Window-Related Energy Consumption in the US Residential and Commercial Building Stock

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Abstract

We present a simple spreadsheet-based tool for estimating window-related energy consumption in the United States. Using available data on the properties of the installed US window stock, we estimate that windows are responsible for 2.15 quadrillion Btu (Quads) of heating energy consumption and 1.48 Quads of cooling energy consumption annually. We develop estimates of average U-factor and SHGC for current window sales. We estimate that a complete replacement of the installed window stock with these products would result in energy savings of approximately 1.2 quads. We demonstrate that future window technologies offer energy savings potentials of up to 3.9 Quads.

Introduction

According to the US Department of Energy, in 2003 space conditioning in residential and commercial buildings was responsible for 9.19 quadrillion Btu (Quads) of site energy consumption, and 12.03 Quads of primary (source) consumption (US DOE Office of Energy Efficiency and Renewable Energy 2005). Although windows are generally understood to be an important driver of space conditioning energy consumption, few studies have directly investigated the energy impacts of windows at the national level. In this study, we introduce a simple spreadsheet-based tool for estimating the national energy impacts of windows in residential and commercial buildings. After presenting estimates of current window-related energy consumption in the US building stock, we discuss the energy savings potential of various technology scenarios.

Methods and Results

This section is divided into two sub-sections. In the first section, we describe the techniques and assumptions involved in estimating the window-related energy consumption of the US building stock. In the second section, we describe the process we used to estimate the energy-savings potential of various window technologies.

Window-Related Energy Consumption of Building Stock

General Approach

In order to estimate the energy consumption attributable to the US window stock, we used a combination of top-down and bottom-up approaches. First, we compiled a set of estimates of total space conditioning energy consumption in the US building stock, broken down by sector (residential, commercial) and conditioning mode (heating, cooling). Second, for each of these four aggregated end use categories, we combined building energy simulations with market and survey data to estimate the fraction of total energy consumption attributable to windows. We then estimated the window-related space conditioning energy consumption for each end use category by multiplying total space conditioning energy consumption by the window-related fraction of that consumption. Finally, we determined a total national estimate by summing across the four end use categories. This approach is formalized below in Equation 1.

Equation 1

$$TWE^{Stock} = \sum_{S.E}\left(THE^{Stock}_{S,E} \times AWF^{Stock}_{S,E}\right)$$

where:

TWE *("Total Window Energy")* represents the total-window related primary energy consumption of the US building stock.
THE (*"Total HVAC Energy"*) represents the total primary HVAC energy consumption for a given end use in a given sector in the US building stock.
S represents a given sector of the US building stock (Residential or Commercial).
E represents a given end use for space conditioning energy (heating or cooling).
AWF ("Aggregate Window Fraction") represents the window-related fraction of space conditioning energy consumption (heating, cooling) for a given stock segment (residential, commercial).

National Energy Consumption Estimates

We used estimates of building space conditioning energy consumption published in the 2005 DOE Buildings Energy Databook as the starting point for our analysis, as presented in Table 1. In the following sections, we estimate the fraction of this energy consumption attributable to the installed window stock in residential and commercial buildings. We then estimate how this fraction would change under a variety of window technology scenarios.

Table 1 - Space Conditioning Energy Consumption in US Buildings

End Use	**Annual HVAC Energy Consumption** Quadrillion Primary BTU (quads)[1]	
	Residential Buildings	Commercial Buildings
Heating	6.90	2.45
Cooling	2.41	1.90
Total	9.31	4.35

Window Fraction of Total Energy Consumption

Background

Although the effects of windows on energy consumption are well understood at the building level, few studies have attempted a detailed characterization of the national energy impacts of windows. This limitation can be explained by several factors. First, the energy impacts of windows, even at the building level, are difficult to quantify without extensive monitoring and instrumentation. Computer energy simulations therefore offer a far more practical approach; however, the US building stock is highly heterogeneous, meaning dozens if not hundreds of models are required. Moreover, the composition and

[1] The term "Quad" is shorthand for 1 quadrillion (10^{15}) Btu = 1.056 EJ. "Primary" energy consumption includes a site-to-source conversion factor of 3.22 for electricity to account for losses in transmission, distribution, and generation. All energy consumption is reported in primary terms unless otherwise noted.

properties of the US building stock are poorly characterized with respect to shell integrity and energy efficiency. Detailed descriptions of the installed window stock are nonexistent. The most detailed datasets tend to be limited to a particular geographical region, while those with a national scope often leave key questions unanswered.

In order to estimate the fraction of building space conditioning energy consumption attributable to windows, we conducted a reanalysis of two simulation studies of building HVAC loads originally conducted by Joe Huang and others at Lawrence Berkeley National Laboratory (Huang and Franconi 1999; Huang et al. 1999). These studies relied on an extensive set of DOE-2 models ("prototypical buildings" or "prototypes") designed to capture the diversity of the US residential and commercial building stock. Using parametric simulations, the authors determined the relative contribution of internal heat gains and building envelope components to total space conditioning loads for each prototypical building. By weighting these building-level estimates with stock size data derived from the EIA Residential- and Commercial Building Energy Consumption Surveys (RECS, CBECS), the authors then developed aggregate estimates of total "component loads" for the US building stock.

General Procedure

We used prototype-level simulation results[2] published in Huang et al. (1999) and Huang and Franconi (1999) as a starting point for our analysis. These results estimate space conditioning loads attributable to each of a set of internal and envelope components for 80 prototypical residential buildings and 120 prototypical commercial buildings. We term these loads "component loads", and a list of the building component loads simulated in this study can be found in Table 10. We entered these loads into separate spreadsheets for residential and commercial buildings, with separate tables for heating loads and cooling loads. In order to estimate the percentage of space conditioning energy consumption attributable to windows for each of these end use categories, we used a six – step process. This process is briefly outlined below (see Figure 1 for a graphical representation) and explained in greater detail in the Residential Buildings and Commercial Buildings subsections.

- First, we categorized the component loads derived by Huang et al. into those that were at least partly attributable to windows (infiltration, window conduction, and window solar gain), and those that were not. For simplicity, we collapsed the loads unrelated to windows into a "non-window" category.
- Second, we used the most recent RECS and CBECS surveys to generate estimates of the size of the US building stock corresponding to each of Huang et al.'s prototypical buildings. We used these size estimates to determine the window-related and total loads at the national level that correspond with each of the 320 prototypical buildings simulated by Huang et al.
- Third, we used prototypical building-specific "efficiency factors" derived by Huang et al. to estimate the primary (source) energy consumption necessary to meet space conditioning loads.

[2] A list of all prototype buildings can be found in Table 9.

- Fourth, we used information from proprietary market research to generate up-to-date estimates of window energy efficiency that reflect the properties of today's window stock. As the assumed window properties of the prototype buildings used in the Huang studies differed from these values, we applied a set of correction factors to the window-related component loads.
- Fifth, we aggregated window and total loads across all building types to develop a set of aggregate space conditioning load estimates for the entire commercial and residential building stocks.
- Finally, we used these aggregated estimates to estimate the window-related fraction of building space conditioning energy consumption in residential and commercial buildings. This value was calculated by dividing the aggregate window-related load by the aggregate total load.

<u>Residential Buildings - Methods</u>

In this section, we provide additional detail on the methods used to estimate the fraction of residential space conditioning energy consumption attributable to windows. Figure 1 and Figure 2 show two different ways of looking at our procedure. Figure 1 breaks the process used into a linear, step-by-step form. However, the actual process used lends itself to being visualized on two axes (Figure 2). One axis involves estimating the window-related properties of individual segments of the residential building stock, while the other axis aggregates these properties across the entire building stock to develop a national-level estimate.

We chose to limit our analysis of the residential building stock to single-family residences, as significant details on window properties were unavailable for larger residential buildings. We therefore assume that residential window performance is well-approximated by single-family homes. As the 80 prototypical single-family homes in Huang et al.'s analysis correspond to buildings responsible for 74% of all residential energy consumption (EIA 2001), we believe this is a reasonable assumption.

The specific number of prototypical buildings (80) stems from Huang et al.'s study design, which divided the US housing stock both spatially (into 20 "climate zones") and temporally, with 4 construction "vintages" per climate zone. As can be seen in Appendix A, Huang et al.'s climate zones reflect not only climatic variation (in the guise of heating degree day and cooling degree day bands), but also political boundaries in the form of the US Census Divisions. In each climate zone, regionally specific construction patterns are represented by one prototypical building for each of four "vintages" or eras: Pre-1950s, 1950 – 1979, 1980 – 1989, and post-1989 [3]. Each of these 80 buildings were simulated with typical weather data (Typical Meteorological Year (TMY) format) for a representative city for each climate zone. Thus, a prototypical home might represent a pre-1950s Boston home, or a 1980s vintage Los Angeles home. For each prototypical

[3] Within a given region, the principal differences between different "vintages" include floor area, number of stories, window area, and level of insulation. Detailed descriptions of the properties of these prototypical buildings can be found in cited references(Huang and Franconi 1999; Huang, Hanford et al. 1999).

building, the contribution of the following components to total HVAC load was estimated:

Roof	Wall	Window Solar Gain*
Ground	Equipment	Window Conduction*
People		Infiltration*

* = Related to windows

As a starting point for our analysis, we transcribed Huang et al.'s estimated component loads into a spreadsheet. In their publicly-available format, these loads were presented as population aggregate loads; that is, they represent the sum of a given component load for all US buildings of a particular type. In order to determine building-level loads, we transcribed Huang's building population estimates, which were derived from the 1993 RECS survey. For simplicity, we grouped all non-window related loads into a single category. We assumed that 15% of total infiltration loads are window related (ASHRAE 2005). This corresponds to step 1 of the general process outlined in Figure 1.

Next, we used data from the 2001 RECS Survey to update Huang's estimates of the national building populations corresponding to each of the 80 prototypical single-family buildings. For our analysis, we used the RECS "microdata", which provides detailed survey responses for each of the 3,000 sampled single-family residences. These data include information on home construction date and local climate (heating degree days and cooling degree days) as well as "sample weight," an estimate of the total number of US homes with comparable properties to the survey home. Using these data, we developed estimates of the number of homes represented by each of the 80 prototypical single-family residences. We then linearly scaled Huang's component loads to reflect changes in building population between 1993 and 2003. For example, if the estimated population corresponding to a particular building decreased by 20% over this time period, then we estimated that aggregate loads were 20% smaller as large as well. This process corresponds to step 2 of the general process outlined in Figure 1.

Huang's building prototypes assume that the residential window stock is largely comprised of double-pane windows with wood or aluminum frames (Ritschard et al. 1992). As window properties were originally reported by Huang et al. in the form of center-of-glass U-factor and shading coefficient, we converted these estimates to whole-window U-factor and SHGC using a procedure developed by Finlayson et al. (Finlayson et al. 1993). In order to develop an up-to-date estimate of today's window stock properties, which have benefited from significant penetration of low-e products, we performed the following procedure. Since windows are replaced on average every 40 years (Ducker Research Company 2004), we estimate that roughly 20% of the US window stock was replaced between 1993 and 2001. Based on this observation, we developed an estimate of the typical properties of windows sold over the time period (Table 2). For each prototypical building, we estimated today's average U and SHGC with the following weighting: Pre-1993 whole window properties, 80%; 1993-2001 Sales properties, 20%. Based on this, we estimate the average U-factor of the residential building stock to be 0.75 Btu/(hr-ft^2-°F) and the average SHGC to be 0.68. For each prototypical building, we developed window load scaling factors that encapsulate our updated estimates of window U and SHGC (Equation 2 and Equation 3). This process corresponds with step 4 in Figure 1. As described below, we use these factors to linearly scale Huang et al.'s estimated window loads.

Equation 2 - Scaling Factor for Window Solar Heat Gain

$$SF^{Stock}_{(P,C=Solar)} = \frac{SHGC^{Stock,2001}_{P}}{SHGC^{1993}_{P}}$$

Equation 3 - Scaling Factor for Window Conduction

$$SF^{Stock}_{(P,C=Conduction)} = \frac{UFactor^{Stock,2001}_{P}}{UFactor^{1993}_{P}}$$

where:

***SF** ("Scaling Factor")* represents the load scaling factor for a particular residential prototypical building and window-related component load type.
C is a given window-related component load type (infiltration, solar gain or conduction);
P is a given prototypical residential building.
SHGC is Solar Heat gain coefficient assumed by Huang et al.. or the current authors. As described in the text, we used whole-window U and SHGC determined using the procedure developed by Finlayson et al.
U-factor is U-factor in Btu/(hr-ft²-°F)assumed by Huang et al. or the current authors. As described in the text, we used whole-window U and SHGC determined using the procedure developed by Finlayson et al.

Table 2 – Assumed Properties of Residential Window Sales 1993 - 2001

Type of Window	Percentage of Sales, 1993 – 2001	U-factor Btu/(hr-ft²-°F)	SHGC
Single Pane	8%	1.16	0.76
Double Pane	45%	0.59	0.56
Double Pane Low-e	45%	0.35	0.35
Triple Pane	2%	0.20	0.40
Average Properties	-	**0.52**	**0.48**

Sources: Window Sales Data: Ducker Research Company, 2004. Typical window properties: Carmody et al, 2000.

At this point in our analysis, we have updated Huang's estimates of window-related loads in all 80 residential buildings to reflect changes in housing stock populations and window energy efficiency. In order to illustrate the process thus far, Figure 2 gives a template view of this process for three fictitious prototypical buildings. This process is formalized in Equation 4 and Equation 5. Our updated estimated loads for all residential buildings can be found in Appendix D.

Equation 4 – Updated Window-Related Loads for Subset of Residential Building Stock

$$WL^{Stock,2001}_{E,C,P} = WL^{2001}_{E,C,P} \times \frac{SS^{2001}_{P}}{SS^{1993}_{P}} \times SF^{Stock}_{E,C}$$

Equation 5 – Updated Total Building Load for Subset of Residential Building Stock

$$TL_{E,P}^{2001} = \left(TL^{1993} + \sum_{C} WL_{E,C,P}^{2001} - \sum_{C} WL_{E,C,P}^{1993} \right) \times \frac{SS_{P}^{2001}}{SS_{P}^{1993}}$$

where:

E *is* a given end use (Heat, Cool).
C is a given window-related component load type (infiltration, solar gain, or conduction);
P is a given prototypical residential building.
WL *("Window Load")* is a window-related load.
SF *("Scaling Factor")* represents the load scaling factor for a particular residential prototypical building and window-related component load type.
TL *("Total Load")* is the total space conditioning load for a given end use in a given prototypical building.
SS *("Stock Size")* is the size of the building stock (in square feet of conditioned floor area) for a given prototypical building for a given year and end use.

The next step in our analysis was to aggregate window related loads to the national level (this corresponds to Step 5 in Figure 1). Since loads were already aggregated to the national level for each prototypical building (Figure 2), it was a trivial step to sum these loads across all 80 prototypical buildings to determine a national total of loads. We performed this separately for total building loads and each of the three window related loads (solar heat gain, conduction, and infiltration). Next, we divided window loads by total loads (formalized in Equation 6) to determine the window fraction of total loads (Step 6 in Figure 1). Finally, we make the assumption that the window fraction of building loads is a good approximation of the window fraction of total energy consumption. We believe that this is a conservative assumption, for two reasons. First, the overall range of efficiencies for home space conditioning systems is relatively small, at least in comparison to commercial buildings. Second, since less energy-efficient windows are likely to be found in homes with less-efficient space conditioning systems, the assumption of equal system efficiency at worst leads to an understatement of the true energy impacts of windows.

Equation 6 – Window Fraction of Total Space Conditioning Consumption for Given End Use

$$AWF_{(S=Residential,E)}^{Stock} = \frac{\sum_{C,P} WL_{E,C,P}^{Stock,2001}}{\sum_{C,P} TL_{E,P}^{2001}}$$

where:

AWF *("Aggregate Window Fraction")* is the aggregate fraction of total space conditioning energy consumption attributable to windows in the US residential building stock, for a given end use.

Residential Buildings – Results

Table 3 – Estimated Window-Related Energy Consumption for 2003 Residential Building Stock

	Total Annual HVAC Consumption [4]	Window % of HVAC Consumption		Window % of HVAC Consumption, No Infiltration	
	Quadrillion Primary BTU (Quads)	*% of total*	Window Quads	*% of Total*	Window Quads
Residential Heat	6.90	*24%*	1.65	*19%*	1.30
Residential Cool	2.41	*42%*	1.02	*39%*	0.94
Residential Total	**9.31**	***29%***	**2.67**	***24%***	**2.24**

Table 3 presents aggregate estimates of window-related energy consumption for the US residential building stock. The first column, "Total Annual HVAC Consumption," contains DOE estimates of total (primary) residential space conditioning energy use for 2003 (see above section entitled "National Energy Consumption Estimates"). In the second column, we present our estimate of the total fraction of residential space conditioning energy use attributable to windows. We estimate that windows are responsible for 24% of residential heating energy use and 42% of residential cooling energy use, or 29% of all residential space conditioning energy use. This is equivalent to 1.65 quads of heating energy use and 1.02 quads of cooling energy use, or a total of 2.67 quads of space conditioning energy use (third column). This is equivalent to roughly 2.7% of total US energy consumption. The final two columns present our estimates excluding window infiltration[5].

Commercial Buildings – Methods

Our methods for determining the window fraction of loads in commercial buildings are similar in general form to those used for residential buildings. Due to the diversity of the commercial building stock, we used Huang and Franconi's DOE-2 simulations of the 12 most common building types (see Table 9), which account for 74% of building floor area and 79% of energy consumption. We thus assume that the window properties of these 12 building types reflect those of the entire commercial building stock. This corresponds to a set of 120 parametric building simulations by Huang et al., described below.

For each of the twelve commercial building types identified by Huang and Franconi in their component load analysis, at least two prototypical buildings were developed to reflect "old" (Pre-1980) and "new" (Post-1980) construction patterns. These prototypical commercial buildings drew heavily on information available in the 1989 CBECS dataset. Owing to insufficient regional data in this CBECS dataset, a single national prototypical building was developed by Huang and Franconi for each of six of the twelve simulated building types (Appendix B). Each of these DOE-2 prototypical buildings was then simulated with weather data from cities corresponding to the 5 CBECS climate zones

[4] As reported in the 2005 Buildings Energy Databook Table 1.2.3 (US DOE Office of Energy Efficiency and Renewable Energy 2005).

[5] Controlling window infiltration is primarily a matter of applying developed technologies to window production and installation. Since the energy savings that improved window products are largely unrelated to infiltration rates, we present total window stock energy consumption both with and without infiltration for comparison purposes.

(Appendix B, Figure 5). For the remaining six building types, prototypical buildings were developed to correspond to broad "North" and "South" geographical regions (Appendix B, Figure 4). Huang and Franconi simulated these prototypical buildings with weather data typifying each of the 5 CBECS climate zones as shown in Appendix B.

This procedure resulted in a set of 120 parametric building simulations. The results of these simulations are publicly available in Huang and Franconi (1999), and are presented as specific loads (MBtu/sq ft floor area) for the following building components:

Roof	Wall	Window Solar Gain*
Ground	Electric/Non-Electric Equipment	Window Conduction*
People	Outdoor Air	Infiltration*
Floor	Lighting	

* = Related to windows

As a starting point for our analysis, we transcribed these results into a spreadsheet and categorized simulated component loads into those related to windows, and those not (Table 10). We assumed that 15% of all infiltration loads were window-related (ASHRAE 2005). As with the residential analysis, we grouped all non-window loads into a single category. This corresponds to Step 1 of the general process outlined in Figure 1.

Next, we used the 1999 CBECS[6] to estimate floor areas associated with each of the prototypical buildings simulated by Huang and Franconi. Similar to our residential analysis above, we used the CBECS "microdata" dataset, which encompasses approximately 3,700 buildings relevant to our study. Relevant reported information from the study included heated and cooled floor area, window type, age, location and sample weight. We used these data to estimate the heated and cooled floor area corresponding to each of Huang and Franconi's simulated prototypical buildings. This corresponds to Step 2 of the general process outlined in Figure 1.

In our analysis of window-related energy consumption in residential buildings, we assumed that the average efficiency of space conditioning systems across all single-family homes was similar. This conservative assumption allowed us to use estimated building loads as a proxy for building energy consumption. However, this is less possible for commercial buildings, where the efficiency of systems exhibits a great range of diversity across building types. Ignoring this diversity would tend to overestimate the energy impacts of windows in relatively more efficient buildings. In order to account for this, Huang and Franconi developed a metric known as "system factor," which estimates the amount of primary energy consumption required by space conditioning equipment to meet a given quantity of space conditioning load. We used building-specific system factors to convert Huang and Franconi's estimated loads into estimated energy consumption. This corresponds to Step 3 of the general process outlined in Figure 1.

[6] Although the 2003 CBECS provides more-up-to-date floor area estimates, regionally disaggregated data were unavailable.

The window properties of the prototypical commercial buildings modeled by Huang and Franconi appeared to be anomalously efficient, with an average U-factor of 0.64 Btu/(hr-ft²-°F) and SHGC of 0.66. Although data on the installed window stock in commercial buildings are exceedingly sparse, information contained in the CBECS survey leads us to believe that roughly half of the installed window stock has double-pane glass, with the remainder single pane (US DOE Energy Information Administration 1999), with windows mostly in aluminum frames. Since a typical U-factor for double-pane window in aluminum frame is around 0.70 Btu/(hr-ft²-°F) (ASHRAE 2005), we believe that Huang's estimated U-factor of 0.65 Btu/(hr-ft²-°F) is anomalously low; for comparison, single-pane windows in aluminum frame have a typical U-factor of ~1.2 Btu/(hr-ft²-°F). In the absence of better data, we assumed that all commercial windows in the 1999 building stock have U-factor of 0.75 Btu/(hr-ft²-°F) and SHGC of 0.66. This may still be a conservative estimate for U-factor given the large installed stock of single-pane glass in commercial buildings.

