# DEVELOPMENT OF A WEB-BASED EMISSIONS REDUCTION CALCULATOR FOR CODE-COMPLIANT COMMERCIAL CONSTRUCTION

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### ABSTRACT

Four areas in Texas, involving 16 counties, have been designated by the United States Environmental Protection Agency (EPA) as nonattainment areas because ozone levels exceed the National Ambient Air Quality Standard (NAAQS) maximum allowable limits. These areas face severe sanctions if attainment is not reached by 2007. Four additional areas in the state are also approaching national ozone limits (i.e., affected areas).

In 2001, the Texas State Legislature formulated and passed the Texas Emissions Reduction Plan (TERP), to reduce ozone levels by encouraging the reduction of emissions of NOx by sources that are currently not regulated by the state. Ozone results from photochemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOCs) in the presence of sunlight. An important part of this legislation is the State's energy efficiency program, which includes reductions in energy use and demand that are associated with the adoption of the 2000 International Energy Conservation Code (IECC IECC 2000), including the 2001 Supplement (IECC 2001) which represents one of the first times that the EPA is considering State Implementation Plan (SIP) credits from energy conservation and renewable energy- an important new development for building efficiency professionals, since this could pave the way for documented procedures for financial reimbursement for building energy conservation from the state's emissions reductions funding.

This paper provides a detailed description of the procedures that have been developed to calculate the electricity and natural gas savings in new office and retail construction that is built in compliance with Chapter 8 of the IECC 2000 Code<sup>1</sup>. For most parts the commercial portion of the IECC 2000 code (i.e., Chapter 8), refers to the ASHRAE 90.1-1999 as current code requirement for commercial construction. Included in the description is an explanation of the simulation models created for codecompliant and pre-code characteristics<sup>2</sup>, which are used for calculating NOx emissions reductions for the electric utility provider associated with the user.

#### BACKGROUND

In 2001, the Texas State Legislature formulated and passed Senate Bill 5 to further reduce ozone levels by encouraging the reduction of emissions of NOx by sources that are currently not regulated by the state, including area sources (e.g., residential emissions), on-road mobile sources (e.g., all types of motor vehicles), and non-road mobile sources (e.g., aircraft, locomotives, etc.)<sup>3</sup>. An important part of this legislation is the evaluation of the State's new energy efficiency programs, which includes reductions in energy use and demand that are associated with specific utility-based energy conservation measures, and mandatory

1

<sup>&</sup>lt;sup>1</sup> Simulations for office and retail commercial construction were created first since they represent the largest two categories of commercial construction in the state. Additional simulation types are being developed for the largest energy using categories.

<sup>&</sup>lt;sup>2</sup> The "pre-code" designation is meant to represent commercial construction characteristics that were in use before the passage of the Texas Emissions Reduction Plan, which became effective in September 2001. In the case of commercial construction, "pre-code" is meant to represent commercial construction that is compliant with ASHRAE Standard 90.1-1989.

<sup>&</sup>lt;sup>3</sup> In the 2003 Texas State legislative session, the emissions reductions legislation in Senate Bill 5 was modified by House bill 3235, and House bill 1365. In general, this new legislation strengthens the previous legislation, and did not reduce the stringency of the building code or the reporting of the emissions reductions.

implementation of the International Energy Conservation Code (IECC), published in 2000 as amended by the 2001 Supplement (IECC 2000; 2001). In 2001 thirty-eight counties in Texas were designated by the EPA as either nonattainment or affected areas<sup>4</sup>. In 2003, three additional counties were classified as affected counties<sup>5</sup>, bringing the total to forty-one counties (sixteen non-attainment and twenty-five affected counties). This paper provides a detailed discussion of the procedures and simulation tools that have been developed to calculate the electricity savings and NOx reductions from fuel-neutral<sup>6</sup>, commercial construction in nonattainment and affected counties out of 254 counties in Texas.

### METHODOLOGY

In order to quantify the reduction of NOx emissions by the implementation of ASHRAE 90.1-1999 (ASHRAE 1999) in new construction, simulation models were created for a general commercial configuration, which could be used both for office and retail end-uses. The simulation models were then modified to accommodate the different scenarios of construction and HVAC equipment typically used in the commercial sector. The simulation models, created with the DOE-2.1e simulation program (LBNL 1993a; 1993b), were then linked to a web-based graphic user interface and the US EPA's eGRID<sup>7</sup> to convert the energy savings to NOx emissions reduction. Overview:

For commercial buildings, office or retail, a complete set of comparison includes three simulation runs<sup>8</sup>: 1) a Pre-code run based on the construction characteristics required by ASHRAE Standard 90.1-1989 (ASHRAE 1989)<sup>9</sup>, 2) a Code run based on the minimum construction requirement of ASHRAE 90.1-1999 (ASHRAE 1999) and 3) the user input. The complete process flow is depicted in Figure 1.

The code characteristics for the office and retail are based on the minimum requirements according to climate zone. Examples of the envelope (i.e., opaque construction) and fenestration code requirements for ASHRAE Standard 90.1-1999 and ASHRAE Standard 90.1-1989 are given in Tables 1 and 2 respectively. The HVAC requirements are selected according to the end use, building size and building loads. Without simplification, in order to run a complete code and pre-code simulation, at least seven DOE-2 runs are required -- four for the code run and three for the pre-code run respectively.

The code and pre-code envelope and glazing characteristics<sup>10</sup> are assigned according to the county chosen by the user as shown in Figure 2. For example, if the user chooses Harris County,

2

<sup>&</sup>lt;sup>4</sup> The sixteen counties designated as non-attainment counties include: Brazoria, Chambers, Collin, Dallas, Denton, El Paso, Fort Bend, Hardin, Harris, Jefferson, Galveston, Liberty, Montgomery, Orange, Tarrant, and Waller counties. The twenty-two counties designated as affected counties include: Bastrop, Bexar, Caldwell, Comal, Ellis, Gregg, Guadalupe, Harrison, Hays, Johnson, Kaufman, Nueces, Parker, Rockwall, Rusk, San Patricio, Smith, Travis, Upshur, Victoria, Williamson, and Wilson County.

<sup>&</sup>lt;sup>5</sup> These counties are Henderson, Hood and Hunt counties in the Dallas – Fort Worth area.

<sup>&</sup>lt;sup>6</sup> The use of the term "fuel neutral" is used signify that several configurations were developed to represent the new construction in a given county. These construction types include: buildings with air conditioning, and electric heating (i.e., electric resistance of heat pumps), and buildings with air conditioning and natural gas-fired heating and service water heating systems.

<sup>&</sup>lt;sup>7</sup> eGRID, is the EPA's Emissions and Generation Resource Integrated Database (Version 2). This publicly available database can be found at www.epa.gov/airmarkets/egrid/. The information in this table is from a special edition of the eGRID database, provided by Art Diem at the USEPA for the TCEQ for use with Senate Bill 5.

<sup>8</sup> Three simulations are needed for the assessment of emissions reductions because the EPA only allows the TCEQ to claim emissions reductions credits from those measures that were implemented after the September 2001 start date for the TERP. Therefore, the pre-code simulation is used to represent the average building characteristics of new commercial being built to the specifications reported by F.W. Dodge and ASHRAE Standard 90.1-1989. The codecompliant simulation represents a simulation of a building with specific characteristics made compliant with ASHRAE Standard 90.1-1989. The user input then represents the current building that the user intends to analyze. The comparison of the user's input to the pre-code shows the savings that would result from conditions that existed prior to September of 2001. The comparison of the user's input to the code-complaint simulation allows the user to see if their building is more efficient than a code-complaint building. The assumption to use ASHRAE Standard 90.1-1989 was based in part on conversations with engineers from several ASHRAE Chapters in Texas who confirmed that, prior to the legislation, most buildings were built to be compliant to ASHRAE Standard 90.1-1989. This is a conservative assumption since it assumes that buildings built before September 1<sup>st</sup>, 2001 were built to meet the requirements of Standard 90.1-1989. This assumption will be verified by site visits in future work.

<sup>&</sup>lt;sup>10</sup> To calculate the compliance for a building in a specific county the calculator has to assume certain characteristics about the building that are compliant with 90.1-1989 and 90.1-1999. These characteristics include the budget building assumptions for the performance modeling and the prescriptive requirements for each county/climate zone.



Figure 1: Office and Retail Analysis Flowchart

1

	Non	residential	Re	sidential	Se	miheated
Opaque Elements	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min R-Value
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.218	R-38ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.167	R-60
Attic and Other	U-0.034	R-30.0	U-0.034	R-30.0	U-0.081	R-13.0
Walls, Above Grade					0.001	11-15.0
Mass	U-0.580	NR	U-0.151*	R-5.7 ci*	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.184	R-60
Steel Framed	U-0.124	R-13.0	U-0.124	R-13.0	U-0.352	NR
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.292	NR
Wall, Below Grade						
Below Grade Wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.137	R-4.2 ci	U-0.107	R-6.3 ci	U-0.322	NR
Steel Joist	U-0.052	R-19.0	U-0.052	R-19.0	U-0.350	NR
Wood Framed and Other	U-0.051	R-19.0	U-0051	R-19.0	U-0.282	NR
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700	$\geq$	U-0.700		U-0.700	
Non-Swinging	U-1.450	AX	U-1.450		U-1.450	
Fenertration	Assembly Max. U (Fixed/	Assembly Max. SHGC (All Orientations/	Assembly Max. U (Fixed/	Assembly Max. SHGC (All Orientations/	Assembly Max. U (Fixed/	Assembly Max SHGC (All Orientations/
Vestical Clasing & a Well	Operatie)	North-Oriented)	Operable)	North-Oriented)	Operable)	North-Oriented
0 10 0%	11 1.22	81100 0.20	11 1.00	61166 A.()		
0-10.0%	U 1.22	SHOCall-0.39	Ufixed 1.22	SHGCall-0.61	Ufixed-1.22	SHGC <sub>all</sub> -NR
10.1.20.05	Uoper 1.27	SHGCnorth-0.61	Uoper 1.27	SHGCnorth-0.61	Uoper 1.27	SHGCnorthNR
10.1-20.0%	U 1 27	SHOC 0.61	Ufixed-1.22	SHGCall-0.44	Ufixed-1.22	SHGC <sub>all</sub> -NR
201-30.0%	Uoper 1.27	SHOC 0.25	Uoper 1.27	SHOC 0.44	Uoper 1.27	SHGCnorthNR
20.1-50.070	U 1 27	SHOC 0.61	U 1 27	SHGC 0.61	U 1.22	SHGC <sub>all</sub> -NR
30 1-40 0%	11c -1.27	SHGC _0.25	Upper 1.27	SHCC 0.40	Uoper 1.27	SHGC NR
30.1-40.0 10	ofixed 1.22	SHOC <sub>all</sub> -0.25	ofixed 1.22	SHOC <sub>all</sub> -0.40	Ofixed 1.22	SHOCall-NR
	Uoper-1.27	SHGCnorth-0.61	U <sub>oper</sub> -1.27	SHGC <sub>north</sub> -0.61	U <sub>oper</sub> -1,27	SHGCnorthNR
40.1-50.0%	Ufixed-1.22	SHGC <sub>all</sub> =0.17	Ufixed-1.22	SHGC <sub>all</sub> -0.29	Ufixed=0.98	SHGC <sub>all</sub> -NR
	U <sub>oper</sub> -1.27	SHGC <sub>north</sub> -0.42	U <sub>oper</sub> -1.27	SHGCnorth=0.41	U <sub>oper</sub> -1.02	SHGCnorthNR
Skylight with Curb, Glass,% of Roo	1				122 0002	
0-2.0%	U <sub>all</sub> -1.98	SHGC <sub>all</sub> =0.39	U <sub>all</sub> -1.98	SHGC <sub>all</sub> -0.36	Uall-1.98	SHGC <sub>all</sub> -NR
2.1-3.0%	Uall-1.98	SHGCall-0.25	U <sub>all</sub> -1.98	SHGC <sub>all</sub> -0.19	Uall-1.98	SHGC <sub>all</sub> -NR
Skylight with Curb, Plastic,% of Ro		0100 0.00			122 2080	1000000-0010
0-2.0%	Uall-1.90	SHGC <sub>all</sub> -0.65	Uall-1.90	SHGC <sub>all</sub> -0.27	U <sub>all</sub> -1.90	SHGC <sub>all</sub> -NR
2.1-3.0%	U <sub>all</sub> -1.90	SHGC <sub>all</sub> =0.39	U <sub>all</sub> -1.90	SHGC <sub>all</sub> -0.27	U <sub>all</sub> -1.90	SHGC <sub>all</sub> -NR
0.2 OF	1 11 120	SUCC 0.30		61100 AAC		
21.50%	Uall-1.36	SHGC <sub>all</sub> -0.39	Uall-1.36	SHGCall-0.36	U <sub>all</sub> -1.36	SHGC <sub>all</sub> -NR
2.1-3.0%	Uali-1.56	SHOCall-0.25	Uall-1.36	SHGC <sub>all</sub> -0.19	U <sub>all</sub> -1.36	SHGC <sub>all</sub> -NR

