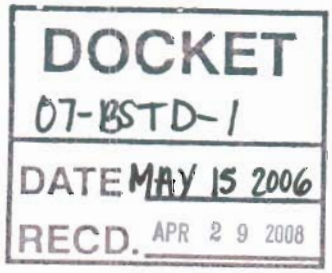
CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)

2008 California Energy Commission Title 24 Building Energy Efficiency Standards
May 15, 2006

# *Draft Report*
# *Insulation Requirements*

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## Table of Contents


***Overview*** ..... ***3***

*Description* ..... *3*
*Energy Benefits* ..... *3*
*Non-energy Benefits* ..... *3*
*Environmental Impact* ..... *3*
*Type of Change* ..... *4*
*Technology Measures* ..... *4*
*Analysis Tools* ..... *4*
*Relationship to Other Measures* ..... *4*

***Methodology*** ..... ***5***

*Approach* ..... *5*
*Categories of Construction* ..... *5*
*Cost Data* ..... *6*
*Energy Use for Each Construction Assembly* ..... *11*
*Life Cycle Cost Model* ..... *14*

***Results*** ..... ***16***

*2005 versus 2008 Insulation Level Comparisons* ..... *16*
*Coefficient Graphs* ..... *17*
*Cost-effectiveness* ..... *50*

***Recommendations*** ..... ***50***

*Proposed Standards Language* ..... *52*
*Alternate Calculation Manual* ..... *52*

***Bibliography and Other Research*** ..... ***53***

***Acknowledgments*** ..... ***53***

***Appendices*** ..... ***53***

*Energy Impacts* ..... *53*
*Energy Coefficients* ..... *61*


## Document information

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## Overview

The nonresidential insulation levels were last updated in 1992 and very few changes have been made to the prescriptive envelope requirements in the last 12 years. The main changes came with the Title 24 2005 Standards as U-factors were pre-calculated for all common construction assemblies and published as Joint Appendix IV for both the residential and nonresidential Alternative Calculation Method (ACM) manuals. Another change with the Title 24 2005 Standards applies to metal buildings; the R-value method was eliminated as a compliance option for metal building roofs.

The approach in this analysis is to calculate the cost effective level of insulation for separate classes of construction. The analysis is based on time dependent valued (TDV) energy, which replaced source energy with the 2005 update to the Standards. TDV electric energy weights consumption and savings by time of day. TDV gas energy weights consumption by season.

The approach is to identify a list of reasonable constructions for each class of construction, estimate the cost for each construction assembly, estimate the TDV energy for each construction assembly in the list, and calculate the life-cycle cost of each construction assembly using the Energy Commission approved life-cycle cost methodology. The objective is to identify the U-Factor of the construction with the lowest life-cycle cost.

## Description

The proposed change is a modification to the prescriptive insulation requirements for nonresidential buildings, which are contained in Tables 143-A, 143-B, and 143-C. The standards for relocatable school buildings in Table 143-C are for buildings that can be relocated to any climate zone, and so the insulation requirements correspond to those of the most severe climate zones in Table 143-A. Since the prescriptive standards set the baseline for the performance method, the performance method would become more stringent also.

## Energy Benefits

The energy benefits are calculated using DOE-2.1E, the California Energy Commission (CEC) reference method for nonresidential buildings. A separate analysis is performed for each opaque construction type (roof, wall, and floor) and class of construction within that type (mass, metal buildings, metal framing and wood framing). The life-cycle cost optimum insulation is determined for each type/class in the sixteen climate zones. The evaluation is performed using a life-cycle cost approach based on TDV energy and the CEC methodology. U-factors from Joint Appendix IV are used in the analysis.

## Non-energy Benefits

Non-energy benefits from improved insulation levels include improved comfort and environmental benefits - environmental benefits are discussed in the next section.

## Environmental Impact

Insulation will reduce heat loss and gain through building envelopes and this will reduce the use of heating and cooling system energy that negatively impacts the environment. The primary environmental impact is the reduction in air emissions from the reduction in furnace or boiler emissions due to reduced heating fuel (natural gas) consumption and power plants due to reduced electricity consumption.[1]

[1] The reduction in emissions due to reduced electricity could occur anywhere throughout the Western United States whereas the reduction in emissions due to reductions in heating will occur at the building site.

## Type of Change

This report recommends changes to the prescriptive requirements. As the prescriptive standards change, the baseline for performance calculations also changes. The Title 24 Standards and Nonresidential ACM Manual will need to be modified accordingly.

## Technology Measures

### *Measure Availability and Cost*

There are numerous manufacturers of insulation products, and products are widely distributed through contractors, wholesale distributors, and retail. The market place for insulation is competitive and healthy. Products being considered in this study are already available in the marketplace, and increasing the minimum insulation requirement should not cause a shortage, if ample time is given before implementation of the requirements so that manufacturers have time to shift production output. Increasing the minimum insulation requirement should not affect the manufacturing process materially.

The cost of insulation is directly related to the quantity that is purchased and installed in the building. Shifting from one type (fiberglass batts) to another (foamed plastic) will change the cost per unit of thermal resistance (R-value). The cost of insulation products is well documented in the literature. More information is provided later in the report on insulation costs, since this is a key input to the analysis.

Performance verification or commissioning of insulation systems is not common in nonresidential buildings. With the 2005 update to the Standards, field verification and diagnostic testing of insulation systems was added as a compliance option for low-rise residential buildings to recognize that research has shown insulation is commonly installed with construction defects. For low-rise residential buildings, the thermal performance of insulation is assumed to be installed according to standard practice methods unless a HERS rater performs field verification and diagnostic testing to demonstrate that high quality installation has been achieved. This report does not propose a similar approach at this time for basing nonresidential insulation performance on the presence of construction defects unless the work is independently verified to insure a high quality installation is achieved.

### *Useful Life, Persistence and Maintenance*

The life-cycle cost analysis uses a 30 year life for insulation. This is the current standard and common practice for envelope requirements. There is no significant persistence or maintenance issues related to increasing insulation levels. The only potential issue is the degradation over time of insulation performance due to the possible condensation of water within a construction assembly. Condensation could result at walls adjacent to moisture laden spaces when there is an inadequate or discontinuous vapor barrier.

## Analysis Tools

Energy savings and peak electricity demand reductions can be quantified using the current reference method or approved ACMs.

## Relationship to Other Measures

Heating and cooling loads will be impacted by improved insulation levels and heating and cooling systems may possibly be downsized. A key input into this analysis was whether the HVAC systems have an air-side economizer. All the models used to develop insulation level recommendations assume that air-side economizers are used on all new buildings. However, Title 24 Section 144(e) requires air side economizers on HVAC units that have a cooling capacity greater than 75,000 Btu/hr (6.25 tons). A sensitivity analysis was performed in climate zones 3, 6, and 12 to determine the effect of economizers. This is detailed in the 2005 versus 2008 Insulation Level Comparisons section under Economizers. A cool roof sensitivity analysis was also performed for this study since the optimal cool roof coating was determined using the 2005 insulation standards as a baseline.

# Methodology

## Approach

A component approach is used for the development of the recommended insulation levels. With this approach, the stringency of each category of construction is determined independently from the others. Construction assemblies addressed in this report are organized by type, class and category, as defined below:

| | |
|---|---|
| Types | The three types of constructions are roofs, walls and floors. These are defined in the standards. |
| Classes | A separate performance criterion is recommended for each class of construction. A class of construction can be a consolidation of more than one category, as defined in the next bullet. |
| Categories | Categories are consolidated into classes. The categories of construction used in this analysis are the same as those used to group information in Joint Appendix IV. |

A separate life-cycle cost analysis was performed for each category and then the data was consolidated into classes. The construction assemblies considered in the life-cycle cost analysis are those that are included in each table of Joint Appendix IV specified below. The initial cost of each construction assembly was estimated from nationally published data[2] but cross checked against regional data for California[3].

The energy consumption of each construction assembly is calculated for three occupancy types, which capture the principal variation within the occupancy schedules referenced in the nonresidential ACM manual. These include occupancy schedules for daytime only, 24-hour (i.e., high-rise residential and hotel/motel), and retail. The schedules of operation, occupant loads, lighting loads, plug loads and other modeling assumptions for these three occupancies are taken from the Nonresidential ACM Manual. Details on these and other modeling assumptions are provided later in this section.

Once the energy use and the initial cost were determined for each construction category, the life-cycle cost is calculated for each construction assembly using the CEC recommended methodology. The approach is to find the construction assembly that minimizes life-cycle cost.

## Categories of Construction

The categories of construction used in the analysis are determined from Joint Appendix IV, as shown below. The tables in Joint Appendix IV present the U-factors and other thermal performance data for just about all levels of insulation. The tables are comprehensive and are intended to provide performance data for all levels of insulation. Every cell in the Joint Appendix IV data tables listed below was evaluated. The categories considered are shown below.

Roofs

Table IV.1 – U-factors of Wood Framed Attic Roofs

Table IV.2 – U-factors of Wood Framed Rafter Roofs

Table IV.4 – U-factors of Metal Framed Attic Roofs

[2] RSMeans, *Means CostWorks 2005, Building Construction Cost Data*, 7th Edition, 2005.

[3] California Public Utilities Commission and California Energy Commission, *2004-05 Database for Energy Efficient Resources (DEER) Version 2.0*, 2005.

Table IV.5 – U-factors of Metal Framed Rafter Roofs

Table IV.6 – U-factors for Span Deck and Concrete Roofs

Table IV.7 – U-factors for Metal Building Roofs

Walls

Table IV.9 – U-factors of Wood Framed Walls

Table IV.11 – U-factors of Metal Framed Walls

Table IV.16 – U-factors for Metal Building Walls

Table IV.19 – Effective R-values for Interior or Exterior Insulation Layers (Note that this table has insulation levels that apply to base mass wall constructions. These are combined with the standard design light and heavy mass walls as defined in the nonresidential ACM manual.)

Floors

Table IV.20 – Standard U-factors for Wood Framed Floors with a Crawl Space

Table IV.21 – Standard U-factor for Wood Framed Floors without a Crawl Space

Table IV.23 – Standard U-factor for Metal Framed Floors with a Crawl Space

Table IV.24 – Standard U-factor for Metal Framed Floors without a Crawl Space

Table IV.25 – Standard U-factors for Concrete Raised Floors

## Cost Data

Cost assumptions are critically important to the life-cycle cost. The higher the initial cost, the less likely a measure will be cost effective. However, only the incremental cost of adding insulation or otherwise improving the thermal performance of the construction assembly is of significance for each category of construction (see above).

In order to remain consistent, the analysis used data from one source, *Means CostWorks 2005*. However, as a cross reference and check, the Means data was compared to the *2005 Database for Energy Efficient Resources (DEER)*, where data is available from both sources. When more than one insulation product can be used for a particular application, the product with the lowest cost was used. Incremental costs include both material and labor.

Specific values for certain insulation levels and framing sizes that are not available in the Means database were determined by regression analysis. Values determined through regression are *italicized* and highlighted in yellow. In Table 1 through Table 8 a separate regression analysis was performed for both the material cost and labor cost. For cavity insulation, no regression was performed for labor cost because the cost is assumed to be fixed to the framing size. In other words, all cavity insulation for 2x4 framing have the same labor cost, and all cavity insulation for 2x6 framing have the same labor cost.

The final cost used in the life-cycle cost analysis includes a 1.09 multiplier to adjust the national figures to California and a 30% markup for contractors' overhead and profit. The multiplier and markup is included in Table 1 through Table 8.

### *Insulation Costs*

*Table 1 – Cavity Insulation Costs*

| R-value | Material Cost ($/ft$^2$) | 16" Labor Cost ($/ft$^2$) | 24" Labor Cost ($/ft$^2$) | Total 16" Cost ($/ft$^2$) | Total 24" Cost ($/ft$^2$) | DEER Cost ($/ft$^2$) |
|---|---|---|---|---|---|---|
| 11 | 0.24 | 0.20 | 0.17 | 0.44 | 0.41 | |
| 13 | 0.31 | 0.20 | 0.17 | 0.51 | 0.48 | |
| 15 | 0.34 | 0.20 | 0.17 | 0.54 | 0.51 | 0.61 |
| 19 | 0.46 | 0.24 | 0.20 | 0.70 | 0.66 | 0.65 |
| 21 | 0.44 | 0.24 | 0.20 | 0.68 | 0.64 | 0.68 |
| 22 | 0.46 | 0.24 | 0.20 | 0.70 | 0.66 | |
| 25 | 0.51 | 0.24 | 0.20 | 0.75 | 0.71 | |
| 30 | 0.60 | 0.27 | 0.24 | 0.87 | 0.84 | 0.76 |
| 38 | 0.70 | 0.27 | 0.24 | 0.97 | 0.94 | 0.86 |
| CostWorks description: wall or ceiling insulation, non-rigid, fiberglass, unfaced, batts or blankets | | | | | | |

*Table 2 – Rigid Insulation Costs*

| R-value | Material Cost ($/ft$^2$) | Labor Cost ($/ft$^2$) | Total Cost ($/ft$^2$) |
|---|---|---|---|
| 3.9 | 0.29 | 0.34 | 0.63 |
| 4.5 | 0.30 | 0.34 | 0.64 |
| 5.4 | 0.24 | 0.34 | 0.58 |
| 7.2 | 0.33 | 0.34 | 0.67 |
| 10.8 | 0.35 | 0.38 | 0.73 |
| 14.4 | 0.46 | 0.38 | 0.84 |
| 21.6 | 1.11 | 0.38 | 1.49 |
| 28.8 | 1.37 | 0.38 | 1.75 |
| CostWorks description: wall insulation, rigid, polyisocyanurate, foil faced, both sides, 4' x 8' sheet | | | |

*Table 3 – Rigid Insulation Costs from Regression Only*

| R-value | Material Cost ($/ft$^2$) | Labor Cost ($/ft$^2$) | Total Cost ($/ft$^2$) |
|---|---|---|---|
| 2 | 0.09 | 0.34 | 0.43 |
| 4 | 0.18 | 0.34 | 0.52 |
| 6 | 0.28 | 0.34 | 0.62 |
| 7 | 0.32 | 0.34 | 0.66 |
| 8 | 0.37 | 0.34 | 0.71 |
| 10 | 0.46 | 0.38 | 0.84 |
| 14 | 0.64 | 0.38 | 1.02 |
| 12 | 0.55 | 0.38 | 0.93 |
| 15 | 0.69 | 0.38 | 1.07 |
| 20 | 0.92 | 0.38 | 1.30 |
| 25 | 1.15 | 0.38 | 1.53 |
| 30 | 1.38 | 0.38 | 1.76 |
| CostWorks description: wall insulation, rigid, isocyanurate, foil faced, both sides, 4' x 8' sheet | | | |

*Table 4 – Metal Building Insulation Costs*

| R-value | Material Cost ($/ft$^2$) | Labor Cost ($/ft$^2$) | Total Cost ($/ft$^2$) |
|---|---|---|---|
| None | 0 | 0 | 0 |
| R-10 | 0.38 | 0.24 | 0.62 |
| R-11 | 0.42 | 0.24 | 0.66 |
| R-13 | 0.47 | 0.24 | 0.71 |
| R-19 | 0.61 | 0.24 | 0.85 |

CostWorks description: pre-engineered steel building access, insulation, foil/scrim/kraft (FSK) faced

## Wall Framing Costs

Wall framing costs were determined by assuming a 10' high wall, which is typical of nonresidential buildings. 16 in. O.C. and 24 in. O.C. framing are compared as separate categories in the analysis, however, the code recommendation used the 16 in. O.C. framing as the basis.

*Table 5 – Wood Framing Costs*

| | Frame Size | Material Cost | Labor Cost | Total Cost | Square Foot Cost ($/ft$^2$) | Total Incremental Cost ($/ft$^2$) |
|---|---|---|---|---|---|---|
| 16 in. O.C | 2x4 | 3.56 | 5.5 | 9.06 | 0.91 | 0 |
| | 2x6 | 5.65 | 6.1 | 11.75 | 1.18 | 0.269 |
| | 2x8 | 7.74 | 6.70 | 14.44 | 1.44 | 0.54 |
| | 2x10 | 9.83 | 7.30 | 17.13 | 1.71 | 0.81 |
| | 2x12 | 11.92 | 7.90 | 19.82 | 1.98 | 1.08 |
| 24 in. O.C | 2x4 | 2.71 | 4.38 | 7.09 | 0.71 | 0 |
| | 2x6 | 4.30 | 4.77 | 9.07 | 0.91 | 0.20 |
| | 2x8 | 5.89 | 5.16 | 11.05 | 1.11 | 0.40 |
| | 2x10 | 7.48 | 5.55 | 13.03 | 1.30 | 0.59 |
| | 2x12 | 9.07 | 5.94 | 15.01 | 1.50 | 0.79 |

Wall framing is assumed to be 10' high as the least cost to the contractor.

CostWorks description: wood framing, partitions, standard & better lumber, 10' high, includes single bottom plate and double bottom plate, excludes waste

*Table 6 – Metal Framing Costs*

| | Frame Size | Material Cost | Labor Cost | Total Cost | Square Foot Cost ($/ft$^2$) | Total Incremental Cost ($/ft$^2$) |
|---|---|---|---|---|---|---|
| 16 in. O.C. | 2x4 | 11.15 | 7.40 | 18.55 | 1.86 | 0 |
| | 2x6 | 14.15 | 7.50 | 21.65 | 2.17 | 0.31 |
| | 2x8 | 17.30 | 7.60 | 24.9 | 2.49 | 0.65 |
| | 2x10 | 20.28 | 7.82 | 28.10 | 2.81 | 0.96 |
| | 2x12 | 23.31 | 8.00 | 31.31 | 3.13 | 1.26 |
| 24 in. O.C. | 2x4 | 8.2 | 5.3 | 13.5 | 1.35 | 0 |
| | 2x6 | 10.45 | 5.45 | 15.9 | 1.59 | 0.24 |
| | 2x8 | 12.85 | 5.5 | 18.35 | 1.835 | 0.48 |
| | 2x10 | 15.06 | 5.69 | 20.75 | 2.08 | 0.73 |
| | 2x12 | 17.33 | 5.84 | 23.17 | 2.32 | 0.97 |

Wall framing is assumed to be 10' high as the least cost to the contractor.

CostWorks reference: partition, galv LB studs, 18 ga, 10' high, incl galv top & bottom track, excl openings, headers, beams, bracing & bridging

## Roof Framing Cost

Rafter roof framing costs were determined by assuming a square foot of framing and applying the framing factor specified in the Title 24 2005 Standards, 10% for 16 in. O.C. and 7% for 24 in. O.C. The same process was used to determine costs for metal rafter roofs. 16 in. O.C. and 24 in. O.C. framing are compared as separate categories in the analysis, however, the code recommendation used the 24 in. O.C. framing as the basis. Metal building roofs that utilize rigid insulation include an additional metal deck (screw down roof) to sandwich the rigid insulation.

*Table 7 – Wood Rafters Roof Costs*

| Framing Size | Material Cost | Labor Cost | Total Cost | 16" Total Cost ($/ft$^2$) | 24" Total Cost ($/ft$^2$) | 16" Incremental Cost ($/ft$^2$) | 24" Incremental Cost ($/ft$^2$) |
|---|---|---|---|---|---|---|---|
| 2x6 | 3.21 | 3.30 | 6.51 | 0.65 | 0.46 | 0 | 0 |
| 2x8 | 4.96 | 3.48 | 8.44 | 0.84 | 0.59 | 0.19 | 0.13 |
| 2x10 | 7.05 | 4.35 | 11.4 | 1.14 | 0.80 | 0.49 | 0.34 |
| 2x12 | 9.60 | 5.22 | 14.83 | 1.48 | 1.04 | 1.83 | 1.58 |
| 2x14 | 12.96 | 6.09 | 19.05 | 1.90 | 1.33 | 0.87 | 0.87 |

Roof framing is determined by multiplying the total square foot framing cost by the framing factor of 10% for 16 in. O.C. and 7% for 24 in. O.C.

CostWorks description: rafters, roof framing, to 14 in 12 pitch

*Table 8 – Metal Rafter Roof Costs*

| Framing Size | Material Cost | Labor Cost | Total Cost | 16" Total Cost ($/ft$^2$) | 24" Total Cost ($/ft$^2$) | 16" Incremental Cost ($/ft$^2$) | 24" Incremental Cost ($/ft$^2$) |
|---|---|---|---|---|---|---|---|
| 2x6 | 5.6 | 3.43 | 9.03 | 0.90 | 0.63 | 0 | 0 |
| 2x8 | 6.2 | 3.65 | 9.85 | 0.99 | 0.69 | 0.09 | 0.06 |
| 2x10 | 7.55 | 3.91 | 11.46 | 1.15 | 0.80 | 0.25 | 0.17 |
| 2x12 | 8.3 | 4.22 | 12.52 | 1.25 | 0.88 | 0.35 | 0.25 |
| 2x14 | 9.28 | 4.46 | 13.74 | 1.37 | 0.96 | 0.47 | 0.33 |

Roof framing is determined by multiplying the total square foot framing cost by the framing factor of 10% for 16 in. O.C. and 7% for 24 in. O.C.

CostWorks description: boxed ridge beam, for CF metal rafters, w/ galv joist & track, double, 18 ga

*Table 9 – Metal Building Roof Costs*

| Framing Size | Material Cost ($/ft$^2$) | Labor Cost ($/ft$^2$) | Total Cost ($/ft$^2$) |
|---|---|---|---|
| Screw Down (no thermal blocks) | 0.77 | 0.97 | 1.74 |
| Standing Seam (thermal blocks at supports) | 1.75 | 1.07 | 2.82 |

Metal building roofs including screw down and standing seam include an addition screw down roof cost for rigid insulation.

CostWorks description (screw): steel roofing, on steel frame, corrugated or ribbed, galvanized, 30 gauge

CostWorks description (standing seam): steel roofing, on steel frame, flat profile, 1-3/4" standing seams, zinc aluminum alloy finish, 12" wide, 26 gauge

## Floor Framing Cost

Floor framing costs were excluded from the calculation because additional insulation may be added to the floor without altering the framing.

## Cost Adjustments

The cost is adjusted for California and a markup is added for the contractors' overhead and profit.

The Means data either specifies a national average or a local city average cost; however, the Means data does not provide a weighting factor for the State of California as a whole. In order to determine a reasonable California adjustment factor, we specified a representative city for each of California's sixteen climate zones. Next, we determined the local adjustment factor for each city and weighted the adjustment factor against the percentage of new construction for the representative city and climate zone. The cost adjustment factors were taken from the Means data and the new construction weighting percentages were taken from the 2005 Title 24 Impact Analysis[4] using the nonresidential new construction database. Table 10 shows the representative city, local adjustment factor, and weighting factor for each of the sixteen climate zones. The weighted markup for each climate zone was determined by multiplying the percent floor area by the local markup. The California adjustment factor or total markup is the sum of the weighted markup.

*Table 10 – California Adjustment Factor*

| Zone | City | Percent Floor Area | Real Area | Local Markup | Weighted Markup |
|---|---|---|---|---|---|
| 1 | Arcata | 0.0031 | 492,900 | 1.04 | 0.003224 |
| 2 | Santa Rosa | 0.0701 | 11,145,900 | 1.124 | 0.0787924 |
| 3 | Oakland | 0.1586 | 25,217,400 | 1.166 | 0.1849276 |
| 4 | San Jose | 0.0713 | 11,336,700 | 1.169 | 0.0833497 |
| 5 | San Louis Obispo | 0.0187 | 2,973,300 | 1.05 | 0.019635 |
| 6 | Los Angeles | 0.0602 | 9,571,800 | 1.068 | 0.0642936 |
| 7 | San Diego | 0.0746 | 11,861,400 | 1.044 | 0.0778824 |
| 8 | Santa Ana | 0.0876 | 13,928,400 | 1.032 | 0.0904032 |
| 9 | Pasadena | 0.1036 | 16,472,400 | 1.04 | 0.107744 |
| 10 | Riverside | 0.0843 | 13,403,700 | 1.059 | 0.0892737 |
| 11 | Redding | 0.0140 | 2,226,000 | 1.084 | 0.015176 |
| 12 | Sacramento | 0.1450 | 23,055,000 | 1.097 | 0.159065 |
| 13 | Fresno | 0.0596 | 9,476,400 | 1.078 | 0.0642488 |
| 14 | Mojave | 0.0240 | 3,816,000 | 1.021 | 0.024504 |
| 15 | Palm Springs | 0.0198 | 3,148,200 | 1.029 | 0.0203742 |
| 16 | Truckee | 0.0055 | 874,500 | 1.084 | 0.005962 |
| Totals | | 1 | 159,000,000 | | 1.0888556 |

[4] California Energy Commission by Eley Associates. Impact Analysis, 2005 Update to the California Energy Efficiency Standards, 2003

## Energy Use for Each Construction Assembly

The energy use for each construction assembly was calculated using the DOE-2.1E reference method. For each construction type, one or more sets of computer runs were made to establish the relationship between changes in U-factor and TDV energy. The runs include three points that represent high, medium and low U-factors that correspond to no insulation, some insulation (similar to that of the current Standard), and high levels of insulation. The exact DOE-2 inputs can be found in Table 12 through Table 14 below. From these runs, a linear regression is performed that approximates TDV energy use per square foot of surface area as a function of U-factor.

**TDV = C0 + C1 x U-factor**

where:

C0: constant

C1: coefficient

U-factor: U-factor is the overall heat transfer coefficient for the assembly including both the inside and outside air film resistance taken from Joint Appendix IV.

The constants and coefficients, along with the $R^2$ for the coefficient can be found in Table 49 – TDV DOE-2 Coefficients of the Appendix. Separate coefficients are calculated for each construction assembly, occupancy type and climate zone. After the constant and coefficient were determined, the energy use of the same assembly with varying levels of insulation can be approximated by applying the appropriate U-factor to the TDV equation above.

## Energy Model and Assumptions

DOE-2.1E version 119 developed by Lawrence Berkeley Laboratory was used to create a database of heating and cooling energy for a wide variety of inputs. For all cases, a simple five-zone model was used. The arrangement for thermal zoning was intentionally designed so that perimeter zones are connected only to the interior zone and not to other perimeter zones. This tends to isolate solar effects on the building. Windows are modeled only on each perimeter zone.

A set of coefficients is developed for each class of construction, climate zone and occupancy type. The following are important factors in the energy model:

- Geometry
  - A 5-zone model
  - Four exterior zones (100 ft X 15 ft) with windows on the long facades, no skylights
  - One interior zone (100 ft X 100 ft) without windows
  - Space height 13 ft
- Fenestration: The fenestration area is set to 30% of window to wall ratio (WWR) for daytime and 24-hour occupancy and 10% WWR for retail occupancy. The fenestration used is DOE-2 code 2204: double tint bronze with a U-factor of 0.48 and a SHGC of 0.49.

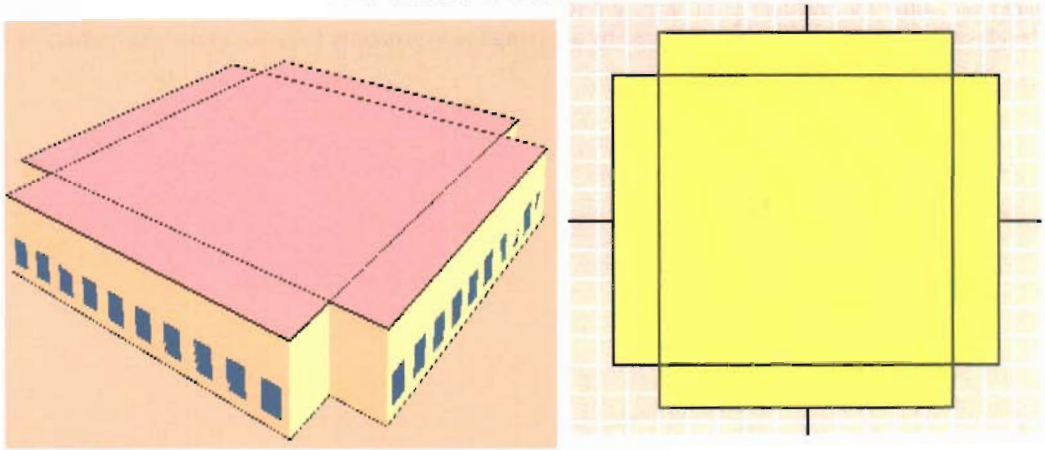

*Figure 1 – Five-Zone DOE-2 Model*

- Internal loads

*Table 11 – Internal Loads*

| Internal Gain | Daytime | Retail | 24-hour |
|---|---|---|---|
| Lighting Power Density | 1.25 | 1.5 | 0.50 |
| Equipment Power Density | 0.75 | 0.94 | 0.50 |
| Occupancy | 29 persons / 1,000 $ft^2$ | 29 persons / 1,000 $ft^2$ | 5 persons / 1,000 $ft^2$ |

- HVAC systems
  - One packaged single zone (PSZ) system for each zone. No plenum.
  - Cooling EER 9.5, fan power at 0.35 W/cfm
  - Integrated air-side economizer
  - Outside air 15 cfm
  - Heating temperature is set to 70°F; cooling temperature is set to 73°F
  - Electricity is used cooling and gas is used for heating
- Operation schedules
  - Daytime only (typical for office buildings). Annual operating hours 4300
  - Retail (typical for retail stores). Annual operating hours 5475
  - 24-hour (typical high-rise residential). Annual operating hours 8760
- Envelope Construction Assemblies Modeled

*Table 12 – Roof Construction Assemblies Modeled*

| Roof Class | ID | DOE-2 Construction Materials | U-factor (Btu/h-sf-°F) |
|---|---|---|---|
| Light | Low | (AR02, BP01, PW03, RWF49, GP01) | 0.020 |
| Light | Medium | (AR02, BP01, PW03, RWF19, GP01) | 0.045 |
| Light | High | (AR02, BP01, PW03, AL33, GP01) | 0.285 |
| Mass | Low | (RG01, BR01, CC14, IN47, GP01) | 0.037 |
| Mass | Medium | (RG01, BR01, CC14, IN74, GP01) | 0.130 |
| Mass | High | (RG01, BR01, CC14, AL33, GP01) | 0.324 |
| Attic | Low | Roof: (RG01, BR01, PW05)<br>Ceiling: (GP02, RWF49) | 0.019 |
| Attic | Medium | Roof: (RG01, BR01, PW05)<br>Ceiling: (GP02, RWF19) | 0.043 |
| Attic | High | Roof: (RG01, BR01, PW05)<br>Ceiling: (GP02) | 0.284 |

*Table 13 – Wall Construction Assemblies Modeled*

| Wall Class | ID | DOE-2 Materials | U-factor (Btu/h-sf-°F) |
|---|---|---|---|
| Light | Low | (SC01, BP01, WWF30, GP01) | 0.032 |
| Light | Medium | (SC01, BP01, WWF11, GP01) | 0.076 |
| Light | High | (SC01, BP01, WMF00, GP01) | 0.417 |
| Mass7 | Low | (SC01, CB49, IN36) | 0.065 |
| Mass7 | Medium | (SC01, CB49, IN33) | 0.143 |
| Mass7 | High | (SC01, CB29) | 0.379 |
| Mass15 | Low | (SC01, CB32, IN36) | 0.066 |
| Mass15 | Medium | (SC01, CB32, IN33) | 0.147 |
| Mass15 | High | (CC05) | 0.510 |

*Table 14 – Floor Construction Assemblies Modeled*

| Floor Class | ID | DOE-2 Materials | U-factor (Btu/h-sf-°F) |
|---|---|---|---|
| Light | Low | (RWF49, PW04, CP01) | 0.019 |
| Light | Medium | (RWF19, PW04, CP01) | 0.042 |
| Light | High | (RWF00, PW04, CP01) | 0.151 |
| Mass | Low | (RWF49, CC14, CP01) | 0.019 |
| Mass | Medium | (RWF11, CC14, CP01) | 0.063 |
| Mass | High | (RWF00, CC14, CP01) | 0.162 |

## Life Cycle Cost Model

The CEC life-cycle cost method[5] was used. Measures are assumed to have a 30 year life and the TDV net present values for 30 years were used in this analysis.

This is summarized in the following equation:

**LCC = Initial_Cost + $PV_{TDV}$ x TDV**

where:

LCC: life cycle cost in dollars

Initial_Cost: incremental cost of the construction assembly from the base case

$PV_{TDV}$: net present value of TDV for 30-year nonresidential measures, $0.145972/kBtu in 2008 PV dollars

TDV: annual electricity and natural gas use for HVAC fan, cooling and heat per square foot of construction (wall, roof or floor) area, TDV kBtu..

The objective of this analysis is to select an insulation level that minimizes total life cycle costs. Figure 2 and Figure 3 illustrate how to select insulation levels for wood-framed walls in climate zones 3 and 12. As insulation levels are increased (U-factor decreases), the life-cycle costs decrease until a point of optimal insulation, and then starts to increase again. As can be seen on the graph in Figure 2, the minimum life cycle cost point is close to a 0.095 Btu/hr·ft$^2$·°F (frame wall with R-15 cavity insulation) and on the graph in Figure 3, the minimum life cycle cost point is close to a 0.059 Btu/hr·ft$^2$·°F (frame wall with R-14 rigid insulation). At lower insulation levels the initial cost jumps disproportionately as compared to energy impacts because thicker studs are required.

The points represent all 104 different insulation combinations for this particular construction assembly according to Joint Appendix IV. Table 15 and Table 16 show the top 10 insulation combinations that minimize life-cycle cost and represent the bottom of the J-curve.