In order to account for the effects of these altered window properties on overall commercial building loads, we developed a set of scaling factors for each of the prototypical buildings simulated by Huang and Franconi. We assumed that conduction loads scale linearly with respect to U-factor, and solar gains scale linearly with respect to SHGC (Equation 6 and Equation 7). In the absence of more detailed data, we assumed that window infiltration is a constant 15% of total building infiltration for all window types. Following these assumptions, we created updated estimates for population aggregated window-related loads (Equation 9) for each prototypical building. This was accomplished by multiplying Huang and Franconi's estimated specific component loads for each prototypical building by their estimated efficiency factors, and our estimated window scaling factors and CBECS population sizes. We compensated for the effect of changed window efficiency by increasing or decreasing Huang and Franconi's estimated total building energy consumption by the amount estimated window energy consumption changed as a result of our modifications (Equation 10). Estimated aggregate window loads for the CBECS populations corresponding to all 120 prototypical building types can be found in Appendix E. Finally, we summed all 120 prototype-specific aggregate estimates of both window and total-building energy consumption in order to derive national totals. By dividing window consumption by total energy consumption, we estimated the window-related fraction of commercial building space conditioning energy consumption (Equation 11).

Equation 7 – Scaling factor for Window Solar Heat Gain

$$SF^{Stock}_{(P,C=Solar)} = \frac{SHGC^{Stock,1999}_{P}}{SHGC^{1991}_{P}}$$

Equation 8 – Scaling Factor for Window Conduction

$$SF^{Stock}_{(P,C=Conduction)} = \frac{UFactor^{Stock,1999}_{P}}{UFactor^{1991}_{P}}$$

Equation 9 - Updated Window-Related Loads for Subset of Commercial Building Stock

$$WE_{E,C,P}^{Stock,1999} = WL_{E,C,P}^{1991} \times \frac{SS_{E,P}^{1999}}{SS_{E,P}^{1991}} \times SF_{P,C}^{Stock} \times EF_{E,C,P}$$

Equation 10 - Updated Total Building Load for Subset of Commercial Building Stock

$$TE_{E,P}^{1999} = \frac{SS_{E,P}^{1999}}{SS_{E,P}^{1991}} \times \sum \left(TL_{E,P}^{1991} \times EF_{E,P} \right) + \left(\sum_{C} WE_{E,C,P}^{Stock,1999} - \sum_{C} \left(WL_{E,C,P}^{1991} \times EF_{E,P} \right) \right)$$

Equation 11 - Window Fraction of Total Space Conditioning Consumption for Given End Use

$$AWF_{(S=Commercial,E)}^{Stock} = \frac{\sum_{C,P} WE_{E,C,P}^{Stock,1999}}{\sum_{C,P} TWE_{E,P}^{1999}}$$

where:

***E** is* a given end use (Heat, Cool).
C is a given window-related component load type (infiltration, solar gain, or conduction).
P is a given prototypical commercial building.
***WL** ("Window Load")* is a window-related load.
***EF** ("Efficiency Factor")* is the ratio of primary energy consumption to HVAC loads for a given end use and prototype.
***WE** ("Window Energy")* is window-related energy consumption.
SHGC is Solar Heat gain coefficient assumed by Huang and Franconi or the authors.
U-factor is U-factor assumed by Huang and Franconi or the authors.
***SF** ("Scaling Factor")* represents the load scaling factor for a particular commercial prototypical building and window-related component load type.
***SS** ("Stock Size")* is the size of the building stock (in square feet of conditioned floor area) for a given prototypical building for a given year and end use.
***TL** ("Total Load")* is the total space conditioning load for a given end use in a given prototypical building.
***TE** ("Total Energy")* is total space conditioning energy consumption for a given end use in a given prototypical building.
***AWF** ("Aggregate Window Fraction")* is the aggregate fraction of total space conditioning energy consumption attributable to windows in the US commercial building stock, for a given end use.

Commercial Buildings – Results

Table 4 - Estimated Window-Related Energy Consumption in Commercial Buildings

	Total Annual HVAC Consumption [7]	**Window % of HVAC Consumption**		**Window % of HVAC Consumption, No Infiltration**	
	Quadrillion Primary BTU (Quads)	*% of total*	Window Quads	*% of Total*	Window Quads
Commercial Heat	2.45	*39%*	0.96	*35%*	0.85
Commercial Cool	1.90	*28%*	0.52	*28%*	0.54
Commercial Total	**4.35**	***34%***	**1.48**	***32%***	**1.39**

[7] As reported in the 2005 Buildings Energy Databook Table 1.3.3 (US DOE Office of Energy Efficiency and Renewable Energy 2005).

Table 4 presents aggregate estimates of window-related energy consumption for the US commercial building stock. The first column, "Total Annual HVAC Consumption," contains DOE estimates of total (primary) commercial space conditioning energy use for 2003 (see above section entitled "National Energy Consumption Estimates"). In the second column, we present our estimate of the total fraction of commercial space conditioning energy use attributable to windows. We estimate that windows are responsible for 39% of commercial heating energy use and 28% of commercial cooling energy use, or 34% of all commercial space conditioning energy use. This is equivalent to 0.96 quads of heating energy use and 0.52 quads of cooling energy use, or a total of 1.48 quads of space conditioning energy use (third column). This is equivalent to roughly 1.5% of total US energy consumption. The final two columns present our estimates excluding window infiltration.

Future Scenarios – Technology Potential Scenarios

In this section, we present estimates of the energy savings potential of a set of potential future window technology scenarios. For each window technology scenario, we present assumptions of typical technical performance characteristics (U-factor and SHGC) and estimates of the overnight stock turnover energy savings potential; that is, the energy savings that would result if today's entire window stock were replaced overnight with that window technology. Although this instant change is unrealistic, such estimates provide useful insight into the relative merits of different window technologies.

General Approach

The methods used in this section draw heavily on the techniques used to estimate the energy consumption of the existing U.S. window stock, as described in previous sections. In order to estimate the energy savings potential of a given window technology, we first estimated the total window-related energy consumption that would result in the US building stock if all windows were replaced with that window technology (Equation 12). In order to do this, we developed a set of scenarios that characterizes the properties (U-factor and SHGC) of a range of existing and future window technologies. For each scenario, we used our models of the existing residential and commercial building stock (see earlier sections) to estimate what the window-related fraction of space conditioning energy consumption would be if all windows in the existing building stock were replaced with that technology. We then estimated the energy savings potential of a given technology scenario using Equation 13. In the following sub-sections, we present a more detailed explanation of the methods and assumptions involved in our energy savings estimates for the U.S. residential and commercial building stock. We then present our results.

Equation 12 - Equation to estimate total window-related energy consumption under a given technology scenario

$$\mathbf{TWE}^{\mathbf{Scenario}} = \sum_{\mathbf{S,E}} \left(\mathbf{THE}^{\mathbf{Stock}}_{\mathbf{S,E}} \times \mathbf{AWF}^{\mathbf{Scenario}}_{\mathbf{S,E}} \right)$$

Equation 13 - Estimation of Energy Savings Potential of a Given Window Technology Scenario

$$TWS^{Scenario} = TWE^{Stock} - TWE^{Scenario}$$

Where:

$TWS^{Scenario}$ ("total window savings") represents the energy savings potential of a given window technology scenario if today's current window stock were replaced with a certain window technology.
$TWE^{Scenario}$ ("total window energy") represents the total-window related primary energy consumption of the US building stock under a given window technology scenario, as estimated in this section.
TWE^{Stock} ("total window energy") represents the total-window related primary energy consumption of today's US building stock, as estimated in the previous section.
THE ("total HVAC energy") represents the total primary HVAC energy consumption for a given end use in a given sector in the US building stock.
S represents a given sector of the US building stock (Residential or Commercial)
E represents a given end use for space conditioning energy (heating or cooling),
and
AWF ("Aggregate Window Fraction") is the aggregate fraction of total space conditioning energy consumption attributable to windows in the US residential building stock, for a given end use.

Residential Buildings – Methods and Assumptions

We estimated energy savings potential for seven residential window technology scenarios, described below. Assumed U-factors and SHGCs are presented in Table 5.

Table 5 - Residential Window Technology Scenarios Considered

Window Type	**U-factor** **Btu /(hr-ft²-°F)**	**Solar Heat Gain Coefficient (SHGC)**
Sales (Business as usual)	0.46	0.42
Energy Star (Low-e)	North: 0.35 North/South Central: 0.4 South : 0.65	0.4
Dynamic Low-e	0.35	0.15 / 0.40
Triple Pane Low-e	0.18	0.40
Mixed Triple, Dynamic	Northern U.S.: See Triple Low-e properties Central/Southern U.S.: See Dynamic Low-e properties	
High-R	0.10	0.40
High-R Dynamic	0.10	0.15 / 0.50

The scenario **Sales** reflects the average properties of residential windows sold today (Ducker Research Company 2004). This could be considered a business-as-usual scenario; if the market shares of today's mix of window technologies stayed constant, we would expect the window stock to eventually become quite similar to sales. Note, however, that savings estimates below present energy savings in terms of an overnight replacement of today's window stock. A detailed description of assumptions is presented in Appendix C.

The **Energy Star** scenario reflects typical properties for products meeting the DOE Energy Star window specification, which often have one or more low-e coatings. These high-performance products are rapidly becoming the standard residential window, with over 50% market penetration (Ducker Research Company 2004). A detailed description of assumptions is presented in Appendix C.

The **Dynamic Low-e** scenario reflects the properties of a hypothetical window product that dynamically changes its solar gain properties to admit or reject solar gains to minimize window-related energy consumption. For modeling purposes, we assume that dynamic window products maintain a low solar heat gain whenever cooling is required and high solar heat gain whenever heating is required. This scenario reflects a window system with a U-factor similar to today's double-glazed low-e windows, but with dynamic solar heat gain control. Such a product is now available commercially from Sage Electrochromics, Inc (Sage Electrochromics 2006).

The **Triple Pane Low-e** scenario is representative of high-end triple glazed windows available today.

The **Mixed Triple, Dynamic** scenario considers a regionally optimized deployment of windows from the **Dynamic Low-e** and **Triple Pane Low-e** scenarios. We assume that triple pane low-e windows are used in the northern US (where heating dominates space conditioning energy consumption, so low U-factors are of particular benefit), and dynamic low-e windows in the remainder of the country. A detailed description of assumptions is presented in Appendix C.

The **High-R** scenario considers a highly insulating (U-factor = 0.10 Btu / (hr-ft^2-°F)) window with fixed solar heat gain properties. Off-the-shelf technologies currently do not exist for such products; however, these windows are under active R&D at Lawrence Berkeley National Laboratory and elsewhere.

The **Dynamic High-R** scenario considers a potential outer bound of window energy performance: highly insulting windows with dynamically controllable solar heat gain across a very large range.

For each of the above-described scenarios, we estimated the potential energy savings from overnight stock turnover as follows. First, for each prototypical building, we developed a set of window energy consumption scaling factors for conduction and solar loads (Equation 14 and Equation 15). For solar loads, this scaling factor reflects the ratio of assumed SHGC in a given window technology scenario to our corrected whole-window estimates of SHGC used by Huang et al. (see residential window stock section). Similarly, for conduction loads, this scaling factor reflects the ratio of scenario U-factor to our corrected estimate of whole-window U-factor.

Second, we estimated window related-energy consumption under each scenario for each subset of the residential building stock corresponding to a single prototypical building (Equation 16)[8]. Third, we aggregated energy consumption across each residential prototypical building category in order to develop an estimate of total window-related

[8]As in the procedure used in Equation 4, we assume that system efficiencies are relatively constant across the residential stock in order to use HVAC loads as a proxy for HVAC energy consumption.

energy consumption for each scenario. By dividing this by the estimated residential building stock energy consumption developed in Equation 5, we estimated the window fraction of HVAC energy consumption for each scenario (Equation 17). These steps correspond to the procedure used earlier in estimating residential window stock energy consumption (Equation 4 and Equation 6). Finally, we used Equation 12 and Equation 13 to calculate the energy savings potential of each technology scenario.

Equation 14 - Solar Load Scaling Factor for Residential Window Technology Scenarios

$$SF^{Scenario}_{(P,C=Solar)} = \frac{SHGC^{Scenario,2001}_{P}}{SHGC^{1993}_{P}}$$

Equation 15 - Conduction Load Scaling Factor for Residential Window Technology Scenarios

$$SF^{Scenario}_{(P,C=Conduction)} = \frac{UFactor^{Scenario,2001}_{P}}{UFactor^{1993}_{P}}$$

Equation 16 - Scenario Total Building Load for Subset of Residential Building Stock

$$WL^{Scenario,2001}_{E,C,P} = WL^{2001}_{E,C,P} \times \frac{SS^{2001}_{P}}{SS^{1993}_{P}} \times SF^{Scenario}_{E,C}$$

Equation 17 - Window Fraction of Residential HVAC Energy Consumption for Window Technology Scenarios

$$AWF^{Scenario}_{(S=Residential,E)} = \frac{\sum_{C,P} WL^{Scenario,2001}_{E,C,P}}{\sum_{C,P} TL^{2001}_{E,P}}$$

Where:

***E** is* a given end use (Heat, Cool).
C is a given window-related component load type (infiltration, solar gain, or conduction).
P is a given prototypical commercial building.
***WL** ("Window Load")* is a window-related load.
SHGC is Solar Heat gain coefficient assumed by Huang et al. or the authors.
U-factor is U-factor assumed by Huang et al. or the authors.
***SF** ("Scaling Factor")* represents the load scaling factor for a particular commercial prototypical building and window-related component load type.
***SS** ("Stock Size")* is the size of the building stock (in square feet of conditioned floor area) for a given prototypical building for a given year and end use.
***AWF** ("Aggregate Window Fraction")* is the aggregate fraction of total space conditioning energy consumption attributable to windows in the US commercial building stock, for a given end use.

Residential Buildings – Results

Estimates of savings potential for residential window technology scenarios are presented in Table 6.

Table 6 - Energy Savings Potential of Residential Window Technology Scenarios

Scenario	Energy Savings over Current Stock		
	Heat, quads	Cool, quads	Total, quads
Sales (Business as usual)	0.49	0.37	0.86
Energy Star (Low-e)	0.69	0.43	1.12
Dynamic Low-e	0.74	0.75	1.49
Triple Pane Low-e	1.20	0.44	1.64
Mixed Triple, Dynamic	1.22	0.55	1.77
High-R Superwindow	1.41	0.44	1.85
High-R Dynamic	1.50	0.75	2.25

We offer the following observations on energy savings potentials in the residential sector:

- The "ENERGY STAR" scenario offers relatively modest energy savings beyond the business-as usual case (0.3 quads). This is due to the large fraction of ENERGY STAR windows which make up current sales.
- Triple pane low-e windows, today's highest-performers, offer 0.8 quads of savings beyond the business-as-usual case, focused mainly in heating dominated climates.
- Next-generation "High-R Superwindows" offer energy savings significantly beyond sales (1.0 quads), with savings again mostly in heating applications.
- Even deeper energy savings can be achieved by coupling dynamic solar heat gain control with highly insulating windows. High-R Dynamic windows offer ~1.4 quads of energy savings beyond sales. Here, the entire U.S. window stock would result in zero net heating energy consumption on a national basis, while cooling energy consumption would be reduced by 80% from current values.

Commercial Buildings – Methods and Assumptions

We estimated energy savings potential for five commercial window technology scenarios, described below. Assumed U-factors and SHGCs are presented in Table 7.

Table 7 - Commercial Window Technology Scenarios Considered

Window Type	U-factor Btu /(hr-ft²-°F)	SHGC
Sales (Business as usual)	0.62	0.48
Low-e	0.40	0.29
Dynamic Low-e	0.40	0.10 / 0.40
Triple Pane Low-e	0.20	0.25
High-R Dynamic	0.15	0.05 / 0.50

The **Sales** (business-as-usual) scenario reflects the average properties of commercial windows sold today (Ducker Research Company 2004). A detailed description of assumptions is presented in Appendix C.

The **Low-e** scenario reflects typical properties for low-e double paned windows in commercial buildings. In contrast to the residential sector, low-e windows still have relatively low market penetration (30%) (Ducker Research Company 2004).

The **Dynamic Low-e** scenario reflects the properties of a hypothetical window product that dynamically changes its solar gain properties to admit or reject solar gains to minimize window-related energy consumption. This scenario reflects a window system with a U-factor similar to today's double-glazed low-e windows, but with dynamic solar heat gain control. For modeling purposes, we assume that dynamic window products maintain a low solar heat gain whenever cooling is required and high solar heat gain whenever heating is required. Note that the control strategy presented achieves optimal results in reducing building HVAC energy consumption, but may produce sub-optimal whole building energy savings due to interactions with lighting.

The **Triple Pane Low-e** scenario is representative of high-end triple glazed windows available today.

The **High-R Dynamic** scenario considers very highly insulating windows with dynamically controllable solar heat gain properties switching over a broad range of SHGCs.

Energy savings potentials for these scenarios were estimated much the same as those for the residential window scenarios (Equation 12 - Equation 17). First, for each prototypical building, we developed a set of window energy consumption scaling factors for conduction and solar loads (Equation 18 and Equation 19). For solar loads, this scaling factor reflects the ratio of assumed SHGC in a given window technology scenario to our corrected whole-window estimates of SHGC used by Huang and Franconi (SHGC = 0.66, see commercial window stock section). Similarly, for conduction loads, this scaling factor reflects the ratio of scenario U-factor to our corrected estimate of whole-window U-factor (0.75 Btu/(hr-ft²-°F)).

Second, we estimated window related-energy consumption under each scenario for each subset of the commercial building stock corresponding to a single prototypical building (Equation 20). Third, we aggregated energy consumption across each residential prototypical building category in order to develop an estimate of total window-related energy consumption for each scenario. By dividing this by the estimated commercial building stock energy consumption developed in Equation 10, we estimated the window fraction of HVAC energy consumption for each scenario (Equation 21). These steps correspond to the procedure used earlier in estimating commercial window stock energy consumption (Equation 9 and Equation 11). Finally, we used Equation 12 and Equation 13 to calculate the energy savings potential of each technology scenario.

Equation 18 - Solar Load Scaling Factor for Commercial Window Technology Scenarios

$$SF_{(P,C=Solar)}^{Scenario} = \frac{SHGC_{P}^{Scenario,1999}}{SHGC_{P}^{1991}}$$

Equation 19 - Conduction Load Scaling Factor for Commercial Window Technology Scenarios

$$SF_{(P,C=Conduction)}^{Scenario} = \frac{UFactor_{P}^{Scenario,1999}}{UFactor_{P}^{1991}}$$

Equation 20 - Scenario Total Building Consumption for Subset of Commercial Building Stock

$$WE_{E,C,P}^{Scenario,1999} = WL_{E,C,P}^{1991} \times \frac{SS_{E,P}^{1999}}{SS_{E,P}^{1991}} \times SF_{P,C}^{Scenario} \times EF_{E,P}$$

Equation 21 - Window Fraction of Commercial HVAC Energy Consumption for Window Technology Scenarios

$$AWF_{(S=Commercial,E)}^{Scenario} = \frac{\sum_{C,P} WC_{E,C,P}^{Scenario,1999}}{\sum_{C,P} TC_{E,P}^{1999}}$$

***E** is* a given end use (Heat, Cool).
C is a given window-related component load type (infiltration, solar gain, or conduction).
P is a given prototypical residential building.
***WL** ("Window Load")* is a window-related load.
***EF** ("Efficiency Factor")* is the ratio of primary energy consumption to HVAC loads for a given end use and prototype.
***WE** ("Window Energy")* is window-related energy consumption.
SHGC is Solar Heat gain coefficient assumed by Huang and Franconi or the authors.
U-factor is U-factor assumed by Huang and Franconi or the authors.
***SF** ("Scaling Factor")* represents the load scaling factor for a particular residential prototypical building and window-related component load type.
***SS** ("Stock Size")* is the size of the building stock (in square feet of conditioned floor area) for a given prototypical building for a given year and end use.
***AWF** ("Aggregate Window Fraction")* is the aggregate fraction of total space conditioning energy consumption attributable to windows in the US residential building stock.

Commercial Buildings – Results

Estimates of savings potential for commercial window technology scenarios are presented in Table 8.

Table 8 - Estimated Energy Savings from Commercial Window Technology Scenarios

Window Type	Energy Savings over Current Stock		
	Heat, quads	Cool, quads	Total, quads
Sales (Business as usual)	0.03	0.17	0.20
Low-e	0.33	0.32	0.65
Dynamic Low-e	0.45	0.53	0.98
Triple Pane Low-e	0.71	0.31	1.02
High-R Dynamic	1.10	0.52	1.62

We offer the following observations on the potentials in the commercial sector:

- Significant energy savings from low-e window technology are possible in the commercial buildings sector where the current penetration of low-e technology is modest. Full adoption of low-e technology would save 0.4 to 0.5 quads over sales.
- Both triple pane low-e and dynamic low-e product scenarios offer substantially larger energy savings than what would be possible with low-e products. Either scenario offers potential energy savings of approximately 0.8 quads over sales. Dynamic low-e products appear particularly promising, as they offer peak demand reductions.
- Adding dynamic solar heat gain control to the High-R Superwindow technology scenario dramatically improves cooling season energy performance. We estimate that this scenario offers energy savings of approximately 1.4 quads over the business as usual case.

Uncertainties

The estimates presented in this paper were developed using the best data and methods available to us. However, these results are strongly dependent on a variety of factors, including especially:

- Estimates of the properties of the current installed window stock.
- Estimates of the properties of today's window sales, as well as those of future products.
- Simplifying assumptions in our methods.