TABLE B-6 Building Envelope Requirements (HDD65: 901-1800, CDD50: 5401-7200)

Table 1: Exam	ple (Table B-6	b) of code red	juirements from	ASHRAE 90.1-1999
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Table 2: Example (Table 8A) of pre-code requirements from ASHRAE 90.1-1989

THE Energy Sys Energy & Emiss	INEERING EXPER tems Laborator ions Calculator	IMENT STATION y - eCalc			
Quick Entry	Project Basics	Point of Contact	Project Mailling Address	Project Details	PROT
Project name	m123				
Contact EMail	mushtaq@esl.tar	nu.edi			
Project classification	New Construction	n 💌			
County	TARRANT	Y			
Power provider	All	×			
	🗹 Building has e	lectricity supply			
	📃 🗌 Building has n	atural gas supply			
Remember me ne	ext time				
Submit					

Figure 2: Input screen for county and PCA information



Figure 3: Available Weather Stations in Texas

then the pre-code and code characteristics would be as shown in Table 3. If the pre-code characteristics are more stringent than the code requirements then the pre-code characteristics are used to simulate the code-compliant building. In Table 3 (i.e., Harris County) it can be seen that the pre-code glazing U-factor is are more stringent than the code requirements, therefore, no savings are attributed to this characteristic since the pre-code value would be used in both the code and pre-code simulation.

Currently, the web-based emissions calculator uses measured weather data for 1999, from the National Oceanic and Atmospheric Administration (NOAA), National Weather Service (NWS), packed into the TRY weather format for nine stations in Texas, to perform the energy simulations for the 41 non-attainment and affected counties (Figure 2). Weather files are assigned according to the counties chosen by the user according to the nearest weather station. For Harris County, measured weather data from Houston's Bush Intercontinental Airport will be used.

The three sets of inputs are then processed through the DOE-2 simulation program to determine the energy consumption of the building. The values of interest from the DOE-2 output are the annual and peak day electricity and gas consumption in kWh and Therms respectively<sup>11</sup>. These values from the user input are then compared with the output from the precode and code runs to determine the annual and peak day energy consumption savings. The electricity saving values are then processed through the EPA's eGRID to calculate the annual and peak day NOx emissions reduction number in lbs and tons. Natural gas savings are converted into NOx emissions using the EPA's emissions factors<sup>12</sup>.

<sup>12</sup> EPA AP42 Project, published in 2003,

www.epa.gov/ttn/chief/ap42/ap42supp.html.

#### Office/Retail Input File:

Table 4a and 4b describe the DOE-2 parameters that are required to generate the office simulation model. The parameters are divided into three major categories; loads, systems and plant<sup>13</sup>. The loads are then further divided into building, construction, space and shading parameters. The building parameters are used to define the location, orientation and the basic dimensions and layout of the building. Currently, the simulation model has the provision of only creating a 4-sided building model with up to one hundred stories with or without a basement. This portion of the input file also has the "building type" parameter which switches between the office and retail version of the inputs.

If a retail building is chosen then 4 additional parameters are activated, which allow the retail store to be placed within a larger conditioned space. The switch between quick and thermal mass mode is fixed at quick construction for the current version<sup>14</sup>. This means that the current DOE-2 simulation is using ASHRAE pre-calculated weighting factors for the calculation of a code-complaint building<sup>15</sup>.

The construction parameters include the material properties and U-values for the different components including the glazing properties and the window-to-wall area ratio. The user has the provision of entering different window areas for the different orientations. The upper limit on the window-to-wall ratio depends on the plenum height (i.e., the plenum height is added to the building section to calculate the maximum window-to-wall area ratio for that building. The maximum upper limit is 90%.

With regards to internal load, Table 6.5, 13.2 and 13.4 of ASHRAE Standard 90.1-1989 describes the requirements for lighting, occupancy and receptacles according to the square footage and end-use. ASHRAE Standard

<sup>&</sup>lt;sup>11</sup> The peak sizing calculations rely on the accuracy of the DOE-2 simulation. Although ASHRAE has developed more accurate methods for accomplishing this, it was appropriate to use the peak sizing algorithms in DOE-2 since much of the simulation work for Standard 90.1-1999 and 90.1-1989 was performed with the DOE-2 or BLAST programs. Newer versions of 90.1 will be using these newer peak load sizing methods, for example Radiant Time Series. In general the impact of equipment sizing was small when compared to other parameters, such as equipment efficiency, window loads, etc. Sizing does have an impact at the boundaries of Standard 90.1's equipment tables.

<sup>&</sup>lt;sup>13</sup> These categories were chosen to align the input with the DOE-2 BDL, which divides a building's description into LOADS, SYSTEMS and PLANT input files.

<sup>&</sup>lt;sup>14</sup> The "quick" and "thermal mass" modes are used to denote the use of pre-calculated ASHRAE weighting factors (quick), or Custom Weighting Factors (thermal mass). Future versions of the calculator are being developed to utilize the thermal mass mode, which requires layered walls and roof, as well as other factors.

<sup>&</sup>lt;sup>15</sup> The use of pre-calculated weighting factors has been shown to be problematic because of the impact of the thermal mass on the cooling and heating loads. For more information see the ESL's 2004 report to the TCEQ (Haberl et al. 2004 a, b, c).

	Fe	enestration	properties	Envelo	pe properties
Harris County	U- factor	SHGC	Window to Wall ratio (%)	Wall U- value	Roof U-value
ASHRAE 90.1- 1989 ACP Table 8A-10 (Requires Internal Load Density ILD)	1.15	0.61	23 (for ILD < 1.5) 18 (for 1.51< ILD < 3 15 (for ILD > 3)	0.15 (Light weight)	0.066
ASHRAE 90.1- 1999 Table B-5	1.22	0.25	< 40%	0.124 (Steel framed)	
(Requires Window to Wall ratio %)	1.22	0.17	> 40%	0.089 (Wood framed) 0.06	0.063

Table 3: Code and pre-code building characteristics for Harris County

90.1-1999 does not give requirements for occupancy and receptacles, but defines the lighting power density (LPD) requirements for different building types in Table 9.3.1.1. For example, Standard 90.1-1989 allows a LPD of  $1.3 \text{ W/ft}^2$  and  $1.9 \text{ W/ft}^2$  for office and retail respectively.

The system parameters include the type of systems, the system capacity and the efficiencies of the system selected. Currently the user can choose from three kinds of system: 1) a Variable Air Volume (VAV) system with a central HVAC plant, 2) a packaged variable air volume (PVAV) system, and 3) a packaged single zone (PSZ) system with either gas or electric heating. The DHW heater can be either gas or electric. If the DHW heater is gas then one pilot light is assumed at a fixed load of 500 Btu/hr.

## System Simulation according to ASHRAE 90.1-1989:

As previously mentioned, for the code and pre-code runs, several simulations need to be performed in order to select the correct size and number of the HVAC equipment for both ASHRAE 90.1-1989 and 1999. Figure 4 shows the complete flow diagram of all the processes required to run an ASHRAE Standard 90.1-1989 performance-based simulation. Standard 90.1-1989 defines 7 system types according to the type of building and conditioned floor area (ASHRAE 90.1-1989, Table 13-5). For office and retail the system requirements are chosen according to the square footage (Table 5). Table 13-6 of ASHRAE Standard 90.1-1989 provides the requirements of the different system components. For buildings with a central plant

the number and size of the chillers and boilers is determined by the simulated cooling and heating loads for the building (ASHRAE 90.1-1989, Table 13-6, Note 11). Equipment efficiencies are determined by the final size of each plant component. Therefore, in order to analyze an ASHRAE Standard 90.1-1989 code-compliant building with the DOE-2 simulation program, three simulations are run: 1) after choosing the system type from the building's conditioned area, the first simulation provides the peak heating and cooling load to allow for the number of selection of chillers, 2) after the type and size of chiller is chosen, a second simulation is performed to choose the efficiency of the chiller, and 3) a third and final simulation is performed with the chosen chiller, boiler and domestic water heater.

The following example illustrates the procedure used to calculate the pre-code run (i.e., a building that is assumed to be compliant with ASHRAE Standard 90.1-1989)<sup>16</sup>. In this analysis, an office building (122 ft x 122 ft, 6stories in height) located in Houston, Texas, is used. To simulate a building that is compliant with ASHRAE Standard 90.1-1989, the building aspect ratio is first fixed at 2.5 is to 1, with the longer side oriented with an east-west axis, vielding an equivalent footprint of 192.89 x 77.16 ft. The envelope details for the building are according to the prescriptive requirements of Standard 90.1-1989 for Harris County (Table 2). In Standard 90.1-1989, the specific values in Table 2 are chosen according to the Internal

<sup>&</sup>lt;sup>16</sup> The user can also perform parametrics, for example, varying the width and length of the building to see if there is a difference in energy use.

