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DETAILED ANALYSIS OF THE BUILDER OPTION PACKAGES FOR CLIMATE ZONES 3,4,5 AND 6 FOR TEXAS' SENATE BILL 5 LEGISLATION FOR REDUCING POLLUTION IN NON-ATTAINMENT AND AFFECTED AREAS

Project for
Texas' Senate Bill 5 Legislation
For Reducing Pollution
in Non-attainment and Affected Areas

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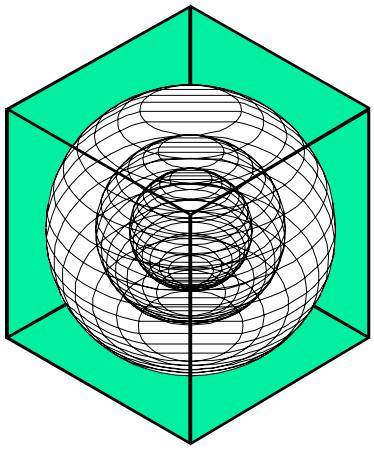

ENERGY SYSTEMS LABORATORY

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Texas A&M University System

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INTRODUCTION

This report is a detailed description of the analysis completed on the Energy Star Builder Option Packages (BOPs) using the Energy Systems Laboratory's (ESL) Code Compliant Test Suite of Tools. This report outlines the basic procedure, which was followed. A description of the Test Suite, along with a detailed explanation of the naming the procedure of the different runs is also a part of this report. A CD-ROM is also provided which has all the 137 runs, inputs and outputs, the window inputs and the summary spreadsheets.

BOPs for climate zones 3,4,5 and 6 were submitted for approval to ESL on April 29,2002. It was stated that the suggested BOPs were 10 to 15% less consumptive than the IECC chapter 4/5 house. Analysis was done on these BOPs and the BOPs which were less consumptive than the standard house were posted on the ESL's website. The same tables have also been included in this report along with the detailed spreadsheets.

ESL's CODE COMPLIANT TEST SUITE OF TOOLS

The Code Compliant Test Suite of Tools comprises of the following two sections:

1. The IECC input file
2. The Automated glass input

Following is a description of how the IECC input file, based on DOE-2.1e version 119, can be used to simulated and verify the energy consumption of the Builder Option Packages. The complete input file can be accessed from the following link:

iecc1103.inp

PROCEDURE FOR RUNNING DIFFERENT SIMULATIONS THROUGH THE IECC TRACEABLE INPUT FILE:

The IECC input file uses the parameter command of DOE-2 to simulate different weather conditions and construction details for different parts of Texas. IECC1100 is not a dynamic file, so if the area changes as in the case of east and west Texas, changes have to made inside the code in addition to the parameters so that all the windows and walls have the correct geometry and connected layout. However for a particular region (same area), changes are only incorporated at the top in the parameters. Following is the complete list parameters along with the corresponding DOE-2 keyword and user input, the shaded ones are changed with every different run.

User Input	Doe-2 Keyword	Corresponding Parametric Input	Examples Values
House dimensions	Gross-Area (total floor area) (floor-weight = 0)	P-AREA	2500 ft^2
House dimensions	Gross-Area (perimeter) (floor-weight > 0)	P-AREA1	200 ft^2
House dimensions	Volume	P-VOLUME	
House dimensions	Width (for exterior wall, shades etc)	P-BUILDINGWIDTH	50 ft
House dimensions	Length (for exterior wall, shades etc)	P-BUILDINGLENGTH	50 ft
Internal wall height	Height (Wall)	P-WALLHEIGHT	8 ft
Orientation of house	Azimuth (Building Location Command)	P-BUILDINGAZIMUTH	0°
Weather Station	Latitude	P-LATITUDE	29.98°

Weather Station	Longitude	P-LONGITUDE	95.37°
Weather Station	Time-zone	P-TIME-ZONE	6
Weather Station	Altitude	P-ALTITUDE	108 ft
No. of Occupants	Number-of-people	P-OCCUPANCY	2
Width of the left wall	Width	P-LEFTWALLWIDTH	28
R-value (roof) (1/U-value)	U-value (Roof)	P-ROOFUVALUE	0.5
Roof outside emissivity	Outside-emiss	P-ROOFOUTEMISS	0.9(fixed)
Roof absorptance	Absorptance	P-ROOFABSORPTANCE	0.5(fixed)
Roof roughness	Roughness	P-ROOFROUGHNESS	1(fixed)
R-value (wall) (1/U-value)	U-value (Wall)	P-WALLUVALUE	0.077
Wall absorptance	Absorptance	P-WALLABSORPTANCE	0.55 (fixed)
Wall roughness	Roughness	P-WALLROUGHNESS	2 (fixed)
Wall outside emissivity	Outside-emiss	P-WALLOUTEMISS	0.9 (fixed)
Wall ground reflectance	Gnd-reflectance	P-GND-REFLECTANCE	0.24 (fixed)
R-value (ceiling) (1/U-value)	U-value (Ceiling)	P-CLNGUVALUE	0.0385
Door height	Height	P-DOORHEIGHT	6.67ft (fixed)
Door width	Width	P-DOORWIDTH	3 ft (fixed)
Window to wall ratio	Width (Window)	P-WINDOWWIDTH	12 ft
Window to wall ratio	Height	P-WINDOWHEIGHT	5 ft (fixed)
Solar heat gain factor (SHGF)	Shading-coeff	P-SHADINGCOEFFICIENT	0.528 (pre-calculated from NFRC 200)
U-Value (Window)	Glass-conductance	P-GLASSCONDUCTANCE	0.65 (pre-calculated from NFRC 100)
Type of frame	Frame-width	P-FRAMEWIDTH	0.23
Type of frame	Frame-conductance	P-FRAMECONDUCTANCE	3.037
Type of frame	Frame-absorptance	P-FRAMEABSORPTANCE	0.7
U-Value (Window)	Panes	P-PANES	2
Floor weight	Floor-weight	P-FLOORWEIGHT	11.5 lbs/ft^2
Floor U-value	U-value (floor)	P-FLOORUVALUE	0.06
U-effective	U-value (floor)	P-UEFFECTIVE	0.0628
Roof Overhang	Height (Building-shade)	P-SHADEWIDTHF	3
Roof Overhang	Height (Building-shade)	P-SHADEWIDTHR	3
Roof Overhang	Height (Building-shade)	P-SHADEWIDTHB	3
Roof Overhang	Height (Building-shade)	P-SHADEWIDTHL	3
Roof Overhang	Transmittance	P-TRANSMITTANCE	1

Roof Overhang	Transmittance schedule	P-SCHEDULE	1
A/C SEER	Cooling-EIR	P-EIR	0.341
Furnace AFUE	Furnace-HIR	P-HIR	1.25
DHW efficiency	DHW-HIR	P-DHWHIR	1.31

The explanation of how the highlighted parameters are put in the simulation.

House Dimension:

Related parameters

P-AREA
P-AREA1
P-VOLUME
P-BUILDINGLENGTH
P-BUILDINGWIDTH
P-LEFTWALLWIDTH

P-AREA:

It is the total floor area of the building and in this case it is the product of the P-BUILDINGLENGTH and P-BUILDINGWIDTH. Right now no external routine is being used to take the product of the two parameters so the area is put in manually.

P-AREA1:

It is the perimeter of the building and it can also be calculated from the P-BUILDINGLENGTH and P-BUILDINGWIDTH, but right now it is being put in manually. This is used for the floor area when the custom weighting factors are not being used, which is the case for the current simulation runs.

P-VOLUME:

It is the product of P-AREA and the P-BUILDINGHEIGHT, the latter is fixed at 8 ft. For this input file this value is being put in manually.

P-BUILDINGLENGTH:

For these simulations the building is being considered rectangular so this parameter corresponds to the two sides of the building.

P-BUILDINGWIDTH:

This gives the dimensions of the remaining two sides of the building.

P-LEFTWALLWIDTH:

This gives the width of the wall, which is exterior after the garage.

Material Properties:

P-ROOFUVALUE
P-WALLUVALUE
P-CLNGUVALUE

P-ROOFUVALUE:

This is the total U-value for the combined construction of the roof. The user inputs an R-value, which is the reciprocal of the U-value. The inversion of the value is manual.

P-WALLUVALUE:

This is the total U-value for the combined construction of the wall. The user inputs an R-value, which is the reciprocal of the U-value. The inversion of the value is manual.

P-CLNGUVALUE:

This is the total U-value for the combined construction of the ceiling. The user inputs an R-value, which is the reciprocal of the U-value. The inversion of the value is manual.

P-FLOORUVALUE:

This gives the total U-value of the floor including the slab and the added insulation.