[5] *Life Cycle Cost Methodology, 2008 California Building Energy Efficiency Standards*

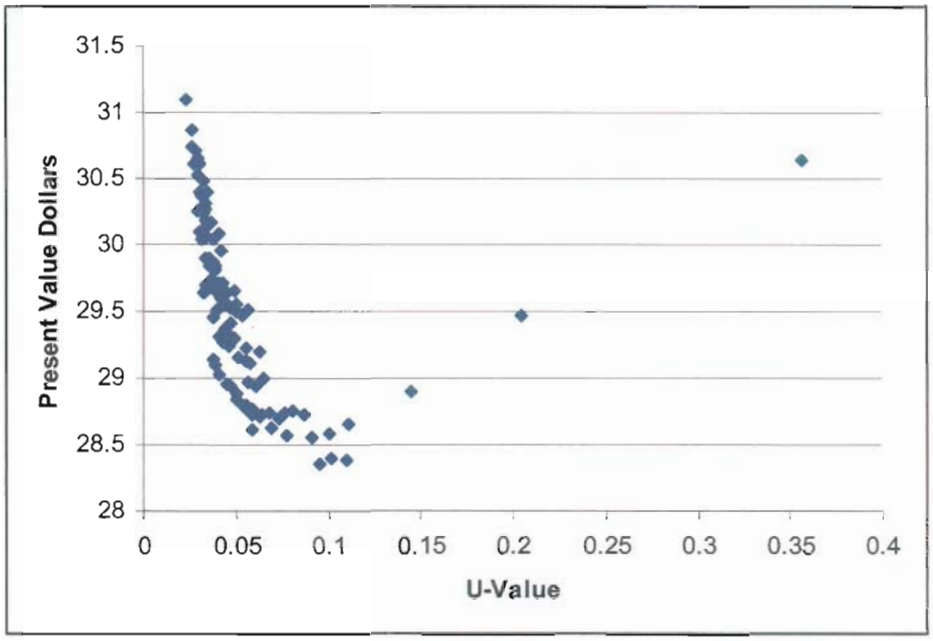


*Figure 2 – Life-cycle Cost versus U-factor Curve of Wood-framed Walls in CZ 3*

*Table 15 – Life-cycle Cost for Daytime Wood-framed Walls CZ 3*

| Cavity R | Sheathing R | U-value | Incremental Cost | TDV total | TDV cost | LCC | Rank |
|---|---|---|---|---|---|---|---|
| R-15 | None | 0.095 | 0.764377 | 189.0305 | 27.59316 | 28.35754 | 1 |
| R-11 | None | 0.11 | 0.622825 | 190.2289 | 27.76809 | 28.39091 | 2 |
| R-13 | None | 0.102 | 0.721911 | 189.5897 | 27.67479 | 28.39671 | 3 |
| None | R-8 | 0.091 | 1.005014 | 188.711 | 27.54652 | 28.55153 | 4 |
| None | R-10 | 0.077 | 1.18903 | 187.5925 | 27.38325 | 28.57228 | 5 |
| None | R-7 | 0.1 | 0.934238 | 189.43 | 27.65147 | 28.58571 | 6 |
| None | R-14 | 0.059 | 1.443823 | 186.1545 | 27.17334 | 28.61716 | 7 |
| R-21 | None | 0.069 | 1.343321 | 186.9534 | 27.28996 | 28.63328 | 8 |
| None | R-6 | 0.111 | 0.877618 | 190.3088 | 27.77975 | 28.65737 | 9 |
| R-11 | R-4 | 0.073 | 1.358892 | 187.2729 | 27.33661 | 28.6955 | 10 |

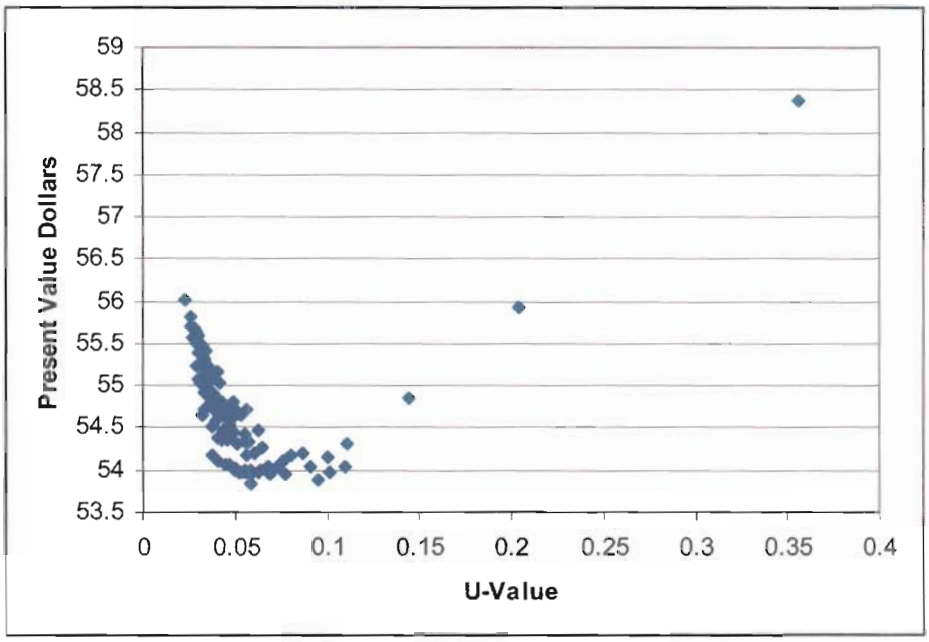


*Figure 3 – Life-cycle Cost versus U-factor Curve of Wood-framed Walls in CZ 12*

*Table 16 – Life-cycle Cost for Daytime Wood-framed Walls CZ 12*

| Cavity R | Sheathing R | U-value | Incremental Cost | TDV total | TDV cost | LCC | Rank |
|---|---|---|---|---|---|---|---|
| None | R-14 | 0.059 | 1.443823 | 358.9405 | 52.39527 | 53.83909 | 1 |
| R-15 | None | 0.095 | 0.764377 | 363.9027 | 53.11961 | 53.88398 | 2 |
| R-21 | None | 0.069 | 1.343321 | 360.3189 | 52.59647 | 53.93979 | 3 |
| None | R-10 | 0.077 | 1.18903 | 361.4216 | 52.75744 | 53.94647 | 4 |
| R-11 | R-7 | 0.059 | 1.557064 | 358.9405 | 52.39527 | 53.95233 | 5 |
| R-11 | R-8 | 0.056 | 1.627839 | 358.527 | 52.33491 | 53.96275 | 6 |
| R-15 | R-7 | 0.053 | 1.698615 | 358.1135 | 52.27455 | 53.97316 | 7 |
| R-11 | R-6 | 0.063 | 1.500443 | 359.4919 | 52.47575 | 53.97619 | 8 |
| R-15 | R-6 | 0.056 | 1.641994 | 358.527 | 52.33491 | 53.9769 | 9 |
| R-13 | R-8 | 0.052 | 1.726925 | 357.9757 | 52.25443 | 53.98135 | 10 |

# Results

## 2005 versus 2008 Insulation Level Comparisons

The figures below provide a comparison between the current standard and the proposed standard for all sixteen climate zones. For both roofs and walls, the proposed standard is usually more stringent than the current standard. This may be due to the Commission's policy to use a longer building life expectancy of 30-years for envelope measures, a change in the cost of natural gas and electricity TDV energy, and a change in insulation price since 1992, the latest update to the envelope criteria.

The figure title also includes statewide energy impacts for the proposed standard for a particular construction assembly. The statewide energy impacts are on an annual per square foot basis and represent a general estimation of

savings weighted by climate zone new construction data and occupancy type. A more detailed breakdown can be found in the Appendices under Energy Impacts.

### Coefficient Graphs

The coefficient graphs display the results of the regression analysis for each assembly by climate zone and occupancy. Each column (daytime, retail and 24-hour) represents the corresponding coefficient for that assembly determined by the regression analysis. For example, in Figure 11, the daytime coefficient for climate zone 1 is the same as the coefficient determined for light weight roofs for climate zone 1 (which can be found in Appendices) as opposed to attic roofs or mass roofs. The Y-axis represents the coefficient threshold for each insulation level. If the coefficient falls within a certain threshold, the corresponding U-Value and R-Value found on the right hand side was determined to have the lowest life cycle cost. For example, in

Figure 21 Wood-framed and Other Roof, if the coefficient was 100 for a particular assembly then a U-Value of 0.060 with R-15 insulation was determined to be the most cost effective. The coefficients represent TDV per $ft^2$ of UA. Therefore, the higher the coefficient, the more energy savings from insulation; a negative coefficient represents an increase in energy consumption from increased insulation.

### Cool Roofs

A sensitivity analysis was performed for cool roofs in all sixteen climate zones. The sensitivity analysis determined the optimal insulation levels without a cool roof using the model described above. One caveat to the sensitivity analysis is that a previous version of the 2008 TDV curves, dated January 5, 2006, was used. The older curves should have minimal impact on the outcome. Other than the cool roofs and economizers sensitivity analyses performed in this report, all other results are using the most updated 2008 TDV curves, dated April 18, 2006.

### Economizers

A sensitivity analysis was performed for economizers in climate zones 3, 6, and 12. The sensitivity analysis determined the optimal insulation level for all envelope assemblies without an economizer using the model described above. The optimal insulation levels remain consistent when no economizers are modeled except floors. One caveat to the sensitivity analysis is that a previous version of the 2008 TDV curves, dated January 5, 2006, was used. The older curves should have minimal impact on the outcome. A second caveat is the mass walls used in the sensitivity analysis were taken from as the default constructions from the ACM Manual and differ by climate zone. For the 2008 Proposed Standard, we selected one default mass wall construction type for $7 \leq HC < 15$ mass wall (8" normal weight CMU wall with solid grout, U-Factor 0.69) and one default mass wall construction type for $15 \leq HC$ mass wall (4" solid concrete wall, U-Factor 0.91).

The "(no) cool roof" figures show the current roof insulation standards as well as the proposed standards with and without a cool roof for roofs only. The "economizer sensitivity" figures show the optimal U-factors for climate zones 3, 6, and 12 when no economizer is modeled.

## *Metal Building Roof*

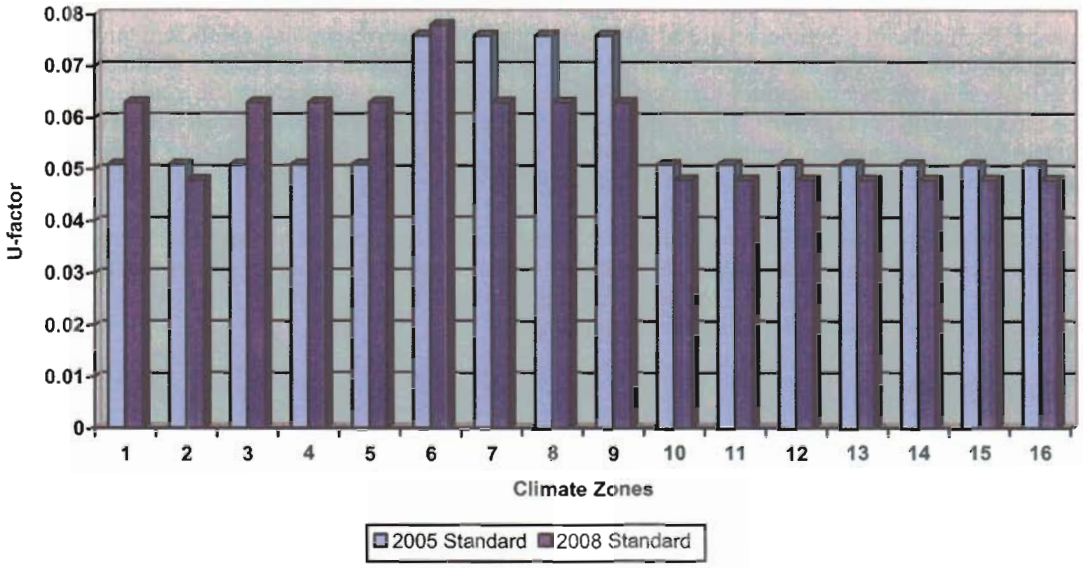


*Figure 4 –Metal Building Roof (Daytime)*
*Statewide Energy Impacts (ft$^2$-yr): TDV=0.222, kWh=0.010, therm=0.000*

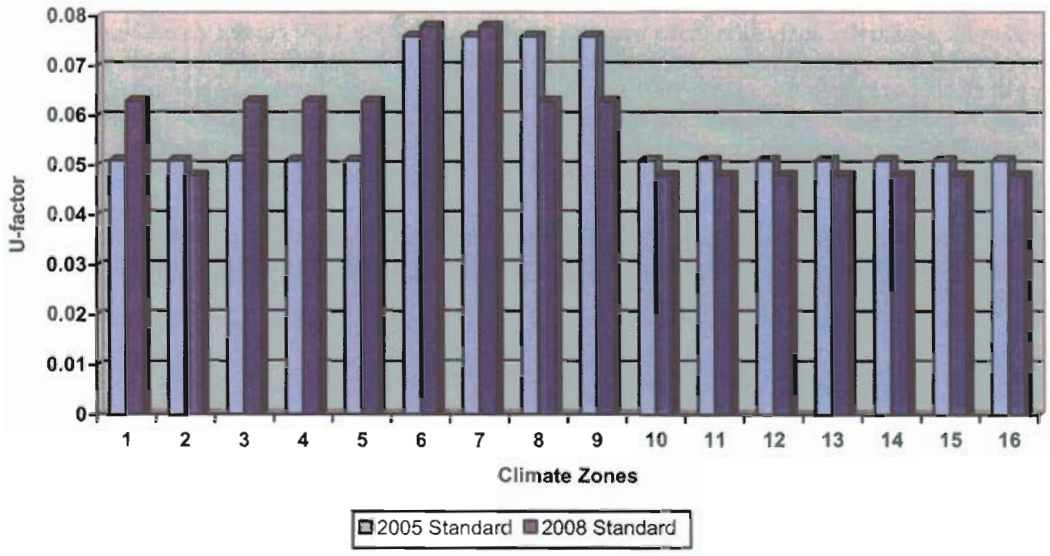


*Figure 5 –Metal Building Roof (Retail)*
*Statewide Energy Impacts (ft2-yr): TDV=0.305, kWh=0.015, therm=0.000*

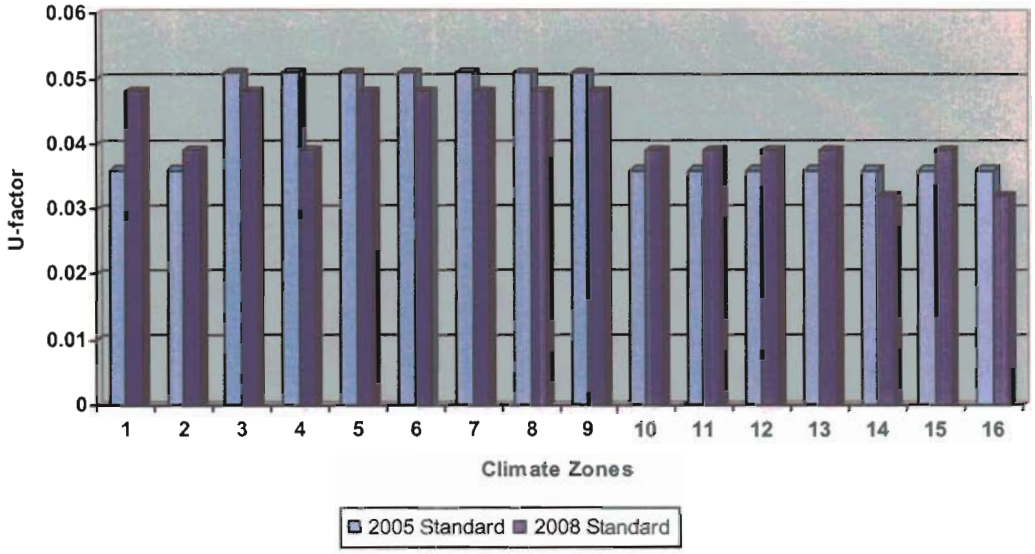


*Figure 6 – Metal Building Roof (24-hour)*
*Statewide Energy Impacts ($ft^2$-yr): TDV=3.761, kWh=0.112, therm=0.016*

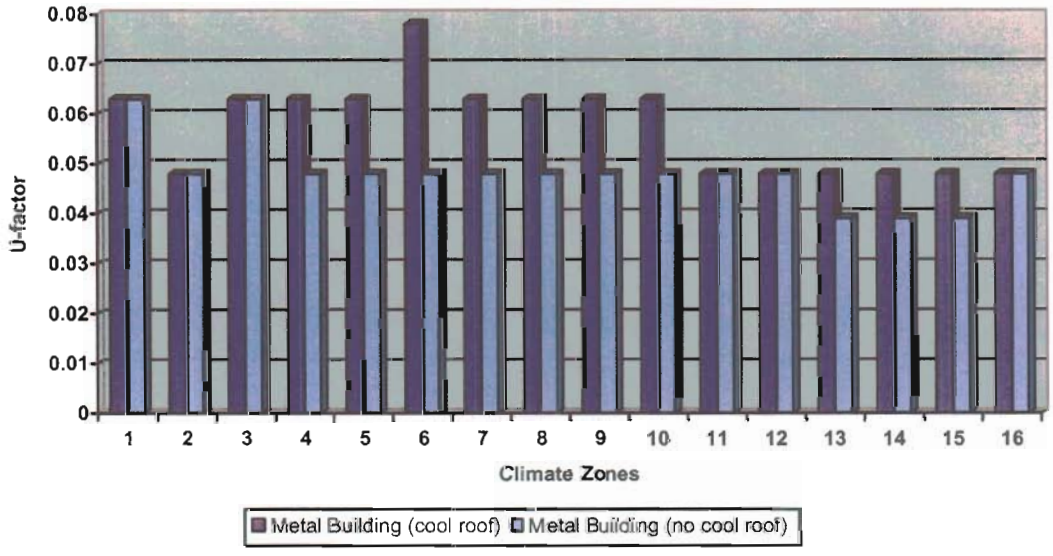


*Figure 7 – Daytime Roof Insulation Cool Roof Sensitivity Analysis for Metal Buildings*

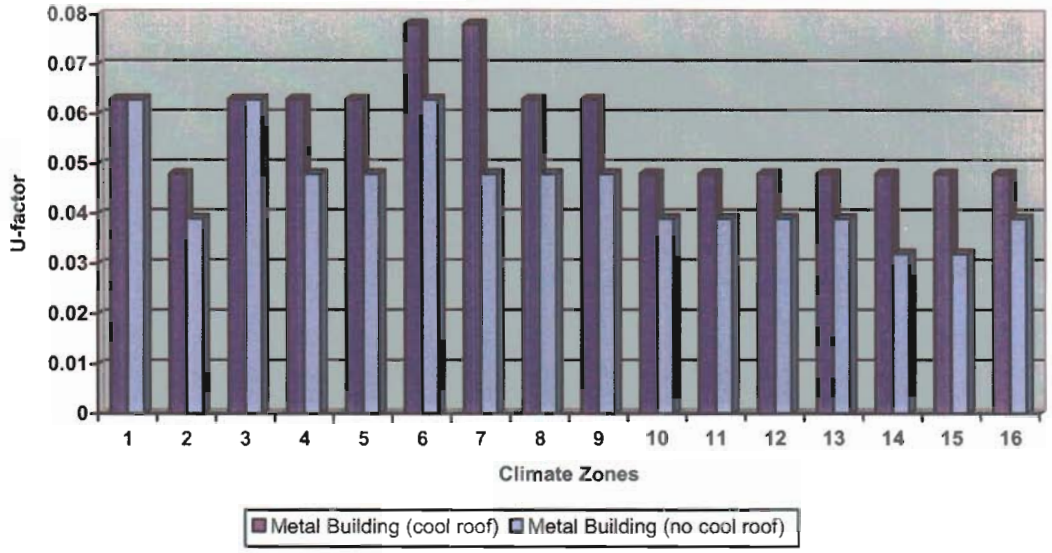


*Figure 8 – Retail Roof Insulation Cool Roof Sensitivity Analysis for Metal Buildings*

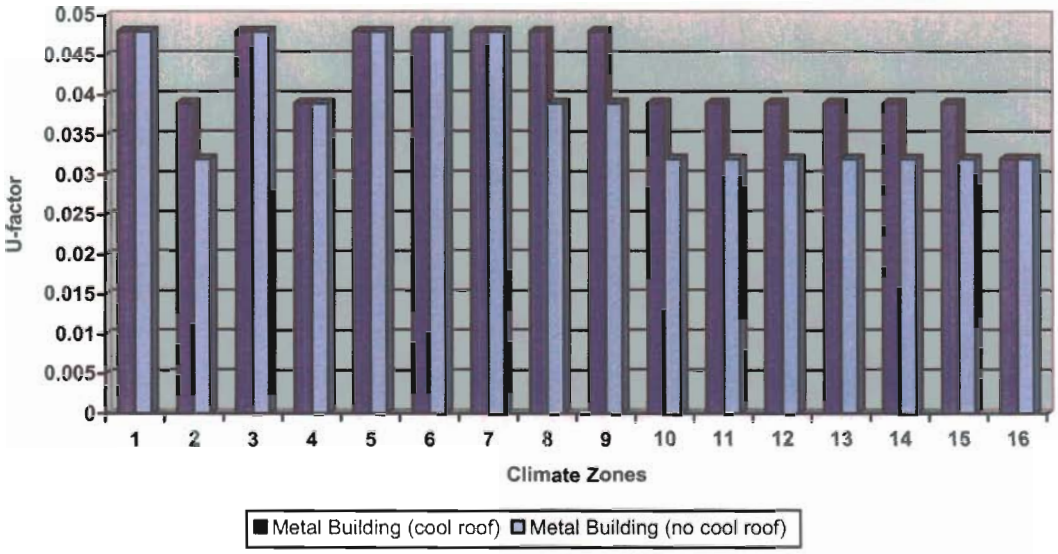


*Figure 9 – 24-hour Roof Insulation Cool Roof Sensitivity Analysis for Metal Buildings*

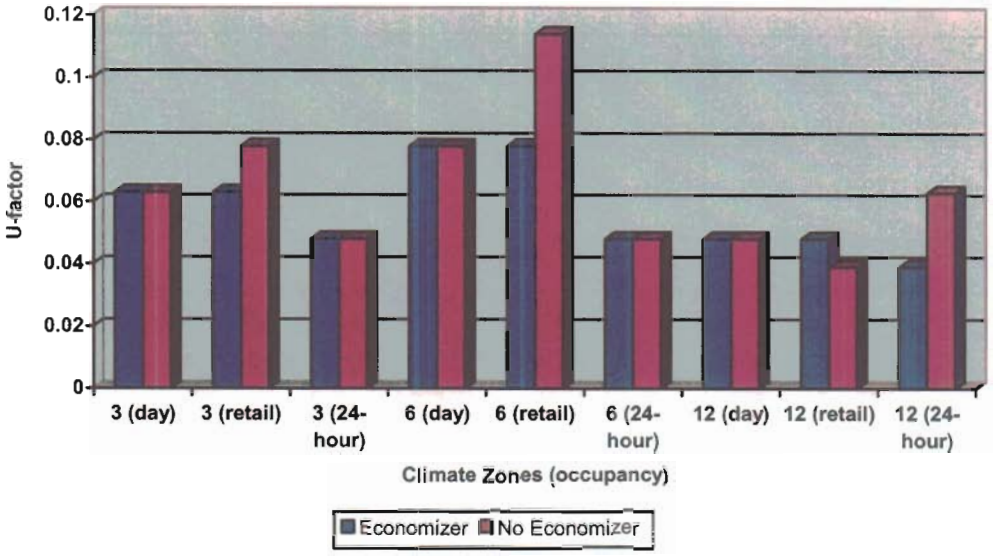


*Figure 10 – Economizer Insulation Sensitivity Analysis for Metal Building Roof*

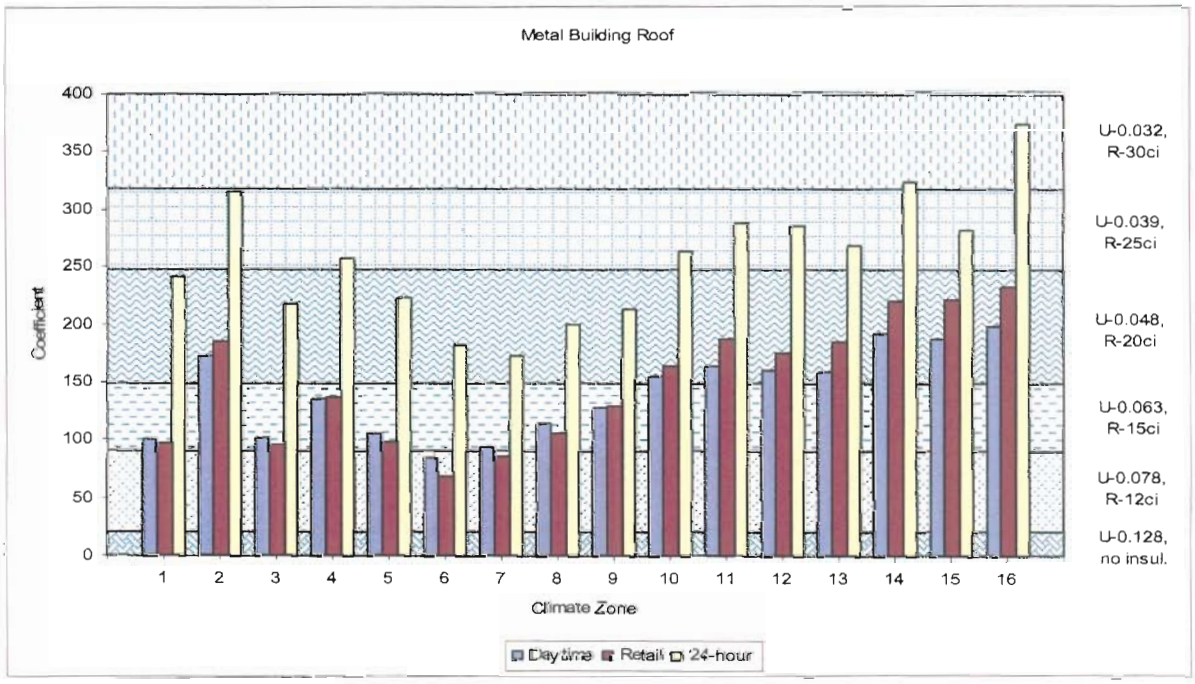


*Figure 11 – Metal Building Roof Coefficients (cool roofs)*

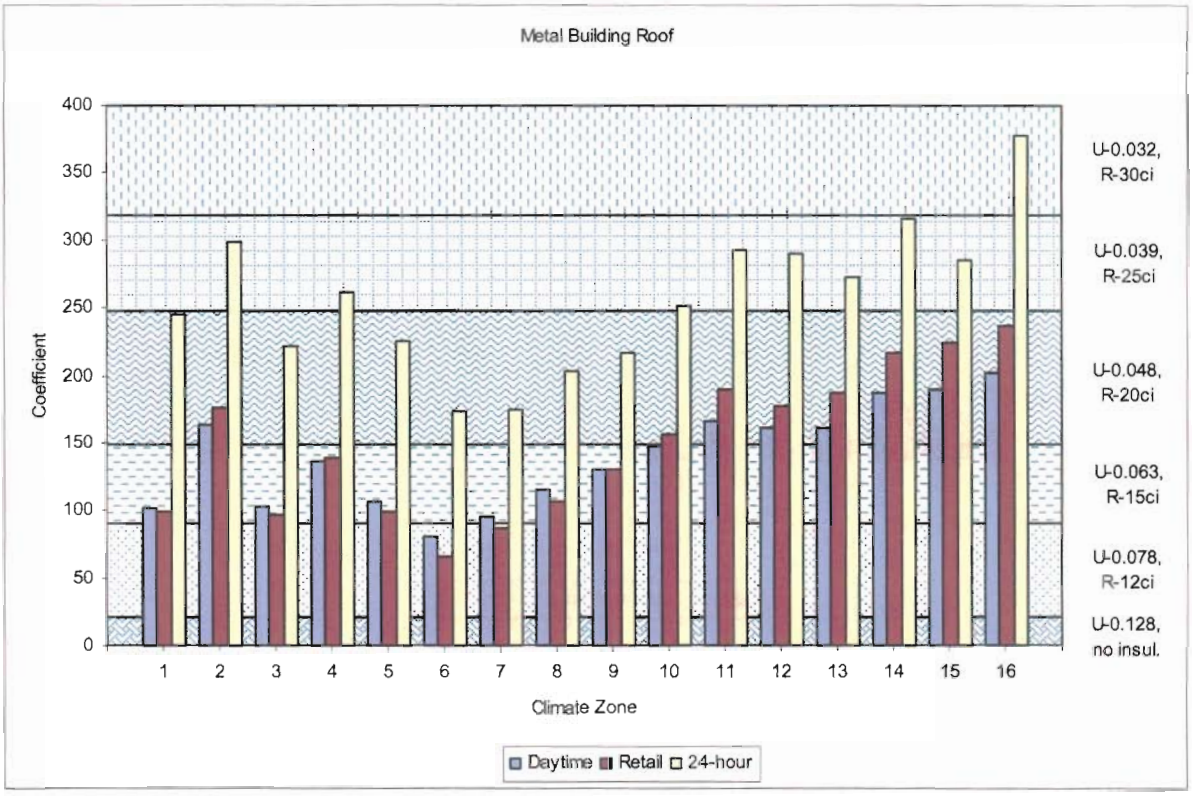


*Figure 12 – Metal Building Roof Coefficients (no cool roof)*

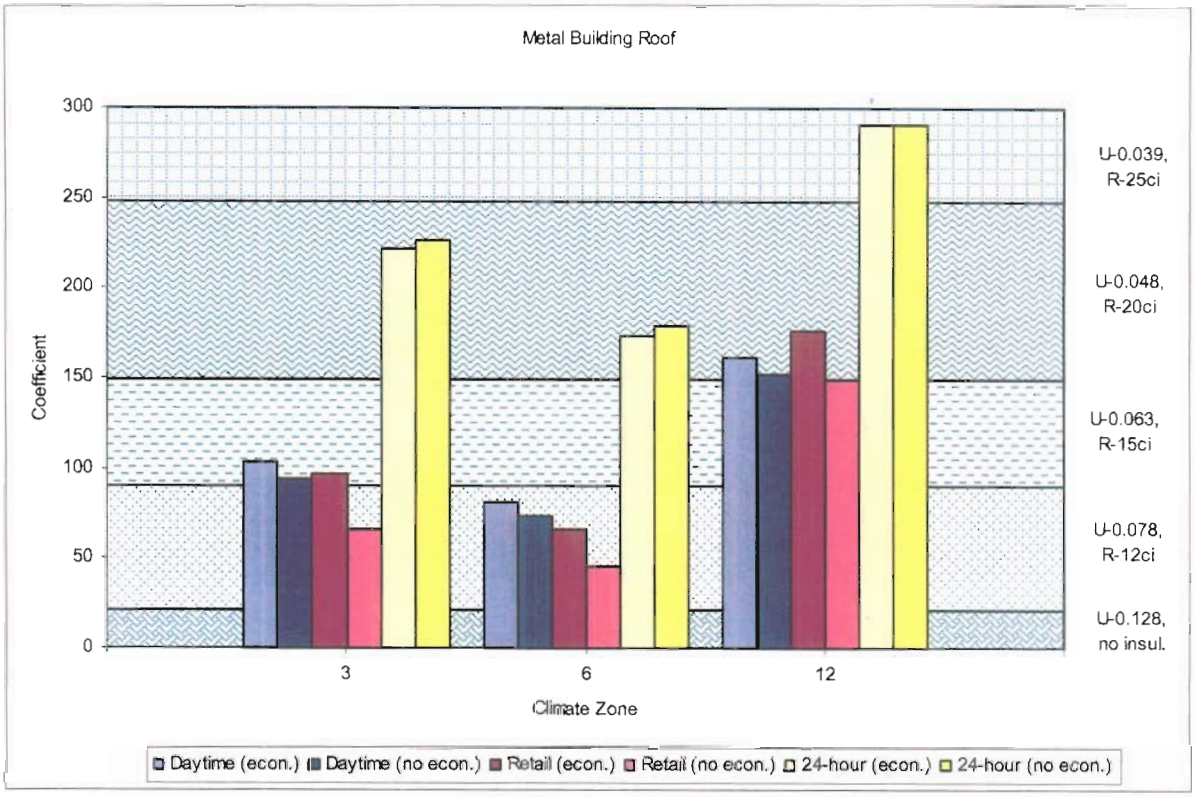


*Figure 13 – Metal Building Roof Coefficients (economizer sensitivity)*

### *Wood-framed and Other Roof*

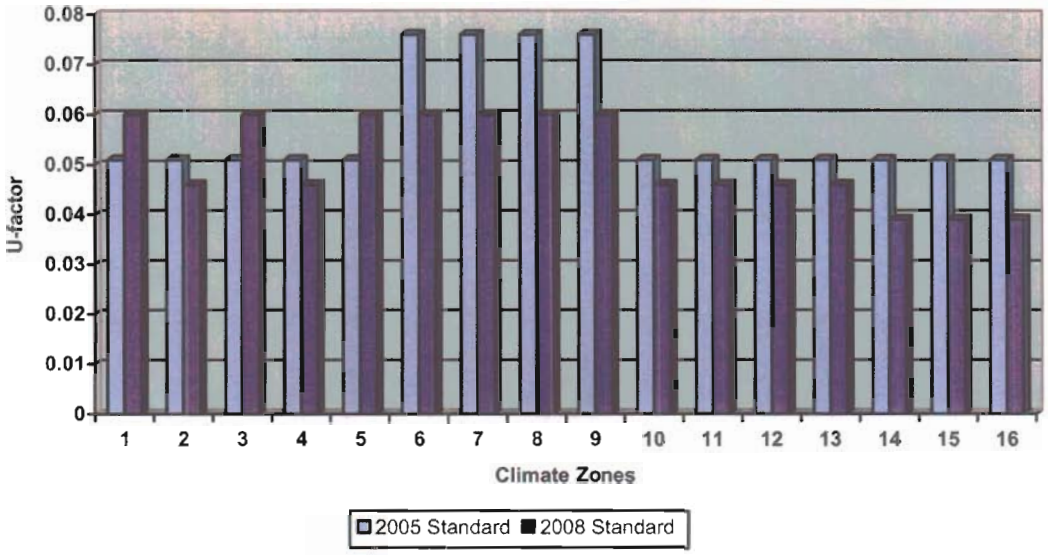


*Figure 14 – Wood-framed and Other Roof (Daytime)*
*Statewide Energy Impacts (ft$^2$-yr): TDV=0.838, kWh=0.027, therm=0.002*

