution systems and their locations (attic, crawlspace, basement, etc).
- Evaluation of light colored building surfaces on annual cooling and heating performance and impacts on duct systems.
- Assessment of various ventilation approaches.
- Characterization of appliance and lighting loads and interaction with heating and cooling.
- Estimation and modeling of the dependence of ceiling insulation conductivity on the temperature difference across the insulation (Parker, et. al., 1999).

# **Defining the Inputs**

All input variables must be input carefully as the accuracy of the simulation depends on the accuracy of the inputs. Table 1 shows the important inputs. The details of the walls, windows, floors, roofs and garages were taken from the blueprints and verified with on-site measurements. The lots were surveyed to determine all surrounding buildings and trees. The infiltrations were measured by the tracer gas decay method (SF<sub>6</sub>) using a photo-acoustic analyzer. The mechanical ventilation was input as zero for all three homes even though the AAC home has the FanRecycler. The FanRecycler only comsumes energy by turning on the fan even when there is no need for cooling. Since this study took place during September the FanRecycler did not add to the energy consumption of the AAC home.

Since these homes were unoccupied, the thermostat settings were under FSEC control. Figure 4 shows the hourly internal temperatures of the three homes during the monitoring period. Three different thermostat settings were seen. August 29 through September 9 (hours 1-310) was the first setting, September 10 through September 17 (hours 311-580) was the second setting and September 18 through September 28 (hours >581) was the third setting. The thermostat settings that were input are shown in Table 2:

Indoor Temperatures by Hour



Figure 4. Indoor Hourly Average Temperatures, by Period

	Period 1	Period 2	Period 3
Block House	78°	71.5°	72°
Frame House	79°	73.5°	72.5°
AAC House	78°	72°	71.5°

## Table 2. Thermostat Settings

Ambient temperatures and solar radiation were monitored and entered into the simulation. Typical Meteorological Year (TMY2) weather files were used as defaults and then modified as necessary. For detailed information on all simulation inputs as well as a step-by-step explanation of modifying the weather data please see Fuehrlein, 1999.

## Results

This experiment served as a comprehensive test of the *EnergyGauge USA* software. The variables in this experiment were the following: 1. Three different home constructions representing base case, energy efficient and improved IAQ homes. 2. Three different periods of thermostat settings that were input into the software. These variables were tested in three periods for each house. Period one represented a warm thermostat setting and periods two and three represented a cooler thermostat setting. By testing a total of nine periods these variables were isolated.

Since many variables are being controlled, if the outputs (i.e. predicted hourly a/c energy use) of the simulation match closely with the measured data, for all three homes, for all three periods, the simulation can be considered valid for entry-level homes. Other conclusions can be drawn depending on which parts of the simulation do not match the measured data.



Figure 5. Block House, Period 1

AAC House Period 1



Figure 6. AAC House, Period 1





Figure 7. Frame House, Period 1

Figures 5 through 7 show the hourly and daily energy consumption of the three houses for period one. There was an excellent relationship between the simulated and the predicted values. There was, however, an anomaly near hour 140 on day six. The measured energy consumption was very high for several hours for all three homes. This was the day that FSEC researchers performed the  $SF_6$  test on the homes. When performing the  $SF_6$  test the air handlers were on for the duration of the test. This was what caused the sharp increase in energy consumption during those few hours. This was something that the simulation would not and should not predict. These bad data points was ignored during the data analysis section. Also, the AAC house was missing data for several days during this period. This data was also ignored.



Figure 8. Block House, Period 2





Figure 9. AAC House, Period 2

Frame House, Period 2



Figure 10. Frame House, Period 2

Figures 8 through 10 show the hourly energy consumption for the three houses for period two. The thermostats for the houses were set near 78 degrees the last day of period one and near 72 degrees for the first day of period two. For the first day of the colder setting the air conditioner not only has to meet the steady state cooling loads but also the load from cooling down the thermal mass of the house itself. In the simulation, the warm up period has to be the same thermostat setting as the period of interest. There is no way to accurately simulate a sudden thermostat change to 72 degrees from 78 degrees. This is the reason that the measured energy consumption was more than the simulated energy consumption. The first day of data from period two was not included in the data analysis.