We offer the following cautions. As discussed in the beginning of this paper, the properties of both today's installed window stock and current window sales are poorly characterized. Our estimates of current window stock properties are based on models originally developed by Huang et al. in the mid-1990s. Although we have made an effort to account for the sales of relatively more energy-efficient windows in the intervening time period, we cannot be certain that we have accurately characterized today's window stock. Our estimates of the properties of today's window sales are based on a single proprietary dataset which contains some information gaps; several inferences were required to estimate the properties of today's window sales. Despite this, we believe that estimated properties of today's window sales are less uncertain than those of today's installed window stock. Because of this, we believe that the relative uncertainty in window-related energy savings between "stock" and "sales" scenarios is likely to be greater than the relative uncertainty between "sales" and future scenarios, or between different future scenarios.

Our savings estimates are also a strong function of the basis for the methodology, which is an understanding of heat flows through conventional windows in the current building stock. As product scenarios deviate more and more from conventional products, the uncertainty in our calculations increases. The utilization of solar gains with highly insulating windows, which leads to windows with positive heating energy flows offsetting building heating needs from other components, makes theoretical sense but needs to be evaluated in the context of buildings with other advanced components where there may be less overall heating demand. Other methodological issues are rooted in the many simplifying assumptions discussed above, such as:

- Uniform national window properties for the “sales” scenario.
- Window-related loads scale linearly with changes in SHGC and U-factor.
- HVAC-optimized operation of dynamic window products.
- Simplification of US building stock to set of prototypical buildings.

We believe that these methodological issues contribute primarily to uncertainty in the overall estimate of window-related energy consumption, and less so to the relative differences in energy savings potential of various window technology scenarios.

Table 9 – Prototypical Buildings used for Residential and Commercial Analyses

Residential	Commercial	
Considered:	Large Offices	Small Offices
Single-family Attached/Detached	Large Hotels	Small Hotels
Not Considered (See Text):	Large Retail Stores	Small Retail Stores
Mobile Homes	Schools	Hospitals
Multi-Family (2-4 Units)	Sit-Down Restaurants	Fast Food Restaurants
Multi-Family (>4 Units)	Supermarkets	Warehouses

Table 10 – Component Loads Simulated by Huang et al.

Residential	Commercial
Window Solar*	Window Solar*
Window Conduction*	Window Conduction*
Infiltration*	Infiltration*
Roof	Floor
Wall	Ground
People	Equipment (Electric/Non-Electric)
Equipment	People
Ground	Lighting
	Outdoor Air

* = Window – Related Load

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Figure 1 – Schematic Overview of Method to Estimate Window % of Space Conditioning Use

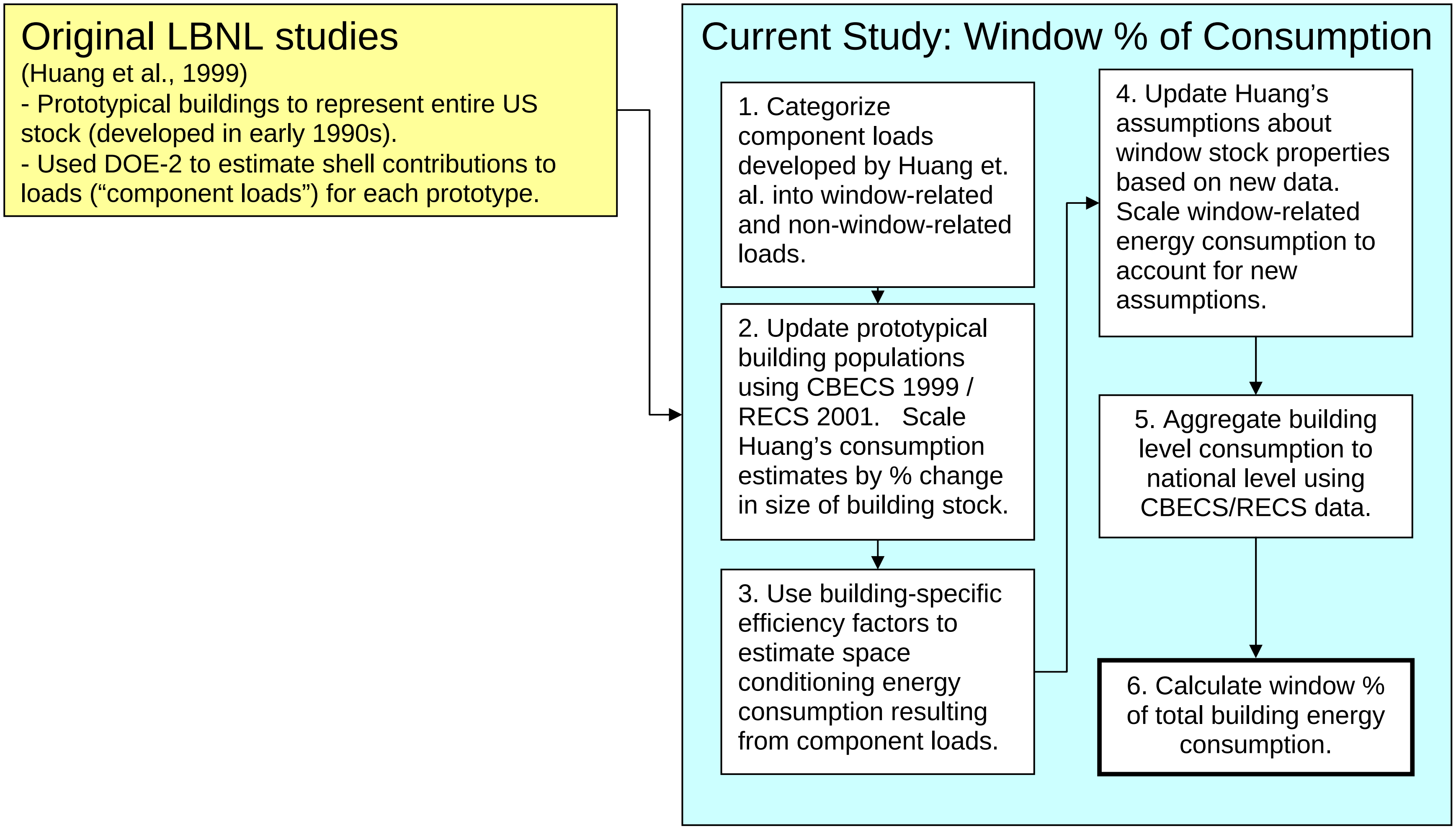


Figure 2 - Template for Estimation of Fraction of Total Loads Attributable to Windows

1. Estimate Window Energy Loads by Building Type

2. Aggregate across building types

Climate Zone	Year Made	1993 Properties Estimated by Huang, Hanford, et al. (1999)								2001 Updated Window Stock Estimates (Apte and Arasteh, 2006)								
			Window Properties		Total Building Heating Loads (Trillion BTU/yr)						Window Properties		Total Building Cooling Loads (Trillion BTU/yr)					
		Number of Buildings (1000's, 1993)	U-factor	SHGC	Wind. Solar	Wind. Cond	Infilt	Other Loads	Total Loads	Number of Buildings (Thousands, 2001)	U Factor	SHGC	Wind. Solar	Wind. Cond	Wind. Infilt.	Non. Wind Infilt	Other Loads	Total Loads
Sample 1†		100	1	1	10	-20	-20	-70	-100	100	0.5	1	10	-10	-3	-17	-70	-90
Sample 2		100	1	1	10	-20	-20	-70	-100	100	0.5	0.5	5	-10	-3	-17	-70	-95
Sample 3		100	1	1	10	-20	-20	-70	-100	200	0.5	0.5	10	-20	-6	-34	-140	-190
1*	Before 1950	1217.5	0.55	0.67	7.65	-18.3	-34.15	-38.11	-82.91	1175.9	0.55	0.65	7.16	-17.57	-4.95	-28.04	-39.64	-83.03
1*	1950-1979	1031.1	0.72	0.72	8.04	-31.59	-32.72	-34.48	-90.75	1292.0	0.61	0.66	9.21	-33.55	-6.15	-34.85	-20.24	-85.59
3*	1980-1989	355.9	0.72	0.72	2	-7.62	-8.77	-10.04	-24.43	1240.3	0.61	0.66	6.37	-22.44	-4.58	-25.98	25.72	-20.92
										Load Totals			47.7	-113.6	-27.7	-156.9	-314.2	-564.54
										Percentage of Total Loads			-8.5%	20.1%	4.9%	28.0%	55.7%	100%
										Total Window Related Loads			16.5% of total loads					
										Total Window Energy Consumption			3 Quads Total Heating * 16.5% of Total Loads = 0.5 Quads Window Energy Consumption (3 Quads is fictitious value for illustration purposes)					

† Sample loads are fictitious values used to illustrate calculation procedure

* Cited from Appendix B

3. Convert Aggregate Loads to Percentage of Total Loads

Three key thematic processes in estimating the total window-related building loads:

1. (Horizontal Axis in Table) – Estimate window-related loads for a particular grouping of similar US residential buildings.
2. (Vertical Axis in Table) – Aggregate window-related loads across entire US residential building population.
3. Convert aggregate loads to percentage of total loads.

Appendix A – Climate Zones used for Residential Analysis

Prototypical Single-family Residential buildings were simulated by Huang, Hanford, et al. (1999) in the following climate zones, which we adopted for use.

Figure 3 - Climate Zones Used by Huang et al. for Residential Simulations

Table 11 – Residential Climate Zone Divisions (after Huang et al, 1999)

Climate Zone	DOE-2 City (16)	Census Division	HDD	CDD
1	Boston	New England		
2	New York	Middle Atlantic		
3	Chicago	East North Central	<7000	
4	Chicago	East North Central	>7000	
5	Minneapolis	West North Central	> 7000	
6	Kansas City	West North Central	< 7000	
7	Washington	South Atlantic	> 4000	
8	Atlanta	South Atlantic	< 4000	< 3000
9	Miami	South Atlantic	< 4000	> 3000
10	Washington	East South Central	> 4000	
11	Atlanta	East South Central	< 4000	
12	Fort Worth	West South Central	> 2000	
13	Lake Charles	West South Central	< 2000	
14	Minneapolis	Mountain	> 7000	
15	Denver	Mountain	< 7000 > 5000	

16	Albuquerque	Mountain	< 5000	< 2000
17	Phoenix	Mountain	< 5000	> 2000
18	Seattle	Pacific	> 4000	
19	San Francisco	Pacific	< 4000 > 2000	
20	Los Angeles	Pacific	< 2000	

Appendix B – CBECS Climate Zones used by Huang and Franconi (1999)

Table 12 - Mapping of CBECS Data to Simulations by Huang and Franconi

CBECS Climate Zone (Figure 5)	**CDD Range**	**HDD Range**	**Regional Prototypical Building Simulated**[9] (Table 13)	**TMY Weather Location**
1	< 2000	> 7000	North	Minneapolis
2	< 2000	5500 – 7000	North	Chicago
3	< 2000	4000 – 4599	North and South Buildings Simulated, Results Averaged	Washington, DC.
4	< 2000	< 4000	South	Los Angeles
5	> 2000	< 4000	South	Houston

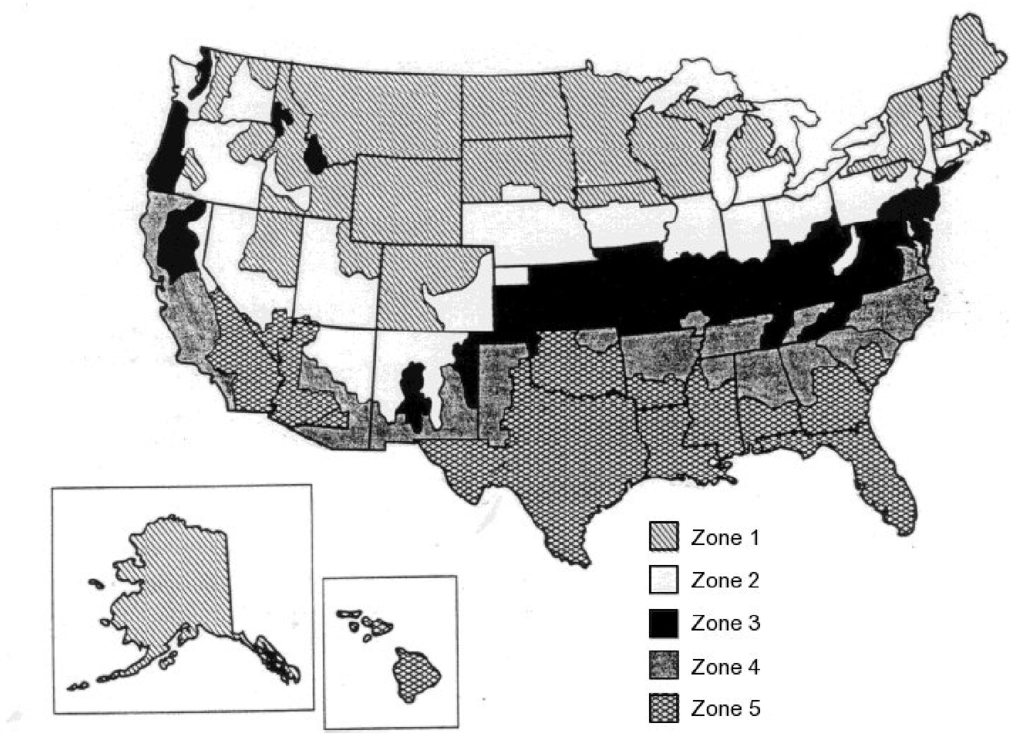
Table 13 – Prototypical Commercial Buildings (Huang and Franconi, 1999)

Building types with single national DOE-2 prototypical building	**Building types with North/South DOE-2 prototypical buildings**
Large Hotels	Large Offices
Small Hotels	Small Offices
Fast Food Restaurants	Large Retail Stores
Sit-Down Restaurants	Small Retail Stores
Hospitals	Schools
Supermarkets	Warehouses

Figure 4 - North/South Climate Zones for Prototypical Commercial Buildings

[9] As shown in Table 13, prototypical commercial buildings were either developed for both North and South climate zones (Figure 4) or for the entire US stock. See main text for explanation.

Figure 5 – CBECS Climate Zones for DOE-2 Simulation of Prototypical Commercial Buildings



After Huang and Franconi (1999)

Appendix C – Window Technology Scenario Assumptions

Residential Sales Scenario

Assumed window properties are presented in Table 14 and were determined as follows. First, we used market survey data to estimate the market shares of dominant window products (Ducker Research Company 2004). Next, we estimated average U-factor and SHGC for typical windows products in each category. We used the following simplifying assumptions:

- All single pane windows use aluminum frames.
- 75% of double pane (clear) windows have wood/vinyl frames, 25% have aluminum frames.
- All Double Pane Low-e windows have wood/vinyl frames and low-moderate solar heat gain.
- Triple pane windows have high-performance wood/vinyl frames and moderate solar heat gain.

Based on these assumptions, we used a database of currently available products to estimate typical window properties for each category (Carmody et al. 2000). Finally, we calculated sales-weighted average U-factor and SHGC for current residential window sales.

Table 14 - Assumed Properties of Residential Window Sales

Window Type	**Percent of Sales**	**U – Factor** Btu / (hr-ft²-°F)	**SHGC**
Single Pane, Clear Glass	4%	1.16	0.76
Double Pane, Clear Glass	40%	0.54	0.56
Double Pane, Low-e Glass	54%	0.35	0.35
Triple Pane, Low-e Glass	2%	0.20	0.40
Average Properties		**0.46**	**0.45**

Residential Energy Star Scenario

US EPA/DOE's Energy Star program specifies minimum window energy performance standards for windows carrying the Energy Star label. Requirements are specified separately for four climate zones (Figure 6). Table 15 presents Energy Star Window product requirements and assumed window properties by climate zone. We assume that windows just meet the Energy Star specification for U-value. Since low-solar heat gain glazings are now the dominant low-e product in the U.S. (Ducker Research Company 2004), we assume that all low-E windows sold in the US have SHGC = 0.40, which is required of Energy Star products in the Southern U.S.

As can be seen in Figure 3 and Figure 6, Energy Star climate zones do not overlap perfectly with the climate zones devised by Huang et al. for the simulation of residential prototypical buildings. We mapped each of Huang's climate zones to one Energy Star climate zone, as presented in Table 16.

Figure 6 - Energy Star Windows Climate Zones

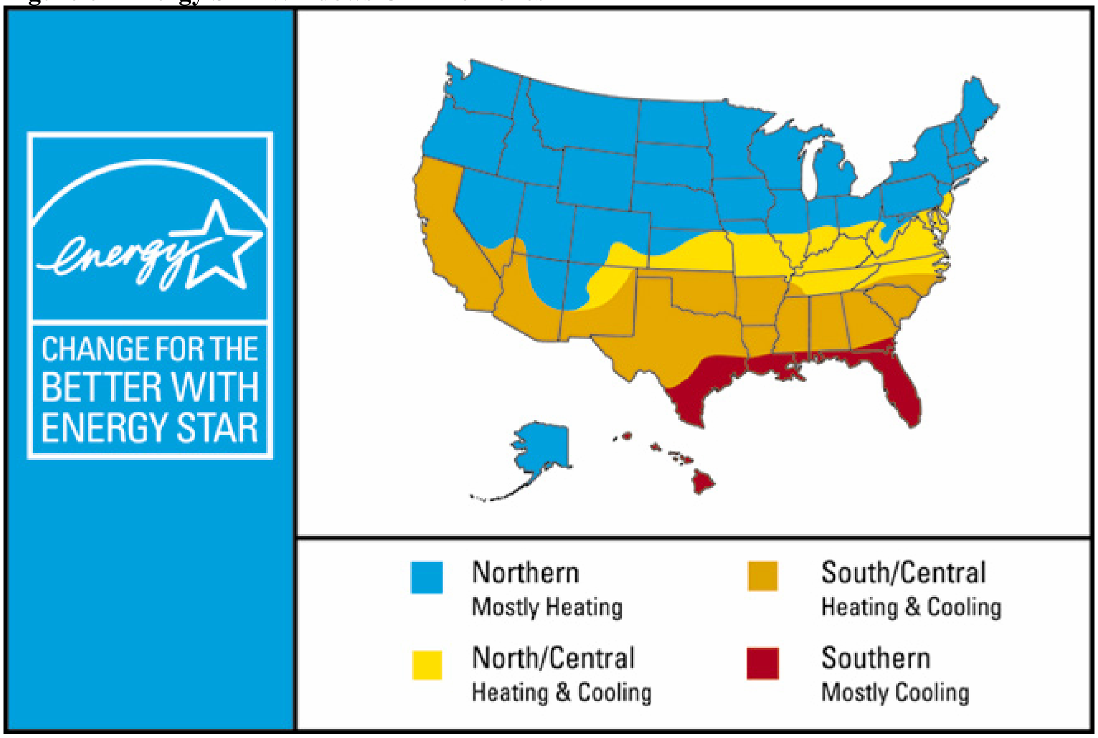


Table 15 - Energy Star Window Assumptions

Energy Star Climate Zone	**Energy Star Specification Requirements**		**Window Properties as Simulated**	
	U – Factor Btu / (hr-ft²-°F)	**SHGC**	**U – Factor** Btu / (hr-ft²-°F)	**SHGC**
Northern	≤ 0.35	Any	0.35	0.40
North/Central	≤ 0.40	≤ 0.55	0.4	0.40
South/Central	≤ 0.40	≤ 0.40	0.4	0.40
Southern	≤ 0.65	≤ 0.40	0.65	0.40

Table 16 - Energy Star Climate Zones

Energy Star Climate Zone	**Corresponding Climate Zones Used by Huang et al.** (see Appendix A)
Northern	1,2,3,4,5,14,15,18
North/Central	6,7,10,16
South/Central	8,11,12,17,19,20
Southern	9,13

<u>Residential Mixed Triple, Dynamic Scenario</u>
The Mixed Triple, Dynamic scenario considers a regionally optimized deployment of windows from the Dynamic Low-e and Triple Pane Low-e scenarios, as described in the main text. Specifically, we assumed that windows from the Triple Pane Low-e scenario

were installed in the climate zones simulated by Huang et al. corresponding to the Northern and North/Central Energy Star Climate Zones. Dynamic Low-e Scenario were assumed to have been installed in the Southern and South/Central Energy Star Climate Zones.

Commercial Sales Scenario

Assumed window properties for the commercial sales scenario are presented in Table 14 and were determined as follows. First, we used market survey data to estimate the market shares of dominant window glazing types (Ducker Research Company 2004). Next, we assumed that all commercial glazings were installed in aluminum curtain wall frames, and assumed typical ASHRAE U-factor and SHGC for this type of installation (ASHRAE 2005)[10]. Based on these assumptions, we calculated sales-weighted average U-Factor and SHGC for commercial windows sales.

Table 17 - Assumed Properties of Commercial Window Sales

Window Type	**Percent of Sales**	**U – Factor** Btu / (hr-ft²-°F)	**SHGC**
Single Pane, Clear Glass	11%	1.16	0.74
Double Pane, Clear Glass	30%	0.62	0.63
Double Pane, Tinted Glass	6%	0.65	0.13
Double Pane, Reflective Glass	20%	0.62	0.46
Double Pane, Low-e Glass	30%	0.51	0.34
Triple Pane, Low-e Glass	3%	0.51	0.34
Average Properties	**100%**	**0.64**	**0.48**

[10] This assumption provides a conservative estimate of window savings from this scenario; if some glazings are installed in more energy-efficient frames, energy savings would be higher.