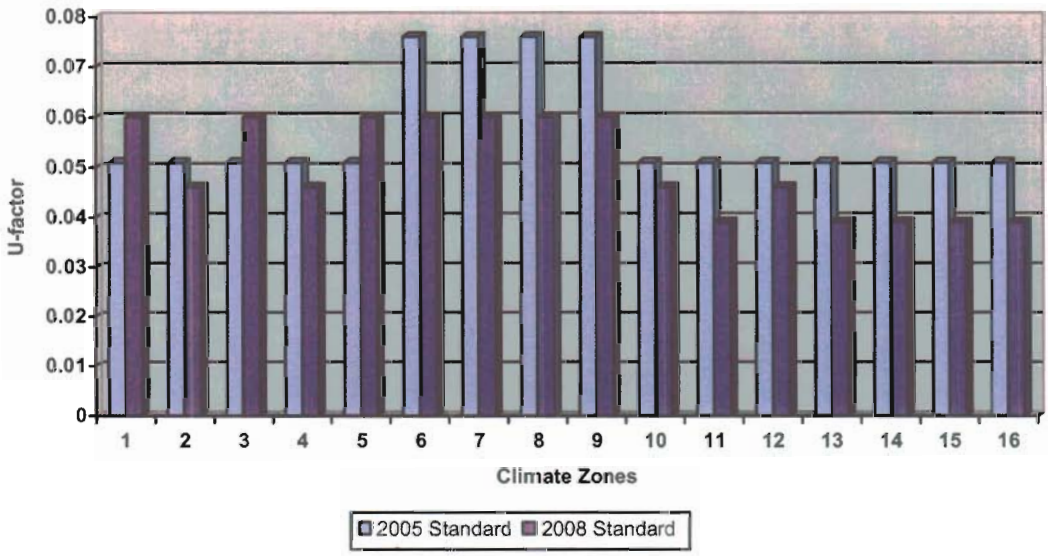


*Figure 15 – Wood-framed and Other Roof (Retail)*
*Statewide Energy Impacts (ft$^2$-yr): TDV=1.088, kWh=0.042, therm=0.003*

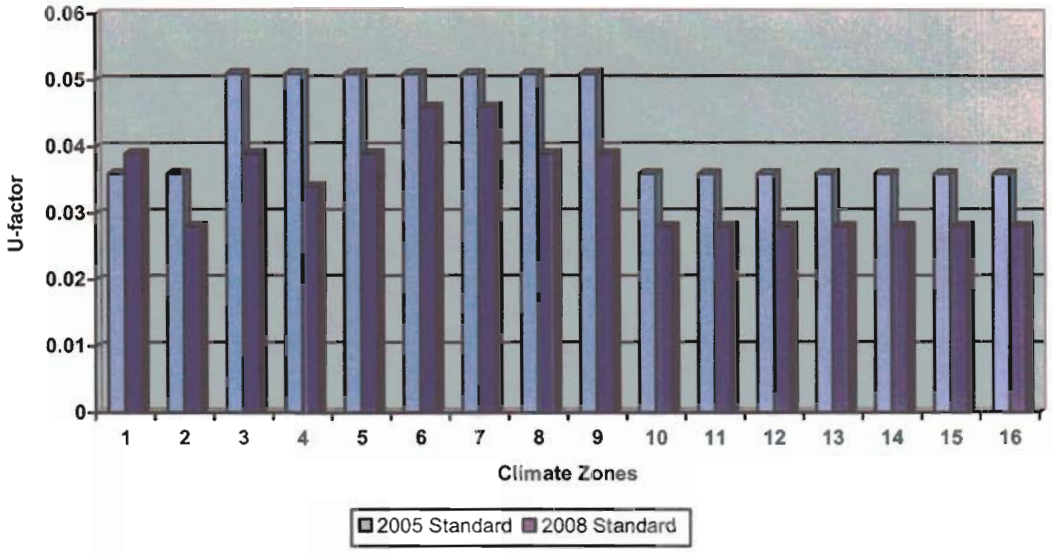


*Figure 16 – Wood-framed and Other Roof (24-hour)*
*Statewide Energy Impacts ($ft^2$-yr): TDV=5.802, kWh=0.168, therm=0.024*

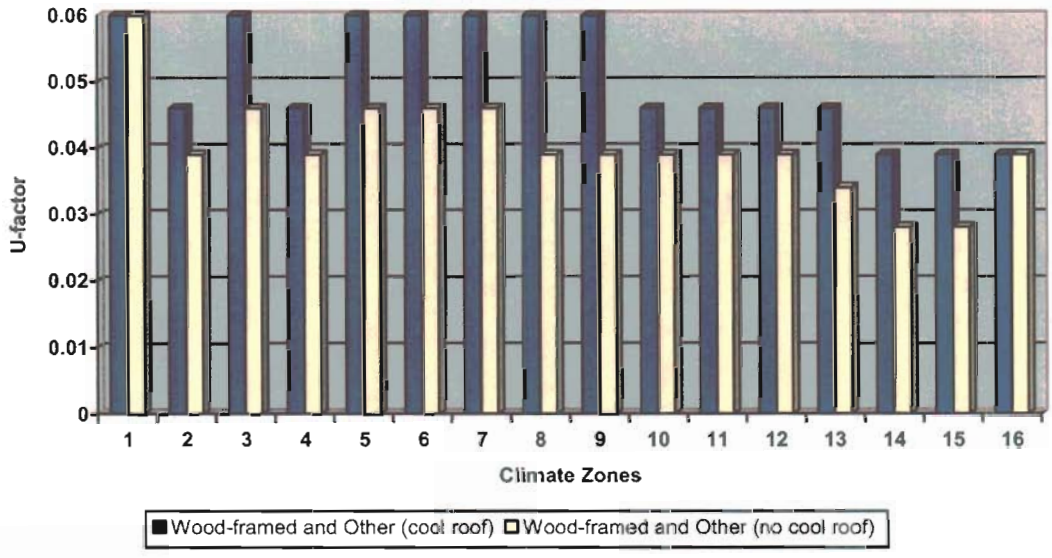


*Figure 17 – Daytime Roof Insulation Cool Roof Sensitivity Analysis for Wood-framed and Other*

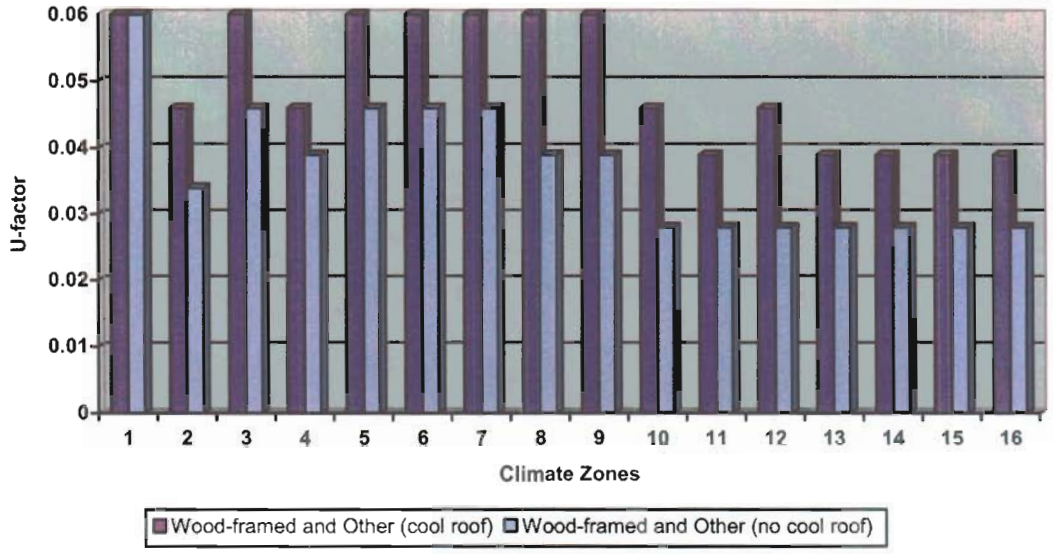


*Figure 18 – Retail Roof Insulation Cool Roof Sensitivity Analysis for Wood-framed and Other*

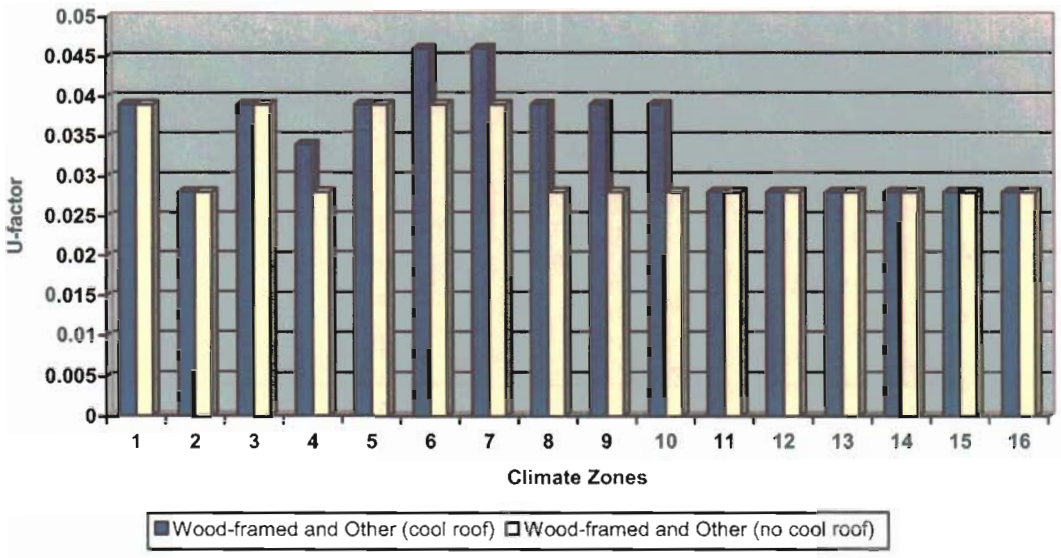


*Figure 19 – 24-hour Roof Insulation Cool Roof Sensitivity Analysis for Wood-framed and Other*

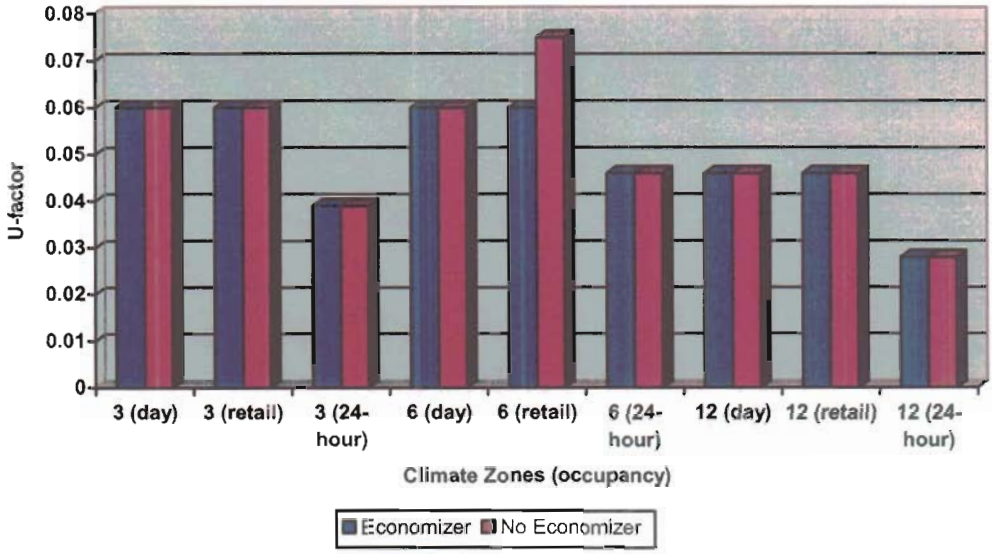


*Figure 20 – Economizer Insulation Sensitivity Analysis for Wood-framed and Other Roof*

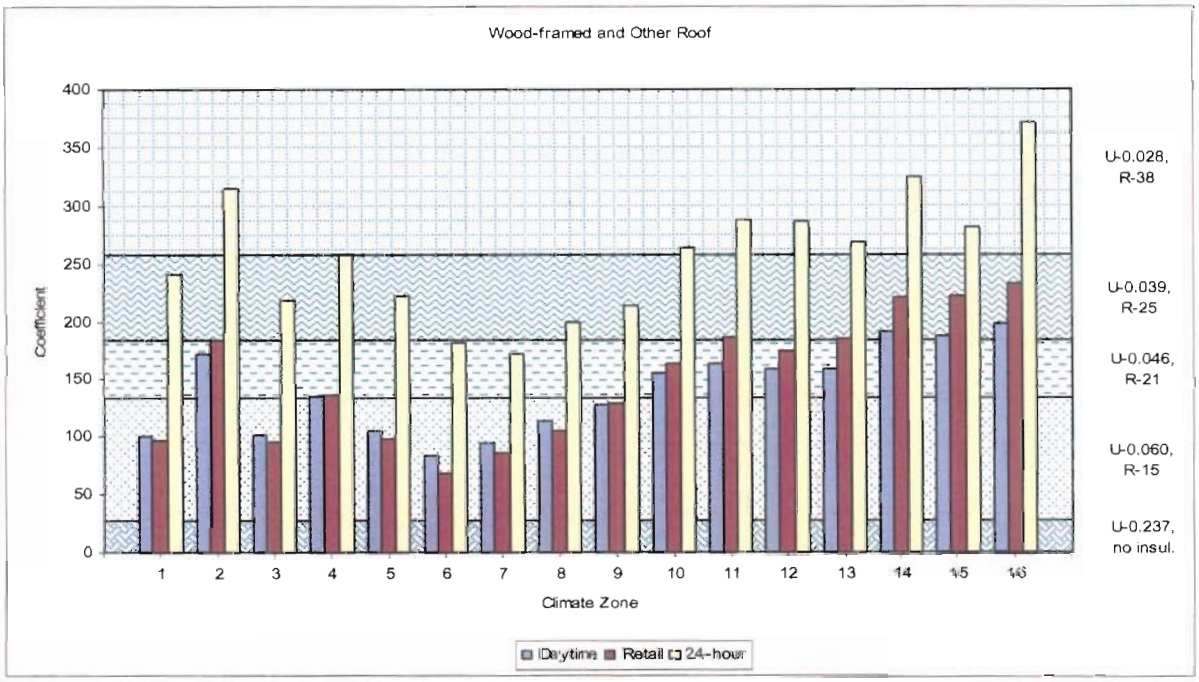


*Figure 21 – Wood-framed and Other Roof Coefficients*

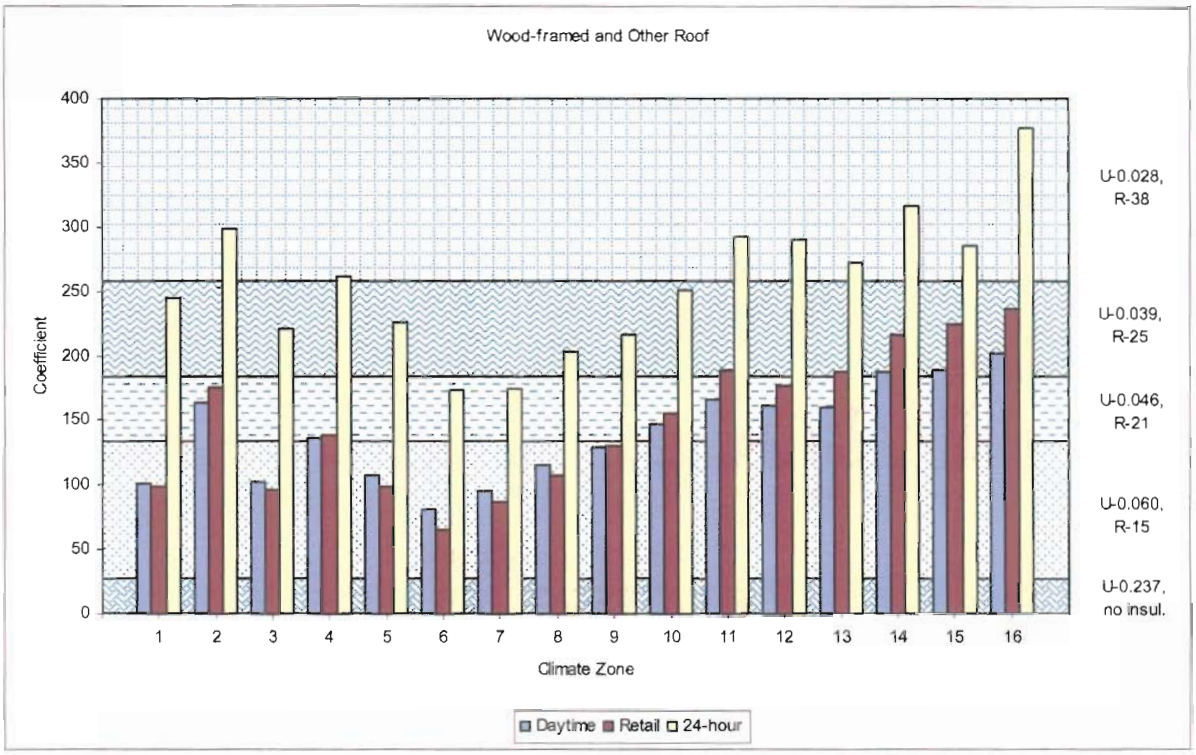


*Figure 22 – Wood-framed and Other Roof Coefficients (no cool roof)*

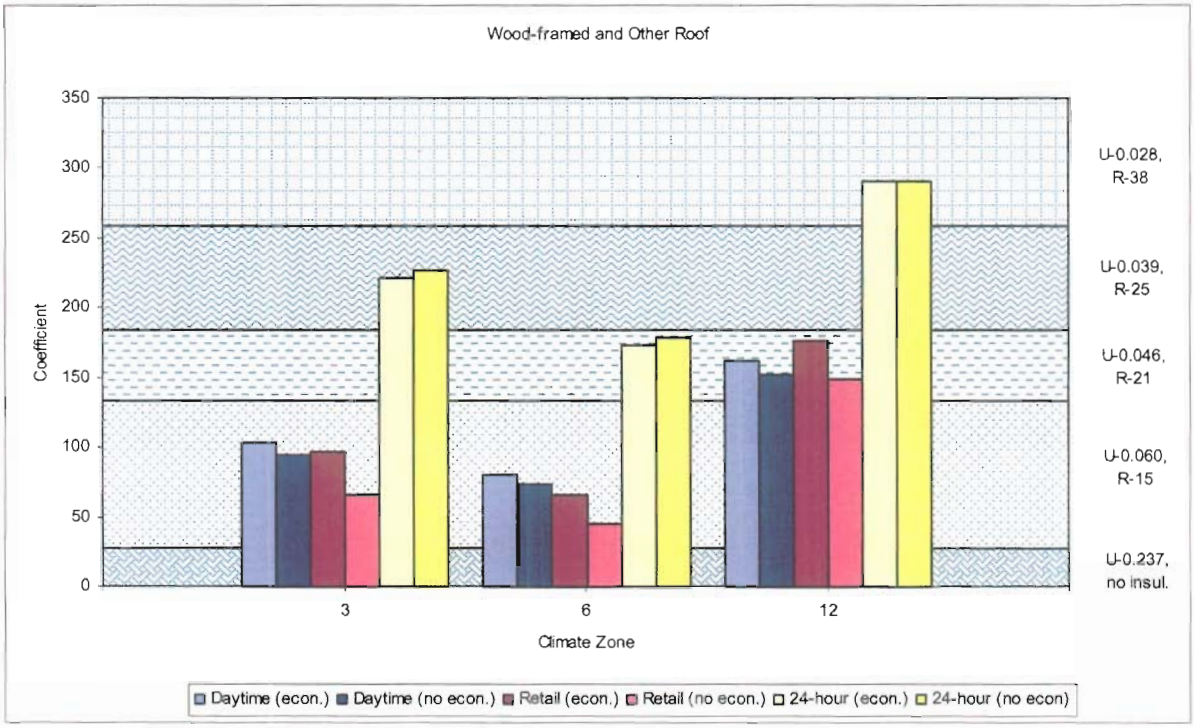


*Figure 23 – Wood-framed and Other Roof Coefficients (economizer sensitivity)*

## Metal Building Wall

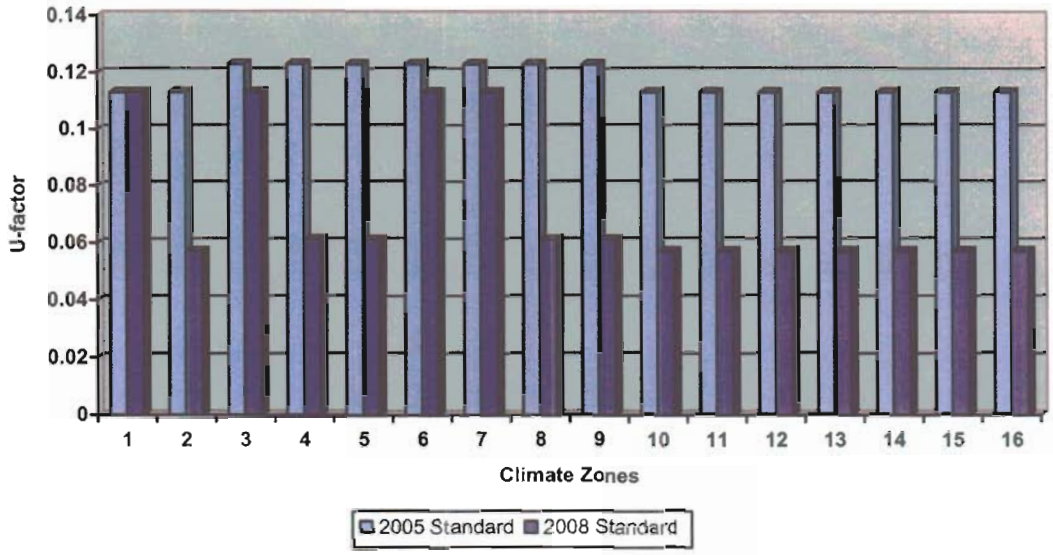


*Figure 24 – Metal Building Wall (Daytime)*
*Statewide Energy Impacts (ft²-yr): TDV=5.554, kWh=0.262, therm=0.013*

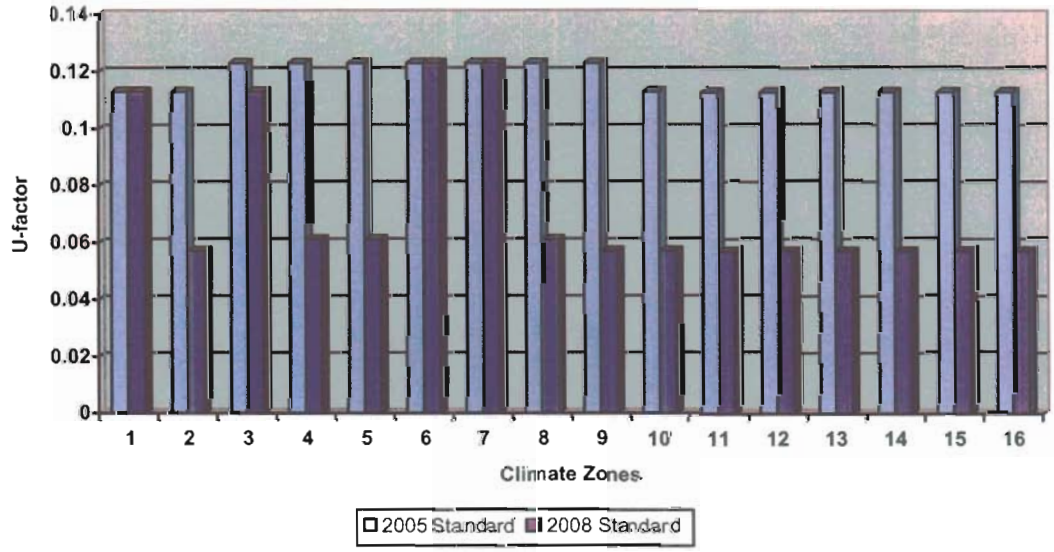


*Figure 25 – Metal Building Wall (Retail)*
*Statewide Energy Impacts (ft²-yr): TDV=6.800, kWh=0.373, therm=0.014*

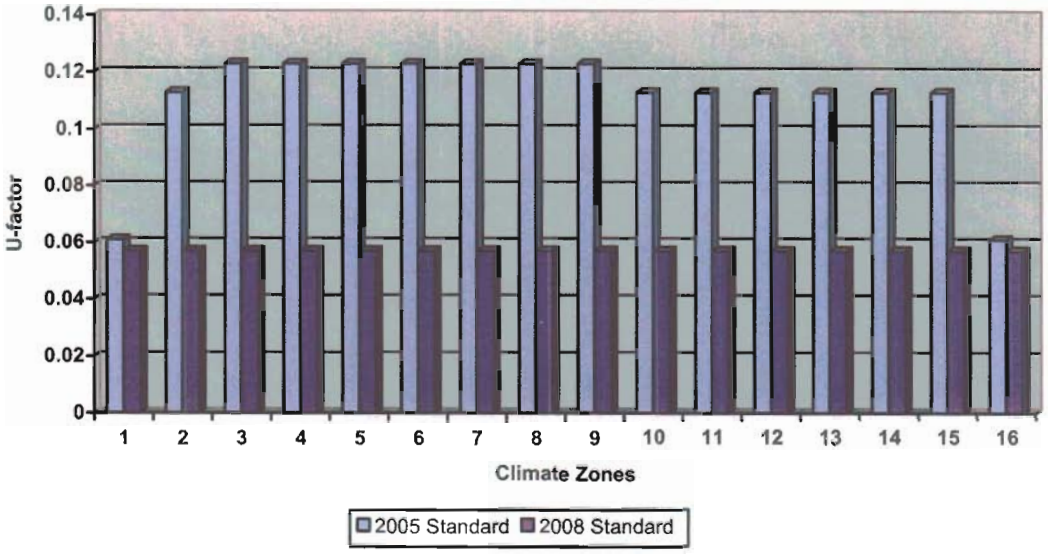


*Figure 26 – Metal Building Wall (24-hour)*
*Statewide Energy Impacts (ft$^2$-yr): TDV=11.138, kWh=0.586, therm=0.040*

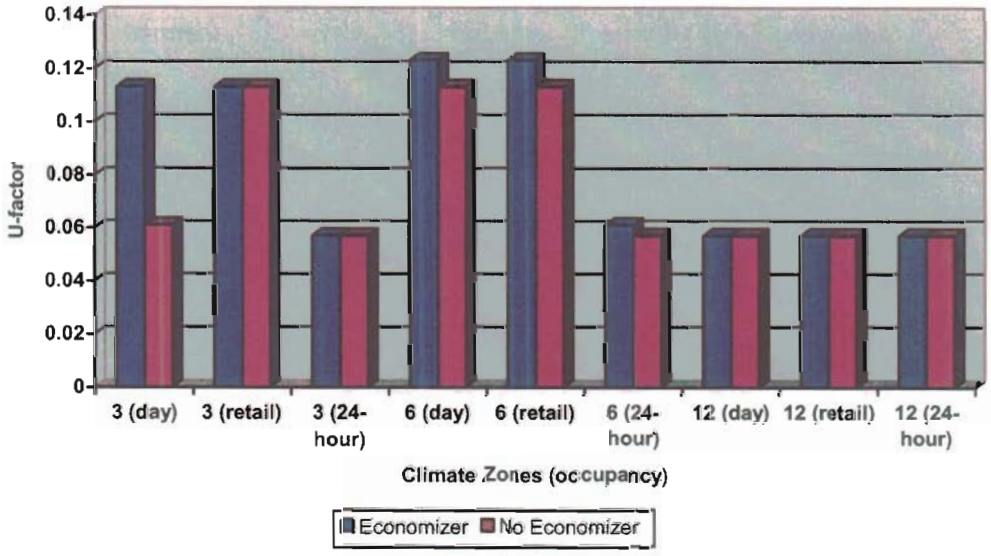


*Figure 27 – Economizer Insulation Sensitivity Analysis for Metal Building Wall*

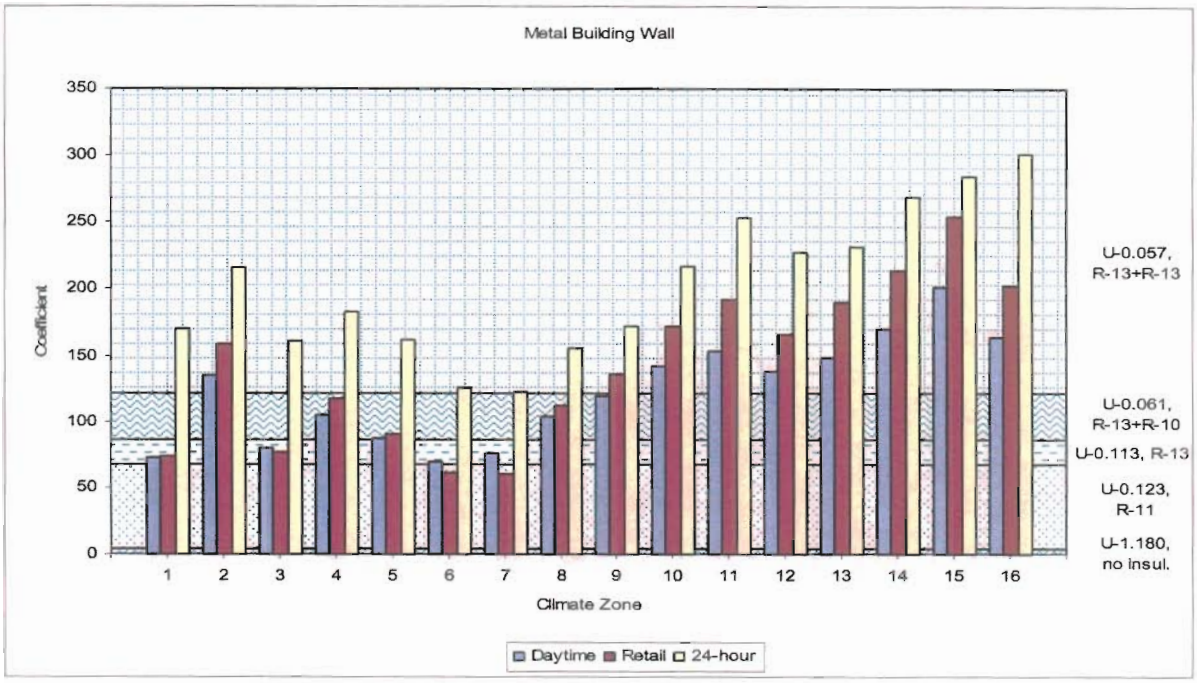


*Figure 28 – Metal Building Wall Coefficients*

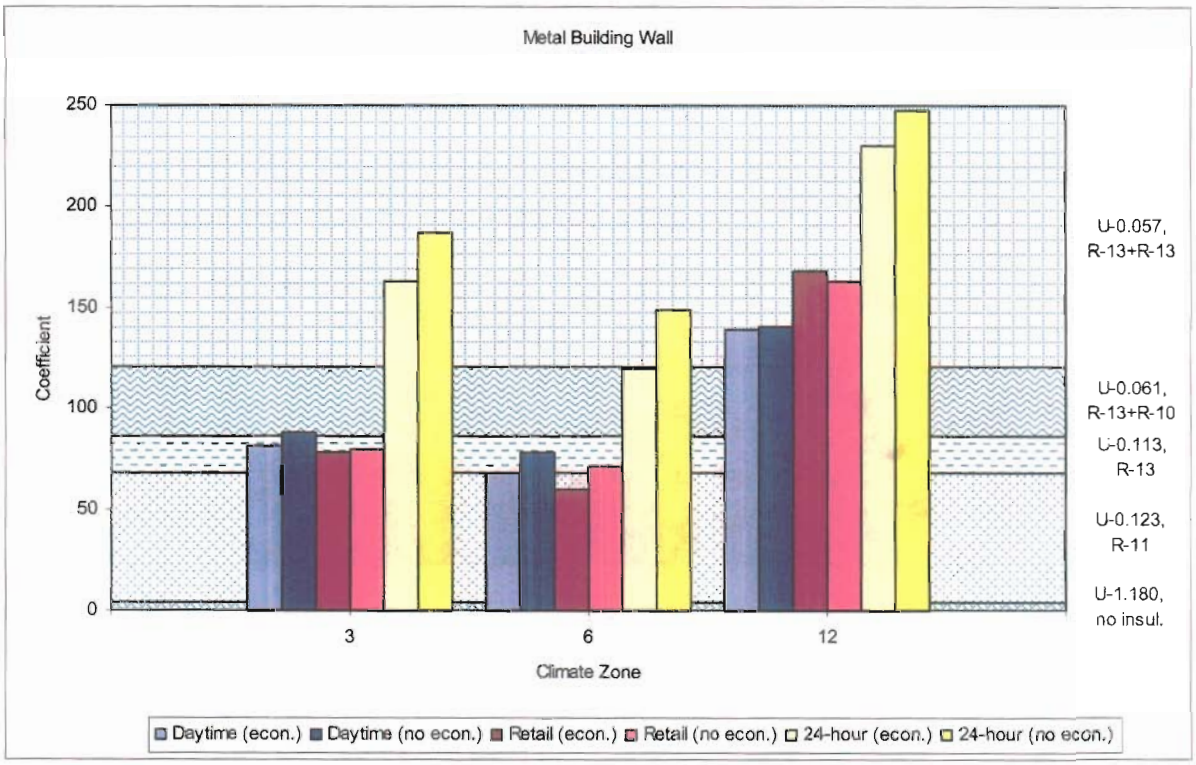


*Figure 29 – Metal Building Wall Coefficients (economizer sensitivity)*

## *Metal-framed Wall*

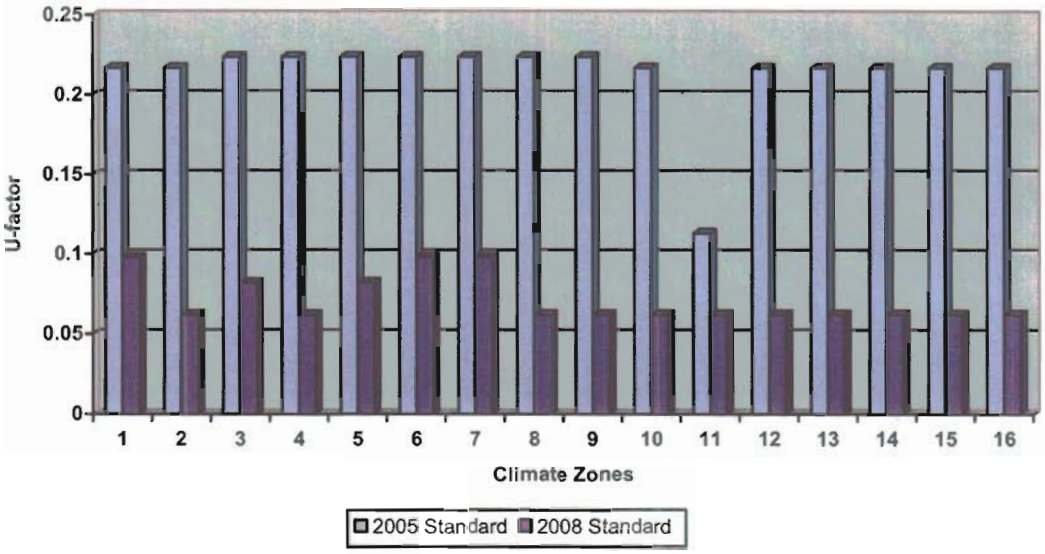


*Figure 30 – Metal-framed Wall (Daytime)*
*Statewide Energy Impacts (ft$^2$-yr): TDV=17.505, kWh=0.821, therm=0.044*