P-UEFFECTIVE:

This value is calculated to just consider the heat transfer from the slab perimeter.

Glazing Dimensions and Properties:

P-WINDOWWIDTH
P-SHADINGCOEFFICIENT
P-FRAMEWIDTH
P-GLASSCONDUCTANCE
P-FRAMECONDUCTANCE

P-WINDOWWIDTH:

This is the equivalent width if a single window is considered on each exterior wall of the house. The value is calculated through a spreadsheet created to input windows in DOE-2. The user just puts in the window to wall ratio.

P-SHADINGCOEFFICIENT:

This is the center of glass shading coefficient, which needs to input into the DOE-2 file. This is also calculated through the spreadsheet. The user just provides the Solar Heat Gain Factor of the complete window.

P-FRAMEWIDTH:

This is the equivalent frame width if a single window is considered on each exterior wall. The value is calculated by the spreadsheet and the user input requires the type of frame.

P-GLASSCONDUCTANCE:

This is the main parameter, which is required as input to define the glass properties. The user defined U-value is transformed to the glass conductance through the NFRC 100 and Doe-2 defined formulae in the glass input spreadsheet.

P-FRAMECONDUCTANCE:

This value is taken from the DOE-2.1e supplement and it depends on the frame type chosen by the user.

The remaining 2 parameters are in the systems portion of the file.

P-EIR:

This input corresponds to the efficiency of the cooling equipment in DOE-2, which is usually defined in SEER. The conversion of Seasonal Energy Efficiency Ration (SEER) to the Energy Input Ratio (EIR) is:

EIR = 3.41/SEER

P-HIR:

This input corresponds to the efficiency of the heating equipment in DOE-2, which is usually defined in AFUE. The conversion of Annual Fuel Utilization Efficiency (AFUE) to the Heat input Ratio (HIR) is:

HIR = 1/ AFUE

Example of typical input for running the IECC code compliant simulation:

House Dimensions:

User Defined Input:

50x50 house with 8ft. ceiling.

Corresponding Parameters:

P-BUILDINGLENGTH = 50 ft.

P-BUILDINGWIDTH = 50 ft.

P-AREA = 50 x 50
= 2500 ft^2 (if the floor weight is taken as zero)

P-AREA1 = 2 x (50 + 50)
= 200 ft. (if floor weight is greater then 0)

P-WALLHEIGHT = 8ft (Typical Value)

P-VOLUME = P-AREA x P-WALLHEIGHT
= 2500 x 8
= 20000 ft^3

Weather Station:

User Defined Input:

The house is situated in Houston, Texas. The TMY2 file will be of Houston

Corresponding Parameters:

P-LATITUDE = 29.98°

P-LONGITUDE = 95.37°

P-TIMEZONE = 6

P-ALTITUDE = 108 ft

Material Properties:

User Defined Input:

Roof R-value = R-2

Wall R-value = R-13

Ceiling R-value = R-26

Corresponding Parameters:

P-ROOFUVALUE = 1/ Roof R-value
= 1 / 2
= 0.5 Btu /hr.°F. ft^2

P-WALLUVALUE = 1/ Wall R-value
= 1/ 13
= 0.077 Btu /hr.°F. ft^2

P-CLNGUVALUE = 1/ Ceiling R-value
= 1/ 26
= 0.0385 Btu /hr.°F. ft^2

Glazing Dimensions and Properties:

User Defined Input:

Window to Wall Ratio = 15%

Window U-value = 0.75

Window Solar Heat Gain Factor = 0.4

Frame Type = Aluminum W/O thermal break

Corresponding parameters: (for calculating procedure of the following parameters refer to the attached Window input explanation)

P-WINDOWWIDTH = Equivalent width of a window if only one window is considered in each wall.

= 12 ft.

P-SHADINGCOEFFICIENT = Shading coefficient for the center of the glass.

= 0.528

P-FRAMEWIDTH =Equivalent width of a frame if only one window is considered each wall.

= 0.23 ft.

P-GLASSCONDUCTANCE = This is the center of glass U-value and is the main property for defining the type of glass.

= 0.65 Btu/hr.°F ft^2

P-FRAMECONDUCTANCE=This values comes directly from the DOE-2 user's manual and is dependent on the type of frame chosen by the user.

= 3.037 Btu/hr.°F ft^2

Equipment Efficiencies:

User Defined Inputs:

Furnace AFUE = 80%

A/C SEER = 10

Corresponding Parameters:

P-EIR = 3.413/SEER

= 3.413/10

= 0.341

P-HIR = 1/AFUE

= 1/0.8

= 1.25

These are the main parameters, which are changed to run different simulations with the code traceable IECC input file.

The glazing properties used in the above simulation require post processing through a spreadsheet, which is based on the NFRC 100 and 200 calculations. The structure and explanation of the spreadsheet is given below:

CONVERSION OF WINDOW U-VALUE TO GLASS CONDUCTANCE ANDSHGF TO SHADING COEFFICIENT

The DOE-2 simulation software allows window to be entered in the following ways:

1. Shading Coefficient
   Username = GLASS-TYPE
   SHADING-COEFF =
   PANES =
   GLASS-CONDUCTANCE =
   VIS-TRANS =
   FRAME-CONDUCTANCE =
   FRAME-ABS =
2. Glass-Type-Code $\leq$ 11
   Username = GLASS-TYPE
   GLASS-TYPE-CODE =
   PANES =
   GLASS-CONDUCTANCE =
   VIS-TRANS =
   FRAME-CONDUCTANCE =
   FRAME-ABS =

3. Window Library (Glass-Type-Code $\geq$ 1000)
   Username = GLASS-TYPE
   GLASS-TYPE-CODE =
   FRAME-CONDUCTANCE =
   FRAME-ABS =

The second of input restricts the user to the predefined U-values and SHGF of the window library while in the third type there is a choice to use windows already defined in the library or add new windows to the DOE-2 library following a certain method explained in the DOE-2.1e reference manual.

For the purposes of the project, which requires the user to input window U-value and Solar heat gain coefficient, the first method is feasible. It requires Shading Coefficient and Glass Conductance as input to the simulation program, while the general practice is to define the Solar Heat Gain Factor and the U-factor. To convert the U-factor and Solar Heat Gain Factor to Glass Conductance and Shading Coefficient, the following steps are required which have been incorporated in a spreadsheet for the ease of calculations. The spreadsheet, which has been used, is:

automated glassinput.xls

- This is a generalized spreadsheet, which requires the following inputs for the calculation of the shading coefficient and glass conductance.

House dimensions:
Length
Width
Height of the interior wall

Glazing Properties:
U-Factor
Solar Heat Gain Factor

Window to wall ratio (%)

- Two separate sections in the spreadsheet calculate the glass-conductance and the SHGF to be input in the DOE-2 input file.

- In DOE-2 there is a choice of 5 types of frames, so in the spreadsheet there are five different rows, which calculate the glass conductance and SHGF for the different frame types.

- Next the total Wall or Floor area of the house is defined, which will be used to determine the area of window on each wall.

- The frame is taken to be a standard 11/2" for Aluminum and 2 ½" for Wood and Vinyl.

- The value of frame conductance is taken from the DOE-2.1e manual.

The rest of the calculation in the spreadsheet are explained below:

1. Calculation of the Frame U-value:
   The following formula is from DOE-2.1e Supplement (p. 2.116)
   Assumption: None

   Frame U-value = $[(\text{frame conductance})^{-1} + 0.197]^{-1}$

1. Calculation of Area of Window on each wall:
   Assumption: window area is equal on all sides

Window area on each wall = $\frac{\text{Total wall area x Window to wall ratio (\%)}}{4}$

2. Calculation of the number of Windows on each wall:
   Assumption: Each window is 3x5 (15 ft^2)

   $$\text{Number of windows} = \frac{\text{Window area on each wall}}{\text{Area of one window (15 } ft^2\text{)}}$$

3. Calculation of Glass Area:
   Assumption: Frame width is 0.125 ft, window height is 5ft and width is 3ft.

   Glass area = (Height of Window - 2x Width of frame) x (Width of Window – 2x Width of frame)

4. Calculation of Frame area:
   Assumption: None

   Frame area = (Window area on each wall) – (Glass Area)

5. Calculation of Window width if one equivalent window:
   Assumption: Window height is 5ft and house is rectangular

   $$\text{Window Width} = \frac{\text{Window to wall ratio(\%) x Total wall area}}{\text{No. of exterior walls x window height}}$$

6. Calculation of equivalent frame width
   Assumption: Window height is 5ft.

   $$\text{Equivalent frame width} = \frac{\text{Frame area}}{\text{2x (equiv. Window width + window height)}}.$$

7. Calculation of center of glass U-value:
   The NFRC 100 is used for this calculation
   Assumption: Edge of glass U-value is neglected
   No dividers are considered

$$\text{Center of glass U-value} = \frac{\text{(Total U-value x Total area) – (Frame U-value x Frame area)}}{\text{Glass Area}}$$

8. Calculation of the Glass Conductance:
   Assumption: None

   $$\text{Glass Conductance} = [(\text{Center of glass U-value})^{-1} - 0.197]^{-1}$$

This value is finally input into the code and this can be checked against the output since the output gives out the total U-value of the Window, which shows that the window is being simulated according to the U-factor provided.