Appendix D – Complete Residential Results

Heating Loads

Climate Zone	Year Made	1991 Properties Estimated by Huang, Hanford, et al (1999)								2001 Updated Window Stock Estimates (Apte and Arasteh, 2006)								
			Window Properties		Total Building Heating Loads (Trillion BTU/yr)						Window Properties		Total Building Cooling Loads (Trillion BTU/yr)					
		Number of Buildings (Thousands, 1993)	U Factor	SHGC	Window Solar	Window Cond	Infiltration	Other Loads	Total Loads	Number of Buildings (Thousands, 2001)	U Factor	SHGC	Window Solar	Window Cond	Window Infiltration	Non-Window Infiltration	Other Loads	Total Loads
1	Before 1950	1217.5	0.55	0.67	7.65	-18.3	-34.15	-38.11	-82.91	1175.9	0.55	0.65	7.16	-17.57	-4.95	-28.04	-39.64	-83.03
1	1950-1979	1031.1	0.72	0.72	8.04	-31.59	-32.72	-34.48	-90.75	1292.0	0.61	0.66	9.21	-33.55	-6.15	-34.85	-20.24	-85.59
1	1980-1989	326	0.72	0.72	1.69	-6.36	-7.95	-8	-20.62	369.2	0.61	0.66	1.75	-6.10	-1.35	-7.65	-6.33	-19.68
1	After 1989	135.2	0.50	0.61	0.04	-2.41	-3.04	-1.64	-7.05	226.4	0.46	0.59	0.07	-3.74	-0.76	-4.33	2.01	-6.76
2	Before 1950	2360.9	0.55	0.67	12.34	-30.28	-59.96	-64.79	-142.69	2132.7	0.55	0.65	10.80	-27.19	-8.12	-46.04	-72.32	-142.87
2	1950-1979	3477.5	0.72	0.72	19.83	-85.15	-94	-101.5	-260.82	2807.8	0.61	0.66	14.63	-58.25	-11.38	-64.51	-132.18	-251.69
2	1980-1989	788.8	0.72	0.72	2.95	-13.47	-19.04	-8.93	-38.49	637.1	0.61	0.66	2.18	-9.20	-2.31	-13.07	-14.61	-37.02
2	After 1989	212.6	0.50	0.61	0	-3.34	-4.78	-2.26	-10.38	536.4	0.46	0.59	0.00	-7.81	-1.81	-10.25	10.11	-9.76
3	Before 1950	961.6	0.55	0.67	7.23	-17.71	-30.31	-38.31	-79.1	3660.2	0.55	0.65	26.68	-67.01	-17.31	-98.07	76.16	-79.54
3	1950-1979	1238.4	0.72	0.72	4.75	-24.12	-23.72	-35.75	-78.84	4153.9	0.61	0.66	14.56	-68.63	-11.93	-67.63	65.69	-67.94
3	1980-1989	355.9	0.72	0.72	2	-7.62	-8.77	-10.04	-24.43	1240.3	0.61	0.66	6.37	-22.44	-4.58	-25.98	25.72	-20.92
3	After 1989	203.8	0.50	0.61	0.08	-4.19	-4.87	-3.19	-12.17	1368.8	0.46	0.59	0.52	-26.07	-4.91	-27.80	48.14	-10.12
4	Before 1950	3409.1	0.55	0.67	25.57	-62.6	-107.15	-135.48	-279.66	0.0	0.55	0.65	0.00	0.00	0.00	0.00	-279.66	-279.66
4	1950-1979	3757	0.72	0.72	14.71	-74.78	-73.54	-110.83	-244.44	0.0	0.61	0.66	0.00	0.00	0.00	0.00	-244.44	-244.44
4	1980-1989	591.8	0.72	0.72	3.46	-13.21	-15.2	-17.39	-42.34	0.0	0.61	0.66	0.00	0.00	0.00	0.00	-42.34	-42.34
4	After 1989	276.4	0.50	0.61	0.11	-5.96	-6.93	-4.55	-17.33	0.0	0.46	0.59	0.00	0.00	0.00	0.00	-17.33	-17.33
5	Before 1950	1414.6	0.55	0.67	10.76	-31.53	-52.1	-71.88	-144.75	852.4	0.55	0.65	6.28	-18.89	-4.71	-26.69	-100.84	-144.83
5	1950-1979	772	0.72	0.72	2.15	-16.02	-15.45	-26.75	-56.07	511.6	0.61	0.66	1.30	-9.00	-1.54	-8.70	-36.64	-54.58
5	1980-1989	47.3	0.72	0.72	0.23	-1.09	-1.41	-1.22	-3.49	148.8	0.61	0.66	0.66	-2.90	-0.67	-3.77	3.65	-3.02
5	After 1989	103.6	0.50	0.61	-0.06	-2.28	-2.1	-1.64	-6.08	49.4	0.46	0.59	-0.03	-1.01	-0.15	-0.85	-3.96	-6.00
6	Before 1950	1051.2	0.55	0.67	6.87	-13.92	-20.94	-27.32	-55.31	1287.7	0.55	0.65	8.16	-16.95	-3.85	-21.80	-21.02	-55.47
6	1950-1979	901.4	0.72	0.72	2.93	-11.03	-9.83	-14.83	-32.76	1428.9	0.61	0.66	4.24	-14.82	-2.34	-13.25	-4.34	-30.50
6	1980-1989	350.6	0.72	0.72	2.23	-6.24	-6.5	-7.66	-18.17	433.9	0.61	0.66	2.52	-6.53	-1.21	-6.84	-5.16	-17.21
6	After 1989	196.6	0.50	0.61	0.32	-2.93	-3.07	-1.87	-7.55	314.0	0.46	0.59	0.50	-4.34	-0.74	-4.17	1.52	-7.22
7	Before 1950	1655.3	1.02	0.75	12.24	-32.18	-30.52	-44.48	-94.94	624.7	0.94	0.72	4.40	-11.14	-1.73	-9.79	-75.90	-94.16
7	1950-1979	3556	1.28	0.81	34.47	-113.07	-70.39	-101.99	-250.98	1118.6	1.06	0.73	9.76	-29.25	-3.32	-18.82	-204.11	-245.75
7	1980-1989	1058.5	0.72	0.72	5.42	-17.25	-17.03	-10.33	-39.19	436.2	0.61	0.66	2.04	-6.02	-1.05	-5.96	-27.30	-38.29
7	After 1989	551.5	0.50	0.61	0.72	-8.61	-9.15	-5.1	-22.14	394.8	0.46	0.59	0.50	-5.71	-0.98	-5.57	-9.94	-21.70
8	Before 1950	166.3	1.02	0.76	0.65	-2.19	-2.36	-2.76	-6.66	1149.8	0.94	0.72	4.28	-13.88	-2.45	-13.87	20.31	-5.62
8	1950-1979	806.5	1.28	0.81	4.08	-16.31	-11.3	-9.17	-32.7	3125.4	1.06	0.73	14.23	-52.01	-6.57	-37.22	58.49	-23.09
8	1980-1989	189.9	0.72	0.72	0.83	-2.03	-2.13	-1.29	-4.62	1130.8	0.61	0.66	4.52	-10.22	-1.90	-10.78	15.21	-3.17
8	After 1989	585.4	0.66	0.68	2.54	-5.27	-6.3	-3.14	-12.17	1690.3	0.59	0.65	7.04	-13.75	-2.73	-15.46	13.90	-10.99
9	Before 1950	114.1	0.55	0.67	0.04	-0.11	-0.11	-0.13	-0.31	67.2	0.55	0.65	0.02	-0.06	-0.01	-0.06	-0.20	-0.31
9	1950-1979	924.1	0.72	0.72	0.41	-1.18	-0.74	-0.35	-1.86	1274.8	0.61	0.66	0.52	-1.38	-0.15	-0.87	0.22	-1.66
9	1980-1989	803.8	1.28	0.81	0.23	-0.57	-0.38	0.08	-0.64	929.8	1.06	0.73	0.24	-0.54	-0.07	-0.37	0.19	-0.55
9	After 1989	185.7	1.13	0.77	0.06	-0.13	-0.09	0.03	-0.13	441.0	0.98	0.72	0.13	-0.27	-0.03	-0.18	0.25	-0.10
10	Before 1950	1110.1	1.02	0.75	4.29	-14.43	-15.54	-18.23	-43.91	213.3	0.94	0.72	0.79	-2.54	-0.45	-2.54	-38.97	-43.72
10	1950-1979	2023.3	1.28	0.81	10.08	-40.29	-27.93	-22.65	-80.79	246.5	1.06	0.73	1.11	-4.04	-0.51	-2.89	-73.71	-80.04
10	1980-1989	540.1	0.72	0.72	2.3	-5.59	-5.87	-3.61	-12.77	194.3	0.61	0.66	0.76	-1.70	-0.32	-1.80	-9.47	-12.53
10	After 1989	259.5	0.50	0.61	1.24	-2.57	-3.08	-1.53	-5.94	251.5	0.46	0.59	1.17	-2.31	-0.45	-2.54	-1.67	-5.79
11	Before 1950	62.9	1.02	0.76	0.15	-0.37	-0.37	-0.51	-1.1	975.2	0.94	0.72	2.21	-5.26	-0.86	-4.88	8.05	-0.74
11	1950-1979	380.6	1.28	0.81	1.28	-3.15	-1.91	-1.05	-4.83	1600.6	1.06	0.73	4.84	-10.90	-1.20	-6.83	11.07	-3.02
11	1980-1989	104.9	0.72	0.72	0.31	-0.72	-0.5	-0.17	-1.08	700.7	0.61	0.66	1.89	-4.07	-0.50	-2.84	5.00	-0.51
11	After 1989	23.8	0.66	0.68	0.08	-0.17	-0.13	-0.01	-0.23	643.7	0.59	0.65	2.08	-4.15	-0.53	-2.99	5.72	0.13
12	Before 1950	1449.4	1.02	0.76	5.2	-12.34	-13.65	-18.92	-39.71	1266.9	0.94	0.72	4.33	-9.89	-1.79	-10.14	-21.54	-39.03
12	1950-1979	3268.1	1.28	0.81	17	-42.72	-28.18	-21.88	-75.78	2015.3	1.06	0.73	9.43	-21.69	-2.61	-14.77	-42.54	-72.18
12	1980-1989	1424.8	1.28	0.81	6.05	-14.89	-11.29	-4.36	-24.49	704.7	1.06	0.73	2.69	-6.06	-0.84	-4.75	-14.53	-23.48
12	After 1989	427.5	1.13	0.77	2.11	-4.83	-3.84	-1.46	-8.02	681.7	0.98	0.72	3.18	-6.72	-0.92	-5.21	2.44	-7.22
13	Before 1950	103.5	1.02	0.76	0.25	-0.6	-0.59	-0.83	-1.77	466.1	0.94	0.72	1.07	-2.48	-0.40	-2.26	2.46	-1.60
13	1950-1979	346.9	1.28	0.81	1.17	-2.87	-1.75	-0.95	-4.4	1816.0	1.06	0.73	5.51	-12.37	-1.37	-7.79	13.66	-2.36
13	1980-1989	180.2	1.28	0.81	0.54	-1.25	-0.87	-0.3	-1.88	516.6	1.06	0.73	1.39	-2.95	-0.37	-2.12	2.65	-1.40
14	Before 1950	383.6	0.55	0.67	3.06	-6.65	-5.69	-12.54	-21.82	270.9	0.55	0.65	2.09	-4.67	-0.60	-3.42	-15.27	-21.86
14	1950-1979	586.3	0.72	0.72	4.56	-11.93	-6.92	-9.78	-24.07	392.6	0.61	0.66	2.79	-6.77	-0.69	-3.94	-14.50	-23.12
14	1980-1989	142.7	0.72	0.72	1.54	-2.92	-2.44	-2.42	-6.24	11.9	0.61	0.66	0.12	-0.21	-0.03	-0.17	-5.92	-6.21
14	After 1989	94.1	0.50	0.61	0.58	-1.83	-1.55	-1.32	-4.12	51.2	0.46	0.59	0.31	-0.92	-0.13	-0.72	-2.60	-4.05
15	Before 1950	202.6	1.02	0.75	1.56	-3.4	-2.91	-6.41	-11.16	326.1	0.94	0.72	2.39	-5.02	-0.70	-3.98	-3.51	-10.83
15	1950-1979	535.1	1.28	0.81	3.84	-10.05	-5.83	-8.22	-20.26	626.0	1.06	0.73	4.04	-9.67	-1.02	-5.80	-6.17	-18.62
15	1980-1989	34.6	0.72	0.72	0.32	-0.61	-0.51	-0.5	-1.3	211.0	0.61	0.66	1.78	-3.14	-0.47	-2.64	3.58	-0.89
15	After 1989	75.8	0.50	0.61	0.39	-1.24	-1.05	-0.89	-2.79	575.6	0.46	0.59	2.89	-8.72	-1.20	-6.78	11.64	-2.17
16	Before 1950	70.4	1.02	0.75	0.5	-0.91	-0.74	-1.59	-2.74	64.7	0.94	0.72	0.44	-0.77	-0.10	-0.58	-1.68	-2.69
16	1950-1979	335.5	1.28	0.81	2.26	-4.73	-2.67	-3.33	-8.47	181.7	1.06	0.73	1.10	-2.11	-0.22	-1.23	-5.69	-8.14
16	1980-1989	74.3	0.72	0.72	0.39	-0.67	-0.67	-0.51	-1.46	0.0	0.61	0.66	0.00	0.00	0.00	0.00	-1.46	-1.46
16	After 1989	28.5	0.50	0.61	0.1	-0.26	-0.28	-0.22	-0.66	13.0	0.46	0.59	0.04	-0.11	-0.02	-0.11	-0.46	-0.65
17	Before 1950	115.3	1.02	0.75	0.24	-0.44	-0.34	-0.74	-1.28	154.7	0.94	0.72	0.31	-0.54	-0.07	-0.39	-0.56	-1.25
17	1950-1979	482.8	1.28	0.81	1.18	-2.03	-1.17	-0.93	-2.95	814.4	1.06	0.73	1.79	-2.82	-0.30	-1.68	0.46	-2.54
17	1980-1989	100.3	0.72	0.72	0.17	-0.25	-0.25	-0.1	-0.43	179.8	0.61	0.66	0.28	-0.38	-0.07	-0.38	0.16	-0.39
18	Before 1950	997.4	0.55	0.67	4.42	-16.96	-28.53	-29.92	-70.99	432.7	0.55	0.65	1.86	-7.31	-1.86	-10.52	-53.17	-71.00
18	1950-1979	966.9	0.72	0.72	3.6	-23.37	-22	-17.99	-59.76	1214.8	0.61	0.66	4.13	-24.90	-4.15	-23.49	-7.28	-55.69
18	1980-1989	531.7	0.72	0.72	3.08	-13.82	-9.44	-2.6	-22.78	308.3	0.61	0.66	1.63	-6.79	-0.82	-4.65	-11.08	-21.71
18	After 1989	205.6	0.50	0.61	-0.01	-5.05	-3.65	-0.38	-9.09	398.7	0.46	0.59	-0.02	-9.09	-1.06	-6.02	7.80	-8.39
19	Before 1950	690	1.02	0.76	7	-12.44	-12.43	-18.32	-36.19	494.2	0.94	0.72	4.77	-8.17	-1.34	-7.57	-23.39	-35.69
19	1950-1979	1642.4	1.28	0.81	15.69	-30.44	-19.28	-25.11	-59.14	1537.4	1.06	0.73	13.22	-23.45	-2.71	-15.34	-27.29	-55.56
19	1980-1989	482.2	0.72	0.72	6.65	-6.69	-4.85	-5.04	-9.93	284.1	0.61	0.66	3.58	-3.34	-0.43	-2.43	-7.05	-9.67
19	After 1989	75.9	0.66	0.68	1.05	-0.95	-0.77	-0.53	-1.2	431.3	0.59	0.65	5.72	-4.88	-0.66	-3.72	2.61	-0.92
20	Before 1950	592	1.02	0.76	2.91	-4.67	-4.01	-7.48	-13.25	927.0	0.94	0.72	4.34	-6.70	-0.94	-5.34	-4.21	-12.86
20	1950-1979	1961.1	1.28	0.81	11.13	-18.78	-10.39	-15.95	-33.99	2110.2	1.06	0.73	10.78	-16.63	-1.68	-9.50	-14.58	-31.61
20	1980-1989	283.4	0.72	0.72	2.07	-1.85	-1.23	-1.03	-2.04	287.4	0.61	0.66	1.92	-1.59	-0.19	-1.06	-1.02	-1.93
20	After 1989	56.5	0.66	0.68	0.51	-0.4	-0.3	-0.19	-0.38	552.9	0.59	0.65	4.79	-3.54	-0.44	-2.50	1.48	-0.21
Totals/Averages			Window Properties		Total Building Heating Loads (Trillion BTU/yr)						Window Properties		Total Building Cooling Loads (Trillion BTU/yr)					
		Number of Buildings (Thousands, 1993)	U Factor	SHGC	Window Solar	Window Cond	Infiltration	Other Loads	Total Loads	Number of Buildings (Thousands, 2001)	U Factor	SHGC	Window Solar	Window Cond	Window Infiltration	Non-Window Infiltration	Other Loads	Total Loads
Total		59230.60	0.85	0.73	328.41	-1015.16	-1053.43	-1217.55	-2957.73	62156.65	0.74	0.68	284.81	-825.57	-146.74	-831.50	-1347.49	-2866.49
Percentage of Total Loads					-11%	34%	36%	41%	100%				-10%	29%	5%	29%	47%	100%

Windows 15% of total infiltration	Window Total	-844.76 Trillion BTU Loads	Window Total	-687.50 Trillion BTU Loads
	Window % of Total	29%	Window % of Total	24%
			Total Quads Heat	6.90 Quads
			Total Quads Window Heat	1.65 Quads