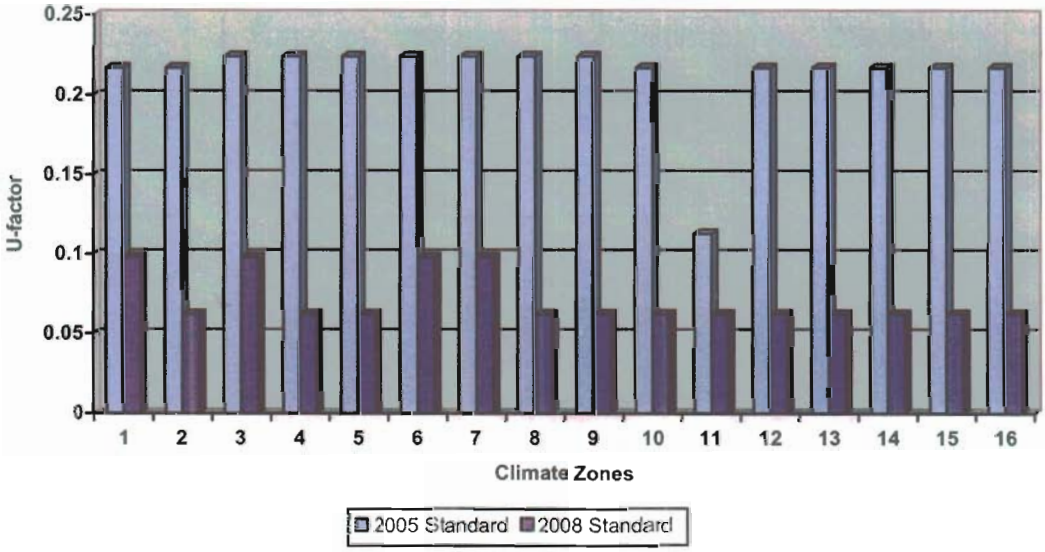


*Figure 31 – Metal-framed Wall (Retail)*
*Statewide Energy Impacts (ft$^2$-yr): TDV=20.385, kWh=1.138, therm=0.045*

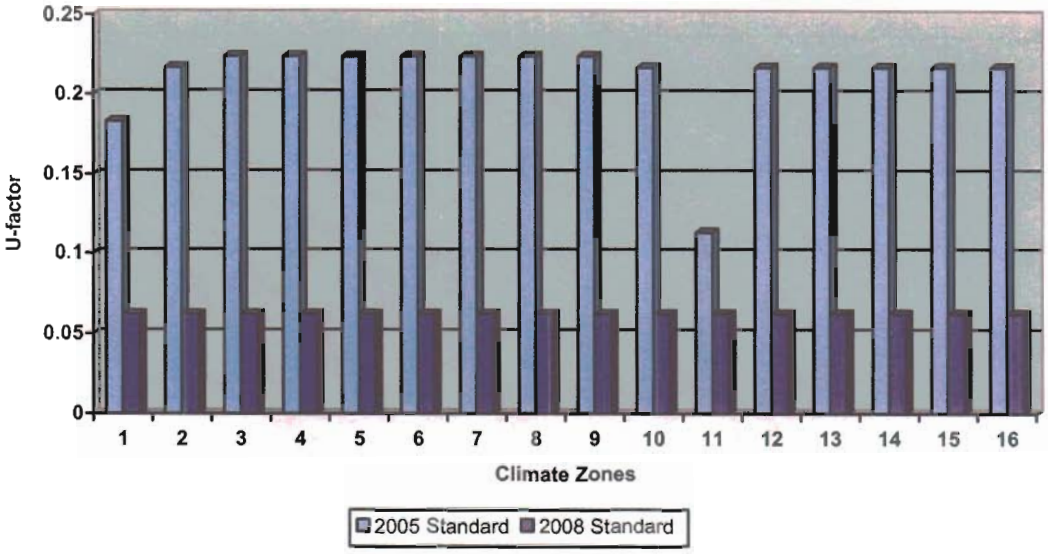


*Figure 32 – Metal-framed Wall (24-hour)*
*Statewide Energy Impacts (ft$^2$-yr): TDV=28.985, kWh=1.524, therm=0.103*

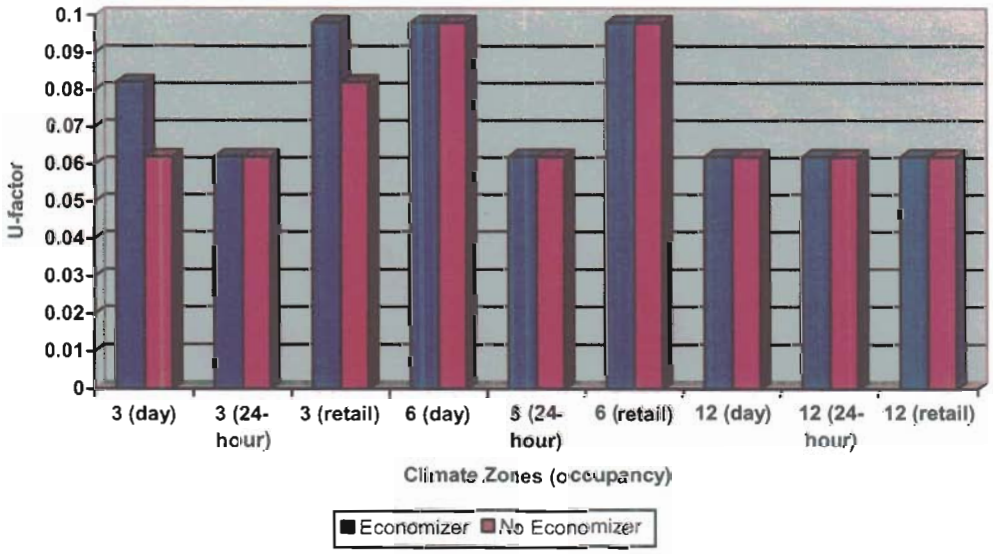


*Figure 33 – Economizer Insulation Sensitivity Analysis for Metal-framed Wall*

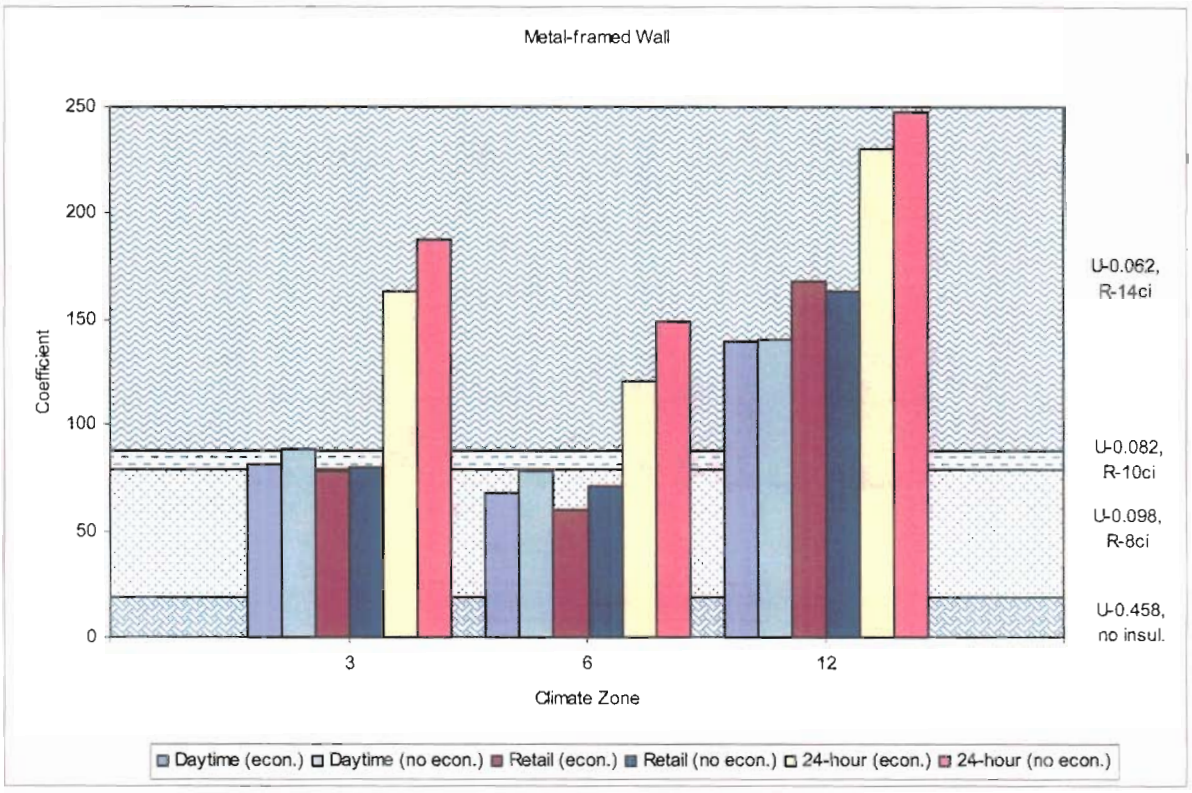


*Figure 34 – Metal-framed Wall Coefficients (economizer sensitivity)*

## *Mass (7.0≤HC<15.0) Wall*

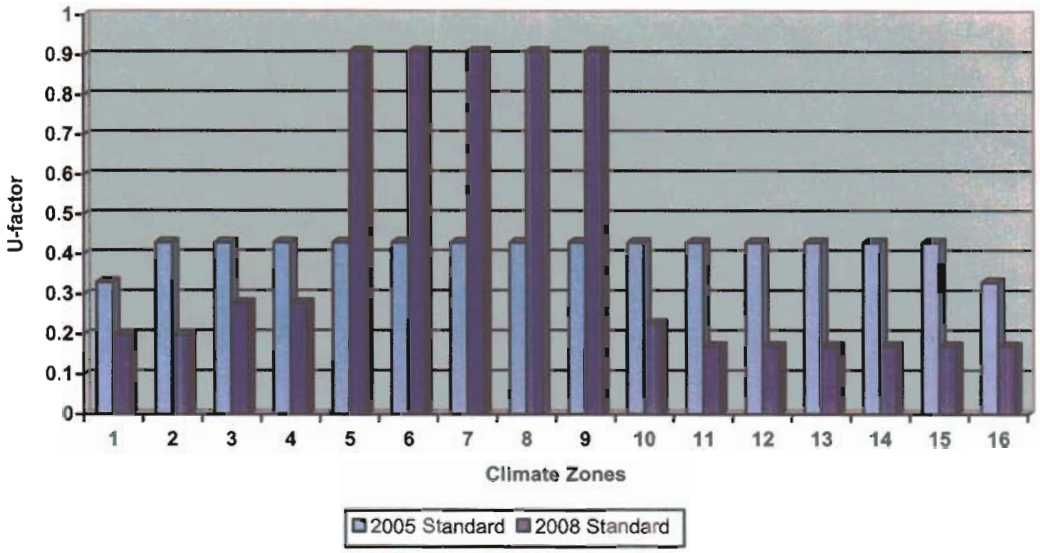


*Figure 35 – Mass (7.0≤HC<15.0) Wall (Daytime)*
*Statewide Energy Impacts (ft²-yr): TDV=4.311, kWh=0.066, therm=0.016*

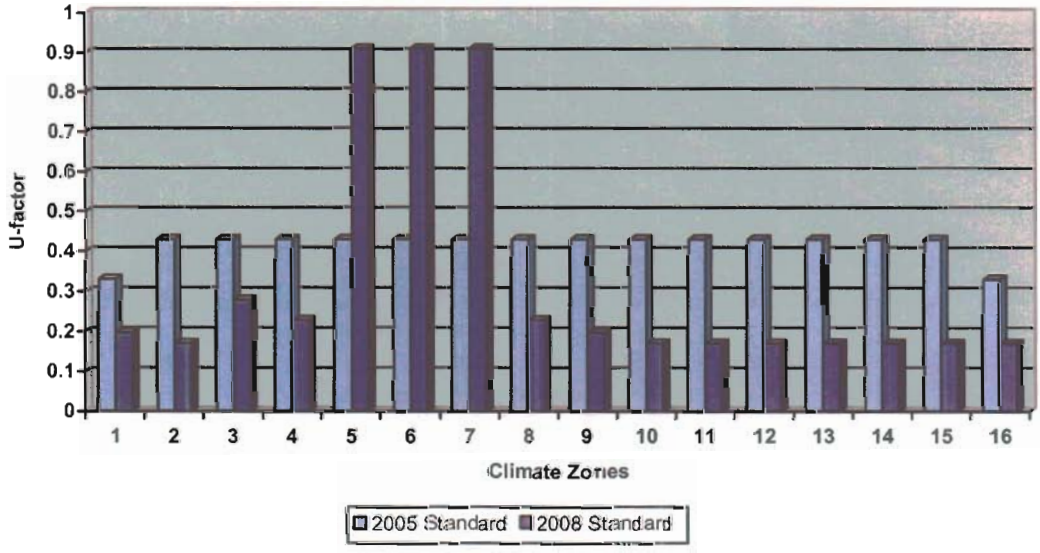


*Figure 36 – Mass (7.0≤HC<15.0) Wall (Retail)*
*Statewide Energy Impacts (ft²-yr): TDV=12.603, kWh=0.507, therm=0.040*

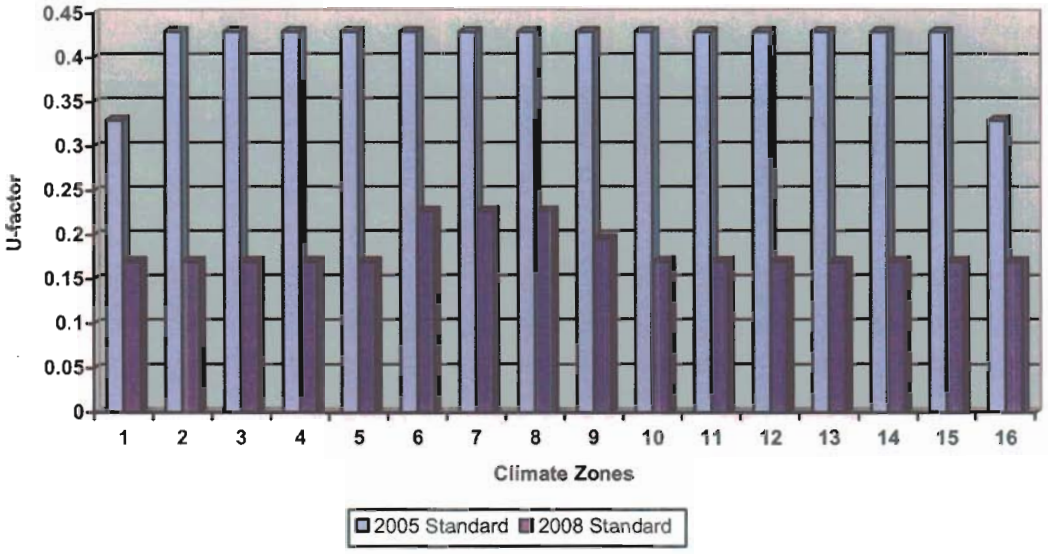


*Figure 37 – Mass (7.0≤HC<15.0) Wall (24-hour)*
*Statewide Energy Impacts (ft$^2$-yr): TDV=23.344, kWh=0.500, therm=0.118*

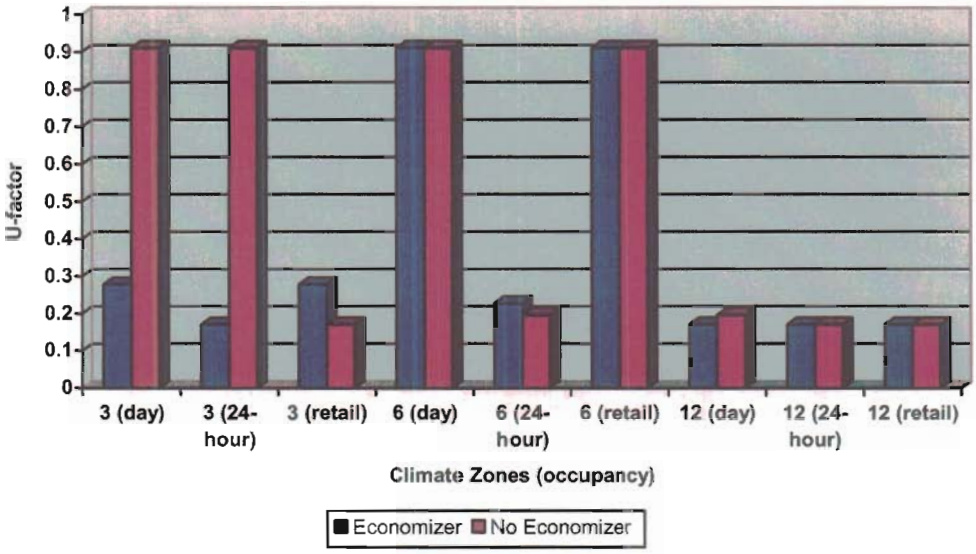


*Figure 38 – Economizer Insulation Sensitivity Analysis for Mass (7.0≤HC<15.0) Wall*

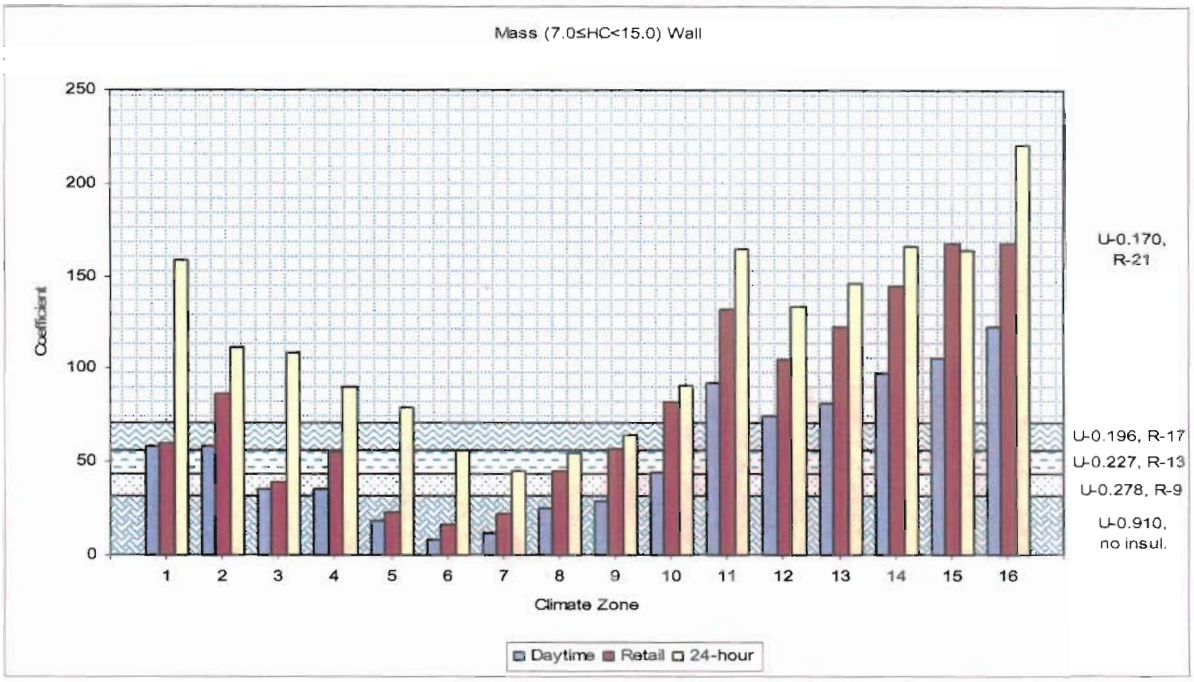


*Figure 39 – Mass (7.0≤HC<15.0) Wall Coefficients*

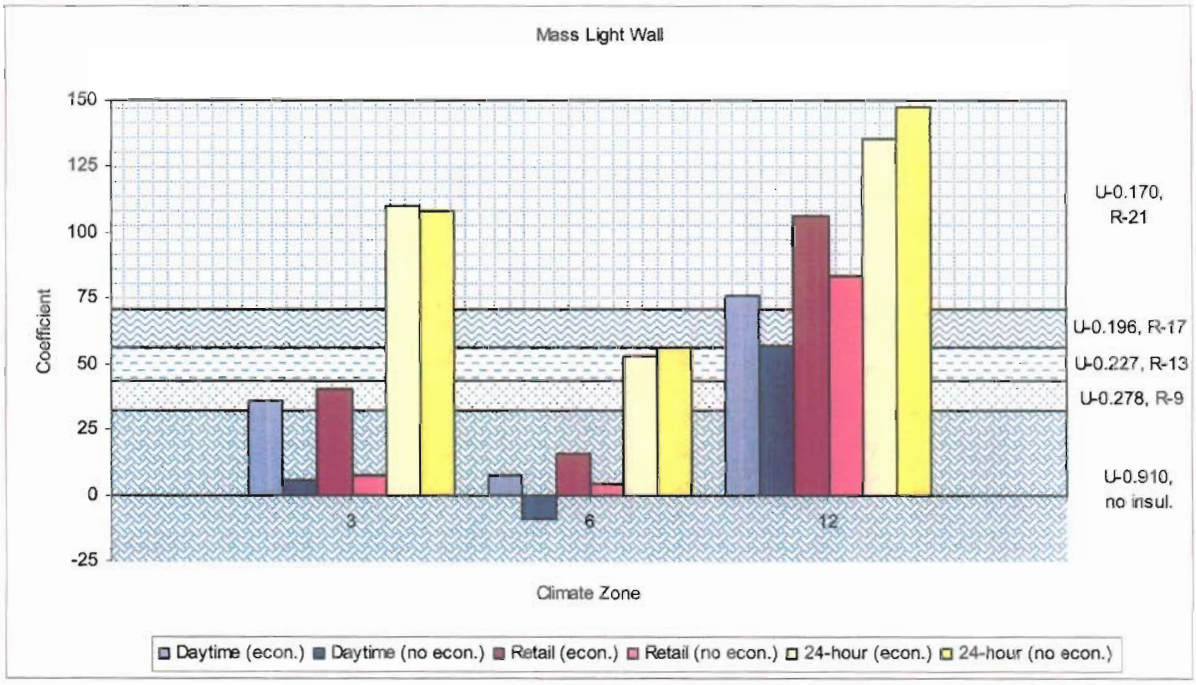


*Figure 40 – Mass (7.0≤HC<15.0) Wall Coefficients (economizer sensitivity)*

## Mass (15.0≤HC) Wall

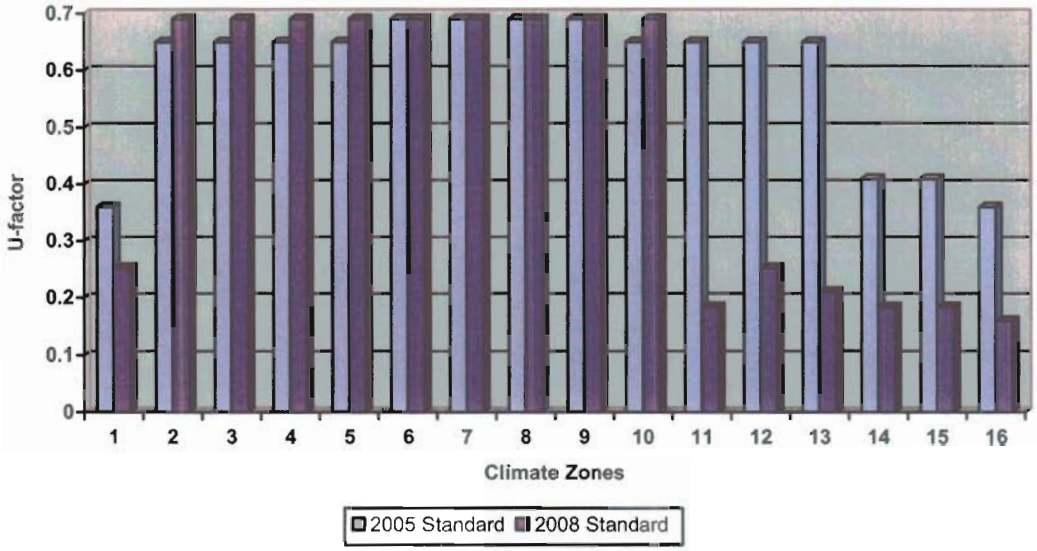


*Figure 41 – Mass (15.0≤HC) Wall (Daytime)*
*Statewide Energy Impacts (ft²-yr): TDV=5.286, kWh=0.062, therm=0.022*

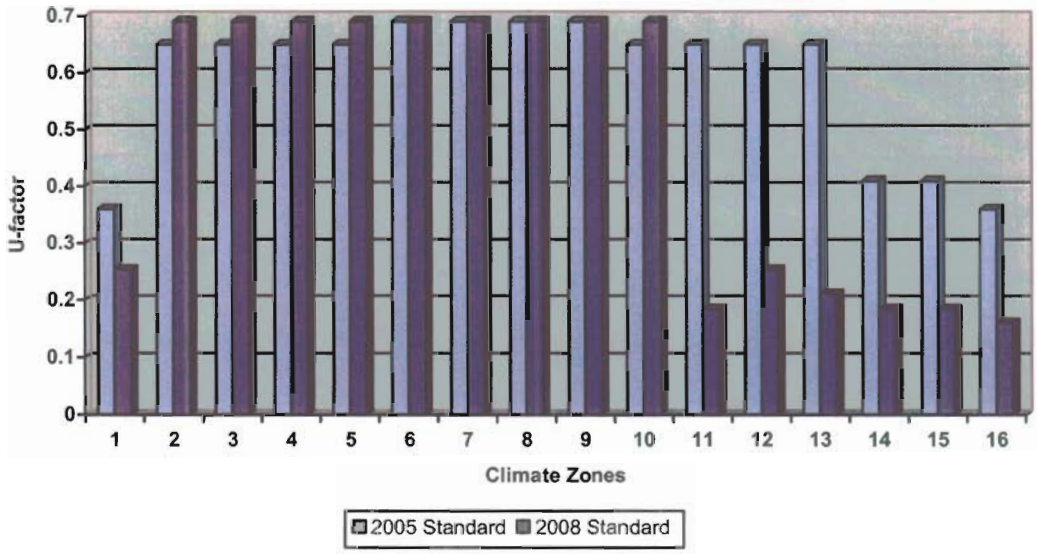


*Figure 42 – Mass (15.0≤HC) Wall (Retail)*
*Statewide Energy Impacts (ft²-yr): TDV=10.520, kWh=0.365, therm=0.038*

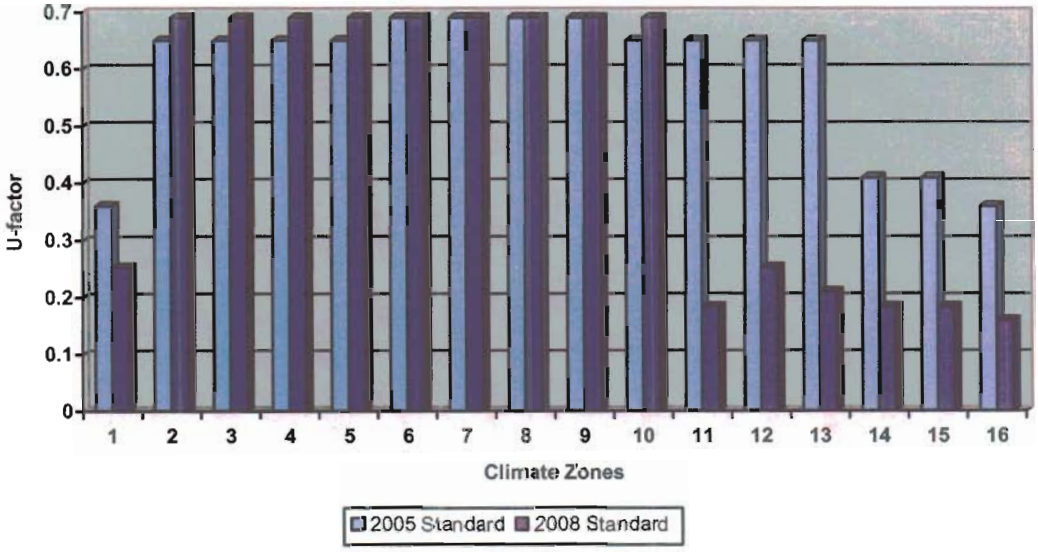


*Figure 43 – Mass (15.0≤HC) Wall (24-hour)*
*Statewide Energy Impacts (ft$^2$-yr): TDV=8.626, kWh=0.198, therm=0.038*

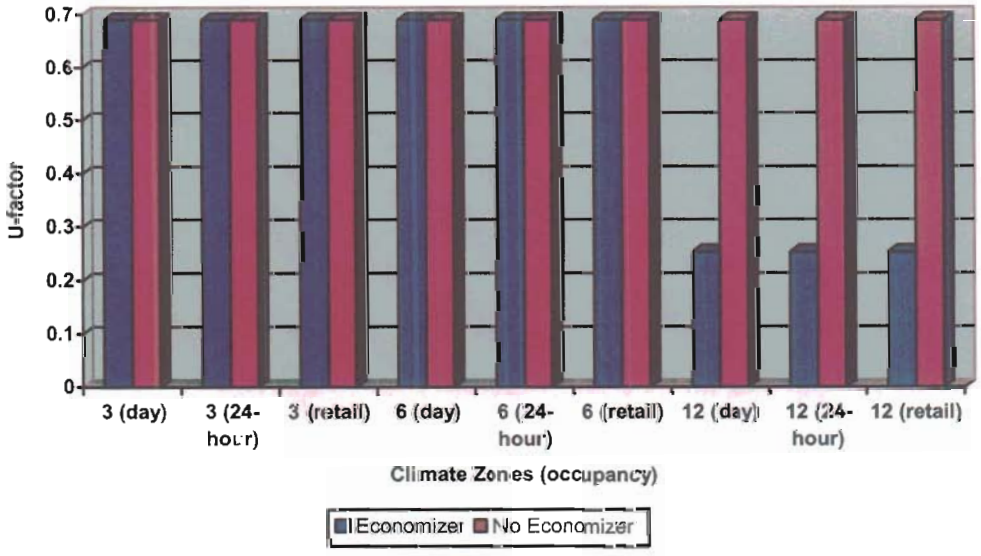


*Figure 44 – Daytime Economizer Insulation Sensitivity Analysis for Mass (15.0≤HC) Wall*