LOADS         Outlet or thermal mode (C or T)         Outlet (C)         Fixed         Or strukters the bulking as ma proble thermal mass.           b82         Location         Bestrop (BAS)         User Defined         Or strukters the bulking as ma proble thermal mass.         Investor thermal mass.         Investor the bulking as ma proble thermal mass.         Investor t	LOADS b01 b02 b03 b04 b05 b06 b07 b08	Quick or thermal mode (Q or T) Location Azimuth of building (degree)	Quick (Q) Bastrop (BAS)	Fixed User Defined	Q simulates the building as massless, T wi include thermal mass 41 counties linked to 9 TRY packed
bit         Ouch or thermin mode (Car T)         Ouch (G)         Fixed         0	b01 b02 b03 b04 b05 b06 b07 b08	Quick or thermal mode (Q or T) Location Azimuth of building (degree)	Quick (Q) Bastrop (BAS)	Fixed User Defined	Q simulates the building as massless, T wi include thermal mass 41 counties linked to 9 TRY packed
b92         Location         Bestrop (BAS)         User Derived         Accurate stiker is STR year           b03         Azimuth of tubiling (ft)         122         User Derived         Oration of the building           b04         Length of building (ft)         122         User Derived         Oration of the building           b05         Width of building (ft)         122         User Derived         Oration of the building           b06         Width of building (ft)         122         User Derived         Oration of the building           b06         Door height (ft)         0         7         Derived (ft)         Oration of the building           b19         Proor to ftor height (ft)         13         User Derived         Tra derives the planum height           b19         Porrote for height (ft)         13         User Derived         Tra derives the user to achive           b19         Porrote for height (ft)         13         User Derived         Tra derives the user to achive           b19         Porrote for height (ft)         14         User porrhead         Tra derives the user to achive           b19         Porrote derive hubiling:         Hb (ft)         User Derived         Tra derives the user to achive hubiling:           b19         Building tyene         Offic (ft)<	b02 b03 b04 b05 b06 b07 b08	Location Azimuth of building (degree)	Bastrop (BAS)	User Defined	41 counties linked to 9 TRY packed
Bit         Attraction of building (degree)         Description         User Defined         Contraction         Contraction           Bit         Length of building (t)         122         User Defined         Contraction of the building           Bit         Product of building (t)         122         User Defined         Contraction of the building           Bit         Product of building (t)         122         User Defined         Contraction of the building           Bit         Product of building (t)         122         User Defined         The defines the plenum height           Bit         Product of building (t)         13         User Defined         The defines the plenum height           Bit         Provide of organic (t)         13         User Defined         The defines the plenum height           Bit         Provide of organic (t)         15         Tread with the user board         The defines the plenum height           Bit         Provide of organic (t)         15         Tread with the user board         The defines the plenum height           Bit         Provide of organic (t)         15         Tread with the user board         The defines the plenum height           Bit         Provide of organic (t)         16         User Defined         The sede parameters are used           Bit <td>b03 b04 b05 b06 b07 b08</td> <td>Azimuth of building (degree)</td> <td></td> <td></td> <td></td>	b03 b04 b05 b06 b07 b08	Azimuth of building (degree)			
Ibi3         Attanch of tability (ft)         122         User Defined         Orientation of the bulking           Ibi6         World of tability (ft)         122         User Defined         Image: Comparison of the bulking           Ibi6         Proof to certing height (ft)         12         User Defined         Image: Comparison of the bulking           Ibi6         Door of certing height (ft)         13         User Defined         Image: Comparison of the bulking           Ibi6         Door of certing height (ft)         13         User Defined         Image: Comparison of the bulking           Ibi7         Primeter degring (ft)         15         Find         User Defined         Image: Comparison of the bulking           Ibi7         Primeter degring (ft)         15         Void         User Defined         Image: Comparison of the bulking           Ibi7         Proof will Attached to andher bulking?         No (ft)         User Defined         Duiding to the defined one of the comparison of the bulking           Ibi7         Back will Attached to andher bulking?         No (ft)         User Defined         Duiding to the defined one of the comparison of the bulking           Ibi7         Back will Attached to andher bulking?         No (ft)         User Defined         Allows user to such bulking           Ibi7         Back will Attached to and	b03 b04 b05 b06 b07 b08	Azimuth of building (degree)	1		weather files according to climate zone
b94         Length of building (11)         122         Use Defined           b95         Workh of fullating (10)         122         Use Defined           b96         Proot to certing (10)         0         0         0           b96         Proot to certing (10)         0         0         0         0           b96         Proot to floor height (11)         13         User Defined         This defines the plenum height           b17         Perimeter dight (11)         15         Fixed         User Defined         This defines the plenum height           b13         Under yound floor mode         NO (N)         User Defined         User to the mail zoing           b13         Underyound floor mode         NO (N)         User Defined         This defines the plenum height           b14         Underyound floor mode         NO (N)         User Defined         These A pownetien are used           b14         Enderyound floor mode         NO (N)         User Defined         These A pownetien are used to another building?           b14         Ender wildings to the differed rome         NO (N)         User Defined         Allows the user to exhich the differed rome           b15         Ender wildings to the differed rome         NO (N)         User Defined         Allows the user to exhi	b04 b05 b06 b07 b08		0	User Defined	Orientation of the building
B46         Wath of loading (11)         122         User Defined           B46         Proof to camp prepart (11)         8         User Defined           B46         Door with (1)         6         Find           B46         Door with (1)         6         Find           B47         Proor to for breight (11)         13         User Defined         The defines the perumetrajor of loar           B47         Perimeter argin (11)         13         User Defined         The defines the perumetrajor of loar           B47         Perimeter argin (11)         15         Find         User Defined         User Defined           B47         Perimeter argin (11)         15         Void         User Defined         User Settined           B47         Perimeter argin (11)         15         Void         User Defined         User Settined         User Settined           B47         Port wall Attached to andrher building?         No (10)         User Defined         User Settined         User Settined           B47         Back wall Attached to andrher building?         No (10)         User Defined         Allows the user to antwo           B47         Back wall Attached to andrher building?         No (10)         User Defined         Allows the user to antwater to antwater to antwo	b05 b06 b07 b08	Length of building (ft)	122	User Defined	
Det         Proof of calls (range) (r)         9         Other Defined           Deg         Boury year         2000         User Defined         The defines the plerum height           Deg         Run year         2000         User Defined         The defines the plerum height           Deg         Run year         2000         User Defined         The defines the plerum height           Deg         Run year         2000         User Defined         The defines the plerum height           Deg         Run year         2000         User Defined         The defines the plerum height           Deg         Run year         Run year         2000         The defines the plerum height           Deg         Run year         Run year         Run year         Run year         Run year           Deg         Run year	b05 b07 b08	Width of building (ft)	122	User Defined	
Image         Door weight (1)         6         Fixed           Image         2000         User Derined         The defines the plenum height conjunction with 0.68           Image         Fixed         Image of floor         6         User Defined         conjunction with 0.68           Image         Fixed         Image of floor         6         User Defined         conjunction with 0.68           Image         Perinder deding (1)         15         Fixed         User Defined         The allows the user to active the defined of the define	b08	Floor to ceiling height (π)	9	User Defined	
beg         Run year         2000         User Defined         The defines the plerum height           b10         Flore to floor height (ft)         13         User Defined         The defines the plerum height           b11         Number of floor         6         User Defined         User of floor         6           b13         Perinder deght (ft)         15         Fixed         User floor         16           b13         User of floor         0         User of floor         The allows the user to activat underground floors           b14         Enderson and the building?         No (N)         User Defined         Intres all parameters are used           b16         Front user Allabored to another building?         No (N)         User Defined         model for the relial scenario           b19         Building type         Office (C)         User Defined         allows the user to swhch being           b19         Code compliance         Code (C)         User Defined         allows the user to actual the instants or is an adverted bandling           b19         Building type         Office (C)         User Defined         allows the user to actual the instants or is an adverted bandling           c041         Roof assignments         1         Fixed         The is useat to calculate the is ocoefficient		Door width (ft)	6	Fixed	-
bre         Floor to foor height (ft)         13         User Defined         The defines the plenum height conjunction with 066           br1         Nameer of foor         6         User Defined         Conjunction with 066           br3         Underground floor mode         No (N)         User Defined         The advices the user to advice underground floor mode         The advices the user to advice underground floor           br4         Underground floor mode         No (N)         User Defined         The advices the user to advice underground floor.           br45         Front wat Attached to another building?         No (N)         User Defined         building to the defined content building type         Office (O)         User Defined         Advex the user to switch left and Retail           br49         Ext wat Attached to another building?         No (N)         User Defined         Advex the user to switch left and Retail           br49         Code compliance         Od5         User Defined         Advex the user to advice and Retail           br30         Code compliance         0.45         User Defined         Advex the user to advice and Retail           c04         Roof absorptance         0.45         User Defined         Code code 3 and cod to deal 40           c04         Roof adsorptance         0.57         User Defined         Code ad 0.07 a	b09	Run year	2000	User Defined	-
bit         Number of floor         6         User Defined           b12         Permeter depth (ft)         15         Fixed         User Defined           b13         Underground floor mode         No (N)         User Defined         The stargound floor the mode floor           b14         Fixed         Underground floor mode         No (N)         User Defined         The stargound floor the starding floor           b15         Fixed wall. Attached to another building?         No (N)         User Defined         The stargound floor the starding floor           b17         Back wall. Attached to another building?         No (N)         User Defined         buildings to the different real scenario           b18         Left wall. Attached to another building?         No (N)         User Defined         Allows user to run user define           b19         Building type         Office (C)         User Defined         Allows user to run user define           c61         Roof adsorptance         0.45         User Defined         cohr in addion activate therais           c62         Roof outside emissivity         0.89         User Defined         cohr in addion activate therais           c63         Roof outside emissivity         0.89         User Defined         cohr in addion activate to adoin           c645	b10	Floor to floor height (ft)	13	User Defined	This defines the plenum height in
bit         Number of hoor         S         User Defined         Used for thermal zoning           bit         Primeter regret(h)         15         Void         This allows the user to activat           bit         Underground floor mode         No (N)         User Defined         These 4 parameters as used           bit         Front weak distanced to another building?         No (N)         User Defined         These 4 parameters as used           bit         Enter weak distanced to another building?         No (N)         User Defined         model for the relat sconnio           bit         Left weak distanced to another building?         No (N)         User Defined         addition of the fired over 1           bit         Left weak distanced to another building?         No (N)         User Defined         addition of the user to activate the order of the sconnio           bit         Left weak distanced to another building?         No (N)         User Defined         addition of the distance of the user to activate the order of order           c64         Roof roughnes         1         Fixed         Coll and COS are used to define of order           c65         Wall roughness         2         Fixed         Coll and COS are used to define of order           c64         Roof roughness         2         Fixed         Coll and COS are used					conjunction with b06
H3         Profession Support         Profession Support         Description Support         Description Support           H4         Underground floor mode         No (N)         User Defined         This allows the user to activat underground floor a underground floor support           H5         Front wait Attached to another building?         No (N)         User Defined         These Aparameters are used buildings to the different origing?           H5         Building type         Office (C)         User Defined         Allows the user to switch bet and Redail           H5         Ext wait Attached to another building?         No (N)         User Defined         Allows the user to switch bet and Redail           H5         Building type         Office (C)         User Defined         Allows tuser to run user define define of ASIPALS 00.1 1908           e01         Roof autside emissivity         0.85         User Defined         COC are used to define color*           e03         Roof outside emissivity         0.89         User Defined         COT and CO3 are used to define color*           e04         Roof insultion R-value (riv-sq. fl-Fibu)         R-15         User Defined         COS and co2 and waiter the transfer of coC*2 allows values from 1 to in anotheres           e03         Roof outside emissivity         0.8         User Defined         COS and co7 are used to defin coC*2 allows value fr	D11 b12	Number of floor	15	User Defined	Used for thermal zoping
br4         Underground floor mode         No (N)         User Defined         This allows the user to active underground floor a           br6         Front wait. Attached to another building?         No (N)         User Defined         These 4 parameters are used bit 6           br16         Right wait. Attached to another building?         No (N)         User Defined         These 4 parameters are used bit 7           br18         Left wait. Attached to another building?         No (N)         User Defined         model for the retail scenario           br19         Building type         Office (O)         User Defined         Allows tuse to switch the different orent edition of ASHAZ 801 1980 c           c01         Roof absorptance         O.45         User Defined         Allows tuse to rule are define edition           c02         Roof roughness         1         Fixed         Doefficient of rotal coal are used to define color           c03         Roof roughness         2         Fixed         Doefficient of rotal coal are used to define color*           c04         Roof insulation R-value (tr-sq. th-Fibu)         R-15         User Defined         Color and CO are used to define color*           c04         Roof insulation R-value (tr-sq. th-Fibu)         R-13         User Defined         Color*           c040         Wail outside emisis/ty         0.3 <td>b12</td> <td></td> <td>Va Va</td> <td>oid</td> <td>Osed for thermal 20hing</td>	b12		Va Va	oid	Osed for thermal 20hing
bris         Front walk Attached to another building?         No. (N)         User Defined         underground floors           b16         Right walk Attached to another building?         No. (N)         User Defined         buildings to the different ortent           b17         Back walk Attached to another building?         No. (N)         User Defined         Allows the user to switch beft and Retail           b19         Editorial type         Office (O)         User Defined         Allows the user to switch beft and Retail           b29         Code compliance         Code (C)         User Defined         Allows user to run user define effect (C)           c01         Roof roughness         1         Fixed         This is used to calculate the origon and Retail action of the transfer or Code?           c02         Roof roughness         1         Fixed         This is used to calculate the origon action of the standard or Code?           c03         Roof oudside emissivity         0.89         User Defined         Code and C2 are used to define (Code?           c04         Roof insulation R-value (hr-sq.RF.FEU)         R-15         User Defined         Code?         Code and C2 are used to define (Code?           c04         Wall insulation R-value (hr-sq.RF.FEU)         R-13         User Defined         Code?         Code and C2 are used to define (Code and C2 are used to define (	b14	Underground floor mode	No (N)	User Defined	This allows the user to activate/deactivate
b15         Front wate Attached to another building?         No. (N)         User Defined         These 4 parameters are used           b17         Back wate Attached to another building?         No. (N)         User Defined         model for the relation scenario           b18         Left wate Attached to another building?         No. (N)         User Defined         and Retail           b29         Code compliance         Code (C)         User Defined         Allows the user to switch bet           c01         Roof absorptance         0.45         User Defined         Cold and Retail           c02         Roof roughness         1         Fixed         This is used to actuate the or 0.00°C           c03         Roof nouside emissivity         0.89         User Defined         Cold and CO are used to defined           c04         Roof nouside emissivity         0.89         User Defined         CO and CO are used to defined           c05         Roof nouside emissivity         0.89         User Defined         CO and CO are used to defined           c06         Wall absorptance         0.57         User Defined         CO and cO are used to defined           c06         Wall absorptance         0.57         User Defined         CO and cO are used to defined           c06         Wall absorptance         <					underground floors
b16         Right walk Attaches to another building?         No (N)         User Defined         buildings to the different orient           b17         Beck walk Attaches to another building?         No (N)         User Defined         Allows the user to switch beth and fedal           b19         Edition of absorptionce         Code (C)         User Defined         Allows the user to switch beth and fedal           cell         Roof absorptionce         0.45         User Defined         Allows user to run user defining the user to switch beth and fedal           cell         Roof absorptionce         0.45         User Defined         Allows user to run user defining the user to conficient or to the transformed to an officient or the transformed to and fedal           cell         Roof outside emissivity         0.89         User Defined         colf and c03 are used to defining another user to cold an officient or the transformed to an another user to an officient or the transformed to an another user to an officient or the transformed to an another user to an officient or the transformed to an another user to an officient or the transformed to an another user to an officient or the transformed to an another user to an officient or the transformed to an an another user to an another user to an officient	b15	Front wall: Attached to another building?	No (N)	User Defined	These 4 parameters are used to attach