The following two steps are used to calculate the shading coefficient when the solar heat gain coefficient is provided as the input.

9. Calculation of the Center of glass SHGF
   The following formula is from NFRC 200
   Assumption: Edge of glass is neglected
   No dividers are considered
   Frame has zero SHGF

$$\text{Center of Glass SHGF} = \frac{\text{Total SHGF x Total Area}}{\text{Area of Glass}}$$

10. Calculation of Shading Coefficient
    The following formula is from NFRC 200
    Assumption: None

Shading Coefficient = (Center of glass SHGF)/0.87

Sample Calculation:

Assuming the following Input values for the spreadsheet:

House dimensions:
Length = 50 ft
Width = 50 ft
Height of the interior wall = 8 ft
Window to wall ratio = 15%

Glazing Properties:
U-Factor = 0.75
Solar Heat Gain Factor = 0.4

Assuming an Aluminum frame without thermal break:

From the spreadsheet

Conductance of Aluminum w/o thermal break = 3.037

Frame U-value = $[(\text{frame conductance})^{-1} + 0.197]^{-1}$

$= [(3.037)^{-1} + 0.197]^{-1}$

$= 1.9$ Btu/hr ft^2 °F

Frame-width = 0.125 ft

Total wall area = (2x width x height) + (2x length x height)

$= (2 \times 50 \times 8) + (2 \times 50 \times 8)$

$= 1600$ ft^2

Total area of a single window = $\frac{\text{Total wall area x Window to wall ratio (\%)}}{4}$

$= \frac{1600 \times 15\%}{4}$

$= 60$ ft^2

Number of windows = $\frac{\text{Window area on each wall}}{\text{Area of one window (15 ft}^2\text{)}}$

$= 60/15$

$= 4$ windows

Glass area = (Height of Window - 2x Width of frame) x (Width of Window – 2x Width of frame)

$= [(5 - 2 \times 0.125) \times (3 - 2 \times 0.125)] \times 4$

$= 52.25$ ft^2

Frame area = (Window area on each wall) – (Glass Area)

$= 60 - 52.25$

$= 7.75$ ft^2

Equivalent width of a single window = $\frac{\text{Window to wall ratio (\%) x Total wall area}}{\text{No. Of exterior walls x window height}}$

$= \frac{15\ \% \times 1600}{4 \times 5}$

= 12 ft.

Equivalent frame width for a single window

$$= \frac{\text{Frame area}}{2\text{x (equiv. Window width x window height)}}$$

$$= 7.75/ [2 \text{ x } (12 \text{ x } 5)]$$

$$= 0.23 \text{ ft.}$$

$$\text{Center of glass U-value} = \frac{\text{(Total U-value x Total area) – (Frame U-value x Frame area)}}{\text{Glass Area}}$$

$$= \frac{(0.75 \text{ x } 60) – (1.9 \text{ x } 7.75)}{52.25}$$

$$= 0.58 \text{ Btu/ hr ft}^2 \text{ °F}$$

$$\text{Glass conductance} = [(\text{Center of glass U-value})^{-1} – 0.197]^{-1}$$

$$= [(0.58)^{-1} – 0.197]^{-1}$$

$$= 0.65 \text{ Btu/ hr ft}^2 \text{ °F}$$

The second part of the spreadsheet is similar to the first one except for the following:

$$\text{Center of glass SHGF} = \frac{\text{Total SHGF x Total Area}}{\text{Area of Glass}}$$

$$= \frac{0.4 \text{ x } 60}{52.25}$$

$$= 0.459$$

Shading Coefficient = Center of glass SHGF/ 0.87

$$= 0.459/0.87$$

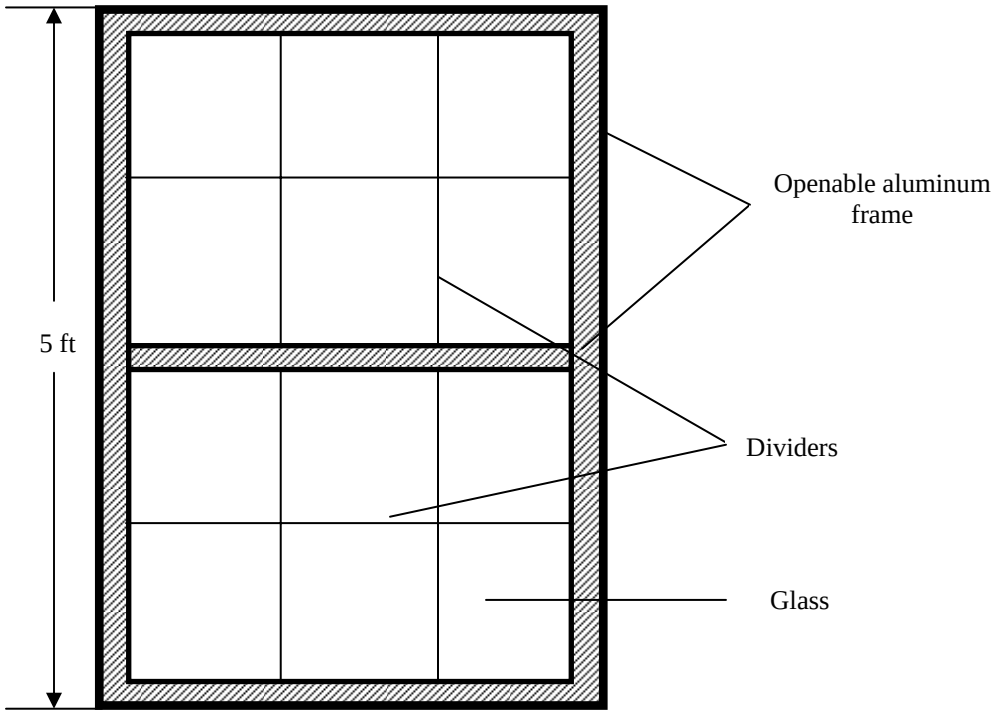
$$= 0.528$$

The spreadsheet is attached for the better understanding of this calculation procedure.

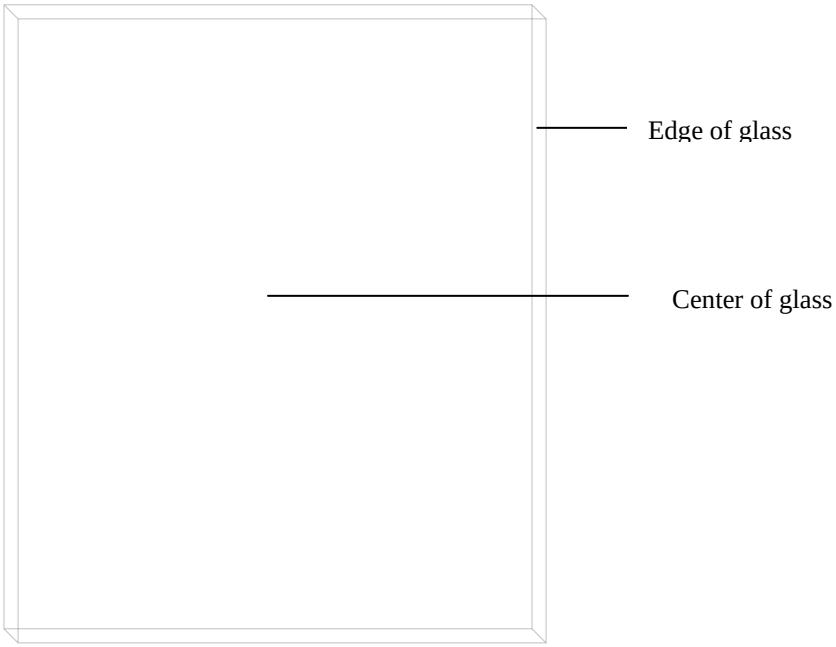
TYPICAL WINDOW CONSTRUCTION:

The following window construction and size is considered for all calculations. The frame is openable and can be of the materials already mentioned. The dividers and the edge of glass U-value are neglected. The height of the window is fixed at 5ft while the width depends on the window to wall ratio.