Cooling Loads

Climate Zone	Year Made	1993 Properties Estimated by Huang, Hanford, et al (1999)								2001 Updated Window Stock Estimates (Apte and Arasteh, 2006)								
			Window Properties		Total Building Cooling Loads (Trillion BTU/yr)						Window Properties		Total Building Cooling Loads (Trillion BTU/yr)					
		Number of Buildings (Thousands, 1993)	U Factor	SHGC	Window Solar	Window Cond	Infiltration	Other Loads	Total Loads	Number of Buildings (Thousands, 2001)	U Factor	SHGC	Window Solar	Window Cond	Window Infiltration	Non-Window Infiltration	Other Loads	Total Loads
1	Before 1950	1217.5	0.55	0.67	2.04	-0.1	-20.21	-17.6	-82.91	1175.9	0.55	0.65	-0.10	1.91	0.10	0.57	2.06	4.54
1	1950-1979	1031.1	0.72	0.72	8.04	-31.59	-32.72	-34.48	-90.75	1292.0	0.61	0.66	-0.07	3.21	0.13	0.73	0.44	4.44
1	1980-1989	326	0.72	0.72	1.69	-6.36	-7.95	-8	-20.62	369.2	0.61	0.66	0.01	0.61	0.03	0.17	0.27	1.09
1	After 1989	135.2	0.50	0.61	0.04	-2.41	-3.04	-1.64	-7.05	226.4	0.46	0.59	0.02	0.41	0.02	0.10	-0.04	0.50
2	Before 1950	2360.9	0.55	0.67	12.34	-30.28	-59.96	-64.79	-142.69	2132.7	0.55	0.65	-0.26	3.99	0.27	1.52	6.98	12.50
2	1950-1979	3477.5	0.72	0.72	19.83	-85.15	-94	-101.5	-260.82	2807.8	0.61	0.66	0.04	11.25	0.58	3.26	16.20	31.32
2	1980-1989	788.8	0.72	0.72	2.95	-13.47	-19.04	-8.93	-38.49	637.1	0.61	0.66	-0.02	1.71	0.10	0.59	2.94	5.32
2	After 1989	212.6	0.50	0.61	0	-3.34	-4.78	-2.26	-10.38	536.4	0.46	0.59	0.07	1.01	0.06	0.34	-0.51	0.97
3	Before 1950	961.6	0.55	0.67	7.23	-17.71	-30.31	-38.31	-79.1	3660.2	0.55	0.65	-0.61	10.70	0.65	3.69	-7.59	6.85
3	1950-1979	1238.4	0.72	0.72	4.75	-24.12	-23.72	-35.75	-78.84	4153.9	0.61	0.66	0.40	9.53	0.53	2.99	-7.71	5.74
3	1980-1989	355.9	0.72	0.72	2	-7.62	-8.77	-10.04	-24.43	1240.3	0.61	0.66	0.80	4.33	0.24	1.33	-4.28	2.42
3	After 1989	203.8	0.50	0.61	0.08	-4.19	-4.87	-3.19	-12.17	1368.8	0.46	0.59	0.37	6.29	0.31	1.77	-6.85	1.89
4	Before 1950	3409.1	0.55	0.67	25.57	-62.6	-107.15	-135.48	-279.66	0.0	0.55	0.65	0.00	0.00	0.00	0.00	28.89	28.89
4	1950-1979	3757	0.72	0.72	14.71	-74.78	-73.54	-110.83	-244.44	0.0	0.61	0.66	0.00	0.00	0.00	0.00	25.71	25.71
4	1980-1989	591.8	0.72	0.72	3.46	-13.21	-15.2	-17.39	-42.34	0.0	0.61	0.66	0.00	0.00	0.00	0.00	5.49	5.49
4	After 1989	276.4	0.50	0.61	0.11	-5.96	-6.93	-4.55	-17.33	0.0	0.46	0.59	0.00	0.00	0.00	0.00	2.48	2.48
5	Before 1950	1414.6	0.55	0.67	10.76	-31.53	-52.1	-71.88	-144.75	852.4	0.55	0.65	-0.16	3.24	0.18	1.00	7.78	12.04
5	1950-1979	772	0.72	0.72	2.15	-16.02	-15.45	-26.75	-56.07	511.6	0.61	0.66	0.06	1.17	0.06	0.35	2.40	4.04
5	1980-1989	47.3	0.72	0.72	0.23	-1.09	-1.41	-1.22	-3.49	148.8	0.61	0.66	0.00	0.46	0.02	0.13	-0.37	0.25
5	After 1989	103.6	0.50	0.61	-0.06	-2.28	-2.1	-1.64	-6.08	49.4	0.46	0.59	0.01	0.16	0.01	0.04	0.46	0.67
6	Before 1950	1051.2	0.55	0.67	6.87	-13.92	-20.94	-27.32	-55.31	1287.7	0.55	0.65	-0.19	9.94	0.88	4.99	8.76	24.38
6	1950-1979	901.4	0.72	0.72	2.93	-11.03	-9.83	-14.83	-32.76	1428.9	0.61	0.66	0.55	7.65	0.60	3.38	2.12	14.30
6	1980-1989	350.6	0.72	0.72	2.23	-6.24	-6.5	-7.66	-18.17	433.9	0.61	0.66	0.20	3.68	0.28	1.60	2.18	7.94
6	After 1989	196.6	0.50	0.61	0.32	-2.93	-3.07	-1.87	-7.55	314.0	0.46	0.59	0.27	2.79	0.19	1.07	0.05	4.37
7	Before 1950	1655.3	1.02	0.75	12.24	-32.18	-30.52	-44.48	-94.94	624.7	0.94	0.72	-0.14	3.37	0.22	1.22	20.48	25.15
7	1950-1979	3556	1.28	0.81	34.47	-113.07	-70.39	-101.99	-250.98	1118.6	1.06	0.73	0.32	9.78	0.45	2.57	62.28	75.41
7	1980-1989	1058.5	0.72	0.72	5.42	-17.25	-17.03	-10.33	-39.19	436.2	0.61	0.66	-0.10	2.91	0.13	0.75	13.53	17.23
7	After 1989	551.5	0.50	0.61	0.72	-8.61	-9.15	-5.1	-22.14	394.8	0.46	0.59	0.05	2.63	0.12	0.68	5.04	8.51
8	Before 1950	166.3	1.02	0.76	0.65	-2.19	-2.36	-2.76	-6.66	1149.8	0.94	0.72	-0.38	5.07	0.51	2.88	-5.00	3.08
8	1950-1979	806.5	1.28	0.81	4.08	-16.31	-11.3	-9.17	-32.7	3125.4	1.06	0.73	-0.38	18.27	1.46	8.30	-13.70	13.96
8	1980-1989	189.9	0.72	0.72	0.83	-2.03	-2.13	-1.29	-4.62	1130.8	0.61	0.66	-0.50	8.44	0.46	2.58	-7.95	3.02
8	After 1989	585.4	0.66	0.68	2.54	-5.27	-6.3	-3.14	-12.17	1690.3	0.59	0.65	-0.99	13.53	0.68	3.83	-6.60	10.44
9	Before 1950	114.1	0.55	0.67	0.04	-0.11	-0.11	-0.13	-0.31	67.2	0.55	0.65	-0.05	0.75	0.13	0.76	4.98	6.57
9	1950-1979	924.1	0.72	0.72	0.41	-1.18	-0.74	-0.35	-1.86	1274.8	0.61	0.66	0.91	17.12	2.30	13.05	16.16	49.54
9	1980-1989	803.8	1.28	0.81	0.23	-0.57	-0.38	0.08	-0.64	929.8	1.06	0.73	-0.40	11.26	1.28	7.28	14.58	34.00
9	After 1989	185.7	1.13	0.77	0.06	-0.13	-0.09	0.03	-0.13	441.0	0.98	0.72	-0.23	6.01	0.62	3.51	-2.23	7.69
10	Before 1950	1110.1	1.02	0.75	4.29	-14.43	-15.54	-18.23	-43.91	213.3	0.94	0.72	-0.07	0.93	0.09	0.52	20.11	21.58
10	1950-1979	2023.3	1.28	0.81	10.08	-40.29	-27.93	-22.65	-80.79	246.5	1.06	0.73	-0.03	1.44	0.12	0.65	37.59	39.78
10	1980-1989	540.1	0.72	0.72	2.3	-5.59	-5.87	-3.61	-12.77	194.3	0.61	0.66	-0.09	1.38	0.08	0.43	8.19	9.99
10	After 1989	259.5	0.50	0.61	1.24	-2.57	-3.08	-1.53	-5.94	251.5	0.46	0.59	-0.15	2.00	0.10	0.56	2.18	4.69
11	Before 1950	62.9	1.02	0.76	0.15	-0.37	-0.37	-0.51	-1.1	975.2	0.94	0.72	-0.57	6.79	1.02	5.80	-11.31	1.73
11	1950-1979	380.6	1.28	0.81	1.28	-3.15	-1.91	-1.05	-4.83	1600.6	1.06	0.73	-0.87	17.56	1.70	9.62	-17.87	10.14
11	1980-1989	104.9	0.72	0.72	0.31	-0.72	-0.5	-0.17	-1.08	700.7	0.61	0.66	0.00	5.68	0.62	3.52	-7.48	2.34
11	After 1989	23.8	0.66	0.68	0.08	-0.17	-0.13	-0.01	-0.23	643.7	0.59	0.65	0.24	5.71	0.57	3.22	-9.40	0.35
12	Before 1950	1449.4	1.02	0.76	5.2	-12.34	-13.65	-18.92	-39.71	1266.9	0.94	0.72	0.45	7.61	1.32	7.50	25.96	42.85
12	1950-1979	3268.1	1.28	0.81	17	-42.72	-28.18	-21.88	-75.78	2015.3	1.06	0.73	2.63	18.03	2.22	12.60	61.81	97.29
12	1980-1989	1424.8	1.28	0.81	6.05	-14.89	-11.29	-4.36	-24.49	704.7	1.06	0.73	0.98	5.14	0.66	3.76	26.13	36.67
12	After 1989	427.5	1.13	0.77	2.11	-4.83	-3.84	-1.46	-8.02	681.7	0.98	0.72	1.15	5.49	0.69	3.90	-0.46	10.78
13	Before 1950	103.5	1.02	0.76	0.25	-0.6	-0.59	-0.83	-1.77	466.1	0.94	0.72	-0.29	3.13	0.48	2.72	-2.97	3.07
13	1950-1979	346.9	1.28	0.81	1.17	-2.87	-1.75	-0.95	-4.4	1816.0	1.06	0.73	-0.99	19.92	1.92	10.90	-22.92	8.84
13	1980-1989	180.2	1.28	0.81	0.54	-1.25	-0.87	-0.3	-1.88	516.6	1.06	0.73	0.00	4.13	0.46	2.61	-2.72	4.47
14	Before 1950	383.6	0.55	0.67	3.06	-6.65	-5.69	-12.54	-21.82	270.9	0.55	0.65	0.00	0.22	0.00	0.02	0.72	0.96
14	1950-1979	586.3	0.72	0.72	4.56	-11.93	-6.92	-9.78	-24.07	392.6	0.61	0.66	0.02	0.24	0.01	0.03	0.51	0.80
14	1980-1989	142.7	0.72	0.72	1.54	-2.92	-2.44	-2.42	-6.24	11.9	0.61	0.66	0.00	0.01	0.00	0.00	0.13	0.14
14	After 1989	94.1	0.50	0.61	0.58	-1.83	-1.55	-1.32	-4.12	51.2	0.46	0.59	0.01	0.04	0.00	0.00	0.08	0.13
15	Before 1950	202.6	1.02	0.75	1.56	-3.4	-2.91	-6.41	-11.16	326.1	0.94	0.72	0.00	0.31	0.01	0.04	0.24	0.59
15	1950-1979	535.1	1.28	0.81	3.84	-10.05	-5.83	-8.22	-20.26	626.0	1.06	0.73	0.04	0.39	0.01	0.05	0.24	0.73
15	1980-1989	34.6	0.72	0.72	0.32	-0.61	-0.51	-0.5	-1.3	211.0	0.61	0.66	0.00	0.11	0.00	0.00	-0.09	0.02
15	After 1989	75.8	0.50	0.61	0.39	-1.24	-1.05	-0.89	-2.79	575.6	0.46	0.59	0.14	1.11	0.01	0.06	-1.08	0.25
16	Before 1950	70.4	1.02	0.75	0.5	-0.91	-0.74	-1.59	-2.74	64.7	0.94	0.72	0.00	0.08	0.00	0.01	0.21	0.30
16	1950-1979	335.5	1.28	0.81	2.26	-4.73	-2.67	-3.33	-8.47	181.7	1.06	0.73	0.01	0.26	0.00	0.02	0.91	1.21
16	1980-1989	74.3	0.72	0.72	0.39	-0.67	-0.67	-0.51	-1.46	0.0	0.61	0.66	0.00	0.00	0.00	0.00	0.31	0.31
16	After 1989	28.5	0.50	0.61	0.1	-0.26	-0.28	-0.22	-0.66	13.0	0.46	0.59	0.01	0.04	0.00	0.01	0.14	0.19
17	Before 1950	115.3	1.02	0.75	0.24	-0.44	-0.34	-0.74	-1.28	154.7	0.94	0.72	0.09	0.40	0.04	0.25	0.71	1.49
17	1950-1979	482.8	1.28	0.81	1.18	-2.03	-1.17	-0.93	-2.95	814.4	1.06	0.73	1.66	5.07	0.44	2.47	1.54	11.18
17	1980-1989	100.3	0.72	0.72	0.17	-0.25	-0.25	-0.1	-0.43	179.8	0.61	0.66	0.46	1.38	0.16	0.93	0.35	3.28
18	Before 1950	997.4	0.55	0.67	4.42	-16.96	-28.53	-29.92	-70.99	432.7	0.55	0.65	-0.01	0.10	0.00	0.00	0.59	0.69
18	1950-1979	966.9	0.72	0.72	3.6	-23.37	-22	-17.99	-59.76	1214.8	0.61	0.66	-0.01	0.32	0.00	0.02	0.28	0.61
18	1980-1989	531.7	0.72	0.72	3.08	-13.82	-9.44	-2.6	-22.78	308.3	0.61	0.66	-0.01	0.13	0.00	0.00	0.25	0.37
18	After 1989	205.6	0.50	0.61	-0.01	-5.05	-3.65	-0.38	-9.09	398.7	0.46	0.59	0.00	0.28	0.00	0.00	-0.06	0.22
19	Before 1950	690	1.02	0.76	7	-12.44	-12.43	-18.32	-36.19	494.2	0.94	0.72	-0.01	0.03	0.00	0.00	0.11	0.13
19	1950-1979	1642.4	1.28	0.81	15.69	-30.44	-19.28	-25.11	-59.14	1537.4	1.06	0.73	-0.02	0.30	0.00	0.00	0.54	0.83
19	1980-1989	482.2	0.72	0.72	6.65	-6.69	-4.85	-5.04	-9.93	284.1	0.61	0.66	0.00	0.09	0.00	0.01	0.16	0.25
19	After 1989	75.9	0.66	0.68	1.05	-0.95	-0.77	-0.53	-1.2	431.3	0.59	0.65	0.00	0.16	0.00	0.00	-0.13	0.03
20	Before 1950	592	1.02	0.76	2.91	-4.67	-4.01	-7.48	-13.25	927.0	0.94	0.72	-0.17	0.70	-0.03	-0.16	0.89	1.23
20	1950-1979	1961.1	1.28	0.81	11.13	-18.78	-10.39	-15.95	-33.99	2110.2	1.06	0.73	-0.56	2.40	-0.13	-0.72	3.37	4.36
20	1980-1989	283.4	0.72	0.72	2.07	-1.85	-1.23	-1.03	-2.04	287.4	0.61	0.66	-0.07	0.55	-0.02	-0.11	0.43	0.78
20	After 1989	56.5	0.66	0.68	0.51	-0.4	-0.3	-0.19	-0.38	552.9	0.59	0.65	-0.18	0.85	-0.03	-0.17	-0.38	0.09
			Window Properties		Total Building Cooling Loads (Trillion BTU/yr)						Window Properties		Total Building Cooling Loads (Trillion BTU/yr)					
Totals/Averages		Number of Buildings (Thousands, 1993)	U Factor	SHGC	Window Solar	Window Cond	Infiltration	Other Loads	Total Loads	Number of Buildings (Thousands, 2001)	U Factor	SHGC	Window Solar	Window Cond	Window Infiltration	Non-Window Infiltration	Other Loads	Total Loads
Total		59230.60	0.85	0.73	322.80	-996.96	-1039.49	-1197.04	-2957.73	62156.65	0.74	0.68	3.28	303.66	26.14	148.11	307.27	788.46
Percentage of Total Loads					-11%	34%	35%	40%	100%				0%	39%	3%	19%	39%	100%

Windows 15% of total infiltration

Window Total	-830.08 Trillion BTU Loads	Window Total	333.08 Trillion BTU Loads
Window % of Total	28%	Window % of Total	42%
		Total Quads Cool	2.41 Quads
		Total Quads Window Cool	1.02 Quads

Appendix E – Complete Commercial Results

Large and Small Office Buildings

Building Type	Climate Zone	Vintage	Space Conditioning Mode	1991 Properties Estimated by Huang and Franconi (1999): Conditioned Area, Million Square Feet	Window Properties: U Factor	Window Properties: SHGC	Building HVAC Load Intensity (kBtu/ft²/yr): Window Solar	Window Cond	Infiltration	Other Loads	Total Loads	System Efficiency Factor (Primary kBtu Energy Consumption / kBtu Load)	1999 Updated Window Stock Estimates (Apte and Arasteh, 2006): Conditioned Area, Million Square Feet	Window Properties: U Factor	Window Properties: SHGC	Total Building Energy Consumption (Trillion BTU/yr): Window Solar	Window Cond	Window Infiltration	Non-Window Infiltration	Other Loads	Total Loads
Large Office	Minneapolis	New	heat	95.1	0.58	0.60	4.5	-11.9	-1.5	-0.5	-9.4	4.76	150.16	0.75	0.66	-1.1E+04	3.5E+03	-1.6E+02	-9.1E+02	-3.6E+02	-8.81E+03
Large Office	Minneapolis	New	cool	76.6	0.58	0.60	15.4	-5.2	-2	17.1	25.3	1.16	139.45	0.75	0.66	-1.1E+03	2.7E+03	-4.9E+01	-2.8E+02	2.8E+03	4.11E+03
Large Office	Chicago	New	heat	705	0.58	0.60	3.8	-8.7	-1.4	0.1	-6.2	5.56	1,068.46	0.75	0.66	-6.6E+04	2.5E+04	-1.2E+03	-7.1E+03	5.9E+02	-4.91E+04
Large Office	Chicago	New	cool	657.6	0.58	0.60	16.3	-5	-1.7	18.4	28	1.22	1,014.30	0.75	0.66	-7.9E+03	2.2E+04	-3.2E+02	-1.8E+03	2.3E+04	3.49E+04
Large Office	Washington	New	heat	556.4	0.59	0.61	2	-4.8	-0.5	0.1	-3.2	8.33	874.34	0.75	0.66	-4.4E+04	1.6E+04	-5.5E+02	-3.1E+03	7.3E+02	-3.14E+04
Large Office	Washington	New	cool	535.2	0.59	0.61	17.6	-4.9	-1.6	21	32.1	1.33	844.21	0.75	0.66	-7.0E+03	2.1E+04	-2.7E+02	-1.5E+03	2.4E+04	3.63E+04
Large Office	Los Angeles	New	heat	686.3	0.60	0.62	0.1	-0.2	0	0	-0.1	100.00	923.04	0.75	0.66	-2.3E+04	9.9E+03	0.0E+00	0.0E+00	0.0E+00	-1.33E+04
Large Office	Los Angeles	New	cool	701.9	0.60	0.62	31.5	-10.2	-1.3	25	45	1.33	925.16	0.75	0.66	-1.6E+04	4.2E+04	-2.4E+02	-1.4E+03	3.1E+04	5.50E+04
Large Office	Houston	New	heat	548.1	0.60	0.62	0.5	-1	-0.1	0.2	-0.4	25.00	451.33	0.75	0.66	-1.4E+04	6.0E+03	-1.7E+02	-9.6E+02	2.3E+03	-6.98E+03
Large Office	Houston	New	cool	548.7	0.60	0.62	24.8	-5.3	-1.4	26.4	44.5	1.43	499.24	0.75	0.66	-4.7E+03	1.9E+04	-1.5E+02	-8.5E+02	1.9E+04	3.20E+04
Large Office	Minneapolis	Old	heat	239.4	0.69	0.70	4.9	-12.2	-1.5	-1.8	-10.6	4.17	304.38	0.75	0.66	-1.7E+04	5.9E+03	-2.9E+02	-1.6E+03	-2.3E+03	-1.50E+04
Large Office	Minneapolis	Old	cool	185.4	0.69	0.70	15.9	-4.8	-2.4	21.7	30.4	3.57	250.74	0.75	0.66	-4.6E+03	1.4E+04	-3.2E+02	-1.8E+03	1.9E+04	2.61E+04
Large Office	Chicago	Old	heat	1621.5	0.69	0.70	4	-8.9	-1.4	-0.7	-7	5.26	1,065.44	0.75	0.66	-5.4E+04	2.1E+04	-1.2E+03	-6.7E+03	-3.9E+03	-4.44E+04
Large Office	Chicago	Old	cool	1360.6	0.69	0.70	16.9	-4.8	-2.1	23.5	33.5	3.13	927.96	0.75	0.66	-1.5E+04	4.6E+04	-9.1E+02	-5.2E+03	6.8E+04	9.35E+04
Large Office	Washington	Old	heat	1745.3	0.71	0.68	1.9	-4.6	-0.5	-0.3	-3.5	8.33	1,556.73	0.75	0.66	-6.3E+04	2.4E+04	-9.7E+02	-5.5E+03	-3.9E+03	-4.99E+04
Large Office	Washington	Old	cool	1761.8	0.71	0.68	17.1	-4.6	-1.8	26.4	37.1	2.86	1,440.47	0.75	0.66	-2.0E+04	6.8E+04	-1.1E+03	-6.3E+03	1.1E+05	1.49E+05
Large Office	Los Angeles	Old	heat	996.2	0.72	0.67	0.1	-0.2	0	0	-0.1	100.00	771.60	0.75	0.66	-1.6E+04	7.6E+03	0.0E+00	0.0E+00	0.0E+00	-8.49E+03
Large Office	Los Angeles	Old	cool	983.2	0.72	0.67	26.2	-8.5	-1.3	31	47.4	2.27	785.41	0.75	0.66	-1.6E+04	4.6E+04	-3.5E+02	-2.0E+03	5.5E+04	8.33E+04
Large Office	Houston	Old	heat	428.8	0.72	0.67	0.5	-0.9	-0.1	0	-0.5	33.33	427.46	0.75	0.66	-1.3E+04	7.0E+03	-2.1E+02	-1.2E+03	0.0E+00	-7.77E+03
Large Office	Houston	Old	cool	324.7	0.72	0.67	20.5	-4.4	-1.5	33	47.6	2.13	507.98	0.75	0.66	-5.0E+03	2.2E+04	-2.4E+02	-1.4E+03	3.6E+04	5.09E+04
Small Office	Minneapolis	New	heat	30.8	0.50	0.62	5.9	-10.3	-8.2	-10.8	-23.4	1.82	108.73	0.75	0.66	-3.0E+03	1.2E+03	-2.4E+02	-1.4E+03	-2.1E+03	-5.55E+03
Small Office	Minneapolis	New	cool	30.6	0.50	0.62	7.5	-1.1	-1	8.6	14	1.27	95.44	0.75	0.66	-2.0E+02	9.7E+02	-1.8E+01	-1.0E+02	1.0E+03	1.69E+03
Small Office	Chicago	New	heat	150.9	0.50	0.62	4.7	-7.6	-6.2	-6.6	-15.7	1.96	323.44	0.75	0.66	-7.2E+03	3.2E+03	-5.9E+02	-3.3E+03	-4.2E+03	-1.21E+04
Small Office	Chicago	New	cool	149.1	0.50	0.62	8.5	-1.3	-1.1	10.4	16.5	1.35	316.85	0.75	0.66	-8.3E+02	3.9E+03	-7.1E+01	-4.0E+02	4.5E+03	7.04E+03
Small Office	Washington	New	heat	214.3	0.56	0.63	3.7	-5.5	-5.2	-5.6	-12.6	1.85	359.68	0.75	0.66	-4.9E+03	2.6E+03	-5.2E+02	-2.9E+03	-3.7E+03	-9.54E+03
Small Office	Washington	New	cool	216	0.56	0.63	6.9	-0.8	-1	12.1	17.2	1.43	332.70	0.75	0.66	-5.1E+02	3.4E+03	-7.1E+01	-4.0E+02	5.8E+03	8.18E+03
Small Office	Los Angeles	New	heat	349.7	0.63	0.65	0.4	-0.4	-0.5	-0.3	-0.8	3.85	551.13	0.75	0.66	-1.0E+03	8.6E+02	-1.6E+02	-9.0E+02	-6.4E+02	-1.84E+03
Small Office	Los Angeles	New	cool	344.5	0.63	0.65	8.7	-1.3	-1.3	13.6	19.7	1.52	537.85	0.75	0.66	-1.3E+03	7.2E+03	-1.6E+02	-9.0E+02	1.1E+04	1.59E+04
Small Office	Houston	New	heat	276.7	0.63	0.65	1.5	-1.6	-1.7	-0.8	-2.6	2.27	174.64	0.75	0.66	-7.5E+02	6.0E+02	-1.0E+02	-5.7E+02	-3.2E+02	-1.14E+03
Small Office	Houston	New	cool	272.3	0.63	0.65	8.4	-0.6	-1	17.6	24.4	1.54	195.93	0.75	0.66	-2.1E+02	2.6E+03	-4.5E+01	-2.6E+02	5.3E+03	7.35E+03
Small Office	Minneapolis	Old	heat	319.4	0.57	0.69	7.7	-14.6		-18.1	-25	1.85	171.87	0.75	0.66	-6.1E+03	2.4E+03	-3.5E+02	-2.0E+03	-3.4E+03	-9.54E+03
Small Office	Minneapolis	Old	cool	265.6	0.57	0.69	13	-2.4	-1.4	10.8	20	1.69	151.66	0.75	0.66	-8.1E+02	3.2E+03	-5.4E+01	-3.1E+02	2.8E+03	4.81E+03
Small Office	Chicago	Old	heat	661.8	0.57	0.69	5.7	-10.2	-5.3	-6.6	-16.4	1.96	315.55	0.75	0.66	-8.3E+03	3.4E+03	-4.9E+02	-2.8E+03	-4.1E+03	-1.23E+04
Small Office	Chicago	Old	cool	582.7	0.57	0.69	14.6	-2.7	-1.5	12.9	23.3	1.72	280.28	0.75	0.66	-1.7E+03	6.8E+03	-1.1E+02	-6.2E+02	6.2E+03	1.06E+04
Small Office	Washington	Old	heat	536.6	0.65	0.70	5.9	-8.7	-4.3	-3.1	-10.2	2.08	579.45	0.75	0.66	-1.2E+04	6.7E+03	-7.8E+02	-4.4E+03	-3.7E+03	-1.44E+04
Small Office	Washington	Old	cool	473.1	0.65	0.70	16.5	-3.3	-1.9	16.1	27.4	1.79	435.39	0.75	0.66	-3.0E+03	1.2E+04	-2.2E+02	-1.3E+03	1.3E+04	2.02E+04
Small Office	Los Angeles	Old	heat	591.4	0.75	0.71	0.3	-0.4	-0.2	-0.2	-0.5	11.11	530.93	0.75	0.66	-2.4E+03	1.6E+03	-1.8E+02	-1.0E+03	-1.2E+03	-3.09E+03
Small Office	Los Angeles	Old	cool	592.6	0.75	0.71	25	-5.4	-2.8	20	36.8	1.75	464.95	0.75	0.66	-4.4E+03	1.9E+04	-3.4E+02	-1.9E+03	1.6E+04	2.85E+04
Small Office	Houston	Old	heat	525.8	0.75	0.71	1.3	-1.7	-0.9	-0.3	-1.6	4.35	293.03	0.75	0.66	-2.2E+03	1.5E+03	-1.7E+02	-9.7E+02	-3.8E+02	-2.17E+03
Small Office	Houston	Old	cool	524.1	0.75	0.71	20	-1.9	-1.4	23.9	40.6	1.72	291.14	0.75	0.66	-9.6E+02	9.3E+03	-1.1E+02	-6.0E+02	1.2E+04	1.96E+04
Large Office	Total	Total	heat	7622.1									7,592.95			-3.22E+05	1.26E+05	-4.77E+03	-2.70E+04	-6.88E+03	-2.35E+05
Large Office	Total	Total	cool	7135.7									7,334.92			-9.70E+04	3.03E+05	-3.96E+03	-2.25E+04	3.86E+05	5.65E+05
Small Office	Total	Total	heat	3657.4									3,408.44			-4.81E+04	2.41E+04	-3.59E+03	-2.03E+04	-2.38E+04	-7.17E+04
Small Office	Total	Total	cool	3450.6									3,102.20			-1.39E+04	6.82E+04	-1.20E+03	-6.78E+03	7.75E+04	1.24E+05