D11         Desk Value Autoched to andher building?         NO 100         User Defined         No 100           D13         Lett walk Attoched to andher building?         NO 100         User Defined         Allows the user to switch bet and Retail           D29         Code compliance         Code (C)         User Defined         Allows the user to switch bet and Retail           D29         Code compliance         Code (C)         User Defined         Allows user to switch bet and Retail           e01         Roof absorptance         0.45         User Defined         Cole (C)           e02         Roof roughness         1         Fixed         This is used to calculate the occurs           e03         Roof number (win significance)         0.89         User Defined         Cole and xovs values from 1 to new retains           e04         Roof insulation R-value (m-sq.ft-F&tu)         R-15         User Defined         col6 and col3 are used to defined color           e04         Roof insulation R-value (m-sq.ft-F&tu)         R-15         User Defined         col6 and col3 are used to defined color           e04         Roof insulation R-value (m-sq.ft-F&tu)         R-13         User Defined         col7 are used to define col7 and col3 are used to defined color and col3 are used to defined color and col3 are used to defined col6 and col3 are used to defin and col3 are used to defined colar are used to adul	b16	Right wall: Attached to another building?	No (N)	User Defined	buildings to the different orientations of the
Drif         Duilding type         Office (0)         User Defined         Allows the user to switch bef and Retail           b20         Code compliance         Code ( C )         User Defined         Allows user to run user defined and Retail           c01         Roof absorptance         0.45         User Defined         Allows user to run user define after of ASPAE 501 1995           c02         Roof roughness         1         Fixed         This is used to define code"         Colf and CO3 are used to define code"           c03         Roof nousidio R-value (rr-sq. ft-F/Etu)         R-15         User Defined         C03 and CO7 are used to defin code"           c04         Roof insulation R-value (ri-sq. ft-F/Etu)         R-15         User Defined         C03 and CO7 are used to defin code"           c05         Wall absorptance         0.57         User Defined         C05 and c07 are used to defin code"           c06         Wall roughness         2         Fixed         This is used to calculate the or coefficient for heat transfer co DOCE2 allows values from 1 to in smoothness           c05         Wall insulation R-value (ri-sq. ft-F/Etu)         R-13         User Defined         C05 and c07 are used to defin in smoothness           c06         Wall insulation R-value (ri-sq. ft-F/Etu)         R-13         User Defined         C05 and c07 are used to defin in smoothness	b18	Left walk Attached to another building?	NO (N)	User Defined	
b20         Code compliance         Code ( C )         User Defined         and Retail Allows user to run, user define ether of AS/RAE 90.11993 ( c01 and 020 are used to define coder           c01         Roof absorptance         0.45         User Defined         c01 and 020 are used to define coder           c02         Roof roughness         1         Fixed         This is used to calculate the coder           c03         Roof outside emissivity         0.89         User Defined         c01 and 020 are used to define color           c04         Roof insulation R-value (in-sq.ft-F&bu)         R-15         User Defined         c03 are used to define color           c06         Wall absorptance         0.57         User Defined         cost of are used to define color           c06         Wall outside emissivity         0.9         User Defined         cost of are used to define cost of intro the at manafer cost intro the at manafer cost of intro the at manafer c	b19	Building type	Office (0)	User Defined	Allows the user to switch between Office
b20         Code compliance         Code ( C )         User Defined         Allows user to num user define ether of ASRAE.2011993 coll c01 and c03 are used to deter color"           c02         Roof roughness         1         Fixed         C11 and c03 are used to deter color"           c03         Roof outside enissivity         0.89         User Defined         c01 and c03 are used to deter color"           c04         Roof outside enissivity         0.89         User Defined         c01 and c03 are used to deter color"           c04         Roof outside enissivity         0.89         User Defined         c01 and c03 are used to deter color"           c06         Wall roughness         2         Fixed         This is used to calculate the or coefficient for heat transfer co DOE-2 allows values from 1 to in smoothness           c07         Wall outside enissivity         0.9         User Defined         c05 and c07 are used to defin coefficient for heat transfer co DOE-2 allows values from 1 to in smoothness           c08         Wall insulation R-value (tr-sq.ft-F&tu)         R-13         User Defined         DCE-2 allows values from 1 to in smoothness           c10         Ground reflectance         0.24         Fixed         This defines the fraction of su reflected from the ground           c10         U-Factor of glazing (fbtuh-sq.ft-F&tu)         R-13         User Defined         User to select fro		2 //			and Retail
effer         Roof absorptance         0.45         User Defined         C01 and 03 are used to defer           e02         Roof roughness         1         Fixed         This is used to calculate the or coefficient for heat transfer or DDE-2 allows values from 1 to in smoothness         DDE-2 allows values from 1 to in smoothness           e03         Roof outside emissivity         0.89         User Defined         c01 and 03 are used to defer           e04         Roof insulation R-value (thr-sq.ft-F8tu)         R-15         User Defined         c05 and c07 are used to defin           e06         Wall roughness         2         Fixed         This is used to calculate the or DDE-2 allows values from 1 to in smoothness in an anothness         DDE-2 allows values from 1 to in smoothness in an anothness           e06         Wall roughness         2         Fixed         This is used to calculate the or DDE-2 allows values from 1 to in anothness in an anothness in a moothness in a moothnese in a moothness in a moothne	b20	Code compliance	Code(C)	User Defined	Allows user to run user defined model or
cvi         roor assorptance         U.45         User Verlined         cut and c03 are used to deter color"           c02         Roof roughness         1         Fixed         This is used to calculate the o coefficient for heat transfer o DCE-2 allows values from 1 to in smoothness           c03         Roof outside enissivity         0.83         User Defined         c01 and c03 are used to deter color"           c04         Roof insulation R-value (tra-sq.ft-F8tu)         R-15         User Defined         c05 and c07 are used to defer color"           c05         Wall absorptance         0.57         User Defined         c05 and c07 are used to defin color"           c06         Wall roughness         2         Fixed         This is used to calculate the o coefficient for heat transfer co DCE-2 allows values from 1 to in smoothness           c07         Wall outside emissivity         0.9         User Defined         c05 and c07 are used to defin or coefficient for heat transfer co DCE-2 allows values from 1 to in smoothness           c09         Ground reflectance         0.24         Fixed         This defines the fraction of su reflected from the ground           c11         U-Factor of glazing (Buhr-sq.ft-F8tu)         R-13         User Defined         C05 and c07 are used to defin or sort reflected from the ground           c12         Solar Heat & Gan Coefficient(SH0C)         0.17         User Defined </th <td></td> <td>Deaf also surfaces</td> <td>0.15</td> <td>Lines Produced</td> <td>either of ASHRAE 90.1 1989 or 1999</td>		Deaf also surfaces	0.15	Lines Produced	either of ASHRAE 90.1 1989 or 1999
c02         Roof roughness         1         Fixed         This is used to calculate the or coefficient for heat transfer or DOE-2 allows values from 1 to in smoothness           c03         Roof outside emissivity         0.89         User Defined         c01 and c03 are used to defer color*           c04         Roof insulation R-value (hr-sq.ft-F8tu)         R-15         User Defined         c05 and c07 are used to defin color*           c06         Wall absorptance         0.57         User Defined         c05 and c07 are used to defin color*           c06         Wall outside emissivity         0.9         User Defined         c05 and c07 are used to defin color*           c07         Wall outside emissivity         0.9         User Defined         c05 and c07 are used to defin in smoothness           c08         Wall insulation R-value (hr-sq.ft-F8tu)         R-13         User Defined         c05 and c07 are used to defin in smoothness           c09         Ground reflectance         0.24         Fixed         This defines the fraction of su reflected from the ground           c11         U-Factor of glazing (Btu/hr-sq.ft-F)         1.22         User Defined         c14           c12         Solar heat Gain Coefficient(SrHGC)         0.17         User Defined         c14           c13         Number of panor of glazing (L14         Number of panor of glazin	c01	Root absorptance	U.45	User Defined	cut and cut are used to determine "roof
c03         Roof outside emissivity         0.69         User Defined in amoothness         coofficient for heat transfer or DOE-2 allows values from 1 to in amoothness           c04         Roof outside emissivity         0.89         User Defined         c01 and c03 are used to defined coofficient for heat transfer or production           c04         Roof insulation R-value (hr-sq.ft-F/Etu)         R-15         User Defined         c05 and c07 are used to defin coofficient for heat transfer or production           c06         Well roughness         2         Fixed         This is used to calculate the or coefficient for heat transfer or production R-value (hr-sq.ft-F/Etu)         0.9         User Defined         c05 and c07 are used to defin or coefficient for heat transfer or production R-value (hr-sq.ft-F/Etu)         R-13         User Defined         c02 are used to defin or coefficient for heat transfer or product reflectance           c07         Well outside emissivity         0.9         User Defined         c03 and c02 are used to defin or coefficient for heat transfer or product reflectance         product reflectance           c08         Well outside emissivity         0.9         User Defined         c05 and c07 are used to defin in smoothness           c09         Ground reflectance         0.24         Fixed         This defines the fraction of su preflected from the ground           c10         U-Factor of glazing         0.7         Fixed         F	c02	Roof roughness	1	Fixed	This is used to calculate the outside film
c03         Roof outside emissivity         0.89         User Defined c04         DOE-2 allows values from 1 to in smoothneess           c04         Roof insulation R-value (hr-sq,ft-F/8tu)         R-15         User Defined         c05 and c07 are used to deter color*           c05         Wall absorptance         0.57         User Defined         c05 and c07 are used to detin coefficient for heat transfer co- DOE-2 allows values from 1 to in smoothnees           c06         Wall outside emissivity         0.9         User Defined         c05 and c07 are used to define coefficient for heat transfer co- DOE-2 allows values from 1 to in smoothnees           c07         Wall outside emissivity         0.9         User Defined         c05 and c07 are used to defin in smoothnees           c08         Wall insulation R-value (hr-sq,ft-F/8tu)         R-13         User Defined         c05 and c07 are used to defin in smoothnees           c10         U-Factor of glazing (Btu/hr-sq,ft-F)         1.2         User Defined         c14           c11         U-Factor of pane of glazing         0.7         Fixed         frame types           c13         Number of pane of glazing         0.7         Fixed         Allows user to select from 5 d frame types           c16         Void         C41         Frame absorptance of glazing         0.7         Fixed           c18         St					coefficient for heat transfer calculations,
c03         Roof outside emissivity         0.8         User Defined color         c01 and c03 are used to defer color           c04         Roof insulation R-value (hr-sq.ft-FBtu)         R-15         User Defined         c03 are used to defer color           c05         Wall absorptance         0.57         User Defined         c05 and c07 are used to defin coefficient for heat transfer or DoCE-2 allows values from 1 to in smoothness           c06         Wall roughness         2         Fixed         This is used to calculate the or coefficient for heat transfer or DoCE-2 allows values from 1 to in smoothness           c07         Wall outside emissivity         0.9         User Defined         c05 and c07 are used to defin in smoothness           c08         Wall insulation R-value (rin-sq.ft-FBtu)         R-13         User Defined         C05 and c07 are used to defin in smoothness           c10         U-Factor of glazing (Etuhr-sq.ft-F)         1.22         User Defined         C14           c11         U-Factor of glazing (Etuhr-sq.ft-F)         1.22         User Defined         C14           c12         Solar Heat Qain Coefficient(SHGC)         0.17         User Defined         C14           c13         Number of glazing         1         Fixed         Allows user to select from 5 d frame types           c16         Void          User De					DOE-2 allows values from 1 to 6 increasin
c03         Roof outside emissivity         0.89         User Defined         c01 and c03 are used to deter color"           c04         Roof insulation R-value (hr-sq.ft-F/Btu)         R-15         User Defined         c05           c06         Wall absorptance         0.57         User Defined         c05 and c07 are used to deter color"           c06         Wall roughness         2         Fixed         This is used to calculate the or coefficient for heat transfer co- DOF-2 allows values from 1 to in smoothness           c07         Wall outside emissivity         0.9         User Defined         c05 and c07 are used to defin or coefficient for heat transfer co- DOF-2 allows values from 1 to in smoothness           c08         Wall insulation R-value (hr-sq.ft-F/Btu)         R-13         User Defined         This defines the fraction of su reflected from the ground reflected from the ground           c10         Ground reflectance         0.24         Fixed         This defines           c11         U-Factor of glazing (Btu/hr-sq.ft-F/Btu)         0.17         User Defined         Allows user to select from 5 d frame types           c13         Number of pane of glazing         0.7         Fixed         This corresponds to medium c user has a choice of inglint, met construction           c14         Frame absorptance of glazing         0.7         Fixed         This corresponds to medium c user has a					in smoothness
c04         Roof insulation R-value (hr-sq.ft-F/Rtu)         R-15         User Defined         c007           c05         Wall absorptance         0.57         User Defined         c05 and c07 are used to defin           c06         Wall roughness         2         Fixed         This is used to calculate the or coefficient for heat transfer coordicate the or coefficient for heat transfer coordicate the or coefficient for heat transfer coordinate transfer coor	c03	Roof outside emissivity	0.89	User Defined	c01 and c03 are used to determine "roof
c04     Non-Tradiation (Nr.sq. 14-1A0)     No.13     Ose Perfined     C05 and c07 are used to defin       c06     Wall roughness     2     Fixed     C05 and c07 are used to defin       c06     Wall roughness     2     Fixed     C05 and c07 are used to defin       c07     Wall outside emissivity     0.9     User Defined     C05 and c07 are used to defin       c08     Wall insulation R-value (hr-sq. ft-F/Btu)     R-13     User Defined     C05 and c07 are used to defin       c09     Ground reflectance     0.24     Fixed     This defines the fraction of su reflected from the ground       c10     User Defined     Fixed     This defines the fraction of su reflected from the ground       c11     U-Factor of glazing (BtuHr-sq. ft-F)     1.22     User Defined       c13     Number of pane of glazing     0     Fixed     Fixed       c14     Frame type - A,B,C,D,E     Aluminum wich thermal break     User Defined     Allows user to select from 5 diffine frame types       c16     Fixed     This corresponds to medum or user has a choice of light, meducine     User Defined     User conchoose from 9 insule values and insulation depths       c18     Stab-on-grade floor insulation, Norizontal) (hr-sq.ft-FBtu)     0.68     Fixed     User can choose from 9 insule values       c20     Below-grade wall insulation, vertical, basement wall = 8 ft	004	Roof insulation R value (br. og ff E@tu)	P 16	Lloor Dofined	color"
c06     Wall roughness     2     Fixed     This is used to calculate the or coefficient for heat transfer or DOE-2 allows values from 1 to in smoothness       c07     Wall outside emissivity     0.9     User Defined     c05 and c07 are used to defin       c08     Well insulation R-value (hr-sq.ft-F/Etu)     R-13     User Defined     c05 and c07 are used to defin       c09     Ground reflectance     0.24     Fixed     This defines the fraction of surface       c11     U-Factor of glazing (Btuhn-sq.ft-F)     1.22     User Defined       c13     Number of pane of glazing     1     Fixed       c14     Frame type - A,B,C,D,E     Aluminum w/o thermal break     User Defined       c16     Void     C16     Void       c17     Floor weight (lb/sq.ft)     70     User Defined       c18     Stab-on-grade floor insulation R-value (hr-sq.ft-F/Etu)     0.88     Fixed       c18     Stab-on-grade floor insulation R-value (hr-sq.ft-F/Etu)     0.88     Fixed       c19     Stab-on-grade floor insulation R-value (hr-sq.ft-F/Etu)     0.88     Fixed       c20     Below-grade wall nsulation R-value (hr-sq.ft-F/Etu)     0.88     Fixed       c21     Below-grade wall R-value (hr-sq.ft-F/Etu)     0.88     Fixed       c21     Below-grade wall R-value (hr-sq.ft-F/Etu)     0.88     Fixed	c05	Wall absorptance	0.57	User Defined	c05 and c07 are used to define "wall color
c06     Wall roughness     2     Fixed     This is used to calculate the or coefficient for heat transfer or DCE-2 allows values from 1 to in smoothness       c07     Wall outside emissivity     0.9     User Defined     c05 and c07 are used to defin       c08     Wall insulation R-value (hr-sq.ft-F/Btu)     R-13     User Defined     c05 and c07 are used to defin       c09     Ground reflectance     0.24     Fixed     This is used to calculate the or coefficient for heat transfer or DCE-2 allows values from 1 to in smoothness       c10     Void     R-13     User Defined     C05 and c07 are used to defin       c10     Void     Void     This is used to calculate the or coefficient for heat transfer or point of glazing (Btu/hr-sq.ft-F)     1.22     User Defined       c11     U-Factor of glazing (Btu/hr-sq.ft-F)     1.22     User Defined     Maine of pane of glazing     0.7       c13     Number of pane of glazing     0.7     Fixed     Aluminum w/o thermal break     User Defined     Allows user to select from 5 d frame type - A, B, C, D, E       c16     Void     Void     This corresponds to medium construction     User Defined     User to select from 9 insult values from 9 insult values and insulation depths       c18     Slab-on-grade floor insulation R-value     R-0 (A)     User Defined     User can choose from 9 insult values       c19     Slab-on-grade floor insulation R-val					
c07         Wall outside emissivity         0.9         User Defined         c05 and c07 are used to defin           c08         Wall insulation R-value (hr-sq.ft-F/Btu)         R-13         User Defined         c05 and c07 are used to defin           c09         Ground reflectance         0.24         Fixed         This defines the fraction of surreflectance           c10         Void         Void         reflected from the ground         reflected from the ground           c11         U-Factor of glazing (Btu/hr-sq.ft-F)         1.22         User Defined         void           c13         Number of pane of glazing         1         Fixed         Fixed         fixed           c14         Frame type - A,B,C,D,E         Aluminum w/o thermal break         User Defined         Allows user to select from 5 d           c15         Frame type - A,B,C,D,E         Aluminum w/o thermal break         User Defined         Insure to select from 5 d           c16         Void         construction         user has a choice of light, mec construction         user has a choice of light, mec construction           c18         Slab-on-grade floor insulation R-value (r-sq.ft-F/Btu)         0.88         Fixed         values           c19         Slab-on-grade floor R-value (rh-sq.ft-F/Btu)         0.88         Fixed         values	c06	Wall roughness	2	Fixed	This is used to calculate the outside film