Complete glazing System



3D of Glass



RESULTS

The following tables summarize the analysis done for the Energy Star BOPs submitted. The tables contain only those BOPs whose annual energy use was less then the standard IECC chapter 4/5 house. The same tables are also posted at the ESL's website **http://eslsb5.tamu.edu/sbill5/download/EnergyStarletter2.pdf.** The detailed spreadsheets are also attached. In addition to that several other comparative analyses were performed, the details of which are included in the appendix.

Table 1 gives the details of the BOPs, which passed for climate zone 3. This climate zone was simulated using Houston TMY2 data.

DOE-2 file name	BOP Number	Maximum Window to floor area ratio	Window Requirements		Minimum Insulation Requirements						Infiltration	Minimum Equipment Requirements		Status
			Max. U-value	Max. SHGC	Attic	Exterior Wall	Floor Above Unheated Space	Basement Wall	Slab	Crawlspace Wall	Max. Rate (ACH)	Heat (AFUE)	Cool (SEER)	
escz33	Z3-1-ES	18%	0.65	0.40	R-30	R-13	R-11	R-6	R-0	R-6	0.35	80%	11	**Pass**
escz35	Z3-2-ES	18%	0.60	0.35	R-30	R-11	R-11	R-6	R-0	R-6	0.35	80%	11	**Pass**
escz318	Z3-3-ES	21%	0.60	0.40	R-19	R-11	R-11	R-6	R-0	R-6	0.35	80%	14	**Pass**

Table 1 Building Option Packages (BOPS) for A-1 Single Family Residences in Climate Zone # 3

Table 2 gives the details of the BOPs, which passed for climate zone 4. This climate zone was simulated using Houston TMY2 data.

DOE-2 file name	BOP Number	Maximum Window to floor area ratio	Window Requirements		Minimum Insulation Requirements						Infiltration	Minimum Equipment Requirements		Status
			Max. U-value	Max. SHGC	Attic	Exterior Wall	Floor Above Unheated Space	Basement Wall	Slab	Crawlspace Wall	Max. Rate (ACH)	Heat (AFUE)	Cool (SEER)	
escz33	Z4-1-ES	18%	0.65	0.40	R-30	R-13	R-11	R-6	R-0	R-6	0.35	80%	11	**Pass**
escz318	Z4-2-ES	18%	0.60	0.35	R-30	R-11	R-11	R-6	R-0	R-6	0.35	80%	11	**Pass**

Table 2 Building Option Packages (BOPS) for A-1 Single Family Residences in Climate Zone # 4

Table 3 gives the details of the BOPs, which passed for climate zone 5. This climate zone was simulated using Fort Worth TMY2 data.

DOE-2 file name	BOP Number	Maximum Window to floor area ratio	Window Requirements		Minimum Insulation Requirements						Infiltration	Minimum Equipment Requirements		Status
			Max U-value	Max SHGC	Attic	Exterior Wall	Floor Above Unheated Space	Basement Wall	Slab	Crawlspace Wall	Max Rate (ACH)	Heat (AFUE)	Cool (SEER)	
Escz52	Z5-1-ES	15%	0.50	0.40	R-30	R-13	R-19	R-7	R-0	R-8	0.35	80%	10	**Pass**
Escz55	Z5-2-ES	18%	0.45	0.35	R-38	R-13	R-19	R-7	R-0	R-8	0.35	80%	10	**Pass**
Escz56	Z5-3-ES	18%	0.45	0.40	R-30	R-13	R-19	R-7	R-0	R-8	0.35	80%	11	**Pass**
Escz57	Z5-4-ES	21%	0.40	0.35	R-30	R-15	R-19	R-7	R-0	R-8	0.35	80%	11	**Pass**
escz510	Z5-5-ES	18%	0.50	0.40	R-30	R-13	R-19	R-7	R-0	R-8	0.35	80%	12	**Pass**
escz511	Z5-6-ES	21%	0.40	0.40	R-30	R-13	R-19	R-7	R-0	R-8	0.35	80%	12	**Pass**
escz512	Z5-7-ES	21%	0.50	0.40	R-30	R-15	R-19	R-7	R-0	R-8	0.35	80%	12	**Pass**
escz518	Z5-8-ES	18%	0.55	0.40	R-30	R-13	R-19	R-7	R-0	R-8	0.35	80%	14	**Pass**
escz519	Z5-9-ES	21%	0.50	0.40	R-30	R-13	R-19	R-7	R-0	R-8	0.35	80%	13	**Pass**

Table 3 Building Option Packages (BOPS) for A-1 Single Family Residences in Climate Zone # 5

Table 4 gives the details of the BOPs, which passed for climate zone 6. This climate zone was simulated using Fort Worth TMY2 data.

DOE-2 file name	BOP Number	Maximum Window to floor area ratio	Window Requirements		Minimum Insulation Requirements						Infiltration	Minimum Equipment Requirements		Status
			Max U-value	Max SHGC	Attic	Exterior Wall	Floor Above Unheated Space	Basement Wall	Slab	Crawlspace Wall	Max Rate (ACH)	Heat (AFUE)	Cool (SEER)	
Escz52	Z6-1-ES	15%	0.50	0.40	R-30	R-13	R-19	R-7	R-0	R-8	0.35	80%	10	**Pass**
Escz55	Z6-2-ES	18%	0.45	0.35	R-38	R-13	R-19	R-7	R-0	R-8	0.35	80%	10	**Pass**
Escz56	Z6-3-ES	18%	0.45	0.40	R-30	R-13	R-19	R-7	R-0	R-8	0.35	80%	11	**Pass**
Escz57	Z6-4-ES	21%	0.40	0.35	R-30	R-15	R-19	R-7	R-0	R-8	0.35	80%	11	**Pass**
escz510	Z6-5-ES	18%	0.50	0.40	R-30	R-13	R-19	R-7	R-0	R-8	0.35	80%	12	**Pass**
escz511	Z6-6-ES	21%	0.40	0.40	R-30	R-13	R-19	R-7	R-0	R-8	0.35	80%	12	**Pass**
escz512	Z6-7-ES	21%	0.50	0.40	R-30	R-15	R-19	R-7	R-0	R-8	0.35	80%	12	**Pass**
escz518	Z6-8-ES	18%	0.55	0.40	R-30	R-13	R-19	R-7	R-0	R-8	0.35	80%	14	**Pass**
escz519	Z6-9-ES	21%	0.50	0.40	R-30	R-13	R-19	R-7	R-0	R-8	0.35	80%	13	**Pass**

Table 4 Building Option Packages (BOPS) for A-1 Single Family Residences in Climate Zone # 6

Table 5 spreadsheet for BOPs analysis for climate zones 3&4

Climate Zone 3(Energy Star)Glazing % of Floor Area (HVAC Autosized)

BOP Number	Window Requirements: Energy Star Maximum Window Area[16]	Window U-value	Window SHGC	IECC Equivalent window to wall ratio[2]	Minimum Insulation Requirements: Attic	Exterior Wall	Floor Above Unheated Space	Basement Wall	Slab	Crawlspace Wall	Infiltration Requirements: Infiltration Rate (ACH)	Minimum Equipment requirements (Gas Furnace Heating, Electric Cooling, Gas Domestic Hot water): Heat (AFUE)	Furnace size (Btu/hr)	Cool (SEER)	A/C size (Tons)	DHW Efficiency (%)	DHW Size (gal/day)	ANNUAL ENERGY USE – Total Electricity Usage: kWh/year	kW(max)	MMBtu/year	0.071 $/kWh	Total Gas Usage: Therms/year	MMBtu/year	0.615 $/therm	Heating,cooling and DHW use: MMBtu/year	Total Energy Usage: MMBtu/year	$/Year	Btu/ sq.ft-year	% equivalent to total IECC Chapter 4/5 house	% equivalent to C/H/DHW of IECC Chapter 4/5 house
2	15%	</= 0.70	</= 0.40	20.60%	R- 30	R- 11	R- 11	R- 0	R- 0	R-6	0.35	80%	106,558	10	4.6	76	40	11,865	3.92	40.48	$842	326	32.60	$200	46.7	73.08	$1,043	37,750	93.12%	89.12%
3	18%	</= 0.65	</= 0.40	24.75%	R- 30	R- 13	R- 11	R- 6	R- 0	R-6	0.35	80%	106,558	11	4.6	76	40	11,871	3.84	40.50	$843	318	31.80	$196	46	72.30	$1,038	37,347	92.13%	87.79%
4	18%	</= 0.60	</= 0.35	24.75%	R- 30	R- 11	R- 11	R- 6	R- 0	R-6	0.35	80%	106,558	11	4.7	76	40	12,357	4.16	42.16	$877	331	33.10	$204	48.9	75.26	$1,081	38,875	95.90%	93.32%
5	21%	</= 0.55	</= 0.35	28.88%	R- 30	R- 13	R- 11	R- 6	R- p	R-6	0.35	80%	106,558	11	4.7	76	40	12,793	4.37	43.65	$908	323	32.30	$199	49.5	75.95	$1,107	39,230	96.77%	94.47%
16	21%	</= 0.55	</= 0.40	28.88%	R- 30	R- 11	R- 11	R- 6	R- 0	R-6	0.35	80%	106,558	13	4.7	76	40	12,593	4.15	42.97	$894	322	32.20	$198	48.8	75.17	$1,092	38,826	95.77%	93.13%
18	21%	</= 0.60	</= 0.40	28.88%	R- 19	R- 11	R- 11	R- 6	R- 0	R-6	0.35	80%	106,558	14	4.6	76	40	12,495	4.20	42.63	$887	348	34.80	$214	51	77.43	$1,101	39,996	98.66%	97.33%