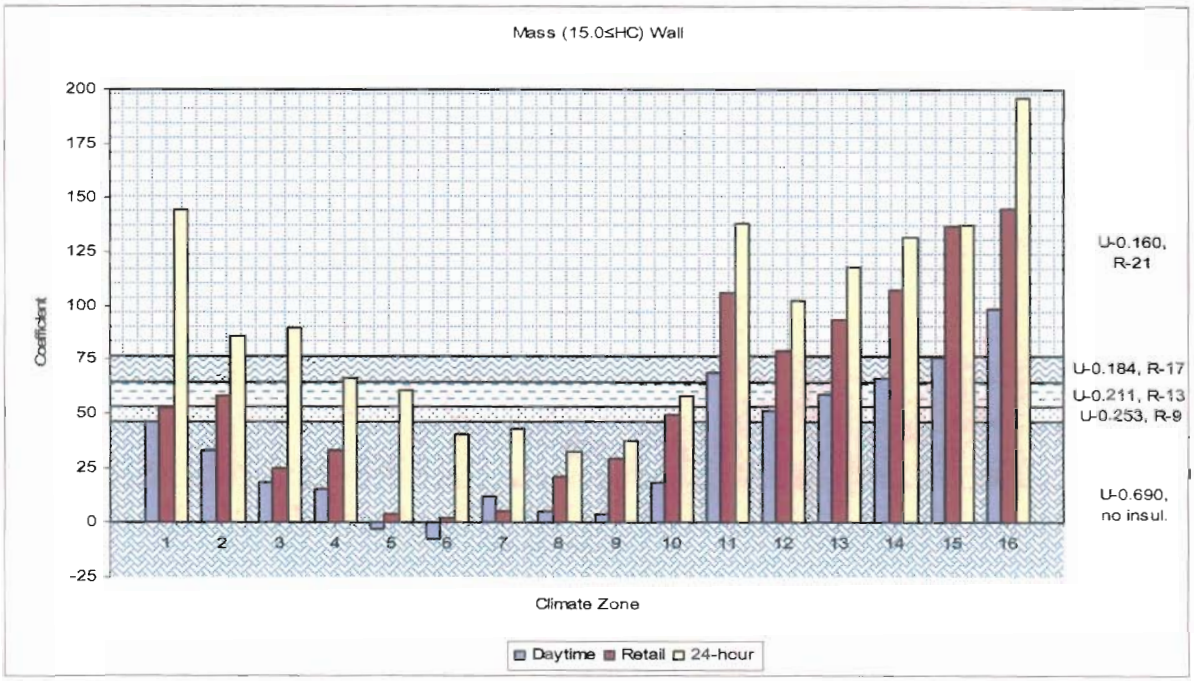


*Figure 45 – Mass (15.0≤HC) Wall Coefficients*

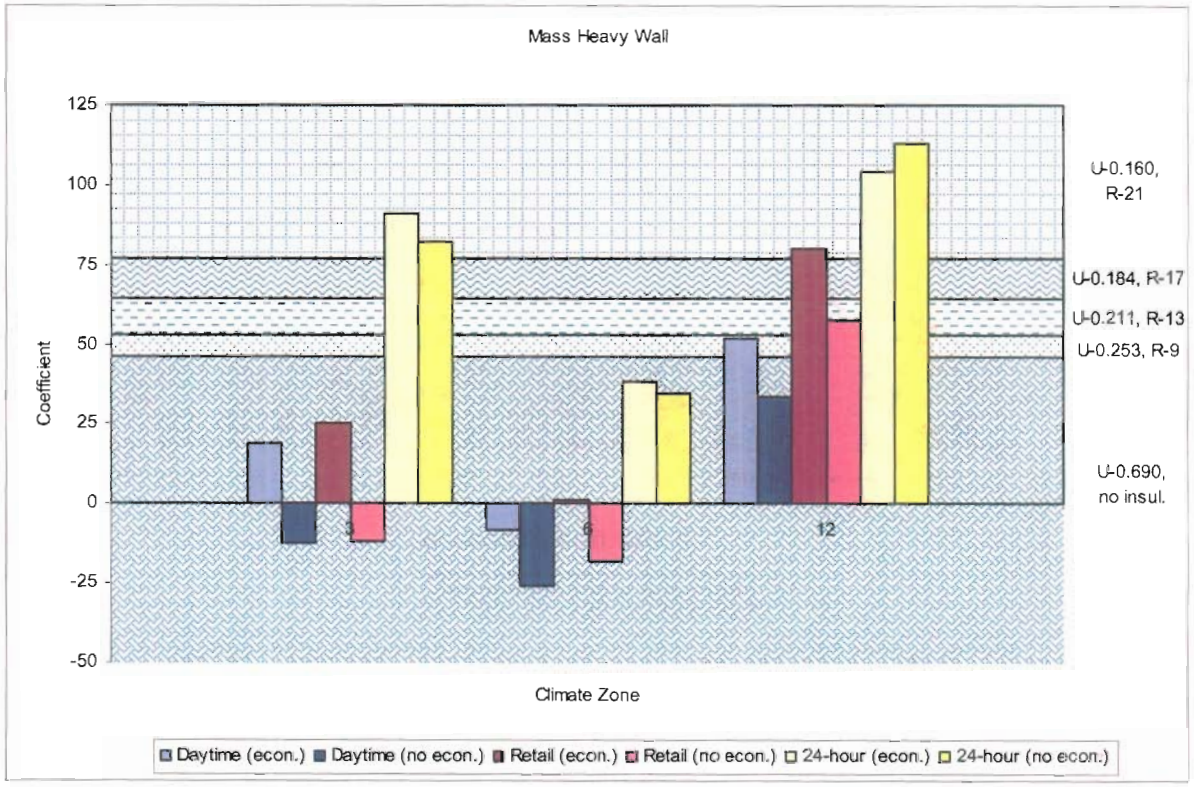


*Figure 46 – Mass (15.0≤HC) Wall Coefficients (economizer sensitivity)*

## Wood-framed and Other Wall

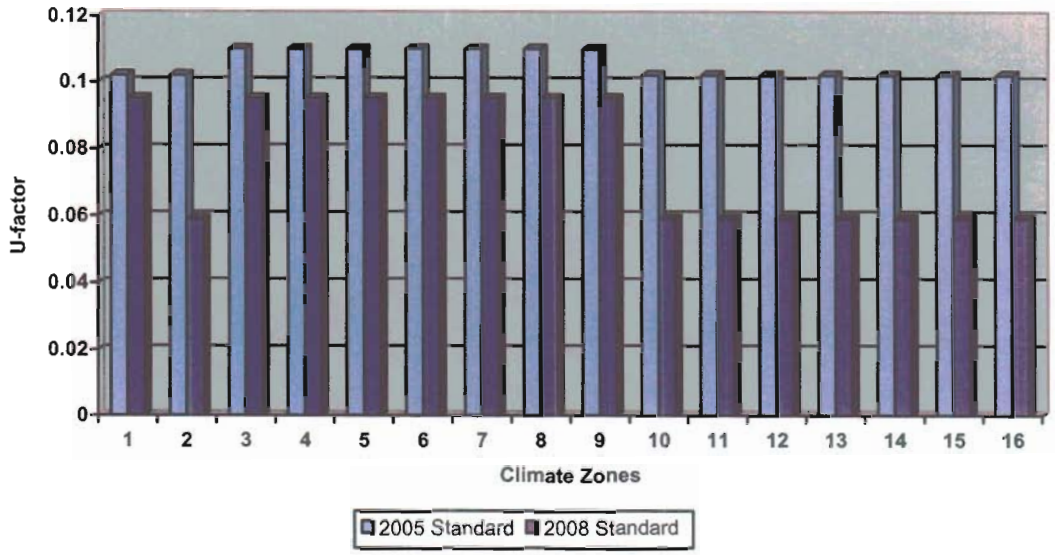


*Figure 47 – Wood-framed and Other Wall (Daytime)*
*Statewide Energy Impacts (ft²-yr): TDV=3.428, kWh=0.159, therm=0.006*

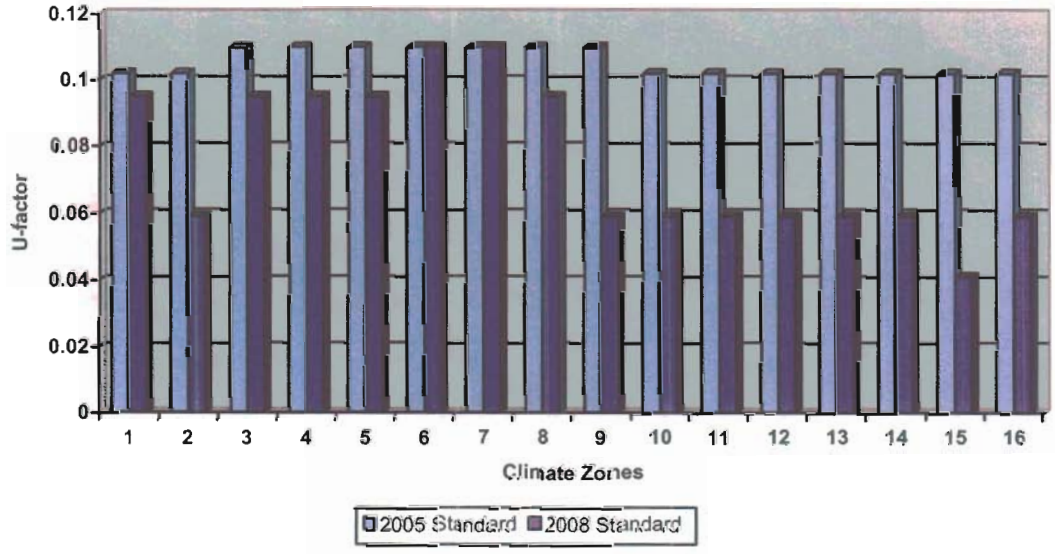


*Figure 48 – Wood-framed and Other Wall (Retail)*
*Statewide Energy Impacts (ft²-yr): TDV=4.825, kWh=0.263, therm=0.010*

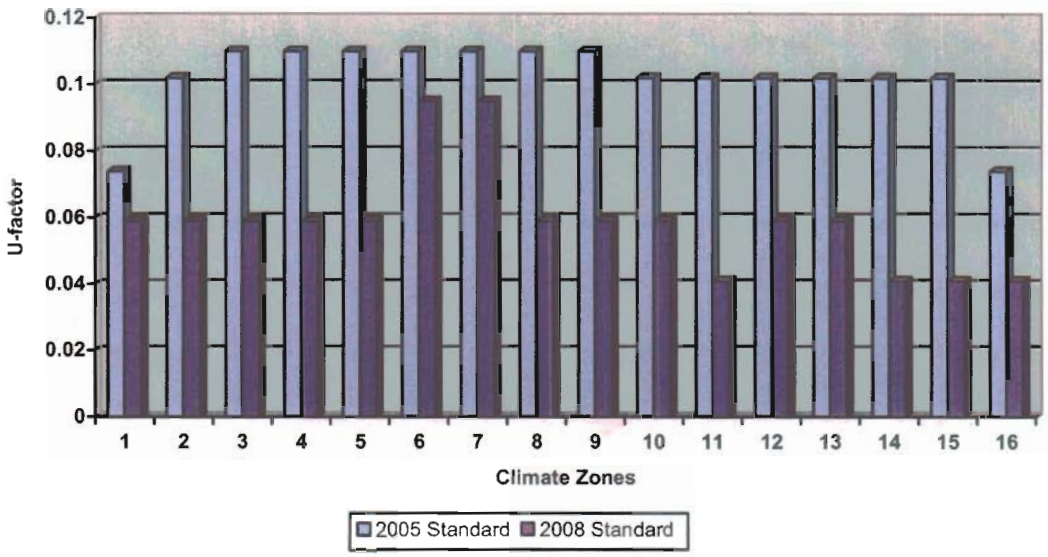


*Figure 49 – Wood-framed and Other Wall (24-hour)*
*Statewide Energy Impacts ($ft^2$-yr): TDV=7.644, kWh=0.394, therm=0.027*

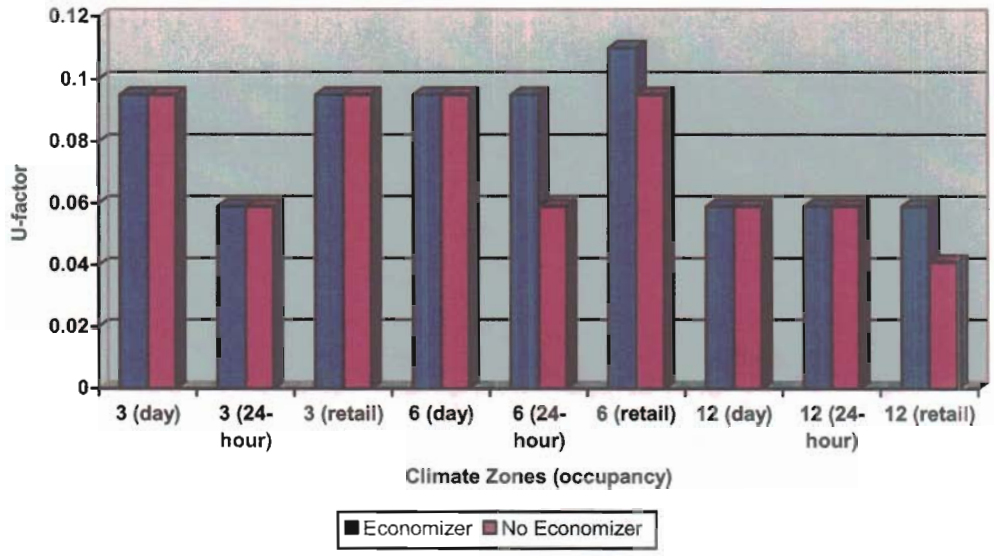


*Figure 50 – Daytime Economizer Insulation Sensitivity Analysis for Wood-framed and Other Wall*

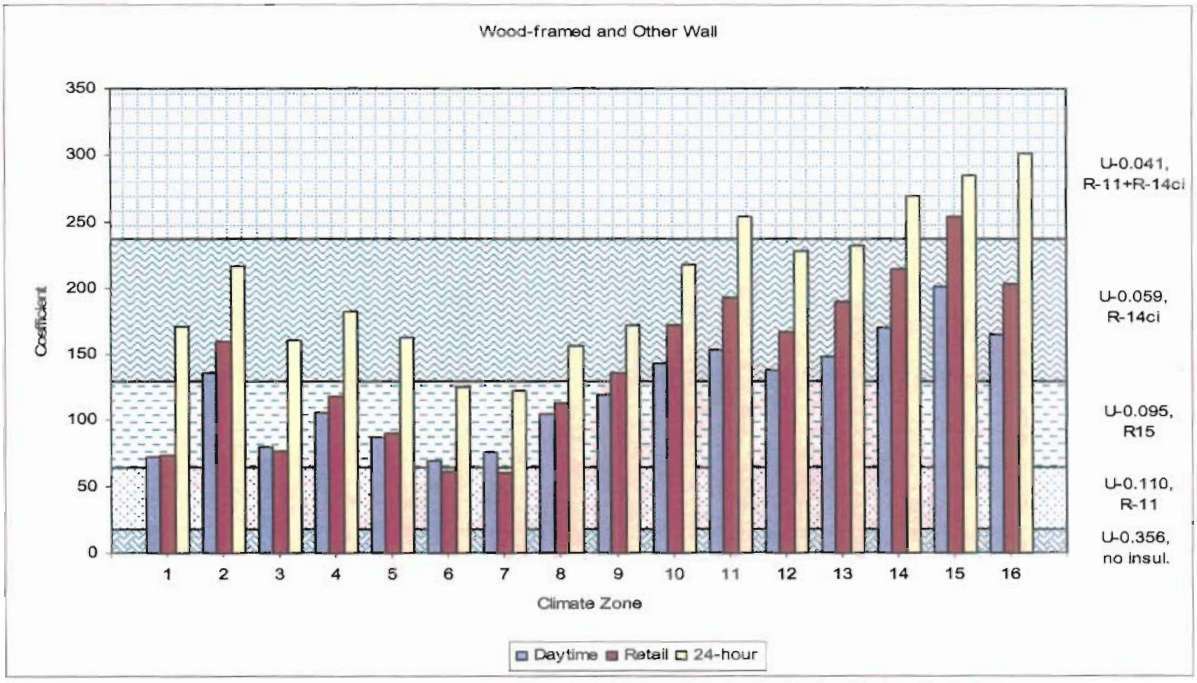


*Figure 51 – Wood-framed and Other Wall Coefficients*

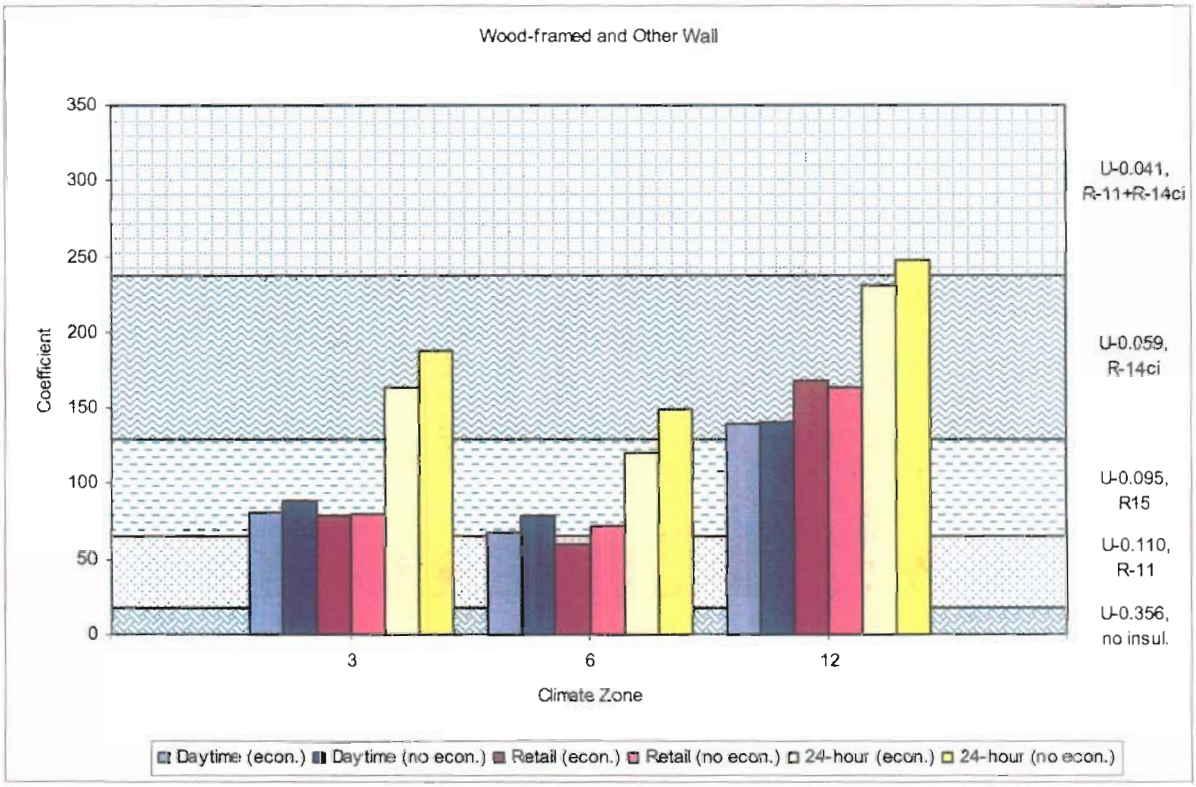


*Figure 52 – Wood-framed and Other Wall Coefficients (economizer sensitivity)*

## Mass Floor

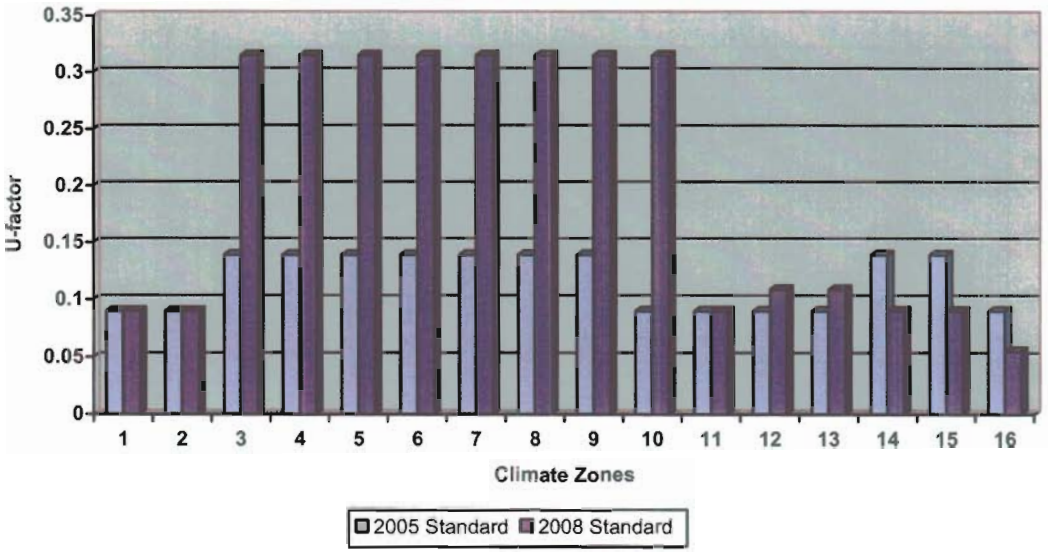


*Figure 53 – Mass Floor (Daytime)*
*Statewide Energy Impacts (ft$^2$-yr): TDV=0.407, kWh=0.260, therm=-0.029*

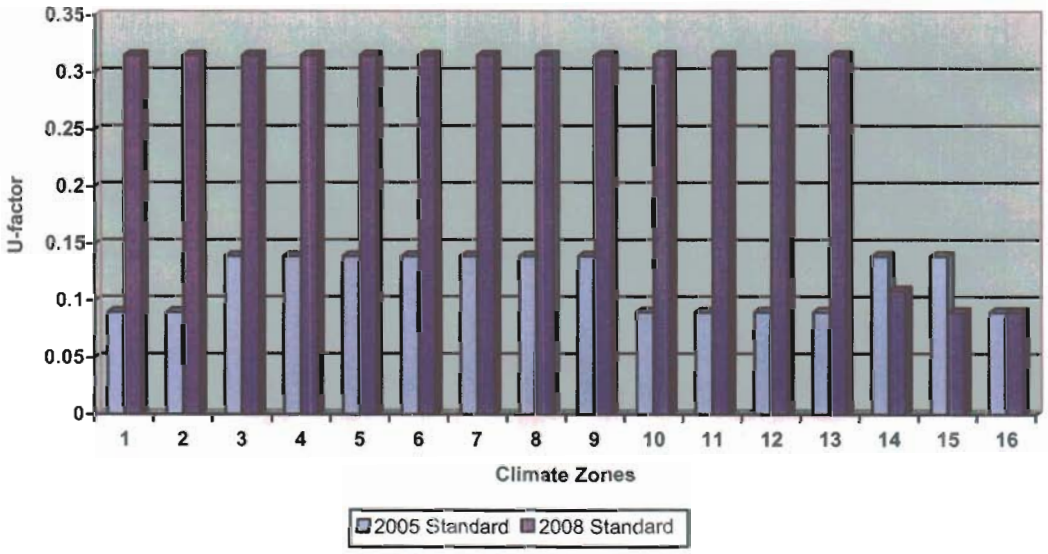


*Figure 54 – Mass Floor (Retail)*
*Statewide Energy Impacts (ft$^2$-yr): TDV=6.200, kWh=0.472, therm=-0.026*

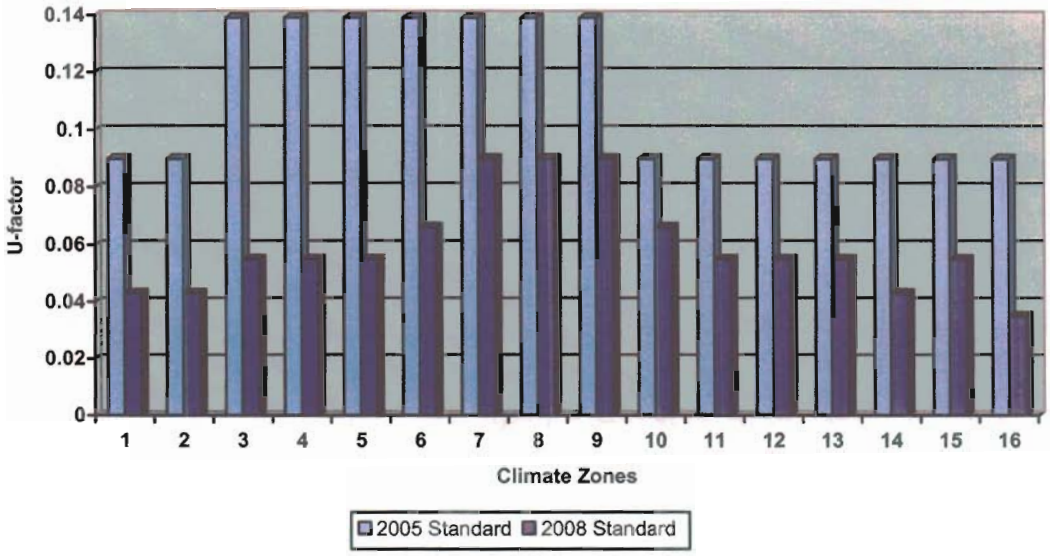


*Figure 55 – Mass Floor (24-hour)*
*Statewide Energy Impacts (ft$^2$-yr): TDV=7.655, kWh=-0.010, therm=0.050*

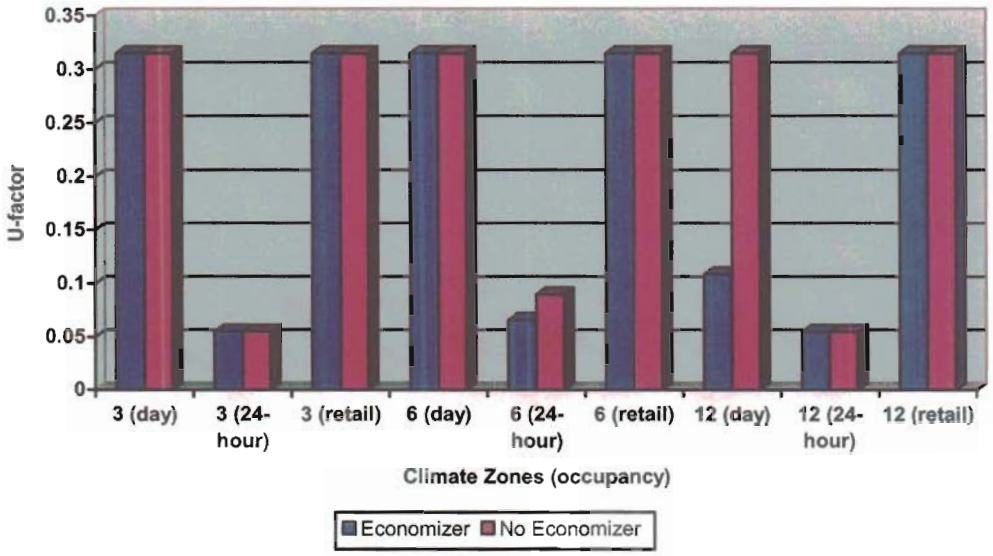


*Figure 56 – Daytime Economizer Insulation Sensitivity Analysis for Mass Floor*

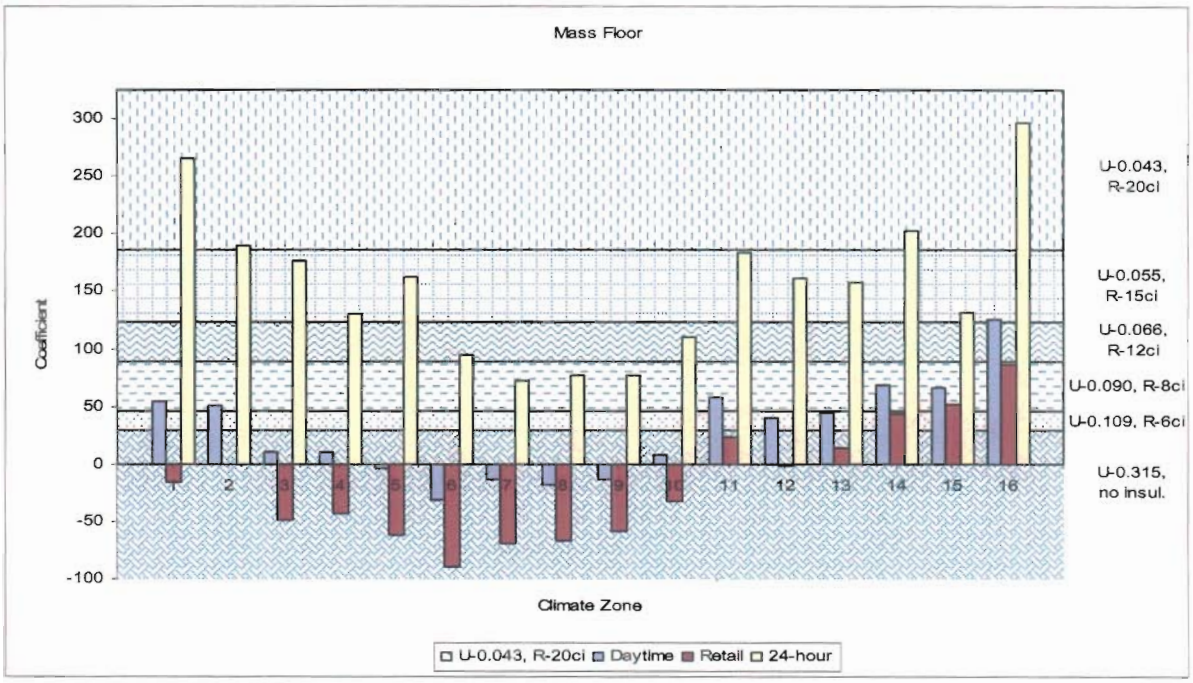


*Figure 57 – Mass Floor Coefficients*

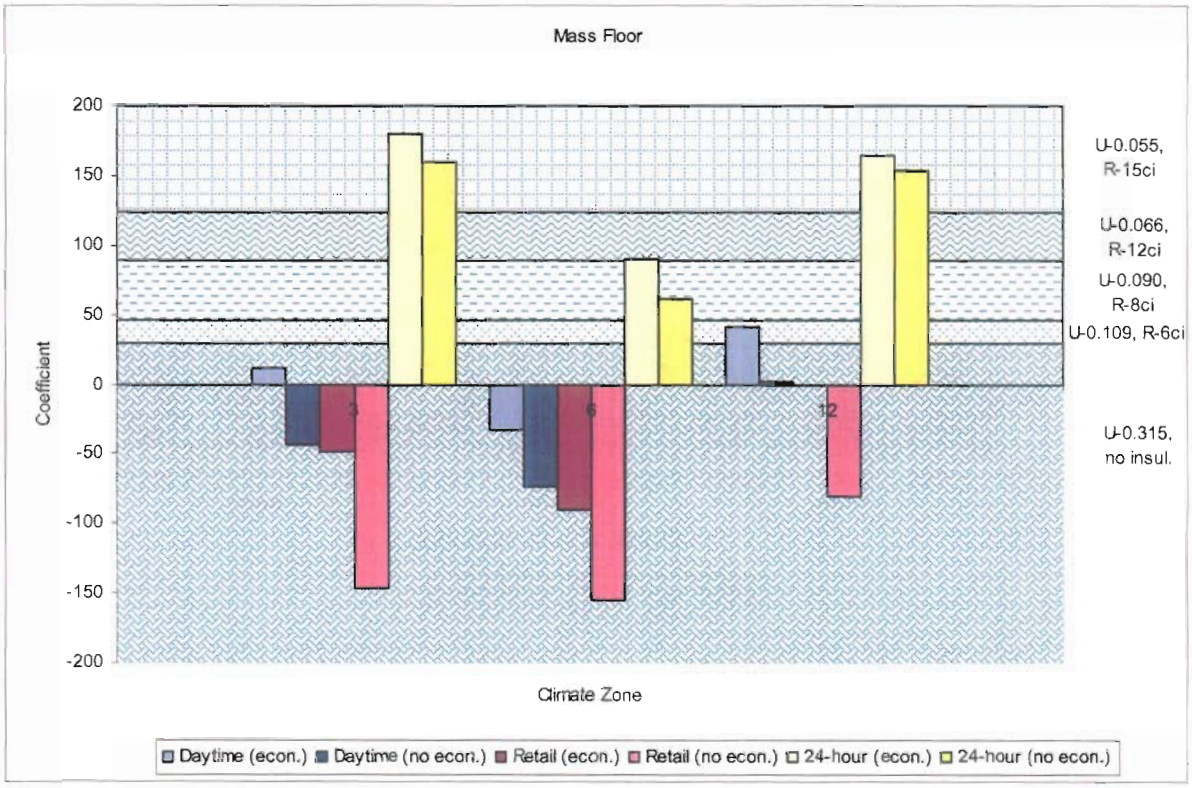


*Figure 58 – Mass Floor Coefficients (economizer sensitivity)*

## *Other Floor*

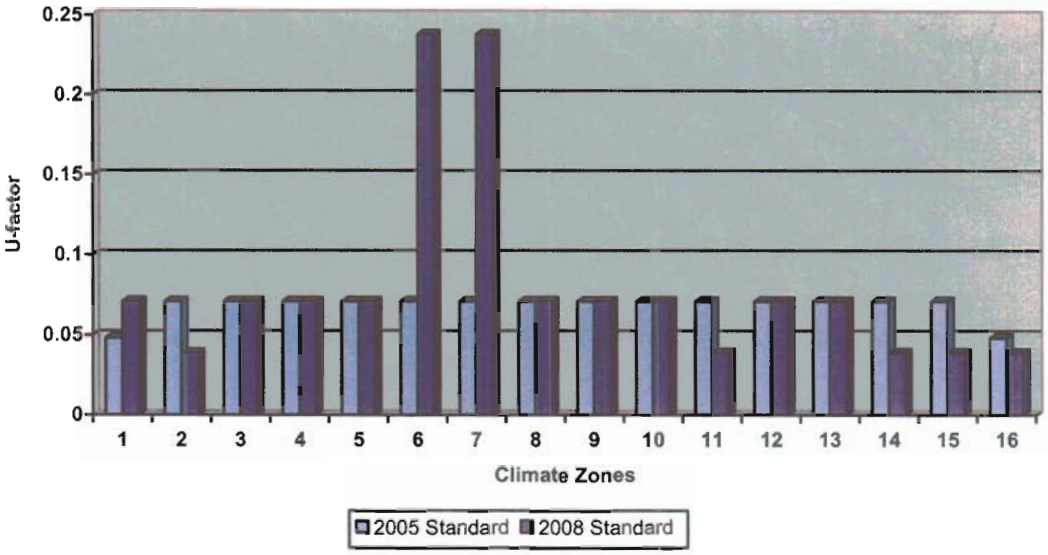


*Figure 59 – Other Floor (Daytime)*
*Statewide Energy Impacts ($ft^2$-yr): TDV=0.218, kWh=0.036, therm=-0.003*