Large and Small Retail Buildings

				1991 Properties Estimated by Huang and Franconi (1999)									1999 Updated Window Stock Estimates (Apte and Arasteh, 2006)								
					Window Properties		Building HVAC Load Intensity (kBtu/ft²/yr)					System Efficiency		Window Properties		Total Building Energy Consumption (Trillion BTU/yr)					
Building Type	Climate Zone	Vintage	heat	Conditioned Area, Million Square Feet	U Factor	SHGC	Window Solar	Window Cond	Infiltration	Other Loads	Total Loads	Factor (Primary kBtu Energy Consumption / kBtu Load)	Conditioned Area, Million Square Feet	U Factor	SHGC	Window Solar	Window Cond	Window Infiltration	Non-Window Infiltration	Other Loads	Total Loads
Large Retail	Minneapolis	New	heat	188.3	0.58	0.64	1.5	-3.8	-5.6	1.4	-6.5	5.00	91.91	0.75	0.66	-2.2E+03	7.1E+02	-3.9E+02	-2.2E+03	6.4E+02	-3.46E+03
Large Retail	Minneapolis	New	cool	177	0.58	0.64	4.6	-1.6	-1.8	18.2	19.4	1.39	76.15	0.75	0.66	-2.2E+02	5.0E+02	-2.9E+01	-1.6E+02	1.9E+03	2.02E+03
Large Retail	Chicago	New	heat	745.6	0.58	0.64	0.9	-2.1	-3.4	1.3	-3.3	7.14	457.24	0.75	0.66	-8.8E+03	3.0E+03	-1.7E+03	-9.4E+03	4.2E+03	-1.26E+04
Large Retail	Chicago	New	cool	546.2	0.58	0.64	4.6	-1.2	-1.1	20.5	22.8	1.43	422.59	0.75	0.66	-9.3E+02	2.8E+03	-1.0E+02	-5.6E+02	1.2E+04	1.36E+04
Large Retail	Washington	New	heat	178.5	0.59	0.65	0.2	-0.5	-1	0.2	-1.1	14.29	481.10	0.75	0.66	-4.4E+03	1.4E+03	-1.0E+03	-5.8E+03	1.4E+03	-8.46E+03
Large Retail	Washington	New	cool	173.6	0.59	0.65	4.8	-0.7	-0.1	23.1	27.1	1.52	466.90	0.75	0.66	-6.3E+02	3.4E+03	-1.1E+01	-6.0E+01	1.6E+04	1.91E+04
Large Retail	Los Angeles	New	heat	230.6	0.60	0.66	0	0	0	0	0	-	784.11	0.75	0.66	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.00E+00
Large Retail	Los Angeles	New	cool	201.3	0.60	0.66	8.4	-2.3	-2.9	32.9	36.1	1.33	789.88	0.75	0.66	-3.0E+03	8.8E+03	-4.6E+02	-2.6E+03	3.5E+04	3.74E+04
Large Retail	Houston	New	heat	409.4	0.60	0.66	0	0	0	0	0	100.00	568.30	0.75	0.66	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.00E+00
Large Retail	Houston	New	cool	368.4	0.60	0.66	6.5	-0.9	-1.1	34.5	39	1.52	647.95	0.75	0.66	-1.1E+03	6.4E+03	-1.6E+02	-9.2E+02	3.4E+04	3.81E+04
Large Retail	Minneapolis	Old	heat	345.9	0.65	0.68	2.3	-5.1	-8.8	2.5	-9.1	6.25	147.66	0.75	0.66	-5.4E+03	2.1E+03	-1.2E+03	-6.9E+03	2.3E+03	-9.19E+03
Large Retail	Minneapolis	Old	cool	243.8	0.65	0.68	4.8	-2	-3.2	18.1	17.7	2.86	121.54	0.75	0.66	-8.0E+02	1.6E+03	-1.7E+02	-9.4E+02	6.3E+03	5.99E+03
Large Retail	Chicago	Old	heat	806.8	0.65	0.68	1.5	-3.1	-5.7	2.2	-5.1	9.09	442.88	0.75	0.66	-1.4E+04	5.9E+03	-3.4E+03	-2.0E+04	8.9E+03	-2.26E+04
Large Retail	Chicago	Old	cool	381.9	0.65	0.68	4.7	-1.3	-2	19.5	20.9	2.50	378.16	0.75	0.66	-1.4E+03	4.3E+03	-2.8E+02	-1.6E+03	1.8E+04	1.94E+04
Large Retail	Washington	Old	heat	1162	0.68	0.68	0.3	-0.8	-1.9	0.7	-1.7	20.00	480.26	0.75	0.66	-8.4E+03	2.8E+03	-2.7E+03	-1.6E+04	6.7E+03	-1.72E+04
Large Retail	Washington	Old	cool	924.6	0.68	0.68	4.5	-0.5	-0.2	21.5	25.3	2.22	445.90	0.75	0.66	-5.4E+02	4.3E+03	-3.0E+01	-1.7E+02	2.1E+04	2.49E+04
Large Retail	Los Angeles	Old	heat	752.3	0.72	0.69	0	0	0	0	0	-	432.25	0.75	0.66	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.00E+00
Large Retail	Los Angeles	Old	cool	686.4	0.72	0.69	8.7	-2.5	-4.5	32.7	34.4	1.72	441.14	0.75	0.66	-2.0E+03	6.4E+03	-5.1E+02	-2.9E+03	2.5E+04	2.58E+04
Large Retail	Houston	Old	heat	477.3	0.72	0.69	0	0	-0.1	0	-0.1	100.00	313.82	0.75	0.66	0.0E+00	0.0E+00	-4.7E+02	-2.7E+03	0.0E+00	-3.14E+03
Large Retail	Houston	Old	cool	412.3	0.72	0.69	6.6	-0.9	-1.8	33.4	37.3	1.72	398.25	0.75	0.66	-6.4E+02	4.4E+03	-1.9E+02	-1.1E+03	2.3E+04	2.54E+04
Small Retail	Minneapolis	New	heat	71.5	0.58	0.74	4.3	-11.2	-9.4	-13.6	-29.9	1.72	106.89	0.75	0.66	-2.6E+03	7.1E+02	-2.6E+02	-1.5E+03	-2.5E+03	-6.18E+03
Small Retail	Minneapolis	New	cool	26.2	0.58	0.74	7.5	-1.2	-1	10.4	15.7	1.64	52.68	0.75	0.66	-1.3E+02	5.8E+02	-1.3E+01	-7.3E+01	9.0E+02	1.26E+03
Small Retail	Chicago	New	heat	189.1	0.58	0.74	3.5	-8.1	-7.1	-8.2	-19.9	1.75	262.51	0.75	0.66	-4.8E+03	1.4E+03	-4.9E+02	-2.8E+03	-3.8E+03	-1.04E+04
Small Retail	Chicago	New	cool	158.9	0.58	0.74	8.8	-1.4	-1.2	12.8	19	1.69	166.54	0.75	0.66	-5.1E+02	2.2E+03	-5.1E+01	-2.9E+02	3.6E+03	4.98E+03
Small Retail	Washington	New	heat	331.6	0.59	0.74	3.7	-6.6	-6	-3.4	-12.3	1.69	172.47	0.75	0.66	-2.4E+03	9.7E+02	-2.6E+02	-1.5E+03	-9.9E+02	-4.22E+03
Small Retail	Washington	New	cool	221.6	0.59	0.74	10.6	-1.9	-1.8	16.7	23.6	1.79	150.98	0.75	0.66	-6.5E+02	2.6E+03	-7.3E+01	-4.1E+02	4.5E+03	5.93E+03
Small Retail	Los Angeles	New	heat	259.7	0.60	0.73	0.4	-0.5	-0.4	0	-0.5	3.45	291.70	0.75	0.66	-6.3E+02	3.6E+02	-6.0E+01	-3.4E+02	0.0E+00	-6.69E+02
Small Retail	Los Angeles	New	cool	187.8	0.60	0.73	16.3	-3.1	-2.1	19.6	30.7	1.59	299.31	0.75	0.66	-1.8E+03	7.0E+03	-1.5E+02	-8.5E+02	9.3E+03	1.35E+04
Small Retail	Houston	New	heat	273.5	0.60	0.73	1.4	-1.8	-1.4	-0.2	-2	1.92	115.98	0.75	0.66	-5.0E+02	2.8E+02	-4.7E+01	-2.7E+02	-4.5E+01	-5.78E+02
Small Retail	Houston	New	cool	192.8	0.60	0.73	12.6	-0.7	-0.9	23.3	34.3	1.89	230.71	0.75	0.66	-3.8E+02	5.0E+03	-5.9E+01	-3.3E+02	1.0E+04	1.43E+04
Small Retail	Minneapolis	Old	heat	528.3	0.81	0.75	4.9	-15.4	-9	-18.1	-37.6	1.72	284.49	0.75	0.66	-7.0E+03	2.1E+03	-6.6E+02	-3.8E+03	-8.9E+03	-1.82E+04
Small Retail	Minneapolis	Old	cool	287	0.81	0.75	8.5	-1.5	-1	11.5	17.5	1.85	187.22	0.75	0.66	-4.8E+02	2.6E+03	-5.2E+01	-2.9E+02	4.0E+03	5.76E+03
Small Retail	Chicago	Old	heat	1470.2	0.81	0.75	3.9	-11.1	-6.8	-10.9	-24.9	1.72	737.37	0.75	0.66	-1.3E+04	4.4E+03	-1.3E+03	-7.3E+03	-1.4E+04	-3.13E+04
Small Retail	Chicago	Old	cool	955.1	0.81	0.75	10	-1.7	-1.2	14.1	21.2	1.89	484.38	0.75	0.66	-1.4E+03	8.1E+03	-1.6E+02	-9.3E+02	1.3E+04	1.84E+04
Small Retail	Washington	Old	heat	929.1	0.76	0.74	4.4	-8.2	-5.9	-4.3	-14	1.69	273.24	0.75	0.66	-3.7E+03	1.8E+03	-4.1E+02	-2.3E+03	-2.0E+03	-6.66E+03
Small Retail	Washington	Old	cool	619	0.76	0.74	12.4	-2.6	-2	19.3	27.1	1.89	198.67	0.75	0.66	-9.6E+02	4.1E+03	-1.1E+02	-6.4E+02	7.2E+03	9.65E+03
Small Retail	Los Angeles	Old	heat	892.8	0.72	0.74	0.6	-0.5	-0.5	-0.1	-0.5	4.00	479.80	0.75	0.66	-1.0E+03	1.0E+03	-1.4E+02	-8.2E+02	-1.9E+02	-1.12E+03
Small Retail	Los Angeles	Old	cool	569.4	0.72	0.74	19.2	-3.9	-2.7	23.7	36.3	1.75	456.64	0.75	0.66	-3.3E+03	1.4E+04	-3.2E+02	-1.8E+03	1.9E+04	2.73E+04
Small Retail	Houston	Old	heat	803.2	0.72	0.74	1.5	-1.8	-1.4	-0.3	-2	2.00	305.05	0.75	0.66	-1.1E+03	8.2E+02	-1.3E+02	-7.3E+02	-1.8E+02	-1.37E+03
Small Retail	Houston	Old	cool	511.8	0.72	0.74	14.6	-1	-1.1	27.6	40.1	1.92	298.04	0.75	0.66	-6.0E+02	7.5E+03	-9.5E+01	-5.4E+02	1.6E+04	2.21E+04
Large Retail	Total	Total	heat	5296.7									4,199.53			-4.37E+04	1.58E+04	-1.10E+04	-6.21E+04	2.42E+04	-7.67E+04
Large Retail	Total	Total	cool	4115.5									4,188.46			-1.13E+04	4.29E+04	-1.94E+03	-1.10E+04	1.93E+05	2.12E+05
Small Retail	Total	Total	heat	5749									3,029.50			-3.70E+04	1.39E+04	-3.76E+03	-2.13E+04	-3.24E+04	-8.06E+04
Small Retail	Total	Total	cool	3729.6									2,525.17			-1.03E+04	5.33E+04	-1.09E+03	-6.19E+03	8.74E+04	1.23E+05