Climate Zone 4(Energy Star)Glazing % of Floor Area (HVAC Autosized)

BOP Number	Window Requirements: Energy Star Maximum Window Area[16]	Window U-value	Window SHGC	IECC Equivalent window to wall ratio[2]	Minimum Insulation Requirements: Attic	Exterior Wall	Floor Above Unheated Space	Basement Wall	Slab	Crawlspace Wall	Infiltration Requirements: Infiltration Rate (ACH)	Minimum Equipment requirements (Gas Furnace Heating, Electric Cooling, Gas Domestic Hot water): Heat (AFUE)	Furnace size (Btu/hr)	Cool (SEER)	A/C size (Tons)	DHW Efficiency (%)	DHW Size (gal/day)	ANNUAL ENERGY USE – Total Electricity Usage: kWh/year	kW(max)	MMBtu/year	0.071 $/kWh	Total Gas Usage: Therms/year	MMBtu/year	0.615 $/therm	Heating,cooling and DHW use: MMBtu/year	Total Energy Usage: MMBtu/year	$/Year	Btu/ sq.ft-year	% equivalent to IECC Chapter 4/5 house	% equivalent to C/H/DHW of IECC Chapter 4/5 house
2	15%	</= 0.70	</= 0.40	20.60%	R- 30	R- 11	R- 11	R- 0	R- 0	R-6	0.35	80%	106,558	10	4.6	76	40	11,865	3.92	40.48	$842	326	32.60	$200	46.7	73.08	$1,043	37,750	96.78%	94.34%
3	18%	</= 0.65	</= 0.40	24.75%	R- 30	R- 13	R- 11	R- 6	R- 0	R-6	0.35	80%	106,558	11	4.6	76	40	11,871	3.84	40.50	$843	318	31.80	$196	46	72.30	$1,038	37,347	95.75%	92.93%
4	18%	</= 0.60	</= 0.35	24.75%	R- 30	R- 11	R- 11	R- 6	R- 0	R-6	0.35	80%	106,558	11	4.7	76	40	12,357	4.16	42.16	$877	331	33.10	$204	48.9	75.26	$1,081	38,875	99.66%	98.79%
5	21%	</= 0.55	</= 0.35	28.88%	R- 30	R- 13	R- 11	R- 6	R- 0	R-6	0.35	80%	106,558	11	4.7	76	40	12,793	4.37	43.65	$908	323	32.30	$199	49.5	75.95	$1,107	39,230	100.57%	100.00%
16	21%	</= 0.55	</= 0.40	28.88%	R- 30	R- 11	R- 11	R- 6	R- 0	R-6	0.35	80%	106,558	13	4.7	76	40	12,593	4.15	42.97	$894	322	32.20	$198	48.8	75.17	$1,092	38,826	99.54%	98.59%
18	21%	</= 0.60	</= 0.40	28.88%	R- 19	R- 11	R- 11	R- 6	R- 0	R-6	0.35	80%	106,558	14	4.6	76	40	12,495	4.20	42.63	$887	348	34.80	$214	51	77.43	$1,101	39,996	102.54%	103.03%

ASSUMPTIONS:

1. One story square house, front facing west having each side equal to 44 feet(1,936 sq.ft)
2. Interior wall height is 8 feet.
3. No exterior shading devices or adjacent building or shade trees.
4. Slab on grade foundation with no basement or crawl space.
5. Attached garage on north side.
6. Exterior doors, one on front and one on back.
7. Solar absorptance of the exterior wall is 0.55.
8. No movable window shades.
9. Window frame is aluminum w/o thermal break, no dividers, edge of glass U-factor is not being considered.
10. The attic is unconditioned, no penaly for duct loss.
11. The roof is flat with a solar absorptance of 0.5.
1. The heating and cooling equipment are sized by the DOE-2.1e, version 119.
13. Thermostat is programmable with customized settings according to IECC 2001 with 68F for heating and 78F for cooling and 5F setback for 6 hours.
14. Water heater is natural gas. , total dail consumption is given by
gal/day= (30xa)+(10xb)
where
a = number of living units in the standard and proposed design
b = number of bedrooms in each living unit (IECC2001)
15. Infiltration rate is 0.35 ACH as define by ENERGY STAR.
16. The efficiency of the furnace of the reference house is 78%.
17. Window percentage is based on conditioned floor area.
18. TMY2 weather file for Houston was used.

Table 6 spreadsheet for BOPs analysis for climate zones 5&6

Climate Zone 5(Energy Star)Glazing % of Floor Area (HVAC Autosized)

BOP Number	Window Requirements: Energy Star Maximum Window Area[16]	Window U-value	Window SHGC	IECC Equivalent window to wall ratio[2]	Minimum Insulation Requirements: Attic	Exterior Wall	Floor Above Unheated Space	Basement Wall	Slab	Crawlspace Wall	Infiltration Requirements: Infiltration Rate (ACH)	Minimum Equipment requirements (Gas Furnace Heating, Electric Cooling, Gas Domestic Hot water): Heat (AFUE)	Furnace size (Btu/hr)	Cool (SEER)	A/C size (Tons)	DHW Efficiency (%)	DHW Size (gal/day)	Annual Energy Use – Total Electricity Usage: kWh/year	kW(max)	MMBtu/year	0.071 $/kWh	Total Gas Usage: Therms/year	MMBtu/year	0.615 $/therm	Heating,cooling and DHW use: MMBtu/year	Total Energy Usage: MMBtu/year	$/Year	Btu/ sq.ft-year	% equivalent to total IECC Chapter 4/5 house	% equivalent to C/H/DHW of IECC Chapter 4/5 house
2	15%	</= 0.50	</= 0.40	20.60%	R- 30	R- 13	R- 19	R- 7	R- 0	R-8	0.35	80%	107,402	10	4.7	76	40	12,324	4.48	42.05	$875	380	38.00	$234	53.7	80.05	$1,109	41,348	97.39%	95.21%
5	18%	</= 0.45	</= 0.35	24.75%	R- 38	R- 13	R- 19	R- 7	R- 0	R-8	0.35	80%	107,402	10	5.0	76	40	12,365	4.49	42.19	$878	371	37.10	$228	52.9	79.29	$1,106	40,955	96.47%	93.79%
6	18%	</= 0.45	</= 0.40	24.75%	R- 30	R- 13	R- 19	R- 7	R- 0	R-8	0.35	80%	107,402	11	4.7	76	40	11,648	3.97	39.74	$827	372	37.20	$229	50.6	76.94	$1,056	39,743	93.61%	89.72%
7	21%	</= 0.40	</= 0.35	28.88%	R- 30	R- 15	R- 19	R- 7	R- 0	R-8	0.35	80%	107,402	11	4.6	76	40	12,582	4.48	42.93	$893	358	35.80	$220	52.4	78.73	$1,113	40,666	95.79%	92.91%
10	18%	</= 0.50	</= 0.40	24.75%	R- 30	R- 13	R- 19	R- 7	R- 0	R-8	0.35	80%	107,402	12	5.0	76	40	12,164	4.25	41.50	$864	382	38.20	$235	53.4	79.70	$1,099	41,169	96.97%	94.68%
11	21%	</= 0.40	</= 0.40	28.88%	R- 30	R- 13	R- 19	R- 7	R- 0	R-8	0.35	80%	107,402	12	4.6	76	40	12,753	4.47	43.51	$905	355	35.50	$218	52.7	79.01	$1,124	40,813	96.13%	93.44%
12	21%	</= 0.50	</= 0.40	28.88%	R- 30	R- 15	R- 19	R- 7	R- 0	R-8	0.35	80%	107,402	12	5.0	76	40	12,650	4.52	43.16	$898	379	37.90	$233	54.7	81.06	$1,131	41,871	98.62%	96.99%
18	18%	</= 0.55	</= 0.40	28.88%	R- 30	R- 13	R- 19	R- 7	R- 0	R-8	0.35	80%	107,402	14	5.0	76	40	11,620	3.86	39.65	$825	395	39.50	$243	52.8	79.15	$1,068	40,882	96.29%	93.62%
19	21%	</= 0.50	</= 0.40	28.88%	R- 30	R- 13	R- 19	R- 7	R- 0	R-8	0.35	80%	107,402	13	4.7	76	40	12,377	4.31	42.23	$879	385	38.50	$237	54.4	80.73	$1,116	41,700	98.22%	96.45%