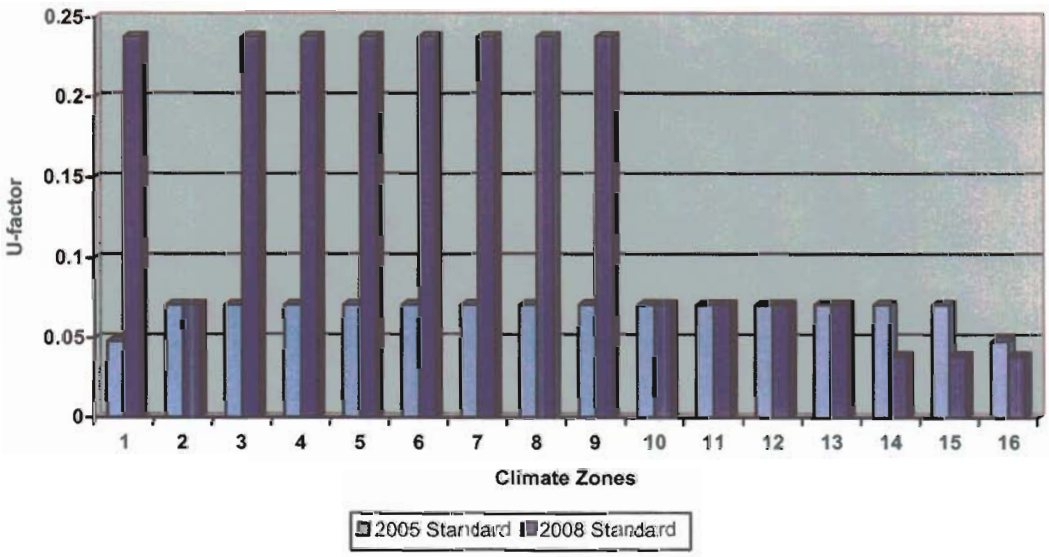


*Figure 60 – Other Floor (Retail)*
*Statewide Energy Impacts ($ft^2$-yr): TDV=2.218, kWh=0.151, therm=-0.012*

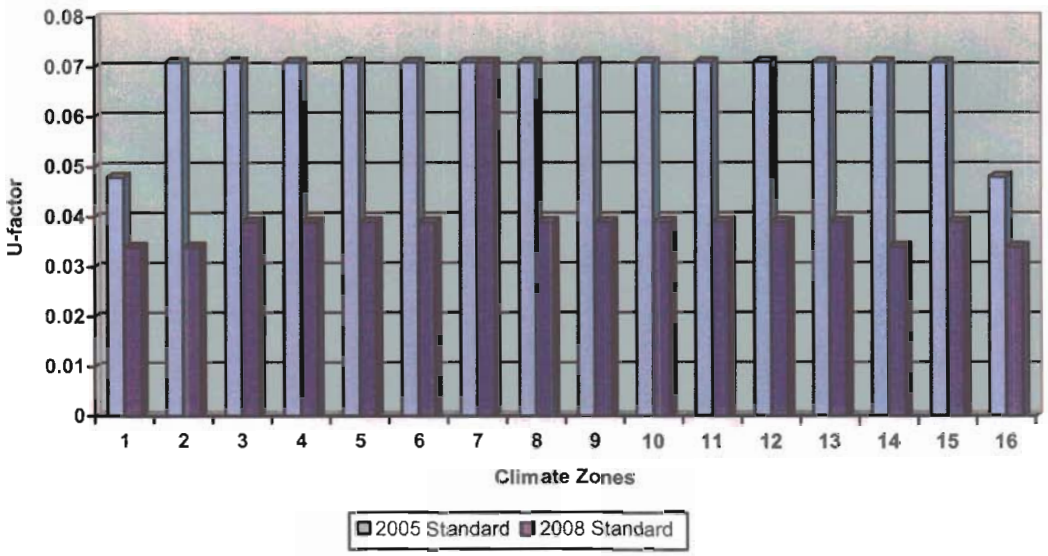


*Figure 61 – Other Floor (24-hour)*
*Statewide Energy Impacts ($ft^2$-yr): TDV=5.188, kWh=0.058, therm=0.029*

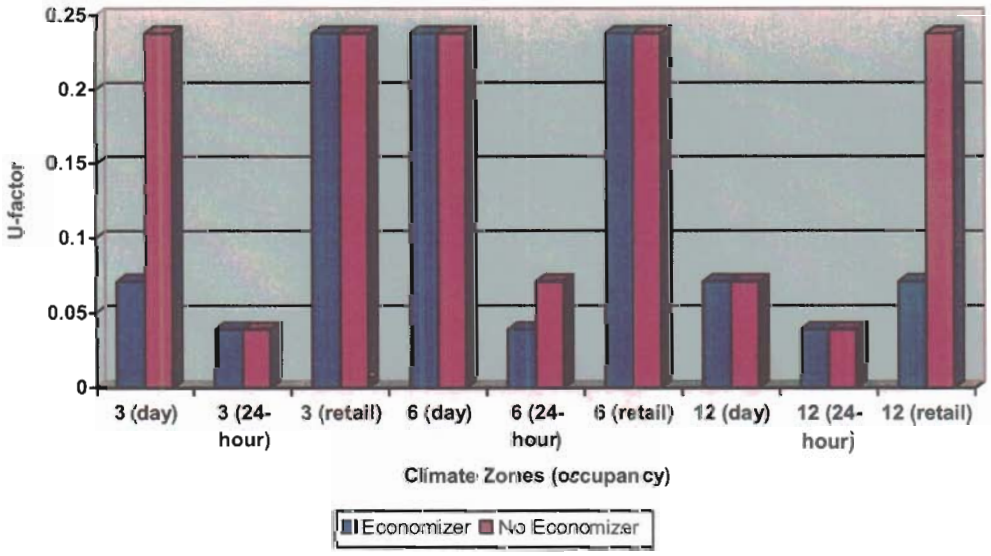


*Figure 62 – Daytime Economizer Insulation Sensitivity Analysis for Other Floor*

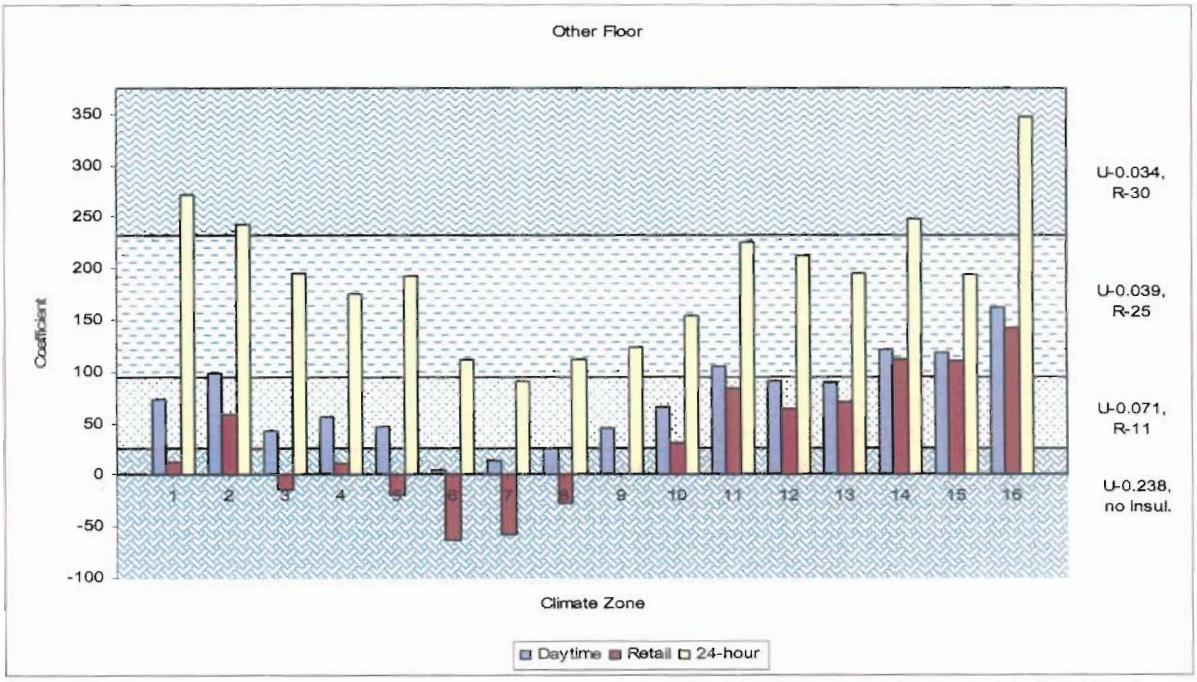


*Figure 63 – Other Floor Coefficients*

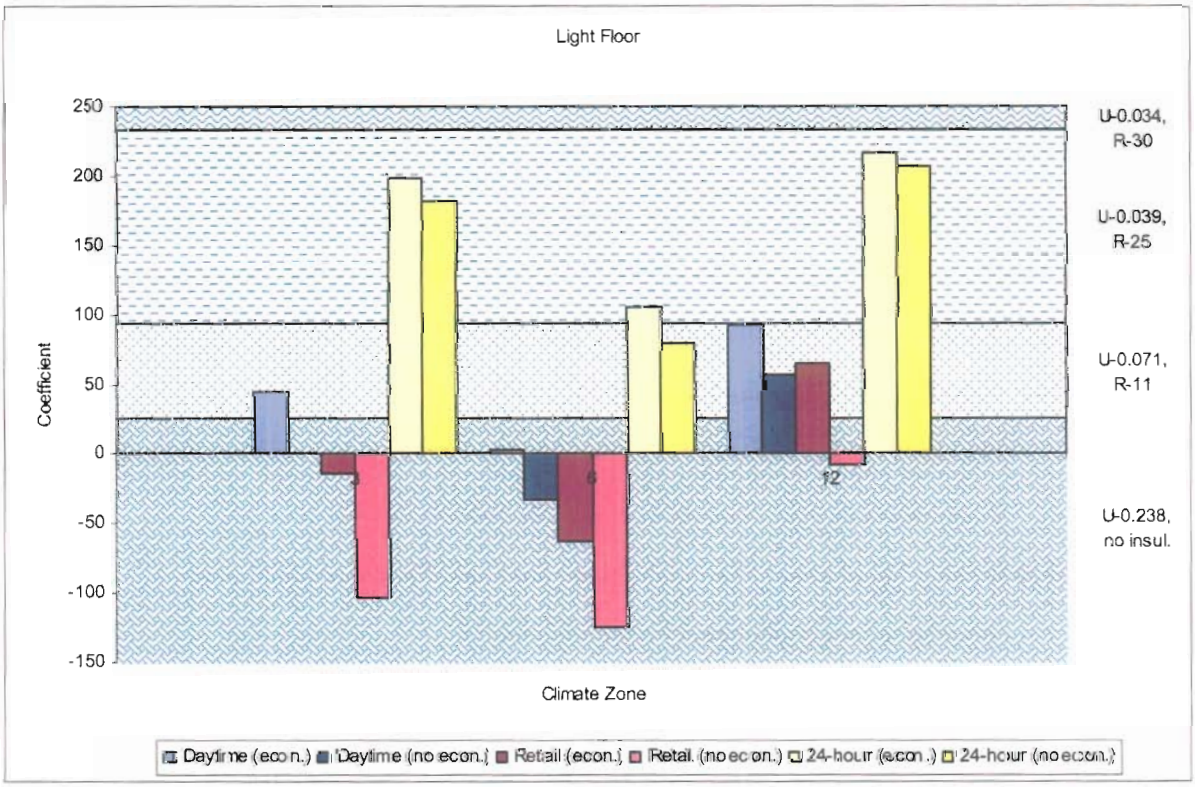


*Figure 64 – Other Floor Coefficients (economizer sensitivity)*

## Cost-effectiveness

A spreadsheet listing the life-cycle cost values for all evaluated construction assemblies can be found at the http link below. The spreadsheet is split by class of construction and can be sorted by the following descriptions:

http://www.archenergy.com/downloads/pub/sf/lcc_envelope_results.xls

*Table 17 – Life-cycle Cost Spreadsheet Definitions*

| Column | Definition |
|---|---|
| Occupancy | Occupancy Type (Daytime, 24-hour, retail) |
| CZ | Climate Zone (1-16) |
| Type | Type of Construction (roof, wall, floor) |
| Class | Class of Construction (wood, metal, metal building, mass, etc.) |
| Category | Category of Construction (heavy mass, light mass, 16" o.c., 24" o.c., etc.) |
| Cavity R | Cavity R-value (non-rigid insulation) |
| Sheathing R | Sheathing R-value (rigid insulation) |
| U-factor | U-factor of combined cavity and sheathing R-value (U-factor) |
| LCC | Life-cycle cost |
| Rank | Rank (Rank=1 is the lowest life-cycle cost among class and category of construction) |
| Class and Category | Class and category of construction combined |

Note: The column and definition used in this table and the corresponding spreadsheet may be different than the definitions used in the rest of the report; however, the definition should still be self-explanatory.

# Recommendations

These are the recommended code changes based on the TDV life-cycle cost analysis. Since the U-factors were used from Joint Appendix IV to calculate the life cycle cost, we recommend that only the U-factors be listed for compliance purposes in the Standards. As long as the construction meets the U-factor requirement, it does not matter whether the requirement is met through non-rigid insulation, rigid insulation, or a combination thereof.

The recommended classes of construction are as follows:

- Roofs: Metal Building and Wood-framed and Others
    - Metal buildings that utilize rigid insulation include a second deck to sandwich the insulation.
    - Wood-framed and others are wood framed rafter roofs 24 in. OC.
- Walls: Metal Building, Metal-framed, Mass Light, Mass Heavy, and Wood-framed and Other
    - Metal-framed and wood-framed walls are 16 in. OC.
- Floors: Mass and Other
    - Mass floor is concrete raised floors or concrete on a metal deck.
    - Other is wood-framed floors without a crawl space 16 in. OC.

The ACM Requirements for mass walls specify different types of mass walls as the base case for each climate zone. During the life cycle cost analysis, the mass wall that was specified in the ACM was used.

*Table 18 – Daytime Occupancy Recommended Standard (corresponds to Table 143-A)*

| | Climate Zones | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| **Roof/Ceiling** | | | | | | | | | | | | | | | | |
| Metal Building | 0.063 | 0.048 | 0.063 | 0.063 | 0.063 | 0.078 | 0.063 | 0.063 | 0.063 | 0.048 | 0.048 | 0.048 | 0.048 | 0.048 | 0.048 | 0.048 |
| Word-framed and other | 0.060 | 0.046 | 0.060 | 0.046 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 | 0.046 | 0.046 | 0.046 | 0.046 | 0.039 | 0.039 | 0.039 |
| **Wall** | | | | | | | | | | | | | | | | |
| Metal Building | 0.113 | 0.057 | 0.113 | 0.061 | 0.061 | 0.113 | 0.113 | 0.061 | 0.061 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 |
| Metal-framed | 0.098 | 0.062 | 0.082 | 0.062 | 0.082 | 0.098 | 0.098 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 |
| Mass Light | 0.196 | 0.196 | 0.278 | 0.278 | 0.910 | 0.910 | 0.910 | 0.910 | 0.910 | 0.227 | 0.170 | 0.170 | 0.170 | 0.170 | 0.170 | 0.170 |
| Mass Heavy | 0.253 | 0.690 | 0.690 | 0.690 | 0.690 | 0.690 | 0.690 | 0.690 | 0.690 | 0.690 | 0.184 | 0.253 | 0.211 | 0.184 | 0.184 | 0.160 |
| Wood-framed and Other | 0.095 | 0.059 | 0.095 | 0.095 | 0.095 | 0.095 | 0.095 | 0.095 | 0.095 | 0.059 | 0.059 | 0.059 | 0.059 | 0.059 | 0.059 | 0.059 |
| **Floor/Soffit** | | | | | | | | | | | | | | | | |
| Mass | 0.090 | 0.090 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.090 | 0.109 | 0.109 | 0.090 | 0.090 | 0.055 |
| Other | 0.071 | 0.039 | 0.071 | 0.071 | 0.071 | 0.238 | 0.238 | 0.071 | 0.071 | 0.071 | 0.039 | 0.071 | 0.071 | 0.039 | 0.039 | 0.039 |

*Table 19 – 24-hour Occupancy Recommended Standard (corresponds to Table 143-B)*

| | Climate Zones | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| **Roof/Ceiling** | | | | | | | | | | | | | | | | |
| Metal Building | 0.048 | 0.039 | 0.048 | 0.039 | 0.048 | 0.048 | 0.048 | 0.048 | 0.048 | 0.039 | 0.039 | 0.039 | 0.039 | 0.032 | 0.039 | 0.032 |
| Word-framed and other | 0.039 | 0.028 | 0.039 | 0.034 | 0.039 | 0.046 | 0.046 | 0.039 | 0.039 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 | 0.028 |
| **Wall** | | | | | | | | | | | | | | | | |
| Metal Building | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 |
| Metal-framed | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 |
| Mass Light | 0.170 | 0.170 | 0.170 | 0.170 | 0.170 | 0.227 | 0.227 | 0.227 | 0.196 | 0.170 | 0.170 | 0.170 | 0.170 | 0.170 | 0.170 | 0.170 |
| Mass Heavy | 0.253 | 0.690 | 0.690 | 0.690 | 0.690 | 0.690 | 0.690 | 0.690 | 0.690 | 0.690 | 0.184 | 0.253 | 0.211 | 0.184 | 0.184 | 0.160 |
| Wood-framed and Other | 0.059 | 0.059 | 0.059 | 0.059 | 0.059 | 0.095 | 0.095 | 0.059 | 0.059 | 0.059 | 0.041 | 0.059 | 0.059 | 0.041 | 0.041 | 0.041 |
| **Floor/Soffit** | | | | | | | | | | | | | | | | |
| Mass | 0.043 | 0.043 | 0.055 | 0.055 | 0.055 | 0.066 | 0.090 | 0.090 | 0.090 | 0.066 | 0.055 | 0.055 | 0.055 | 0.043 | 0.055 | 0.035 |
| Other | 0.034 | 0.034 | 0.039 | 0.039 | 0.039 | 0.039 | 0.071 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | 0.034 | 0.039 | 0.034 |

*Table 20 – Retail Occupancy Recommended Standard (new table)*

| | Climate Zones | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| Roof/Ceiling | | | | | | | | | | | | | | | | |
| Metal Building | 0.063 | 0.048 | 0.063 | 0.063 | 0.063 | 0.078 | 0.078 | 0.063 | 0.063 | 0.048 | 0.048 | 0.048 | 0.048 | 0.048 | 0.048 | 0.048 |
| Word-framed and other | 0.060 | 0.046 | 0.060 | 0.046 | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 | 0.046 | 0.039 | 0.046 | 0.039 | 0.039 | 0.039 | 0.039 |
| Wall | | | | | | | | | | | | | | | | |
| Metal Building | 0.113 | 0.057 | 0.113 | 0.061 | 0.061 | 0.123 | 0.123 | 0.061 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 |
| Metal-framed | 0.098 | 0.062 | 0.098 | 0.062 | 0.062 | 0.098 | 0.098 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 | 0.062 |
| Mass Light | 0.196 | 0.170 | 0.278 | 0.227 | 0.910 | 0.910 | 0.910 | 0.227 | 0.196 | 0.170 | 0.170 | 0.170 | 0.170 | 0.170 | 0.170 | 0.170 |
| Mass Heavy | 0.253 | 0.690 | 0.690 | 0.690 | 0.690 | 0.690 | 0.690 | 0.690 | 0.690 | 0.690 | 0.184 | 0.253 | 0.211 | 0.184 | 0.184 | 0.160 |
| Wood-framed and Other | 0.095 | 0.059 | 0.095 | 0.095 | 0.095 | 0.110 | 0.110 | 0.095 | 0.059 | 0.059 | 0.059 | 0.059 | 0.059 | 0.059 | 0.041 | 0.059 |
| Floor/Soffit | | | | | | | | | | | | | | | | |
| Mass | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.315 | 0.109 | 0.090 | 0.090 |
| Other | 0.238 | 0.071 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.238 | 0.071 | 0.071 | 0.071 | 0.071 | 0.039 | 0.039 | 0.039 |

## Proposed Standards Language

The proposed changes to the Standards are the substitution of the tables shown above for Tables 143-A and 143-B and the addition of a new Table 143-C for retail occupancies. Table 143-D would be changed to include the new values for the most severe climate zone to allow for relocatable school buildings to be located throughout the state.

## Alternate Calculation Manual

Table N2-1 of the nonresidential ACM will need to be modified to reflect the choices from Joint Appendix IV that are recommended.

## Bibliography and Other Research

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## Appendices

### Energy Impacts

Table 21 through Table 47 below provide a comparison of energy impacts between the current standard and the proposed standard for all sixteen climate zones. The delta (Δ) TDV, kWh and therm represents the absolute change between the current standard and the proposed standard on an annual per square foot basis. The weighted (wt.) TDV, kWh and therm represents the weighted change by climate zone, occupancy type and square foot of construction. Therefore, the weighted totals represent the average statewide savings on an annual per square foot basis. A positive number represents lower energy consumption (savings) from the proposed standard, whereas a negative number represents higher energy consumption. In certain instances, the proposed standard results in higher energy consumption in certain climate zones, however, the statewide impact is a reduction in energy consumption measured in TDV.

*Table 21 – Metal Building Roof (Daytime) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | -1.200 | 0.516 | -1.218 | -1.615 | -1.265 | -0.168 | 1.227 | 1.478 | 1.661 | 0.466 | 0.491 | 0.478 | 0.475 | 0.574 | 0.561 | 0.595 | 3.058 |
| Wt. TDV | -0.004 | 0.035 | -0.202 | -0.126 | -0.024 | -0.010 | 0.087 | 0.126 | 0.168 | 0.041 | 0.006 | 0.069 | 0.027 | 0.014 | 0.011 | 0.003 | 0.222 |
| | | | | | | | | | | | | | | | | | |
| Δ kWh | -0.015 | 0.011 | -0.025 | -0.042 | -0.027 | -0.004 | 0.038 | 0.048 | 0.055 | 0.015 | 0.014 | 0.013 | 0.017 | 0.017 | 0.023 | 0.010 | 0.150 |
| Wt. kWh | 0.000 | 0.001 | -0.004 | -0.003 | -0.001 | 0.000 | 0.003 | 0.004 | 0.006 | 0.001 | 0.000 | 0.002 | 0.001 | 0.000 | 0.000 | 0.000 | 0.010 |
| | | | | | | | | | | | | | | | | | |
| Δ therm | -0.007 | 0.002 | -0.006 | -0.006 | -0.006 | -0.001 | 0.004 | 0.004 | 0.005 | 0.001 | 0.002 | 0.002 | 0.001 | 0.002 | 0.001 | 0.003 | -0.001 |
| Wt. therm | 0.000 | 0.000 | -0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

*Table 22 – Metal Building Roof (Retail) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | -1.165 | 0.552 | -1.144 | -1.633 | -1.170 | -0.137 | -0.171 | 1.369 | 1.674 | 0.490 | 0.559 | 0.523 | 0.555 | 0.661 | 0.667 | 0.697 | 2.328 |
| Wt. TDV | -0.003 | 0.032 | -0.147 | -0.076 | -0.017 | -0.009 | -0.012 | 0.128 | 0.192 | 0.041 | 0.014 | 0.092 | 0.040 | 0.015 | 0.013 | 0.004 | 0.305 |
| | | | | | | | | | | | | | | | | | |
| Δ kWh | -0.017 | 0.015 | -0.026 | -0.050 | -0.028 | -0.004 | -0.006 | 0.054 | 0.068 | 0.020 | 0.019 | 0.018 | 0.024 | 0.023 | 0.032 | 0.013 | 0.155 |
| Wt. kWh | 0.000 | 0.001 | -0.003 | -0.002 | 0.000 | 0.000 | 0.000 | 0.005 | 0.008 | 0.002 | 0.000 | 0.003 | 0.002 | 0.001 | 0.001 | 0.000 | 0.015 |
| | | | | | | | | | | | | | | | | | |
| Δ therm | -0.008 | 0.002 | -0.006 | -0.007 | -0.006 | -0.001 | -0.001 | 0.004 | 0.005 | 0.001 | 0.002 | 0.002 | 0.001 | 0.002 | 0.001 | 0.003 | -0.005 |
| Wt. therm | 0.000 | 0.000 | -0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

*Table 23 – Metal Building Roof (24-hour) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | 0.724 | 3.785 | 0.654 | 3.093 | 0.667 | 5.095 | 4.815 | 5.595 | 5.975 | 3.166 | 3.459 | 3.437 | 3.225 | 6.172 | 3.386 | 7.064 | 60.313 |
| Wt. TDV | 0.003 | 0.433 | 0.097 | 0.180 | 0.014 | 0.350 | 0.529 | 0.549 | 0.641 | 0.148 | 0.045 | 0.348 | 0.207 | 0.118 | 0.066 | 0.031 | 3.761 |
| | | | | | | | | | | | | | | | | | |
| Δ kWh | 0.007 | 0.084 | 0.012 | 0.080 | 0.013 | 0.114 | 0.156 | 0.183 | 0.205 | 0.106 | 0.099 | 0.094 | 0.120 | 0.185 | 0.153 | 0.112 | 1.723 |
| Wt. kWh | 0.000 | 0.010 | 0.002 | 0.005 | 0.000 | 0.008 | 0.017 | 0.018 | 0.022 | 0.005 | 0.001 | 0.010 | 0.008 | 0.004 | 0.003 | 0.000 | 0.112 |
| | | | | | | | | | | | | | | | | | |
| Δ therm | 0.004 | 0.017 | 0.004 | 0.014 | 0.004 | 0.024 | 0.020 | 0.023 | 0.023 | 0.011 | 0.014 | 0.015 | 0.011 | 0.022 | 0.007 | 0.036 | 0.250 |
| Wt. therm | 0.000 | 0.002 | 0.001 | 0.001 | 0.000 | 0.002 | 0.002 | 0.002 | 0.003 | 0.001 | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.016 |

*Table 24 – Wood-framed and Other Roof (Daytime) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | -0.900 | 0.860 | -0.914 | 0.673 | -0.949 | 1.342 | 1.510 | 1.819 | 2.045 | 0.776 | 0.818 | 0.797 | 0.792 | 2.296 | 2.246 | 2.382 | 15.594 |
| Wt. TDV | -0.003 | 0.058 | -0.152 | 0.052 | -0.018 | 0.078 | 0.107 | 0.155 | 0.206 | 0.069 | 0.010 | 0.115 | 0.045 | 0.057 | 0.045 | 0.013 | 0.838 |
| | | | | | | | | | | | | | | | | | |
| Δ kWh | -0.011 | 0.018 | -0.019 | 0.018 | -0.020 | 0.032 | 0.047 | 0.059 | 0.068 | 0.025 | 0.024 | 0.022 | 0.028 | 0.069 | 0.092 | 0.041 | 0.494 |
| Wt. kWh | 0.000 | 0.001 | -0.003 | 0.001 | 0.000 | 0.002 | 0.003 | 0.005 | 0.007 | 0.002 | 0.000 | 0.003 | 0.002 | 0.002 | 0.002 | 0.000 | 0.027 |
| | | | | | | | | | | | | | | | | | |
| Δ therm | -0.005 | 0.003 | -0.005 | 0.003 | -0.005 | 0.005 | 0.005 | 0.005 | 0.006 | 0.002 | 0.003 | 0.003 | 0.002 | 0.006 | 0.003 | 0.011 | 0.042 |
| Wt. therm | 0.000 | 0.000 | -0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 |

*Table 25 – Metal Building Roof (Retail) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | -0.874 | 0.920 | -0.858 | 0.680 | -0.877 | 1.096 | 1.369 | 1.685 | 2.061 | 0.817 | 2.238 | 0.871 | 2.219 | 2.644 | 2.666 | 2.790 |
| Wt. TDV | -0.002 | 0.053 | -0.111 | 0.032 | -0.012 | 0.073 | 0.098 | 0.157 | 0.236 | 0.069 | 0.057 | 0.153 | 0.161 | 0.059 | 0.050 | 0.016 |
| | | | | | | | | | | | | | | | | |
| Δ kWh | -0.013 | 0.026 | -0.019 | 0.021 | -0.021 | 0.031 | 0.050 | 0.067 | 0.084 | 0.033 | 0.075 | 0.029 | 0.094 | 0.092 | 0.128 | 0.052 |
| Wt. kWh | 0.000 | 0.001 | -0.002 | 0.001 | 0.000 | 0.002 | 0.004 | 0.006 | 0.010 | 0.003 | 0.002 | 0.005 | 0.007 | 0.002 | 0.002 | 0.000 |
| | | | | | | | | | | | | | | | | |
| Δ therm | -0.006 | 0.003 | -0.005 | 0.003 | -0.005 | 0.005 | 0.004 | 0.005 | 0.006 | 0.002 | 0.007 | 0.003 | 0.005 | 0.007 | 0.003 | 0.013 |
| Wt. therm | 0.000 | 0.000 | -0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 |

*Table 26 – Wood-framed and Other Roof (24-hour) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | 2.894 | 7.255 | 2.617 | 4.382 | 2.668 | 5.459 | 5.158 | 7.394 | 7.895 | 6.069 | 6.631 | 6.588 | 6.181 | 7.472 | 6.490 | 8.551 | 93.704 |
| Wt. TDV | 0.014 | 0.829 | 0.389 | 0.256 | 0.058 | 0.375 | 0.567 | 0.726 | 0.847 | 0.283 | 0.086 | 0.667 | 0.398 | 0.143 | 0.127 | 0.038 | 5.802 |
| | | | | | | | | | | | | | | | | | |
| Δ kWh | 0.030 | 0.160 | 0.047 | 0.113 | 0.050 | 0.122 | 0.167 | 0.241 | 0.271 | 0.203 | 0.190 | 0.181 | 0.229 | 0.224 | 0.293 | 0.136 | 2.659 |
| Wt. kWh | 0.000 | 0.018 | 0.007 | 0.007 | 0.001 | 0.008 | 0.018 | 0.024 | 0.029 | 0.009 | 0.002 | 0.018 | 0.015 | 0.004 | 0.006 | 0.001 | 0.168 |
| | | | | | | | | | | | | | | | | | |
| Δ therm | 0.017 | 0.032 | 0.015 | 0.020 | 0.015 | 0.026 | 0.022 | 0.030 | 0.031 | 0.021 | 0.027 | 0.028 | 0.022 | 0.027 | 0.013 | 0.044 | 0.390 |
| Wt. therm | 0.000 | 0.004 | 0.002 | 0.001 | 0.000 | 0.002 | 0.002 | 0.003 | 0.003 | 0.001 | 0.000 | 0.003 | 0.001 | 0.001 | 0.000 | 0.000 | 0.024 |

*Table 27 -- Metal Building Wall (Daytime) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | 0.000 | 7.575 | 0.799 | 6.528 | 5.395 | 0.695 | 0.755 | 6.467 | 7.386 | 7.994 | 8.594 | 7.719 | 8.317 | 9.516 | 11.263 | 9.193 | 98.195 |
| Wt. TDV | 0.000 | 0.508 | 0.132 | 0.508 | 0.104 | 0.040 | 0.053 | 0.551 | 0.745 | 0.711 | 0.102 | 1.114 | 0.470 | 0.237 | 0.225 | 0.051 | 5.554 |
| | | | | | | | | | | | | | | | | | |
| Δ kWh | 0.000 | 0.314 | 0.032 | 0.284 | 0.239 | 0.037 | 0.042 | 0.337 | 0.393 | 0.401 | 0.360 | 0.335 | 0.427 | 0.412 | 0.583 | 0.251 | 4.446 |
| Wt. kWh | 0.000 | 0.021 | 0.005 | 0.022 | 0.005 | 0.002 | 0.003 | 0.029 | 0.040 | 0.036 | 0.004 | 0.048 | 0.024 | 0.010 | 0.012 | 0.001 | 0.262 |
| | | | | | | | | | | | | | | | | | |
| Δ therm | 0.000 | 0.022 | 0.003 | 0.021 | 0.021 | 0.002 | 0.002 | 0.012 | 0.013 | 0.012 | 0.021 | 0.020 | 0.015 | 0.019 | 0.008 | 0.038 | 0.230 |
| Wt. therm | 0.000 | 0.001 | 0.001 | 0.002 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.000 | 0.003 | 0.001 | 0.000 | 0.000 | 0.000 | 0.013 |

*Table 28 – Metal Building Wall (Retail) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | 0.000 | 8.923 | 0.768 | 7.291 | 5.592 | 0.000 | 0.000 | 6.967 | 8.983 | 9.648 | 10.781 | 9.318 | 10.620 | 11.982 | 14.222 | 11.361 | 116.458 |
| Wt. TDV | 0.000 | 0.515 | 0.099 | 0.340 | 0.079 | 0.000 | 0.000 | 0.649 | 1.029 | 0.812 | 0.273 | 1.632 | 0.768 | 0.269 | 0.269 | 0.065 | 6.800 |
| | | | | | | | | | | | | | | | | | |
| Δ kWh | 0.000 | 0.441 | 0.042 | 0.384 | 0.307 | 0.000 | 0.000 | 0.437 | 0.555 | 0.554 | 0.508 | 0.467 | 0.613 | 0.580 | 0.803 | 0.353 | 6.044 |
| Wt. kWh | 0.000 | 0.025 | 0.005 | 0.018 | 0.004 | 0.000 | 0.000 | 0.041 | 0.064 | 0.047 | 0.013 | 0.082 | 0.044 | 0.013 | 0.015 | 0.002 | 0.373 |
| | | | | | | | | | | | | | | | | | |
| Δ therm | 0.000 | 0.024 | 0.004 | 0.022 | 0.022 | 0.000 | 0.000 | 0.012 | 0.014 | 0.013 | 0.024 | 0.023 | 0.018 | 0.022 | 0.008 | 0.047 | 0.253 |
| Wt. therm | 0.000 | 0.001 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.001 | 0.001 | 0.004 | 0.001 | 0.001 | 0.000 | 0.000 | 0.014 |

*Table 29 – Metal Building Wall (24-hour) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | 9.549 | 12.095 | 10.605 | 12.032 | 10.711 | 7.774 | 8.064 | 10.290 | 11.347 | 12.177 | 14.180 | 12.752 | 12.996 | 15.076 | 15. |
| Wt. TDV | 0.045 | 1.382 | 1.576 | 0.702 | 0.231 | 0.535 | 0.886 | 1.010 | 1.218 | 0.569 | 0.184 | 1.291 | 0.836 | 0.288 | 0.3 |
| | | | | | | | | | | | | | | | |
| Δ kWh | 0.319 | 0.585 | 0.429 | 0.579 | 0.471 | 0.425 | 0.490 | 0.615 | 0.726 | 0.707 | 0.658 | 0.613 | 0.768 | 0.742 | 0.9 |
| Wt. kWh | 0.002 | 0.067 | 0.064 | 0.034 | 0.010 | 0.029 | 0.054 | 0.060 | 0.078 | 0.033 | 0.009 | 0.062 | 0.049 | 0.014 | 0.0 |
| | | | | | | | | | | | | | | | |
| Δ therm | 0.056 | 0.045 | 0.056 | 0.049 | 0.054 | 0.033 | 0.030 | 0.032 | 0.031 | 0.028 | 0.046 | 0.046 | 0.034 | 0.042 | 0.0 |
| Wt. therm | 0.000 | 0.005 | 0.008 | 0.003 | 0.001 | 0.002 | 0.003 | 0.003 | 0.003 | 0.001 | 0.001 | 0.005 | 0.002 | 0.001 | 0.0 |