C07     Wall outside emissivity     0.9     User Defined     C05 and c07 are used to defin       c08     Wall insulation R-value (hr-sq.ft-F/Btu)     R-13     User Defined     C05 and c07 are used to defin       c09     Ground reflectance     0.24     Fixed     This defines the fraction of sureflected from the ground       c10     U-Factor of glazing (Btu/hr-sq.ft-F)     1.22     User Defined     User Defined       c11     U-Factor of glazing (Btu/hr-sq.ft-F)     1.22     User Defined     User Defined       c13     Number of pane of glazing     1     Fixed     Fixed       c14     Frame absorptance of glazing     0.7     Fixed     Allows user to select from 5 d frame types       c16     Void     C17     Floor weight (Ib/sq.ft)     70     User Defined     User construction       c18     Slab-on-grade floor insulation R-value (Exterior insulation R-value (Fr-sq.ft-F/Btu)     R-0 (A)     User Defined     User can choose from 9 insular values and insulation depths       c20     Below-grade wall insulation R-value (fr-sq.ft-F/Btu)     0.88     Fixed     Values       c21     Below-grade wall insulation R-value (fr-sq.ft-F/Btu)     0.88     Fixed     Values       c21     Below-grade wall insulation R-value (fr-sq.ft-F/Btu)     0.88     Fixed     Values       c22     Elev-grade wall insulation					coefficient for heat transfer calculations,
e07     Wall outside emissivity     0.9     User Defined     c05 and c07 are used to defin       c08     Wall insulation R-value (hr-sq.ft-F/Btu)     R-13     User Defined     c05 and c07 are used to defin       c09     Ground reflectance     0.24     Fixed     This defines the fraction of su reflected from the ground       c10     Void     Void        c11     U-Factor of glazing (Btu/hr-sq.ft-F)     1.22     User Defined       c12     Solar Heat Gain Coefficient(SHGC)     0.17     User Defined       c13     Number of pane of glazing     0.7     Fixed       c14     Frame absorptance of glazing     0.7     Fixed       c15     Frame type - A,B,C,D,E     Aluminum w/o thermal break     User Defined       c16     Void     This corresponds to medium construction       c18     Slab-on-grade floor insulation R-value     R-0 (A)     User Defined     User can choose from 9 insulation depths       c19     Slab-on-grade floor R-value (hr-sq.ft-F/Btu)     0.88     Fixed     values       c20     Below-grade wall insulation R-value (hr-sq.ft-F/Btu)     0.88     Fixed       c21     Below-grade wall insulation R-value     R-0 (A)     User Defined     User can choose from 9 insulation and sulation depths       c19     Slab-on-grade wall insulation, vertical, basement wall = 8 ft) <td></td> <td></td> <td></td> <td></td> <td>DOE-2 allows values from 1 to 6 increasin</td>					DOE-2 allows values from 1 to 6 increasin
C01     Vial dotate terms vity     0.3     Cost Perind     Cost Perind       c08     Wall insulation R-value (hr-sq.ft-F/Btu)     R-13     User Defined     Init Set The fination of surget action action of surget action action of surget action action action of surget action	c07	VA/all outside emissivity	0.0	User Defined	In smoothness
c08         Wall insulation R-value (hr-sq.ft-F/Btu)         R-13         User Defined           c09         Ground reflectance         0.24         Fixed         This defines the fraction of su reflected from the ground           c10         Void         Void         reflected from the ground         reflected from the ground           c11         U-Factor of glazing (Btu/hr-sq.ft-F)         1.22         User Defined         reflected from the ground           c13         Number of pane of glazing         1         Fixed         Fixed         reflected from the ground           c14         Frame absorptance of glazing         0.7         Fixed         Allows user to select from 5 d (A)           c15         Frame type - A,B,C,D,E         Aluminum w/o thermal break         User Defined         Allows user to select from 5 d (A)           c16         Void         Void         Triame types         construction         user has a choice of light, med construction           c18         Slab-on-grade floor insulation R-value (Exterior insulation, horizontal) (hr-sq.ft-F/Btu)         0.88         Fixed         values           c20         Below-grade wall insulation R-value (hr-sq.ft-F/Btu)         0.88         Fixed         values           c21         Below-grade wall R-value (concrete wall)         0.88         Fixed         values	007	wai outside emissivity	0.8	USER DETINIEG	
c09         Ground reflectance         0.24         Fixed         This defines the fraction of surreflected from the ground reflected from the ground reflected from the ground           c10         U-Factor of glazing (Btu/hr-sq.ft-F)         1.22         User Defined         reflected from the ground           c11         U-Factor of glazing (Btu/hr-sq.ft-F)         1.22         User Defined            c13         Number of pane of glazing         0.7         Fixed            c13         Number of pane of glazing         0.7         Fixed            c14         Frame absorptance of glazing         0.7         Fixed            c15         Frame type - A,B,C,D,E         Alluminum w/o thermal break         User Defined         Allows user to select from 5 d           c16         Void         Void         This corresponds to medium c         user has a choice of light, med           c17         Floor weight (Ib/sq-ft)         70         User Defined         User can choose from 9 insult           c18         Stab-on-grade floor insulation R-value (hr-sq.ft-F/Btu)         0.88         Fixed         User can choose from 9 insult           c19         Stab-on-grade floor R-value (hr-sq.ft-F/Btu)         0.88         Fixed         user           c20         Below-grade wall insulation r	c08	Wall insulation R-value (hr-sq.ft-F/Btu)	R-13	User Defined	
c10         Image: Construction of glazing (Btu/hr-sq.ft-F)         1.22         User Defined           c11         U-Factor of glazing (Btu/hr-sq.ft-F)         1.22         User Defined           c12         Solar Heat Qain Coefficient(SHGC)         0.17         User Defined           c13         Number of pane of glazing         1         Fixed           c14         Frame absorptance of glazing         0.7         Fixed           c15         Frame type - A,B,C,D,E         Aluminum w/o thermal break         User Defined         Allows user to select from 5 d           c16         Yoid         Void         Trame types         AB(or user to select from 5 d)           c16         Yoid         Void         This corresponds to medium c         user has a choice of light, meet construction           c18         Slab-on-grade floor insulation R-value (rx-sq.ft-F,Btu)         R-0 (A)         User Defined         User can choose from 9 insulation values and insulation depths           c19         Slab-on-grade wall insulation R-value (hr-sq.ft-F,Btu)         0.88         Fixed         values           c20         Below-grade wall insulation revalue (hr-sq.ft-F,Btu)         0.88         Fixed         values           c21         Below-grade wall R-value (concrete wall)         0.88         Fixed         values	c09	Ground reflectance	0.24	Fixed	This defines the fraction of sunlight
C10     Void       c11     U-Factor of glazing (Btu/hr-sq.ft-F)     1.22     User Defined       c12     Solar Heat Gain Coefficient(SHGC)     0.17     User Defined       c13     Number of pane of glazing     1     Fixed       c14     Frame absorptance of glazing     0.7     Fixed       c15     Frame type - A,B,C,D,E     Aluminum w/o thermal break     User Defined       c16     Void     Trame types     frame types       c16     Void     User Defined     User Defined       c17     Floor weight (Ib/sq-ft)     70     User Defined     user has a choice of light, mec construction       c18     Slab-on-grade floor insulation, horizontal) (hr-sq,ft-F/Btu)     70     User Defined     User can choose from 9 insulation sulation floor 9 (light, mec construction       c19     Slab-on-grade floor R-value (hr-sq,ft-F/Btu)     0.88     Fixed     values and insulation depths values (hr-sq,ft-F/Btu)       c20     Below-grade wall insulation R-value (hr -sq,ft-F/Btu)     0.88     Fixed     values       c21     Below-grade wall R-value (concrete wall)     0.88     Fixed     values       c22     Void     Void     values     values       c23     Floor R-value     1.67     Fixed       c24     Celing R-value (hr-sq, ft-F/Btu)     1.89	-40			- 1-1	reflected from the ground
c12     Solar Heat Gain Coefficient(SHC)     0.17     User Defined       c13     Number of pane of glazing     1     Fixed       c14     Frame absorptance of glazing     0.7     Fixed       c15     Frame type - A,B,C,D,E     Aluminum w/o thermal break (A)     User Defined       c16     Void       c17     Floor weight (lb/sq-ft)     70     User Defined       c18     Stab-on-grade floor insulation, horizontal) (hr-sq.ft- F/Btu)     R-0 (A)     User Defined     User can choose from 9 insula values and insulation depths       c19     Stab-on-grade floor R-value (hr-sq.ft-F/Btu)     0.88     Fixed     Values       c20     Below-grade wall insulation, ervalue (hr-sq.ft-F/Btu)     0.88     Fixed       c21     Below-grade wall R-value (concrete wall) (hr-sq.ft-F/Btu)     0.88     Fixed       c22     Floor R-value     1.67     Fixed       c23     Floor R-value     1.67     Fixed       c24     Celling R-value (hr-sq.ft-F/Btu)     1.89     Fixed	c10 c11	LLEactor of glazing (Btubr-sg ft-E)	1 22	Jia User Defined	
c13     Number of pane of glazing     1     Fixed       c14     Frame absorptance of glazing     0.7     Fixed       c15     Frame type - A,B,C,D,E     Aluminum w/o thermal break (A)     User Defined     Allows user to select from 5 d frame types       c16     Void     Void     Tris corresponds to medium c user has a choice of light, med construction       c18     Slab-on-grade floor insulation R-value (Exterior insulation, horizontal) (hr-sq.ft- F&tu)     R-0 (A)     User Defined     User can choose from 9 insule values and insulation depths       c19     Slab-on-grade wall insulation R-value (hr-sq.ft-F&tu)     0.88     Fixed     Values       c20     Below-grade wall insulation R-value (hr-sq.ft-F&tu)     0.88     Fixed     values       c21     Below-grade wall insulation R-value (hr-sq.ft-F&tu)     0.88     Fixed     values       c22     Edow-grade wall insulation R-value (hr-sq.ft-F&tu)     0.88     Fixed     values       c23     Floor R-value (hr-sq.ft-F&tu)     0.88     Fixed     values       c24     Celling R-value (hr-sq.ft-F&tu)     1.89     Fixed     values	c12	Solar Heat Gain Coefficient(SHGC)	0.17	User Defined	
c14         Frame absorptance of glazing         0.7         Fixed           c15         Frame type - A,B,C,D,E         Alluminum w/o thermal break (A)         User Defined         Allows user to select from 5 d frame types           c16         Void         Void         This corresponds to medium c user has a choice of light, med construction           c18         Slab-on-grade floor insulation R-value (Exterior insulation, horizontal) (hr-sq.ft- F/Btu)         R-0 (A)         User Defined         User can choose from 9 insula values and insulation depths           c19         Slab-on-grade wall insulation R-value (hr- sq.ft-F/Btu)         R-0 (A)         User Defined         User can choose from 9 insula values and insulation depths           c20         Below-grade wall insulation R-value (hr-sq.ft-F/Btu)         0.88         Fixed         values           c21         Below-grade wall insulation, vertical, basement wall = 8 ft)         0.88         Fixed         values           c22         Void           Void            c23         Floor R-value (concrete wall)         0.88         Fixed            c24         Void               c25         Ceiling R-value (hr-sq.ft-F/Btu)         1.89         Fixed	c13	Number of pane of glazing	1	Fixed	-
c15     Frame type - A,B,C,D,E     Aluminum w/o thermal break (A)     User Defined     Allows user to select from 5 d frame types       c16     Void     Void     This corresponds to medium c user has a choice of light, mer construction       c18     Slab-on-grade floor insulation, horizontal) (hr-sq.ft- F/Btu)     R-0 (A)     User Defined     User can choose from 9 insule values and insulation depths       c19     Slab-on-grade floor R-value (hr-sq.ft-F/Btu)     0.88     Fixed     Void       c20     Below-grade wall insulation, vertical, basement wall = 8 ft)     R-0 (A)     User Defined     User can choose from 9 insule values and insulation values       c21     Below-grade wall R-value (concrete wall) (hr-sq.ft-F/Btu)     0.88     Fixed     Void       c22     Void     Void     Void     Void       c23     Floor R-value     1.67     Fixed       c24     Celling R-value (hr-sq.ft-F/Btu)     1.89     Fixed	c14	Frame absorptance of glazing	0.7	Fixed	
c16         Void           c17         Floor weight (lb/sq-ft)         70         User Defined         user has a choice of light, med construction           c18         Slab-on-grade floor insulation, horizontal) (hr-sq.ft- Fibtu)         R-0 (A)         User Defined         User can choose from 9 insule values and insulation depths           c19         Slab-on-grade wall insulation, the construction, vertical, basement wall = 8 ft)         0.88         Fixed           c20         Below-grade wall insulation, vertical, basement wall = 8 ft)         0.88         Fixed           c21         Below-grade loor R-value (concrete wall) (hr-sq.ft-Fibtu)         0.88         Fixed           c22         Void         Void         Void           c23         Floor R-value         1.67         Fixed           c24         Celling R-value (hr-sq.ft-Fibtu)         1.89         Fixed	c15	Frame type - A,B,C,D,E	Aluminum w/o thermal break	User Defined	Allows user to select from 5 different
c10     Floor weight (lb/sq-ft)     70     User Defined     This corresponds to medium c user has a choice of light, med construction       c18     Stab-on-grade floor insulation R-value (Exterior insulation, horizontal) (hr-sq,ft- F/Btu)     R-0 (A)     User Defined     User can choose from 9 insule values and insulation depths       c19     Stab-on-grade floor R-value (hr-sq,ft-F/Btu)     0.88     Fixed     User can choose from 9 insule values and insulation depths       c20     Below-grade wall insulation R-value (hr- sq,ft-F/Btu) (Exterior insulation, evrical, basement wall = 8 ft)     0.88     Fixed       c21     Below-grade wall R-value (concrete wall) (hr-sq,ft-F/Btu)     0.88     Fixed       c22     Void     c23     Floor R-value     1.67       c24     Void     c25     Celling R-value (hr-sq,ft-F/Btu)     1.89	c16		(A)	pid.	Trane types
c18     Stab-on-grade floor insulation R-value (Exterior insulation, horizontal) (hr-sq.ft- F.Btu)     R-0 (A)     User Defined     User an choose from 9 insule values and insulation depths       c19     Stab-on-grade floor R-value (hr-sq.ft-F.Btu)     0.88     Fixed     User can choose from 9 insule values       c20     Below-grade wall insulation R-value (hr- sq.ft-F.Btu) (Exterior insulation, vertical, basement wall = 8 ft)     0.88     Fixed       c21     Below-grade wall R-value (concrete wall) (hr-sq.ft-F.Btu)     0.88     Fixed       c22     Void       c23     Floor R-value     1.67       c24     Void       c25     Ceiling R-value (hr-sq.ft-F.Btu)     1.89	c10	Floor weight (lb/sg-ft)	70	User Defined	This corresponds to medium construction
c18     Slab-on-grade floor insulation R-value (Exterior insulation, horizortal) (hr-sq.ft- <i>FA</i> tu)     R-0 (A)     User Defined     User can choose from 9 insula values and insulation depths       c19     Slab-on-grade floor R-value (hr-sq.ft- <i>F</i> ./Btu)     0.88     Fixed        c20     Below-grade wall insulation, vertical, basement wall = 8 ft)     0.88     Fixed        c21     Below-grade wall R-value (concrete wall) (hr-sq.ft- <i>F</i> ./Btu)     0.88     Fixed     values       c22     Void           c23     Floor R-value     1.67     Fixed       c24     Void          c24     Ceiling R-value (hr-sq.ft-F./Btu)     1.89     Fixed					user has a choice of light, medium or heav
c18     Stab-on-grade floor insultation R-value (Exterior insultation, horizontal) (hr-sq.ft- F/Btu)     R-0 (A)     User Defined     User can choose from 9 insult values and insultation depths values and insultation depths       c19     Stab-on-grade floor R-value (hr- F/Btu)     0.88     Fixed     Values and insultation depths       c20     Below-grade wall insultation, vertical, basement twall = 8 ft)     0.88     Fixed     User can choose from 9 insult values       c21     Below-grade wall R-value (concrete wall) (hr-sq.ft-F/Btu)     0.88     Fixed     values       c22     Void					construction
Image: constraint of the constr	c18	Slab-on-grade floor insulation R-value	R-0 (A)	User Defined	User can choose from 9 insulation R-
c19     Slab-on-grade floor R-value (hr-sq.ft-F/Btu)     0.88     Fixed       c20     Below-grade wall insulation R-value (hr- sq.ft-F/Btu) (Exterior insulation, vertical, basement wall = 8 ft)     0.88     Fixed       c21     Below-grade wall R-value (concrete wall) (hr-sq.ft-F/Btu)     0.88     Fixed       c22     Void       c23     Floor R-value     1.67       c24     Void       c25     Ceiling R-value (hr-sq.ft-F/Btu)     1.89		(Exterior insulation, horizontal) (hr-sq.ft-			values and insulation depths
c20     Below-grade wall insulation R-value (hr- sq.ft-F/Btu) (Exterior insulation, vertical, basement wall = 8 ft)     R-0 (A)     User Defined     User can choose from 9 insula values       c21     Below-grade wall R-value (concrete wall) (hr-sq.ft-F/Btu)     0.88     Fixed       c22     Void       c23     Floor R-value     1.67       c24     Void       c25     Ceiling R-value (hr-sq.ft-F/Btu)     1.89       Fixed     1.89	c19	Slab-on-grade floor R-value (hr-sg.ff-E/Ptu)	0,88	Fixed	+
c20         Below-grade wall insulation R-value (hr- sq.ft-F/Btu) (Exterior insulation, vertical, basement wall = 8 ft)         R-0 (A)         User Defined         User can choose from 9 insult values           c21         Below-grade wall R-value (concrete wall) (hr-sq.ft-F/Btu)         0.88         Fixed		an grant her in raide (in equilit /bid)			
sq.ft-F/Btu) (Exterior insulation, vertical, basement wall = 8 ft)         values           c21         Below-grade walls (concrete wall) elow-grade walls (concrete wall)         0.88         Fixed           c22         Void         Void           c23         Floor R-value         1.67         Fixed           c24         Void         Void           c25         Ceiling R-value (hr-sq.ft-F/Btu)         1.89         Fixed	c20	Below-grade wall insulation R-value (hr-	R-0 (A)	User Defined	User can choose from 9 insulation R-
basement wall = 8 tt)         0.88         Fixed           c21         Below-grade wall R-value (concrete wall) (hr-sq.ft-F/Btu)         0.88         Fixed           c22         Void             c23         Floor R-value         1.67         Fixed           c24         Void             c25         Ceiling R-value (hr-sq.ft-F/Btu)         1.89         Fixed		sq.ft-F/Btu) (Exterior insulation, vertical,			values
c21         Delow-grate waiii (-value (cultorete waii))         0.00         Fixed           c22         (hr-sq.ft-F/Btu)         Void           c23         Floor R-value         1.67         Fixed           c24         Void         Void           c25         Ceiling R-value (hr-sq.ft-F/Btu)         1.89         Fixed	-24	basement wall = 8 ft)	0.00	Eisenal	
C22         Void           c23         Floor R-value         1.67         Fixed           c24         Void         Void         Ceiling R-value (hr-sq.ft-F/Btu)         1.89         Fixed           c25         Ceiling R-value (hr-sq.ft-F/Btu)         1.89         Fixed         Image: Control of the sq.ft-F/Btu (hr - sq.ft-F/Btu (hr	CZT	(hr_sq ff_F@tu)	0.68	Fixed	
c23         Floor R-value         1.67         Fixed           c24         Void         Void           c25         Ceiling R-value (hr-sq.ft-F/Btu)         1.89         Fixed	c22	(in squite aboy	ve Ve	ji Did	
c24         Void           c25         Ceiling R-value (hr-sq.ft-F/Btu)         1.89         Fixed	c23	Floor R-value	1.67	Fixed	
c25 Ceiling R-value (hr-sq.ft-F/Btu) 1.89 Fixed	c24		Vc	pid	
a 16 Interview well D under a fit E Otto 1 0.04 Event	c25	Ceiling R-value (hr-sq.ft-F/Btu)	1.89	Fixed	
ezv interior waii rc-value (rr-sq.rc-rbtu) 2.01 Fixed	c26	Recent window frost (%)	2.01	Liser Defined	+
c28 Percent window-right (%) 50 User Defined	c28	Percent window-right (%)	50	User Defined	-
c29 Percent window-back (%) 50 User Defined	c29	Percent window-back (%)	50	User Defined	
c30 Percent window-left (%) 50 User Defined	c 30	Percent window-left (%)	50	User Defined	
sp01 void	sp01		VO	bid	
sp02 void	sp02		V0	Jid Lloor Daffaard	
sprov Area per person (in person ) for onice 275 USEr Defined sp04 Lighting land (WH2) for office 1.3 User Defined	5p03 5n04	Lighting load (A//ft2) for office	2/5	User Defined	+
sp05 Equipment load (W/t2) for office 0.75 User Defined	sp04	Equipment load (VV/ft2) for office	0.75	User Defined	+
sp06 Area per person (ft <sup>2</sup> /person) for retail 300 User Defined	<u> </u>	Area per person (ft <sup>2</sup> /person) for retail	300	User Defined	
sp07 Lighting load (W/ft2) for retail 1.9 User Defined	sp06	Lighting load (VW/ft2) for retail	1.9	User Defined	
sp08 Equipment load (W/W12) for retail 0.25 User Defined	sp06 sp07				
svn Front Shade (S) 0 User Defined	sp06 sp07 sp08	Equipment load (VV/ft2) for retail	0.25	User Defined	
svz         Data Snate (n)         U         User Defined           \$03         Left Shade (W)         0         Liser Defined	sp06 sp07 sp08 s01	Equipment load (VV/ft2) for retail Front Shade (S)	0.25	User Defined	-
	sp06 sp07 sp08 s01 s02 s03	Equipment load (W/ft2) for retail Front Shade (S) Back Shade (N) Left Shade (M)	0.25	User Defined User Defined User Defined	