Climate Zone 6(Energy Star)Glazing % of Floor Area (HVAC Autosized)

BOP Number	Window Requirements: Energy Star Maximum Window Area[16]	Window U-value	Window SHGC	IECC Equivalent window to wall ratio[2]	Minimum Insulation Requirements: Attic	Exterior Wall	Floor Above Unheated Space	Basement Wall	Slab	Crawlspace Wall	Infiltration Requirements: Infiltration Rate (ACH)	Minimum Equipment requirements (Gas Furnace Heating, Electric Cooling, Gas Domestic Hot water): Heat (AFUE)	Furnace size (Btu/hr)	Cool (SEER)	A/C size (Tons)	DHW Efficiency (%)	DHW Size (gal/day)	Annual Energy Use – Total Electricity Usage: kWh/year	kW(max)	MMBtu/year	0.071 $/kWh	Total Gas Usage: Therms/year	MMBtu/year	0.615 $/therm	Heating,cooling and DHW use: MMBtu/year	Total Energy Usage: MMBtu/year	$/Year	Btu/ sq.ft-year	% equivalent to IECC Chapter 4/5 house	% equivalent to C/H/DHW of IECC Chapter 4/5 house
2	15%	</= 0.50	</= 0.40	20.60%	R- 30	R- 13	R- 19	R- 7	R- 0	R-8	0.35	80%	107,402	10	4.7	76	40	12,324	4.48	42.05	$875	380	38.00	$234	53.7	80.05	$1,109	41,348	98.34%	96.58%
5	18%	</= 0.45	</= 0.35	24.75%	R- 38	R- 13	R- 19	R- 7	R- 0	R-8	0.35	80%	107,402	10	5.0	76	40	12,365	4.49	42.19	$878	371	37.10	$228	52.9	79.29	$1,106	40,955	97.41%	95.14%
6	18%	</= 0.45	</= 0.40	24.75%	R- 30	R- 13	R- 19	R- 7	R- 0	R-8	0.35	80%	107,402	11	4.7	76	40	11,648	3.97	39.74	$827	372	37.20	$229	50.6	76.94	$1,056	39,743	94.53%	91.01%
7	21%	</= 0.40	</= 0.35	28.88%	R- 30	R- 15	R- 19	R- 7	R- 0	R-8	0.35	80%	107,402	11	4.6	76	40	12,582	4.48	42.93	$893	358	35.80	$220	52.4	78.73	$1,113	40,666	96.72%	94.24%
10	18%	</= 0.50	</= 0.40	24.75%	R- 30	R- 13	R- 19	R- 7	R- 0	R-8	0.35	80%	107,402	12	5.0	76	40	12,164	4.25	41.50	$864	382	38.20	$235	53.4	79.70	$1,099	41,169	97.92%	96.04%
11	21%	</= 0.40	</= 0.40	28.88%	R- 30	R- 13	R- 19	R- 7	R- 0	R-8	0.35	80%	107,402	12	4.6	76	40	12,753	4.47	43.51	$905	364	36.40	$224	52.7	79.91	$1,129	41,277	98.18%	94.78%
12	21%	</= 0.50	</= 0.40	28.88%	R- 30	R- 15	R- 19	R- 7	R- 0	R-8	0.35	80%	107,402	12	5.0	76	40	12,650	4.52	43.16	$898	379	37.90	$233	54.7	81.06	$1,131	41,871	99.59%	98.38%
18	18%	</= 0.55	</= 0.40	28.88%	R- 30	R- 13	R- 19	R- 7	R- 0	R-8	0.35	80%	107,402	14	5.0	76	40	11,620	3.86	39.65	$825	395	39.50	$243	52.8	79.15	$1,068	40,882	97.24%	94.96%
19	21%	</= 0.50	</= 0.40	28.88%	R- 30	R- 13	R- 19	R- 7	R- 0	R-8	0.35	80%	107,402	13	4.7	76	40	12,377	4.31	42.23	$879	391	39.10	$240	54.4	81.33	$1,119	42,009	99.92%	97.84%

ASSUMPTIONS:

1. One story square house, front facing west having each side equal to 44 feet(1,936 sq.ft)
2. Interior wall height is 8 feet.
3. No exterior shading devices or adjacent building or shade trees.
4. Slab on grade foundation with no basement or crawl space.
5. Attached garage on north side.
6. Exterior doors, one on front and one on back.
7. Solar absorptance of the exterior wall is 0.55.
8. No movable window shades.
9. Window frame is aluminum w/o thermal break, no dividers, edge of glass U-factor is not being considered.
10. The attic is unconditioned, no penaly for duct loss.
11. The roof is flat with a solar absorptance of 0.5.
12. The heating and cooling equipment are sized by the DOE-2.1e, version 110.
13. Thermostat is programmable with customized settings according to IECC 2001 with 68F for heating and 78F for cooling and 5F setback for 6 hours.
14. Water heater is natural gas. ,total dail consumption is given by

    gal/day= (30xa)+(10xb)

    where

    a = number of living units in the standard and proposed design

    b = number of bedrooms in each living unit (IECC2001)
15. Infiltration rate is 0.35 ACH as define by ENERGY STAR.
16. The efficiency of the furnace of the reference house is 78%.
17. Window percentage is based on conditioned floor area.
18. TMY2 weather file for Houston was used.

Table 7 Spreadsheet of the simulation results for IECC chapter 4/5 house for climate zones 3&4

Climate Zone 3(Builder's Guide) (HVAC Autosized)

Window Requirements			Minimum Insulation Requirements						Infiltration Requirements	Minimum Equipment requirements						ANNUAL ENERGY USE												
										Gas Furnace Heating, Electric Cooling, Gas Domestic Hot water						Total Electricity Usage				Total Gas Usage			Heating,cooling and DHW use	Total Energy Usage			% equivalent to total IECC Chapter 4/5 house	% equivalent to C/H/DHW of IECC Chapter 4/5 house
IECC Maximum Window Area[16]	Window U-value[9]	Window SHGC	Attic	Exterior Wall[7]	Floor Above Unheated Space	Basement Wall	Slab	Crawlspace Wall	Infiltration Rate (ACH)	Heat (AFUE)	Furnace size (Btu/hr)	Cool (SEER)	A/C size (Tons)	DHW Efficiency (%)	DHW Size (gal/day)	kWh/year	kW(max)	MMBtu/year	0.071$/kWh	Therms/year	MMBtu/year	0.615$/therm	MMBtu/year	MMBtu/year		Btu/ sq.ft-year		
15%(Standard)	0.75	0.40	R- 19	R- 11	R- 11	R- 0	R- 0	R- 5	0.57	78%	106,558	10	4.7	76	40	12,334	4.40	42.08	$ 876	364	36.40	$ 224	52.4	78.48	$ 1,100	40,539	100.00%	100.00%
20%	0.70	0.40	R- 30	R- 13	R- 11	R- 0	R- 0	R- 5	0.57	78%	106,558	10	4.9	76	40	12,685	4.51	43.28	$ 901	342	34.20	$ 210	51	77.48	$ 1,111	40,021	98.72%	97.33%
25%	0.55	0.40	R- 30	R- 13	R- 11	R- 0	R- 0	R- 5	0.57	78%	106,558	10	4.9	76	40	13,423	4.84	45.80	$ 953	327	32.70	$ 210	52.1	78.50	$ 1,163	40,547	100.02%	99.43%

Climate Zone 4(Builder's Guide) (HVAC Autosized)