**Block House, Period 3** 











Frame House, Period 3



Figure 13. Frame House, Period 3

Figures 11 through 13 show the energy consumption of the three houses for period three. Since the thermostat change was very small for all three homes between period two and three, the warm-up period will be ignored. There were no other anomalies with the data throughout period three.

Period averages were looked at in an effort to draw initial conclusions about the difference between the predicted data and the measured data. Period averages for the overall simulation, for each house, for the high thermostat and for the low thermostat settings are presented in Table 3. Table 4 shows the period averages broken down individually for each house. All units are in KWH.

	Overall	Block	Frame	AAC	High Thermo	Low Thermo
Predicted	0.69	0.75	0.55	0.79	0.51	0.80
Measured	0.69	0.75	0.57	0.76	0.51	0.79
Error	0.00%	0.00%	-3.51%	3.95%	0.00%	1.27 %

## **Table 3. Overall Period Averages**

The overall averages were practically the same showing a strong overall accuracy of the software. Isolating each building technique and thermostat setting as variables, the period average error did not exceed four percent.

	Period 1			Period 2			Period 3		
	Block	Frame	AAC	Block	Frame	AAC	Block	Frame	AAC
Predicted	0.57	0.40	0.57	0.87	0.61	0.87	0.85	0.67	0.89
Measured	0.57	0.41	0.58	0.95	0.64	0.86	0.81	0.69	0.84
Error	0.00%	-2.44%	-1.72%	-8.42%	-4.69%	1.16%	4.94%	-2.99%	5.95%

**Table 4. Individual Period Averages** 

Table 4 shows a detailed look at all nine sets of data. The high thermostat setting represents period one for all three houses and the low thermostat setting represents periods two and three for all three houses. Again, regardless of thermostat setting, the simulation model is very accurate with error never exceeding nine percent.

A second analysis was conducted to test the simulation accuracy during peak cooling load periods. In the summertime in Florida, peak cooling occurs between the hours of four and six p.m. Data points for the four o'clock and five o'clock hours were isolated from the data sets and then the error between the measured and predicted data was calculated. Similar to Table 4 above, the data is broken down by period and by construction technique so all nine data sets are presented.

[	Period 1			Period 2			Period 3		
	Block	Frame	AAC	Block	Frame	AAC	Block	Frame	AAC
Predicted	0.82	0.65	0.83	1.2	0.87	1.19	1.11	0.88	1.15
Measured	0.82	0.64	0.81	1.36	0.91	1.22	1.08	0.89	1.09
Error	0.00%	1.56%	2.47%	-11.76%	-4.40%	-2.46%	2.78%	-1.12%	5.50%

#### **Table 5. Peak Load Error**

Table 5 shows that even under extreme cooling load conditions the *EnergyGauge* USA software is accurate. The error only exceeded ten percent once and all other times was consistently below six percent.

#### Conclusions

Overall, the *EnergyGauge USA* software was accurate in predicting energy consumption in entry level homes. Period average errors were consistently under nine percent. Even under extreme cooling loads, i.e., in Florida, in September, between four and six p.m., the software was still consistently within six percent of the measured values, only once having an error greater than ten percent (11.76%).

## **Future Research**

This research did not address homes other than small, entry level homes. The results of this research do not indicate an increase in error with an increase in energy consumption so there is no reason to believe that the software would not be just as accurate with larger homes. A similar study should be carried out for larger homes.

This study was conducted under unoccupied conditions. In order to verify the accuracy of the software under occupied conditions, further studies must be conducted.

#### Acknowledgements

The homes were constructed by the Viking Builders (Mr. Paul Mashburn, president) in partnership with the Affordable Housing Institute (Mr. William T. Nolan, president). This research was sponsored by the U.S. Department of Energy, Office of Building Technology, State and Community Programs - - Mr. George James, program manager. Dr. Lixing Gu of the Florida Solar Energy Center was instrumental in modifying the TMY2 weather data file to incorporate measured data. Their support is gratefully acknowledged.

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