*Table 30 – Metal-framed Wall (Daytime) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | 8.626 | 20.966 | 11.344 | 17.057 | 12.356 | 8.756 | 9.516 | 16.897 | 19.300 | 22.125 | 23.786 | 21.365 | 23.021 | 26.340 | 31.175 | 25.444 | 298.074 |
| Wt. TDV | 0.026 | 1.407 | 1.881 | 1.328 | 0.238 | 0.507 | 0.673 | 1.439 | 1.948 | 1.969 | 0.282 | 3.085 | 1.300 | 0.656 | 0.624 | 0.142 | 17.505 |
| | | | | | | | | | | | | | | | | | |
| Δ kWh | 0.303 | 0.870 | 0.454 | 0.742 | 0.547 | 0.467 | 0.526 | 0.882 | 1.028 | 1.109 | 0.997 | 0.926 | 1.181 | 1.140 | 1.613 | 0.695 | 13.478 |
| Wt. kWh | 0.001 | 0.058 | 0.075 | 0.058 | 0.011 | 0.027 | 0.037 | 0.075 | 0.104 | 0.099 | 0.012 | 0.134 | 0.067 | 0.028 | 0.032 | 0.004 | 0.821 |
| | | | | | | | | | | | | | | | | | |
| Δ therm | 0.049 | 0.061 | 0.050 | 0.054 | 0.049 | 0.026 | 0.023 | 0.032 | 0.035 | 0.034 | 0.057 | 0.056 | 0.043 | 0.053 | 0.023 | 0.104 | 0.748 |
| Wt. therm | 0.000 | 0.004 | 0.008 | 0.004 | 0.001 | 0.002 | 0.002 | 0.003 | 0.004 | 0.003 | 0.001 | 0.008 | 0.002 | 0.001 | 0.000 | 0.001 | 0.044 |

*Table 31 – Metal-framed Wall (Retail) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | 8.759 | 24.698 | 9.676 | 19.051 | 14.613 | 7.662 | 7.613 | 18.205 | 22.050 | 26.705 | 29.841 | 25.791 | 29.396 | 33.185 | 39.364 | 31.445 | 348.032 |
| Wt. TDV | 0.022 | 1.425 | 1.247 | 0.888 | 0.208 | 0.509 | 0.547 | 1.697 | 2.527 | 2.247 | 0.757 | 4.516 | 2.127 | 0.745 | 0.745 | 0.181 | 20.385 |
| | | | | | | | | | | | | | | | | | |
| Δ kWh | 0.409 | 1.221 | 0.526 | 1.004 | 0.801 | 0.571 | 0.594 | 1.143 | 1.363 | 1.533 | 1.406 | 1.293 | 1.696 | 1.606 | 2.223 | 0.977 | 18.365 |
| Wt. kWh | 0.001 | 0.070 | 0.068 | 0.047 | 0.011 | 0.038 | 0.043 | 0.107 | 0.156 | 0.129 | 0.036 | 0.226 | 0.123 | 0.036 | 0.042 | 0.006 | 1.138 |
| | | | | | | | | | | | | | | | | | |
| Δ therm | 0.056 | 0.068 | 0.046 | 0.058 | 0.057 | 0.025 | 0.021 | 0.031 | 0.035 | 0.036 | 0.066 | 0.062 | 0.049 | 0.062 | 0.023 | 0.130 | 0.824 |
| Wt. therm | 0.000 | 0.004 | 0.006 | 0.003 | 0.001 | 0.002 | 0.002 | 0.003 | 0.004 | 0.003 | 0.002 | 0.011 | 0.004 | 0.001 | 0.000 | 0.001 | 0.045 |

*Table 32 – Metal-framed Wall (24-hour) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | 26.430 | 33.477 | 26.030 | 29.533 | 26.292 | 20.312 | 19.793 | 25.258 | 27.851 | 33.704 | 39.248 | 35.296 | 35.972 | 41.727 | 44.094 | 46.633 | 511.649 |
| Wt. TDV | 0.125 | 3.826 | 3.869 | 1.723 | 0.567 | 1.397 | 2.175 | 2.479 | 2.989 | 1.574 | 0.508 | 3.574 | 2.314 | 0.796 | 0.862 | 0.205 | 28.985 |
| | | | | | | | | | | | | | | | | | |
| Δ kWh | 0.882 | 1.618 | 1.053 | 1.420 | 1.157 | 1.112 | 1.202 | 1.509 | 1.781 | 1.957 | 1.821 | 1.697 | 2.127 | 2.054 | 2.747 | 1.339 | 25.476 |
| Wt. kWh | 0.004 | 0.185 | 0.156 | 0.083 | 0.025 | 0.076 | 0.132 | 0.148 | 0.191 | 0.091 | 0.024 | 0.172 | 0.137 | 0.039 | 0.054 | 0.006 | 1.524 |
| | | | | | | | | | | | | | | | | | |
| Δ therm | 0.155 | 0.124 | 0.137 | 0.120 | 0.132 | 0.086 | 0.074 | 0.079 | 0.075 | 0.078 | 0.127 | 0.126 | 0.094 | 0.116 | 0.051 | 0.224 | 1.796 |
| Wt. therm | 0.001 | 0.014 | 0.020 | 0.007 | 0.003 | 0.006 | 0.008 | 0.008 | 0.008 | 0.004 | 0.002 | 0.013 | 0.006 | 0.002 | 0.001 | 0.001 | 0.103 |

*Table 33 – Mass (7.0≤HC<15.0) Wall (Daytime) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | 7.808 | 23.825 | 5.335 | 5.337 | -8.827 | -3.889 | -5.743 | -12.024 | -13.922 | 9.003 | 23.941 | 19.461 | 21.111 | -12.405 | -1 |
| Wt. TDV | 0.023 | 1.599 | 0.885 | 0.416 | -0.170 | -0.225 | -0.406 | -1.024 | -1.405 | 0.801 | 0.284 | 2.810 | 1.192 | -0.309 | -0 |
| | | | | | | | | | | | | | | | |
| Δ kWh | -0.070 | 0.195 | -0.094 | -0.022 | 0.417 | 0.307 | 0.045 | -0.198 | -0.187 | 0.228 | 0.397 | 0.252 | 0.578 | -0.262 | -0 |
| Wt. kWh | 0.000 | 0.013 | -0.016 | -0.002 | 0.008 | 0.018 | 0.003 | -0.017 | -0.019 | 0.020 | 0.005 | 0.036 | 0.033 | -0.007 | -0 |
| | | | | | | | | | | | | | | | |
| Δ therm | 0.056 | 0.119 | 0.044 | 0.036 | -0.114 | -0.070 | -0.053 | -0.060 | -0.061 | 0.027 | 0.094 | 0.086 | 0.064 | -0.037 | -0 |
| Wt. therm | 0.000 | 0.008 | 0.007 | 0.003 | -0.002 | -0.004 | -0.004 | -0.005 | -0.006 | 0.002 | 0.001 | 0.012 | 0.004 | -0.001 | 0. |

*Table 34 – Mass (7.0≤HC<15.0) Wall (Retail) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | 7.955 | 22.424 | 5.951 | 11.154 | -10.899 | -7.894 | -10.446 | 9.174 | 13.213 | 21.254 | 34.297 | 27.213 | 31.797 | -18.370 | -21.271 | 26.814 | 142.366 |
| Wt. TDV | 0.020 | 1.294 | 0.767 | 0.520 | -0.155 | -0.524 | -0.750 | 0.855 | 1.514 | 1.788 | 0.870 | 4.765 | 2.300 | -0.413 | -0.402 | 0.154 | 12.603 |
| | | | | | | | | | | | | | | | | | |
| Δ kWh | 0.062 | 0.821 | 0.092 | 0.349 | -0.124 | -0.325 | -0.651 | 0.497 | 0.756 | 1.096 | 1.199 | 1.002 | 1.456 | -0.686 | -1.152 | 0.331 | 4.724 |
| Wt. kWh | 0.000 | 0.047 | 0.012 | 0.016 | -0.002 | -0.022 | -0.047 | 0.046 | 0.087 | 0.092 | 0.030 | 0.175 | 0.105 | -0.015 | -0.022 | 0.002 | 0.507 |
| | | | | | | | | | | | | | | | | | |
| Δ therm | 0.064 | 0.094 | 0.050 | 0.061 | -0.136 | -0.080 | -0.063 | 0.031 | 0.038 | 0.048 | 0.114 | 0.102 | 0.080 | -0.050 | -0.015 | 0.148 | 0.486 |
| Wt. therm | 0.000 | 0.005 | 0.006 | 0.003 | -0.002 | -0.005 | -0.005 | 0.003 | 0.004 | 0.004 | 0.003 | 0.018 | 0.006 | -0.001 | 0.000 | 0.001 | 0.040 |

*Table 35 – Mass (7.0≤HC<15.0) Wall (24-hour) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | 25.371 | 29.026 | 28.225 | 23.368 | 20.552 | 11.321 | 9.106 | 11.126 | 14.949 | 23.597 | 42.749 | 34.722 | 38.048 | 43.097 | 42.547 | 35.270 | 433.075 |
| Wt. TDV | 0.120 | 3.317 | 4.195 | 1.363 | 0.444 | 0.779 | 1.001 | 1.092 | 1.605 | 1.102 | 0.553 | 3.516 | 2.448 | 0.823 | 0.832 | 0.155 | 23.344 |
| | | | | | | | | | | | | | | | | | |
| Δ kWh | -0.011 | 0.522 | 0.143 | 0.213 | -0.024 | 0.110 | 0.239 | 0.354 | 0.452 | 0.866 | 1.114 | 0.799 | 1.365 | 1.200 | 2.179 | 0.328 | 9.847 |
| Wt. kWh | 0.000 | 0.060 | 0.021 | 0.012 | -0.001 | 0.008 | 0.026 | 0.035 | 0.048 | 0.040 | 0.014 | 0.081 | 0.088 | 0.023 | 0.043 | 0.001 | 0.500 |
| | | | | | | | | | | | | | | | | | |
| Δ therm | 0.153 | 0.153 | 0.178 | 0.142 | 0.145 | 0.075 | 0.059 | 0.057 | 0.071 | 0.078 | 0.181 | 0.172 | 0.132 | 0.151 | 0.046 | 0.205 | 1.999 |
| Wt. therm | 0.001 | 0.018 | 0.026 | 0.008 | 0.003 | 0.005 | 0.006 | 0.006 | 0.008 | 0.004 | 0.002 | 0.017 | 0.008 | 0.003 | 0.001 | 0.001 | 0.118 |

*Table 36 – Mass (15.0≤HC) Wall (Daytime) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | 4.951 | -1.322 | -0.744 | -0.603 | 0.123 | 0.000 | 0.000 | 0.000 | 0.000 | -0.737 | 32.102 | 20.284 | 25.766 | 15.068 | 17.209 | 19.686 | 131.783 |
| Wt. TDV | 0.015 | -0.089 | -0.123 | -0.047 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | -0.066 | 0.380 | 2.929 | 1.454 | 0.375 | 0.344 | 0.110 | 5.286 |
| | | | | | | | | | | | | | | | | | |
| Δ kWh | -0.115 | 0.014 | 0.053 | 0.038 | 0.066 | 0.000 | 0.000 | 0.000 | 0.000 | -0.002 | 0.299 | 0.005 | 0.486 | 0.220 | 0.604 | -0.126 | 1.542 |
| Wt. kWh | 0.000 | 0.001 | 0.009 | 0.003 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.001 | 0.027 | 0.005 | 0.012 | -0.001 | 0.062 |
| | | | | | | | | | | | | | | | | | |
| Δ therm | 0.038 | -0.008 | -0.009 | -0.007 | -0.006 | 0.000 | 0.000 | 0.000 | 0.000 | -0.003 | 0.146 | 0.110 | 0.088 | 0.051 | 0.012 | 0.126 | 0.537 |
| Wt. therm | 0.000 | -0.001 | -0.002 | -0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.016 | 0.005 | 0.001 | 0.000 | 0.001 | 0.022 |

*Table 37 – Mass (15.0≤HC) Wall (Retail) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | 5.587 | -2.327 | -0.991 | -1.313 | -0.165 | 0.000 | 0.000 | 0.000 | 0.000 | -1.987 | 49.348 | 31.297 | 41.038 | 24.300 | 30.961 | 29.011 | 204.757 |
| Wt. TDV | 0.014 | -0.134 | -0.128 | -0.061 | -0.002 | 0.000 | 0.000 | 0.000 | 0.000 | -0.167 | 1.251 | 5.480 | 2.969 | 0.546 | 0.586 | 0.167 | 10.520 |
| | | | | | | | | | | | | | | | | | |
| Δ kWh | -0.022 | -0.071 | 0.011 | -0.023 | 0.028 | 0.000 | 0.000 | 0.000 | 0.000 | -0.107 | 1.456 | 0.947 | 1.713 | 0.822 | 1.657 | 0.183 | 6.596 |
| Wt. kWh | 0.000 | -0.004 | 0.001 | -0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | -0.009 | 0.037 | 0.166 | 0.124 | 0.018 | 0.031 | 0.001 | 0.365 |
| | | | | | | | | | | | | | | | | | |
| Δ therm | 0.046 | -0.011 | -0.011 | -0.010 | -0.008 | 0.000 | 0.000 | 0.000 | 0.000 | -0.005 | 0.189 | 0.140 | 0.116 | 0.074 | 0.018 | 0.173 | 0.709 |
| Wt. therm | 0.000 | -0.001 | -0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.005 | 0.024 | 0.008 | 0.002 | 0.000 | 0.001 | 0.038 |

*Table 38 – Mass (15.0≤HC) Wall (24-hour) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | 15.447 | -3.429 | 0.000 | 0.000 | 0.000 | -1.627 | -1.718 | -1.287 | -1.501 | -2.329 | 64.460 | 40.719 | 51.853 | 29.753 | 31.082 | 39.218 | 260.646 |
| Wt. TDV | 0.073 | -0.392 | 0.000 | 0.000 | 0.000 | -0.112 | -0.189 | -0.126 | -0.161 | -0.109 | 0.834 | 4.123 | 3.336 | 0.568 | 0.608 | 0.172 | 8.626 |
| | | | | | | | | | | | | | | | | | |
| Δ kWh | -0.113 | -0.014 | 0.000 | 0.000 | 0.000 | 0.024 | -0.012 | -0.011 | -0.011 | -0.057 | 1.274 | 0.563 | 1.399 | 0.628 | 1.468 | 0.114 | 5.250 |
| Wt. kWh | -0.001 | -0.002 | 0.000 | 0.000 | 0.000 | 0.002 | -0.001 | -0.001 | -0.001 | -0.003 | 0.016 | 0.057 | 0.090 | 0.012 | 0.029 | 0.001 | 0.198 |
| | | | | | | | | | | | | | | | | | |
| Δ therm | 0.093 | -0.020 | 0.000 | 0.000 | 0.000 | -0.012 | -0.009 | -0.009 | -0.009 | -0.009 | 0.300 | 0.227 | 0.200 | 0.115 | 0.030 | 0.237 | 1.134 |
| Wt. therm | 0.000 | -0.002 | 0.000 | 0.000 | 0.000 | -0.001 | -0.001 | -0.001 | -0.001 | 0.000 | 0.004 | 0.023 | 0.013 | 0.002 | 0.001 | 0.001 | 0.038 |

*Table 39 – Wood-framed and Other Wall (Daytime) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | 0.507 | 5.816 | 1.198 | 1.579 | 1.305 | 1.042 | 1.133 | 1.564 | 1.787 | 6.138 | 6.599 | 5.927 | 6.386 | 7.307 | 8.648 | 7.059 | 63.998 |
| Wt. TDV | 0.002 | 0.390 | 0.199 | 0.123 | 0.025 | 0.060 | 0.080 | 0.133 | 0.180 | 0.546 | 0.078 | 0.856 | 0.361 | 0.182 | 0.173 | 0.039 | 3.428 |
| | | | | | | | | | | | | | | | | | |
| Δ kWh | 0.018 | 0.241 | 0.048 | 0.069 | 0.058 | 0.056 | 0.063 | 0.082 | 0.095 | 0.308 | 0.277 | 0.257 | 0.328 | 0.316 | 0.447 | 0.193 | 2.854 |
| Wt. kWh | 0.000 | 0.016 | 0.008 | 0.005 | 0.001 | 0.003 | 0.004 | 0.007 | 0.010 | 0.027 | 0.003 | 0.037 | 0.018 | 0.008 | 0.009 | 0.001 | 0.159 |
| | | | | | | | | | | | | | | | | | |
| Δ therm | 0.003 | 0.017 | 0.005 | 0.005 | 0.005 | 0.003 | 0.003 | 0.003 | 0.003 | 0.010 | 0.016 | 0.015 | 0.012 | 0.015 | 0.006 | 0.029 | 0.150 |
| Wt. therm | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.002 | 0.001 | 0.000 | 0.000 | 0.000 | 0.008 |

*Table 40 – Wood-framed and Other Wall (Retail) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | 0.515 | 6.852 | 1.152 | 1.764 | 1.353 | 0.000 | 0.000 | 1.686 | 6.942 | 7.408 | 8.279 | 7.155 | 8.155 | 9.201 | 15.491 | 8.723 |
| Wt. TDV | 0.001 | 0.395 | 0.148 | 0.082 | 0.019 | 0.000 | 0.000 | 0.157 | 0.795 | 0.623 | 0.210 | 1.253 | 0.590 | 0.207 | 0.293 | 0.050 |
| | | | | | | | | | | | | | | | | |
| Δ kWh | 0.024 | 0.339 | 0.063 | 0.093 | 0.074 | 0.000 | 0.000 | 0.106 | 0.429 | 0.425 | 0.390 | 0.359 | 0.470 | 0.445 | 0.875 | 0.271 |
| Wt. kWh | 0.000 | 0.020 | 0.008 | 0.004 | 0.001 | 0.000 | 0.000 | 0.010 | 0.049 | 0.036 | 0.010 | 0.063 | 0.034 | 0.010 | 0.017 | 0.002 |
| | | | | | | | | | | | | | | | | |
| Δ therm | 0.003 | 0.019 | 0.005 | 0.005 | 0.005 | 0.000 | 0.000 | 0.003 | 0.011 | 0.010 | 0.018 | 0.017 | 0.013 | 0.017 | 0.009 | 0.036 |
| Wt. therm | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 | 0.003 | 0.001 | 0.000 | 0.000 | 0.000 |

*Table 41 – Mass (15.0≤HC) Wall (24-hour) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | 7.332 | 9.287 | 8.195 | 9.298 | 8.277 | 0.878 | 0.855 | 6.704 | 7.392 | 9.350 | 15.446 | 9.792 | 9.979 | 16.422 | 17.353 | 18.352 | 154.912 |
| Wt. TDV | 0.035 | 1.061 | 1.218 | 0.542 | 0.179 | 0.060 | 0.094 | 0.658 | 0.793 | 0.437 | 0.200 | 0.992 | 0.642 | 0.313 | 0.339 | 0.081 | 7.644 |
| | | | | | | | | | | | | | | | | | |
| Δ kWh | 0.245 | 0.449 | 0.331 | 0.447 | 0.364 | 0.048 | 0.052 | 0.401 | 0.473 | 0.543 | 0.717 | 0.471 | 0.590 | 0.808 | 1.081 | 0.527 | 7.547 |
| Wt. kWh | 0.001 | 0.051 | 0.049 | 0.026 | 0.008 | 0.003 | 0.006 | 0.039 | 0.051 | 0.025 | 0.009 | 0.048 | 0.038 | 0.015 | 0.021 | 0.002 | 0.394 |
| | | | | | | | | | | | | | | | | | |
| Δ therm | 0.043 | 0.035 | 0.043 | 0.038 | 0.041 | 0.004 | 0.003 | 0.021 | 0.020 | 0.022 | 0.050 | 0.035 | 0.026 | 0.046 | 0.020 | 0.088 | 0.534 |
| Wt. therm | 0.000 | 0.004 | 0.006 | 0.002 | 0.001 | 0.000 | 0.000 | 0.002 | 0.002 | 0.001 | 0.001 | 0.004 | 0.002 | 0.001 | 0.000 | 0.000 | 0.027 |

*Table 42 – Mass Floor (Daytime) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | 0.000 | 0.000 | -1.880 | -1.919 | 0.711 | 5.572 | 2.397 | 3.245 | 2.305 | -1.816 | 0.000 | -0.768 | -0.850 | 3.385 | 3.225 | 4.402 | 18.010 |
| Wt. TDV | 0.000 | 0.000 | -0.312 | -0.149 | 0.014 | 0.323 | 0.170 | 0.276 | 0.233 | -0.162 | 0.000 | -0.111 | -0.048 | 0.084 | 0.065 | 0.025 | 0.407 |
| | | | | | | | | | | | | | | | | | |
| Δ kWh | 0.000 | 0.000 | 0.410 | 0.422 | 0.495 | 0.487 | 0.417 | 0.367 | 0.319 | 0.262 | 0.000 | 0.023 | 0.004 | -0.008 | 0.111 | -0.052 | 3.257 |
| Wt. kWh | 0.000 | 0.000 | 0.068 | 0.033 | 0.010 | 0.028 | 0.030 | 0.031 | 0.032 | 0.023 | 0.000 | 0.003 | 0.000 | 0.000 | 0.002 | 0.000 | 0.260 |
| | | | | | | | | | | | | | | | | | |
| Δ therm | 0.000 | 0.000 | -0.057 | -0.061 | -0.054 | -0.028 | -0.022 | -0.029 | -0.029 | -0.049 | 0.000 | -0.008 | -0.006 | 0.022 | 0.006 | 0.034 | -0.282 |
| Wt. therm | 0.000 | 0.000 | -0.010 | -0.005 | -0.001 | -0.002 | -0.002 | -0.002 | -0.003 | -0.004 | 0.000 | -0.001 | 0.000 | 0.001 | 0.000 | 0.000 | -0.029 |

*Table 43 – Mass Floor (Retail) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | 3.424 | 0.061 | 8.639 | 7.539 | 10.831 | 15.772 | 12.269 | 11.736 | 10.291 | 7.162 | -5.389 | 0.262 | -3.065 | 1.315 | 2.533 | 0.000 | 83.379 |
| Wt. TDV | 0.009 | 0.004 | 1.113 | 0.351 | 0.154 | 1.047 | 0.881 | 1.094 | 1.179 | 0.603 | -0.137 | 0.046 | -0.222 | 0.030 | 0.048 | 0.000 | 6.200 |
| | | | | | | | | | | | | | | | | | |
| Δ kWh | 0.645 | 0.448 | 0.580 | 0.639 | 0.751 | 0.762 | 0.745 | 0.598 | 0.508 | 0.386 | 0.082 | 0.387 | 0.088 | 0.001 | 0.142 | 0.000 | 6.761 |
| Wt. kWh | 0.002 | 0.026 | 0.075 | 0.030 | 0.011 | 0.051 | 0.053 | 0.056 | 0.058 | 0.032 | 0.002 | 0.068 | 0.006 | 0.000 | 0.003 | 0.000 | 0.472 |
| | | | | | | | | | | | | | | | | | |
| Δ therm | -0.051 | -0.059 | -0.022 | -0.030 | -0.019 | -0.005 | -0.004 | -0.008 | -0.008 | -0.019 | -0.061 | -0.056 | -0.044 | 0.010 | 0.002 | 0.000 | -0.374 |
| Wt. therm | 0.000 | -0.003 | -0.003 | -0.001 | 0.000 | 0.000 | 0.000 | -0.001 | -0.001 | -0.002 | -0.002 | -0.010 | -0.003 | 0.000 | 0.000 | 0.000 | -0.026 |

*Table 44 – Mass Floor (24-hour) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | 12.481 | 8.939 | 14.818 | 10.976 | 13.601 | 6.930 | 3.545 | 3.790 | 3.790 | 2.639 | 6.438 | 5.645 | 5.518 | 19.498 | 11.038 |
| Wt. TDV | 0.059 | 1.022 | 2.202 | 0.640 | 0.294 | 0.477 | 0.390 | 0.372 | 0.407 | 0.123 | 0.083 | 0.572 | 0.355 | 0.372 | 0.216 |
| | | | | | | | | | | | | | | | |
| Δ kWh | -0.050 | 0.004 | -0.062 | -0.107 | -0.079 | -0.079 | -0.041 | -0.030 | -0.012 | 0.015 | 0.073 | 0.007 | 0.075 | 0.235 | 0.495 |
| Wt. kWh | 0.000 | 0.000 | -0.009 | -0.006 | -0.002 | -0.005 | -0.004 | -0.003 | -0.001 | 0.001 | 0.001 | 0.001 | 0.005 | 0.004 | 0.010 |
| | | | | | | | | | | | | | | | |
| Δ therm | 0.076 | 0.054 | 0.095 | 0.082 | 0.090 | 0.050 | 0.028 | 0.030 | 0.028 | 0.016 | 0.037 | 0.037 | 0.030 | 0.101 | 0.029 |
| Wt. therm | 0.000 | 0.006 | 0.014 | 0.005 | 0.002 | 0.003 | 0.003 | 0.003 | 0.003 | 0.001 | 0.000 | 0.004 | 0.002 | 0.002 | 0.001 |

*Table 45 – Mass Floor (Daytime) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | -1.688 | 3.144 | 0.000 | 0.000 | 0.000 | -0.742 | -2.319 | 0.000 | 0.000 | 0.000 | 3.351 | 0.000 | 0.000 | 3.852 | 3.777 | 1.455 | 10.829 |
| Wt. TDV | -0.005 | 0.211 | 0.000 | 0.000 | 0.000 | -0.043 | -0.164 | 0.000 | 0.000 | 0.000 | 0.040 | 0.000 | 0.000 | 0.096 | 0.076 | 0.008 | 0.218 |
| | | | | | | | | | | | | | | | | | |
| Δ kWh | 0.030 | 0.012 | 0.000 | 0.000 | 0.000 | 0.257 | 0.225 | 0.000 | 0.000 | 0.000 | 0.043 | 0.000 | 0.000 | 0.044 | 0.133 | 0.001 | 0.745 |
| Wt. kWh | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.015 | 0.016 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.001 | 0.003 | 0.000 | 0.036 |
| | | | | | | | | | | | | | | | | | |
| Δ therm | -0.014 | 0.018 | 0.000 | 0.000 | 0.000 | -0.041 | -0.035 | 0.000 | 0.000 | 0.000 | 0.016 | 0.000 | 0.000 | 0.017 | 0.006 | 0.009 | -0.023 |
| Wt. therm | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | -0.002 | -0.003 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | -0.003 |

*Table 46 – Other Floor (Retail) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | -2.243 | 0.000 | 2.378 | -1.799 | 3.260 | 10.537 | 9.529 | 4.454 | 0.008 | 0.000 | 0.000 | 0.000 | 0.000 | 3.560 | 3.539 | 1.277 | 34.501 |
| Wt. TDV | -0.006 | 0.000 | 0.306 | -0.084 | 0.046 | 0.699 | 0.685 | 0.415 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.080 | 0.067 | 0.007 | 2.218 |
| | | | | | | | | | | | | | | | | | |
| Δ kWh | 0.392 | 0.000 | 0.283 | 0.158 | 0.345 | 0.493 | 0.558 | 0.228 | 0.022 | 0.000 | 0.000 | 0.000 | 0.000 | 0.065 | 0.172 | 0.002 | 2.718 |
| Wt. kWh | 0.001 | 0.000 | 0.036 | 0.007 | 0.005 | 0.033 | 0.040 | 0.021 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.003 | 0.000 | 0.151 |
| | | | | | | | | | | | | | | | | | |
| Δ therm | -0.063 | 0.000 | -0.035 | -0.047 | -0.037 | -0.012 | -0.012 | -0.018 | -0.020 | 0.000 | 0.000 | 0.000 | 0.000 | 0.015 | 0.003 | 0.008 | -0.215 |
| Wt. therm | 0.000 | 0.000 | -0.004 | -0.002 | -0.001 | -0.001 | -0.001 | -0.002 | -0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | -0.012 |

*Table 47 – Mass Floor (24-hour) Energy Impacts*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ TDV | 3.806 | 8.971 | 6.255 | 5.605 | 6.144 | 3.564 | 0.000 | 3.582 | 3.975 | 4.919 | 7.221 | 6.810 | 6.251 | 9.170 | 6.189 | 4.855 | 87.316 |
| Wt. TDV | 0.018 | 1.025 | 0.930 | 0.327 | 0.133 | 0.245 | 0.000 | 0.352 | 0.427 | 0.230 | 0.093 | 0.690 | 0.402 | 0.175 | 0.121 | 0.021 | 5.188 |
| | | | | | | | | | | | | | | | | | |
| Δ kWh | -0.011 | 0.070 | 0.024 | 0.046 | 0.036 | -0.007 | 0.000 | 0.047 | 0.065 | 0.091 | 0.123 | 0.088 | 0.138 | 0.156 | 0.271 | 0.023 | 1.159 |
| Wt. kWh | 0.000 | 0.008 | 0.004 | 0.003 | 0.001 | 0.000 | 0.000 | 0.005 | 0.007 | 0.004 | 0.002 | 0.009 | 0.009 | 0.003 | 0.005 | 0.000 | 0.058 |
| | | | | | | | | | | | | | | | | | |
| Δ therm | 0.023 | 0.048 | 0.039 | 0.035 | 0.038 | 0.024 | 0.000 | 0.022 | 0.022 | 0.024 | 0.036 | 0.037 | 0.030 | 0.042 | 0.014 | 0.029 | 0.460 |
| Wt. therm | 0.000 | 0.005 | 0.006 | 0.002 | 0.001 | 0.002 | 0.000 | 0.002 | 0.002 | 0.001 | 0.000 | 0.004 | 0.002 | 0.001 | 0.000 | 0.000 | 0.029 |

## Energy Coefficients

TDV energy per square foot of opaque surface area is calculated through regression analysis, using the coefficients in Table 49. The coefficients are calculated for all 16 climate zones and all three occupancy types (daytime, 24-hour, and retail). Details of the models used for the three occupancy types are provided earlier in the report. Coefficients are calculated separately for floors, roofs and walls and for each of these

As described earlier the form of the regression equation is as follows:

TDV kBtu/sf = Constant + Coefficient * Wall U-factor (Btu/hr·sf·°F)

The U-factors used for each construction assembly come from the Joint Appendices for the 2005 Building Efficiency Standards. The section in the joint appendices where each category of construction can be found is given in Table 48 below.

*Table 48 – Application of Energy Coefficients to Construction Categories*

| Type | Coefficient Type | Category of Construction |
|---|---|---|
| Floors | Floor Light | Table IV.20 – Standard U-factors for Wood Framed Floors with a Crawl Space<br>Table IV.21 – Standard U-factor for Wood Framed Floors without a Crawl Space<br>Table IV.23 – Standard U-factor for Metal Framed Floors with a Crawl Space<br>Table IV.24 – Standard U-factor for Metal Framed Floors without a Crawl Space |
| | Floor Mass | Table IV.25 – Standard U-factors for Concrete Raised Floors |
| Roofs | Roof Attic | Table IV.1 – U-factors of Wood Framed Attic Roofs<br>Table IV.4 – U-factors of Metal Framed Attic Roofs |
| | Roof Light | Table IV.2 – U-factors of Wood Framed Rafter Roofs<br>Table IV.5 – U-factors of Metal Framed Rafter Roofs<br>Table IV.7 – U-factors for Metal Building Roofs |
| | Roof Mass | Table IV.6 – U-factors for Span Deck and Concrete Roofs |
| Walls | Wall Light | Table IV.9 – U-factors of Wood Framed Walls<br>Table IV.11 – U-factors of Metal Framed Walls<br>Table IV.16 – U-factors for Metal Building Walls |
| | Wall Mass 15 | Table IV.19 – Effective R-values for Interior or Exterior Insulation Layers (in combination with mass construction specified in N2-1 of the nonresidential ACM manual) |
| | Wall Mass 7 | Table IV.19 – Effective R-values for Interior or Exterior Insulation Layers (in combination with mass construction specified in N2-1 of the nonresidential ACM manual) |

Table 49 contains the constant and the coefficient with corresponding $R^2$ by construction type, occupancy schedule and climate zone. The $R^2$ indicates how the regression equation fits to three points of data as described in the Energy Model and Assumptions section of this report. The closer $R^2$ is to 1.0 the better the linear regression model fits the data.