Window Requirements			Minimum Insulation Requirements						Infiltration Requirements	Minimum Equipment requirements						ANNUAL ENERGY USE												
										Gas Furnace Heating, Electric Cooling, Gas Domestic Hot water						Total Electricity Usage				Total Gas Usage			Heating,cooling and DHW use	Total Energy Usage			% equivalent to IECC Chapter 4/5 house	% equivalent to C/H/DHW of IECC Chapter 4/5 house
IECC Maximum Window Area[16]	Window U-value[9]	Window SHGC	Attic	Exterior Wall[7]	Floor Above Unheated Space	Basement Wall	Slab	Crawlspace Wall	Infiltration Rate (ACH)	Heat (AFUE)	Furnace size (Btu/hr)	Cool (SEER)	A/C size (Tons)	DHW Efficiency (%)	DHW Size (gal/day)	kWh/year	kW(max)	MMBtu/year	0.071$/kWh	Therms/year	MMBtu/year	0.615$/therm	MMBtu/year	MMBtu/year		Btu/ sq.ft-year		
15%(Standard)	0.75	0.40	R- 26	R- 13	R- 11	R- 5	R- 0	R- 5	0.57	78%	106,558	10	4.9	76	40	12,080	4.17	41.22	$ 858	343	34.30	$ 211	49.5	75.52	$ 1,069	39,007	100.00%	100.00%
20%	0.60	0.40	R- 30	R- 13	R- 11	R- 5	R- 0	R- 5	0.57	78%	106,558	10	4.9	76	40	12,708	4.46	43.36	$ 902	329	32.90	$ 202	49.8	76.26	$ 1,105	39,390	100.98%	100.61%
25%	0.52	0.40	R- 30	R- 13	R- 13	R- 6	R- 0	R- 6	0.57	78%	106,558	10	4.9	76	40	13,437	4.82	45.85	$ 954	321	32.10	$ 197	51.6	77.95	$ 1,151	40,262	103.22%	104.24%

ASSUMPTIONS:

1. One story square house, front facing west having each side equal to 44 feet(1,936 sq.ft)
2. Interior wall height is 8 feet.
3. No exterior shading devices or adjacent building or shade trees.
4. Slab on grade foundation with no basement or crawl space.
5. Attached garage on north side.
6. Exterior doors, one on front and one on back.
7. Solar absorptance of the exterior wall is 0.55.
8. No movable window shades.
9. Window frame is aluminum w/o thermal break, no dividers, edge of glass U-factor is not being considered.
10. The attic is unconditioned, no penaly for duct loss.
11. The roof is flat with a solar absorptance of 0.5.
12. The heating and cooling equipment are sized by the DOE-2.1e, version 110.
13. Thermostat is programmable with customized settings according to IECC 2001
with 68F for heating and 78F for cooling and 5F setback for 6 hours.
14. Water heater is natural gas. , total dail consumption is given by
gal/day= (30xa)+(10xb)
where
a = number of living units in the standard and proposed design
b = number of bedrooms in each living unit (IECC2001)
15. Infiltration rate is given by
ACH = normalized leakeage x weather factor
where
normalized leakage = 0.57
weather factor = determined from ASHRAE Standard 136
16. Window percentage is based on gross wall area.
17. TMY2 weather file for Houston was used.

Table 8 Spreadsheet of the simulation results for IECC chapter 4/5 house for climate zones 5&6

Climate Zone 5(Builder's Guide) (HVAC Autosized)

Window Requirements			Minimum Insulation Requirements						Infiltration Requirements	Minimum Equipment requirements: Gas Furnace Heating, Electric Cooling, Gas Domestic Hot water						ANNUAL ENERGY USE: Total Electricity Usage				Total Gas Usage			Heating,cooling and DHW use	Total Energy Usage			% equivalent to IECC Chapter 4/5 house	% equivalent to C/H/DHW of IECC Chapter 4/5 house
IECC Maximum Window Area[16]	Window U-value[9]	Window SHGC	Attic	Exterior Wall[7]	Floor Above Unheated Space	Basement Wall	Slab	Crawlspace Wall	Infiltration Rate (ACH)	Heat (AFUE)	Furnace size (Btu/hr)	Cool (SEER)	A/C size (Tons)	DHW Efficiency (%)	DHW Size (gal/day)	kWh/year	kW(max)	MMBtu/year	0.071$/kWh	Therms/year	MMBtu/year	0.615$/therm	MMBtu/year	MMBtu/year		Btu/ sq.ft-year		
15%(Standard)	0.65	0.40	R- 30	R- 13	R- 11	R- 5	R- 0	R- 6	0.57	78%	107,402	10	5.1	76	40	11,399	4.11	38.89	$ 809	433	43.30	$ 266	56.4	82.19	$ 1,076	42,455	100.00%	100.00%
20%	0.52	0.40	R- 38	R- 13	R- 11	R- 5	R- 0	R- 6	0.57	78%	107,402	10	5.1	76	40	12,291	4.69	41.94	$ 873	404	40.40	$ 248	56	82.34	$ 1,121	42,529	100.17%	99.29%
25%	0.50	0.40	R- 38	R- 13	R- 19	R- 8	R- 0	R- 10	0.57	78%	107,402	10	5.1	76	40	13,002	5.10	44.36	$ 923	400	40.00	$ 246	58.1	84.36	$ 1,169	43,576	102.64%	103.01%

Climate Zone 6(Builder's Guide) (HVAC Autosized)

Window Requirements			Minimum Insulation Requirements						Infiltration Requirements	Minimum Equipment requirements: Gas Furnace Heating, Electric Cooling, Gas Domestic Hot water						ANNUAL ENERGY USE: Total Electricity Usage				Total Gas Usage			Heating,cooling and DHW use	Total Energy Usage			% equivalent to IECC Chapter 4/5 house	% equivalent to C/H/DHW of IECC Chapter 4/5 house
IECC Maximum Window Area[16]	Window U-value[9]	Window SHGC	Attic	Exterior Wall[7]	Floor Above Unheated Space	Basement Wall	Slab	Crawlspace Wall	Infiltration Rate (ACH)	Heat (AFUE)	Furnace size (Btu/hr)	Cool (SEER)	A/C size (Tons)	DHW Efficiency (%)	DHW Size (gal/day)	kWh/year	kW(max)	MMBtu/year	0.071$/kWh	Therms/year	MMBtu/year	0.615$/therm	MMBtu/year	MMBtu/year		Btu/ sq.ft-year		
15%(Standard)	0.60	0.40	R- 30	R- 13	R- 19	R- 6	R- 4 2ft	R- 7	0.57	78%	107,402	10	5.1	76	40	11,400	4.09	38.90	$ 809	425	42.50	$ 261	55.6	81.40	$ 1,071	42,044	100.00%	100.00%
20%	0.50	0.40	R- 38	R- 13	R- 19	R- 6	R- 0	R- 7	0.57	78%	107,402	10	5.1	76	40	12,947	5.04	44.18	$ 919	389	38.90	$ 239	56.7	83.08	$ 1,158	42,911	102.06%	101.98%
25%	0.46	0.40	R- 38	R- 16	R- 19	R- 6	R- 0	R- 7	0.57	78%	107,402	10	5.1	76	40	12,966	5.02	44.24	$ 921	380	38.00	$ 234	55.9	82.24	$ 1,154	42,479	101.04%	100.54%

ASSUMPTIONS:

1. One story square house, front facing west having each side equal to 44 feet(1,936 sq.ft)
2. Interior wall height is 8 feet.
3. No exterior shading devices or adjacent building or shade trees.
4. Slab on grade foundation with no basement or crawl space.
5. Attached garage on north side.
6. Exterior doors, one on front and one on back.
7. Solar absorptance of the exterior wall is 0.55.
8. No movable window shades.
9. Window frame is aluminum w/o thermal break, no dividers, edge of glass U-factor is not being considered.
10. The attic is unconditioned, no penaly for duct loss.
11. The roof is flat with a solar absorptance of 0.5.
12. The heating and cooling equipment are sized by the DOE-2.1e, version 110.
13. Thermostat is programmable with customized settings according to IECC 2001 with 68F for heating and 78F for cooling and 5F setback for 6 hours.
14. Water heater is natural gas. , total dail consumption is given by

    gal/day= (30xa)+(10xb)

    where

    a = number of living units in the standard and proposed design

    b = number of bedrooms in each living unit (IECC2001)
15. Infiltration rate is given by

    ACH = normalized leakeage x weather factor

    where

    normalized leakage = 0.57

    weather factor = determined from ASHRAE Standard 136
16. Window percentage is based on gross wall area.
17. TMY2 weather file for Fort Worth was used.