Table 4a: Office/retail input parameters.

NAME	DESCRIPTION	DEFAULT	STATUS	COMMENT
SYSTEM				
sy01	Mode of system	Variable air volume (2)	User Defined	User can choose from Packaged single zone, variable air volume or packaged usrichle ushme sustem
sy02	Cooling Capacity of cooling system (Btu/hr)	0	Fixed	DOE-2 is autosizing the system
sy03	Heating Capacity of heating system (Btu/hr)	0	Fixed	DOE-2 is autosizing the system
sy04	Seasonal Energy Efficiency Ratio (SEER) for PVAVS and PSZ	10	User Defined	
sy05	ANNUAL FUEL UTILIZATION EFFICIENCY (AFUE) for PSZ	0.8	User Defined	
sy06	**Spare parameter for systems other than VAVS**HEATING SEASONAL PERFORMANCE FACTOR (HSPF)	6.8	User Defined	Unused, since heatpump systems are not included in the office/retail scenario
sv07	**Spare parameter for Pilot light	0	Fixed	Unused
sv08	**Spare parameter for Pilot light	0 0	Fixed	Unused
sv09	**Spare parameter for Pilot light	0	Fixed	Unused
sv10		Va	id	
	Exterior lighting (KW)	0	Fixed	
sv12		Va	id	
sy13	Fan control type	Variable frequency drives (1)	User Defined	User can choose from 4 different type of fan control
sy14	Economizer type	None (1)	User Defined	
sy15	Economizer drybulb limit (F) (use when economizer type(sy14) = dry bulb(2))	65	Fixed	This corresponds to the temperature above which the outside air dampers return to the minimum position
sy16	User input for numbers of fans	Autosized (A)	Fixed	Autosized by DOE-2
sy17	Number of Fans	6	Fixed	equal to the number of floors
sy18	Supply fan total pressure (in W.G)	5.5	Fixed	
sy19	Supply fan efficiency	0.54	Fixed	
sy20	Return fan total pressure (in W.G)	2	Fixed	
sy21	Return fan efficiency	0.51	Fixed	
sy22	Supply motor efficiency	0.5	Fixed	
sy23	Return motor efficiency	0.5	Fixed	
sy24	User input for DH/V gallon/hr-person	Autosized (A)	Fixed	The size of DHW depends on the gallons per hour per person requirements of ASHRAE 90.1
sy25	Maximum DH/V gallon/h-person (maximum hourly, to be used with occupancy schedule)	0.4	Fixed	
PLANT				
p01	Chiller type	Electric Centrifugal (1)	Fixed	
p02	Number of chillers	1	Fixed	
p03	Chillers size (MBtu/h)	-999	Fixed	Chiller is being autosized by DOE-2
p04	Condenser type	water-cooled (VV)	Fixed	
p05	COP	5	User Defined	
p06	Switch for a chiller sizing	Autosized (A)	Fixed	Chiller is being autosized by DOE-2
p07	Cooling tower type	Open tower (O)		
p08		Va	bid	
p09	Gpm/hp	38.2	Fixed	Value from ASHRAE 90.1 1999 for axial fan cooling towers
p10	Cooling tower capacity control	Two-speed fan (1)	Fixed	
p11	Boiler type	Gas fired-hotwater boiler (1)	User Defined	User can choose from gas fired or electric boilers
p12	Number of boilers	1	Fixed	
p13	Boiler size (MBtu/h)	-999	Fixed	Boiler is being autosized by DOE-2
p14	Boller fuel type	Gas (G)	Fixed	Depends on the value of p10
p15	Bollers efficiency (Et,Ec,AFUE) (%)	80	User Defined	
p16	Switch for a boiler sizing	Autosized (A)	Fixed	Boiler is being autosized by DOE-2
p17 p18	DHW heater type	Vc Gas water heater (1)	id User Defined	User can choose from gas fired or electric water heaters
p19	Number of DHW heater	1	Fixed	
p20	DHW size (MBtu/h)	-999	Fixed	Water heater is being autosized by DOE-2
p21	DHW fuel type	Gas (G)	Fixed	Depends on the value of p18
p22	DHW heater Efficiency (Et,Ec,Energy factor) (%)	54	User Defined	
p23	Switch for a DHW heater sizing	Autosized (A)	Fixed	Water heater is being autosized by DOE-2
p24	DHW Storage Capacity (gal)	75	Fixed	