Large and Small Hotels

				1991 Properties Estimated by Huang and Franconi (1999)									1999 Updated Window Stock Estimates (Apte and Arasteh, 2006)								
					Window Properties		Building HVAC Load Intensity (kBtu/ft²/yr)							Window Properties		Total Building Energy Consumption (Trillion BTU/yr)					
Building Type	**Climate Zone**	**Vintage**	**Space Conditioning Mode**	Conditioned Area, Million Square Feet	U Factor	SHGC	Window Solar	Window Cond	Infiltration	Other Loads	Total Loads	**System Efficiency Factor** (Primary kBtu Energy Consumption / kBtu Load)	Conditioned Area, Million Square Feet	U Factor	SHGC	Window Solar	Window Cond	Window Infiltration	Non-Window Infiltration	Other Loads	Total Loads
Large Hotel	Minneapolis	New	heat	18.6	0.60	0.64	4	-10.2	-3.3	-1.6	-11.1	2.70	51.31	0.75	0.66	-1.8E+03	5.7E+02	-6.9E+01	-3.9E+02	-2.2E+02	-1.88E+03
Large Hotel	Minneapolis	New	cool	18.5	0.60	0.64	12.3	-2.9	-0.9	12.9	21.4	1.20	43.23	0.75	0.66	-1.9E+02	6.6E+02	-7.0E+00	-4.0E+01	6.7E+02	1.09E+03
Large Hotel	Chicago	New	heat	39.8	0.60	0.64	3	-7.1	-2.3	-0.5	-6.9	3.03	223.08	0.75	0.66	-6.0E+03	2.1E+03	-2.3E+02	-1.3E+03	-3.4E+02	-5.83E+03
Large Hotel	Chicago	New	cool	34.7	0.60	0.64	13.2	-2.7	-0.9	15	24.6	1.22	191.12	0.75	0.66	-7.9E+02	3.2E+03	-3.1E+01	-1.8E+02	3.5E+03	5.65E+03
Large Hotel	Washington	New	heat	21.4	0.60	0.64	2	-4.5	-1.4	0.2	-3.7	3.57	305.54	0.75	0.66	-6.2E+03	2.2E+03	-2.3E+02	-1.3E+03	2.2E+02	-5.22E+03
Large Hotel	Washington	New	cool	15.7	0.60	0.64	14.2	-2.7	-0.9	18.2	28.8	1.30	277.72	0.75	0.66	-1.2E+03	5.3E+03	-4.9E+01	-2.8E+02	6.6E+03	1.03E+04
Large Hotel	Los Angeles	New	heat	234.2	0.60	0.64	0.1	-0.1	0	-0.1	-0.1	100.00	528.19	0.75	0.66	-6.6E+03	5.4E+03	0.0E+00	0.0E+00	-5.3E+03	-6.48E+03
Large Hotel	Los Angeles	New	cool	218.7	0.60	0.64	24.4	-6.2	-2.4	24.8	40.6	1.00	567.94	0.75	0.66	-4.4E+03	1.4E+04	-2.0E+02	-1.2E+03	1.4E+04	2.25E+04
Large Hotel	Houston	New	heat	156	0.60	0.64	0.3	-0.5	-0.2	0	-0.4	16.67	160.43	0.75	0.66	-1.7E+03	8.2E+02	-8.0E+01	-4.5E+02	0.0E+00	-1.39E+03
Large Hotel	Houston	New	cool	153.2	0.60	0.64	18.7	-2.1	-0.9	28.1	43.8	1.23	165.35	0.75	0.66	-5.4E+02	3.9E+03	-2.8E+01	-1.6E+02	5.7E+03	8.93E+03
Large Hotel	Minneapolis	Old	heat	98.1	0.72	0.71	4.3	-10.3	-3.5	-4.5	-14	2.86	94.15	0.75	0.66	-2.9E+03	1.1E+03	-1.4E+02	-8.0E+02	-1.2E+03	-3.97E+03
Large Hotel	Minneapolis	Old	cool	79.7	0.72	0.71	11.1	-2.7	-0.8	12.5	20.1	1.32	25.52	0.75	0.66	-9.5E+01	3.4E+02	-4.0E+00	-2.3E+01	4.2E+02	6.43E+02
Large Hotel	Chicago	Old	heat	221	0.72	0.71	3.5	-7.6	-2.6	-2.3	-9	3.03	582.07	0.75	0.66	-1.4E+04	5.7E+03	-6.9E+02	-3.9E+03	-4.1E+03	-1.69E+04
Large Hotel	Chicago	Old	cool	92.5	0.72	0.71	12.1	-2.7	-0.9	14.8	23.3	1.33	341.47	0.75	0.66	-1.3E+03	5.1E+03	-6.1E+01	-3.5E+02	6.7E+03	1.01E+04
Large Hotel	Washington	Old	heat	125.6	0.72	0.71	2.2	-4.6	-1.5	-1	-4.9	3.23	198.50	0.75	0.66	-3.1E+03	1.3E+03	-1.4E+02	-8.2E+02	-6.4E+02	-3.37E+03
Large Hotel	Washington	Old	cool	20.3	0.72	0.71	12.9	-2.4	-0.8	17.9	27.6	1.41	176.66	0.75	0.66	-6.2E+02	3.0E+03	-3.0E+01	-1.7E+02	4.5E+03	6.60E+03
Large Hotel	Los Angeles	Old	heat	117.8	0.72	0.71	0.1	-0.2	-0.1	0.1	-0.1	33.33	325.08	0.75	0.66	-2.3E+03	1.0E+03	-1.6E+02	-9.2E+02	1.1E+03	-1.26E+03
Large Hotel	Los Angeles	Old	cool	134.1	0.72	0.71	22.5	-5.6	-2.2	24	38.7	1.11	304.60	0.75	0.66	-2.0E+03	7.0E+03	-1.1E+02	-6.3E+02	8.1E+03	1.24E+04
Large Hotel	Houston	Old	heat	294.1	0.72	0.71	0.4	-0.7	-0.2	-0.1	-0.6	11.11	284.17	0.75	0.66	-2.3E+03	1.2E+03	-9.5E+01	-5.4E+02	-3.2E+02	-2.08E+03
Large Hotel	Houston	Old	cool	302.4	0.72	0.71	17.2	-1.8	-0.8	27.9	42.5	1.32	346.34	0.75	0.66	-8.6E+02	7.3E+03	-5.5E+01	-3.1E+02	1.3E+04	1.87E+04
Small Hotel	Minneapolis	New	heat	0	0.58	0.66	8.2	-11.6	-13.4	-7.3	-24.1	2.70	39.84	0.75	0.66	-1.6E+03	8.8E+02	-2.2E+02	-1.2E+03	-7.9E+02	-2.95E+03
Small Hotel	Minneapolis	New	cool	0	0.58	0.66	10.3	-2.2	-1.2	5.4	12.3	2.27	38.75	0.75	0.66	-2.5E+02	9.1E+02	-1.6E+01	-9.0E+01	4.8E+02	1.03E+03
Small Hotel	Chicago	New	heat	4.4	0.58	0.66	6.7	-8.7	-9.7	-3.5	-15.2	2.94	6.24	0.75	0.66	-2.0E+02	1.2E+02	-2.7E+01	-1.5E+02	-6.4E+01	-3.24E+02
Small Hotel	Chicago	New	cool	4.4	0.58	0.66	11.5	-2.3	-1.2	7.1	15.1	2.22	4.93	0.75	0.66	-3.2E+01	1.3E+02	-2.0E+00	-1.1E+01	7.8E+01	1.58E+02
Small Hotel	Washington	New	heat	15.7	0.58	0.66	3.8	-5.1	-5.5	-0.7	-7.5	3.45	13.96	0.75	0.66	-3.1E+02	1.8E+02	-4.0E+01	-2.3E+02	-3.4E+01	-4.31E+02
Small Hotel	Washington	New	cool	17.4	0.58	0.66	13.6	-2.9	-1.6	9.9	19	2.44	14.18	0.75	0.66	-1.3E+02	4.7E+02	-8.3E+00	-4.7E+01	3.4E+02	6.28E+02
Small Hotel	Los Angeles	New	heat	55.9	0.58	0.66	0.1	-0.1	-0.1	0	-0.1	100.00	38.05	0.75	0.66	-4.9E+02	3.8E+02	-5.7E+01	-3.2E+02	0.0E+00	-4.89E+02
Small Hotel	Los Angeles	New	cool	55.8	0.58	0.66	23.6	-6	-4.1	12.8	26.3	1.85	41.88	0.75	0.66	-6.0E+02	1.8E+03	-4.8E+01	-2.7E+02	9.9E+02	1.90E+03
Small Hotel	Houston	New	heat	66.7	0.58	0.66	0.5	-0.6	-0.6	0.1	-0.6	33.33	70.54	0.75	0.66	-1.8E+03	1.2E+03	-2.1E+02	-1.2E+03	2.4E+02	-1.81E+03
Small Hotel	Houston	New	cool	67.5	0.58	0.66	18.3	-2.6	-0.2	12.9	28.4	2.63	80.01	0.75	0.66	-7.0E+02	3.8E+03	-6.3E+00	-3.6E+01	2.7E+03	5.82E+03
Small Hotel	Minneapolis	Old	heat	103.3	0.69	0.71	9.7	-14.7	-13.3	-9.3	-27.6	2.08	6.90	0.75	0.66	-2.3E+02	1.3E+02	-2.9E+01	-1.6E+02	-1.3E+02	-4.24E+02
Small Hotel	Minneapolis	Old	cool	94.8	0.69	0.71	12.8	-2.8	-1.2	5.8	14.6	0.18	7.45	0.75	0.66	-4.0E+00	1.6E+01	-2.4E-01	-1.3E+00	7.7E+00	1.77E+01
Small Hotel	Chicago	Old	heat	89.1	0.69	0.71	8	-11	-9.6	-5.1	-17.7	2.22	49.35	0.75	0.66	-1.3E+03	8.1E+02	-1.6E+02	-8.9E+02	-5.6E+02	-2.10E+03
Small Hotel	Chicago	Old	cool	73	0.69	0.71	14.2	-3	-1.2	7.5	17.5	0.16	20.25	0.75	0.66	-1.0E+01	4.1E+01	-5.7E-01	-3.2E+00	2.4E+01	5.12E+01
Small Hotel	Washington	Old	heat	67.8	0.69	0.71	4.4	-6.4	-5.4	-1.8	-9.2	2.50	99.76	0.75	0.66	-1.7E+03	1.0E+03	-2.0E+02	-1.1E+03	-4.5E+02	-2.50E+03
Small Hotel	Washington	Old	cool	62.5	0.69	0.71	16.8	-3.8	-1.7	10.5	21.8	0.16	68.12	0.75	0.66	-4.5E+01	1.7E+02	-2.8E+00	-1.6E+01	1.2E+02	2.22E+02
Small Hotel	Los Angeles	Old	heat	130.9	0.69	0.71	0.1	-0.2	-0.1	0.1	-0.1	-	151.55	0.75	0.66	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.00E+00
Small Hotel	Los Angeles	Old	cool	146.2	0.69	0.71	28.3	-7.1	-3.8	12.9	30.3	0.14	69.06	0.75	0.66	-7.5E+01	2.6E+02	-5.6E+00	-3.2E+01	1.3E+02	2.69E+02
Small Hotel	Houston	Old	heat	177.7	0.69	0.71	0.7	-0.9	-0.7	0	-0.9	50.00	120.32	0.75	0.66	-5.8E+03	3.9E+03	-6.3E+02	-3.6E+03	0.0E+00	-6.16E+03
Small Hotel	Houston	Old	cool	177.2	0.69	0.71	22.4	-3.4	-0.3	14.5	33.2	0.18	126.29	0.75	0.66	-8.6E+01	4.8E+02	-1.1E+00	-6.0E+00	3.4E+02	7.30E+02
Large Hotel	Total	Total	heat	1326.6									2,752.52			-4.67E+04	2.14E+04	-1.84E+03	-1.04E+04	-1.08E+04	-4.84E+04
Large Hotel	Total	Total	cool	1069.8									2,439.96			-1.20E+04	4.99E+04	-5.81E+02	-3.29E+03	6.30E+04	9.70E+04
Small Hotel	Total	Total	heat	711.5									596.52			-1.35E+04	8.59E+03	-1.57E+03	-8.91E+03	-1.79E+03	-1.72E+04
Small Hotel	Total	Total	cool	698.8									470.92			-1.93E+03	8.14E+03	-9.03E+01	-5.12E+02	5.22E+03	1.08E+04

Fast Food and Sit Down Restaurants

				1991 Properties Estimated by Huang and Franconi (1999)									1999 Updated Window Stock Estimates (Apte and Arasteh, 2006)								
					Window Properties		Building HVAC Load Intensity (kBtu/ft²/yr)					System Efficiency		Window Properties		Total Building Energy Consumption (Trillion BTU/yr)					
Building Type	Climate Zone	Vintage	Space Conditioning Mode	Conditioned Area, Million Square Feet	U Factor	SHGC	Window Solar	Window Cond	Infiltration	Other Loads	Total Loads	Factor (Primary kBtu Energy Consumption / kBtu Load)	Conditioned Area, Million Square Feet	U Factor	SHGC	Window Solar	Window Cond	Window Infiltration	Non-Window Infiltration	Other Loads	Total Loads
Fast Food Restaurant	Minneapolis	New	heat	2.4	0.67	0.70	12.6	-19.1	-1.1	-53.2	-60.8	6.25	23.89	0.75	0.66	-3.2E+03	1.8E+03	-2.5E+01	-1.4E+02	-7.9E+03	-9.51E+03
Fast Food Restaurant	Minneapolis	New	cool	1.7	0.67	0.70	12.6	-1.2	-0.3	32.2	43.3	1.45	16.92	0.75	0.66	-3.3E+01	2.9E+02	-1.1E+00	-6.3E+00	7.9E+02	1.04E+03
Fast Food Restaurant	Chicago	New	heat	35.4	0.67	0.70	11.6	-15.3	-1	-37.5	-42.2	6.67	63.53	0.75	0.66	-7.2E+03	4.7E+03	-6.4E+01	-3.6E+02	-1.6E+04	-1.89E+04
Fast Food Restaurant	Chicago	New	cool	32.4	0.67	0.70	13.5	-1.1	-0.3	39.5	51.6	1.54	56.98	0.75	0.66	-1.1E+02	1.1E+03	-3.9E+00	-2.2E+01	3.5E+03	4.45E+03
Fast Food Restaurant	Washington	New	heat	19.6	0.67	0.70	9.2	-11.1	-0.5	-24.3	-26.7	6.67	83.87	0.75	0.66	-6.9E+03	4.9E+03	-4.2E+01	-2.4E+02	-1.4E+04	-1.59E+04
Fast Food Restaurant	Washington	New	cool	23.6	0.67	0.70	15.1	-0.9	-0.3	50.9	64.8	1.75	80.28	0.75	0.66	-1.4E+02	2.0E+03	-6.3E+00	-3.6E+01	7.2E+03	9.00E+03
Fast Food Restaurant	Los Angeles	New	heat	21.5	0.67	0.70	4.2	-3.4	-0.1	-4.5	-3.8	14.29	65.30	0.75	0.66	-3.5E+03	3.7E+03	-1.4E+01	-7.9E+01	-4.2E+03	-4.12E+03
Fast Food Restaurant	Los Angeles	New	cool	24.1	0.67	0.70	23.6	-2.2	-0.2	59.1	80.3	1.41	76.74	0.75	0.66	-2.7E+02	2.4E+03	-3.2E+00	-1.8E+01	6.4E+03	8.52E+03
Fast Food Restaurant	Houston	New	heat	12.9	0.67	0.70	4	-3.7	-0.2	-6.1	-6	8.33	25.61	0.75	0.66	-8.8E+02	8.1E+02	-6.4E+00	-3.6E+01	-1.3E+03	-1.42E+03
Fast Food Restaurant	Houston	New	cool	12.3	0.67	0.70	21.2	-0.2	-0.3	70.6	91.3	2.33	29.92	0.75	0.66	-1.6E+01	1.4E+03	-3.1E+00	-1.8E+01	4.9E+03	6.27E+03
Fast Food Restaurant	Minneapolis	Old	heat	38.2	0.65	0.70	17.7	-28.1	-1.1	-54.6	-66.1	5.88	52.31	0.75	0.66	-1.0E+04	5.2E+03	-5.1E+01	-2.9E+02	-1.7E+04	-2.20E+04
Fast Food Restaurant	Minneapolis	Old	cool	32.6	0.65	0.70	20.1	-2.2	-0.2	30.8	48.5	1.75	39.95	0.75	0.66	-1.8E+02	1.3E+03	-2.1E+00	-1.2E+01	2.2E+03	3.30E+03
Fast Food Restaurant	Chicago	Old	heat	203.3	0.65	0.70	16	-22.3	-1.1	-38	-45.4	6.25	116.93	0.75	0.66	-1.9E+04	1.1E+04	-1.2E+02	-6.8E+02	-2.8E+04	-3.63E+04
Fast Food Restaurant	Chicago	Old	cool	178.7	0.65	0.70	21.6	-2.1	-0.3	38	57.2	1.85	83.97	0.75	0.66	-3.8E+02	3.2E+03	-7.0E+00	-4.0E+01	5.9E+03	8.67E+03
Fast Food Restaurant	Washington	Old	heat	144.2	0.65	0.70	12.4	-16	-0.6	-24	-28.2	6.67	118.65	0.75	0.66	-1.5E+04	9.3E+03	-7.1E+01	-4.0E+02	-1.9E+04	-2.48E+04
Fast Food Restaurant	Washington	Old	cool	128.1	0.65	0.70	23.4	-1.6	-0.3	49.6	71.1	2.08	95.31	0.75	0.66	-3.7E+02	4.4E+03	-8.9E+00	-5.1E+01	9.8E+03	1.38E+04
Fast Food Restaurant	Los Angeles	Old	heat	102.2	0.65	0.70	5	-4.5	-0.1	-4	-3.6	14.29	108.06	0.75	0.66	-8.0E+03	7.3E+03	-2.3E+01	-1.3E+02	-6.2E+03	-7.03E+03
Fast Food Restaurant	Los Angeles	Old	cool	97.5	0.65	0.70	37.5	-4.1	-0.2	58.3	91.5	1.69	111.31	0.75	0.66	-8.9E+02	6.7E+03	-5.7E+00	-3.2E+01	1.1E+04	1.68E+04
Fast Food Restaurant	Houston	Old	heat	99.2	0.65	0.70	4.9	-5	-0.2	-5.8	-6.1	8.33	101.84	0.75	0.66	-4.9E+03	3.9E+03	-2.5E+01	-1.4E+02	-4.9E+03	-6.05E+03
Fast Food Restaurant	Houston	Old	cool	90.8	0.65	0.70	32.9	-0.7	-0.3	70.1	102	2.63	124.22	0.75	0.66	-2.6E+02	1.0E+04	-1.5E+01	-8.3E+01	2.3E+04	3.28E+04
Sit-Down Restaurant	Minneapolis	New	heat	2.4	0.67	0.70	4.9	-7.8	-2.1	-48.4	-53.4	1.96	23.89	0.75	0.66	-4.1E+02	2.2E+02	-1.5E+01	-8.4E+01	-2.3E+03	-2.56E+03
Sit-Down Restaurant	Minneapolis	New	cool	1.7	0.67	0.70	5.6	-0.8	-0.3	28.7	33.2	1.82	16.92	0.75	0.66	-2.7E+01	1.6E+02	-1.4E+00	-7.8E+00	8.8E+02	1.01E+03
Sit-Down Restaurant	Chicago	New	heat	35.4	0.67	0.70	4.4	-6.1	-1.7	-32.4	-35.8	1.92	63.53	0.75	0.66	-8.3E+02	5.1E+02	-3.1E+01	-1.8E+02	-4.0E+03	-4.49E+03
Sit-Down Restaurant	Chicago	New	cool	32.4	0.67	0.70	6.1	-0.8	-0.3	34.8	39.8	1.89	56.98	0.75	0.66	-9.6E+01	6.2E+02	-4.8E+00	-2.7E+01	3.7E+03	4.23E+03
Sit-Down Restaurant	Washington	New	heat	19.6	0.67	0.70	3.4	-4.4	-1.3	-18.4	-20.7	1.75	83.87	0.75	0.66	-7.2E+02	4.7E+02	-2.9E+01	-1.6E+02	-2.7E+03	-3.15E+03
Sit-Down Restaurant	Washington	New	cool	23.6	0.67	0.70	6.4	-0.6	-0.3	45	50.5	1.96	80.28	0.75	0.66	-1.1E+02	9.6E+02	-7.1E+00	-4.0E+01	7.1E+03	7.89E+03
Sit-Down Restaurant	Los Angeles	New	heat	21.5	0.67	0.70	0.7	-0.7	-0.3	-1.2	-1.5	3.13	65.30	0.75	0.66	-1.6E+02	1.4E+02	-9.2E+00	-5.2E+01	-2.4E+02	-3.30E+02
Sit-Down Restaurant	Los Angeles	New	cool	24.1	0.67	0.70	10.5	-1.5	-0.4	51.9	60.5	1.64	76.74	0.75	0.66	-2.1E+02	1.3E+03	-7.5E+00	-4.3E+01	6.5E+03	7.52E+03
Sit-Down Restaurant	Houston	New	heat	12.9	0.67	0.70	1.1	-1.1	-0.4	-3	-3.4	2.08	25.61	0.75	0.66	-6.6E+01	5.6E+01	-3.2E+00	-1.8E+01	-1.6E+02	-1.91E+02
Sit-Down Restaurant	Houston	New	cool	12.3	0.67	0.70	9	-0.3	-0.3	68.6	77	1.96	29.92	0.75	0.66	-2.0E+01	5.0E+02	-2.6E+00	-1.5E+01	4.0E+03	4.49E+03
Sit-Down Restaurant	Minneapolis	Old	heat	38.2	0.65	0.70	6.5	-10.3	-2.1	-52.5	-58.4	1.96	52.31	0.75	0.66	-1.2E+03	6.3E+02	-3.2E+01	-1.8E+02	-5.4E+03	-6.19E+03
Sit-Down Restaurant	Minneapolis	Old	cool	32.6	0.65	0.70	7.5	-1	-0.3	28.7	34.9	2.22	39.95	0.75	0.66	-1.0E+02	6.3E+02	-4.0E+00	-2.3E+01	2.5E+03	3.05E+03
Sit-Down Restaurant	Chicago	Old	heat	203.3	0.65	0.70	5.8	-8.2	-1.7	-35.3	-39.4	1.92	116.93	0.75	0.66	-2.1E+03	1.2E+03	-5.7E+01	-3.2E+02	-7.9E+03	-9.21E+03
Sit-Down Restaurant	Chicago	Old	cool	178.7	0.65	0.70	8.1	-1	-0.3	34.9	41.7	2.33	83.97	0.75	0.66	-2.3E+02	1.5E+03	-8.8E+00	-5.0E+01	6.8E+03	8.03E+03
Sit-Down Restaurant	Washington	Old	heat	144.2	0.65	0.70	4.6	-5.9	-1.3	-20.4	-23	1.75	118.65	0.75	0.66	-1.4E+03	9.1E+02	-4.1E+01	-2.3E+02	-4.2E+03	-5.03E+03
Sit-Down Restaurant	Washington	Old	cool	128.1	0.65	0.70	8.6	-0.7	-0.3	45.1	52.7	2.33	95.31	0.75	0.66	-1.8E+02	1.8E+03	-1.0E+01	-5.7E+01	1.0E+04	1.16E+04
Sit-Down Restaurant	Los Angeles	Old	heat	102.2	0.65	0.70	1	-1	-0.4	-1.4	-1.8	2.70	108.06	0.75	0.66	-3.4E+02	2.8E+02	-1.8E+01	-9.9E+01	-4.1E+02	-5.86E+02
Sit-Down Restaurant	Los Angeles	Old	cool	97.5	0.65	0.70	13.9	-1.8	-0.3	52	63.8	2.04	111.31	0.75	0.66	-4.7E+02	3.0E+03	-1.0E+01	-5.8E+01	1.2E+04	1.43E+04
Sit-Down Restaurant	Houston	Old	heat	99.2	0.65	0.70	1.4	-1.5	-0.4	-3.5	-4	2.00	101.84	0.75	0.66	-3.5E+02	2.7E+02	-1.2E+01	-6.9E+01	-7.1E+02	-8.77E+02
Sit-Down Restaurant	Houston	Old	cool	90.8	0.65	0.70	12.1	-0.4	-0.3	69.2	80.6	2.38	124.22	0.75	0.66	-1.4E+02	3.4E+03	-1.3E+01	-7.5E+01	2.0E+04	2.36E+04
Fast Food Restaurant	Total	Total	heat	678.9									759.99			-7.81E+04	5.27E+04	-4.42E+02	-2.50E+03	-1.18E+05	-1.46E+05
Fast Food Restaurant	Total	Total	cool	621.8									715.59			-2.64E+03	3.31E+04	-5.62E+01	-3.18E+02	7.46E+04	1.05E+05
Sit-Down Restaurant	Total	Total	heat	678.9									759.99			-7.65E+03	4.72E+03	-2.47E+02	-1.40E+03	-2.80E+04	-3.26E+04
Sit-Down Restaurant	Total	Total	cool	621.8									715.59			-1.58E+03	1.38E+04	-6.98E+01	-3.95E+02	7.39E+04	8.57E+04