APPENDICES

A. Input file name explanation
B. Simulation file name list
C. Detailed spreadsheets of the analysis

The accompanying CD contains the following materials related to the current analysis:

- Input simulation files
- Output files
- Simulation detailed spreadsheets
- Glass input spreadsheet
- IECC input file
- The weather files
- The complete report

APPENDIX A:

INPUT FILE NAME EXPLANATION:

In addition to verifying the different Builder Option Packages, detailed analysis was performed to check the performance of an IECC chapter 4/5 house to average 1999 house. Another set of simulations were performed by enhancing the equipment efficiency of an IECC chapter 4/5 house. Also simulations were performed by fixing the equipment size according house instead of allowing the simulation program to auto size. So the analysis and the input files are divided into four main sections:

1. Comparison of the Energy Star BOPs with the standard IECC chapter 4/5 house (HVAC auto sized).

2. Comparison of the Energy Star BOPs with the standard IECC chapter 4/5 house (HVAC sized fixed).

3. Comparison of the average residential house of 1999 with the standard IECC chapter 4/5 house.

4. Comparison of the standard IECC chapter 4/5 house with enhanced equipment efficiencies and reduced infiltration rates with a standard IECC chapter 4/5 house.

The naming procedure of the simulation runs is as follows:

- The IECC standard house

  Input file name example: bgcz31.inp

  bg = Builder's guide
  cz = Climate zone
  3 = Climate zone number
  1 = Window to wall ratio (1=15%, 2=20%, 3=25%)

  Input file name example: bgcz31f

  f = HVAC size fixed

  Input file name example: bgcz31a (for enhanced features in the standard house)
  a= A/C SEER 12
  b= A/C SEER 13
  c= ACH 0.35
  d= A/C SEER 12, ACH 0.35

e= A/C SEER 13, ACH 0.35

Input file name example: bgcz31af (for enhanced features in the standard house)
f= HVAC fixed

- Energy Star house

  Input file name example: escz31

  es= Energy Star
  cz= Climate zone
  3= Climate zone number
  1= BOPs number

  Input file name example: escz31W

  W= window to wall area ratio

  Input file name example: escz31f

  f= HVAC equipment size fixed

- Average 1999 house

  Input file name example: arb1999

  arb= Average residential building 1999

  Input file name example: arb1999a

  a= for climate zones 5 and 6

  Input file name example: arb19991

  1= average 1999 house with A/C SEER 11

  Input file name example: arb1999f

  f= HVAC equipment size fixed

APPENDIX B:

SIMULATION FILE NAME LIST:

INPUT FILES:

arb1999.inp
arb19991.inp
arb19991a.inp
arb19991af.inp
arb19991f.inp
arb1999a.inp
arb1999af.inp
arb1999f.inp
bgcz31.inp
bgcz31f.inp
bgcz32.inp
bgcz32f.inp
bgcz33.inp
bgcz33a.inp
bgcz33af.inp
bgcz33b.inp
bgcz33bf.inp
bgcz33c.inp
bgcz33cf.inp
bgcz33d.inp
bgcz33df.inp
bgcz33e.inp
bgcz33ef.inp
bgcz41.inp
bgcz41f.inp
bgcz42.inp
bgcz42f.inp
bgcz43.inp
bgcz43a.inp
bgcz43af.inp
bgcz43b.inp
bgcz43bf.inp
bgcz43c.inp
bgcz43cf.inp
bgcz43d.inp
bgcz43df.inp
bgcz43e.inp
bgcz43ef.inp
bgcz51.inp
bgcz51f.inp
bgcz52.inp
bgcz52f.inp
bgcz53.inp
bgcz53a.inp
bgcz53af.inp
bgcz53b.inp
bgcz53bf.inp
bgcz53c.inp
bgcz53cf.inp
bgcz53d.inp
bgcz53df.inp
bgcz53e.inp
bgcz53ef.inp
bgcz61.inp
bgcz61f.inp
bgcz62.inp
bgcz62f.inp
bgcz63.inp
bgcz63a.inp
bgcz63af.inp
bgcz63b.inp
bgcz63bf.inp
bgcz63c.inp
bgcz63cf.inp
bgcz63d.inp
bgcz63df.inp
bgcz63e.inp
bgcz63ef.inp
escz32.inp
escz32f.inp
escz32w.inp
escz32wf.inp
escz34.inp
escz34f.inp
escz34w.inp
escz34wf.inp
escz35.inp
escz35f.inp
escz35w.inp

escz35wf.inp
escz316.inp
escz316f.inp
escz316w.inp
escz316wf.inp
escz318.inp
escz318f.inp
escz318w.inp
escz318wf.inp
escz52.inp
escz52f.inp
escz52w.inp
escz52wf.inp
escz55.inp
escz55f.inp
escz55w.inp
escz55wf.inp
escz56.inp
escz56f.inp
escz56w.inp
escz56wf.inp
escz57.inp
escz57f.inp
escz57w.inp
escz57wf.inp
escz510.inp
escz510f.inp
escz510w.inp
escz510wf.inp
escz511.inp
escz511f.inp
escz511w.inp
escz511wf.inp
escz512.inp
escz512f.inp
escz512w.inp
escz512wf.inp
escz518.inp
escz518f.inp
escz518w.inp
escz518wf.inp
escz519.inp
escz519f.inp
escz519w.inp
escz519wf.inp

OUTPUT FILES:

arb1999.out
arb19991.out
arb19991a.out
arb19991af.out
arb19991f.out
arb1999a.out
arb1999af.out
arb1999f.out
bgcz31.out
bgcz31f.out
bgcz32.out
bgcz32f.out
bgcz33.out
bgcz33a.out
bgcz33af.out
bgcz33b.out
bgcz33bf.out
bgcz33c.out
bgcz33cf.out
bgcz33d.out
bgcz33df.out
bgcz33e.out
bgcz33ef.out
bgcz41.out
bgcz41f.out
bgcz42.out
bgcz42f.out
bgcz43.out
bgcz43a.out
bgcz43af.out
bgcz43b.out
bgcz43bf.out
bgcz43c.out
bgcz43cf.out
bgcz43d.out
bgcz43df.out
bgcz43e.out
bgcz43ef.out
bgcz51.out
bgcz51f.out
bgcz52.out
bgcz52f.out
bgcz53.out
bgcz53a.out
bgcz53af.out
bgcz53b.out
bgcz53bf.out
bgcz53c.out
bgcz53cf.out
bgcz53d.out
bgcz53df.out
bgcz53e.out
bgcz53ef.out
bgcz61.out
bgcz61f.out
bgcz62.out
bgcz62f.out
bgcz63.out
bgcz63a.out
bgcz63af.out
bgcz63b.out
bgcz63bf.out
bgcz63c.out
bgcz63cf.out
bgcz63d.out
bgcz63df.out
bgcz63e.out
bgcz63ef.out
escz32.out
escz32f.out
escz32w.out
escz32wf.out
escz34.out
escz34f.out
escz34w.out
escz34wf.out
escz35.out
escz35f.out
escz35w.out
escz35wf.out
escz316.out
escz316f.out
escz316w.out
escz316wf.out
escz318.out
escz318f.out
escz318w.out
escz318wf.out
escz52.out

escz52f.out
escz52w.out
escz52wf.out
escz55.out
escz55f.out
escz55w.out
escz55wf.out
escz56.out
escz56f.out
escz56w.out
escz56wf.out
escz57.out
escz57f.out
escz57w.out
escz57wf.out
escz510.out
escz510f.out
escz510w.out
escz510wf.out
escz511.out
escz511f.out
escz511w.out
escz511wf.out
escz512.out
escz512f.out
escz512w.out
escz512wf.out
escz518.out
escz518f.out
escz518w.out
escz518wf.out
escz519.out
escz519f.out
escz519w.out
escz519wf.out

APPENDIX C:

DETAILED SPREADSHEETS OF THE ANALYSIS:

The links to the following spreadsheets have been included in the appendix to explain the analysis:

1. Comparison of an average 1999 house with the standard IECC chapter 4/5 house for climate zones 3,4,5 & 6. (Average residential building(1999)comp.xls)

2. Comparison of an average 1999 house with the standard IECC chapter 4/5 house for climate zones 3,4,5 & 6. (A/C size fixed)(Average residential building(1999)comp(ac fix).xls)

3. Comparison of the Energy Star BOPs with the standard IECC chapter 4/5 house, climate zones 3,4,5 & 6. (comparison(energystar&BG)selected(cor).xls)

4. Comparison of the Energy Star BOPs with the standard IECC chapter 4/5 house, climate zones 3,4,5 & 6. (A/C size fixed) (comparison(energystar&BG)selected(cor)(ac fix).xls)

5. Comparison of an IECC house with increased system efficiencies with a standard IECC chapter 4/5 house. (ieccplus.xls)

6. Comparison of an IECC house with increased system efficiencies with a standard IECC chapter 4/5 house. (A/C size fixed) (ieccplus(ac fixed).xls)