Table 4b: Office/retail input parameters.

Building Type	System
Office	
a) $\leq 20,000 \text{ ft}^2$	Packaged roof top single zone system
b) $\geq$ 20,000 ft <sup>2</sup> and either $\leq$ 3 floors or $\leq$	Packaged roof top VAV with perimeter reheat
75,000 $ft^2$	
c) > 3 floors or > 75,000 $ft^2$	Built-up central VAV with perimeter reheat
Retail	
a) $\leq$ 50,000 ft <sup>2</sup>	Package roof top single zone <b>or</b> air-handler per zone
	with central plant
b) > 50,000 ft <sup>2</sup>	Packaged roof top VAV with perimeter reheat or
	built-up central VAV with perimeter reheat

Table 5: System requirements according the total conditioned floor area for ASHRAE-90.1 1989

Load Density (ILD) which includes the occupancy, lighting and receptacle loads. For this building the ILD due to occupancy, lighting and receptacles was obtained from Table 13-2, Section 6 and Table 13-4 of Standard 90.1-1989, yielding an occupancy density of  $275 \text{ ft}^2$  / person, the Lighting Power Density (LPD) is  $1.57 \text{ W/ft}^2$  and receptacle loads are  $0.75 \text{ W/ft}^2$ . In Standard 90.1-1989 the resultant ILD density is then used to determine the window-to-wall area ratio (WWR) for the standard building that is used for the simulation. For this example an 18% window-to-wall area is calculated for the building.

Since the total square footage is more than 75,000 ft<sup>2</sup> and the number of floors exceeds 3, according to Table 5, the system should be a built-up VAV system with perimeter reheat. The remaining characteristics of the system, including fan control, static pressure rise and fan efficiencies are taken from Table 13-6 of Standard 90.1-1989. From Table 13-6 the values for supply and return static are 4.0 in. of WC and 1.0 in. of WC respectively. The required supply and return fan efficiencies are set at 61% and 32%, respectively, which are the combined efficiencies for the motor and the fan including the variable frequency drives.

For the first run, the system is auto-sized by the DOE-2 simulation to meet the peak heating and cooling load requirements for the wholebuilding, including the envelope characteristics and interior loads defined by Table 2. From DOE-2's verification report (PV-A), from the plant portion of the DOE-2 simulation output, the number and type of chillers are determined. For this example, the chiller size comes out to be 1.806 MMBtu/hr which corresponds to 150.5 tons. According to ASHRAE Standard 90.1-1989 (Table 13-6, Note 11), for cooling loads less than 175 tons, a single reciprocating chiller should be used. Therefore, for the second simulation run, one reciprocating chiller is used and the simulation is used again to determine the size of the one chiller.

The results of the second run are then used to determine the efficiency of the chiller, size and efficiency of the boiler and DHW heater. For a reciprocating chiller between 150 and 300 tons, Standard 90.1-1989 requires that the COP is 4.2 (Table 10-7). The boiler size from the second run is 1,241,000 Btu/hr, which corresponds to an efficiency of 80% for boiler sizes > 300,000Btu/hr (Table 10-8). For the gas-fired domestic water heater, if the rating is less than 75,000 Btu/hr, the energy factor is determined from the NAECA requirement (NAECA 1987): Energy Factor =  $0.62 - 0.0019 \times V$ , where V = storage capacity of the tank in gallons. For this example, the storage capacity of the domestic water heater is taken as 75 gallons<sup>17</sup>, which yields an energy factor of 0.4775.

The efficiencies of the chiller, boiler and domestic water heater are entered into the DOE-2 simulation using the DOE-2 keywords: ELEC-INPUT-RATIO, HW-BOILER-HIR and DHW-HIR<sup>18</sup>. These values are then updated in the input file to complete the system selection process according to ASHRAE 90.1-1989. The annual energy consumption from this third run, which includes the correctly-sized systems according to ASHRAE Standard 90.1-1989, is then used to determine the pre-code energy use of the building.

The variations from the 1<sup>st</sup> to 3<sup>rd</sup> simulations of the Standard 90.1-1989 simulation, which include the change in the system sizing, type of equipment and equipment efficiency, can be seen

<sup>&</sup>lt;sup>17</sup> This is the default value from the USDOE's COMCHECK program 1.1, release 2 (USDOE 2003).