Hospitals and Schools

Building Type	Climate Zone	Vintage	Space Conditioning Mode	1991 Properties Estimated by Huang and Franconi (1999)									1999 Updated Window Stock Estimates (Apte and Arasteh, 2006)								
					Window Properties		Building HVAC Load Intensity (kBtu/ft²/yr)					System Efficiency Factor		Window Properties		Total Building Energy Consumption (Trillion BTU/yr)					
				Conditioned Area, Million Square Feet	U Factor	SHGC	Window Solar	Window Cond	Infiltration	Other Loads	Total Loads	(Primary kBtu Energy Consumption / kBtu Load)	Conditioned Area, Million Square Feet	U Factor	SHGC	Window Solar	Window Cond	Window Infiltration	Non-Window Infiltration	Other Loads	Total Loads
Hospital	Minneapolis	New	heat	0	0.51	0.57	1.8	-5	0	-3.7	-6.9	5.88	32.09	0.75	0.66	-1.4E+03	3.9E+02	0.0E+00	0.0E+00	-7.0E+02	-1.70E+03
Hospital	Minneapolis	New	cool	0	0.51	0.57	12.1	-5.7	0	88	94.4	0.83	23.43	0.75	0.66	-1.6E+02	2.7E+02	0.0E+00	0.0E+00	1.7E+03	1.81E+03
Hospital	Chicago	New	heat	85.7	0.51	0.57	1.5	-3.6	0	-2.2	-4.3	7.69	149.67	0.75	0.66	-6.1E+03	2.0E+03	0.0E+00	0.0E+00	-2.5E+03	-6.64E+03
Hospital	Chicago	New	cool	84.4	0.51	0.57	12.9	-5.5	0	95.7	103.1	0.85	142.36	0.75	0.66	-9.8E+02	1.8E+03	0.0E+00	0.0E+00	1.2E+04	1.25E+04
Hospital	Washington	New	heat	42.7	0.51	0.57	0.5	-1.4	0	-0.8	-1.7	12.50	65.71	0.75	0.66	-1.7E+03	4.7E+02	0.0E+00	0.0E+00	-6.6E+02	-1.88E+03
Hospital	Washington	New	cool	42.4	0.51	0.57	13.8	-4.7	0	107.5	116.6	0.92	64.61	0.75	0.66	-4.1E+02	9.4E+02	0.0E+00	0.0E+00	6.4E+03	6.90E+03
Hospital	Los Angeles	New	heat	43.5	0.51	0.57	0	0	0	0	0	-	101.83	0.75	0.66	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.00E+00
Hospital	Los Angeles	New	cool	34.5	0.51	0.57	22.2	-6.8	0	127.4	142.8	0.83	101.49	0.75	0.66	-8.4E+02	2.1E+03	0.0E+00	0.0E+00	1.1E+04	1.20E+04
Hospital	Houston	New	heat	8.6	0.51	0.57	0	-0.1	0	0	-0.1	100.00	76.10	0.75	0.66	-1.1E+03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	-1.12E+03
Hospital	Houston	New	cool	8.6	0.51	0.57	16.4	-2.9	0	126.8	140.3	1.03	75.63	0.75	0.66	-3.3E+02	1.5E+03	0.0E+00	0.0E+00	9.9E+03	1.10E+04
Hospital	Minneapolis	Old	heat	71.1	0.56	0.62	3.2	-8.3	0	-6.3	-11.4	9.09	148.59	0.75	0.66	-1.5E+04	4.6E+03	0.0E+00	0.0E+00	-8.5E+03	-1.89E+04
Hospital	Minneapolis	Old	cool	46.6	0.56	0.62	10.7	-3.8	0	72.4	79.3	0.97	120.63	0.75	0.66	-6.0E+02	1.3E+03	0.0E+00	0.0E+00	8.5E+03	9.22E+03
Hospital	Chicago	Old	heat	324.4	0.56	0.62	2.6	-5.6	0	-4	-7	12.50	381.33	0.75	0.66	-3.6E+04	1.3E+04	0.0E+00	0.0E+00	-1.9E+04	-4.17E+04
Hospital	Chicago	Old	cool	285.7	0.56	0.62	11.9	-4.3	0	79.7	87.3	1.02	261.80	0.75	0.66	-1.5E+03	3.4E+03	0.0E+00	0.0E+00	2.1E+04	2.31E+04
Hospital	Washington	Old	heat	199.9	0.56	0.62	1.2	-2.9	0	-1.5	-3.2	20.00	384.17	0.75	0.66	-3.0E+04	9.9E+03	0.0E+00	0.0E+00	-1.2E+04	-3.16E+04
Hospital	Washington	Old	cool	152.1	0.56	0.62	12.9	-4.1	0	89.9	98.7	1.10	346.76	0.75	0.66	-2.1E+03	5.3E+03	0.0E+00	0.0E+00	3.4E+04	3.74E+04
Hospital	Los Angeles	Old	heat	390.4	0.56	0.62	0	-0.1	0	0	-0.1	-	259.98	0.75	0.66	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.00E+00
Hospital	Los Angeles	Old	cool	389.3	0.56	0.62	20.7	-5.8	0	105.5	120.4	1.01	253.14	0.75	0.66	-2.0E+03	5.7E+03	0.0E+00	0.0E+00	2.7E+04	3.06E+04
Hospital	Houston	Old	heat	117.6	0.56	0.62	0.1	-0.3	0	-0.1	-0.3	100.00	140.05	0.75	0.66	-5.6E+03	1.5E+03	0.0E+00	0.0E+00	-1.4E+03	-5.54E+03
Hospital	Houston	Old	cool	123.9	0.56	0.62	15.8	-2.4	0	109.7	123.1	1.23	190.49	0.75	0.66	-7.6E+02	4.0E+03	0.0E+00	0.0E+00	2.6E+04	2.90E+04
School	Minneapolis	New	heat	102.6	0.58	0.62	5.1	-9	-18.1	-21.6	-43.6	2.33	285.50	0.75	0.66	-7.7E+03	3.6E+03	-1.8E+03	-1.0E+04	-1.4E+04	-3.04E+04
School	Minneapolis	New	cool	85.7	0.58	0.62	2.8	-0.6	-1.1	4.1	5.2	2.38	123.50	0.75	0.66	-2.3E+02	8.8E+02	-4.9E+01	-2.7E+02	1.2E+03	1.54E+03
School	Chicago	New	heat	228.4	0.58	0.62	4.8	-7.2	-14.5	-14.9	-31.8	2.33	477.16	0.75	0.66	-1.0E+04	5.7E+03	-2.4E+03	-1.4E+04	-1.7E+04	-3.72E+04
School	Chicago	New	cool	185.2	0.58	0.62	3.1	-0.7	-1.1	5	6.3	2.27	278.72	0.75	0.66	-5.7E+02	2.1E+03	-1.0E+02	-5.9E+02	3.2E+03	4.00E+03
School	Washington	New	heat	172.2	0.59	0.63	4.5	-5.5	-10.7	-9.5	-21.2	2.38	374.74	0.75	0.66	-6.2E+03	4.2E+03	-1.4E+03	-8.1E+03	-8.5E+03	-2.00E+04
School	Washington	New	cool	169.4	0.59	0.63	4	-0.8	-1.5	7.2	8.9	2.38	318.17	0.75	0.66	-7.7E+02	3.2E+03	-1.7E+02	-9.7E+02	5.5E+03	6.74E+03
School	Los Angeles	New	heat	206.8	0.60	0.64	3.9	-2.6	-5.1	-1.9	-5.7	4.00	397.12	0.75	0.66	-5.2E+03	6.4E+03	-1.2E+03	-6.9E+03	-3.0E+03	-9.85E+03
School	Los Angeles	New	cool	206.4	0.60	0.64	4	-0.8	-0.7	8.2	10.7	2.50	367.53	0.75	0.66	-9.2E+02	3.8E+03	-9.6E+01	-5.5E+02	7.5E+03	9.79E+03
School	Houston	New	heat	189.8	0.60	0.64	3.1	-2.3	-4.2	-3.1	-6.5	3.13	358.11	0.75	0.66	-3.2E+03	3.6E+03	-7.1E+02	-4.0E+03	-3.5E+03	-7.79E+03
School	Houston	New	cool	188.5	0.60	0.64	6.5	-0.8	-1	11.2	15.9	2.50	339.82	0.75	0.66	-8.5E+02	5.7E+03	-1.3E+02	-7.2E+02	9.5E+03	1.36E+04
School	Minneapolis	Old	heat	486.4	0.63	0.70	6.1	-10.4	-18.1	-23.9	-46.3	1.64	499.71	0.75	0.66	-1.0E+04	4.7E+03	-2.2E+03	-1.3E+04	-2.0E+04	-3.99E+04
School	Minneapolis	Old	cool	226.9	0.63	0.70	3.6	-0.8	-1.2	4.1	5.7	-	164.92	0.75	0.66	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.00E+00
School	Chicago	Old	heat	2352.1	0.63	0.70	5.6	-8.4	-14.5	-16.5	-33.8	1.64	1,998.88	0.75	0.66	-3.3E+04	1.7E+04	-7.1E+03	-4.0E+04	-5.4E+04	-1.17E+05
School	Chicago	Old	cool	1034.1	0.63	0.70	4.1	-0.9	-1.3	5	6.9	-	894.43	0.75	0.66	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.00E+00
School	Washington	Old	heat	1828.2	0.67	0.71	5.5	-6.9	-10.7	-11	-23.1	1.59	1,753.40	0.75	0.66	-2.2E+04	1.4E+04	-4.5E+03	-2.5E+04	-3.1E+04	-6.77E+04
School	Washington	Old	cool	964.1	0.67	0.71	5.6	-1.2	-1.6	7.1	9.9	-	949.82	0.75	0.66	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.00E+00
School	Los Angeles	Old	heat	1582.7	0.72	0.72	4.4	-3.2	-5.1	-2.3	-6.2	1.54	1,344.33	0.75	0.66	-6.9E+03	8.3E+03	-1.6E+03	-9.0E+03	-4.8E+03	-1.39E+04
School	Los Angeles	Old	cool	1511.6	0.72	0.72	5.8	-1.3	-0.8	8.5	12.2	-	1,096.70	0.75	0.66	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.00E+00
School	Houston	Old	heat	1116	0.72	0.72	3.7	-3	-4.2	-3.5	-7	1.59	804.60	0.75	0.66	-4.0E+03	4.3E+03	-8.0E+02	-4.6E+03	-4.5E+03	-9.51E+03
School	Houston	Old	cool	1048.5	0.72	0.72	8.9	-1.2	-1.3	11.8	18.2	-	807.74	0.75	0.66	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.00E+00
Hospital	Total	Total	heat	1283.9									1,739.52			-9.67E+04	3.21E+04	0.00E+00	0.00E+00	-4.44E+04	-1.09E+05
Hospital	Total	Total	cool	1167.5									1,580.32			-9.71E+03	2.62E+04	0.00E+00	0.00E+00	1.57E+05	1.74E+05
School	Total	Total	heat	8265.2									8,293.54			-1.08E+05	7.26E+04	-2.38E+04	-1.35E+05	-1.59E+05	-3.53E+05
School	Total	Total	cool	5620.4									5,341.35			-3.34E+03	1.57E+04	-5.47E+02	-3.10E+03	2.69E+04	3.56E+04

Supermarkets, Warehouses, and Totals

Building Type	Climate Zone	Vintage	Space Conditioning Mode	1991 Properties Estimated by Huang and Franconi (1999)									1999 Updated Window Stock Estimates (Apte and Arasteh, 2006)								
					Window Properties		Building HVAC Load Intensity (kBtu/ft²/yr)					System Efficiency Factor		Window Properties		Total Building Energy Consumption (Trillion BTU/yr)					
				Conditioned Area, Million Square Feet	U Factor	SHGC	Window Solar	Window Cond	Infiltration	Other Loads	Total Loads	(Primary kBtu Energy Consumption / kBtu Load)	Conditioned Area, Million Square Feet	U Factor	SHGC	Window Solar	Window Cond	Window Infiltration	Non-Window Infiltration	Other Loads	Total Loads
Supermarket	Minneapolis	New	heat	3.4	0.63	0.69	3.1	-6.3	-3.2	-13.5	-19.9	1.96	83.25	0.75	0.66	-1.2E+03	4.9E+02	-7.8E+01	-4.4E+02	-2.2E+03	-3.47E+03
Supermarket	Minneapolis	New	cool	3.4	0.63	0.69	6.6	-1.1	-0.7	36.4	41.2	2.22	71.36	0.75	0.66	-2.1E+02	1.0E+03	-1.7E+01	-9.4E+01	5.8E+03	6.46E+03
Supermarket	Chicago	New	heat	60.9	0.63	0.69	2.4	-4.4	-2.1	-7	-11.1	1.75	63.70	0.75	0.66	-5.9E+02	2.6E+02	-3.5E+01	-2.0E+02	-7.8E+02	-1.35E+03
Supermarket	Chicago	New	cool	60.9	0.63	0.69	7.3	-1.3	-0.8	43.1	48.3	2.27	59.89	0.75	0.66	-2.1E+02	9.5E+02	-1.6E+01	-9.3E+01	5.9E+03	6.50E+03
Supermarket	Washington	New	heat	57.8	0.63	0.69	1	-2	-1.1	-2.2	-4.3	1.37	55.40	0.75	0.66	-1.8E+02	7.3E+01	-1.3E+01	-7.1E+01	-1.7E+02	-3.60E+02
Supermarket	Washington	New	cool	53.4	0.63	0.69	7.8	-1	-0.7	51.8	57.9	2.27	62.52	0.75	0.66	-1.7E+02	1.1E+03	-1.5E+01	-8.5E+01	7.4E+03	8.15E+03
Supermarket	Los Angeles	New	heat	35.3	0.63	0.69	0	0	0	0	0	-	156.77	0.75	0.66	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.00E+00
Supermarket	Los Angeles	New	cool	37.7	0.63	0.69	13.6	-3.4	-1.6	64.5	73.1	1.82	183.58	0.75	0.66	-1.4E+03	4.4E+03	-8.0E+01	-4.5E+02	2.2E+04	2.40E+04
Supermarket	Houston	New	heat	30.2	0.63	0.69	0	-0.1	-0.1	0	-0.2	7.69	76.05	0.75	0.66	-7.0E+01	0.0E+00	-8.8E+00	-5.0E+01	0.0E+00	-1.29E+02
Supermarket	Houston	New	cool	26.2	0.63	0.69	10.8	-1.3	-0.9	73.6	82.2	2.17	87.64	0.75	0.66	-3.0E+02	2.0E+03	-2.6E+01	-1.5E+02	1.4E+04	1.55E+04
Supermarket	Minneapolis	Old	heat	62.4	0.66	0.71	3.5	-7	-3.3	-18.3	-25.1	1.96	28.11	0.75	0.66	-4.4E+02	1.8E+02	-2.7E+01	-1.5E+02	-1.0E+03	-1.45E+03
Supermarket	Minneapolis	Old	cool	63.9	0.66	0.71	6.7	-1.1	-0.7	35.2	40.1	2.27	26.47	0.75	0.66	-7.5E+01	3.7E+02	-6.3E+00	-3.6E+01	2.1E+03	2.37E+03
Supermarket	Chicago	Old	heat	104.3	0.66	0.71	2.8	-5	-2.4	-9.9	-14.5	1.79	132.64	0.75	0.66	-1.3E+03	6.1E+02	-8.5E+01	-4.8E+02	-2.3E+03	-3.64E+03
Supermarket	Chicago	Old	cool	94	0.66	0.71	7.3	-1.2	-0.7	41.8	47.2	2.33	122.75	0.75	0.66	-3.9E+02	1.9E+03	-3.0E+01	-1.7E+02	1.2E+04	1.33E+04
Supermarket	Washington	Old	heat	100.8	0.66	0.71	1.4	-2.6	-1.3	-3.7	-6.2	1.39	65.72	0.75	0.66	-2.7E+02	1.2E+02	-1.8E+01	-1.0E+02	-3.4E+02	-6.07E+02
Supermarket	Washington	Old	cool	89.2	0.66	0.71	7.9	-1	-0.8	51	57.1	2.33	51.34	0.75	0.66	-1.4E+02	8.7E+02	-1.4E+01	-8.1E+01	6.1E+03	6.73E+03
Supermarket	Los Angeles	Old	heat	85.3	0.66	0.71	0	0	0	0	0	-	53.87	0.75	0.66	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.00E+00
Supermarket	Los Angeles	Old	cool	86.8	0.66	0.71	13.8	-3.3	-1.3	62.9	72.1	1.89	52.10	0.75	0.66	-3.7E+02	1.3E+03	-1.9E+01	-1.1E+02	6.2E+03	6.94E+03
Supermarket	Houston	Old	heat	134.1	0.66	0.71	0.1	-0.2	-0.1	-0.2	-0.4	4.35	44.61	0.75	0.66	-4.4E+01	1.8E+01	-2.9E+00	-1.6E+01	-3.9E+01	-8.42E+01
Supermarket	Houston	Old	cool	119.6	0.66	0.71	11	-1.1	-0.8	73.4	82.5	2.22	70.92	0.75	0.66	-2.0E+02	1.6E+03	-1.9E+01	-1.1E+02	1.2E+04	1.28E+04
Warehouse	Minneapolis	New	heat	168.3	0.58	0.70	0.8	-0.8	-1	-11.6	-12.6	1.56	276.99	0.75	0.66	-4.4E+02	3.3E+02	-6.5E+01	-3.7E+02	-5.0E+03	-5.57E+03
Warehouse	Minneapolis	New	cool	88.4	0.58	0.70	0.2	0	0	0.7	0.9	1.59	76.00	0.75	0.66	0.0E+00	2.3E+01	0.0E+00	0.0E+00	8.4E+01	1.07E+02
Warehouse	Chicago	New	heat	329.6	0.58	0.70	0.7	-0.6	-0.8	-7.8	-8.5	1.56	734.76	0.75	0.66	-8.8E+02	7.6E+02	-1.4E+02	-7.8E+02	-9.0E+03	-9.99E+03
Warehouse	Chicago	New	cool	90.4	0.58	0.70	0.4	0	0	1.1	1.5	1.35	183.73	0.75	0.66	0.0E+00	9.4E+01	0.0E+00	0.0E+00	2.7E+02	3.67E+02
Warehouse	Washington	New	heat	693.1	0.59	0.70	0.6	-0.5	-0.6	-4.7	-5.2	1.79	672.86	0.75	0.66	-7.6E+02	6.8E+02	-1.1E+02	-6.1E+02	-5.6E+03	-6.45E+03
Warehouse	Washington	New	cool	277.6	0.59	0.70	0.6	0	0	2.2	2.8	1.54	183.54	0.75	0.66	0.0E+00	1.6E+02	0.0E+00	0.0E+00	6.2E+02	7.80E+02
Warehouse	Los Angeles	New	heat	588.2	0.60	0.71	0.3	-0.2	-0.2	-1	-1.1	2.27	339.26	0.75	0.66	-1.9E+02	2.1E+02	-2.3E+01	-1.3E+02	-7.7E+02	-9.04E+02
Warehouse	Los Angeles	New	cool	193.2	0.60	0.71	0.8	0	0	2.7	3.5	1.75	265.43	0.75	0.66	0.0E+00	3.4E+02	0.0E+00	0.0E+00	1.3E+03	1.60E+03
Warehouse	Houston	New	heat	306.8	0.60	0.71	0.4	-0.2	-0.3	-1.8	-1.9	1.92	273.63	0.75	0.66	-1.3E+02	1.9E+02	-2.4E+01	-1.3E+02	-9.5E+02	-1.04E+03
Warehouse	Houston	New	cool	232.1	0.60	0.71	0.5	0.1	0	1.5	2.1	2.13	267.12	0.75	0.66	7.1E+01	2.6E+02	0.0E+00	0.0E+00	8.5E+02	1.19E+03
Warehouse	Minneapolis	Old	heat	769.3	0.72	0.72	1.6	-1.8	-1	-12.3	-13.5	1.59	234.69	0.75	0.66	-7.0E+02	5.4E+02	-5.6E+01	-3.2E+02	-4.6E+03	-5.11E+03
Warehouse	Minneapolis	Old	cool	233.8	0.72	0.72	0.6	0	0	0.8	1.4	1.89	58.89	0.75	0.66	0.0E+00	6.1E+01	0.0E+00	0.0E+00	8.9E+01	1.50E+02
Warehouse	Chicago	Old	heat	2465.1	0.72	0.72	1.3	-1.4	-0.8	-8.3	-9.2	1.61	710.74	0.75	0.66	-1.7E+03	1.4E+03	-1.4E+02	-7.8E+02	-9.5E+03	-1.07E+04
Warehouse	Chicago	Old	cool	476	0.72	0.72	0.9	0	0	1.2	2.1	1.69	115.02	0.75	0.66	0.0E+00	1.6E+02	0.0E+00	0.0E+00	2.3E+02	3.94E+02
Warehouse	Washington	Old	heat	1481.1	0.72	0.73	1.1	-1	-0.6	-5.1	-5.6	1.79	543.39	0.75	0.66	-1.0E+03	9.6E+02	-8.7E+01	-4.9E+02	-4.9E+03	-5.58E+03
Warehouse	Washington	Old	cool	540.6	0.72	0.73	1.2	0	0	2.2	3.4	1.89	176.09	0.75	0.66	0.0E+00	3.6E+02	0.0E+00	0.0E+00	7.3E+02	1.09E+03
Warehouse	Los Angeles	Old	heat	771.7	0.72	0.74	0.5	-0.3	-0.2	-1.2	-1.2	2.04	373.64	0.75	0.66	-2.4E+02	3.4E+02	-2.3E+01	-1.3E+02	-9.2E+02	-9.66E+02
Warehouse	Los Angeles	Old	cool	377.7	0.72	0.74	1.8	-0.1	0	3.1	4.8	2.17	219.17	0.75	0.66	-5.0E+01	7.7E+02	0.0E+00	0.0E+00	1.5E+03	2.19E+03
Warehouse	Houston	Old	heat	696.8	0.72	0.74	0.7	-0.4	-0.2	-2.1	-2	1.96	243.04	0.75	0.66	-2.0E+02	3.0E+02	-1.4E+01	-8.1E+01	-1.0E+03	-9.97E+02
Warehouse	Houston	Old	cool	547.7	0.72	0.74	1.4	0.2	0.1	1.7	3.4	2.27	182.35	0.75	0.66	8.6E+01	5.2E+02	6.2E+00	3.5E+01	7.0E+02	1.35E+03
Supermarket	Total	Total	heat	674.5									760.12			-4.17E+03	1.74E+03	-2.68E+02	-1.52E+03	-6.88E+03	-1.11E+04
Supermarket	Total	Total	cool	635.1									788.58			-3.41E+03	1.54E+04	-2.42E+02	-1.37E+03	9.24E+04	1.03E+05
Warehouse	Total	Total	heat	8270									4,403.01			-6.23E+03	5.68E+03	-6.76E+02	-3.83E+03	-4.23E+04	-4.74E+04
Warehouse	Total	Total	cool	3057.5									1,727.33			1.08E+02	2.75E+03	6.22E+00	3.52E+01	6.32E+03	9.22E+03

	1999 Updated Window Stock Estimates (Apte and Arasteh, 2006)								
		Window Properties		Total Building Energy Consumption (Trillion BTU/yr)					
	Conditioned Area, Million Square Feet	U Factor	SHGC	Window Solar	Window Cond	Window Infiltration	Non-Window Infiltration	Other Loads	Total Loads
Total Heat	38,295.64			(812,350.07)	378,903.43	(51,890.48)	(294,046.08)	(449,998.29)	(1,229,381.49)
Total Cool	30,930.38			(166,992.36)	632,221.04	(9,770.85)	(55,368.13)	1,243,318.20	1,643,407.90
Percent, Heat				66%	-31%	4%	24%	37%	100%
Percent, Cool				-10%	38%	-1%	-3%	76%	100%
Total Window	Heat			39%					
	Cool			28%					

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