*Table 49 – TDV DOE-2 Coefficients*

| Type | Occupancy | CZ | Constant | Coefficient | $R^2$ |
|---|---|---|---|---|---|
| Wall Light | 1 | Daytime | 126.32 | 72.49 | 0.9997 |
| Wall Medium | 1 | Daytime | 122.84 | 58.27 | 0.9940 |
| Wall Heavy | 1 | Daytime | 122.66 | 46.27 | 0.9925 |
| Roof Light | 1 | Daytime | 25.23 | 100.03 | 0.9996 |
| Roof Mass | 1 | Daytime | 23.34 | 82.85 | 0.9998 |
| Roof Attic | 1 | Daytime | 22.92 | 116.49 | 0.9998 |
| Floor Light | 1 | Daytime | 18.92 | 73.39 | 0.9973 |
| Floor Mass | 1 | Daytime | 17.13 | 54.09 | 0.9668 |
| Wall Light | 2 | Daytime | 297.31 | 135.26 | 0.9997 |
| Wall Medium | 2 | Daytime | 292.90 | 58.05 | 0.9899 |
| Wall Heavy | 2 | Daytime | 293.31 | 33.04 | 0.9811 |
| Roof Light | 2 | Daytime | 61.99 | 172.08 | 0.9998 |
| Roof Mass | 2 | Daytime | 59.94 | 82.19 | 0.9998 |
| Roof Attic | 2 | Daytime | 58.95 | 181.54 | 0.9998 |
| Floor Light | 2 | Daytime | 55.23 | 98.24 | 0.9995 |
| Floor Mass | 2 | Daytime | 52.81 | 50.23 | 0.9929 |
| Wall Light | 3 | Daytime | 181.44 | 79.89 | 1.0000 |
| Wall Medium | 3 | Daytime | 178.60 | 35.10 | 0.9832 |
| Wall Heavy | 3 | Daytime | 178.61 | 18.60 | 0.9522 |
| Roof Light | 3 | Daytime | 38.01 | 101.52 | 1.0000 |
| Roof Mass | 3 | Daytime | 36.05 | 56.84 | 0.9996 |
| Roof Attic | 3 | Daytime | 36.28 | 115.85 | 0.9996 |
| Floor Light | 3 | Daytime | 36.07 | 43.41 | 0.9908 |
| Floor Mass | 3 | Daytime | 34.59 | 10.68 | 0.6550 |
| Wall Light | 4 | Daytime | 292.62 | 105.29 | 0.9999 |
| Wall Medium | 4 | Daytime | 289.58 | 35.11 | 0.9827 |
| Wall Heavy | 4 | Daytime | 289.86 | 15.06 | 0.9328 |
| Roof Light | 4 | Daytime | 62.28 | 134.55 | 1.0000 |
| Roof Mass | 4 | Daytime | 60.23 | 58.34 | 0.9997 |
| Roof Attic | 4 | Daytime | 60.27 | 140.76 | 0.9997 |
| Floor Light | 4 | Daytime | 60.01 | 55.58 | 0.9977 |
| Floor Mass | 4 | Daytime | 58.15 | 10.90 | 0.7143 |
| Wall Light | 5 | Daytime | 209.46 | 87.01 | 0.9998 |
| Wall Medium | 5 | Daytime | 205.15 | 18.39 | 0.9557 |
| Wall Heavy | 5 | Daytime | 206.60 | -3.06 | 0.1598 |
| Roof Light | 5 | Daytime | 44.24 | 105.40 | 0.9998 |
| Roof Mass | 5 | Daytime | 41.21 | 45.13 | 0.9996 |
| Roof Attic | 5 | Daytime | 42.35 | 114.81 | 0.9996 |
| Floor Light | 5 | Daytime | 42.00 | 47.25 | 0.9852 |

| Type | Occupancy | CZ | Constant | Coefficient | $R^2$ |
|---|---|---|---|---|---|
| Floor Mass | 5 | Daytime | 40.48 | -4.04 | 0.0944 |
| Wall Light | 6 | Daytime | 244.43 | 69.49 | 1.0000 |
| Wall Medium | 6 | Daytime | 242.83 | 8.10 | 0.7726 |
| Wall Heavy | 6 | Daytime | 243.38 | -7.58 | 0.9108 |
| Roof Light | 6 | Daytime | 53.07 | 83.90 | 1.0000 |
| Roof Mass | 6 | Daytime | 51.38 | 24.18 | 0.9993 |
| Roof Attic | 6 | Daytime | 51.87 | 90.71 | 0.9993 |
| Floor Light | 6 | Daytime | 56.08 | 4.44 | 0.3242 |
| Floor Mass | 6 | Daytime | 55.25 | -31.66 | 0.9141 |
| Wall Light | 7 | Daytime | 269.20 | 75.52 | 1.0000 |
| Wall Medium | 7 | Daytime | 267.58 | 11.96 | 0.9427 |
| Wall Heavy | 7 | Daytime | 266.28 | 12.06 | 0.8292 |
| Roof Light | 7 | Daytime | 58.32 | 94.40 | 1.0000 |
| Roof Mass | 7 | Daytime | 57.09 | 32.67 | 0.9994 |
| Roof Attic | 7 | Daytime | 57.24 | 94.64 | 0.9994 |
| Floor Light | 7 | Daytime | 60.42 | 13.89 | 0.9009 |
| Floor Mass | 7 | Daytime | 59.82 | -13.62 | 0.9540 |
| Wall Light | 8 | Daytime | 334.75 | 104.30 | 1.0000 |
| Wall Medium | 8 | Daytime | 333.22 | 25.05 | 0.9780 |
| Wall Heavy | 8 | Daytime | 333.35 | 5.54 | 0.9101 |
| Roof Light | 8 | Daytime | 72.91 | 113.67 | 1.0000 |
| Roof Mass | 8 | Daytime | 70.91 | 40.21 | 0.9996 |
| Roof Attic | 8 | Daytime | 71.25 | 117.99 | 0.9996 |
| Floor Light | 8 | Daytime | 74.05 | 25.69 | 0.9622 |
| Floor Mass | 8 | Daytime | 72.75 | -18.44 | 0.8312 |
| Wall Light | 9 | Daytime | 368.32 | 119.13 | 0.9999 |
| Wall Medium | 9 | Daytime | 365.49 | 29.00 | 0.9744 |
| Wall Heavy | 9 | Daytime | 366.28 | 4.30 | 0.6126 |
| Roof Light | 9 | Daytime | 80.03 | 127.80 | 1.0000 |
| Roof Mass | 9 | Daytime | 78.04 | 37.33 | 0.9997 |
| Roof Attic | 9 | Daytime | 78.08 | 130.99 | 0.9997 |
| Floor Light | 9 | Daytime | 79.01 | 45.16 | 0.9812 |
| Floor Mass | 9 | Daytime | 78.15 | -13.09 | 0.7372 |
| Wall Light | 10 | Daytime | 396.77 | 142.74 | 0.9999 |
| Wall Medium | 10 | Daytime | 393.60 | 44.35 | 0.9886 |
| Wall Heavy | 10 | Daytime | 394.24 | 18.44 | 0.9613 |
| Roof Light | 10 | Daytime | 85.52 | 155.30 | 0.9998 |
| Roof Mass | 10 | Daytime | 83.41 | 56.14 | 0.9998 |
| Roof Attic | 10 | Daytime | 83.14 | 156.42 | 0.9998 |
| Floor Light | 10 | Daytime | 82.83 | 65.72 | 0.9960 |
| Floor Mass | 10 | Daytime | 81.51 | 8.07 | 0.5084 |
| Wall Light | 11 | Daytime | 375.05 | 153.46 | 0.9999 |
| Wall Medium | 11 | Daytime | 370.68 | 92.08 | 0.9951 |
| Wall Heavy | 11 | Daytime | 371.15 | 68.89 | 0.9950 |
| Roof Light | 11 | Daytime | 80.47 | 163.51 | 0.9999 |

| Type | Occupancy | CZ | Constant | Coefficient | $R^2$ |
|---|---|---|---|---|---|
| Roof Mass | 11 | Daytime | 78.40 | 100.03 | 0.9998 |
| Roof Attic | 11 | Daytime | 77.34 | 180.36 | 0.9998 |
| Floor Light | 11 | Daytime | 72.20 | 104.71 | 0.9996 |
| Floor Mass | 11 | Daytime | 70.82 | 57.42 | 0.9957 |
| Wall Light | 12 | Daytime | 350.81 | 137.84 | 0.9999 |
| Wall Medium | 12 | Daytime | 346.49 | 74.85 | 0.9918 |
| Wall Heavy | 12 | Daytime | 346.96 | 51.09 | 0.9899 |
| Roof Light | 12 | Daytime | 74.90 | 159.38 | 0.9999 |
| Roof Mass | 12 | Daytime | 72.64 | 89.76 | 0.9998 |
| Roof Attic | 12 | Daytime | 72.12 | 173.69 | 0.9998 |
| Floor Light | 12 | Daytime | 68.53 | 90.65 | 0.9994 |
| Floor Mass | 12 | Daytime | 66.88 | 40.41 | 0.9814 |
| Wall Light | 13 | Daytime | 398.79 | 148.52 | 0.9999 |
| Wall Medium | 13 | Daytime | 394.98 | 81.20 | 0.9955 |
| Wall Heavy | 13 | Daytime | 395.64 | 58.69 | 0.9955 |
| Roof Light | 13 | Daytime | 85.94 | 158.48 | 0.9999 |
| Roof Mass | 13 | Daytime | 84.05 | 91.75 | 0.9999 |
| Roof Attic | 13 | Daytime | 82.96 | 171.47 | 0.9999 |
| Floor Light | 13 | Daytime | 79.84 | 89.40 | 0.9997 |
| Floor Mass | 13 | Daytime | 78.89 | 44.73 | 0.9952 |
| Wall Light | 14 | Daytime | 424.72 | 169.93 | 0.9999 |
| Wall Medium | 14 | Daytime | 418.76 | 97.68 | 0.9934 |
| Wall Heavy | 14 | Daytime | 419.48 | 66.67 | 0.9919 |
| Roof Light | 14 | Daytime | 90.62 | 191.36 | 0.9998 |
| Roof Mass | 14 | Daytime | 88.19 | 113.76 | 0.9999 |
| Roof Attic | 14 | Daytime | 86.72 | 207.36 | 0.9999 |
| Floor Light | 14 | Daytime | 81.49 | 120.37 | 1.0000 |
| Floor Mass | 14 | Daytime | 79.52 | 69.08 | 0.9995 |
| Wall Light | 15 | Daytime | 623.48 | 201.13 | 1.0000 |
| Wall Medium | 15 | Daytime | 619.67 | 105.31 | 0.9964 |
| Wall Heavy | 15 | Daytime | 620.80 | 76.15 | 0.9972 |
| Roof Light | 15 | Daytime | 136.81 | 187.17 | 1.0000 |
| Roof Mass | 15 | Daytime | 134.77 | 96.06 | 0.9998 |
| Roof Attic | 15 | Daytime | 133.49 | 191.53 | 0.9998 |
| Floor Light | 15 | Daytime | 127.63 | 118.03 | 0.9975 |
| Floor Mass | 15 | Daytime | 126.26 | 65.81 | 0.9898 |
| Wall Light | 16 | Daytime | 335.02 | 164.16 | 0.9999 |
| Wall Medium | 16 | Daytime | 329.34 | 122.08 | 0.9970 |
| Wall Heavy | 16 | Daytime | 329.74 | 98.43 | 0.9974 |
| Roof Light | 16 | Daytime | 69.82 | 198.47 | 0.9998 |
| Roof Mass | 16 | Daytime | 67.96 | 142.00 | 0.9999 |
| Roof Attic | 16 | Daytime | 65.49 | 224.18 | 0.9999 |
| Floor Light | 16 | Daytime | 54.73 | 161.72 | 1.0000 |
| Floor Mass | 16 | Daytime | 51.55 | 125.78 | 0.9991 |
| Wall Light | 1 | Retail | 76.29 | 73.60 | 1.0000 |

| Type | Occupancy | CZ | Constant | Coefficient | $R^2$ |
|---|---|---|---|---|---|
| Wall Medium | 1 | Retail | 74.19 | 59.37 | 0.9936 |
| Wall Heavy | 1 | Retail | 73.56 | 52.21 | 0.9904 |
| Roof Light | 1 | Retail | 19.77 | 97.08 | 0.9999 |
| Roof Mass | 1 | Retail | 17.39 | 79.98 | 0.9831 |
| Roof Attic | 1 | Retail | 18.91 | 107.40 | 0.9988 |
| Floor Light | 1 | Retail | 22.07 | 11.80 | 0.6847 |
| Floor Mass | 1 | Retail | 22.40 | -15.22 | 0.6074 |
| Wall Light | 2 | Retail | 255.04 | 159.34 | 0.9999 |
| Wall Medium | 2 | Retail | 251.31 | 86.25 | 0.9911 |
| Wall Heavy | 2 | Retail | 251.83 | 58.17 | 0.9904 |
| Roof Light | 2 | Retail | 70.07 | 183.93 | 1.0000 |
| Roof Mass | 2 | Retail | 67.63 | 88.20 | 0.9880 |
| Roof Attic | 2 | Retail | 67.73 | 194.26 | 0.9994 |
| Floor Light | 2 | Retail | 69.22 | 59.12 | 0.9814 |
| Floor Mass | 2 | Retail | 68.28 | -0.27 | 0.0005 |
| Wall Light | 3 | Retail | 145.96 | 76.79 | 1.0000 |
| Wall Medium | 3 | Retail | 143.69 | 39.15 | 0.9780 |
| Wall Heavy | 3 | Retail | 143.37 | 24.77 | 0.9467 |
| Roof Light | 3 | Retail | 40.42 | 95.29 | 0.9995 |
| Roof Mass | 3 | Retail | 38.10 | 51.61 | 0.9486 |
| Roof Attic | 3 | Retail | 39.59 | 108.65 | 0.9984 |
| Floor Light | 3 | Retail | 46.43 | -14.24 | 0.8180 |
| Floor Mass | 3 | Retail | 46.38 | -49.09 | 0.9669 |
| Wall Light | 4 | Retail | 275.42 | 117.60 | 1.0000 |
| Wall Medium | 4 | Retail | 272.44 | 54.95 | 0.9893 |
| Wall Heavy | 4 | Retail | 272.60 | 32.82 | 0.9766 |
| Roof Light | 4 | Retail | 77.28 | 136.06 | 0.9999 |
| Roof Mass | 4 | Retail | 75.06 | 55.17 | 0.9704 |
| Roof Attic | 4 | Retail | 75.90 | 145.19 | 0.9993 |
| Floor Light | 4 | Retail | 81.49 | 10.77 | 0.6624 |
| Floor Mass | 4 | Retail | 80.96 | -42.84 | 0.9376 |
| Wall Light | 5 | Retail | 163.42 | 90.20 | 0.9998 |
| Wall Medium | 5 | Retail | 162.09 | 22.71 | 0.9480 |
| Wall Heavy | 5 | Retail | 162.48 | 4.13 | 0.4894 |
| Roof Light | 5 | Retail | 45.74 | 97.49 | 0.9993 |
| Roof Mass | 5 | Retail | 43.38 | 34.46 | 0.8647 |
| Roof Attic | 5 | Retail | 45.95 | 99.99 | 0.9979 |
| Floor Light | 5 | Retail | 52.58 | -19.52 | 0.8943 |
| Floor Mass | 5 | Retail | 52.49 | -61.54 | 0.9807 |
| Wall Light | 6 | Retail | 223.05 | 60.81 | 0.9992 |
| Wall Medium | 6 | Retail | 221.58 | 16.45 | 0.8922 |
| Wall Heavy | 6 | Retail | 221.83 | 1.85 | 0.1426 |
| Roof Light | 6 | Retail | 64.09 | 68.50 | 0.9957 |
| Roof Mass | 6 | Retail | 62.99 | 11.42 | 0.5778 |
| Roof Attic | 6 | Retail | 64.08 | 70.90 | 0.9955 |

| Type | Occupancy | CZ | Constant | Coefficient | $R^2$ |
|---|---|---|---|---|---|
| Floor Light | 6 | Retail | 75.95 | -63.10 | 0.9948 |
| Floor Mass | 6 | Retail | 77.24 | -89.61 | 0.9939 |
| Wall Light | 7 | Retail | 249.95 | 60.42 | 0.9058 |
| Wall Medium | 7 | Retail | 251.53 | 21.76 | 0.9575 |
| Wall Heavy | 7 | Retail | 251.79 | 5.26 | 0.6500 |
| Roof Light | 7 | Retail | 69.80 | 85.56 | 0.9988 |
| Roof Mass | 7 | Retail | 68.81 | 25.96 | 0.9807 |
| Roof Attic | 7 | Retail | 69.41 | 87.23 | 0.9980 |
| Floor Light | 7 | Retail | 81.79 | -57.06 | 0.9998 |
| Floor Mass | 7 | Retail | 81.13 | -69.71 | 0.9941 |
| Wall Light | 8 | Retail | 317.76 | 112.38 | 1.0000 |
| Wall Medium | 8 | Retail | 315.78 | 45.19 | 0.9984 |
| Wall Heavy | 8 | Retail | 315.92 | 20.84 | 0.9543 |
| Roof Light | 8 | Retail | 91.06 | 105.29 | 0.9995 |
| Roof Mass | 8 | Retail | 89.67 | 34.02 | 0.9528 |
| Roof Attic | 8 | Retail | 90.25 | 116.13 | 0.9984 |
| Floor Light | 8 | Retail | 99.38 | -26.67 | 0.9562 |
| Floor Mass | 8 | Retail | 98.82 | -66.88 | 0.9864 |
| Wall Light | 9 | Retail | 360.00 | 136.11 | 1.0000 |
| Wall Medium | 9 | Retail | 356.70 | 56.46 | 0.9872 |
| Wall Heavy | 9 | Retail | 357.22 | 28.92 | 0.9682 |
| Roof Light | 9 | Retail | 102.87 | 128.79 | 0.9998 |
| Roof Mass | 9 | Retail | 100.68 | 34.52 | 0.9085 |
| Roof Attic | 9 | Retail | 101.38 | 137.90 | 0.9998 |
| Floor Light | 9 | Retail | 108.29 | -0.05 | 0.0001 |
| Floor Mass | 9 | Retail | 107.90 | -58.47 | 0.9887 |
| Wall Light | 10 | Retail | 385.27 | 172.29 | 0.9999 |
| Wall Medium | 10 | Retail | 381.59 | 81.75 | 0.9949 |
| Wall Heavy | 10 | Retail | 382.32 | 49.67 | 0.9909 |
| Roof Light | 10 | Retail | 109.31 | 163.37 | 1.0000 |
| Roof Mass | 10 | Retail | 106.78 | 62.04 | 0.9698 |
| Roof Attic | 10 | Retail | 107.04 | 167.33 | 0.9992 |
| Floor Light | 10 | Retail | 111.84 | 31.07 | 0.9534 |
| Floor Mass | 10 | Retail | 111.22 | -31.83 | 0.9244 |
| Wall Light | 11 | Retail | 343.65 | 192.52 | 1.0000 |
| Wall Medium | 11 | Retail | 338.77 | 131.91 | 0.9956 |
| Wall Heavy | 11 | Retail | 338.96 | 105.90 | 0.9953 |
| Roof Light | 11 | Retail | 96.42 | 186.48 | 1.0000 |
| Roof Mass | 11 | Retail | 93.63 | 118.96 | 0.9929 |
| Roof Attic | 11 | Retail | 93.65 | 201.41 | 0.9997 |
| Floor Light | 11 | Retail | 92.06 | 84.21 | 0.9916 |
| Floor Mass | 11 | Retail | 91.45 | 23.95 | 0.8212 |
| Wall Light | 12 | Retail | 319.58 | 166.39 | 0.9999 |
| Wall Medium | 12 | Retail | 315.03 | 104.67 | 0.9941 |
| Wall Heavy | 12 | Retail | 315.20 | 78.83 | 0.9938 |

| Type | Occupancy | CZ | Constant | Coefficient | $R^2$ |
|---|---|---|---|---|---|
| Roof Light | 12 | Retail | 89.37 | 174.28 | 1.0000 |
| Roof Mass | 12 | Retail | 86.54 | 100.45 | 0.9891 |
| Roof Attic | 12 | Retail | 87.06 | 186.53 | 0.9996 |
| Floor Light | 12 | Retail | 87.51 | 63.89 | 0.9828 |
| Floor Mass | 12 | Retail | 86.81 | -1.17 | 0.0097 |
| Wall Light | 13 | Retail | 380.71 | 189.65 | 0.9999 |
| Wall Medium | 13 | Retail | 376.56 | 122.30 | 0.9973 |
| Wall Heavy | 13 | Retail | 377.16 | 93.48 | 0.9973 |
| Roof Light | 13 | Retail | 107.28 | 184.93 | 1.0000 |
| Roof Mass | 13 | Retail | 104.94 | 108.39 | 0.9944 |
| Roof Attic | 13 | Retail | 104.59 | 192.12 | 0.9998 |
| Floor Light | 13 | Retail | 104.96 | 70.65 | 0.9911 |
| Floor Mass | 13 | Retail | 104.65 | 13.62 | 0.6380 |
| Wall Light | 14 | Retail | 389.05 | 213.97 | 0.9998 |
| Wall Medium | 14 | Retail | 383.10 | 144.65 | 0.9963 |
| Wall Heavy | 14 | Retail | 383.82 | 107.52 | 0.9963 |
| Roof Light | 14 | Retail | 108.49 | 220.37 | 0.9999 |
| Roof Mass | 14 | Retail | 105.41 | 135.66 | 0.9959 |
| Roof Attic | 14 | Retail | 104.81 | 235.28 | 0.9998 |
| Floor Light | 14 | Retail | 101.84 | 111.25 | 0.9953 |
| Floor Mass | 14 | Retail | 100.81 | 43.83 | 0.9296 |
| Wall Light | 15 | Retail | 615.39 | 253.96 | 1.0000 |
| Wall Medium | 15 | Retail | 606.80 | 167.49 | 0.9987 |
| Wall Heavy | 15 | Retail | 607.38 | 137.00 | 0.9986 |
| Roof Light | 15 | Retail | 175.14 | 222.20 | 0.9997 |
| Roof Mass | 15 | Retail | 173.61 | 114.01 | 0.9900 |
| Roof Attic | 15 | Retail | 172.38 | 219.81 | 0.9997 |
| Floor Light | 15 | Retail | 169.01 | 110.58 | 0.9987 |
| Floor Mass | 15 | Retail | 166.76 | 51.70 | 0.9975 |
| Wall Light | 16 | Retail | 255.06 | 202.87 | 0.9999 |
| Wall Medium | 16 | Retail | 249.03 | 167.59 | 0.9972 |
| Wall Heavy | 16 | Retail | 248.77 | 145.05 | 0.9972 |
| Roof Light | 16 | Retail | 68.64 | 232.47 | 1.0000 |
| Roof Mass | 16 | Retail | 65.25 | 179.76 | 0.9971 |
| Roof Attic | 16 | Retail | 65.26 | 250.01 | 0.9998 |
| Floor Light | 16 | Retail | 57.68 | 141.89 | 0.9951 |
| Floor Mass | 16 | Retail | 55.65 | 86.00 | 0.9501 |
| Wall Light | 1 | 24-hour | 285.47 | 170.51 | 0.9998 |
| Wall Medium | 1 | 24-hour | 285.61 | 158.57 | 0.9999 |
| Wall Heavy | 1 | 24-hour | 286.23 | 144.37 | 0.9998 |
| Roof Light | 1 | 24-hour | 56.69 | 241.17 | 0.9998 |
| Roof Mass | 1 | 24-hour | 56.97 | 213.10 | 0.9994 |
| Roof Attic | 1 | 24-hour | 56.09 | 218.71 | 0.9999 |
| Floor Light | 1 | 24-hour | 26.98 | 271.87 | 1.0000 |
| Floor Mass | 1 | 24-hour | 26.36 | 265.55 | 0.9997 |

| Type | Occupancy | CZ | Constant | Coefficient | $R^2$ |
|---|---|---|---|---|---|
| Wall Light | 2 | 24-hour | 349.64 | 215.98 | 0.9998 |
| Wall Medium | 2 | 24-hour | 348.81 | 111.64 | 1.0000 |
| Wall Heavy | 2 | 24-hour | 349.20 | 85.71 | 0.9999 |
| Roof Light | 2 | 24-hour | 68.70 | 315.45 | 0.9999 |
| Roof Mass | 2 | 24-hour | 67.47 | 190.51 | 1.0000 |
| Roof Attic | 2 | 24-hour | 69.33 | 267.29 | 0.9999 |
| Floor Light | 2 | 24-hour | 46.81 | 242.47 | 1.0000 |
| Floor Mass | 2 | 24-hour | 45.14 | 190.18 | 1.0000 |
| Wall Light | 3 | 24-hour | 213.35 | 160.68 | 1.0000 |
| Wall Medium | 3 | 24-hour | 213.35 | 108.56 | 1.0000 |
| Wall Heavy | 3 | 24-hour | 213.82 | 89.78 | 1.0000 |
| Roof Light | 3 | 24-hour | 41.39 | 218.06 | 1.0000 |
| Roof Mass | 3 | 24-hour | 40.78 | 167.97 | 1.0000 |
| Roof Attic | 3 | 24-hour | 41.93 | 191.99 | 1.0000 |
| Floor Light | 3 | 24-hour | 21.82 | 195.46 | 0.9998 |
| Floor Mass | 3 | 24-hour | 20.62 | 176.41 | 0.9997 |
| Wall Light | 4 | 24-hour | 275.06 | 182.30 | 0.9999 |
| Wall Medium | 4 | 24-hour | 274.57 | 89.88 | 0.9995 |
| Wall Heavy | 4 | 24-hour | 275.01 | 66.34 | 0.9994 |
| Roof Light | 4 | 24-hour | 54.02 | 257.77 | 1.0000 |
| Roof Mass | 4 | 24-hour | 52.72 | 153.93 | 0.9995 |
| Roof Attic | 4 | 24-hour | 55.03 | 215.08 | 1.0000 |
| Floor Light | 4 | 24-hour | 39.32 | 175.15 | 0.9997 |
| Floor Mass | 4 | 24-hour | 37.81 | 130.67 | 0.9996 |
| Wall Light | 5 | 24-hour | 210.14 | 162.30 | 0.9999 |
| Wall Medium | 5 | 24-hour | 209.88 | 79.05 | 0.9999 |
| Wall Heavy | 5 | 24-hour | 210.00 | 60.49 | 0.9992 |
| Roof Light | 5 | 24-hour | 40.43 | 222.35 | 0.9999 |
| Roof Mass | 5 | 24-hour | 39.28 | 148.23 | 0.9998 |
| Roof Attic | 5 | 24-hour | 41.50 | 181.95 | 0.9999 |
| Floor Light | 5 | 24-hour | 21.67 | 192.00 | 0.9998 |
| Floor Mass | 5 | 24-hour | 20.06 | 161.91 | 0.9997 |
| Wall Light | 6 | 24-hour | 149.25 | 125.38 | 1.0000 |
| Wall Medium | 6 | 24-hour | 149.11 | 55.77 | 0.9972 |
| Wall Heavy | 6 | 24-hour | 149.51 | 40.67 | 0.9987 |
| Roof Light | 6 | 24-hour | 28.05 | 181.96 | 1.0000 |
| Roof Mass | 6 | 24-hour | 27.37 | 113.99 | 0.9991 |
| Roof Attic | 6 | 24-hour | 29.23 | 140.70 | 1.0000 |
| Floor Light | 6 | 24-hour | 19.26 | 111.38 | 0.9985 |
| Floor Mass | 6 | 24-hour | 17.53 | 94.94 | 0.9944 |
| Wall Light | 7 | 24-hour | 157.78 | 122.18 | 1.0000 |
| Wall Medium | 7 | 24-hour | 157.26 | 44.86 | 0.9974 |
| Wall Heavy | 7 | 24-hour | 156.11 | 42.95 | 0.9880 |
| Roof Light | 7 | 24-hour | 30.41 | 171.95 | 1.0000 |
| Roof Mass | 7 | 24-hour | 29.92 | 96.47 | 1.0000 |

| Type | Occupancy | CZ | Constant | Coefficient | $R^2$ |
|---|---|---|---|---|---|
| Roof Attic | 7 | 24-hour | 31.47 | 132.27 | 1.0000 |
| Floor Light | 7 | 24-hour | 24.39 | 90.07 | 0.9985 |
| Floor Mass | 7 | 24-hour | 23.02 | 72.35 | 0.9999 |
| Wall Light | 8 | 24-hour | 216.27 | 155.91 | 1.0000 |
| Wall Medium | 8 | 24-hour | 214.95 | 54.81 | 0.9895 |
| Wall Heavy | 8 | 24-hour | 215.91 | 32.17 | 0.9936 |
| Roof Light | 8 | 24-hour | 42.97 | 199.83 | 1.0000 |
| Roof Mass | 8 | 24-hour | 41.87 | 109.89 | 0.9998 |
| Roof Attic | 8 | 24-hour | 43.37 | 163.28 | 1.0000 |
| Floor Light | 8 | 24-hour | 34.98 | 111.94 | 0.9987 |
| Floor Mass | 8 | 24-hour | 32.91 | 77.34 | 0.9940 |
| Wall Light | 9 | 24-hour | 257.53 | 171.92 | 1.0000 |
| Wall Medium | 9 | 24-hour | 255.91 | 63.88 | 0.9956 |
| Wall Heavy | 9 | 24-hour | 256.21 | 37.51 | 0.9914 |
| Roof Light | 9 | 24-hour | 51.98 | 213.39 | 1.0000 |
| Roof Mass | 9 | 24-hour | 50.37 | 107.07 | 0.9977 |
| Roof Attic | 9 | 24-hour | 52.41 | 175.64 | 1.0000 |
| Floor Light | 9 | 24-hour | 42.80 | 124.22 | 0.9991 |
| Floor Mass | 9 | 24-hour | 40.59 | 77.35 | 0.9957 |
| Wall Light | 10 | 24-hour | 320.24 | 217.44 | 1.0000 |
| Wall Medium | 10 | 24-hour | 318.16 | 90.76 | 0.9969 |
| Wall Heavy | 10 | 24-hour | 318.87 | 58.24 | 0.9952 |
| Roof Light | 10 | 24-hour | 64.77 | 263.87 | 1.0000 |
| Roof Mass | 10 | 24-hour | 63.87 | 134.27 | 0.9992 |
| Roof Attic | 10 | 24-hour | 65.13 | 217.56 | 1.0000 |
| Floor Light | 10 | 24-hour | 53.43 | 153.72 | 0.9999 |
| Floor Mass | 10 | 24-hour | 50.48 | 109.94 | 0.9984 |
| Wall Light | 11 | 24-hour | 416.09 | 253.22 | 1.0000 |
| Wall Medium | 11 | 24-hour | 414.95 | 164.42 | 0.9999 |
| Wall Heavy | 11 | 24-hour | 415.25 | 138.33 | 0.9997 |
| Roof Light | 11 | 24-hour | 85.98 | 288.29 | 1.0000 |
| Roof Mass | 11 | 24-hour | 84.98 | 205.92 | 0.9998 |
| Roof Attic | 11 | 24-hour | 84.84 | 270.93 | 1.0000 |
| Floor Light | 11 | 24-hour | 64.99 | 225.65 | 0.9999 |
| Floor Mass | 11 | 24-hour | 63.04 | 183.94 | 1.0000 |
| Wall Light | 12 | 24-hour | 371.06 | 227.71 | 1.0000 |
| Wall Medium | 12 | 24-hour | 370.26 | 133.55 | 0.9999 |
| Wall Heavy | 12 | 24-hour | 371.17 | 102.57 | 0.9999 |
| Roof Light | 12 | 24-hour | 75.33 | 286.43 | 1.0000 |
| Roof Mass | 12 | 24-hour | 73.94 | 186.46 | 0.9998 |
| Roof Attic | 12 | 24-hour | 75.09 | 258.22 | 1.0000 |
| Floor Light | 12 | 24-hour | 56.27 | 212.82 | 0.9999 |
| Floor Mass | 12 | 24-hour | 54.80 | 161.28 | 1.0000 |
| Wall Light | 13 | 24-hour | 401.07 | 232.08 | 0.9999 |
| Wall Medium | 13 | 24-hour | 399.52 | 146.34 | 0.9998 |

| Type | Occupancy | CZ | Constant | Coefficient | $R^2$ |
|---|---|---|---|---|---|
| Wall Heavy | 13 | 24-hour | 400.18 | 118.12 | 0.9998 |
| Roof Light | 13 | 24-hour | 83.06 | 268.75 | 1.0000 |
| Roof Mass | 13 | 24-hour | 82.20 | 184.10 | 0.9999 |
| Roof Attic | 13 | 24-hour | 82.04 | 246.21 | 1.0000 |
| Floor Light | 13 | 24-hour | 65.84 | 195.34 | 1.0000 |
| Floor Mass | 13 | 24-hour | 63.88 | 157.65 | 1.0000 |
| Wall Light | 14 | 24-hour | 466.17 | 269.21 | 0.9999 |
| Wall Medium | 14 | 24-hour | 463.96 | 165.76 | 0.9997 |
| Wall Heavy | 14 | 24-hour | 464.70 | 131.67 | 0.9997 |
| Roof Light | 14 | 24-hour | 95.70 | 324.85 | 0.9999 |
| Roof Mass | 14 | 24-hour | 95.05 | 229.38 | 1.0000 |
| Roof Attic | 14 | 24-hour | 94.58 | 300.35 | 1.0000 |
| Floor Light | 14 | 24-hour | 73.40 | 247.84 | 1.0000 |
| Floor Mass | 14 | 24-hour | 70.92 | 203.10 | 1.0000 |
| Wall Light | 15 | 24-hour | 526.27 | 284.47 | 1.0000 |
| Wall Medium | 15 | 24-hour | 516.46 | 163.64 | 0.9990 |
| Wall Heavy | 15 | 24-hour | 516.48 | 137.53 | 0.9982 |
| Roof Light | 15 | 24-hour | 111.18 | 282.17 | 0.9996 |
| Roof Mass | 15 | 24-hour | 110.14 | 175.33 | 0.9987 |
| Roof Attic | 15 | 24-hour | 108.96 | 256.90 | 1.0000 |
| Floor Light | 15 | 24-hour | 95.51 | 193.39 | 0.9999 |
| Floor Mass | 15 | 24-hour | 92.39 | 131.40 | 0.9932 |
| Wall Light | 16 | 24-hour | 512.69 | 300.86 | 0.9999 |
| Wall Medium | 16 | 24-hour | 512.55 | 220.44 | 1.0000 |
| Wall Heavy | 16 | 24-hour | 513.34 | 196.09 | 1.0000 |
| Roof Light | 16 | 24-hour | 104.79 | 371.78 | 0.9999 |
| Roof Mass | 16 | 24-hour | 104.08 | 287.74 | 1.0000 |
| Roof Attic | 16 | 24-hour | 103.58 | 345.32 | 1.0000 |
| Floor Light | 16 | 24-hour | 69.58 | 346.76 | 1.0000 |
| Floor Mass | 16 | 24-hour | 68.52 | 296.44 | 1.0000 |