 $<sup>^{\</sup>bar{1}8}$  Values for equipment quadratics use the appropriate values from the COMCHECK program 1.1, release 2.

from Figure 6(a). In this figure the cooling energy consumption in the second run reduces by approximately 25% compared to the first run. This reduction is from the change in the chiller type from centrifugal to reciprocating, and reflects the difference in efficiency factors. The third run shows an increase in cooling energy use of about 15% compared to the second run, which reflects a change in the default COP of 5, which is reset to the required COP of 4.2 for the chosen chiller. Heating equipment efficiency is changed in the third simulation to match the requirements of Standard 90.1-1989, which results in the heating consumption decreasing by approximately 10%. In the third run the domestic hot water consumption goes up by 20%, this is caused by the change in the domestic water heating efficiency, which is reset to the required 47.75% from the default of 75%.

# System Simulation according to ASHRAE 90.1-1999:

As expected, the requirements for ASHRAE Standard 90.1-1999 are different from ASHRAE Standard 90.1-1989. The complete process flow for simulating Standard 90.1-1999 is shown in Figure 5. In difference to the Standard 90.1-1989, Standard 90.1-1999 does not specify the type of system according the to the total conditioned floor area of the building. Instead, Standard 90.1-1999 assigns the system type according to the information provided in Figure 11.4.3. Also, Standard 90.1-1999 has a lower limit of 25 hp on the VSD fan size, below which variable inlet vanes are used to meet the VAV specification. (Table 11.4.3.A. Note 4). In a similar fashion as Standard 90.1-1989, Standard 90.1-1999 chooses the number, type and efficiency of the chiller according to the peak building cooling load (Table 11.4.3A to 11.4.3C), with efficiencies determined by sequencing the runs for each plant component.

Using this approach, an ASHRAE Standard 90.1-1999 code-compliant simulation is completed in four simulations: 1) The first run determines the peak building cooling load that is used to determine the number of chillers and boilers, and the size and type of fans, 2) the second simulation then uses this information to determine the size of the chillers from which the type of chiller is chosen, 3) in the third run the number and type of chiller(s) are fixed and the size determined again by DOE-2 to allow for the efficiency to be determined, and 4) in the fourth run, the number, type, size and efficiency of the fans, chillers, boilers, and domestic water heating

equipment are fixed, yielding the total annual energy use for all equipment complying with Standard 90.1-1999.

In difference to Standard 90.1-1989, the physical characteristics of the building are input as-is into the Standard 90.1-1999 simulation (i.e., 122 ft \* 122 ft, 6-story building, oriented North-South) to perform the simulation, since Standard 90.1-1999 does not require a specific aspect ratio and orientation<sup>19</sup>. For this example, the windowto-wall ratio was assumed to be 18%, to allow for a more meaningful comparison to Standard 90.1-1989 for comparison purposes<sup>20</sup>. The envelope characteristics for the Standard 90.1-1999 simulation were taken from Table B-5 of the standard (Harris County). The internal gains from occupancy and equipment were the same as for the Standard 90.1-1989 run, while the lighting power density (LPD) is taken as 1.3  $W/ft^2$ .

In Standard 90.1-1999 (Table 11.4.3.A, Note 4), when the proposed design system has a supply, return, or relief fan motor 25 hp or larger, the corresponding fan in VAV system of the budget building shall be modeled assuming a variable speed drive. For smaller fans, a forwardcurved centrifugal fan with inlet vanes is required for the budget building model. Therefore, DOE-2's verification report "SV-A" is checked to determine the total fan power consumption of the fan. For this example, the total fan kW is 68.73 kW, from "SV-A", which is equivalent to 92 hp, thus allowing a VSD for variable air flow.

From this same simulation output, verification report "PV-A" is checked to determine the number of chillers and boilers required to meet the cooling and heating load. For the sample building simulation, the size of boiler is 1.166 MBtu/hr and the size of chiller is 1.346 MBtu/hr (= $1.346 \times 10^6$  Btu/hr / 12,000 = 112.17 tons). Since the chiller capacity is less than 300 tons, according to Standard 90.1-1999 (Table 11.4.3.B), the number of chillers is set to "1". In determine the code-compliant boiler

<sup>&</sup>lt;sup>19</sup> Standard 90.1-1999 requires that the budget building have the same orientation and aspect ratio as the proposed building, which was assumed to be a square building oriented so each facade faced N,S,E,W.

<sup>&</sup>lt;sup>20</sup> Standard 90.1-1999 requires that the budget building have the same window-to-wall ratio as proposed building. Hence, if one were running one's building against 90.1-1989 and 90.1-1999, Standard 90.1-1989 would require the fixed aspect ratio of 2.5:1, and Standard 90.1-1999 would use the aspect ratio of the proposed building. In most cases, this fixed aspect ratio for the budget building makes Standard 90.1-1989 more stringent.



Figure 4: Flow chart of the procedure required to run an ASHRAE 90.1 1989 simulation



Figure 5: Flow chart of the procedure required to run an ASHRAE 90.1 1999 simulation



Figure 6(a,b,c,d): Comparison between ASHRAE 90.1 1989 and 1999.

characteristics, Standard 90.1-1999 (Table 11.4.3.A, Note 6) requires that the budget building design boiler shall be modeled with a single boiler if the budget building design plant load is 600,000 Btu/h or less, or with two equally-sized boilers for plant capacities exceeding 600,000 Btu/h. Since the size of boiler of sample building exceeds 600,000 Btu/hr, two boilers were chosen, with a final size of each boiler of 583,000 Btu/hr<sup>21</sup>. For the second simulation, the above adjustments are incorporated into the input file. From the "PV-A" report of second simulation output, the size of the cooling equipment is re-evaluated using the number of chillers from the first simulation. However, in this example, it remains the same because only one chiller is used for the simulation. Since the chiller size is between 100 and 300 tons, a screw-type chiller should be selected according to Standard 90.1-1999 (Table 11.4.3.C)<sup>22</sup>.

In the third simulation the updated chiller type and performance curves are used to determine the size of the chiller. Boiler and domestic water heater sizes are also determined. From the "PV-A" report of the third simulation output, the chiller size is 1.346 MBtu/hr  $(=1.346*10^{6} \text{ Btu/hr} / 12,000 = 112.17 \text{ ton})$ , the boiler size is 0.583 MBtu/hr, and the DHWheater is 0.017 MBtu/hr. According to Standard 90.1-1999 (Table 6.2.1.C), if the chiller is a water-cooled, electrically operated, positive displacement machine (rotary screw and scroll) and the size is less than 150 tons, then the COP is determined to be 4.45. In the case of the boiler, from Standard 90.1-1999 (Table 6.2.1.F), the efficiency of the boiler is determined to be 75% if boiler size is between 300,000 Btu/hr and 2.500.000 Btu/hr. For the domestic water heater. the energy factor  $(EF)^{23}$  is calculated using equation 1, which results in an EF = 0.4775.

In the fourth simulation the annual energy consumption reflects equipment that complies with Standard 90.1-1999. The variations in the system sizing, type of equipment and efficiencies for all four simulations can be seen in Figure 6(b). For the first two runs, there are no changes in the cooling energy consumption and the DHW consumption. However the heating energy use goes down by around 5%, due to the selection of two boilers in the third simulation, from the previous one boiler in the first two simulations, with the decrease energy use attributable to the part load operation of the one boiler.

In the third simulation, updating the chiller type and curves from centrifugal to screw, increases the energy consumption by 9%. The heating and DHW consumption remains the same. In the fourth simulation, use of the required efficiencies for the chiller, boiler, fans and DHW increases the cooling energy and DHW consumption. This is because in the case of chiller the default COP of 5 (used in the third simulation) is more efficient than the COP of 4.45 required by Standard 90.1-1999, and for the DHW, the default 75% efficiency used in the third simulation, is more efficient than the energy factor of 0.4775 required by Standard 90.1-1999.

Figures 6(c, d) and Figure 7 summarize the comparison between the annual energy performance of the example building, in Houston, constructed according to ASHRAE 90.1-1989 and 1999. Overall, the total annual energy use of ASHRAE Standard 90.1-1999 (3,207.81 MMBtu/year) is 13.4% less than the same building built to the specifications of ASHRAE Standard 90.1-1989 (3,705 MMBtu/year). The major portion of this (45% of the annual decrease, or a 17% reduction in the lighting load) is coming from the more stringent LPD criteria in ASHRAE Standard 90.1-1999 which limits the LPD to  $1.3 \text{ W/ft}^2$ . Another significant improvement is coming from the use of two smaller, staged boilers in the 1999 versus the one large boiler in 1989, which runs at lower



Figure 7: Comparison of Annual Energy Use (90.1-1989 vs 90.1-1999)

<sup>&</sup>lt;sup>21</sup> This is probably an unrealistic boiler size, since boilers are usually available in fixed sizes. Therefore, a more realistic simulation would have an index of actual boiler sizes to choose from.

<sup>&</sup>lt;sup>22</sup> For this simulation the performance curves from the USDOE's COMCHECK program input file were used, Version 1.1, Release 2.

<sup>&</sup>lt;sup>23</sup> This uses the same approach as Standard 90.1-1989.

part-load levels for a larger portion of the year (12% of the total annual savings, or a 21% reduction in the heating energy use). The fans, cooling energy and cooling tower also show an improvement because of the lower heating/cooling loads and more stringent envelope and interior load requirements (i.e., the BEPS categories: heat rejection, pumps and misc., and vent fans, 39% of the total annual savings).

#### Using the web-based calculator.

Figures 8 and 9 show the main menu and the "Express Calc" page of the Energy System Laboratory's web-based calculator for a commercial building. The "Express Calc" option was created to simplify the use of the analysis, and only requires 14 inputs to complete an analysis of the user input, code-compliant and pre-code simulations. If the user has more detailed information about the project, the input screen can be switched to the detailed mode by pressing the tab at the bottom of the page. This detailed mode allows for more information to be entered by the user, such as shading, surface colors, and system characteristics. To complete the simulated comparison of the user input with ASHRAE 90.1-1989 and ASHRAE 90.1-1999, seven simulations are run, and the results emailed to the user. The resultant savings from the simulations are then processed by the EPA's eGRID program to calculate the annual and peak NOx emissions reductions at the power plants that provided the electricity to the building. Additional information about the emissions calculations can be found in Haberl et al. (2003a,b; 2004a,b,c).

#### SUMMARY

This paper explains in detail the commercial DOE-2 simulation models that are employed in the Energy Systems Laboratory's web-based emissions reduction calculator (ecalc.tamu.edu<sup>24</sup>) and provides an example performance comparison for a 6 story building in Houston, Texas, built to meet ASHRAE Standard 90.1-1989, or Standard 90.1-1999. These models are used to determine the annual and peak day energy savings attained by constructing codecomplaint buildings for office and retail

buildings<sup>25</sup>. These resultant savings from the simulations are then processed by the EPA's eGRID program to calculate the annual and peak NOx emissions reductions at the power plants that provided the electricity to the building.

## ACKNOWLEDGMENTS

This project would not have been possible without significant input from the Senate Bill 5 team, including: Bahman Yazdani, Tom Fitzpatrick, Shirley Muns, Malcolm Verdict, Dan Turner, Sherrie Hughes, Rebecca Brister, and Holly Wiley. DOE-2 programming and graphics were supported by the efforts of Piljae Im and Jaya Mukhopadhyay. Significant input was also provided by the TCEQ program managers, including Steven Anderson and Alfred Reyes.

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<sup>&</sup>lt;sup>24</sup> To obtain copies of the DOE-2 input files, which include the .INC include files necessary for it to run, please contact the authors.

<sup>&</sup>lt;sup>25</sup> Additional models are being developed for other commercial/institutional building types, such as schools, hotels, etc.

	THE Energy Syste Energy & Emissio	EERING EXPER	IMENT STATION Y - eCalc		
l					
	SINGLE FAMILY	MULTI-F/	AMILY	OFFICE	RETAIL
	Community Proj		TRAFFIC LIGH	TS WATER SUPP	CORE WATER
	Penewables	v	SOLAR THERM	AL	WIND

Figure 8: Main menu of the emissions calculator

The Energy Systems Laborator Energy & Emissions Calculator	У ·- eCalc	
Express Calc     Building	Shade     Construction     System     Plant	
Duilding		
building	Couth	
Faces	3001	
Front (Width)	122 ft.	
Side (Depth)	122 ft.	
Number of floors	6	
Roof		
Roof insulation	R-15	
Wall		
Wall Insulation	R-13	
Windows		
Frame type	Aluminum without a thermal break	
U factor glazing	1.22 Btu/hr-ft2-F	
Solar Heat Gain Coefficient	0.17 SHGC	
Window-to-wall area ratio	50 %	
System		
Economizer type	None	
Cooling/heating choices	Electric   Electric	
Cooling efficiency	5 COP	
	75	

Figure 9: Office/retail input parameters screen

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